# United States Patent [19]

**Christopher et al.**

[11] **4,075,679**

[45] **Feb. 21, 1978**

[54] **PROGRAMMABLE CALCULATOR**

[75] Inventors: **Chris J. Christopher; Fred W. Wenninger; Donald E. Morris; Wayne F. Covington; Jerry B. Folsom; Joseph W. Beyers**, all of Loveland; **John H. Nairn; Jeffrey C. Osborne**, both of Longmont, all of Colo.

[73] Assignee: **Hewlett-Packard Company**, Palo Alto, Calif.

[21] Appl. No.: **638,381**

[22] Filed: **Dec. 8, 1975**

[51] **Int. Cl.**$^2$ .......................... **G06F 3/02**; G06F 9/18

[52] **U.S. Cl.** .................................. **364/200**; 364/900; 340/365 R; 364/706

[58] **Field of Search** ...................... 340/172.5, 365 R; 445/1; 235/152, 156; 364/200, 900

[56] **References Cited**

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| | | | |
|---|---|---|---|
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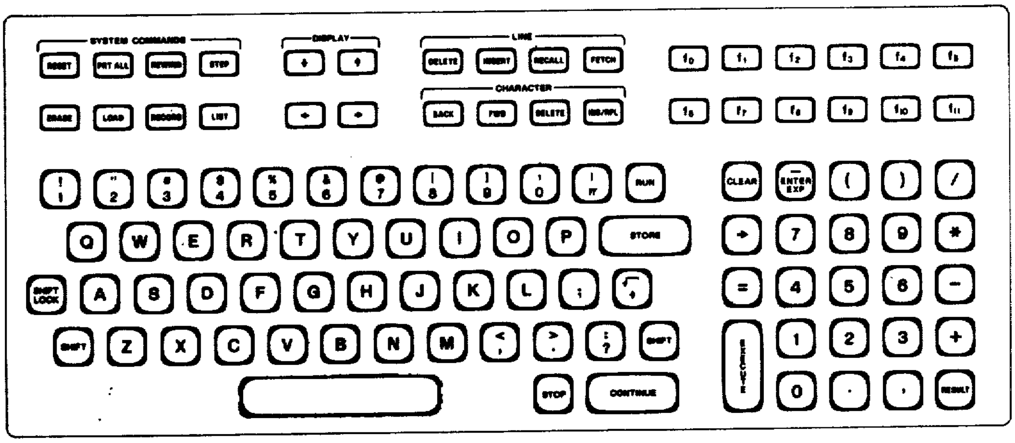
| 3,593,313 | 7/1971 | Tomaszewski et al. | 340/172.5 |
| 3,610,902 | 10/1971 | Rahenkamp | 235/152 |
| 3,623,012 | 11/1971 | Lowry et al. | 340/172.5 |
| 3,675,213 | 7/1972 | Spangler | 340/172.5 |
| 3,769,621 | 10/1973 | Osborne | 340/172.5 |
| 3,839,630 | 10/1974 | Olander et al. | 235/156 |
| 3,859,630 | 1/1975 | Watson et al. | 340/172.5 |
| 4,015,245 | 3/1977 | Mercurio et al. | 340/172.5 |

*Primary Examiner*—Mark E. Nusbaum
*Attorney, Agent, or Firm*—William E. Hein

[57] **ABSTRACT**

An adaptable programmable calculator employs modular read-write and read-only memories separately expandable to provide additional program and data storage functions within the calculator oriented toward the environment of the user, and an LSI NMOS central processing unit, capable of handling sixteen-bit parallel binary operations, binary-coded-decimal arithmetic, sixteen-bit parallel input/output operations, two-level interrupt from up to sixteen input/output devices, and a direct memory access channel. The input/output units include a keyboard input unit having a full complement of alphanumeric keys, a magnetic tape cassette reading and recording unit capable of bidirectionally transferring programs and data between the calculator and a magnetic tape, a 32-character solid state output display unit capable of displaying every alphabetic and numeric character and many other symbols individually or in combination, and a sixteen-column alphanumeric thermal printer for printing results of computations, program listings, messages generated by the user and the calculator itself, and error conditions encountered during use of the calculator. All of these input/output units are included within the calculator itself. Many other external input/output units may be employed with the calculator. The calculator may be operated manually by the user from the keyboard input unit or automatically through a program stored within the read-write memory to perform calculations and to provide an output indication of the results thereof. While a program stored within the read-write memory is being executed, the user can perform calculations manually from the keyboard. Execution of the program is temporarily suspended at convenient points within the program to allow execution of the calculations manually selected by the user. If desired, the user may be prevented from manually selecting calculations from the keyboard input unit by disabling the keyboard input unit during program execution. The calculator employs a natural algebraic program language that allows the user to enter lines of one or more alphanumeric algebraic statements into the calculator from the keyboard input unit while visually observing each line as it is entered to check for errors therein. The user may immediately execute each entered line or store that line as part of a program in the read-write memory, may subsequently recall the executed or stored line so that it may be reinspected, and, if necessary, edited and re-executed or re-stored, thereby automatically replacing the previously stored line. The program language of the calculator is contained within a plug-in language read-only memory and may be changed by inserting a different language read-only memory.

**8 Claims, 276 Drawing Figures**



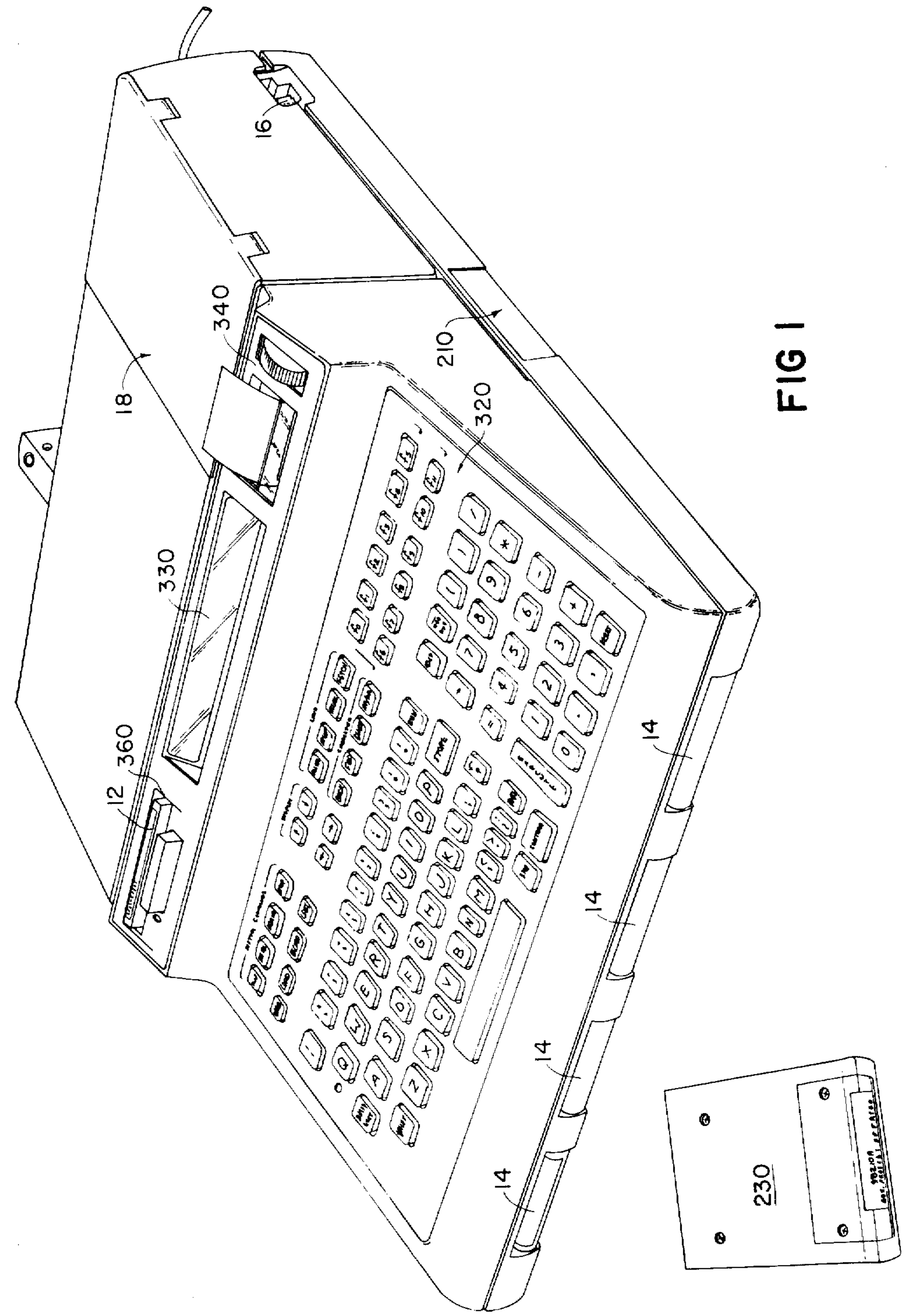


FIG I

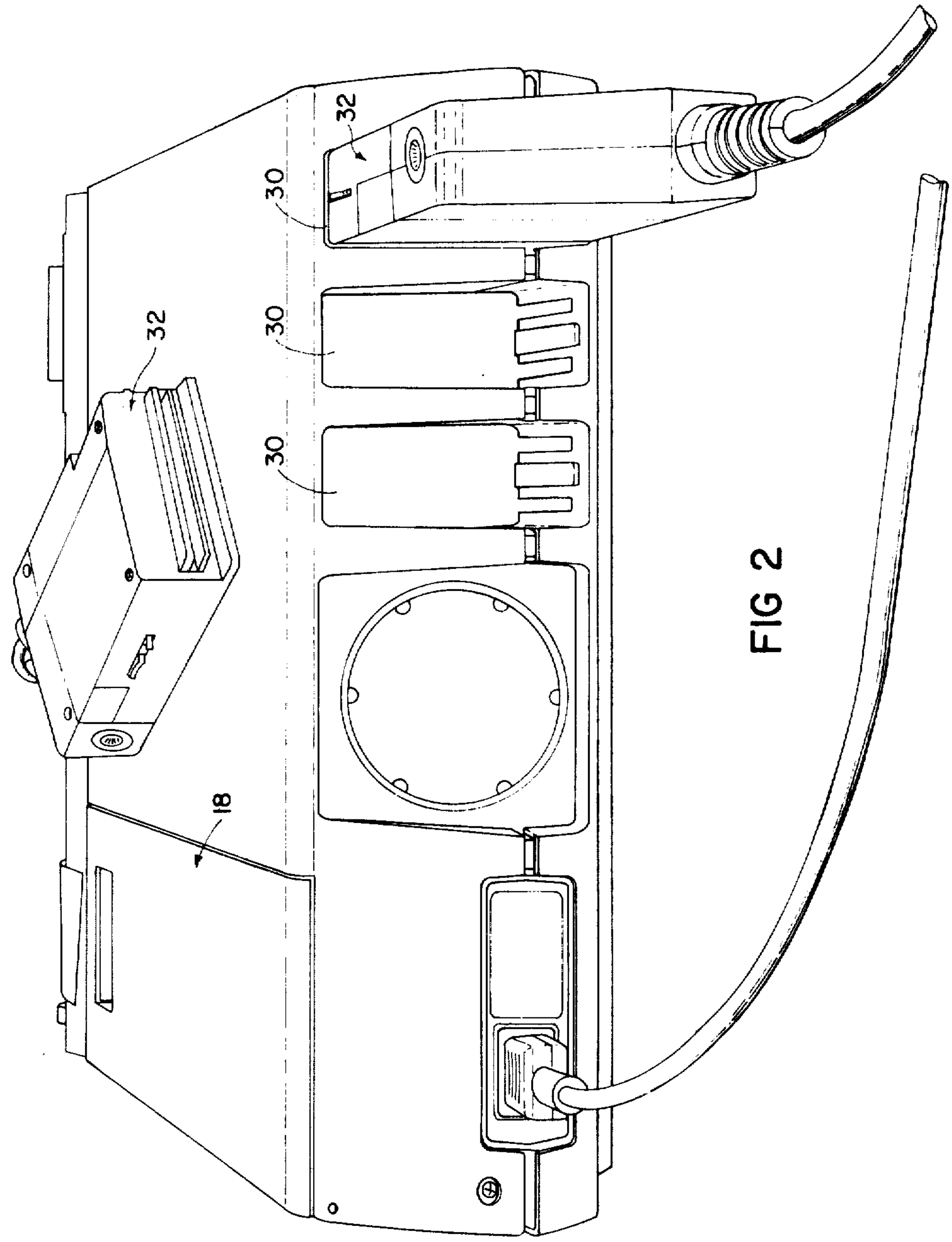


FIG 2

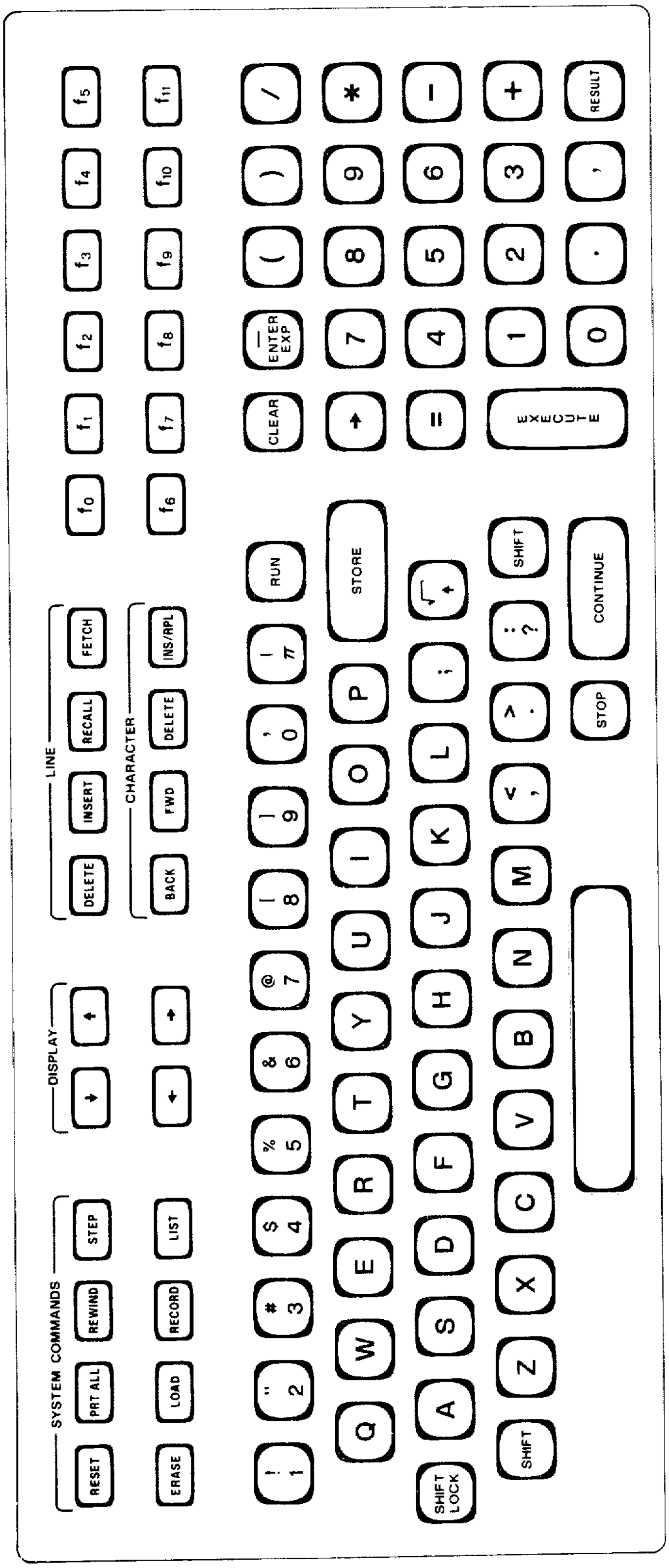

SYSTEM COMMANDS
RESET
PRT ALL
REWIND
STEP
ERASE
LOAD
RECORD
LIST
DISPLAY
LINE
DELETE
INSERT
RECALL
FETCH
CHARACTER
BACK
FWD
DELETE
INS/RPL
$f_0$
$f_1$
$f_2$
$f_3$
$f_4$
$f_5$
$f_6$
$f_7$
$f_8$
$f_9$
$f_{10}$
$f_{11}$
CLEAR
ENTER EXP
RUN
STORE
SHIFT
CONTINUE
STOP
SHIFT LOCK
SHIFT
EXECUTE
RESULT
/
*
-
+
=
π

FIG 3

FIG 4

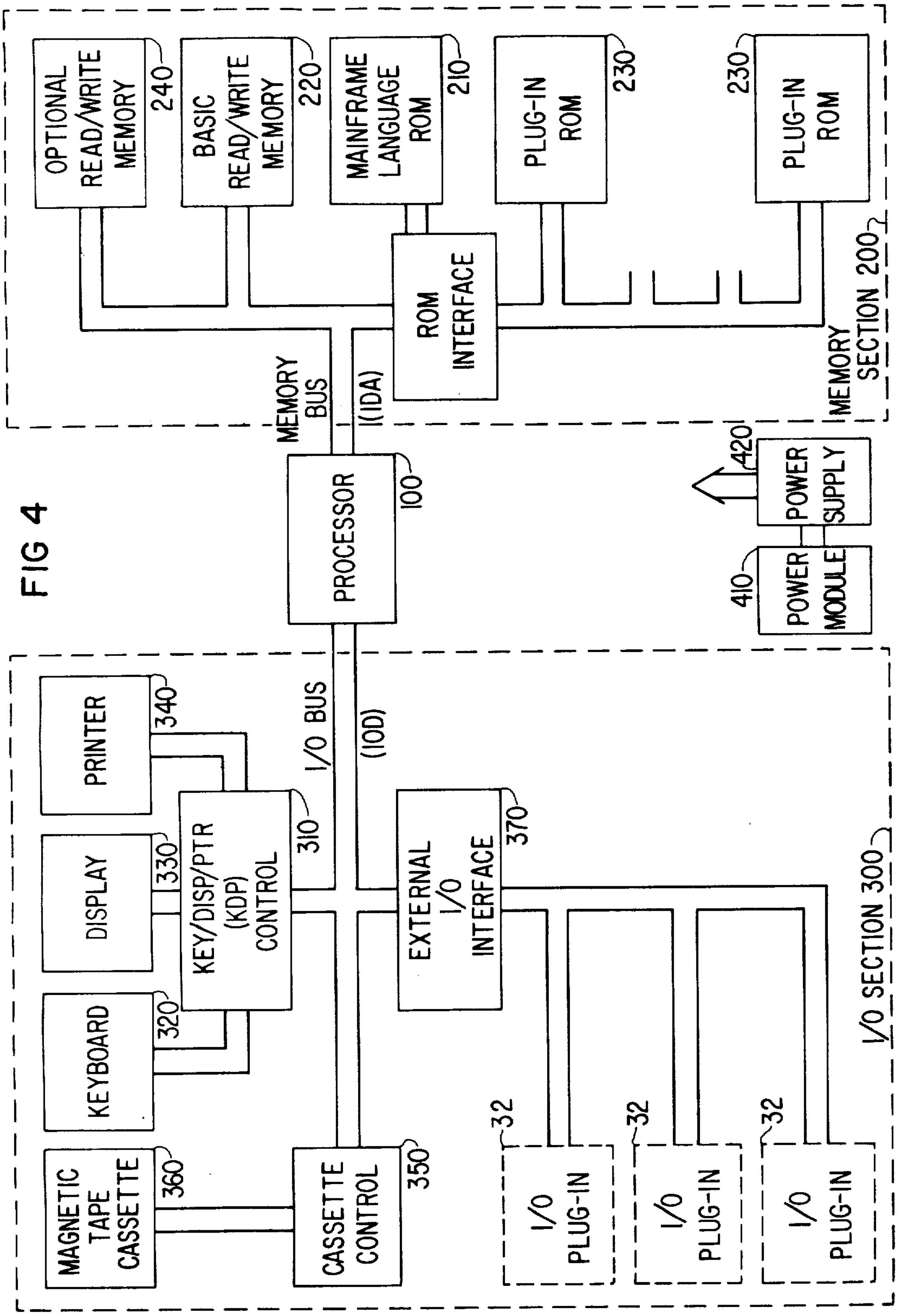
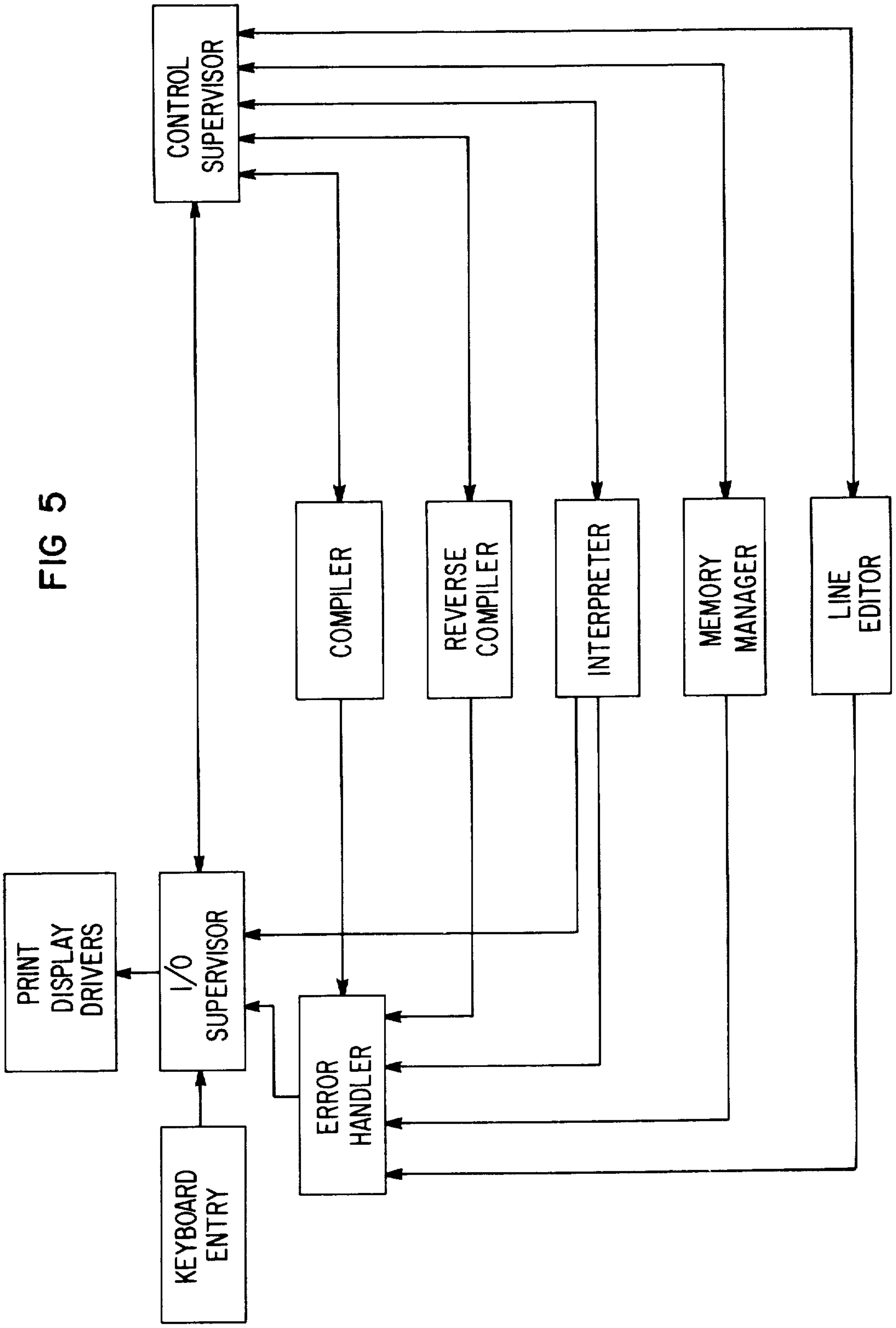

OPTIONAL READ/WRITE MEMORY
240
BASIC READ/WRITE MEMORY
220
MAINFRAME LANGUAGE ROM
210
PLUG-IN ROM
230
PLUG-IN ROM
230
ROM INTERFACE
MEMORY SECTION 200
MEMORY BUS
I(IDA)
PROCESSOR
100
POWER SUPPLY
420
POWER MODULE
410
I/O BUS
(IOD)
PRINTER
340
DISPLAY
330
KEYBOARD
320
KEY/DISP/PTR (KDP) CONTROL
310
EXTERNAL I/O INTERFACE
370
I/O SECTION 300
MAGNETIC TAPE CASSETTE
360
CASSETTE CONTROL
350
I/O PLUG-IN
32
I/O PLUG-IN
32
I/O PLUG-IN
32

FIG 5


CONTROL SUPERVISOR
COMPILER
REVERSE COMPILER
INTERPRETER
MEMORY MANAGER
LINE EDITOR
PRINT DISPLAY DRIVERS
I/O SUPERVISOR
ERROR HANDLER
KEYBOARD ENTRY

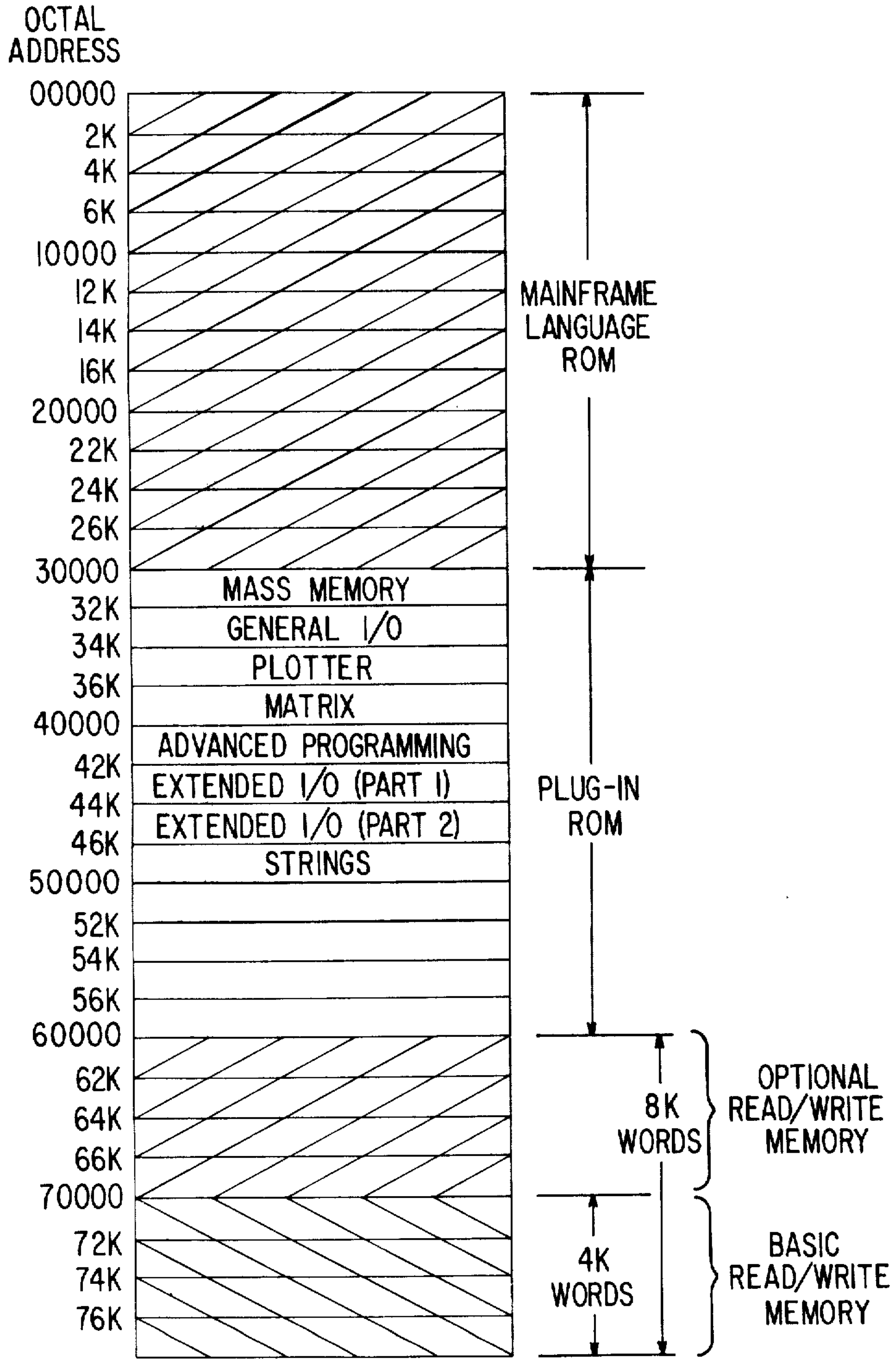

OCTAL ADDRESS
00000
2K
4K
6K
10000
12K
14K
16K
20000
22K
24K
26K
30000
32K
34K
36K
40000
42K
44K
46K
50000
52K
54K
56K
60000
62K
64K
66K
70000
72K
74K
76K
MAINFRAME LANGUAGE ROM
MASS MEMORY
GENERAL I/O
PLOTTER
MATRIX
ADVANCED PROGRAMMING
EXTENDED I/O (PART I)
EXTENDED I/O (PART 2)
STRINGS
PLUG-IN ROM
8K WORDS
OPTIONAL READ/WRITE MEMORY
4K WORDS
BASIC READ/WRITE MEMORY

FIG 6

MAINFRAME LANGUAGE ROM MAP

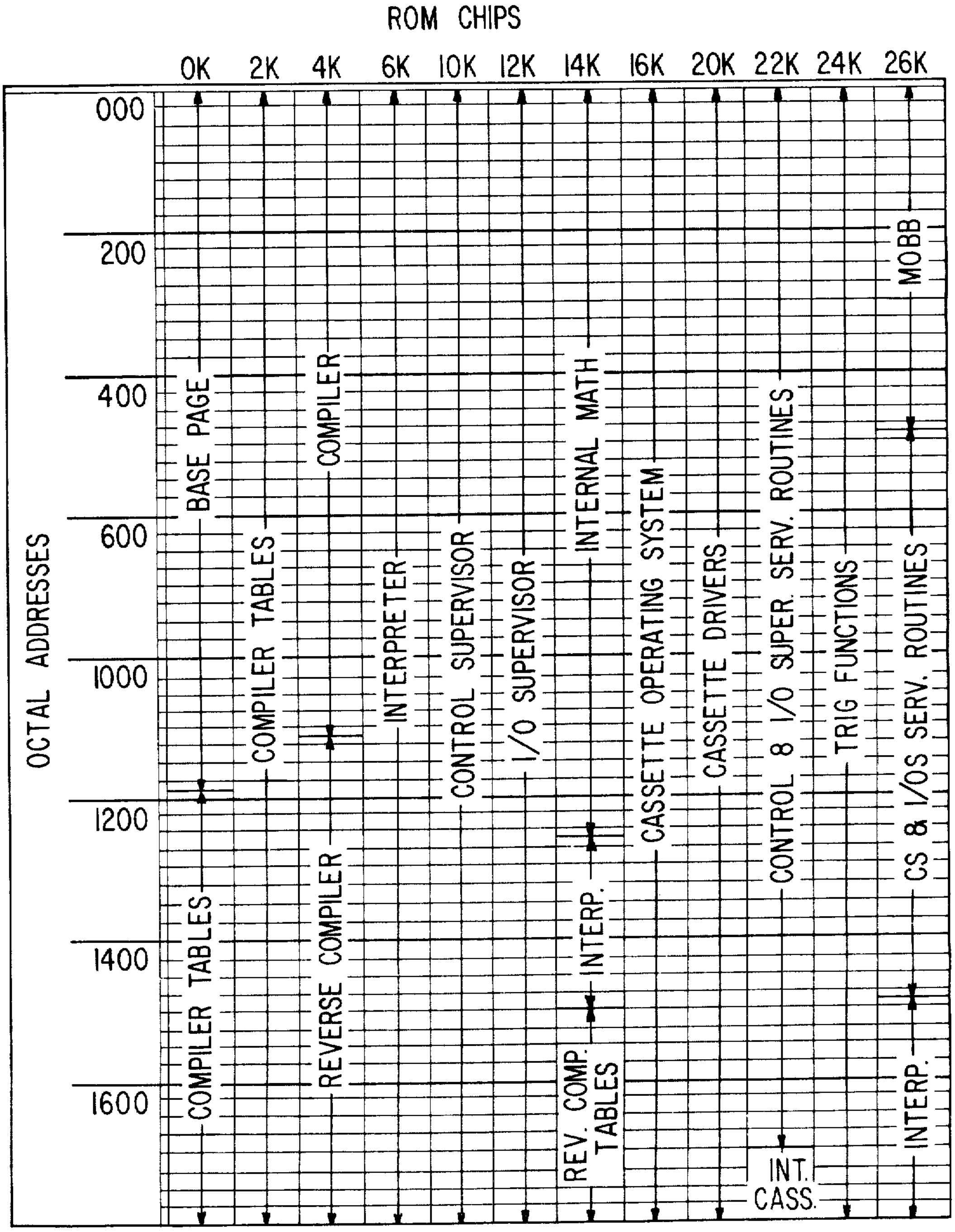
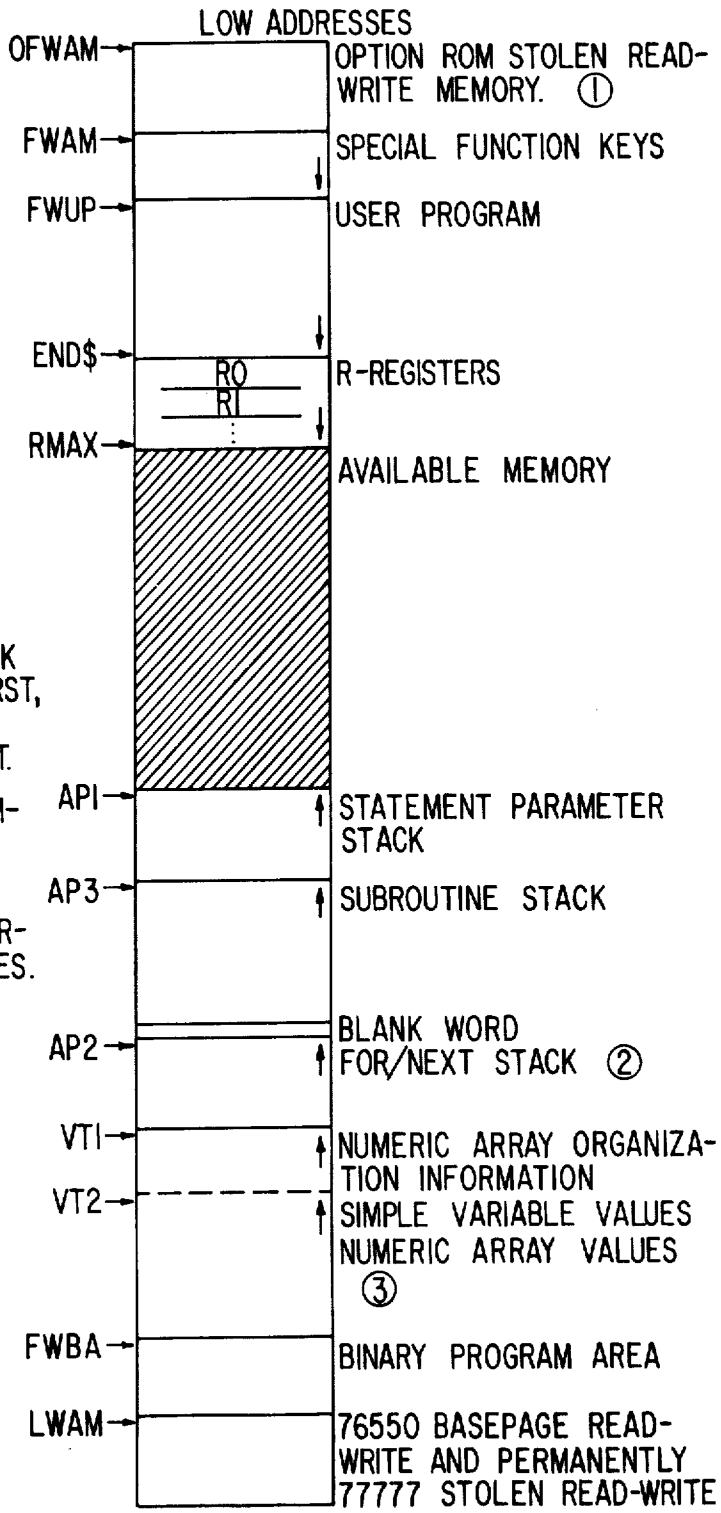


FIG 7

| MEMORY SIZE | STARTING ADDRESS |
|---|---|
| 4K | 70000 |
| 8K | 60000 |



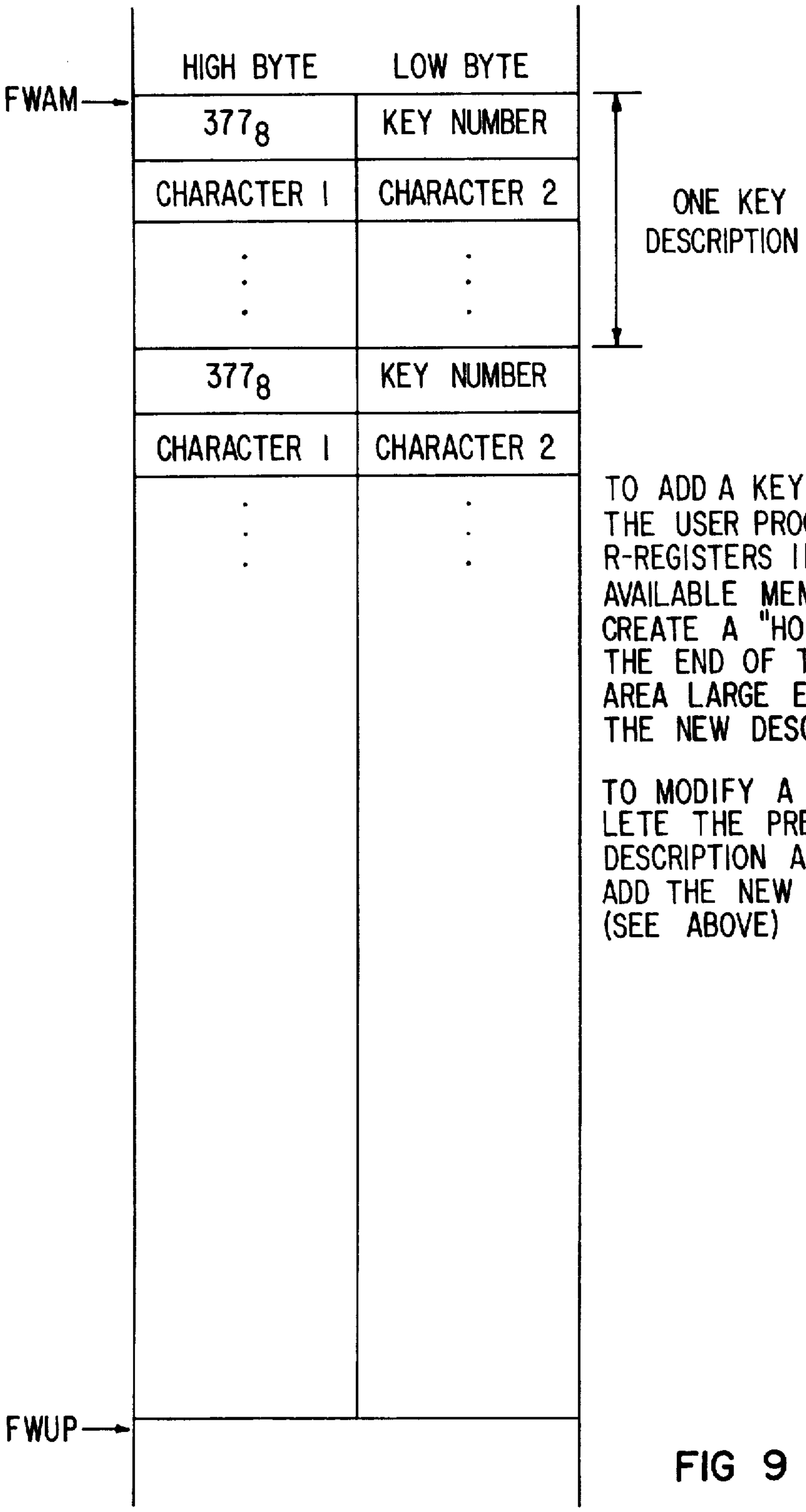
—NOTES—

① OPTION ROM AT 30K TAKES MEMORY FIRST, BINARY PROGRAMS TAKE MEMORY LAST.

② ADVANCED PROGRAMING ROM.

③ STRING VARIABLES ORGANIZATION INFORMATION AND VALUES.

FIG 8



TO ADD A KEY MOVE THE USER PROGRAM AND R-REGISTERS INTO THE AVAILABLE MEMORY. TO CREATE A "HOLE" AT THE END OF THE KEY AREA LARGE ENOUGH FOR THE NEW DESCRIPTION.

TO MODIFY A KEY DELETE THE PREVIOUS DESCRIPTION AND THEN ADD THE NEW DESCRIPTION. (SEE ABOVE)

FIG 9

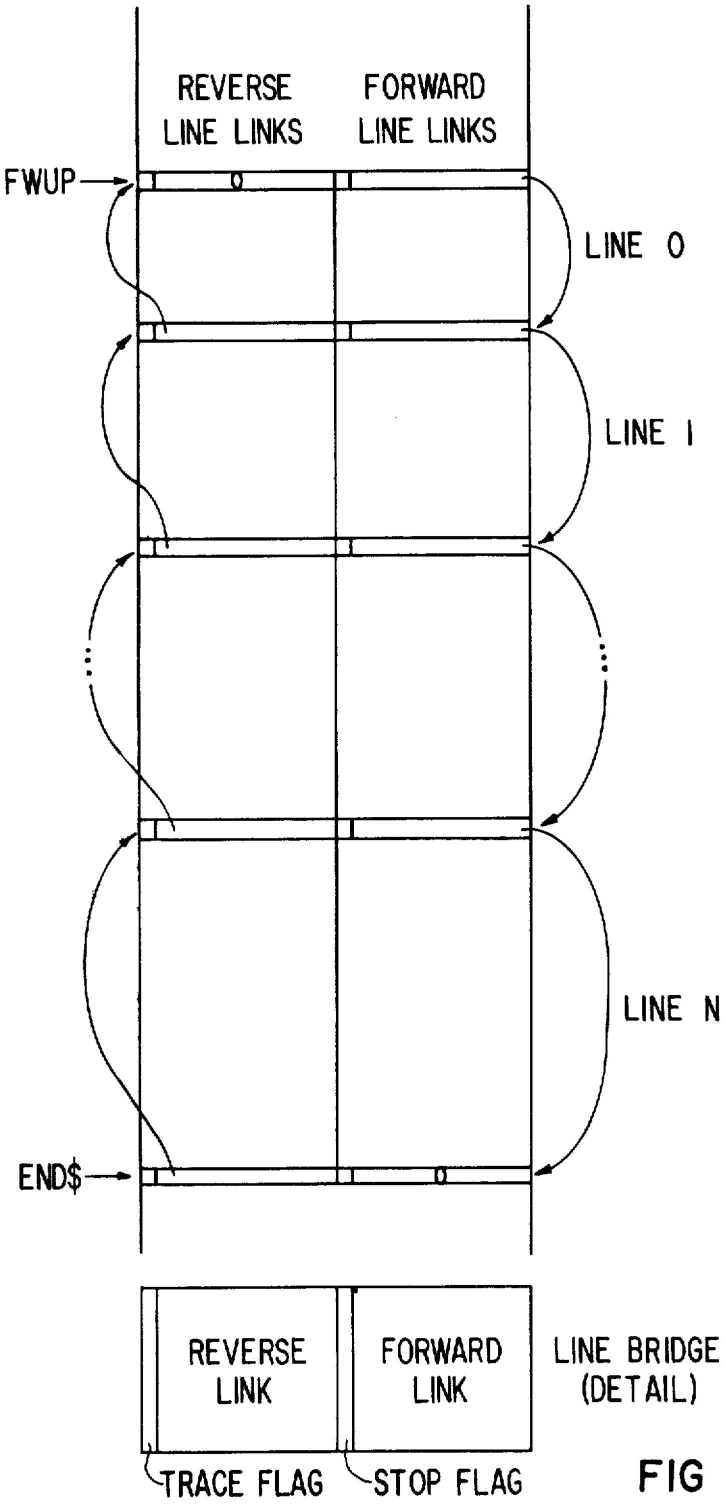
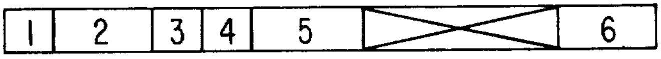

REVERSE LINE LINKS
FORWARD LINE LINKS
FWUP
0
LINE 0
LINE 1
LINE N
END$
0
REVERSE LINK
FORWARD LINK
LINE BRIDGE (DETAIL)
TRACE FLAG
STOP FLAG

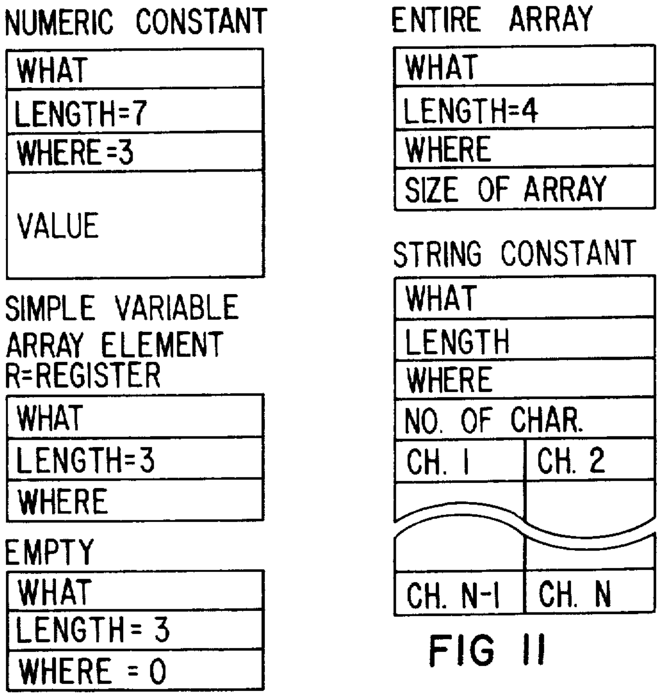
FIG 10

STATEMENT PARAMETER STACK ENTITIES

"WHAT" WORD DESCRIPTION:



1. 1=VARIABLE
   0=CONSTANT
2. CLASS
   0
   1 FULL PRECISION NO.
   2
   3
   4
   5
   6 ENTIRE ARRAY
   7 EMPTY
3. COMMA LINK
4. COLON LINK
5. SUB CLASS
6. ADDRESSING MODE
   0 ABSOLUTE
   1 RELATIVE TO "WHAT" WORD
   2 RELATIVE TO END$
   3 RELATIVE TO AP2



NUMERIC CONSTANT

| |
|---|
| WHAT |
| LENGTH=7 |
| WHERE=3 |
| VALUE |

SIMPLE VARIABLE
ARRAY ELEMENT
R=REGISTER

| |
|---|
| WHAT |
| LENGTH=3 |
| WHERE |

EMPTY

| |
|---|
| WHAT |
| LENGTH= 3 |
| WHERE = 0 |

ENTIRE ARRAY

| |
|---|
| WHAT |
| LENGTH=4 |
| WHERE |
| SIZE OF ARRAY |

STRING CONSTANT

| | |
|---|---|
| WHAT | |
| LENGTH | |
| WHERE | |
| NO. OF CHAR. | |
| CH. 1 | CH. 2 |
| | |
| | |
| CH. N-1 | CH. N |

FIG 11

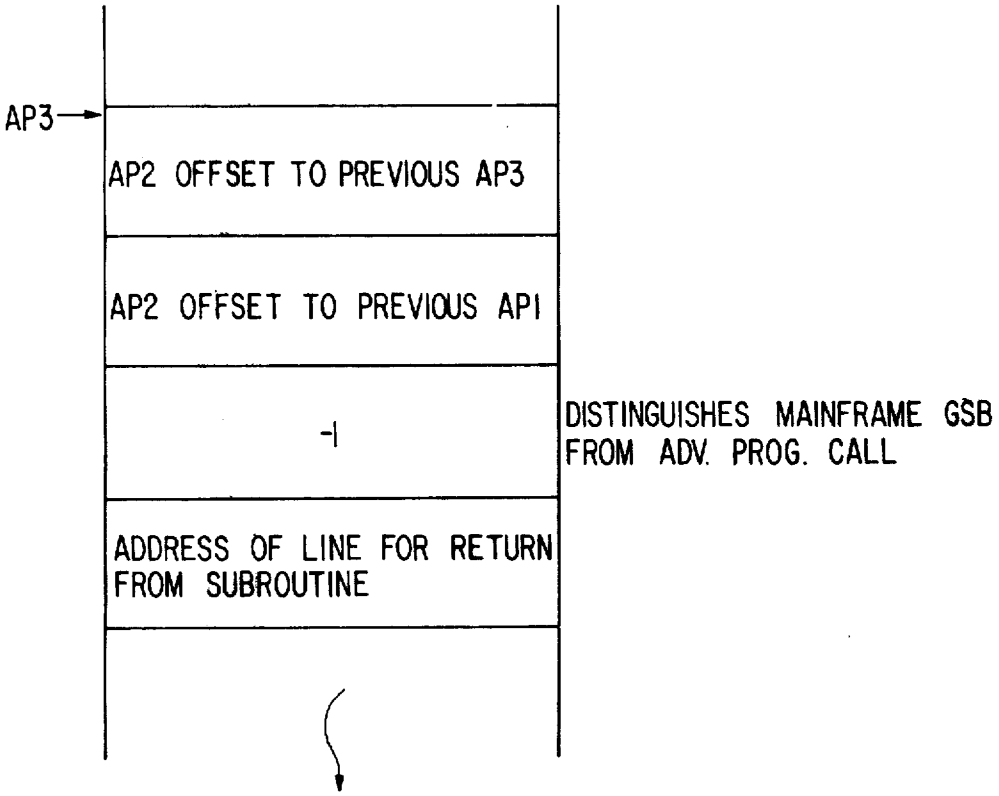
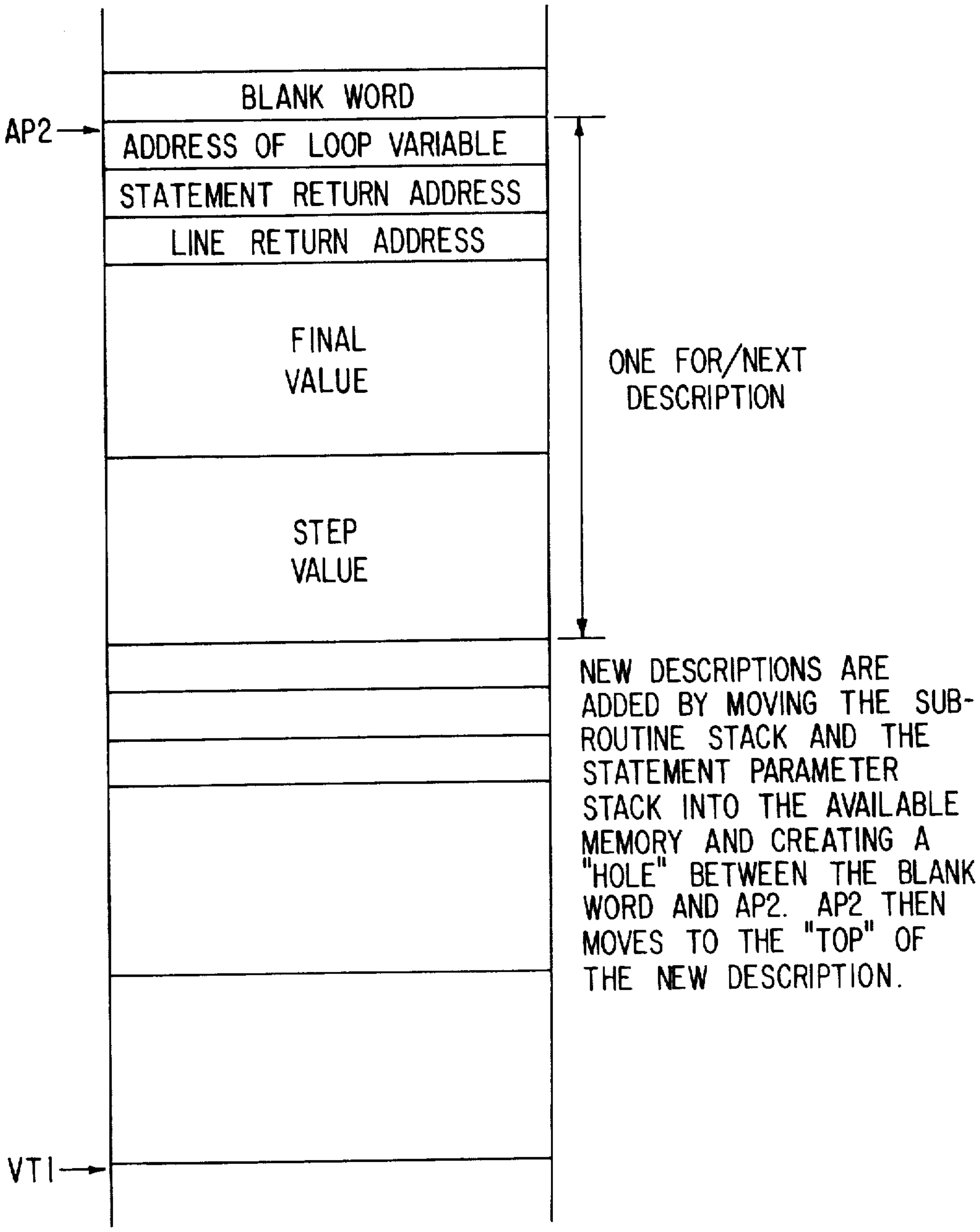

AP3
AP2 OFFSET TO PREVIOUS AP3
AP2 OFFSET TO PREVIOUS AP1
-1
DISTINGUISHES MAINFRAME GSB FROM ADV. PROG. CALL
ADDRESS OF LINE FOR RETURN FROM SUBROUTINE

FIG 12


BLANK WORD
AP2
ADDRESS OF LOOP VARIABLE
STATEMENT RETURN ADDRESS
LINE RETURN ADDRESS
FINAL VALUE
STEP VALUE
ONE FOR/NEXT DESCRIPTION
NEW DESCRIPTIONS ARE ADDED BY MOVING THE SUB-ROUTINE STACK AND THE STATEMENT PARAMETER STACK INTO THE AVAILABLE MEMORY AND CREATING A "HOLE" BETWEEN THE BLANK WORD AND AP2. AP2 THEN MOVES TO THE "TOP" OF THE NEW DESCRIPTION.
VT1

NOTE: THIS STACK IS NULL UNLESS THE ADVANCED PROGRAMMING ROM IS IN USE.

FIG 13

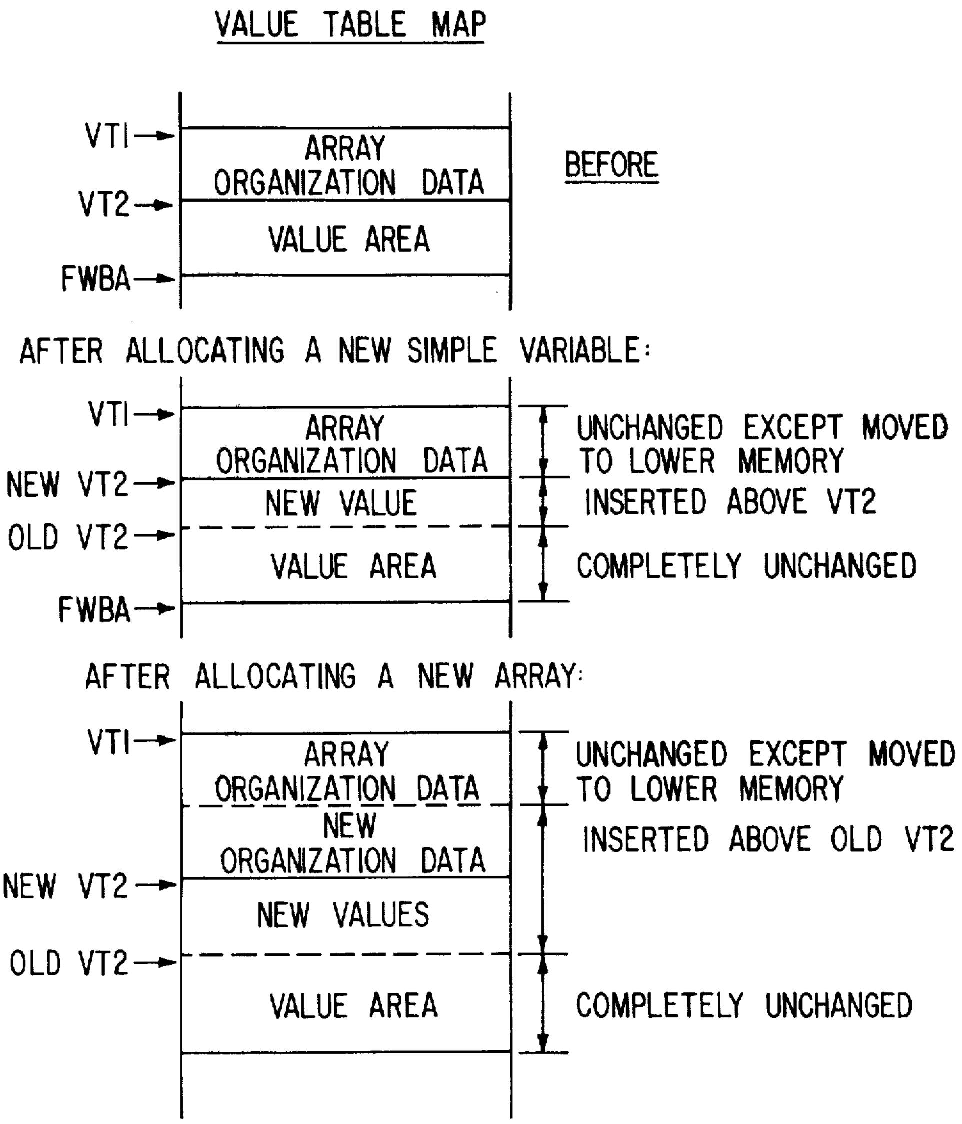

VALUE TABLE MAP
VT1
VT2
FWBA
ARRAY ORGANIZATION DATA
VALUE AREA
BEFORE
AFTER ALLOCATING A NEW SIMPLE VARIABLE:
VT1
NEW VT2
OLD VT2
FWBA
ARRAY ORGANIZATION DATA
NEW VALUE
VALUE AREA
UNCHANGED EXCEPT MOVED TO LOWER MEMORY
INSERTED ABOVE VT2
COMPLETELY UNCHANGED
AFTER ALLOCATING A NEW ARRAY:
VT1
NEW VT2
OLD VT2
ARRAY ORGANIZATION DATA
NEW ORGANIZATION DATA
NEW VALUES
VALUE AREA
UNCHANGED EXCEPT MOVED TO LOWER MEMORY
INSERTED ABOVE OLD VT2
COMPLETELY UNCHANGED

FIG 14A

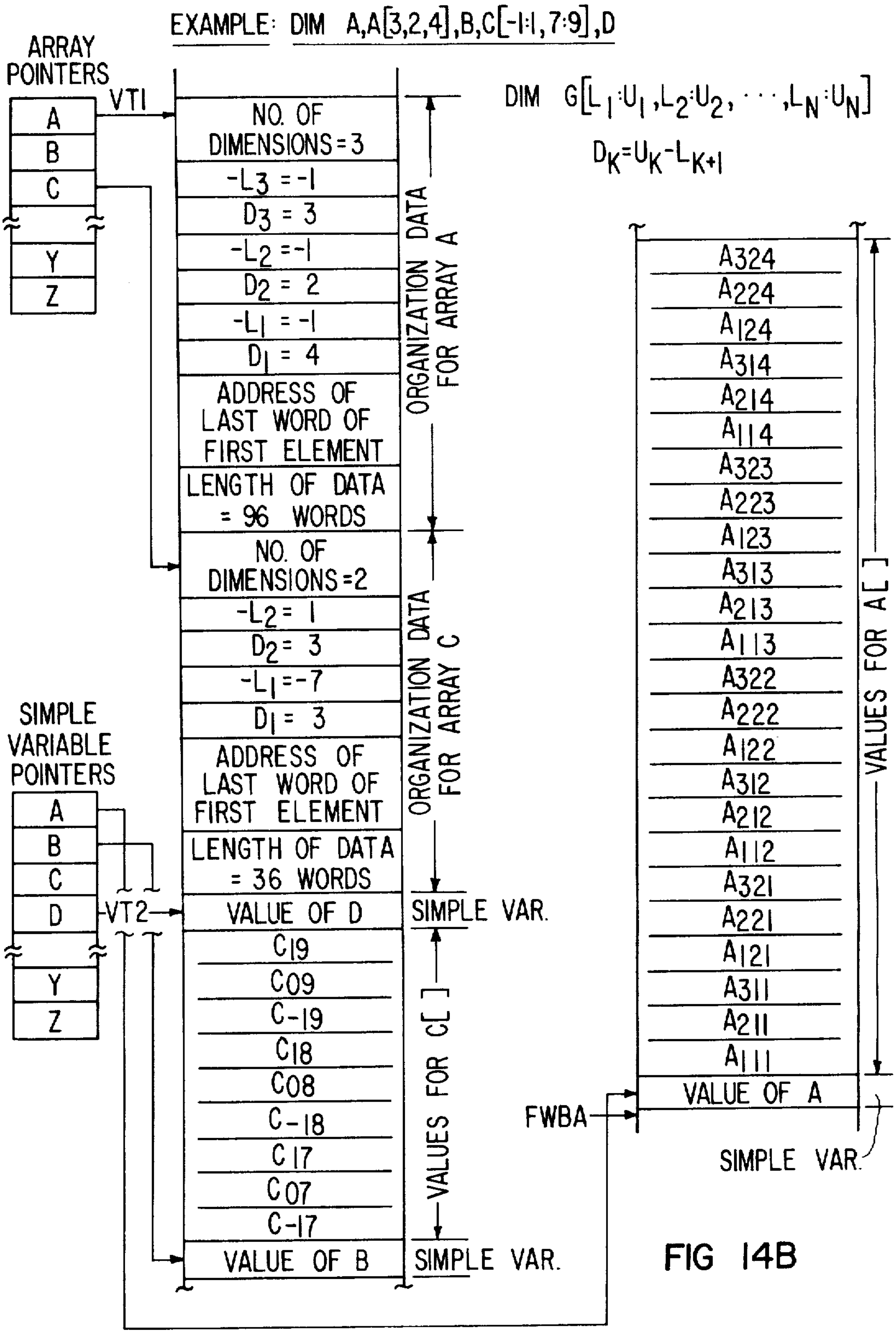

EXAMPLE: DIM A,A[3,2,4],B,C[-1:1,7:9],D
ARRAY POINTERS
VT1
A
B
C
Y
Z
NO. OF DIMENSIONS=3
-L3 =-1
D3 = 3
-L2 =-1
D2 = 2
-L1 =-1
D1 = 4
ADDRESS OF LAST WORD OF FIRST ELEMENT
LENGTH OF DATA = 96 WORDS
ORGANIZATION DATA FOR ARRAY A
NO. OF DIMENSIONS=2
-L2= 1
D2= 3
-L1=-7
D1= 3
ADDRESS OF LAST WORD OF FIRST ELEMENT
LENGTH OF DATA = 36 WORDS
ORGANIZATION DATA FOR ARRAY C
SIMPLE VARIABLE POINTERS
A
B
C
D
Y
Z
VT2
VALUE OF D
SIMPLE VAR.
C19
C09
C-19
C18
C08
C-18
C17
C07
C-17
VALUES FOR C[ ]
VALUE OF B
SIMPLE VAR.
DIM G[L1:U1,L2:U2, · · · ,LN:UN]
DK=UK-LK+1
A324
A224
A124
A314
A214
A114
A323
A223
A123
A313
A213
A113
A322
A222
A122
A312
A212
A112
A321
A221
A121
A311
A211
A111
VALUES FOR A[ ]
VALUE OF A
FWBA
SIMPLE VAR.

FIG 14B

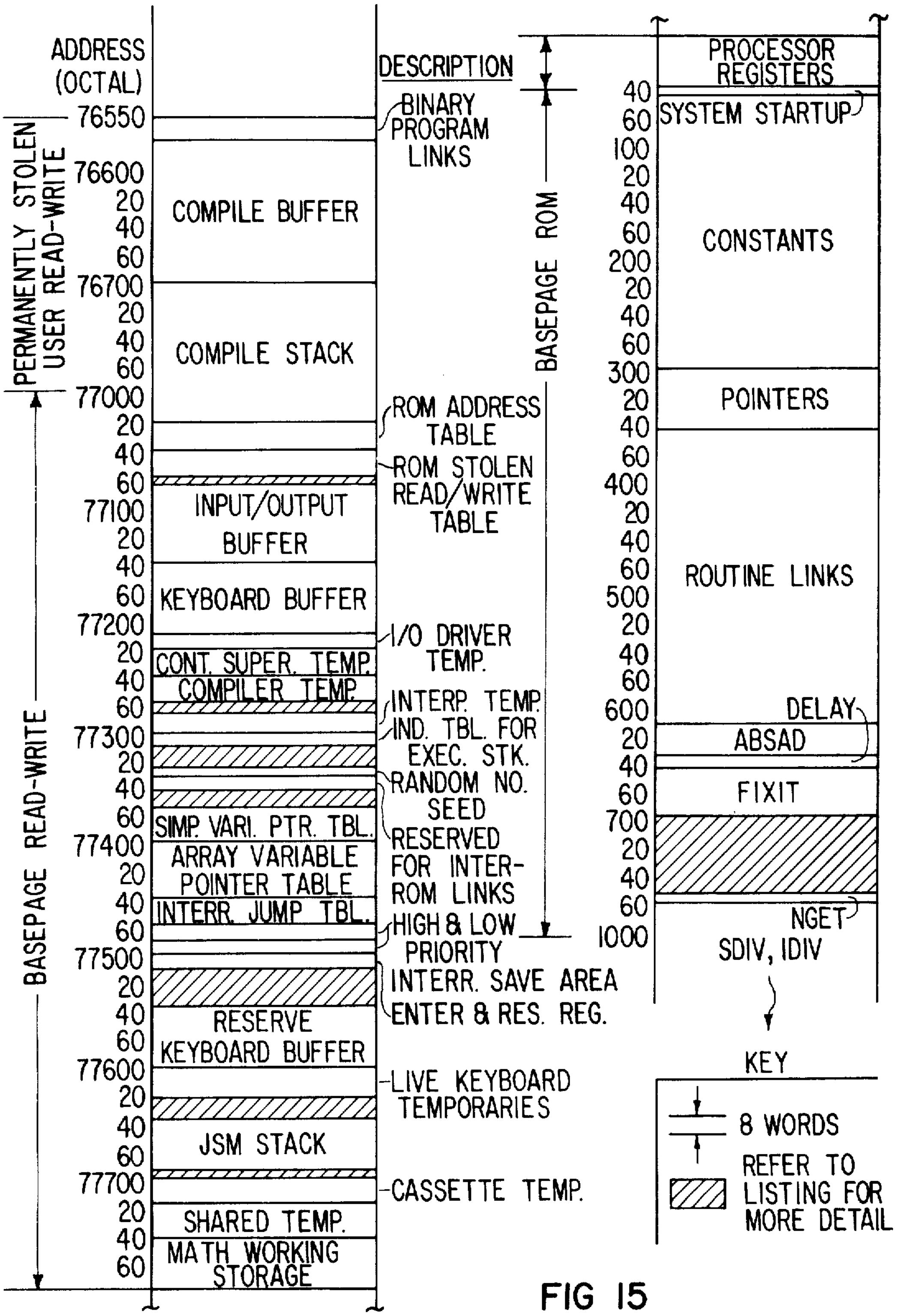

ADDRESS (OCTAL)
DESCRIPTION
PERMANENTLY STOLEN USER READ-WRITE
BASEPAGE READ-WRITE
76550
76600
20
40
60
76700
20
40
60
77000
20
40
60
77100
20
40
60
77200
20
40
60
77300
20
40
60
77400
20
40
60
77500
20
40
60
77600
20
40
60
77700
20
40
60
BINARY PROGRAM LINKS
COMPILE BUFFER
COMPILE STACK
ROM ADDRESS TABLE
ROM STOLEN READ/WRITE TABLE
INPUT/OUTPUT BUFFER
KEYBOARD BUFFER
I/O DRIVER TEMP.
CONT. SUPER. TEMP.
COMPILER TEMP
INTERP. TEMP.
IND. TBL. FOR EXEC. STK.
RANDOM NO. SEED
SIMP. VARI. PTR. TBL.
RESERVED FOR INTER-ROM LINKS
ARRAY VARIABLE POINTER TABLE
INTERR. JUMP TBL.
HIGH & LOW PRIORITY INTERR. SAVE AREA
ENTER & RES. REG.
RESERVE KEYBOARD BUFFER
LIVE KEYBOARD TEMPORARIES
JSM STACK
CASSETTE TEMP.
SHARED TEMP.
MATH WORKING STORAGE
BASEPAGE ROM
PROCESSOR REGISTERS
40
60
100
20
40
60
200
20
40
60
300
20
40
60
400
20
40
60
500
20
40
60
600
20
40
60
700
20
40
60
1000
SYSTEM STARTUP
CONSTANTS
POINTERS
ROUTINE LINKS
DELAY
ABSAD
FIXIT
NGET
SDIV, IDIV
KEY
8 WORDS
REFER TO LISTING FOR MORE DETAIL

FIG 15

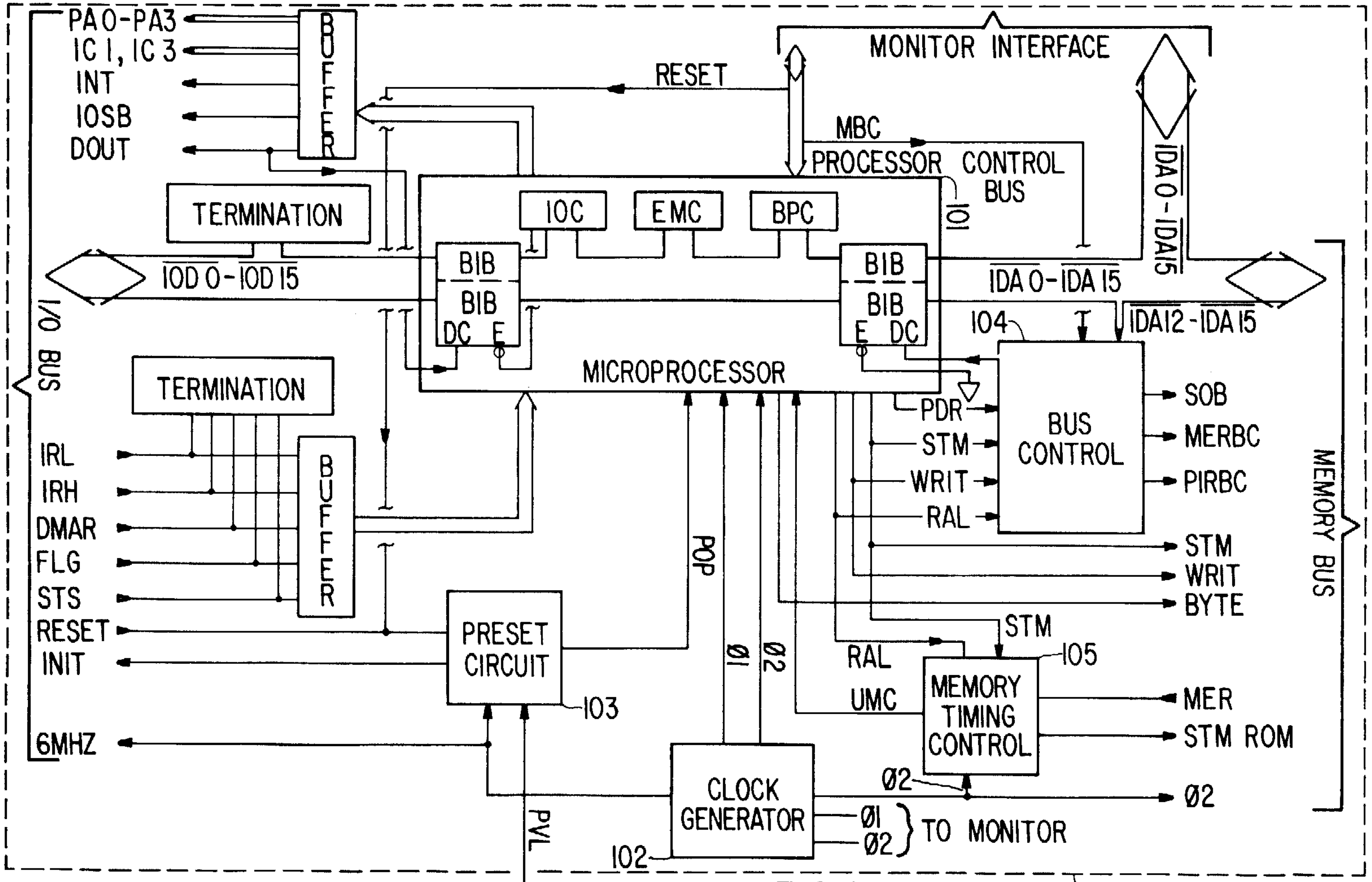

PA0-PA3
IC1, IC3
INT
IOSB
DOUT
BUFFER
RESET
MONITOR INTERFACE
MBC
PROCESSOR CONTROL BUS
101
IDA0-IDA15
TERMINATION
IOC
EMC
BPC
BIB
BIB
DC
E
BIB
BIB
E
DC
IOD0-IOD15
I/O BUS
IDA0-IDA15
104
IDA12-IDA15
MICROPROCESSOR
TERMINATION
PDR
STM
WRIT
RAL
BUS CONTROL
SOB
MERBC
PIRBC
MEMORY BUS
IRL
IRH
DMAR
FLG
STS
RESET
INIT
BUFFER
POP
STM
WRIT
BYTE
STM
105
PRESET CIRCUIT
103
Ø1
Ø2
RAL
UMC
MEMORY TIMING CONTROL
MER
STM ROM
6MHZ
CLOCK GENERATOR
102
Ø2
Ø2
Ø1
Ø2
TO MONITOR
PVL
FROM POWER SUPPLY
PROCESSOR 100

FIG 16

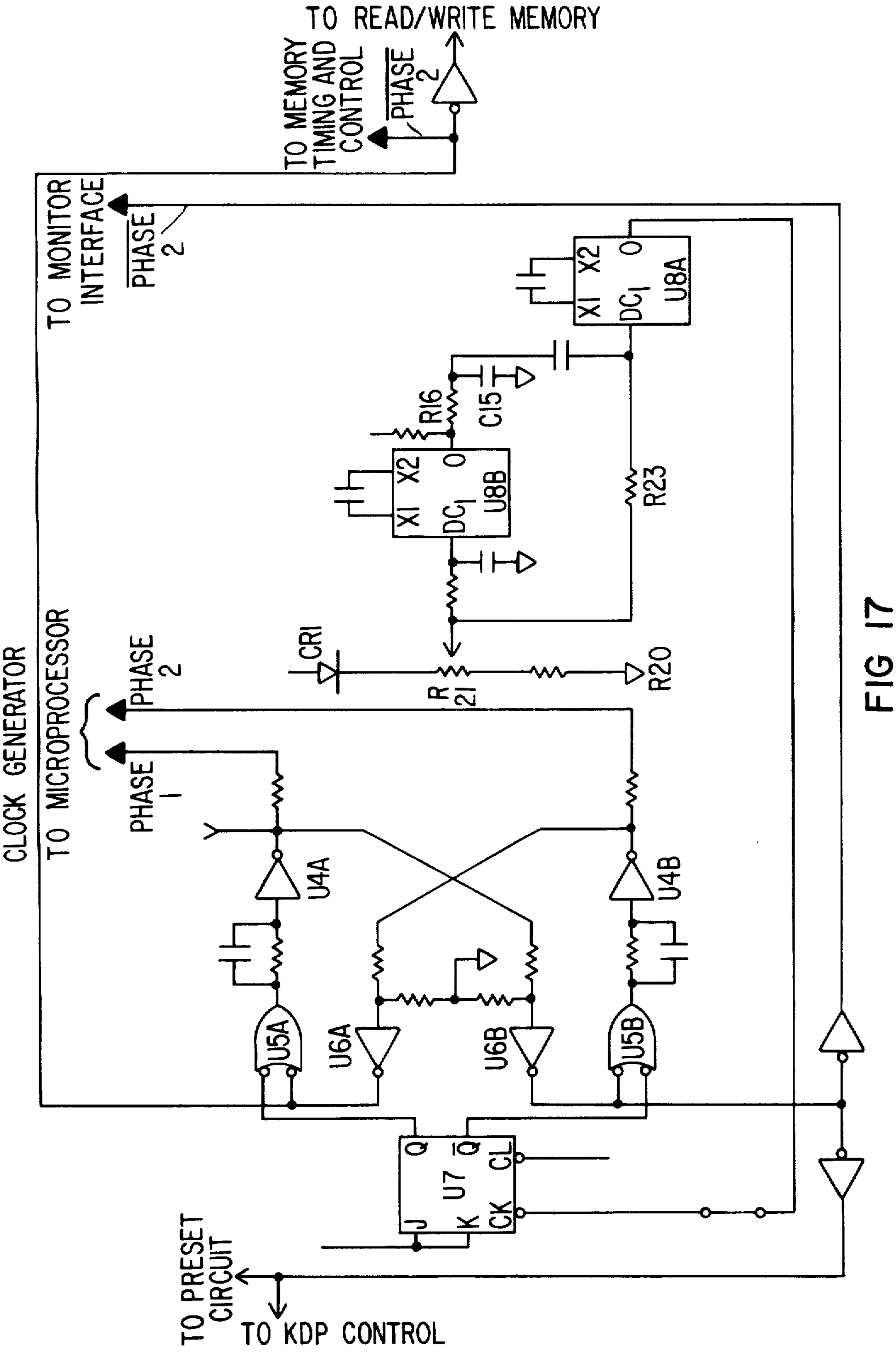

TO READ/WRITE MEMORY
TO MEMORY TIMING AND CONTROL
$\overline{\text{PHASE}}$ 2
TO MONITOR INTERFACE
$\overline{\text{PHASE}}$ 2
X1
X2
DC1
O
U8A
R16
C15
X1
X2
DC1
O
U8B
R23
CR1
R 21
R20
CLOCK GENERATOR
TO MICROPROCESSOR
PHASE 2
PHASE 1
U4A
U4B
U5A
U6A
U6B
U5B
Q
$\overline{Q}$
CL
U7
J
K
CK
TO PRESET CIRCUIT
TO KDP CONTROL

FIG 17

PRESET CIRCUIT

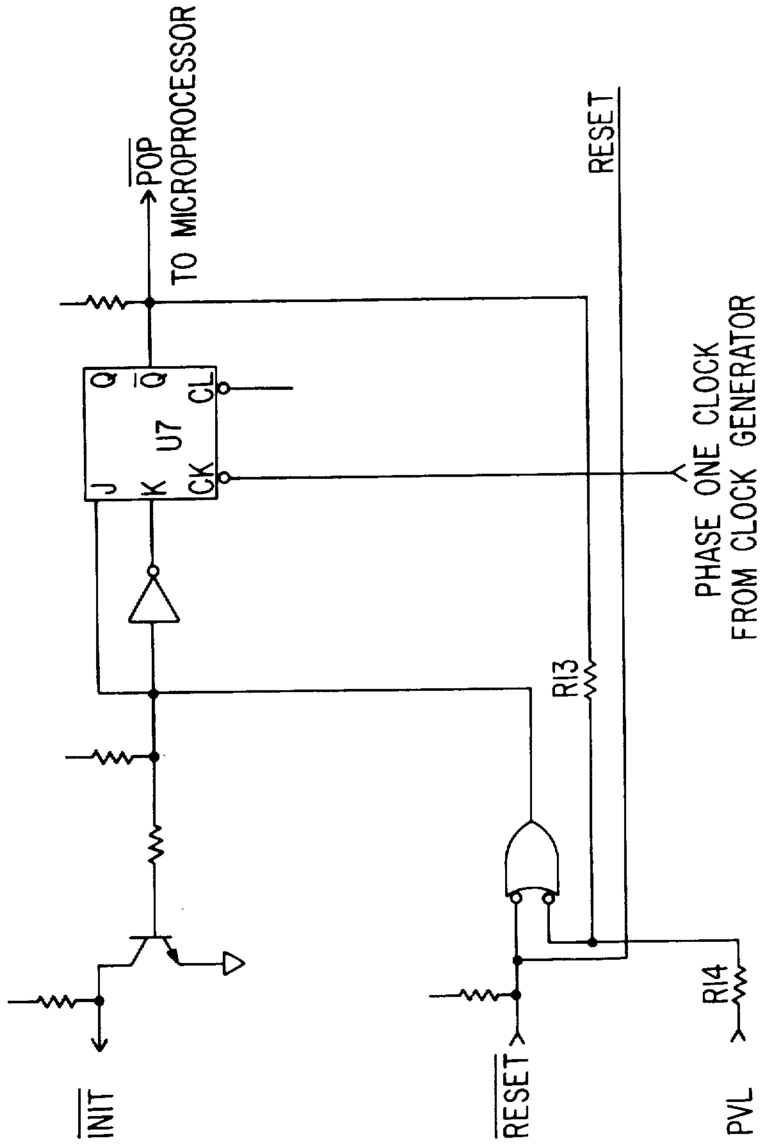


FIG 18

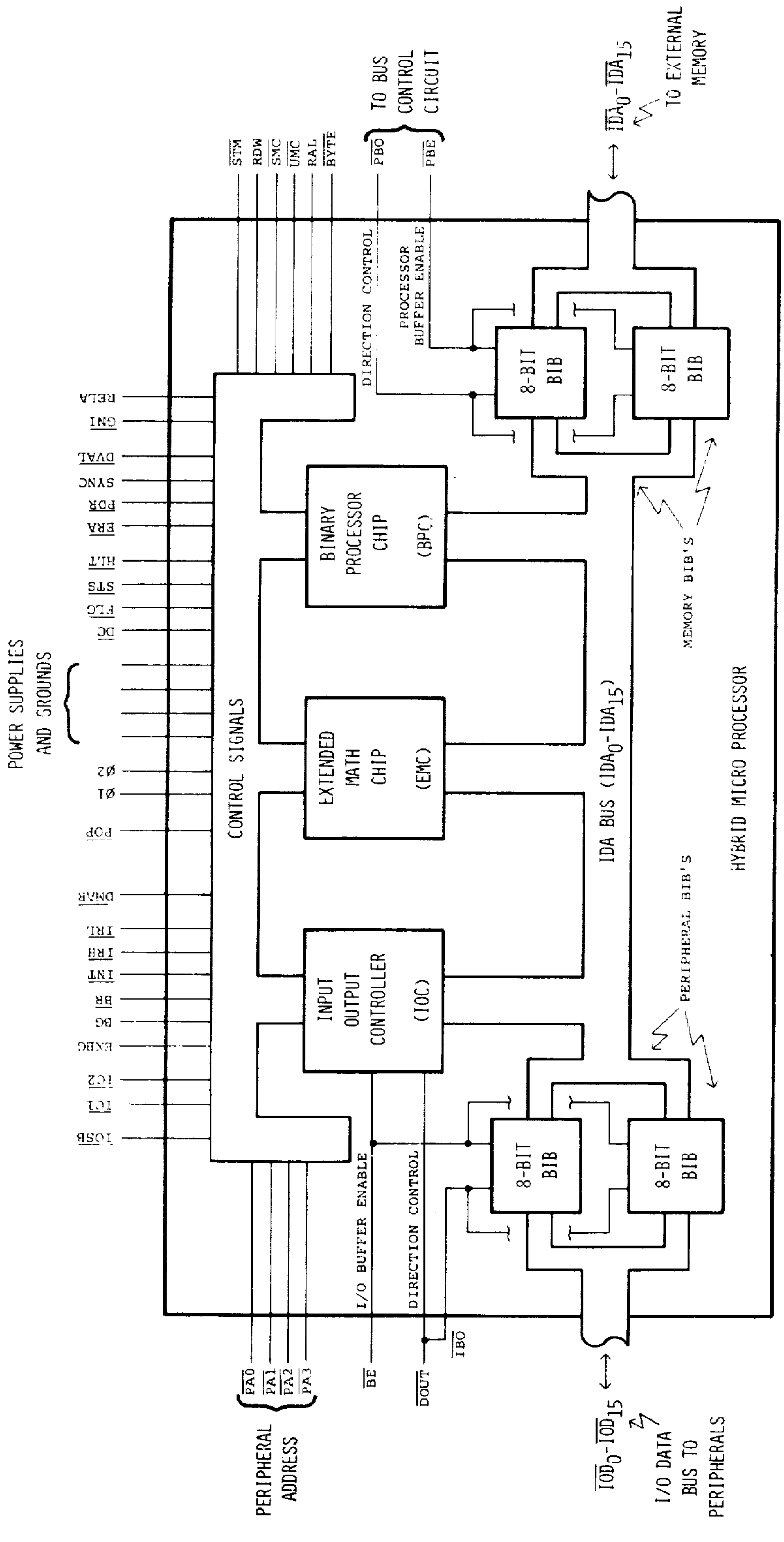

STM
RDW
SMC
UMC
RAL
BYTE
PBO
PBE
TO BUS CONTROL CIRCUIT
$\overline{IDA}_0$-$\overline{IDA}_{15}$
TO EXTERNAL MEMORY
DIRECTION CONTROL
PROCESSOR BUFFER ENABLE
8-BIT BIB
8-BIT BIB
RELA
GNI
DVAL
SYNC
PDR
ERA
HLT
STS
FLG
DC
POWER SUPPLIES AND GROUNDS
2Ø
1Ø
POP
DMAR
IRL
IRH
INT
BR
BG
EXBG
IC2
IC1
IOSB
CONTROL SIGNALS
BINARY PROCESSOR CHIP (BPC)
EXTENDED MATH CHIP (EMC)
INPUT OUTPUT CONTROLLER (IOC)
IDA BUS ($IDA_0$-$IDA_{15}$)
MEMORY BIB'S
PERIPHERAL BIB'S
HYBRID MICRO PROCESSOR
I/O BUFFER ENABLE
DIRECTION CONTROL
8-BIT BIB
8-BIT BIB
PA0
PA1
PA2
PA3
PERIPHERAL ADDRESS
BE
DOUT
IBO
$\overline{IOD}_0$-$\overline{IOD}_{15}$
I/O DATA BUS TO PERIPHERALS

FIG 19

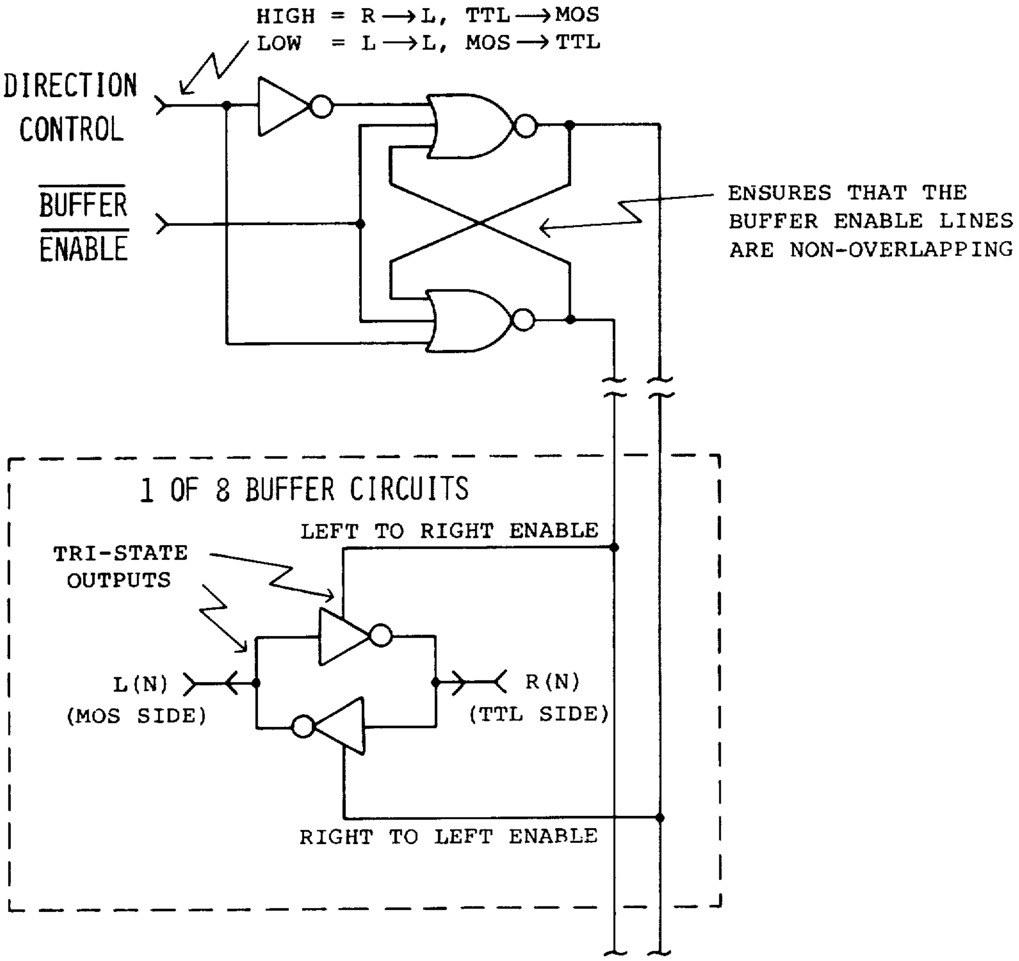
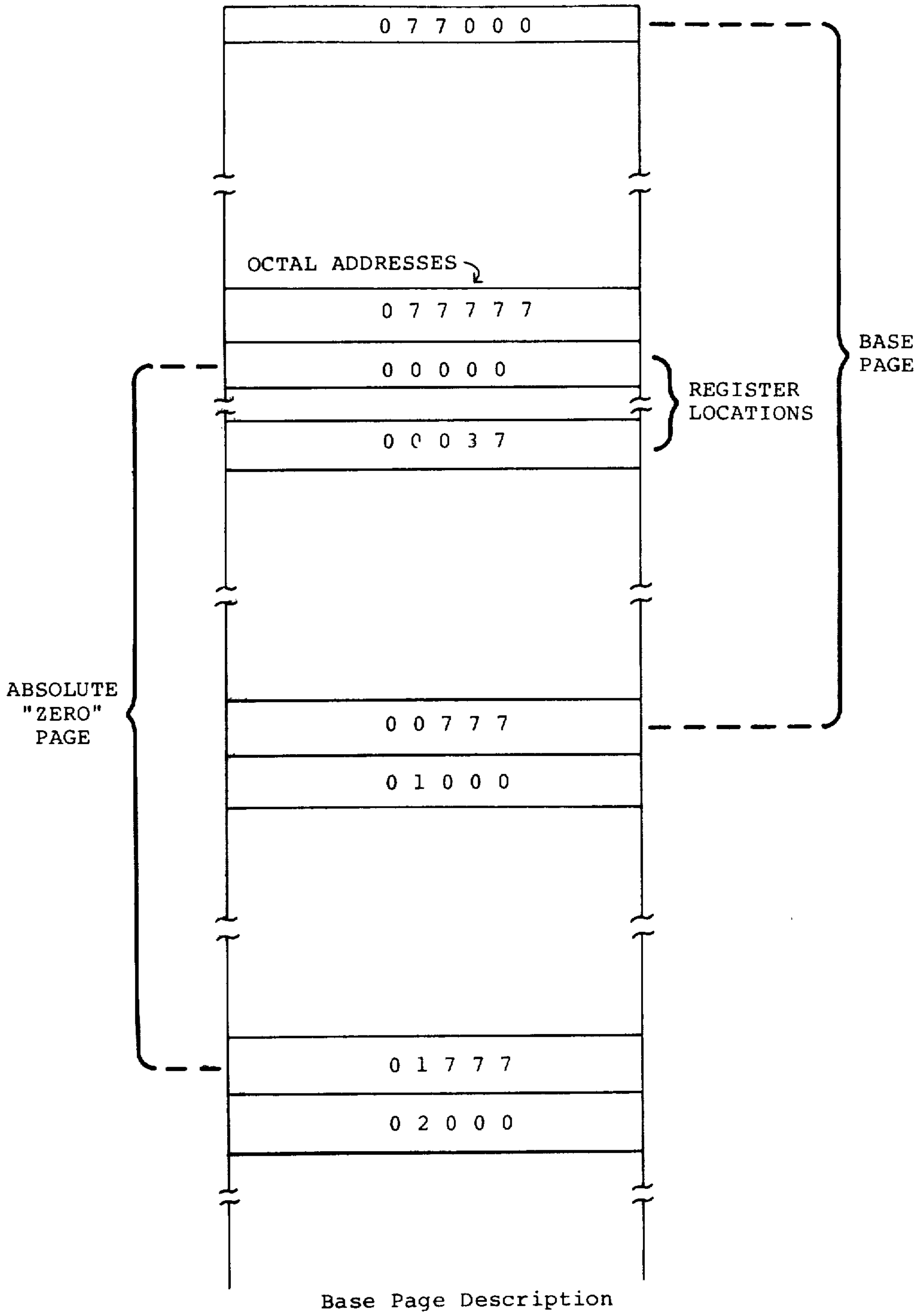

HIGH = R ⟶ L, TTL ⟶ MOS
LOW = L ⟶ L, MOS ⟶ TTL
DIRECTION CONTROL
BUFFER ENABLE
ENSURES THAT THE BUFFER ENABLE LINES ARE NON-OVERLAPPING
1 OF 8 BUFFER CIRCUITS
LEFT TO RIGHT ENABLE
TRI-STATE OUTPUTS
L(N) (MOS SIDE)
R(N) (TTL SIDE)
RIGHT TO LEFT ENABLE

FIG 20



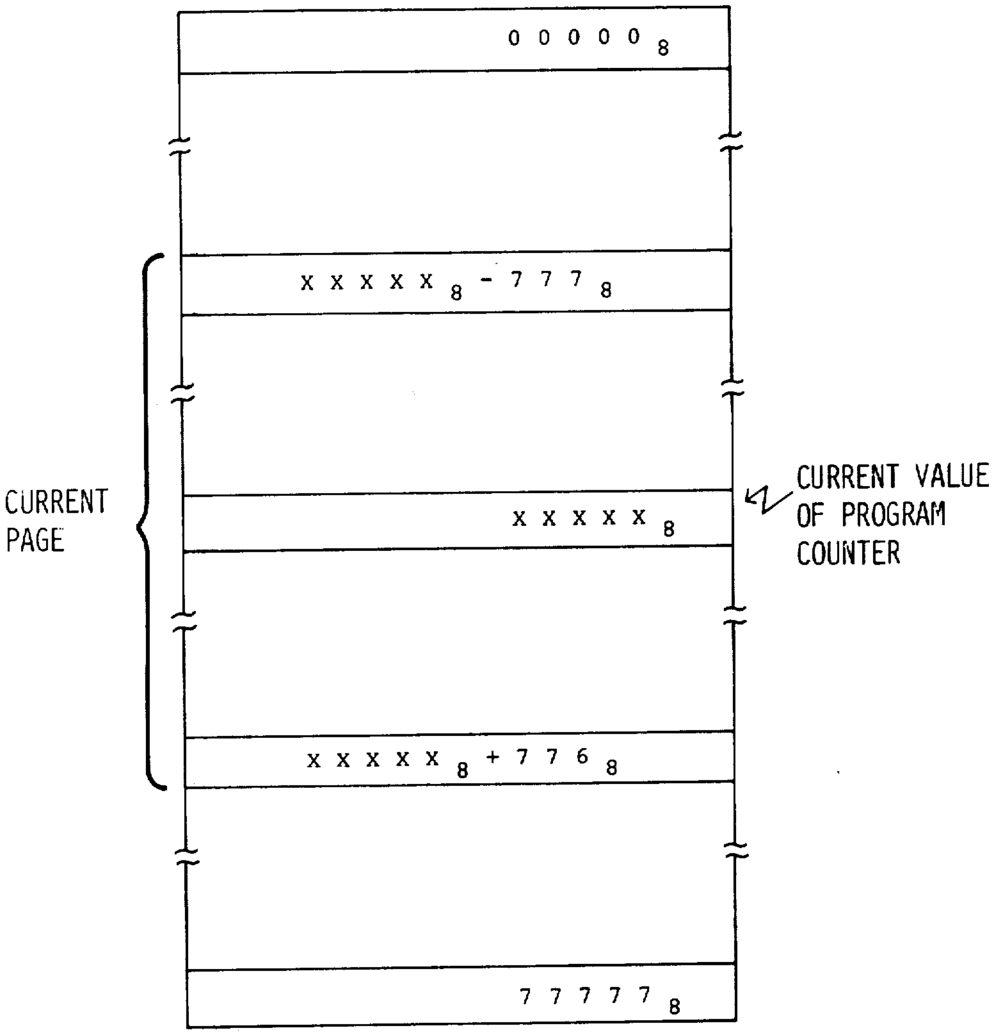
Base Page Description

FIG 21

CURRENT PAGE ABSOLUTE ADDRESSING CORRESPONDENCE
FOR MEMORY REFERENCE INSTRUCTIONS

| LEAST 10 BITS OF ASSEMBLER OUTPUT (octal) | "REAL ADDRESS" | |
|---|---|---|
| | TOP 5 BITS (of P) | LOWER 10 BITS (octal) |
| 1 0 0 0 | X X X X X | 0 0 0 0 START OF PAGE |
| 1 0 0 1 | X X X X X | 0 0 0 1 |
| 1 0 0 2 | X X X X X | 0 0 0 2 |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| 1 7 7 7 | . | 0 7 7 7 |
| 0 0 0 0 | . | 1 0 0 0 |
| 0 0 0 1 | . | 1 0 0 1 |
| 0 0 0 2 | . | 1 0 0 2 |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| 0 7 7 7 | X X X X X | 1 7 7 7 END OF PAGE |

FIG 22



RELATIVE ADDRESSING

FIG 23

## BPC INSTRUCTION BIT PATTERNS

GROUP: MEMORY REFERENCE

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LDA | D/I | 0 | 0 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| LDB | D/I | 0 | 0 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| CPA | D/I | 0 | 0 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| CPB | D/I | 0 | 0 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| ADA | D/I | 0 | 1 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| ADB | D/I | 0 | 1 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| STA | D/I | 0 | 1 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| STB | D/I | 0 | 1 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| JSM | D/I | 1 | 0 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| ISZ | D/I | 1 | 0 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| AND | D/I | 1 | 0 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| DSZ | D/I | 1 | 0 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| IOR | D/I | 1 | 1 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| JMP | D/I | 1 | 1 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |

* 10 BIT ADDRESS FIELD.

* ADDRESSES 0-$37_8$ ARE REGISTERS.

* FOR BIT 9=0, BITS 0-8 = POSITIVE ADDR.

* FOR BIT 9=1, ADDRESS IS NEGATIVE.
IGNORE BIT 9, COMPLIMENT BITS 0-8,
THEN ADD ONE.

* BASE PAGE ADDRESS ENCODING IS ALWAYS
WITH RESPECT TO MEMORY LOCATION ZERO.

* CURRENT PAGE ENCODING:

(ABSOLUTE) RELATIVE TO THE
MIDDLE OF THE PAGE (1000B, 3000B,
ETC.)

(RELATIVE) RELATIVE TO THE
CURRENT VALUE OF P, +511, -512.

D/I (DIRECT/INDIRECT) AND $B/\overline{B}$ (BASE PAGE/ NOT BASE PAGE) ARE CODED AS 0/1.

FIG 24A

BPC INSTRUCTION BIT PATTERNS (CONTINUED)

GROUP: SHIFT-ROTATE

| INST.<br>NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | * 4 BITS OF SHIFT-ROTATE FIELD.<br>* IN SOURCE 1≤N≤16.<br>* BINARY IN THIS FIELD IS N-1. | | | |
| ABR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | | | |
| SAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | | | |
| SBR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | | | |
| SAL | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | | | |
| SBL | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | | | |
| RAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | | | | |
| RBR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | | | | |

FIG 24B

## BPC INSTRUCTION BIT PATTERNS (CONTINUED)

GROUP: ALTER

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RLA | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | * 6 BIT SKIP FIELD, +31, -32.<br>* IF BIT 5=0, SKIP TO P+#; #=BITS 0 THRU 4.<br>* IF BIT 5=1, SKIP TO P-#, #=1+ COMP OF BITS 0-4. | | | | | |
| RLB | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SLA | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SLB | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SAP | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SBP | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SAM | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SBM | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SOC | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SOS | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SEC | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SES | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |

$H/\overline{H}$ (HOLD/DON'T HOLD) AND C/S (CLEAR/SET) ARE CODED AS 0/1. HOWEVER: $H/\overline{H}$ IS SET BY THE ASSEMBLER ITSELF. IF NEITHER S NOR C IS PRESENT, BOTH $H/\overline{H}$ AND C/S ARE MADE 0'S. THE PRESENCE OF EITHER A C OR AN S PRODUCES H (A 1).

FIG 24C

BPC INSTRUCTION BIT PATTERNS (CONTINUED)

GROUP: SKIP

| INST.<br>NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RZA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| RZB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| SZA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | | | | | | |
| SZB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | | | | | | |
| RIA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | | | | | | |
| RIB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | | | | | | |
| SIA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | | | | | | |
| SIB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | | | | | | |
| SFS | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | | | | | | |
| SFC | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | | | | | | |
| SSS | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | | | | | | |
| SSC | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | |
| SDS | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | | | | | | |
| SDC | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | | | | | | |
| SHS | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | | | | | | |
| SHC | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | |

- * 6 BIT SKIP FIELD, +31, -32.
- * IF BIT 5=0, SKIP TO P+#; #=BITS 0 THRU 4.
- * IF BIT 5=1, SKIP TO P-#; #=1+ COMP OF BITS 0-4.

FIG 24D

# BPC INSTRUCTION BIT PATTERNS (CONT.)

GROUP: RETURN

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RET | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | $\overline{P}$/P | 6 BIT, 2'S COMPLIMENT SKIP FIELD (ALLOWS -32 THRU +31). | | | | | |

$\overline{P}$/P (DON'T POP/POP THE IOC) ENCODED AS 0/1.

FIG 24E

GROUP: COMPLIMENT

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CMA | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| CMB | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| TCA | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| TCB | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

FIG 24F

GROUP: EXECUTE

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXE | D/I | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 BIT REGISTER ADDRESS (0-$37_8$). | | | | |

D/I (DIRECT/INDIRECT) ENCODED AS 0/1.

FIG 24G

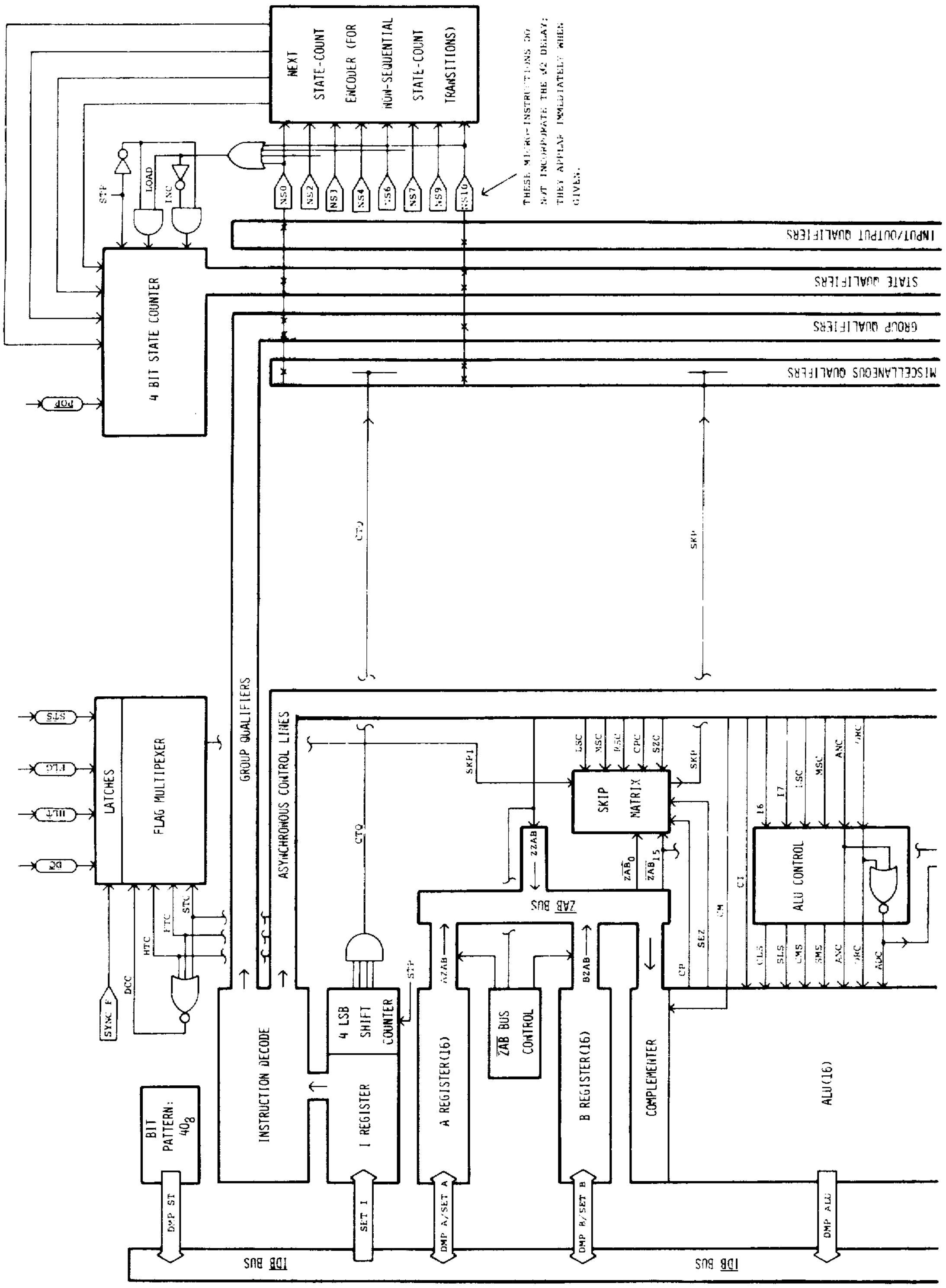

NEXT STATE-COUNT ENCODER (FOR NON-SEQUENTIAL STATE-COUNT TRANSITIONS)
NS0
NS2
NS3
NS4
NS6
NS7
NS9
NS10
THESE MICRO-INSTRUCTIONS DO NOT INCORPORATE THE φ2 DELAY; THEY APPEAR IMMEDIATELY WHEN GIVEN.
STP
LOAD
INC
4 BIT STATE COUNTER
POF
INPUT/OUTPUT QUALIFIERS
STATE QUALIFIERS
GROUP QUALIFIERS
MISCELLANEOUS QUALIFIERS
CTQ
SKP
STS
FLG
IRH
DC
LATCHES
FLAG MULTIPEXER
GROUP QUALIFIERS
ASYNCHROHOUS CONTROL LINES
SYNC F
DCC
HTC
FTC
STC
SKP1
CTQ
LSC
MSC
RSC
CPC
SZC
SKP
SKIP MATRIX
ZZAB
$\overline{ZAB}_0$
$\overline{ZAB}_{15}$
ZAB BUS
I6
I7
LSC
MSC
ANC
ORC
ALU CONTROL
CI
CM
SEZ
CP
CLS
SLS
CMS
SMS
ANC
ORC
ADC
STP
AZAB
BZAB
4 LSB SHIFT COUNTER
$\overline{ZAB}$ BUS CONTROL
BIT PATTERN: $40_8$
INSTRUCTION DECODE
I REGISTER
A REGISTER(16)
B REGISTER(16)
COMPLEMENTER
ALU(16)
DMP ST
SET I
DMP A/SET A
DMP B/SET B
DMP ALU
IDB BUS
IDB BUS

FIG 25A

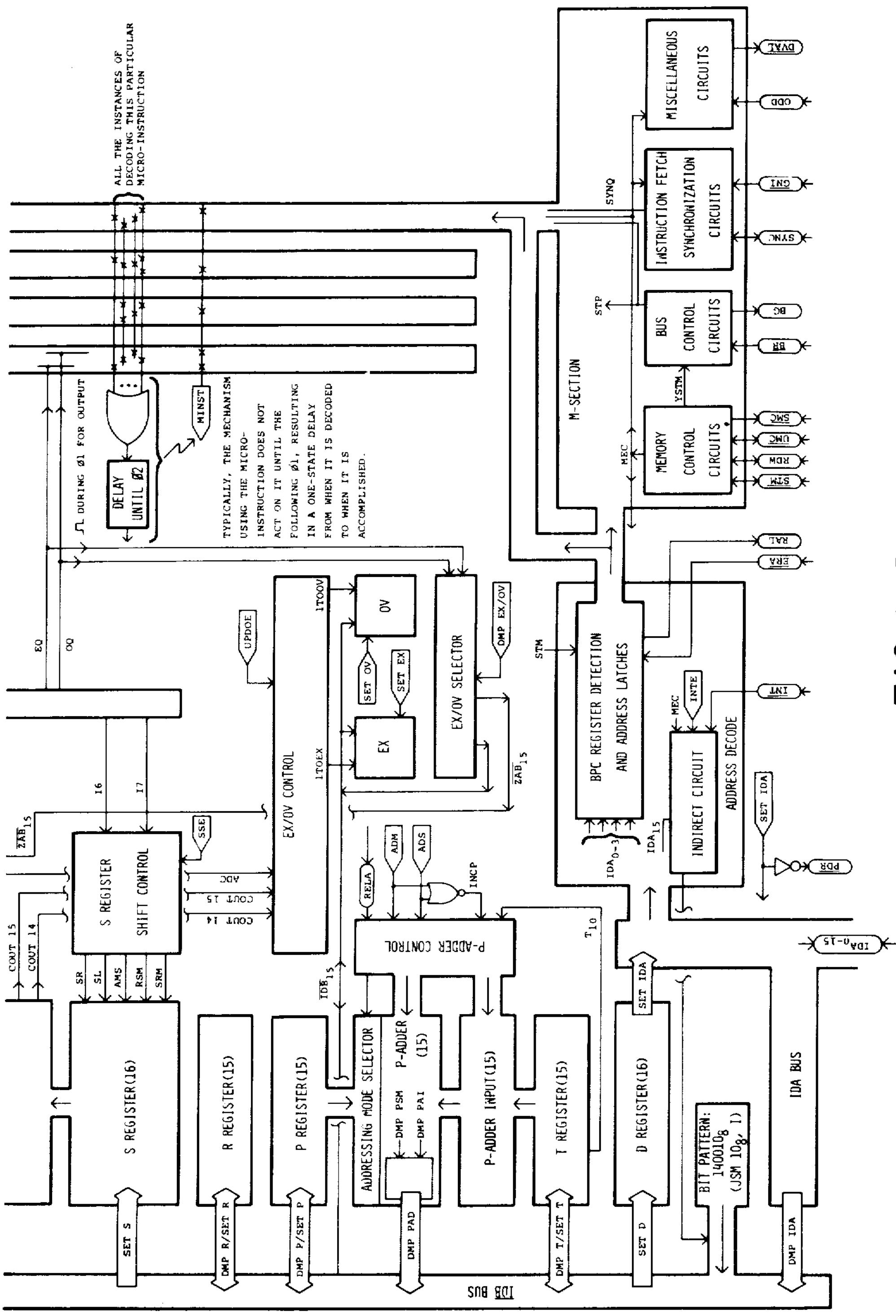
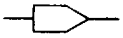
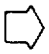
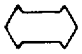
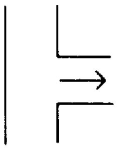

ALL THE INSTANCES OF DECODING THIS PARTICULAR MICRO-INSTRUCTION
DURING Ø1 FOR OUTPUT
DELAY UNTIL Ø2
MINST
TYPICALLY, THE MECHANISM USING THE MICRO-INSTRUCTION DOES NOT ACT ON IT UNTIL THE FOLLOWING Ø1, RESULTING IN A ONE-STATE DELAY FROM WHEN IT IS DECODED TO WHEN IT IS ACCOMPLISHED.
M-SECTION
MISCELLANEOUS CIRCUITS
INSTRUCTION FETCH SYNCHRONIZATION CIRCUITS
BUS CONTROL CIRCUITS
MEMORY CONTROL CIRCUITS
SYNQ
STP
YSTM
MEC
DVAL
ODD
CNI
SYNC
BG
BR
SMC
UMC
RDM
STM
RAL
ERA
INT
PDR
EQ
OQ
UPDOE
EX/OV CONTROL
ITOOV
ITOEX
OV
EX
SET OV
SET EX
EX/OV SELECTOR
DMP EX/OV
$ZAB_{15}$
STM
BPC REGISTER DETECTION AND ADDRESS LATCHES
MEC
INTE
INDIRECT CIRCUIT
ADDRESS DECODE
SET IDA
$IDA_{0-3}$
$IDA_{15}$
16
17
SSE
S REGISTER SHIFT CONTROL
ADC
COUT 15
COUT 14
SR
SL
AMS
RSM
SRM
RELA
ADM
ADS
INCP
P-ADDER CONTROL
$T_{10}$
$IDB_{15}$
$IDA_{0-15}$
S REGISTER(16)
R REGISTER(15)
P REGISTER(15)
ADDRESSING MODE SELECTOR
DMP PSM
DMP PAI
P-ADDER (15)
P-ADDER INPUT(15)
T REGISTER(15)
SET IDA
D REGISTER(16)
BIT PATTERN: $140010_8$ (JSM $10_8$, I)
IDA BUS
SET S
DMP R/SET R
DMP P/SET P
DMP PAD
DMP T/SET T
SET D
DMP IDA
IDB BUS

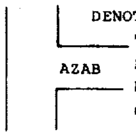
FIG 25B

NOTES:

1.  DENOTES A MICRO-INSTRUCTION DECODED IN THE ROM.

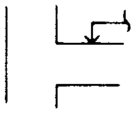
2.  AND  DENOTE ONE- AND TWO-WAY INTERCONNECTIONS TO A BUS; ALWAYS CONTROLLED BY A ROM MICRO-INSTRUCTION.

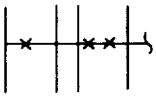
3.  DENOTES A DIRECT CONNECTION BETWEEN TWO ITEMS.

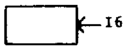
4. 

DENOTES A CONNECTION BETWEEN TWO ITEMS THAT IS ACTIVE ONLY WHEN THE STATED SIGNAL IS GIVEN. SUCH SIGNALS ARE NOT ROM DECODED MICRO-INSTRUCTIONS. SOME ARE PRESENT THROUGHOUT AN ENTIRE EXECUTION CYCLE, WHILE OTHERS REFLECT MORE TEMPORARY CONDITIONS.

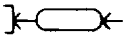
OR

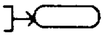


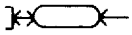
5.  DENOTES THAT THE STATED LINE REPRESENTS A DECODED CONDITION.

6. 

REPRESENTS A NON-MICRO-INSTRUCTION CONTROL LINE OR SOME OTHER SIGNAL.

7.  REPRESENTS AN INPUT TERMINAL TO THE BPC

8.  REPRESENTS AN OUTPUT TERMINAL FROM THE BPC

9.  REPRESENTS A TERMINAL THAT IS BOTH AN INPUT AND AN OUTPUT.

10. NUMBERS IN PARENTHESES INDICATE THE NUMBER OF BITS A MECHANISM HANDLES.

11. THE LOGICAL SENSE (XXX VERSUS $\overline{XXX}$) OF THE I/O TERMINALS IS CORRECTLY INDICATED. HOWEVER, THE DRAWING IS NOT A RELIABLE INDICATOR OF THE EXACT SENSE OF THE INTERNAL SIGNALS. TYPICALLY BOTH SENSES EXIST, AND FREQUENTLY THE PHYSICAL PROXIMITY OF SIGNALS TO THEIR DESTINATIONS WAS MORE IMPORTANT IN DECIDING WHICH SENSE TO USE, RATHER THAN AGREEMENT OF LOGICAL SENSE.
BECAUSE STRICT ACCURACY IN REPORTING SIGNAL SENSES ON SUCH A GENERAL LEVEL DRAWING WOULD SHARPLY INCREASE THE NUMBER OF INTERCONNECTIONS, WITH ONLY A SLIGHT INCREASE IN USEFULNESS, WE USUALLY SHOW ONLY THE NAME OF THE SIGNAL.

FIG 25C

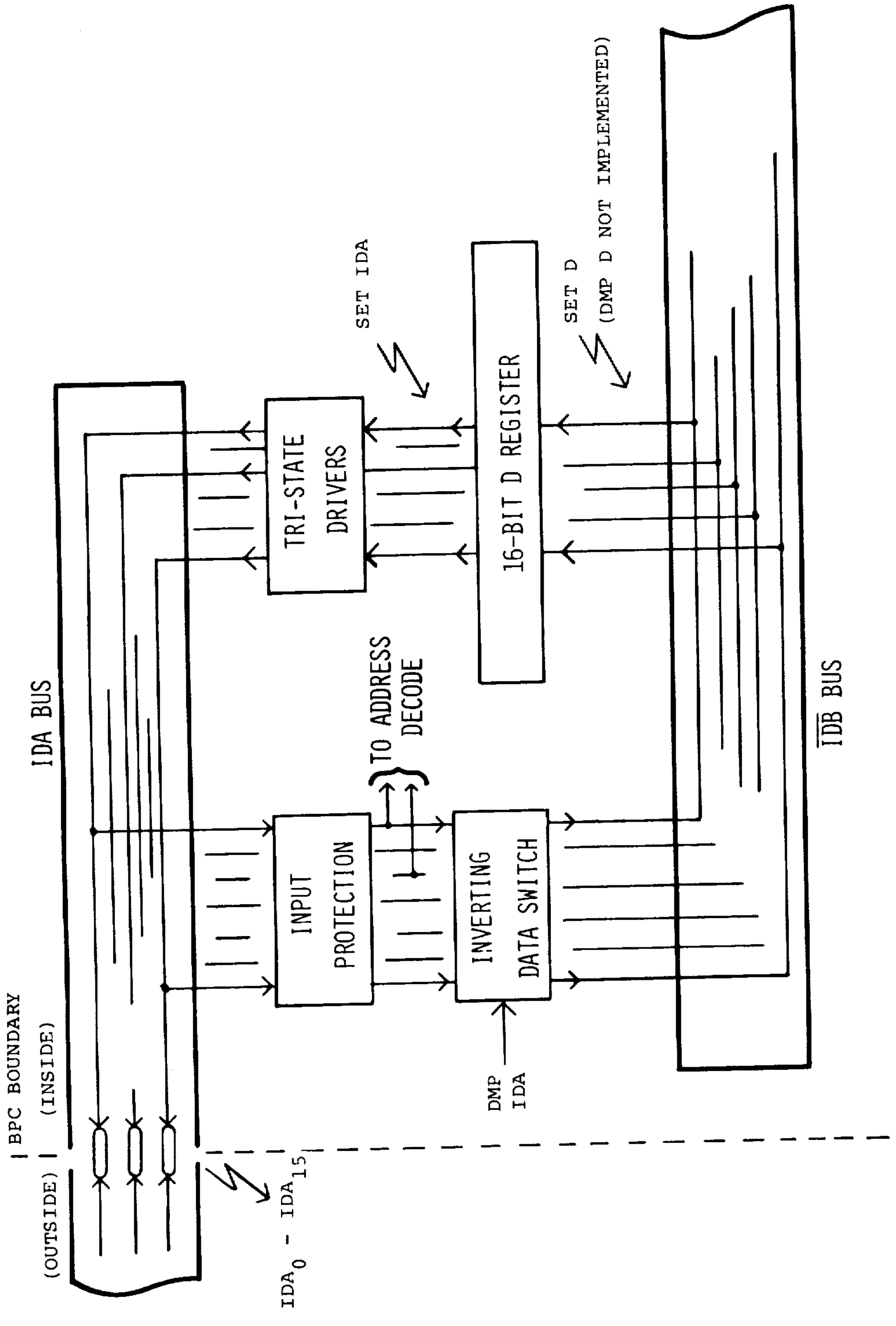

BPC BOUNDARY
(OUTSIDE)
(INSIDE)
$IDA_0$ - $IDA_{15}$
IDA BUS
INPUT PROTECTION
TO ADDRESS DECODE
INVERTING DATA SWITCH
DMP IDA
TRI-STATE DRIVERS
SET IDA
16-BIT D REGISTER
SET D
(DMP D NOT IMPLEMENTED)
$\overline{IDB}$ BUS

FIG 26

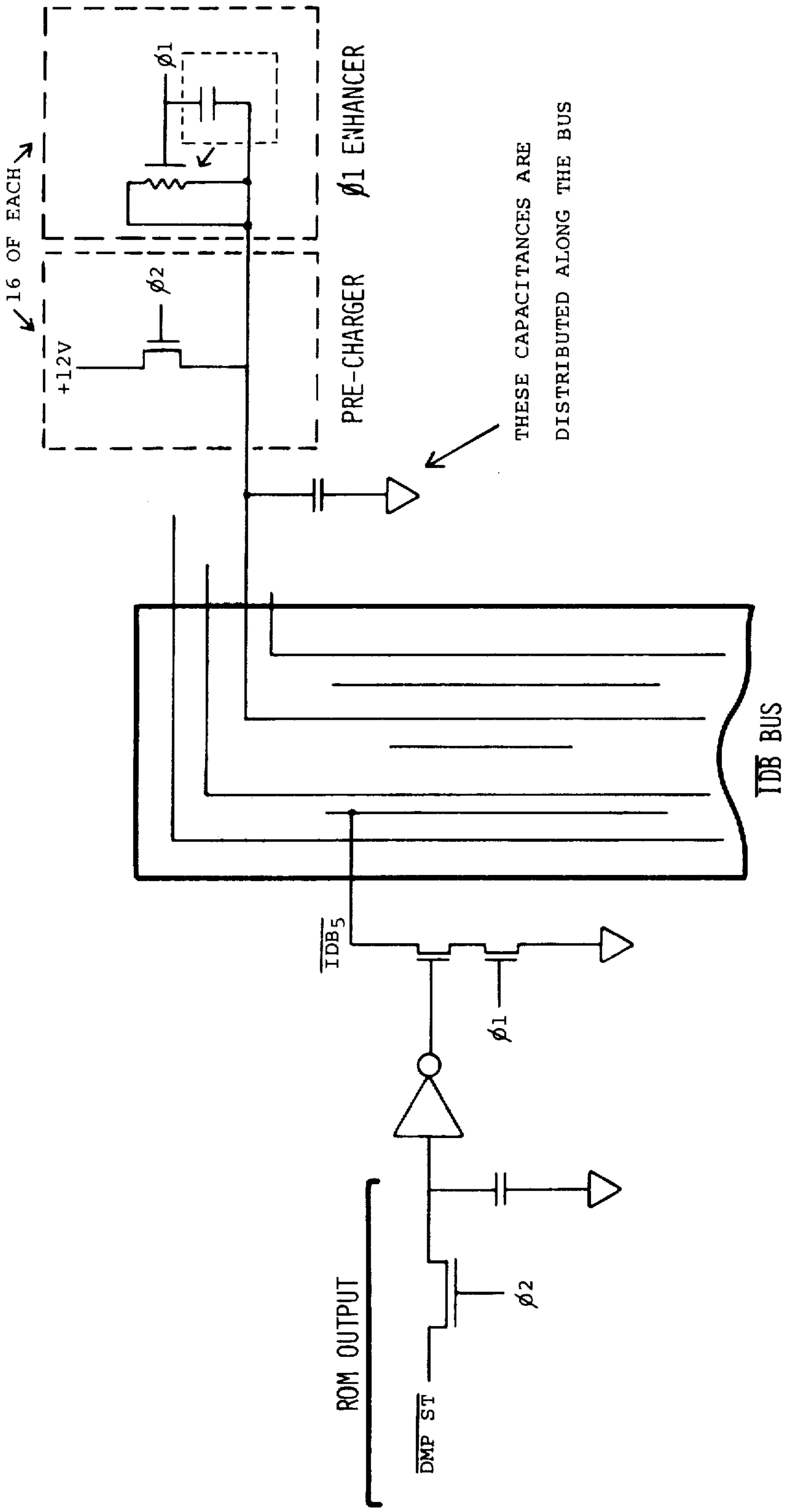
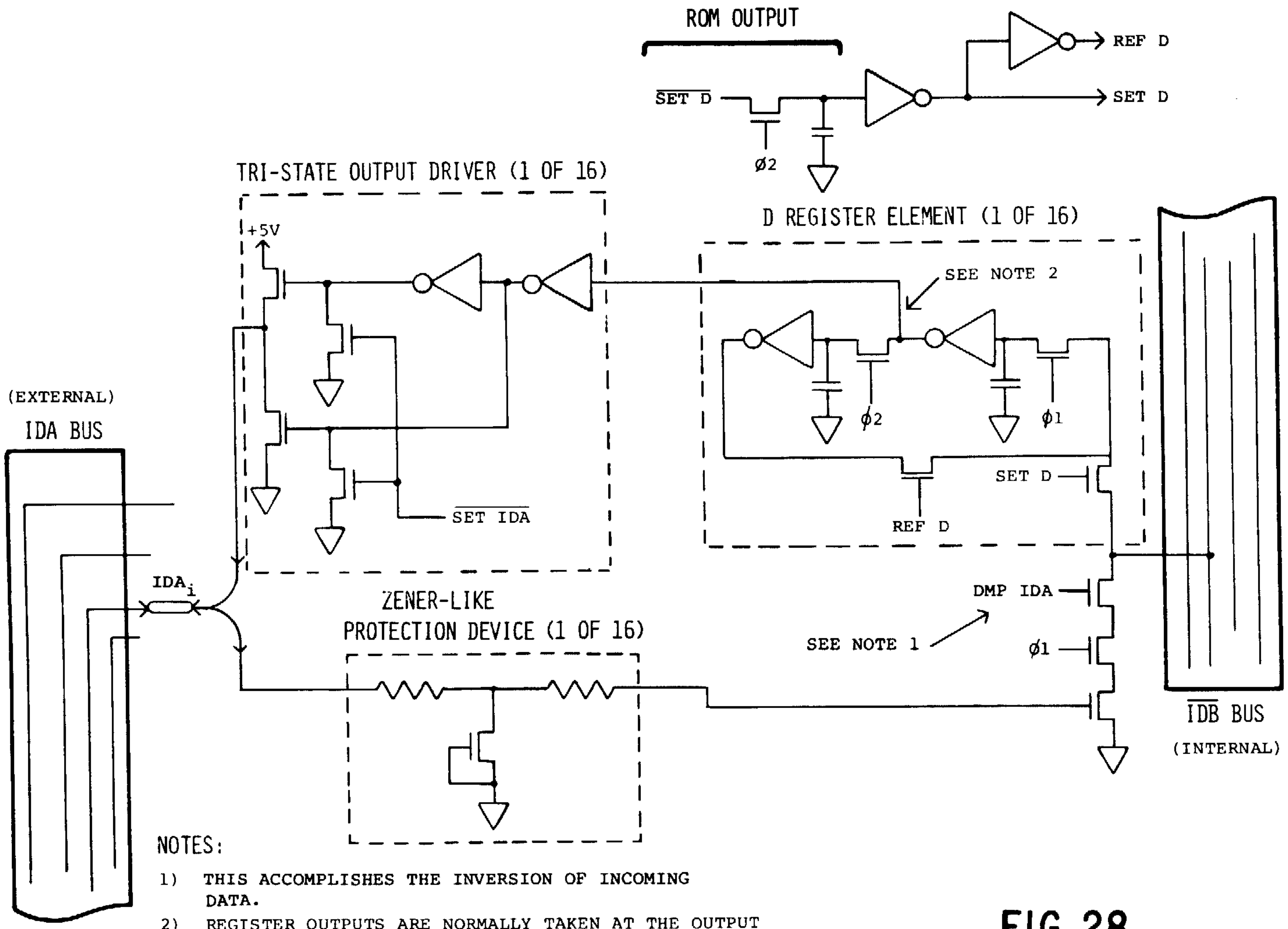

16 OF EACH
$\phi 1$
$\phi 1$ ENHANCER
+12V
$\phi 2$
PRE-CHARGER
THESE CAPACITANCES ARE DISTRIBUTED ALONG THE BUS
$\overline{IDB}$ BUS
$\overline{IDB_5}$
$\phi 1$
$\phi 2$
ROM OUTPUT
$\overline{DMP\ ST}$

FIG 27

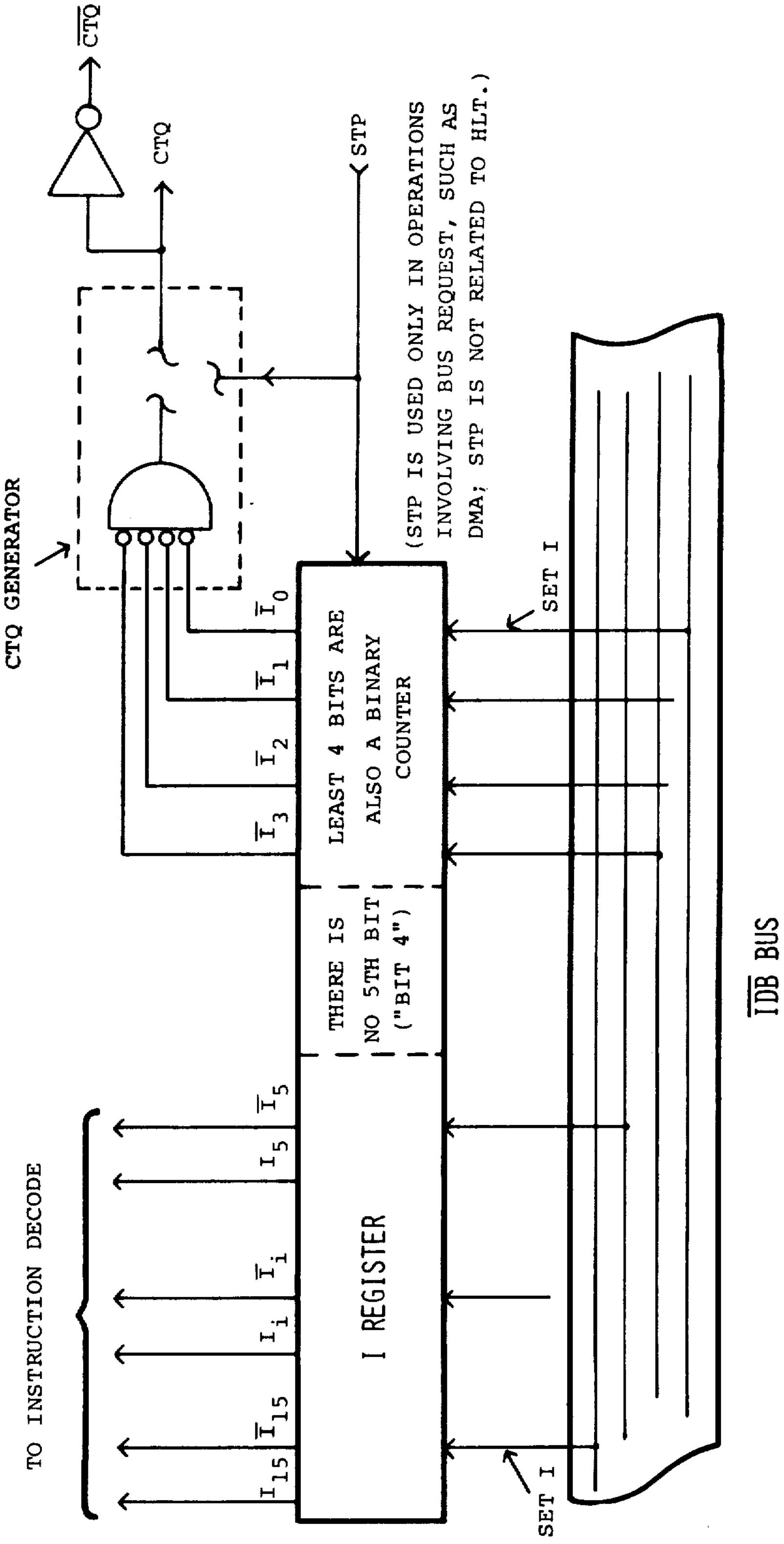

ROM OUTPUT
$\overline{\text{SET D}}$
Ø2
REF D
SET D
TRI-STATE OUTPUT DRIVER (1 OF 16)
+5V
$\overline{\text{SET IDA}}$
D REGISTER ELEMENT (1 OF 16)
SEE NOTE 2
ϕ2
ϕ1
SET D
REF D
(EXTERNAL)
IDA BUS
$IDA_i$
ZENER-LIKE
PROTECTION DEVICE (1 OF 16)
DMP IDA
SEE NOTE 1
ϕ1
$\overline{\text{IDB}}$ BUS
(INTERNAL)

NOTES:

1) THIS ACCOMPLISHES THE INVERSION OF INCOMING DATA.

2) REGISTER OUTPUTS ARE NORMALLY TAKEN AT THE OUTPUT OF THE INVERTER DRIVEN BY THE Ø2 TRANSFER GATE. BY TAKING IT HERE, $\overline{\text{IDB}}$ BUS DATA IS REINVERTED BACK TO NORMAL BEFORE GOING ONTO THE IDA BUS.

FIG 28



(STP IS USED ONLY IN OPERATIONS INVOLVING BUS REQUEST, SUCH AS DMA; STP IS NOT RELATED TO HLT.)

FIG 29

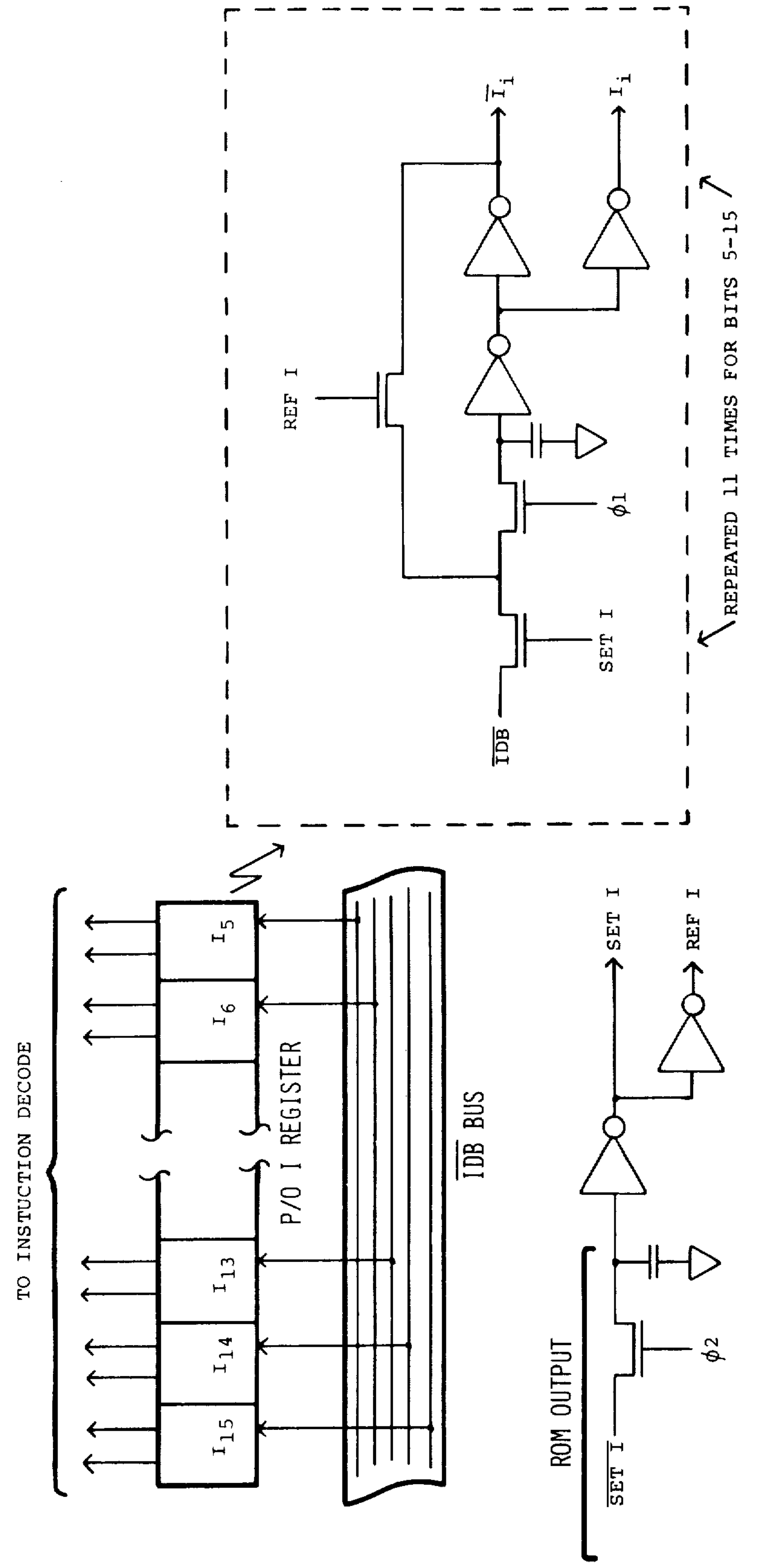

$\overline{I}_i$
$I_i$
REF I
$\phi 1$
SET I
$\overline{IDB}$
REPEATED 11 TIMES FOR BITS 5-15
TO INSTUCTION DECODE
$I_5$
$I_6$
$I_{13}$
$I_{14}$
$I_{15}$
P/O I REGISTER
$\overline{IDB}$ BUS
SET I
REF I
$\phi 2$
$\overline{SET\ I}$
ROM OUTPUT

FIG 30

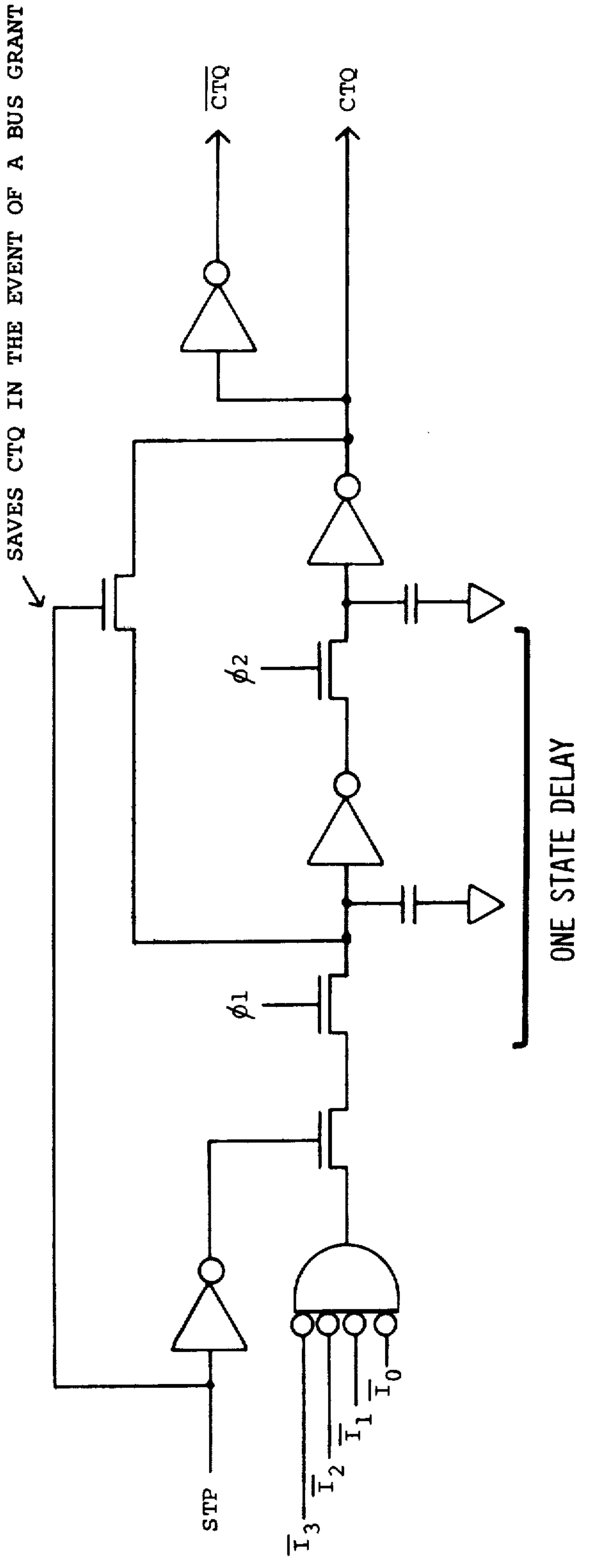

SAVES CTQ IN THE EVENT OF A BUS GRANT
$\overline{CTQ}$
CTQ
$\phi 2$
$\phi 1$
ONE STATE DELAY
STP
$\overline{I}_3$
$\overline{I}_2$
$\overline{I}_1$
$\overline{I}_0$

FIG 31

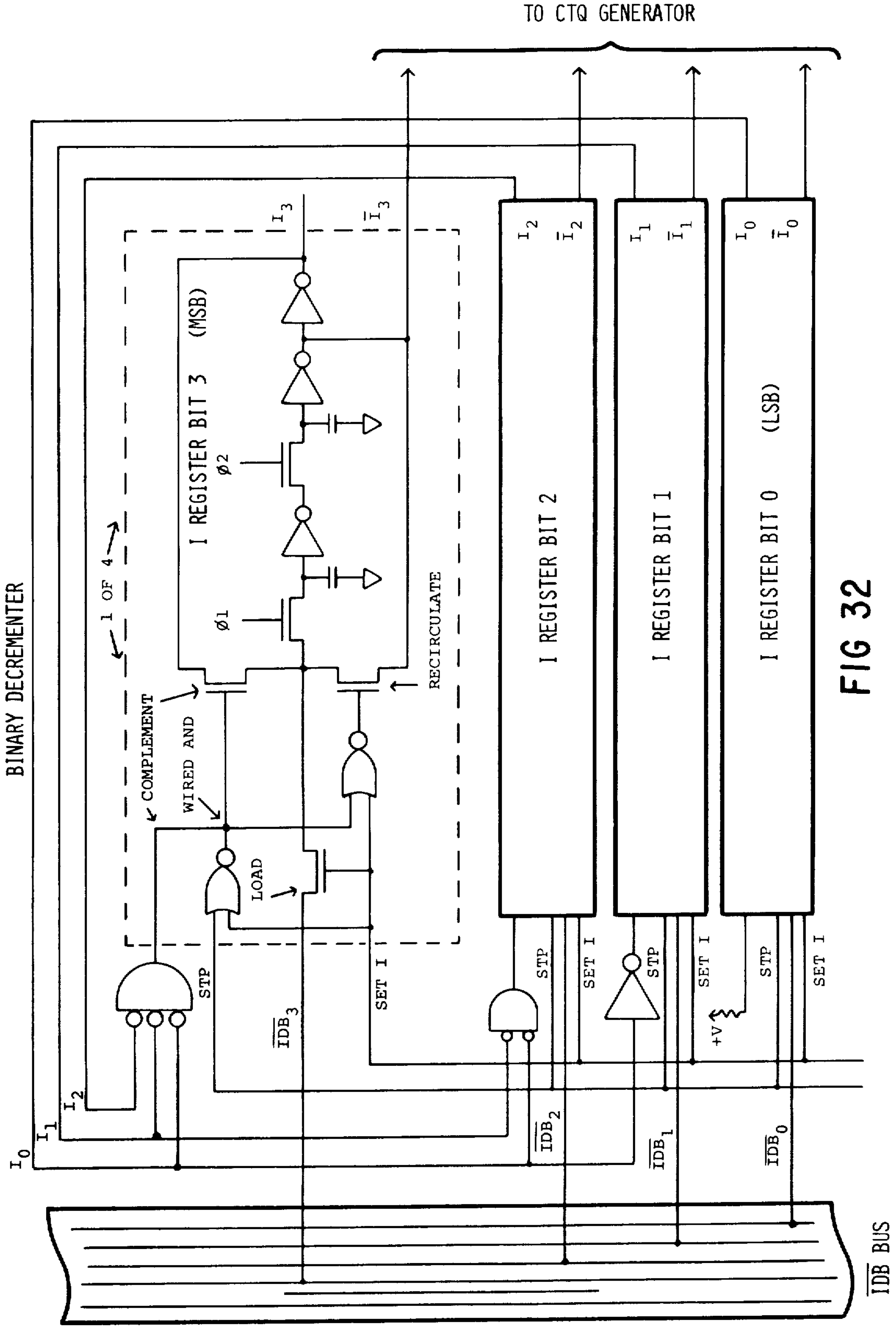

TO CTQ GENERATOR
BINARY DECREMENTER
1 OF 4
I REGISTER BIT 3 (MSB)
$I_3$
$\bar{I}_3$
Ø2
Ø1
COMPLEMENT
WIRED AND
RECIRCULATE
LOAD
STP
SET I
$\overline{IDB}_3$
$I_0$
$I_1$
$I_2$
I REGISTER BIT 2
$I_2$
$\bar{I}_2$
STP
SET I
$\overline{IDB}_2$
I REGISTER BIT 1
$I_1$
$\bar{I}_1$
STP
SET I
$\overline{IDB}_1$
+V
I REGISTER BIT 0 (LSB)
$I_0$
$\bar{I}_0$
STP
SET I
$\overline{IDB}_0$
$\overline{IDB}$ BUS

FIG 32

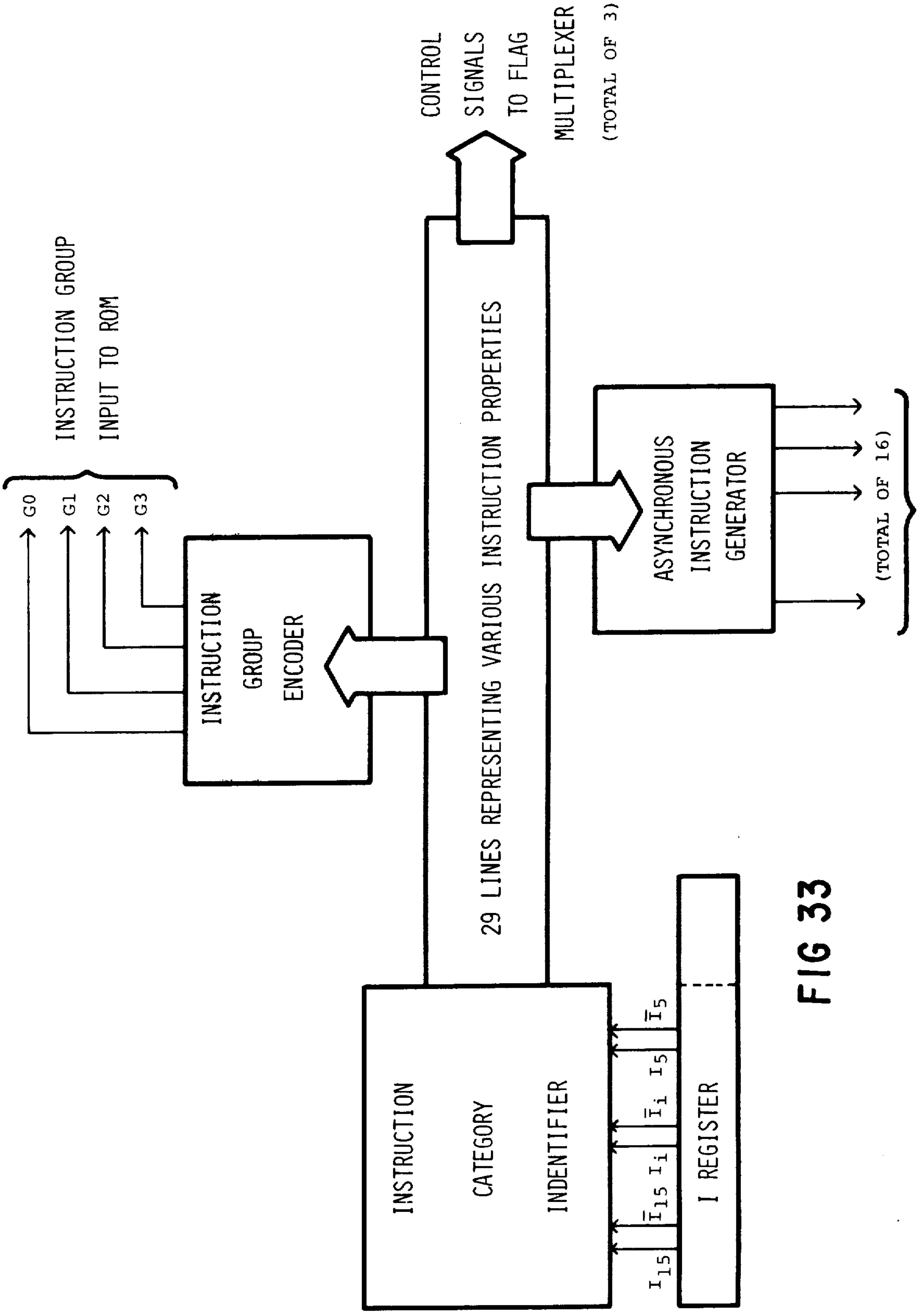

INSTRUCTION GROUP
INPUT TO ROM
G0
G1
G2
G3
INSTRUCTION
GROUP
ENCODER
CONTROL
SIGNALS
TO FLAG
MULTIPLEXER
(TOTAL OF 3)
29 LINES REPRESENTING VARIOUS INSTRUCTION PROPERTIES
ASYNCHRONOUS
INSTRUCTION
GENERATOR
(TOTAL OF 16)
INSTRUCTION
CATEGORY
INDENTIFIER
$I_{15}$
$\bar{I}_{15}$
$I_i$
$\bar{I}_i$
$I_5$
$\bar{I}_5$
I REGISTER

FIG 33

| SIGNAL NAME | MEANING AND ASSOCIATED ASSEMBLY LANGUAGE INSTRUCTIONS | FORMULA FOR GENERATION |
|---|---|---|
| LD* | INSTRUCTION IS EITHER LDA OR LDB (LOAD A OR LOAD B). $\overline{\text{I11}}$ DIFFERENTIATES BETWEEN THE TWO. | $\overline{I}_{14}\cdot\overline{I}_{13}\cdot\overline{I}_{12}$ |
| ST* | INSTRUCTION IS EITHER STA OR STB (STORE A OR STORE B). $\overline{\text{I11}}$ DIFFERENTIATES BETWEEN THE TWO. | $\overline{I}_{14}\cdot I_{13}\cdot I_{12}$ |
| AD* | INSTRUCTION IS EITHER ADA OR ADB (ADD TO A OR ADD TO B). $\overline{\text{I11}}$ DIFFERENTIATES BETWEEN THE TWO. | $\overline{I}_{14}\cdot I_{13}\cdot\overline{I}_{12}$ |
| CP* | INSTRUCTION IS EITHER CPA OR CPB (COMPARE TO A OR COMPARE TO B). $\overline{\text{I11}}$ DIFFERENTIATES BETWEEN THE TWO. | $\overline{I}_{14}\cdot\overline{I}_{13}\cdot I_{12}$ |
| $\overline{\text{I11}}$ | DIFFERENTIATES BETWEEN INSTRUCTIONS INVOLVING THE A REGISTER AND THOSE INVOLVING THE B REGISTER. | $\overline{I}_{11}$ |
| JMP | INSTRUCTION IS JMP (JUMP). | $I_{14}\cdot I_{13}\cdot\overline{I}_{12}\cdot I_{11}$ |
| JSM | INSTRUCTION IS JSM (JUMP TO SUBROUTINE). | $I_{14}\cdot\overline{I}_{13}\cdot\overline{I}_{12}\cdot\overline{I}_{11}$ |
| ISZ | INSTRUCTION IS ISZ (INCREMENT AND THEN SKIP IF ZERO). | $I_{14}\cdot\overline{I}_{13}\cdot\overline{I}_{12}\cdot I_{11}$ |
| DSZ | INSTRUCTION IS DSZ (DECREMENT AND THEN SKIP IF ZERO). | $I_{14}\cdot\overline{I}_{13}\cdot I_{12}\cdot I_{11}$ |
| AND | INSTRUCTION IS AND (AND TO A). | $I_{14}\cdot\overline{I}_{13}\cdot I_{12}\cdot\overline{I}_{11}$ |
| IOR | INSTRUCTION IS IOR (INCLUSIVE OR WITH A). | $I_{14}\cdot I_{13}\cdot\overline{I}_{12}\cdot\overline{I}_{11}$ |
| ASG | INSTRUCTION IS AND ALTER-SKIP GROUP INSTRUCTION:<br>RLA SKIP IF $A_0$=1, ALTER $A_0$.<br>RLB SKIP IF $B_0$=1, ALTER $B_0$.<br>SLA SKIP IF $A_0$=0, ALTER $A_0$.<br>SLB SKIP IF $B_0$=0, ALTER $B_0$.<br>SAP SKIP IF $A_{15}$=0, ALTER $A_{15}$.<br>SBP SKIP IF $B_{15}$=0, ALTER $B_{15}$.<br>SAM SKIP IF $A_{15}$=1, ALTER $A_{15}$.<br>SBM SKIP IF $B_{15}$=1, ALTER $B_{15}$. | $I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}$ |

FIG 34A

| SIGNAL NAME | MEANING AND ASSOCIATED ASSEMBLY LANGUAGE INSTRUCTIONS | FORMULA FOR GENERATION |
|---|---|---|
| ASG<br>(CONT.) | SOC SKIP IF OVERFLOW= 0, ALTER OVERFLOW.<br>SOS SKIP IF OVERFLOW=1, ALTER OVERFLOW.<br>SEC SKIP IF EXTEND=0, ALTER EXTEND.<br>SES SKIP IF EXTEND=1, ALTER EXTEND.<br>RZA SKIP IF A IS NOT ZERO.<br>RZB SKIP IF B IS NOT ZERO.<br>SZA SKIP IF A IS ZERO.<br>SZB SKIP IF B IS ZERO.<br>RIA RZA, THEN INCREMENT A.<br>RIB RZB, THEN INCREMENT B.<br>SIA SZA, THEN INCREMENT A.<br>SIB SZB, THEN INCREMENT B.<br>SFS SKIP IF FLAG SET.<br>SFC SKIP IF FLAG CLEAR.<br>SSS SKIP IF STATUS SET.<br>SSC SKIP IF STATUS CLEAR.<br>SDS SKIP IF DECIMAL CARRY SET.<br>SDC SKIP IF DECIMAL CARRY CLEAR.<br>SHS SKIP IF HALT SET.<br>SHC SKIP IF HALT CLEAR. | |
| I7 | DIFFERNETIATES BETWEEN HOLD, AND ALTER BY SETTING OR CLEARING, THE TESTED BIT IN THE FOLLOWING ALTER INSTRUCTIONS: RLA, RLB, SLA, SLB, SAP, SBP, SAM, SBM, SOC, SOS, SEC, SES. I7=0 IMPLIES HOLD; I7=1 IMPLIES ALTER. | $I_7$ |
| $\overline{I6}$ | IF I7=0, $\overline{I6}$ DIFFERENTIATES BETWEEN CLEARING OR SETTING THE TESTED BIT, WHEN DOING AN ALTER INSTRUCTION. $\overline{I6}$=1 IMPLIES CLEAR; $\overline{I6}$=0 IMPLIES SET. | $\bar{I}_6$ |
| LSC | INSTRUCTION IS AN ALTER INSTRUCTION INVOLVING A LEAST-SIGNIFICANT BIT: RLA, RLB, SLA, SLB. | $\bar{I}_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}\cdot I_9$ |
| MSC | INSTRUCTION IS AN ALTER INSTRUCTION INVOLVING A MOST-SIGNIFICANT BIT, EXTEND, OR OVERFLOW: SAP, SAM, SBP, SBM, SOC, SOS, SEC, SES. | $I_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}$ |

FIG 34B

| SIGNAL NAME | MEANING AND ASSOCIATED ASSEMBLY LANGUAGE INSTRUCTIONS | FORMULA FOR GENERATION |
|---|---|---|
| RSS | DIFFERENTIATES BETWEEN THE SKIP AND REVERSE-SKIP SENSES AMONG THE ALTER AND SKIP GROUP INSTRUCTIONS. | $I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}\cdot I_{8}$ |
| EQ | INSTRUCTION IS EITHER SEC OR SES. RSS DIFFERENTIATES BETWEEN THE TWO. | $I_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{11}\cdot I_{10}\cdot I_{9}$ |
| OQ | INSTRUCTION IS EITHER SOC OR SOS. RSS DIFFERENTIATES BETWEEN THE TWO. | $I_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot \overline{I}_{11}\cdot I_{10}\cdot I_{9}$ |
| S/RI | INSTRUCTIONS IS A "SKIP/REVERSE-SKIP, THEN INCREMENT" INSTRUCTION: SIA, RIA, SIB, RIB. | $\overline{I}_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}\cdot \overline{I}_{9}\cdot \overline{I}_{7}\cdot I_{6}$ |
| S/RZ | INSTRUCTION IS A "SKIP/REVERSE-SKIP, WITHOUT INCREMENT" INSTRUCTION: SZA, RZA, SZB, RZB. | $\overline{I}_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot I_{10}\cdot \overline{I}_{9}\cdot \overline{I}_{7}\cdot \overline{I}_{6}$ |
| FGC | IF ASG IS A 1, AND EACH OF S/RI, S/RZ, MSC AND LSC ARE 0'S, INSTRUCTION IS EITHER SFS OR SFC. RSS DIFFERENTIATES BETWEEN THE TWO. | $\overline{I}_{11}\cdot \overline{I}_{6}$ |
| STC | IF ASG IS A 1, AND EACH OF S/RI, S/RZ, MSC AND LSC ARE 0'S, INSTRUCTION IS EITHER SSS OR SSC. RSS DIFFERENTIATES BETWEEN THE TWO. | $I_{11}\cdot \overline{I}_{6}$ |
| HTC | IF ASG IS A 1, AND EACH OF S/RI, S/RZ, MSC AND LSC ARE 0'S, INSTRUCTION IS EITHER SHS OR SHC. RSS DIFFERENTIATES BETWEEN THE TWO. SEE NOTE AT BOTTOM. | $I_{11}\cdot I_{6}$ |
| RET | INSTRUCTION IS RET (RETURN). [THE $\overline{P}$/P BIT ($I_6$) IS A DON'T CARE BIT FOR THE BINARY PROCESSOR CHIP.] | $I_{15}\cdot I_{14}\cdot I_{13}\cdot I_{12}\cdot \overline{I}_{11}\cdot \overline{I}_{10}\cdot \overline{I}_{9}\cdot \overline{I}_{8}\cdot I_{7}$ |
| EXE | INSTRUCTION IS EXE (EXECUTE). | $I_{14}\cdot I_{13}\cdot I_{12}\cdot \overline{I}_{11}\cdot \overline{I}_{10}\cdot \overline{I}_{9}\cdot \overline{I}_{8}\cdot \overline{I}_{7}\cdot \overline{I}_{6}\cdot \overline{I}_{5}$ |

NOTE: THE NOR OF FGC, STC AND HTC, IF TRUE WHILE ASG IS ALSO TRUE, WHILE S/RI, S/RZ, MSC AND LSC ARE FALSE, SPECIFIES EITHER SDS OR SDC. RSS DIFFERENTIATES BETWEEN THE TWO.

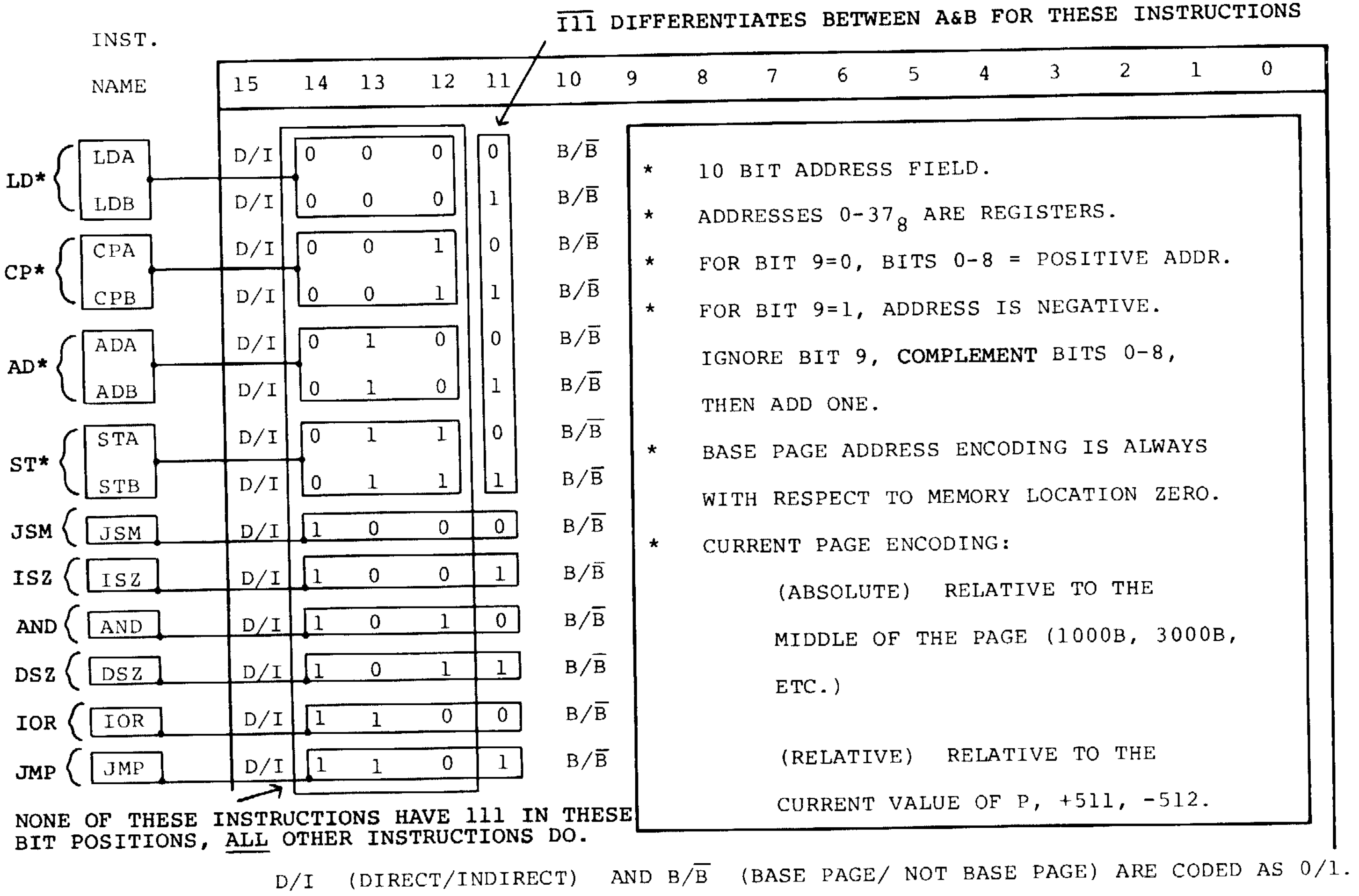
FIG 34C

| SIGNAL NAME | MEANING AND ASSOCIATED ASSEMBLY LANGUAGE INSTRUCTIONS | FORMULA FOR GENERATION |
|---|---|---|
| T/CM | INSTRUCTION IS ANY COMPLEMENT INSTRUCTION: CMA, CMB, TCA, TCB (ONE'S COMPLEMENT OF A, ONE'S COMPLEMENT OF B, TWO'S COMPLEMENT OF A, TWO' COMPLEMENT OF B). | $I_{15} \cdot I_{14} \cdot I_{13} \cdot I_{12} \cdot \overline{I}_{10} \cdot \overline{I}_9 \cdot \overline{I}_8 \cdot \overline{I}_7 \cdot I_5$ |
| TC* | INSTRUCTION IS EITHER TCA OR TCB (TWO'S COMPLEMENT A OR TWO'S COMPLEMENT B). | $I_{15} \cdot I_{14} \cdot I_{13} \cdot I_{12} \cdot \overline{I}_{10} \cdot \overline{I}_9 \cdot \overline{I}_8 \cdot \overline{I}_7 \cdot \overline{I}_6 \cdot I_5$ |
| SRG | SHIFT-ROTATE GROUP—INSTRUCTION IS ONE OF THE FOLLOWING:<br>AAR ARITHMETIC RIGHT SHIFT OF A.<br>ABR ARITHMETIC RIGHT SHIFT OF B.<br>SAR SHIFT A RIGHT.<br>SBR SHIFT B RIGHT.<br>SAL SHIFT A LEFT.<br>SBL SHIFT B LEFT.<br>RAR ROTATE A RIGHT.<br>RBR ROTATE B RIGHT.<br>$\overline{\text{I6}}$, I7 AND $\overline{\text{I11}}$ ARE USED TO DISTINGUISH BETWEEN THESE INSTRUCTIONS. | $I_{15} \cdot I_{14} \cdot I_{13} \cdot I_{12} \cdot \overline{I}_{10} \cdot \overline{I}_9 \cdot I_8 \cdot \overline{I}_5$ |

FIG 34D

# FIG 35A

GROUP: MEMORY REFERENCE



$\overline{1}\overline{1}\overline{1}$ DIFFERENTIATES BETWEEN A&B FOR THESE INSTRUCTIONS

| | INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LD* | LDA | D/I | 0 | 0 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| | LDB | D/I | 0 | 0 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| CP* | CPA | D/I | 0 | 0 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| | CPB | D/I | 0 | 0 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| AD* | ADA | D/I | 0 | 1 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| | ADB | D/I | 0 | 1 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| ST* | STA | D/I | 0 | 1 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| | STB | D/I | 0 | 1 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| JSM | JSM | D/I | 1 | 0 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| ISZ | ISZ | D/I | 1 | 0 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| AND | AND | D/I | 1 | 0 | 1 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| DSZ | DSZ | D/I | 1 | 0 | 1 | 1 | $B/\overline{B}$ | | | | | | | | | | |
| IOR | IOR | D/I | 1 | 1 | 0 | 0 | $B/\overline{B}$ | | | | | | | | | | |
| JMP | JMP | D/I | 1 | 1 | 0 | 1 | $B/\overline{B}$ | | | | | | | | | | |

* 10 BIT ADDRESS FIELD.

* ADDRESSES $0\text{-}37_8$ ARE REGISTERS.

* FOR BIT 9=0, BITS 0-8 = POSITIVE ADDR.

* FOR BIT 9=1, ADDRESS IS NEGATIVE.

IGNORE BIT 9, **COMPLEMENT** BITS 0-8,

THEN ADD ONE.

* BASE PAGE ADDRESS ENCODING IS ALWAYS

WITH RESPECT TO MEMORY LOCATION ZERO.

* CURRENT PAGE ENCODING:

(ABSOLUTE) RELATIVE TO THE

MIDDLE OF THE PAGE (1000B, 3000B,

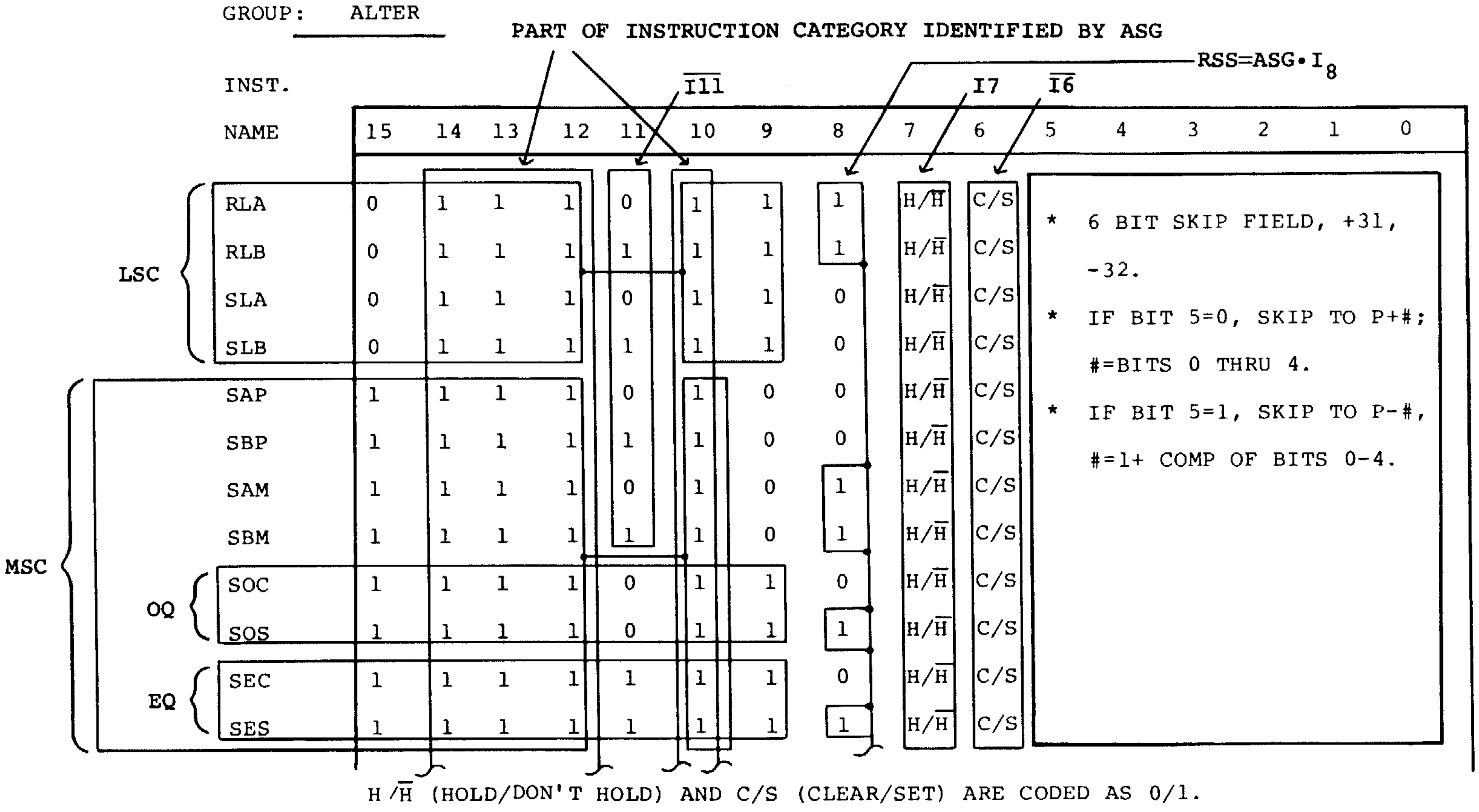
ETC.)

(RELATIVE) RELATIVE TO THE

CURRENT VALUE OF P, +511, -512.

NONE OF THESE INSTRUCTIONS HAVE 111 IN THESE BIT POSITIONS, ALL OTHER INSTRUCTIONS DO.

D/I (DIRECT/INDIRECT) AND $B/\overline{B}$ (BASE PAGE/ NOT BASE PAGE) ARE CODED AS 0/1.



GROUP: ALTER

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RLA | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| RLB | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SLA | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SLB | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SAP | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SBP | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SAM | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SBM | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SOC | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SOS | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |
| SEC | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | $H/\overline{H}$ | C/S | | | | | | |
| SES | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $H/\overline{H}$ | C/S | | | | | | |

* 6 BIT SKIP FIELD, +31, -32.

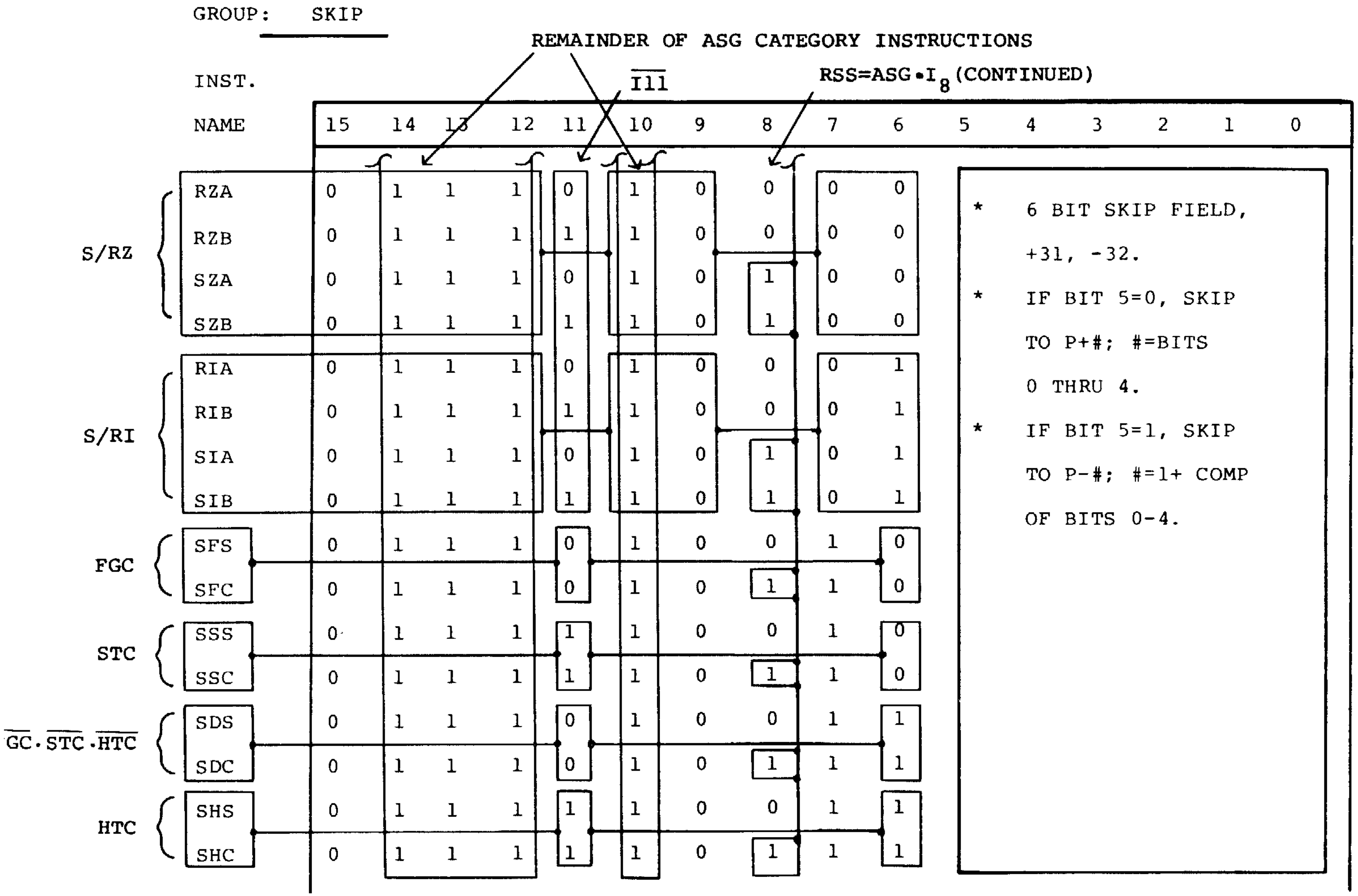
* IF BIT 5=0, SKIP TO P+#; #=BITS 0 THRU 4.

* IF BIT 5=1, SKIP TO P-#, #=1+ COMP OF BITS 0-4.

$H/\overline{H}$ (HOLD/DON'T HOLD) AND C/S (CLEAR/SET) ARE CODED AS 0/1.

FIG 35B

FIG 35C



GROUP: SKIP

REMAINDER OF ASG CATEGORY INSTRUCTIONS

$\overline{I11}$

RSS=ASG$\cdot I_8$ (CONTINUED)

| | INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S/RZ | RZA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| | RZB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| | SZA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | | | | | | |
| | SZB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | | | | | | |
| S/RI | RIA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | | | | | | |
| | RIB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | | | | | | |
| | SIA | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | | | | | | |
| | SIB | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | | | | | | |
| FGC | SFS | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | | | | | | |
| | SFC | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | | | | | | |
| STC | SSS | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | | | | | | |
| | SSC | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | | | | | |
| $\overline{GC}\cdot\overline{STC}\cdot\overline{HTC}$ | SDS | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | | | | | | |
| | SDC | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | | | | | | |
| HTC | SHS | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | | | | | | |
| | SHC | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | | | |

* 6 BIT SKIP FIELD, +31, -32.

* IF BIT 5=0, SKIP TO P+#; #=BITS 0 THRU 4.

* IF BIT 5=1, SKIP TO P-#; #=1+ COMP OF BITS 0-4.

# FIG 35D

GROUP: COMPLEMENT

|  |  | INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T/CM |  | CMA | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
|  |  | CMB | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
|  | TC* | TCA | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
|  |  | TCB | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

GROUP: RETURN

|  | INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RET | RET | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | $\overline{P}$/P | 6 BIT, 2'S COMPLEMENT SKIP FIELD (ALLOWS -32 THRU +31). |  |  |  |  |  |

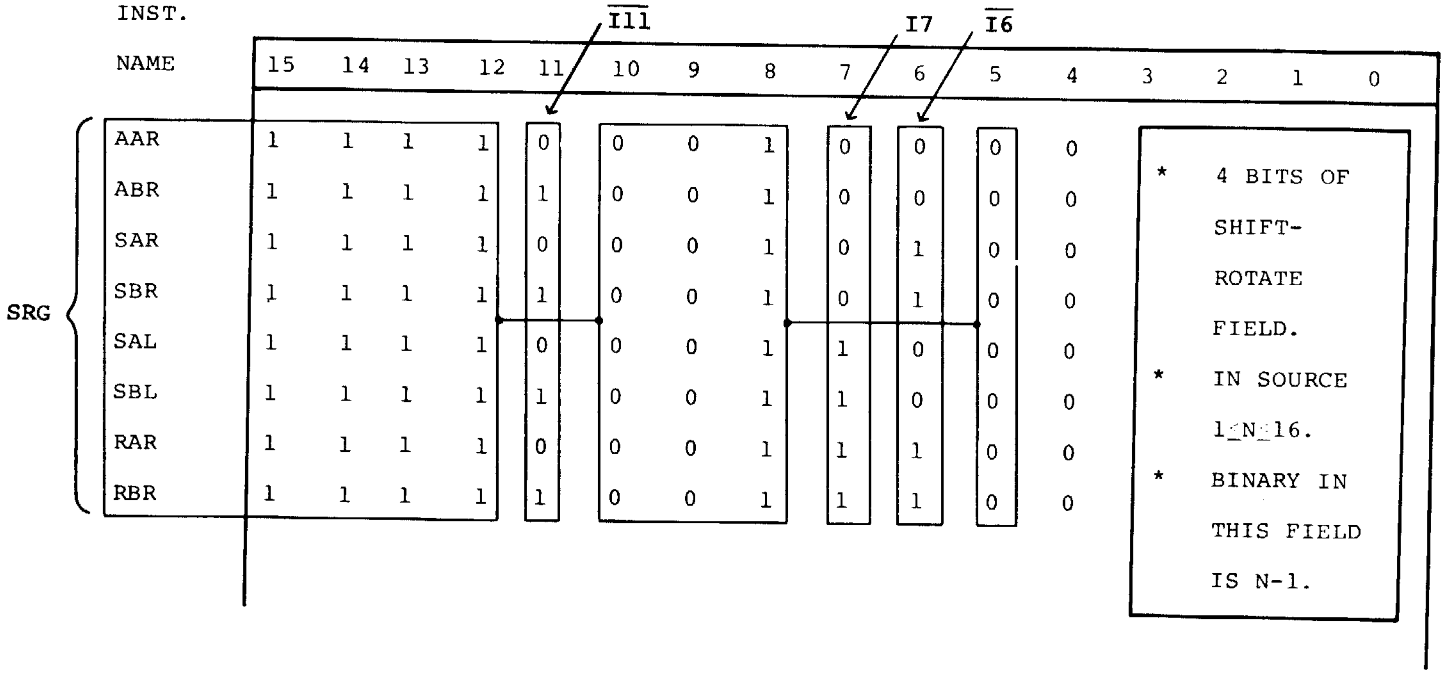
$\overline{P}$/P (DON'T POP/POP THE IOC) ENCODED AS 0/1.

GROUP: EXECUTE

|  | INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXE | EXE | D/I | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 BIT REGISTER ADDRESS (0-$37_8$). |  |  |  |  |

D/I (DIRECT/INDIRECT) ENCODED AS 0/1.

GROUP: SHIFT-ROTATE


$\overline{I11}$
I7
$\overline{I6}$
SRG

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | * 4 BITS OF SHIFT-ROTATE FIELD.<br>* IN SOURCE 1≤N≤16.<br>* BINARY IN THIS FIELD IS N-1. | | | |
| ABR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | | | |
| SAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | | | |
| SBR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | | | |
| SAL | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | | | |
| SBL | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | | | |
| RAR | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | | | | |
| RBR | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | | | | |

FIG 35E

TABLE OF GROUP
ENCODING QUALIFIER GENERATION

| INSTRUCTION | GROUP QUALIFIERS GENERATED | | | |
|---|---|---|---|---|
| CATEGORY | G3 | G2 | G1 | G0 |
| ST* | 1 | 1 | 1 | 1 |
| AD* | 0 | 1 | 1 | 1 |
| JMP | 1 | 0 | 1 | 0 |
| EXE | 1 | 1 | 1 | 0 |
| ASG | 1 | 1 | 0 | 0 |
| LD* | 0 | 1 | 1 | 1 |
| SRG | 0 | 1 | 0 | 0 |
| ISZ | 0 | 0 | 1 | 0 |
| JSM | 1 | 0 | 1 | 1 |
| DSZ | 0 | 0 | 1 | 0 |
| RET | 1 | 0 | 0 | 0 |
| T/CM | 0 | 1 | 0 | 1 |
| CP* | 0 | 1 | 1 | 0 |
| AND | 0 | 1 | 1 | 1 |
| IOR | 0 | 1 | 1 | 1 |

FIG 36

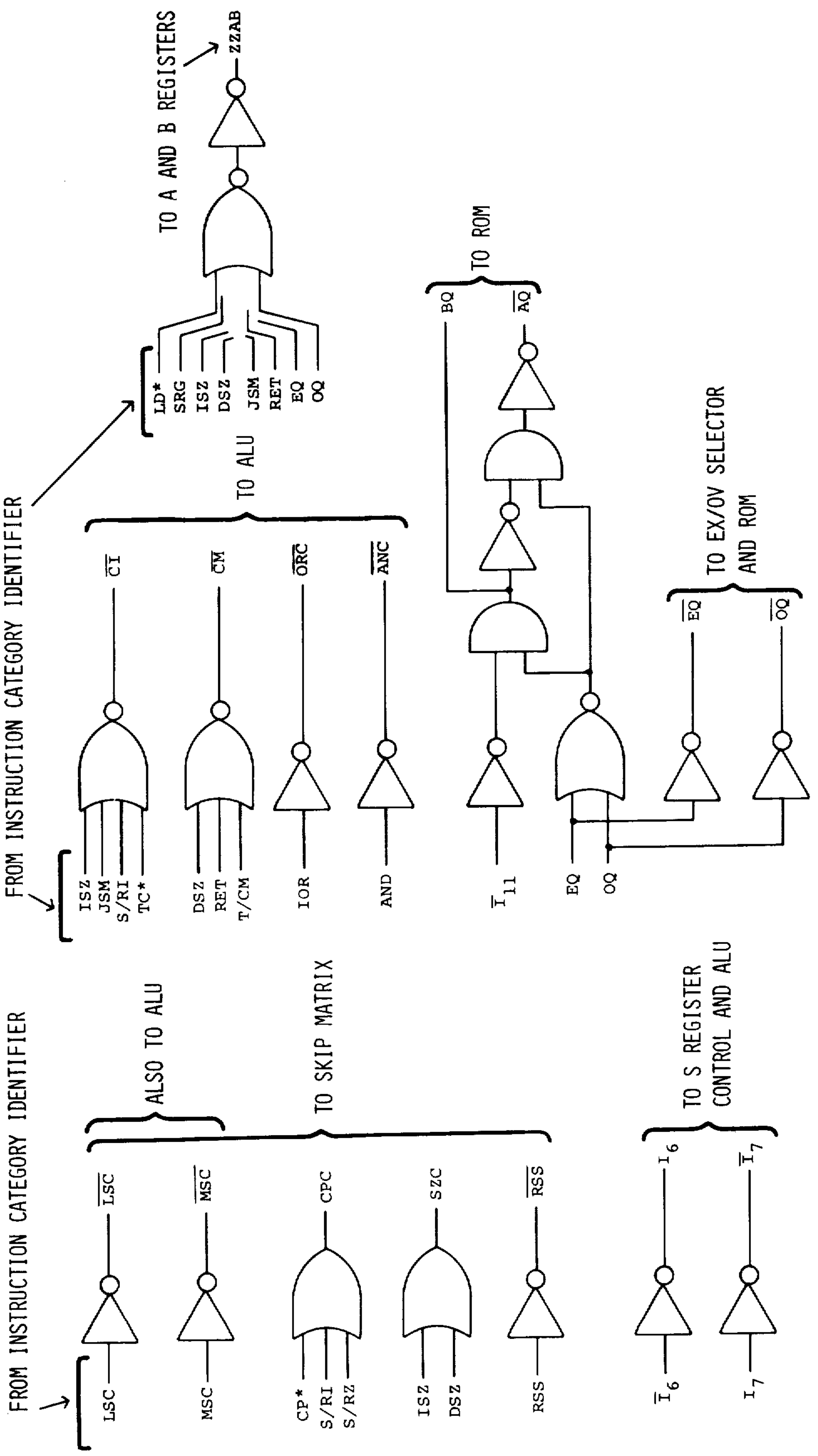

TO A AND B REGISTERS
ZZAB
FROM INSTRUCTION CATEGORY IDENTIFIER
LD*
SRG
ISZ
DSZ
JSM
RET
EQ
OQ
TO ALU
ISZ
JSM
S/RI
TC*
$\overline{CI}$
DSZ
RET
T/CM
$\overline{CM}$
IOR
$\overline{ORC}$
AND
$\overline{ANC}$
TO ROM
BQ
$\overline{AQ}$
$\overline{I}_{11}$
EQ
OQ
TO EX/OV SELECTOR AND ROM
$\overline{EQ}$
$\overline{OQ}$
FROM INSTRUCTION CATEGORY IDENTIFIER
ALSO TO ALU
TO SKIP MATRIX
LSC
$\overline{LSC}$
MSC
$\overline{MSC}$
CP*
S/RI
S/RZ
CPC
ISZ
DSZ
SZC
RSS
$\overline{RSS}$
TO S REGISTER CONTROL AND ALU
$\overline{I}_6$
$I_6$
$I_7$
$\overline{I}_7$

FIG 37

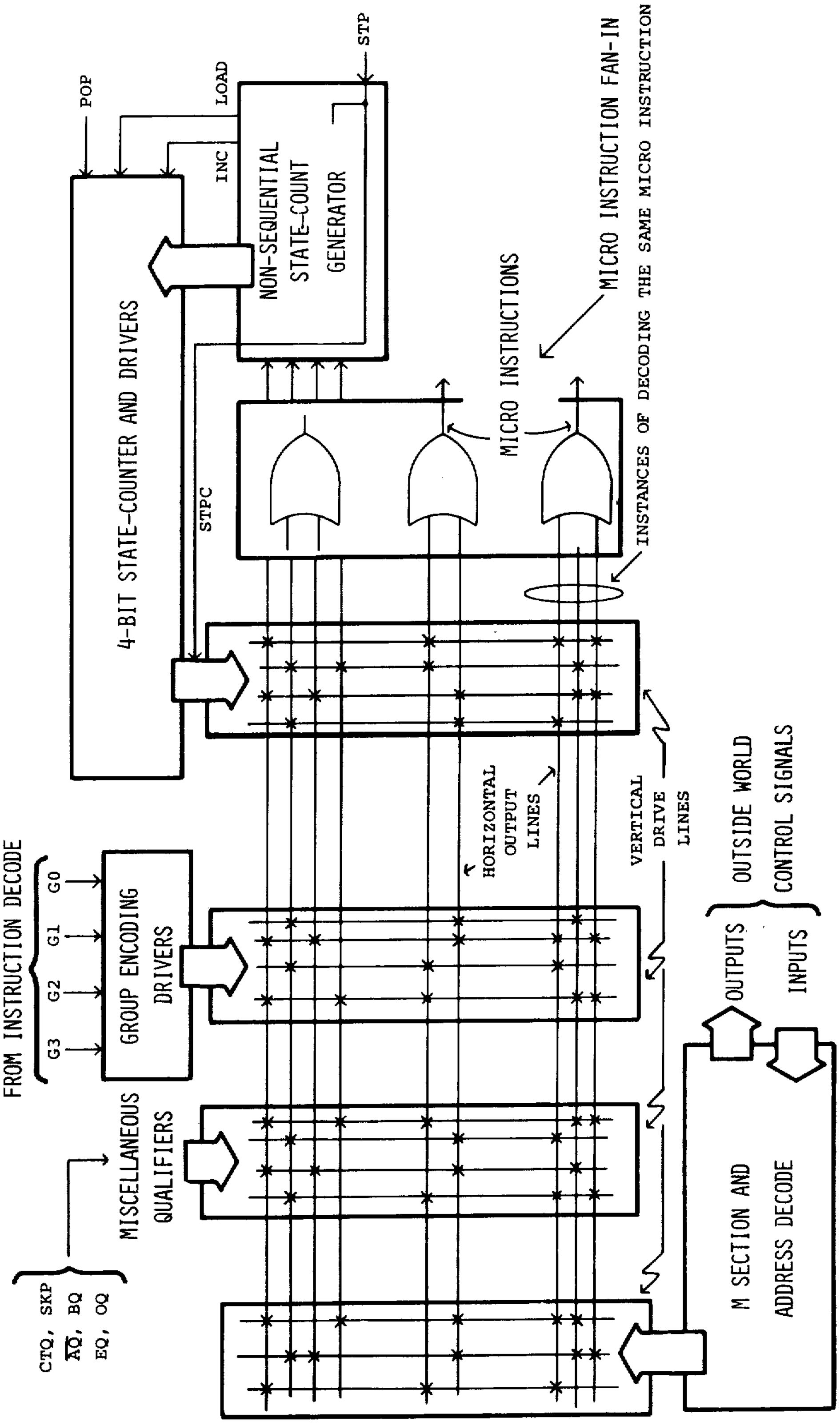

POP
LOAD
STP
INC
4-BIT STATE-COUNTER AND DRIVERS
NON-SEQUENTIAL STATE-COUNT GENERATOR
MICRO INSTRUCTION FAN-IN
INSTANCES OF DECODING THE SAME MICRO INSTRUCTION
MICRO INSTRUCTIONS
STPC
HORIZONTAL OUTPUT LINES
VERTICAL DRIVE LINES
FROM INSTRUCTION DECODE
G0
G1
G2
G3
GROUP ENCODING DRIVERS
OUTPUTS
INPUTS
OUTSIDE WORLD CONTROL SIGNALS
CTQ, SKP
$\overline{AQ}$, BQ
EQ, OQ
MISCELLANEOUS QUALIFIERS
M SECTION AND ADDRESS DECODE

FIG 38

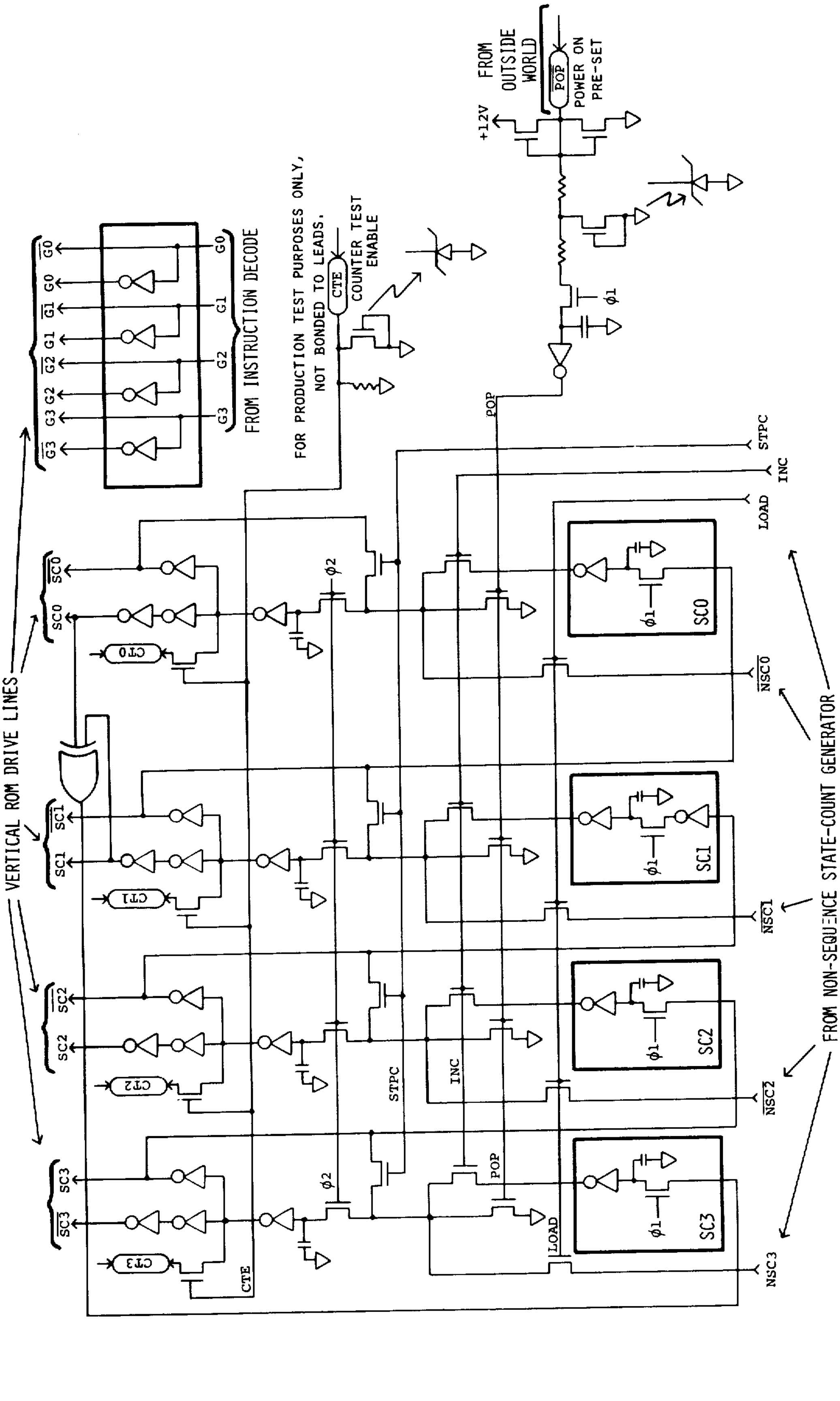
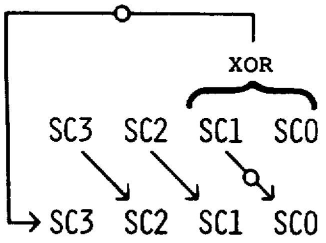

VERTICAL ROM DRIVE LINES
$\overline{G0}$
G0
$\overline{G1}$
G1
$\overline{G2}$
G2
G3
$\overline{G3}$
G0
G1
G2
G3
FROM INSTRUCTION DECODE
FOR PRODUCTION TEST PURPOSES ONLY, NOT BONDED TO LEADS.
CTE
COUNTER TEST ENABLE
FROM OUTSIDE WORLD
$\overline{POP}$
POWER ON PRE-SET
+12V
φ1
POP
STPC
INC
LOAD
$\overline{SC0}$
SC0
CT0
φ2
φ1
SC0
$\overline{NSC0}$
$\overline{SC1}$
SC1
CT1
φ1
SC1
$\overline{NSC1}$
$\overline{SC2}$
SC2
CT2
STPC
INC
φ1
SC2
$\overline{NSC2}$
SC3
$\overline{SC3}$
CT3
CTE
φ2
POP
LOAD
φ1
SC3
NSC3
FROM NON-SEQUENCE STATE-COUNT GENERATOR

FIG 39

RULE FOR COMPUTING NTH STATE COUNT FROM N-1TH STATE COUNT:



1. ↘ DENOTES NTH SC(I)= N-1TH SC(I-1)

2. ○↘ DENOTES NTH SC(I)= N-1TH $\overline{\text{SC(I-1)}}$

ROM STATE-COUNTS

| ASM CHART STATE # | ROM STATE-COUNTER OUTPUTS | | | |
|---|---|---|---|---|
| | SC 3 | SC 2 | SC 1 | SC 0 |
| 14 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 2 | 1 | 0 | 1 | 1 |
| 3 | 1 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 0 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 0 | 1 | 0 |
| 8 | 0 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 0 | 1 | 0 | 1 |
| 11 | 0 | 0 | 1 | 1 |
| 12 | 1 | 0 | 0 | 0 |
| 13 | 1 | 1 | 0 | 1 |
| 14 | 0 | 1 | 1 | 1 |

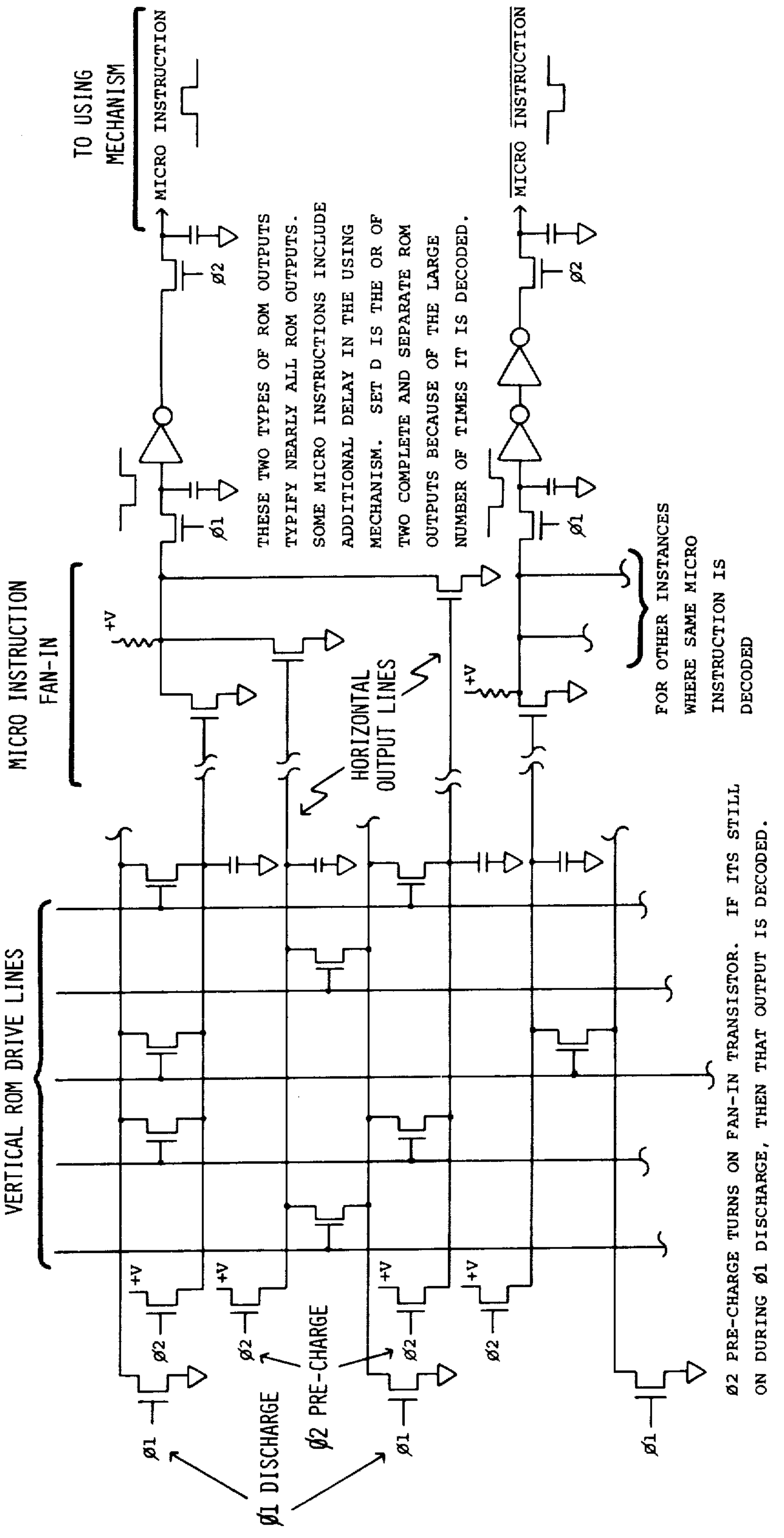
THESE STATES NOT USED {

START-UP STATE (CAUSED BY POP) {

"FORBIDDEN" STATE (TRANSITIONS TO ITSELF ONLY) {

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 |

FIG 40



THESE TWO TYPES OF ROM OUTPUTS TYPIFY NEARLY ALL ROM OUTPUTS. SOME MICRO INSTRUCTIONS INCLUDE ADDITIONAL DELAY IN THE USING MECHANISM. SET D IS THE OR OF TWO COMPLETE AND SEPARATE ROM OUTPUTS BECAUSE OF THE LARGE NUMBER OF TIMES IT IS DECODED.

FOR OTHER INSTANCES WHERE SAME MICRO INSTRUCTION IS DECODED

Ø2 PRE-CHARGE TURNS ON FAN-IN TRANSISTOR. IF ITS STILL ON DURING Ø1 DISCHARGE, THEN THAT OUTPUT IS DECODED.

FIG 41

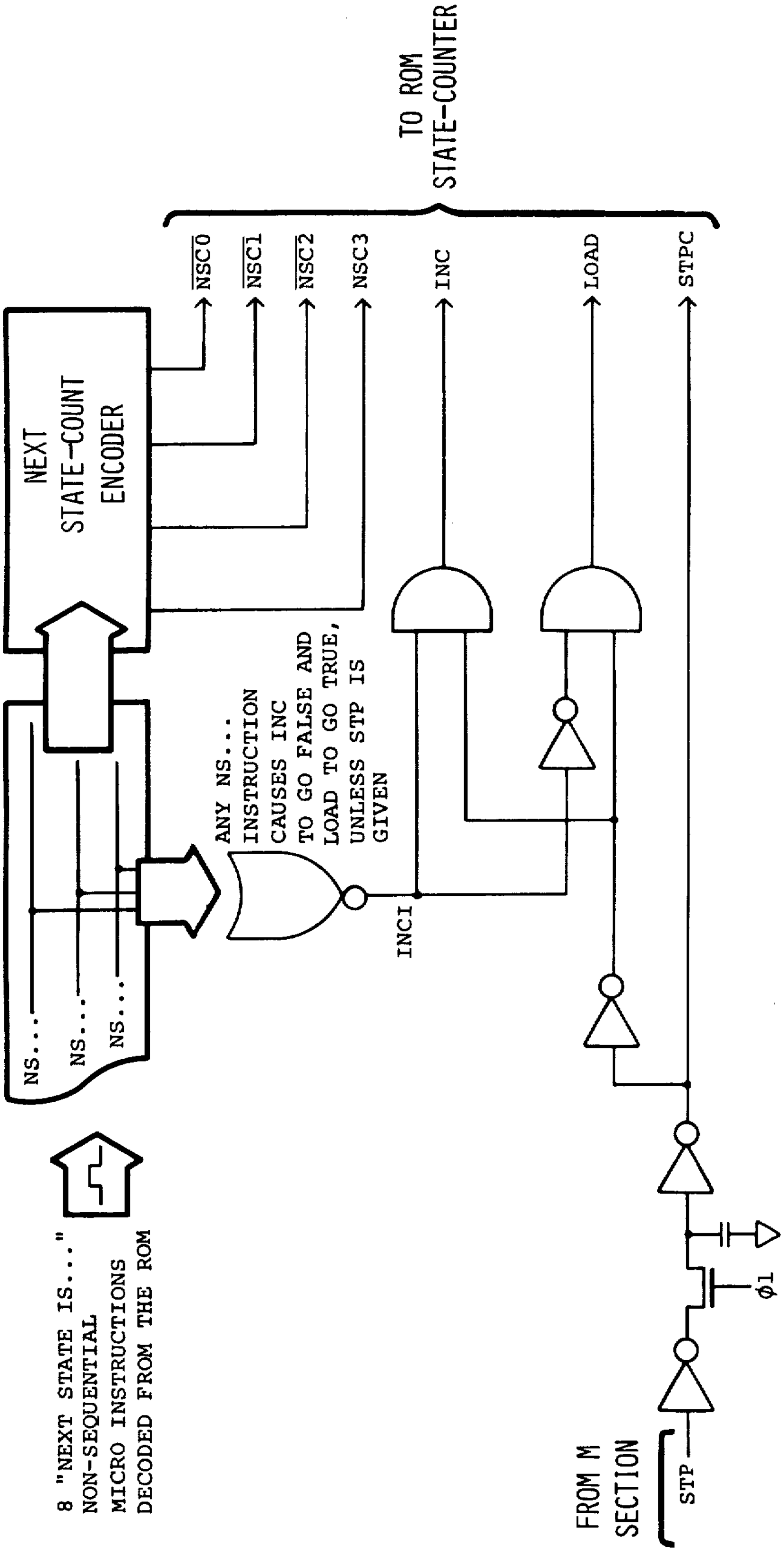

TO ROM
STATE-COUNTER
$\overline{NSC0}$
$\overline{NSC1}$
$\overline{NSC2}$
NSC3
INC
LOAD
STPC
NEXT
STATE-COUNT
ENCODER
NS...
NS...
NS...
ANY NS...
INSTRUCTION
CAUSES INC
TO GO FALSE AND
LOAD TO GO TRUE,
UNLESS STP IS
GIVEN
INCI
8 "NEXT STATE IS..."
NON-SEQUENTIAL
MICRO INSTRUCTIONS
DECODED FROM THE ROM
FROM M
SECTION
STP
φ1

FIG 42

THE ASM CHART HAS THESE 20 NON-SEQUENTIAL
STATE-COUNT TRANSITIONS:

| | | | | |
|---|---|---|---|---|
| 0 TO 0 | 3 TO 2 | 2 TO 4 | 3 TO 7 | 2 TO 10 |
| 5 TO 0 | 4 TO 2 | 4 TO 4 | 5 TO 7 | 6 TO 10 |
| 10 TO 0 | 3 TO 3 | 2 TO 6 | 4 TO 9 | 7 TO 10 |
| 2 TO 2 | 6 TO 3 | 3 TO 6 | 9 TO 9 | 14 TO 10 |

REQUIRING THESE 8 "NEXT-STATE IS..."
NON-SEQUENTIAL STATE-COUNT
MICRO-INSTRUCTIONS:

| | | | |
|---|---|---|---|
| NS0 | NS3 | NS6 | NS9 |
| NS2 | NS4 | NS7 | NS10 |

DEFINITION OF THE "NEXT-STATE IS..."
NON-SEQUENTIAL MICRO-INSTRUCTIONS:

| NON-SEQUENTIAL STATE-COUNT MICRO-INSTRUCTION | STATE-COUNTER CONTROL LINES | | | | |
|---|---|---|---|---|---|
| | INCI | NSC3 | $\overline{NSC2}$ | $\overline{NSC1}$ | $\overline{NSC0}$ |
| NS0 | 0 | 1 | 1 | 0 | 1 |
| NS2 | 0 | 1 | 1 | 0 | 0 |
| NS3 | 0 | 1 | 0 | 1 | 1 |
| NS4 | 0 | 1 | 0 | 0 | 0 |
| NS6 | 0 | 0 | 0 | 0 | 1 |
| NS7 | 0 | 0 | 1 | 0 | 1 |
| NS9 | 0 | 1 | 1 | 1 | 0 |
| NS10 | 0 | 0 | 0 | 1 | 0 |
| NONE OF THE ABOVE | 1 | - | - | - | - |

← THESE PATTERNS, WHEN PUT THROUGH THE STATE-COUNTER'S RULE FOR STATE-TO-STATE TRANSITIONS, RESULT IN THE DESIRED STATE-COUNTS.

FIG 43

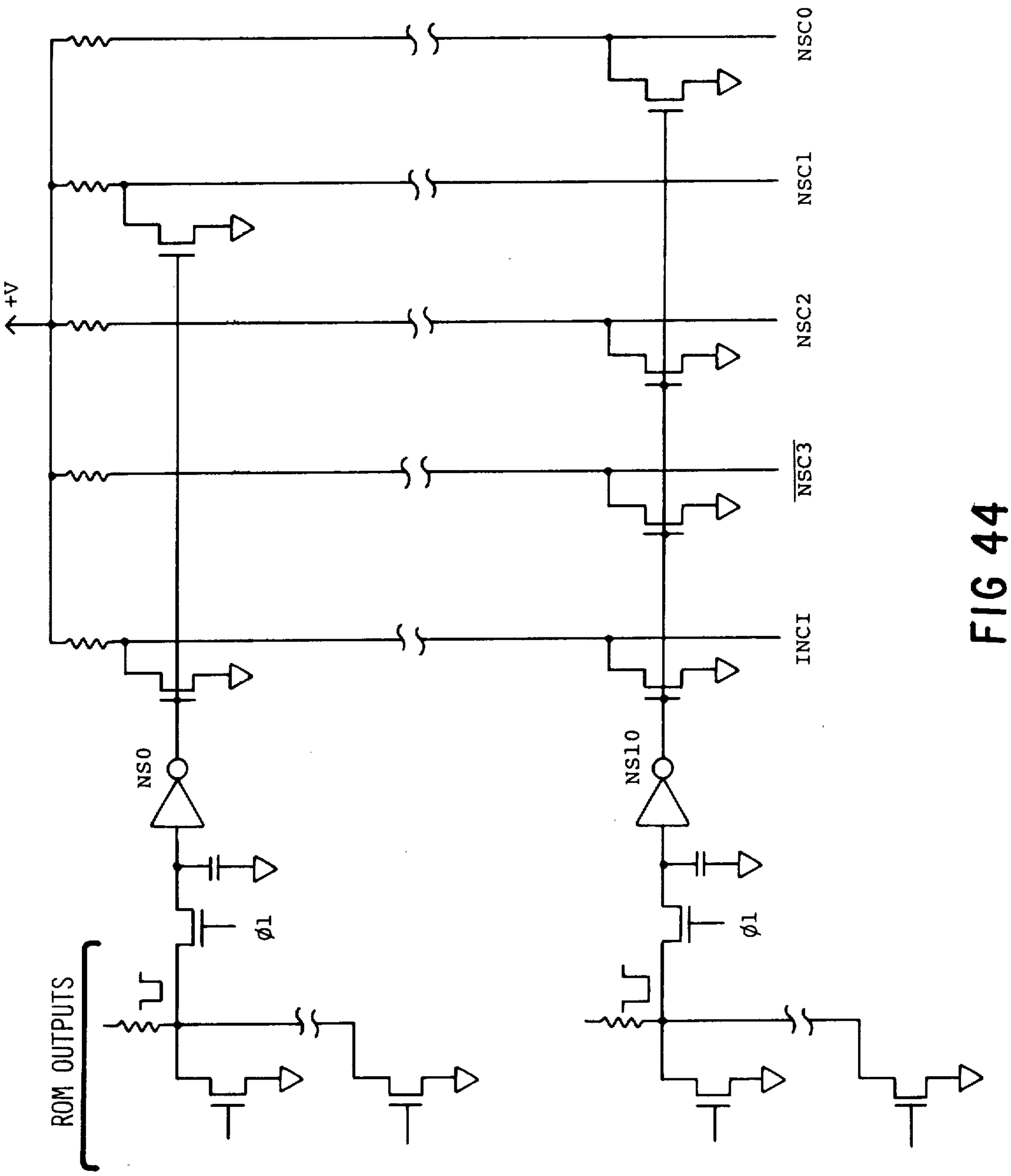

+V
NSC0
NSC1
NSC2
$\overline{\text{NSC3}}$
INCI
NS0
NS10
ϕ1
ϕ1
ROM OUTPUTS

FIG 44

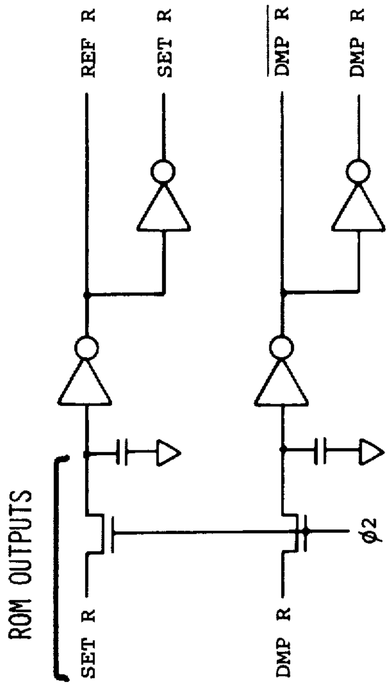


FIG 45B

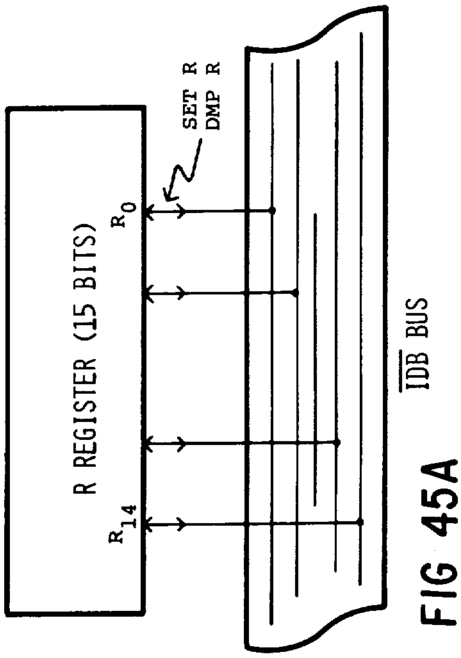


FIG 45A

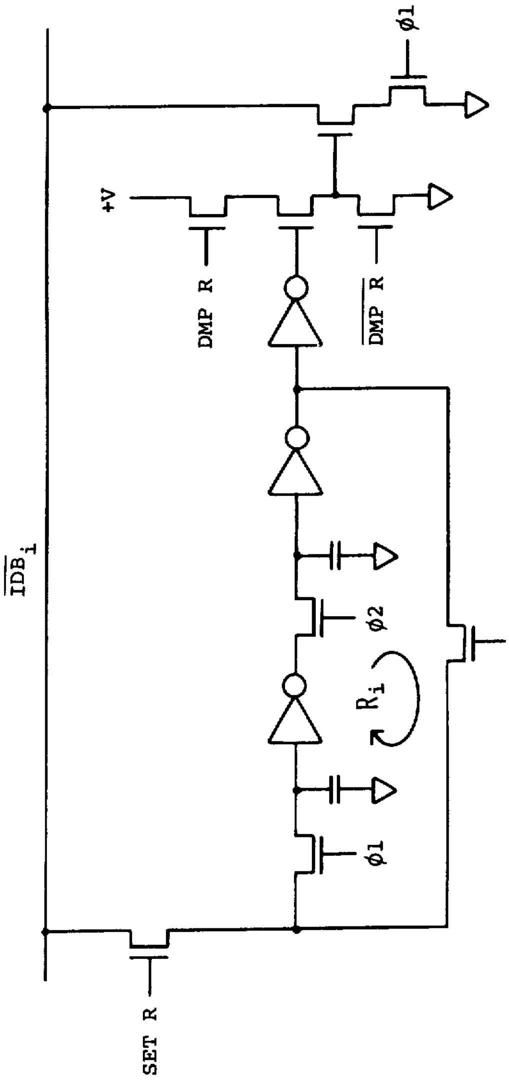


FIG 45C

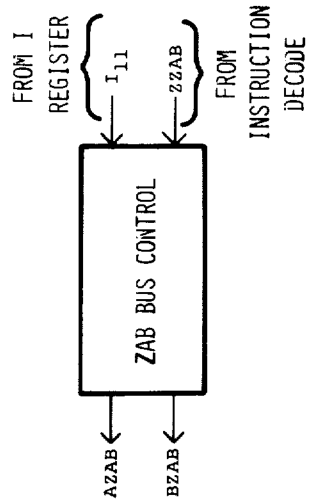


FIG 46B

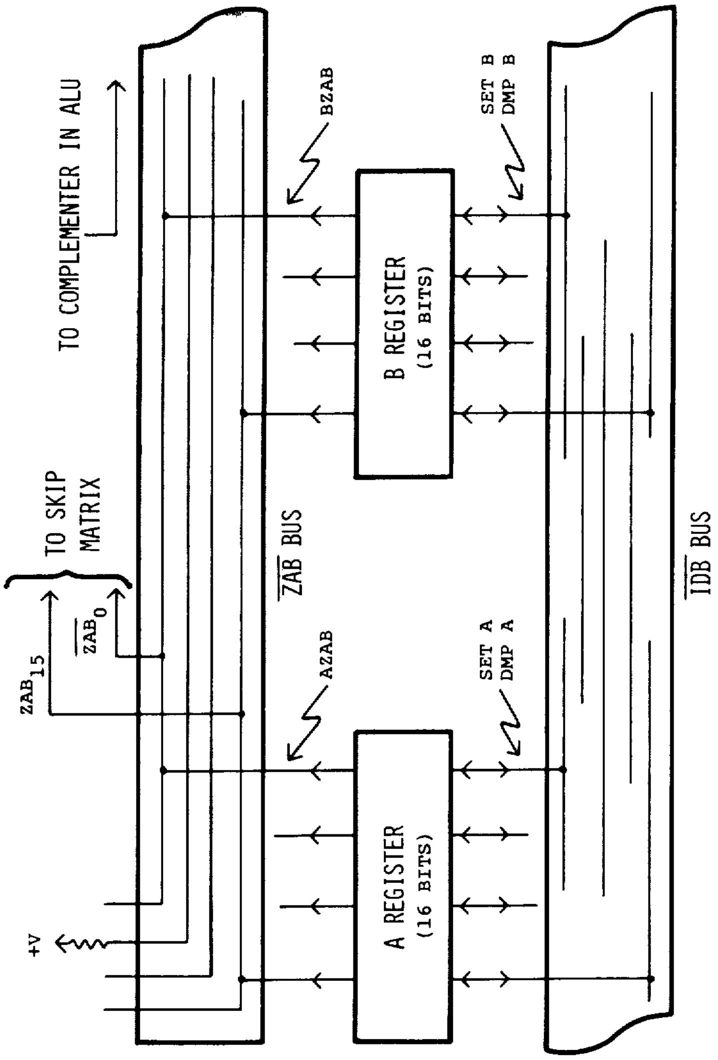


FIG 46A

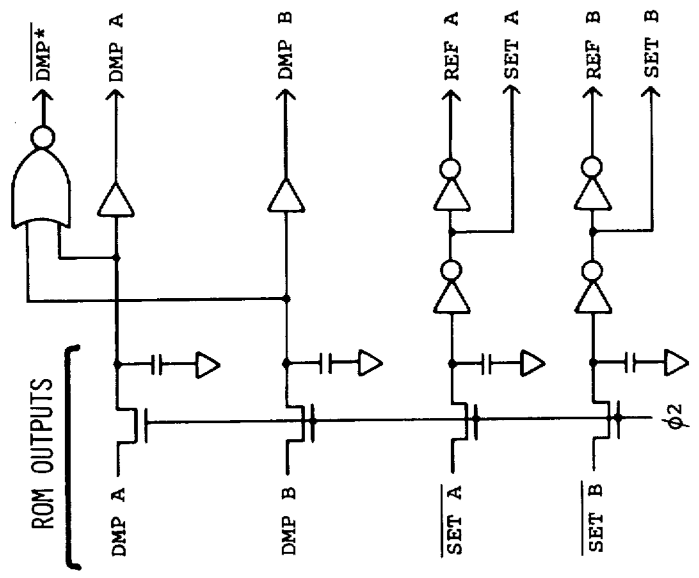


FIG 47B

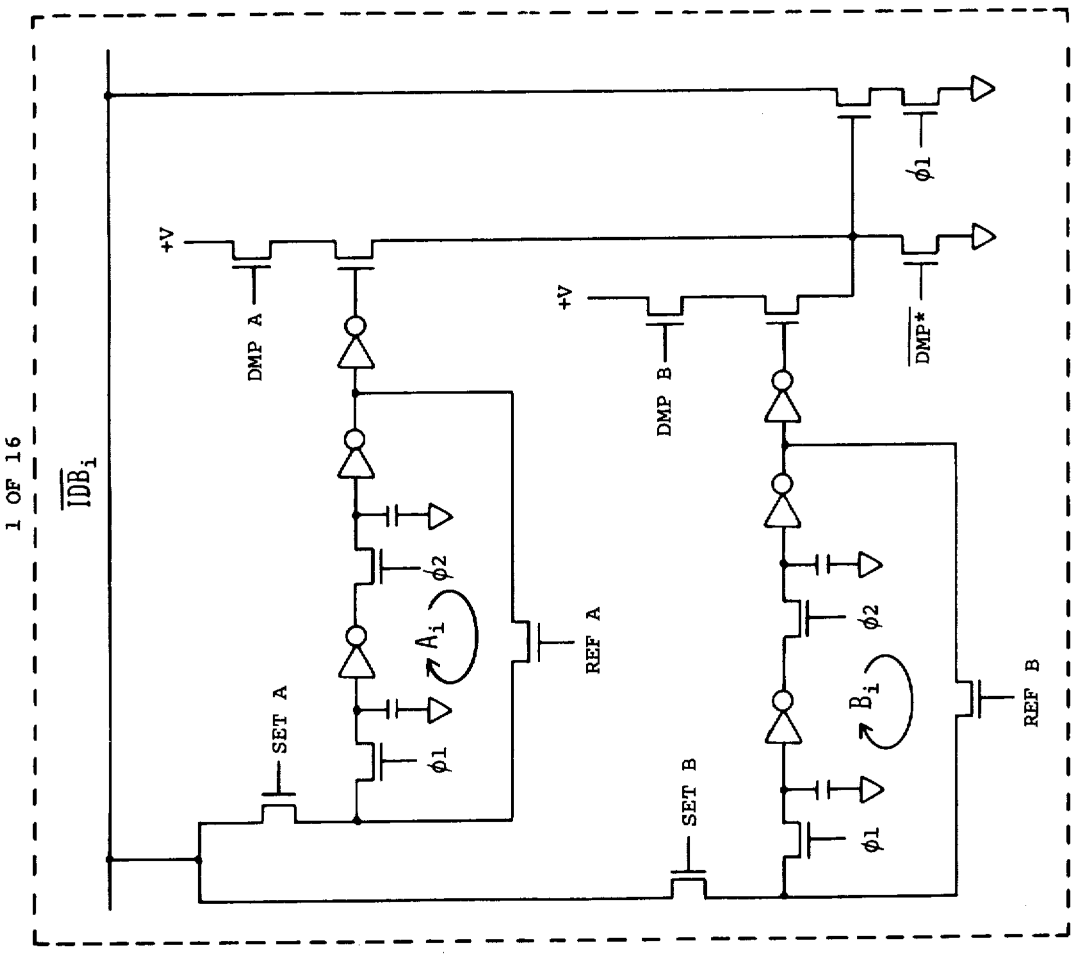


FIG 47A

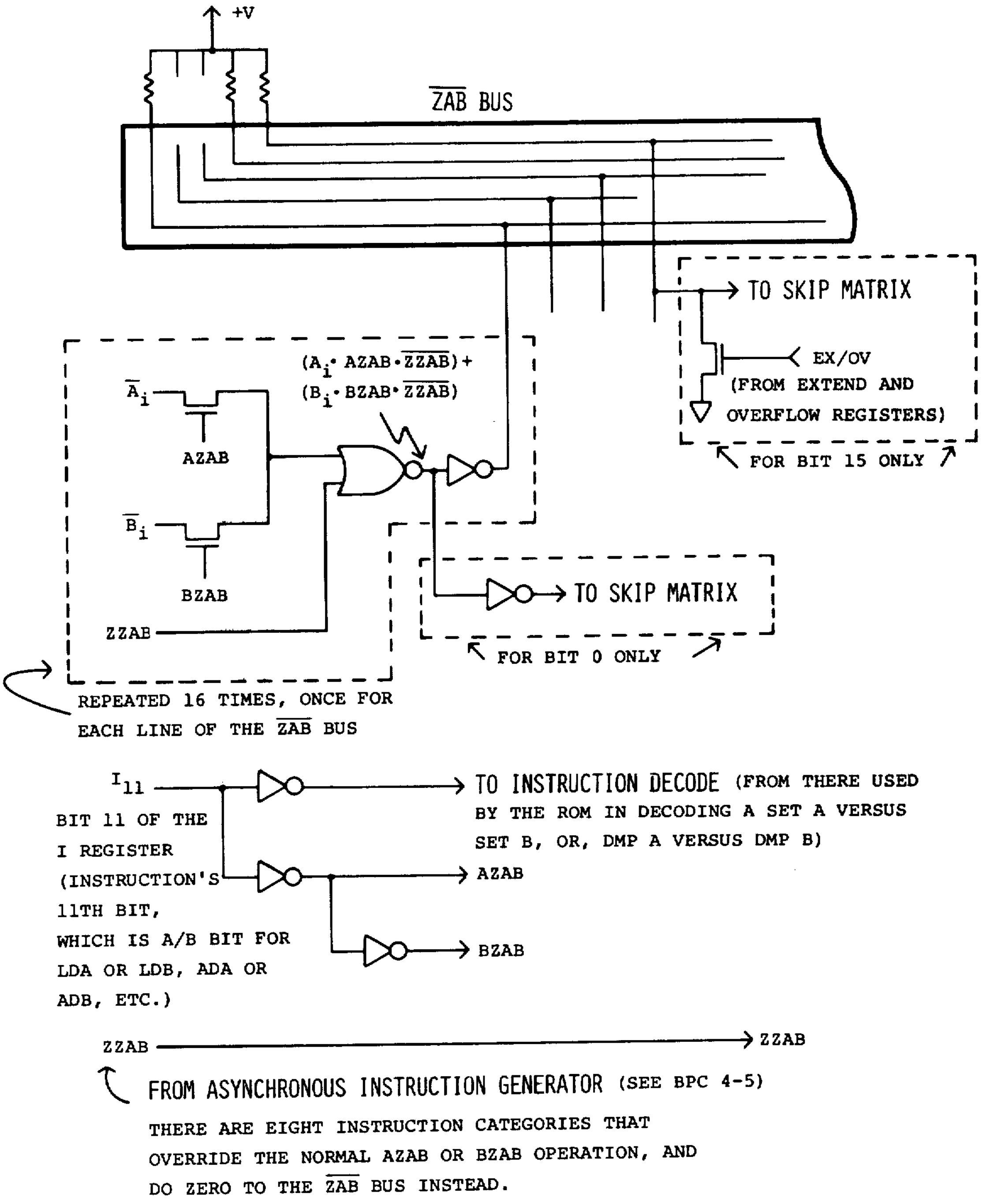
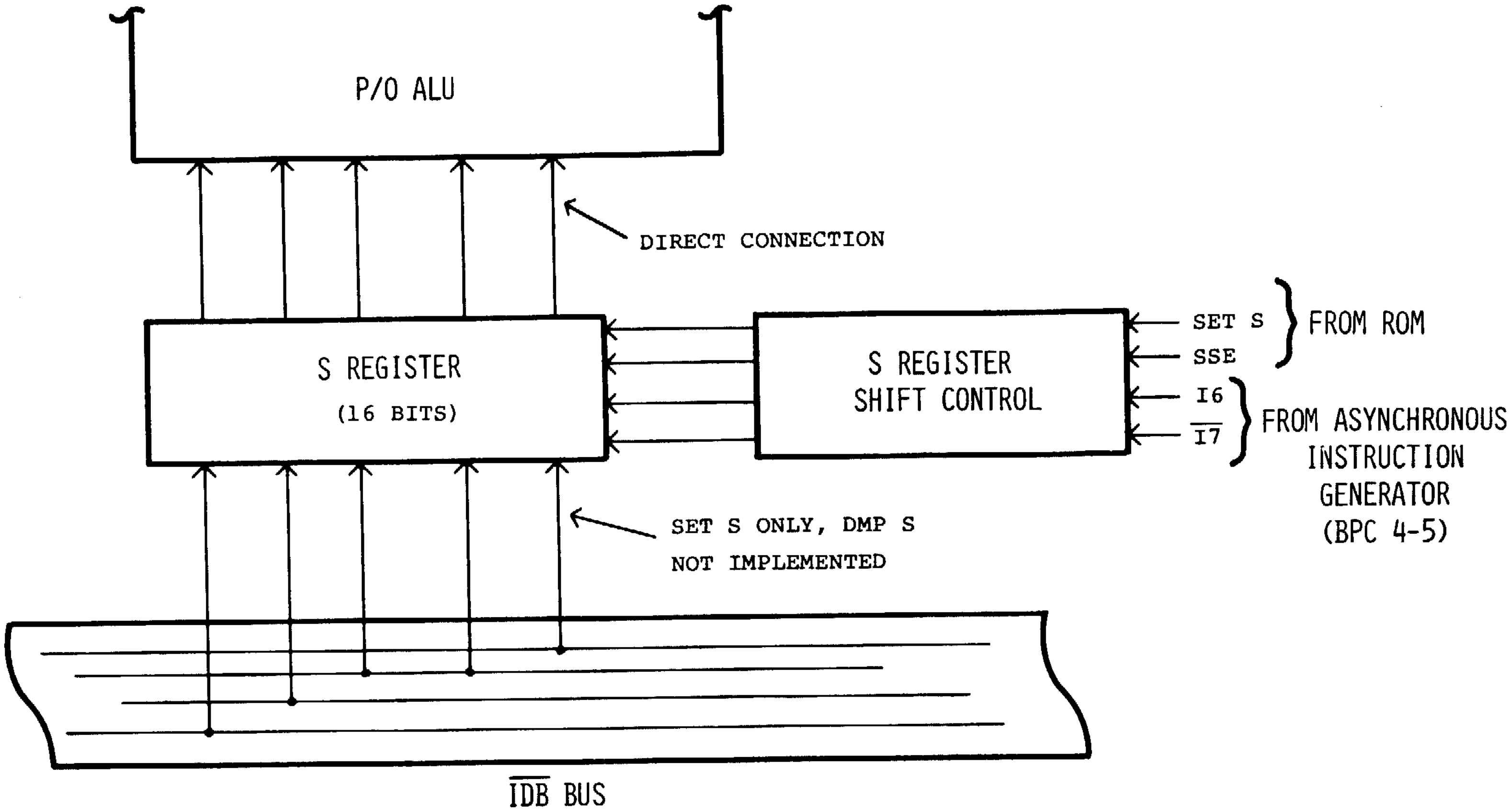

+V
$\overline{ZAB}$ BUS
TO SKIP MATRIX
EX/OV
(FROM EXTEND AND
OVERFLOW REGISTERS)
FOR BIT 15 ONLY
$(A_i \cdot AZAB \cdot \overline{ZZAB}) +$
$(B_i \cdot BZAB \cdot \overline{ZZAB})$
$\overline{A}_i$
AZAB
$\overline{B}_i$
BZAB
ZZAB
TO SKIP MATRIX
FOR BIT 0 ONLY
REPEATED 16 TIMES, ONCE FOR
EACH LINE OF THE $\overline{ZAB}$ BUS
$I_{11}$
BIT 11 OF THE
I REGISTER
(INSTRUCTION'S
11TH BIT,
WHICH IS A/B BIT FOR
LDA OR LDB, ADA OR
ADB, ETC.)
TO INSTRUCTION DECODE (FROM THERE USED
BY THE ROM IN DECODING A SET A VERSUS
SET B, OR, DMP A VERSUS DMP B)
AZAB
BZAB
ZZAB
ZZAB
FROM ASYNCHRONOUS INSTRUCTION GENERATOR (SEE BPC 4-5)
THERE ARE EIGHT INSTRUCTION CATEGORIES THAT
OVERRIDE THE NORMAL AZAB OR BZAB OPERATION, AND
DO ZERO TO THE $\overline{ZAB}$ BUS INSTEAD.

FIG 48



S REGISTER OPERATIONS:

SET S ($\overline{IDB}$ BUS TO S)
RIGHT SHIFT WITH $0 \rightarrow S_{15}$
ARITHMETIC RIGHT SHIFT ($S_{15}$ UNALTERED)
ROTATE S RIGHT ($S_0 \rightarrow S_{15}$)
SHIFT S LEFT WITH $0 \rightarrow S_0$

FIG 49

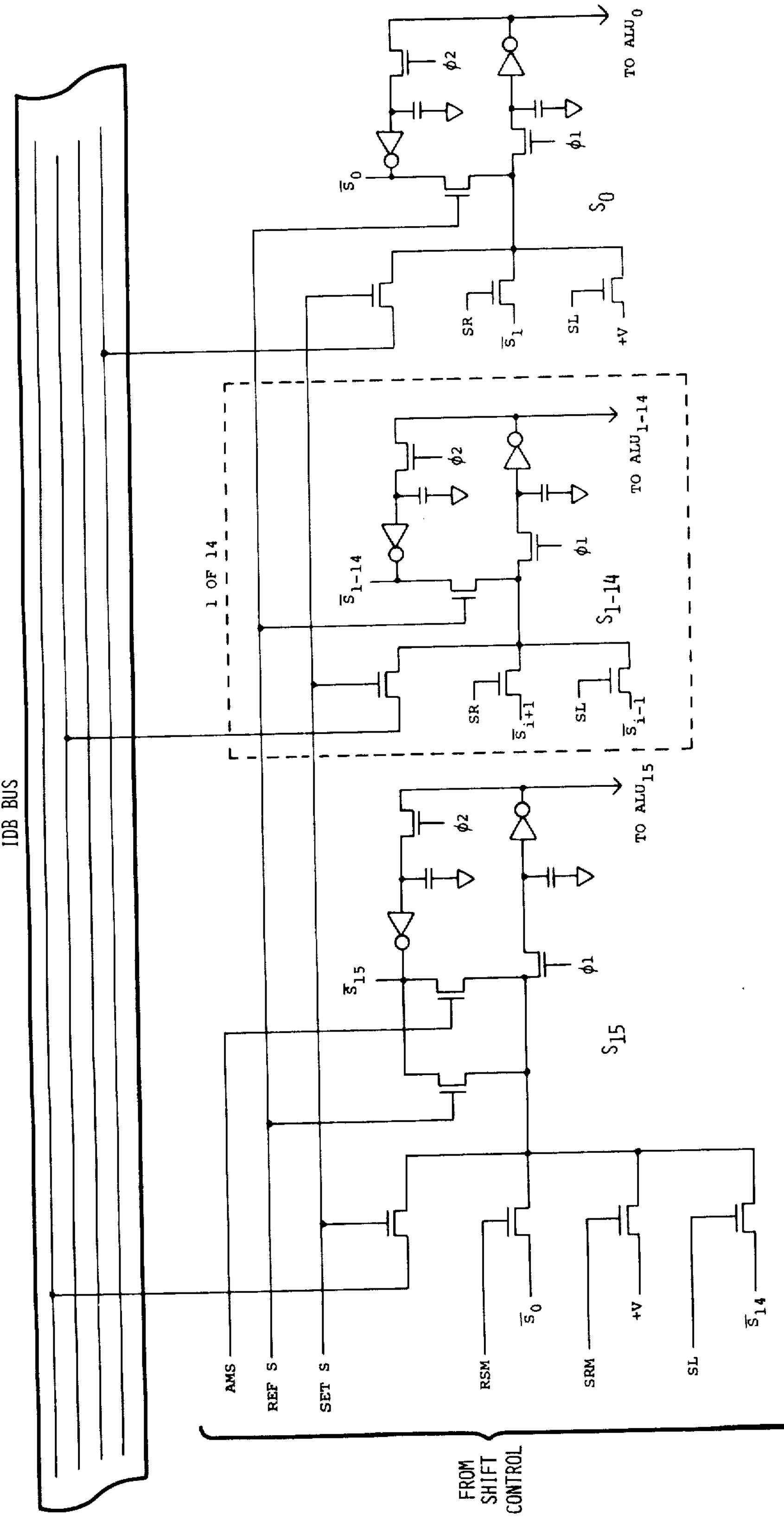

TO ALU$_0$
$\phi 2$
$\phi 1$
$\overline{S}_0$
$S_0$
SR
$\overline{S}_1$
SL
+V
1 OF 14
TO ALU$_{1-14}$
$\phi 2$
$\phi 1$
$\overline{S}_{1-14}$
$S_{1-14}$
SR
$\overline{S}_{i+1}$
SL
$\overline{S}_{i-1}$
$\overline{IDB}$ BUS
TO ALU$_{15}$
$\phi 2$
$\phi 1$
$\overline{S}_{15}$
$S_{15}$
$\overline{S}_0$
+V
$\overline{S}_{14}$
AMS
REF S
SET S
RSM
SRM
SL
FROM SHIFT CONTROL

FIG 50

| INSTRUCTION | ACTION | $I_7$ | $I_6$ | CONTROL SIGNALS |
|---|---|---|---|---|
| AAR, ABR | SHIFT RIGHT/KEEP BIT 15 | 0 | 0 | SSE, SR, AMS |
| SAR, SBR | SHIFT RIGHT/0→BIT 15 | 0 | 1 | SSE, SR, SRM |
| SAL, SBL | SHIFT LEFT/0→BIT 15 | 1 | 0 | SSE, SL |
| RAR, RBR | ROTATE RIGHT/BIT 0→BIT 15 | 1 | 1 | SSE, SR, RSM |

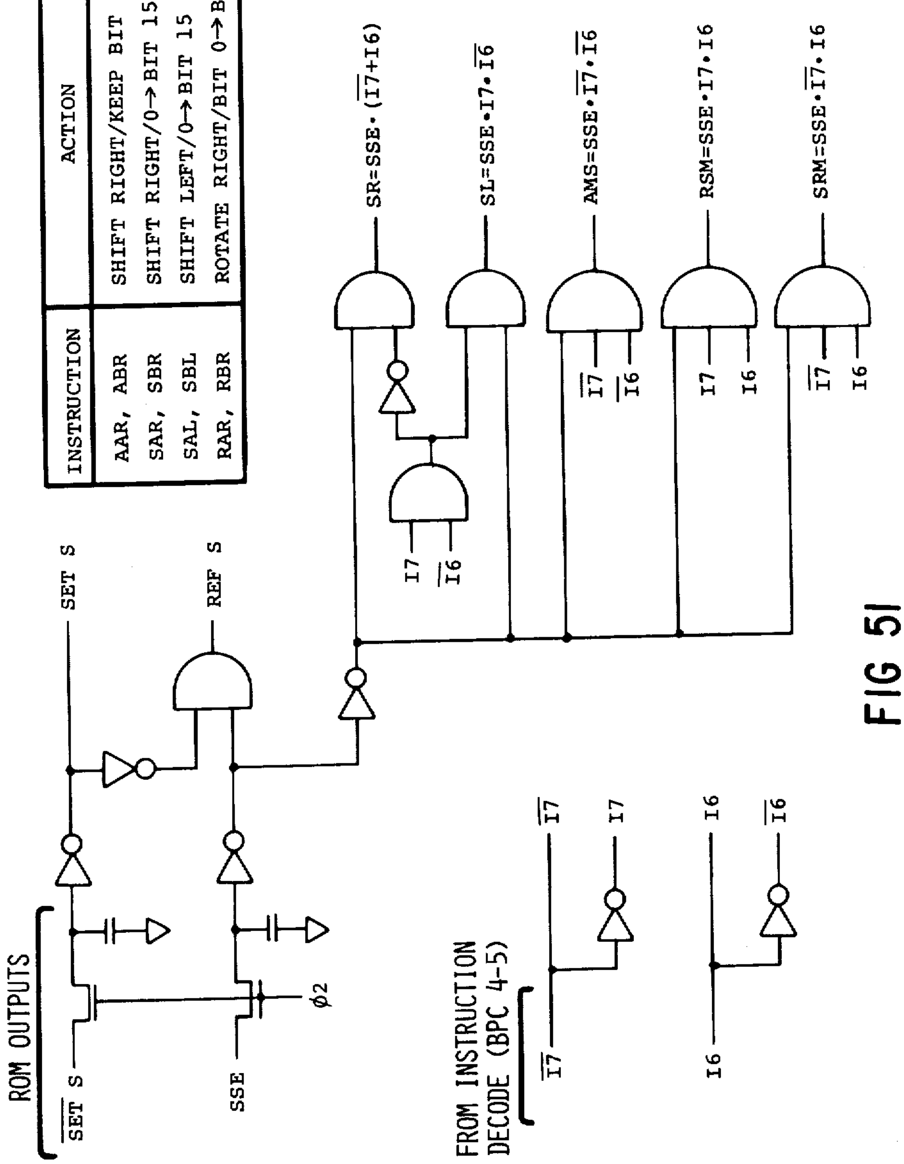

ROM OUTPUTS
$\overline{SET}$ S
SSE
φ2
SET S
REF S
SR=SSE·($\overline{I7}$+I6)
SL=SSE·I7·$\overline{I6}$
AMS=SSE·$\overline{I7}$·$\overline{I6}$
RSM=SSE·I7·I6
SRM=SSE·$\overline{I7}$·I6
I7
$\overline{I6}$
$\overline{I7}$
I6
FROM INSTRUCTION DECODE (BPC 4-5)

FIG 5I

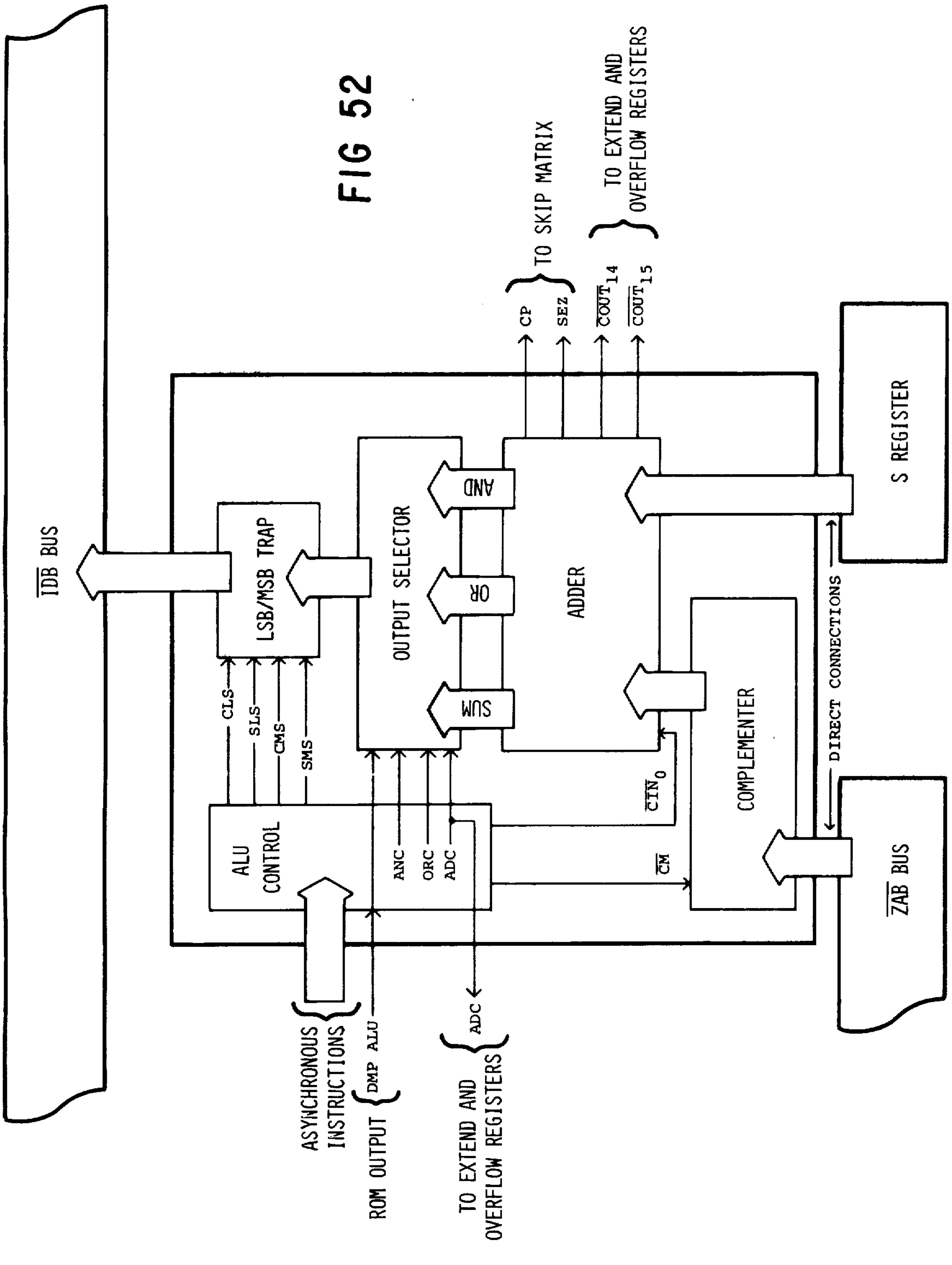


FIG 52

IDB BUS
LSB/MSB TRAP
OUTPUT SELECTOR
AND
OR
SUM
ADDER
S REGISTER
COMPLEMENTER
ZAB BUS
DIRECT CONNECTIONS
ALU CONTROL
CLS
SLS
CMS
SMS
ANC
ORC
ADC
$\overline{CIN}_0$
$\overline{CM}$
CP
SEZ
$\overline{COUT}_{14}$
$\overline{COUT}_{15}$
TO SKIP MATRIX
TO EXTEND AND OVERFLOW REGISTERS
ASYNCHRONOUS INSTRUCTIONS
ROM OUTPUT
DMP ALU
ADC
TO EXTEND AND OVERFLOW REGISTERS

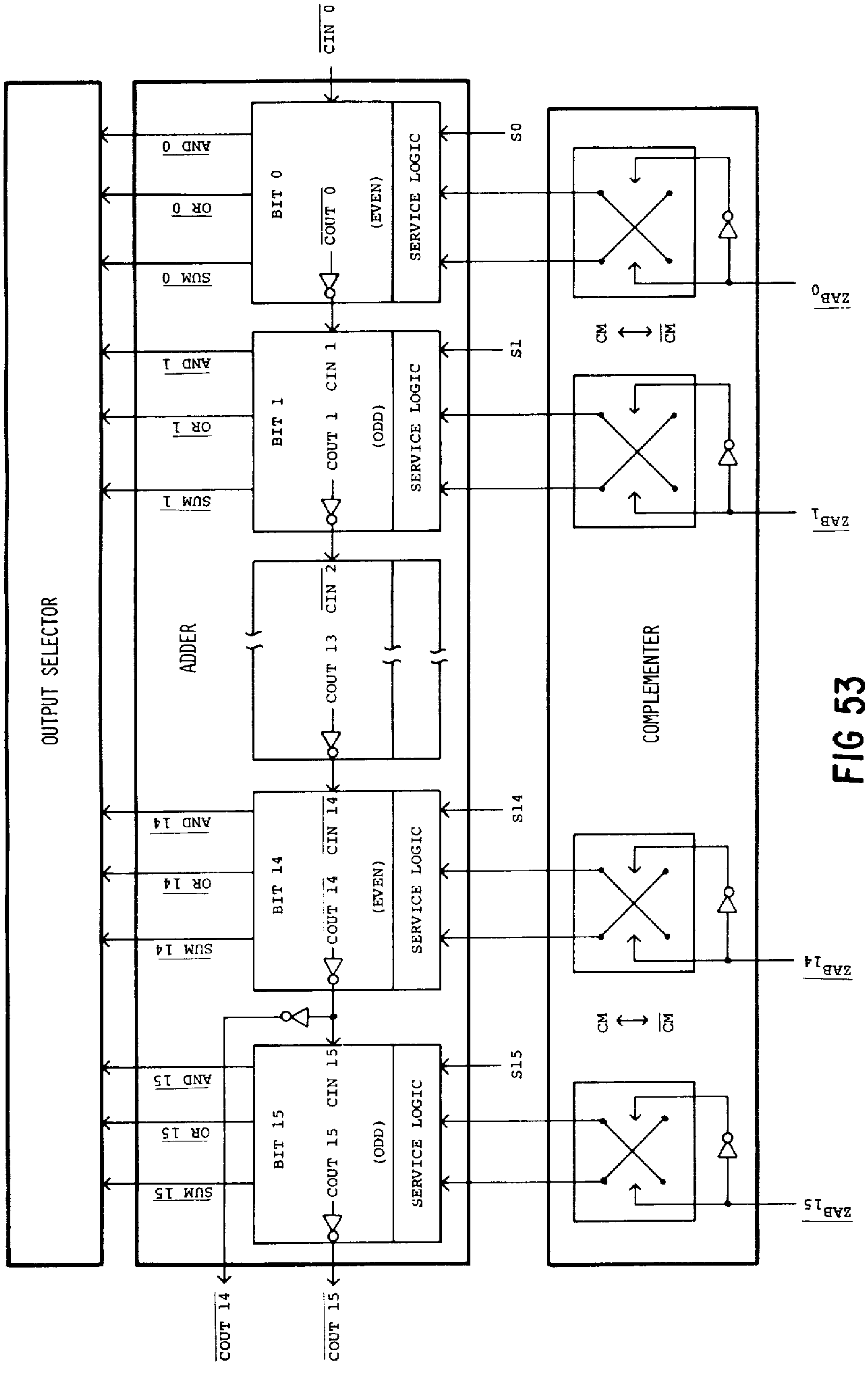

$\overline{\text{CIN 0}}$
OUTPUT SELECTOR
ADDER
COMPLEMENTER
AND 0
OR 0
SUM 0
BIT 0
$\overline{\text{COUT 0}}$
(EVEN)
SERVICE LOGIC
S0
$ZAB_0$
CM ⟷ $\overline{\text{CM}}$
AND 1
OR 1
SUM 1
BIT 1
CIN 1
COUT 1
(ODD)
SERVICE LOGIC
S1
$ZAB_1$
$\overline{\text{CIN 2}}$
COUT 13
AND 14
OR 14
SUM 14
BIT 14
$\overline{\text{CIN 14}}$
$\overline{\text{COUT 14}}$
(EVEN)
SERVICE LOGIC
S14
$ZAB_{14}$
CM ⟷ $\overline{\text{CM}}$
AND 15
OR 15
SUM 15
BIT 15
CIN 15
COUT 15
(ODD)
SERVICE LOGIC
S15
$ZAB_{15}$
$\overline{\text{COUT 14}}$
$\overline{\text{COUT 15}}$

FIG 53

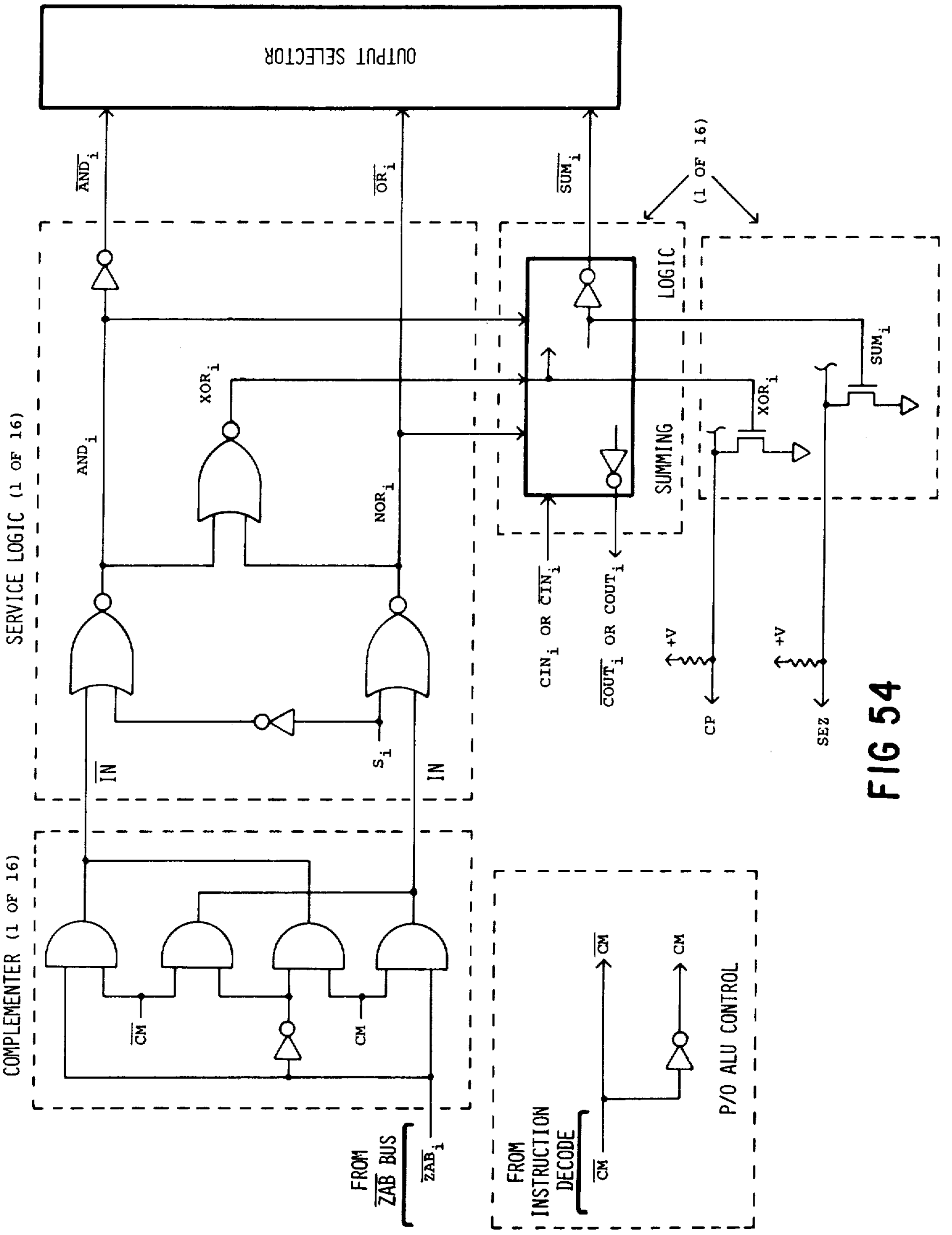

OUTPUT SELECTOR
$\overline{AND_i}$
$\overline{OR_i}$
$\overline{SUM_i}$
(1 OF 16)
LOGIC
SUMMING
$SUM_i$
$XOR_i$
$XOR_i$
$AND_i$
$NOR_i$
SERVICE LOGIC (1 OF 16)
$S_i$
$\overline{IN}$
IN
$CIN_i$ OR $\overline{CIN_i}$
$\overline{COUT_i}$ OR $COUT_i$
+V
+V
CP
SEZ
COMPLEMENTER (1 OF 16)
$\overline{CM}$
CM
FROM $\overline{ZAB}$ BUS
$\overline{ZAB_i}$
FROM INSTRUCTION DECODE
$\overline{CM}$
$\overline{CM}$
CM
P/O ALU CONTROL

FIG 54

RULES FOR GENERATING SUM AND CARRY BITS

| SERVICE LOGIC SIGNALS | INPUTS | | | OUTPUTS | |
|---|---|---|---|---|---|
| | $CIN_i$ | $ZAB_i$ | $S_i$ | $COUT_i$ | $SUM_i$ |
| NOR | 0 | 0 | 0 | 0 | 0 |
| XOR | 0 | 0 | 1 | 0 | 1 |
| XOR | 0 | 1 | 0 | 0 | 1 |
| AND | 0 | 1 | 1 | 1 | 0 |
| CIN•NOR | 1 | 0 | 0 | 0 | 1 |
| CIN•XOR | 1 | 0 | 1 | 1 | 0 |
| CIN•XOR | 1 | 1 | 0 | 1 | 0 |
| CIN•AND | 1 | 1 | 1 | 1 | 1 |

"AND","NOR" AND "XOR" ARE MUTUALLY EXCLUSIVE CONDITIONS, AMONG WHICH EXACTLY ONE MUST ALWAYS BE TRUE. NOW:

A. $SUM_i$=1 IF EXACTLY ONE OR THREE INPUTS (AMONG $S_i$, $ZAB_i$ AND $CIN_i$)=1.

B. $COUT_i$=1 IF $AND_i$+($XOR_i$•$CIN_i$)=1.

A AND B CAN BE IMPLEMENTED BY CIRCUITRY THAT PERFORMS THE FOLLOWING OPERATIONS:

1. IF $NOR_i$=1, THEN $SUM_i$=$CIN_i$; $COUT_i$=0 (FOR ODD BITS), $\overline{COUT_i}$=1 (FOR EVEN BITS)
2. IF $XOR_i$=1, THEN $SUM_i$=$\overline{CIN_i}$; $COUT_i$=$CIN_i$
3. IF $AND_i$=1, THEN $SUM_i$=$CIN_i$; $COUT_i$=1

FIG 55

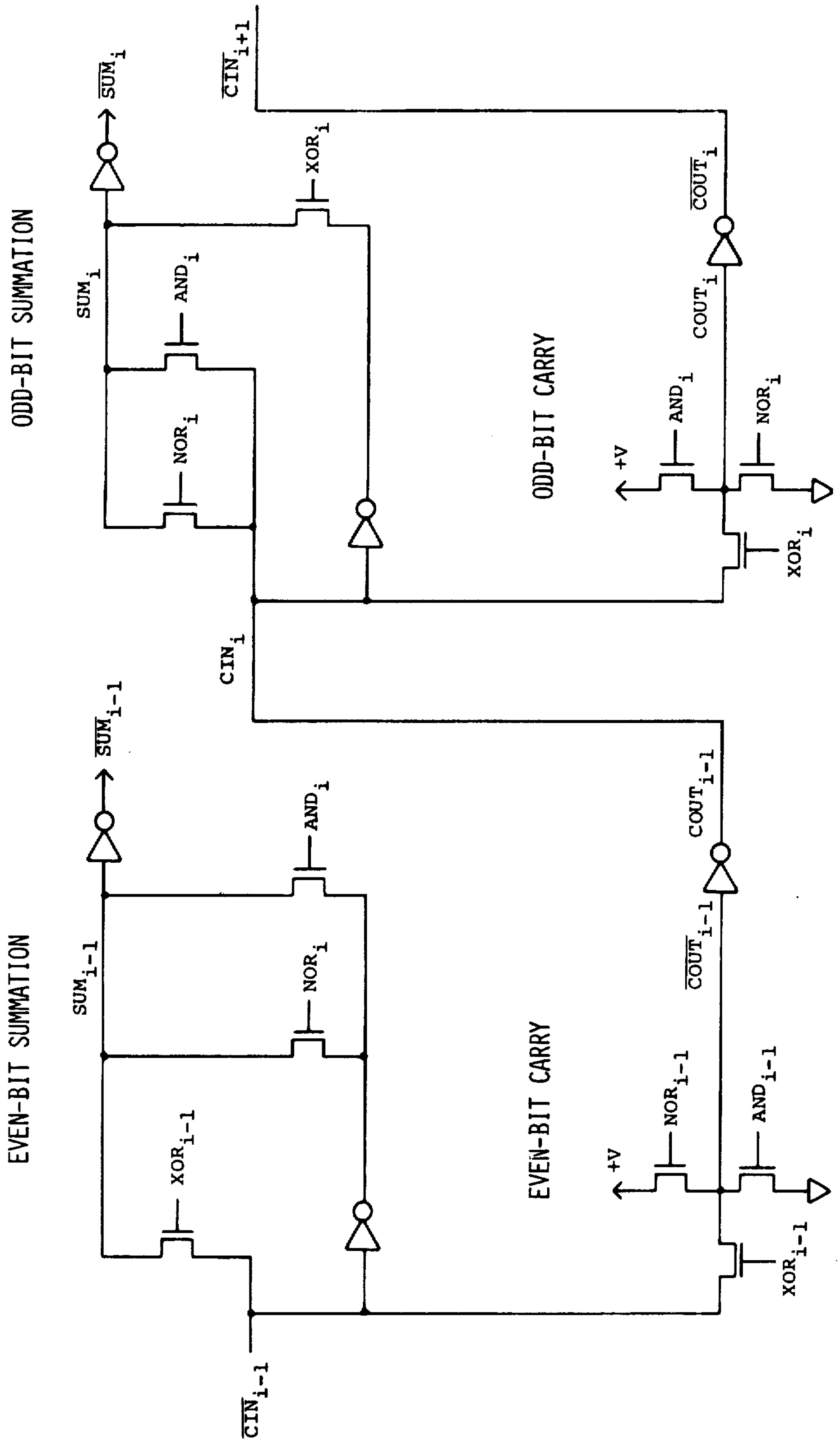

ODD-BIT SUMMATION
$\overline{SUM}_i$
$SUM_i$
$AND_i$
$NOR_i$
$XOR_i$
$\overline{CIN}_{i+1}$
ODD-BIT CARRY
$\overline{COUT}_i$
$COUT_i$
$AND_i$
$NOR_i$
+V
$XOR_i$
$CIN_i$
EVEN-BIT SUMMATION
$\overline{SUM}_{i-1}$
$SUM_{i-1}$
$AND_i$
$NOR_i$
$XOR_{i-1}$
EVEN-BIT CARRY
$COUT_{i-1}$
$\overline{COUT}_{i-1}$
$NOR_{i-1}$
$AND_{i-1}$
+V
$XOR_{i-1}$
$\overline{CIN}_{i-1}$

FIG 56

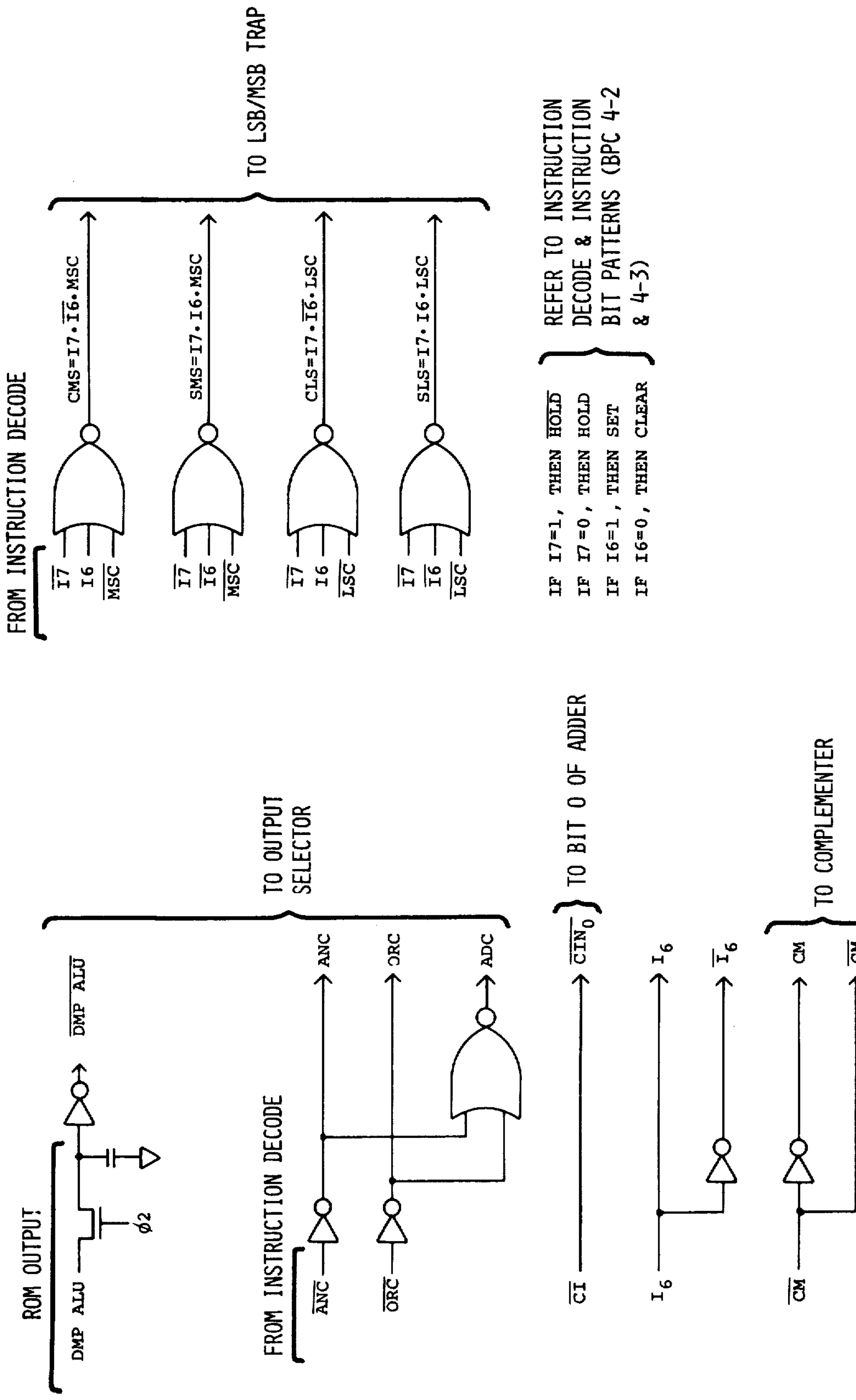

FROM INSTRUCTION DECODE
I7 (overbar) I6 MSC (overbar)
CMS=I7·I6 (overbar)·MSC
I7 (overbar) I6 (overbar) MSC (overbar)
SMS=I7·I6·MSC
I7 (overbar) I6 LSC (overbar)
CLS=I7·I6 (overbar)·LSC
I7 (overbar) I6 (overbar) LSC (overbar)
SLS=I7·I6·LSC
TO LSB/MSB TRAP
IF I7=1, THEN HOLD (overbar)
IF I7=0, THEN HOLD
IF I6=1, THEN SET
IF I6=0, THEN CLEAR
REFER TO INSTRUCTION DECODE & INSTRUCTION BIT PATTERNS (BPC 4-2 & 4-3)
ROM OUTPUT
DMP ALU
φ2
DMP ALU (overbar)
FROM INSTRUCTION DECODE
ANC (overbar)
ORC (overbar)
ANC
ORC
ADC
TO OUTPUT SELECTOR
CI (overbar)
CIN0 (overbar)
TO BIT 0 OF ADDER
I6
I6
I6 (overbar)
CM (overbar)
CM
CM (overbar)
TO COMPLEMENTER

FIG 57

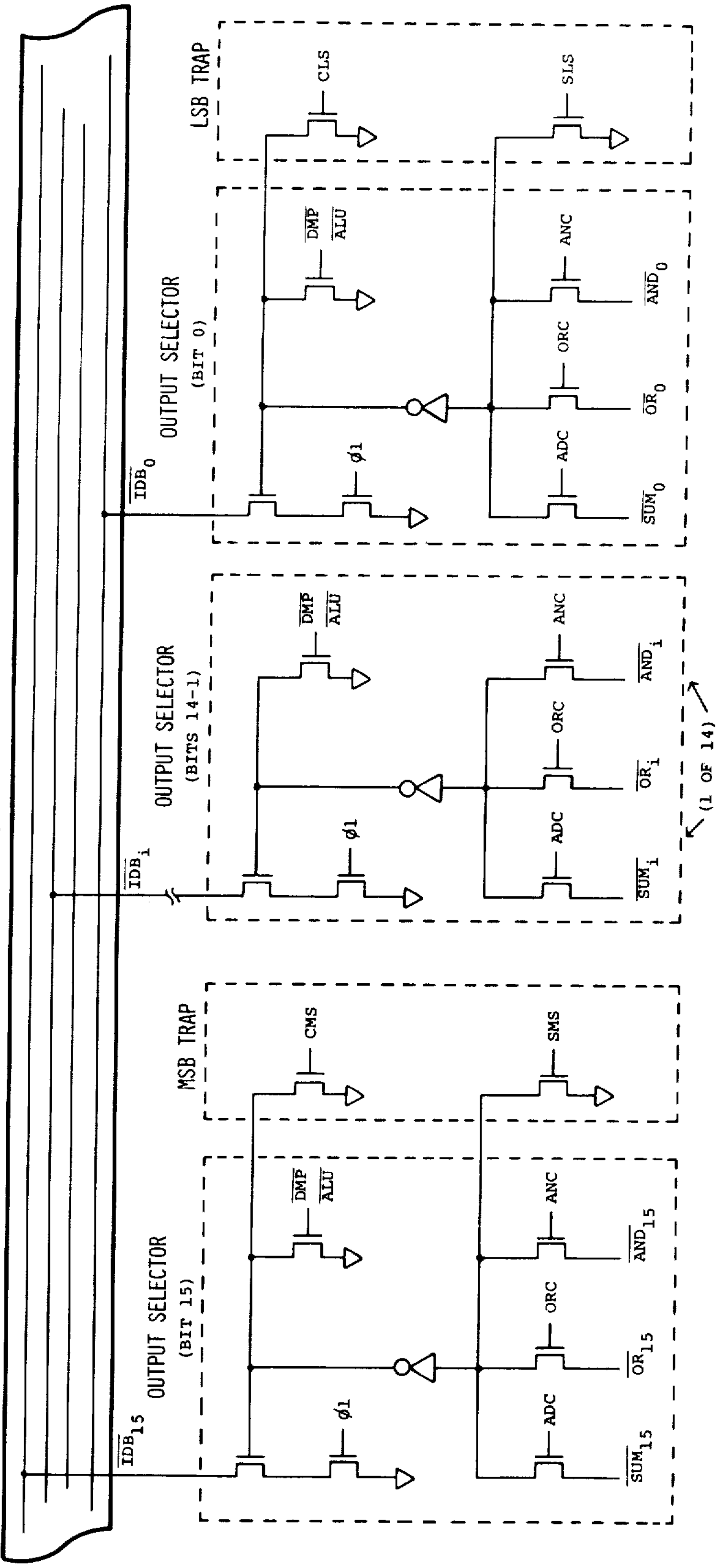

LSB TRAP
CLS
SLS
OUTPUT SELECTOR
(BIT 0)
$\overline{IDB}_0$
$\overline{DMP}$
$\overline{ALU}$
ANC
ORC
ADC
ϕ1
$\overline{AND}_0$
$\overline{OR}_0$
$\overline{SUM}_0$
OUTPUT SELECTOR
(BITS 14-1)
$\overline{IDB}_i$
$\overline{DMP}$
$\overline{ALU}$
ANC
ORC
ADC
ϕ1
$\overline{AND}_i$
$\overline{OR}_i$
$\overline{SUM}_i$
(1 OF 14)
$\overline{IDB}$ BUS
MSB TRAP
CMS
SMS
OUTPUT SELECTOR
(BIT 15)
$\overline{IDB}_{15}$
$\overline{DMP}$
$\overline{ALU}$
ANC
ORC
ADC
ϕ1
$\overline{AND}_{15}$
$\overline{OR}_{15}$
$\overline{SUM}_{15}$

FIG 58

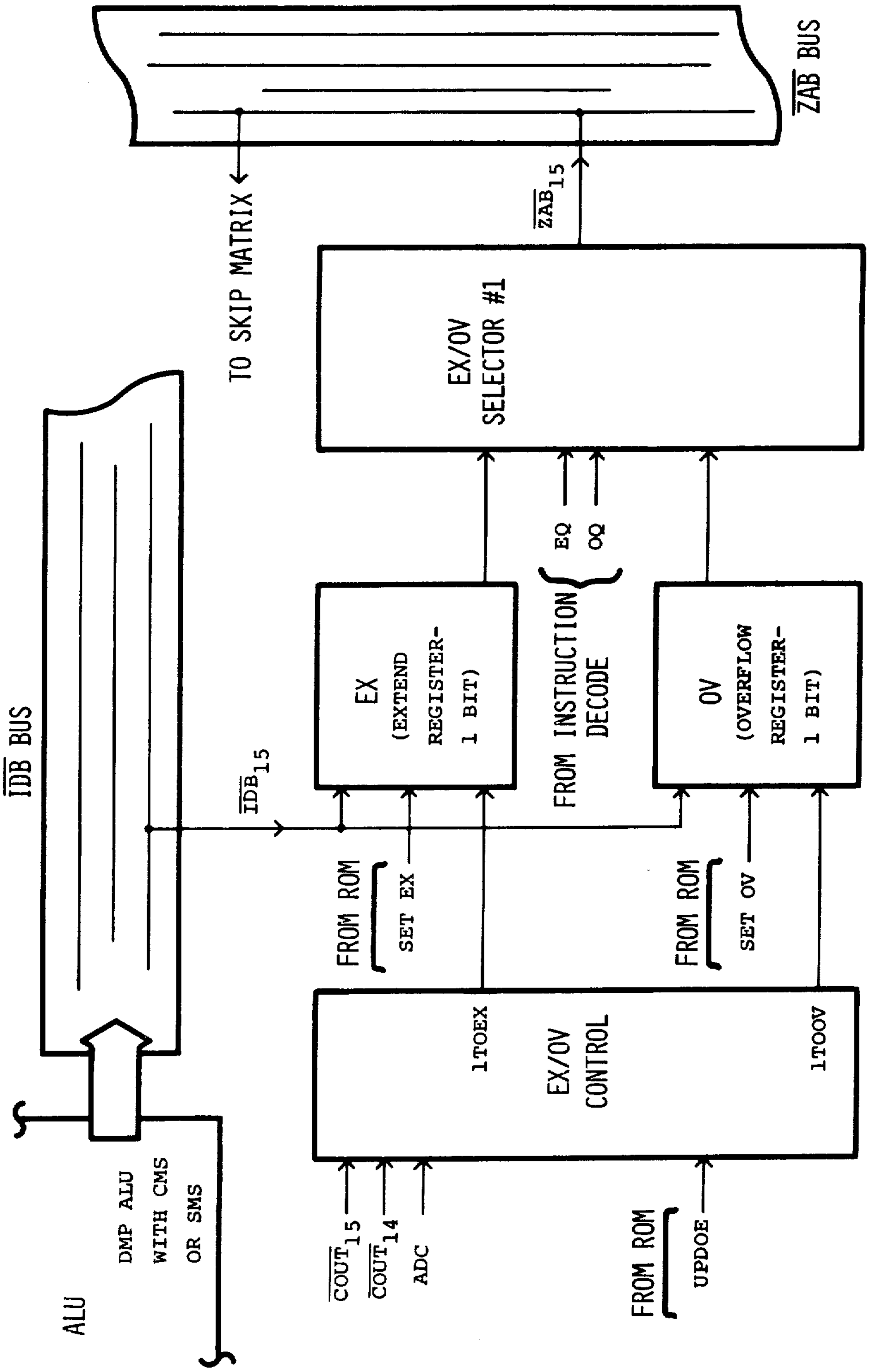

$\overline{ZAB}$ BUS
TO SKIP MATRIX
$\overline{ZAB}_{15}$
EX/OV SELECTOR #1
$\overline{IDB}$ BUS
$\overline{IDB}_{15}$
EX (EXTEND REGISTER-1 BIT)
FROM INSTRUCTION DECODE
EQ
OQ
OV (OVERFLOW REGISTER-1 BIT)
FROM ROM
SET EX
FROM ROM
SET OV
1TOEX
EX/OV CONTROL
1TOOV
ALU
DMP ALU WITH CMS OR SMS
$\overline{COUT}_{15}$
$\overline{COUT}_{14}$
ADC
FROM ROM
UPDOE

FIG 59

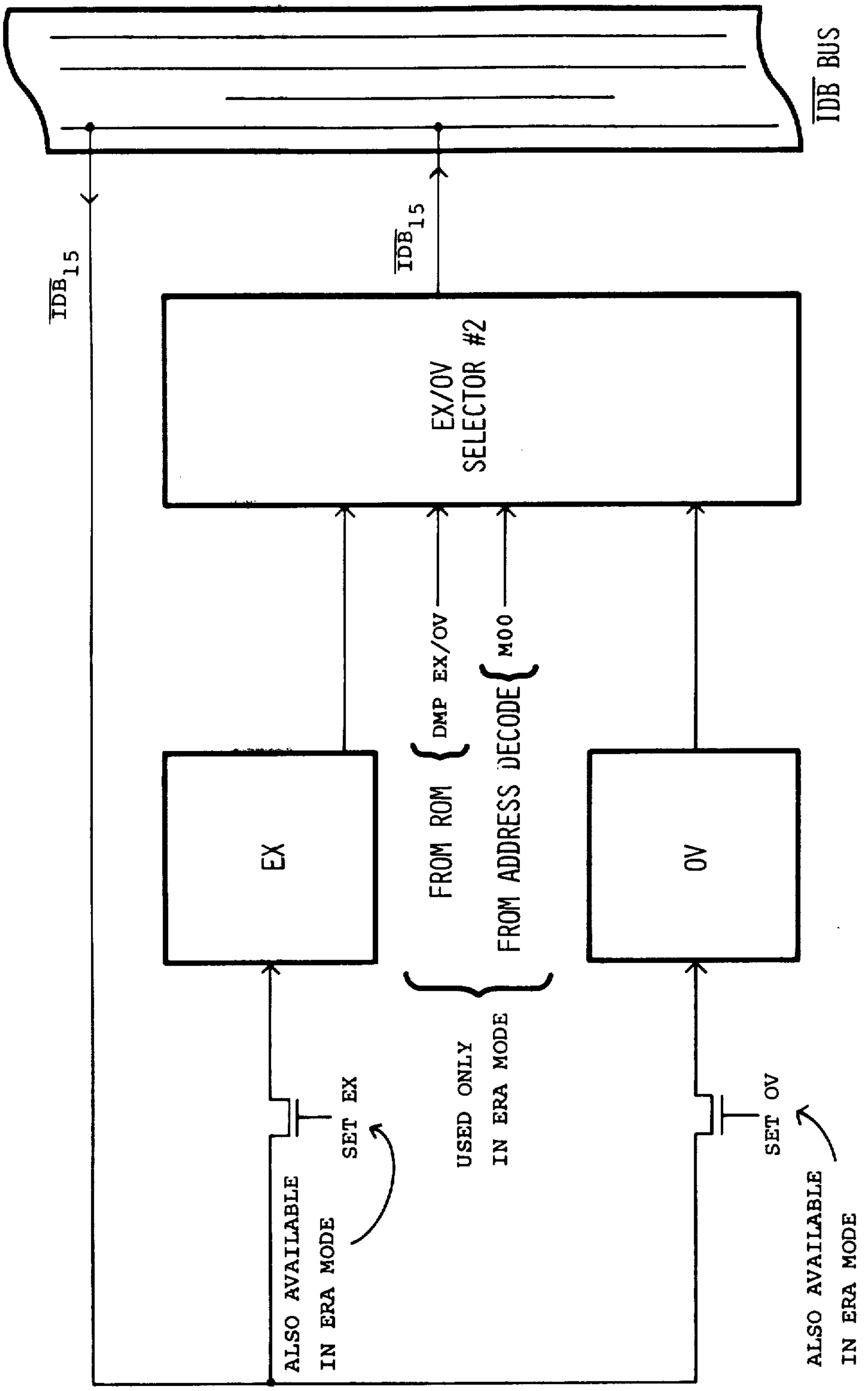

$\overline{IDB}$ BUS
$\overline{IDB}_{15}$
$\overline{IDB}_{15}$
EX/OV SELECTOR #2
EX
OV
FROM ROM { DMP EX/OV
FROM ADDRESS DECODE { M00
USED ONLY IN ERA MODE
SET EX
SET OV
ALSO AVAILABLE IN ERA MODE
ALSO AVAILABLE IN ERA MODE

FIG 60

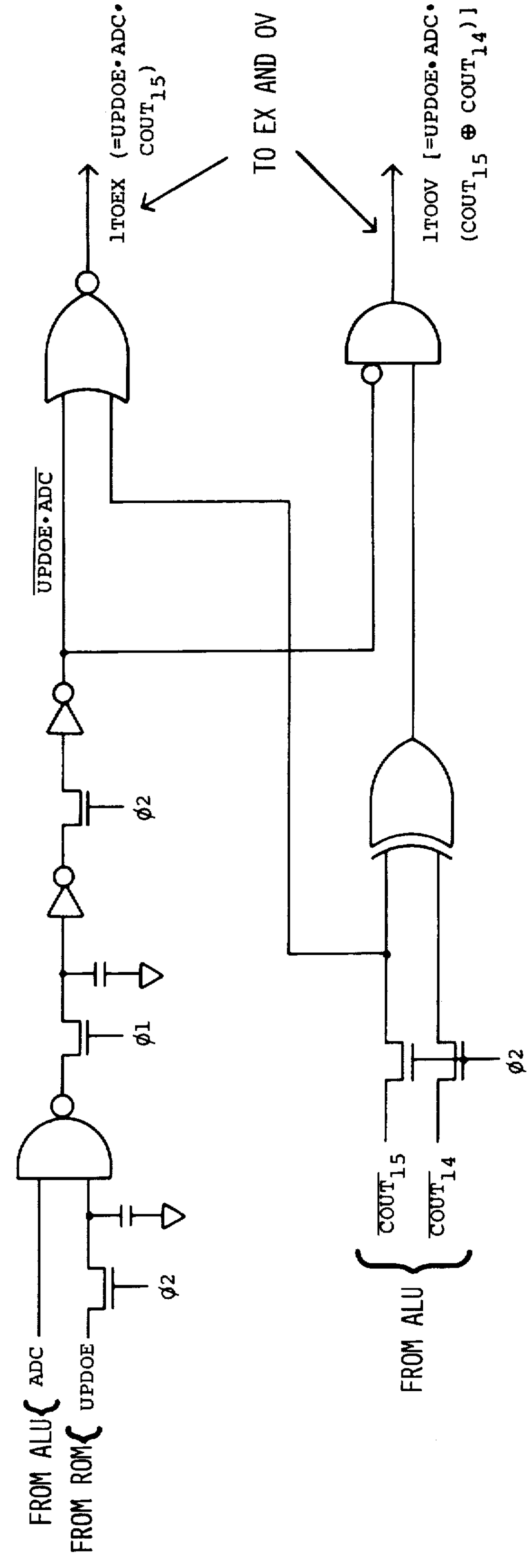

1TOEX (=UPDOE·ADC·$COUT_{15}$)
TO EX AND OV
1TOOV [=UPDOE·ADC·($COUT_{15}$ ⊕ $COUT_{14}$)]
$\overline{UPDOE \cdot ADC}$
φ2
φ1
φ2
φ2
FROM ALU { ADC
FROM ROM { UPDOE
$\overline{COUT}_{15}$
$\overline{COUT}_{14}$
FROM ALU

FIG 61

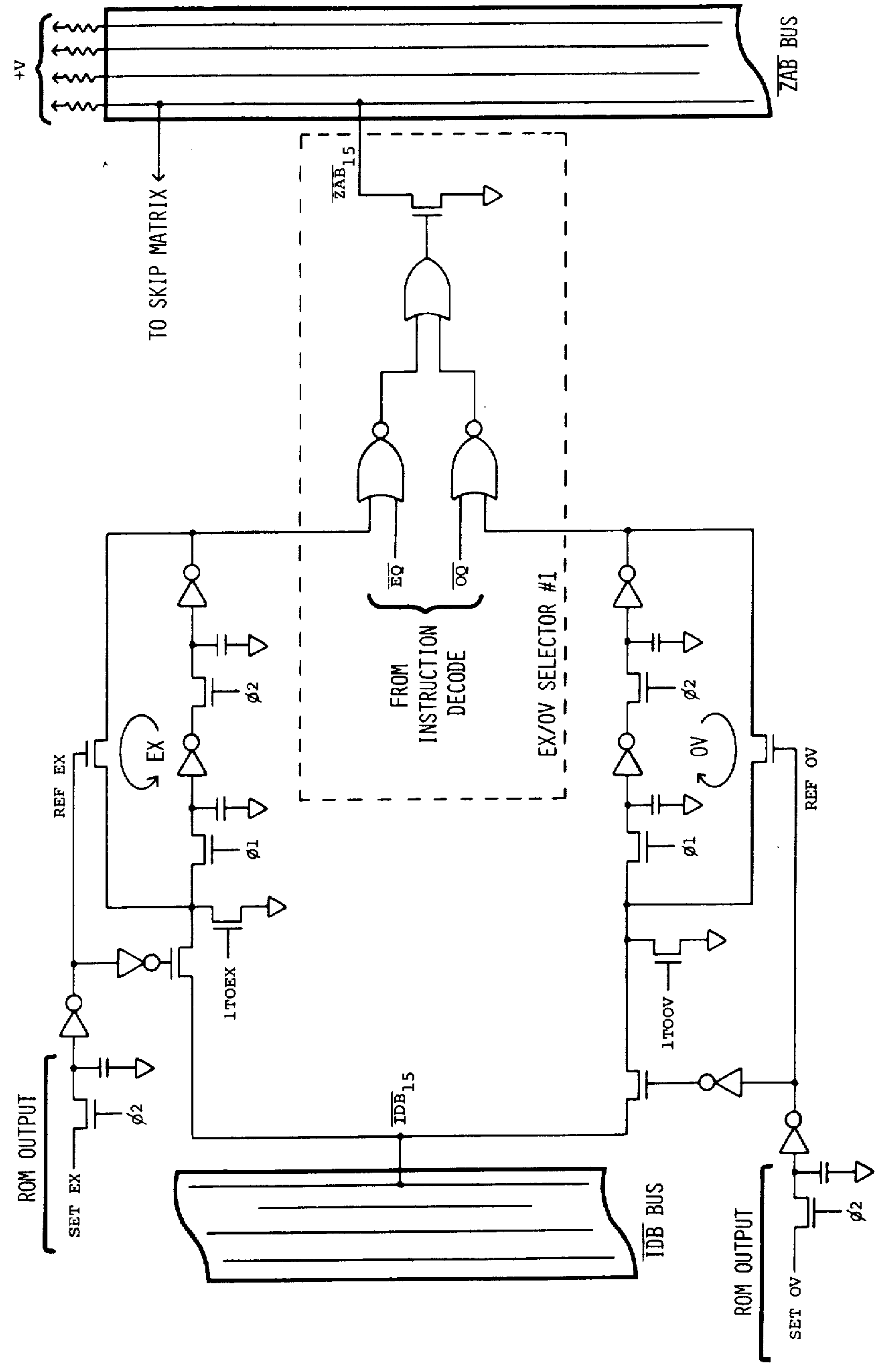

+V
$\overline{ZAB}$ BUS
TO SKIP MATRIX
$\overline{ZAB}_{15}$
$\overline{EQ}$
$\overline{OQ}$
FROM INSTRUCTION DECODE
EX/OV SELECTOR #1
REF EX
EX
ø2
ø1
1TOEX
REF OV
OV
ø2
ø1
1TOOV
ROM OUTPUT
SET EX
ø2
$\overline{IDB}_{15}$
$\overline{IDB}$ BUS
ROM OUTPUT
SET OV
ø2

FIG 62

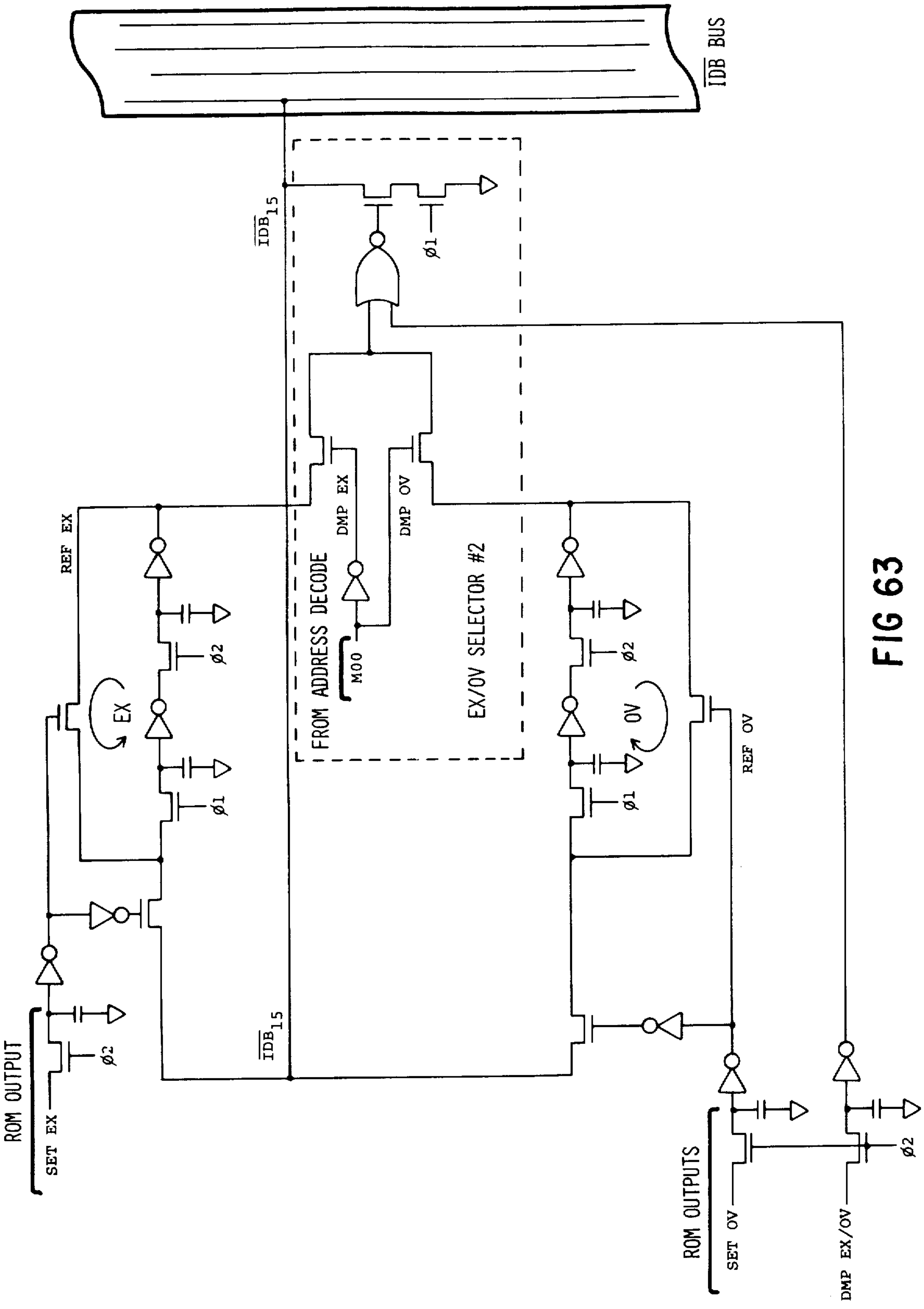

$\overline{IDB}$ BUS
$\overline{IDB}_{15}$
ϕ1
FROM ADDRESS DECODE
DMP EX
DMP OV
M00
EX/OV SELECTOR #2
REF EX
ϕ2
EX
ϕ1
ϕ2
OV
ϕ1
REF OV
$\overline{IDB}_{15}$
ROM OUTPUT
SET EX
ϕ2
ROM OUTPUTS
SET OV
DMP EX/OV
ϕ2

FIG 63

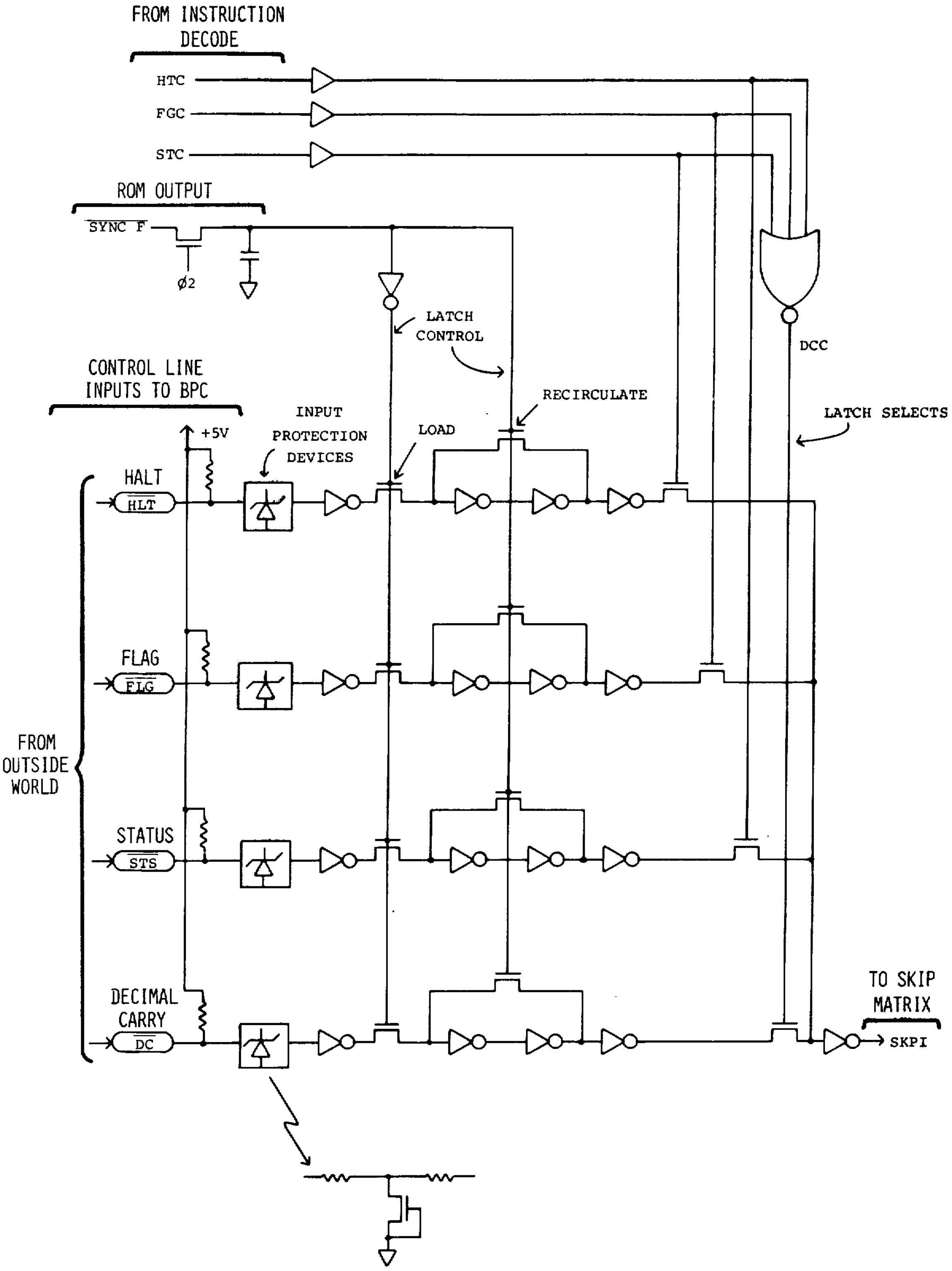
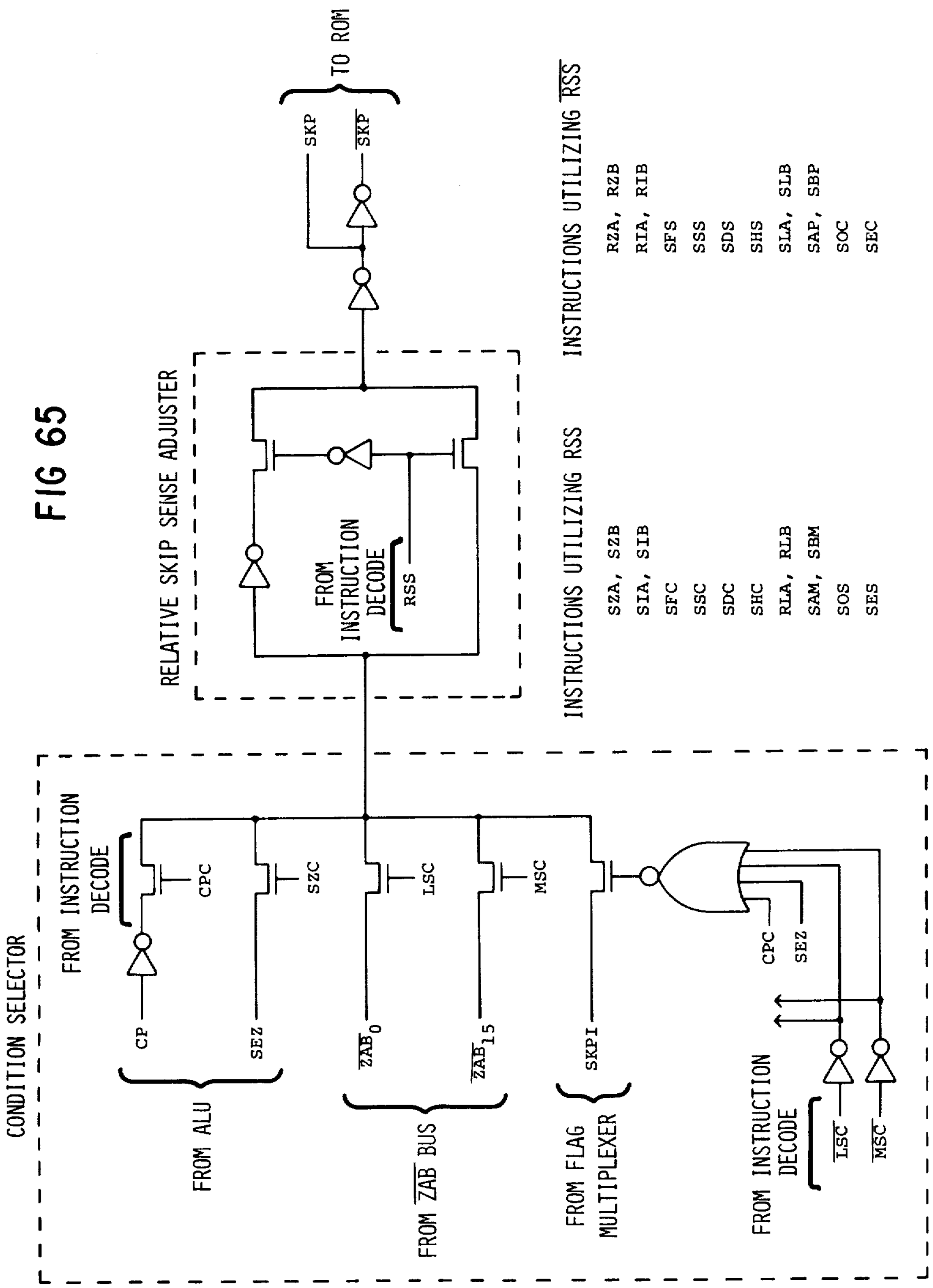

FROM INSTRUCTION DECODE
HTC
FGC
STC
ROM OUTPUT
SYNC F
Ø2
LATCH CONTROL
DCC
CONTROL LINE INPUTS TO BPC
+5V
INPUT PROTECTION DEVICES
LOAD
RECIRCULATE
LATCH SELECTS
HALT
HLT
FLAG
FLG
STATUS
STS
DECIMAL CARRY
DC
FROM OUTSIDE WORLD
TO SKIP MATRIX
SKPI

FIG 64

FIG 65



| INSTRUCTIONS UTILIZING RSS | INSTRUCTIONS UTILIZING $\overline{RSS}$ |
|---|---|
| SZA, SZB | RZA, RZB |
| SIA, SIB | RIA, RIB |
| SFC | SFS |
| SSC | SSS |
| SDC | SDS |
| SHC | SHS |
| RLA, RLB | SLA, SLB |
| SAM, SBM | SAP, SBP |
| SOS | SOC |
| SES | SEC |

FIG 66

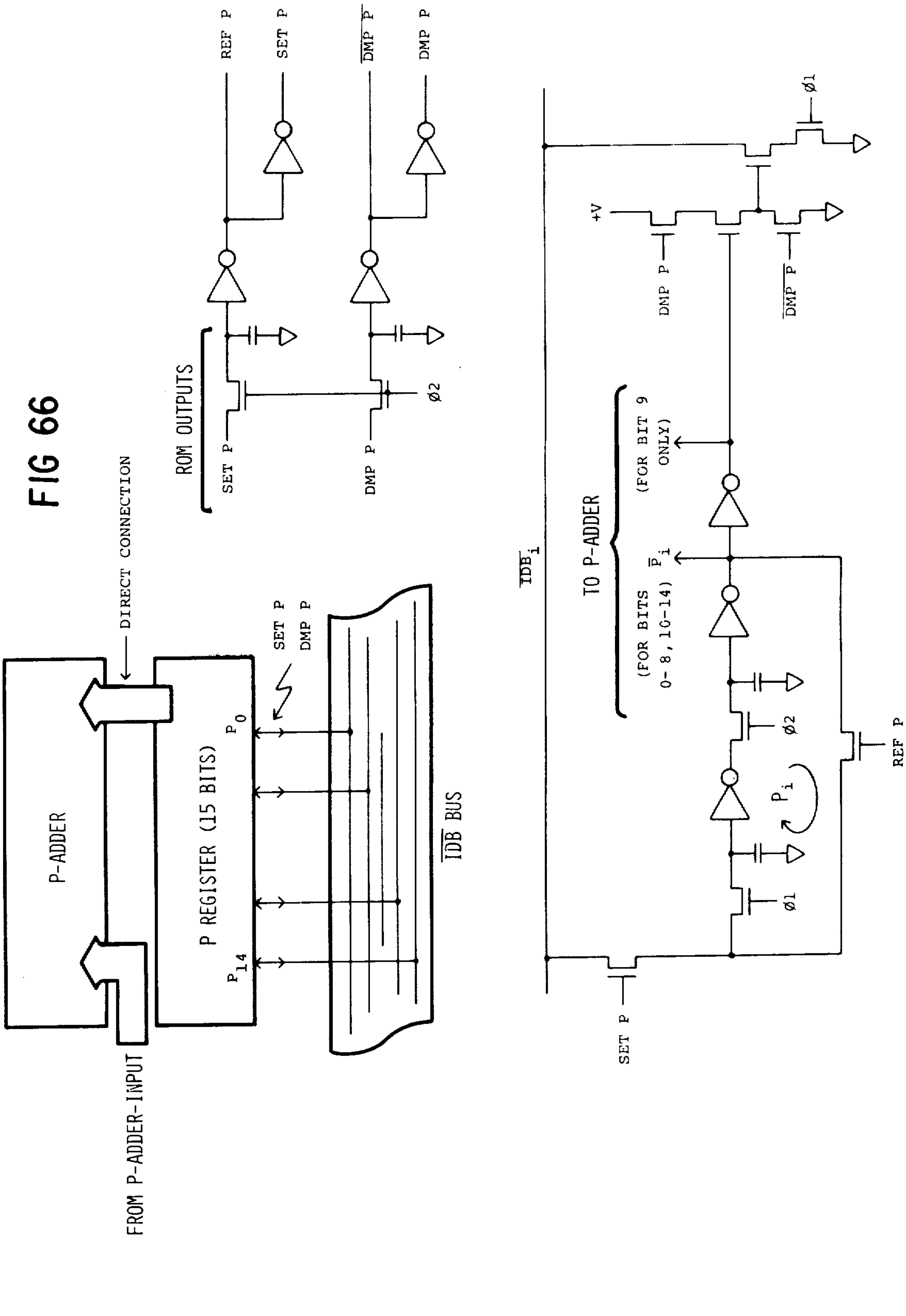
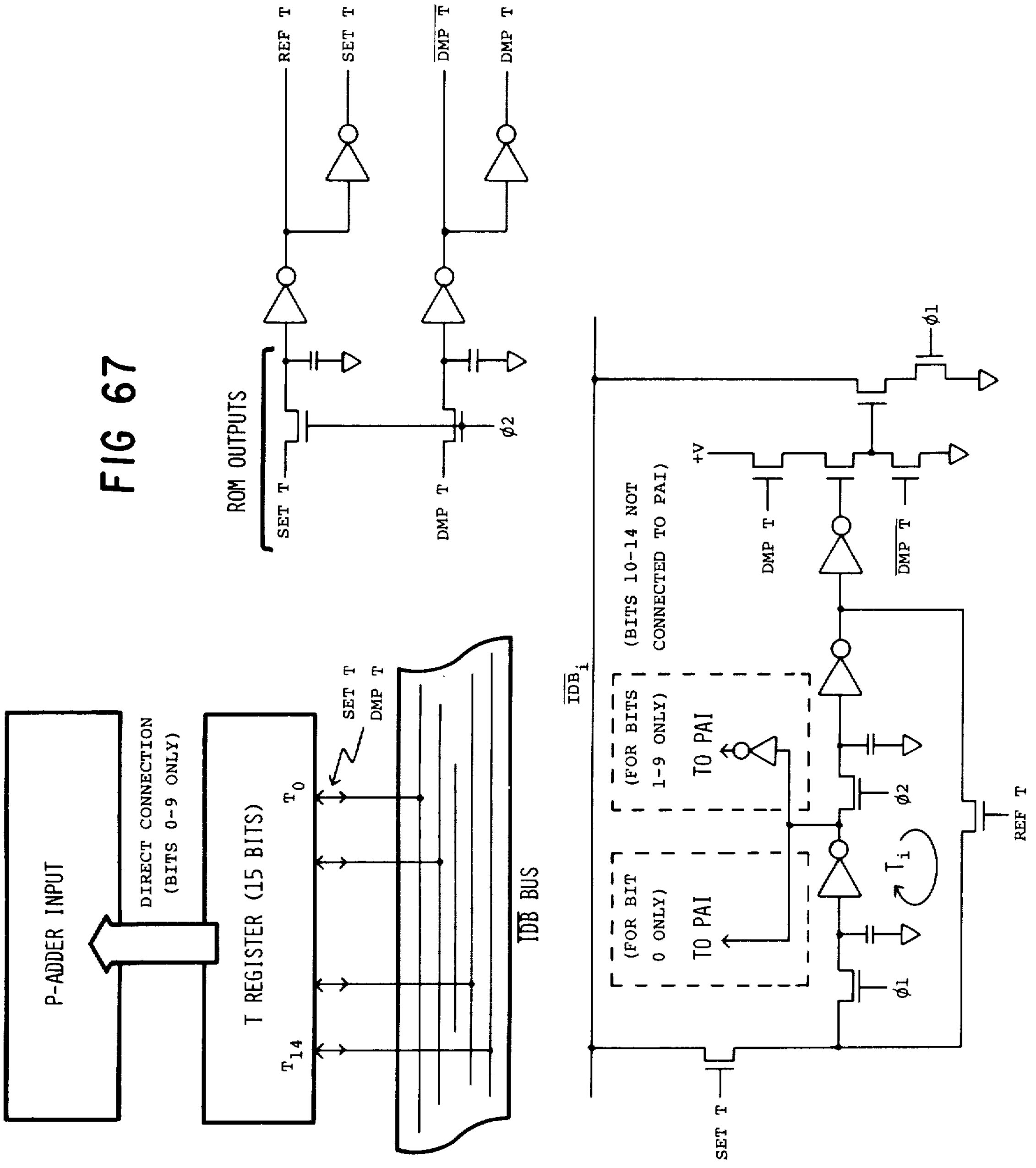

P-ADDER
DIRECT CONNECTION
FROM P-ADDER-INPUT
P REGISTER (15 BITS)
$P_0$
$P_{14}$
SET P
DMP P
$\overline{IDB}$ BUS
ROM OUTPUTS
SET P
DMP P
Ø2
REF P
SET P
$\overline{DMP\ P}$
DMP P
$\overline{IDB}_i$
TO P-ADDER
(FOR BITS 0-8, 10-14)
$\overline{P}_i$
(FOR BIT 9 ONLY)
Ø1
Ø2
$P_i$
REF P
SET P
+V
DMP P
$\overline{DMP\ P}$
Ø1

FIG 67


REF T
SET T
$\overline{\text{DMP T}}$
DMP T
ROM OUTPUTS
SET T
DMP T
$\phi 2$
P-ADDER INPUT
DIRECT CONNECTION
(BITS 0-9 ONLY)
T REGISTER (15 BITS)
$T_0$
$T_{14}$
SET T
DMP T
$\overline{\text{IDB}}$ BUS
$\overline{\text{IDB}}_i$
(BITS 10-14 NOT
CONNECTED TO PAI)
(FOR BITS
1-9 ONLY)
TO PAI
(FOR BIT
0 ONLY)
TO PAI
$T_i$
$\phi 1$
$\phi 2$
$\phi 1$
+V
DMP T
$\overline{\text{DMP T}}$
REF T
SET T

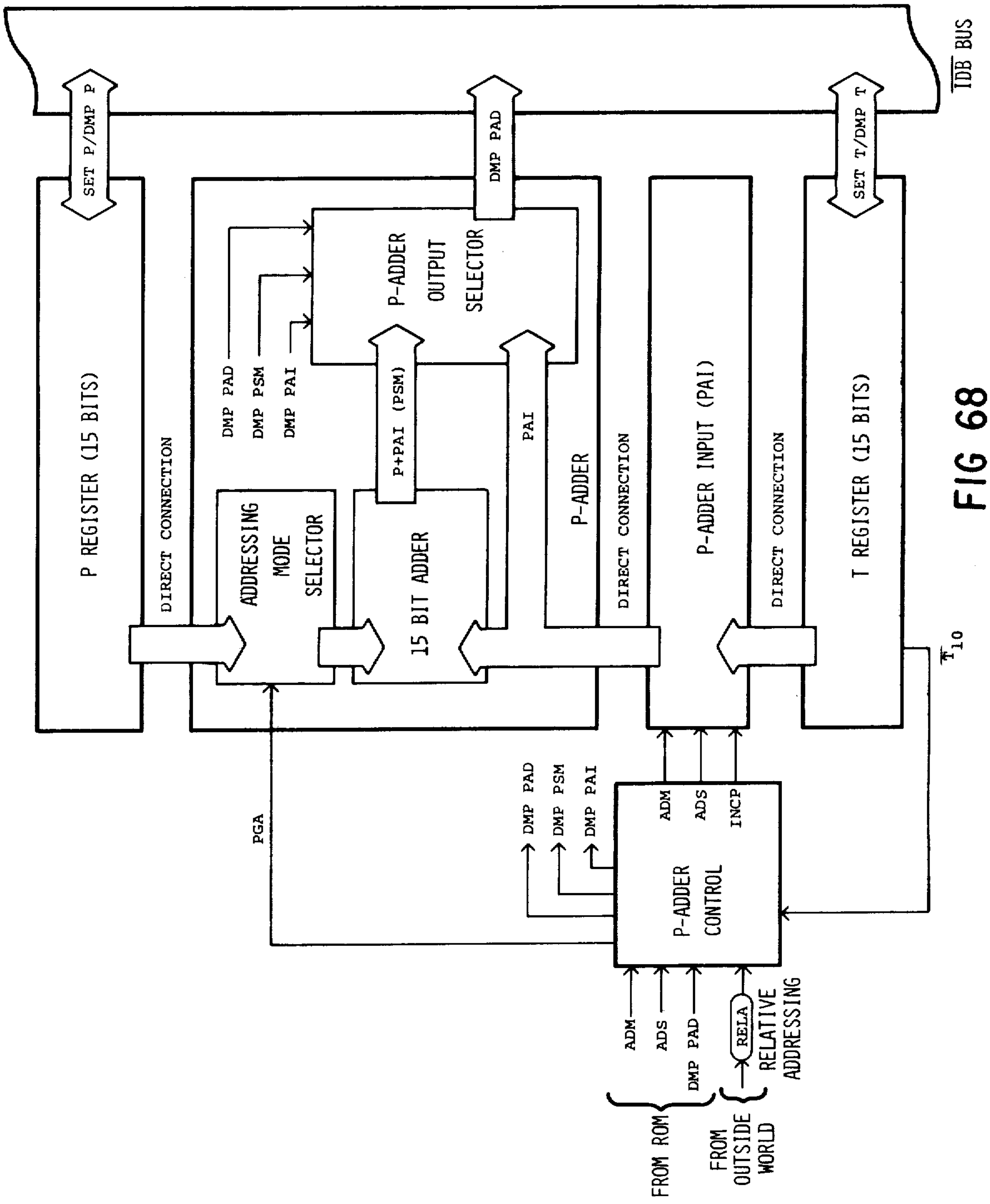

IDB BUS
SET P/DMP P
DMP PAD
SET T/DMP T
P REGISTER (15 BITS)
DIRECT CONNECTION
DMP PAD
DMP PSM
DMP PAI
P-ADDER
OUTPUT
SELECTOR
P+PAI (PSM)
PAI
P-ADDER
ADDRESSING
MODE
SELECTOR
15 BIT ADDER
DIRECT CONNECTION
P-ADDER INPUT (PAI)
DIRECT CONNECTION
T REGISTER (15 BITS)
$\overline{T}_{10}$
PGA
DMP PAD
DMP PSM
DMP PAI
ADM
ADS
INCP
P-ADDER
CONTROL
ADM
ADS
DMP PAD
RELA
RELATIVE
ADDRESSING
FROM ROM
FROM
OUTSIDE
WORLD

FIG 68

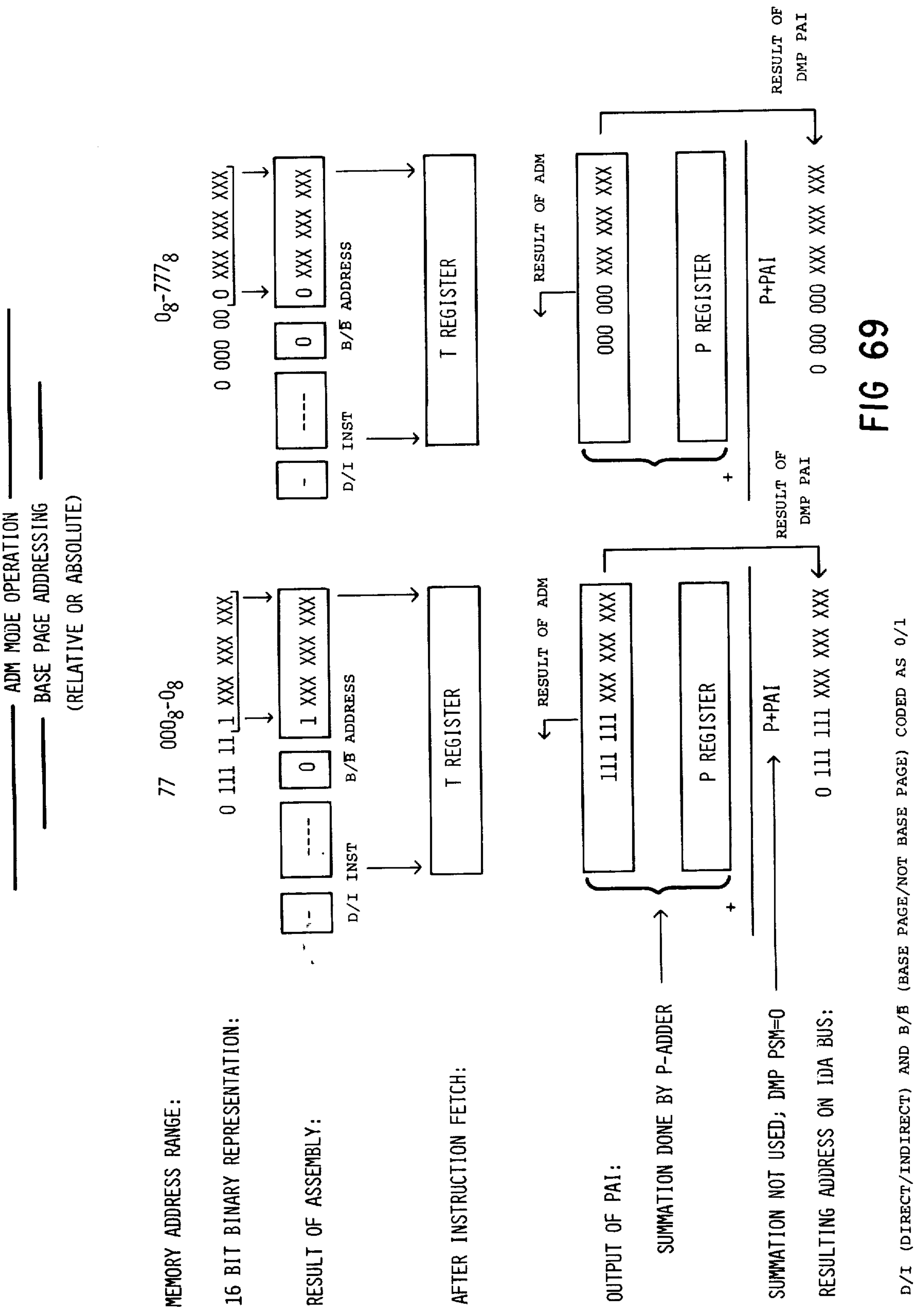
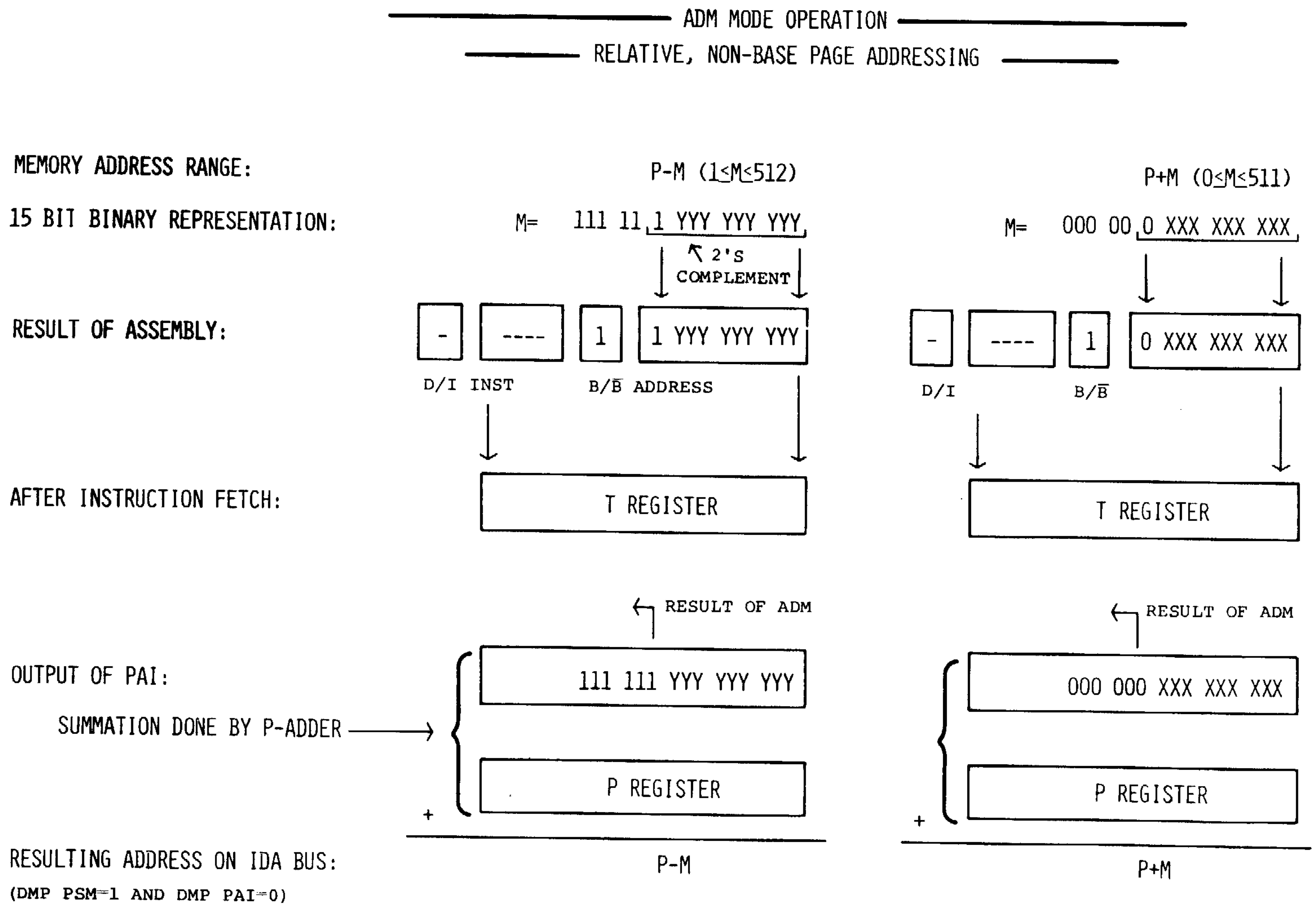

ADM MODE OPERATION
BASE PAGE ADDRESSING
(RELATIVE OR ABSOLUTE)
MEMORY ADDRESS RANGE:
16 BIT BINARY REPRESENTATION:
RESULT OF ASSEMBLY:
AFTER INSTRUCTION FETCH:
OUTPUT OF PAI:
SUMMATION DONE BY P-ADDER
SUMMATION NOT USED; DMP PSM=0
RESULTING ADDRESS ON IDA BUS:
77 000$_8$-0$_8$
0 111 11 1 1 XXX XXX XXX
-
----
0
1 XXX XXX XXX
D/I INST
B/$\bar{B}$ ADDRESS
T REGISTER
RESULT OF ADM
111 111 XXX XXX XXX
P REGISTER
+
P+PAI
RESULT OF DMP PAI
0 111 111 XXX XXX XXX
0$_8$-777$_8$
0 000 00 0 XXX XXX XXX
-
----
0
0 XXX XXX XXX
D/I INST
B/$\bar{B}$ ADDRESS
T REGISTER
RESULT OF ADM
000 000 XXX XXX XXX
P REGISTER
+
P+PAI
RESULT OF DMP PAI
0 000 000 XXX XXX XXX
D/I (DIRECT/INDIRECT) AND B/$\bar{B}$ (BASE PAGE/NOT BASE PAGE) CODED AS 0/1

FIG 69

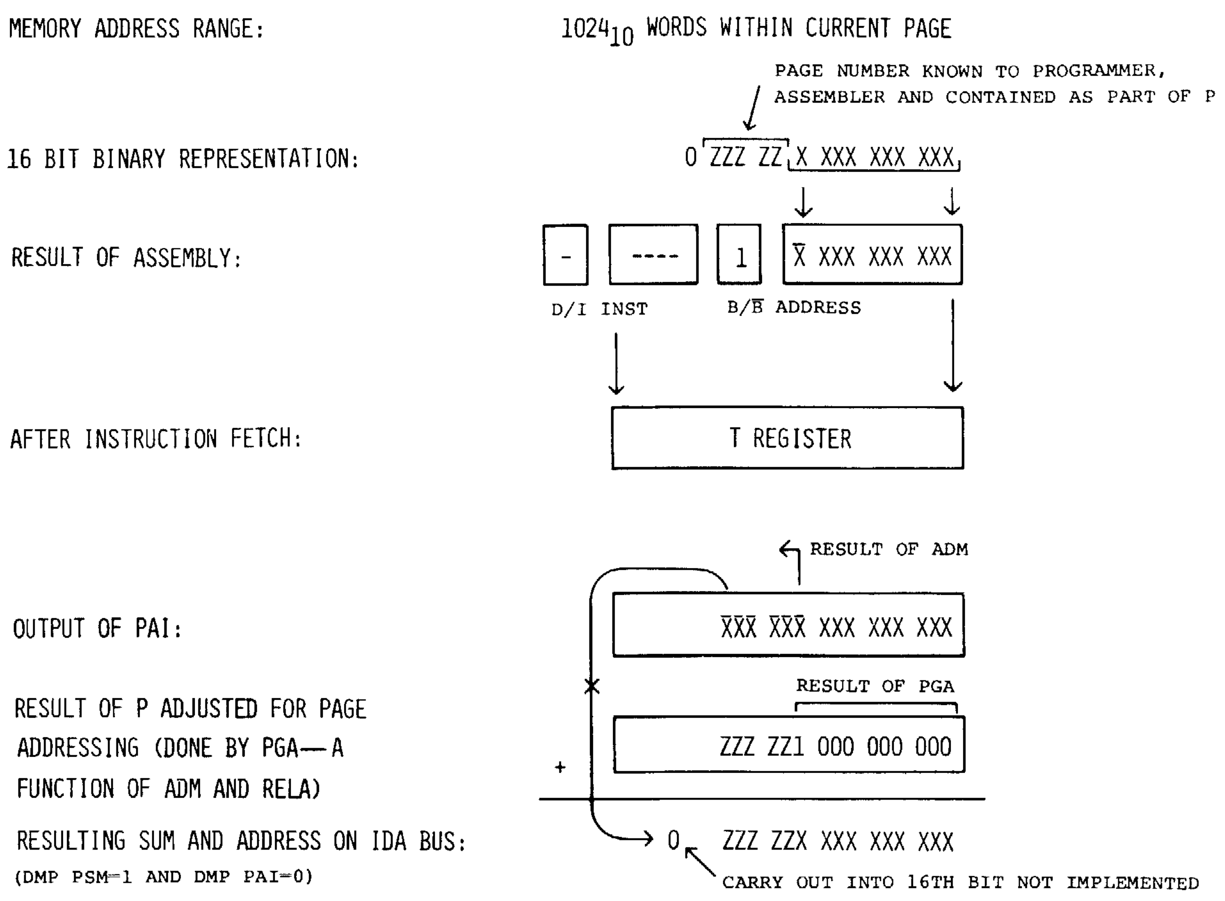


D/I (DIRECT/INDIRECT) AND B/B̄ (BASE PAGE/NOT BASE PAGE) CODED AS 0/1

FIG 70

ADM MODE OPERATION

ABSOLUTE, NON-BASE PAGE ADDRESSING


MEMORY ADDRESS RANGE:
$1024_{10}$ WORDS WITHIN CURRENT PAGE
PAGE NUMBER KNOWN TO PROGRAMMER, ASSEMBLER AND CONTAINED AS PART OF P
16 BIT BINARY REPRESENTATION:
0 ZZZ ZZ X XXX XXX XXX
RESULT OF ASSEMBLY:
-
----
1
$\bar{X}$ XXX XXX XXX
D/I INST
B/$\bar{B}$ ADDRESS
AFTER INSTRUCTION FETCH:
T REGISTER
RESULT OF ADM
OUTPUT OF PAI:
$\bar{XXX}$ $\bar{XXX}$ XXX XXX XXX
RESULT OF PGA
RESULT OF P ADJUSTED FOR PAGE ADDRESSING (DONE BY PGA—A FUNCTION OF ADM AND RELA)
ZZZ ZZ1 000 000 000
+
RESULTING SUM AND ADDRESS ON IDA BUS:
(DMP PSM=1 AND DMP PAI=0)
0
ZZZ ZZX XXX XXX XXX
CARRY OUT INTO 16TH BIT NOT IMPLEMENTED

D/I (DIRECT/INDIRECT) AND B/$\bar{B}$ (BASE PAGE/NOT BASE PAGE) CODED AS 0/1

FIG 71

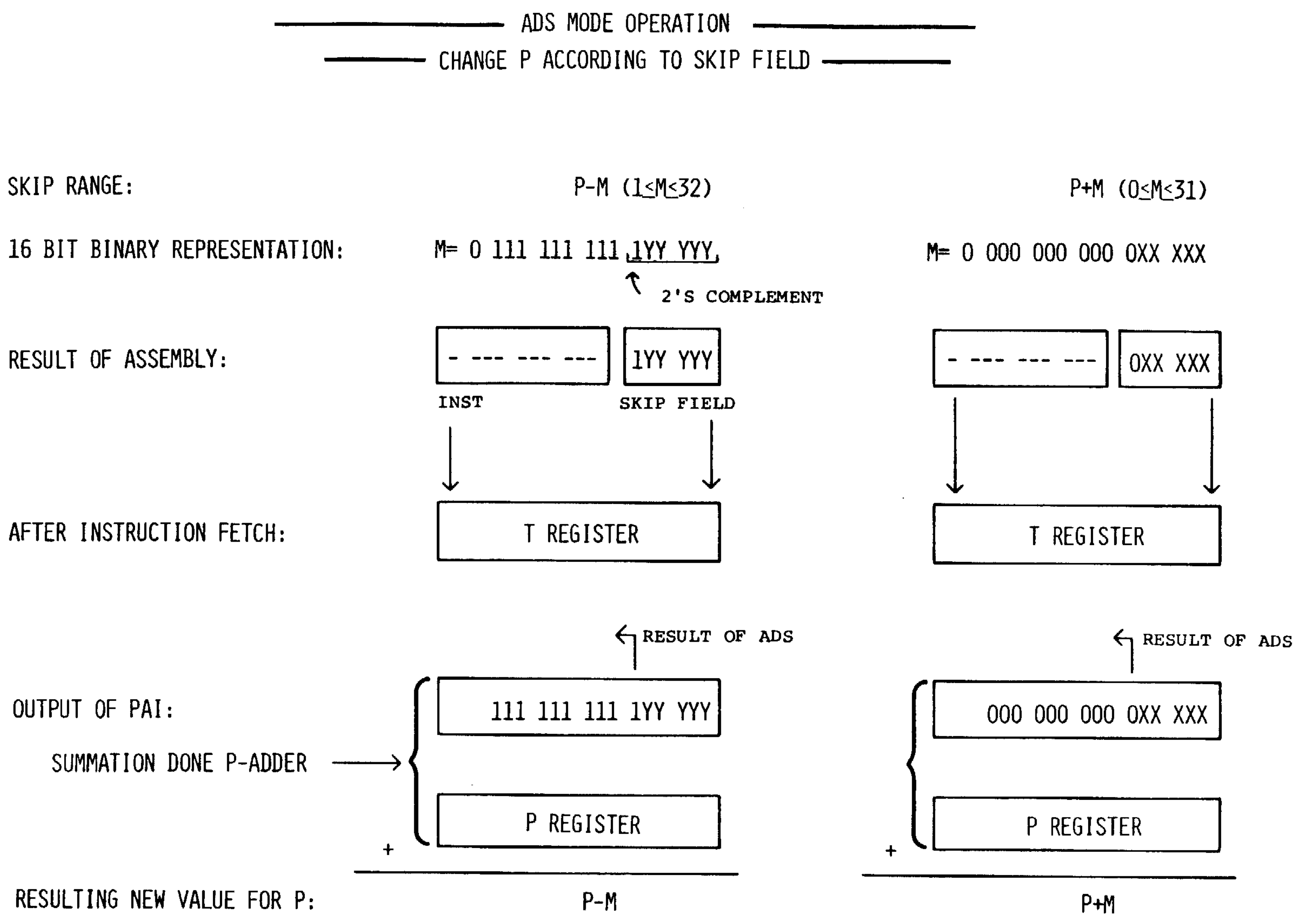

ADS MODE OPERATION
CHANGE P ACCORDING TO SKIP FIELD
SKIP RANGE:
P-M (1≤M≤32)
P+M (0≤M≤31)
16 BIT BINARY REPRESENTATION:
M= 0 111 111 111 1YY YYY
2'S COMPLEMENT
M= 0 000 000 000 0XX XXX
RESULT OF ASSEMBLY:
- --- --- ---
1YY YYY
INST
SKIP FIELD
- --- --- ---
0XX XXX
AFTER INSTRUCTION FETCH:
T REGISTER
T REGISTER
RESULT OF ADS
RESULT OF ADS
OUTPUT OF PAI:
111 111 111 1YY YYY
000 000 000 0XX XXX
SUMMATION DONE P-ADDER
P REGISTER
P REGISTER
+
+
RESULTING NEW VALUE FOR P:
(DMP PSM=1 AND DMP PAI=0)
P-M
P+M

FIG 72

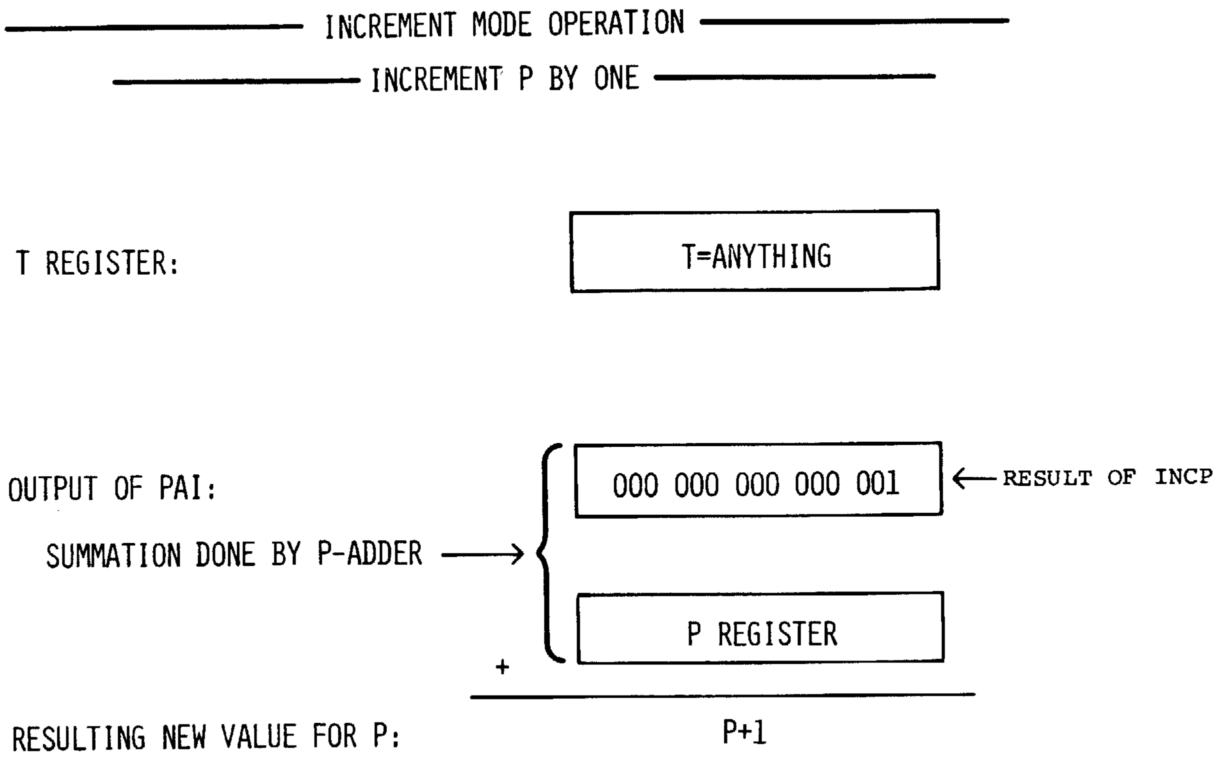

INCREMENT MODE OPERATION
INCREMENT P BY ONE
T REGISTER:
T=ANYTHING
OUTPUT OF PAI:
000 000 000 000 001
RESULT OF INCP
SUMMATION DONE BY P-ADDER
P REGISTER
+
RESULTING NEW VALUE FOR P:
P+1

FIG 73

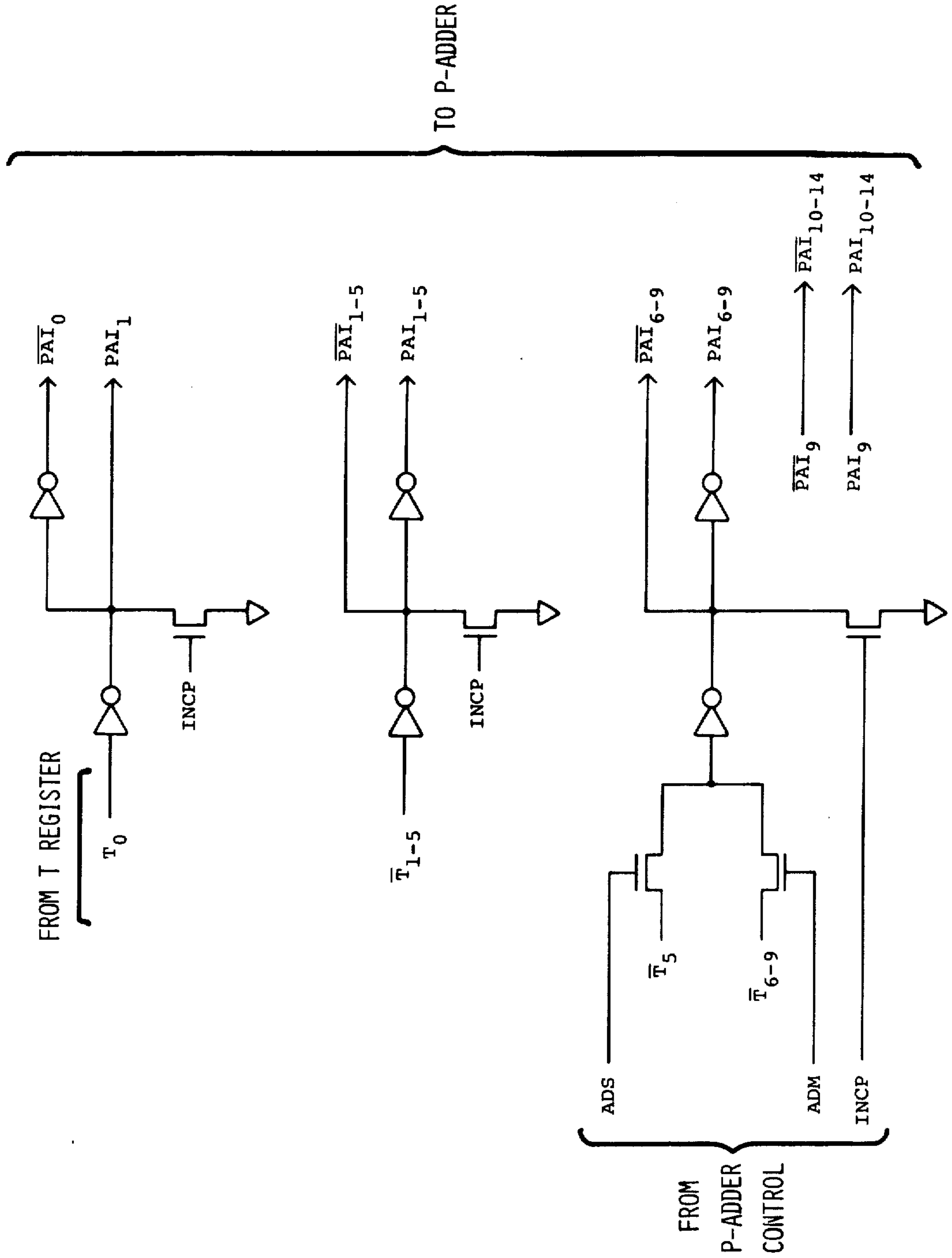

TO P-ADDER
$\overline{PAI}_0$
$PAI_1$
$\overline{PAI}_{1-5}$
$PAI_{1-5}$
$\overline{PAI}_{6-9}$
$PAI_{6-9}$
$\overline{PAI}_9$
$\overline{PAI}_{10-14}$
$PAI_9$
$PAI_{10-14}$
INCP
INCP
FROM T REGISTER
$T_0$
$\overline{T}_{1-5}$
$\overline{T}_5$
$\overline{T}_{6-9}$
ADS
ADM
INCP
FROM
P-ADDER
CONTROL

FIG 74

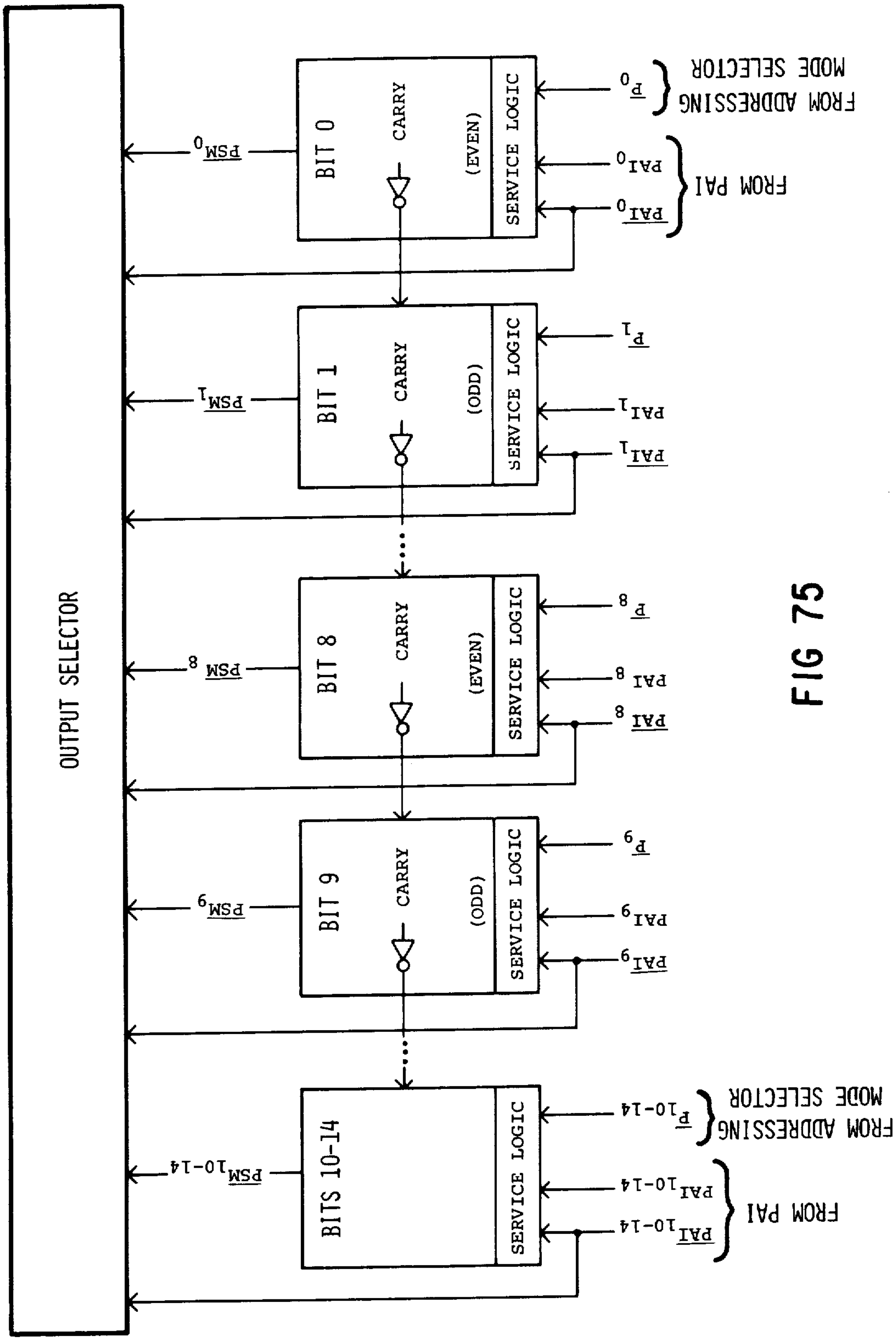

OUTPUT SELECTOR
BIT 0
CARRY
(EVEN)
SERVICE LOGIC
$PSM_0$
$P_0$
FROM ADDRESSING MODE SELECTOR
$PAI_0$
$\overline{PAI_0}$
FROM PAI
BIT 1
CARRY
(ODD)
SERVICE LOGIC
$PSM_1$
$P_1$
$PAI_1$
$\overline{PAI_1}$
BIT 8
CARRY
(EVEN)
SERVICE LOGIC
$PSM_8$
$P_8$
$PAI_8$
$\overline{PAI_8}$
BIT 9
CARRY
(ODD)
SERVICE LOGIC
$PSM_9$
$P_9$
$PAI_9$
$\overline{PAI_9}$
BITS 10-14
SERVICE LOGIC
$PSM_{10-14}$
$P_{10-14}$
FROM ADDRESSING MODE SELECTOR
$PAI_{10-14}$
$\overline{PAI_{10-14}}$
FROM PAI

FIG 75

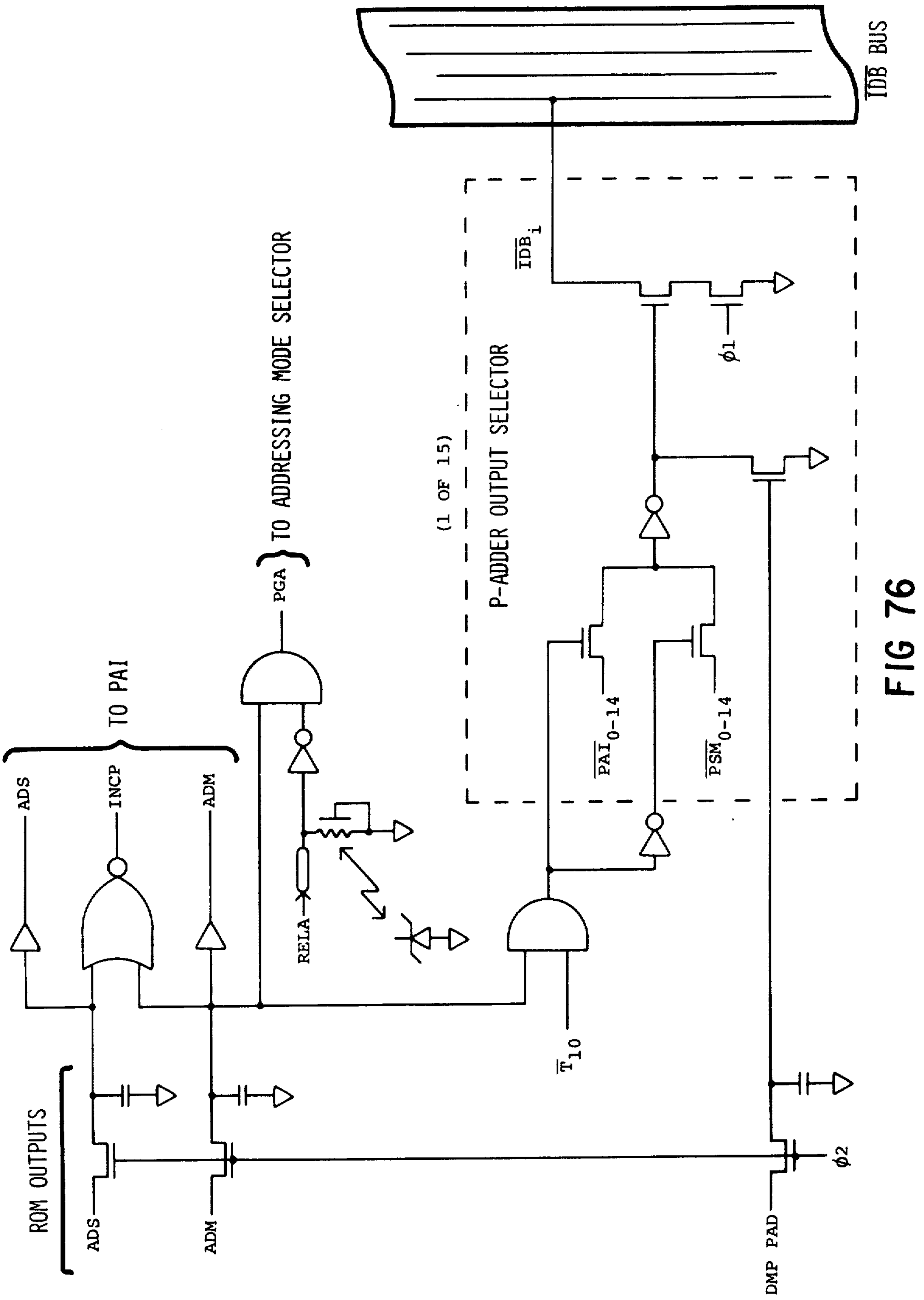

$\overline{\text{IDB}}$ BUS
$\overline{\text{IDB}}_i$
$\phi 1$
(1 OF 15)
P-ADDER OUTPUT SELECTOR
$\overline{\text{PAI}}_{0-14}$
$\overline{\text{PSM}}_{0-14}$
TO ADDRESSING MODE SELECTOR
PGA
TO PAI
ADS
INCP
ADM
RELA
$\overline{T}_{10}$
ROM OUTPUTS
ADS
ADM
DMP PAD
$\phi 2$

FIG 76

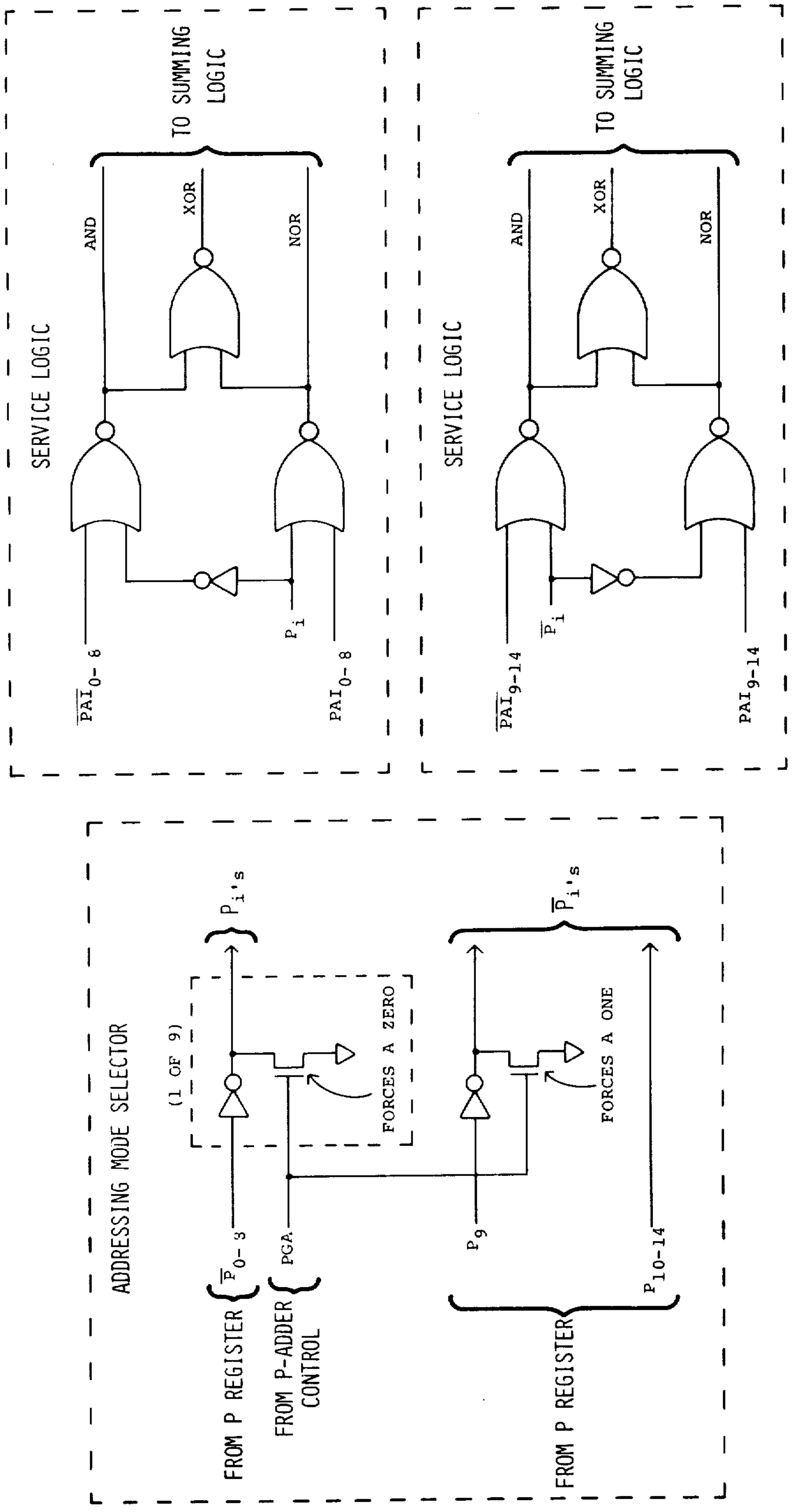

SERVICE LOGIC
TO SUMMING LOGIC
AND
XOR
NOR
$\overline{PAI}_{0-8}$
$P_i$
$PAI_{0-8}$
SERVICE LOGIC
TO SUMMING LOGIC
AND
XOR
NOR
$\overline{PAI}_{9-14}$
$\overline{P}_i$
$PAI_{9-14}$
ADDRESSING MODE SELECTOR
$P_i$'s
(1 OF 9)
FORCES A ZERO
$\overline{P}_i$'s
FORCES A ONE
$\overline{P}_{0-3}$
PGA
$P_9$
$P_{10-14}$
FROM P REGISTER
FROM P-ADDER CONTROL
FROM P REGISTER

FIG 77

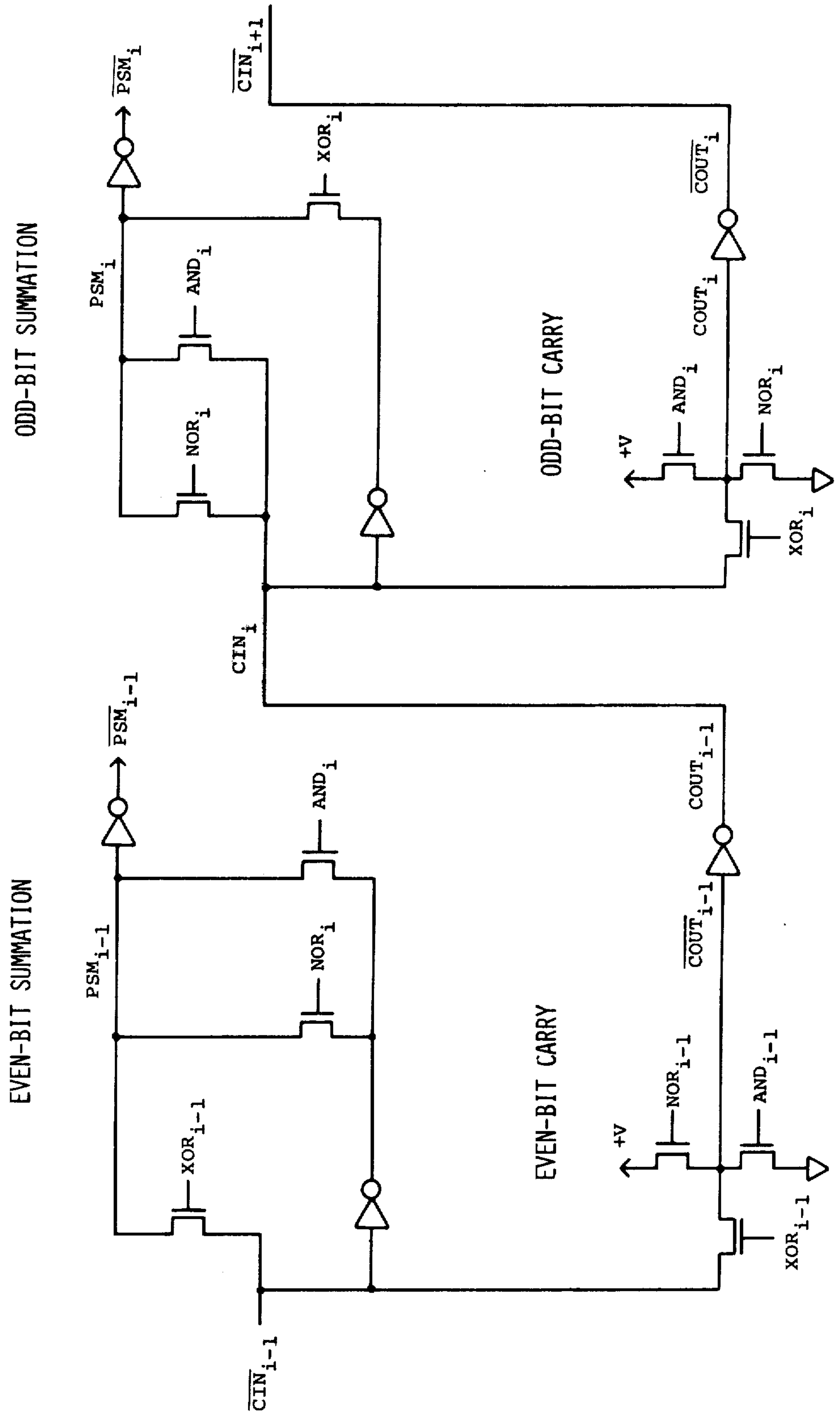

ODD-BIT SUMMATION
$\overline{PSM}_i$
$\overline{CIN}_{i+1}$
$XOR_i$
$PSM_i$
$AND_i$
$NOR_i$
ODD-BIT CARRY
$\overline{COUT}_i$
$COUT_i$
$AND_i$
$NOR_i$
+V
$XOR_i$
$CIN_i$
EVEN-BIT SUMMATION
$\overline{PSM}_{i-1}$
$AND_i$
$PSM_{i-1}$
$NOR_i$
$XOR_{i-1}$
EVEN-BIT CARRY
$COUT_{i-1}$
$\overline{COUT}_{i-1}$
$NOR_{i-1}$
$AND_{i-1}$
+V
$XOR_{i-1}$
$\overline{CIN}_{i-1}$

FIG 78

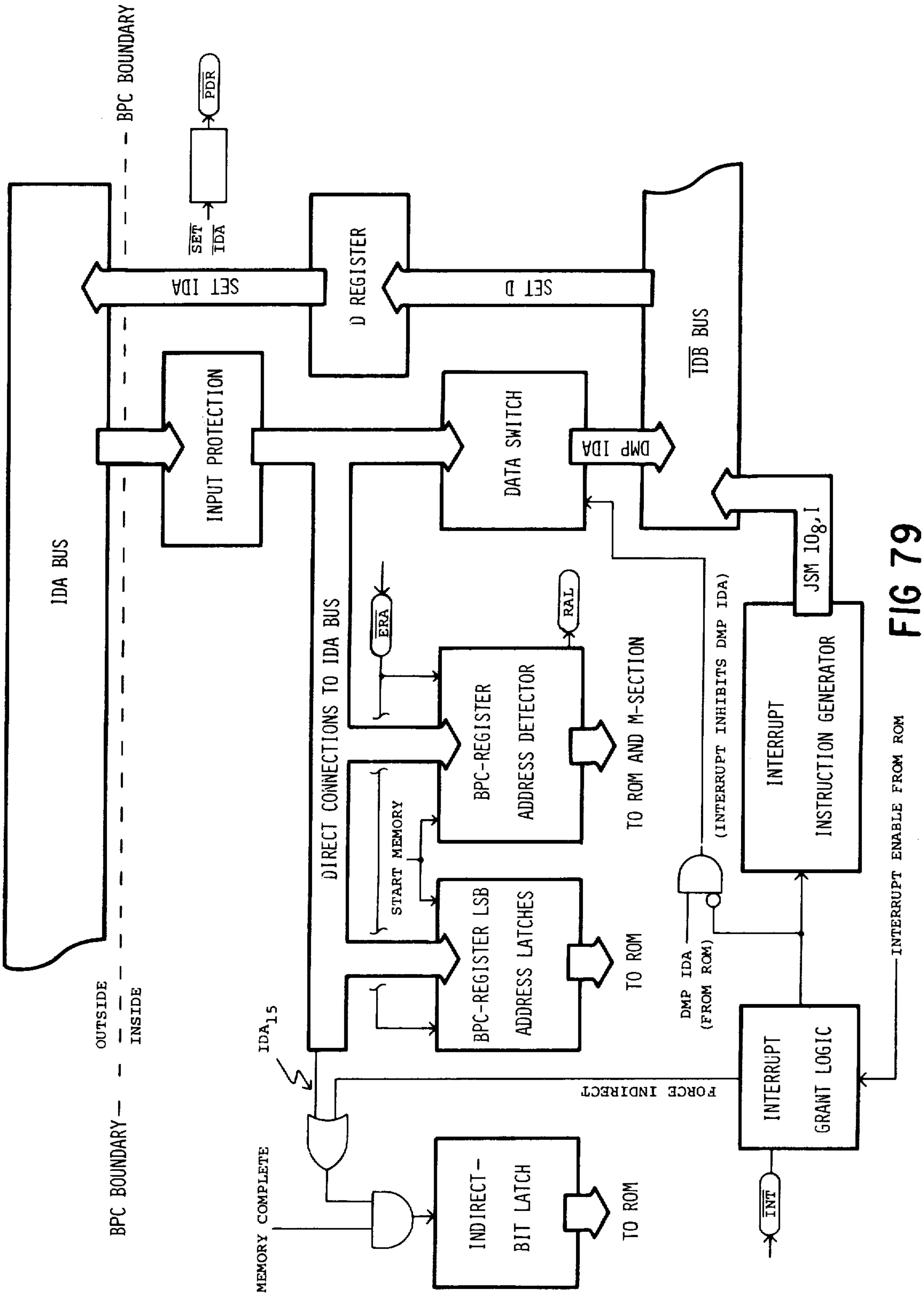

BPC BOUNDARY
OUTSIDE
INSIDE
IDA BUS
SET IDA
$\overline{\text{SET}}$ $\overline{\text{IDA}}$
$\overline{\text{PDR}}$
D REGISTER
SET D
$\overline{\text{IDB}}$ BUS
INPUT PROTECTION
DATA SWITCH
DMP IDA
DIRECT CONNECTIONS TO IDA BUS
$\overline{\text{ERA}}$
RAL
BPC-REGISTER ADDRESS DETECTOR
TO ROM AND M-SECTION
START MEMORY
BPC-REGISTER LSB ADDRESS LATCHES
TO ROM
$IDA_{15}$
MEMORY COMPLETE
INDIRECT-BIT LATCH
TO ROM
FORCE INDIRECT
(INTERRUPT INHIBITS DMP IDA)
DMP IDA (FROM ROM)
JSM $10_8$,I
INTERRUPT INSTRUCTION GENERATOR
INTERRUPT GRANT LOGIC
INTERRUPT ENABLE FROM ROM
$\overline{\text{INT}}$

FIG 79

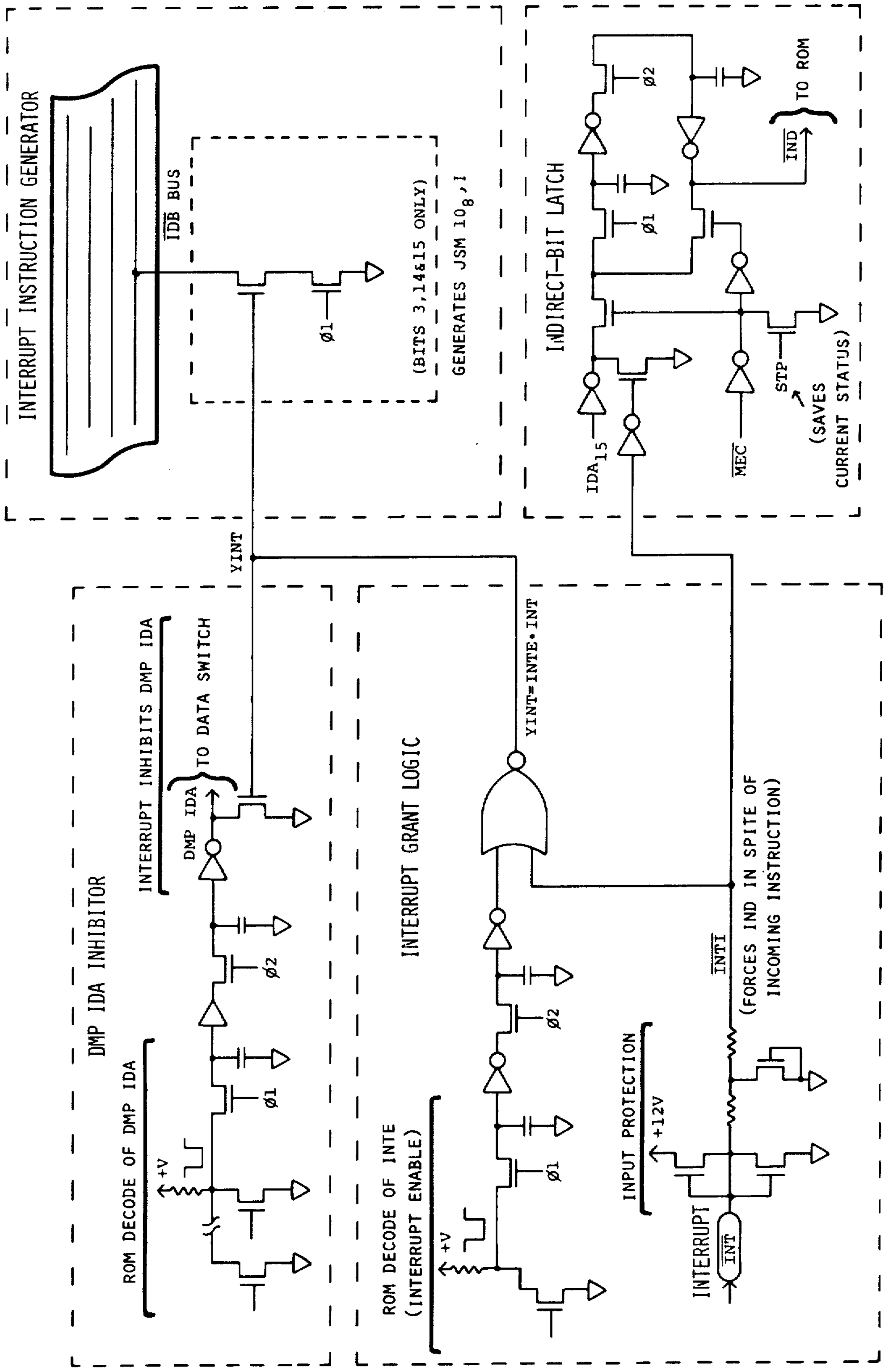

INTERRUPT INSTRUCTION GENERATOR
$\overline{IDB}$ BUS
Ø1
(BITS 3,14&15 ONLY)
GENERATES JSM $10_8$,I
INDIRECT-BIT LATCH
Ø2
Ø1
TO ROM
$\overline{IND}$
$IDA_{15}$
$\overline{MEC}$
STP
(SAVES CURRENT STATUS)
YINT
DMP IDA INHIBITOR
INTERRUPT INHIBITS DMP IDA
TO DATA SWITCH
DMP IDA
Ø2
Ø1
+V
ROM DECODE OF DMP IDA
INTERRUPT GRANT LOGIC
YINT=INTE•INT
$\overline{INTI}$
(FORCES IND IN SPITE OF INCOMING INSTRUCTION)
Ø2
Ø1
+V
ROM DECODE OF INTE (INTERRUPT ENABLE)
INPUT PROTECTION
+12V
INTERRUPT
$\overline{INT}$

FIG 80

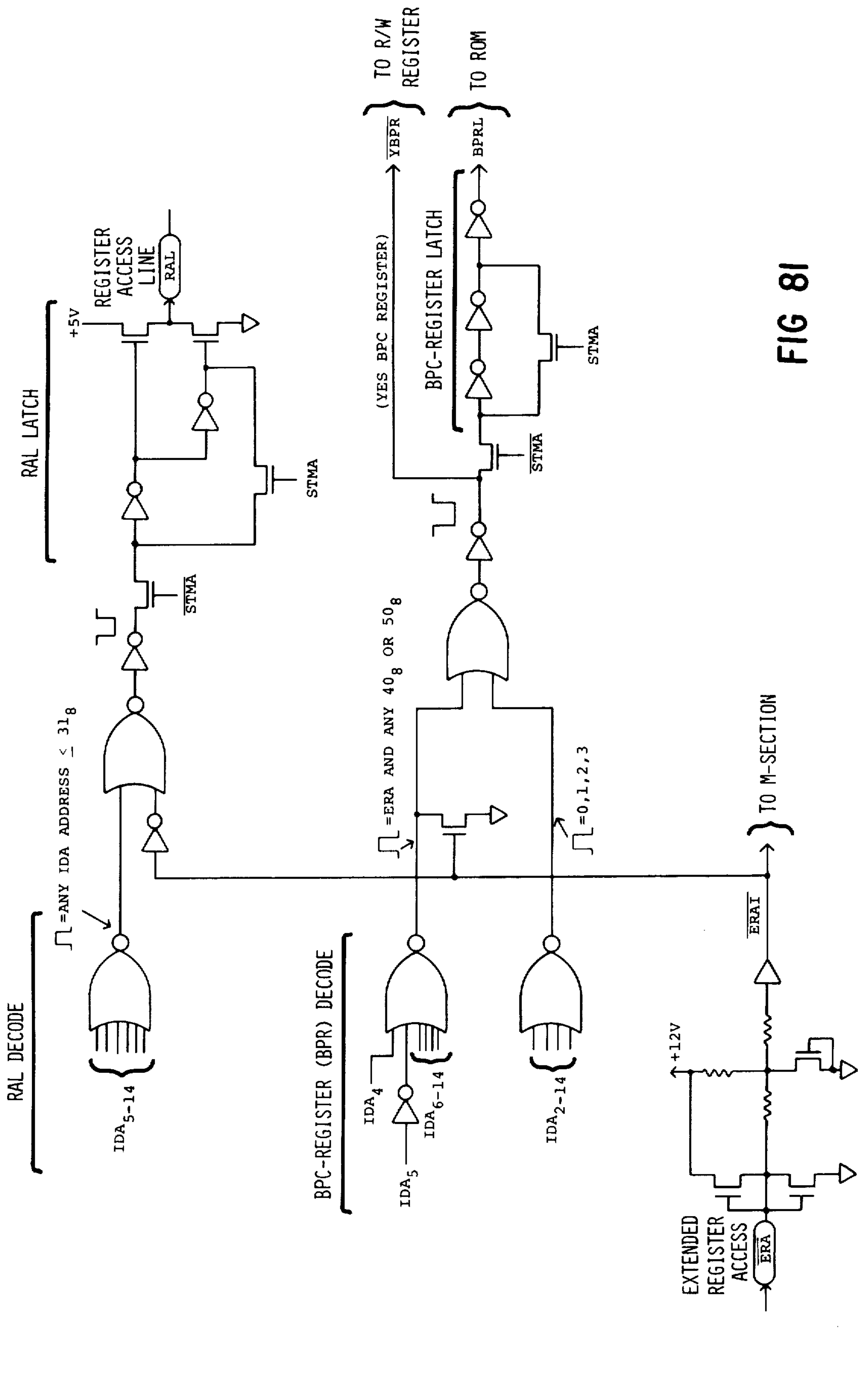

RAL LATCH
+5V
REGISTER ACCESS LINE
RAL
STMA
STMA
=ANY IDA ADDRESS ≤ 31₈
RAL DECODE
IDA5-14
TO R/W REGISTER
YBPR
TO ROM
BPRL
(YES BPC REGISTER)
BPC-REGISTER LATCH
STMA
STMA
=ERA AND ANY 40₈ OR 50₈
=0,1,2,3
TO M-SECTION
BPC-REGISTER (BPR) DECODE
IDA4
IDA5
IDA6-14
IDA2-14
ERAI
+12V
EXTENDED REGISTER ACCESS
ERA

FIG 81

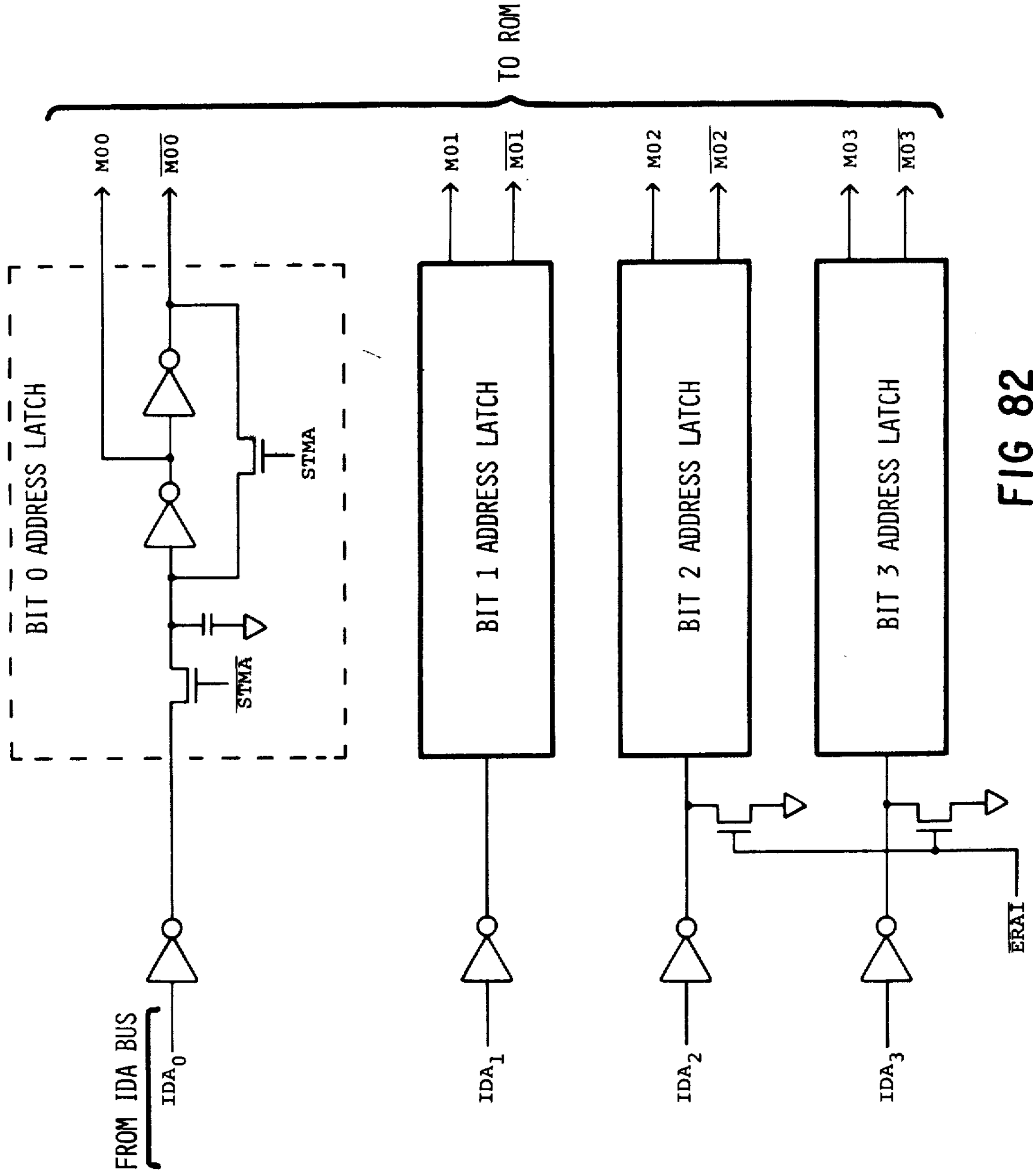
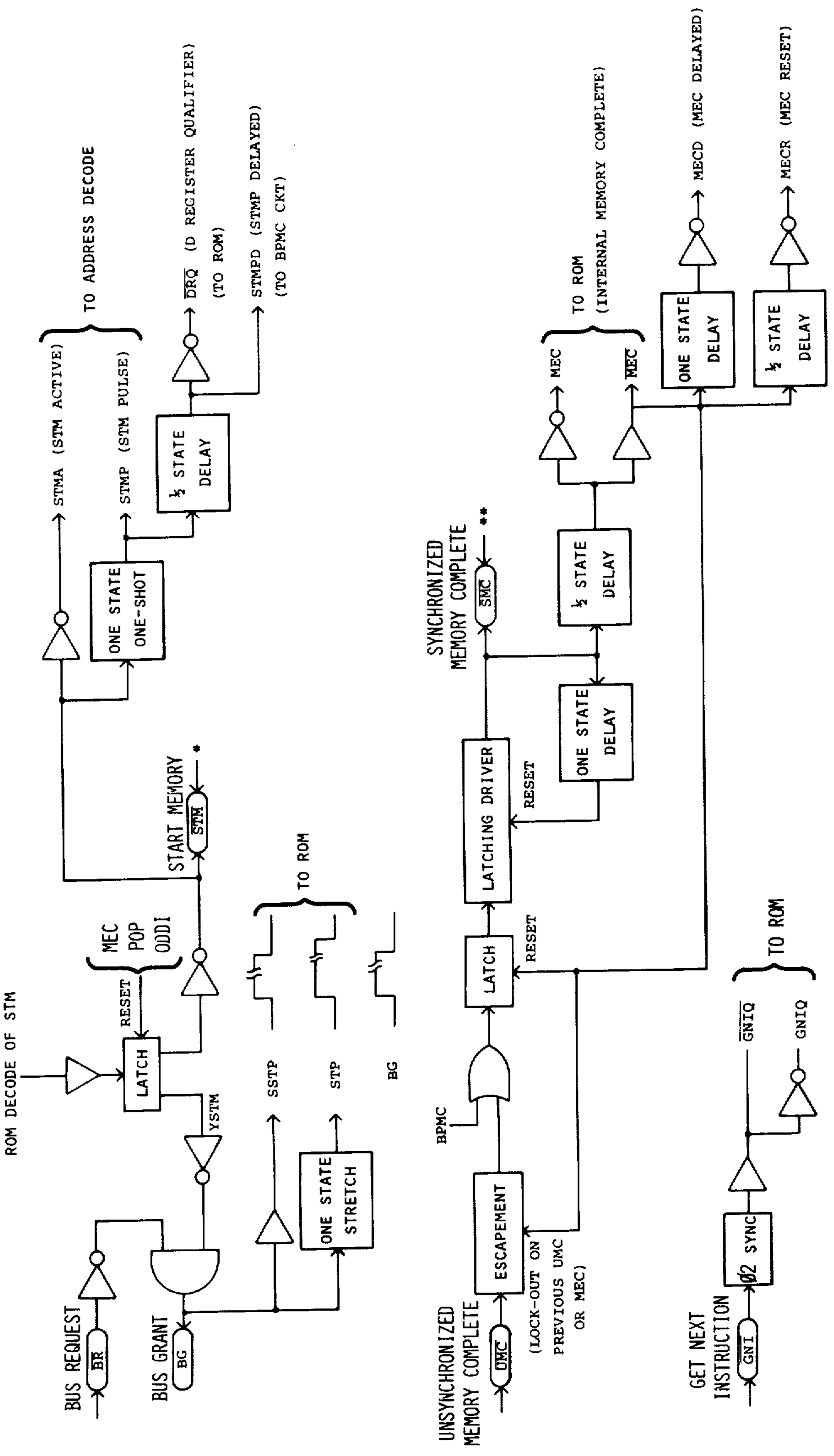

TO ROM
M00
$\overline{\text{M00}}$
M01
$\overline{\text{M01}}$
M02
$\overline{\text{M02}}$
M03
$\overline{\text{M03}}$
BIT 0 ADDRESS LATCH
STMA
$\overline{\text{STMA}}$
BIT 1 ADDRESS LATCH
BIT 2 ADDRESS LATCH
BIT 3 ADDRESS LATCH
$\overline{\text{ERAI}}$
FROM IDA BUS
$IDA_0$
$IDA_1$
$IDA_2$
$IDA_3$

FIG 82



*ACTIVE PULL-UP DURING MECD
**ACTIVE PULL-UP DURING MECR

FIG 83A

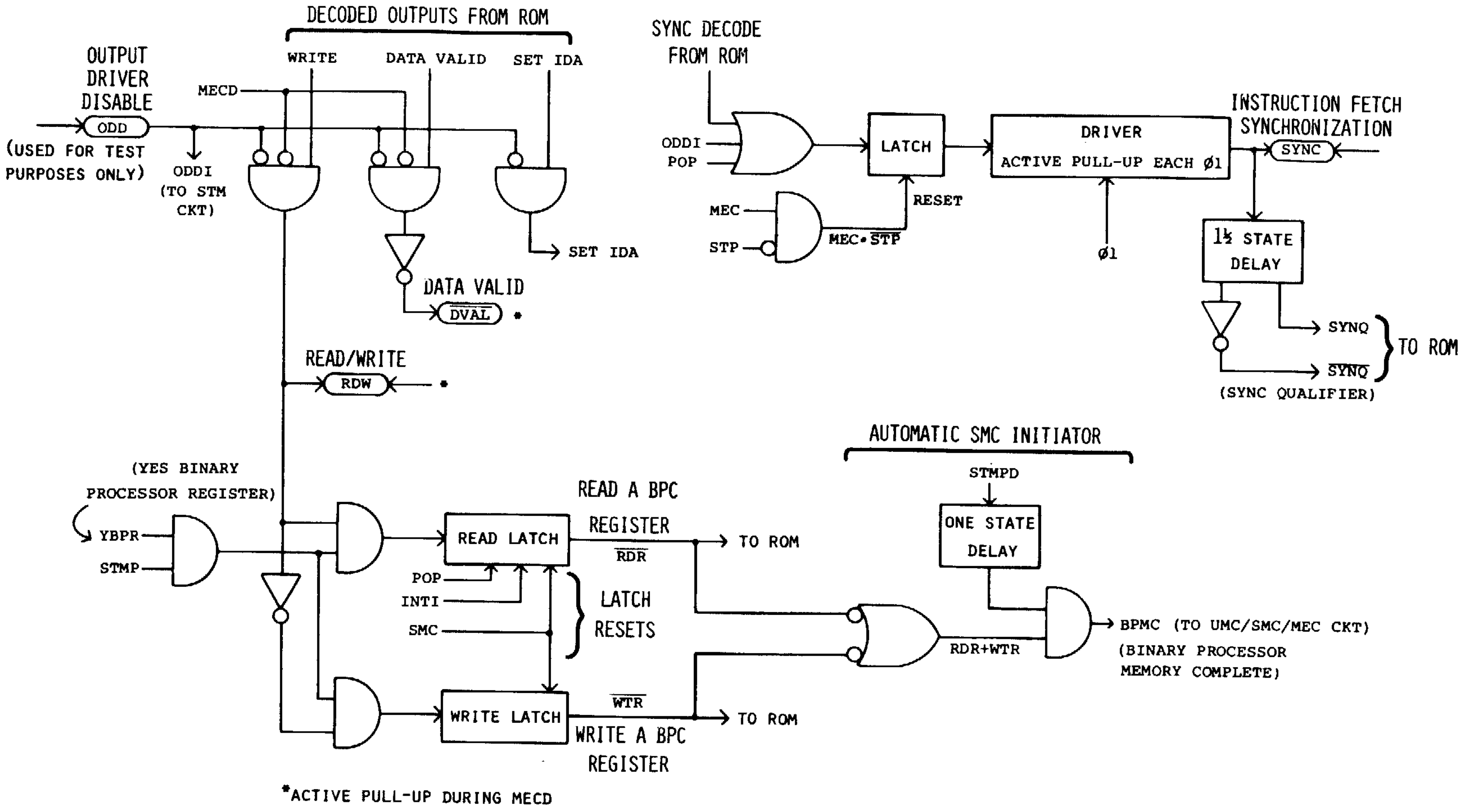

DECODED OUTPUTS FROM ROM
WRITE
DATA VALID
SET IDA
OUTPUT DRIVER DISABLE
ODD
(USED FOR TEST PURPOSES ONLY)
MECD
ODDI (TO STM CKT)
SET IDA
DATA VALID
DVAL
*
READ/WRITE
RDW
*
SYNC DECODE FROM ROM
ODDI
POP
MEC
STP
MEC•$\overline{STP}$
LATCH
RESET
DRIVER
ACTIVE PULL-UP EACH Ø1
Ø1
INSTRUCTION FETCH SYNCHRONIZATION
SYNC
1½ STATE DELAY
SYNQ
$\overline{SYNQ}$
TO ROM
(SYNC QUALIFIER)
AUTOMATIC SMC INITIATOR
STMPD
ONE STATE DELAY
(YES BINARY PROCESSOR REGISTER)
YBPR
STMP
READ LATCH
POP
INTI
SMC
LATCH RESETS
WRITE LATCH
READ A BPC REGISTER
$\overline{RDR}$
TO ROM
$\overline{WTR}$
WRITE A BPC REGISTER
TO ROM
RDR+WTR
BPMC (TO UMC/SMC/MEC CKT)
(BINARY PROCESSOR MEMORY COMPLETE)
*ACTIVE PULL-UP DURING MECD

FIG 83B

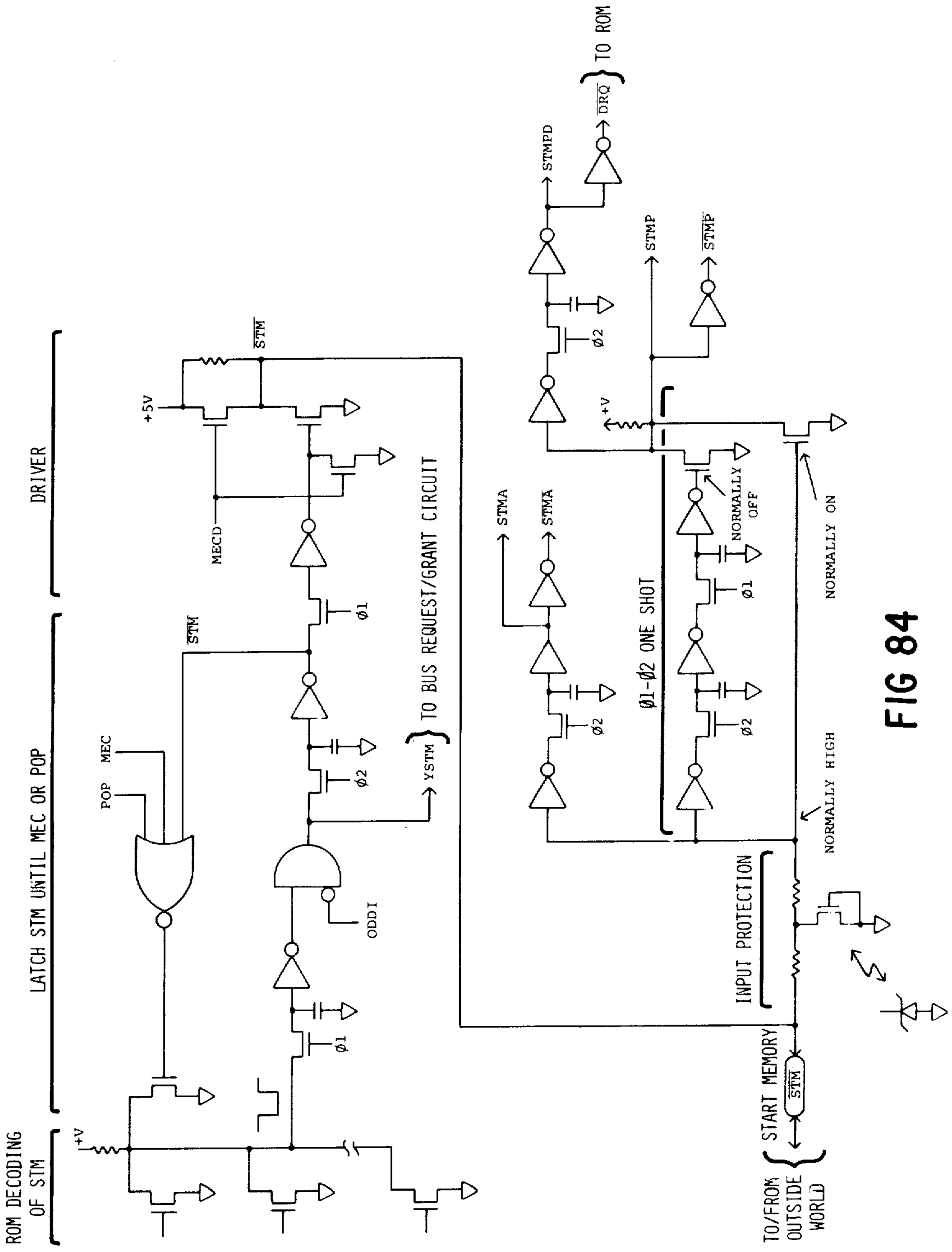

ROM DECODING OF STM
LATCH STM UNTIL MEC OR POP
DRIVER
+V
POP
MEC
$\overline{\text{STM}}$
+5V
$\overline{\text{STM}}$
MECD
ø1
ø2
ø1
ø1
ø2
ODDI
YSTM
TO BUS REQUEST/GRANT CIRCUIT
STMPD
$\overline{\text{DRQ}}$
TO ROM
ø2
STMP
$\overline{\text{STMP}}$
+V
STMA
$\overline{\text{STMA}}$
ø2
ø1-ø2 ONE SHOT
ø1
ø2
NORMALLY OFF
NORMALLY ON
NORMALLY HIGH
INPUT PROTECTION
START MEMORY
$\overline{\text{STM}}$
TO/FROM OUTSIDE WORLD

FIG 84

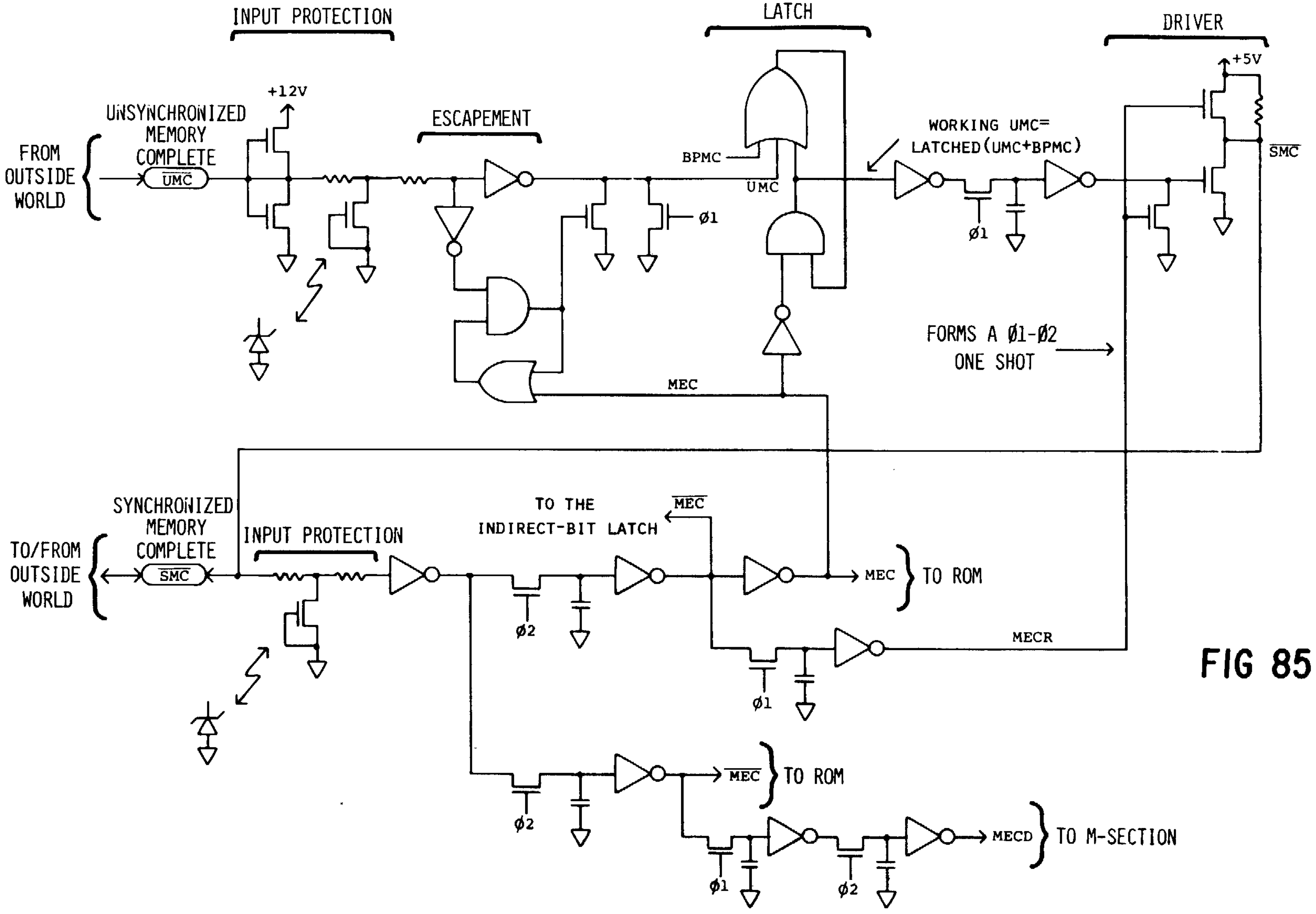
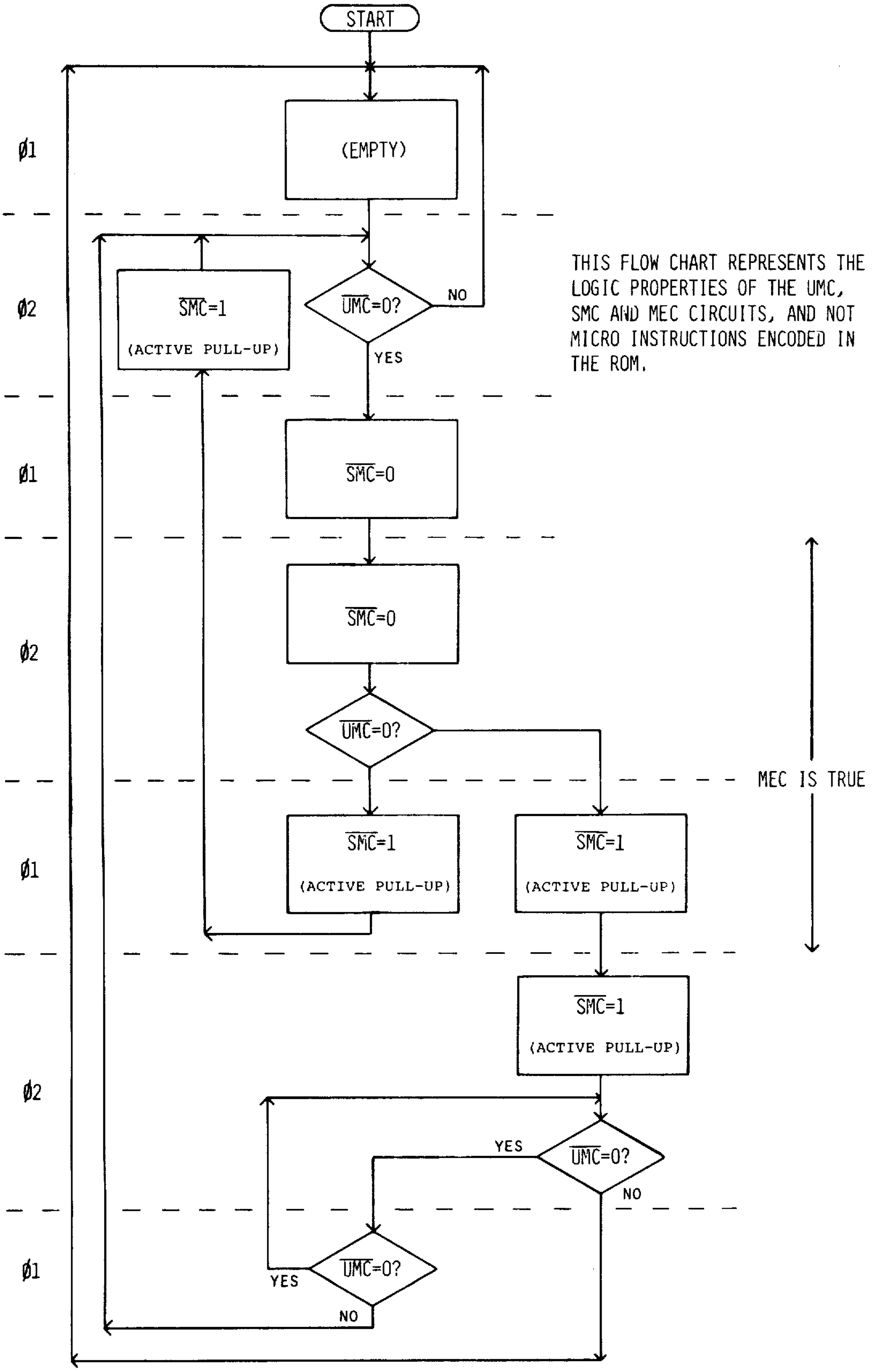

INPUT PROTECTION
LATCH
DRIVER
+5V
+12V
UNSYNCHRONIZED
MEMORY
COMPLETE
$\overline{UMC}$
FROM
OUTSIDE
WORLD
ESCAPEMENT
BPMC
UMC
Ø1
WORKING UMC=
LATCHED(UMC+BPMC)
Ø1
$\overline{SMC}$
FORMS A Ø1-Ø2
ONE SHOT
MEC
SYNCHRONIZED
MEMORY
COMPLETE
$\overline{SMC}$
TO/FROM
OUTSIDE
WORLD
INPUT PROTECTION
TO THE
INDIRECT-BIT LATCH
$\overline{MEC}$
Ø2
MEC
TO ROM
MECR
Ø1
Ø2
$\overline{MEC}$
TO ROM
Ø1
Ø2
MECD
TO M-SECTION

FIG 85



THIS FLOW CHART REPRESENTS THE LOGIC PROPERTIES OF THE UMC, SMC AND MEC CIRCUITS, AND NOT MICRO INSTRUCTIONS ENCODED IN THE ROM.

FIG 86

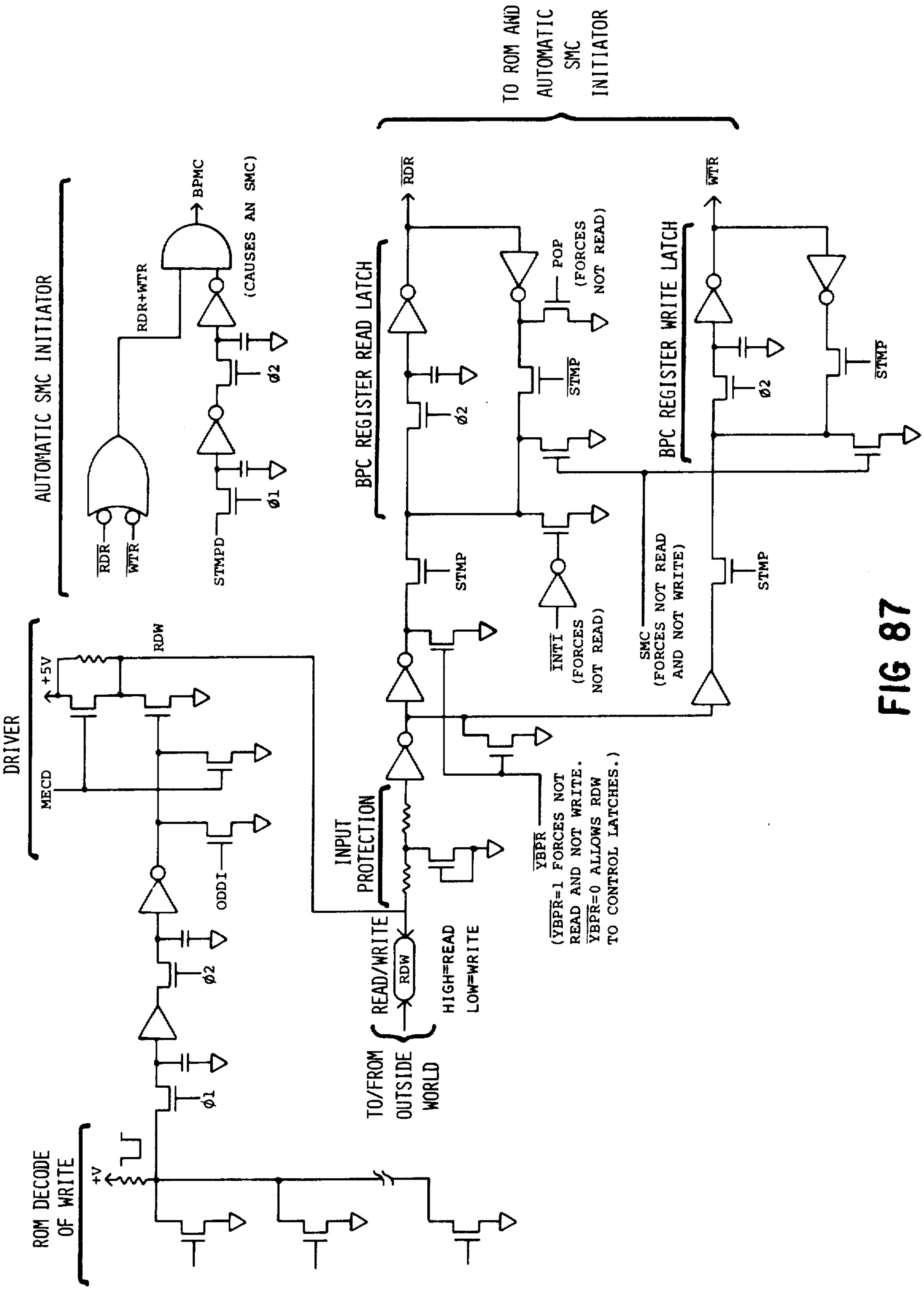

ROM DECODE
OF WRITE
+V
φ1
φ2
DRIVER
MECD
+5V
RDW
ODDI
TO/FROM
OUTSIDE
WORLD
READ/WRITE
RDW
HIGH=READ
LOW=WRITE
INPUT
PROTECTION
STMP
YBPR
(YBPR=1 FORCES NOT
READ AND NOT WRITE.
YBPR=0 ALLOWS RDW
TO CONTROL LATCHES.)
AUTOMATIC SMC INITIATOR
RDR
WTR
RDR+WTR
BPMC
(CAUSES AN SMC)
STMPD
φ1
φ2
BPC REGISTER READ LATCH
φ2
STMP
POP
(FORCES
NOT READ)
INTI
(FORCES
NOT READ)
SMC
(FORCES NOT READ
AND NOT WRITE)
RDR
BPC REGISTER WRITE LATCH
φ2
STMP
STMP
WTR
TO ROM AND
AUTOMATIC
SMC
INITIATOR

FIG 87

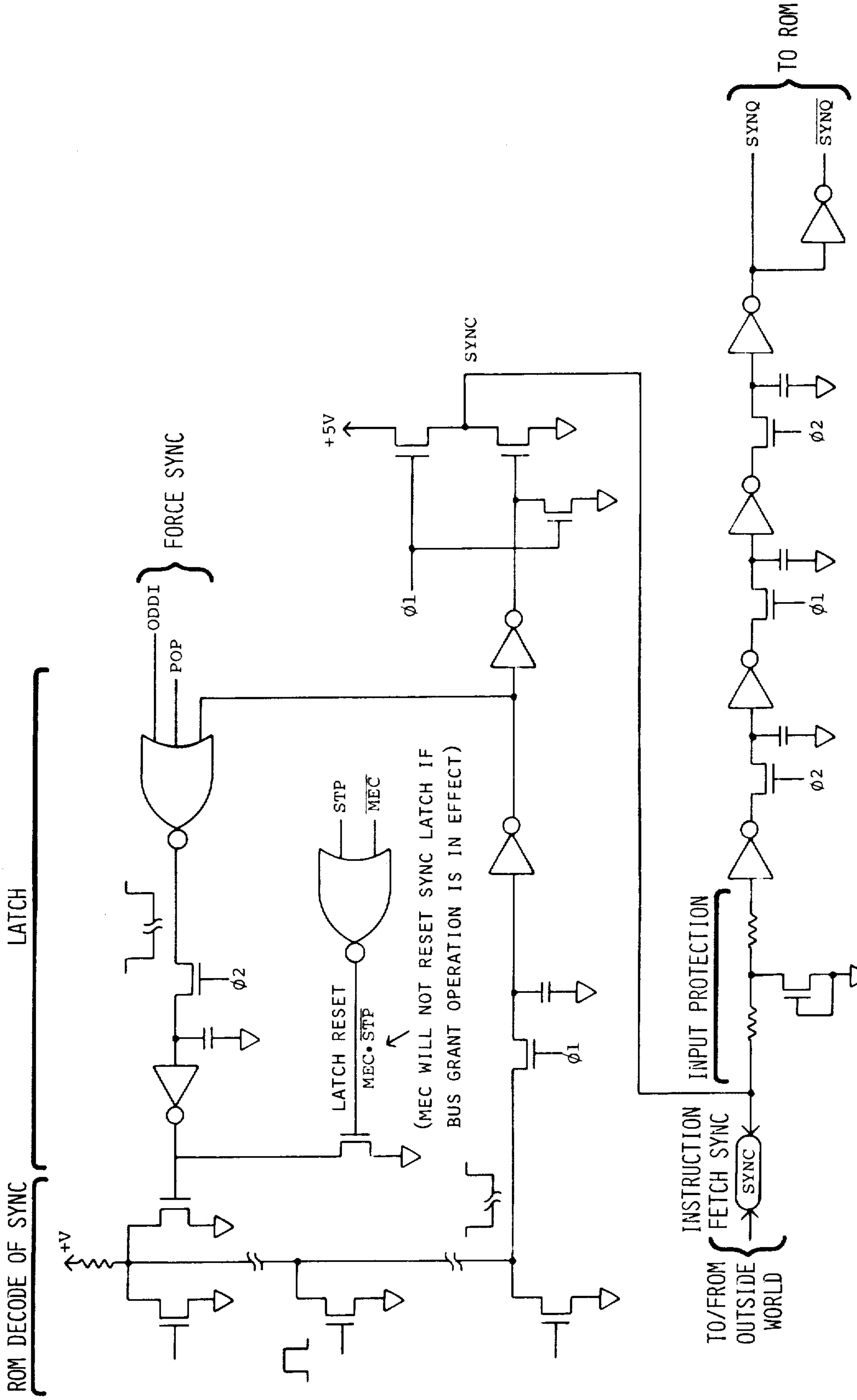

ROM DECODE OF SYNC
LATCH
+V
ODDI
POP
FORCE SYNC
φ2
STP
$\overline{MEC}$
LATCH RESET
MEC•$\overline{STP}$
(MEC WILL NOT RESET SYNC LATCH IF
BUS GRANT OPERATION IS IN EFFECT)
φ1
+5V
φ1
SYNC
TO/FROM
OUTSIDE
WORLD
INSTRUCTION
FETCH SYNC
SYNC
INPUT PROTECTION
φ1
φ2
φ1
φ2
SYNQ
$\overline{SYNQ}$
TO ROM

FIG 88

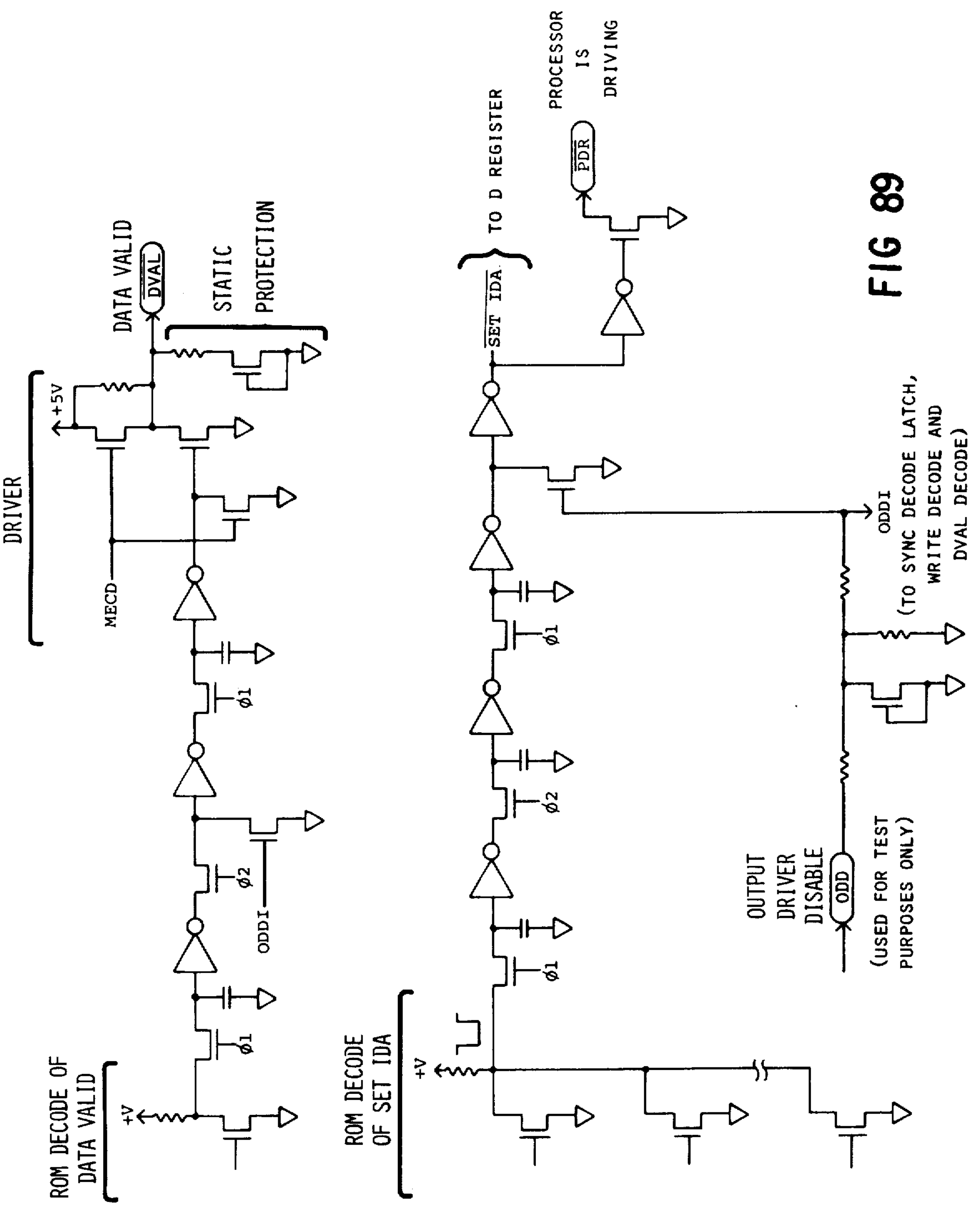

ROM DECODE OF DATA VALID
+V
ϕ1
ϕ2
ODDI
ϕ1
MECD
DRIVER
+5V
DATA VALID
$\overline{DVAL}$
STATIC PROTECTION
ROM DECODE OF SET IDA
+V
ϕ1
ϕ2
ϕ1
$\overline{SET\ IDA}$
TO D REGISTER
PROCESSOR IS DRIVING
$\overline{PDR}$
ODDI
(TO SYNC DECODE LATCH, WRITE DECODE AND DVAL DECODE)
OUTPUT DRIVER DISABLE
ODD
(USED FOR TEST PURPOSES ONLY)

FIG 89

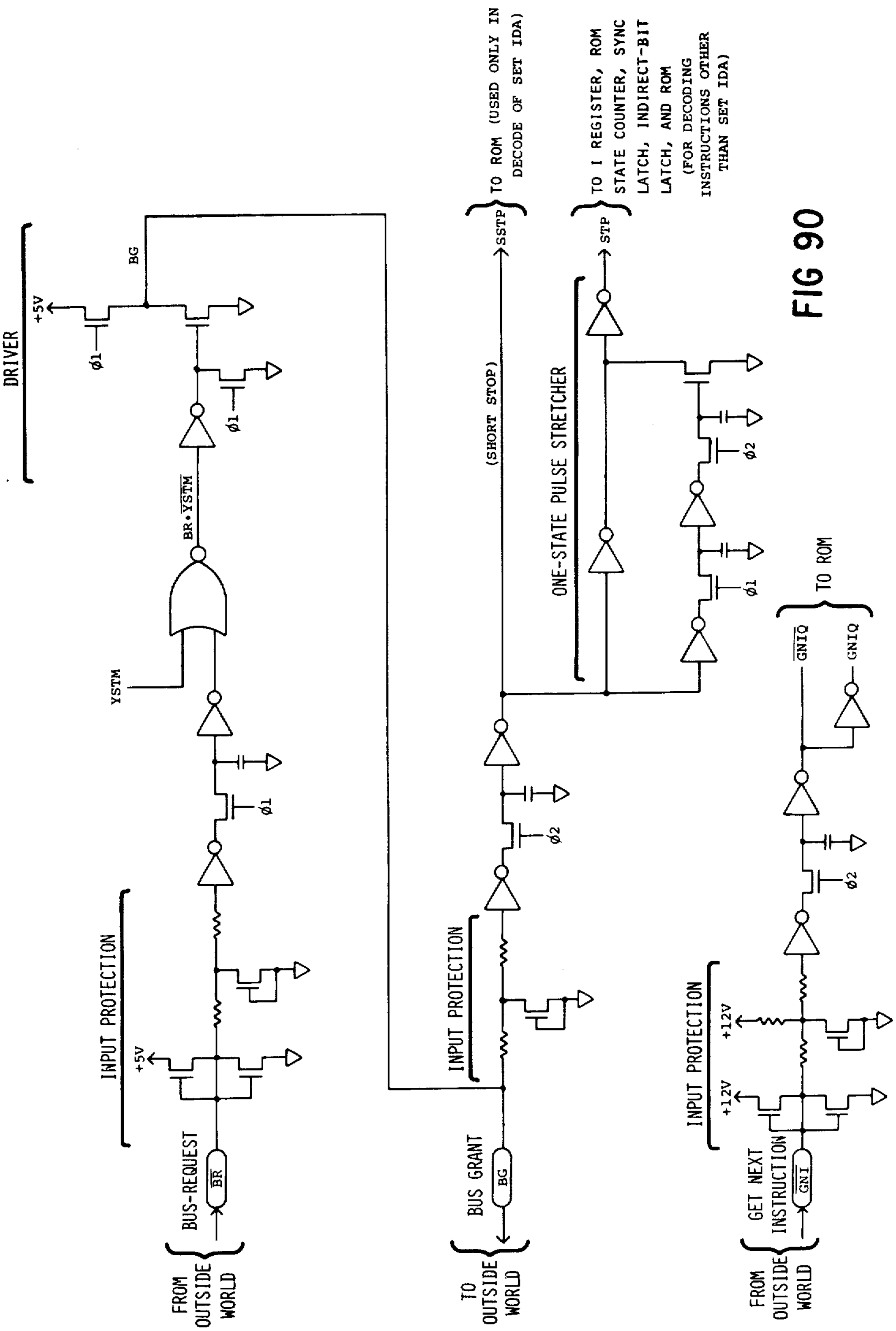

DRIVER
+5V
φ1
BG
φ1
BR•$\overline{YSTM}$
YSTM
φ1
INPUT PROTECTION
+5V
BUS-REQUEST
$\overline{BR}$
FROM OUTSIDE WORLD
TO ROM (USED ONLY IN DECODE OF SET IDA)
SSTP
(SHORT STOP)
φ2
INPUT PROTECTION
BUS GRANT
BG
TO OUTSIDE WORLD
TO I REGISTER, ROM STATE COUNTER, SYNC LATCH, INDIRECT-BIT LATCH, AND ROM (FOR DECODING INSTRUCTIONS OTHER THAN SET IDA)
STP
ONE-STATE PULSE STRETCHER
φ2
φ1
TO ROM
$\overline{GNIQ}$
GNIQ
φ2
INPUT PROTECTION
+12V
+12V
GET NEXT INSTRUCTION
$\overline{GNI}$
FROM OUTSIDE WORLD

FIG 90

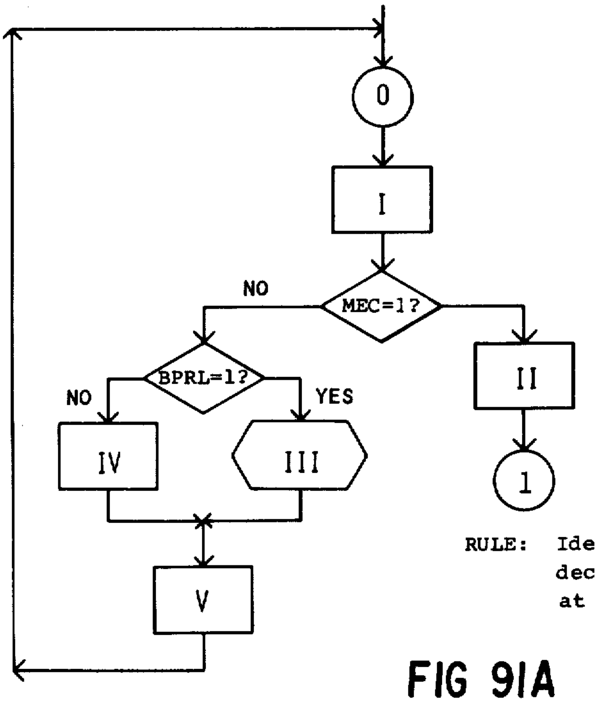
## HOW TO INTERPRET THE BPC ASM CHART

1. What we usually refer to simply as a state ("state 4 for LOAD A") is generally a coincidence of that particular state-count and some group encoding qualifier pattern (representing a particular group). The most precise way to refer to a location on the ASM chart is indicate both the group and state-counts, (say, B4). Some states (0,1,and 14) are completely group independent. States are indicated by circles with numbers in them:④. Group information is prominently displayed next to sections to which it pertains.

2. Each state represents a ∅2 pre-charge and ∅1 decode in the ROM. The ASM chart represents what is decoded from the ROM in the various states; it does not necessarily represent end-results that occur simultaneously. If, for instance, two instructions decoded in the same state have different delays coming from the ROM, then they do not result in simultaneous activity, even though they are drawn as being in the same state.

3. Rectangular boxes ( SET A ) denote micro-instructions. Diamonds ( MEC=1? ) denote qualifiers affecting the decoding of micro-instructions. Ovals ( STM ) denote micro-instructions that are actually decoded and given, but that are "don't-cares". That is, they are present but do not affect the algorithmic process. Sometimes these don't-cares are the result of minimization, and sometimes they are a result of the way the flow charts have been drawn (in an attempt to make them more easily understood).

4. All activity within a state is decoded and initiated (its delay is begun) at the same time. The fact that a state is shown as a sequential arrangement of boxes and diamonds does not imply sequential activity; the entire state is decoded simultaneously. For example, state 0 is represented below:



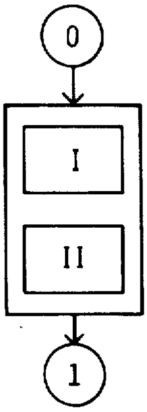
RULE: Identify the path, then decode all instructions at once.

FIG 91A

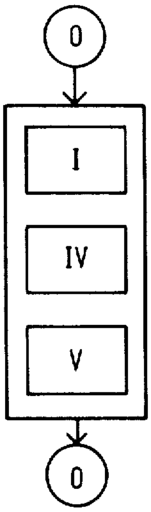
## HOW TO INTERPRET THE BPC ASM CHART, CONT.

Another way to represent the same activity is illustrated below. We don't draw the ASM chart that way because of the increased size and because of problems in achieving connectedness. Also, overall algorithmic process would be hard to see; the more compact notation results in a more effective visual outline. Within a state however, the expanded notation is often less confusing as it more closely represents the actual way things are done.

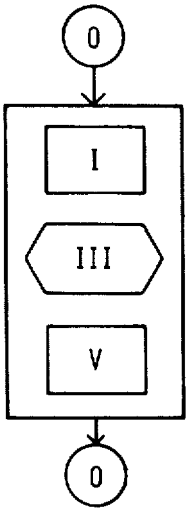
If MEC=1, then:



If MEC=0, and BPRL=0, then:



If MEC=0 and BPRL=1, then:



5. Within a state, related instructions are grouped together in the same box solely for the sake of algorithmic clarity.

6. Because of limitations on transistor device size, and the large capacitances of the IDA lines, two consecutive SET IDA's are required to ensure that IDA lines assume their proper final values. If what is being transmitted with the SET IDA is an address for Memory, the STM will accompany the second SET IDA. If data is being written to Memory, DVAL will accompany the second and all subsequent SET IDA's until Memory Complete is received. In either case, the IDA lines will be stable before the start of the second SET IDA.

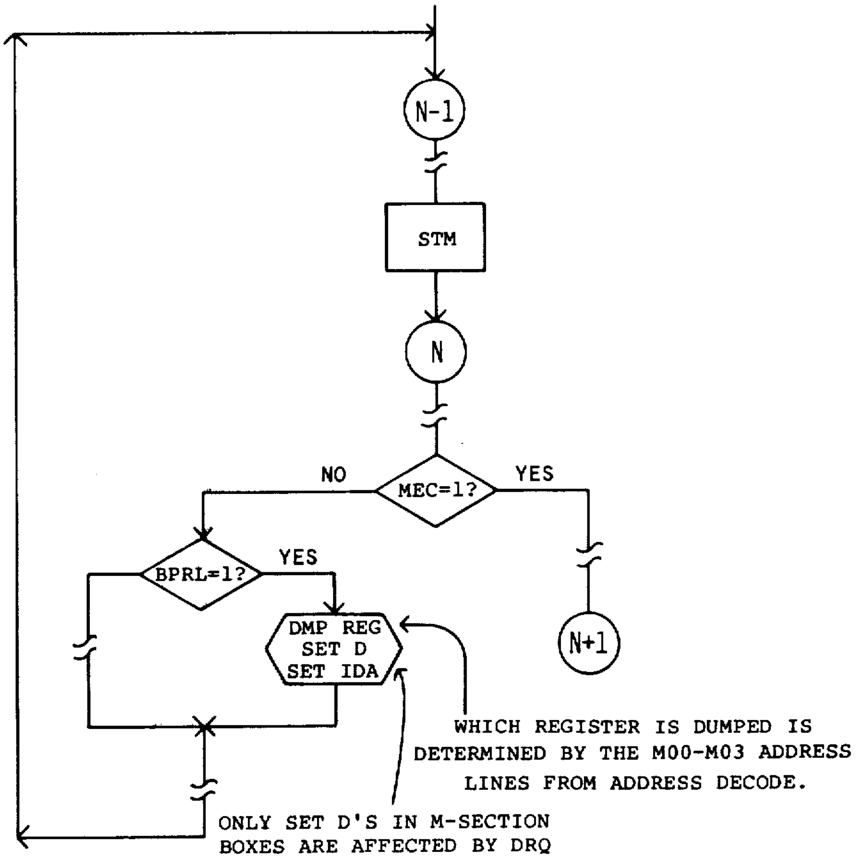
7. The symbol represents activity controlled by the M-Section. The micro-instructions shown inside are encoded in the ROM, just as are any other micro-instructions. However, these particular instances of decoding those micro-instructions are independent of all group and state-count qualifier lines in the ROM. They are decoded against qualifiers generated by the M-Section and Address Decode. ($\overline{RDR}$, $\overline{WTR}$, $\overline{DRQ}$, M00-M03).

8. The qualifiers that enable such M-Section activity are generated when STM occurs in conjuction with an address on the IDA lines that specifies a register within the BPC. These qualifiers are not always generated immediately, nor are they necessarily co-incident with one another.

FIG 91B

## HOW TO INTERPRET THE BPC ASM CHART, CONT.

9. Consider the following typical situation:



WHICH REGISTER IS DUMPED IS DETERMINED BY THE M00-M03 ADDRESS LINES FROM ADDRESS DECODE.

ONLY SET D'S IN M-SECTION BOXES ARE AFFECTED BY DRQ

In this example the STM occurs in the state prior to the one with the M-Section activity. The machine will stay in state N for 4 consecutive state-times: 3 "no's" and a "yes" for the MEC qualifier. The BPRL qualifier (from Address Decode) will be met each time, but due to delays in the M-Section the first pass through state N generates none of the M-Section activity. The second and third passes do perform the indicated activity, except for the SET D. It is done during the second pass, but not during the third. This is a result of $\overline{\text{DRQ}}$, and prevents D from tracking the pre-charge of the $\overline{\text{IDB}}$ Bus which follows the execution of the SET D. This prevents the second SET IDA from producing a glitch on the IDA lines.

Sometimes the STM is given in state N-2. In such a case the one state of M-Section delay is spent while in state N-1, and only three state-times are spent in state N. When this happens the M-Section activity occurs immediately on the first and second of these; the third meets the MEC qualifier. As before, the SET D is done only once.

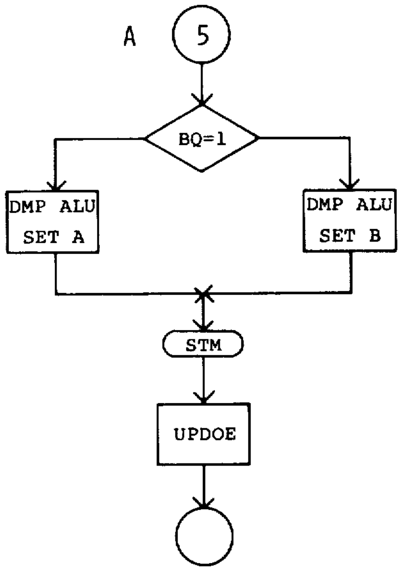
Such an instance occurs between states C2 and C9. There are several others.

FIG 91C

## HOW TO INTERPRET THE BPC ASM CHART, CONT.

10. Sometimes, as in state C9, the BPRL qualifier is shown by a dotted line: <BPRL=1?> This occurs only when the machine represented by the ASM chart has no activity in that state that is conditional upon BPRL. Therefore, BPRL is a don't-care for the ASM chart at that state, and indeed is not used in the ROM there. However, it still initiates M-Section activity when met. And when it is met no externally caused MEC will be forthcoming, since no memory external to the BPC is involved. The MEC will be supplied by the M-Section itself, as soon as its activity is finished. In these cases the timing is as outlined in 9 above, and we show a BPRL qualifier that affects the M-Section, but not that point in the ROM, to remind the reader of what's happening.

11. Finally, a word about the correspondence between what's in the ROM and how the flow charts are drawn. The flow charts have been "de-minimized" to promote their ease of understanding. For instance, state A5 is shown as:



There are not two instances of decoding DMP ALU for state A5. The decoding of DMP ALU in that state is independent of the BQ qualifier, as it is done regardless of that qualifiers outcome.

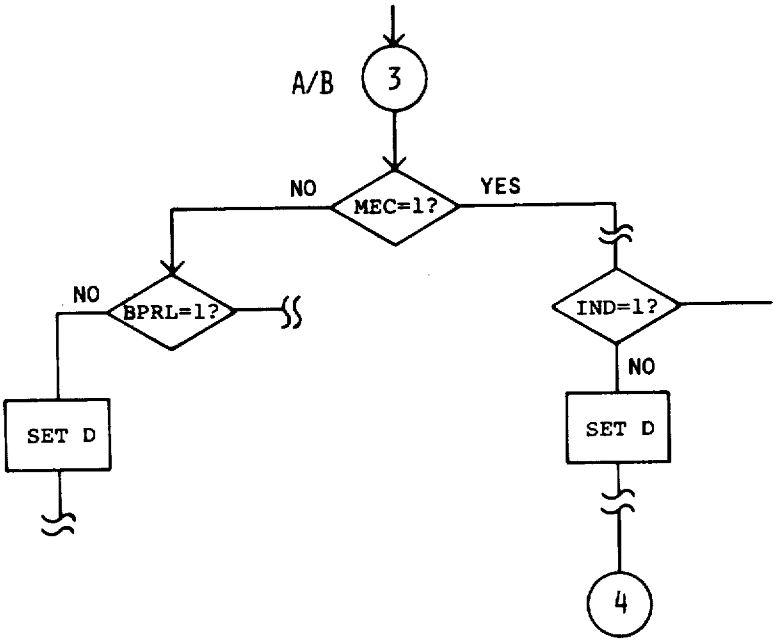
State A5 could just as easily be drawn with a single DMP ALU in the same box as the UPDOE, or in a separate box of its own, ahead of the BQ qualifier.

Such redrawing often adds a welcome measure of clarity in loops involving repeated SET IDA's and multiple qualifiers. It lets us indicate what's in D at the time a SET IDA is given after certain qualifiers have been met or failed.

FIG 91D

## HOW TO INTERPRET THE BPC ASM CHART, CONT.

Not all instances of the same instruction appearing twice in the same state are the result of de-minimization, however. The two SET D's in state A/B3 represent separate instances of decoding that instruction. The partial structure of the state is shown below:



Here each SET D is conditional upon a different qualifier. Because of the way the ROM is organized, an instance of an instruction being decoded represents the "AND" of selected conditions:

$$\text{IF STATE 3 AND } \underbrace{\text{GROUP A/B}}_{GP1\cdot GP2\cdot \overline{GP3} \;\longleftarrow\; (GP0=1 \text{ for A, 0 for B})} \text{ AND NOT BPRL, THEN SET D}$$

The other instance of decoding SET D in that state is:

IF STATE 3 AND GROUP A/B AND NOT IND, THEN SET D

The combination:

THE CONDITION OR CONDITION, THEN SET D

does not exist as a single encoding. It is simply the "OR" (during fan-in) of the two separate "AND's" as shown above.

FIG 91E

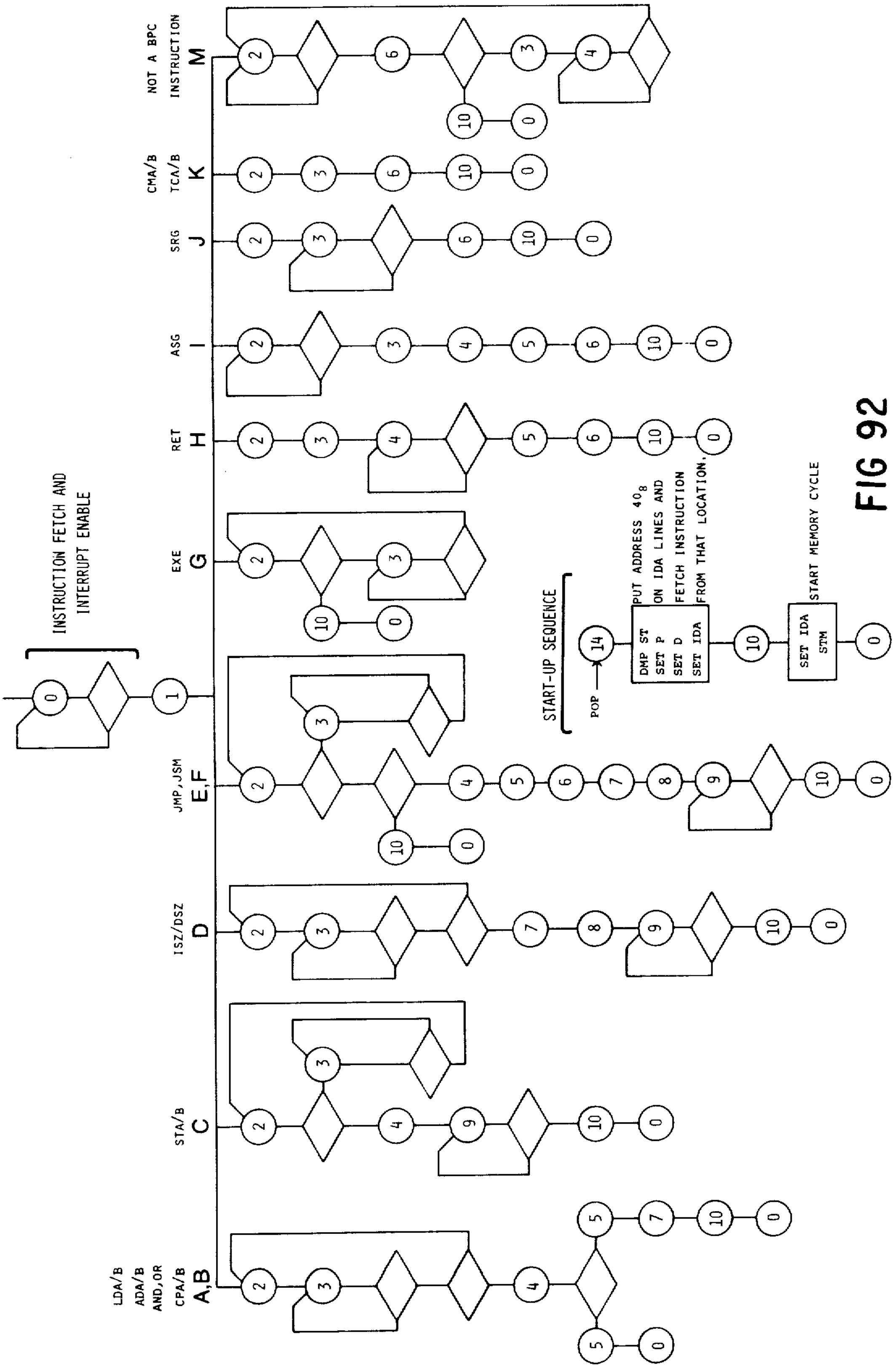

INSTRUCTION FETCH AND INTERRUPT ENABLE
LDA/B
ADA/B
AND,OR
CPA/B
A,B
STA/B
C
ISZ/DSZ
D
JMP,JSM
E,F
EXE
G
RET
H
ASG
I
SRG
J
CMA/B
TCA/B
K
NOT A BPC
INSTRUCTION
M
START-UP SEQUENCE
POP
14
DMP ST
SET P
SET D
SET IDA
PUT ADDRESS $40_8$
ON IDA LINES AND
FETCH INSTRUCTION
FROM THAT LOCATION.
SET IDA
STM
START MEMORY CYCLE

FIG 92

THE MICRO-INSTRUCTIONS SHOWN IN STATES 0 AND 1 (THAT IS, THIS SECTION OF FLOWCHART) ARE, IN THESE INSTANCES, INDEPENDENT OF THE GROUP QUALIFIERS (GP0-GP3). IN GENERAL, OTHER INSTANCES OF DECODING THESE (OR OTHER) MICRO-INSTRUCTIONS ARE NOT INDEPENDENT OF THE GROUP QUALIFIERS.

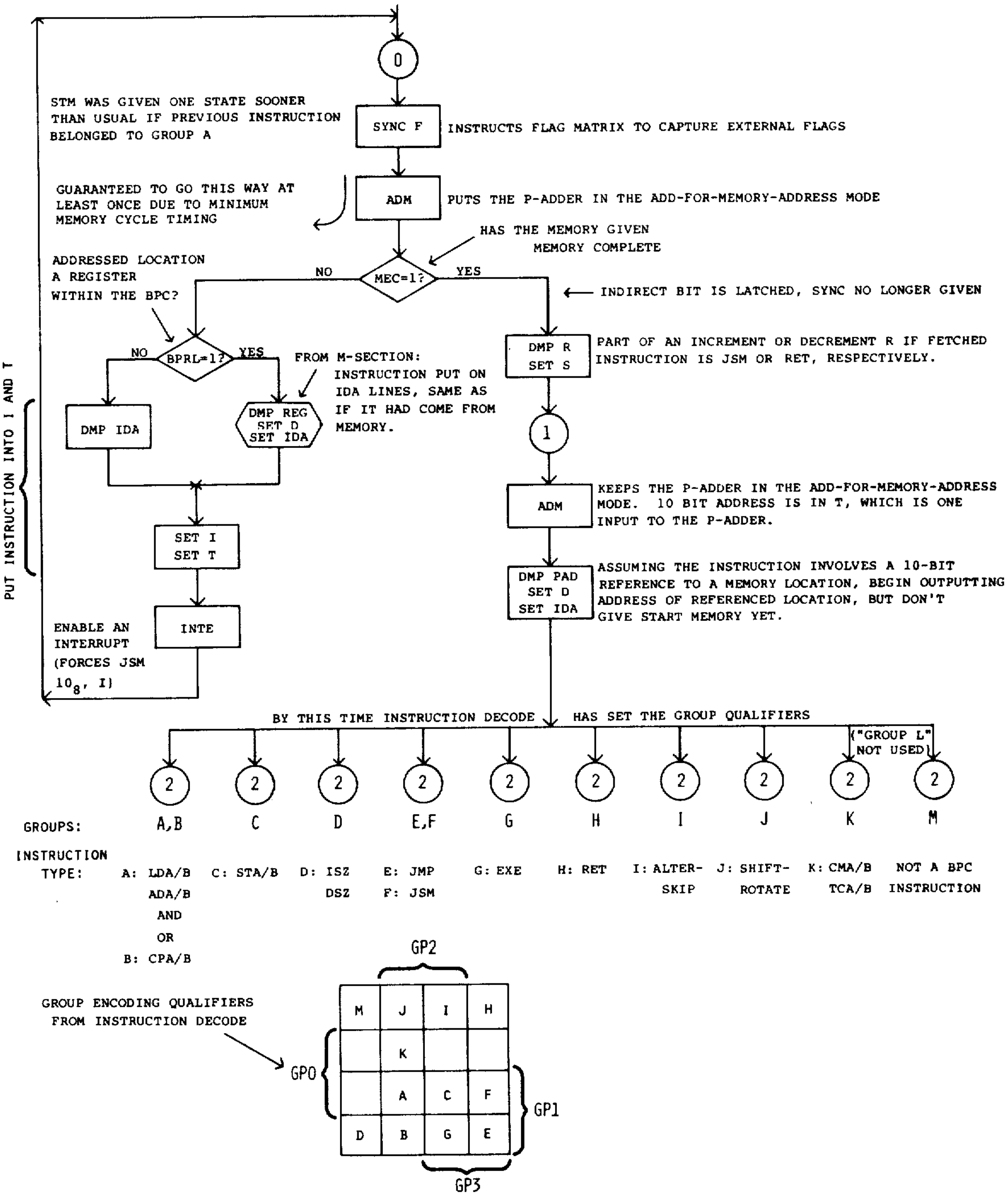

0
STM WAS GIVEN ONE STATE SOONER THAN USUAL IF PREVIOUS INSTRUCTION BELONGED TO GROUP A
SYNC F
INSTRUCTS FLAG MATRIX TO CAPTURE EXTERNAL FLAGS
GUARANTEED TO GO THIS WAY AT LEAST ONCE DUE TO MINIMUM MEMORY CYCLE TIMING
ADM
PUTS THE P-ADDER IN THE ADD-FOR-MEMORY-ADDRESS MODE
HAS THE MEMORY GIVEN MEMORY COMPLETE
ADDRESSED LOCATION A REGISTER WITHIN THE BPC?
NO
MEC=1?
YES
INDIRECT BIT IS LATCHED, SYNC NO LONGER GIVEN
NO
BPRL=1?
YES
FROM M-SECTION: INSTRUCTION PUT ON IDA LINES, SAME AS IF IT HAD COME FROM MEMORY.
DMP R
SET S
PART OF AN INCREMENT OR DECREMENT R IF FETCHED INSTRUCTION IS JSM OR RET, RESPECTIVELY.
DMP IDA
DMP REG
SET D
SET IDA
1
PUT INSTRUCTION INTO I AND T
ADM
KEEPS THE P-ADDER IN THE ADD-FOR-MEMORY-ADDRESS MODE. 10 BIT ADDRESS IS IN T, WHICH IS ONE INPUT TO THE P-ADDER.
SET I
SET T
DMP PAD
SET D
SET IDA
ASSUMING THE INSTRUCTION INVOLVES A 10-BIT REFERENCE TO A MEMORY LOCATION, BEGIN OUTPUTTING ADDRESS OF REFERENCED LOCATION, BUT DON'T GIVE START MEMORY YET.
ENABLE AN INTERRUPT (FORCES JSM $10_8$, I)
INTE
BY THIS TIME INSTRUCTION DECODE HAS SET THE GROUP QUALIFIERS
("GROUP L" NOT USED)
2 2 2 2 2 2 2 2 2 2
GROUPS: A,B C D E,F G H I J K M
INSTRUCTION TYPE:
A: LDA/B ADA/B AND OR
B: CPA/B
C: STA/B
D: ISZ DSZ
E: JMP
F: JSM
G: EXE
H: RET
I: ALTER-SKIP
J: SHIFT-ROTATE
K: CMA/B TCA/B
NOT A BPC INSTRUCTION
GROUP ENCODING QUALIFIERS FROM INSTRUCTION DECODE
GP2
GP0
GP1
GP3
M J I H
K
A C F
D B G E

FIG 93

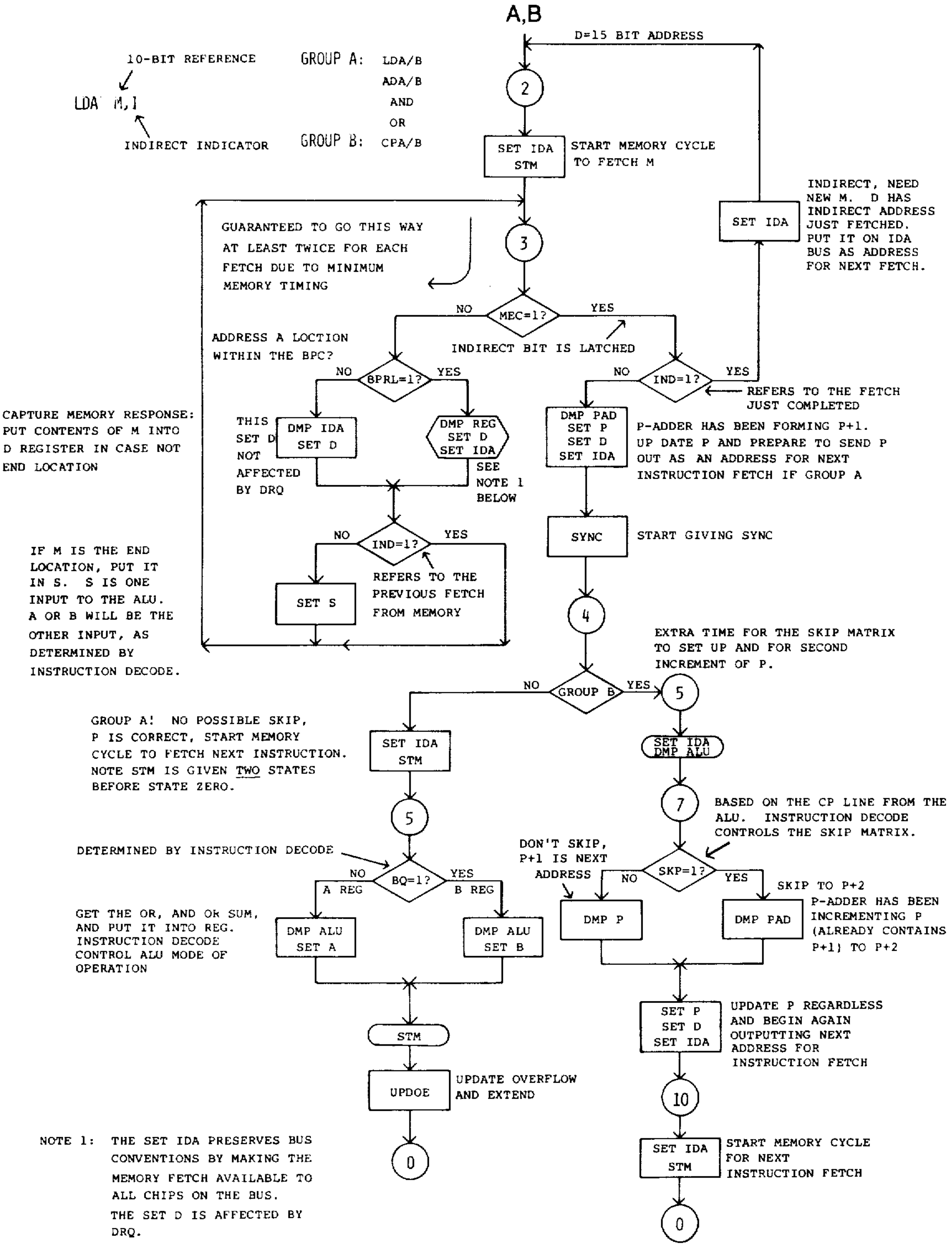

A,B
D=15 BIT ADDRESS
10-BIT REFERENCE
LDA M,I
INDIRECT INDICATOR
GROUP A: LDA/B
ADA/B
AND
OR
GROUP B: CPA/B
2
SET IDA
STM
START MEMORY CYCLE
TO FETCH M
SET IDA
INDIRECT, NEED
NEW M. D HAS
INDIRECT ADDRESS
JUST FETCHED.
PUT IT ON IDA
BUS AS ADDRESS
FOR NEXT FETCH.
GUARANTEED TO GO THIS WAY
AT LEAST TWICE FOR EACH
FETCH DUE TO MINIMUM
MEMORY TIMING
3
NO
MEC=1?
YES
INDIRECT BIT IS LATCHED
ADDRESS A LOCTION
WITHIN THE BPC?
NO
BPRL=1?
YES
NO
IND=1?
YES
REFERS TO THE FETCH
JUST COMPLETED
CAPTURE MEMORY RESPONSE:
PUT CONTENTS OF M INTO
D REGISTER IN CASE NOT
END LOCATION
THIS
SET D
NOT
AFFECTED
BY DRQ
DMP IDA
SET D
DMP REG
SET D
SET IDA
SEE
NOTE 1
BELOW
DMP PAD
SET P
SET D
SET IDA
P-ADDER HAS BEEN FORMING P+1.
UP DATE P AND PREPARE TO SEND P
OUT AS AN ADDRESS FOR NEXT
INSTRUCTION FETCH IF GROUP A
NO
IND=1?
YES
REFERS TO THE
PREVIOUS FETCH
FROM MEMORY
SET S
IF M IS THE END
LOCATION, PUT IT
IN S. S IS ONE
INPUT TO THE ALU.
A OR B WILL BE THE
OTHER INPUT, AS
DETERMINED BY
INSTRUCTION DECODE.
SYNC
START GIVING SYNC
4
EXTRA TIME FOR THE SKIP MATRIX
TO SET UP AND FOR SECOND
INCREMENT OF P.
NO
GROUP B
YES
5
GROUP A! NO POSSIBLE SKIP,
P IS CORRECT, START MEMORY
CYCLE TO FETCH NEXT INSTRUCTION.
NOTE STM IS GIVEN TWO STATES
BEFORE STATE ZERO.
SET IDA
STM
SET IDA
DMP ALU
7
BASED ON THE CP LINE FROM THE
ALU. INSTRUCTION DECODE
CONTROLS THE SKIP MATRIX.
5
DETERMINED BY INSTRUCTION DECODE
NO
A REG
BQ=1?
YES
B REG
DON'T SKIP,
P+1 IS NEXT
ADDRESS
NO
SKP=1?
YES
SKIP TO P+2
GET THE OR, AND OR SUM,
AND PUT IT INTO REG.
INSTRUCTION DECODE
CONTROL ALU MODE OF
OPERATION
DMP ALU
SET A
DMP ALU
SET B
DMP P
DMP PAD
P-ADDER HAS BEEN
INCREMENTING P
(ALREADY CONTAINS
P+1) TO P+2
SET P
SET D
SET IDA
UPDATE P REGARDLESS
AND BEGIN AGAIN
OUTPUTTING NEXT
ADDRESS FOR
INSTRUCTION FETCH
STM
UPDOE
UPDATE OVERFLOW
AND EXTEND
10
SET IDA
STM
START MEMORY CYCLE
FOR NEXT
INSTRUCTION FETCH
0
0
NOTE 1: THE SET IDA PRESERVES BUS
CONVENTIONS BY MAKING THE
MEMORY FETCH AVAILABLE TO
ALL CHIPS ON THE BUS.
THE SET D IS AFFECTED BY
DRQ.

FIG 94

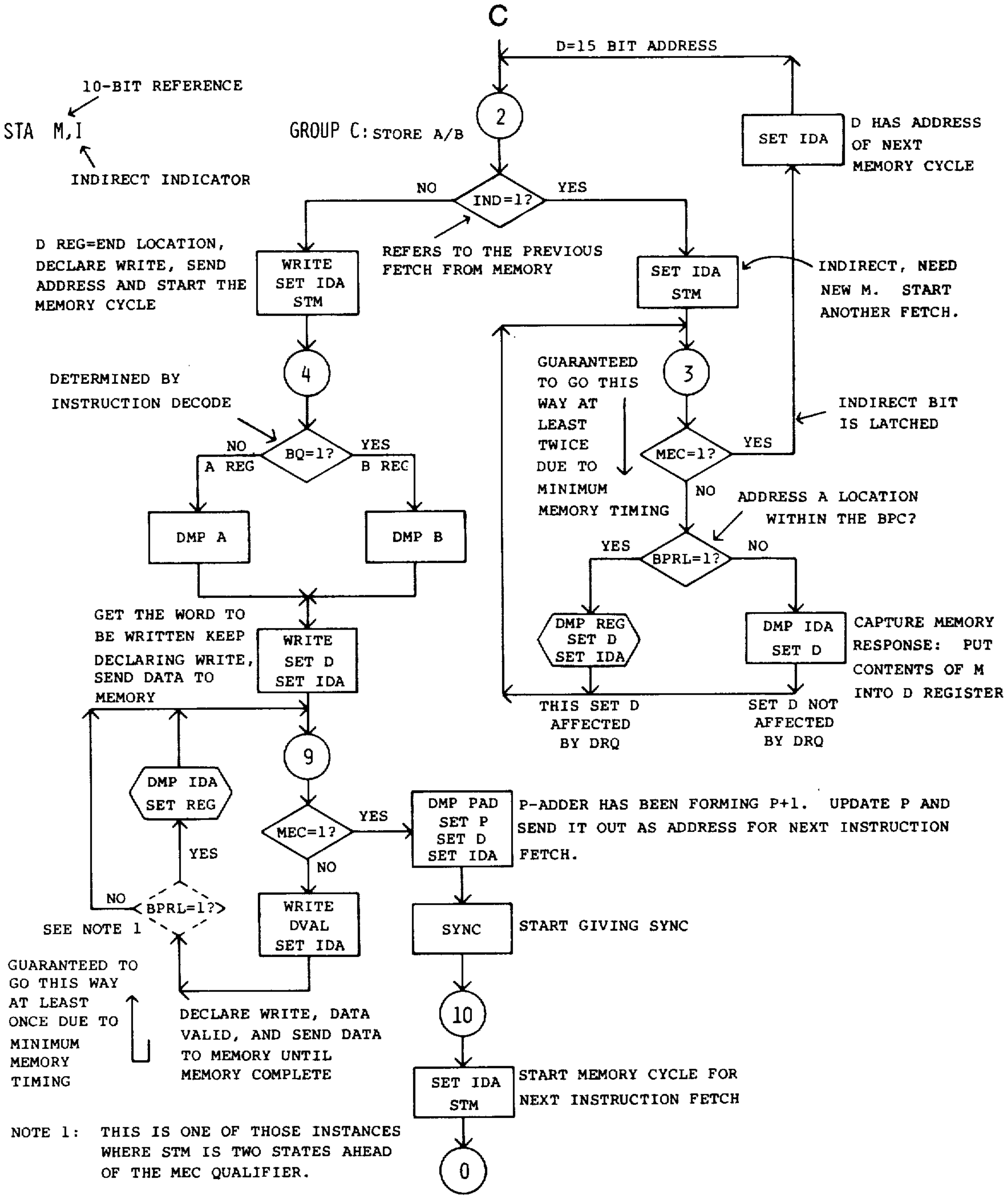

C
D=15 BIT ADDRESS
10-BIT REFERENCE
STA M,I
INDIRECT INDICATOR
GROUP C: STORE A/B
2
SET IDA
D HAS ADDRESS OF NEXT MEMORY CYCLE
NO
IND=1?
YES
D REG=END LOCATION, DECLARE WRITE, SEND ADDRESS AND START THE MEMORY CYCLE
WRITE
SET IDA
STM
REFERS TO THE PREVIOUS FETCH FROM MEMORY
SET IDA
STM
INDIRECT, NEED NEW M. START ANOTHER FETCH.
4
DETERMINED BY INSTRUCTION DECODE
GUARANTEED TO GO THIS WAY AT LEAST TWICE DUE TO MINIMUM MEMORY TIMING
3
INDIRECT BIT IS LATCHED
NO
A REG
BQ=1?
YES
B REG
MEC=1?
YES
NO
ADDRESS A LOCATION WITHIN THE BPC?
DMP A
DMP B
YES
BPRL=1?
NO
GET THE WORD TO BE WRITTEN KEEP DECLARING WRITE, SEND DATA TO MEMORY
WRITE
SET D
SET IDA
DMP REG
SET D
SET IDA
DMP IDA
SET D
CAPTURE MEMORY RESPONSE: PUT CONTENTS OF M INTO D REGISTER
THIS SET D AFFECTED BY DRQ
SET D NOT AFFECTED BY DRQ
9
DMP IDA
SET REG
MEC=1?
YES
DMP PAD
SET P
SET D
SET IDA
P-ADDER HAS BEEN FORMING P+1. UPDATE P AND SEND IT OUT AS ADDRESS FOR NEXT INSTRUCTION FETCH.
YES
NO
NO
BPRL=1?
SEE NOTE 1
WRITE
DVAL
SET IDA
SYNC
START GIVING SYNC
GUARANTEED TO GO THIS WAY AT LEAST ONCE DUE TO MINIMUM MEMORY TIMING
DECLARE WRITE, DATA VALID, AND SEND DATA TO MEMORY UNTIL MEMORY COMPLETE
10
SET IDA
STM
START MEMORY CYCLE FOR NEXT INSTRUCTION FETCH
NOTE 1: THIS IS ONE OF THOSE INSTANCES WHERE STM IS TWO STATES AHEAD OF THE MEC QUALIFIER.
0

FIG 95

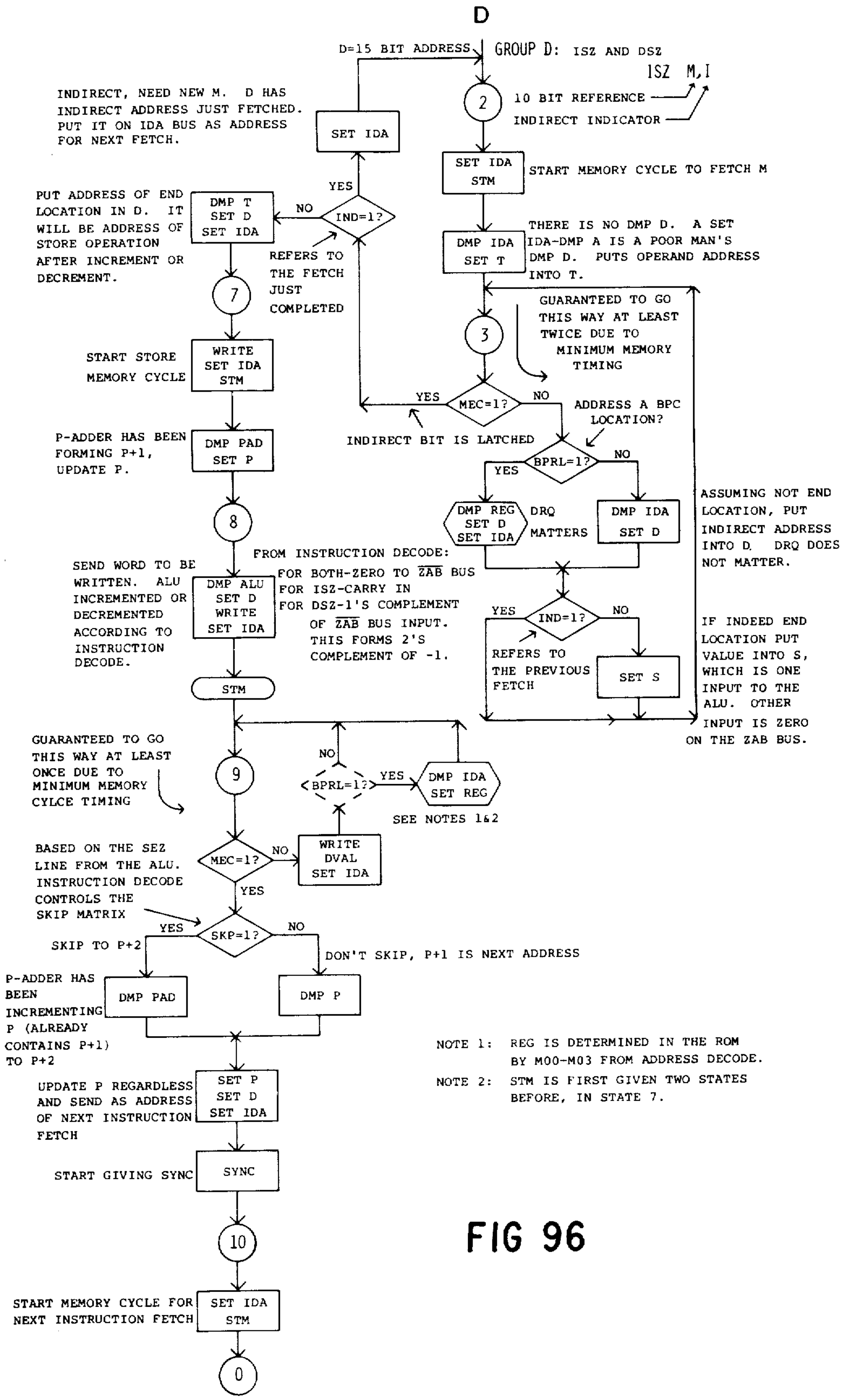

D
D=15 BIT ADDRESS
GROUP D: ISZ AND DSZ
ISZ M,I
2
10 BIT REFERENCE
INDIRECT INDICATOR
INDIRECT, NEED NEW M. D HAS INDIRECT ADDRESS JUST FETCHED. PUT IT ON IDA BUS AS ADDRESS FOR NEXT FETCH.
SET IDA
SET IDA STM
START MEMORY CYCLE TO FETCH M
YES
PUT ADDRESS OF END LOCATION IN D. IT WILL BE ADDRESS OF STORE OPERATION AFTER INCREMENT OR DECREMENT.
DMP T SET D SET IDA
NO
IND=1?
REFERS TO THE FETCH JUST COMPLETED
DMP IDA SET T
THERE IS NO DMP D. A SET IDA-DMP A IS A POOR MAN'S DMP D. PUTS OPERAND ADDRESS INTO T.
7
GUARANTEED TO GO THIS WAY AT LEAST TWICE DUE TO MINIMUM MEMORY TIMING
3
START STORE MEMORY CYCLE
WRITE SET IDA STM
YES
MEC=1?
NO
ADDRESS A BPC LOCATION?
INDIRECT BIT IS LATCHED
P-ADDER HAS BEEN FORMING P+1, UPDATE P.
DMP PAD SET P
BPRL=1?
YES
NO
ASSUMING NOT END LOCATION, PUT INDIRECT ADDRESS INTO D. DRQ DOES NOT MATTER.
8
DMP REG SET D SET IDA
DRQ MATTERS
DMP IDA SET D
FROM INSTRUCTION DECODE:
SEND WORD TO BE WRITTEN. ALU INCREMENTED OR DECREMENTED ACCORDING TO INSTRUCTION DECODE.
DMP ALU SET D WRITE SET IDA
FOR BOTH-ZERO TO $\overline{ZAB}$ BUS
FOR ISZ-CARRY IN
FOR DSZ-1'S COMPLEMENT OF $\overline{ZAB}$ BUS INPUT. THIS FORMS 2'S COMPLEMENT OF -1.
YES
IND=1?
NO
IF INDEED END LOCATION PUT VALUE INTO S, WHICH IS ONE INPUT TO THE ALU. OTHER INPUT IS ZERO ON THE ZAB BUS.
REFERS TO THE PREVIOUS FETCH
SET S
STM
GUARANTEED TO GO THIS WAY AT LEAST ONCE DUE TO MINIMUM MEMORY CYLCE TIMING
NO
9
BPRL=1?
YES
DMP IDA SET REG
SEE NOTES 1&2
BASED ON THE SEZ LINE FROM THE ALU. INSTRUCTION DECODE CONTROLS THE SKIP MATRIX
MEC=1?
NO
WRITE DVAL SET IDA
YES
YES
SKP=1?
NO
SKIP TO P+2
DON'T SKIP, P+1 IS NEXT ADDRESS
P-ADDER HAS BEEN INCREMENTING P (ALREADY CONTAINS P+1) TO P+2
DMP PAD
DMP P
NOTE 1: REG IS DETERMINED IN THE ROM BY M00-M03 FROM ADDRESS DECODE.
NOTE 2: STM IS FIRST GIVEN TWO STATES BEFORE, IN STATE 7.
UPDATE P REGARDLESS AND SEND AS ADDRESS OF NEXT INSTRUCTION FETCH
SET P SET D SET IDA
START GIVING SYNC
SYNC
10
START MEMORY CYCLE FOR NEXT INSTRUCTION FETCH
SET IDA STM
0

FIG 96

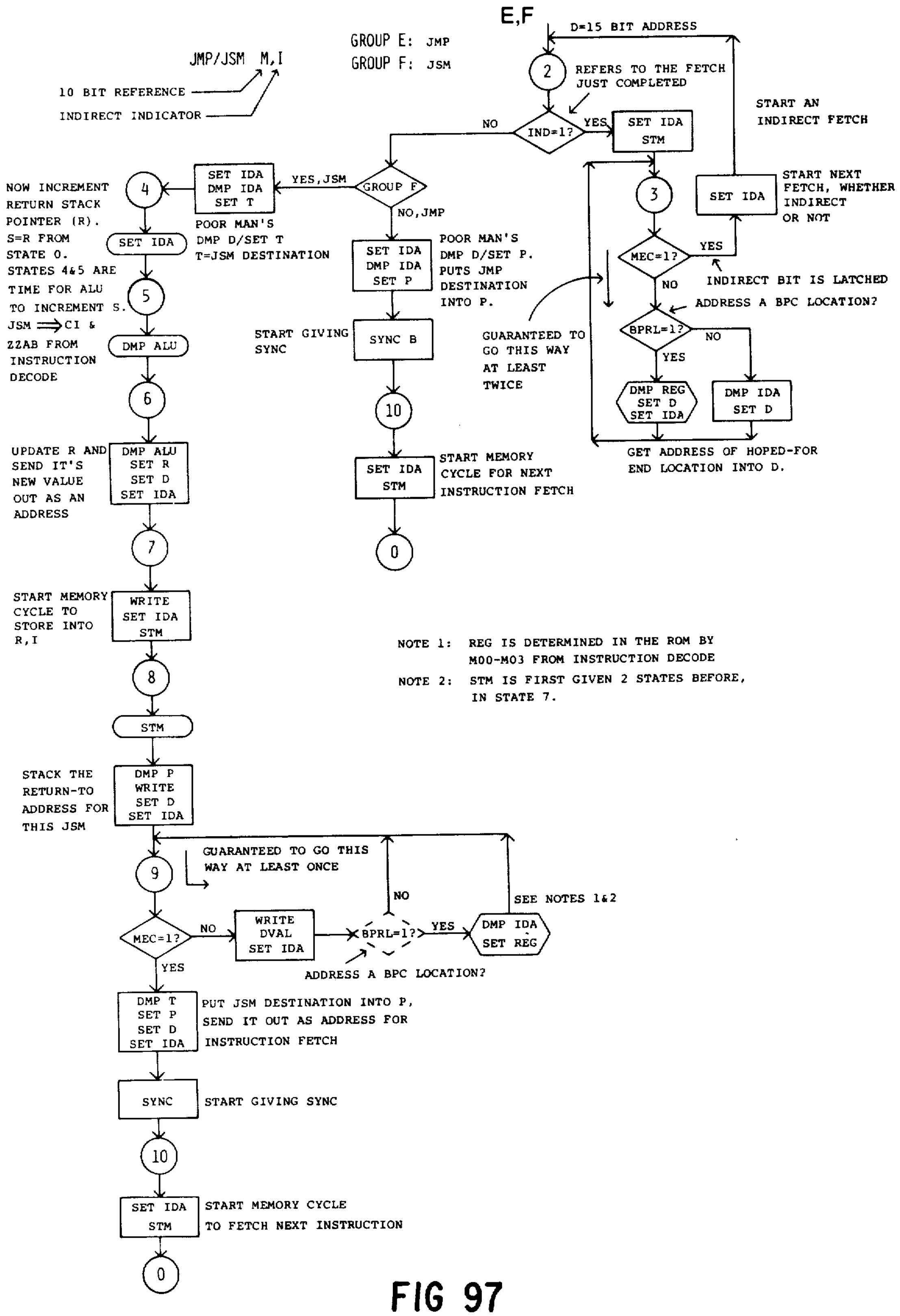

E,F
D=15 BIT ADDRESS
GROUP E: JMP
GROUP F: JSM
JMP/JSM M,I
10 BIT REFERENCE
INDIRECT INDICATOR
2
REFERS TO THE FETCH JUST COMPLETED
START AN INDIRECT FETCH
NO
IND=1?
YES
SET IDA STM
3
SET IDA
START NEXT FETCH, WHETHER INDIRECT OR NOT
MEC=1?
YES
NO
INDIRECT BIT IS LATCHED
ADDRESS A BPC LOCATION?
BPRL=1?
NO
YES
DMP REG SET D SET IDA
DMP IDA SET D
GET ADDRESS OF HOPED-FOR END LOCATION INTO D.
GUARANTEED TO GO THIS WAY AT LEAST TWICE
GROUP F
YES,JSM
NO,JMP
SET IDA DMP IDA SET T
POOR MAN'S DMP D/SET T T=JSM DESTINATION
SET IDA DMP IDA SET P
POOR MAN'S DMP D/SET P. PUTS JMP DESTINATION INTO P.
START GIVING SYNC
SYNC B
10
SET IDA STM
START MEMORY CYCLE FOR NEXT INSTRUCTION FETCH
0
NOW INCREMENT RETURN STACK POINTER (R). S=R FROM STATE 0. STATES 4&5 ARE TIME FOR ALU TO INCREMENT S. JSM ⟹CI & ZZAB FROM INSTRUCTION DECODE
4
SET IDA
5
DMP ALU
6
UPDATE R AND SEND IT'S NEW VALUE OUT AS AN ADDRESS
DMP ALU SET R SET D SET IDA
7
START MEMORY CYCLE TO STORE INTO R,I
WRITE SET IDA STM
8
STM
STACK THE RETURN-TO ADDRESS FOR THIS JSM
DMP P WRITE SET D SET IDA
GUARANTEED TO GO THIS WAY AT LEAST ONCE
9
MEC=1?
NO
WRITE DVAL SET IDA
BPRL=1?
YES
NO
DMP IDA SET REG
SEE NOTES 1&2
ADDRESS A BPC LOCATION?
YES
DMP T SET P SET D SET IDA
PUT JSM DESTINATION INTO P, SEND IT OUT AS ADDRESS FOR INSTRUCTION FETCH
SYNC
START GIVING SYNC
10
SET IDA STM
START MEMORY CYCLE TO FETCH NEXT INSTRUCTION
0
NOTE 1: REG IS DETERMINED IN THE ROM BY M00-M03 FROM INSTRUCTION DECODE
NOTE 2: STM IS FIRST GIVEN 2 STATES BEFORE, IN STATE 7.

FIG 97

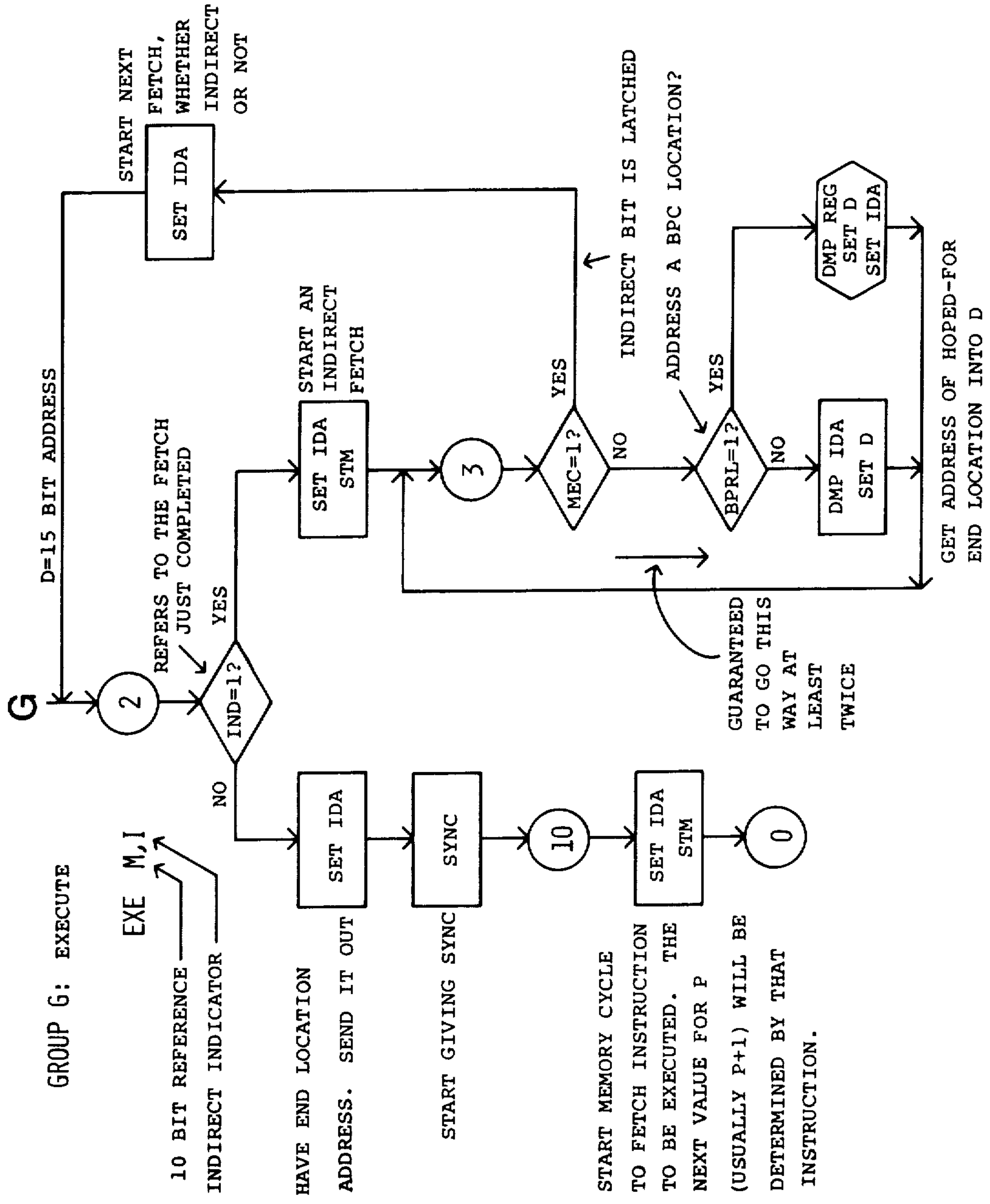
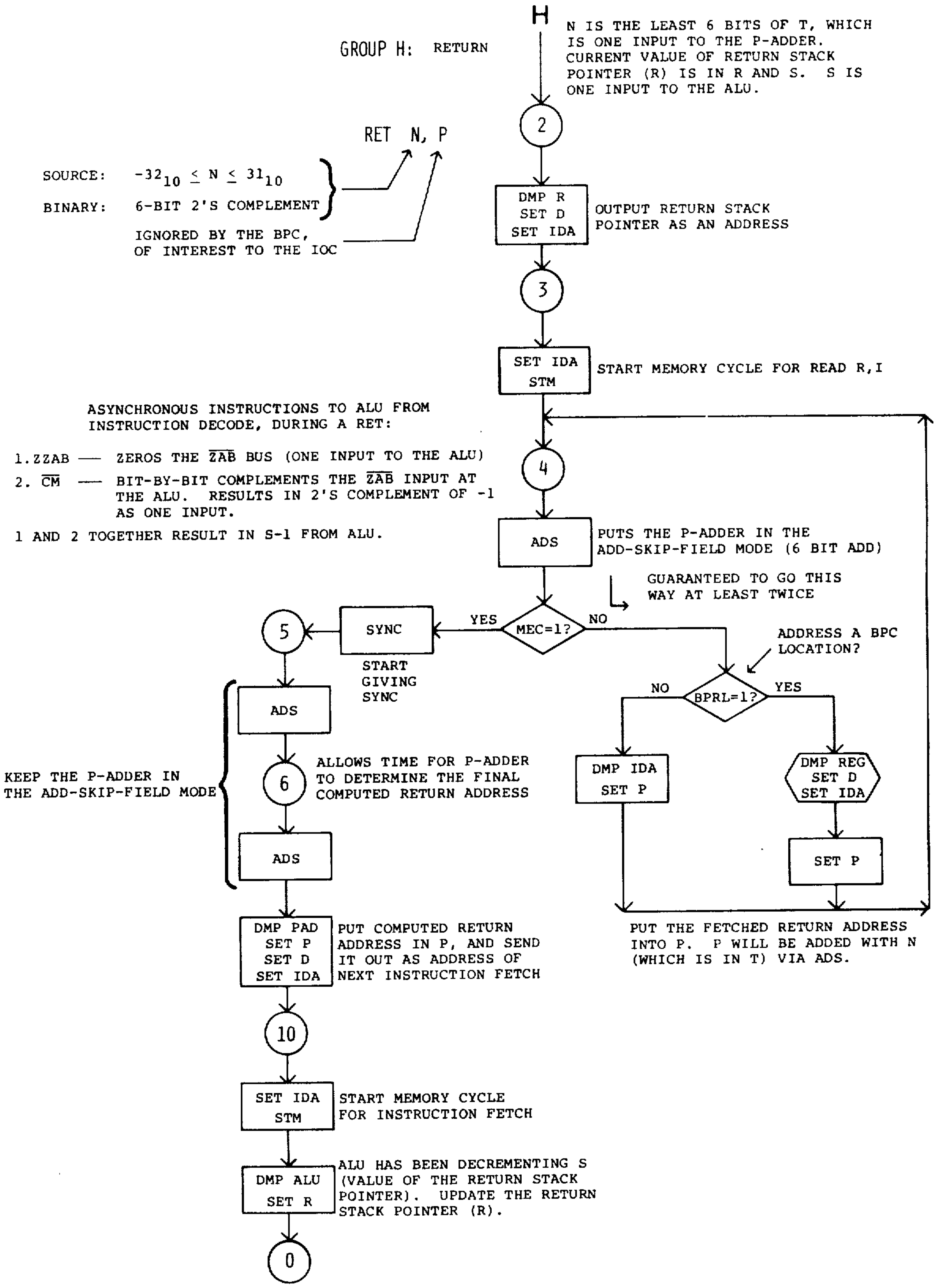

GROUP G: EXECUTE
EXE M,I
10 BIT REFERENCE
INDIRECT INDICATOR
G
D=15 BIT ADDRESS
2
REFERS TO THE FETCH JUST COMPLETED
IND=1?
YES
NO
SET IDA
HAVE END LOCATION ADDRESS. SEND IT OUT
SYNC
START GIVING SYNC
10
SET IDA STM
START MEMORY CYCLE TO FETCH INSTRUCTION TO BE EXECUTED. THE NEXT VALUE FOR P (USUALLY P+1) WILL BE DETERMINED BY THAT INSTRUCTION.
0
SET IDA STM
START AN INDIRECT FETCH
3
MEC=1?
YES
NO
INDIRECT BIT IS LATCHED
SET IDA
START NEXT FETCH, WHETHER INDIRECT OR NOT
BPRL=1?
ADDRESS A BPC LOCATION?
YES
NO
DMP REG SET D SET IDA
DMP IDA SET D
GET ADDRESS OF HOPED-FOR END LOCATION INTO D
GUARANTEED TO GO THIS WAY AT LEAST TWICE

FIG 98



GROUP H: RETURN

N IS THE LEAST 6 BITS OF T, WHICH IS ONE INPUT TO THE P-ADDER. CURRENT VALUE OF RETURN STACK POINTER (R) IS IN R AND S. S IS ONE INPUT TO THE ALU.

SOURCE: $-32_{10} \leq N \leq 31_{10}$

BINARY: 6-BIT 2'S COMPLEMENT

IGNORED BY THE BPC, OF INTEREST TO THE IOC

OUTPUT RETURN STACK POINTER AS AN ADDRESS

START MEMORY CYCLE FOR READ R,I

ASYNCHRONOUS INSTRUCTIONS TO ALU FROM INSTRUCTION DECODE, DURING A RET:

1. ZZAB — ZEROS THE $\overline{\text{ZAB}}$ BUS (ONE INPUT TO THE ALU)

2. $\overline{\text{CM}}$ — BIT-BY-BIT COMPLEMENTS THE $\overline{\text{ZAB}}$ INPUT AT THE ALU. RESULTS IN 2'S COMPLEMENT OF -1 AS ONE INPUT.

1 AND 2 TOGETHER RESULT IN S-1 FROM ALU.

PUTS THE P-ADDER IN THE ADD-SKIP-FIELD MODE (6 BIT ADD)

GUARANTEED TO GO THIS WAY AT LEAST TWICE

START GIVING SYNC

ADDRESS A BPC LOCATION?

KEEP THE P-ADDER IN THE ADD-SKIP-FIELD MODE

ALLOWS TIME FOR P-ADDER TO DETERMINE THE FINAL COMPUTED RETURN ADDRESS

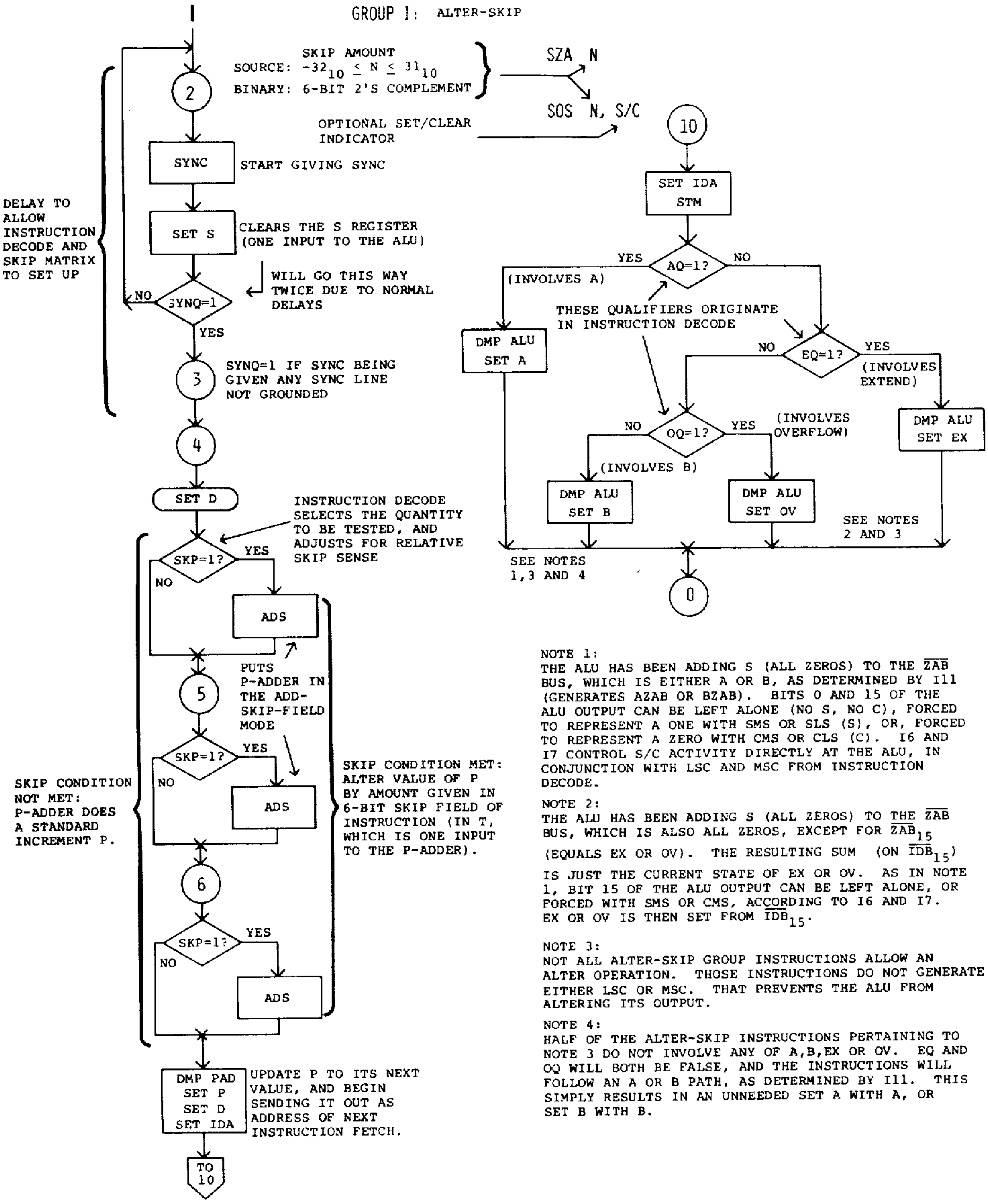
PUT COMPUTED RETURN ADDRESS IN P, AND SEND IT OUT AS ADDRESS OF NEXT INSTRUCTION FETCH

PUT THE FETCHED RETURN ADDRESS INTO P. P WILL BE ADDED WITH N (WHICH IS IN T) VIA ADS.

START MEMORY CYCLE FOR INSTRUCTION FETCH

ALU HAS BEEN DECREMENTING S (VALUE OF THE RETURN STACK POINTER). UPDATE THE RETURN STACK POINTER (R).

FIG 99


GROUP I: ALTER-SKIP
SKIP AMOUNT
SOURCE: $-32_{10} \leq N \leq 31_{10}$
BINARY: 6-BIT 2'S COMPLEMENT
SZA N
SOS N, S/C
OPTIONAL SET/CLEAR INDICATOR
2
SYNC
START GIVING SYNC
SET S
CLEARS THE S REGISTER (ONE INPUT TO THE ALU)
DELAY TO ALLOW INSTRUCTION DECODE AND SKIP MATRIX TO SET UP
WILL GO THIS WAY TWICE DUE TO NORMAL DELAYS
NO
SYNQ=1
YES
3
SYNQ=1 IF SYNC BEING GIVEN ANY SYNC LINE NOT GROUNDED
4
SET D
INSTRUCTION DECODE SELECTS THE QUANTITY TO BE TESTED, AND ADJUSTS FOR RELATIVE SKIP SENSE
SKP=1?
YES
NO
ADS
PUTS P-ADDER IN THE ADD-SKIP-FIELD MODE
5
SKP=1?
YES
NO
ADS
SKIP CONDITION NOT MET: P-ADDER DOES A STANDARD INCREMENT P.
SKIP CONDITION MET: ALTER VALUE OF P BY AMOUNT GIVEN IN 6-BIT SKIP FIELD OF INSTRUCTION (IN T, WHICH IS ONE INPUT TO THE P-ADDER).
6
SKP=1?
YES
NO
ADS
DMP PAD
SET P
SET D
SET IDA
UPDATE P TO ITS NEXT VALUE, AND BEGIN SENDING IT OUT AS ADDRESS OF NEXT INSTRUCTION FETCH.
TO 10
10
SET IDA
STM
YES
AQ=1?
NO
(INVOLVES A)
DMP ALU
SET A
THESE QUALIFIERS ORIGINATE IN INSTRUCTION DECODE
NO
EQ=1?
YES
(INVOLVES EXTEND)
DMP ALU
SET EX
NO
OQ=1?
YES
(INVOLVES OVERFLOW)
(INVOLVES B)
DMP ALU
SET B
DMP ALU
SET OV
SEE NOTES 2 AND 3
SEE NOTES 1,3 AND 4
0

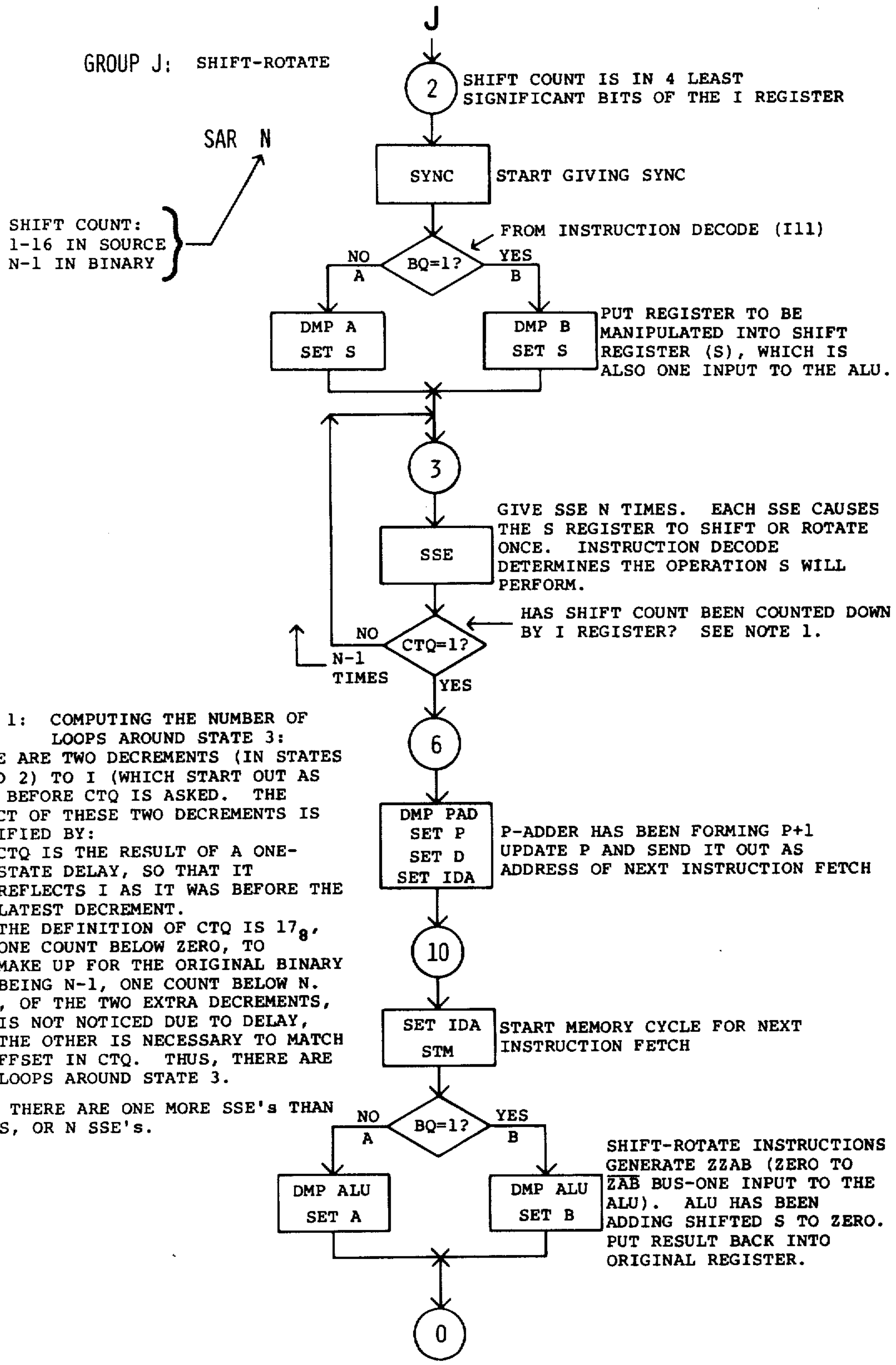
NOTE 1:
THE ALU HAS BEEN ADDING S (ALL ZEROS) TO THE $\overline{ZAB}$ BUS, WHICH IS EITHER A OR B, AS DETERMINED BY I11 (GENERATES AZAB OR BZAB). BITS 0 AND 15 OF THE ALU OUTPUT CAN BE LEFT ALONE (NO S, NO C), FORCED TO REPRESENT A ONE WITH SMS OR SLS (S), OR, FORCED TO REPRESENT A ZERO WITH CMS OR CLS (C). I6 AND I7 CONTROL S/C ACTIVITY DIRECTLY AT THE ALU, IN CONJUNCTION WITH LSC AND MSC FROM INSTRUCTION DECODE.

NOTE 2:
THE ALU HAS BEEN ADDING S (ALL ZEROS) TO THE $\overline{ZAB}$ BUS, WHICH IS ALSO ALL ZEROS, EXCEPT FOR $\overline{ZAB}_{15}$ (EQUALS EX OR OV). THE RESULTING SUM (ON $\overline{IDB}_{15}$) IS JUST THE CURRENT STATE OF EX OR OV. AS IN NOTE 1, BIT 15 OF THE ALU OUTPUT CAN BE LEFT ALONE, OR FORCED WITH SMS OR CMS, ACCORDING TO I6 AND I7. EX OR OV IS THEN SET FROM $\overline{IDB}_{15}$.

NOTE 3:
NOT ALL ALTER-SKIP GROUP INSTRUCTIONS ALLOW AN ALTER OPERATION. THOSE INSTRUCTIONS DO NOT GENERATE EITHER LSC OR MSC. THAT PREVENTS THE ALU FROM ALTERING ITS OUTPUT.

NOTE 4:
HALF OF THE ALTER-SKIP INSTRUCTIONS PERTAINING TO NOTE 3 DO NOT INVOLVE ANY OF A,B,EX OR OV. EQ AND OQ WILL BOTH BE FALSE, AND THE INSTRUCTIONS WILL FOLLOW AN A OR B PATH, AS DETERMINED BY I11. THIS SIMPLY RESULTS IN AN UNNEEDED SET A WITH A, OR SET B WITH B.

FIG 100


J
GROUP J: SHIFT-ROTATE
2
SHIFT COUNT IS IN 4 LEAST SIGNIFICANT BITS OF THE I REGISTER
SAR N
SHIFT COUNT: 1-16 IN SOURCE N-1 IN BINARY
SYNC
START GIVING SYNC
FROM INSTRUCTION DECODE (I11)
NO
A
BQ=1?
YES
B
DMP A SET S
DMP B SET S
PUT REGISTER TO BE MANIPULATED INTO SHIFT REGISTER (S), WHICH IS ALSO ONE INPUT TO THE ALU.
3
SSE
GIVE SSE N TIMES. EACH SSE CAUSES THE S REGISTER TO SHIFT OR ROTATE ONCE. INSTRUCTION DECODE DETERMINES THE OPERATION S WILL PERFORM.
HAS SHIFT COUNT BEEN COUNTED DOWN BY I REGISTER? SEE NOTE 1.
NO
CTQ=1?
N-1 TIMES
YES
6
DMP PAD SET P SET D SET IDA
P-ADDER HAS BEEN FORMING P+1 UPDATE P AND SEND IT OUT AS ADDRESS OF NEXT INSTRUCTION FETCH
10
SET IDA STM
START MEMORY CYCLE FOR NEXT INSTRUCTION FETCH
NO
A
BQ=1?
YES
B
DMP ALU SET A
DMP ALU SET B
SHIFT-ROTATE INSTRUCTIONS GENERATE ZZAB (ZERO TO $\overline{\text{ZAB}}$ BUS-ONE INPUT TO THE ALU). ALU HAS BEEN ADDING SHIFTED S TO ZERO. PUT RESULT BACK INTO ORIGINAL REGISTER.
0

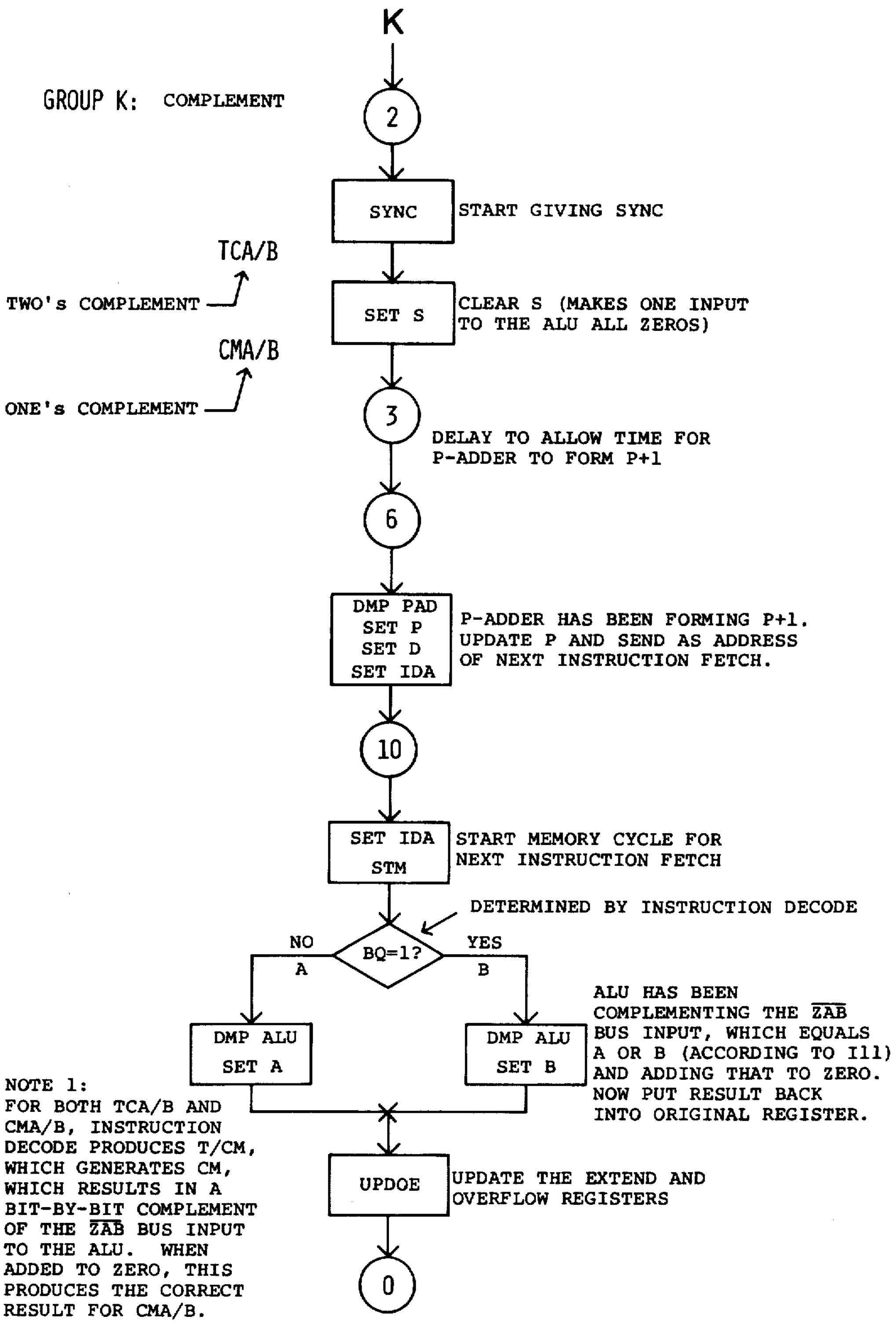
NOTE 1: COMPUTING THE NUMBER OF LOOPS AROUND STATE 3:
THERE ARE TWO DECREMENTS (IN STATES 1 AND 2) TO I (WHICH START OUT AS N-1) BEFORE CTQ IS ASKED. THE EFFECT OF THESE TWO DECREMENTS IS NULLIFIED BY:

1) CTQ IS THE RESULT OF A ONE-STATE DELAY, SO THAT IT REFLECTS I AS IT WAS BEFORE THE LATEST DECREMENT.
2) THE DEFINITION OF CTQ IS $17_8$, ONE COUNT BELOW ZERO, TO MAKE UP FOR THE ORIGINAL BINARY BEING N-1, ONE COUNT BELOW N.

THUS, OF THE TWO EXTRA DECREMENTS, ONE IS NOT NOTICED DUE TO DELAY, AND THE OTHER IS NECESSARY TO MATCH AN OFFSET IN CTQ. THUS, THERE ARE N-1 LOOPS AROUND STATE 3.

NOW, THERE ARE ONE MORE SSE's THAN LOOPS, OR N SSE's.

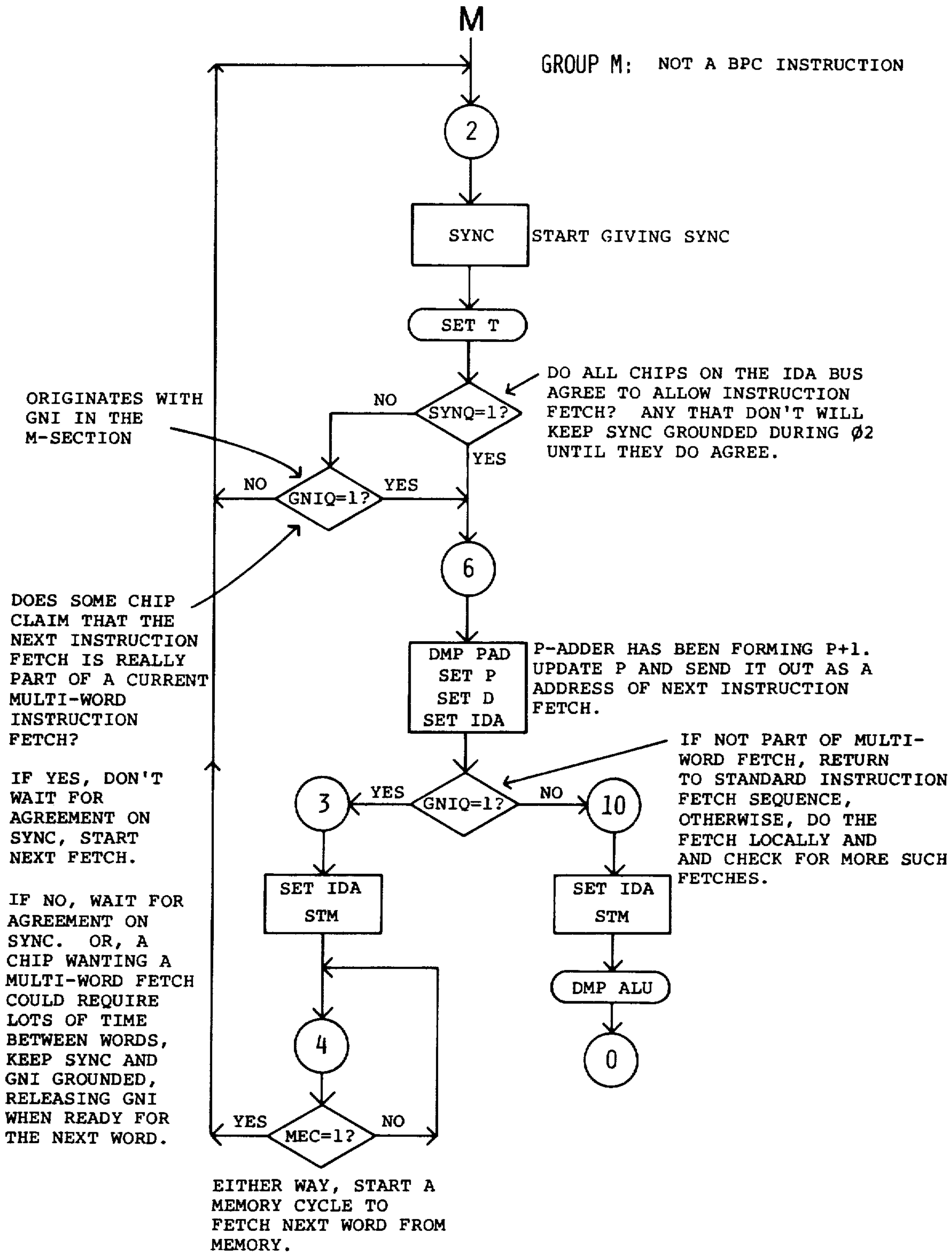
FIG 101


K
GROUP K: COMPLEMENT
2
SYNC
START GIVING SYNC
TCA/B
TWO's COMPLEMENT
SET S
CLEAR S (MAKES ONE INPUT TO THE ALU ALL ZEROS)
CMA/B
ONE's COMPLEMENT
3
DELAY TO ALLOW TIME FOR P-ADDER TO FORM P+1
6
DMP PAD
SET P
SET D
SET IDA
P-ADDER HAS BEEN FORMING P+1. UPDATE P AND SEND AS ADDRESS OF NEXT INSTRUCTION FETCH.
10
SET IDA
STM
START MEMORY CYCLE FOR NEXT INSTRUCTION FETCH
DETERMINED BY INSTRUCTION DECODE
NO
A
BQ=1?
YES
B
DMP ALU
SET A
DMP ALU
SET B
ALU HAS BEEN COMPLEMENTING THE $\overline{ZAB}$ BUS INPUT, WHICH EQUALS A OR B (ACCORDING TO I11) AND ADDING THAT TO ZERO. NOW PUT RESULT BACK INTO ORIGINAL REGISTER.
UPDOE
UPDATE THE EXTEND AND OVERFLOW REGISTERS
0

NOTE 1:
FOR BOTH TCA/B AND CMA/B, INSTRUCTION DECODE PRODUCES T/CM, WHICH GENERATES CM, WHICH RESULTS IN A BIT-BY-BIT COMPLEMENT OF THE $\overline{ZAB}$ BUS INPUT TO THE ALU. WHEN ADDED TO ZERO, THIS PRODUCES THE CORRECT RESULT FOR CMA/B.

FOR TCA/B ONLY, TC* GENERATES A CI (CARRY IN), WHICH, WHEN COMBINED WITH THE ABOVE ADDITION, PRODUCES A TWO's COMPLEMENT.

FIG 102



GROUP M: NOT A BPC INSTRUCTION

START GIVING SYNC

DO ALL CHIPS ON THE IDA BUS AGREE TO ALLOW INSTRUCTION FETCH? ANY THAT DON'T WILL KEEP SYNC GROUNDED DURING Ø2 UNTIL THEY DO AGREE.

ORIGINATES WITH GNI IN THE M-SECTION

DOES SOME CHIP CLAIM THAT THE NEXT INSTRUCTION FETCH IS REALLY PART OF A CURRENT MULTI-WORD INSTRUCTION FETCH?

IF YES, DON'T WAIT FOR AGREEMENT ON SYNC, START NEXT FETCH.

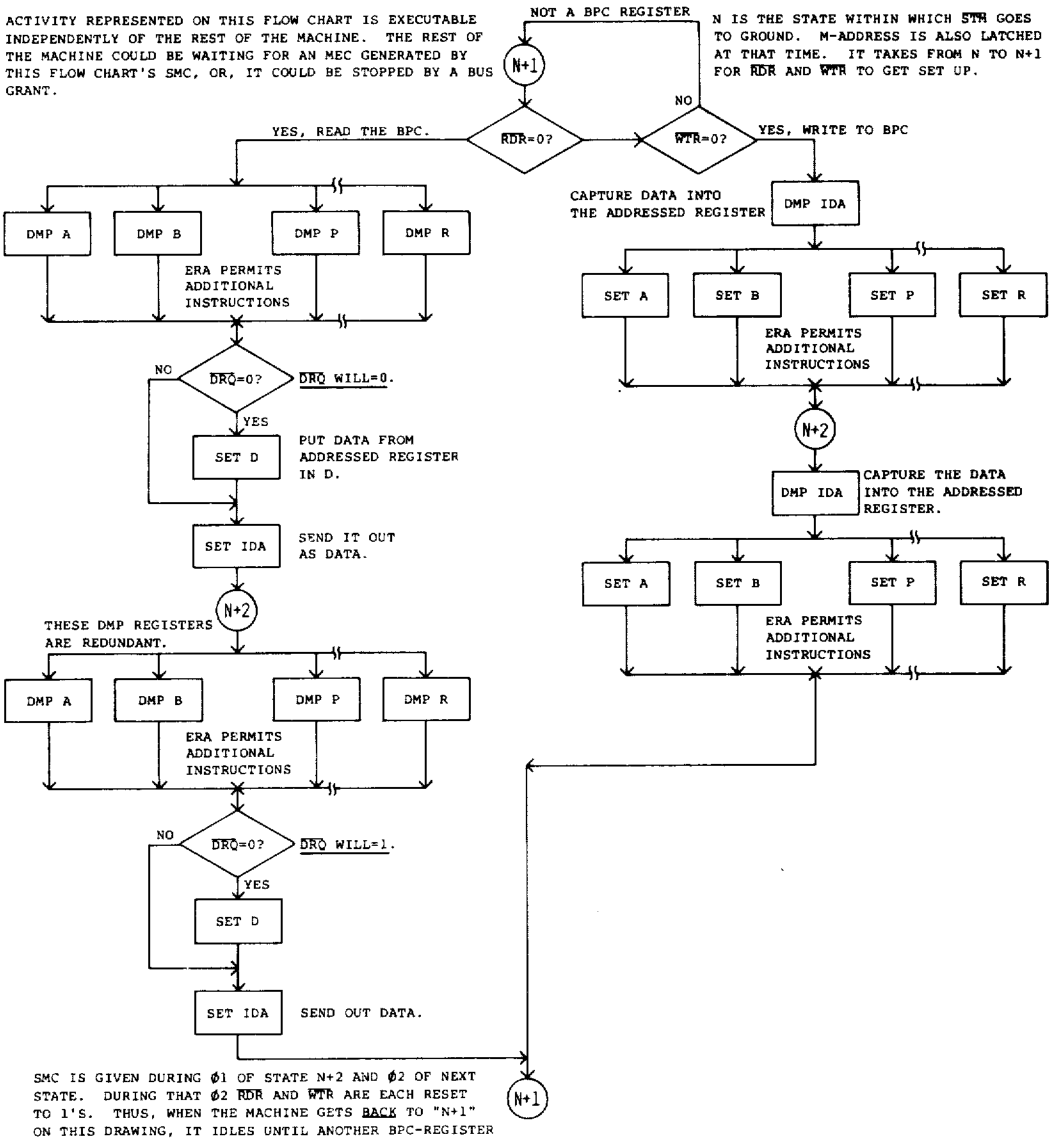
IF NO, WAIT FOR AGREEMENT ON SYNC. OR, A CHIP WANTING A MULTI-WORD FETCH COULD REQUIRE LOTS OF TIME BETWEEN WORDS, KEEP SYNC AND GNI GROUNDED, RELEASING GNI WHEN READY FOR THE NEXT WORD.

P-ADDER HAS BEEN FORMING P+1. UPDATE P AND SEND IT OUT AS A ADDRESS OF NEXT INSTRUCTION FETCH.

IF NOT PART OF MULTI-WORD FETCH, RETURN TO STANDARD INSTRUCTION FETCH SEQUENCE, OTHERWISE, DO THE FETCH LOCALLY AND AND CHECK FOR MORE SUCH FETCHES.

EITHER WAY, START A MEMORY CYCLE TO FETCH NEXT WORD FROM MEMORY.

FIG 103



ACTIVITY REPRESENTED ON THIS FLOW CHART IS EXECUTABLE INDEPENDENTLY OF THE REST OF THE MACHINE. THE REST OF THE MACHINE COULD BE WAITING FOR AN MEC GENERATED BY THIS FLOW CHART'S SMC, OR, IT COULD BE STOPPED BY A BUS GRANT.

N IS THE STATE WITHIN WHICH $\overline{STM}$ GOES TO GROUND. M-ADDRESS IS ALSO LATCHED AT THAT TIME. IT TAKES FROM N TO N+1 FOR $\overline{RDR}$ AND $\overline{WTR}$ TO GET SET UP.

SMC IS GIVEN DURING ∅1 OF STATE N+2 AND ∅2 OF NEXT STATE. DURING THAT ∅2 $\overline{RDR}$ AND $\overline{WTR}$ ARE EACH RESET TO 1'S. THUS, WHEN THE MACHINE GETS BACK TO "N+1" ON THIS DRAWING, IT IDLES UNTIL ANOTHER BPC-REGISTER MEMORY CYCLE IS STARTED.

FIG 104

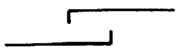
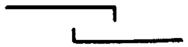
## BPC ERA ADDRESSING

| IDA ADDRESS (OCTAL) | READ/WRITE | RESULTING u-INSTRUCTION (S) |
|---|---|---|
| (NOTE 1) | | |
| 40 | R | DMP PAD (,INC P) (NOTE 2) |
| 41 | R | DMP PAD, ADS |
| 42 | R | DMP PAD, ADM |
| 42 | R | DMP PAD (,INC P) |
| 44 | R | DMP EX |
| 44 | W | SET EX |
| 45 | R | DMP OV |
| 45 | W | SET OV |
| 46 | R | DMP T |
| 46 | W | SET T |
| 47 | W | SET D |
| 51 | R | DMP ALU (NOTE 3) |
| 52 | W | SET S |
| 53 | R | DMP ST |
| 53 | W | SET I |
| 54 | R | DMP A |
| 54 | W | SET A |
| 55 | R | DMP B |
| 55 | W | SET B |
| 56 | R | DMP P |
| 56 | W | SET P |
| 57 | R | DMP R |
| 57 | W | SET R |

NOTES

1. IN THE ERA MODE, THE BPC REGISTER ADDRESS DETECTOR RESPONDS TO IDA BUS ADDRESSES, AS SHOWN. HOWEVER, ONLY THE FOUR LEAST SIGNIFICANT BITS OF THAT ADDRESS ARE USED AS QUALIFIERS IN THE ROM. HENCE, WHILE $57_8$ IS DECODED (FOR R), THE SET R AND DMP R IN THE ROM RESPOND TO $17_8$ ON THE M-ADDRESS LINES.
2. INC P (P-ADDER OUTPUT = P+1) IS THE NOR OF ADM AND ADS. IN GENERAL, THE RESULT OF A DUM PAD IS DIFFICULT TO PREDICT, AS IT DEPENDS UPON WHERE IN ITS FLOW CHART THE BPC IS STOPPED.
3. IN GENERAL, THE RESULT OF A DMP ALU IS DIFFICULT TO PREDICT. IT DEPENDS UPON WHAT IS IN THE I, A, AND B REGISTERS.

FIG 105

1.  OR 

TRANSITION UP OR TRANSITION DOWN CAN OCCUR ANYTIME WITHIN THE INDICATED INTERVAL. USED TO INDICATE TIME-WINDOWS WITHIN WHICH EXTERNALLY ORIGINATED EVENTS CAN HAPPEN. REPRESENTS IDEALIZED LOGICAL ACTIVITY; RISE TIMES AND DELAYS ARE NOT TAKEN INTO CONSIDERATION.

2. ▨

REPRESENTS THE SET-UP TIME OF A SIGNAL BEING DRIVEN.

3. ≋

REPRESENTS A LINE THAT IS EITHER UNDEFINED OR A DON'T CARE.

4. ▥

REPRESENTS A LINE THAT IS ACTIVELY PULLED-UP.

5. CAPITAL LETTERS FROM THE START OF THE ALPHABET REPRESENT EXPLANATORY NOTES. LETTERS FROM THE END OF ALPHABET ARE SOMETIMES USED TO DENOTE DIFFERENT STATES (IN THE ROM).

6. NUMERALS IN THE $\phi 2$-$\phi 1$ WAVEFORMS ARE STRICTLY FOR REFERENCE WITHIN ANY PARTICULAR SET OF WAVEFORMS, AND HAVE NO SIGNIFICANCE OUTSIDE THAT SET.

7. IN GENERAL, THE WAVEFORMS ARE QUITE IDEALIZED. THEY EXPLAIN THE LOGICAL RELATIONSHIPS BETWEEN SIGNALS, BUT ACTUAL DELAYS, RISE TIMES, SIGNAL LEVELS AND THRESHOLDS ARE NOT INDICATED.

CONVENTIONS USED IN THE WAVEFORMS

FIG 106

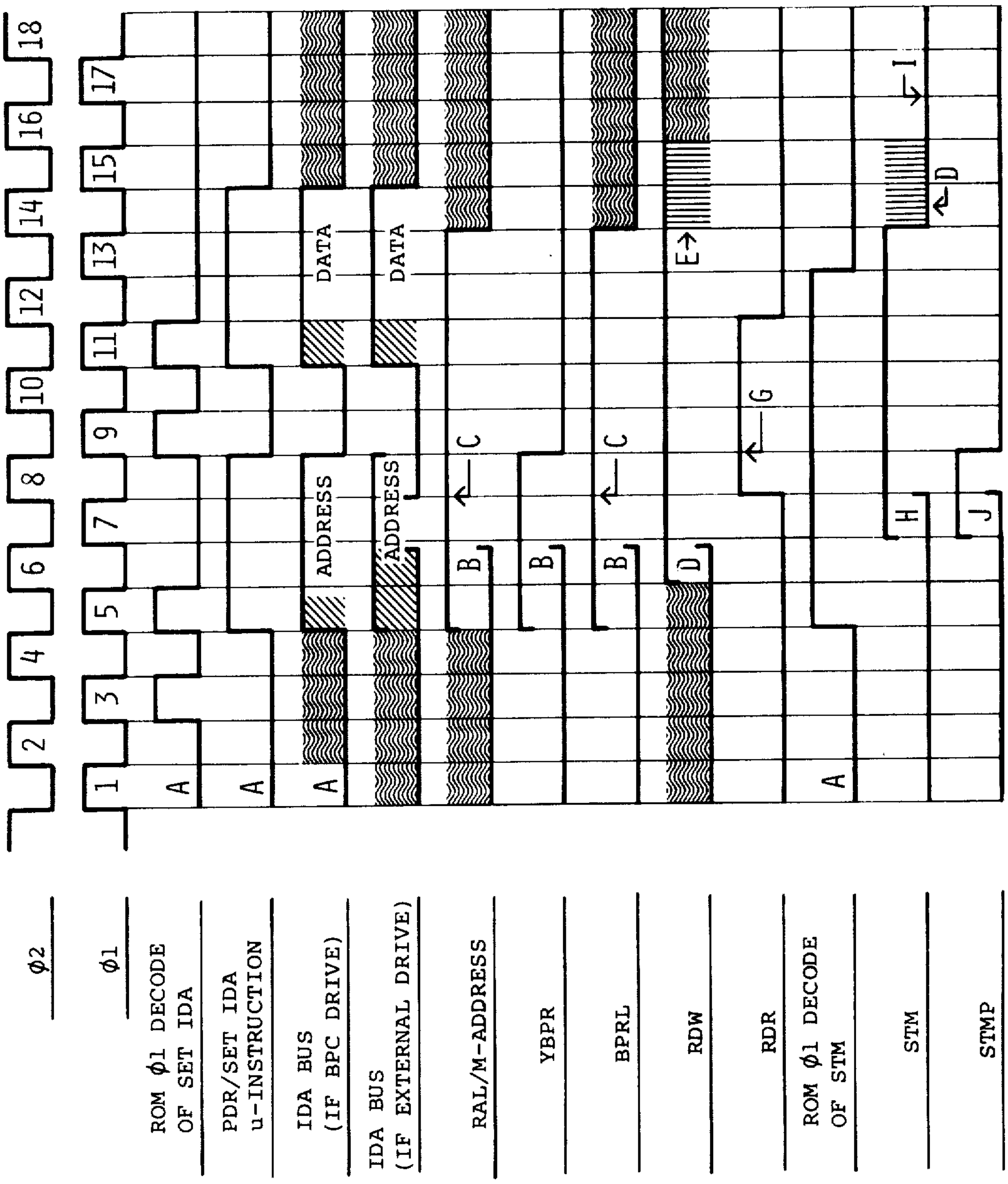

φ2
φ1
ROM φ1 DECODE OF SET IDA
PDR/SET IDA u-INSTRUCTION
IDA BUS (IF BPC DRIVE)
IDA BUS (IF EXTERNAL DRIVE)
RAL/M-ADDRESS
YBPR
BPRL
RDW
RDR
ROM φ1 DECODE OF STM
STM
STMP
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
A
A
A
A
ADDRESS
ADDRESS
DATA
DATA
B
B
B
C
C
D
D
E
G
H
I
J

FIG 107A

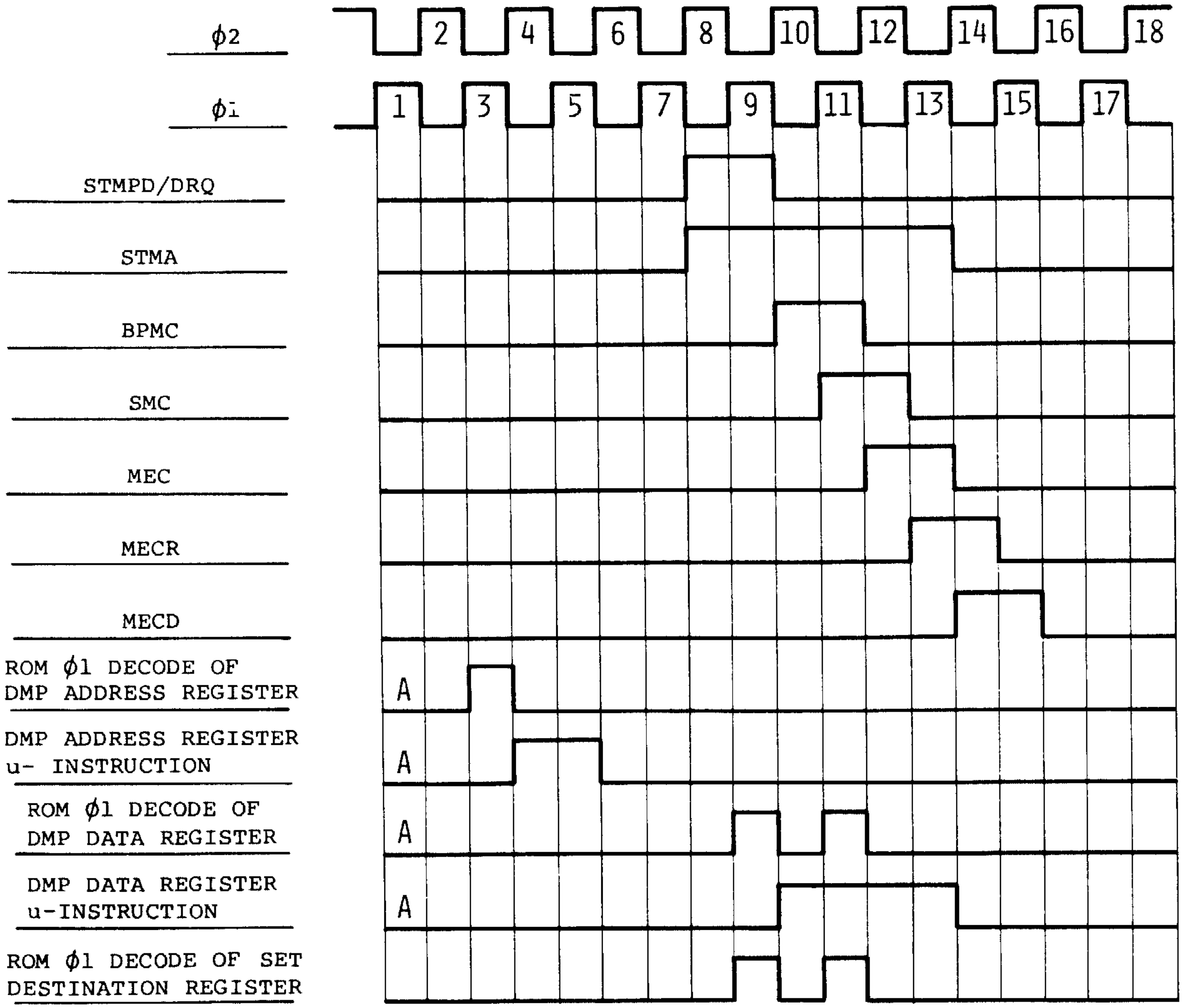
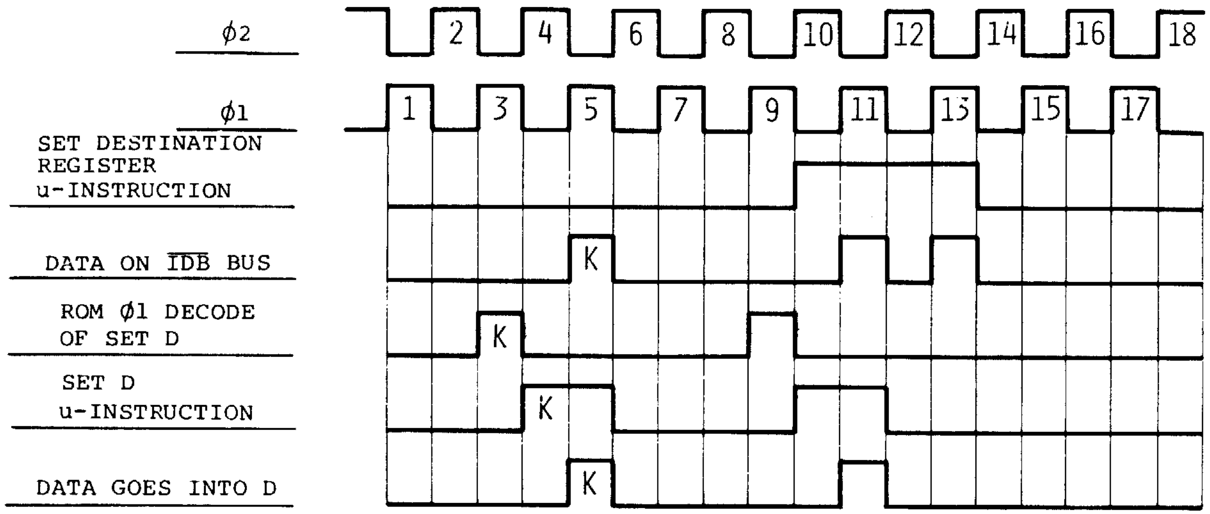

φ2
φ1
2
4
6
8
10
12
14
16
18
1
3
5
7
9
11
13
15
17
STMPD/DRQ
STMA
BPMC
SMC
MEC
MECR
MECD
ROM φ1 DECODE OF DMP ADDRESS REGISTER
DMP ADDRESS REGISTER u- INSTRUCTION
ROM φ1 DECODE OF DMP DATA REGISTER
DMP DATA REGISTER u-INSTRUCTION
ROM φ1 DECODE OF SET DESTINATION REGISTER
A
A
A
A

FIG 107B


$\phi2$
$\phi1$
SET DESTINATION REGISTER u-INSTRUCTION
DATA ON $\overline{\text{IDB}}$ BUS
ROM $\phi1$ DECODE OF SET D
SET D u-INSTRUCTION
DATA GOES INTO D
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
K
K
K
K

NOTES

A. PRESENT ONLY IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE.

B. DEPENDS UPON WHEN THE ADDRESS ON THE IDA BUS STABILIZES.

C. LATCHED WHEN STMA IS TRUE.

D. IF THIS READ MEMORY CYCLE IMMEDIATELY FOLLOWS A PREVIOUS WRITE CYCLE, THE START OF THIS $\phi2$ IS WHEN RDW WILL GO HIGH.

E. ACTIVE PULL-UP OF RDW AND $\overline{\text{STM}}$ DURING MECD.

F. THIS NOTE HAS BEEN DELETED.

G. LATCHED WHEN STMP IS FALSE.

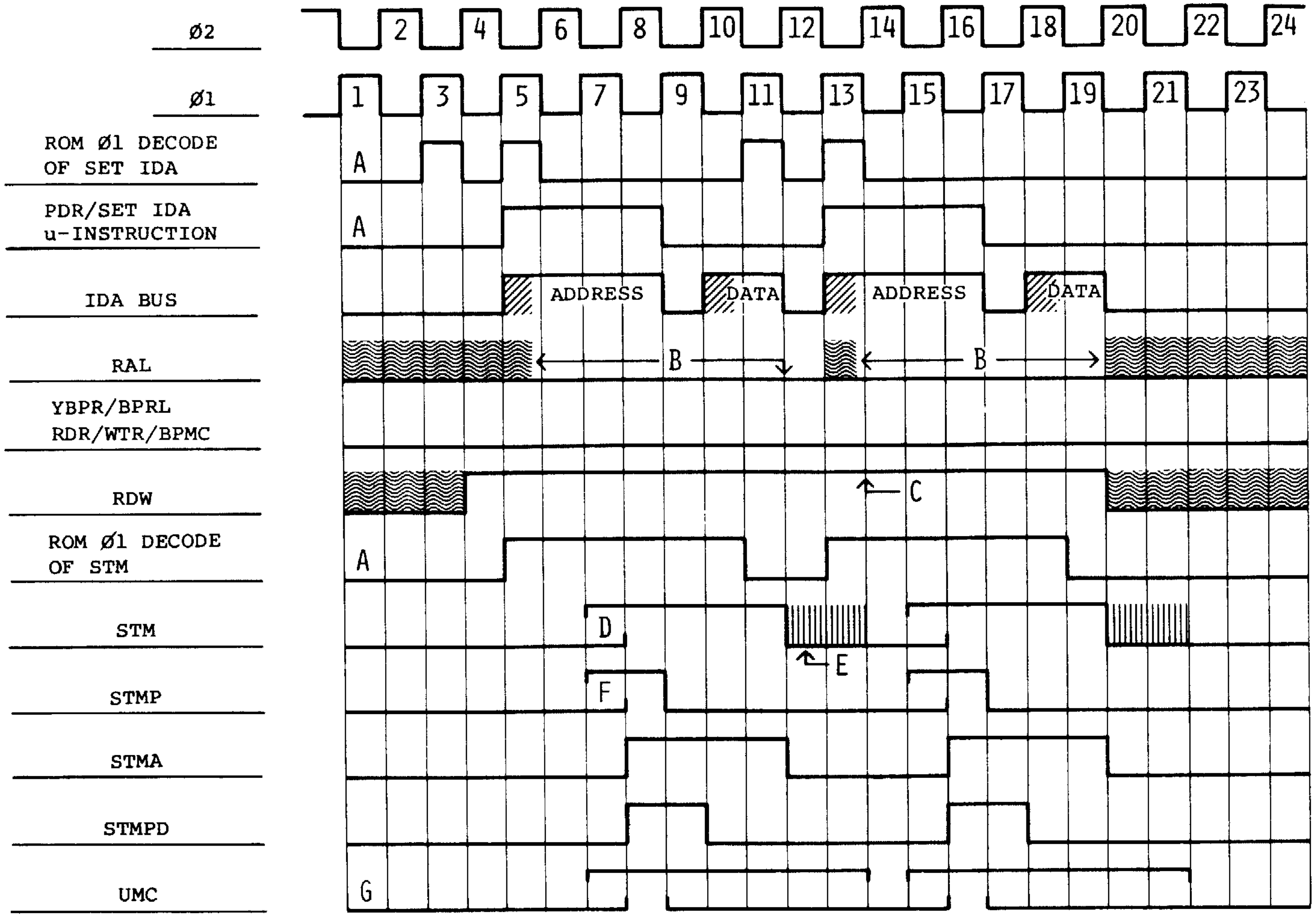
H. TRANSITIONS AT THE START OF $\phi1$ IF THE BPC IS THE ORIGINATOR. AN EXTERNAL AGENCY HAS UNTIL PRIOR TO $\phi2$.

I. EARLIEST NEXT STM.

J. FOLLOWS STM.

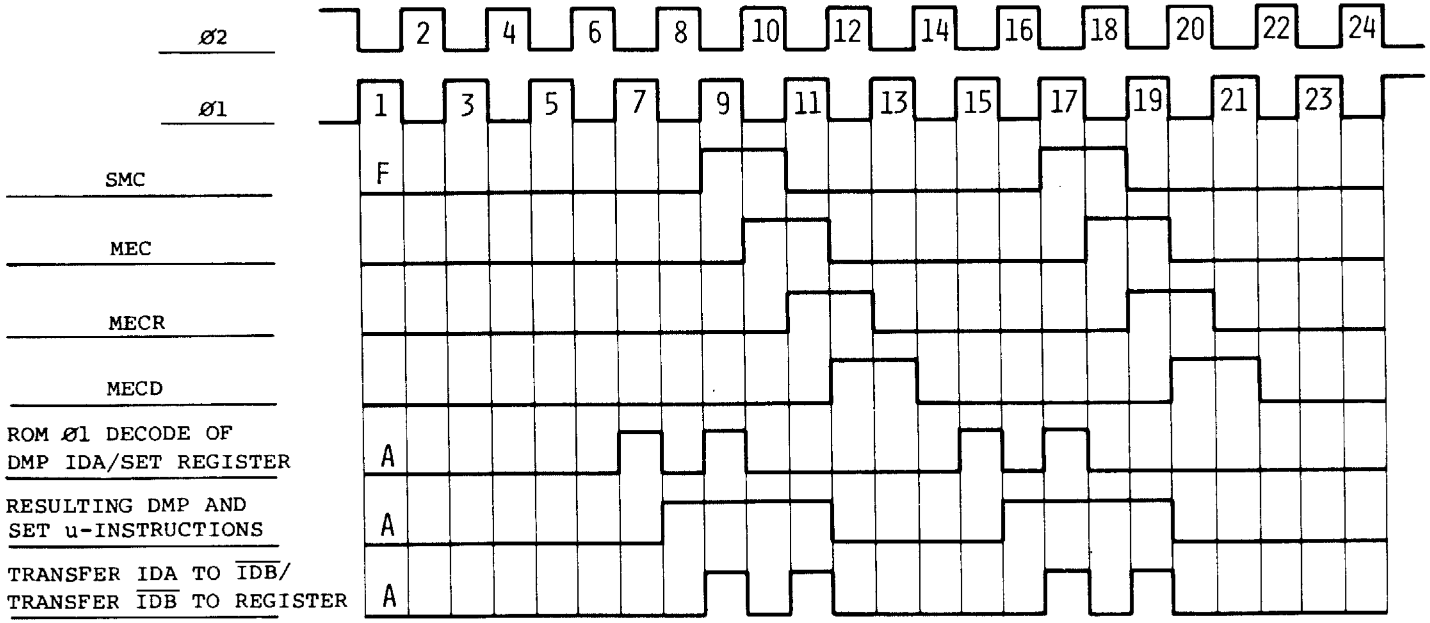
K. PRESENT ONLY IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE. PART OF SENDING OUT THE ADDRESS AND THE DATA ON THE IDA BUS TO PRESERVE THE BUS CONVENTIONS.

FIG 107C



BPC READS MEMORY (TWO CONSECUTIVE FASTEST CYCLES SHOWN)

FIG 108A


Ø2
Ø1
SMC
MEC
MECR
MECD
ROM Ø1 DECODE OF DMP IDA/SET REGISTER
RESULTING DMP AND SET u-INSTRUCTIONS
TRANSFER IDA TO $\overline{\text{IDB}}$/ TRANSFER $\overline{\text{IDB}}$ TO REGISTER
2
4
6
8
10
12
14
16
18
20
22
24
1
3
5
7
9
11
13
15
17
19
21
23
F
A
A
A

NOTES

A. PRESENT ONLY IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE. (SOME OTHER ENTITY ON THE BUS COULD BE READING MEMORY)

B. MEANINGFUL DURING THIS TIME, BUT LATCHED DURING STMA ONLY. SHOULD BE LOOKED AT DURING STM ONLY.

C. SOONEST POSSIBLE TRANSITION TO WRITE IF NEXT MEMORY CYCLE WERE A WRITE INSTEAD OF A READ.

D. TRANSITIONS IMMEDIATELY AT THE START OF Ø1 IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE.

E. ACTIVE PULL-UP ON $\overline{\text{STM}}$.

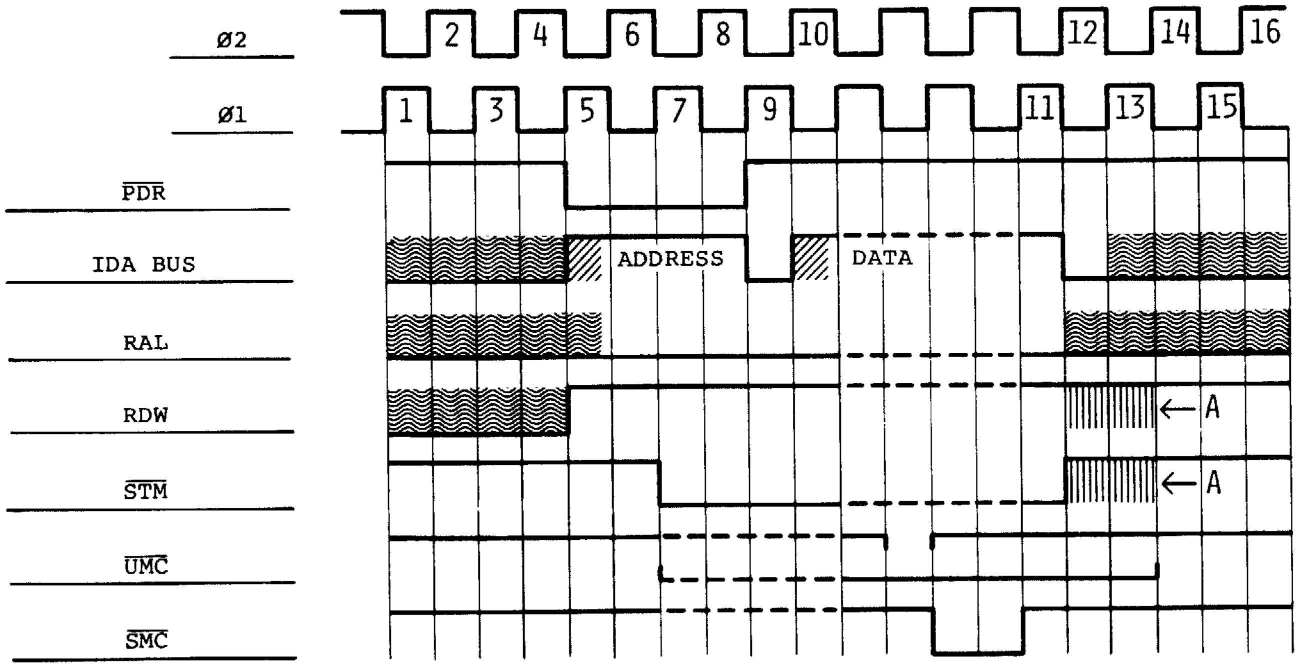
F. FOLLOWS STM.

G. UMC NEED NOT BE USED IF SMC IS GIVEN BY THE ORIGINATOR EXACTLY AS SHOWN, INSTEAD. HOWEVER, IF UMC IS GIVEN AS SHOWN, IT WILL ALSO RESULT IN SMC AS SHOWN.

UMC IS IDLE IF THE BPC IS THE ORIGINATOR.

BPC READS MEMORY (TWO CONSECUTIVE FASTEST CYCLES SHOWN)

FIG 108B



NOTES

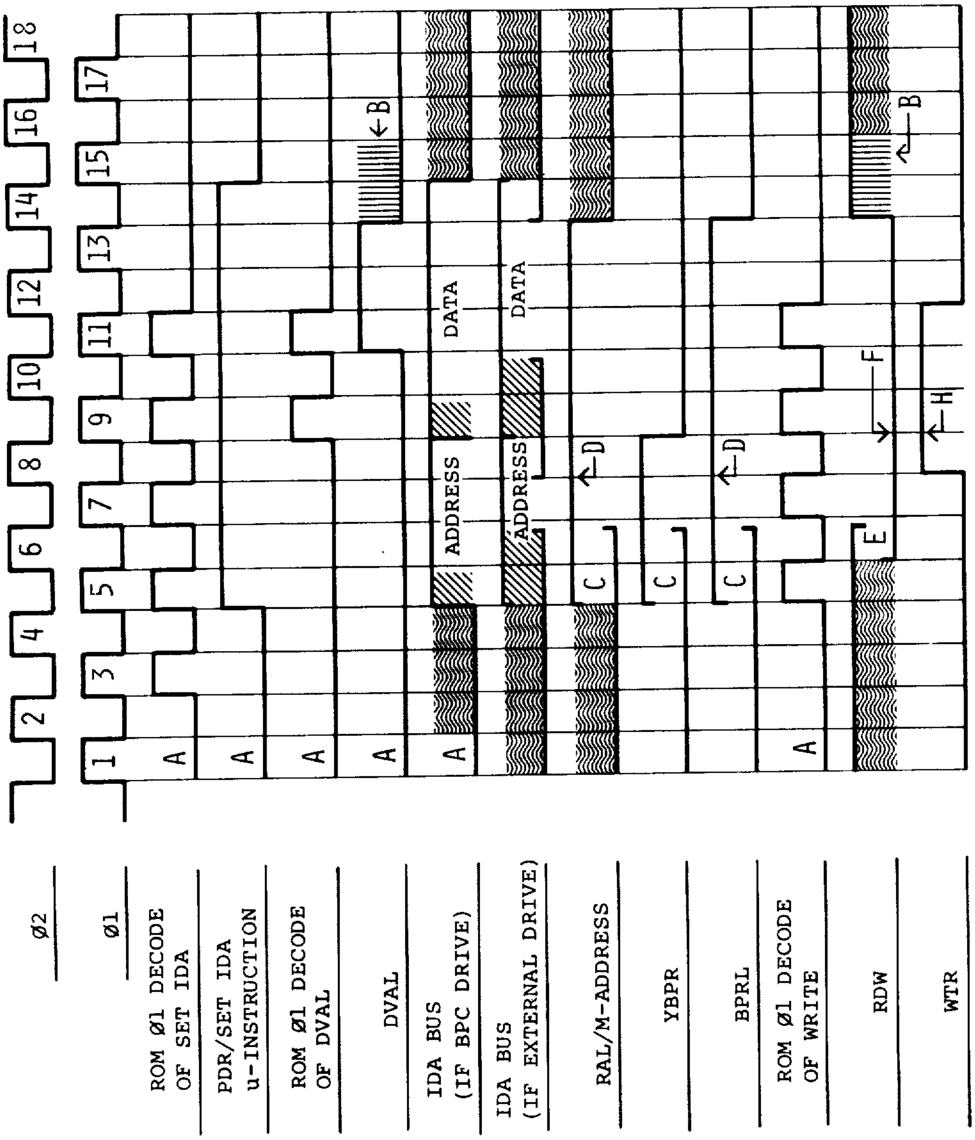
A. ACTIVE PULL UP DURING MECD.

B. DOTTED LINES REPRESENT ZERO OR ANY INTEGRAL NUMBER OF Ø1-Ø2 PAIRS.

C. NOTE THAT UMC COULD EQUAL STM.

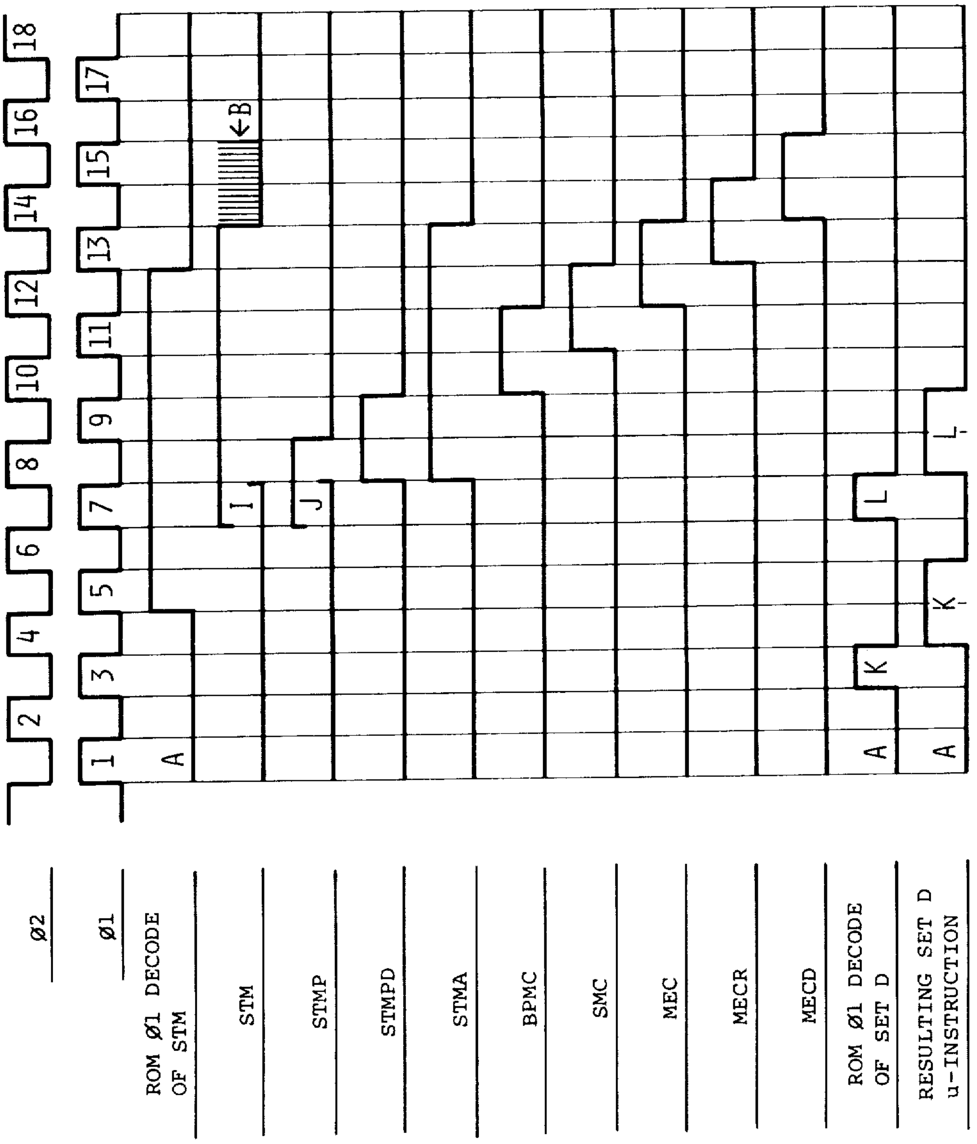
GENERALIZED 4-STATE BPC READ MEMORY CYCLE (WITH IMPLICIT HANDSHAKE BASED ON UMC AND SMC)

FIG 109



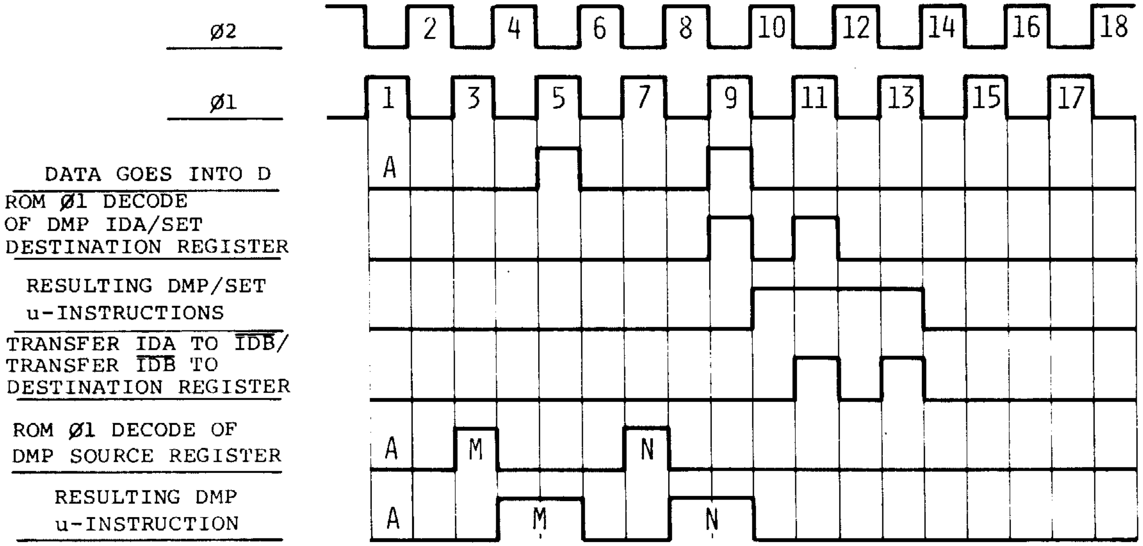
WRITE TO A BPC REGISTER

FIG 110A



WRITE TO A BPC REGISTER

FIG 110B


Ø2
Ø1
2
4
6
8
10
12
14
16
18
1
3
5
7
9
11
13
15
17
DATA GOES INTO D
ROM Ø1 DECODE OF DMP IDA/SET DESTINATION REGISTER
RESULTING DMP/SET u-INSTRUCTIONS
TRANSFER $\overline{\text{IDA}}$ TO $\overline{\text{IDB}}$/ TRANSFER $\overline{\text{IDB}}$ TO DESTINATION REGISTER
ROM Ø1 DECODE OF DMP SOURCE REGISTER
RESULTING DMP u-INSTRUCTION
A
A
M
N
A
M
N

WRITE TO A BPC REGISTER

FIG 110C

NOTES

A. PRESENT ONLY IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE.

B. ACTIVE PULL-UP OF $\overline{\text{DVAL}}$, RDW AND $\overline{\text{STM}}$ DURING MECD.

C. DEPENDS UPON WHEN THE ADDRESS ON THE IDA BUS STABILIZES.

D. LATCHED WHEN STMA GOES TRUE.

E. IF THE BPC IS THE ORIGINATOR, RDW WILL TRANSITION AT THE START OF Ø2. AN EXTERNAL AGENCY HAS UNTIL THE END OF Ø2.

F. EARLIEST RELEASE OF RDW IF AN EXTERNAL AGENCY WERE THE ORIGINATOR OF THE MEMORY CYCLE.

G. THIS NOTE HAS BEEN DELETED.

H. LATCHED WHEN STMP GOES FALSE.

I. TRANSITIONS AT THE START OF Ø1 IF THE BPC IS THE ORIGINATOR. AN EXTERNAL AGENCY HAS UNTIL PRIOR TO Ø2.

J. FOLLOWS STM.

K. FOR THE ADDRESS.

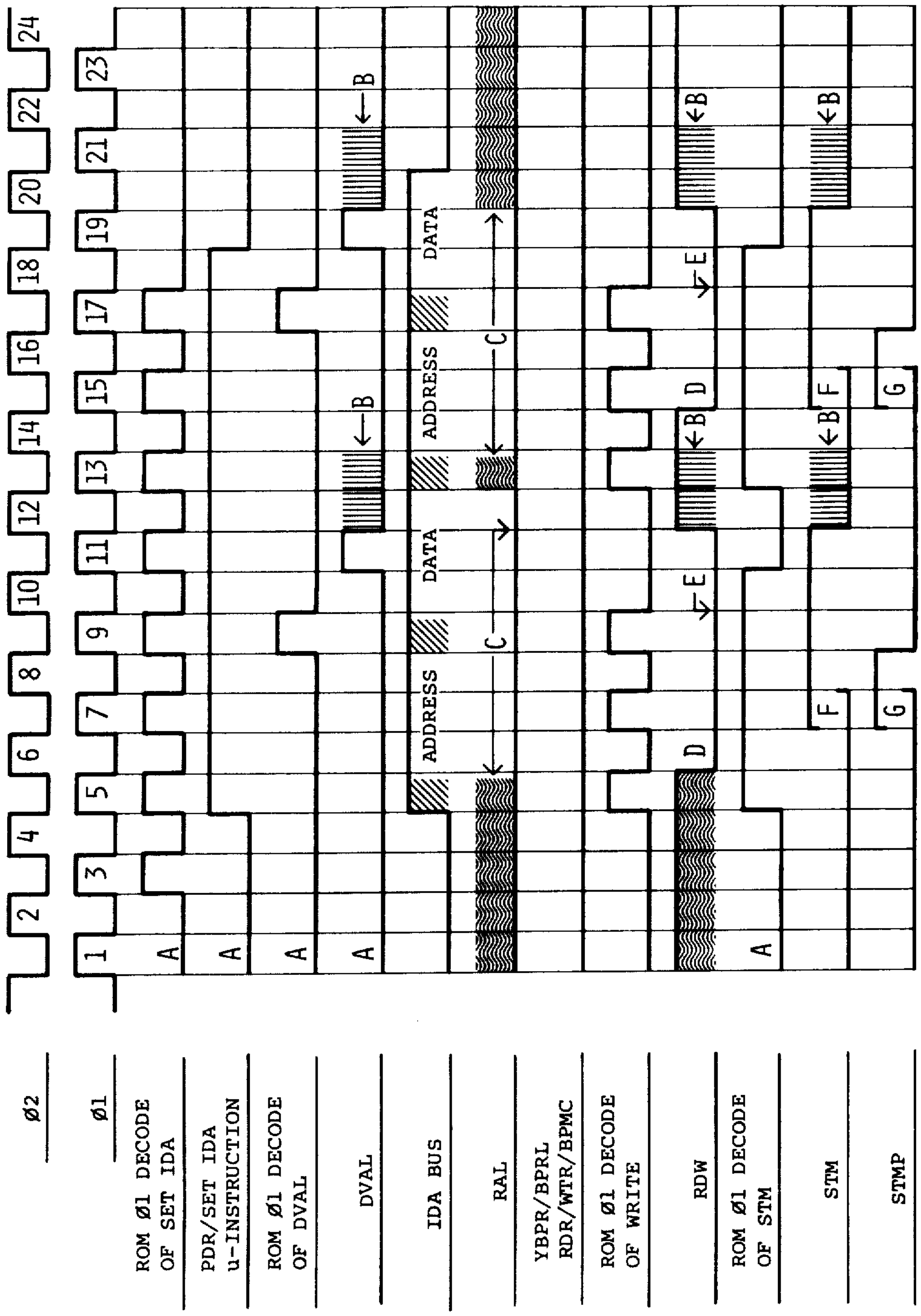
L. FOR THE DATA.

M. FOR THE ADDRESS. SEE NOTE N.

N. FOR THE DATA. ADDRESS AND DATA TYPICALLY INVOLVE DIFFERENT REGISTERS.

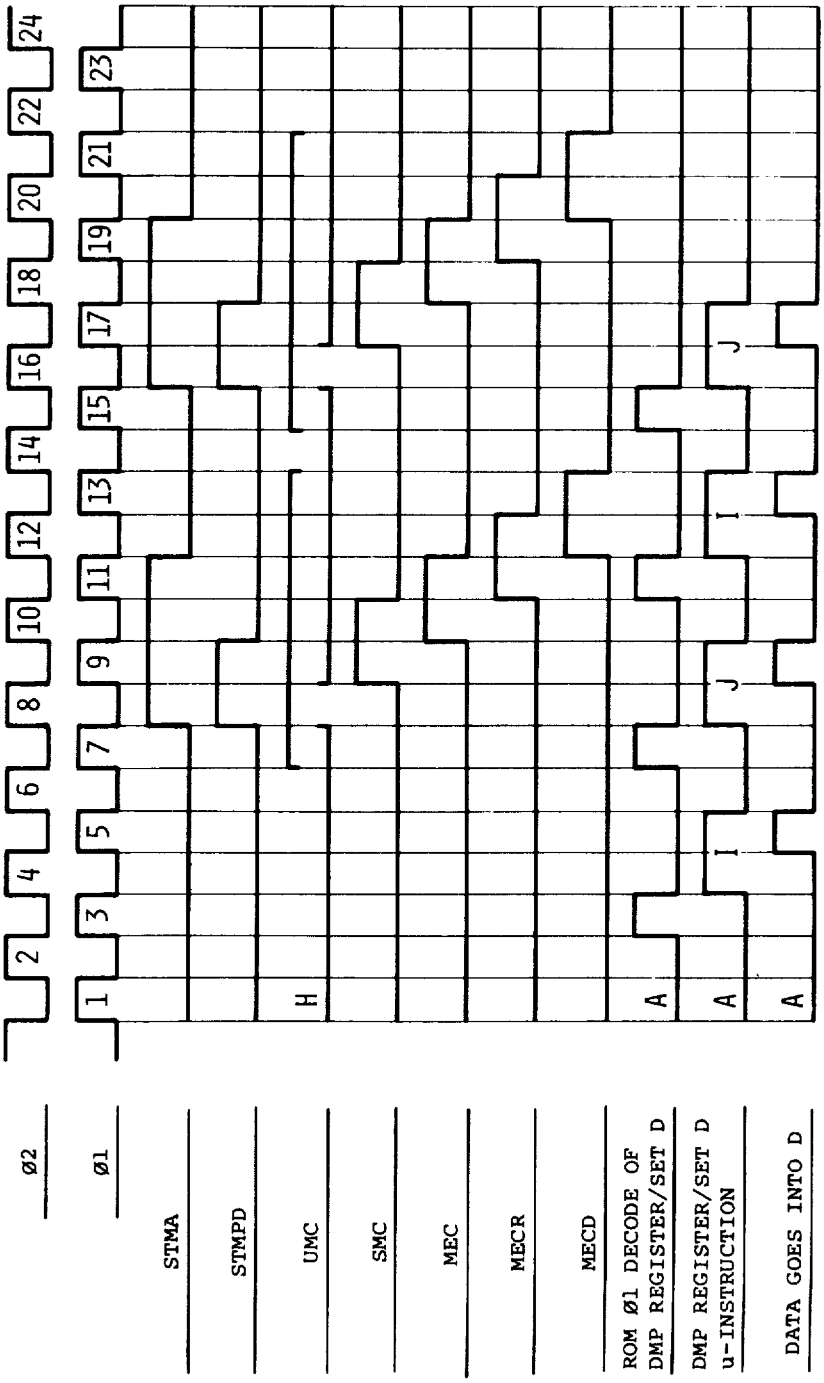
WRITE TO A BPC REGISTER

FIG 110D



WRITE MEMORY (TWO CONSECUTIVE FASTEST CYCLES SHOWN)

FIG 111A



WRITE MEMORY (TWO CONSECUTIVE FASTEST CYCLES SHOWN)

FIG 111B

NOTES

A. THIS WAVE FORM PRESENT ONLY IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE.

B. ACTIVE PULL-UP DURING MECD ON $\overline{\text{DVAL}}$, RDW, AND $\overline{\text{STM}}$.

C. MEANING DURING THIS TIME, BUT LATCHED DURING STMA ONLY. SHOULD BE LOOKED AT DURING STM ONLY.

D. WAVEFORM SHOWN ASSUMES BPC AS THE ORIGINATOR OF THE MEMORY CYCLE. IF THE ORIGINATOR WERE AN EXTERNAL AGENCY, RDW COULD TRANSITION TOGETHER WITH STM.

E. EARLIEST RELEASE OF RDW IF AN EXTERNAL AGENCY WERE THE ORIGINATOR OF THE MEMORY CYCLE.

F. TRANSITIONS IMMEDIATELY AT THE START OF Ø1 IF THE BPC IS THE ORIGINATOR OF THE MEMORY CYCLE.

G. FOLLOWS STM.

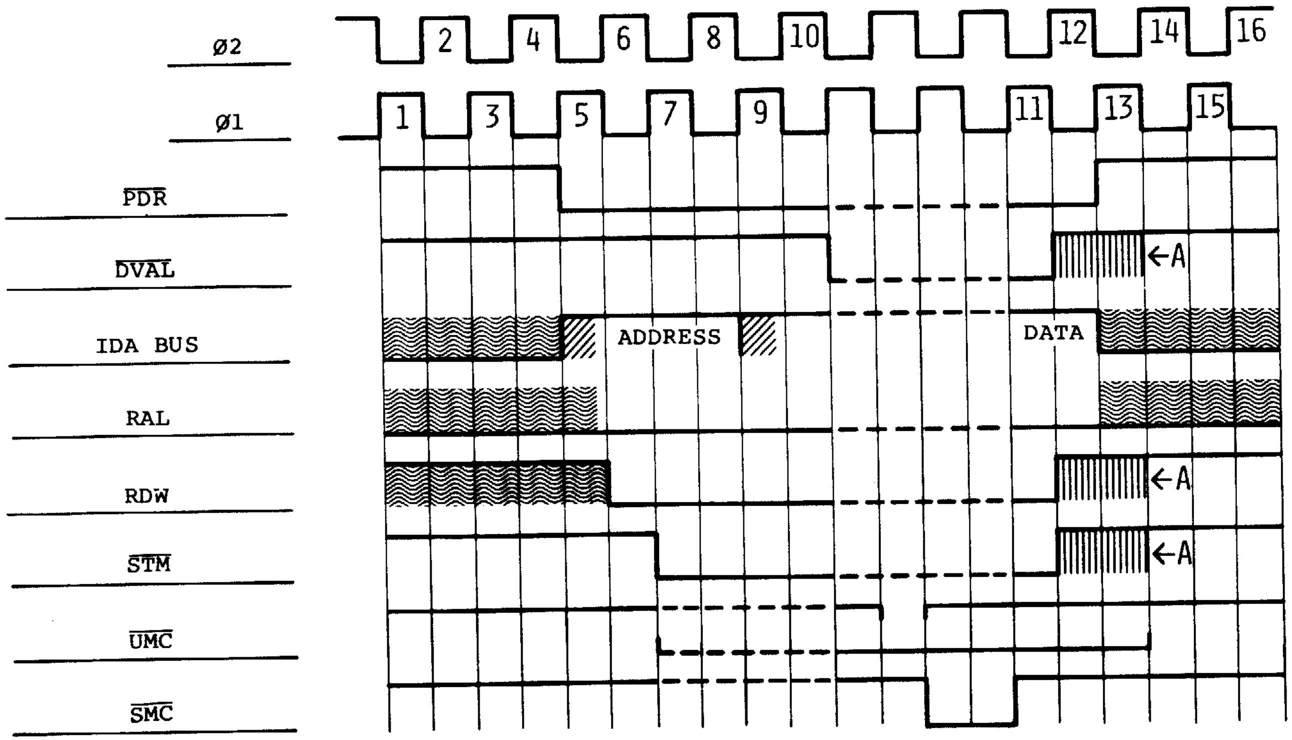
H. UMC NEED NOT BE USED IF SMC IS GIVEN BY THE ORIGINATOR EXACTLY AS SHOWN, INSTEAD. HOWEVER, IF UMC IS GIVEN AS SHOWN, IT WILL RESULT IN SMC AS SHOWN.
UMC IS IDLE IF THE BPC IS THE ORIGINATOR.

I. FOR ADDRESS.

J. FOR DATA.

WRITE MEMORY (TWO CONSECUTIVE FASTEST CYCLES SHOWN)

FIG 111C



NOTES

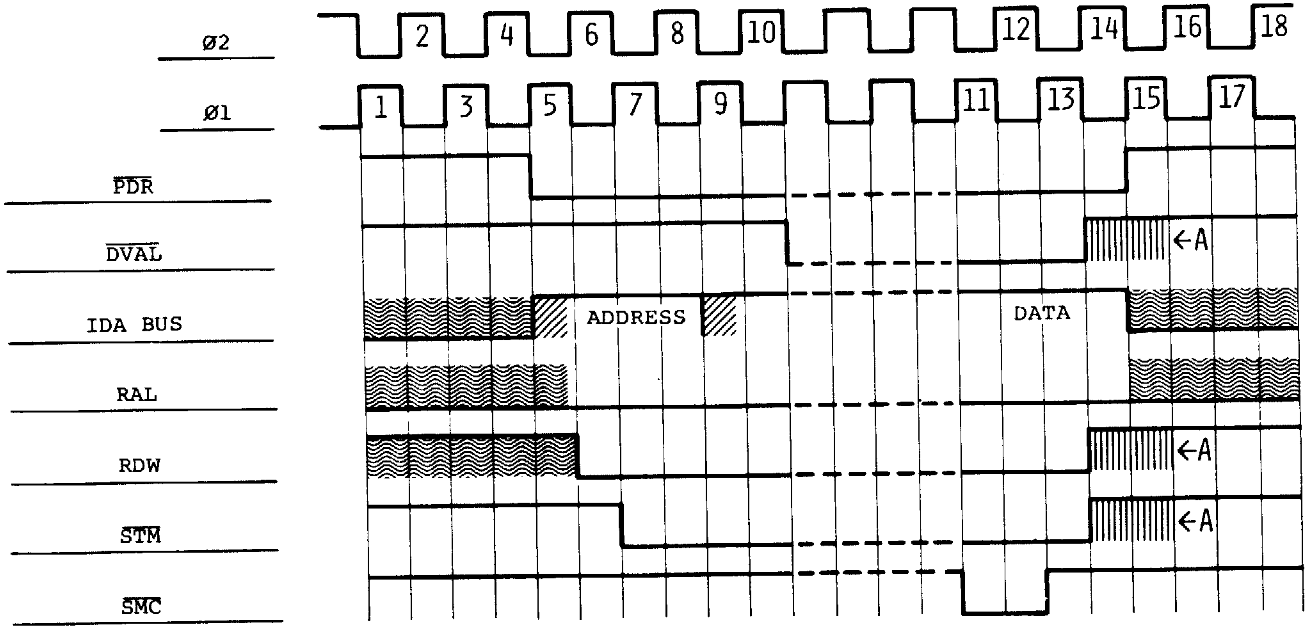
A. ACTIVE PULL-UP DURING MECD.

B. DOTTED LINES REPRESENT ZERO ON ANY INTEGRAL NUMBER OF Ø1-Ø2 PAIRS.

C. NOTE THAT $\overline{\text{UMC}}$ COULD EQUAL $\overline{\text{STM}}$.

GENERALIZED 4-STATE BPC WRITE MEMORY CYCLE WITHOUT HANDSHAKE

FIG 112



NOTES

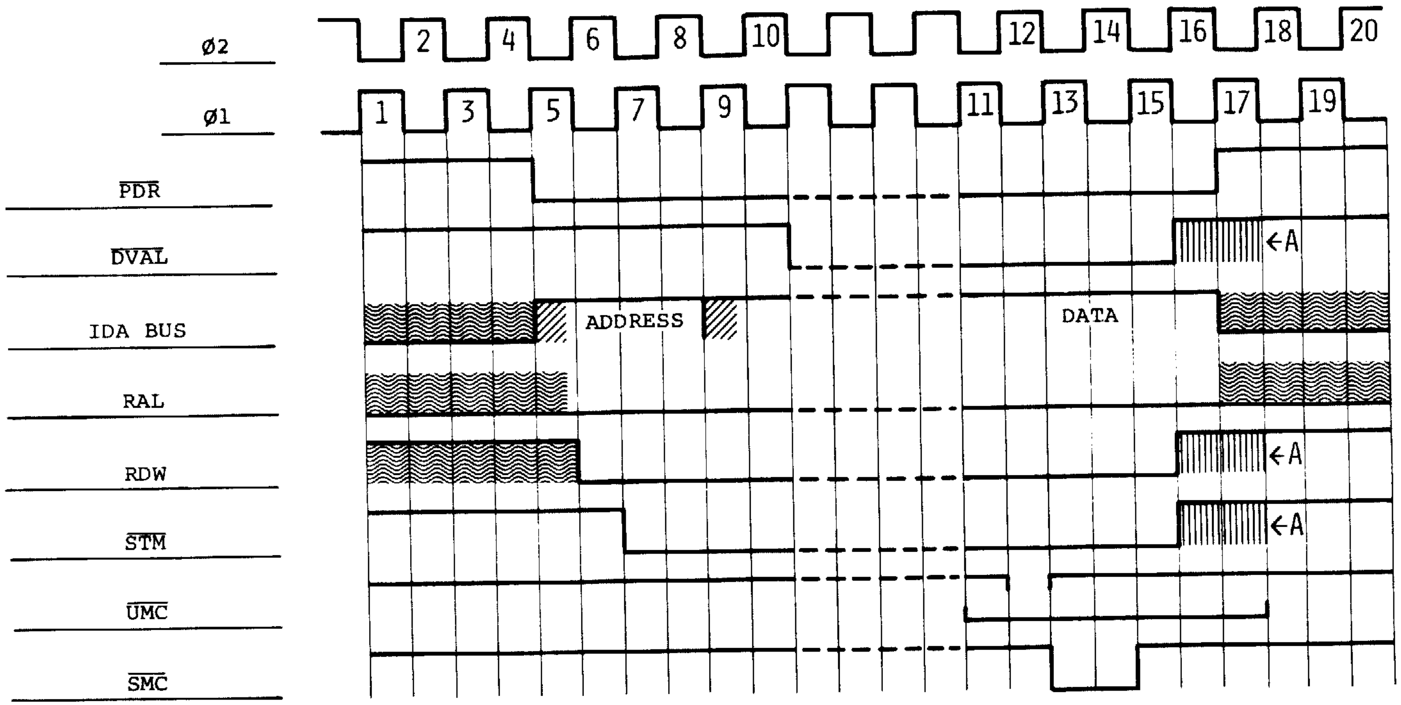
A. ACTIVE PULL-UP DURING MECD.

B. DOTTED LINES REPRESENT ZERO OR ANY INTEGRAL NUMBER OF Ø1-Ø2 PAIRS.

C. NOTE THAT $\overline{\text{SMC}}$ CANNOT EQUAL $\overline{\text{DVAL}}$; $\overline{\text{DVAL}}$ LASTS TOO LONG.

GENERALIZED 5-STATE BPC WRITE MEMORY CYCLE WITH HANDSHAKE
(LEADING EDGE OF DVAL USED TO INITIATE SMC)

FIG 113



NOTES

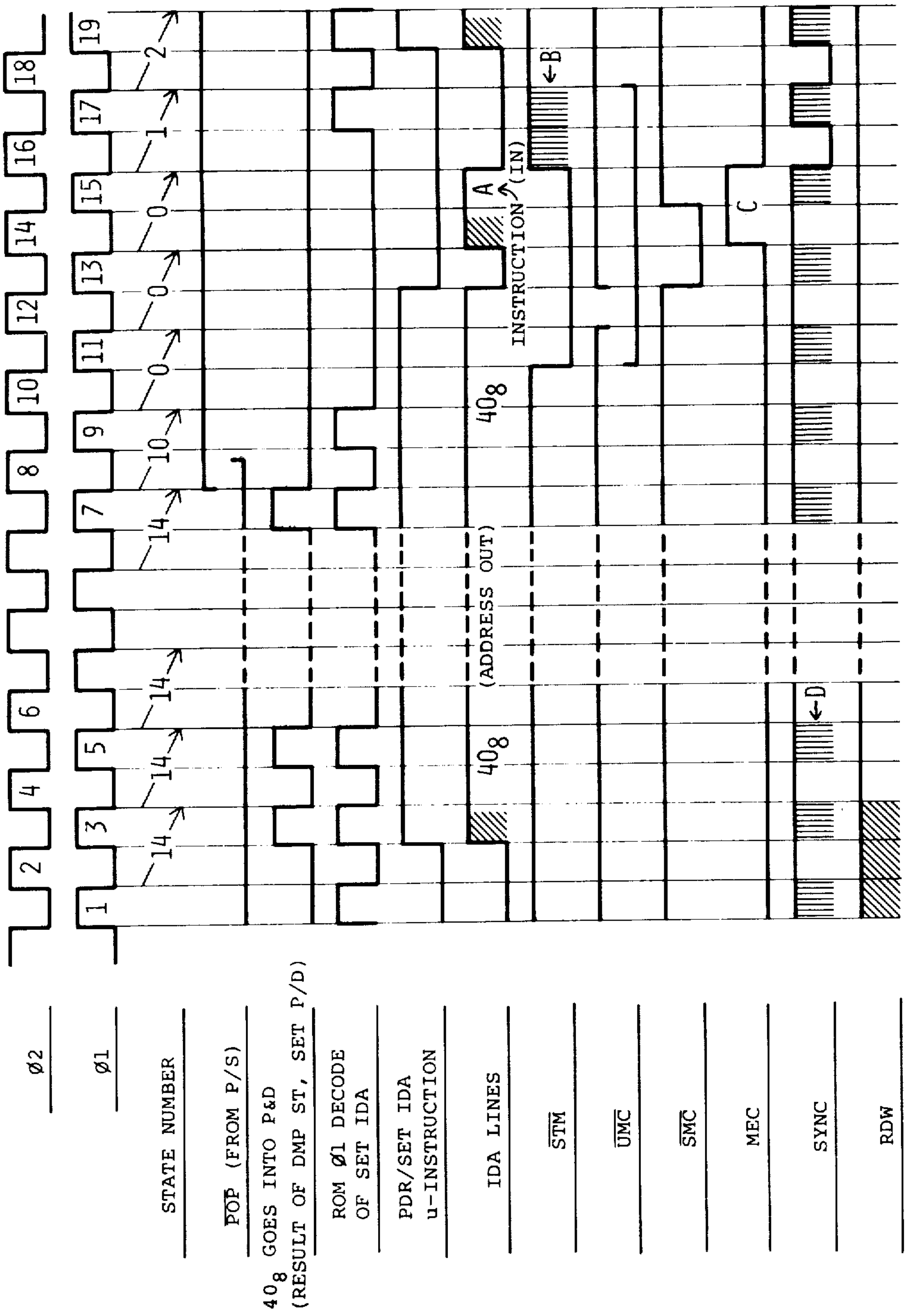
A. ACTIVE PULL-UP DURING MECD.

B. DOTTED LINES REPRESENT ZERO OR ANY INTEGRAL NUMBER OF Ø1-Ø2 PAIRS.

C. NOTE THAT $\overline{\text{UMC}}$ COULD EQUAL $\overline{\text{DVAL}}$.

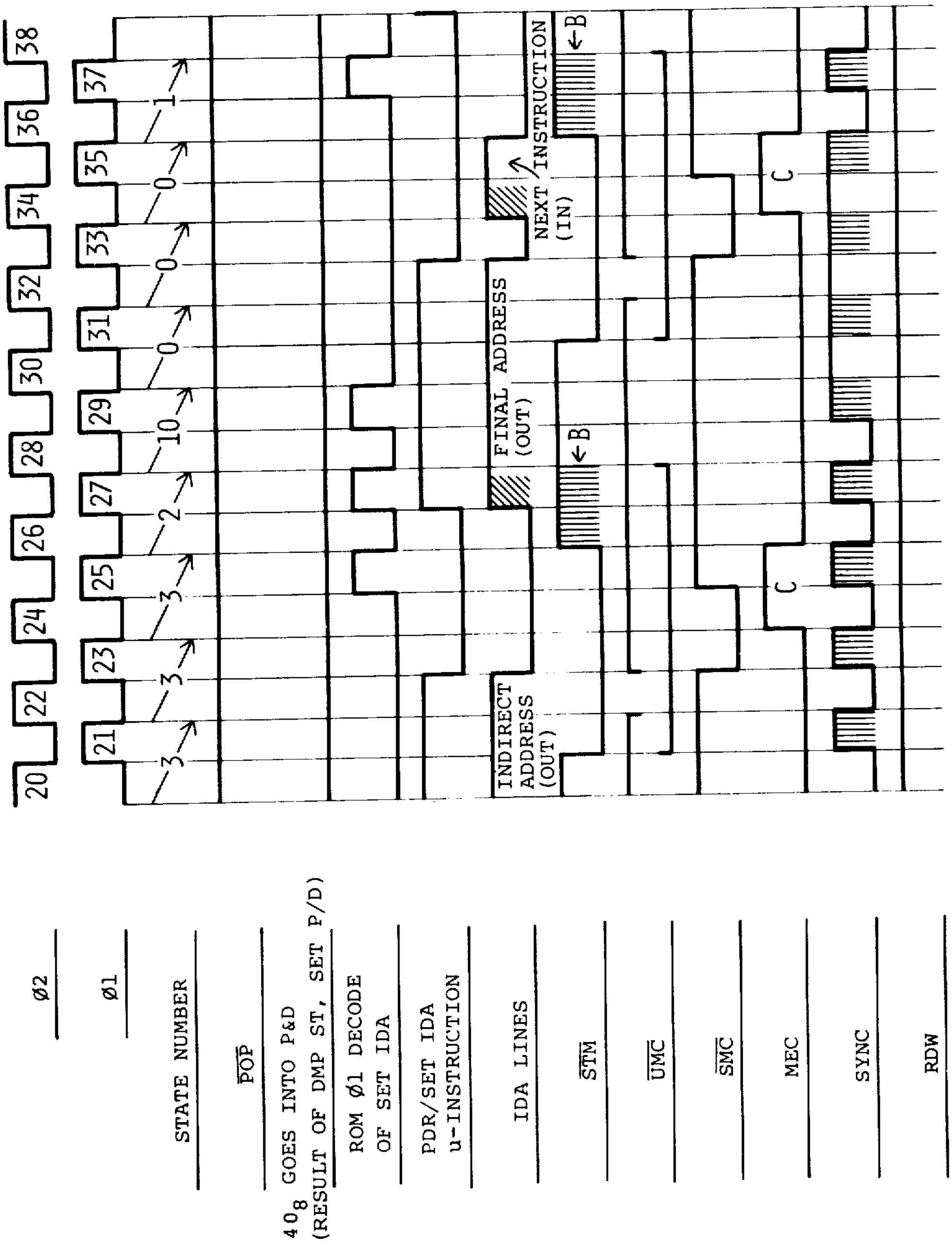
GENERALIZED 6-STATE BPC WRITE MEMORY CYCLE WITH HANDSHAKE
(LEADING EDGE OF DVAL USED TO INITIATE UMC)

FIG 114



BPC START-UP AND FIRST INSTRUCTION FETCH SEQUENCE

FIG 115A



BPC START-UP AND FIRST INSTRUCTION FETCH SEQUENCE

FIG 115B

NOTES

A. IDA EQUALS THE INSTRUCTION FETCHED FROM LOCATION $40_8$. IN THIS EXAMPLE WE ASSUME THAT IT IS JMP $41_8$, I.

B. ACTIVE PULL-UP ON $\overline{STM}$ DURING MECD.

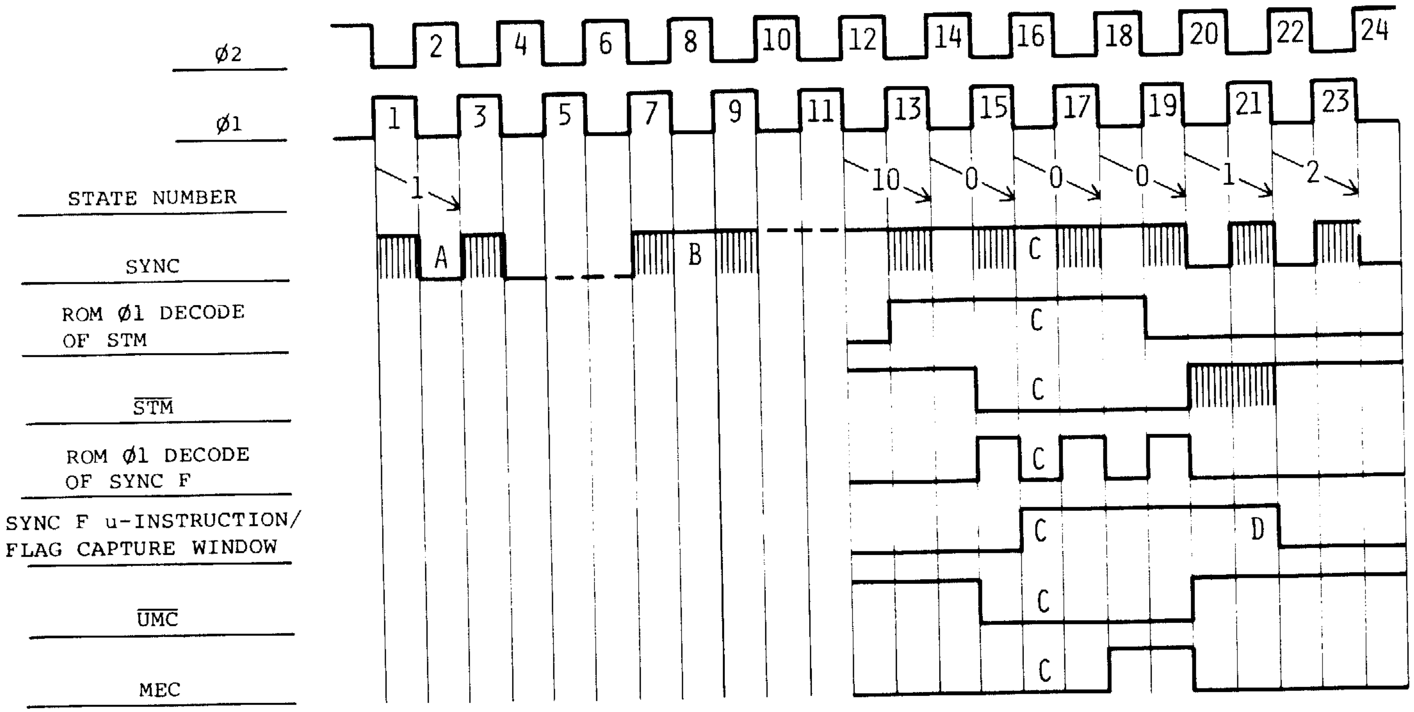
C. MEC RESETS THE LATCHED ROM OUTPUT FOR SYNC.

D. POP FORCES AN INITIAL SYNC. SYNC IS ALWAYS PRE-CHARGED ON Ø1.

E. DOTTED LINES REPRESENT AN INDEFINITE DELAY.

BPC START-UP AND FIRST INSTRUCTION FETCH SEQUENCE

FIG 115C



NOTES

A. SYNC IS FALSE AT THE END OF THE PREVIOUS INSTRUCTION FETCH.

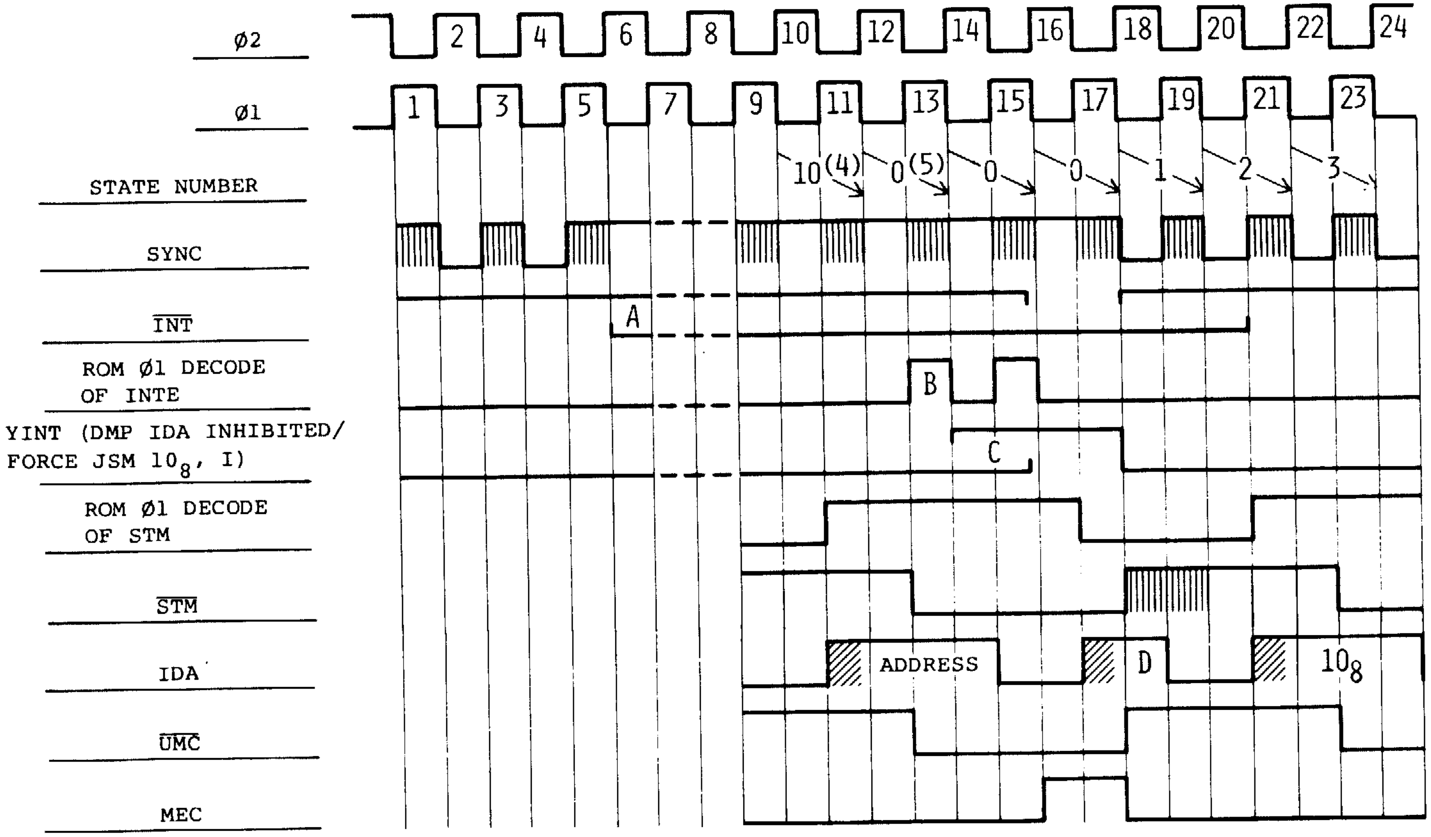
B. DURING THE EXECUTION OF THE PREVIOUS INSTRUCTION, SYNC GOES TRUE ON OR BEFORE STATE 10.

C. CAN BE IN STATE 0 FOR 2, 3, OR 4 STATES. TYPICALLY IT IS 3. THE EXACT NUMBER DEPENDS UPON WHEN STM WAS GIVEN, AND WHETHER OR NOT THE FETCH IS FROM A BPC REGISTER.

D. AT VERY LEAST, FLAGS MUST BE TRUE DURING THIS Ø2.

CAPTURE OF FLAGS DURING BPC INSTRUCTION FETCH

FIG 116



INTERRUPT DURING A BPC INSTRUCTION FETCH

FIG 117A

NOTES

A. $\overline{\text{INT}}$ MUST NOT BE PULLED BEFORE SYNC IS GIVEN.

B. IF THE PREVIOUS INSTRUCTION WAS A GROUP A INSTRUCTION, ONE LESS STATE-TIME IS SPENT IN STATE 0, AND THIS PULSE DOES NOT OCCUR. ALSO, THE STATE NUMBERS CHANGE AS INDICATED IN THE PARENTHESIS.

C. DEPENDS UPON $\overline{\text{INT}}$. IF NOTE B APPLIES, YINT TRANSITIONS AT START OF CLOCK #16.

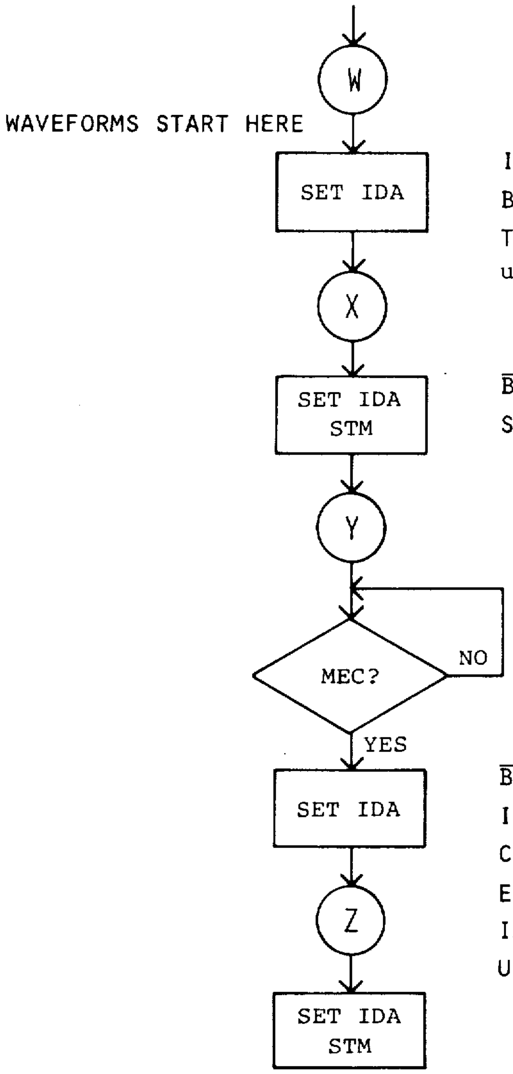
D. FETCHED INSTRUCTION THAT IS ABORTED AND REPLACED INTERNALLY BY JSM $10_8$, I.

E. PRESENT VERSION OF THE BPC DOES NOT ALLOW AN INSTRUCTION FETCH FROM A BPC REGISTER TO BE INTERRUPTED.

INTERRUPT DURING A BPC INSTRUCTION FETCH

FIG 117B

EQUIVALENT STRUCTURE OF TWO
BACK TO BACK MEMORY CYCLES



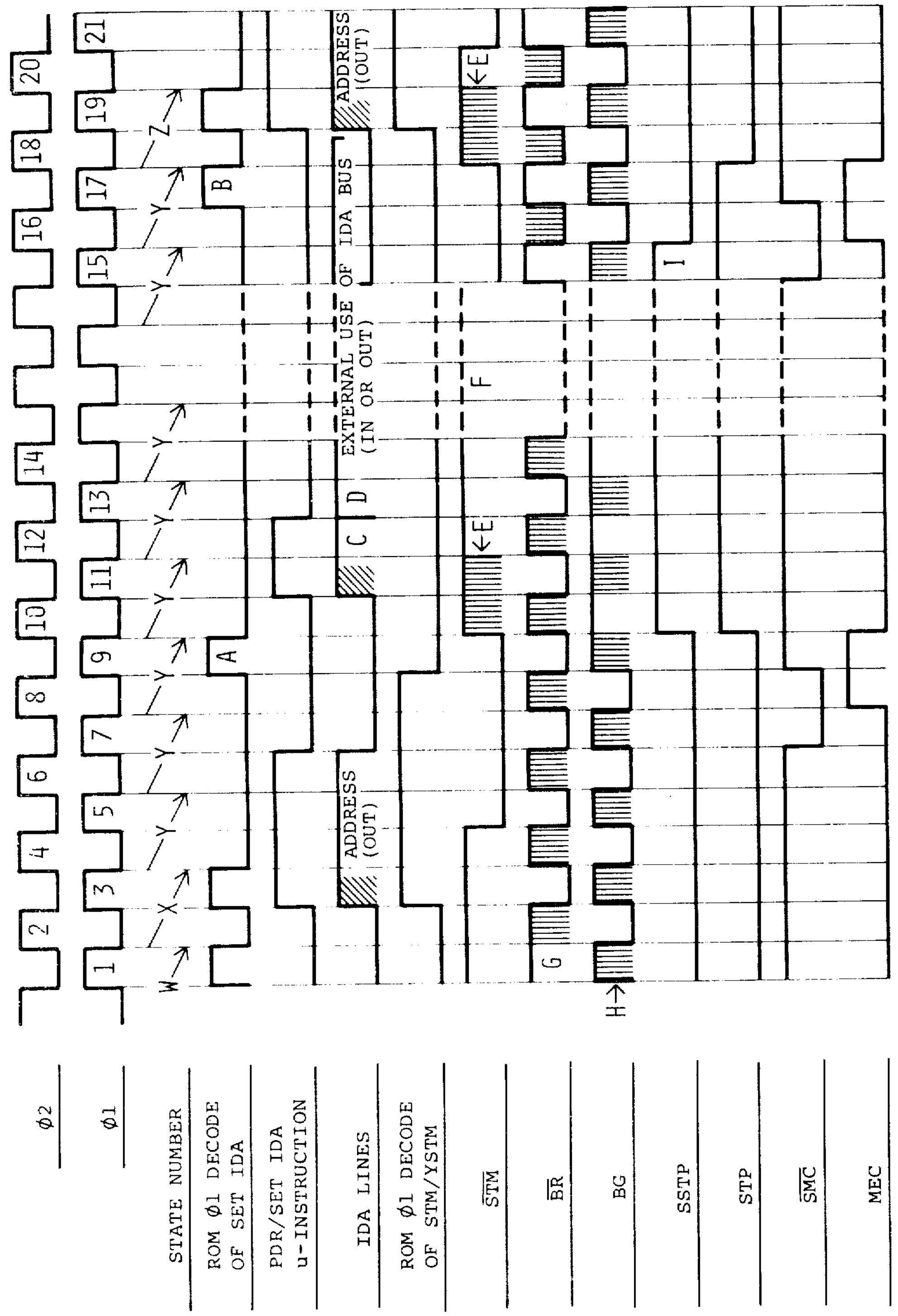
IF $\overline{BR}$ GROUNDED HERE AND BG IS GIVEN, WOULD HAVE TO WAIT UNTIL SET IDA u-INSTRUCTION IS OVER.

$\overline{BR}$ GROUNDED HERE, BUT STM PREVENTS BG.

$\overline{BR}$ STILL GROUNDED. BREAK IN STM ALLOWS BG. FLOWCHART IS SUSPENDED. HOWEVER, MUST WAIT FOR SET IDA TO GO AWAY, BEFORE USING BUS.

BUS REQUEST AND BUS GRANT DURING MEMORY CYCLES

FIG 118



BUS REQUEST AND BUS GRANT DURING MEMORY CYCLES

FIG 119A

NOTES

A. THIS IS THE FIRST OF TWO SET IDA'S. THE SECOND ONE IS NOT DECODED DUE TO THE GRANTING OF THE BUS. NOTE THAT EXTERNAL USE OF THE BUS MUST WAIT UNTIL THE EFFECT OF THIS SET IDA IS OVER.

B. THIS IS A RE-DECODING OF THE SAME SET IDA MENTIONED IN NOTE A. IN THIS WAY THE SET IDA/SET IDA-STM SEQUENCE IS PRESERVED.

C. MEMORY DATA. IT SO HAPPENS WE SHOW DATA FOR A READ CYCLE, AS OPPOSED TO THAT FOR A WRITE CYCLE. IT DOESN'T MATTER.

D. EARLIEST POSSIBLE USE OF THE BUS.

E. ACTIVE PULL-UP ON $\overline{\text{STM}}$ DURING MECD.

F. DOTTED LINES REPRESENT AN INDEFINITE INTERRUPTION.

G. IF AN IOC IS IN THE SYSTEM, IT WILL PRE-CHARGE $\overline{\text{BR}}$ DURING ∅2.

H. ACTIVE PULL-UP OF BG DURING ∅1.

I. SSTP ENDS SOONER THAN STP. THIS ALLOWS A POSSIBLE SET IDA TO BE RE-DECODED 1 STATE PRIOR TO ALL OTHER RESUMED ROM ACTIVITY.

BUS REQUEST AND BUS GRANT DURING MEMORY CYCLES

FIG 119B

TABLE OF BPC ROM CONTENTS

| MICRO-INSTRUCTION | ROM LINE | GIVEN IN ANY OF THESE GROUPS | WHEN IN ANY OF THESE STATES | PROVIDED ALL OF THESE CONDITIONS ARE MET |
|---|---|---|---|---|
| INTE | 1 | ABCDEFGHIJKM | 0 | $\overline{MEC}$ |
| SET IDA | 2 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | RDR |
| | 3 | ABCDEFGHIJKM | 1 6 7 8 10 14 | $\overline{SSTP}$ |
| | 4 | ABCDEFG | 1 3 8 9 10 | MEC · $\overline{SSTP}$ |
| | 5 | ABCDEFG | 2 4 14 | $\overline{SSTP}$ |
| | 6 | ABCDEFGHIJKM | 9 10 | $\overline{SSTP}$ |
| | 7 | EFH | 2 9 | $\overline{SSTP}$ |
| | 8 | HM | 1 3 8 9 10 | $\overline{SSTP}$ |
| SET D | 9 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | RDR · DRQ |
| | 10 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 7 · WTR |
| | 11 | ABCDEFGHIJKM | 6 14 | $\overline{STP}$ |
| | 12 | ABCDEFGHIJKM | 1 8 | $\overline{STP}$ |
| | 13 | ABCDEFG | 1 3 8 | $\overline{BPRL}$ · $\overline{MEC}$ · $\overline{STP}$ |
| | 14 | ABD | 1 3 8 | $\overline{IND}$ · MEC · $\overline{STP}$ |
| | 15 | ABCGIJK | 7 8 | $\overline{STP}$ |
| | 16 | CGI | 4 | |
| | 17 | ABCDEFGHIJKM | 9 | MEC |
| | 18 | H | 2 9 | $\overline{STP}$ |
| | 19 | H | 2 9 | $\overline{STP}$ |
| DMP IDA | 20 | ABCDEFG | 3 | $\overline{BPRL}$ · $\overline{MEC}$ |
| | 21 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | WTR |
| | 22 | D | 2 | $\overline{STP}$ |
| | 23 | DEF | 2 | $\overline{IND}$ · $\overline{STP}$ |
| | 24 | H | 4 | $\overline{BPRL}$ · $\overline{MEC}$ |
| | 25 | ABCDEFGHIJKM | 0 | $\overline{BPRL}$ · $\overline{MEC}$ |
| DMP T | 27 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 6 · RDR |
| | 30 | D | 3 4 5 | $\overline{IND}$ · MEC |
| | 31 | EFH | 9 | MEC |
| STM | 28 | ABD | 2 | $\overline{STP}$ |
| | 29 | AK | 4 5 | $\overline{STP}$ |
| | 32 | ABCDEFGHIJKM | 10 | $\overline{STP}$ |
| | 33 | AC | 2 | $\overline{STP}$ |
| | 36 | ABCDEFG | 2 | IND · $\overline{STP}$ |

FIG 120A

TABLE OF BPC ROM CONTENTS

| MICRO-INSTRUCTION | ROM LINE | GIVEN IN ANY OF THESE GROUPS | WHEN IN ANY OF THESE STATES | PROVIDED ALL OF THESE CONDITIONS ARE MET |
|---|---|---|---|---|
| STM | 37 | DEF | 7 8 | $\overline{STP}$ |
| (CONT.) | 40 | HM | 3 9 | $\overline{STP}$ |
| SET T | 34 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 6·WTR |
| | 35 | ABCDEFGHIJKM | 0 | $\overline{MEC}$ |
| | 38 | DM | 2 | $\overline{STP}$ |
| | 39 | F | 2 | $\overline{IND}\cdot\overline{STP}$ |
| | 41 | F | 2 | $\overline{IND}\cdot\overline{STP}$ |
| ADM | 42 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 2·RDR |
| | 43 | ABCDEFGHIJKM | 0 | |
| | 45 | ABCDEFGHIJKM | 1 | |
| DVAL | 44 | ABCDEFGHIJKM | 9 | $\overline{MEC}$ |
| SET P | 46 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 16·WTR |
| | 47 | AB | 3 | $\overline{IND}\cdot$MEC |
| | 48 | ABD | 7 | $\overline{STP}$ |
| | 49 | ABCDEFGHIJKM | 9 | MEC |
| | 50 | E | 2 4 14 | $\overline{IND}\cdot\overline{STP}$ |
| | 51 | HIJKM | 6 14 | $\overline{STP}$ |
| | 52 | H | 4 | $\overline{MEC}$ |
| | 53 | ABCDEFGHIJKM | 14 | |
| DMP P | 54 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 16·RDR |
| | 55 | CEFGHI | 8 | |
| | 56 | ABD | 9 | $\overline{SKP}\cdot$MEC |
| | 57 | ABCG | 7 8 | $\overline{SKP}\cdot\overline{STP}$ |
| DMP R | 58 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 17·RDR |
| | 59 | ABCDEFGHIJKM | 0 | MEC |
| | 61 | H | 2 | $\overline{STP}$ |
| WRITE | 60 | C | 2 4 | $\overline{IND}\cdot\overline{STP}$ |
| | 64 | ABCDEFGHIJKM | 9 | $\overline{MEC}$ |
| | 65 | DEF | 7 8 | $\overline{STP}$ |
| SET R | 62 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 17·WTR |
| | 63 | ABCDEFG | 6 14 | $\overline{STP}$ |
| | 66 | H | 9 10 | $\overline{STP}$ |

FIG 120B

TABLE OF BPC ROM CONTENTS

| MICRO-INSTRUCTION | ROM LINE | GIVEN IN ANY OF THESE GROUPS | WHEN IN ANY OF THESE STATES | PROVIDED ALL OF THESE CONDITIONS ARE MET |
|---|---|---|---|---|
| SET S | 67 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 12·WTR |
| | 68 | ABCDEFGHIJKM | 0 | MEC |
| | 69 | ABD | 3 | $\overline{\text{IND}}\cdot\overline{\text{MEC}}\cdot\overline{\text{STP}}$ |
| | 70 | IJK | 2 | $\overline{\text{STP}}$ |
| SSE | 71 | J | 3 9 | $\overline{\text{STP}}$ |
| SYNC | 72 | AB | 3 9 | $\overline{\text{IND}}\cdot\text{MEC}$ |
| | 73 | ABCDEFGHIJKM | 9 | MEC |
| | 76 | EG | 2 4 | $\overline{\text{IND}}$ |
| | 77 | H | 4 | MEC |
| | 80 | IJK | 2 | |
| | 81 | JKM | 2 | |
| DMP EX/OV | 75 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | (M-ADD 4 + M-ADD 5)·RDR |
| SET OV | 78 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 5·WTR |
| | 79 | I | 9 10 | $\text{OQ}\cdot\overline{\text{STP}}$ |
| SET EX | 82 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 4·WTR |
| | 83 | I | 9 10 | $\text{EQ}\cdot\overline{\text{STP}}$ |
| DMP PAD | 84 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | (M-ADD 0 + M-ADD 1 + M-ADD 2 + M-ADD 3)·RDR |
| | 85 | AB | 3 9 | $\overline{\text{IND}}\cdot\text{MEC}$ |
| | 86 | ACK | 9 | MEC |
| | 87 | DM | 7 | $\overline{\text{STP}}$ |
| | 88 | HIJKM | 1 6 | $\overline{\text{STP}}$ |
| | 89 | ABCDEFGHIJKM | 1 | $\overline{\text{STP}}$ |
| | 90 | BG | 7 8 | $\text{SKP}\cdot\overline{\text{STP}}$ |
| | 91 | ABD | 9 | SKP·MEC |
| RTP | 92 | ABCDEFGHIJKM | 0 | |
| NSO | 93 | ABCDEFGHIJKM | 0 | $\overline{\text{MEC}}$ |
| | 96 | AC | 5 6 | |
| | 97 | ABCDEFGHIJKM | 10 | |
| ADS | 94 | HI | 4 5 6 14 | SKP |
| | 95 | H | 4 5 6 14 | |

FIG 120C

TABLE OF BPC ROM CONTENTS

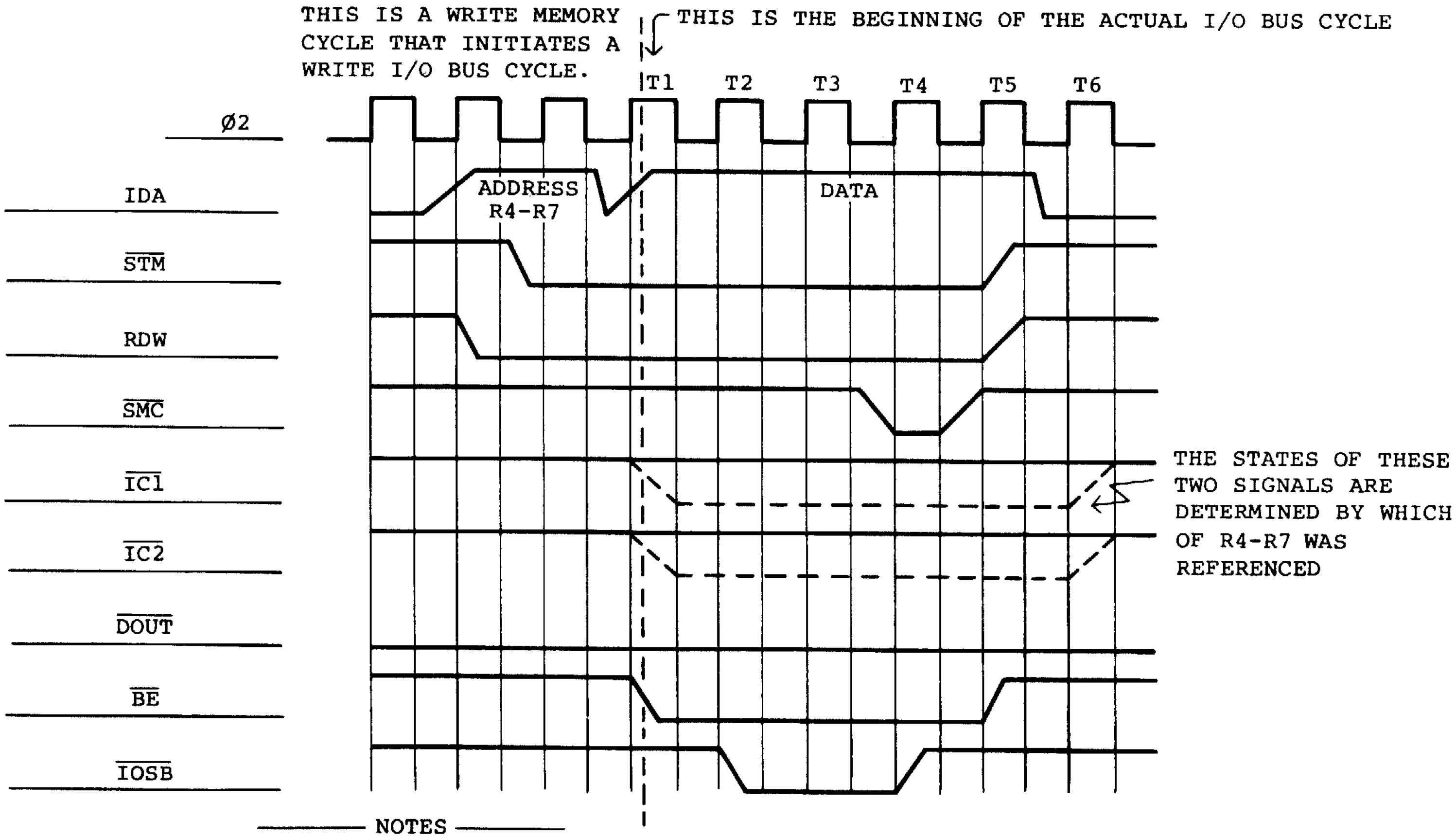
| MICRO-INSTRUCTION | ROM LINE | GIVEN IN ANY OF THESE GROUPS | WHEN IN ANY OF THESE STATES | PROVIDED ALL OF THESE CONDITIONS ARE MET |
|---|---|---|---|---|
| UPDOE | 98 | K | 10 | |
| | 99 | A | 5 6 | |
| NS9 | 100 | C | 4 | |
| | 101 | ABCDEFGHIJKM | 9 | $\overline{\text{MEC}}$ |
| DMP ALU | 102 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 11·RDR |
| | 103 | ABCDEFG | 5 6 | $\overline{\text{STP}}$ |
| | 106 | ABDJKM | 8 | |
| | 107 | HIJKM | 10 | $\overline{\text{STP}}$ |
| NS7 | 104 | BG | 5 6 | |
| | 105 | D | 3 4 5 | $\overline{\text{IND}}$·MEC |
| NS4 | 108 | CF | 2 | $\overline{\text{IND}}$ |
| | 109 | HM | 4 | $\overline{\text{MEC}}$ |
| SET B | 111 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 15·WTR |
| | 114 | ACK | 5 | BQ |
| | 115 | IJK | 9 10 | BQ·$\overline{\text{STP}}$ |
| NS6 | 112 | JK | 3 | CTQ |
| | 113 | M | 2 | SYNCQ |
| | 116 | K | 3 | |
| | 117 | M | 2 | GNI |
| DMP B | 118 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 15·RDR |
| | 119 | J | 2 4 | BQ·$\overline{\text{STP}}$ |
| | 122 | C | 4 | BQ·$\overline{\text{STP}}$ |
| NS10 | 120 | ABCG | 7 8 | |
| | 121 | HIJM | 6 14 | $\overline{\text{GNI}}$ |
| | 124 | IJK | 6 14 | |
| | 125 | ABCDEFGHIJKM | 14 | |
| | 128 | EG | 2 4 9 | $\overline{\text{IND}}$ |
| DMP A | 123 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 14·RDR |
| | 126 | J | 2 4 | AQ·$\overline{\text{STP}}$ |
| | 127 | C | 4 | AQ·$\overline{\text{STP}}$ |

FIG 120D

TABLE OF BPC ROM CONTENTS

| MICRO-INSTRUCTION | ROM LINE | GIVEN IN ANY OF THESE GROUPS | WHEN IN ANY OF THESE STATES | PROVIDED ALL OF THESE CONDITIONS ARE MET |
|---|---|---|---|---|
| NS2 | 129 | ABD | 3 | IND·MEC |
| | 132 | CEFG | 3 | MEC |
| | 133 | I | 2 | $\overline{\text{SYNCQ}}$ |
| | 136 | M | 2 | $\overline{\text{SYNCQ}}\cdot\overline{\text{GNI}}$ |
| | 137 | DM | 4 | MEC |
| SET A | 130 | ABCDEFHGIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 14·WTR |
| | 131 | ACK | 5 | AQ |
| | 134 | IJK | 9 10 | AQ·$\overline{\text{STP}}$ |
| DMP ST | 135 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 13·RDR |
| | 138 | ABCDEFGHIJKM | 14 | $\overline{\text{STP}}$ |
| SET I | 139 | ABCDEFGHIJKM | 0 1 2 3 4 5 6 7 8 9 10 14 | M-ADD 13·WTR |
| | 142 | ABCDEFGHIJKM | 0 | $\overline{\text{MEC}}$ |
| NS3 | 140 | ABCDEFG | 3 | $\overline{\text{MEC}}$ |
| | 141 | DM | 5 6 | GNI |
| | 144 | J | 3 4 5 | $\overline{\text{CTQ}}$ |
| SYNC F | 143 | ABCDEFGHIJKM | 0 | |

FIG 120E

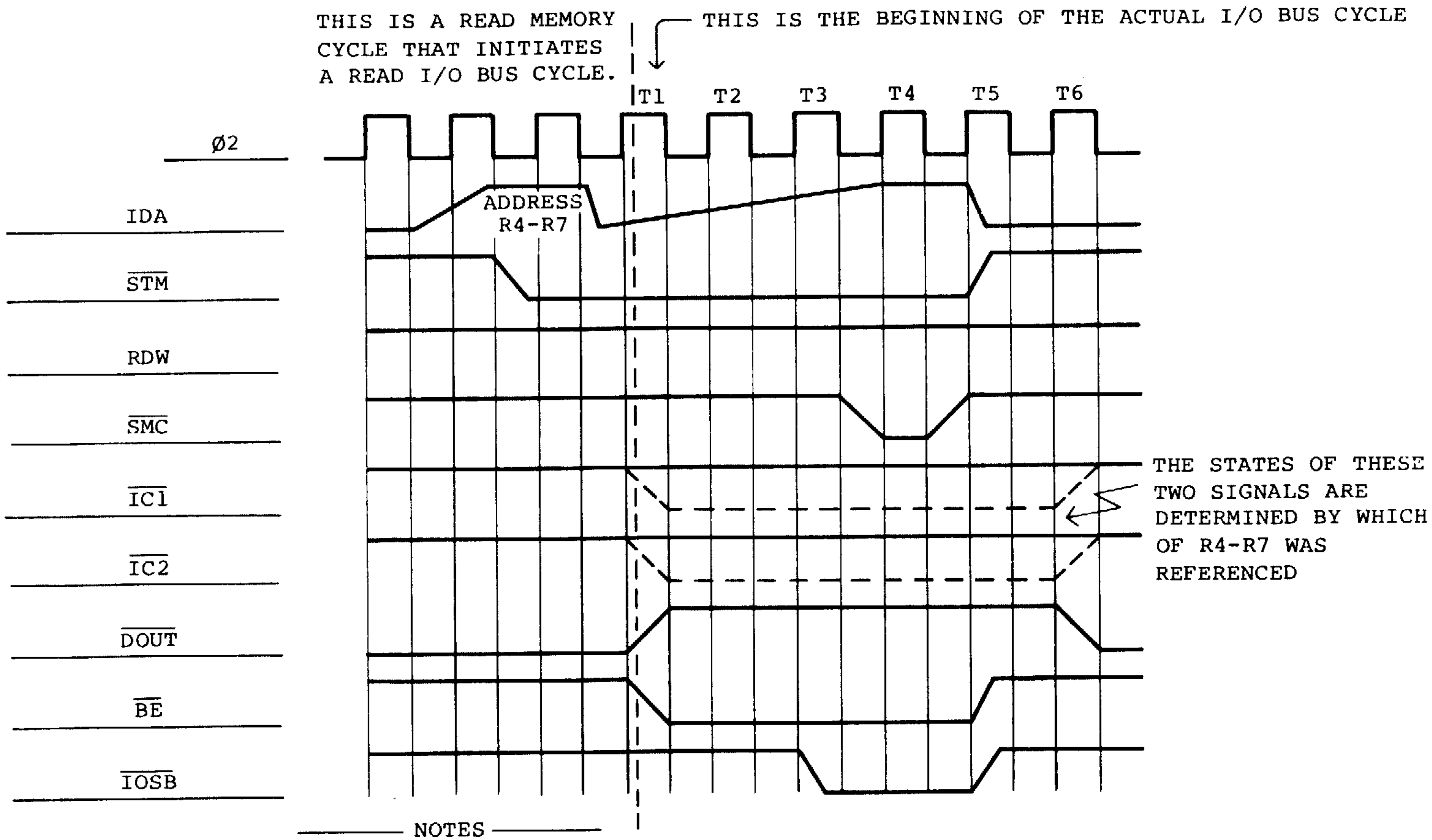

THIS IS A WRITE MEMORY CYCLE THAT INITIATES A WRITE I/O BUS CYCLE.
THIS IS THE BEGINNING OF THE ACTUAL I/O BUS CYCLE
T1
T2
T3
T4
T5
T6
Ø2
IDA
$\overline{STM}$
RDW
$\overline{SMC}$
$\overline{IC1}$
$\overline{IC2}$
$\overline{DOUT}$
$\overline{BE}$
$\overline{IOSB}$
ADDRESS R4-R7
DATA
THE STATES OF THESE TWO SIGNALS ARE DETERMINED BY WHICH OF R4-R7 WAS REFERENCED

NOTES

1. THIS I/O BUS CYCLE WAS INITIATED BY ANY WRITE-INTO-MEMORY INSTRUCTION WHICH REFERENCED ONE OF R4 THRU R7.
2. CONTROL INFORMATION IS VALID ON BOTH EDGES OF IOSB.
3. DATA IS LATCHED INTO THE INTERFACE ON THE TRAILING EDGE OF IOSB.

WRITE I/O BUS CYCLE

FIG 121

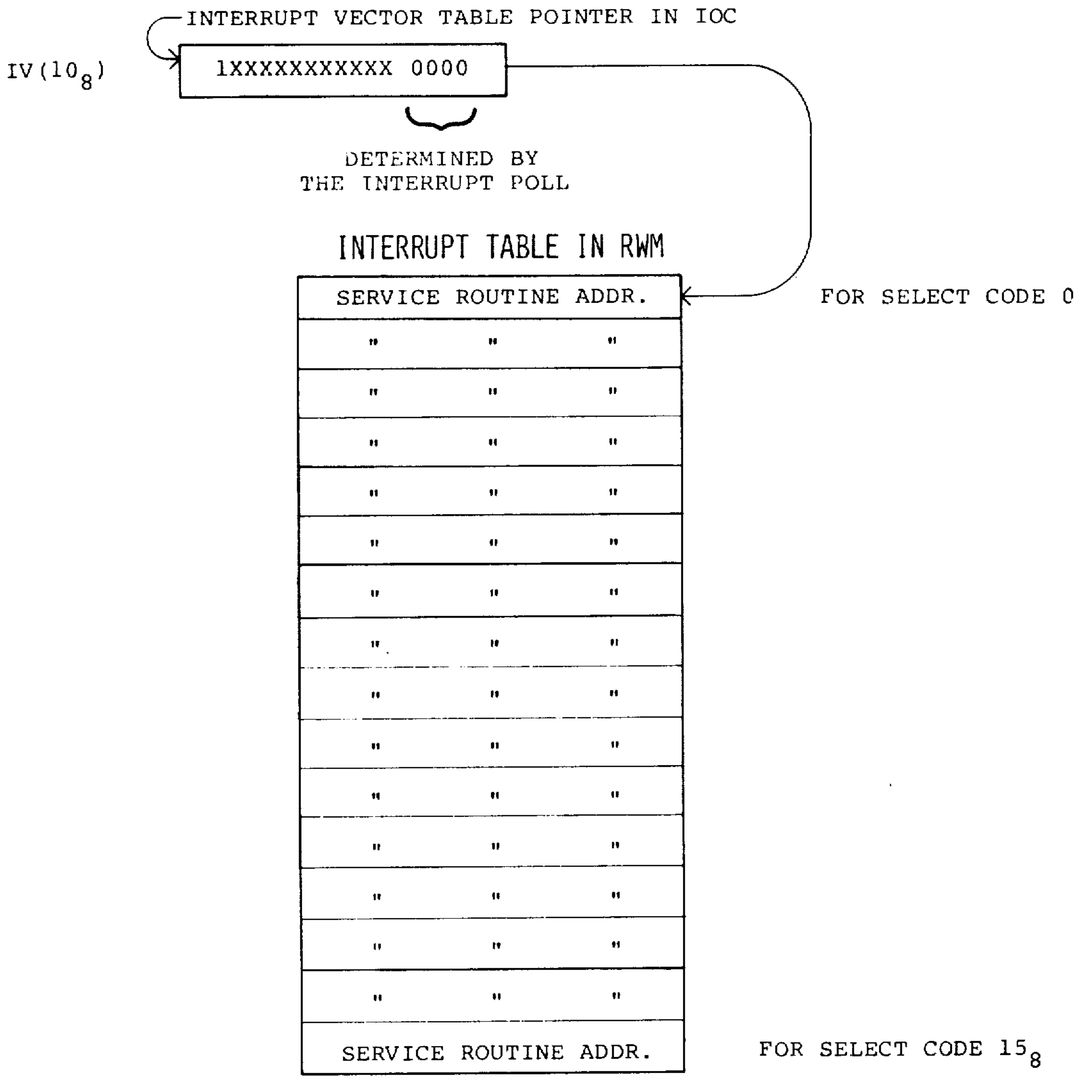

THIS IS A READ MEMORY CYCLE THAT INITIATES A READ I/O BUS CYCLE.
THIS IS THE BEGINNING OF THE ACTUAL I/O BUS CYCLE
T1
T2
T3
T4
T5
T6
Ø2
IDA
ADDRESS R4-R7
$\overline{STM}$
RDW
$\overline{SMC}$
$\overline{IC1}$
$\overline{IC2}$
$\overline{DOUT}$
$\overline{BE}$
$\overline{IOSB}$
THE STATES OF THESE TWO SIGNALS ARE DETERMINED BY WHICH OF R4-R7 WAS REFERENCED

NOTES

1. THIS I/O BUS CYCLE WAS INITIATED BY ANY READ-FROM-MEMORY INSTRUCTION WHICH REFERENCED ONE OF R4 THRU R7.
2. CONTROL INFORMATION IS VALID ON BOTH EDGES OF IOSB.
3. DATA FROM THE INTERFACE IS LATCHED INTO THE BPC DURING T4.

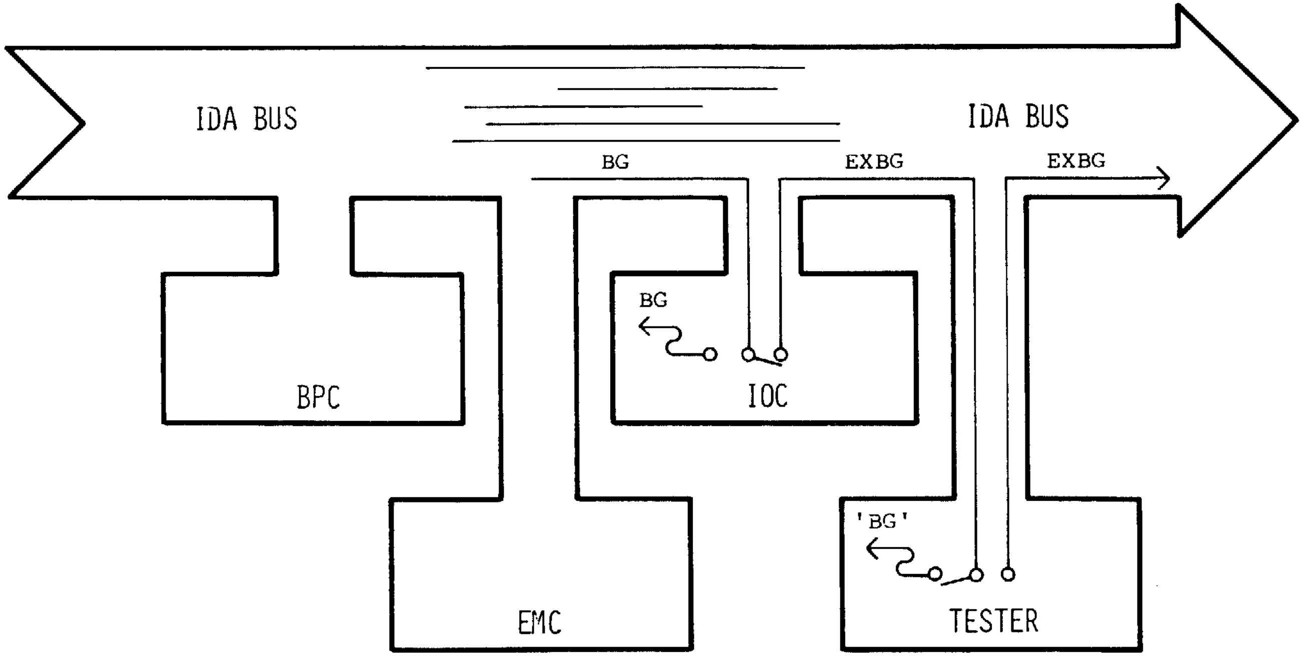
READ I/O BUS CYCLE

FIG 122



JSM THROUGH THE INTERRUPT TABLE

FIG 123



THE IOC IS NOT REQUESTING THE IDA BUS. IT PASSES BUS GRANT ALONG AS EXBG. THE TESTER IS REQUESTING THE BUS; IT USES EXBG AS BUS GRANT, AND DOES NOT PASS EXBG ALONG.

EXTENDED BUS GRANT

FIG 124

## IOC INSTRUCTION BIT PATTERNS

GROUP: STACK

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PWC | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | I/D | 1 | 1 | 0 | 0 | * 3 BIT REGISTER ADDRESS FIELD $(0-7_8)$.<br>* PLACE INST'S INC/DEC THE STACK POINTER BEFORE THE OPERATION.<br>* WITHDRAW INST'S INC/DEC THE STACK POINTER AFTERWARDS. | | |
| PBC | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | I/D | 1 | 1 | 0 | 0 | | | |
| PWD | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | I/D | 1 | 1 | 0 | 1 | | | |
| PBD | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | I/D | 1 | 1 | 0 | 1 | | | |
| WWC | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | I/D | 1 | 1 | 1 | 0 | | | |
| WBC | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | I/D | 1 | 1 | 1 | 0 | | | |
| WWD | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | I/D | 1 | 1 | 1 | 1 | | | |
| WBD | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | I/D | 1 | 1 | 1 | 1 | | | |

1. I/D (INCREMENT/DECREMENT) IS ENCODED AS 0/1
2. FOR BYTE INSTRUCTIONS, A 1 IN BIT 15 OF THE POINTER REGISTER IMPLIES A LEFT-HALF

FIG 125A

## IOC INSTRUCTION BIT PATTERNS (CONTINUED)

GROUP: INTERRUPT

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EIR | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| DIR | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |

FIG 125B

GROUP: DMA

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMA | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| PCM | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| DDR | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |

FIG 125C

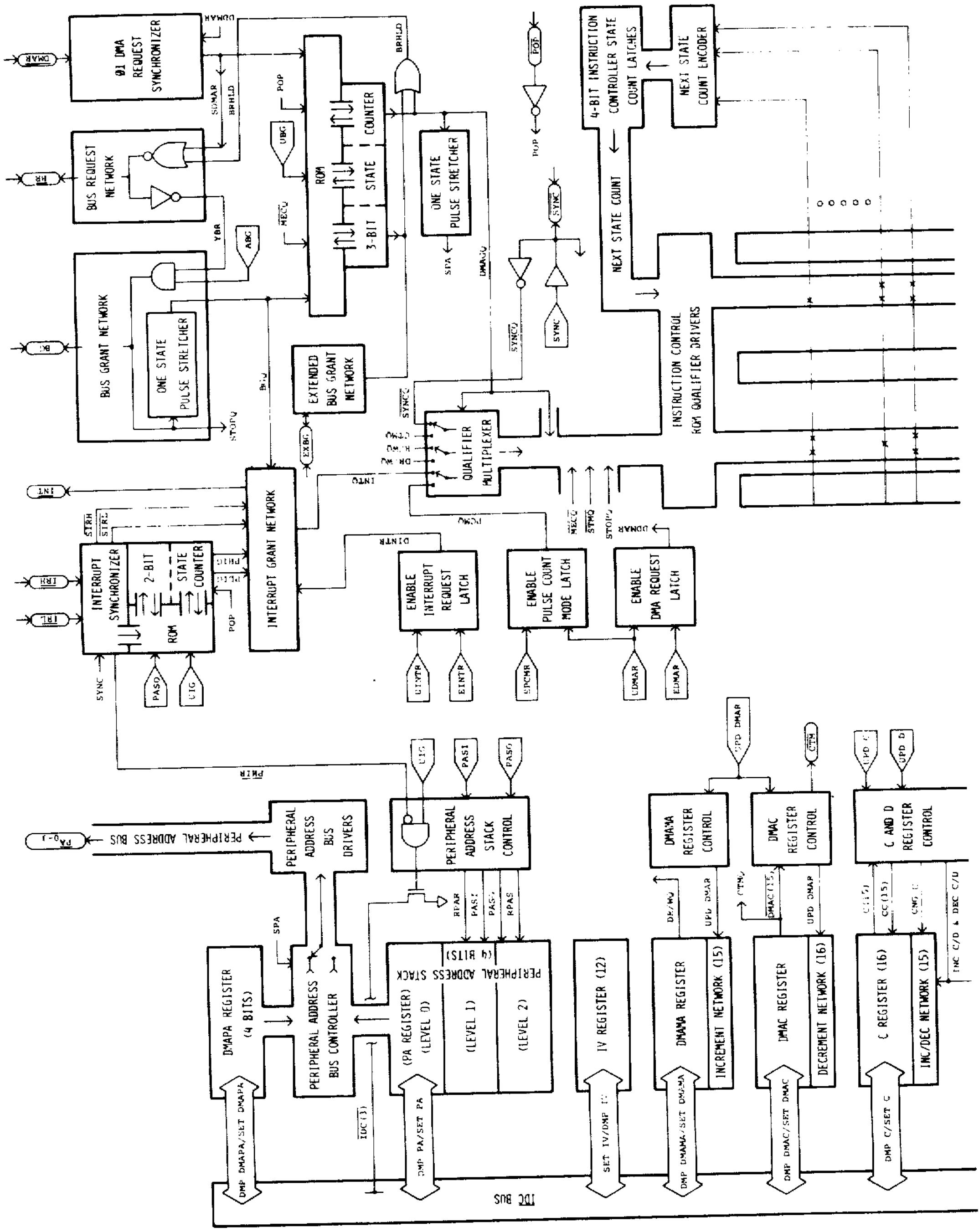

DMAR
Ø1 DMA REQUEST SYNCHRONIZER
DDMAR
SDMAR
BRHLD
BR
BUS REQUEST NETWORK
YBR
ABG
BG
BUS GRANT NETWORK
ONE STATE PULSE STRETCHER
STOPG
BRHLD
POP
UBG
NECU
ROM
3-BIT STATE COUNTER
ONE STATE PULSE STRETCHER
SPA
DMACU
POT
POP
SYNC
SYNCG
SYNCG
EXTENDED BUS GRANT NETWORK
EXBG
QUALIFIER MULTIPLEXER
INTQ
INT
STRH
STRL
IRH
IRL
INTERRUPT SYNCHRONIZER
2-BIT STATE COUNTER
ROM
PASO
UIG
POP
SYNC
INTERRUPT GRANT NETWORK
DINTR
ENABLE INTERRUPT REQUEST LATCH
UINTR
EINTR
ENABLE PULSE COUNT MODE LATCH
EPCMR
NECQ
STMQ
STOPQ
DDMAR
ENABLE DMA REQUEST LATCH
UDMAR
EDMAR
4-BIT INSTRUCTION CONTROLLER STATE COUNT LATCHES
NEXT STATE COUNT ENCODER
NEXT STATE COUNT
INSTRUCTION CONTROL ROM QUALIFIER DRIVERS
PMIR
PA0-3
PERIPHERAL ADDRESS BUS
PERIPHERAL ADDRESS BUS DRIVERS
UIG
PAS1
PASO
PERIPHERAL ADDRESS STACK CONTROL
RPAR
PAS1
PASO
RPAS
SPA
DMAPA REGISTER (4 BITS)
PERIPHERAL ADDRESS BUS CONTROLLER
PERIPHERAL ADDRESS STACK (4 BITS)
(PA REGISTER) (LEVEL 0)
(LEVEL 1)
(LEVEL 2)
IDC(3)
DMP DMAPA/SET DMAPA
DMP PA/SET PA
IV REGISTER (12)
SET IV/DMP IV
IDC BUS
UPD DMAR
DMAMA REGISTER CONTROL
DMAC REGISTER CONTROL
CTM
DE/MQ
UPD DMAR
CTMQ
DMAC(15)
UPD DMAR
DMAMA REGISTER
INCREMENT NETWORK (15)
DMP DMAMA/SET DMAMA
DMAC REGISTER
DECREMENT NETWORK (16)
DMP DMAC/SET DMAC
UPD C
UPD D
C AND D REGISTER CONTROL
CC(15)
INC C/D & DEC C/D
C REGISTER (16)
INC/DEC NETWORK (15)
DMP C/SET C

FIG 126A

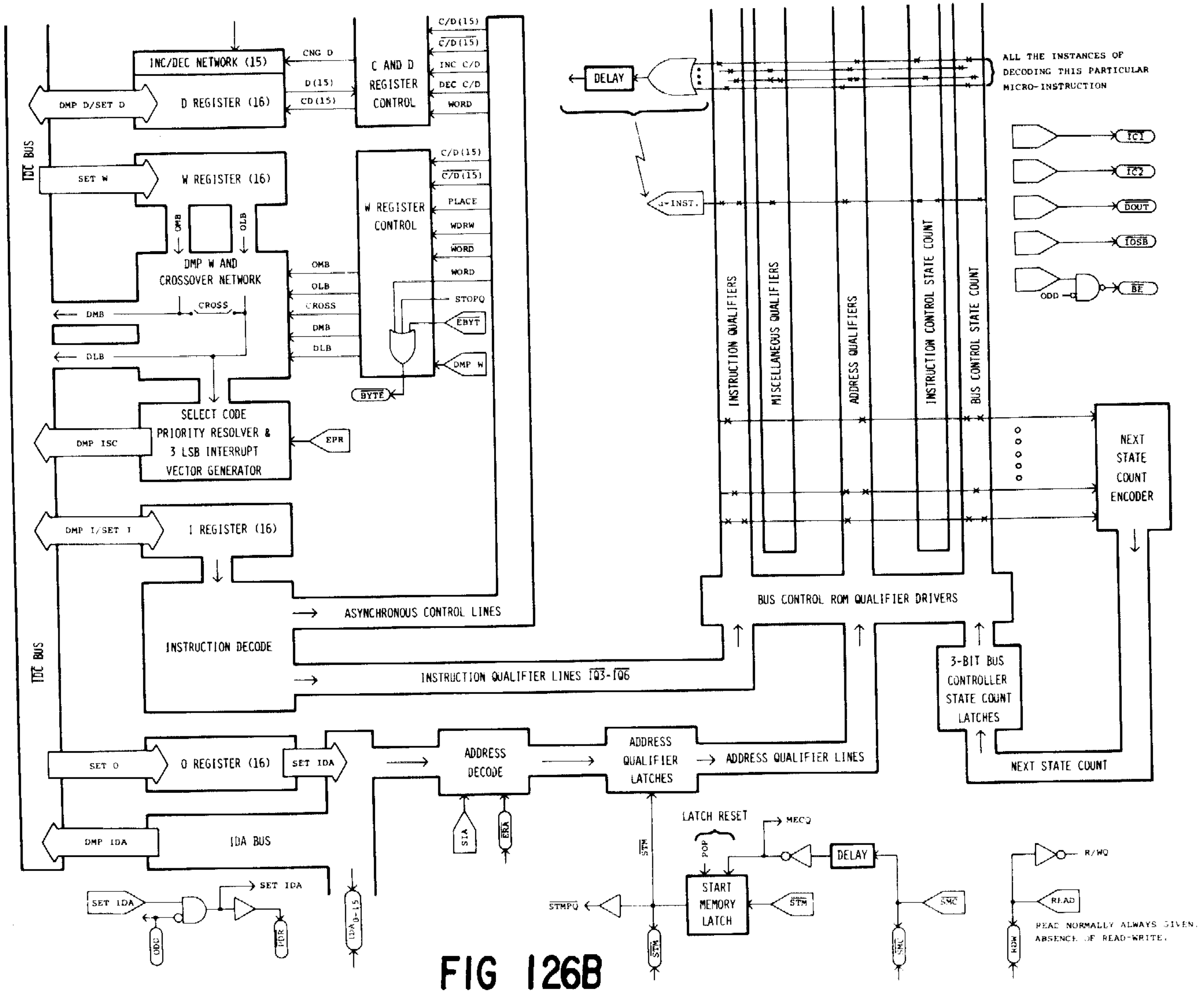
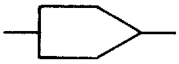
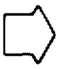
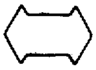
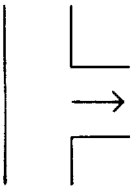

INC/DEC NETWORK (15)
D REGISTER (16)
DMP D/SET D
CNG D
D(15)
CD(15)
C AND D REGISTER CONTROL
C/D(15)
C/D(15)
INC C/D
DEC C/D
WORD
IDC BUS
SET W
W REGISTER (16)
OMB
OLB
DMP W AND CROSSOVER NETWORK
CROSS
DMB
DLB
W REGISTER CONTROL
C/D(15)
C/D(15)
PLACE
WDRW
WORD
WORD
STOPQ
EBYT
DMP W
BYTE
OMB
OLB
CROSS
DMB
DLB
SELECT CODE PRIORITY RESOLVER & 3 LSB INTERRUPT VECTOR GENERATOR
DMP ISC
EPR
I REGISTER (16)
DMP I/SET I
INSTRUCTION DECODE
ASYNCHRONOUS CONTROL LINES
INSTRUCTION QUALIFIER LINES IQ3-IQ6
IDC BUS
SET O
O REGISTER (16)
SET IDA
ADDRESS DECODE
SIA
ERA
ADDRESS QUALIFIER LATCHES
ADDRESS QUALIFIER LINES
DMP IDA
IDA BUS
SET IDA
SET IDA
ODD
PDR
IDA0-15
DELAY
μ-INST.
INSTRUCTION QUALIFIERS
MISCELLANEOUS QUALIFIERS
ADDRESS QUALIFIERS
INSTRUCTION CONTROL STATE COUNT
BUS CONTROL STATE COUNT
ALL THE INSTANCES OF DECODING THIS PARTICULAR MICRO-INSTRUCTION
IC1
IC2
DOUT
IOSB
ODD
BE
NEXT STATE COUNT ENCODER
BUS CONTROL ROM QUALIFIER DRIVERS
3-BIT BUS CONTROLLER STATE COUNT LATCHES
NEXT STATE COUNT
LATCH RESET
POP
MECQ
DELAY
STM
START MEMORY LATCH
STMPQ
STM
STM
SMC
SMC
R/WQ
READ
RDW
READ NORMALLY ALWAYS GIVEN. ABSENCE OF READ-WRITE.

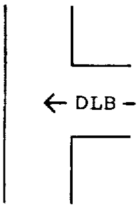
FIG 126B

NOTES:

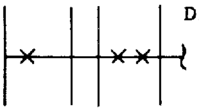
1.  DENOTES A MICRO-INSTRUCTION DECODED IN THE ROM.

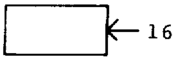
2.  AND  DENOTE ONE- AND TWO-WAY INTERCONNECTIONS TO A BUS; ALWAYS CONTROLLED BY A ROM MICRO-INSTRUCTION.

3.  DENOTES A DIRECT CONNECTION BETWEEN TWO ITEMS.

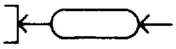
4. 

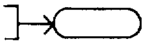
DENOTES A CONNECTION BETWEEN TWO ITEMS THAT IS ACTIVE ONLY WHEN THE STATED SIGNAL IS GIVEN. SOME SUCH SIGNALS ARE ROM DECODED MICRO-INSTRUCTIONS, WHILE OTHERS ARE PRESENT THROUGHOUT AN ENTIRE EXECUTION CYCLE.

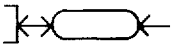
5.  DENOTES THAT THE STATED LINE REPRESENTS A DECODED CONDITION.

6. 

REPRESENTS A NON-MICRO-INSTRUCTION CONTROL LINE OR SOME OTHER SIGNAL.

7.  REPRESENTS AN INPUT TERMINAL TO THE IOC.

8.  REPRESENTS AN OUTPUT TERMINAL FROM THE IOC.

9.  REPRESENTS A TERMINAL THAT IS BOTH AN INPUT AND AN OUTPUT.

10. NUMBERS IN PARENTHESES INDICATE THE NUMBER OF BITS A MECHANISM HANDLES.

11. THE LOGICAL SENSE (XXX VERSUS $\overline{XXX}$) OF THE I/O TERMINALS IS CORRECTLY INDICATED. HOWEVER, THE DRAWING IS NOT A RELIABLE INDICATOR OF THE EXACT SENSE OF THE INTERNAL SIGNALS. TYPICALLY BOTH SENSES EXIST, AND FREQUENTLY THE PHYSICAL PROXIMITY OF SIGNALS TO THEIR DESTINATIONS WAS MORE IMPORTANT IN DECIDING WHICH SENSE TO USE, RATHER THAN AGREEMENT OF LOGICAL SENSE.

BECAUSE STRICT ACCURACY IN REPORTING SIGNAL SENSES ON SUCH A GENERAL LEVEL DRAWING WOULD SHARPLY INCREASE THE NUMBER OF INTERCONNECTIONS, WITH ONLY A SLIGHT INCREASE IN USEFULNESS, WE USUALLY SHOW ONLY THE NAME OF THE SIGNAL.

FIG 126C

| ADDRESS | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | $E_S$ | TWO'S COMPLEMENT EXPONENT | | | | | | | | | EMPTY | | | | | $M_S$ |
| M + 1 | $D_1$ | | | | $D_2$ | | | | $D_3$ | | | | $D_4$ | | | |
| M + 2 | $D_5$ | | | | $D_6$ | | | | $D_7$ | | | | $D_8$ | | | |
| M + 3 | $D_9$ | | | | $D_{10}$ | | | | $D_{11}$ | | | | $D_{12}$ | | | |

| THE BCD DIGITS | | | |
|---|---|---|---|
| 0 | 0000 | 5 | 0101 |
| 1 | 0001 | 6 | 0110 |
| 2 | 0010 | 7 | 0111 |
| 3 | 0011 | 8 | 1000 |
| 4 | 0100 | 9 | 1001 |

THE INTERNAL FLOATING POINT REPRESENTATION OF

.003587219 ( = 3.587219 X $10^{-3}$)

| ADDRESS | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| M + 1 | 0011 | | | | 0101 | | | | 1000 | | | | 0111 | | | |
| M + 2 | 0010 | | | | 0001 | | | | 1001 | | | | 0000 | | | |
| M + 3 | 0000 | | | | 0000 | | | | 0000 | | | | 0000 | | | |

BCD FLOATING POINT FORMAT

FIG 127

EMC INSTRUCTION BIT PATTERNS

GROUP: ARITHMETIC

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FXA | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MWA | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CMX | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| CMY | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | C | 1 | 0 | 0 | 0 | 0 | 0 |
| FMP | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FDV | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| MPY | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| CDC | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

FIG 128A

EMC INSTRUCTION BIT PATTERNS (CONTINUED)

GROUP: FOUR WORD OPERATION

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLR | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | * 4 BIT FIELD<br># OF WORDS<br>* BINARY = N-1 | | | |
| XFR | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | | | | |

FIG 128B

GROUP: MANTISSA SHIFT

| INST. NAME | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MRX | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DRS | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| MLY | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| MRY | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRM | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

FIG 128C

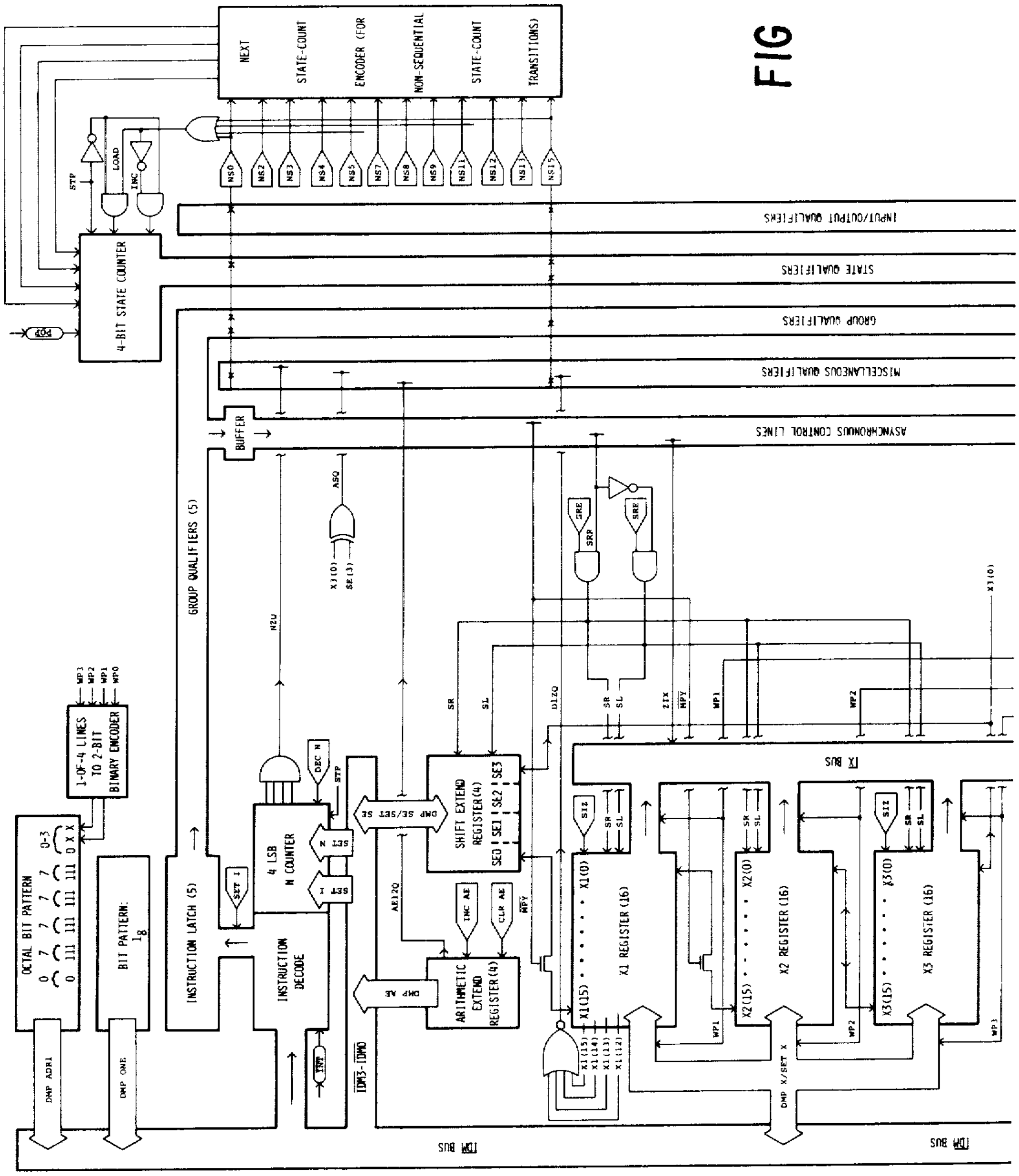

NEXT
STATE-COUNT
ENCODER (FOR
NON-SEQUENTIAL
STATE-COUNT
TRANSITIONS)
NS0
NS2
NS3
NS4
NS5
NS7
NS8
NS9
NS11
NS12
NS13
NS15
STP
LOAD
INC
4-BIT STATE COUNTER
POP
INPUT/OUTPUT QUALIFIERS
STATE QUALIFIERS
GROUP QUALIFIERS
MISCELLANEOUS QUALIFIERS
ASYNCHRONOUS CONTROL LINES
BUFFER
GROUP QUALIFIERS (5)
ASQ
X1(0)
SE(3)
NZU
SRE
SRP
SRE
SR
SL
D12Q
SR
SL
Z1X
MPY
WP1
WP2
X1(0)
IX BUS
WP3
WP2
WP1
WP0
1-OF-4 LINES
TO 2-BIT
BINARY ENCODER
OCTAL BIT PATTERN
0 7 7 7 0-3
0 111 111 111 0 X X
BIT PATTERN:
1₈
INSTRUCTION LATCH (5)
SET I
INSTRUCTION DECODE
INT
4 LSB
N COUNTER
DEC N
STP
SET N
SET I
DMP SE/SET SE
SHIFT EXTEND
REGISTER(4)
SE0 SE1 SE2 SE3
AE12Q
INC AE
CLR AE
MPY
ARITHMETIC
EXTEND
REGISTER(4)
DMP AE
IDM3-IDM0
SIZ
SR
SL
X1(15) • • • • • • X1(0)
X1 REGISTER (16)
X1(15)
X1(14)
X1(13)
X1(12)
SR
SL
X2(15) • • • • • • X2(0)
X2 REGISTER (16)
WP1
SIZ
SR
SL
X3(15) • • • • • • X3(0)
X3 REGISTER (16)
WP2
WP3
DMP X/SET X
DMP ADR1
DMP ONE
IDM BUS
IDM BUS

FIG 129A

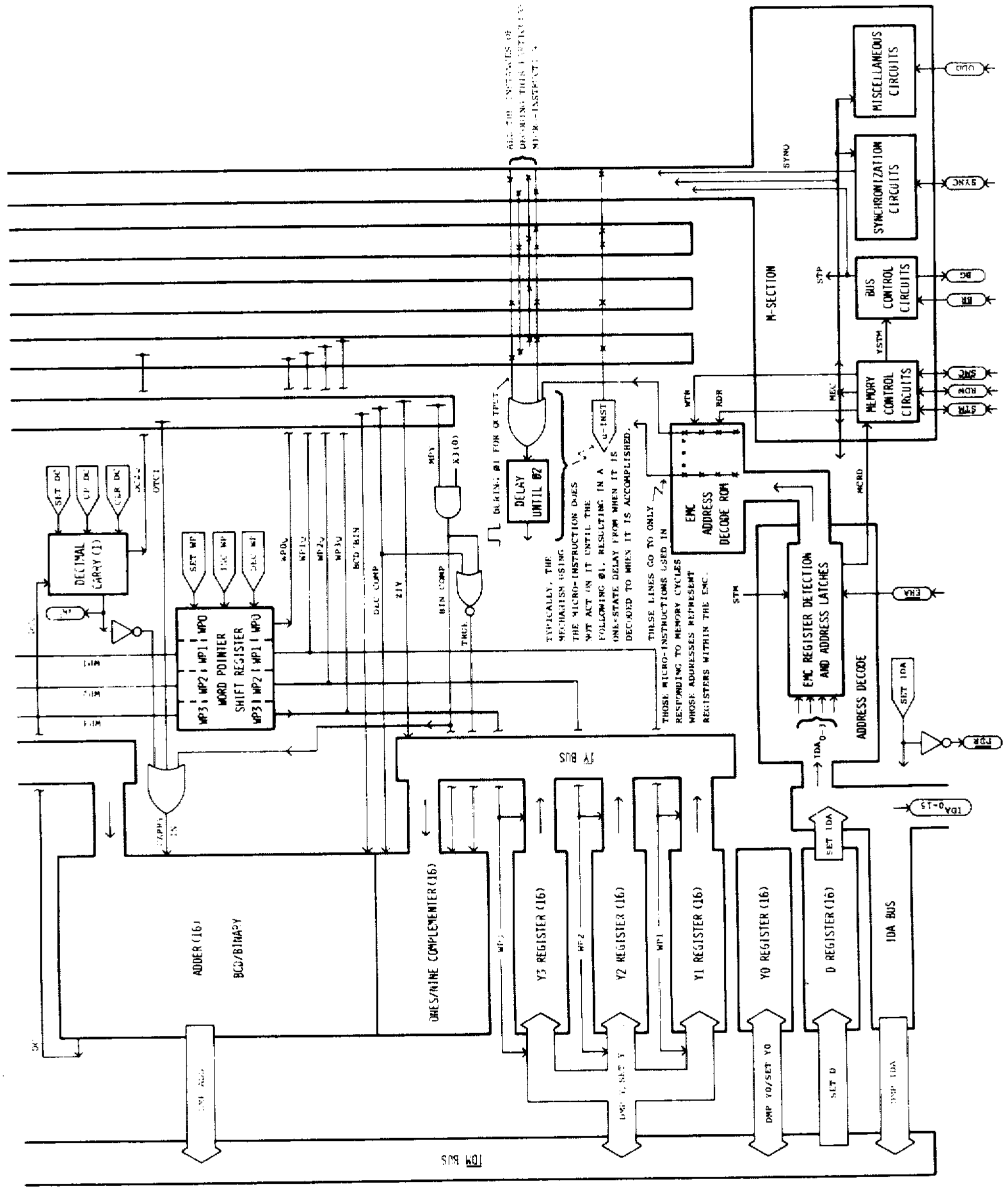
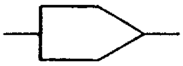
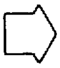
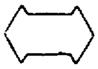
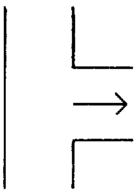

MISCELLANEOUS CIRCUITS
SYNCHRONIZATION CIRCUITS
BUS CONTROL CIRCUITS
MEMORY CONTROL CIRCUITS
M-SECTION
SYNO
STP
YSTM
MEC
SYNC
BG
BR
RDM
STM
WTM
RDR
EMC ADDRESS DECODE ROM
EMC REGISTER DETECTION AND ADDRESS LATCHES
ADDRESS DECODE
MCRD
IRA
SET IDA
FDR
IDA0-15
IDA0-3
DELAY UNTIL Φ2
DURING Φ1 FOR OUTPUT
μ-INST
TYPICALLY, THE MECHANISM USING THE MICRO-INSTRUCTION DOES NOT ACT ON IT UNTIL THE FOLLOWING Φ1, RESULTING IN A ONE-STATE DELAY FROM WHEN IT IS DECODED TO WHEN IT IS ACCOMPLISHED.
THESE LINES GO TO ONLY THOSE MICRO-INSTRUCTIONS USED IN RESPONDING TO MEMORY CYCLES WHOSE ADDRESSES REPRESENT REGISTERS WITHIN THE EMC.
DECIMAL CARRY (1)
SET DC
UP DC
CLR DC
DC
WORD POINTER SHIFT REGISTER
WP3 WP2 WP1 WP0
SET WP
INC WP
DEC WP
WP0
WP1
WP2
WP3
BCD BIN
DEC COMP
BIN COMP
TRUE
ZIY
ΣY BUS
ADDER (16) BCD/BINARY
ONES/NINE COMPLEMENTER (16)
Y3 REGISTER (16)
Y2 REGISTER (16)
Y1 REGISTER (16)
Y0 REGISTER (16)
D REGISTER (16)
IDA BUS
SET IDA
SET D
DMP IDA
DMP Y0/SET Y0
IDM BUS

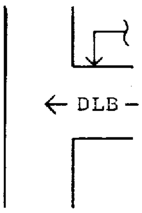
FIG 129B

NOTES:

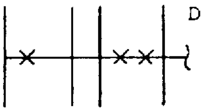
1.  DENOTES A MICRO-INSTRUCTION DECODED IN THE ROM.

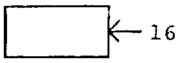
2.  AND  DENOTE ONE- AND TWO-WAY INTERCONNECTIONS TO A BUS; ALWAYS CONTROLLED BY A ROM MICRO-INSTRUCTION.

3.  DENOTES A DIRECT CONNECTION BETWEEN TWO ITEMS.

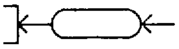
4. 

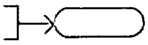
DENOTES A CONNECTION BETWEEN TWO ITEMS THAT IS ACTIVE ONLY WHEN THE STATED SIGNAL IS GIVEN. SOME SUCH SIGNALS ARE ROM DECODED MICRO-INSTRUCTIONS, WHILE OTHERS ARE PRESENT THROUGHOUT AN ENTIRE EXECUTION CYCLE.

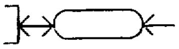
5.  DENOTES THAT THE STATED LINE REPRESENTS A DECODED CONDITION.

6. 

REPRESENTS A NON-MICRO-INSTRUCTION CONTROL LINE OR SOME OTHER SIGNAL.

7.  REPRESENTS AN INPUT TERMINAL TO THE EMC.

8.  REPRESENTS AN OUTPUT TERMINAL FROM THE EMC.

9.  REPRESENTS A TERMINAL THAT IS BOTH AN INPUT AND AN OUTPUT.

10. NUMBERS IN PARENTHESES INDICATE THE NUMBER OF BITS A MECHANISM HANDLES.

11. THE LOGICAL SENSE (XXX VERSUS $\overline{XXX}$) OF THE I/O TERMINALS IS CORRECTLY INDICATED. HOWEVER, THE DRAWING IS NOT A RELIABLE INDICATOR OF THE EXACT SENSE OF THE INTERNAL SIGNALS. TYPICALLY BOTH SENSES EXIST, AND FREQUENTLY THE PHYSICAL PROXIMITY OF SIGNALS TO THEIR DESTINATIONS WAS MORE IMPORTANT IN DECIDING WHICH SENSE TO USE, RATHER THAN AGREEMENT OF LOGICAL SENSE.

BECAUSE STRICT ACCURACY IN REPORTING SIGNAL SENSES ON SUCH A GENERAL LEVEL DRAWING WOULD SHARPLY INCREASE THE NUMBER OF INTERCONNECTIONS, WITH ONLY A SLIGHT INCREASE IN USEFULNESS, WE USUALLY SHOW ONLY THE NAME OF THE SIGNAL.

FIG 129C

BUS CONTROL

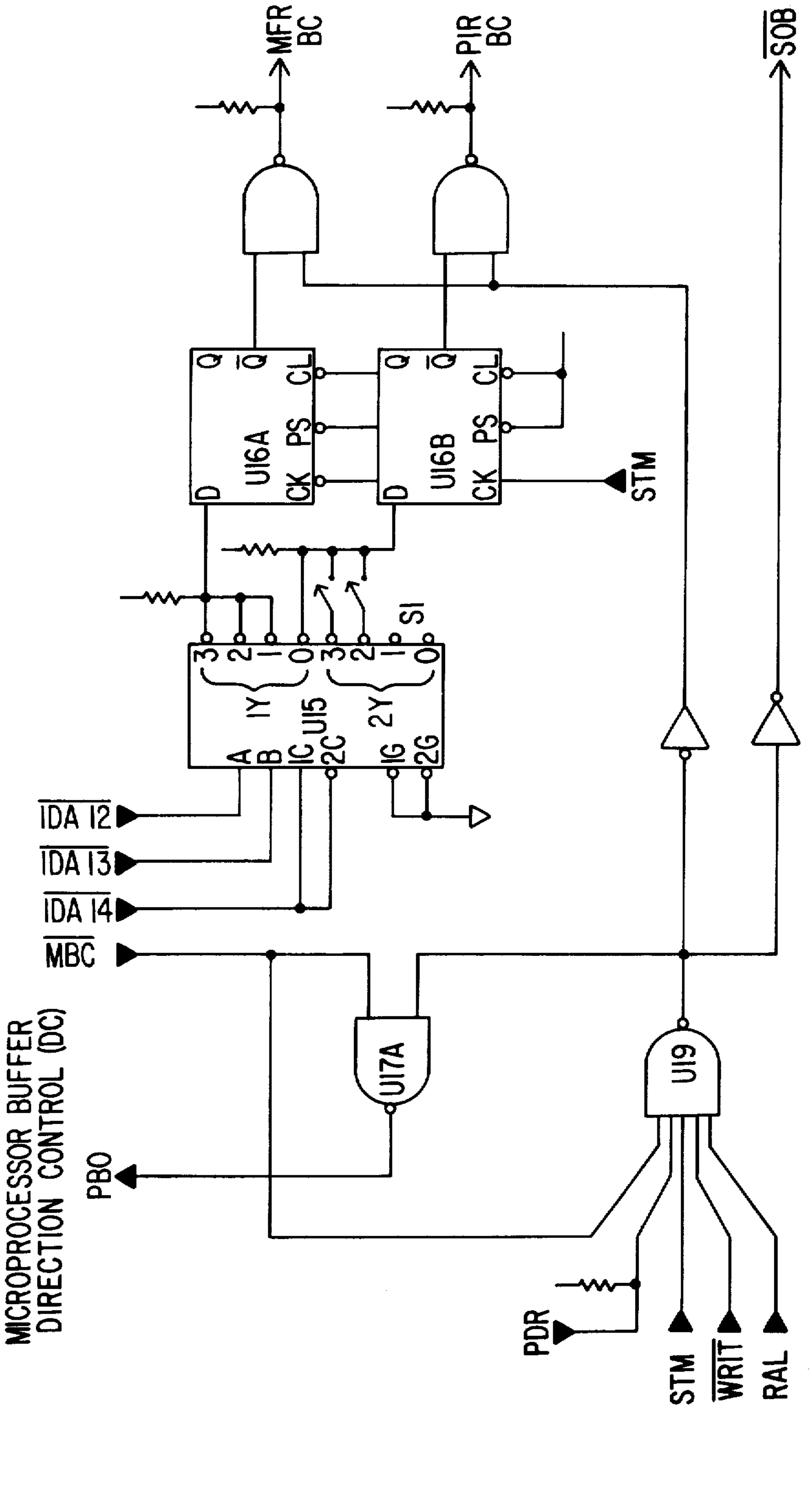


FIG 130

MEMORY TIMING AND CONTROL

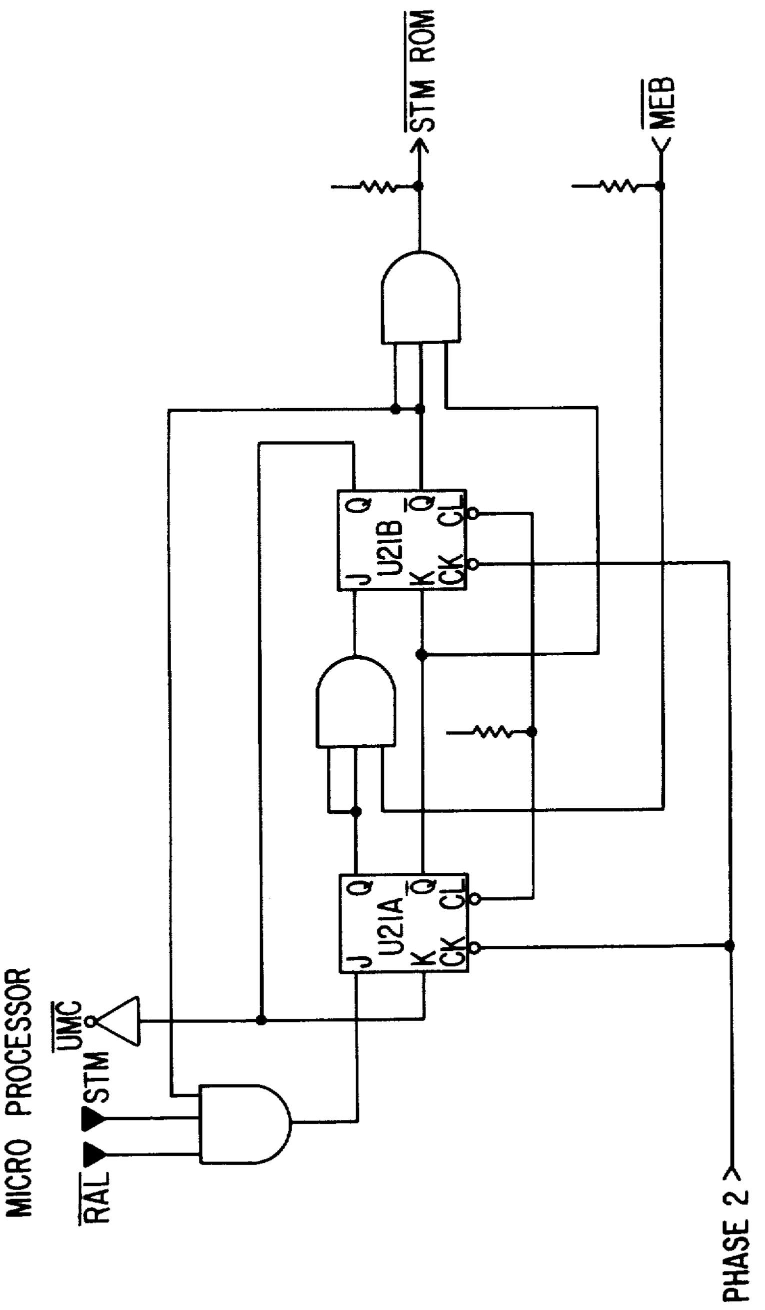


FIG 131

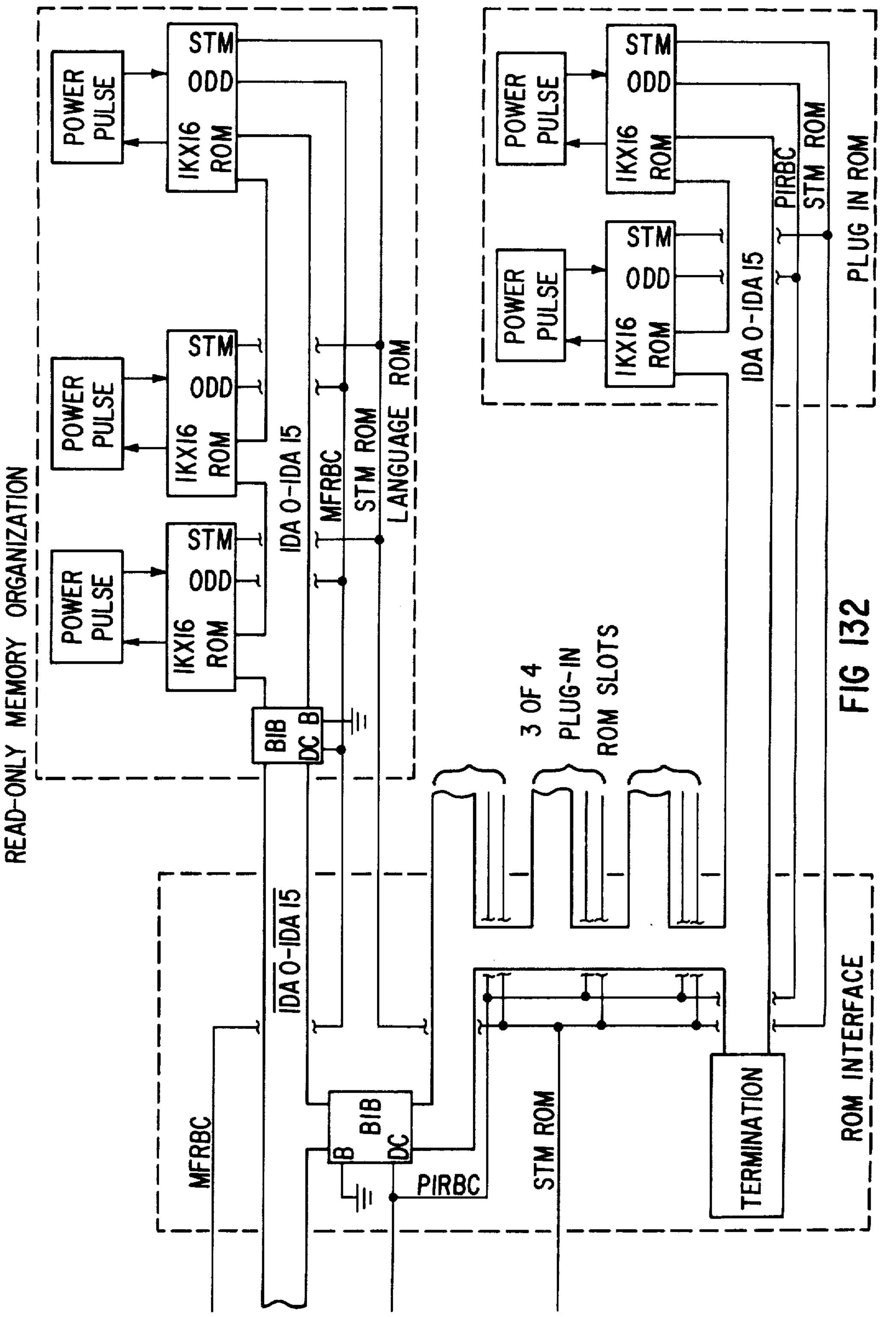

READ-ONLY MEMORY ORGANIZATION
POWER PULSE
STM
ODD
IKX16 ROM
POWER PULSE
STM
ODD
IKX16 ROM
POWER PULSE
STM
ODD
IKX16 ROM
IDA 0-IDA 15
MFRBC
STM ROM
LANGUAGE ROM
BIB DC B
POWER PULSE
STM
ODD
IKX16 ROM
POWER PULSE
STM
ODD
IKX16 ROM
IDA 0-IDA 15
PIRBC
STM ROM
PLUG IN ROM
3 OF 4 PLUG-IN ROM SLOTS
$\overline{IDA 0}$-$\overline{IDA 15}$
MFRBC
B BIB DC
PIRBC
STM ROM
TERMINATION
ROM INTERFACE

FIG 132

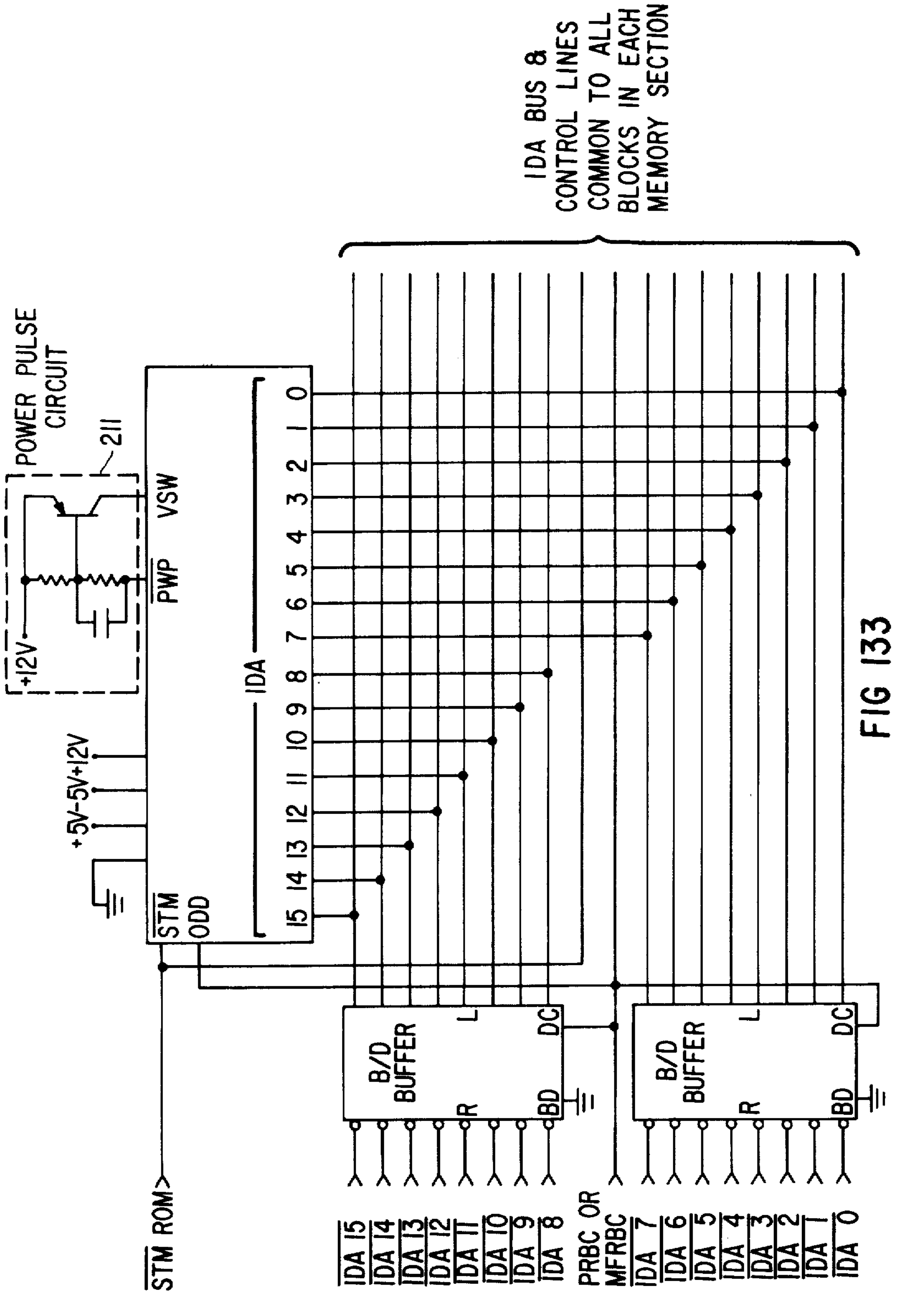

POWER PULSE CIRCUIT
211
+12V
PWP
VSW
+5V -5V +12V
STM
ODD
IDA
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
IDA BUS & CONTROL LINES COMMON TO ALL BLOCKS IN EACH MEMORY SECTION
B/D BUFFER
L
R
DC
BD
B/D BUFFER
L
R
DC
BD
STM ROM
IDA 15
IDA 14
IDA 13
IDA 12
IDA 11
IDA 10
IDA 9
IDA 8
PRBC OR MFRBC
IDA 7
IDA 6
IDA 5
IDA 4
IDA 3
IDA 2
IDA 1
IDA 0

FIG 133

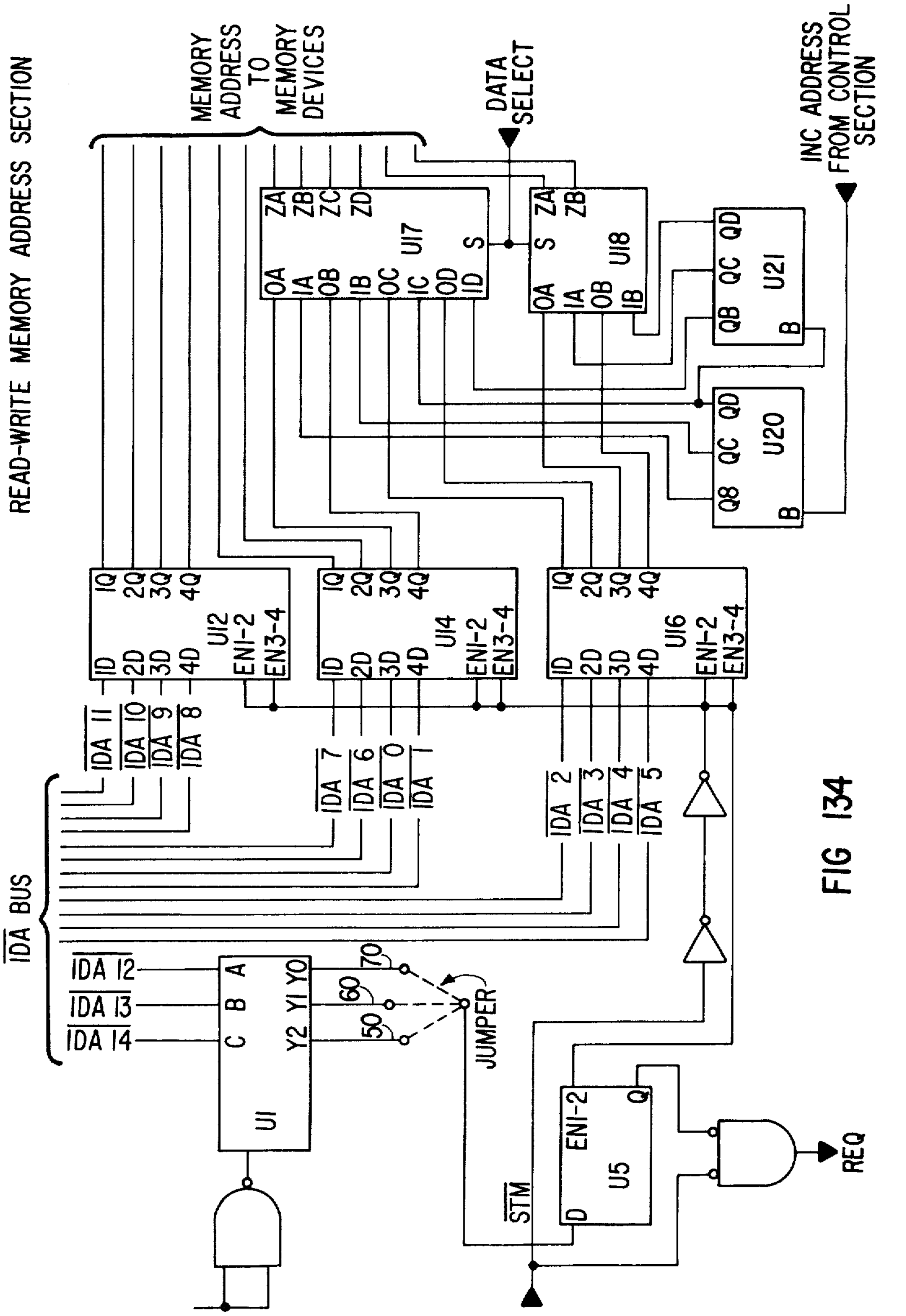

READ-WRITE MEMORY ADDRESS SECTION
MEMORY ADDRESS TO MEMORY DEVICES
DATA SELECT
INC ADDRESS FROM CONTROL SECTION
ZA ZB ZC ZD
U17
S
0A 1A 0B 1B 0C 1C 0D 1D
ZA ZB
S
U18
0A 1A 0B 1B
QD QC QB
U21
B
QD QC Q8
U20
B
1Q 2Q 3Q 4Q
U12
1D 2D 3D 4D EN1-2 EN3-4
1Q 2Q 3Q 4Q
U14
1D 2D 3D 4D EN1-2 EN3-4
1Q 2Q 3Q 4Q
U16
1D 2D 3D 4D EN1-2 EN3-4
IDA 11
IDA 10
IDA 9
IDA 8
IDA 7
IDA 6
IDA 0
IDA 1
IDA 2
IDA 3
IDA 4
IDA 5
IDA BUS
IDA 12
IDA 13
IDA 14
A B C
Y0 Y1 Y2
U1
70
60
50
JUMPER
EN1-2
Q
U5
D
STM
REQ

FIG 134

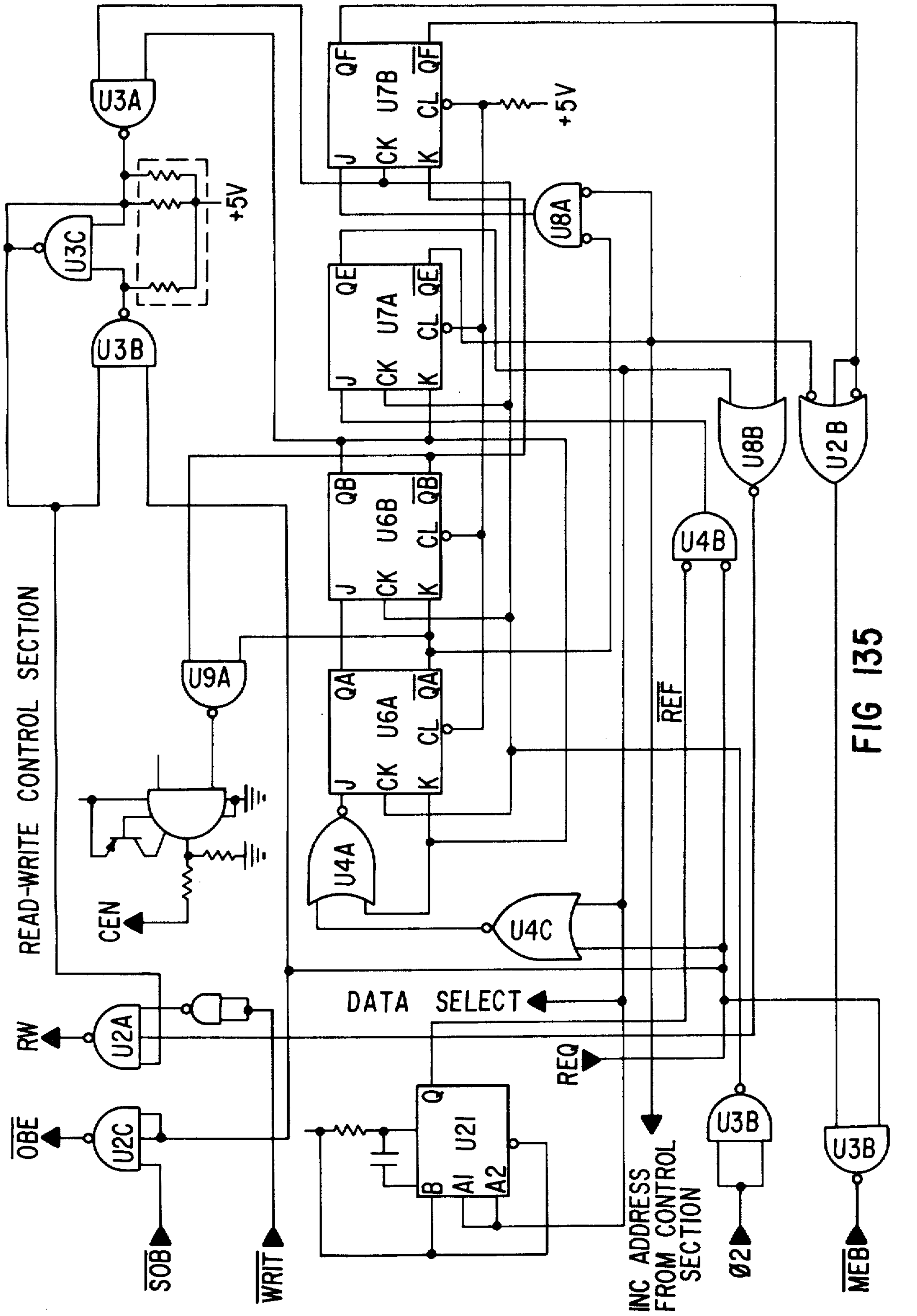
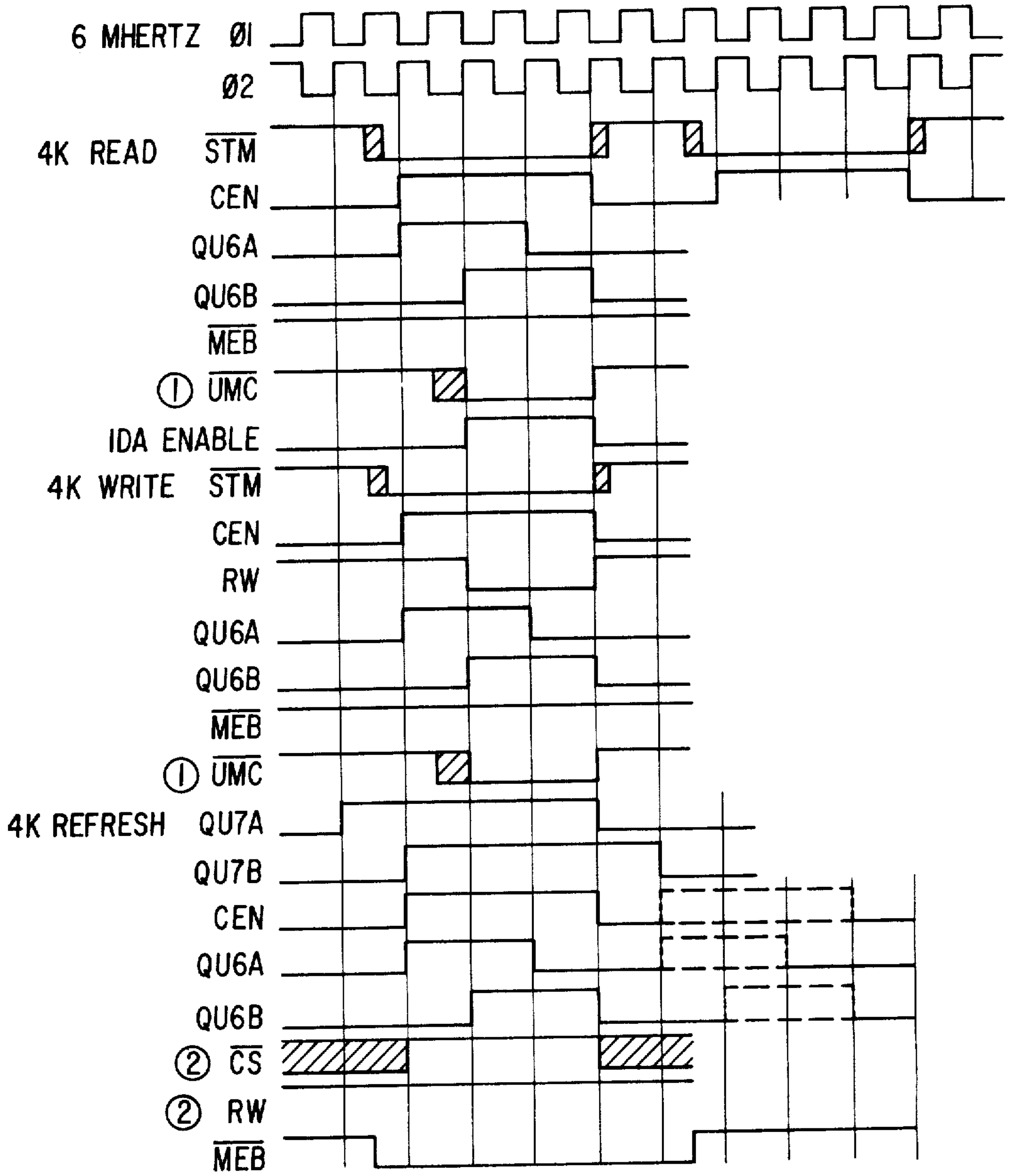

READ-WRITE CONTROL SECTION
U3A
U3C
U3B
+5V
U7B
QF
$\overline{QF}$
J
CK
K
CL
U8A
U7A
QE
$\overline{QE}$
U6B
QB
$\overline{QB}$
U6A
QA
$\overline{QA}$
U9A
U4A
U4C
U8B
U2B
U4B
$\overline{REF}$
CEN
DATA SELECT
RW
U2A
$\overline{OBE}$
U2C
$\overline{SOB}$
$\overline{WRIT}$
REQ
U21
Q
B
A1
A2
INC ADDRESS FROM CONTROL SECTION
Ø2
$\overline{MEB}$

FIG 135



READ/WRITE MEMORY CONTROL TIMING

① UMC IS GIVEN BY MEMORY TIMING AND CONTROL CIRCUIT.
② CS AND RW ARE NECESSARY DURING A REFRESH FOR A MOTOROLA OR AMI PART. TI'S PART DOESN'T CARE.

FIG 136

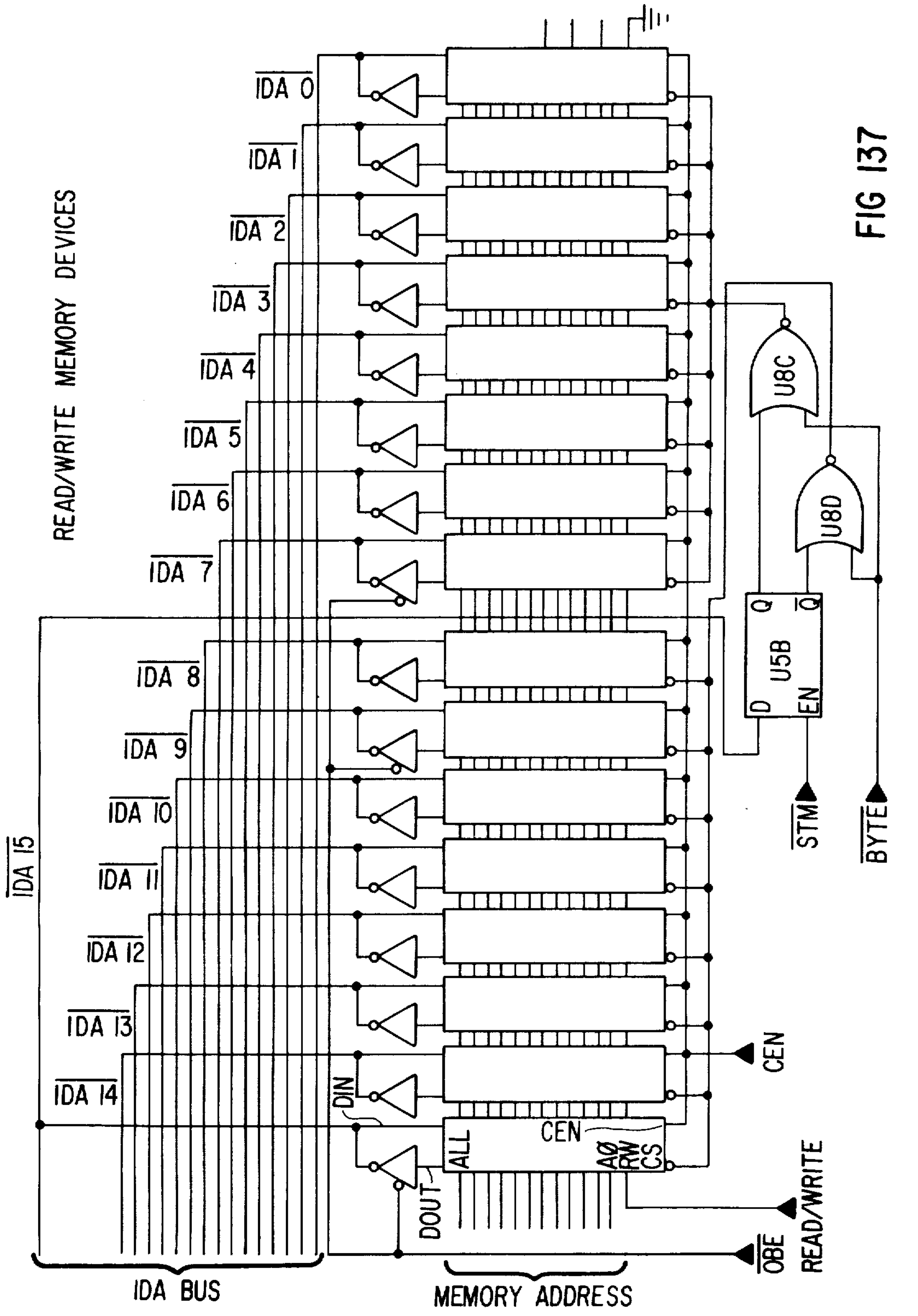

READ/WRITE MEMORY DEVICES
IDA 0
IDA 1
IDA 2
IDA 3
IDA 4
IDA 5
IDA 6
IDA 7
IDA 8
IDA 9
IDA 10
IDA 11
IDA 12
IDA 13
IDA 14
IDA 15
DIN
DOUT
ALL
CEN
AØ
RW
CS
U8C
U8D
Q
Q̄
U5B
D
EN
STM
BYTE
CEN
READ/WRITE
OBE
IDA BUS
MEMORY ADDRESS

FIG 137

KDP CONTROL I/O INTERFACE

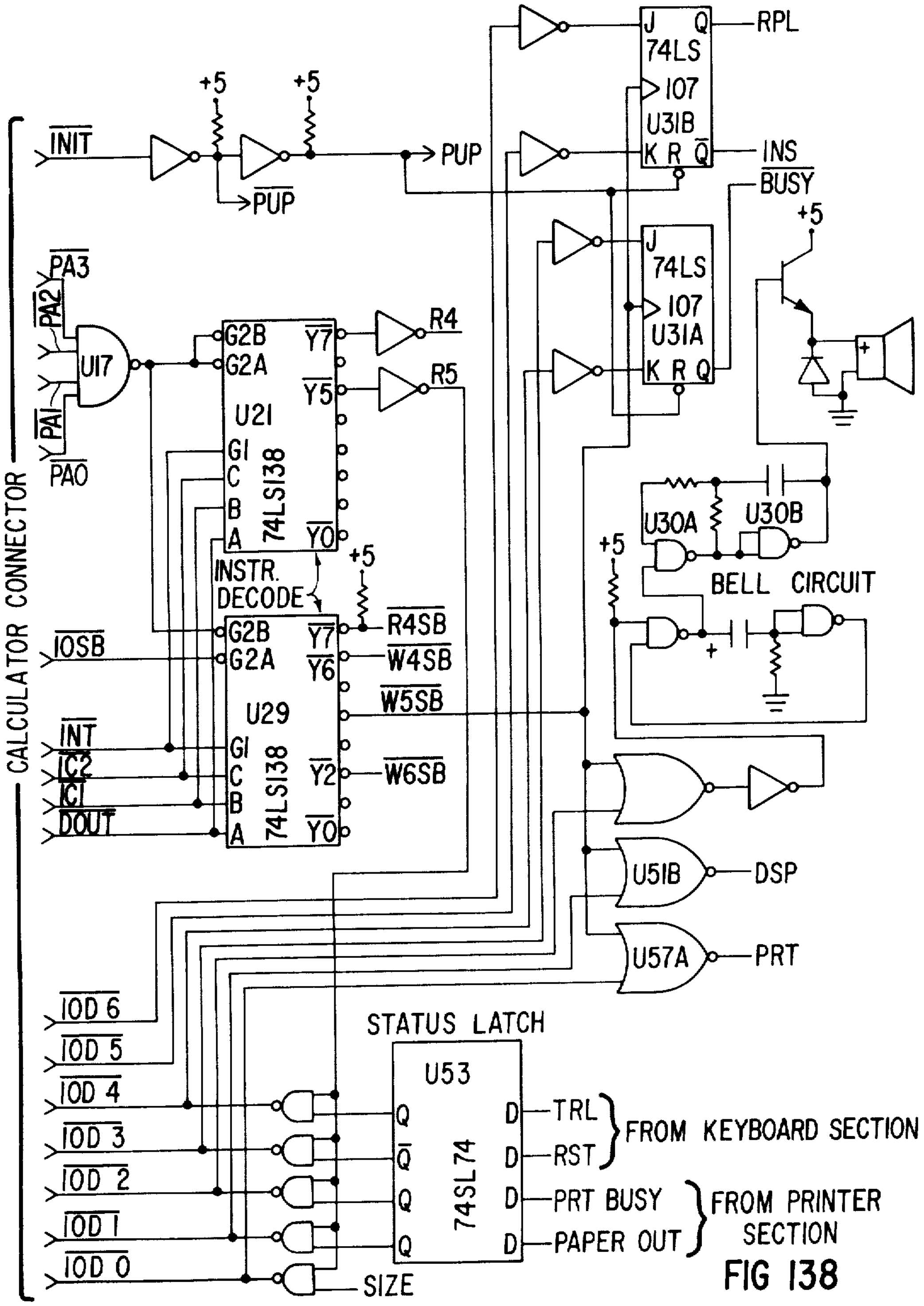
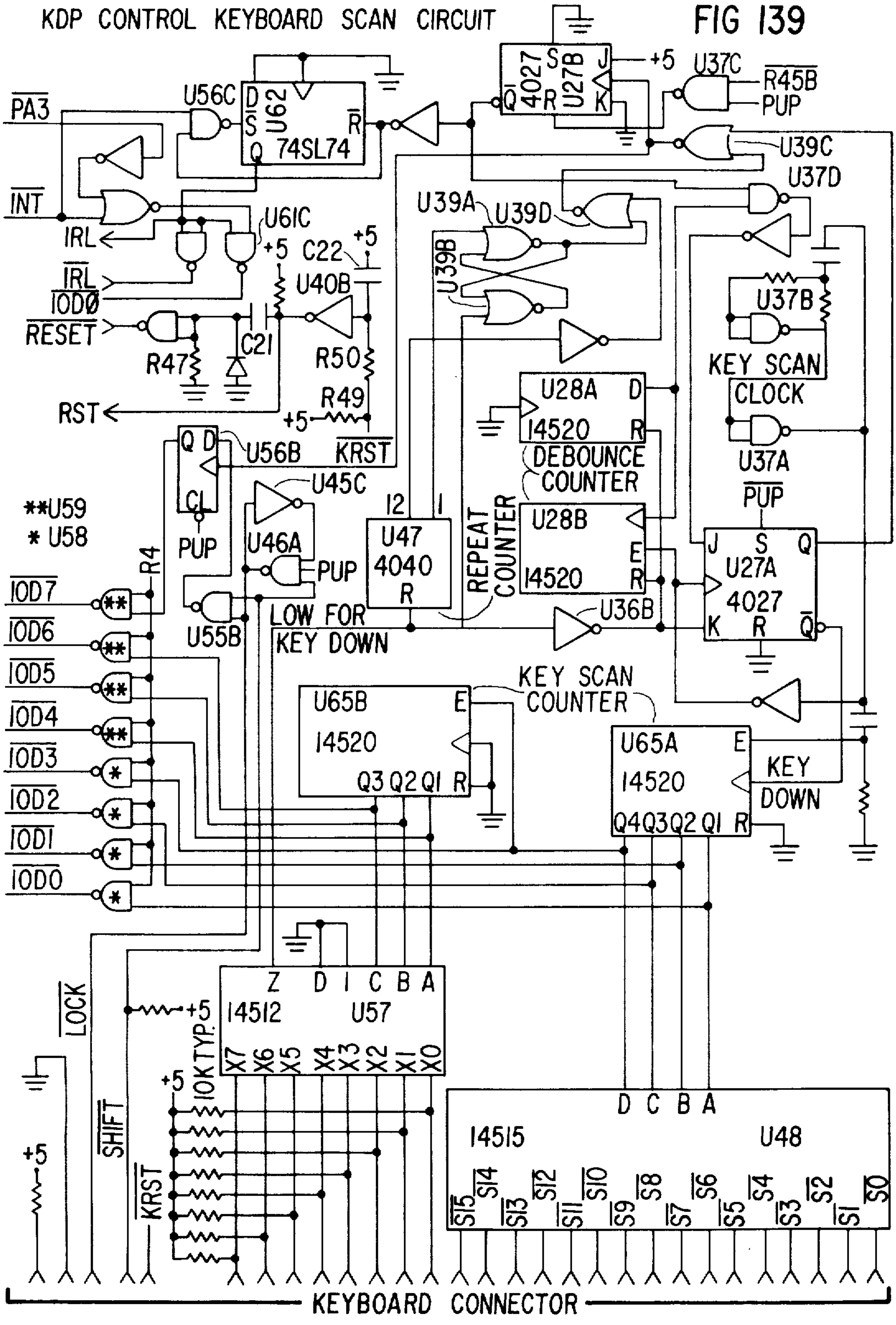


FIG 138

KDP CONTROL KEYBOARD SCAN CIRCUIT

FIG 139



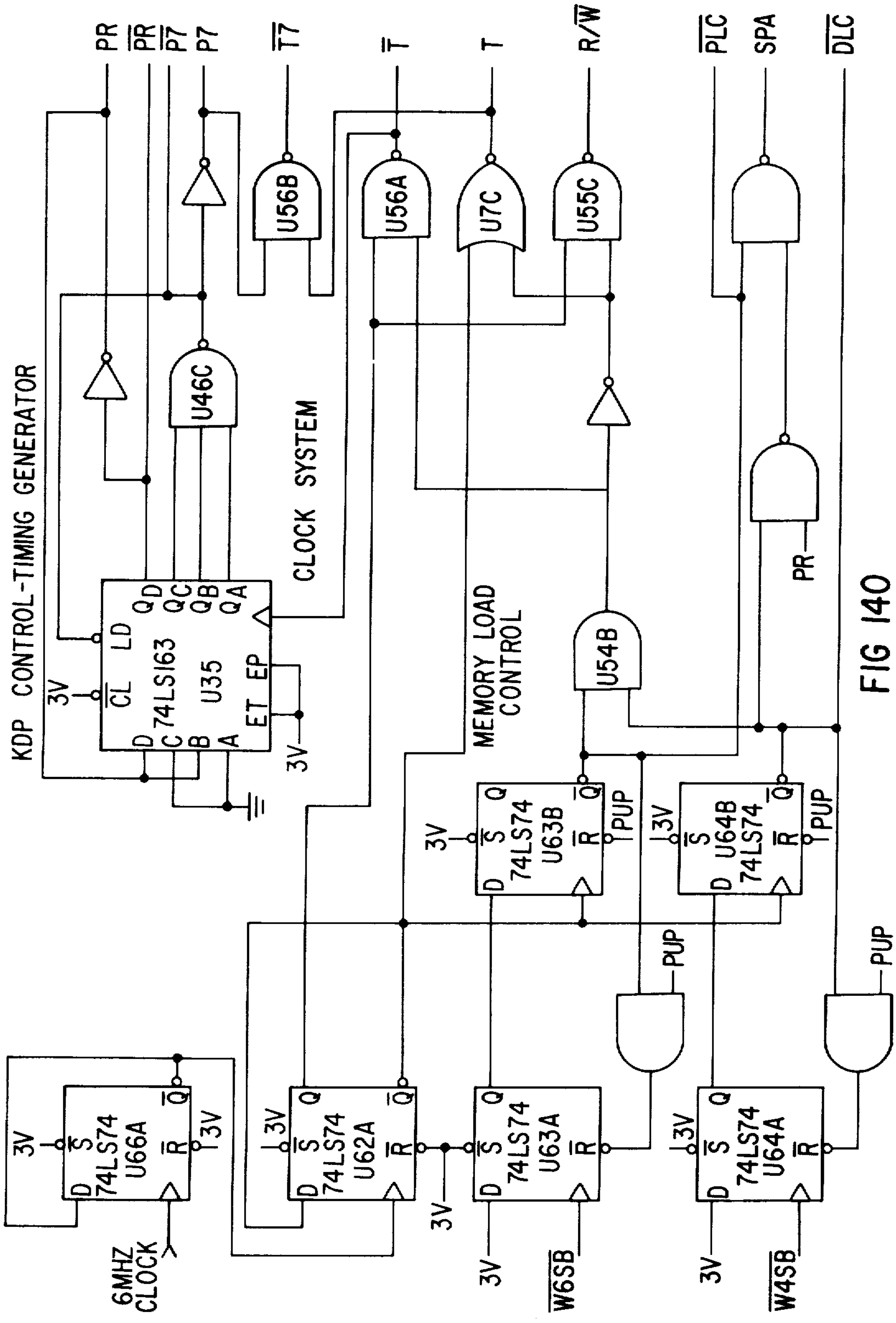

KDP CONTROL-TIMING GENERATOR
CLOCK SYSTEM
MEMORY LOAD CONTROL
PR
PR
P7
P7
T7
T
T
R/W
PLC
SPA
DLC
U56B
U56A
U7C
U55C
U46C
U54B
74LS163
U35
CL
LD
QD
QC
QB
QA
D
C
B
A
ET
EP
3V
74LS74
U63B
U64B
U66A
U62A
U63A
U64A
S
R
D
Q
Q
PUP
6MHZ CLOCK
W6SB
W4SB

FIG 140

BASIC TIMING

KDP CLOCK IS 1.5 MHZ (DERIVED FROM 6MHZ SYSTEM CLOCK)

MAIN TIMING SIGNALS (COMPLEMENTS ALSO USED)

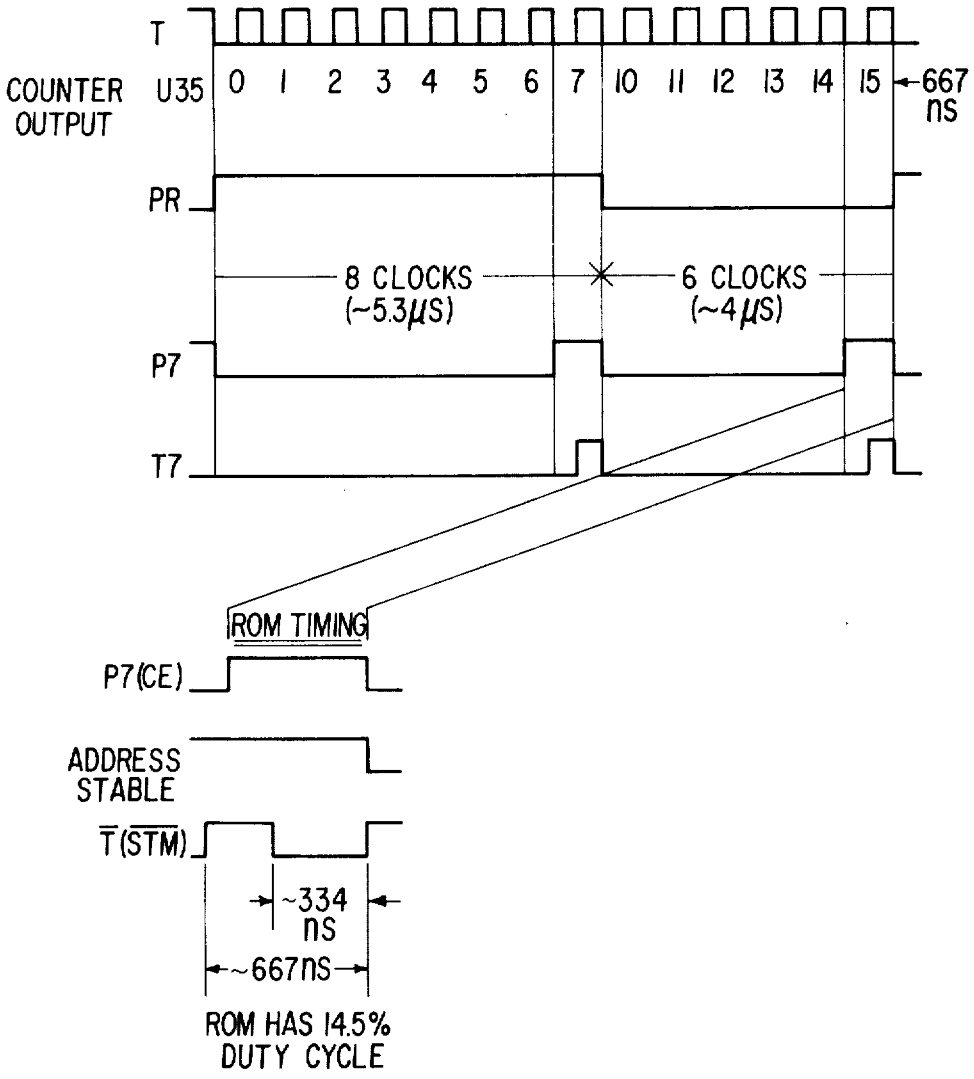
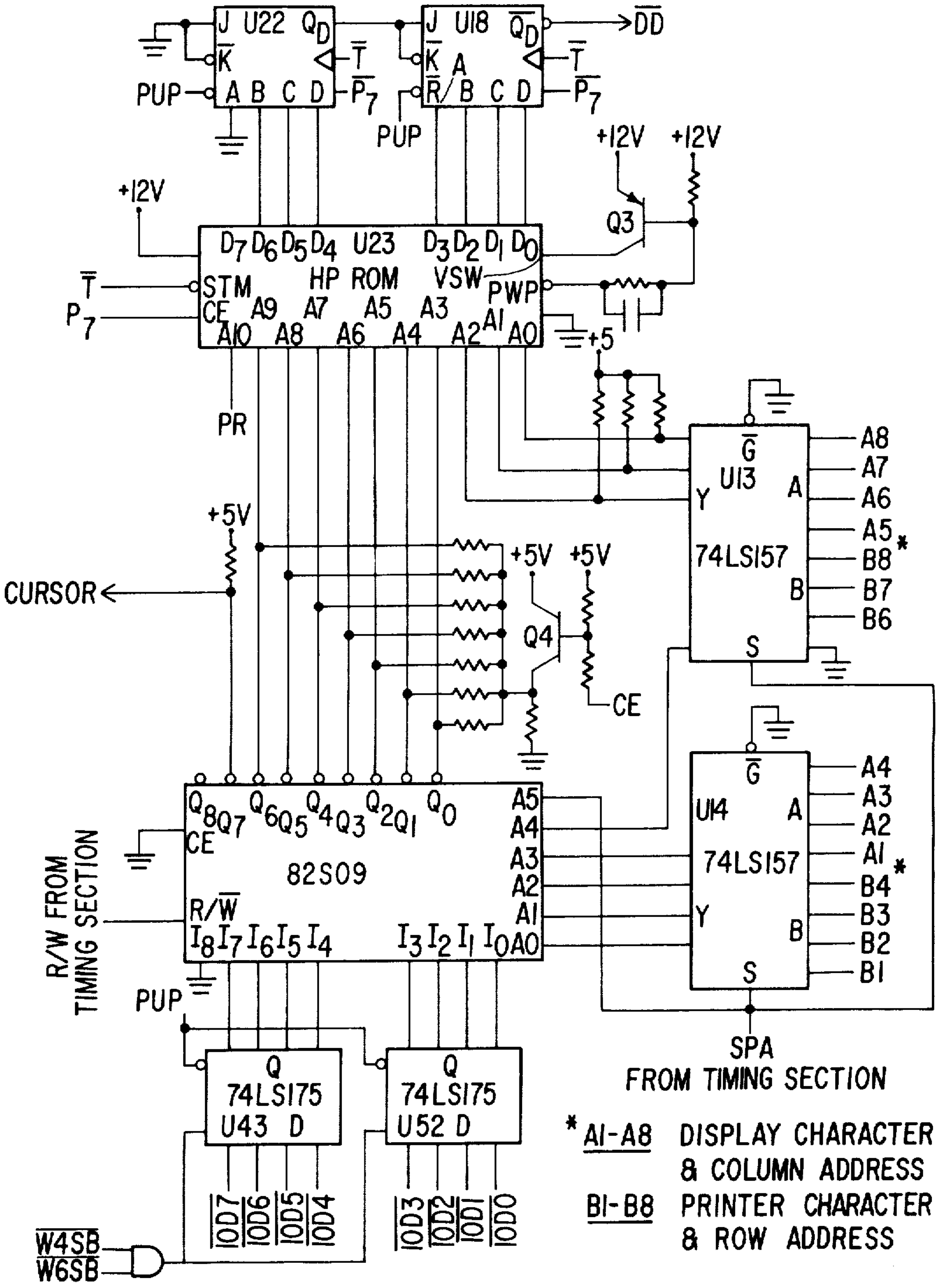


FIG 141

KDP CONTROL MEMORY SECTION

FIG 142



*A1-A8 DISPLAY CHARACTER & COLUMN ADDRESS

B1-B8 PRINTER CHARACTER & ROW ADDRESS

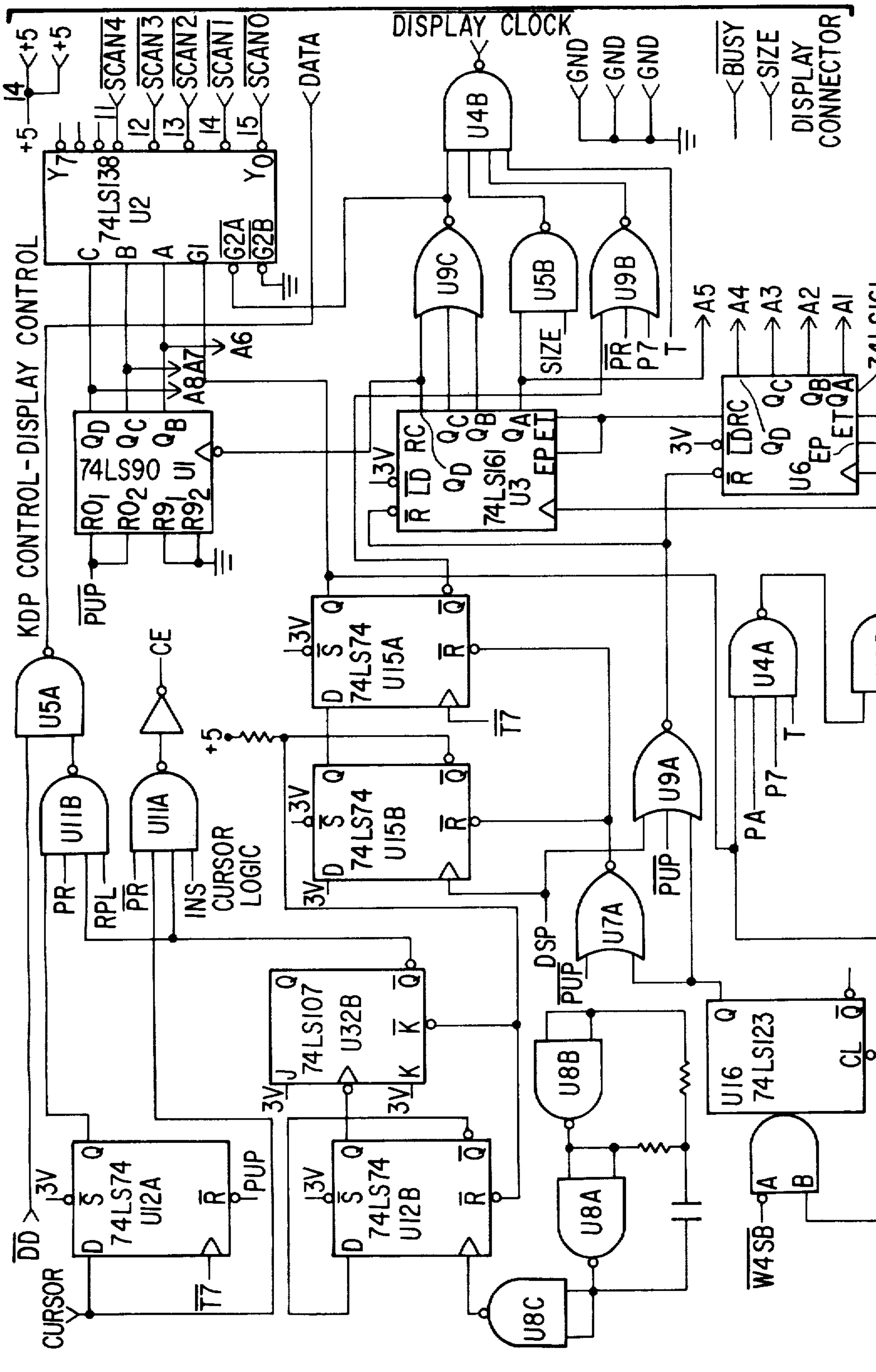

KDP CONTROL-DISPLAY CONTROL
DISPLAY CLOCK
DISPLAY CONNECTOR
+5
+5
I4
SCAN4
SCAN3
SCAN2
SCAN1
SCAN0
DATA
GND
GND
GND
BUSY
SIZE
74LS138
U2
Y7
Y0
C
B
A
G1
G2A
G2B
I1
I2
I3
I4
I5
U4B
U9C
U5B
U9B
SIZE
PR
P7
T
A5
A4
A3
A2
A1
A6
A8
A7
74LS90
U1
QD
QC
QB
RO1
RO2
R91
R92
PUP
74LS161
U3
RC
LD
R
EP
ET
QA
3V
74LS161
U6
74LS74
U15A
74LS74
U15B
T7
+5
U5A
U11B
U11A
CE
PR
RPL
PR
INS
CURSOR LOGIC
U9A
U7A
DSP
PUP
PUP
U4A
PA
P7
T
U10D
DLC
74LS107
U32B
J
K
74LS74
U12A
74LS74
U12B
DD
CURSOR
T7
PUP
U8A
U8B
U8C
U16
74LS123
CL
A
B
W4SB

FIG 143

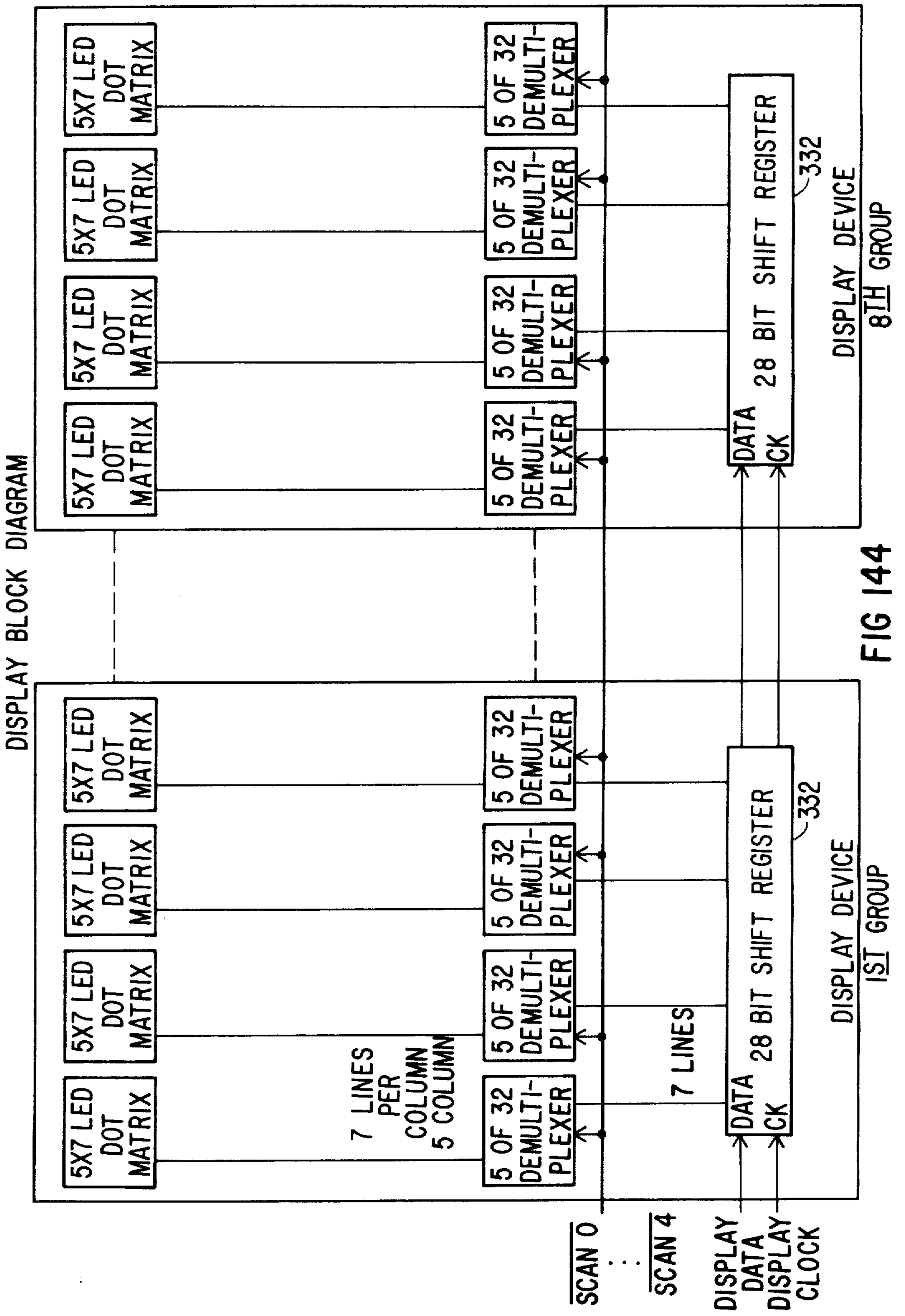

DISPLAY BLOCK DIAGRAM
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
DATA
CK
28 BIT SHIFT REGISTER
332
DISPLAY DEVICE
8TH GROUP
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
5X7 LED DOT MATRIX
7 LINES PER COLUMN 5 COLUMN
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
5 OF 32 DEMULTI-PLEXER
7 LINES
DATA
CK
28 BIT SHIFT REGISTER
332
DISPLAY DEVICE
1ST GROUP
$\overline{\text{SCAN 0}}$
...
$\overline{\text{SCAN 4}}$
DISPLAY DATA
DISPLAY CLOCK

FIG 144

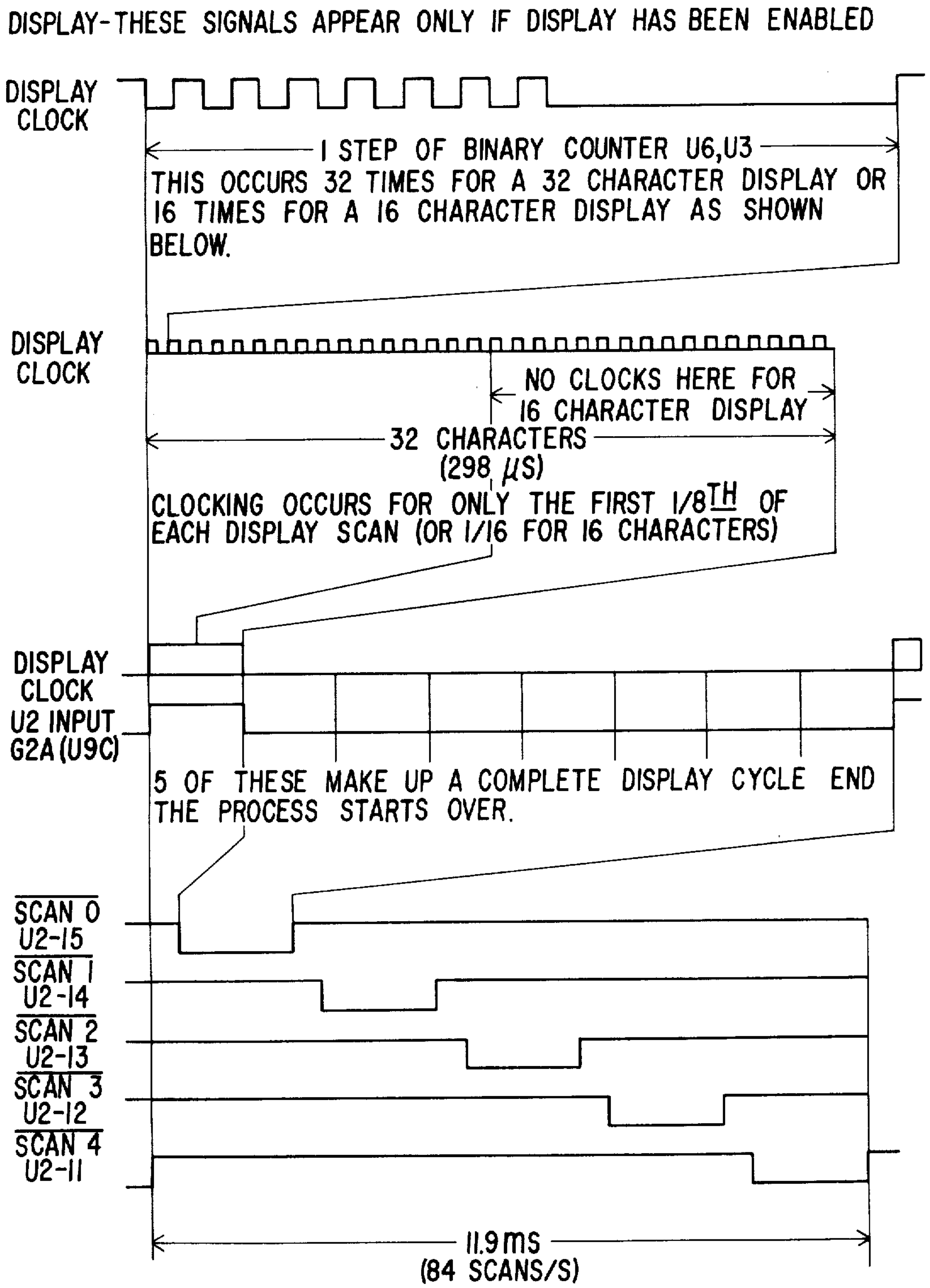

DISPLAY-THESE SIGNALS APPEAR ONLY IF DISPLAY HAS BEEN ENABLED
DISPLAY CLOCK
1 STEP OF BINARY COUNTER U6,U3
THIS OCCURS 32 TIMES FOR A 32 CHARACTER DISPLAY OR 16 TIMES FOR A 16 CHARACTER DISPLAY AS SHOWN BELOW.
DISPLAY CLOCK
NO CLOCKS HERE FOR 16 CHARACTER DISPLAY
32 CHARACTERS (298 μS)
CLOCKING OCCURS FOR ONLY THE FIRST 1/8TH OF EACH DISPLAY SCAN (OR 1/16 FOR 16 CHARACTERS)
DISPLAY CLOCK
U2 INPUT G2A (U9C)
5 OF THESE MAKE UP A COMPLETE DISPLAY CYCLE END THE PROCESS STARTS OVER.
$\overline{\text{SCAN 0}}$ U2-15
$\overline{\text{SCAN 1}}$ U2-14
$\overline{\text{SCAN 2}}$ U2-13
$\overline{\text{SCAN 3}}$ U2-12
$\overline{\text{SCAN 4}}$ U2-11
11.9 ms (84 SCANS/S)

FIG 145

KDP CONTROL-PRINTER CONTROL SECTION

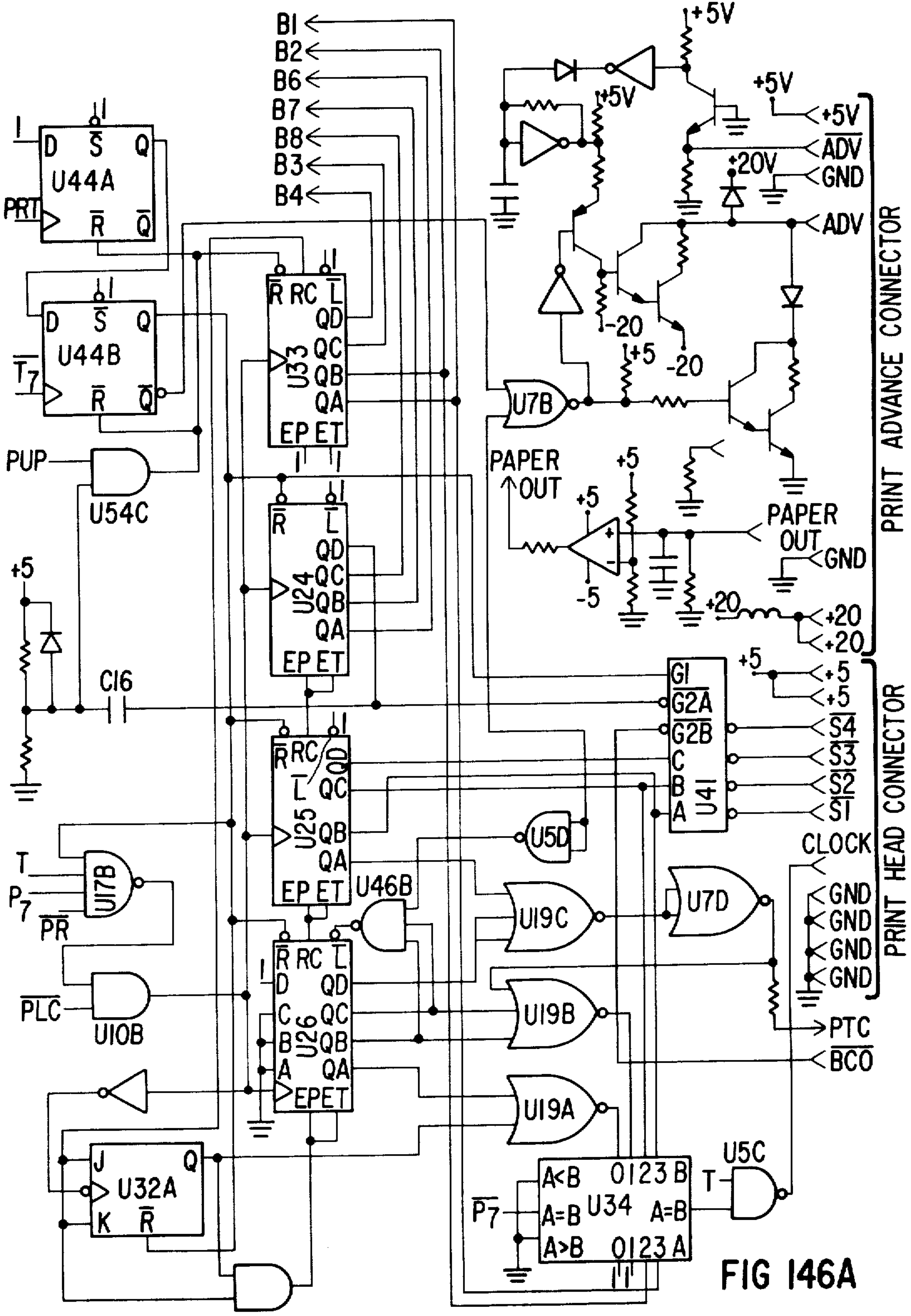


FIG 146A

KDP CONTROL-PRINTER BURN CONTROL

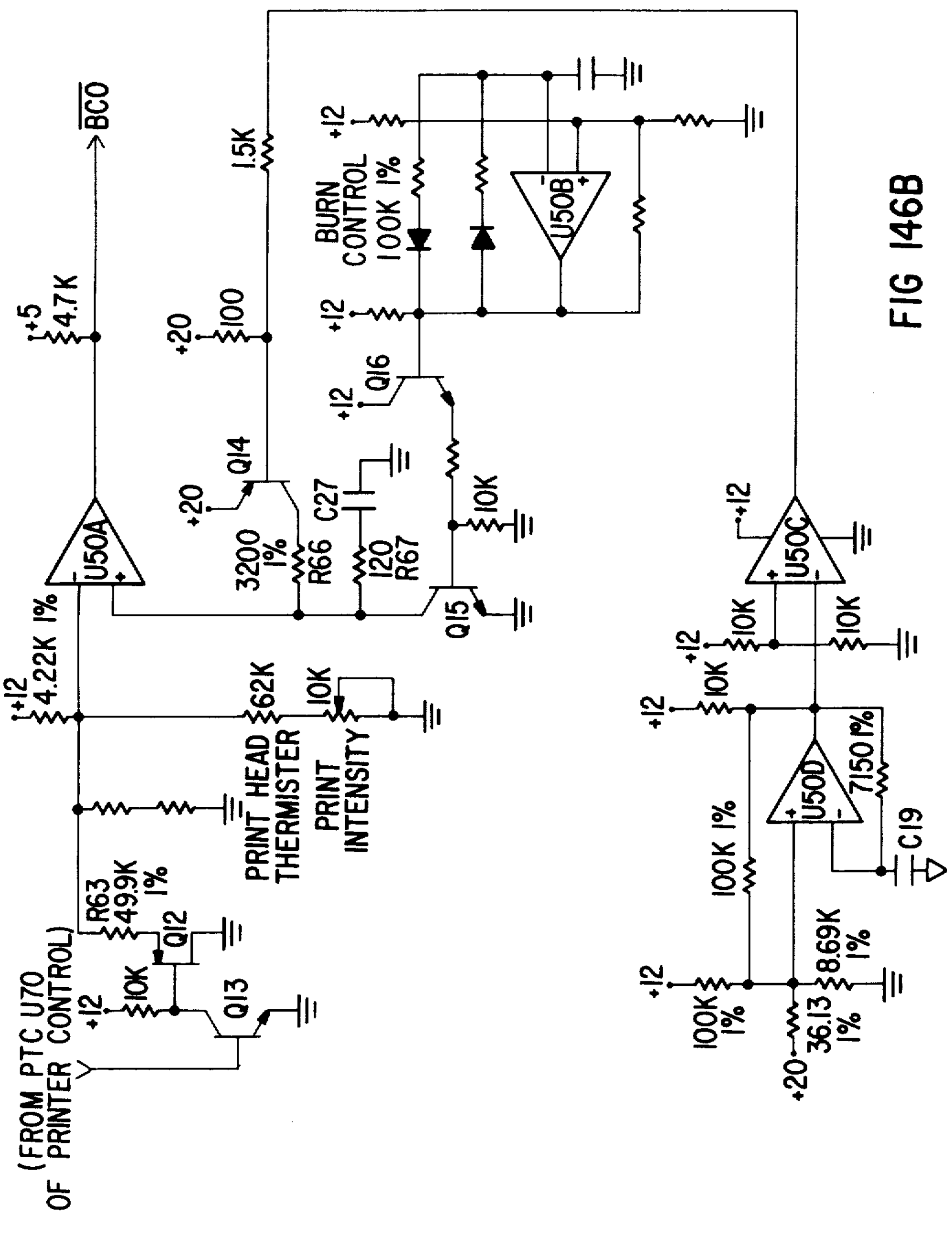


FIG 146B

PRINTER BLOCK DIAGRAM

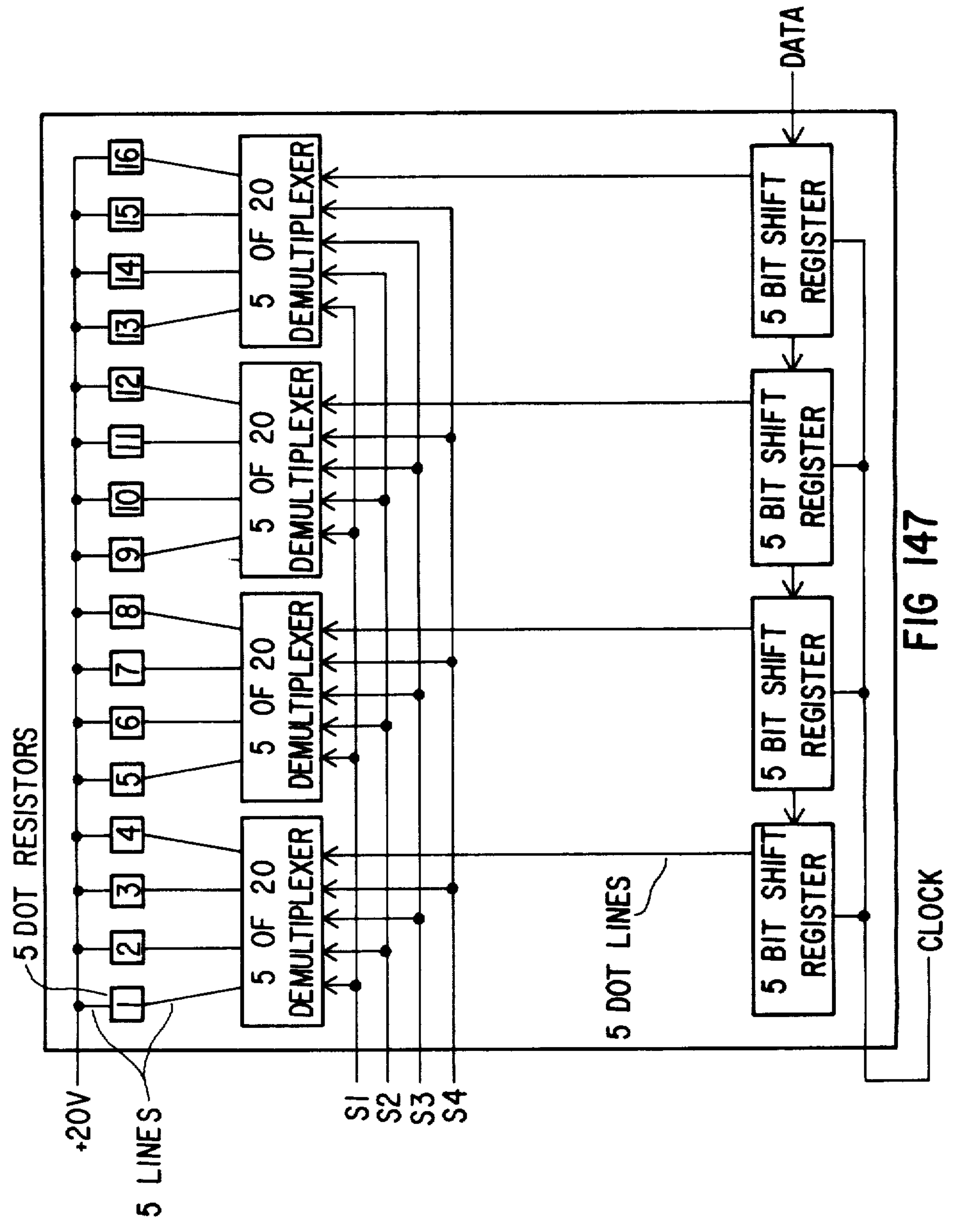


FIG 147

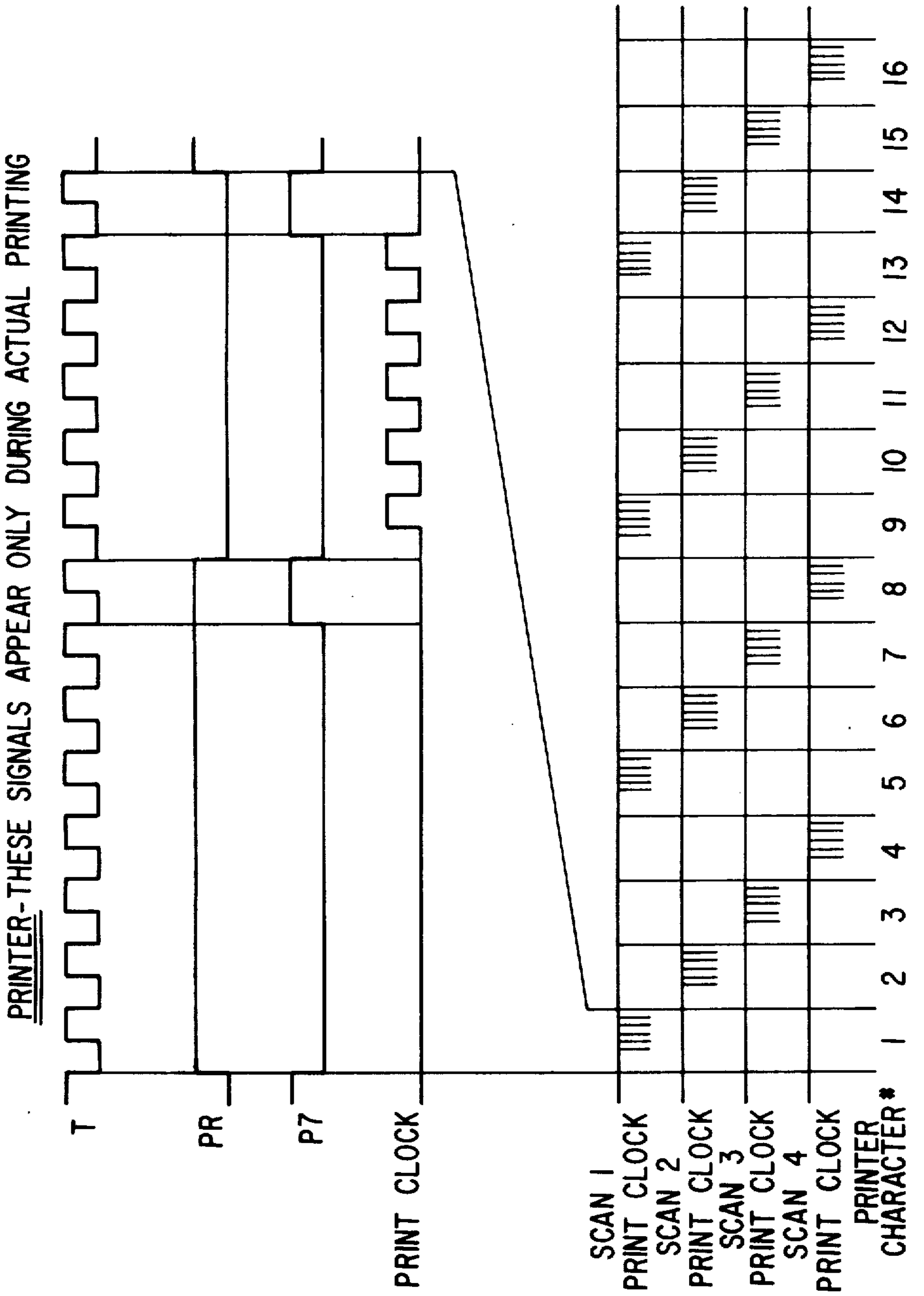

PRINTER-THESE SIGNALS APPEAR ONLY DURING ACTUAL PRINTING
T
PR
P7
PRINT CLOCK
SCAN 1
PRINT CLOCK
SCAN 2
PRINT CLOCK
SCAN 3
PRINT CLOCK
SCAN 4
PRINT CLOCK
PRINTER
CHARACTER #
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

FIG 148A

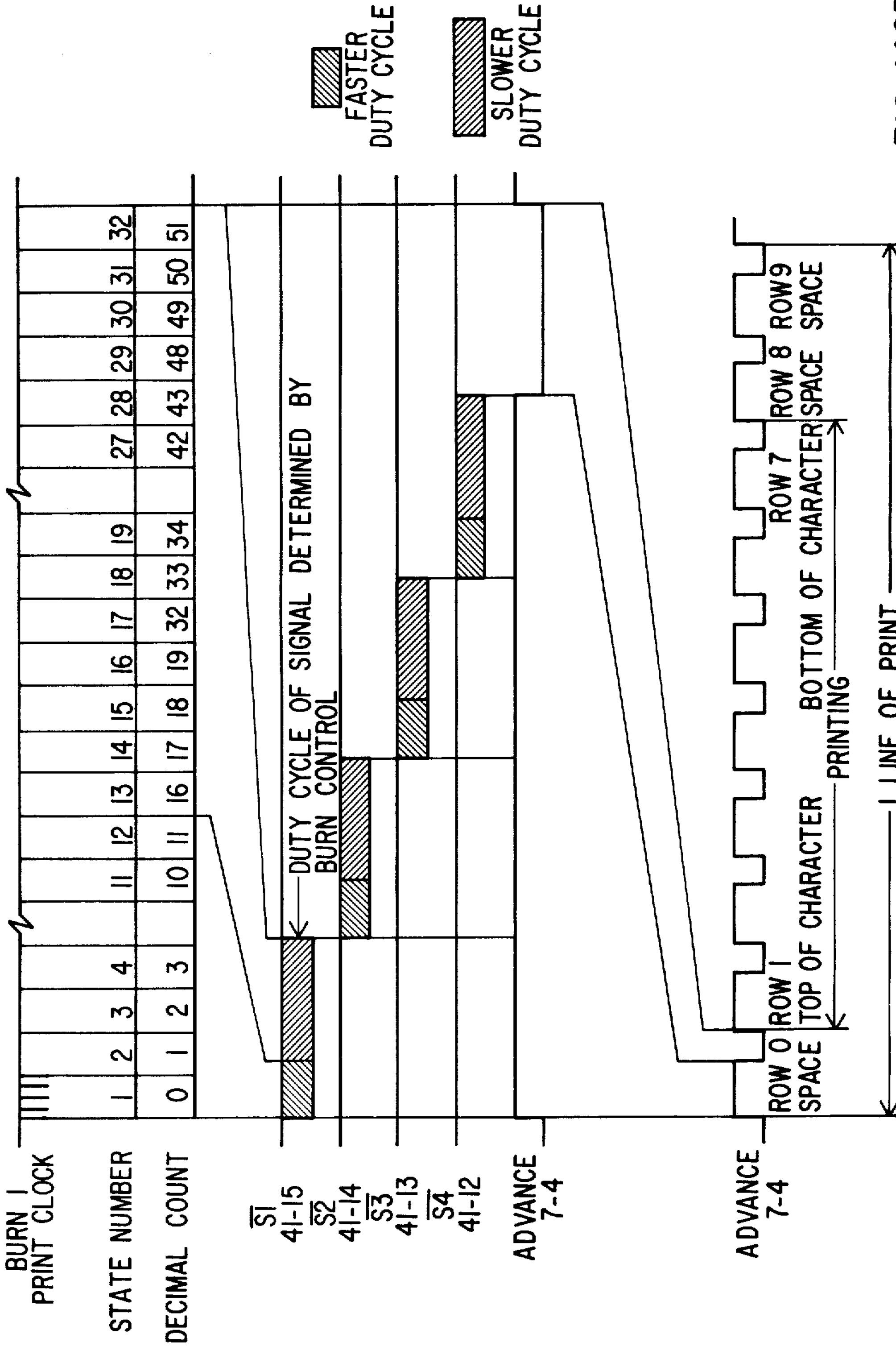

BURN I
PRINT CLOCK
STATE NUMBER
1 2 3 4 11 12 13 14 15 16 17 18 19 27 28 29 30 31 32
DECIMAL COUNT
0 1 2 3 10 11 16 17 18 19 32 33 34 42 43 48 49 50 51
$\overline{S1}$ 41-15
$\overline{S2}$ 41-14
$\overline{S3}$ 41-13
$\overline{S4}$ 41-12
ADVANCE 7-4
ADVANCE 7-4
DUTY CYCLE OF SIGNAL DETERMINED BY BURN CONTROL
FASTER DUTY CYCLE
SLOWER DUTY CYCLE
ROW 0 SPACE
ROW 1 TOP OF CHARACTER
PRINTING
ROW 7 BOTTOM OF CHARACTER
ROW 8 SPACE
ROW 9 SPACE
1 LINE OF PRINT

FIG 148B

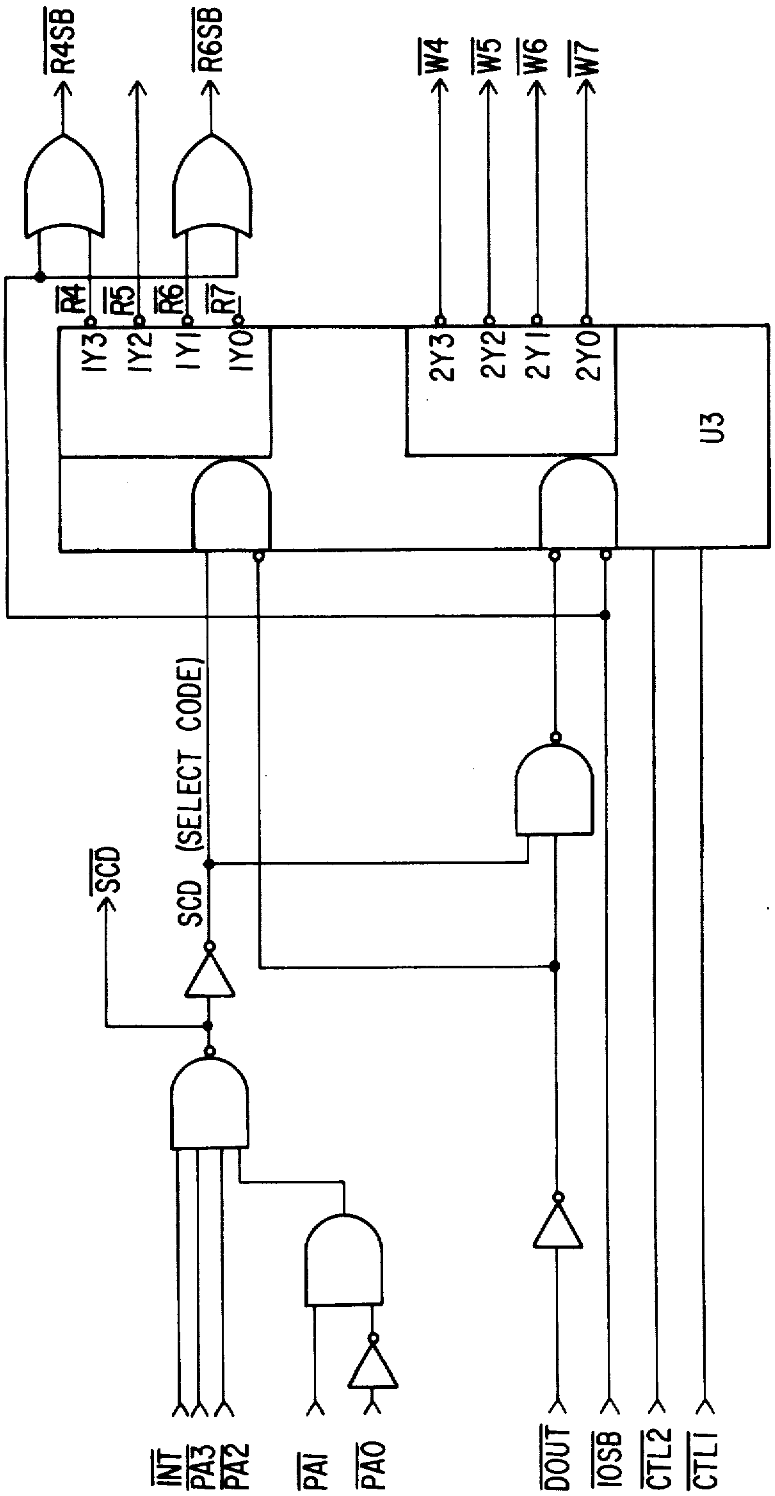

$\overline{R4SB}$
$\overline{R6SB}$
$\overline{W4}$
$\overline{W5}$
$\overline{W6}$
$\overline{W7}$
$\overline{R4}$
$\overline{R5}$
$\overline{R6}$
$\overline{R7}$
1Y3
1Y2
1Y1
1Y0
2Y3
2Y2
2Y1
2Y0
U3
SCD (SELECT CODE)
$\overline{SCD}$
SCD
$\overline{INT}$
$\overline{PA3}$
$\overline{PA2}$
$\overline{PA1}$
$\overline{PA0}$
$\overline{DOUT}$
$\overline{IOSB}$
$\overline{CTL2}$
$\overline{CTL1}$

FIG 149A

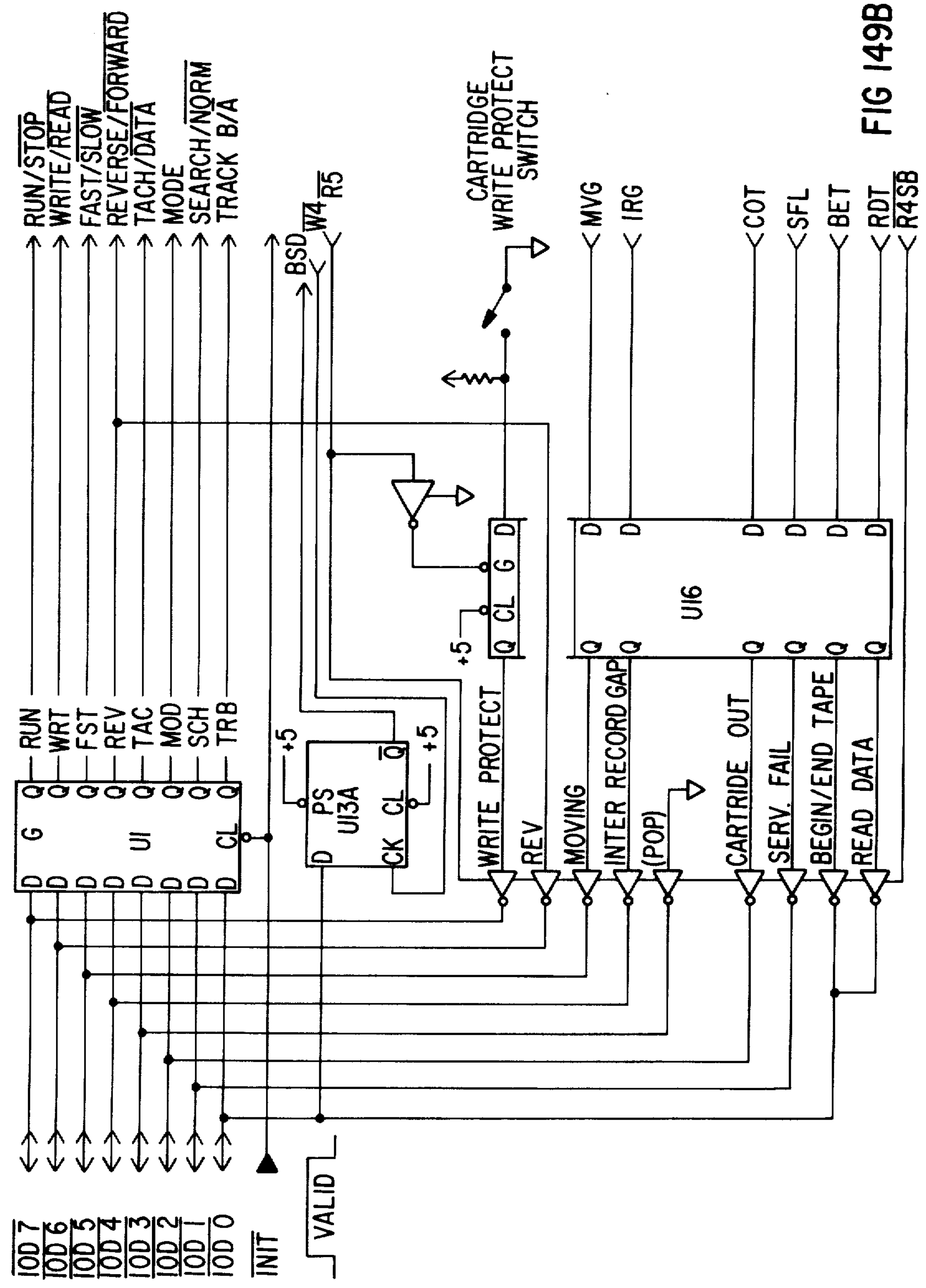

RUN/STOP
WRITE/READ
FAST/SLOW
REVERSE/FORWARD
TACH/DATA
MODE
SEARCH/NORM
TRACK B/A
BSD
W4
R5
CARTRIDGE
WRITE PROTECT
SWITCH
MVG
IRG
COT
SFL
BET
RDT
R4SB
RUN
WRT
FST
REV
TAC
MOD
SCH
TRB
G
UI
CL
Q
D
+5
PS
UI3A
CL
CK
Q̄
+5
G
CL
Q
D
U16
WRITE PROTECT
REV
MOVING
INTER RECORD GAP
(POP)
CARTRIDE OUT
SERV. FAIL
BEGIN/END TAPE
READ DATA
IOD 7
IOD 6
IOD 5
IOD 4
IOD 3
IOD 2
IOD 1
IOD 0
INIT
VALID

FIG 149B

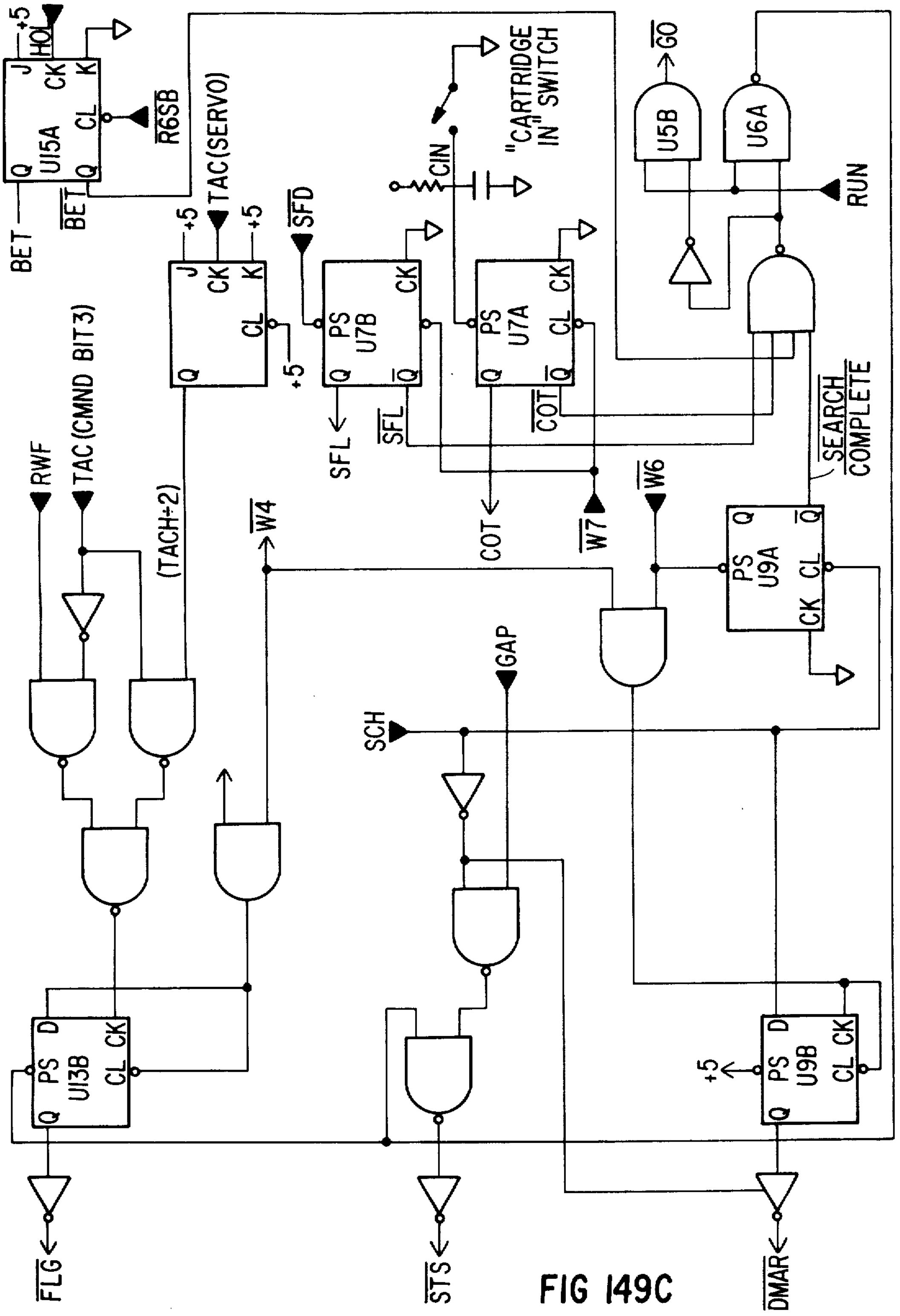

+5
HOL
R6SB
J
CK
K
CL
Q
U15A
BET
TAC(SERVO)
+5
SFD
"CARTRIDGE IN" SWITCH
CIN
GO
U5B
U6A
RUN
CL
+5
PS
U7B
SFL
PS
U7A
COT
SEARCH COMPLETE
RWF
TAC (CMND BIT 3)
(TACH÷2)
W4
COT
W7
W6
PS
U9A
GAP
SCH
PS
U13B
D
+5
U9B
FLG
STS
DMAR

FIG 149C

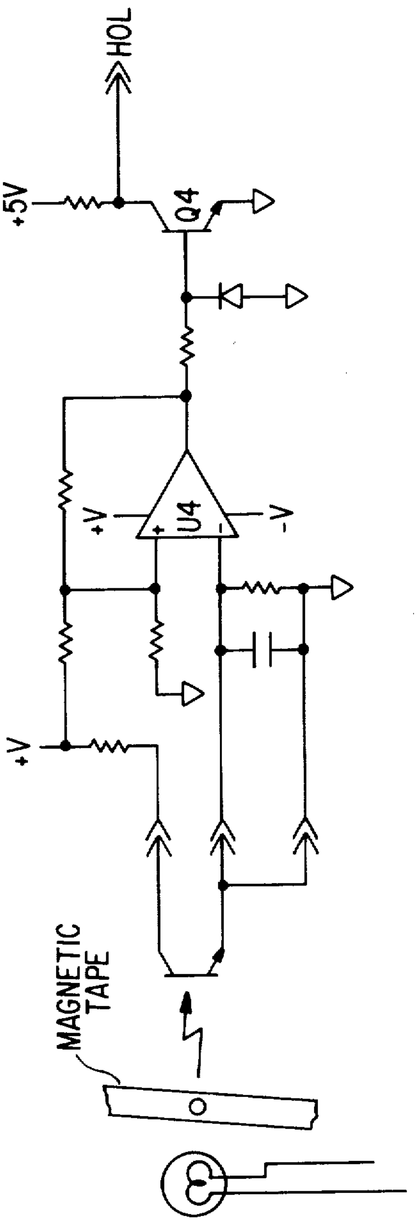


FIG 150

CASSETTE CONTROL-SERVO SECTION

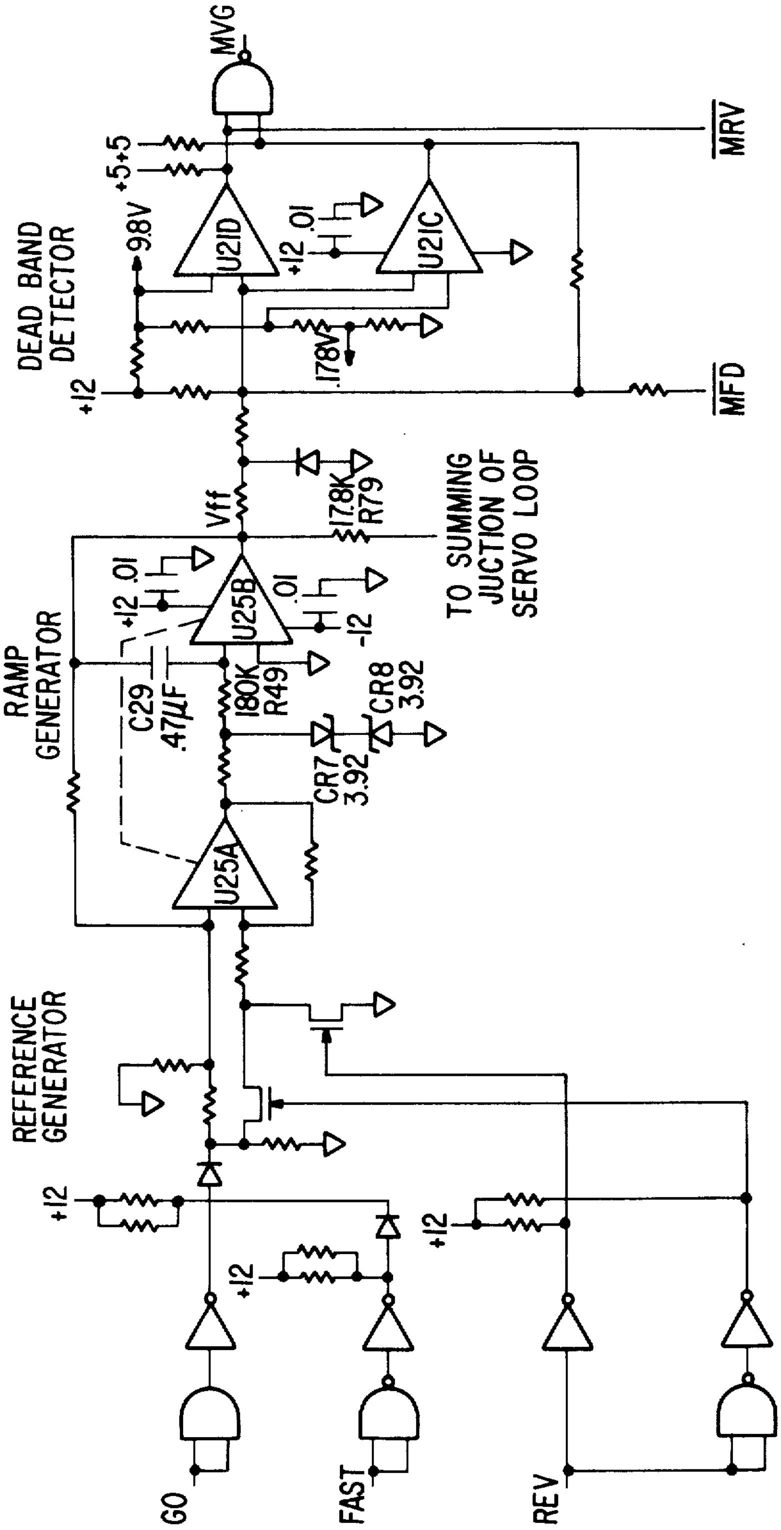


FIG 151A

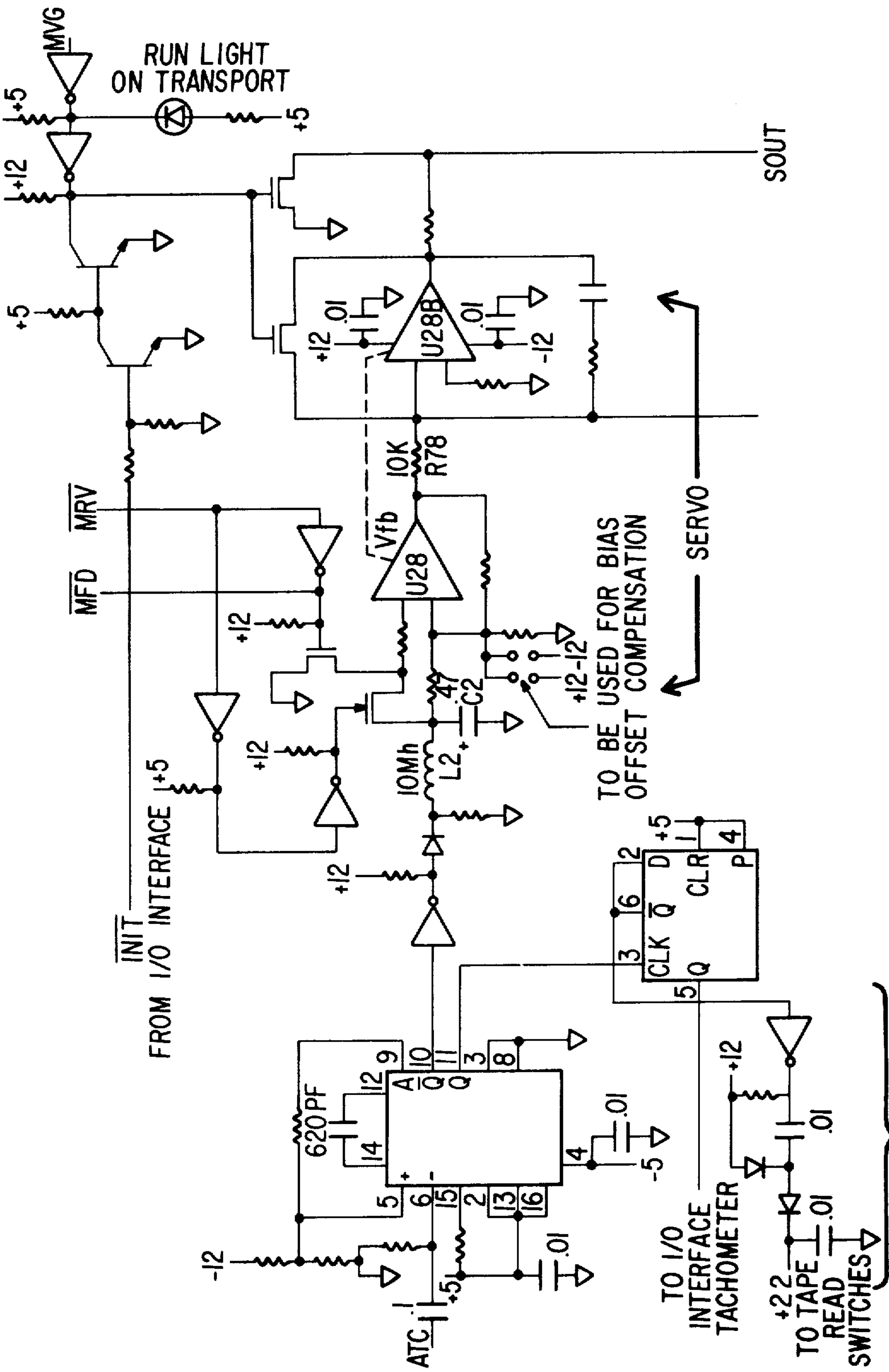

MVG
RUN LIGHT ON TRANSPORT
+5
+5
+12
+5
SOUT
+12
.01
U28B
.01
-12
SERVO
MRV
MFD
Vfb
U28
10K
R78
+12
+12
.47
C2
TO BE USED FOR BIAS OFFSET COMPENSATION
+12 -12
10Mh
L2
+12
+5
INIT
FROM I/O INTERFACE
+12
+5
2
D
1
CLR
4
P
6
Q̄
3
CLK
5
Q
9
10
11
3
8
12
A
Q̄
Q
620PF
14
.01
4
-5
5
6
15
2
13
16
-12
.01
ATC
.1
+5
TO I/O INTERFACE TACHOMETER
+12
.01
.01
+22
TO TAPE READ SWITCHES
VOLTAGE DOUBLES WHEN MOTOR IS ON

FIG 151B

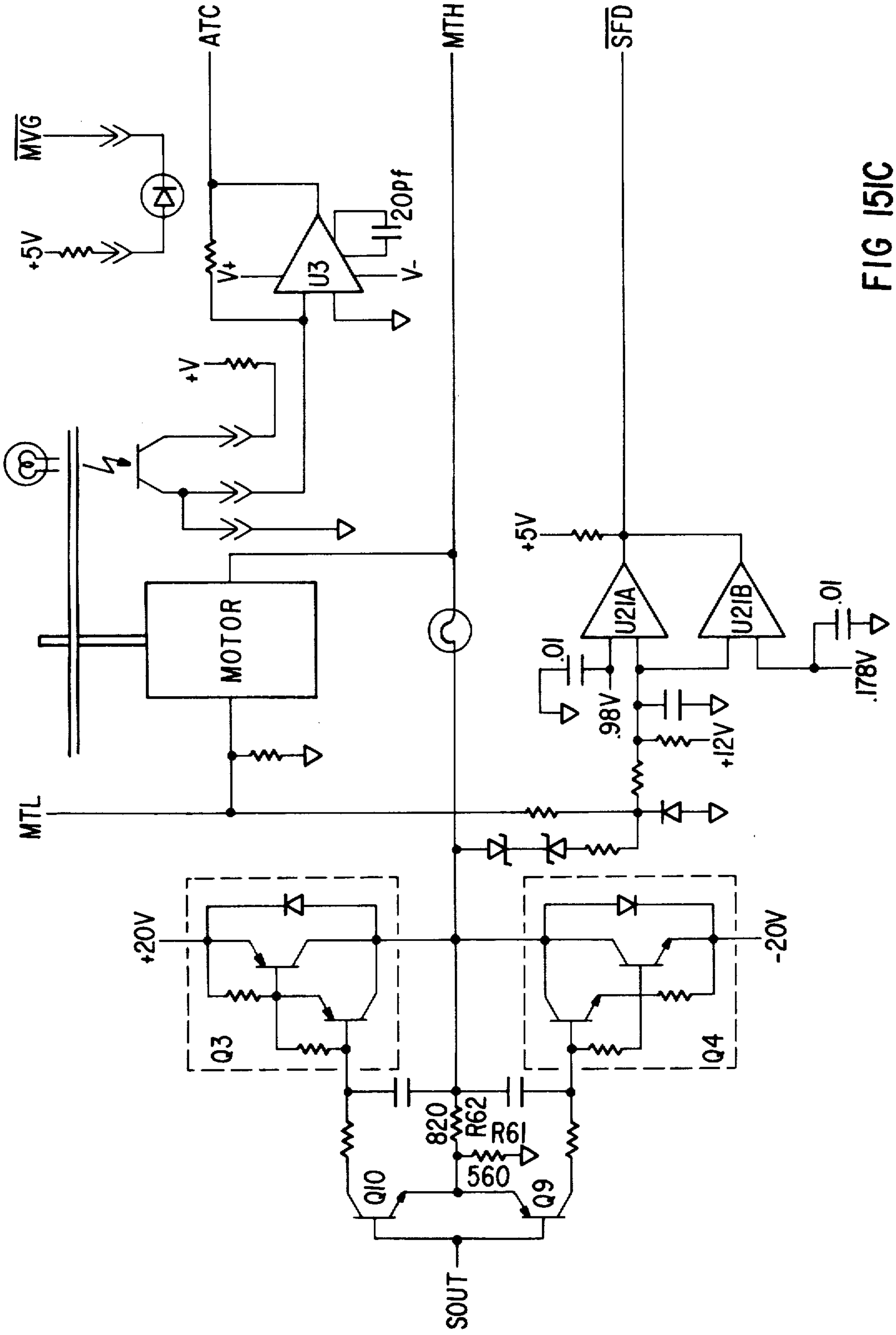

ATC
MTH
SFD
MVG
+5V
20Pf
V+
U3
V-
+V
MOTOR
+5V
U21A
U21B
.01
.98V
+12V
.01
.178V
MTL
+20V
-20V
Q3
Q4
820
R62
R61
560
Q10
Q9
SOUT

FIG 151C

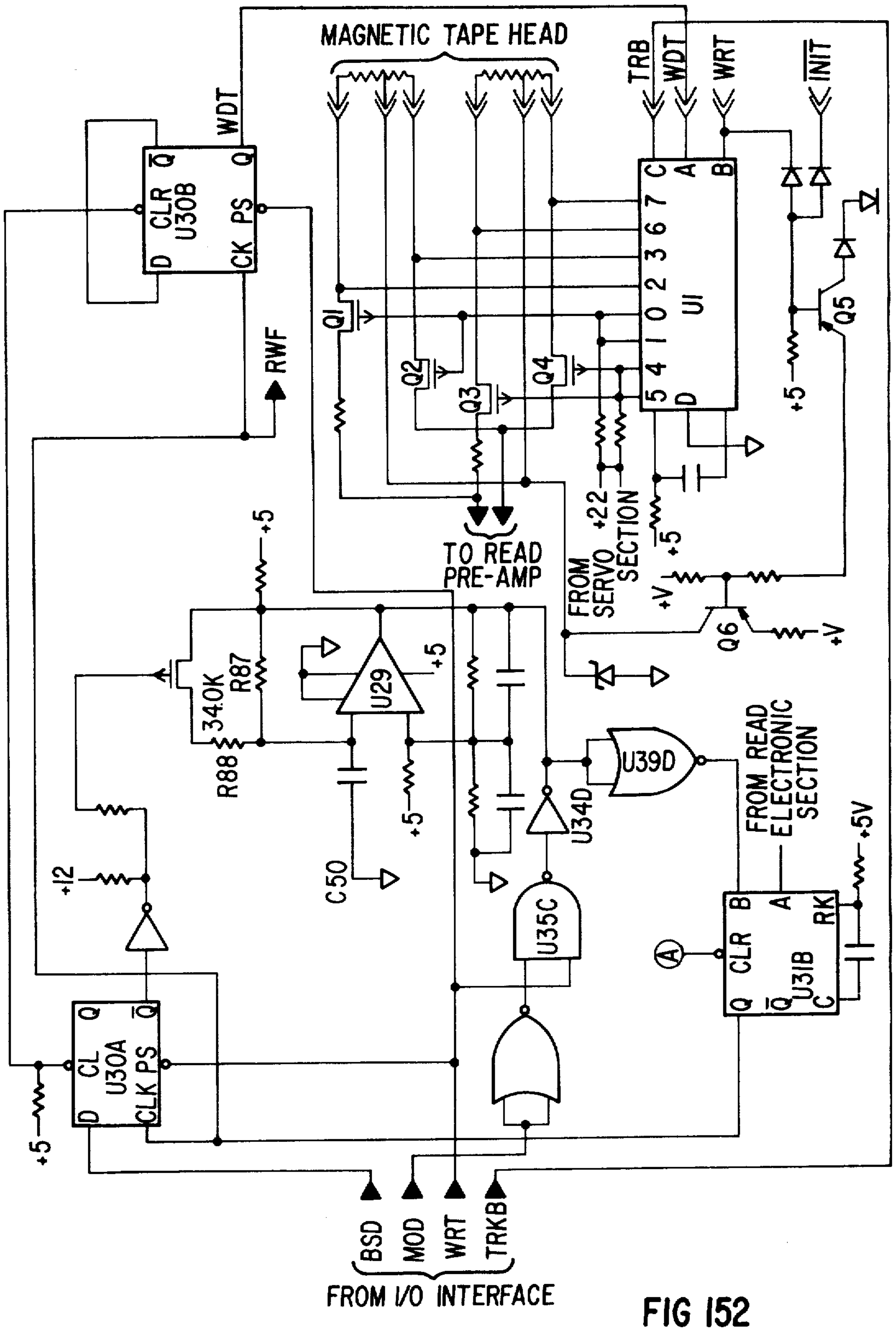

MAGNETIC TAPE HEAD
TRB
WDT
WRT
INIT
WDT
CLR
U30B
Q̄
D
CK
PS
Q
C
A
B
7
3
6
3
2
0
1
4
5
D
UI
Q1
Q2
Q3
Q4
Q5
Q6
RWF
+5
+22
FROM SERVO SECTION
+5
TO READ PRE-AMP
+V
+V
+5
R87
340K
R88
U29
+5
C50
+5
U34D
U39D
FROM READ ELECTRONIC SECTION
+5V
B
A
RK
CLR
U31B
Q
Q̄
C
A
U35C
+12
CL
U30A
Q
Q̄
D
CLK
PS
+5
BSD
MOD
WRT
TRKB
FROM I/O INTERFACE

FIG 152

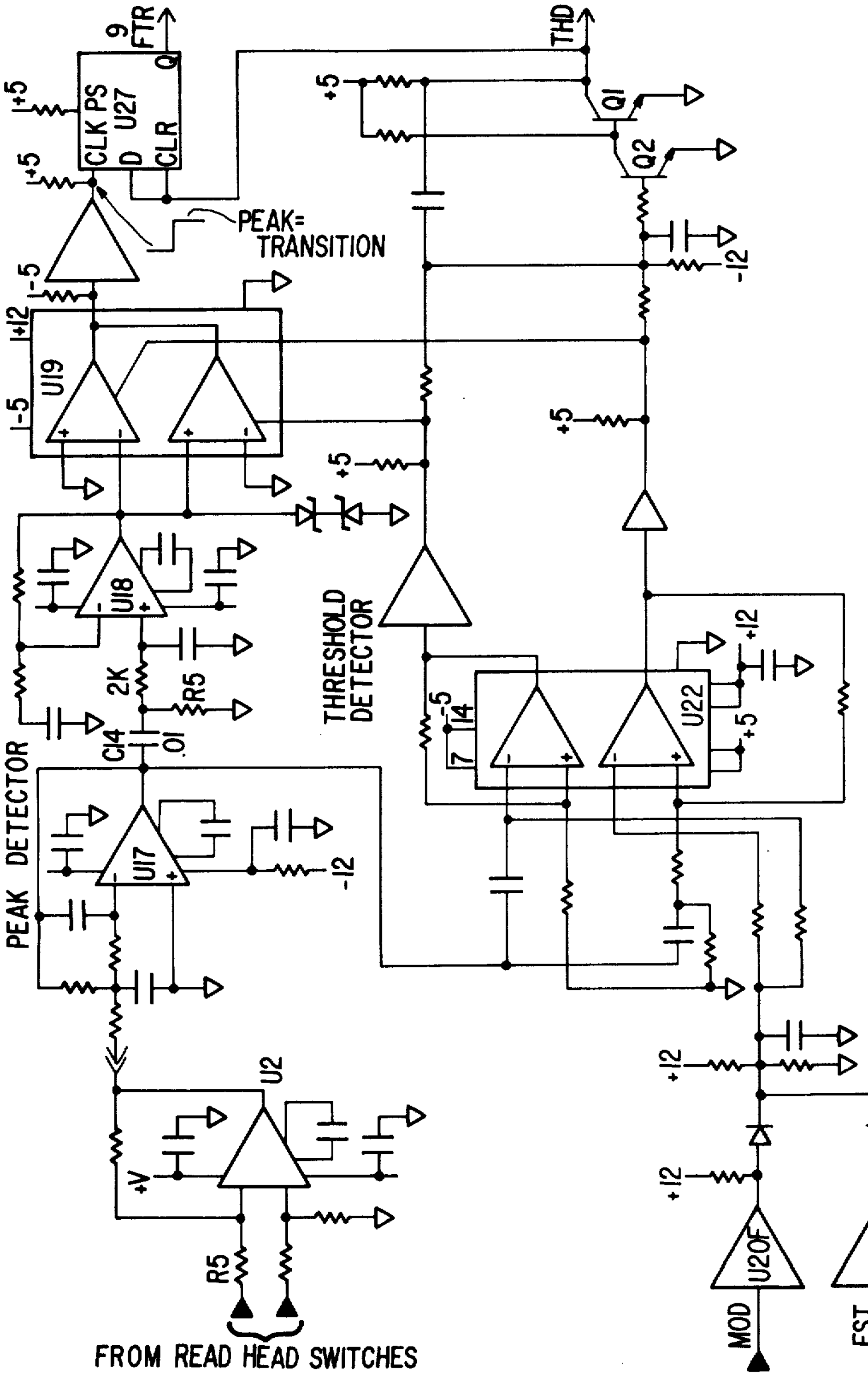

9
FTR
Q
CLK PS
U27
D
CLR
+5
+5
PEAK=
TRANSITION
THD
+5
Q1
Q2
-12
-5
+12
U19
-5
+5
+5
U18
THRESHOLD
DETECTOR
2K
R5
C14
.01
-5
14
7
U22
+12
+5
PEAK DETECTOR
U17
-12
+12
+12
U2
+V
R5
FROM READ HEAD SWITCHES
U20F
U20E
MOD
FST

FIG 153A

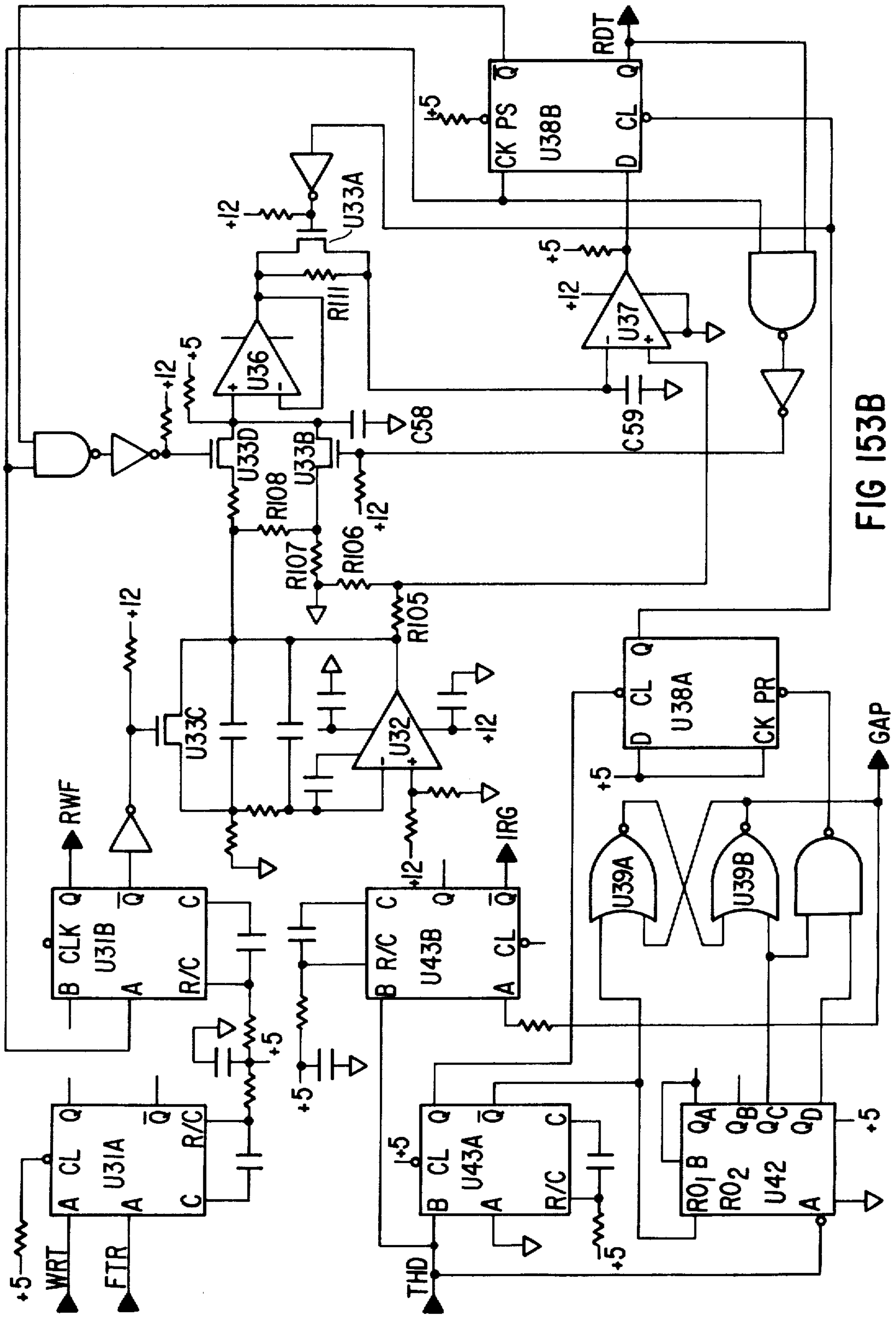

RDT
Q̄
Q
+5
PS
CK
U38B
CL
D
+12
U33A
R111
U36
U37
C59
C58
U33D
U33B
R108
R107
R106
+12
R105
U33C
U32
RWF
CLK
U31B
B
A
R/C
C
Q
Q̄
IRG
U43B
U31A
CL
WRT
FTR
THD
U43A
U38A
PR
GAP
U39A
U39B
U42
RO1
RO2
QA
QB
QC
QD
+5

FIG 153B

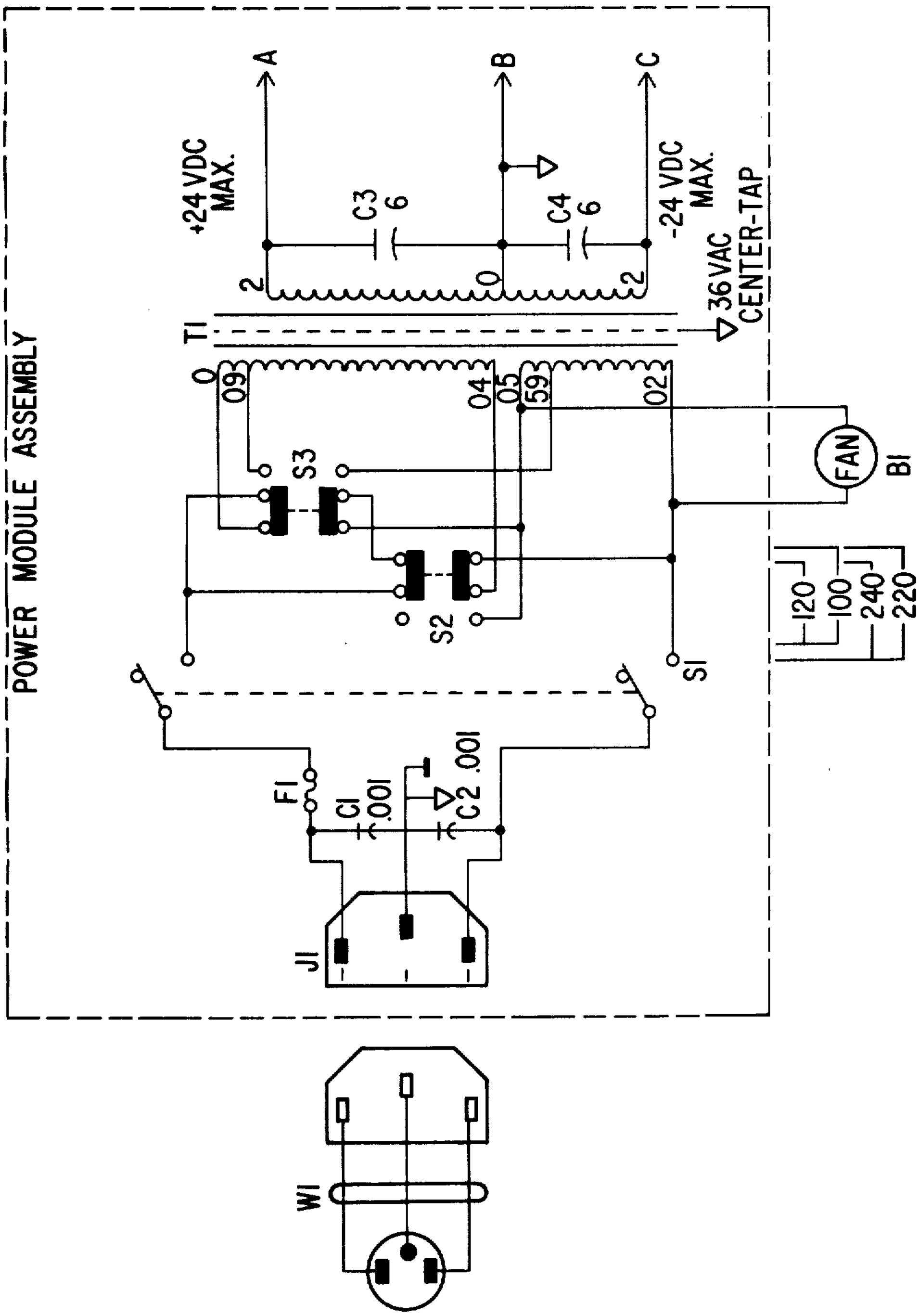

POWER MODULE ASSEMBLY
A
B
C
+24 VDC MAX.
-24 VDC MAX.
C3 6
C4 6
2
0
2
T1
36 VAC CENTER-TAP
0
60
04
05
59
02
S3
S2
S1
FAN
B1
120
100
240
220
F1
C1 .001
C2 .001
J1
W1

FIG 154A

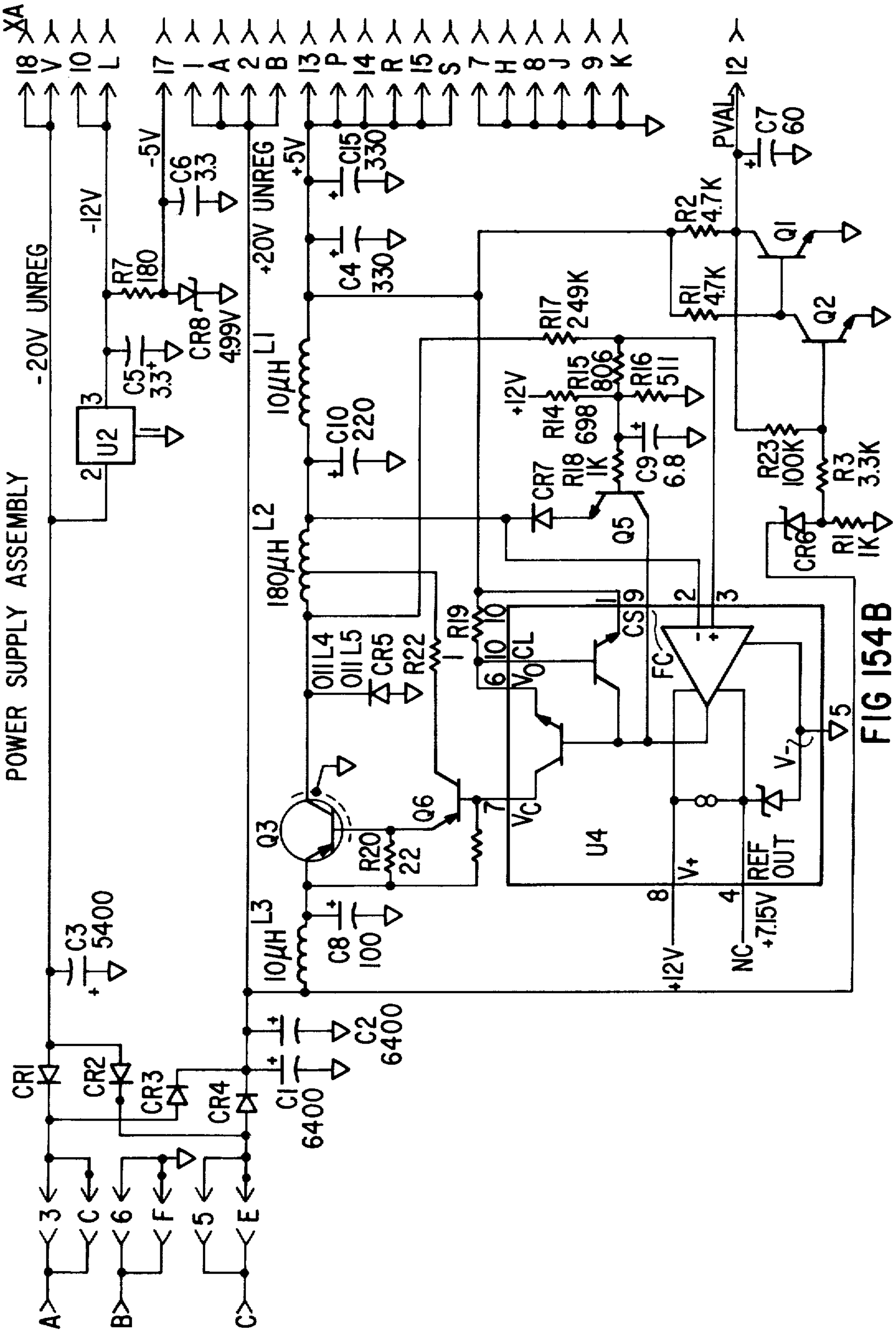

POWER SUPPLY ASSEMBLY
-20V UNREG
-12V
-5V
+20V UNREG
+5V
XA
18
V
10
L
17
1
A
2
B
13
P
14
R
15
S
7
H
8
J
9
K
12
PVAL
C7
60
R2
4.7K
R1
4.7K
Q1
Q2
R17
249K
R15
806
R16
511
+12V
R14
698
R18
1K
C9
6.8
CR7
Q5
R23
100K
R3
3.3K
R1
1K
CR6
U2
1
2
3
C5
3.3
R7
180
CR8
4.99V
C6
3.3
C15
330
C4
330
L1
10μH
C10
220
L2
180μH
011 L4
011 L5
CR5
R22
R19
1
10
6
10
CL
V0
CS
9
FC
2
3
-
+
5
V-
8
REF OUT
V+
U4
VC
7
Q6
Q3
R20
22
L3
10μH
C8
100
8
4
+12V
NC
+7.15V
C3
5400
C2
6400
C1
6400
CR1
CR2
CR3
CR4
3
C
6
F
5
E
A
B
C

FIG 154B

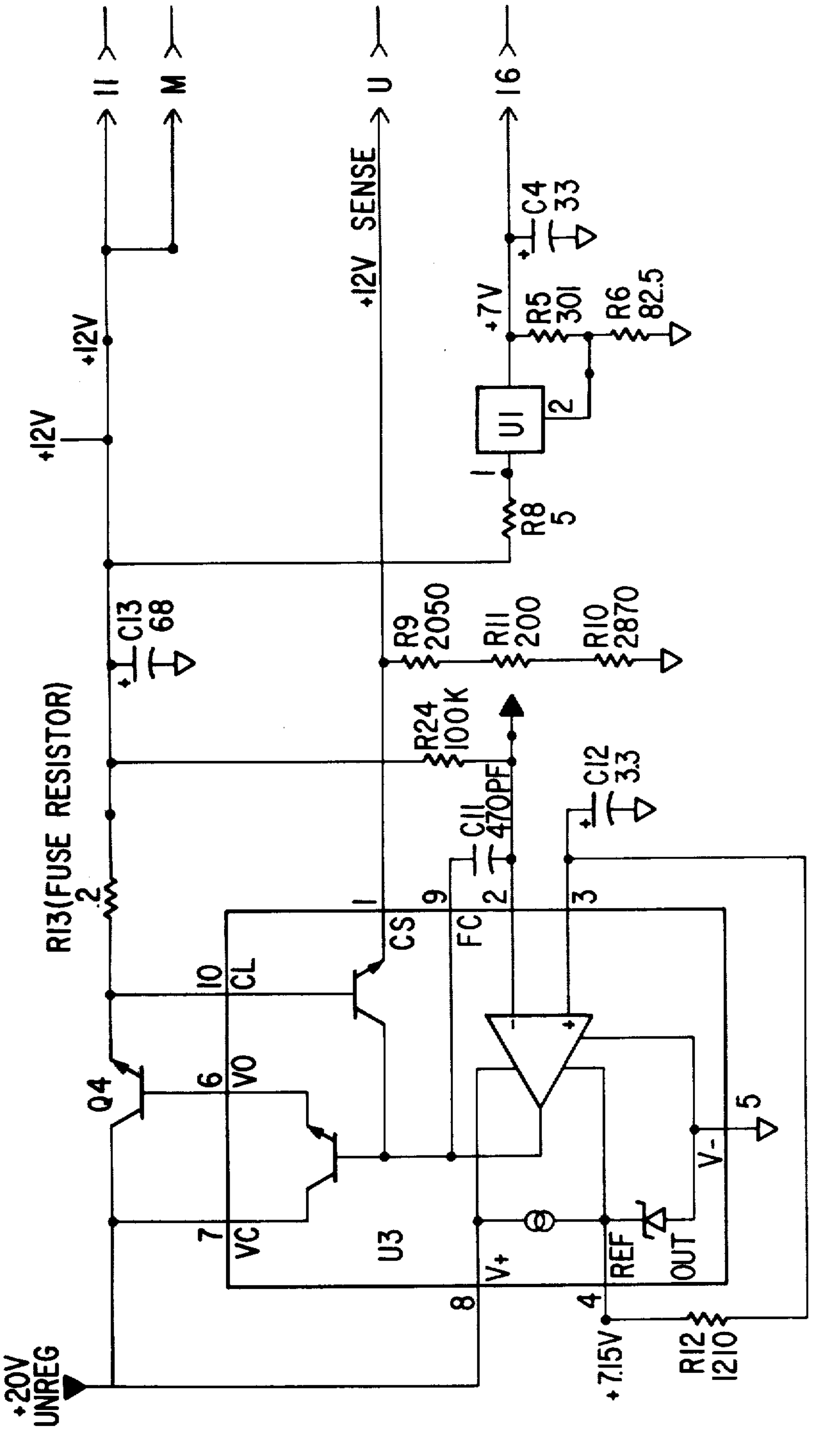

+20V
UNREG
Q4
R13(FUSE RESISTOR)
.2
+12V
+12V
C13
68
R24
100K
R9
2050
R11
200
R10
2870
+12V SENSE
11
M
U
16
C4
33
+7V
R5
301
R6
82.5
U1
1
2
R8
5
C11
470PF
C12
3.3
10
CL
6
VO
7
VC
U3
8
V+
1
CS
9
FC
2
3
REF
4
OUT
V-
5
+7.15V
R12
1210

FIG 154C

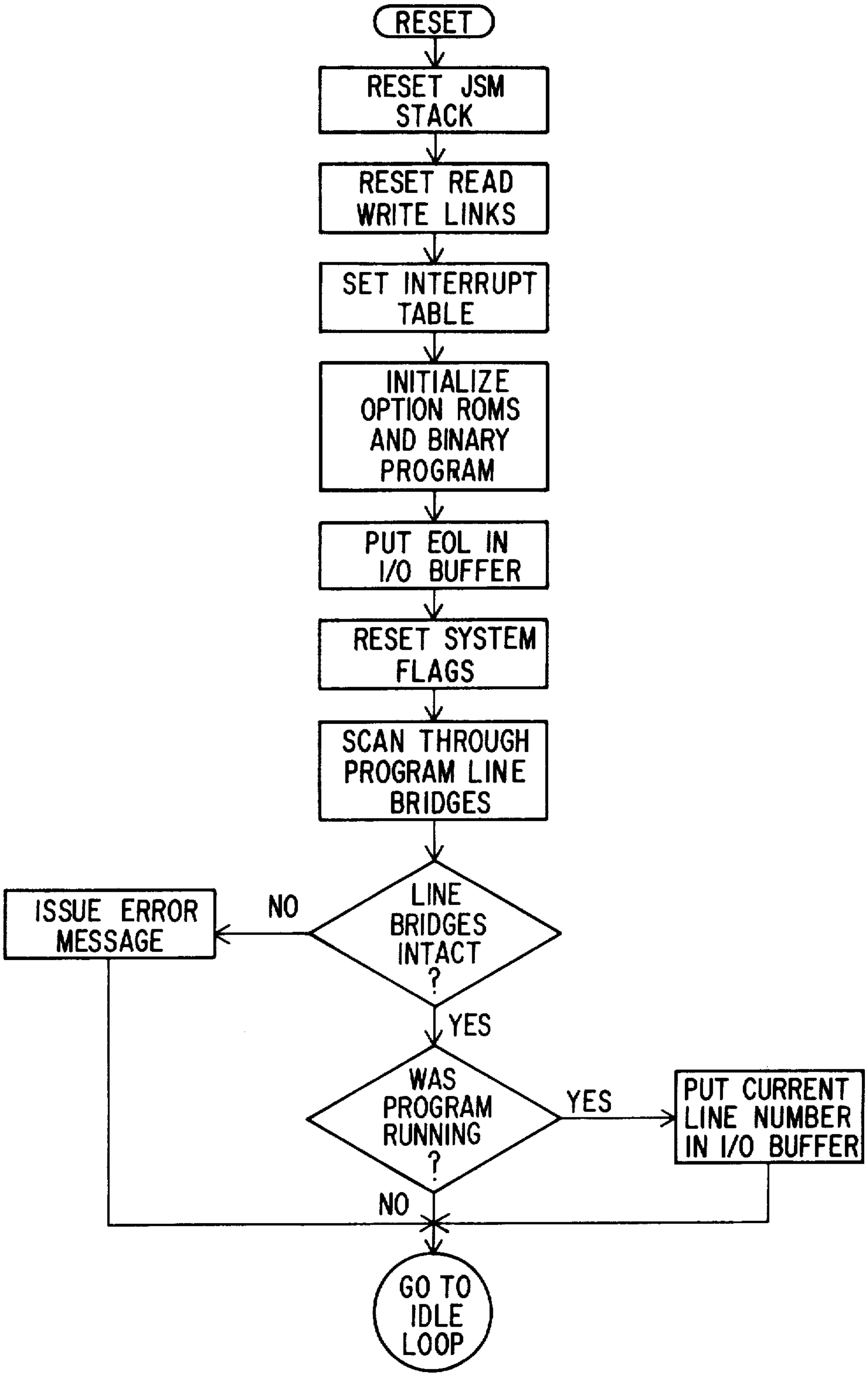

RESET
RESET JSM STACK
RESET READ WRITE LINKS
SET INTERRUPT TABLE
INITIALIZE OPTION ROMS AND BINARY PROGRAM
PUT EOL IN I/O BUFFER
RESET SYSTEM FLAGS
SCAN THROUGH PROGRAM LINE BRIDGES
LINE BRIDGES INTACT ?
NO
ISSUE ERROR MESSAGE
YES
WAS PROGRAM RUNNING ?
YES
PUT CURRENT LINE NUMBER IN I/O BUFFER
NO
GO TO IDLE LOOP

FIG 155

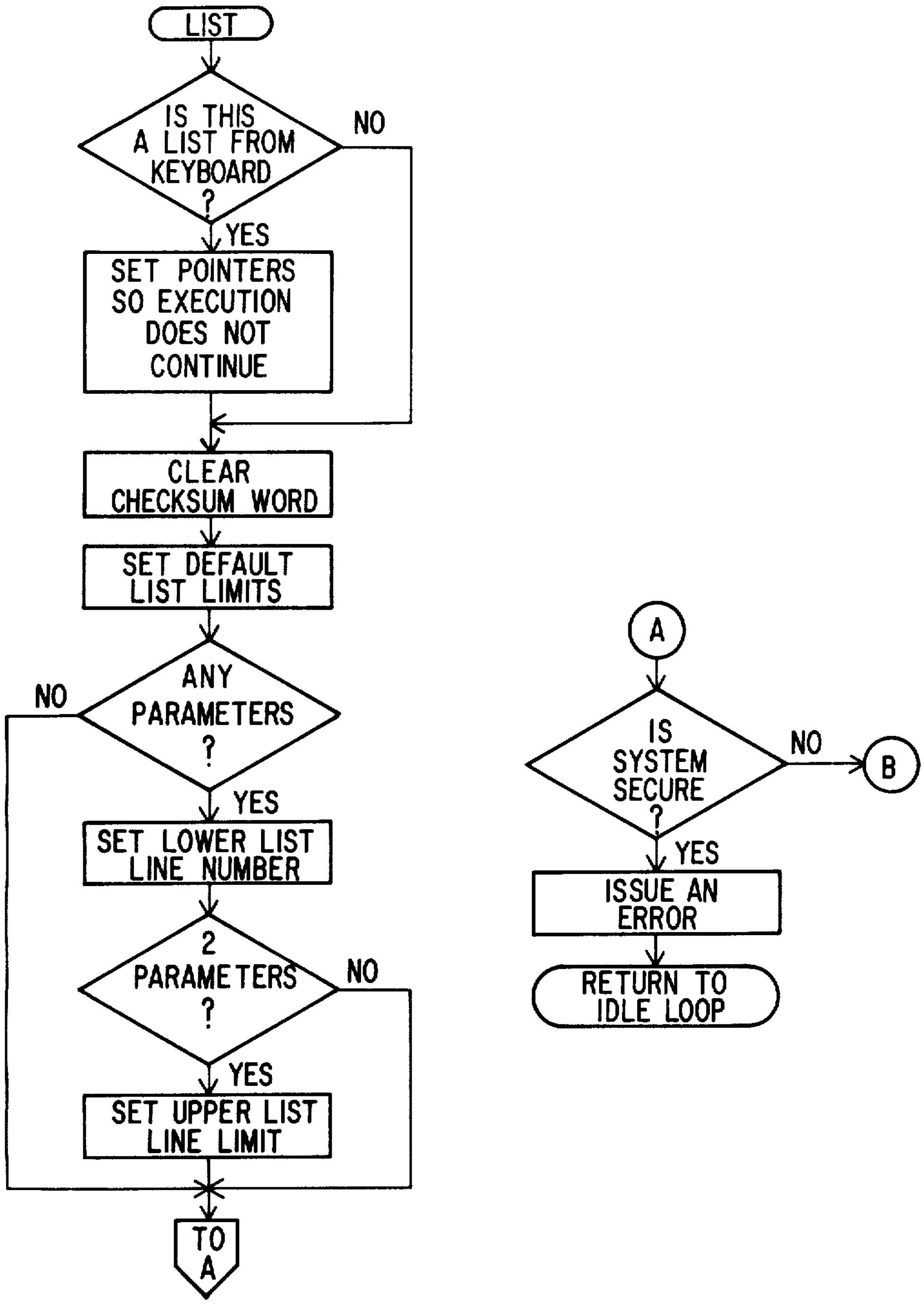

LIST
IS THIS A LIST FROM KEYBOARD ?
NO
YES
SET POINTERS SO EXECUTION DOES NOT CONTINUE
CLEAR CHECKSUM WORD
SET DEFAULT LIST LIMITS
ANY PARAMETERS ?
NO
YES
SET LOWER LIST LINE NUMBER
2 PARAMETERS ?
NO
YES
SET UPPER LIST LINE LIMIT
TO A
A
IS SYSTEM SECURE ?
NO
B
YES
ISSUE AN ERROR
RETURN TO IDLE LOOP

FIG 156A

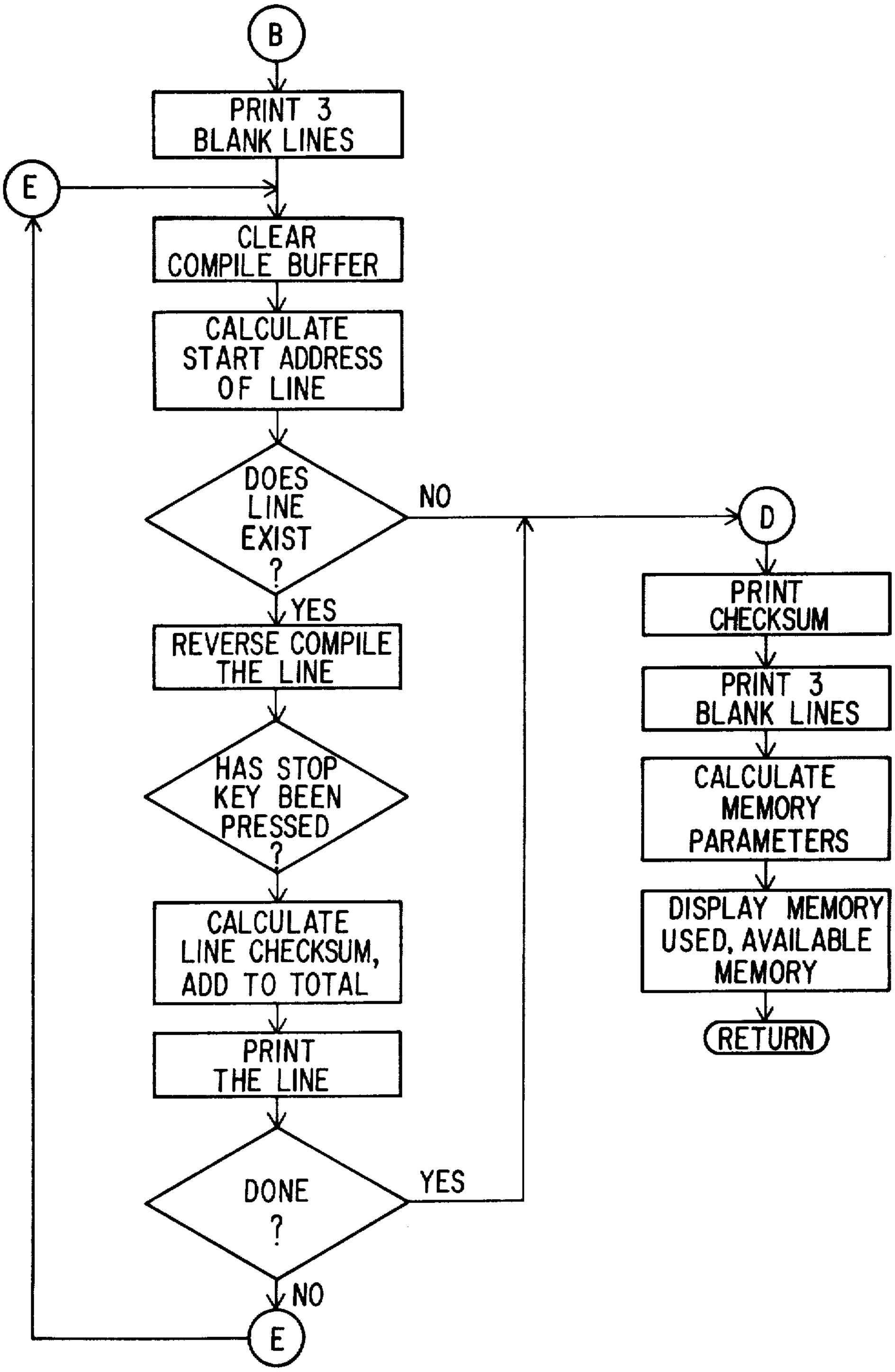

B
PRINT 3 BLANK LINES
E
CLEAR COMPILE BUFFER
CALCULATE START ADDRESS OF LINE
DOES LINE EXIST ?
NO
YES
D
REVERSE COMPILE THE LINE
HAS STOP KEY BEEN PRESSED ?
CALCULATE LINE CHECKSUM, ADD TO TOTAL
PRINT THE LINE
DONE ?
YES
NO
E
PRINT CHECKSUM
PRINT 3 BLANK LINES
CALCULATE MEMORY PARAMETERS
DISPLAY MEMORY USED, AVAILABLE MEMORY
RETURN

FIG 156B

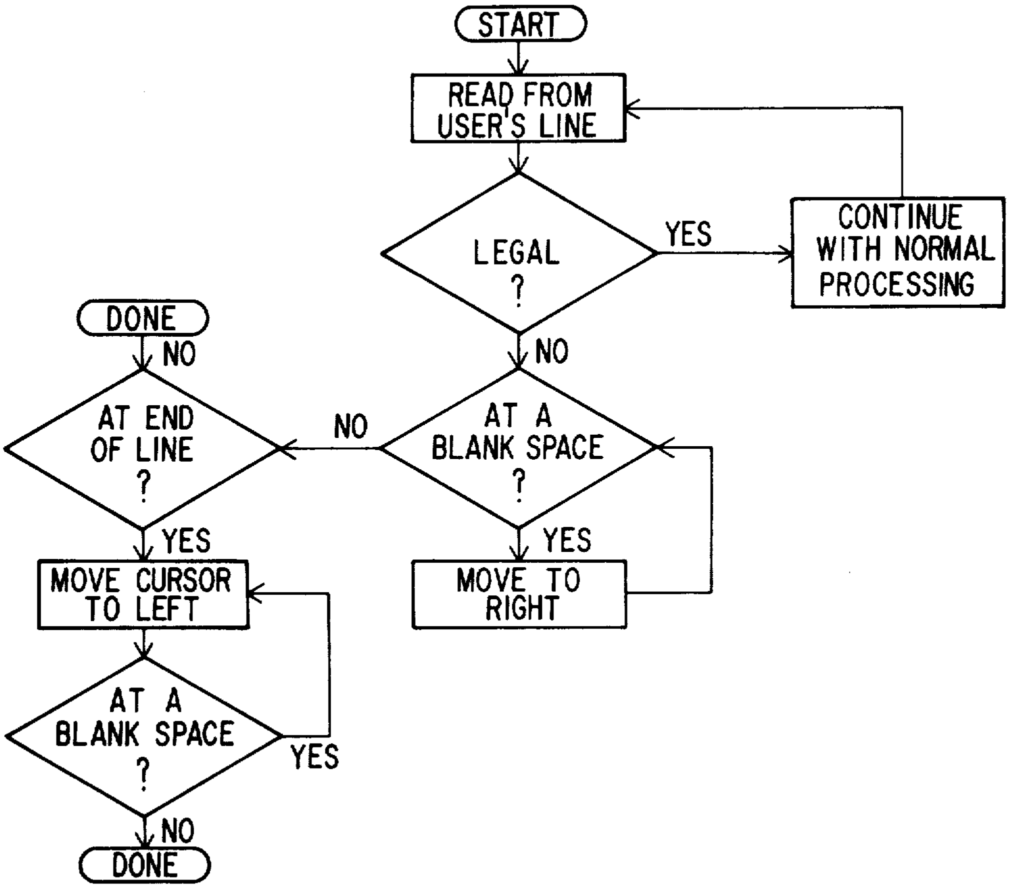

START
READ FROM USER'S LINE
LEGAL ?
YES
CONTINUE WITH NORMAL PROCESSING
NO
AT A BLANK SPACE ?
YES
MOVE TO RIGHT
NO
DONE
NO
AT END OF LINE ?
YES
MOVE CURSOR TO LEFT
AT A BLANK SPACE ?
YES
NO
DONE

FIG 157

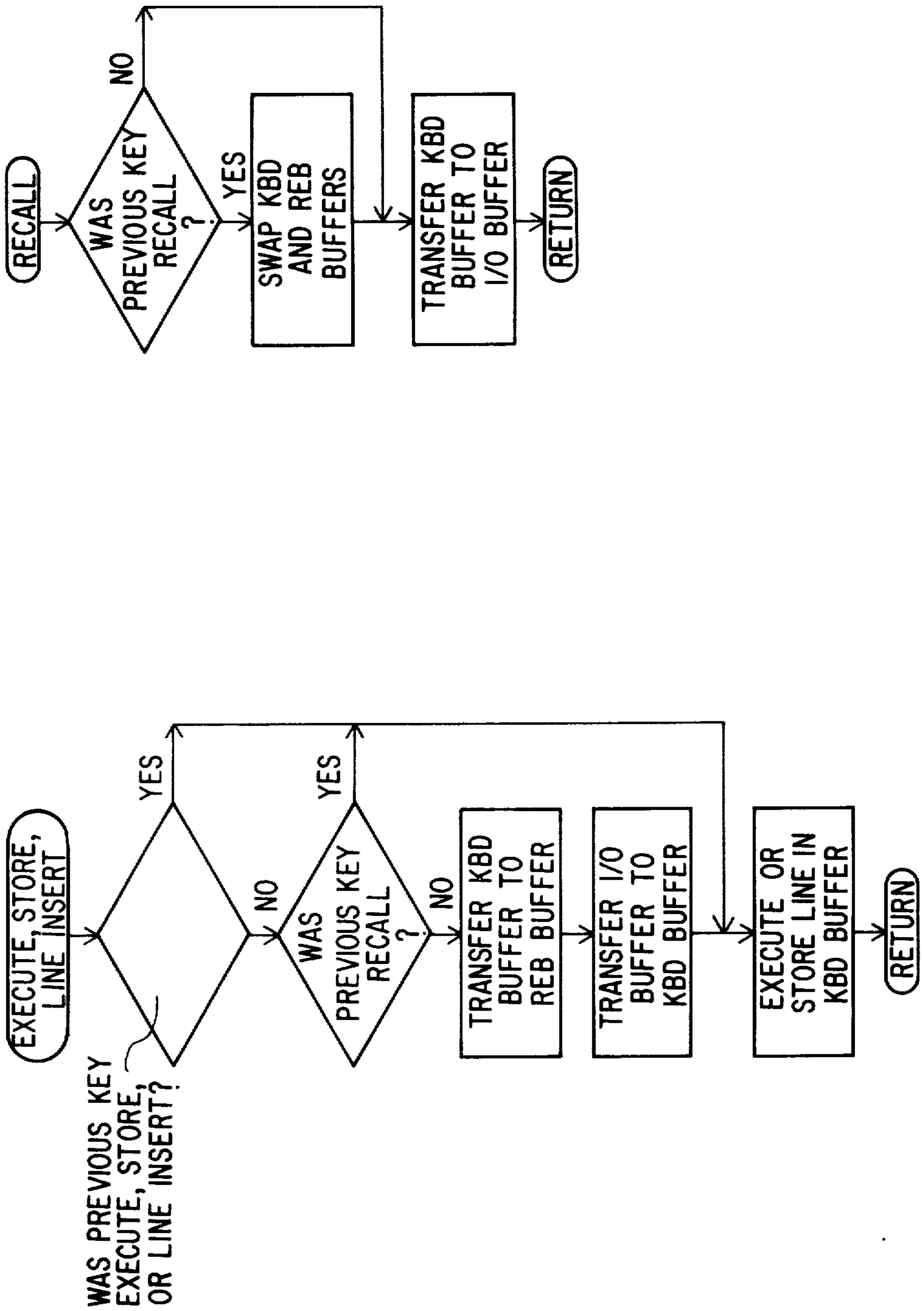

RECALL
WAS PREVIOUS KEY RECALL ?
YES
NO
SWAP KBD AND REB BUFFERS
TRANSFER KBD BUFFER TO I/O BUFFER
RETURN
EXECUTE, STORE, LINE INSERT
WAS PREVIOUS KEY EXECUTE, STORE, OR LINE INSERT?
YES
NO
WAS PREVIOUS KEY RECALL ?
YES
NO
TRANSFER KBD BUFFER TO REB BUFFER
TRANSFER I/O BUFFER TO KBD BUFFER
EXECUTE OR STORE LINE IN KBD BUFFER
RETURN

FIG 158A

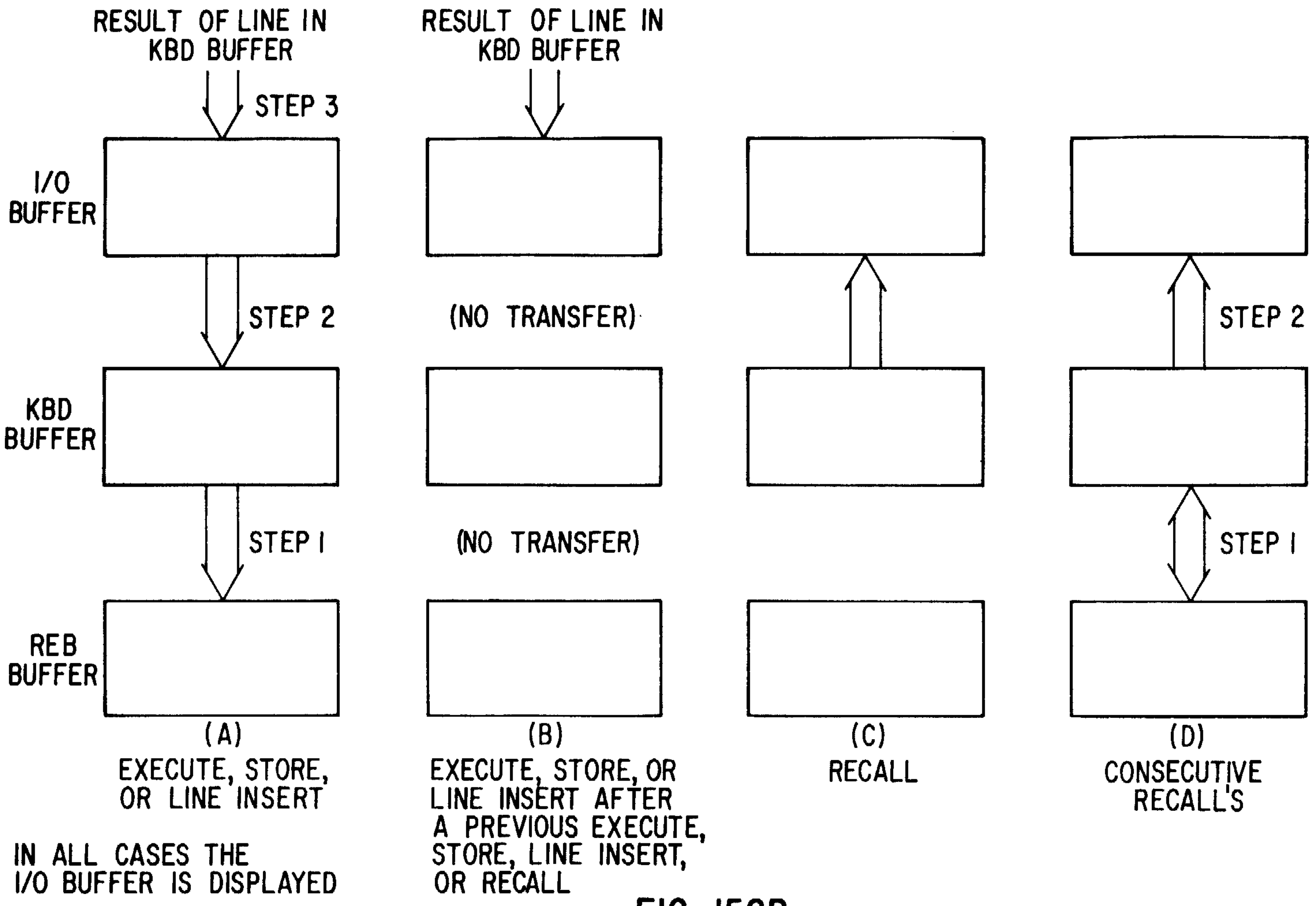

RESULT OF LINE IN
KBD BUFFER
STEP 3
I/O
BUFFER
STEP 2
KBD
BUFFER
STEP I
REB
BUFFER
(A)
EXECUTE, STORE,
OR LINE INSERT
IN ALL CASES THE
I/O BUFFER IS DISPLAYED
RESULT OF LINE IN
KBD BUFFER
(NO TRANSFER)
(NO TRANSFER)
(B)
EXECUTE, STORE, OR
LINE INSERT AFTER
A PREVIOUS EXECUTE,
STORE, LINE INSERT,
OR RECALL
(C)
RECALL
STEP 2
STEP I
(D)
CONSECUTIVE
RECALL'S

FIG 158B

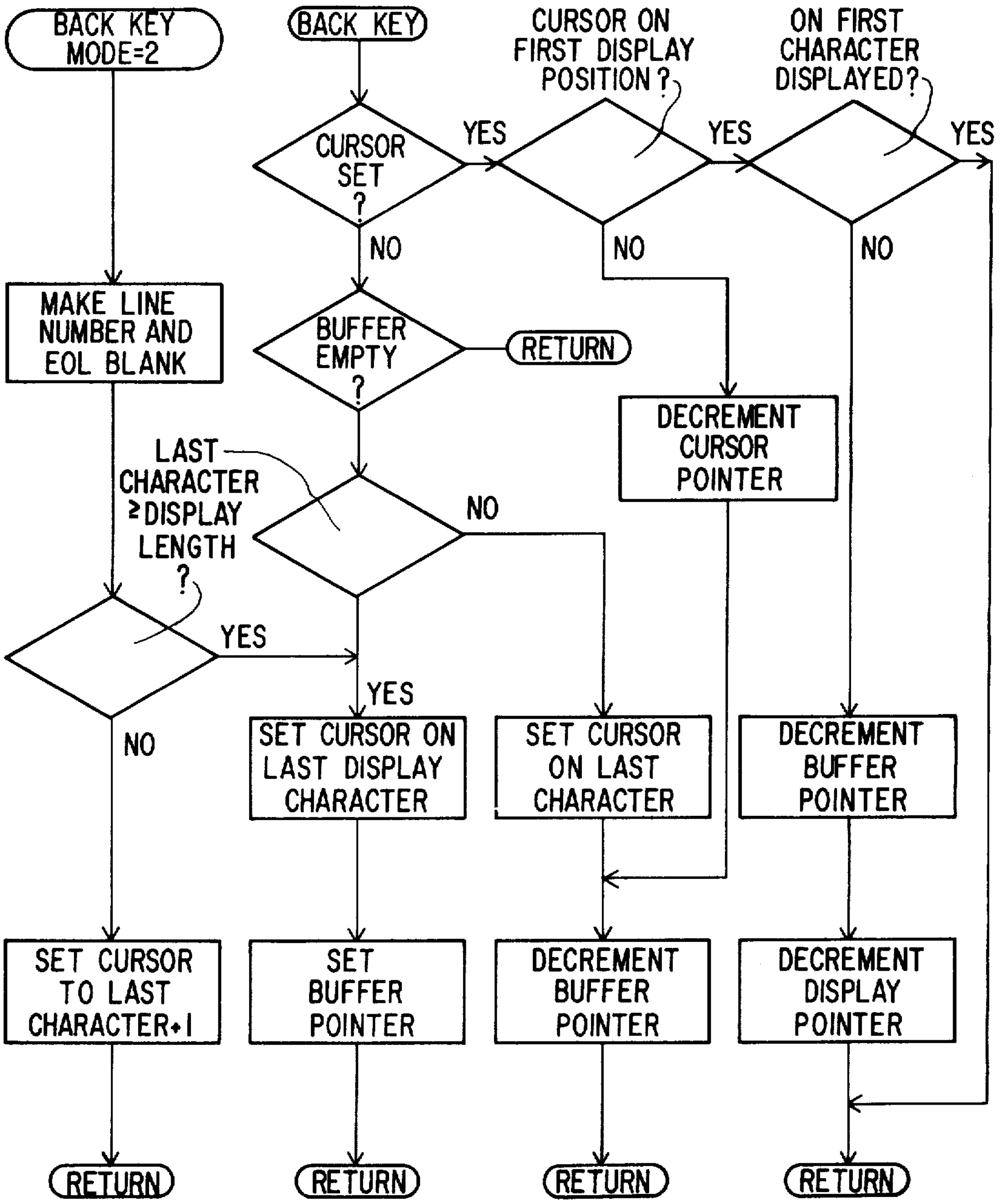

BACK KEY MODE=2
BACK KEY
CURSOR SET ?
YES
CURSOR ON FIRST DISPLAY POSITION ?
YES
ON FIRST CHARACTER DISPLAYED ?
YES
NO
NO
NO
MAKE LINE NUMBER AND EOL BLANK
BUFFER EMPTY ?
RETURN
DECREMENT CURSOR POINTER
LAST CHARACTER ≥DISPLAY LENGTH ?
NO
YES
YES
NO
SET CURSOR ON LAST DISPLAY CHARACTER
SET CURSOR ON LAST CHARACTER
DECREMENT BUFFER POINTER
SET CURSOR TO LAST CHARACTER+1
SET BUFFER POINTER
DECREMENT BUFFER POINTER
DECREMENT DISPLAY POINTER
RETURN
RETURN
RETURN
RETURN

FIG 159A

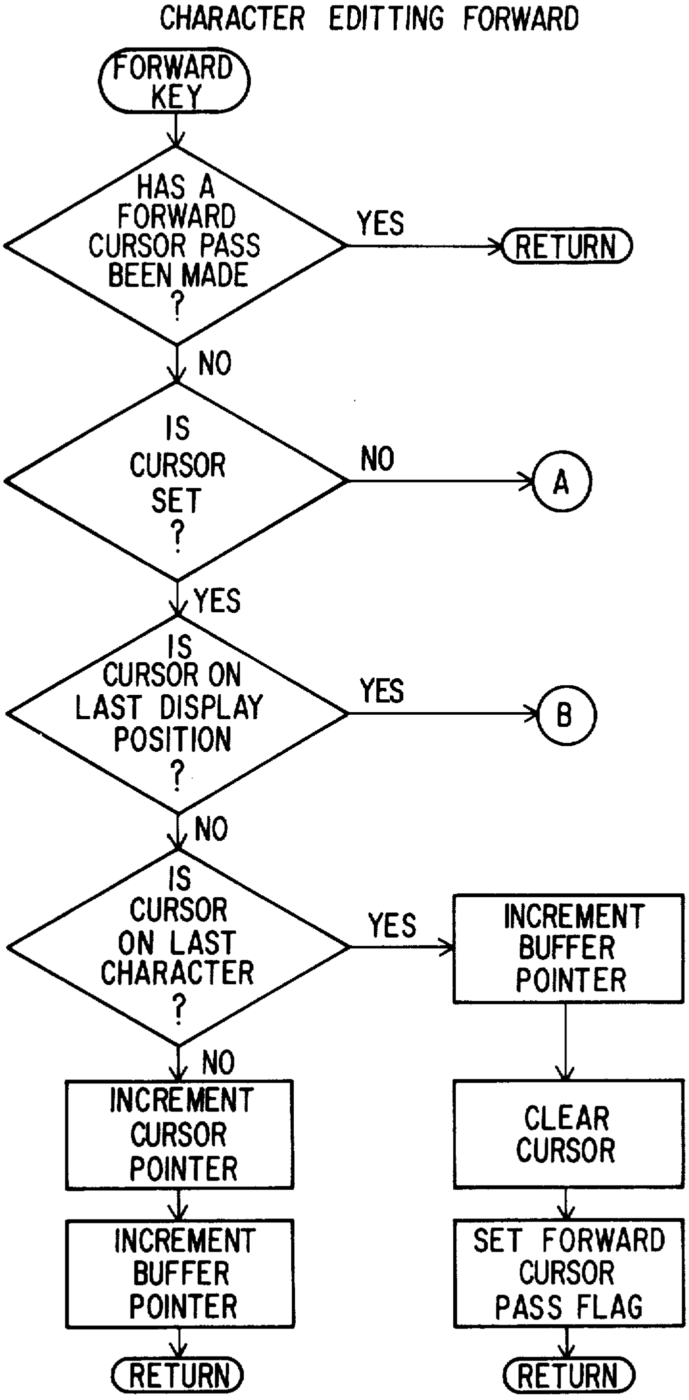

CHARACTER EDITTING FORWARD
FORWARD KEY
HAS A FORWARD CURSOR PASS BEEN MADE ?
YES
RETURN
NO
IS CURSOR SET ?
NO
A
YES
IS CURSOR ON LAST DISPLAY POSITION ?
YES
B
NO
IS CURSOR ON LAST CHARACTER ?
YES
INCREMENT BUFFER POINTER
NO
INCREMENT CURSOR POINTER
INCREMENT BUFFER POINTER
RETURN
CLEAR CURSOR
SET FORWARD CURSOR PASS FLAG
RETURN

FIG 159B

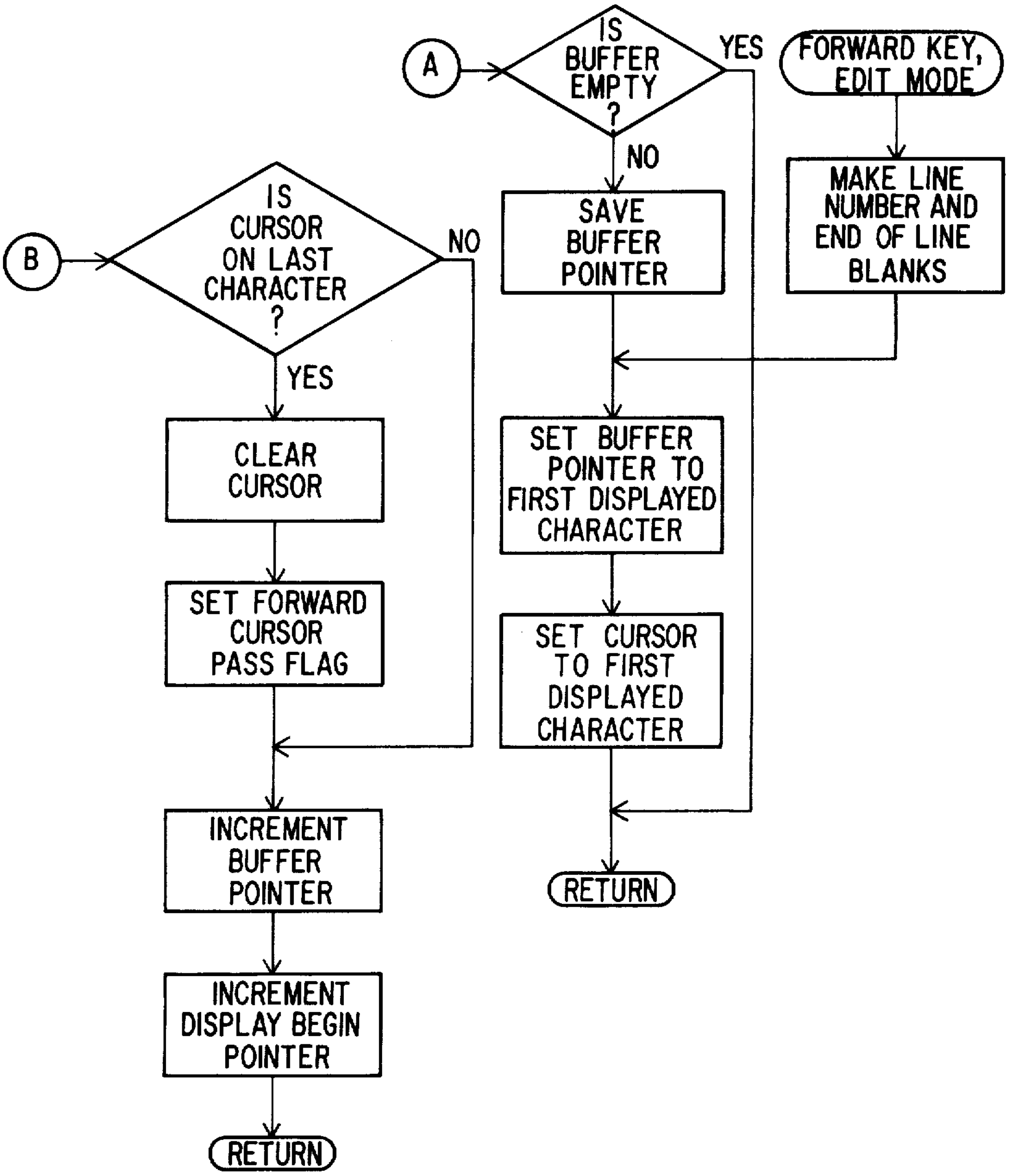

A
IS BUFFER EMPTY ?
YES
NO
FORWARD KEY, EDIT MODE
SAVE BUFFER POINTER
MAKE LINE NUMBER AND END OF LINE BLANKS
SET BUFFER POINTER TO FIRST DISPLAYED CHARACTER
SET CURSOR TO FIRST DISPLAYED CHARACTER
RETURN
B
IS CURSOR ON LAST CHARACTER ?
NO
YES
CLEAR CURSOR
SET FORWARD CURSOR PASS FLAG
INCREMENT BUFFER POINTER
INCREMENT DISPLAY BEGIN POINTER
RETURN

FIG 159C

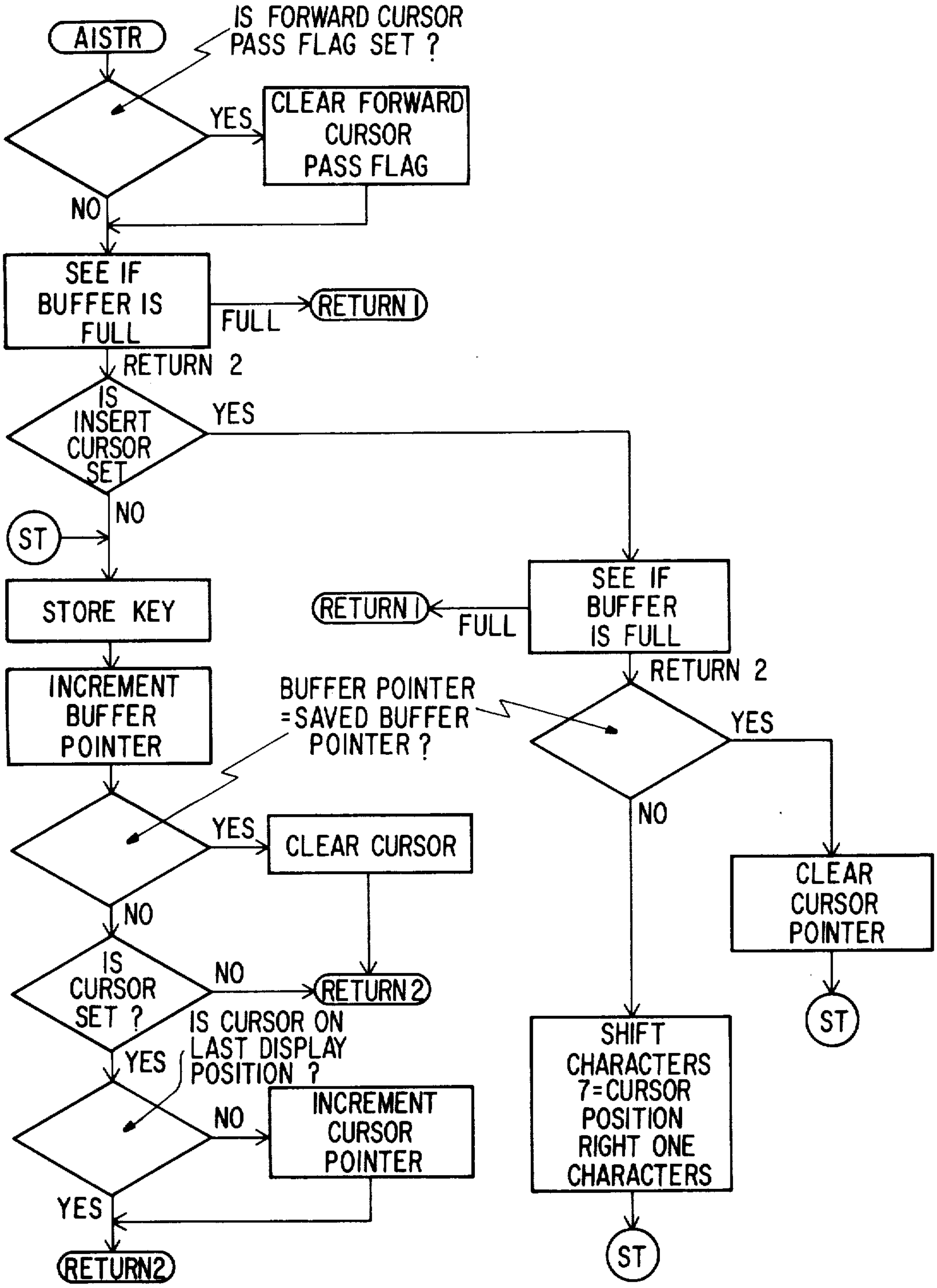

AISTR
IS FORWARD CURSOR PASS FLAG SET ?
YES
CLEAR FORWARD CURSOR PASS FLAG
NO
SEE IF BUFFER IS FULL
FULL
RETURN 1
RETURN 2
IS INSERT CURSOR SET
YES
NO
ST
STORE KEY
INCREMENT BUFFER POINTER
SEE IF BUFFER IS FULL
FULL
RETURN 1
RETURN 2
BUFFER POINTER =SAVED BUFFER POINTER ?
YES
NO
CLEAR CURSOR
YES
NO
CLEAR CURSOR POINTER
ST
IS CURSOR SET ?
NO
RETURN 2
IS CURSOR ON LAST DISPLAY POSITION ?
YES
NO
INCREMENT CURSOR POINTER
SHIFT CHARACTERS 7=CURSOR POSITION RIGHT ONE CHARACTERS
YES
RETURN2
ST

FIG 159D

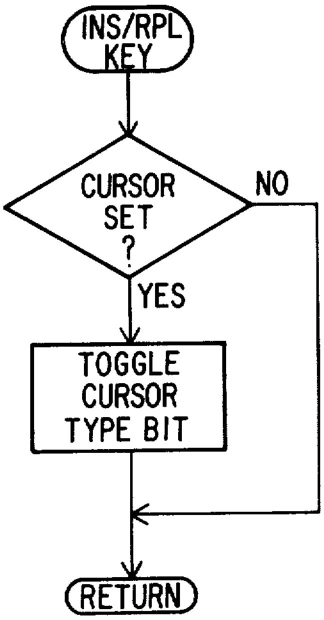


FIG 159E

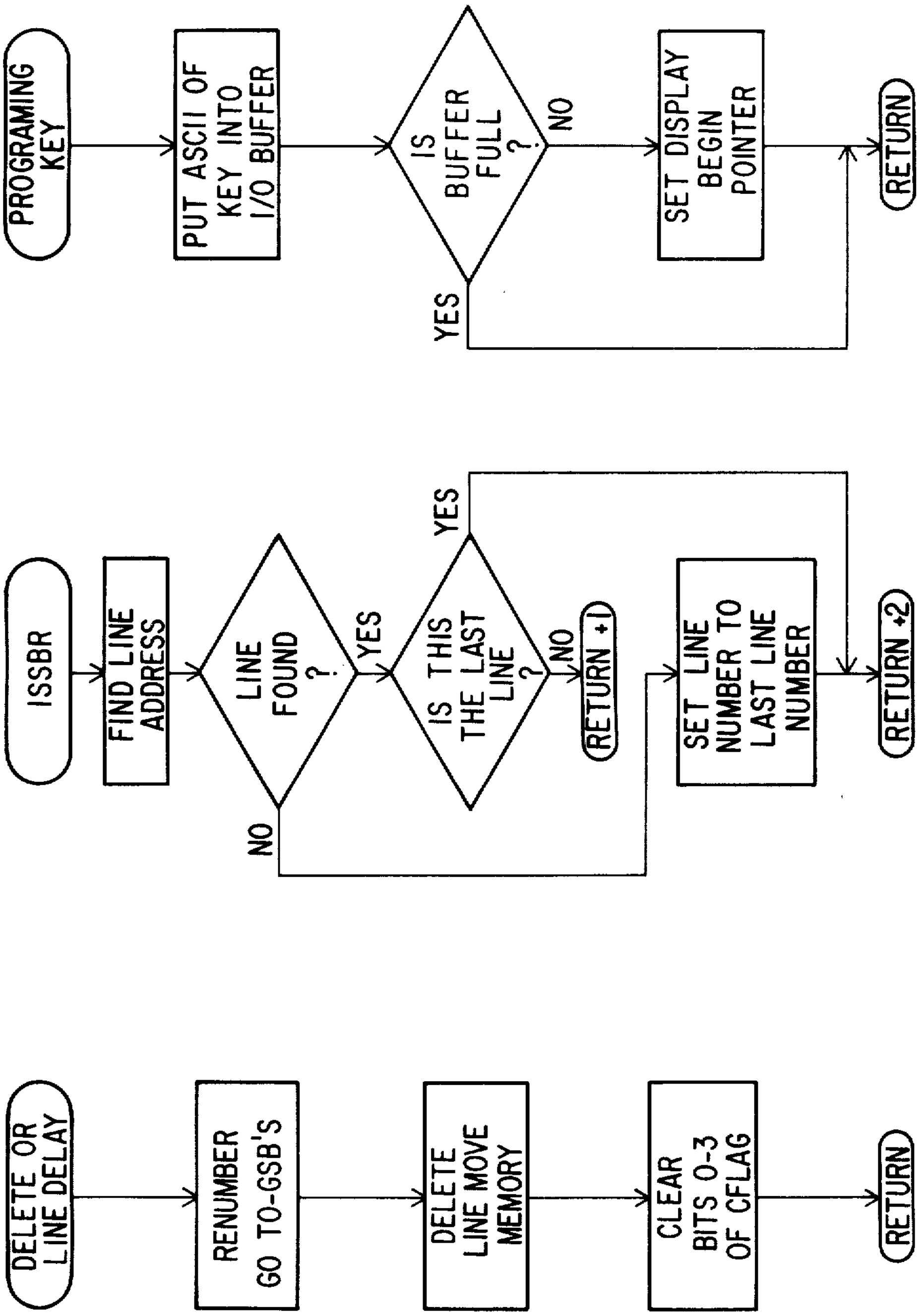

DELETE OR LINE DELAY
RENUMBER GO TO-GSB'S
DELETE LINE MOVE MEMORY
CLEAR BITS 0-3 OF CFLAG
RETURN
ISSBR
FIND LINE ADDRESS
LINE FOUND ?
NO
YES
IS THIS THE LAST LINE ?
YES
NO
RETURN +1
SET LINE NUMBER TO LAST LINE NUMBER
RETURN +2
PROGRAMING KEY
PUT ASCII OF KEY INTO I/O BUFFER
IS BUFFER FULL ?
YES
NO
SET DISPLAY BEGIN POINTER
RETURN

FIG 159F

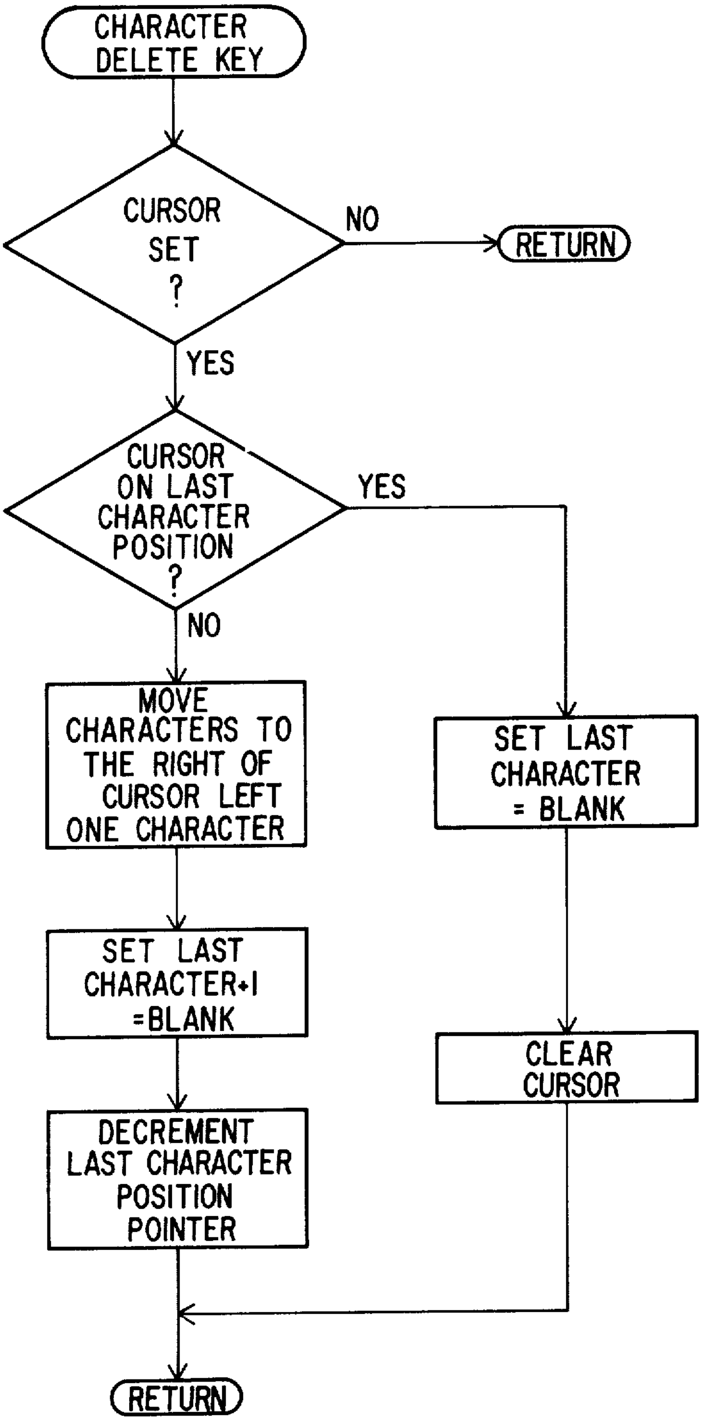

CHARACTER DELETE KEY
CURSOR SET ?
NO
RETURN
YES
CURSOR ON LAST CHARACTER POSITION ?
YES
NO
MOVE CHARACTERS TO THE RIGHT OF CURSOR LEFT ONE CHARACTER
SET LAST CHARACTER = BLANK
SET LAST CHARACTER+I =BLANK
CLEAR CURSOR
DECREMENT LAST CHARACTER POSITION POINTER
RETURN

FIG 159G

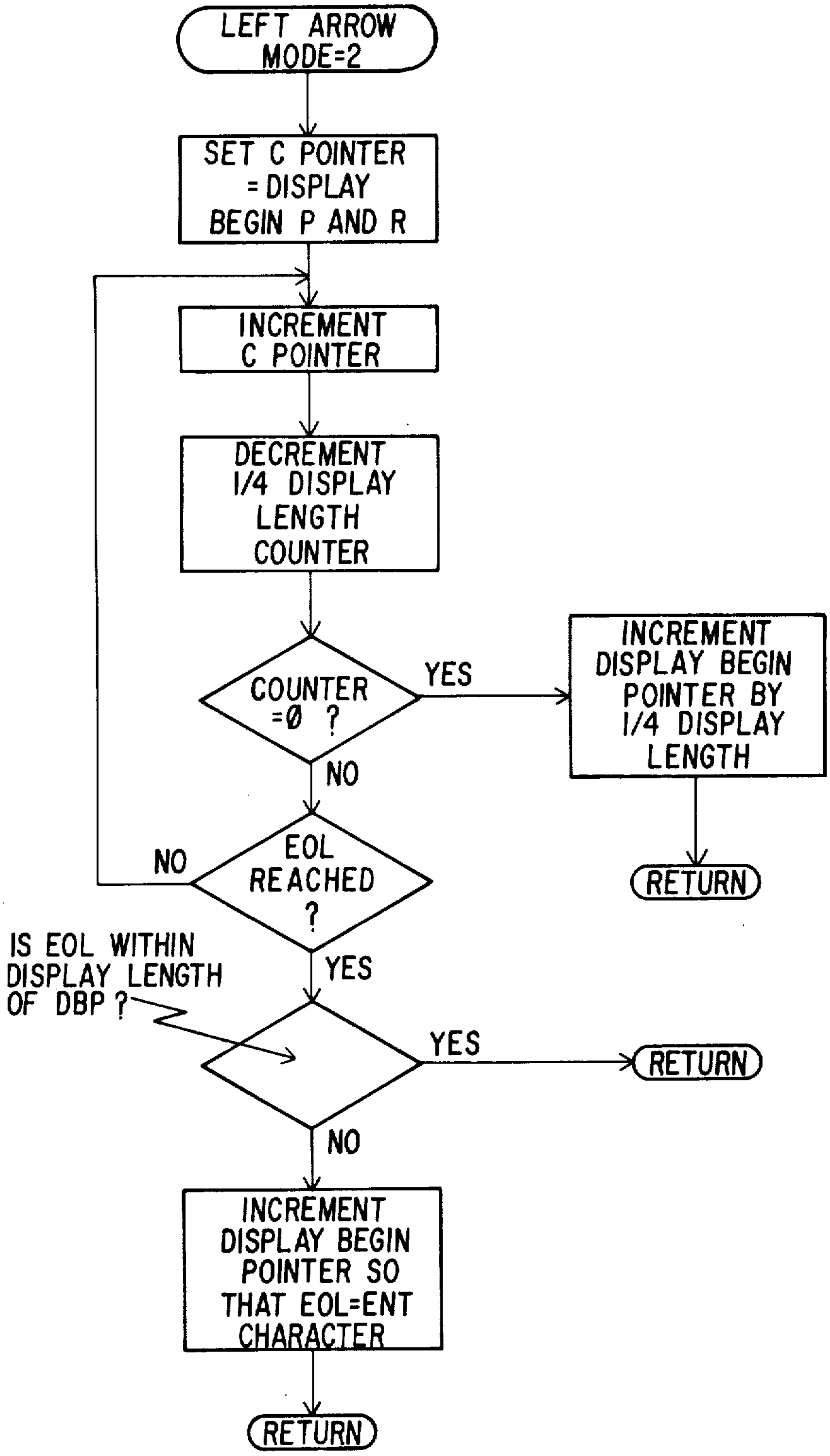

LEFT ARROW MODE=2
SET C POINTER =DISPLAY BEGIN P AND R
INCREMENT C POINTER
DECREMENT 1/4 DISPLAY LENGTH COUNTER
COUNTER =Ø ?
YES
INCREMENT DISPLAY BEGIN POINTER BY 1/4 DISPLAY LENGTH
RETURN
NO
EOL REACHED ?
NO
YES
IS EOL WITHIN DISPLAY LENGTH OF DBP ?
YES
RETURN
NO
INCREMENT DISPLAY BEGIN POINTER SO THAT EOL=ENT CHARACTER
RETURN

FIG 159H

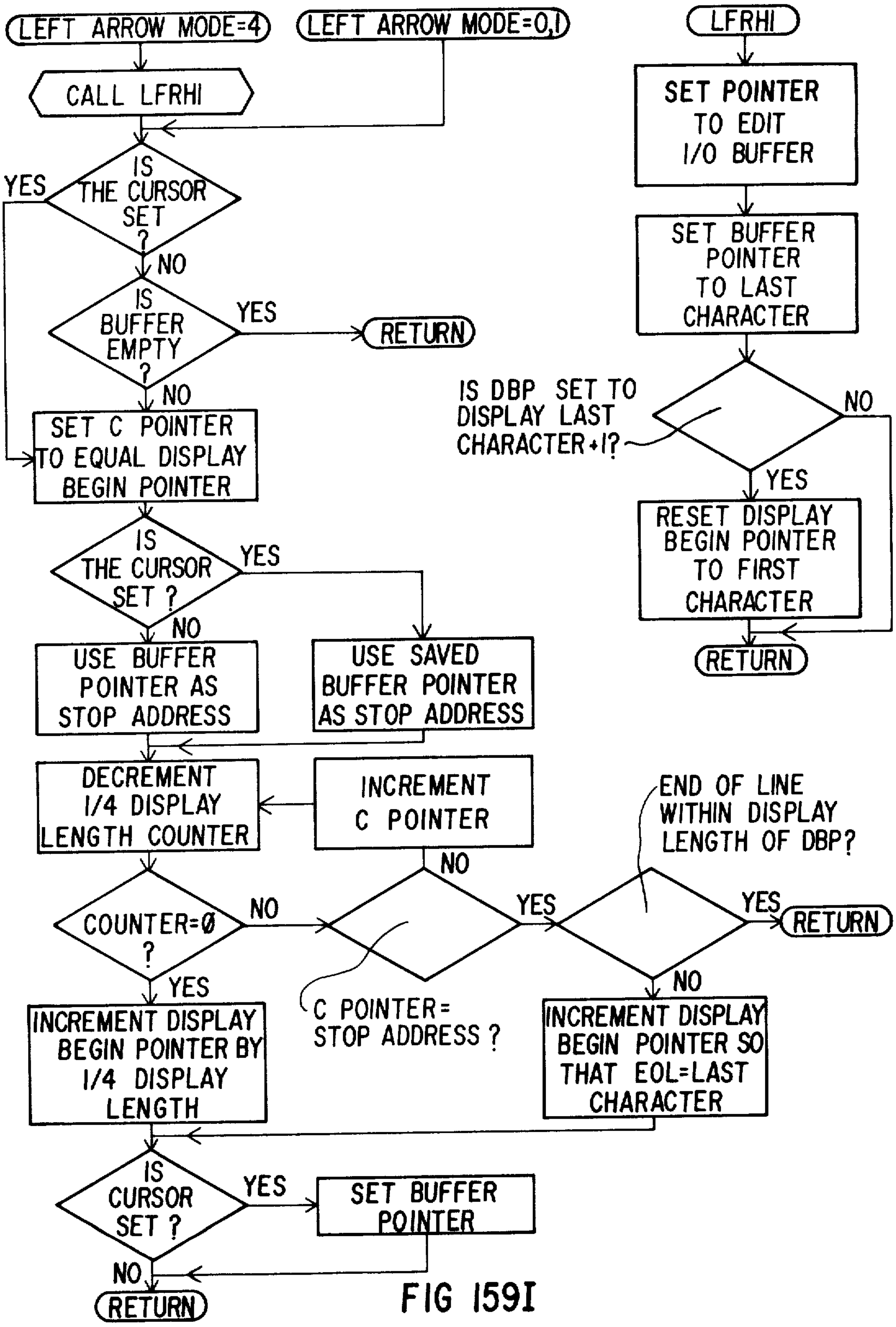

LEFT ARROW MODE=4
LEFT ARROW MODE=0,1
LFRHI
CALL LFRHI
SET POINTER TO EDIT I/O BUFFER
IS THE CURSOR SET ?
YES
NO
IS BUFFER EMPTY ?
YES
RETURN
NO
SET BUFFER POINTER TO LAST CHARACTER
IS DBP SET TO DISPLAY LAST CHARACTER+1?
NO
YES
SET C POINTER TO EQUAL DISPLAY BEGIN POINTER
RESET DISPLAY BEGIN POINTER TO FIRST CHARACTER
IS THE CURSOR SET ?
YES
NO
RETURN
USE BUFFER POINTER AS STOP ADDRESS
USE SAVED BUFFER POINTER AS STOP ADDRESS
DECREMENT 1/4 DISPLAY LENGTH COUNTER
INCREMENT C POINTER
END OF LINE WITHIN DISPLAY LENGTH OF DBP?
NO
COUNTER=Ø ?
NO
YES
YES
RETURN
YES
NO
INCREMENT DISPLAY BEGIN POINTER BY 1/4 DISPLAY LENGTH
C POINTER= STOP ADDRESS ?
INCREMENT DISPLAY BEGIN POINTER SO THAT EOL=LAST CHARACTER
IS CURSOR SET ?
YES
SET BUFFER POINTER
NO
RETURN

FIG 159I

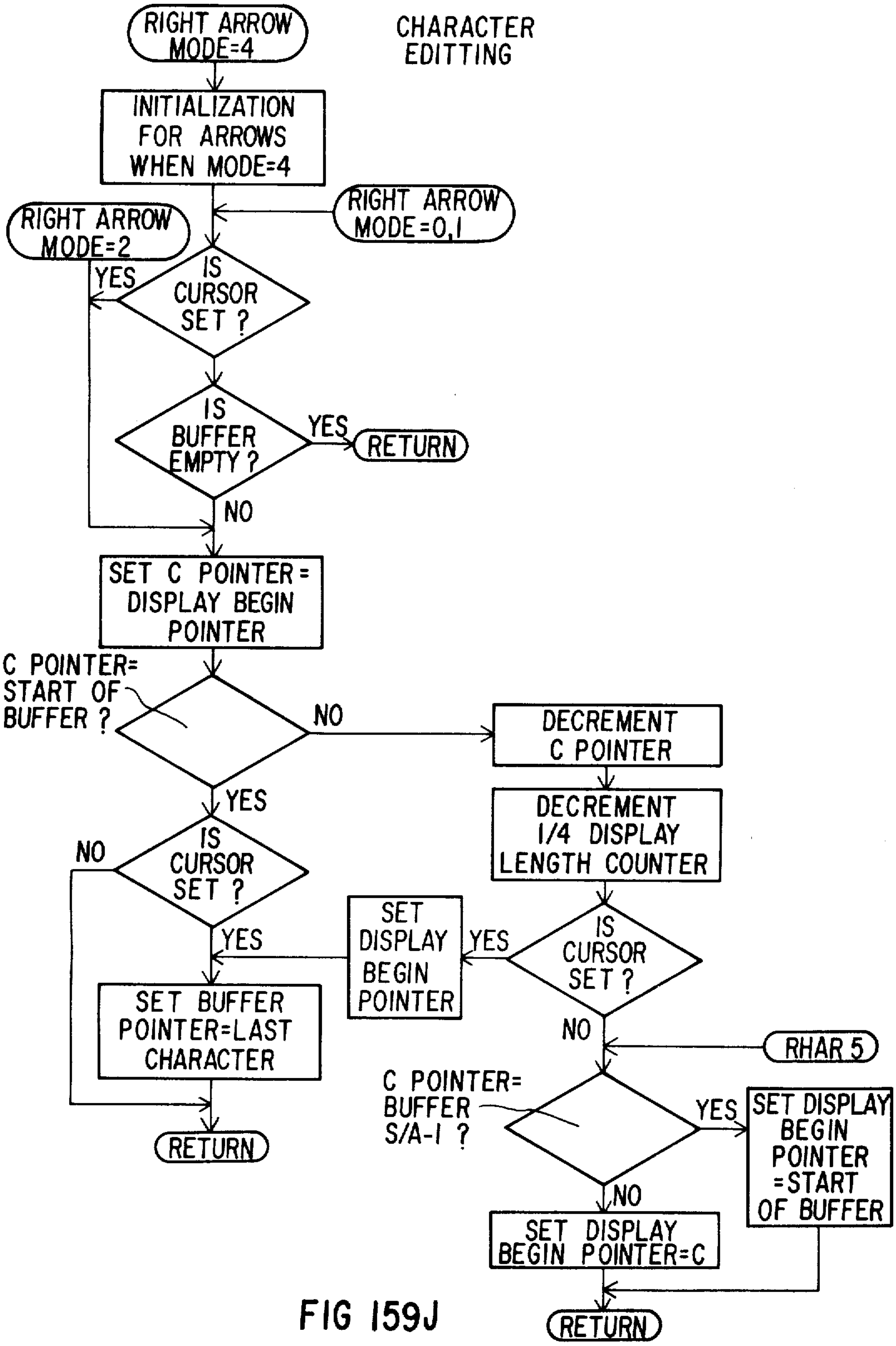

RIGHT ARROW MODE=4
CHARACTER EDITTING
INITIALIZATION FOR ARROWS WHEN MODE=4
RIGHT ARROW MODE=0,1
RIGHT ARROW MODE=2
YES
IS CURSOR SET ?
IS BUFFER EMPTY ?
YES
RETURN
NO
SET C POINTER = DISPLAY BEGIN POINTER
C POINTER= START OF BUFFER ?
NO
DECREMENT C POINTER
YES
DECREMENT 1/4 DISPLAY LENGTH COUNTER
NO
IS CURSOR SET ?
YES
SET DISPLAY BEGIN POINTER
YES
IS CURSOR SET ?
SET BUFFER POINTER=LAST CHARACTER
NO
RHAR 5
C POINTER= BUFFER S/A-1 ?
YES
SET DISPLAY BEGIN POINTER =START OF BUFFER
RETURN
NO
SET DISPLAY BEGIN POINTER=C
RETURN

FIG 159J

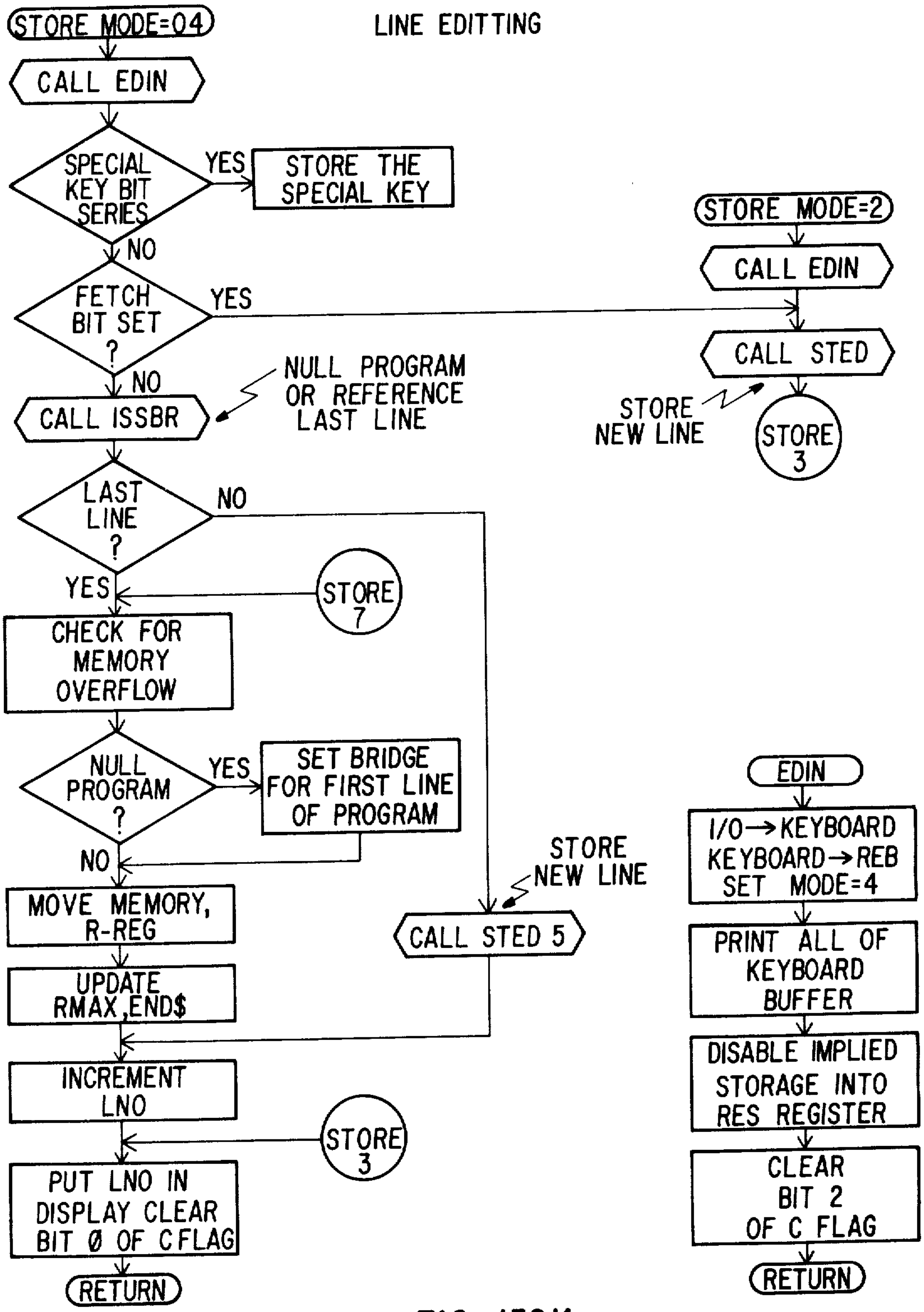

STORE MODE=04
LINE EDITTING
CALL EDIN
SPECIAL KEY BIT SERIES
YES
STORE THE SPECIAL KEY
NO
FETCH BIT SET ?
YES
NO
NULL PROGRAM OR REFERENCE LAST LINE
CALL ISSBR
LAST LINE ?
NO
YES
STORE 7
CHECK FOR MEMORY OVERFLOW
NULL PROGRAM ?
YES
SET BRIDGE FOR FIRST LINE OF PROGRAM
NO
MOVE MEMORY, R-REG
UPDATE RMAX,END$
STORE NEW LINE
CALL STED 5
INCREMENT LNO
STORE 3
PUT LNO IN DISPLAY CLEAR BIT Ø OF CFLAG
RETURN
STORE MODE=2
CALL EDIN
CALL STED
STORE NEW LINE
STORE 3
EDIN
I/O→KEYBOARD KEYBOARD→REB SET MODE=4
PRINT ALL OF KEYBOARD BUFFER
DISABLE IMPLIED STORAGE INTO RES REGISTER
CLEAR BIT 2 OF C FLAG
RETURN

FIG 159K

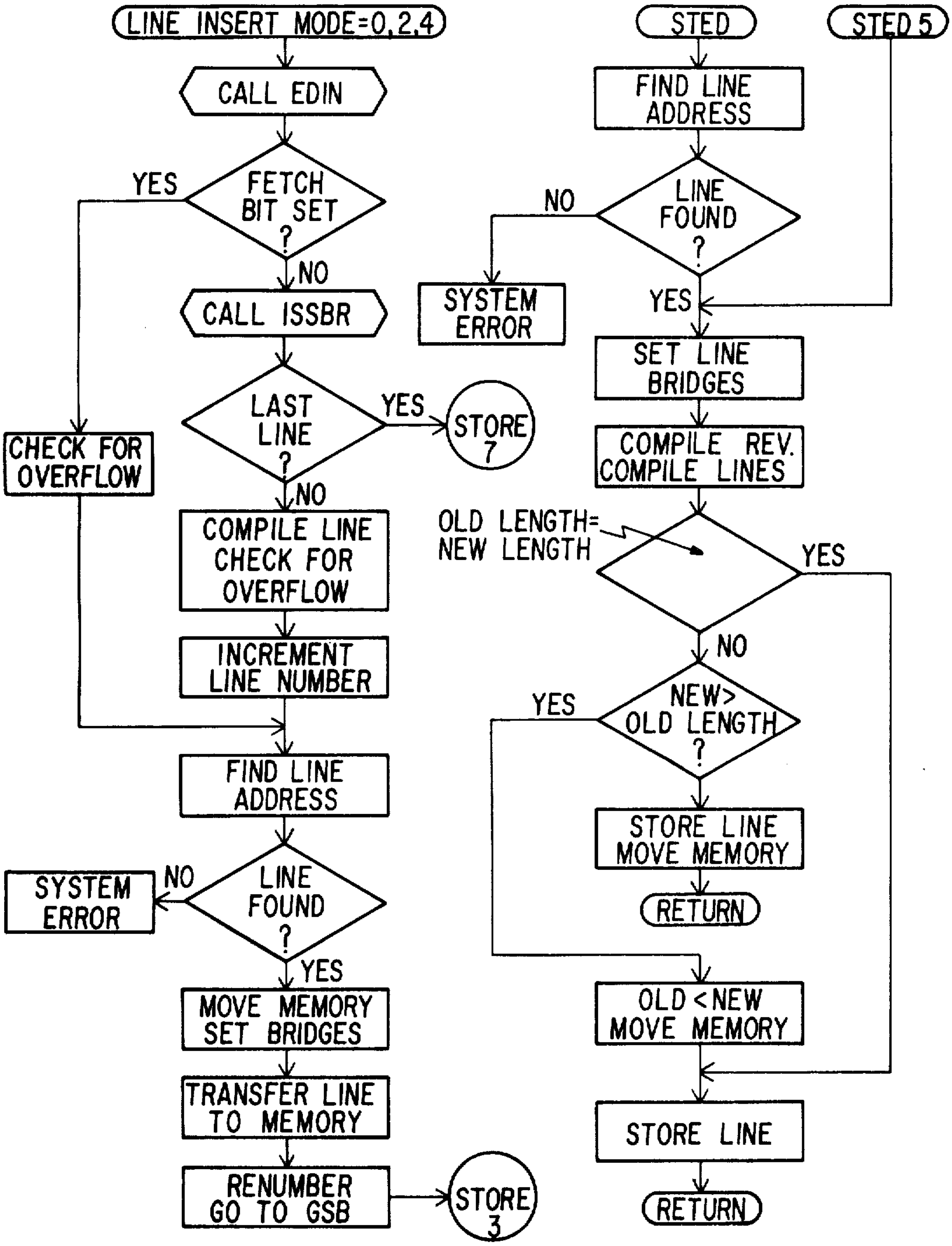

LINE INSERT MODE=0,2,4
CALL EDIN
FETCH BIT SET ?
YES
NO
CALL ISSBR
LAST LINE ?
YES
STORE 7
NO
CHECK FOR OVERFLOW
COMPILE LINE CHECK FOR OVERFLOW
INCREMENT LINE NUMBER
FIND LINE ADDRESS
LINE FOUND ?
NO
SYSTEM ERROR
YES
MOVE MEMORY SET BRIDGES
TRANSFER LINE TO MEMORY
RENUMBER GO TO GSB
STORE 3
STED
STED 5
FIND LINE ADDRESS
LINE FOUND ?
NO
SYSTEM ERROR
YES
SET LINE BRIDGES
COMPILE REV. COMPILE LINES
OLD LENGTH= NEW LENGTH
YES
NO
NEW> OLD LENGTH ?
YES
STORE LINE MOVE MEMORY
RETURN
OLD<NEW MOVE MEMORY
STORE LINE
RETURN

FIG 159L

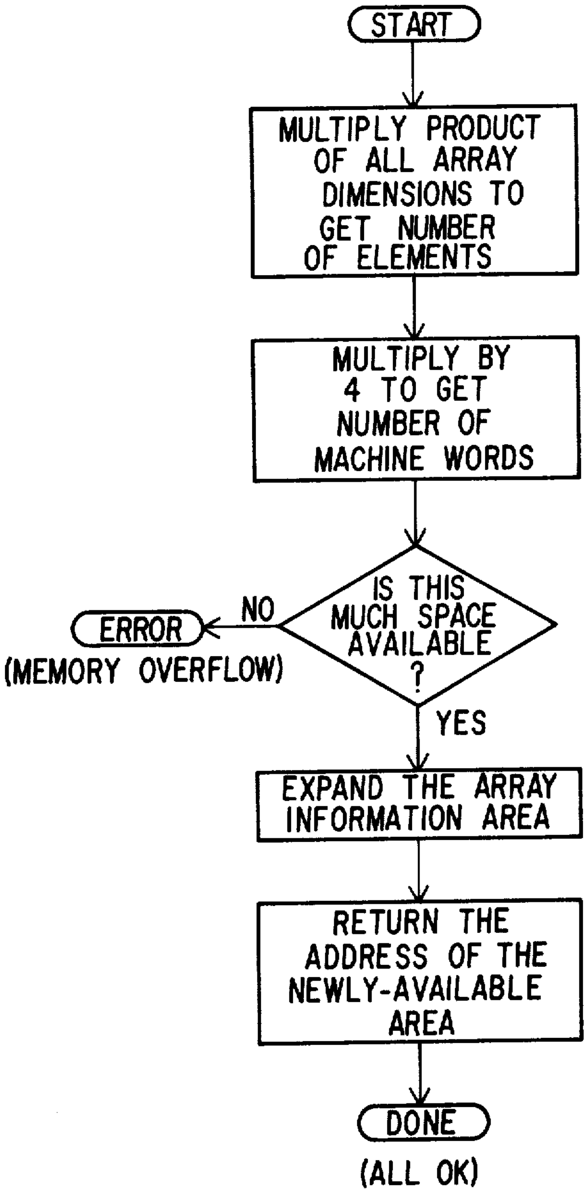

START
MULTIPLY PRODUCT OF ALL ARRAY DIMENSIONS TO GET NUMBER OF ELEMENTS
MULTIPLY BY 4 TO GET NUMBER OF MACHINE WORDS
IS THIS MUCH SPACE AVAILABLE ?
NO
ERROR
(MEMORY OVERFLOW)
YES
EXPAND THE ARRAY INFORMATION AREA
RETURN THE ADDRESS OF THE NEWLY-AVAILABLE AREA
DONE
(ALL OK)

FIG 160A

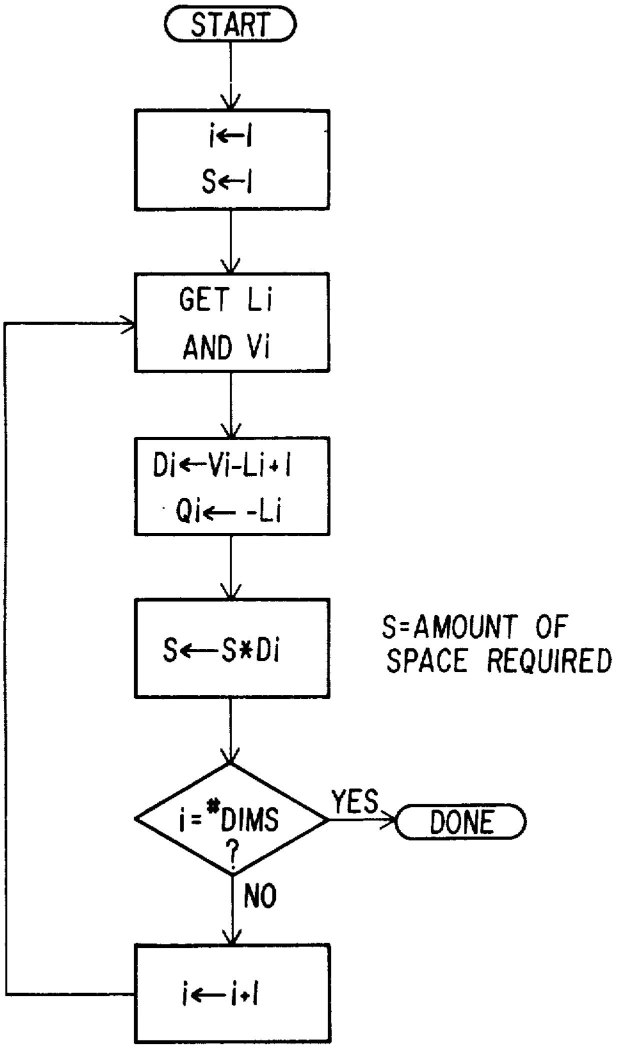

START
i←I
S←I
GET Li
AND Vi
Di←Vi-Li+I
Qi← -Li
S←S*Di
S=AMOUNT OF
SPACE REQUIRED
i=*DIMS
?
YES
DONE
NO
i←i+I

FIG 160B

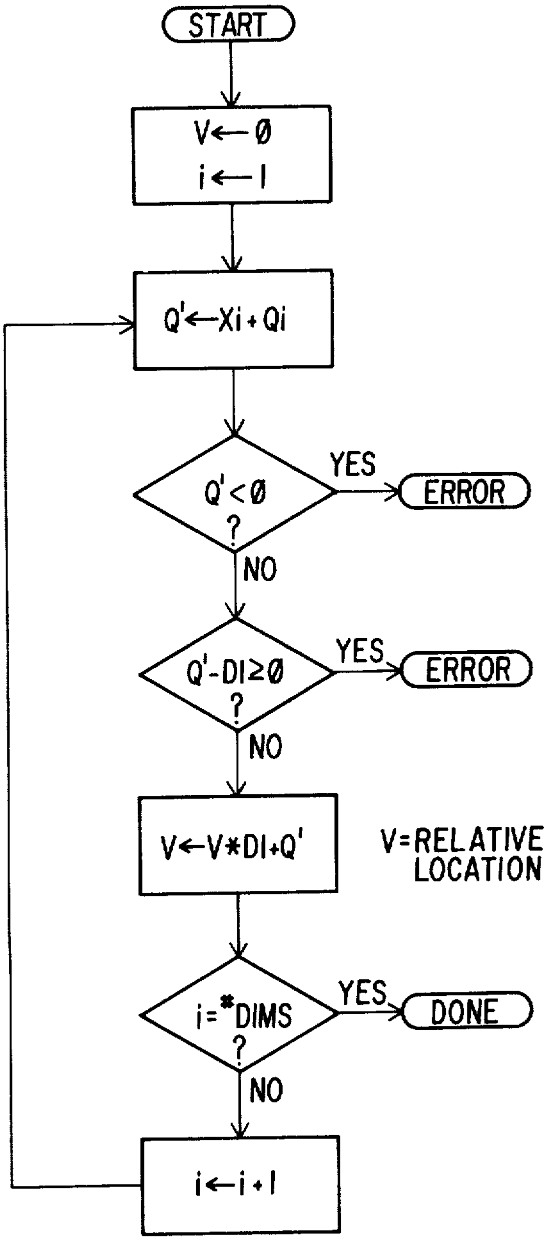

START
V←Ø
i←1
Q'←Xi+Qi
Q'<Ø ?
YES
ERROR
NO
Q'-DI≥Ø ?
YES
ERROR
NO
V←V*DI+Q'
V=RELATIVE LOCATION
i=*DIMS ?
YES
DONE
NO
i←i+1

FIG 160C

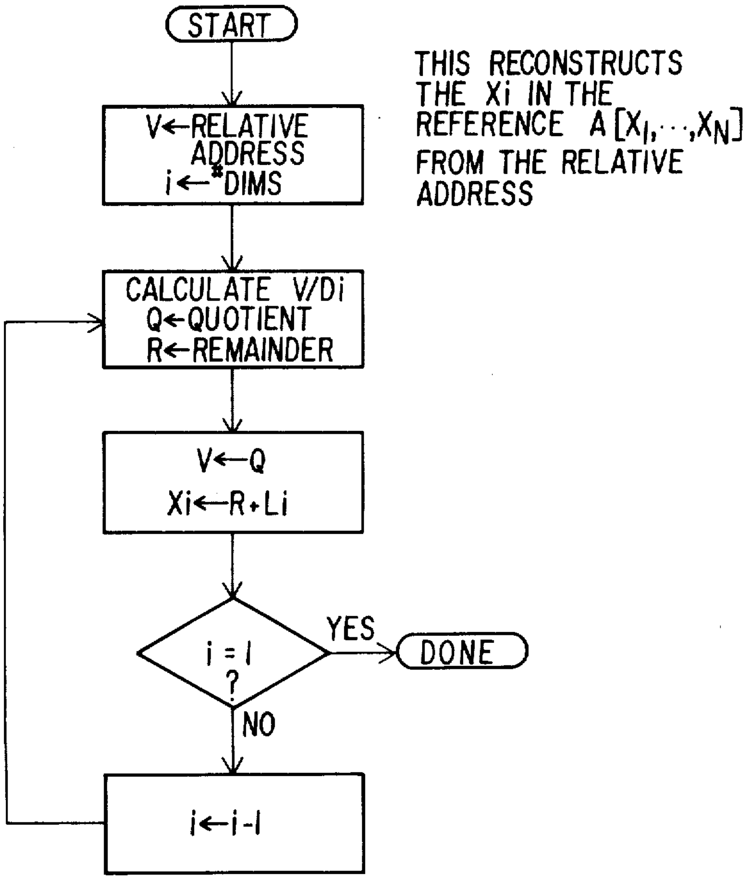

START
V←RELATIVE ADDRESS
i←*DIMS
THIS RECONSTRUCTS THE Xi IN THE REFERENCE A[X1,···,XN] FROM THE RELATIVE ADDRESS
CALCULATE V/Di
Q←QUOTIENT
R←REMAINDER
V←Q
Xi←R+Li
i = 1 ?
YES
DONE
NO
i←i-1

FIG 160D

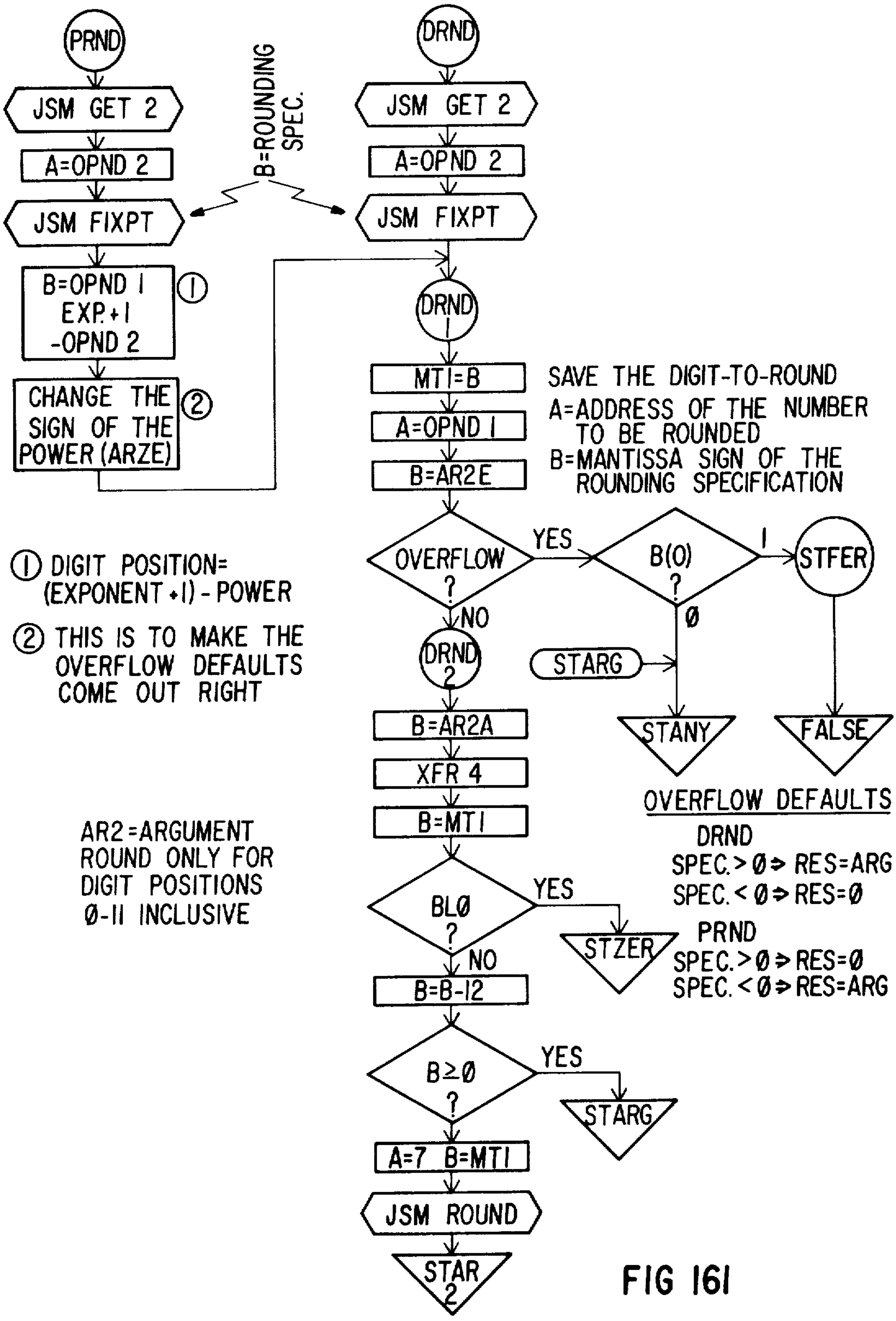

PRND
JSM GET 2
A=OPND 2
JSM FIXPT
B=OPND 1 EXP.+1 -OPND 2
①
CHANGE THE SIGN OF THE POWER (ARZE)
②
B=ROUNDING SPEC.
DRND
JSM GET 2
A=OPND 2
JSM FIXPT
DRND 1
MT1=B
SAVE THE DIGIT-TO-ROUND
A=OPND 1
A=ADDRESS OF THE NUMBER TO BE ROUNDED
B=AR2E
B=MANTISSA SIGN OF THE ROUNDING SPECIFICATION
OVERFLOW ?
YES
NO
B(0) ?
1
Ø
STFER
STARG
STANY
FALSE
DRND 2
B=AR2A
XFR 4
B=MT1
BLØ ?
YES
NO
STZER
B=B-12
B≥Ø ?
YES
STARG
A=7 B=MT1
JSM ROUND
STAR 2
① DIGIT POSITION= (EXPONENT+1)-POWER
② THIS IS TO MAKE THE OVERFLOW DEFAULTS COME OUT RIGHT
AR2=ARGUMENT
ROUND ONLY FOR DIGIT POSITIONS Ø-11 INCLUSIVE
OVERFLOW DEFAULTS
DRND
SPEC.>Ø⇒RES=ARG
SPEC.<Ø⇒RES=Ø
PRND
SPEC.>Ø⇒RES=Ø
SPEC.<Ø⇒RES=ARG

FIG 161

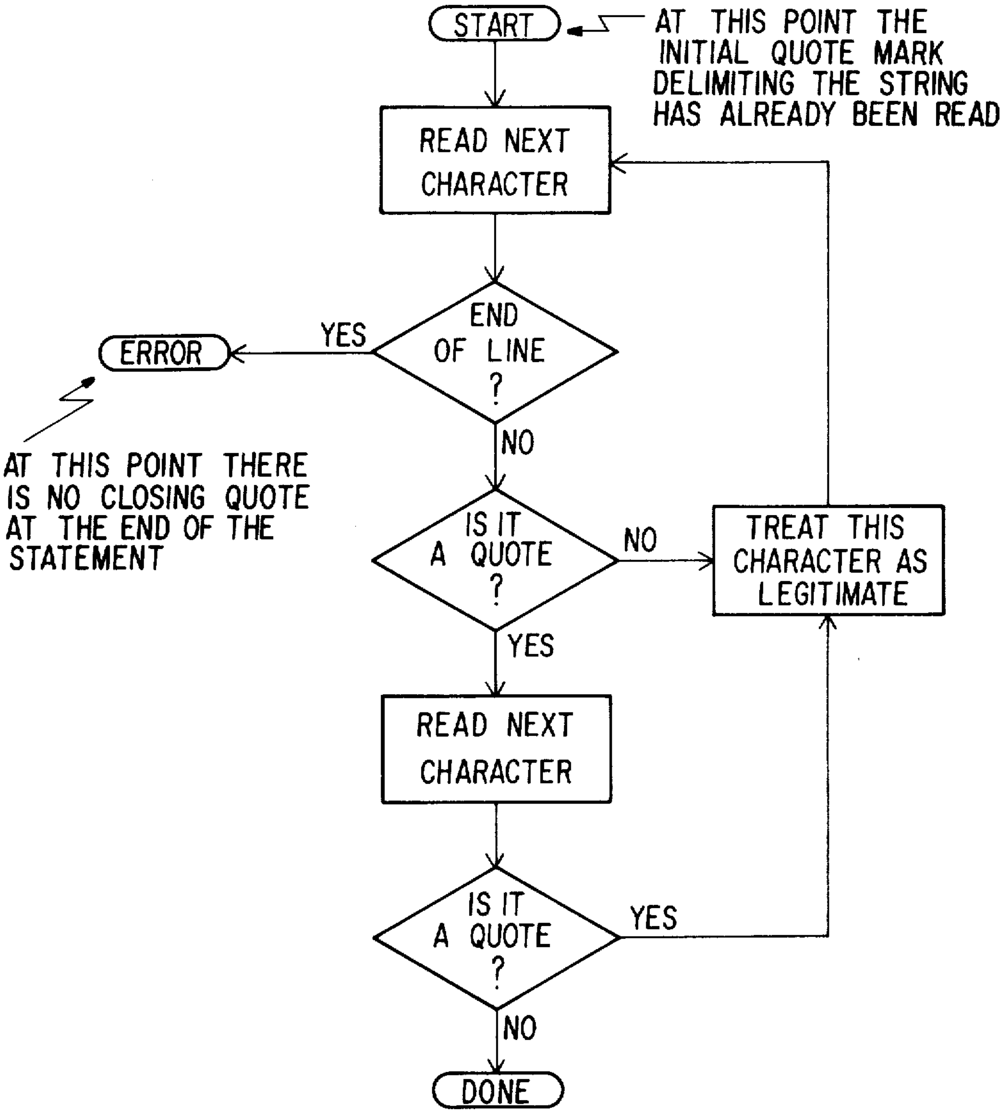

START
AT THIS POINT THE INITIAL QUOTE MARK DELIMITING THE STRING HAS ALREADY BEEN READ
READ NEXT CHARACTER
END OF LINE ?
YES
ERROR
AT THIS POINT THERE IS NO CLOSING QUOTE AT THE END OF THE STATEMENT
NO
IS IT A QUOTE ?
NO
TREAT THIS CHARACTER AS LEGITIMATE
YES
READ NEXT CHARACTER
IS IT A QUOTE ?
YES
NO
DONE

FIG 162

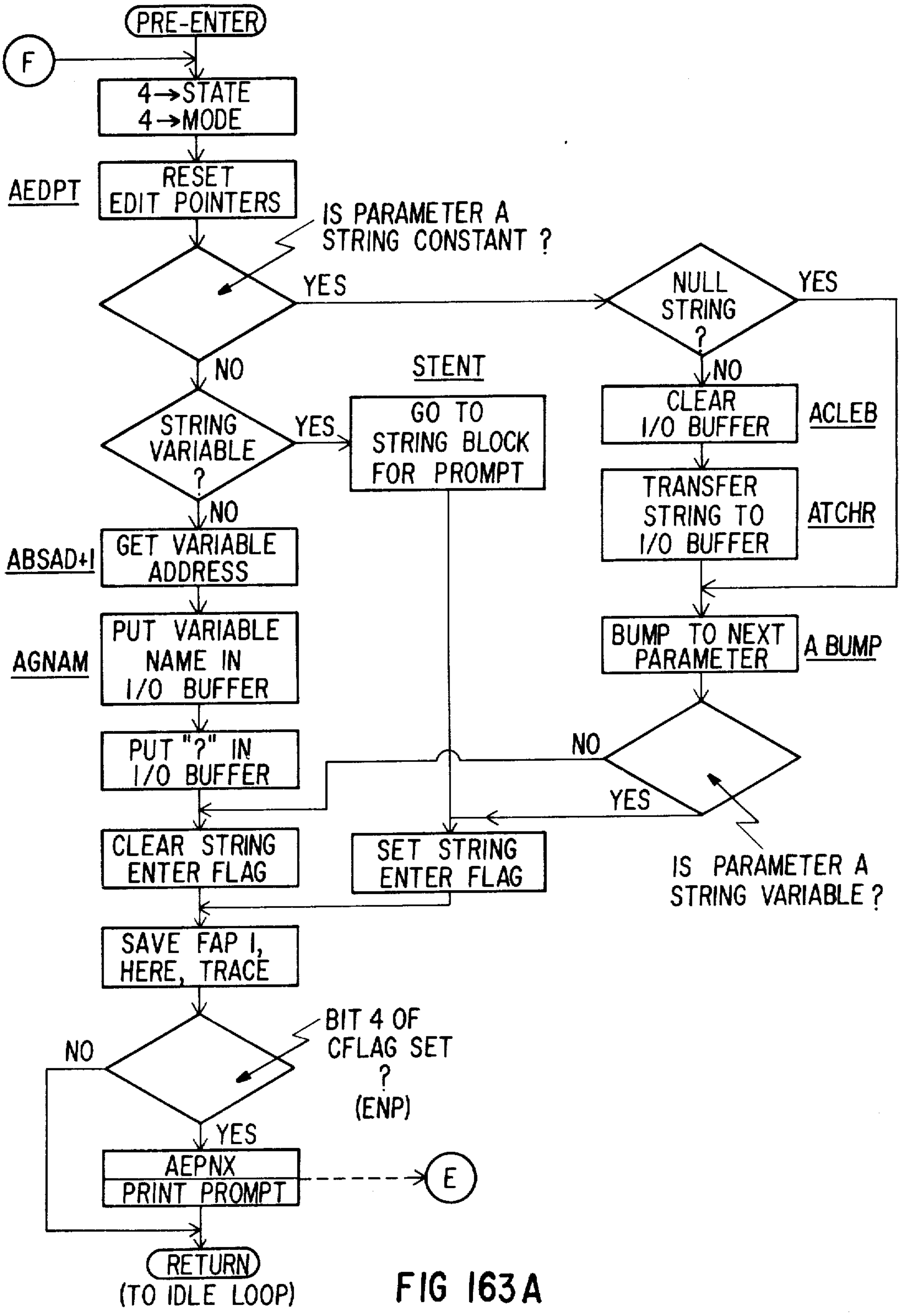

PRE-ENTER
F
4→STATE
4→MODE
AEDPT
RESET
EDIT POINTERS
IS PARAMETER A
STRING CONSTANT ?
YES
NO
NULL
STRING
?
YES
NO
STENT
STRING
VARIABLE
?
YES
GO TO
STRING BLOCK
FOR PROMPT
CLEAR
I/O BUFFER
ACLEB
TRANSFER
STRING TO
I/O BUFFER
ATCHR
NO
ABSAD+I
GET VARIABLE
ADDRESS
AGNAM
PUT VARIABLE
NAME IN
I/O BUFFER
BUMP TO NEXT
PARAMETER
A BUMP
PUT "?" IN
I/O BUFFER
NO
YES
CLEAR STRING
ENTER FLAG
SET STRING
ENTER FLAG
IS PARAMETER A
STRING VARIABLE ?
SAVE FAP I,
HERE, TRACE
NO
BIT 4 OF
CFLAG SET
?
(ENP)
YES
AEPNX
PRINT PROMPT
E
RETURN
(TO IDLE LOOP)

FIG 163A

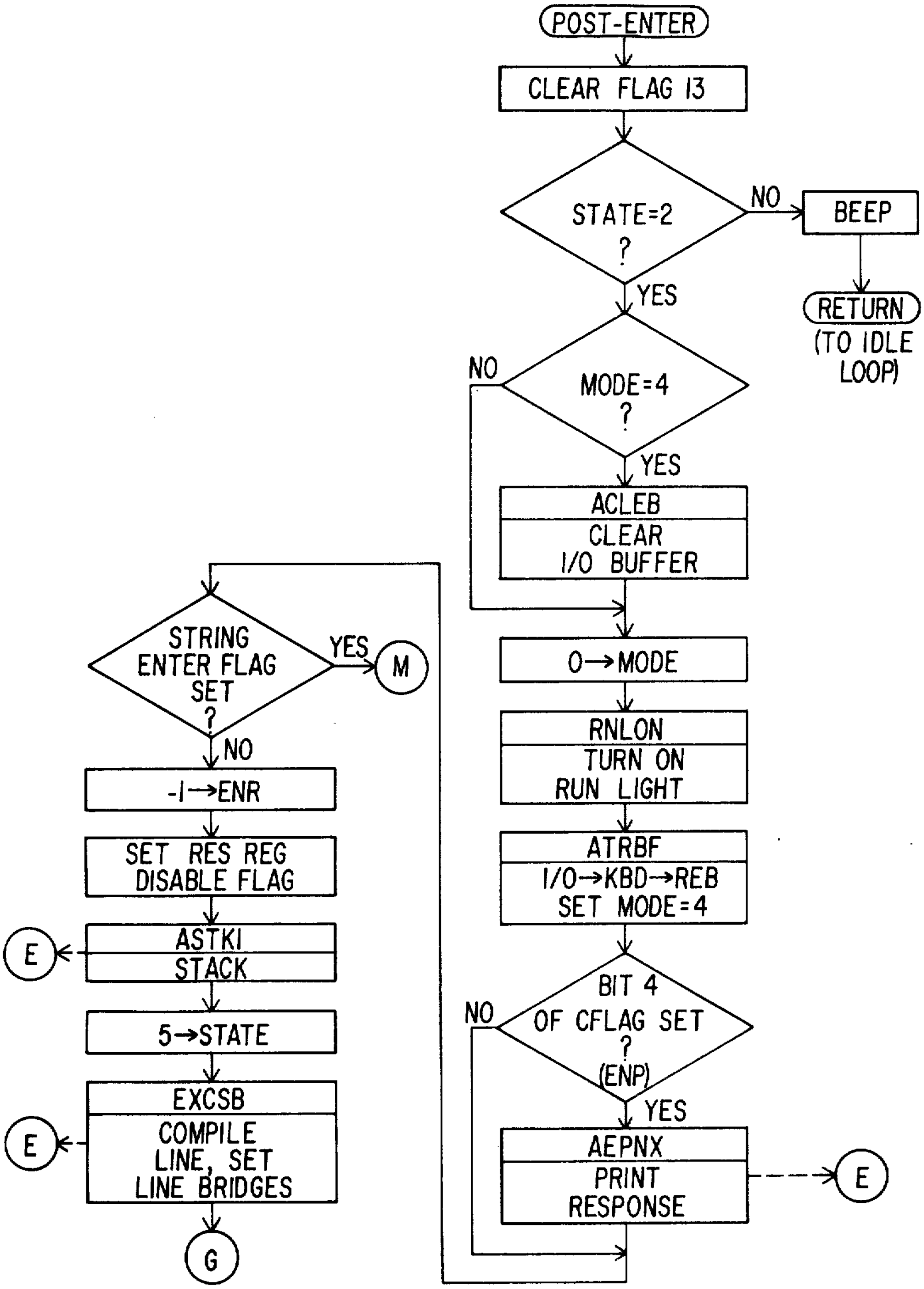

POST-ENTER
CLEAR FLAG 13
STATE=2 ?
NO
BEEP
RETURN (TO IDLE LOOP)
YES
MODE=4 ?
NO
YES
ACLEB
CLEAR I/O BUFFER
0→MODE
RNLON
TURN ON RUN LIGHT
ATRBF
I/O→KBD→REB SET MODE=4
BIT 4 OF CFLAG SET ? (ENP)
NO
YES
AEPNX
PRINT RESPONSE
E
STRING ENTER FLAG SET ?
YES
M
NO
-1→ENR
SET RES REG DISABLE FLAG
ASTKI
STACK
E
5→STATE
EXCSB
COMPILE LINE, SET LINE BRIDGES
E
G

FIG 163B

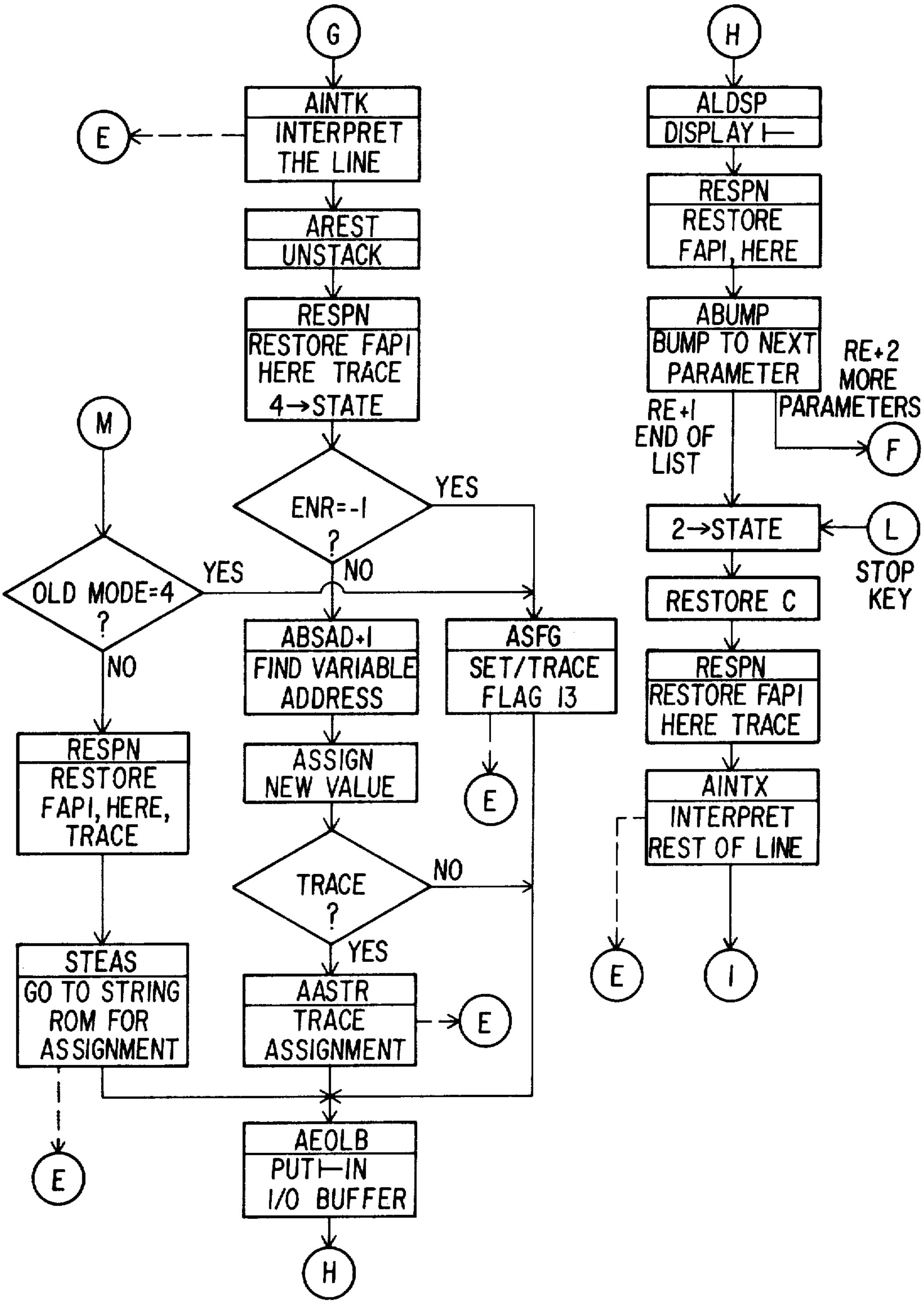

G
AINTK
INTERPRET THE LINE
E
AREST
UNSTACK
RESPN
RESTORE FAPI HERE TRACE 4→STATE
ENR=-1 ?
YES
NO
M
OLD MODE=4 ?
YES
NO
ABSAD+1
FIND VARIABLE ADDRESS
ASFG
SET/TRACE FLAG 13
E
RESPN
RESTORE FAPI, HERE, TRACE
ASSIGN NEW VALUE
TRACE ?
NO
YES
STEAS
GO TO STRING ROM FOR ASSIGNMENT
AASTR
TRACE ASSIGNMENT
E
E
AEOLB
PUT⊢IN I/O BUFFER
H
H
ALDSP
DISPLAY ⊢
RESPN
RESTORE FAPI, HERE
ABUMP
BUMP TO NEXT PARAMETER
RE+2 MORE PARAMETERS
F
RE+1 END OF LIST
2→STATE
L
STOP KEY
RESTORE C
RESPN
RESTORE FAPI HERE TRACE
AINTX
INTERPRET REST OF LINE
E
I

FIG 163C

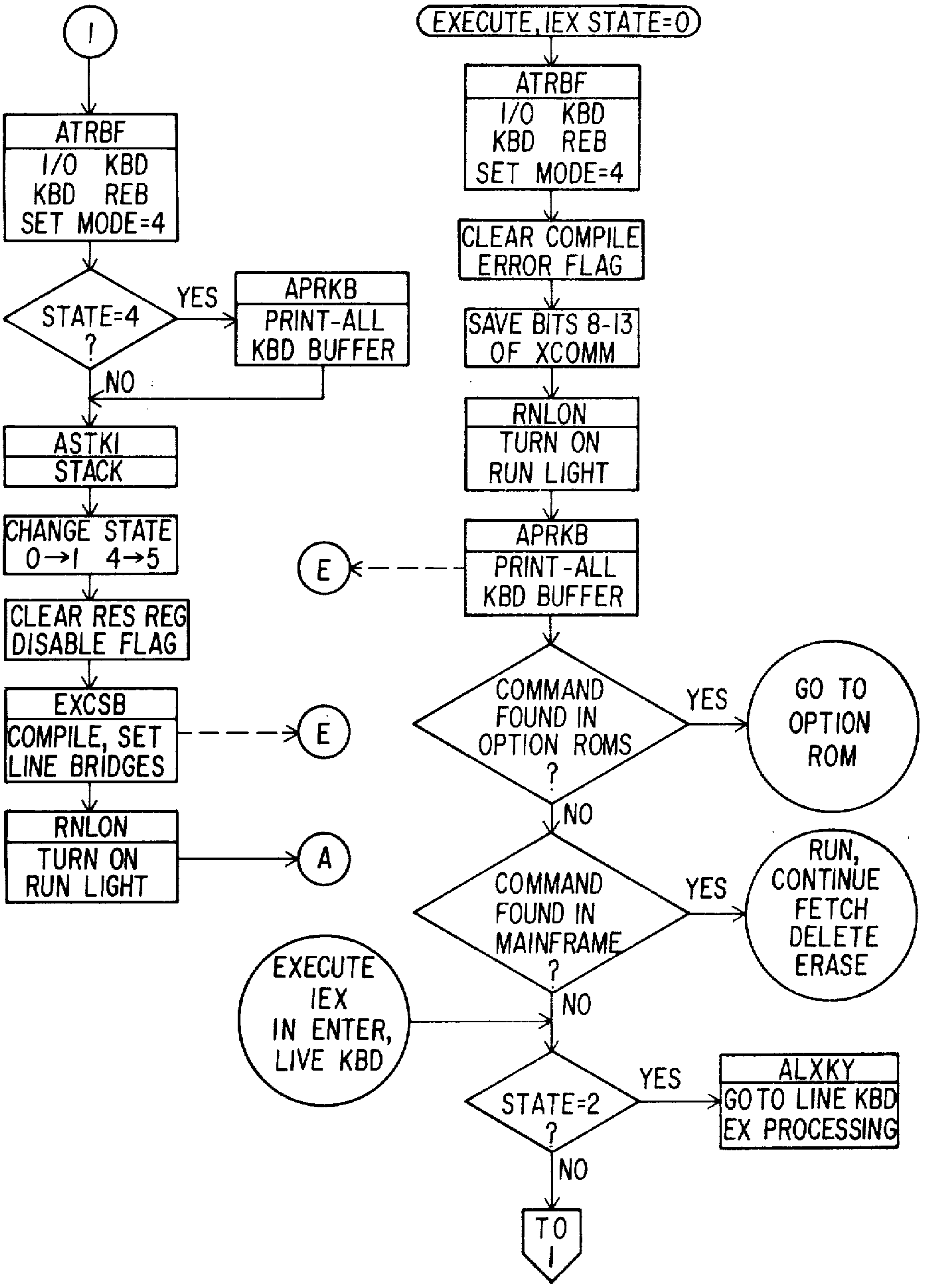

I
ATRBF
I/O KBD
KBD REB
SET MODE=4
STATE=4 ?
YES
APRKB
PRINT-ALL KBD BUFFER
NO
ASTKI
STACK
CHANGE STATE 0→1 4→5
CLEAR RES REG DISABLE FLAG
EXCSB
COMPILE, SET LINE BRIDGES
E
RNLON
TURN ON RUN LIGHT
A
EXECUTE, IEX STATE=0
ATRBF
I/O KBD
KBD REB
SET MODE=4
CLEAR COMPILE ERROR FLAG
SAVE BITS 8-13 OF XCOMM
RNLON
TURN ON RUN LIGHT
APRKB
PRINT-ALL KBD BUFFER
E
COMMAND FOUND IN OPTION ROMS ?
YES
GO TO OPTION ROM
NO
COMMAND FOUND IN MAINFRAME ?
YES
RUN, CONTINUE FETCH DELETE ERASE
NO
EXECUTE IEX IN ENTER, LIVE KBD
STATE=2 ?
YES
ALXKY
GO TO LINE KBD EX PROCESSING
NO
TO I

FIG 163D

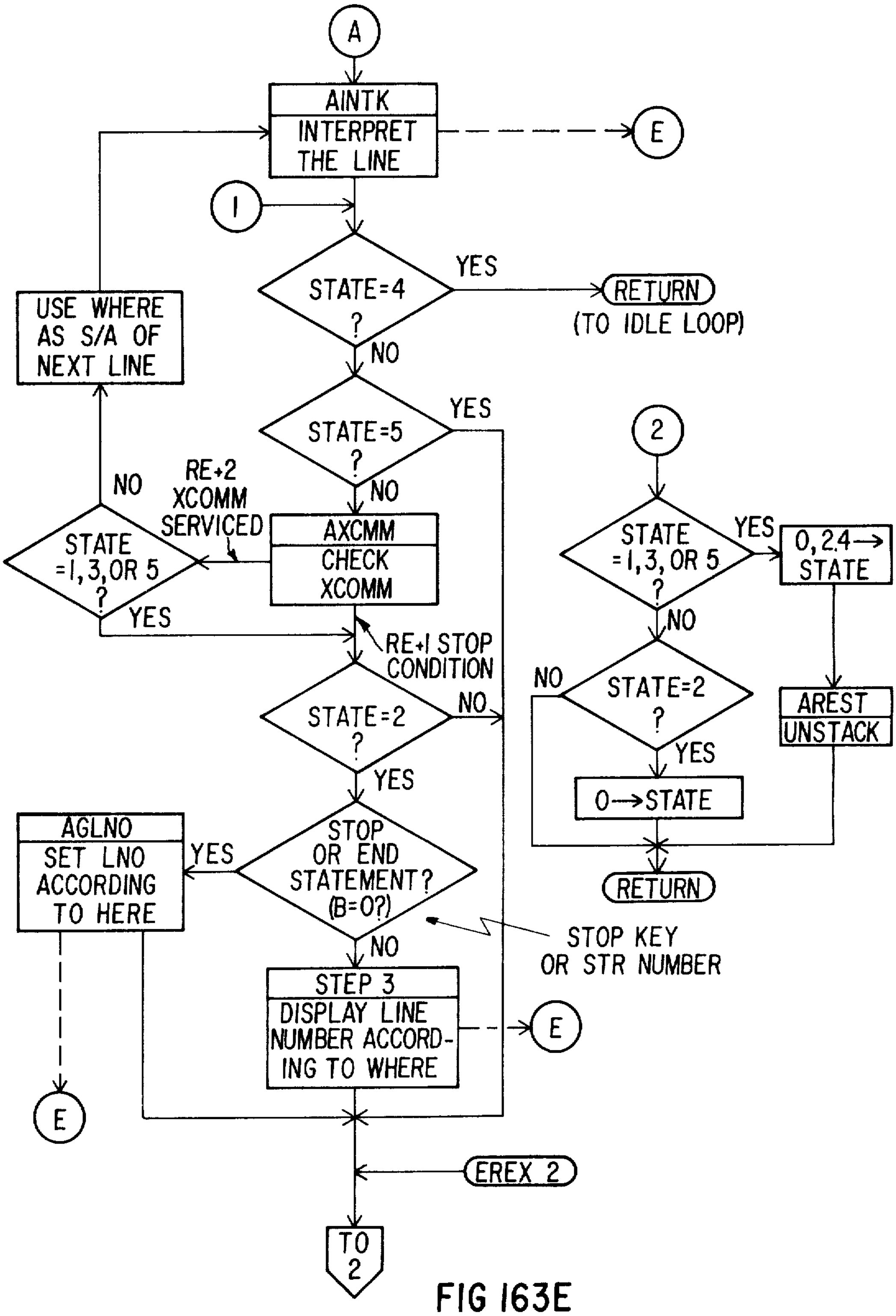

A
AINTK
INTERPRET THE LINE
E
1
STATE=4 ?
YES
RETURN
(TO IDLE LOOP)
NO
USE WHERE AS S/A OF NEXT LINE
STATE=5 ?
YES
NO
NO
RE+2 XCOMM SERVICED
STATE =1,3,OR 5 ?
AXCMM
CHECK XCOMM
YES
RE+1 STOP CONDITION
STATE=2 ?
NO
YES
AGLNO
SET LNO ACCORDING TO HERE
YES
STOP OR END STATEMENT? (B=0?)
NO
STOP KEY OR STR NUMBER
STEP 3
DISPLAY LINE NUMBER ACCORDING TO WHERE
E
E
EREX 2
TO 2
2
STATE =1,3,OR 5 ?
YES
0,2,4→ STATE
NO
NO
STATE=2 ?
YES
0→STATE
AREST
UNSTACK
RETURN

FIG 163E

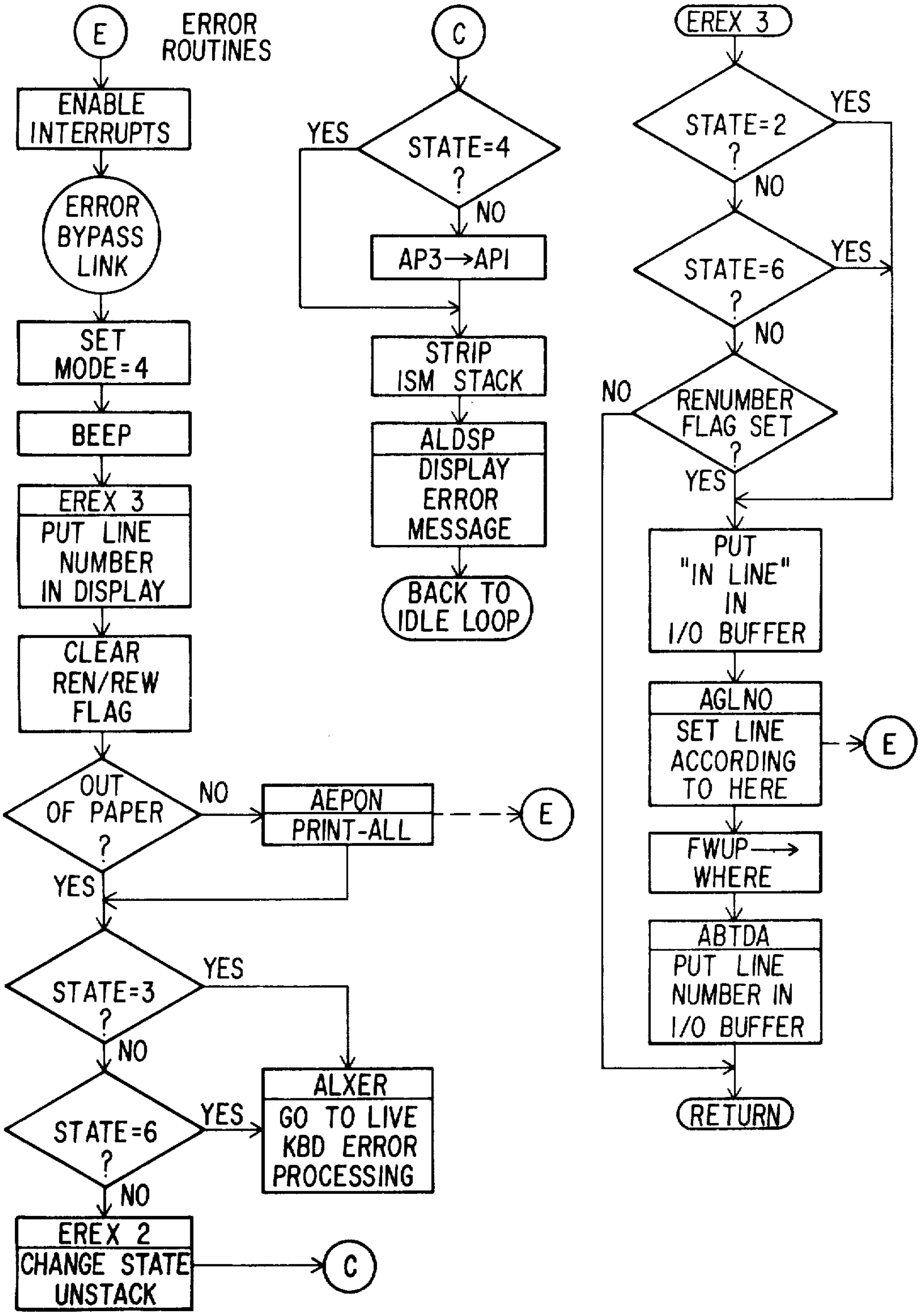
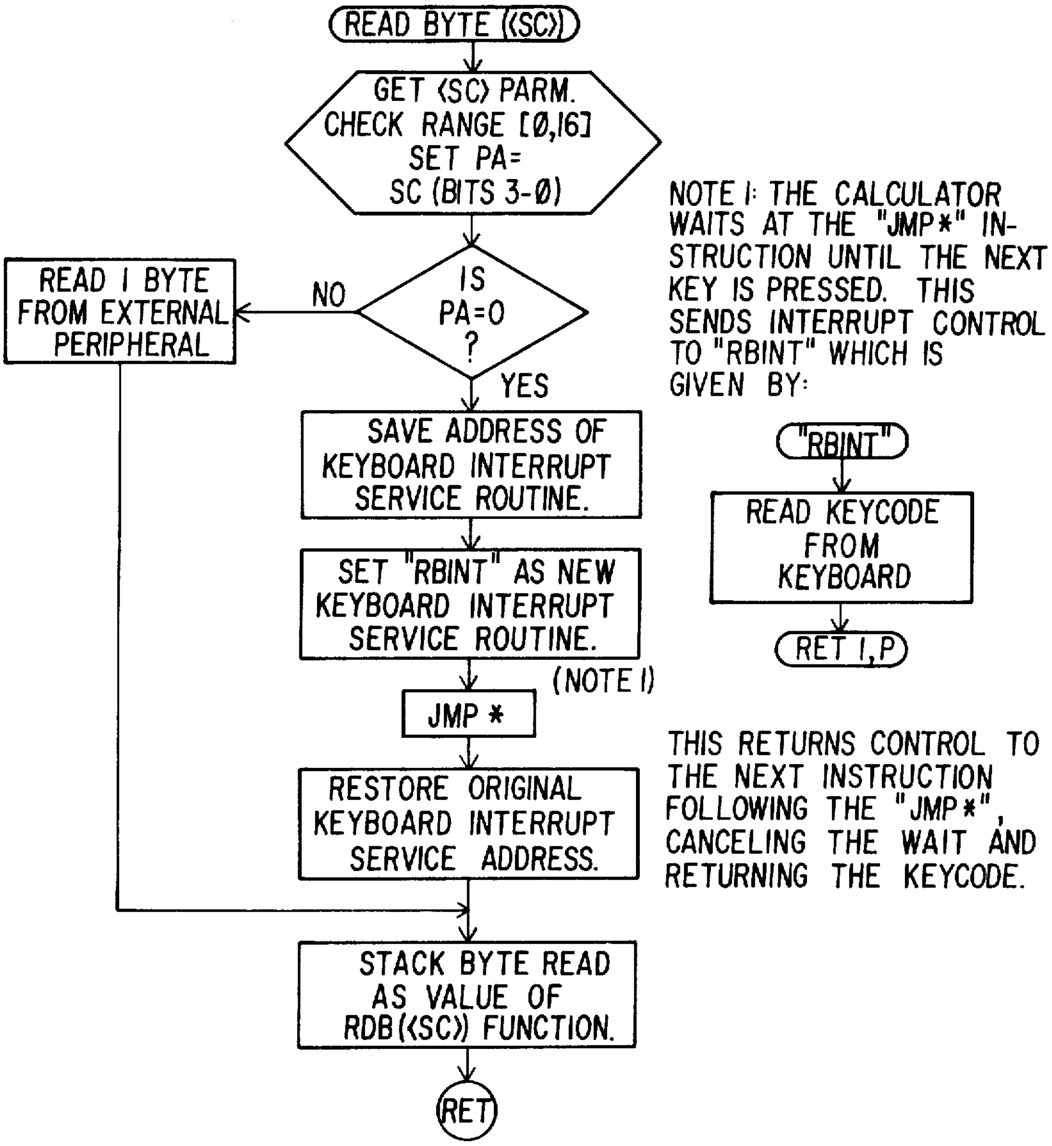

E
ERROR ROUTINES
ENABLE INTERRUPTS
ERROR BYPASS LINK
SET MODE=4
BEEP
EREX 3
PUT LINE NUMBER IN DISPLAY
CLEAR REN/REW FLAG
OUT OF PAPER ?
NO
YES
AEPON
PRINT-ALL
E
STATE=3 ?
YES
NO
STATE=6 ?
YES
NO
ALXER
GO TO LIVE KBD ERROR PROCESSING
EREX 2
CHANGE STATE UNSTACK
C
C
STATE=4 ?
YES
NO
AP3→API
STRIP ISM STACK
ALDSP
DISPLAY ERROR MESSAGE
BACK TO IDLE LOOP
EREX 3
STATE=2 ?
YES
NO
STATE=6 ?
YES
NO
RENUMBER FLAG SET ?
NO
YES
PUT "IN LINE" IN I/O BUFFER
AGLNO
SET LINE ACCORDING TO HERE
E
FWUP→ WHERE
ABTDA
PUT LINE NUMBER IN I/O BUFFER
RETURN

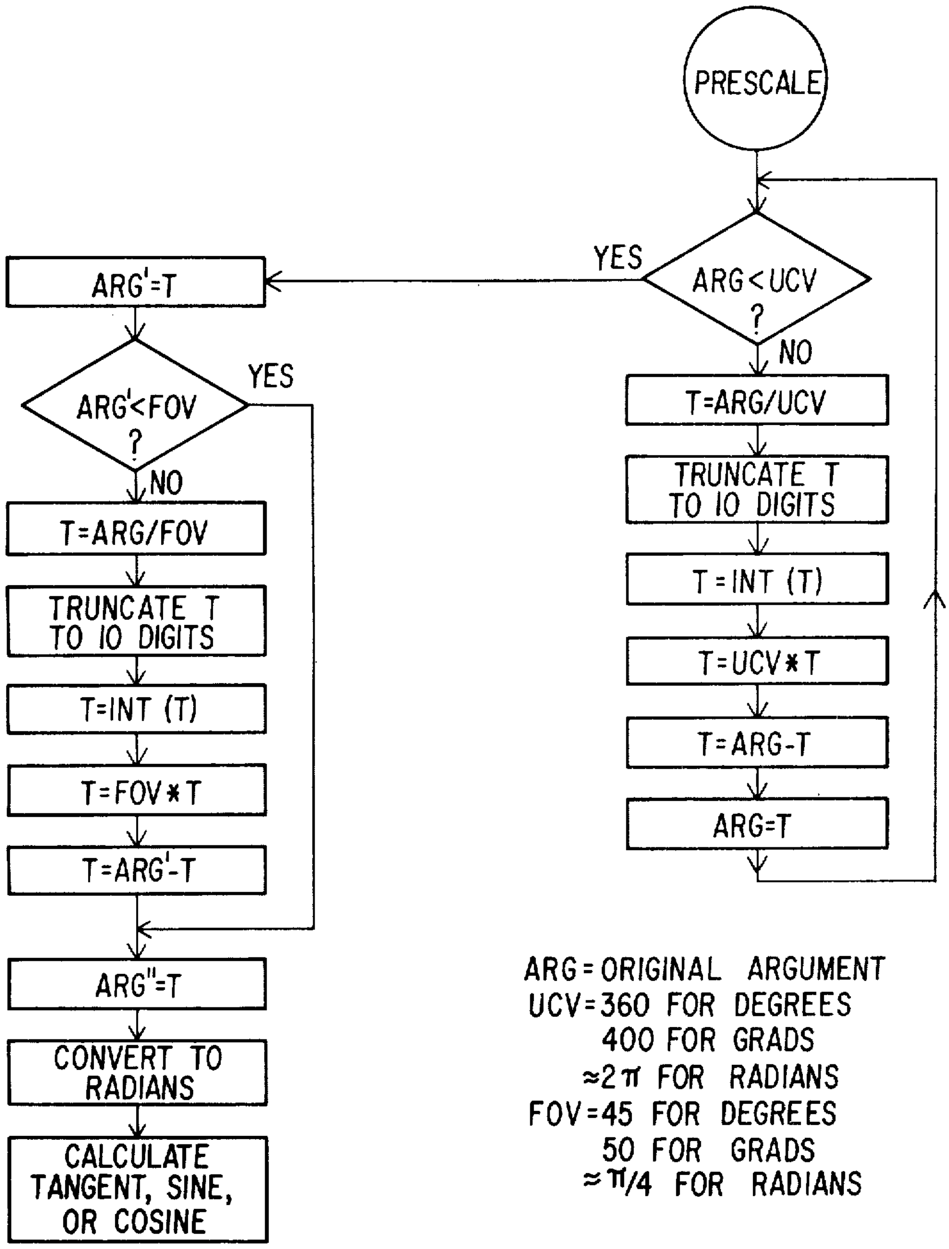
FIG 163F


READ BYTE ((SC))
GET (SC) PARM. CHECK RANGE [Ø,16] SET PA= SC (BITS 3-Ø)
IS PA=0 ?
NO
YES
READ 1 BYTE FROM EXTERNAL PERIPHERAL
SAVE ADDRESS OF KEYBOARD INTERRUPT SERVICE ROUTINE.
SET "RBINT" AS NEW KEYBOARD INTERRUPT SERVICE ROUTINE.
(NOTE 1)
JMP *
RESTORE ORIGINAL KEYBOARD INTERRUPT SERVICE ADDRESS.
STACK BYTE READ AS VALUE OF RDB((SC)) FUNCTION.
RET
"RBINT"
READ KEYCODE FROM KEYBOARD
RET 1,P

NOTE 1: THE CALCULATOR WAITS AT THE "JMP*" INSTRUCTION UNTIL THE NEXT KEY IS PRESSED. THIS SENDS INTERRUPT CONTROL TO "RBINT" WHICH IS GIVEN BY:

THIS RETURNS CONTROL TO THE NEXT INSTRUCTION FOLLOWING THE "JMP*", CANCELING THE WAIT AND RETURNING THE KEYCODE.

FIG 164



ARG=ORIGINAL ARGUMENT
UCV=360 FOR DEGREES
400 FOR GRADS
≈2π FOR RADIANS
FOV=45 FOR DEGREES
50 FOR GRADS
≈π/4 FOR RADIANS

FIG 165

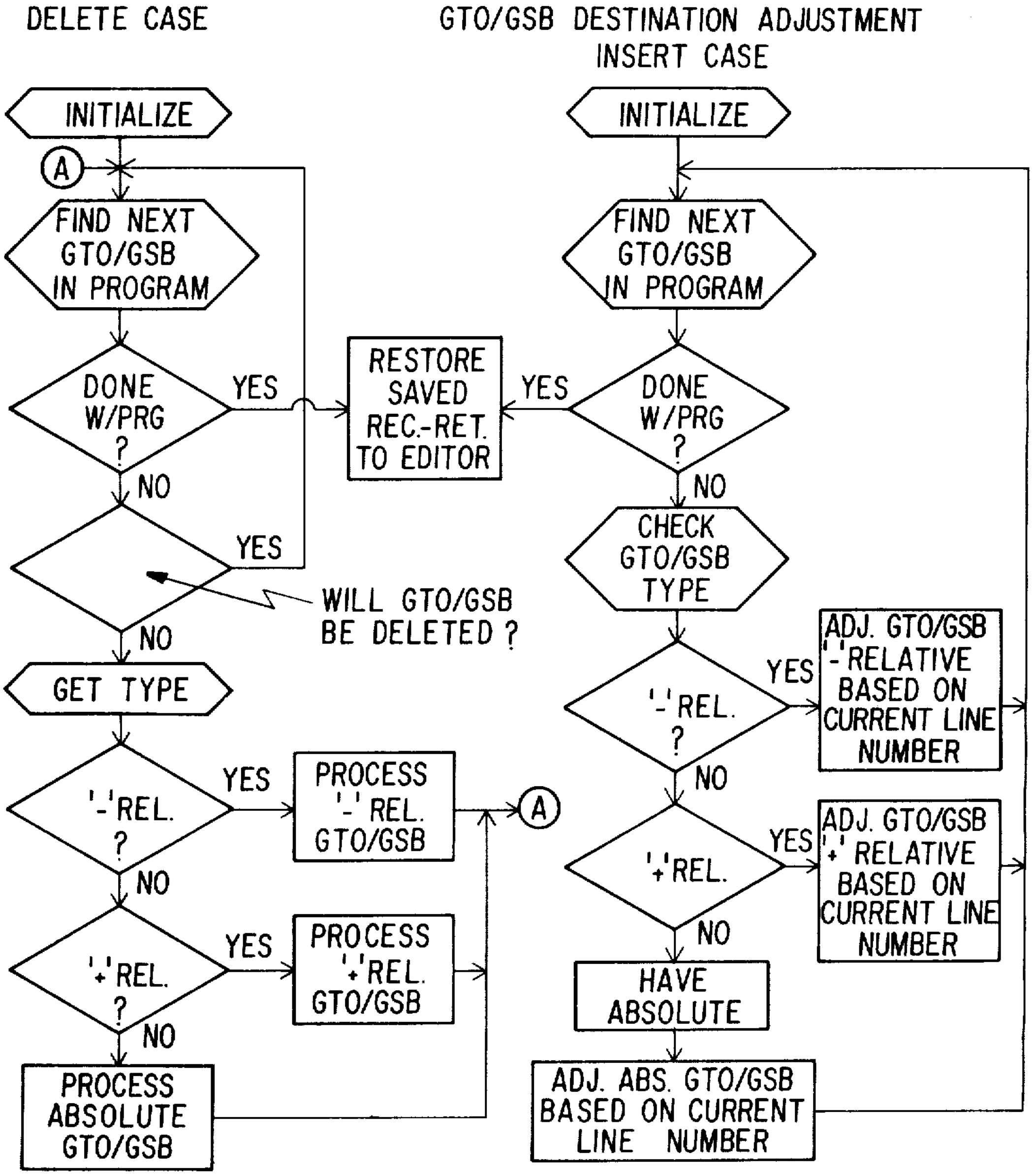

DELETE CASE
GTO/GSB DESTINATION ADJUSTMENT
INSERT CASE
INITIALIZE
A
FIND NEXT GTO/GSB IN PROGRAM
DONE W/PRG ?
YES
NO
RESTORE SAVED REC.-RET. TO EDITOR
YES
WILL GTO/GSB BE DELETED ?
NO
GET TYPE
'-'REL. ?
YES
PROCESS '-' REL. GTO/GSB
A
NO
'+'REL. ?
YES
PROCESS '+'REL. GTO/GSB
NO
PROCESS ABSOLUTE GTO/GSB
INITIALIZE
FIND NEXT GTO/GSB IN PROGRAM
YES
DONE W/PRG ?
NO
CHECK GTO/GSB TYPE
'-'REL. ?
YES
ADJ. GTO/GSB '-'RELATIVE BASED ON CURRENT LINE NUMBER
NO
'+'REL.
YES
ADJ. GTO/GSB '+' RELATIVE BASED ON CURRENT LINE NUMBER
NO
HAVE ABSOLUTE
ADJ. ABS. GTO/GSB BASED ON CURRENT LINE NUMBER

FIG 166

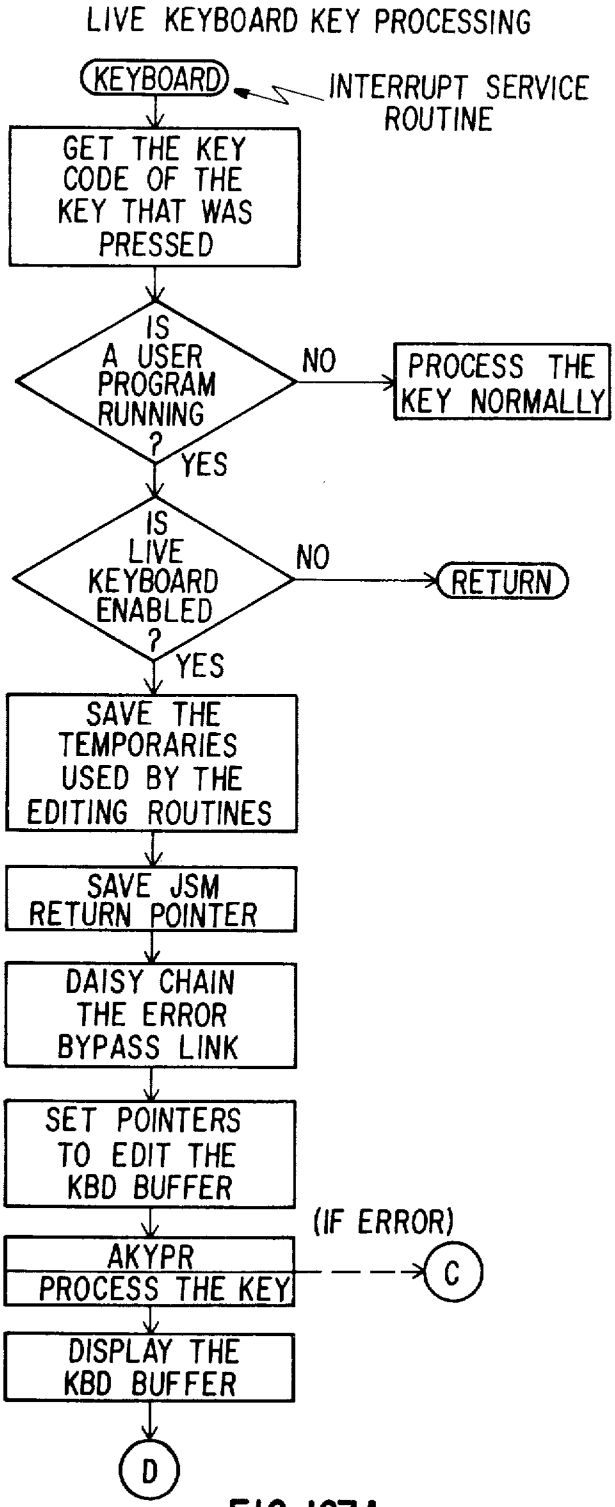

LIVE KEYBOARD KEY PROCESSING
KEYBOARD
INTERRUPT SERVICE ROUTINE
GET THE KEY CODE OF THE KEY THAT WAS PRESSED
IS A USER PROGRAM RUNNING ?
NO
PROCESS THE KEY NORMALLY
YES
IS LIVE KEYBOARD ENABLED ?
NO
RETURN
YES
SAVE THE TEMPORARIES USED BY THE EDITING ROUTINES
SAVE JSM RETURN POINTER
DAISY CHAIN THE ERROR BYPASS LINK
SET POINTERS TO EDIT THE KBD BUFFER
AKYPR
PROCESS THE KEY
(IF ERROR)
C
DISPLAY THE KBD BUFFER
D

FIG 167A

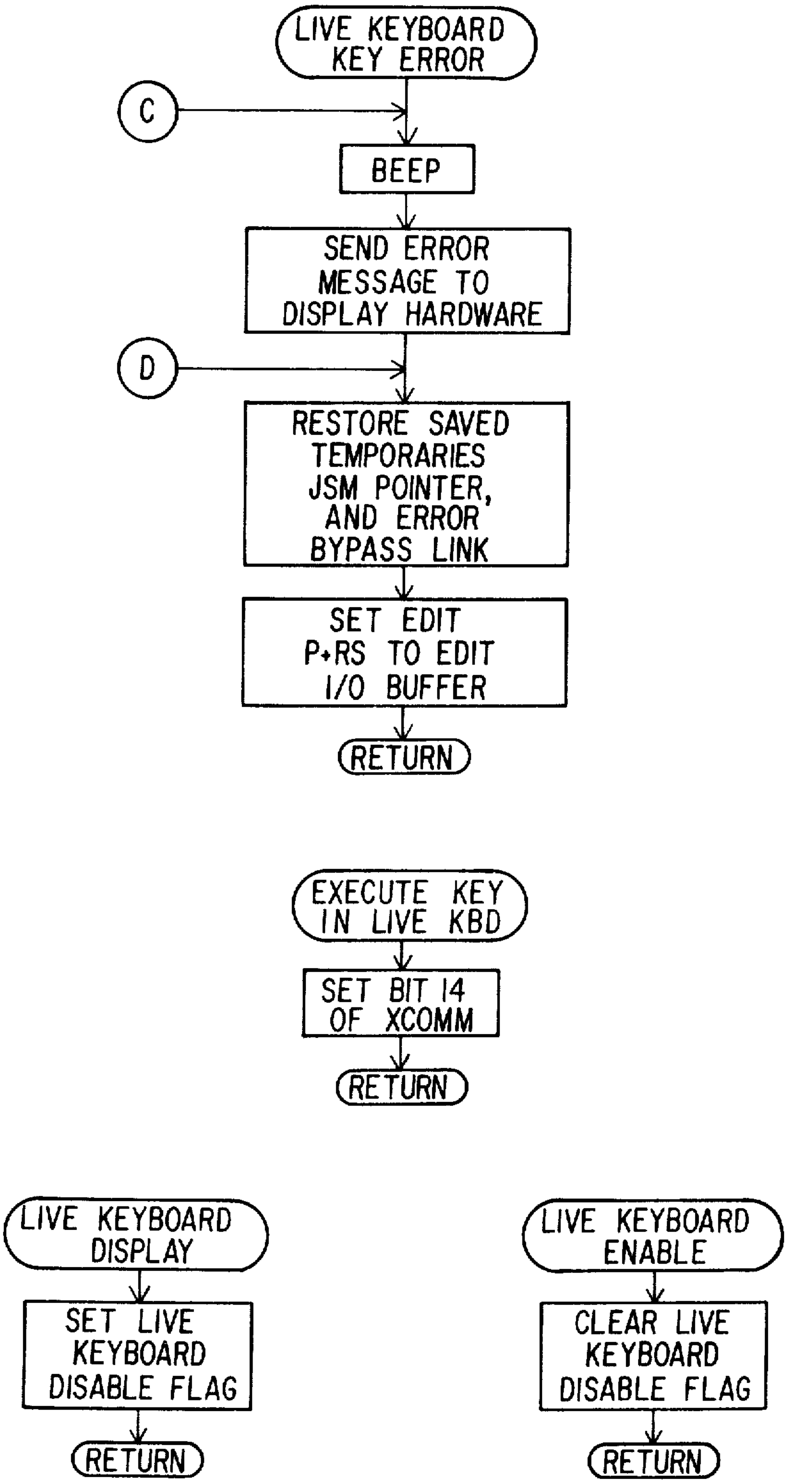

LIVE KEYBOARD KEY ERROR
C
BEEP
SEND ERROR MESSAGE TO DISPLAY HARDWARE
D
RESTORE SAVED TEMPORARIES JSM POINTER, AND ERROR BYPASS LINK
SET EDIT P+RS TO EDIT I/O BUFFER
RETURN
EXECUTE KEY IN LIVE KBD
SET BIT 14 OF XCOMM
RETURN
LIVE KEYBOARD DISPLAY
SET LIVE KEYBOARD DISABLE FLAG
RETURN
LIVE KEYBOARD ENABLE
CLEAR LIVE KEYBOARD DISABLE FLAG
RETURN

FIG 167B

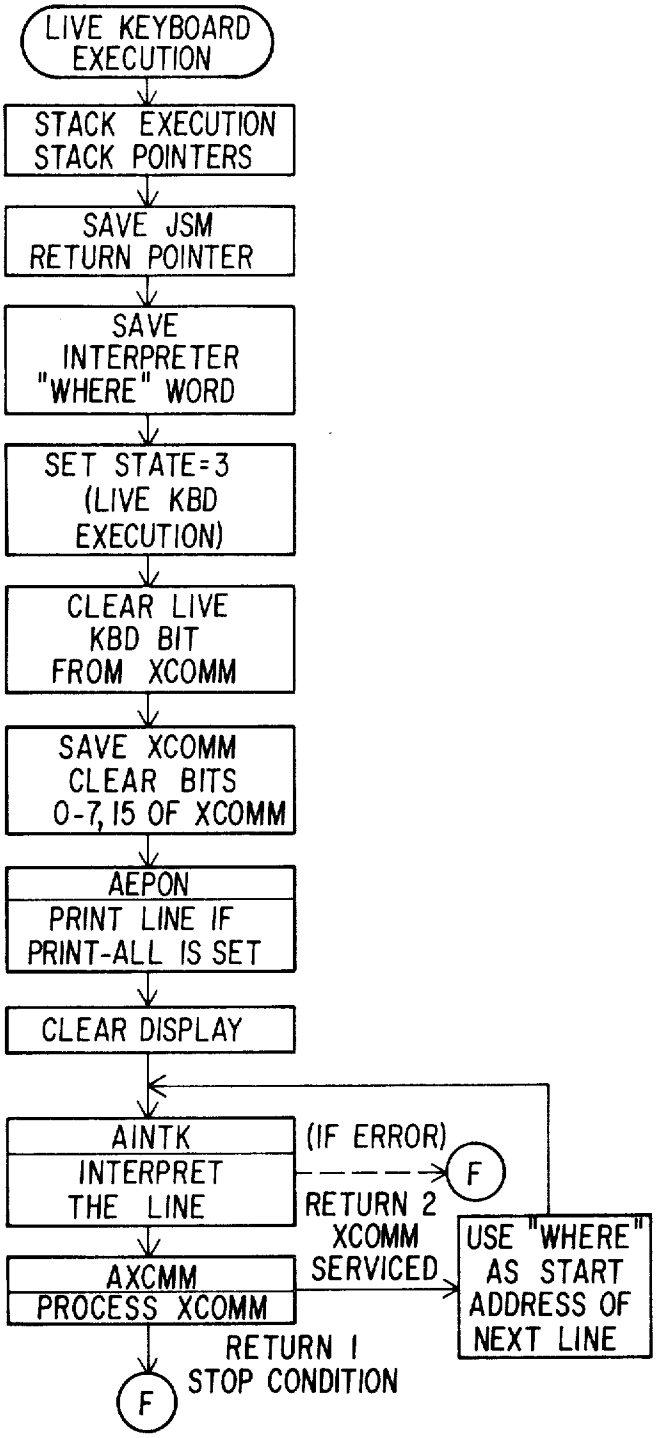

LIVE KEYBOARD EXECUTION
STACK EXECUTION STACK POINTERS
SAVE JSM RETURN POINTER
SAVE INTERPRETER "WHERE" WORD
SET STATE=3 (LIVE KBD EXECUTION)
CLEAR LIVE KBD BIT FROM XCOMM
SAVE XCOMM CLEAR BITS 0-7, 15 OF XCOMM
AEPON
PRINT LINE IF PRINT-ALL IS SET
CLEAR DISPLAY
AINTK
INTERPRET THE LINE
(IF ERROR)
F
RETURN 2 XCOMM SERVICED
USE "WHERE" AS START ADDRESS OF NEXT LINE
AXCMM
PROCESS XCOMM
RETURN 1 STOP CONDITION
F

FIG 168A

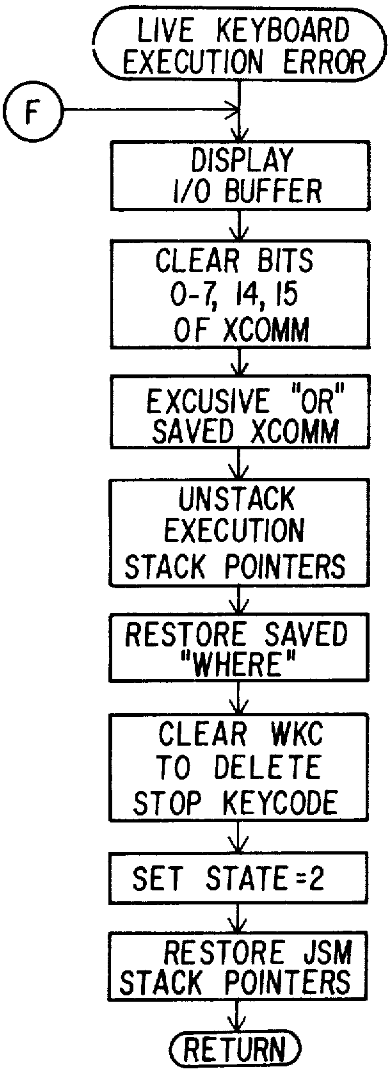

LIVE KEYBOARD EXECUTION ERROR
F
DISPLAY I/O BUFFER
CLEAR BITS 0-7, 14, 15 OF XCOMM
EXCUSIVE "OR" SAVED XCOMM
UNSTACK EXECUTION STACK POINTERS
RESTORE SAVED "WHERE"
CLEAR WKC TO DELETE STOP KEYCODE
SET STATE=2
RESTORE JSM STACK POINTERS
RETURN

FIG 168B

LIVE KEYBOARD

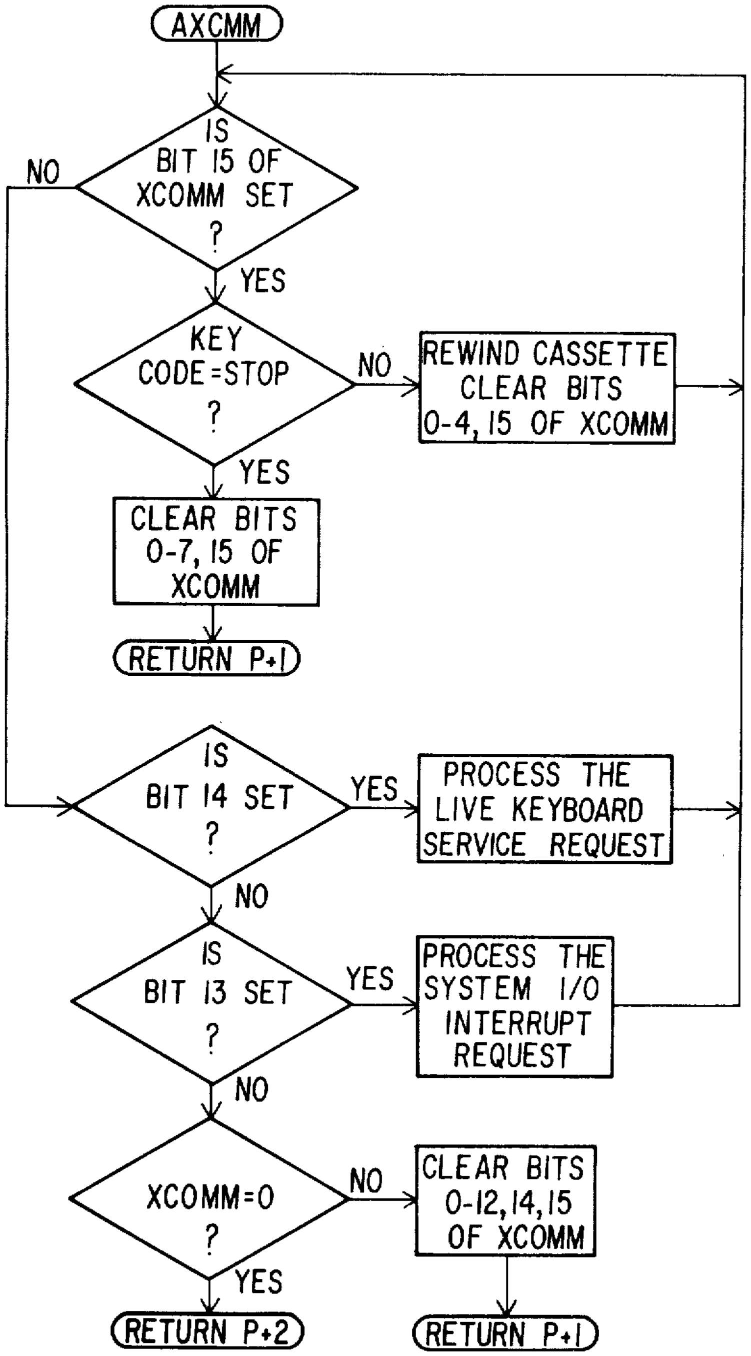

AXCMM
IS BIT 15 OF XCOMM SET ?
NO
YES
KEY CODE=STOP ?
NO
REWIND CASSETTE CLEAR BITS 0-4, 15 OF XCOMM
YES
CLEAR BITS 0-7, 15 OF XCOMM
RETURN P+1
IS BIT 14 SET ?
YES
PROCESS THE LIVE KEYBOARD SERVICE REQUEST
NO
IS BIT 13 SET ?
YES
PROCESS THE SYSTEM I/O INTERRUPT REQUEST
NO
XCOMM=0 ?
NO
CLEAR BITS 0-12, 14, 15 OF XCOMM
YES
RETURN P+2
RETURN P+1

FIG 169A

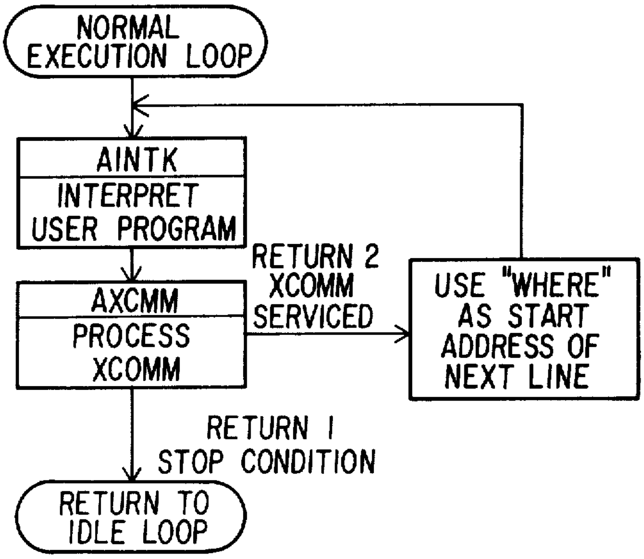

NORMAL EXECUTION LOOP
AINTK
INTERPRET USER PROGRAM
AXCMM
PROCESS XCOMM
RETURN 2 XCOMM SERVICED
USE "WHERE" AS START ADDRESS OF NEXT LINE
RETURN 1 STOP CONDITION
RETURN TO IDLE LOOP

FIG 169B

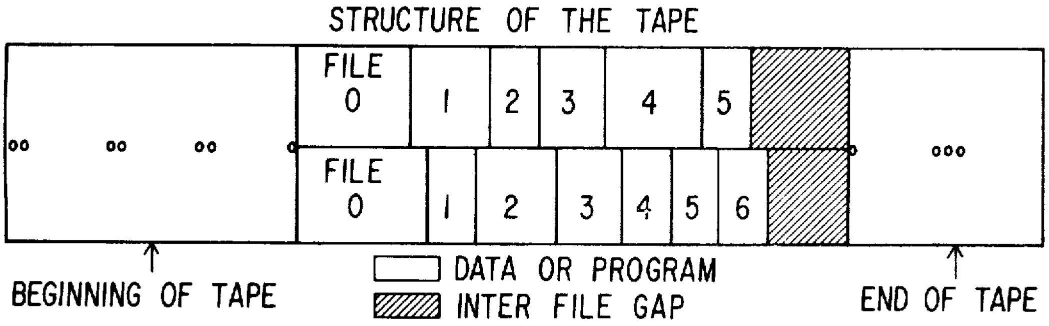


FIG 170A

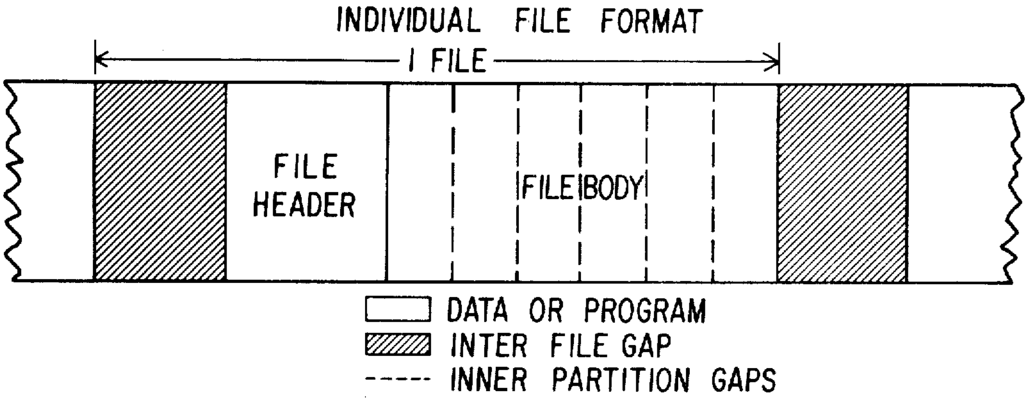


FIG 170B

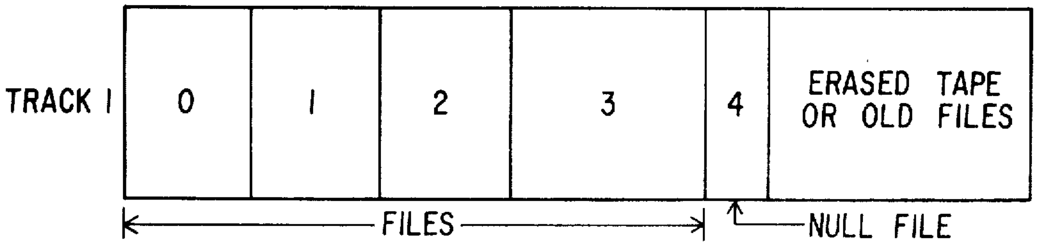


FIG 170C

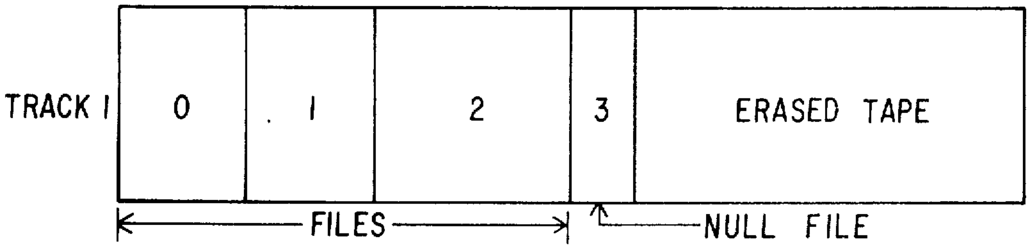


FIG 170D

CASSETTE OPERATING SYSTEM LEVEL
PARTITION SUPPORT CODE

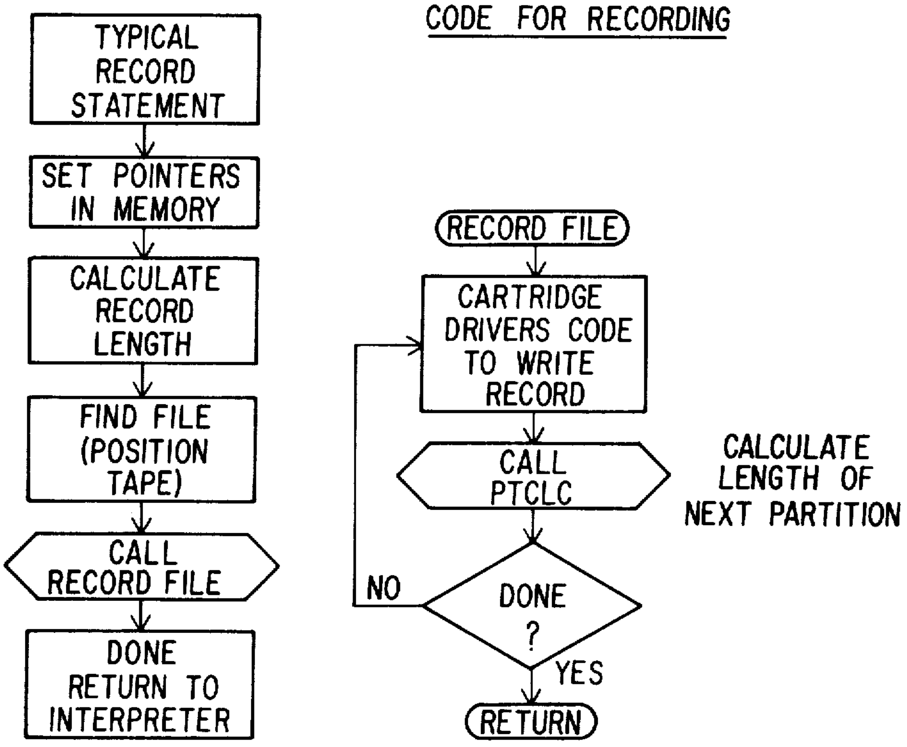


FIG 171A

CODE TO CALCULATE PARTITION LENGTHS
AS TAPE IS MOVING-WRITING INNER-PARTITION GAP

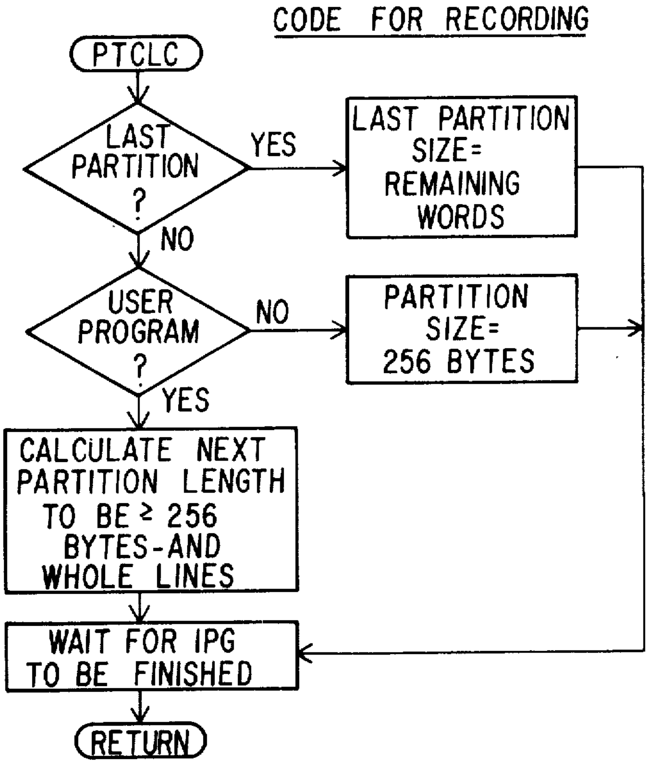

CODE FOR RECORDING
PTCLC
LAST PARTITION ?
YES
LAST PARTITION SIZE= REMAINING WORDS
NO
USER PROGRAM ?
NO
PARTITION SIZE= 256 BYTES
YES
CALCULATE NEXT PARTITION LENGTH TO BE ≥ 256 BYTES-AND WHOLE LINES
WAIT FOR IPG TO BE FINISHED
RETURN

FIG 171B

THE FOLLOWING CHARTS OUTLINE THE STEPS TAKEN IN LOADING A FILE. (READING THE RECORD'S PARTITIONS)

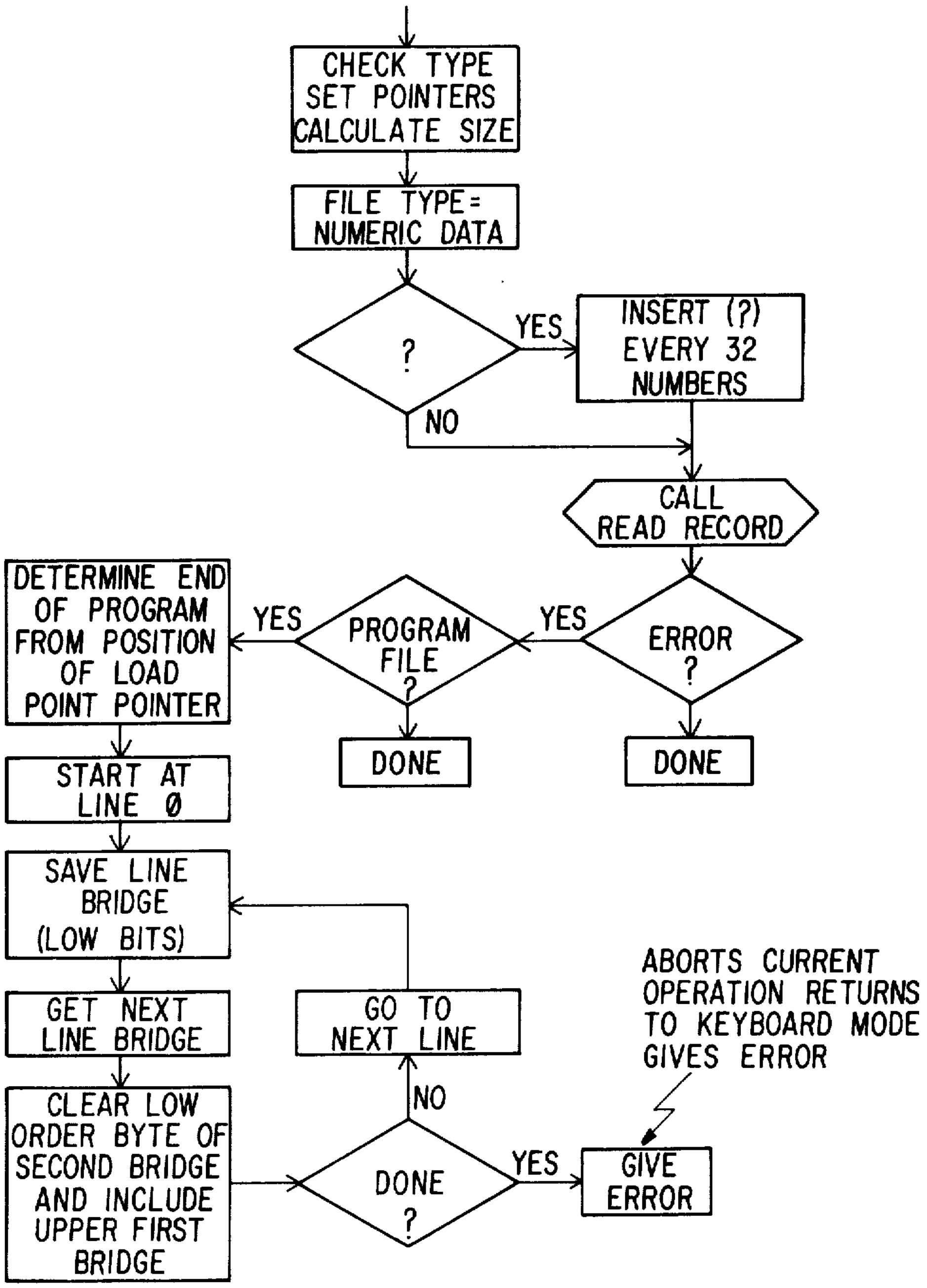

CHECK TYPE
SET POINTERS
CALCULATE SIZE
FILE TYPE= NUMERIC DATA
?
YES
INSERT (?) EVERY 32 NUMBERS
NO
CALL READ RECORD
ERROR ?
YES
DONE
PROGRAM FILE ?
YES
DONE
DETERMINE END OF PROGRAM FROM POSITION OF LOAD POINT POINTER
START AT LINE Ø
SAVE LINE BRIDGE (LOW BITS)
GET NEXT LINE BRIDGE
CLEAR LOW ORDER BYTE OF SECOND BRIDGE AND INCLUDE UPPER FIRST BRIDGE
DONE ?
NO
GO TO NEXT LINE
YES
GIVE ERROR
ABORTS CURRENT OPERATION RETURNS TO KEYBOARD MODE GIVES ERROR

FIG 172A

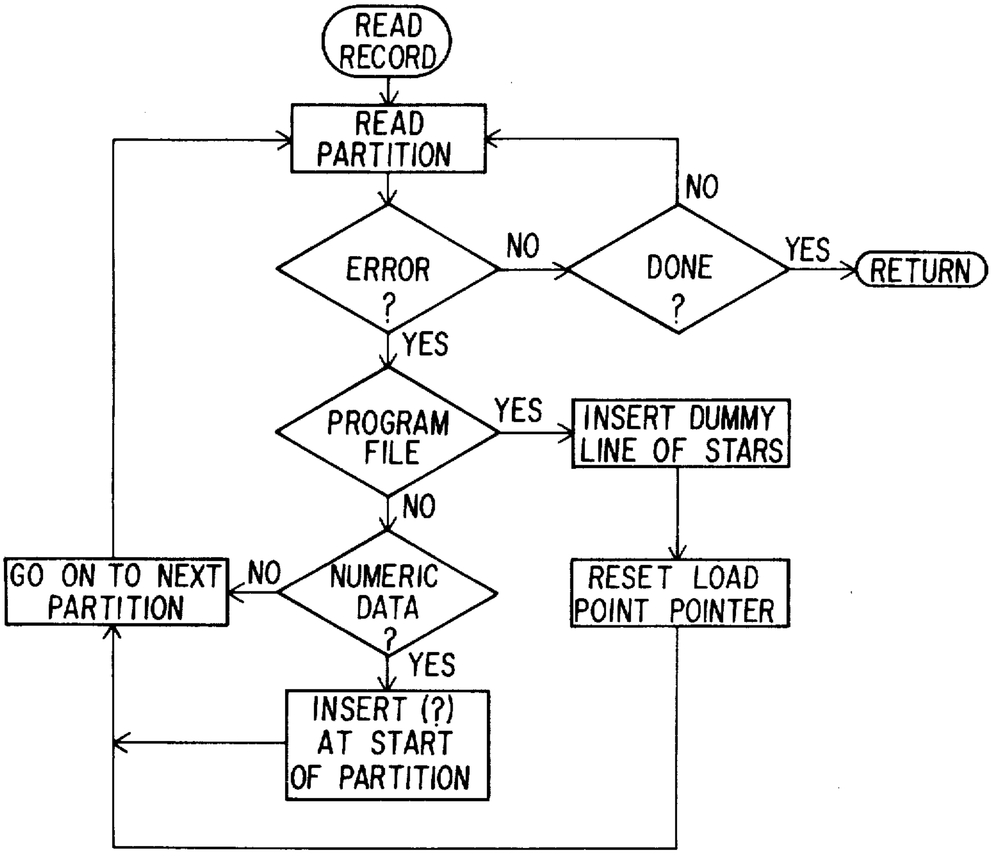
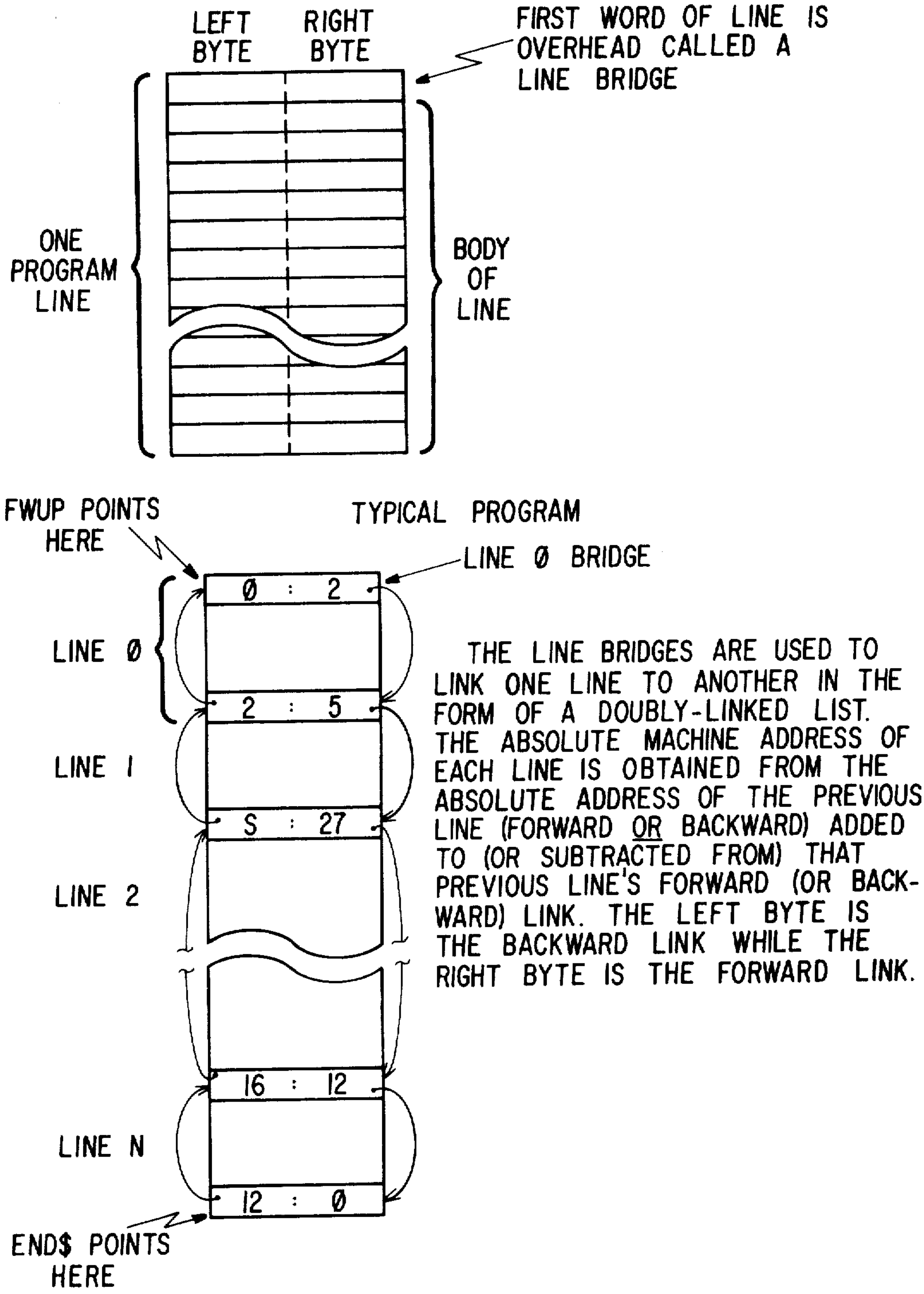

READ RECORD
READ PARTITION
ERROR ?
NO
YES
DONE ?
NO
YES
RETURN
PROGRAM FILE
YES
NO
INSERT DUMMY LINE OF STARS
RESET LOAD POINT POINTER
NUMERIC DATA ?
NO
YES
GO ON TO NEXT PARTITION
INSERT (?) AT START OF PARTITION

FIG 172B



THE LINE BRIDGES ARE USED TO LINK ONE LINE TO ANOTHER IN THE FORM OF A DOUBLY-LINKED LIST. THE ABSOLUTE MACHINE ADDRESS OF EACH LINE IS OBTAINED FROM THE ABSOLUTE ADDRESS OF THE PREVIOUS LINE (FORWARD OR BACKWARD) ADDED TO (OR SUBTRACTED FROM) THAT PREVIOUS LINE'S FORWARD (OR BACKWARD) LINK. THE LEFT BYTE IS THE BACKWARD LINK WHILE THE RIGHT BYTE IS THE FORWARD LINK.

FIG 173

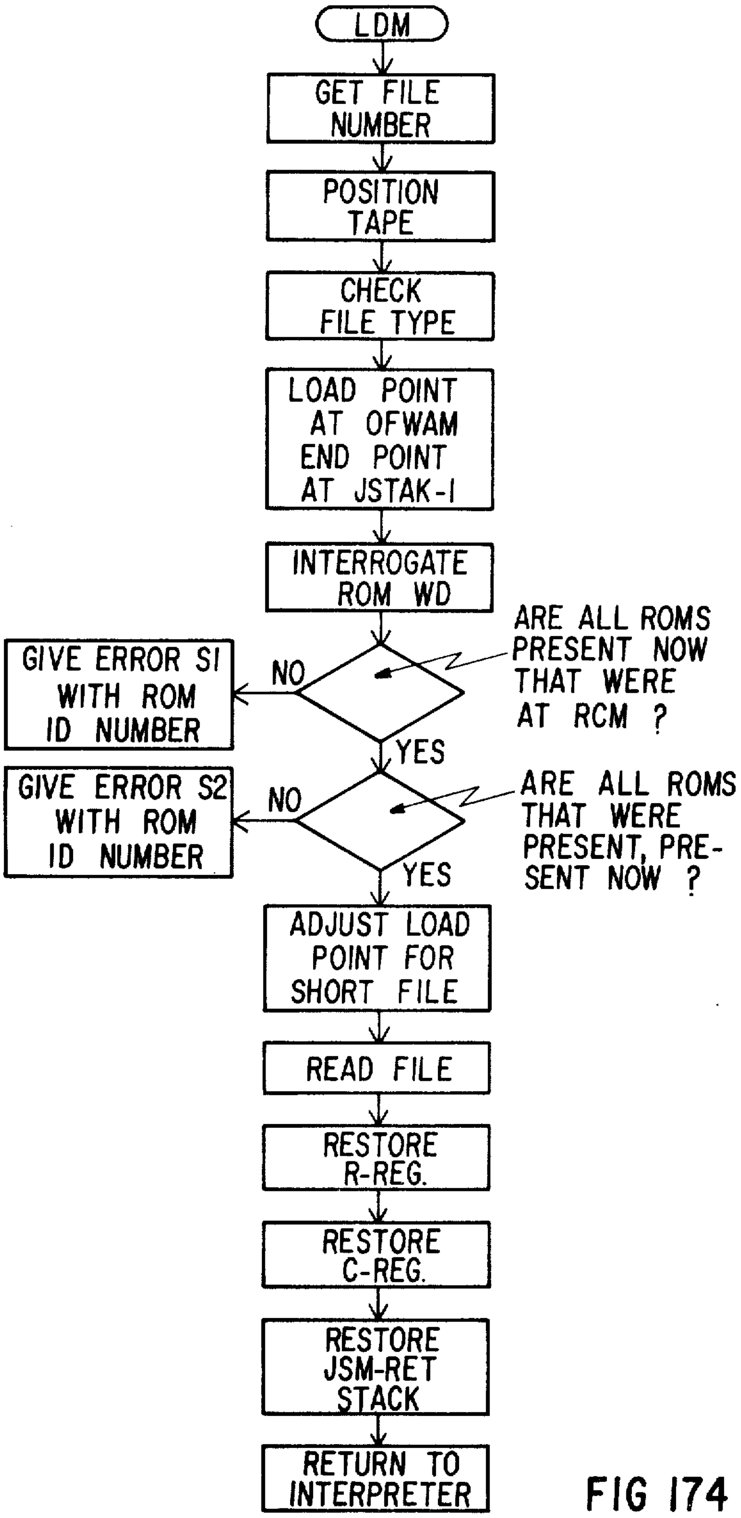

LDM
GET FILE NUMBER
POSITION TAPE
CHECK FILE TYPE
LOAD POINT AT OFWAM END POINT AT JSTAK-1
INTERROGATE ROM WD
ARE ALL ROMS PRESENT NOW THAT WERE AT RCM ?
NO
GIVE ERROR S1 WITH ROM ID NUMBER
YES
ARE ALL ROMS THAT WERE PRESENT, PRESENT NOW ?
NO
GIVE ERROR S2 WITH ROM ID NUMBER
YES
ADJUST LOAD POINT FOR SHORT FILE
READ FILE
RESTORE R-REG.
RESTORE C-REG.
RESTORE JSM-RET STACK
RETURN TO INTERPRETER

FIG 174

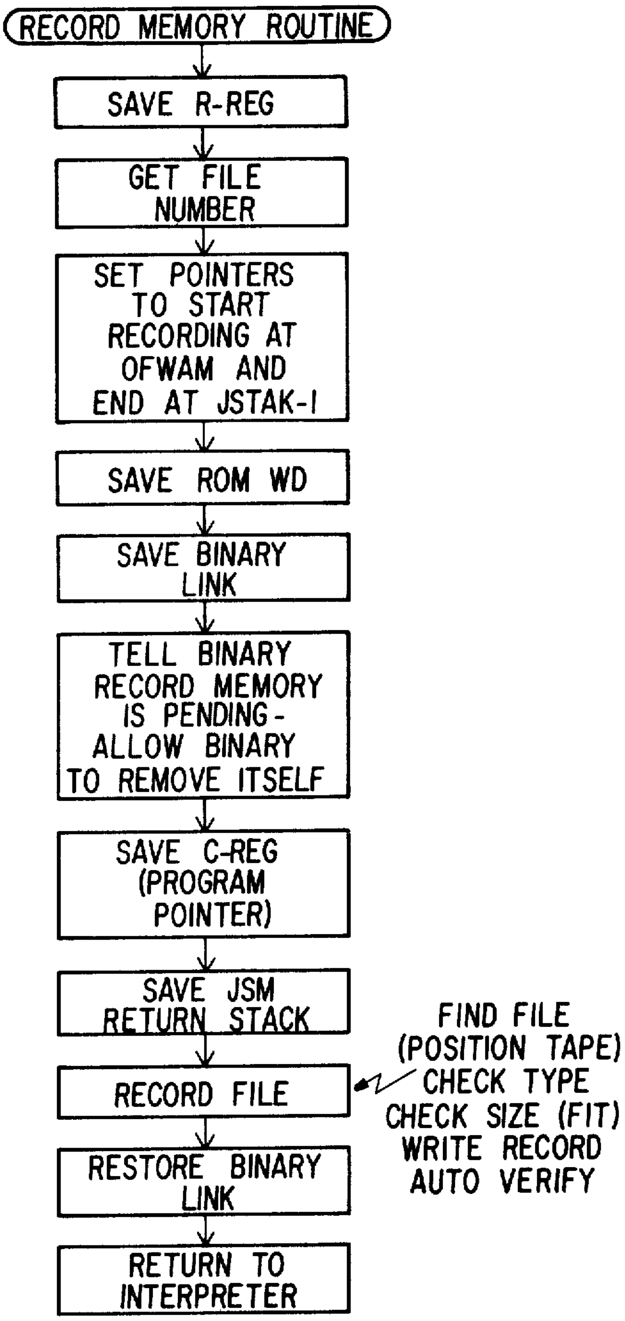

RECORD MEMORY ROUTINE
SAVE R-REG
GET FILE NUMBER
SET POINTERS TO START RECORDING AT OFWAM AND END AT JSTAK-1
SAVE ROM WD
SAVE BINARY LINK
TELL BINARY RECORD MEMORY IS PENDING - ALLOW BINARY TO REMOVE ITSELF
SAVE C-REG (PROGRAM POINTER)
SAVE JSM RETURN STACK
RECORD FILE
RESTORE BINARY LINK
RETURN TO INTERPRETER
FIND FILE (POSITION TAPE) CHECK TYPE CHECK SIZE (FIT) WRITE RECORD AUTO VERIFY

FIG 175

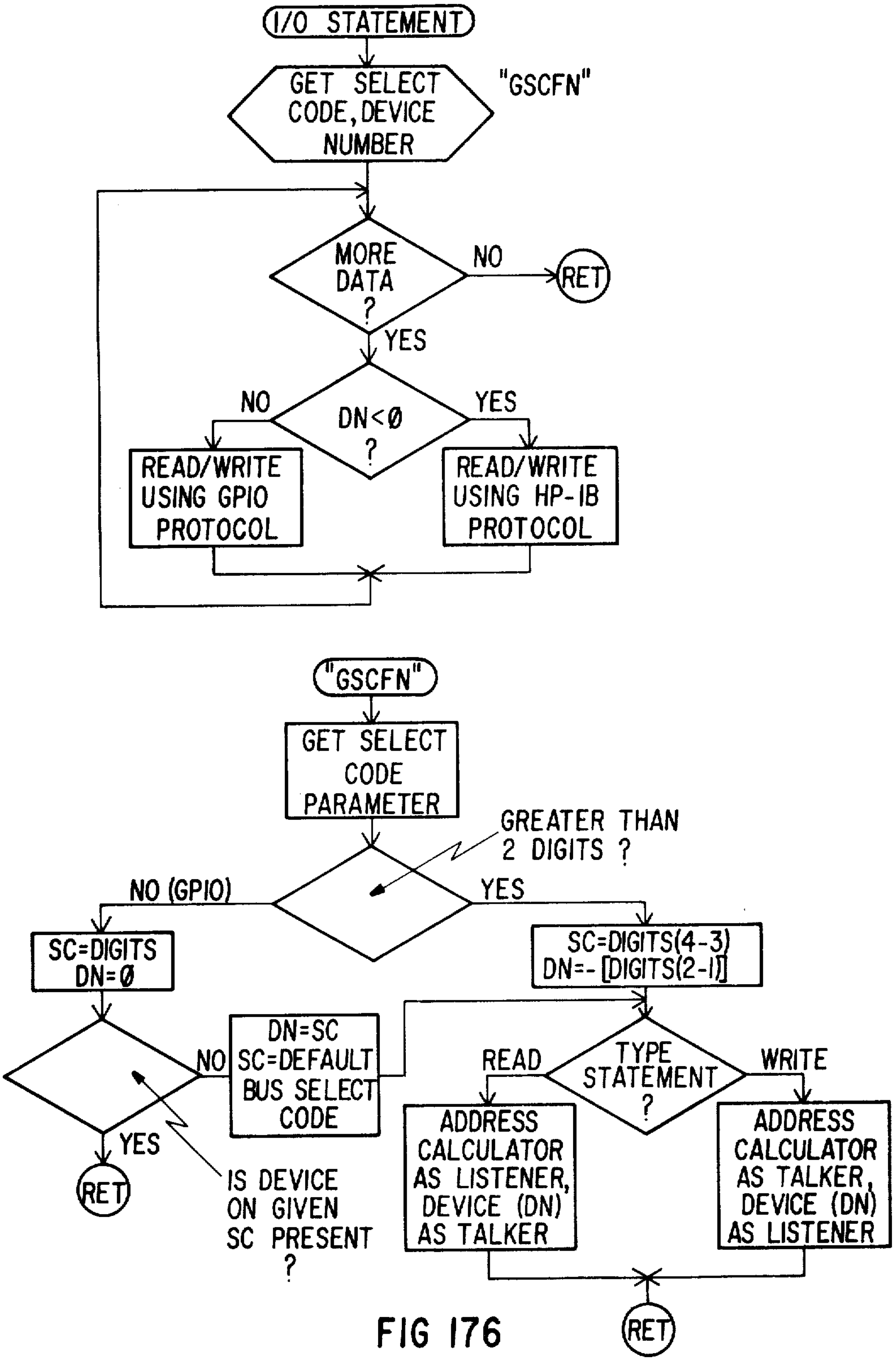

I/O STATEMENT
GET SELECT CODE, DEVICE NUMBER
"GSCFN"
MORE DATA ?
NO
RET
YES
DN<Ø ?
NO
YES
READ/WRITE USING GPIO PROTOCOL
READ/WRITE USING HP-IB PROTOCOL
"GSCFN"
GET SELECT CODE PARAMETER
GREATER THAN 2 DIGITS ?
NO (GPIO)
YES
SC=DIGITS DN=Ø
SC=DIGITS(4-3) DN=-[DIGITS(2-1)]
NO
DN=SC SC=DEFAULT BUS SELECT CODE
YES
RET
IS DEVICE ON GIVEN SC PRESENT ?
READ
TYPE STATEMENT ?
WRITE
ADDRESS CALCULATOR AS LISTENER, DEVICE (DN) AS TALKER
ADDRESS CALCULATOR AS TALKER, DEVICE (DN) AS LISTENER
RET

FIG 176

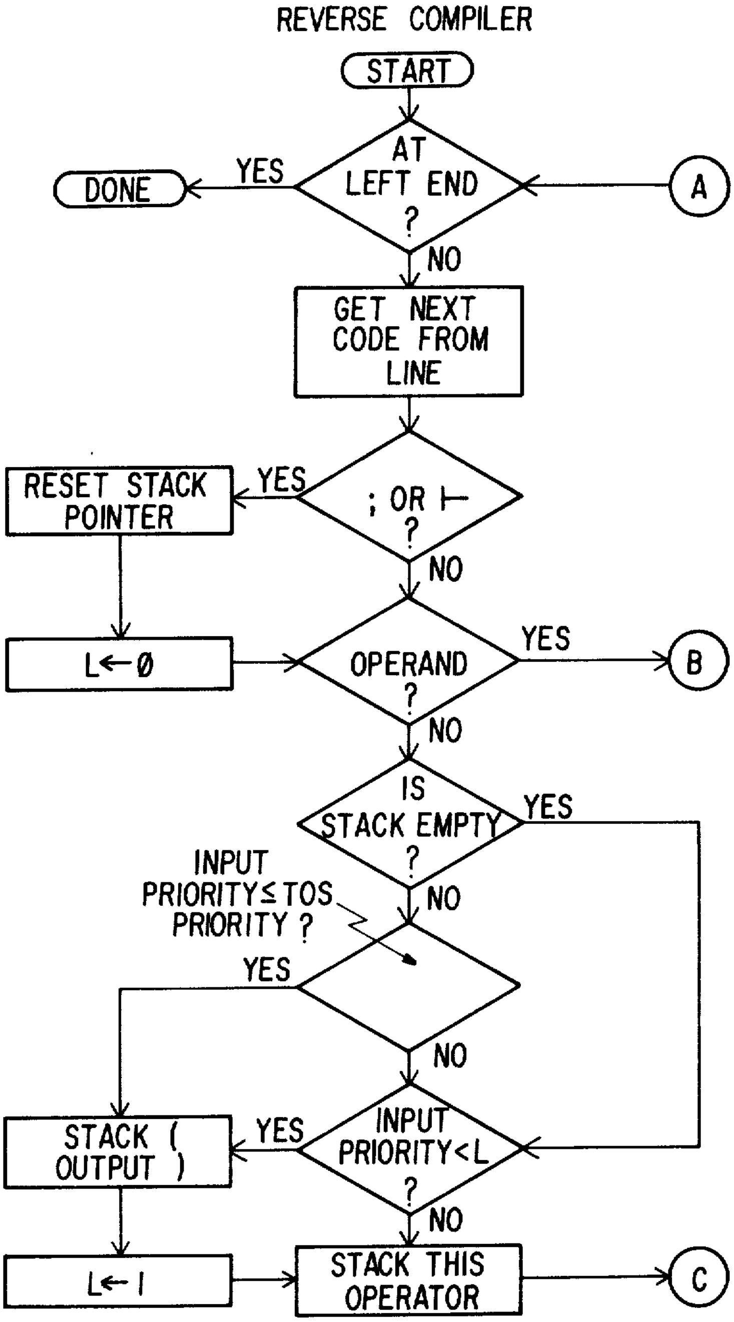

REVERSE COMPILER
START
AT LEFT END ?
YES
DONE
NO
A
GET NEXT CODE FROM LINE
; OR ⊢ ?
YES
RESET STACK POINTER
NO
L←Ø
OPERAND ?
YES
B
NO
IS STACK EMPTY ?
YES
NO
INPUT PRIORITY≤TOS PRIORITY ?
YES
NO
INPUT PRIORITY<L ?
YES
STACK ( OUTPUT )
NO
L←1
STACK THIS OPERATOR
C

FIG 177A

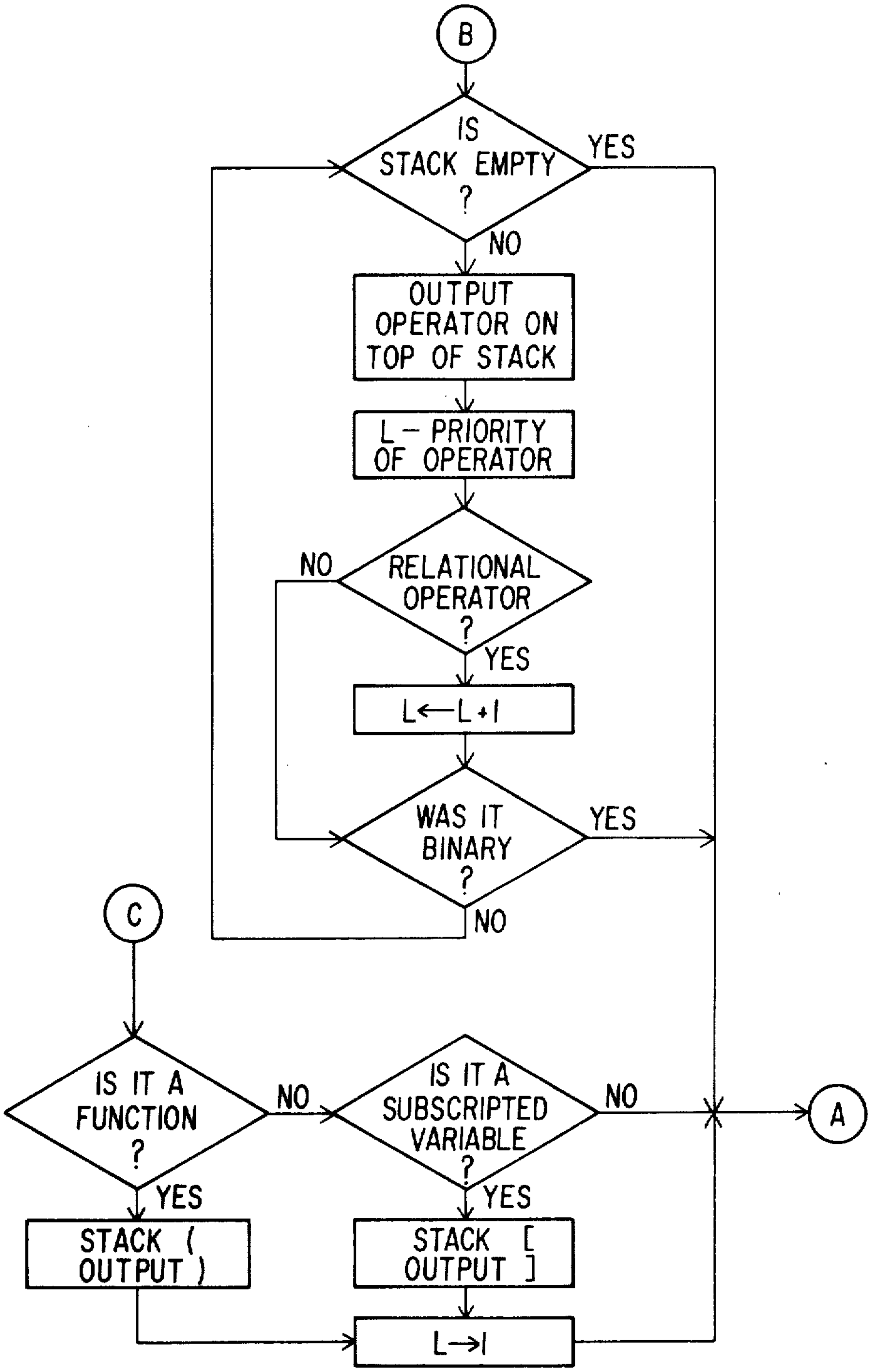

B
IS STACK EMPTY ?
YES
NO
OUTPUT OPERATOR ON TOP OF STACK
L ← PRIORITY OF OPERATOR
NO
RELATIONAL OPERATOR ?
YES
L←L+1
WAS IT BINARY ?
YES
NO
C
IS IT A FUNCTION ?
NO
IS IT A SUBSCRIPTED VARIABLE ?
NO
A
YES
STACK ( OUTPUT )
YES
STACK [ OUTPUT ]
L→1

FIG 177B

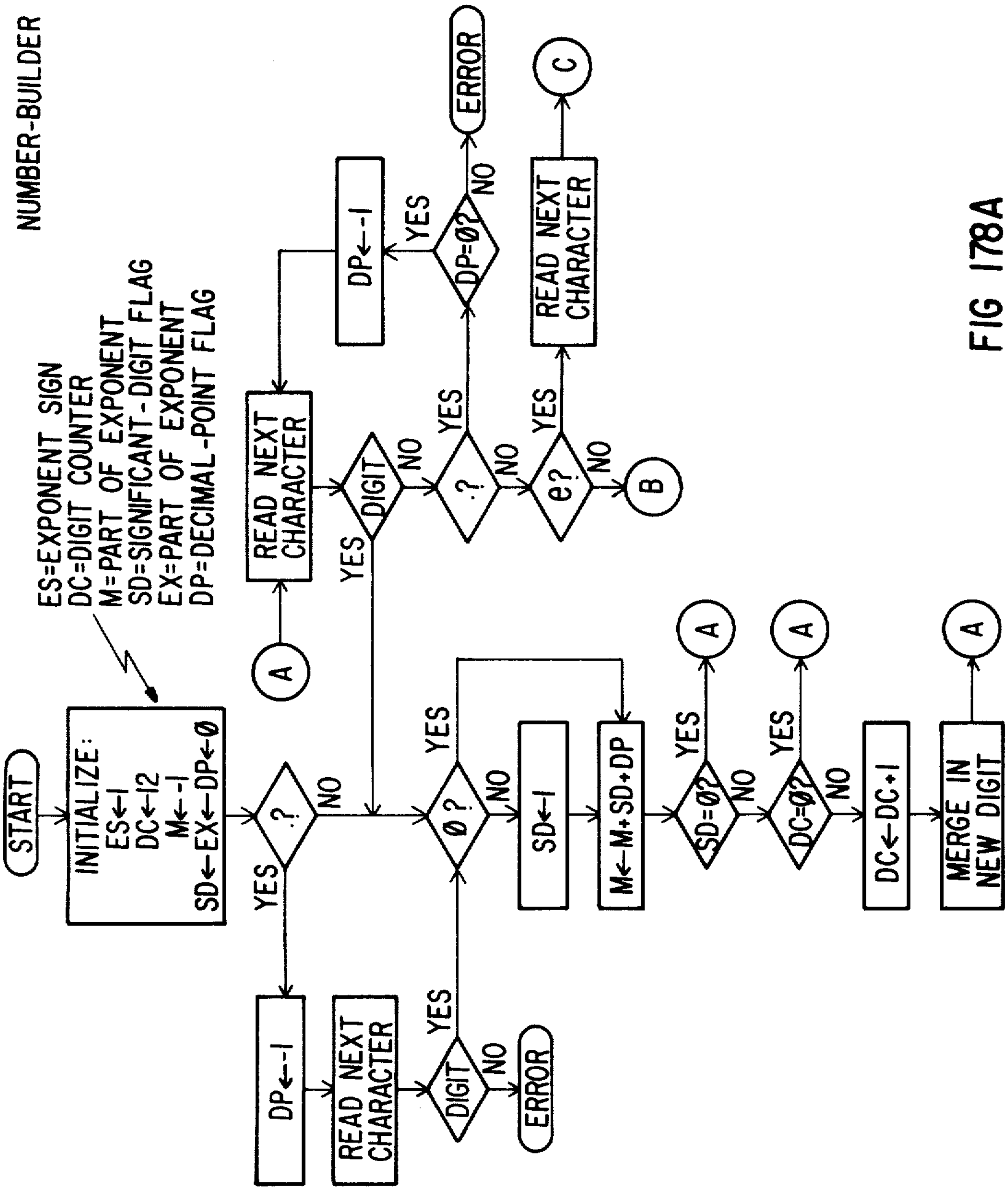

NUMBER-BUILDER
ES=EXPONENT SIGN
DC=DIGIT COUNTER
M=PART OF EXPONENT
SD=SIGNIFICANT-DIGIT FLAG
EX=PART OF EXPONENT
DP=DECIMAL-POINT FLAG
START
INITIALIZE:
ES←1
DC←12
M←-1
SD←EX←DP←Ø
.?
YES
NO
DP←-1
READ NEXT CHARACTER
DIGIT
YES
NO
ERROR
Ø?
YES
NO
SD←1
M←M+SD+DP
SD=Ø?
YES
NO
A
DC=Ø?
YES
NO
A
DC←DC+1
MERGE IN NEW DIGIT
A
A
READ NEXT CHARACTER
DIGIT
YES
NO
.?
YES
NO
DP=Ø?
YES
NO
DP←-1
ERROR
e?
YES
NO
B
READ NEXT CHARACTER
C

FIG 178A

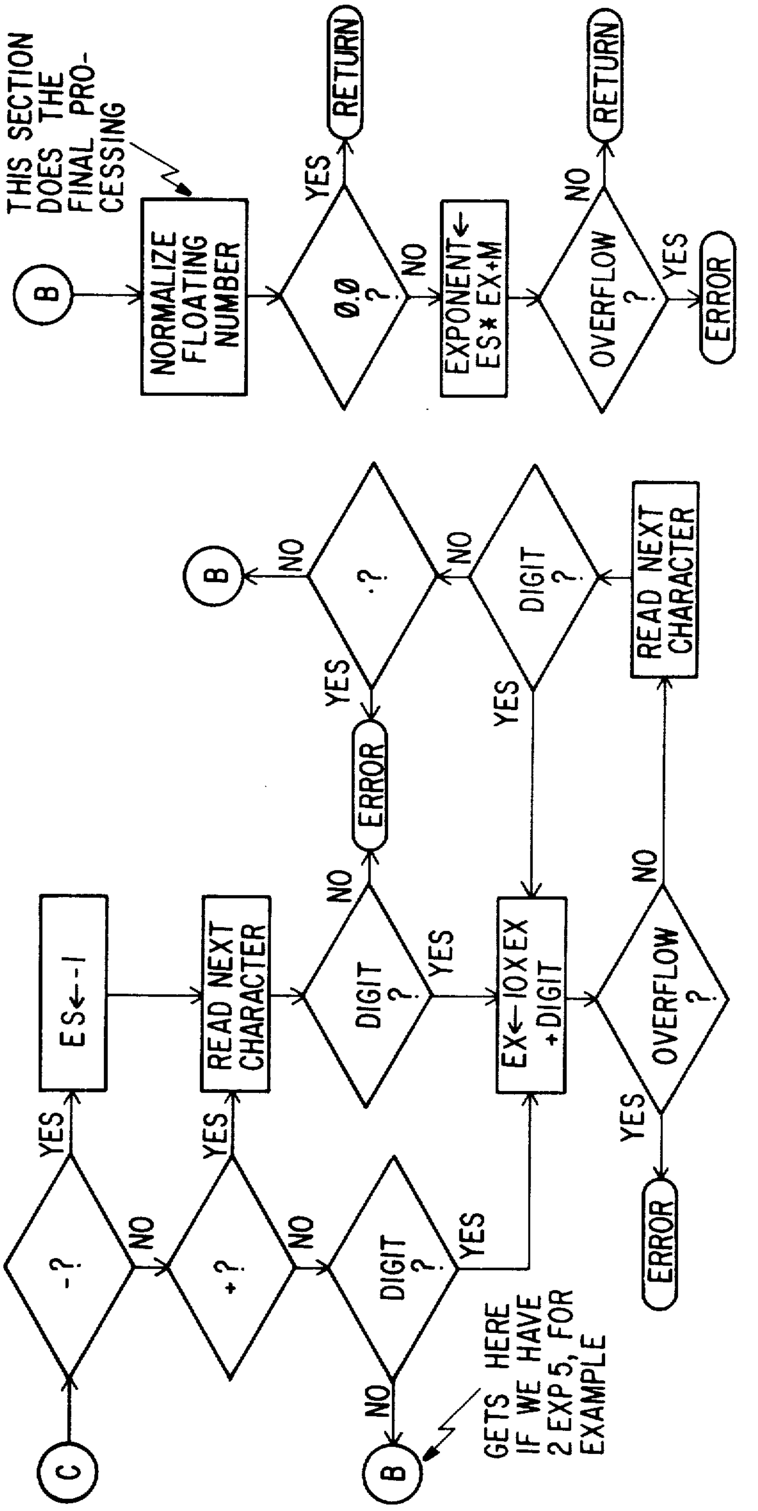
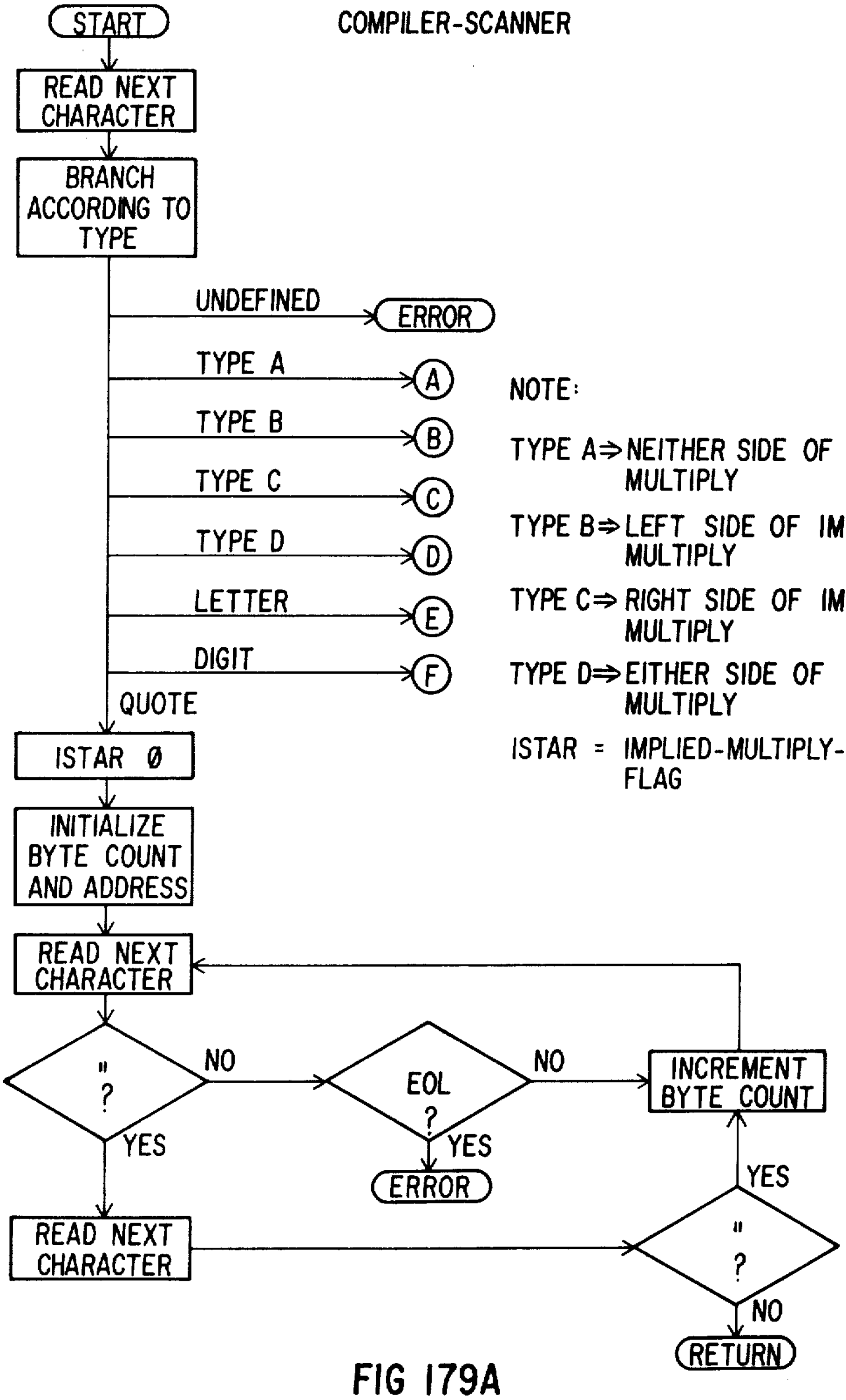

C
-?
YES
ES←-1
NO
+?
YES
READ NEXT CHARACTER
NO
DIGIT ?
NO
B
GETS HERE IF WE HAVE 2 EXP 5, FOR EXAMPLE
YES
DIGIT ?
NO
ERROR
YES
EX←10XEX +DIGIT
OVERFLOW ?
YES
ERROR
NO
READ NEXT CHARACTER
DIGIT ?
YES
NO
.?
YES
ERROR
NO
B
B
THIS SECTION DOES THE FINAL PRO-CESSING
NORMALIZE FLOATING NUMBER
0.0 ?
YES
RETURN
NO
EXPONENT← ES* EX+M
OVERFLOW ?
NO
RETURN
YES
ERROR

FIG 178B

COMPILER-SCANNER



NOTE:

TYPE A⇒NEITHER SIDE OF IMPLIED MULTIPLY

TYPE B⇒LEFT SIDE OF IMPLIED MULTIPLY

TYPE C⇒RIGHT SIDE OF IMPLIED MULTIPLY

TYPE D⇒EITHER SIDE OF IMPLIED MULTIPLY

ISTAR = IMPLIED-MULTIPLY-PENDING FLAG

FIG 179A

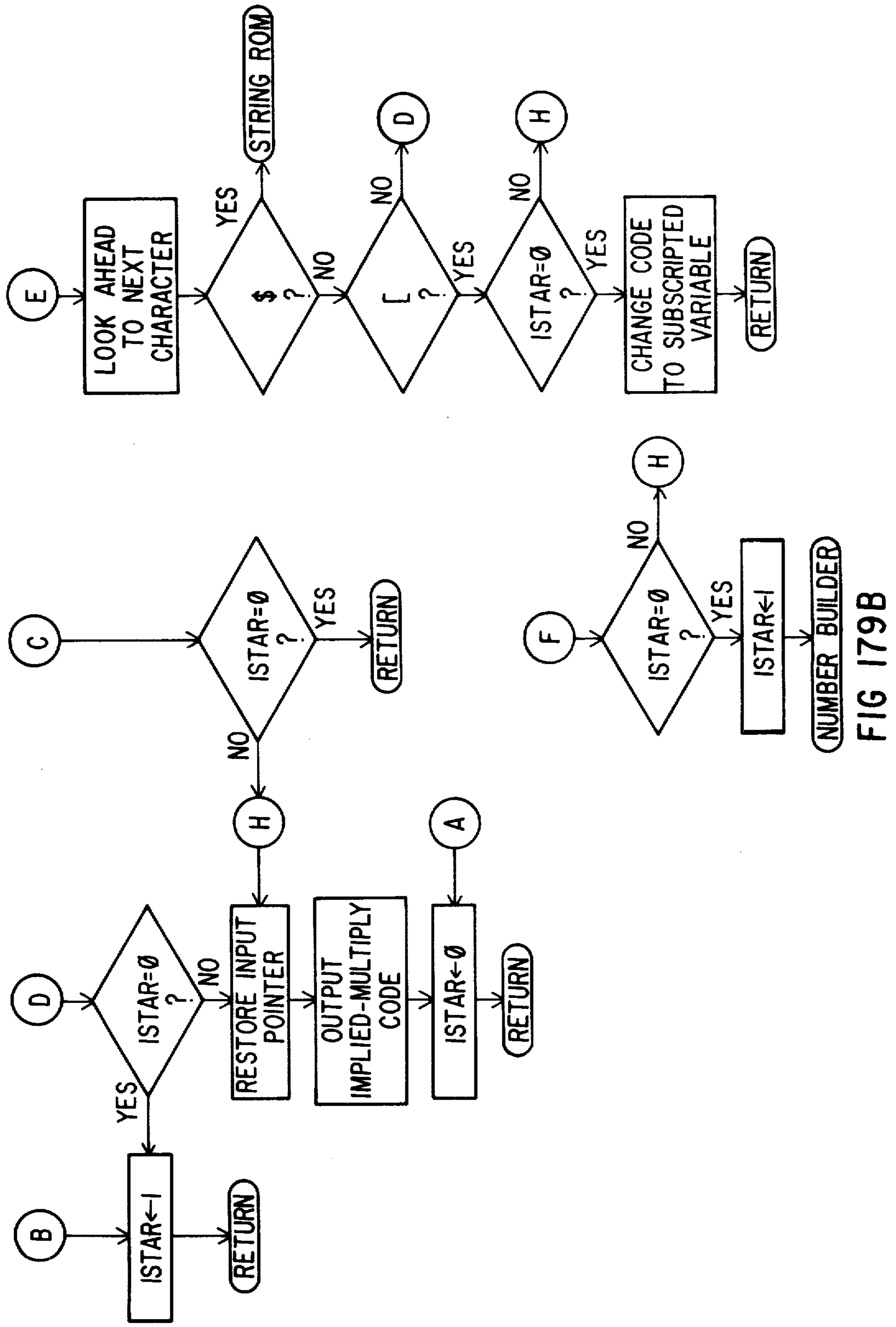

E
LOOK AHEAD TO NEXT CHARACTER
$ ?
YES
STRING ROM
NO
[ ?
NO
D
YES
ISTAR=Ø ?
NO
H
YES
CHANGE CODE TO SUBSCRIPTED VARIABLE
RETURN
C
ISTAR=Ø ?
YES
RETURN
NO
H
F
ISTAR=Ø ?
NO
H
YES
ISTAR←1
NUMBER BUILDER
D
ISTAR=Ø ?
NO
H
RESTORE INPUT POINTER
OUTPUT IMPLIED-MULTIPLY CODE
A
ISTAR←Ø
RETURN
YES
B
ISTAR←1
RETURN

FIG 179B

FINAL PROCESSING OF GO TO/GOSUB:

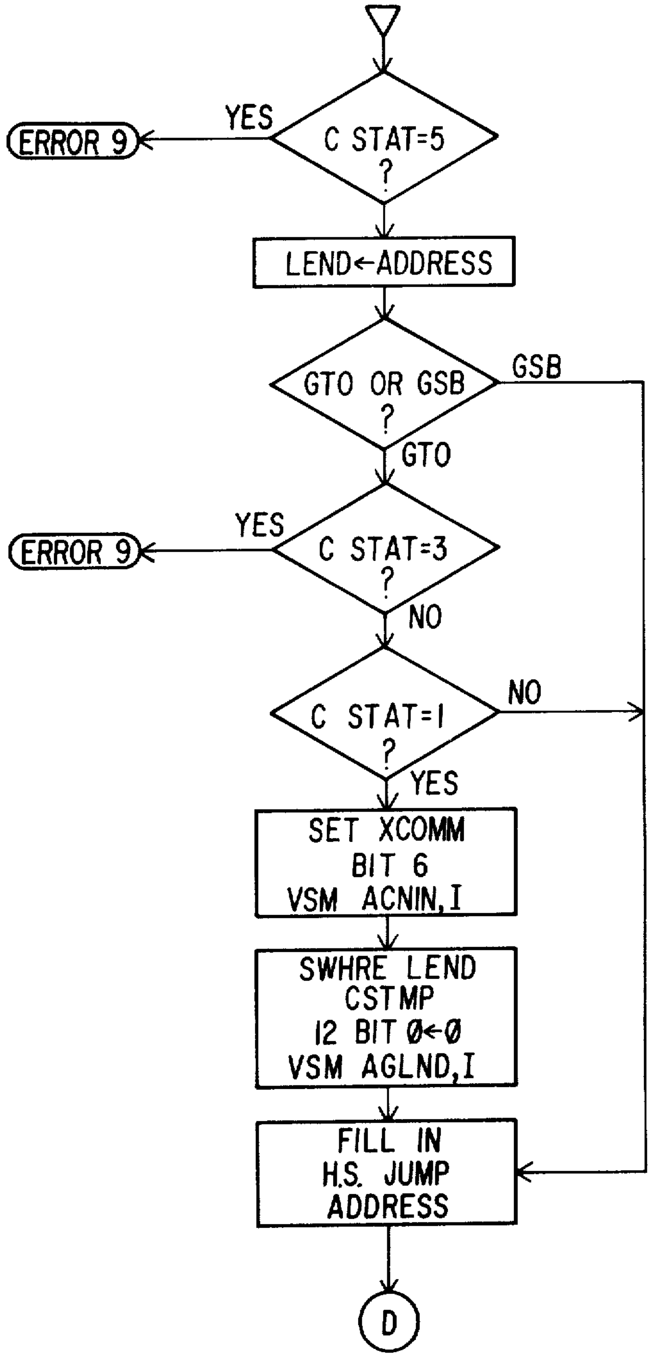

C STAT=5 ?
YES
ERROR 9
LEND←ADDRESS
GTO OR GSB ?
GSB
GTO
C STAT=3 ?
YES
ERROR 9
NO
C STAT=1 ?
NO
YES
SET XCOMM BIT 6 VSM ACNIN,I
SWHRE LEND CSTMP 12 BIT Ø←Ø VSM AGLND,I
FILL IN H.S. JUMP ADDRESS
D

FIG 180A

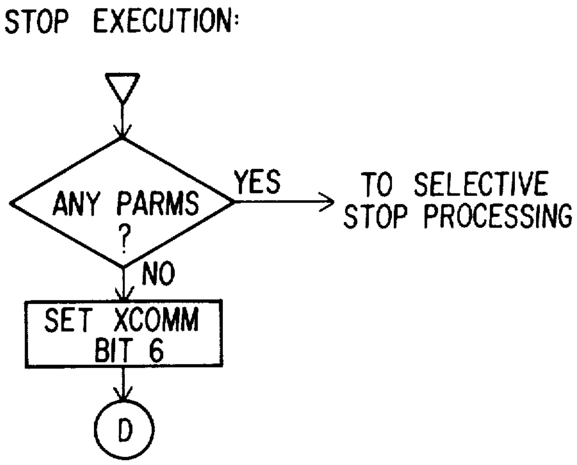

STOP EXECUTION:
ANY PARMS ?
YES
TO SELECTIVE STOP PROCESSING
NO
SET XCOMM BIT 6
D

FIG 180B

ENTER EXECUTION PROLOGUE:

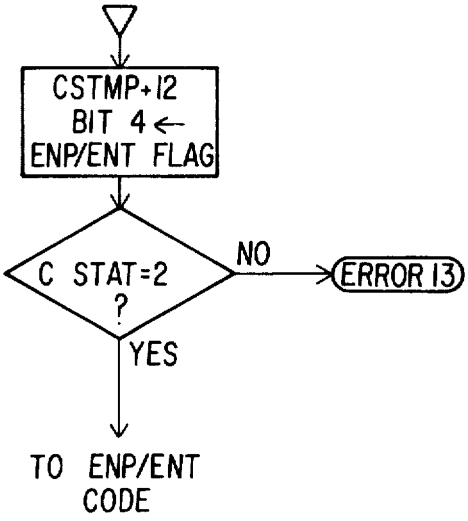


FIG 180C

EOL EXECUTION

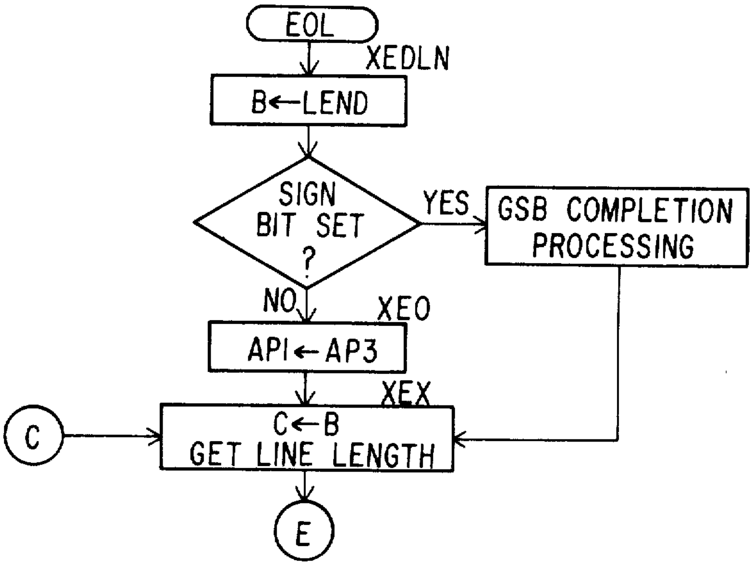


FIG 181A

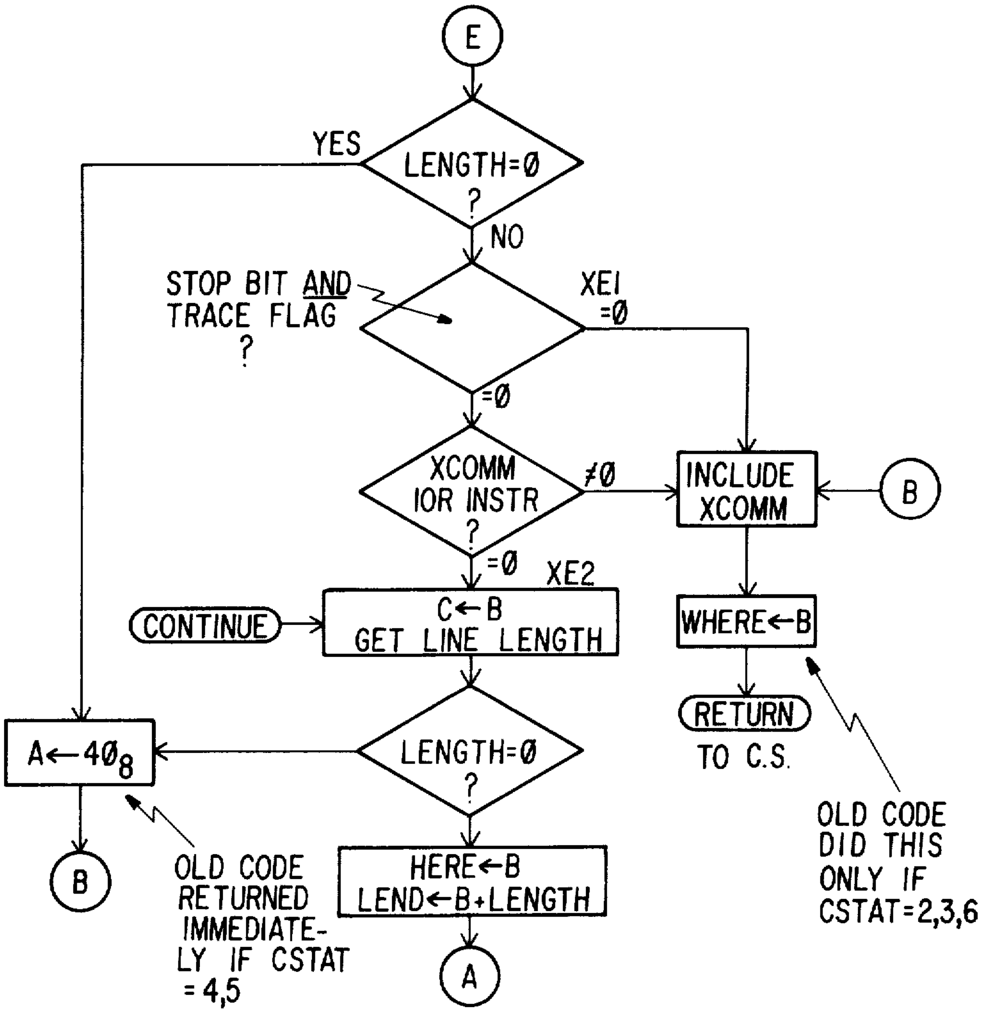
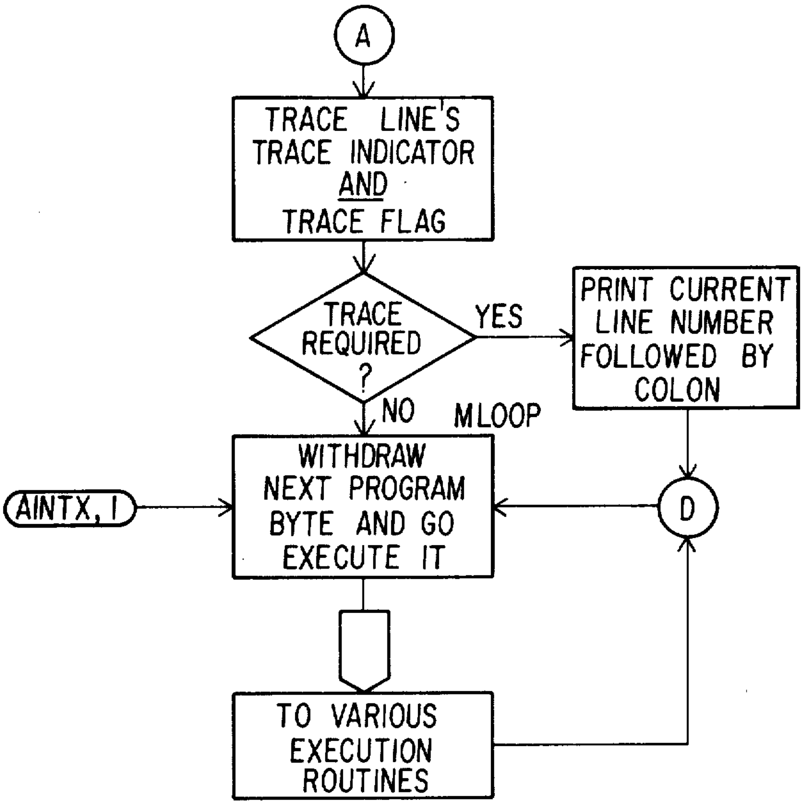

E
LENGTH=Ø ?
YES
NO
STOP BIT AND TRACE FLAG ?
XE1 =Ø
=Ø
XCOMM IOR INSTR ?
≠Ø
INCLUDE XCOMM
B
=Ø
XE2
CONTINUE
C←B GET LINE LENGTH
WHERE←B
RETURN TO C.S.
A←40₈
LENGTH=Ø ?
B
HERE←B LEND←B+LENGTH
A
OLD CODE RETURNED IMMEDIATE-LY IF CSTAT =4,5
OLD CODE DID THIS ONLY IF CSTAT=2,3,6

FIG 181B


A
TRACE LINE'S TRACE INDICATOR AND TRACE FLAG
TRACE REQUIRED ?
YES
PRINT CURRENT LINE NUMBER FOLLOWED BY COLON
NO
MLOOP
AINTX, I
WITHDRAW NEXT PROGRAM BYTE AND GO EXECUTE IT
D
TO VARIOUS EXECUTION ROUTINES

CSTAT SETTING

Ø IDLE            1 EXECUTE
2 RUN             3 LIVE-KEYBOARD RUN
4 ENT WAIT        5 ENT RUN
6 GSB IN LIVE KEYBOARD

FIG 181C

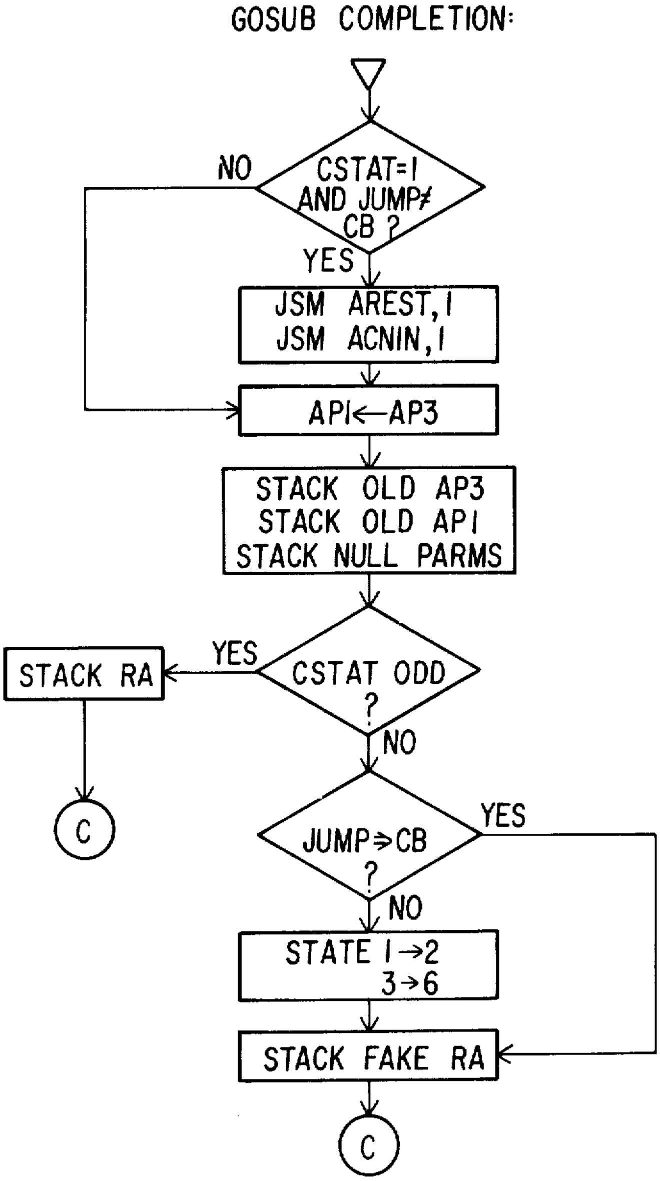

GOSUB COMPLETION:
CSTAT=1 AND JUMP≠ CB ?
NO
YES
JSM AREST,I
JSM ACNIN,I
API←AP3
STACK OLD AP3
STACK OLD API
STACK NULL PARMS
CSTAT ODD ?
YES
STACK RA
C
NO
JUMP⇒CB ?
YES
NO
STATE 1→2
3→6
STACK FAKE RA
C

FIG 181D

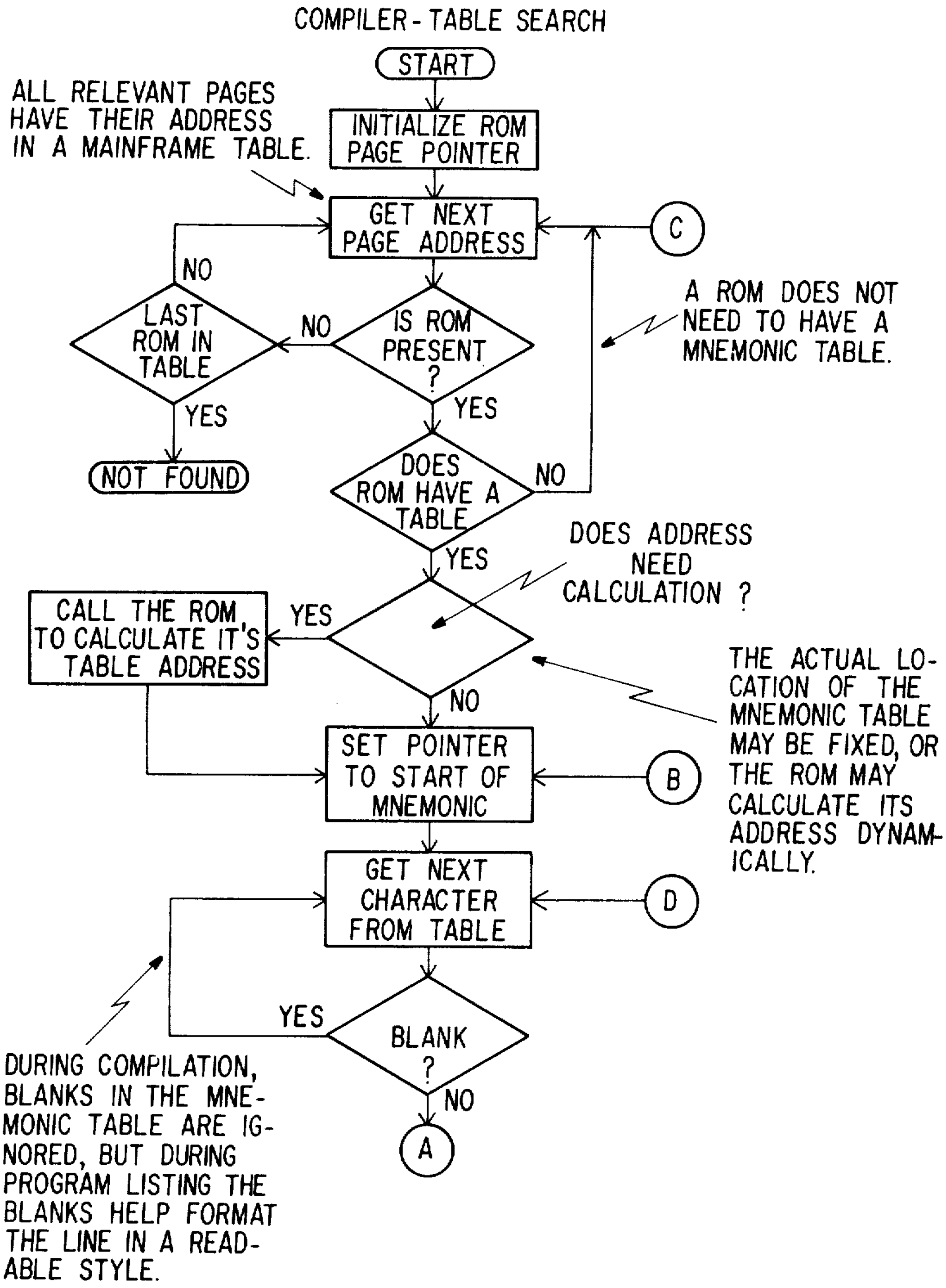

COMPILER-TABLE SEARCH
START
INITIALIZE ROM PAGE POINTER
ALL RELEVANT PAGES HAVE THEIR ADDRESS IN A MAINFRAME TABLE.
GET NEXT PAGE ADDRESS
C
NO
LAST ROM IN TABLE
NO
IS ROM PRESENT ?
A ROM DOES NOT NEED TO HAVE A MNEMONIC TABLE.
YES
YES
NOT FOUND
DOES ROM HAVE A TABLE
NO
YES
DOES ADDRESS NEED CALCULATION ?
CALL THE ROM TO CALCULATE IT'S TABLE ADDRESS
YES
NO
THE ACTUAL LOCATION OF THE MNEMONIC TABLE MAY BE FIXED, OR THE ROM MAY CALCULATE ITS ADDRESS DYNAMICALLY.
SET POINTER TO START OF MNEMONIC
B
GET NEXT CHARACTER FROM TABLE
D
YES
BLANK ?
NO
A
DURING COMPILATION, BLANKS IN THE MNEMONIC TABLE ARE IGNORED, BUT DURING PROGRAM LISTING THE BLANKS HELP FORMAT THE LINE IN A READABLE STYLE.

FIG 182A

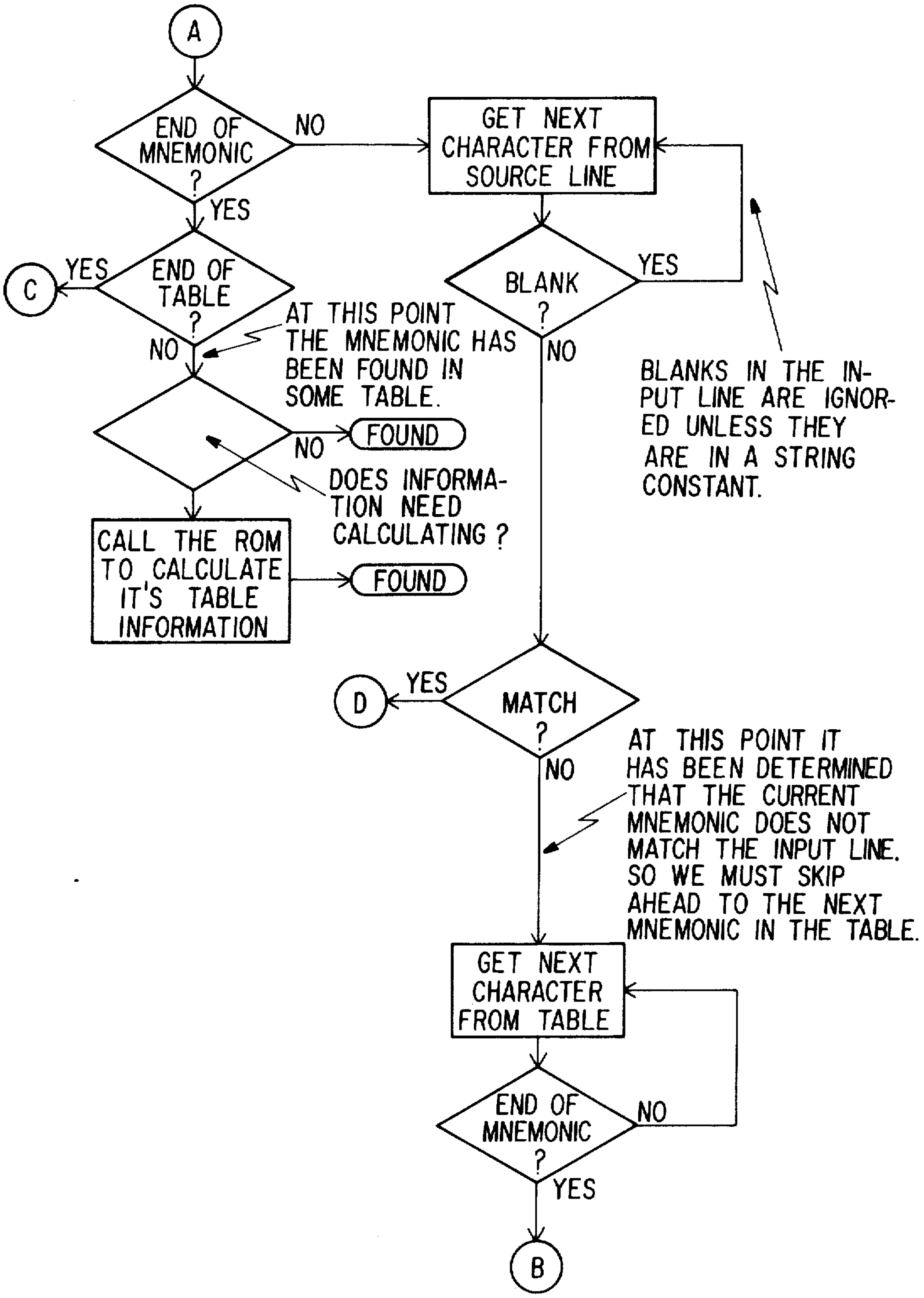

A
END OF MNEMONIC ?
NO
YES
GET NEXT CHARACTER FROM SOURCE LINE
BLANK ?
YES
NO
BLANKS IN THE INPUT LINE ARE IGNORED UNLESS THEY ARE IN A STRING CONSTANT.
C
YES
END OF TABLE ?
NO
AT THIS POINT THE MNEMONIC HAS BEEN FOUND IN SOME TABLE.
NO
FOUND
DOES INFORMATION NEED CALCULATING ?
CALL THE ROM TO CALCULATE IT'S TABLE INFORMATION
FOUND
D
YES
MATCH ?
NO
AT THIS POINT IT HAS BEEN DETERMINED THAT THE CURRENT MNEMONIC DOES NOT MATCH THE INPUT LINE. SO WE MUST SKIP AHEAD TO THE NEXT MNEMONIC IN THE TABLE.
GET NEXT CHARACTER FROM TABLE
END OF MNEMONIC ?
NO
YES
B

FIG 182B

# PROGRAMMABLE CALCULATOR

## BACKGROUND OF THE INVENTION

This invention relates generally to calculators and improvements therein and more particularly to programmable calculators that may be controlled both manually from the keyboard input unit and automatically by means of a stored program that has previously been loaded into the calculator memory from the keyboard input unit or an external magnetic record member.

Computational problems may be solved manually, with the aid of a calculator (a dedicated computational keyboard-given machine that may be either programmable or nonprogrammable) or a general purpose computer. Manual solution of computational problems is often very slow, so slow in many cases so as to be an impractical, expensive, and ineffective use of the human resource, particularly when there are other alternatives for solution of the computational problems.

Nonprogrammable calculators may be employed to solve many relatively simple computational problems more efficiently than they could be solved by manual methods. However, the keyboard operations or language employed by these calculators is typically trivial in structure, thereby requiring many keyboard operations to solve more general arithmetic problems. Programmable calculators may be employed to solve many additional computational problems at rates hundreds of times faster than manual methods. However, the keyboard language employed by these calculators is also typically relatively simple in structure, thereby again requiring many keyboard operations to solve more general arithmetic problems.

Conventional programmable calculators have also been restricted to operation in accordance with a single fixed program language. It would be advantageous to provide a programmable calculator in which the user may select at will any one of a number of different calculator or computer languages.

## SUMMARY OF THE INVENTION

The principal object of this invention is to provide an improved programmable calculator that has more capability and flexibility than conventional programmable calculators, that is smaller, less expensive, and more efficient in evaluating mathematical functions than are conventional computer systems, and that is much easier for the unskilled user to operate than either conventional programmable calculators or computer systems.

Another object of this invention is to provide a programmable calculator in which the user may employ a reset key at any time during operation of the calculator to initialize the calculator without thereby erasing any information stored in the calculator memory.

Another object of this invention is to provide a programmable calculator in which a visual cursor can be selectively entered into a displayed line of alphanumeric characters from either the left-hand end of that line or the right-hand end of that line.

Another object of this invention is to provide a programmable calculator in which the user may execute statements manually from the keyboard at the same time the calculator is executing a program stored in the calculator memory.

Another object of this invention is to provide a programmable calculator in which the user may obtain, under program control, a printed listing of selected information stored in the calculator memory.

Another object of this invention is to provide a programmable calculator in which the user may, at any point during execution of a program stored in the calculator read-write memory, transfer the entire contents of the read-write memory, including all data and relevant housekeeping information existing at the time of transfer, to an external magnetic tape, and may thereafter load that transferred information back into the calculator read-write memory for automatic resumption of execution of the program at the point therein at which the transfer occurred.

Another object of this invention is to provide a programmable calculator in which the user may insert additional characters at a designated position in a line of alphanumeric information by moving an insert cursor to that position and by then simply actuating keys representing the desired characters to be inserted.

Another object of this invention is to provide a programmable calculator in which the user may coarsely and finely position, within a display, a line of alphanumeric information whose length exceeds that of the display by selectively actuating a group of display position control keys.

Another object of this invention is to provide a programmable calculator in which an attempt to store a line of alphanumeric statements containing a syntax error results in a visual error message being indicated to the user and in which subsequent actuation of a recall key results in that erroneous line being visually displayed with a cursor indicating the location of the syntax error.

Another object of this invention is to provide a programmable calculator in which the user may select either one of two visual cursors to designate separate editing functions to be performed in connection with a displayed line of alphanumeric information.

Another object of this invention is to provide a programmable calculator in which interrupt service routines employed in connection with peripheral input/output units may be written by the user in keyboard language.

Another object of this invention is to provide a programmable calculator in which the user can declare an interrupt priority among a plurality of peripheral input/output units to eliminate user attention to interrupt requests.

Another object of this invention is to provide a programmable calculator that automatically adjusts addresses designated in relative branch statements of a program stored in the calculator memory in accordance with any program editing performed by the user.

Another object of this invention is to provide a programmable calculator in which the user may specify an array through use of a dimension statement that includes one or more variables to represent the size of the array.

Another object of this invention is to provide a programmable calculator in which the user may specify, as part of an enter statement, an array that may include an expression to specify a subscript thereof and in which the expression is automatically evaluated by the calculator and the result thereof displayed for the user.

Another object of this invention is to provide a programmable calculator in which a specified array may include an expression to designate a subscript thereof and in which a trace mode of operation is provided to automatically evaluate the expression and display the result thereof to the user.

Another object of this invention is to provide a programmable calculator in which the user may completely change the language of the calculator by replacing a plug-in language read-only memory.

Another object of this invention is to provide a programmable calculator in which the user may call a rounding function for rounding a number to a specified number of digits.

Another object of this invention is to provide a programmable calculator in which the user may call a tangent function and specify as an argument of that function any angle up to $10^{99}$°.

Another object of this invention is to provide a programmable calculator in which the user may direct execution of a program to begin or continue at a labelled program statement.

Another object of this invention is to provide a programmable calculator in which the user may select an exclusive or logic operator for use in constructing alphanumeric statements.

Another object of this invention is to provide a programmable calculator in which the user may recall into the display either the last or the penultimate line of one or more alphanumeric statements executed by the calculator or stored in the calculator memory by actuating a recall key either once or twice, respectively.

Another object of this invention is to provide a programmable calculator in which the user may, during program execution, direct execution of the program to any one of a plurality of program lines by simply actuating an appropriate one of the keys of a keyboard input unit.

Another object of this invention is to provide a programmable calculator in which the user may communicate via the calculator keyboard with a plurality of peripheral input/output units connected to the calculator by means of a universal interface but without regard for conventions of that universal interface bus.

Other and incidental objects of this invention will become apparent to those persons skilled in the art upon detailed examination of the following portions of this specification.

These objects are accomplished in accordance with the illustrated preferred embodiment of this invention by employing a keyboard input unit, a magnetic tape cassette reading and recording unit, a 32-character light-emitting diode (LED) display, a 16-character thermal printer unit, a memory unit, and a central processing unit (CPU) to provide an adaptable programmable calculator having manual operating, automatic operating, program entering, magnetic tape reading, and magnetic tape recording modes.

The keyboard input unit includes a group of numeric data keys for entering data into the calculator, a group of algebraic operator keys for use in entering algebraic statements into the calculator, a second set of numeric keys, a complete set of alphabetic keys and a group of special character keys all arranged in a configuration slightly modified from that of a typewriter keyboard, a group of program editing and display control keys useful in editing displayed lines of alphanumeric information, a group of system command keys for listing programs of alphanumeric statements stored in the calculator memory, for controlling the operation of the magnetic tape cassette reading and recording unit, for controlling the calculator memory, and for otherwise controlling operation of the calculator, and a group of user-definable keys. Many of these groups of keys are useful in both the manual and automatic operating modes of the calculator.

The magnetic tape cassette reading and recording unit includes a reading and recording head, a drive mechanism for driving a magnetic tape past the reading and recording head, and reading and recording drive circuits coupled to the reading and recording head for bidirectionally transferring information between the magnetic tape and the calculator as determined by alphanumeric statements executed from the keyboard or as part of a program stored in the calculator memory.

The memory unit includes a modular random-access read-write memory having a dedicated system area and a separate user area for storing alphanumeric program statements and/or data. The user portion of the read-write memory may be expanded without increasing the overall dimensions of the calculator by the addition of a plug-in read-write memory module. Additionl read-write memory made available to the user is automatically accommodated by the calculator, and the user is automatically informed of the number of available program storage locations and when the storage capacity of the read-write memory has been exceeded.

The memory unit also includes a modular read-only memory in which routines and subroutines of assembly language instructions for performing the various functions of the calculator are stored. The read-only memory comprises a plug-in mainframe language read-only memory for defining the language of the calculator and a group of optional plug-in function read-only memories that may be selectively added by the user to increase the functional capability of the calculator within the framework of the language defined by the mainframe language ROM. Receptacles are provided in the front base of the calculator housing to accommodate up to four plug-in function read-only memories. A receptacle is likewise provided on the right side panel of the calculator housing to accommodate the single mainframe language ROM. By plugging an appropriate different mainframe language ROM into the receptacle provided therefore, the operating language of the calculator can be changed from the standard algebraic language described hereinafter to either BASIC, FORTRAN, ALGOL or APL computer languagte, for example. Different mainframe language plug-in read-only memories, as well as any plug-in function read-only memories added by the user, are automatically accommodated by the calculator.

Exemplary of the plug-in function read-only memories that the user may add to increase the functional capabilities of the calculator are a plotter ROM, a string variables ROM, a general input/output ROM, a matrix ROM, an advanced programming ROM, an extended input/output ROM, and a disc memory ROM.

The LED display unit is hardware-refreshed and features 32-character 5 × 7 dot matrix alphanumeric capability. Hardware refreshing of the display allows the user to use the display in connection with keyboard calculations at the same time the microprocessor is executing a program stored in the calculator memory.

The central processing unit (CPU) may comprise, for example, an LSI MOS hybrid microprocessor that includes a binary processor chip, an input/output (I/O) chip, and an extended math chip together with necessary buffering circuitry. This processor utilizes 16-bit parallel bus architecture which, at various points in time, handles address, instruction or data information. Also included are two 16-bit general purpose accumulators, memory stack instruction capability, two-level vectored interrupt capability, a single direct memory access channel, and math instructions for handling binary-coded-decimal floating point numbers.

In the run mode of operation, the calculator is controlled by an internal stored format generated by the calculator in response to actuation by the user of selected keys of the keyboard input unit. Each internal stored format is employed as a pointer to the address of the routine stored in the calculator read-only memory that is required for execution of the selected keyboard instruction.

In the program mode of operation, the internal stored format generated by the calculator during entry of a program is stored in the program storage area of the user read-write memory. This internal stored format, compiled from lines of alphanumeric statements entered into the calculator by the user, constitutes a program that may be automatically executed by the calculator upon request by the user. During program entry, the output printer may be commanded, by means of a keyboard switch, to provide a printed listing of the keyboard statements entered by the user together with the corresponding program line at which the associated internal stored format is stored. Since several key actuations may result in generation by the calculator of a single compiled instruction code and since the calculator executes only these internal instruction codes, a complex program can be stored and executed by the calculator very efficiently and in a short period of time.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of a programmable calculator according to the preferred embodiment of this invention.

FIG. 2 is a rear perspective view of the programmable calculator of FIG. 1.

FIG. 3 is a plan view of the keyboard input unit employed in the programmable calculator of FIG. 1.

FIG. 4 is a simplified block diagram of the hardware associated with the calculator of FIG. 1.

FIG. 5 is a simplified block diagram of the firmware associated with the calculator of FIG. 1.

FIG. 6 is a memory map showing the format of the various read-write and read-only memories within the calculator memory section of FIG. 4.

FIG. 7 is a memory map showing the format of each of the twelve individual read-only memory chips within the mainframe language ROM of FIG. 4.

FIG. 8 is a memory map of the basic and optional read-write memories of FIGS. 4 and 6.

FIG. 9 is a detailed memory map of a portion of the read-write memory of FIG. 8 that is reserved for the special function keys.

FIG. 10 is a detailed memory map of the portion of the read-write memory of FIG. 8 that is employed as a user program area.

FIG. 11 is a detailed memory map of the portion of the read-write memory of FIG. 8 that is employed as a statement parameter stack.

FIG. 12 is a detailed memory map of the portion of the read-write memory of FIG. 8 that is employed as a subroutine stack.

FIG. 13 is a detailed memory map of the portion of the read-write memory of FIG. 8 that is employed as a for/next stack.

FIGS. 14A-B are a detailed memory map of the portion of the read-write memory of FIG. 8 that is employed as a value table.

FIG. 15 is a detailed memory map of the base page portions of the language read-only memory of FIG. 7 and the read-write memory of FIG. 8.

FIG. 16 is a detailed block diagram of the processor of FIG. 4.

FIG. 17 is a detailed schematic diagram of the clock generator of FIG. 16.

FIG. 18 is a detailed schematic diagram of the preset circuit of FIG. 16.

FIG. 19 is a detailed block diagram of the microprocessor of FIG. 16.

FIG. 20 is a detailed logic diagram of one of the BIBs of FIGS. 16 and 19.

FIG. 21 is a diagram illustrating the memory addressing convention employed by the BPC of FIG. 19.

FIG. 22 is a diagram illustrating current page absolute addressing employed by the BPC of FIG. 19.

FIG. 23 is a diagram illustrating relative addressing employed by the BPC of FIG. 19.

FIGS. 24A-G are a tabular illustration of the instruction set and corresponding bit patterns associated with the BPC of FIG. 19.

FIGS. 25A-C are a detailed block diagram of the BPC of FIG. 19.

FIG. 26 is a detailed block diagram of the connection between the IDA bus of FIG. 19 and the $\overline{\text{IDB}}$ bus of FIGS. 25A-B.

FIG. 27 is a detailed schematic diagram illustrating how the DMP ST microinstruction is placed on the $\overline{\text{IDB}}$ bus of FIGS. 25A-B and illustrating the details of a pre-charger and a 01 enhancer associated with the $\overline{\text{IDB}}$ bus.

FIG. 28 is a detailed schematic diagram of the D register of FIGS. 25A-B.

FIG. 29 is a detailed block diagram of the I register of FIGS. 25A-B.

FIG. 30 is a detailed schematic diagram of the upper twelve bits of the I register of FIG. 29.

FIG. 31 is a detailed schematic diagram of the CTQ generator of FIG. 29.

FIG. 32 is a detailed schematic diagram of the lower four bits of the I register of FIG. 29.

FIG. 33 is a detailed block diagram of the instruction decode block of FIGS. 24A-B.

FIGS. 34A-D are a table of the 29 instruction categories decoded by the instruction category identifier of FIG. 33.

FIGS. 35A-E are a tabular illustration of the relationship between the 29 instruction categories of FIGS. 34A-D and the instruction bit patterns of FIGS. 24A-G.

FIG. 36 is a tabular illustration of the details of generation of the instruction group qualifiers appearing at the output of the instruction group decoder of FIG. 33 from the outputs of the instruction category identifier of FIG. 33.

FIG. 37 is a detailed schematic diagram of the asynchronous instruction generator of FIG. 33.

FIG. 38 is a detailed block diagram of the control ROM included within the BPC of FIGS. 25A-B.

FIG. 39 is a detailed schematic diagram of the 4-bit state counter and drivers of FIG. 38.

FIG. 40 is a diagram illustrating the natural state sequence of the state counter of FIG. 38.

FIG. 41 is a detailed schematic diagram of the microinstruction decoding circuitry of FIG. 38.

FIG. 42 is a detailed schematic diagram of the non-sequential state-count generator of FIG. 38.

FIG. 43 is a diagram illustrating the logical properties of the non-sequential state-count generator of FIG. 38.

FIG. 44 is a detailed schematic diagram of the next state-count encoder of FIG. 42.

FIG. 45A is a detailed block diagram of the R register of FIG. 25A-B.

FIG. 45B is a detailed schematic diagram showing the origin of various signals employed by the R register of FIG. 45A.

FIG. 45C is a detailed schematic diagram of one of the bits of the R register of FIG. 45A.

FIG. 46A is a detailed block diagram of the A and B registers of FIGS. 25A-B.

FIG. 46B is a detailed block diagram of the ZAB bus control of FIGS. 25A-B.

FIG. 47A is a detailed schematic diagram of one of the bits of each of the A and B registers of FIG. 46A.

FIG. 48 is a detailed schematic diagram of the $\overline{ZAB}$ bus and the $\overline{ZAB}$ bus control block of FIGS. 25A-B.

FIG. 49 is a detailed block diagram of the S register and the S register shift control block of FIGS. 25A-B.

FIG. 50 is a detailed schematic diagram of the S register of FIG. 49.

FIG. 51 is a detailed schematic diagram of the S register shift control block of FIG. 49.

FIG. 52 is a detailed schematic diagram of the ALU of FIGS. 25A-B.

FIG. 53 is a detailed block diagram of the adder and complementer of FIG. 52.

FIG. 54 is a detailed schematic diagram of the complementer of FIG. 53 together with its associated circuitry.

FIG. 55 is a diagram illustrating the rules for generating sum and carry bits during addition operations performed by the ALU of FIG. 52.

FIG. 56 is a detailed schematic diagram of a portion of the circuitry within the adder of FIG. 53.

FIG. 57 is a detailed schematic diagram of the ALU control block of FIG. 52.

FIG. 58 is a detailed schematic diagram of the output selector and LSB/MSB trap blocks of FIG. 52.

FIG. 59 is a detailed block diagram of the extend and overflow registers of FIGS. 25A-N in a non-ERA mode.

FIG. 60 is a detailed block diagram of the extend and overflow registers of FIGS. 25A-B connected in a non-ERA mode.

FIG. 60 is a detailed block diagram of the extend and overflow registers of FIGS. 25A-B connected in an ERA mode.

FIG. 61 is a detailed schematic diagram of the EX/OV control block FIG. 59.

FIG. 62 is a detailed schematic diagram of the extend, overflow, set EX, set OV, and EX/OV selector #1 blocks of FIG. 59.

FIG. 63 is a detailed schematic diagram of EX, OV, and EX/OV selector #2 of blocks of FIG. 60.

FIG. 64 is a detailed schematic diagram of the flag multiplexor of FIGS. 25A-B.

FIG. 65 is a detailed schematic diagram of the skip matrix of FIGS. 25-B.

FIG. 66 is a detailed schematic diagram of the P register of FIGS. 25A-B.

FIG. 67 is a detailed schematic diagram of the T register of FIGS. 25A-B.

FIG. 68 is a detailed block diagram of a portion of the overall block diagram of FIGS. 25A-B that comprises a program adder section.

FIG. 69 is a diagram illustrating how the program adder section of FIG. 68 generates a 15-bit base page address from the 10-bit field of a memory reference instruction.

FIG. 70 is a diagram illustrating how the program adder section of FIG. 68 generates a 15-bit relative current page address from the 10-bit field of a memory reference instruction.

FIG. 71 is a diagram illustrating how the program adder section of FIG. 68 generates a 15-bit absolute current page address from the 10-bit field of a memory reference instruction.

FIG. 72 is a diagram illustrating how the program adder section of FIG. 68 generates a 15-bit memory address from the 6-bit field of a skip instruction.

FIG. 73 is a diagram illustrating the increment P mode of operation of the program adder section of FIG. 68.

FIG. 74 is a detailed schematic diagram of the P-adder input (PAI) of FIG. 68.

FIG. 75 is a detailed block diagram of the P-adder of FIG. 68.

FIG. 76 is a detailed schematic diagram of the P-adder control and the P-adder output selector blocks of FIG. 68.

FIG. 77 is a detailed schematic diagram of the addressing mode selector of FIG. 68 and the service logic of FIG. 75.

FIG. 78 is a detailed schematic diagram of the P-adder of FIG. 75.

FIG. 79 is a detailed block diagram of the BPC register detection and address latches block and the indirect circuit of FIGS. 25A-B.

FIG. 80 is a detailed schematic diagram of a portion of the circuitry of FIG. 79.

FIG. 81 is a detailed schematic diagram of the BPC-register address detector of FIG. 79.

FIG. 82 is a detailed schematic diagram of the BPC-register LSB address latches of FIG. 79.

FIGS. 83A-B are a detailed block diagram of the M-section of FIGS. 25A-B.

FIG. 84 is a detailed schematic diagram of a portion of the circuitry of FIG. 83A.

FIG. 85 is a detailed schematic diagram of a portion of the circuitry of FIG. 83A.

FIG. 86 is a flow chart illustrating the logic flow of the circutry of FIGS. 84 and 85.

FIG. 87 is a detailed schematic diagram of a portion of the circuitry of FIG. 83B.

FIG. 88 is a detailed schematic diagram of a portion of the circuitry of FIG. 83B.

FIG. 89 is a detailed schematic diagram of a portion of the M-section of FIGS. 25A-B.

FIG. 90 is a detailed schematic diagram of a portion of the circuitry of FIG. 83A.

FIGS. 91A-E are illustrations of the conventions used in the BPC ASM chart of FIGS. 92-103.

FIG. 92 is a diagram showing the overall relationship of the flow chart segments of FIGS. 93-103.

FIG. 93 is a flow chart segment of the instruction fetch and fanout activity of the BPC of FIG. 19.

FIG. 94 is a flow chart segment of the load, add, and, or, and compare machine instructions executed by the BPC of FIG. 19.

FIG. 95 is a flow chart segment of the STA and STB machine instruction executed by the BPC of FIG. 19.

FIG. 96 is a flow chart segment of the ISZ and DSZ machine instructions executed by the BPC of FIG. 19.

FIG. 97 is a flow chart segment of the JMP and JSM machine instructions executed by the BPC of FIG. 19.

FIG. 98 is a flow chart segment of the EXE machine instruction executed by the BPC of FIG. 19.

FIG. 99 is a flow chart segment of the RET machine instruction executed by the BPC of FIG. 19.

FIG. 100 is a flow chart segment of the alter-skip group of machine instructions executed by the BPC of FIG. 19.

FIG. 101 is a flow chart segment of the shift-rotate group of machine instructions executed by the BPC of FIG. 19.

FIG. 102 is a flow chart segment of the complement group of machine instructions executed by the BPC of FIG. 19.

FIG. 103 is a flow chart segment illustrating the response of the BPC of FIG. 19 to a request for execution of a non-BPC machine instruction.

FIG. 104 is a flow chart of memory cycle operation initiated by the M-section of FIGS. 25A-B.

FIG. 105 is a tabular illustration of the addressing capability embodied in the flow chart of FIG. 104.

FIG. 106 is an illustration of the conventions used in the waveform diagrams of FIGS. 107A-119B.

FIGS. 107A-C are a waveform diagram illustrating a read memory cycle in which the source address is a BPC register.

FIGS. 108A-B are a waveform diagram illustrating two consecutive read memory cycles originating with the BPC in which the source addresses are in the external memory.

FIG. 109 is a waveform diagram illustrating a generalized BPC-originated read memory cycle.

FIGS. 110A-D are a waveform diagram illustrating a write memory cycle in which the destination address is a BPC register

FIGS. 111A-C are a waveform diagram illustrating two consecutive write memory cycles originating with the BPC in which the destination addresses are in the external memory.

FIG. 112 is a waveform diagram illustrating a generalized BPC-originated write memory cycle not involving handshake.

FIG. 113 is a waveform diagram illustrating a generalized 5-state BPC-originated write memory cycle with handshake.

FIG. 114 is a waveform diagram illustrating a generalized 6-state BPC-originated write memory cycle with handshake.

FIGS. 115A-C are a waveform diagram illustrating the initial start up and first instruction fetch of the BPC.

FIG. 116 is a waveform diagram illustrating the capture of external flags during a BPC instruction fetch.

FIGS. 117A-B are a waveform diagram illustrating an interrupt of the BPC during an instruction fetch.

FIG. 118 is a flow chart illustrating the logical relationship betweeen a bus request and a bus grant.

FIGS. 119A-B are a waveform diagram illustrating the timing relationship between a bus request and a bus grant.

FIGS. 120A-E are a tabular representation of the contents of the read-only memory portion of the BPC of FIGS. 19 and 25A-B.

FIG. 121 is a waveform diagram illustrating a write I/O bus cycle.

FIG. 122 is a waveform diagram illustrating a read I/O bus cycle.

FIG. 123 is a diagram illustrating the indirect addressing sequence implemented by the BPC and IOC of FIG. 19 during an interrupt.

FIG. 124 is a pictorial representation of the use of the extended bus grant capability of the microprocessor of FIG. 19.

FIGS. 125A-C are a tabular illustration of the instruction set and corresponding bit patterns associated with the IOC of FIG. 19.

FIGS. 126A-C are a detailed block diagram of the IOC of FIG. 19.

FIG. 127 is a diagram illustrating the format in which 12-digit floating point binary-coded-decimal numbers are encoded for use by the EMC of FIG. 19.

FIGS. 128A-C are a tabular illustration of the instruction set and corresponding bit patterns associated with the EMC of FIG. 19.

FIGS. 129A-C are a detailed block diagram of the EMC of FIG. 19.

FIG. 130 is a detailed schematic diagram of the bus control block of FIG. 16.

FIG. 131 is a detailed schematic diagram of the memory timing control block of FIG. 16.

FIG. 132 is a detailed block diagram of the mainframe language ROM, ROM interface, and plug-in ROM of FIG. 4.

FIG. 133 is a detailed schematic diagram of one of the individual ROM chips employed in the mainframe language ROM, ROM interface, and plug-in ROM of FIGS. 4 and 132.

FIG. 134 is a detailed schematic diagram of an address section of the basic and optional read-write memories of FIG. 4.

FIG. 135 is a detailed schematic diagram of a memory control section of the basic and optional read-write memories of FIG. 4.

FIG. 136 is a waveform diagram illustrating the timing relationship between various signals involved in the read-write memory control section circuitry of FIG. 135.

FIG. 137 is a detailed schematic diagram of a read-write memory devices section of the basic and optional read-write memories of FIG. 4.

FIG. 138 is a detailed schematic diagram of an I/O interface section of the KDP control block of FIG. 4.

FIG. 139 is a detailed schematic diagram of a keyboard scan circuit section of the KDP control block of FIG. 4.

FIG. 140 is a detailed schematic diagram of a timing generator section of the KDP control block of FIG. 4.

FIG. 141 is a waveform diagram illustrating the timing relationship between various signals involved in the timing generator section of FIG. 140.

FIG. 142 is a detailed schematic diagram of a memory section of the KDP control block of FIG. 4.

FIG. 143 is a detailed schematic diagram of a display control section of the KDP control block of FIG. 4.

FIG. 144 is a detailed block diagram of the display of FIG. 4.

FIG. 145 is a waveform diagram illustrating the timing relationship between various signals involved in the display control section of FIG. 143.

FIGS. 146A–B are a detailed schematic diagram of a printer control section of the KDP control block of FIG. 4.

FIG. 147 is a detailed block diagram of the printer of FIG. 4.

FIGS. 148A–B are a waveform diagram illustrating the timing relationship between various signals involved in the printer control section of FIGS. 146A–B.

FIGS. 149A–C are a detailed schematic diagram of an I/O interface section of the cassette control block of FIG. 4.

FIG. 150 is a detailed schematic diagram of a tape hole detection circuit section of the magnetic tape cassette unit of FIG. 4.

FIGS. 151A–C are a detailed schematic diagram of a servo section of the cassette control block of FIG. 4.

FIG. 152 is a detailed schematic diagram of a write electronics section of the cassette control block of FIG. 4.

FIGS. 153A–B are a detailed schematic diagram of a read electronics section of the cassette control block of FIG. 4.

FIGS. 154A–C are a detailed schematic diagram of the power module and power supply blocks of FIG. 4.

FIG. 155 is a flow chart of a reset subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 156A–B are a flow chart of a list subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 157 is a flow chart of a flashing cursor subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 158A–B are a flow chart illustrating a double buffering feature of the calculator of FIG. 1.

FIGS. 159A–L are a flow chart of line editing subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 160A–D are a flow chart of array allocation subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 161 is a flow chart of two rounding subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 172 is a flow chart of a quote recognition subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 163A–F are a flow chart of enter statement subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 164 is a flow chart of a read binary subroutine stored in the calculator read-only memory.

FIG. 165 is a flow chart of a prescale subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 166 is a flow chart of a GTO/GSB destinaton adjustment subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 167A–B are a flow chart of live keyboard key processing subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 168A–B are a flow chart of live keyboard execution routines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 169A–B are a flow chart of live keyboard interpreter routines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 170A–D illustrate the information structure of a magnetic tape employed in the magnetic tape cassette reading and recording unit of the calculator.

FIGS. 171A–B are a flow chart of a magnetic tape recording routine and subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 172A–B are a flow chart of a magnetic tape reading routine and subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 173 is a diagram illustrating line bridging performed by the routine of FIGS. 172A–B.

FIG. 174 is a flow chart of a load memory subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 175 is a flow chart of a record memory subroutine stored in the mainframe language ROM of FIGS. 4 and 7.

FIG. 176 is a flow chart of an HPIB transparency routine and subroutine stored in the calculator read-only memory.

FIGS. 177A–B are a flow chart of a reverse compiler routine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 178A–B are a flow chart of a number builder routine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 179A–B are a flow chart of a compiler-scanner routine stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 180A–C are a flow chart of GOTO/GOSUB processing subroutines stored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 181A–D are a flow chart of end-of-line execution routines astored in the mainframe language ROM of FIGS. 4 and 7.

FIGS. 182A–B are a flow chart of a compiler-table search routine stored in the mainframe language ROM of FIGS. 4 and 7.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

## GENERAL DESCRIPTION

Referring to FIG. 1, there is shown a programmable calculator including both a keyboard 320 for entering information into the calculator and for controlling the operation of the calculator and a magnetic tape cassette reading and recording unit 360 for recording information stored within the calculator onto one or more external tape cartridges 12 and for loading information stored on such tape cartridges back into the calculator. The calculator also includes a 32-character 5 × 7 dot matrix light-emitting diode (LED) display 330 for displaying alphanumeric statements entered into the calculator, results of statement execution, error conditions encountered during operation of the calculator, and messages and data prompts generated during program execution. The calculator further includes a 16-column alphanumeric thermal printer 340 for printing computation results, program listings, and messages generated by the calculator or the user. One or more plug-in read-only memories 230 for increasing the functional capability of the calculator may be plugged into a group of four ROM receptacles 14 provided in the front base of the calculator. A plug-in mainframe language ROM 210 that defines the operating language of the calculator resides in a slot provided on the right base of the calculator. By replacing the mainframe language ROM, the operating language of the calculator may be changed, for example, to either BASIC, FORTRAN, ALGOL or APL computer language.

As shown in FIG. 2, the rear panel of the calculator includes three input/output (I/O) receptacles **30** for accepting I/O interface modules **32**. These I/O interface modules serve to couple the calculator to various selected peripheral I/O units such as X-Y plotters, printers, typewriters, photoreaders, paper tape punches, digitizers, BCD-compatible data gathering instruments such as digital voltmeters, frequency synthesizers, and network analyzers, and a universal interface bus for interfacing to most bus-compatible instrumentation.

The overall operation of the calculator hardware may be understood with reference to the block diagram of FIG. **4**. A central processing unit (CPU) **100** handles all data processing performed by the calculator and is arranged to cooperate with a memory section **200** and an I/O section **300**. Memory section **200** comprises the mainframe language ROM **210**, a basic read-write memory **220**, the optional plug-in read-only memory modules **230**, and an optional read-write memory **240**. I/O section **300** includes a keyboard/display/printer (KDP) control circuit **310**, the keyboard input unit **320**, the display **330**, the thermal printer **340**, the magnetic tape cassette reading and recording unit **360**, a magnetic tape control circuit **350**, and an I/O interface circuit **370**. A power module **410** includes a line transformer, a power switch **16** located on the right panel of the calculator, a group of line voltage selection switches, and a group of fuses. The fuses and line voltage selection switches are located within a printer paper supply compartment that is accessible through a hinged cover **18** on the top panel of the calculator.

## CENTRAL PROCESSING UNIT

Referring now to FIG. **16**, there is shown a more detailed block diagram of the central processing unit **100** of FIG. **4**. The heart of the CPU **100** is a microprocessor **101**. Microprocessor **101** is a hybrid combination of three NMOS integrated circuits and four schottky TTL bidirectional data buffers. Microprocessor **101** requires two-phase clocking that is generated by a clock generator circuit **102**. A preset circuit **103** initializes the microprocessor **101** by means of a signal POP when the power is not valid, as indicated by a line PVL, or when a RESET key on keyboard input unit **320** is actuated, as indicated by a RESET line. A bus control circuit **104** determines the direction of data flow on the memory bus and further determines which memory section is allowed to place data on the memory bus. A memory timing and control circuit **105** provides the proper timing signals for interfacing the the microprocessor **101** to the various memory sections.

## CLOCK GENERATOR

Operation of the clock generator circuit **102** of FIG. **16** may be understood with reference to the detailed schematic diagram of FIG. **17** and with further reference to copending U.S. Pat. application Ser. No. 599,500 entitled TWO-PHASE CLOCK CIRCUIT, filed Jul. 28, 1975, by Loyd F. Nelson et al and assigned to the same assignee as the present application. A duel voltage controlled multivibrator **U8** may comprise, for example, a Motorola MC**4024** package. Section **U8A** of this package and its associated components are employed to generate a nominal frequency of 11.6 megahertz. Section **U8A** is biased at a nominal voltage of 4.0 volts via resistor **R23** from a power supply and a divider network comprising diode **CR1** and resistors **R20** and **R21**. Section **U8B**, similarly biased, generates a signal having a nominal frequency of 10 kilohertz that is integrated by resistor **R16** and capacitor **C15** to produce a triangular waveform. The triangular waveform is then used to modulate the nominal 10-kilohertz frequency, thus spreading the energy associated with the basic frequency over a frequency spectrum of 11.2 megahertz to 12 megahertz and reducnbg both the conducted and radiated energy to an acceptable limit at any given frequency. The resulting frequency is divided by a flip-flop **U7** to produce the clock frequency used in the calculator. Devices **U4**, **U5**, and **U6** provide the two non-overlapping clock signals required by the microprocessor **101**. Device **U4**, which may comprise, for example, a Motorola MMH**0026**, converts the TTL signal levels to MOS levels, as requied by microprocessor **101**. A pair of inverters **U6A** and **U6B** feed back the clock signals to **U5B** and **U5A** to inhibit each clock signal from proceeding to the high logic state until the other clock signal has reached the low logic state. Schottky TTL devices are utilized for the gates of devices **U5** and **U6** to minimize the amount of time each clock signals resides in the low logic state while insuring that the two clock signals will not overlap. The feedback signals of both inverters **U6A** and **U6B** are also distributed to various circuits within the calculator requiring synchronization with the microprocessor. Exemplary of these circuits are the memory timing control circuit **105**, the basic and optional read-write memories **220** and **240**, a monitor interface circuit, and the preset circuit **103**. An output of clock generator **102** is also provided for the KDP control circuit **310** of FIG. **4** for display and printer timing purposes

## PRESET CIRCUIT

Operation of the preset circuit **103** of FIG. **16** may be understood with reference to the detailed schematic diagram of FIG. **18**. The output of a flip-flop **U7** is a power-on pulse POP that is employed to initialize microprocessor **101**. Flip-flop **U7** synchronizes a power valid line PVL and a reset key line RESET for the microprocessor **101**. The PVL line indicates when the power supply voltages are valid. Since the signal on the PVL line transitions slowly, a pair of resistors **R13** and **R14** are employed to provide sufficient hysteresis to protect against false transitions. Preset circuit **103** also generates an initialization signal INIT that is coupled via the I/O bus of FIG. **16** to the various I/O control circuits **310**, **350**, and **370** of FIG. **4** to initialize I/O section **300** simultaneously with initialization of microprocessor **101**.

## MICROPROCESSOR

Operation of the microprocessor **101** of FIG. **15** may be understood with reference to the detailed block and schematic diagrams of FIGS. **19–129C**. Microprocessor **101** is employed to fetch and execute programmed machine language instructions stored in the memory and to provide a means of communication with various peripheral I/O units. Microprocessor **101** is a hybrid assembly whose active components are four 8-bit bidirectional interface buffers (BIB), a binary processor chip (BPC), an input/output controller (IOC), and an extended math chip (EMC), as shown in the detailed block diagram of FIG. 19. The BPC, IOC, and EMC are each NMOS LSI integrated circuits, while each BIB comprises bipolar devices exclusively,.

Referring now to FIG. 20, there is shown a detailed diagram of the internal logic of each 8-bit BIB. Each bit is buffered in both directions by tri-state buffers controlled by non-overlapping buffer enable signals. A pair of 8-bit BIBs forms a 16-bit buffer between the three NMOS chips of the microprocessor and the calculator memory. Those BIBs are hereinafter referred to as the memory BIBs. The remaining pair of 8-bit BIBs forms a 16-bit buffer used for communication with peripheral input/output units and are hereinafter referred to as the peripheral BIBs.

The elements of the microprocessor are interconnected by an MOS-level instruction-data bus (IDA). Within the microprocessor 101, the IDA bus comprises sixteen lines labelled $IDA_{\sigma}$-$IDA_{15}$ that are common to the memory and perpheral BIBs as well as the BPC, IOC, and EMC. Also included are a number of other MOS-level lines, some of which are common to all of the chips within microprocessor 101 and some of which form interconnections with only certain ones of the chips. The IDA bus is employed to transmit encoded information representing either machine language instructions, memory or register addresses, or memory or register data to and from various peripheral input/output units. The remaining lines comprise control lines, preclock lines, power supply lines, etc.

The peripheral and memory BIBs selectively connect the MOS-level IDA bus within microprocessor 101 to the TTL-level circuitry outside the microprocessor. In the case of operations involving the microprocessor and portions of the calculator memory outside the microprocessor such as transmission of address, data, and instruction information, the memory BIBs are enabled in the direction determined by a bus control circuit 104. The peripheral BIBs are enabled in the appropriate direction by the IOC whenever a word of information is to be exchanged between a peripheral I/O unit and the microprocessor.

As referred to in the following detailed description of the microprocessor 101, the term "memory" means any addressable memory location of the calculator both within and without the microprocessor itself. The term "external memory" refers to the calculator memory section 200 of FIG. 4. The term "register" refers to the various storage locations within the microprocessor itself. These registers range in size from one bit to sixteen bits. The term "addressable register" refers to a register within one of the microprocessor chips that responds as memory when addressed. Most registers are not addressable. In most discussions that follow the context clarifies whether or not a register has addressability so that it is not deemed necessary to explicity differentiate between addressable registers and registers. Those registers that are addressable are included in the meaning of the term "memory". The term "memory cycle"]refers to a read or write operation involving a memory location.

The first 32 memory addresses do not refer to external memory. Instead, these addresses ($0$–$37_8$) are reserved to designate addressable registers within the microprocessor. Table 1 below lists the addressable registers within the microprocessor.

Table 1

| Register | Location | Octal Address | Description and # of Bits |
|---|---|---|---|
| A | BPC | 0 | Arithmetic Accumulator (16) |
| B | BPC | 1 | Arithmetic Accumulator (16) |
| P | BPC | 2 | Program Location Counter (least 15) |
| R | BPC | 3 | Return Stack Pointer (least 15) |
| R4 | IOC | 4 | Peripheral Activity Designator (-) |
| R5 | IOC | 5 | Peripheral Activity Designator (-) |
| R6 | IOC | 6 | Peripheral Activity Designator (-) |
| R7 | IOC | 7 | Peripheral Activity Designator (-) |
| SE | EMC | 24 | Shift Extend Register (least 4) |
| IV | IOC | 10 | Interrupt Vector (upper 12) |
| PA | IOC | 11 | Peripheral Address Register (least 4) |
| W | IOC | 12 | Working Register (16) |
| DMAPA | IOC | 13 | DMA Peripheral Address Register (least 4) |
| DMAC | IOC | 14 | DMA Count Register (16) |
| DMAMA | IOC | 15 | DMA Memory Address & Direction Register (16) |
| C | IOC | 16 | Stack Pointer (16) |
| D | IOC | 17 | Stack Pointer (16) |
| AR2 | EMC | 20 | BCD Arithmetic Accumulator (4×16) |

Among several service functions performed by the BOC for the IOC and EMC is the generation of a signal on a register access line RAL whenever an address on the IDA bus is within the range reserved for register designation. The signal on line RAL functions to prevent the external memory from responding to any memory cycle having such an address. Functional Description of the BPC

The BPC has two main functions. The first is to fetch machine instructions from memory for itself, the IOC, and for the EMC. A fetched instruction may pertain to one or more of those elements. An element that is not associated with a fetched instruction simply ignores that instruction. The second main function of the BPC is to execute the 56 instructions in its repertoire. These instructions include general purpose register and memory reference instructions, branching instructions, bit manipulation instructions, and some binary arithmetic instructions. Most of the BOC's instructions evolve one of the two accumulator registers: A and B.

The four addressable registers within the BPC have the following functions: The A and B registers are used as accumulator registers for the arithmetic operations, and also as source and destination locations for most BPC machine-instructions referencing memory. The R register is an indirect pointer into an area of RWM designated to store return addresses associated with nests of subroutines encountered during program execution. The P register contains the program counter; its value is the address of the memory location from which the next machine-instruction will be fetched.

Upon the completion of each instruction the program counter (P register) has been incremented by one, except for the instructions JMP, JSM, RET, and SKIP instructions whose SKIP condition has been met. For those instructions the value of P will depend on the activity of the particular instruction.

Indirect Addressing

Memory addresses appear on the IDA Bus as 15-bit patterns during the address portion of a memory cycle. The BPC machine-instructions that reference memory are capable of multi-level indirect addressing. The initial indirect indicator is a particular bit in the machine-instruction itself (the most-significant, or left-most, bit: bit 15). The internal operation of the BPC is so arranged that if the memory content of that address also has a one in bit 15, the other bits of the contents are themselves taken as an indirect address. The process of accessing via an indirect address continues until a location is accessed which does not have a one in bit 15. At that time the content of that location is taken as the final address; that is, it is taken to be the address of the desired location and the memory cycle is completed when that location is accessed.

### Page Addressing

Machine-instructions fetched from memory are 16-bit instructions. Some of those bits represent the particular type of instruction, and if it is an instruction that requires a memory cycle, other bits represent the address to be referenced. Only ten bits of a memory reference instruction are devoted to indicating that address. Those ten bits represent one of $1024_{10}$ locations on either the base page or the current page of memory. An additional bit in the machine-instruction indicates which. The base page is always a particular, non-changing, range of addresses, exactly $1024_{10}$ in number. A memory reference machine-instruction fetched from any location in memory (i.e., from any value of the program counter) may directly reference (that is, need not use indirect addressing) any location on the base page.

There are two types of current pages. Each type is also $1024_{10}$ consecutive words in length. A memory reference machine-instruction can directly reference only locations that are on the same page as it; that is, locations that are within the page containing the current value of the program counter (P). Thus the value of P determines the particular collection of addresses that are the current page at any given time. This is done in one of two distinct ways, and the particular way is determined by whether the signal called RELA is grounded or not. If RELA is ungrounded, the BPC is said to address memory in the "relative" mode. If RELA is grounded it is said to operate in the "absolute" mode.

During its execution each memory reference machine-instruction causes the BPC to form a full 15-bit address based on the ten bits contained within the instruction. How the supplied ten bits are manipulated before becoming part of the address, and how the remaining five bits are supplied, depends upon whether the instruction calls for a base page reference or not, and upon whether the addressing mode is relative or absolute. The differences are determined primarily by the two different definitions of the current page; one for each mode of addressing. Base page addressing is the same in either mode. FIG. 21 depicts the base page.

### Absolute Addressing

In the absolute mode of addressing the memory address space is divided into a base page and 32 possible current pages. The base page consists of addresses $77000$- $77777_8$ and $00000_8$ - $00777_8$. The possible current pages are the consecutive $1024_{10}$ word groups beginning with $00000_8$. The possible current pages can be numbered, 0 through $31_{10}$. Thus the "zero page" is addressed $00000_8$ - $17777_8$. Note that the base page is not the same as the zero page; the base page overlaps the zero page and page 31.

### Relative Addressing

In relative addressing there are as many possible current pages as there are values of the program counter. In the relative addressing mode a current page is the $512_{10}$ consecutive locations prior (that is, having lower valued addresses) to the current location (value of P), and the $511_{10}$ consecutive locations following the current location.

### Base Page Addressing

All memory reference instructions include a 10-bit field that specifies the location referenced by the instruction. What goes in this field is a displacement from some reference location; an actual complete address has too many bits in it to fit in the instruction. This 10-bit field is bit 0 through bit 9. Bit 10 tells whether the referenced location is on the base page, or someplace else. Bit 10 is called the B/$\overline{B}$ bit, as it alone is used to indicate the base page references. Bit 10 will be a zero if it is on the base page, and a one if otherwise. In addition, bit 15 indicates whether the reference is indirect, or not. (A one implies indirect.)

If bit 10 is a zero for a memory reference instruction (base page reference), the 10-bit field is sufficient to indicate completely which of the 1024 locations is to be referenced. There are two ways to described the rule that is the correspondence between bit patterns in the 10-bit field, and the locations that are the base page: (1) the least significant 10 bits of the "real address" (i.e., $77{,}000_8$ through $777_8$) are put into the 10-bit field, bit for bit. (2) Another way to describe this is as a displacement of $+777_8$ or $-1000_8$ about 0, with bit 9 being the sign.

The 32 register addresses are considered to be a part of the base page. Base page addressing is always done in the manner indicated above, regardless of whether relative or non-relative addressing is employed by the BPC.

### Current Page Addressing

Current page addressing refers to memory reference instructions which reference a location which is not on the base page. The same 10-bit field of the machine-instruction is involved, but the B/$\overline{B}$ bit is a one ($\overline{B}$). Now, since there are more than 1024 locations that are not the base page, the 10-bit field by itself, is not enough to completely specify the exact location involved. An "assumption" has to be made about which page of the memory is involved.

The hardware inside the BPC handles 15 bits of address and thus can reference any address in a 32K address space. The "assumption" is that the most significant 5 bits correspond the page, and last 10 bits determine the location within that page.

The assumption for absolute addressing requires that there will be no page changes except by certain ways. This means that once the program counter is set to a particular location the top 5 bits need not be changed for any addressing on that (which ever it is) page. When the assembler assembles a memory reference instruction, it computes the least 10 bits and puts them in the instruction. When the BPC executes the instruction it concatenates its own top 5 bits of P with the address represented by the least 10 bits of the instruction; that produces the complete address for the location referenced by the instruction.

However, the least 10 bits produced by the assembler and placed in the machine-instruction do not correspond exactly to the "real" memory address that is referenced. Bit 9 (the 10th bit) is complmented before it is placed in the address field of the instruction. The other 9 bits are left unchanged. This induces a one-half page offset whose effect is to make current page addressing relative to the middle of the page. FIG. 22 depicts current page absolute addressing. This similarity between current page and base page addressing is deliberate, and results in simplified hardware in the BPC.

Page changes can be accomplished in two ways: incrementing or decrementing the program counter in the BPC, and through indirect addressing. An example of incrementing to a new page is a continuous block of code that spans two adjacent pages. A page change through an increment or decrement can occur in the same general way due to skip instructions.

Indirect addressing allows page changes because the object of an indirect reference is always taken as a full 15-bit address. Indirect addressing is the method used for an instruction on a given page to either reference a memory location on another page (LDA, STA, etc.), or, to jump (JMP or JSM) to a location on another page.

Instructions on any page can make references to any location on the base page without using indirect addressing. This is because the B/$\overline{B}$ bit designates whether the 10-bit field in the instruction refers to the base page or to the current page. If B/$\overline{B}$ is a zero (B), the BPC automatically assumes the upper 5 bits are all zeros, and thus the 10-bit field refers to the base page. If B/$\overline{B}$ is a one ($\overline{B}$), the top 5 bits are taken for what they are, and the current page is referenced (whichever it is).

It is the responsibility of the assembler to control the B/B bit at the time the machine-instruction is assembled. It does this easily enough by determining if the address of the operated (or its "value") of an instruction is in the range of $77,000_8$ or, 0 through $777_8$. If it is, then it's a base page reference and B/B is made a zero for that instruction.

Relative addressing does not require the concept of a fixed page, as in absolute addressing. The word "page" can still be used, but requires a new definition:

In relative addressing, a page is $1024_{10}$ consecutive locations, having $512_{10}$ locations prior to the current location, and $511_{10}$ locations following the current location.

As before, direct addressing is possible anywhere within the page. But off-page references (other than to the base page) require indirect addressing, which, once started, works as before — it is not relative, but produces a full 15-bit absolute address.

FIG. 23 illustrates relative addressing. Relative current page addressing is done in such the same was as base page addressing. The 10-bit field in the memory reference instructions is encoded with a displacement relative to the current location.

Bit 9 (the 10th, and most significant bit of the 10) is a sign bit. If it is a zero, then the displacement is positive, and bits 0 - 8 are taken at face value. If bit 9 is a one, the displacement is negative. Bits 0 - 8 have been commplemented and then incremented (two's complement) before being placed in the field. To get the absolute value of the displacement, simply complement them again, and increment, ignoring bit 9.

BPC Machine Instructions

The Assembly language representation of the BPC machine instructions are three-letter mnemonics. Each machine instruction source statement corresponds to a machine operation in the object program produced by an assembler.

The symbolic notation used in representing the BPC machine instructions is explained in Table 2 below.

Table 2

| | |
|---|---|
| m | Memory location. |
| n | Numerical quantity. A numeric value that is not an address, but represents a shift or skip amount. |
| I | Indirect addressing indicator. |
| S,C,P | Instruction modifiers. These indicators have various meanings, depending upon the instruction. Each will be explained as it is encountered. |
| ,S/,C | The slash indicates that either item (but not both) may be used at this place in the source statement. |
| [ ] | Brackets indicate that the item contained within them is optional |

Memory Reference Group of Instructions

The **14** memory reference instructions listed below refer to specified address in memory determined by the 10-bit address field (*m*), by the B/B bit, and by the Direct/Indirect bit (1).

LDA *m* [, I ]

Load A from *m*. The A register is loaded with the contents of the addressed memory location.

LDB *m* [, I ]

Load B from *m*. The B register is loaded with the contents of the addressed memory location.

CPA *m* [, I]

Compare the contents of *m* with the contents of A; skip if unequal. The two 16-bit words are compared bit by bit. If they differ the next instruction is skipped, otherwise it is executed next.

CPB *m* [, I ]

Compare the contents of *m* with the contents of B; skip if unequal. The two 16-bit words are compared bit by bit. If they differ the next instruction is skipped, otherwise it is executed next.

ADA *m* [, I]

Add the contents of *m* to A. The contents of the addressed memory location are added to that of A. The binary sum remains in A, while the contents of *m* remain unchanged. If a carry occurs from bit **15** the E register is loaded with one, otherwise, E is left unchanged. If an overflow occurs the O register is loaded with one, otherwise the O register is left unchanged. The overflow condition occurs if there is a carry from either bits 14 or 15, but not both together. The E and O registers are one-bit registers within the BPC. They represent the extend (carry out from bit 15) and overflow conditions for binary arithmetic performed by the BPC.

ADB *m* [, I]

Add the contents of *m* to B. Otherwise identical to ADA.

STA *m* [, I]

Store the contents of A in *m*. The contents of the A register are stored into the addressed memory location, whose previous contents are lost.

STB *m* [, I]

Store the contents of B in *m*. The contents of the B register are stored into the addressed memory location, whose previous contents are lost.

JSM *m* [, I]

Jump to subroutine. JSM permits jumping to subroutines in either ROM or R/W memory. The contents of the return stack register (R) are incremented by one and the contents of P stored in R.I. Program execution resumes at *m*.

JMP *m* [, I]

Jump to *m*. Program execution continues at location *m*.

ISZ *m* [, I]

Increment *m*; skip if zero. ISZ adds one to the contents of the referenced location, and writes the sum into that location. If the sum is zero, the next instruction is skipped.

DSZ *m* [, I]

Decrement *m;* skip if zero. DSZ subtracts one from the contents of the referenced location, and writes the difference into that location. If the difference is zero, the next instruction is skipped.

AND *m* [, I]

Logical and of A and *m*. The contents of A and *m* are anded, bit by bit, and the result is left in A.

IOR *m* [, I]

Inclusive or of A and *m*. The contents of A and *m* are inclusive or'ed, bit by bit, and the result is left in A.

Shift-Rotate Group of Instructions

Each shift-rotate instruction listed below includes a four-bit field in which the shift or rotate amount is encoded. The number to be encoded in the field is represented by *n*, and may range from 1 to 16, inclusive. The four-bit field (bits 0 through 3) will contain the binary code for $n-1$.

AAR *n*

Arithmetic right shift of A. The A register is shifted right *n* places with the sign bit (bit 15) filling all vacated bit positions; the $n-1$ most significant bits become equal to the sign bit.

SAR *n*

Shift A right. The A register is shifted right *n* places with all vacated bit positions cleared; the *n* most significant bits become zeros.

SBR *n*

Shift B right. The B register is shifted right *n* places with all vacated bit positions cleared; the *n* most significant bits become zeros.

SAL *n*

Shift A left. The A register is shifted left *n* places; the *n* least significant cant bits become zeros.

SBL *n*

Shift B left. The B register is shifted left *n* places; the least significant bits become zeros.

RAR *n*

Rotate A right. The A register is rotated right *n* places, with bit 0 rotating into bit 15.

RBR *n*

Rotate B right. The B register is rotated right *n* places, with bit 0 rotating into bit 15.

Alter-Skip Group of Instructions

The alter-skip instructions each contain a six bit field which allows a relative branch to any of 64 locations. The distance of the branch is represented by a displacement, *n;* *n* may be within the range of $-32_{10}$ to $31_{10}$ inclusive.

Bits 0 through 5 are coded with the value of *n* as follows: if the value is positive or zero, bit 5 is zero, and bits 0 through 4 receive the straight binary code for the value of *n;* if the value is negative, bit 5 is a one, and bits 0 through 4 receive a complemented and incremented binary code. Table 3 below illustrates this convention.

Table 3

| For n= | bits 5-0 | meaning: (*denotes current value of P) |
|---|---|---|
| −32 | 100000 | if skip, next instruction is *−32 |
| − 7 | 111001 | if skip, next instruction is *−7 |
| − 1 | 111111 | if skip, next instruction is *−1 |
| 0 | 000000 | if skip, repeat this instruction |
| 1 | 000001 | do next instruction, regardless |
| 7 | 000111 | if skip, next instruction is *+15 |
| 31 | 011111 | if skip, next instruction is *+31 |

All instructions in the alter-skip group have the "skip" properties outlined above. Some of the instructions also have an optional "alter" property. This is where the general instruction form "skip if ... <some one bit condition>" is supplemented with the ability to alter the state of the bit mentioned in the condition. The alteration is to either set the bit, or clear it. If specified, the alteration is done after the condition is tested, never before.

To indicate in a source statement that an instruction includes the alter option, and to specify whether to clear or to set the tested bit, a C or S follows *n*. The C indicates clearing the bit, while an S indicates setting the bit.

The "alter" information is encoded into the 16-bit instruction word with 2 bits. Bit 7 is called the H/H (Hold/Don't Hold) bit, and bit 6 is the C/S (Clear/Set) bit, for such instructions. If bit 7 is a zero (specifying H) the "alter" option is not active; neither S nor C followed *n* in the source statement of the instruction, and the tested bit is left unchanged. If bit 7 is a one (specifying H), then "alter" option is active, and bit 6 specifies whether it is S or C. The alter-skip instructions are listed below.

SZA *n*

Skip if A is zero. If all 16 bits of the A register are zero, skip the amount indicated by *n*.

SZB *n*

Skip if B is zero. If all 16 bits of the B register are zero, skip the amount indicated by *n*.

RZA *n*

Skip if A is not zero. If any of the 16 bits of the A register are set, skip the amount indicated by *n*.

RZB *n*

Skip if B is not zero. If any of the 16 bits of the B register are set, skip the amount indicated by *n*.

SIA *n*

Skip if A is zero, and then increment A. The A register is tested, and then incremented by one. If all 16 bits of A were zero before the increment, skip the amount indicated by *n*.

SIB *n*

Skip if B is zero, and then increment B. The B register is tested, and then incremented by one. If all 16 bits of B were zero before the increment, skip the amount indicated by *n*.

RIA *n*

Skip if A is not zero, and then increment A. The A register is tested, and then incremented by one. If any bits of A were one before the increment, skip the amount indicated by *n*.

In connection with the next four instructions, Flag and Status are controlled by the peripheral interface addressed by the current select code. The select code is the number that is stored in the register named PA, located in the IOC. Both Status and Flag originate as negative true signals, so that when a missing interface is addressed Status and Flag will appear to be false, or not set.

SFS *n*

Skip if Flag line is set. If the Flag line is true, skip the amount indicated by *n*.

SFC *n*

Skip if Flag line is clear. If the flag line is false, skip the amount indicated by *n*.

SSS *n*

Skip if Status line set. If the status line is true, skip the amount indicated by *n*.

SSC *n*

Skip if Status line is clear. If the status line is false, skip the amount indicated by *n*.

SDS *n*

Skip if decimal carry set. Decimal carry (DC) is a one bit register in the EMC. It is controlled by the EMC, but connected to the decimal carry input of the BPC. If DC is set, skip the amount indicated by *n*.

SDC *n*

Skip if decimal carry clear. Decimal carry (DC) is a one bit register in the EMC. It is controlled by the EMC, but connected to the decimal carry input of the BPC. If DC is clear, skip the amount indicated by *n*.

SHS *n*

Skip if halt line set. If the halt line is rue, skip the amount indicated by *n*.

SHC *n*

Skip if halt line clear. If the halt line is false, skip the amount indicated by *n*.

SLA *n* [, S/,C ]

Skip if the least significant bit of A is zero. If the least significant bit (bit 0) of the A egister is a zero, skip the amount indicated by *n*. If either S or C is present, bit 0 of A is altered accordingly after the test.

SLB *n* [,S/,C]

Skip if the least significant bit of B is zero. If the least significant bit (bit 0) of the B register is a zero, skip the amount indicated by *n*. If either S or C is present, bit 0 of B is altered accordingly after the test.

RLA *n* [,S/,C]

Skip if the least significant bit of A is non-zero. If the least signifcant bit (bit 0) of the A register is a one, skip the amount indicated by *n*. If either S or C is present, bit 0 of A is altered accordingly after the test.

RLB *n* [,S/,C]

Skip if the least significant bit of B is non-zero. If the least significant bit (bit 0) of the A register is a one, skip the amount indicated by *n*. If either S or C is present, bit 0 of B is altered accordingly after the test.

SAP *n* [,S/,C]

Skip if A is positive. If the sign bit (bit 15) of the A register is a zero, skip the amount indicated by *n*. If either S or C is present, bit 15 of A is altered accordingly after the test.

SBP *n* [,S/,C]

Skip if B is positive. If the sign bit (bit 15) of the A register is a zero, skip the amount indicated by *n*. If either S or C is present, bit 15 of B is altered accordingly after the test.

SAM *n* [,S/,C]

Skip if A is minus. If the sign bit (bit 15) of the A register is a one, skip the amount indicated by *n*. If either S or C is present, bit 15 of A is altered accordingly after the test.

SBM *n* [,S/,C]

Skip if B is minus. If the sign bit (bit 15) of the B register is a one, skip the amount indicated by *n*. If either S or C is present, bit 15 of B is altered accordingly after the test.

SOS *n* [,S/,C]

Skip if Overflow is set. If the one-bit Overflow register (O) is set, skip the amount indicated by *n*. If either S or C is present, the O register is altered accordingly after the test.

SOC *n* [,S/,C]

Skip if Overflow is clear. If the one-bit register is clear, skip the amount indicated by *n*. If either S or C is present, the O register is altered accordingly after the test.

SES *n* [,S/,C]

Skip if Extend is set. If the Extend register (E) is set, skip the amount indicated by *n*. If either S or C is present, E is altered accordingly after the test.

SEC *n* [,S/,C]

Skip if Extend is clear. If the Extend register (E) is clear, skip the amount indicated by *n*. If either S or C is present, E is altered accordingly after the test.

Return Group of Instructions

Listed below is the return instruction for the BPC.

RET *n* [,P]

Return. The R register is a pointer into a stack of words containing the addresses of previous subroutine calls. A read R,I occurs. That produces the address (value of P) for the latest JSM that occurred. The BPC then jumps to address P+*n*. The value of *n* may range from −32 to 31, inclusive. The value of *n* is encoded into bits 0 through 5 of the instructions as a 6 bit, two's complement, binary number. The ordinary, non-interrupt-service routine return, is RET 1. If a P is present, it "pops" the interrupt system. Two things in the 10C occur when this happens: first, the peripheral address stack in the 10C is popped, and second, the interrupt grant network of the 10C is "decremented".

The peripheral address stack is a hardward stack in the 10C, 4 bits wide, and three levels deep. On the top of this stack is the current select code for I/O operations. Select codes are stacked as interrupts occur during I/O operations. A RET *n*, P at the end of an interrupt service routine puts the select code of the interrupted device back on the top of the stack.

The interrupt grant network in the 10C keeps track of which interrupt priority level is currently in use. From this it determines whether or not to grant an interrupt requiest. A RET *n*, P at the end of an interrupt service routine causes the interrupt grant network to change the current interrupt priority level to the next lower level (unless it is already at the lowest level).

Complement Group of Instructions

Listed below are the complement group machine-instructions of the BPC.

CMA

Complement A. The A register is replaced by its one's (bit by bit) complement.

CMB

Complement B. The B register is replaced by its one's (bit by bit) complement.

TCA

Two's complement A. The A register is replaced by its one's (bit by bit) complement, and then incremented by one.

TCB

Two's complement B. The B register is replaced by its one's (bit by bit) complement, and then incremented by one.

Execute Group of Instructions

Listed below is the execute machine-instruction for the BPC.

EXE $0 \leqq m \leqq 37_8$ [,I]

Execute register *m*. The contents of any addressable register can be treated as the current instruction, and executed in the normal manner. The register is left unchanged unless the fetched machine-instruction causes it to be altered. The next instruction executed will be the one following the EXE *m*, unless the instruction in *m* causes a branch.

Multi-level indirect addressing is allowed. An EXE *m*,I causes the contents of *m* to be taken as the address of the place in memory whose contents are to be executed; this can be anywhere in memory, and need not be another register. But regardless, only 15 bits are required to specify this location. If the 16th bit of *m* is set, the lower 15 bits are taken as the address of the address, instead of the address of the instruction. This continues until an address is encountered whose 16th bit is zero. Then that address is taken as the final address of the instruction. Using that address one more fetch is done, and the bit pattern found executed as an instruction, even if it has a one in the 16th bit. FIGS. **24**A–G depict the bit patterns of the BPC machine-instructions.

Internal Description of the BPC

The details of the BPC may be understood with reference to the block diagram of FIGS. **25**A–C. The majority of activity within the BPC is controlled by a ROM. This is a programmed logic array whose input qualifiers are a 4-bit state-count, group, miscellaneous, and input-output qualifiers. From the ROM are decoded micro-instructions. Each machine-instruction that the BPC executes, and the BPC's response to memory cycles directed at its addressable registers, is a complex series of micro-instructions. This activity is represented by the flow charts depicted in FIGS. **91**A through **105**.

Changes in the state-count correspond to the step-by-step sequence of activity shown in the flow charts. The State-Counter has a natural sequence that was chosen by computer simulation to reduce the complexity of the necessary number of non-sequential transitions. When a section of the flow chart requires a non-sequential transition it decodes a special microinstruction whose purpose is to override the natural sequence and produce the desired alteration in the state-count.

The Group Qualifiers are generated by Instruction Decode. The Group Qualifiers represent the instruction that has been fetched and that must now be executed.

The Input-Output Qualifiers are controlled by the M-Section. Those qualifiers are used in decoding micro-instructions, and in flow chart branching, that are dependent upon or have to do with input and output to the BPC.

The $\overline{\text{IDB}}$ Bus is the internal BPC representation of the IDA Bus. To conserve power, this bus is used dynamically; it is precharged on phase two, and is available for data transmission only during phase one. Data on the $\overline{\text{IDB}}$ Bus is transmitted in negative true form; a logical one is encoded on a given line of the bus by grounding that line.

The main means of inter-register communication with the BPC is via the $\overline{\text{IDB}}$ Bus and the various set and dump micro-instructions. For instance, a SET I loads the I Register with the contents of the $\overline{\text{IDB}}$ Bus. A DMP IDA places the contents of the IDA Bus onto the $\overline{\text{IDB}}$ Bus. A simultaneous DMP IDA and SET I loads the I Register with the word encoded on the IDA Bus. As a further instance, that very activity is part of what is decoded from the ROM at the conclusion of a memory cycle that is an instruction fetch. FIGS. **115**A–C and **116** illustrate the waveforms associated with the start-up sequence and an instruction fetch.

Once the instruction is in the I Register, the bit pattern of the instruction is felt by Instruction Decode. Aside from the afore-mentioned Group Qualifiers, Instruction Decode generates two other groups of signals. One of these are control lines that go to the Flag Multiplexer to determine which, if any, of the external flag lines is involved in the execution of the current machine-instruction. The remaining group of signals are called the Asynchronous Control Lines. These are signals that, unlike micro-instructions, are steady-state signals present the entire time that the machine-instruction is in the I Register. The Asynchronous Control Lines are used to determine the various modes in which much of the remaining hardware will operate during the execution of the machine-instruction. For example, the S Register is capable of several types of shifting operations, and the micro-instruction that causes S to shift (SSE) means only that S should now shift one time. The exact nature of the particular type of shift to be done corresponds to the type of shift machine-instruction in the I Register. This in turn affects Instruction Decode and the Asynchronous Control Lines, which in turn affect the circuitry called S Register Shift Control. It is that circuitry that determines the particular type of shift operation that S will perform when an SSE is given.

In a similar way the Asynchronous Control Line affect the nature of the operation of the Arithmetic-Logic Unit (ALU), the Skip Matrix, and the A and B registers.

The least four bits of the I Register are a binary decrementer and CTQ Qualifier network. This circuitry is used in conjunction with machine-instructions that involve shift operations. Such machine-instructions have the number of shifts to be performed encoded in their least four bits. When such an instruction is in the I Register, the least four bits are decremented once for each shift that is performed. The CTQ Qualifier indicates when the last shift has been performed.

The A and B Registers are primarily involved in machine-instructions that; read to, or write from, memory; do binary arithmetic; shift; or, branch. Machine-instructions that simply read from, or, write to, memory, are relatively easily executed, as the main activity consists of dumping or setting the A or B Register. The arithmetic instructions involve the ALU.

The ALU has three inputs. One is the $\overline{\text{ZAB}}$ Bus. This bus can transmit either zero, the A Register, or the B Register. The choice is determined by the Asynchronous Control Lines. The input from the $\overline{\text{ZAB}}$ Bus can be understood in its true, or in its complemented form. The second input to the ALU is the S Register. The remaining input is a carry-in signal.

The ALU can perform three basic operations: logical and, logical inclusive or, and binary addition. The choice is determined by the Asynchronous Control Lines.

Whatever operation is performed is done between the complemented or uncomplemented contents of the $\overline{\text{ZAB}}$ Bus, and the contents of the S Register. The output of the ALU is available through the DMP ALU micro-instruction, as well as through lines representing the carry-out from the 14th and 15th bits of the result. These carry-outs are used to determine whether or not to set the one-bit Extend and Overflow Registers.

The R Register is the return stack pointer for the RET machine-instruction.

The P Register is the program counter. Associated with it are several other pieces of circuitry used for incrementing the program counter, as well as for forming complete 15-bit addreses for memory cycles needed in the execution of memory reference or skip machine-instructions. These other pieces of circuitry are the T Register, the P-Adder Input, P-Adder Control, and the P-Adder.

The P-Adder mechanism can operate in one of three modes. These modes are established by micro-instructions, not by the Asynchronous Control Lines. In the memory reference machine-instruction mode (established for the duration of the ADM micro-instruction) the T Register will contain a duplicate copy of the memory reference machine-instruction being executed. Thus the 10-bit address field of the machine-instruction and the base page bit (bit 10) as well as top 5 bits of all the program counter, are available to the adder mechanism. In accordance with the rules for either relative or absolute addressing (as determined by RELA) the P-Adder Input and P-Adder operate to produce the correct full 15-bit address needed for the associated memory cycle.

The ADS micro-instruction establishes a mode where only the least five bits of a skip machine-instruction are combined with the program counter to produce a new value for the program counter.

In the absence of either an ADM or ADS micro-instruction the P-Adder mechanism defaults to an increment-P mode. In this mode the value of P+1 is continuously being formed. This is the typical way in which the value of the program counter is changed at the end of non-branching machine-instructions.

The output of the P-Adder mechanism is available to the $\overline{\text{IDB}}$ Bus through the DMP PAD micro-instruction.

The D Register is used to drive the IDA Bus through the SET IDA micro-instruction. Because of limitations on transitor device sizes and the large capacitances possible on the IDA Bus, two consecutive SET IDA's are required to ensure that the IDA Bus properly represents the desired data.

The PBC has special circuitry to detect a machine-instruction that requires an indirect memory cycle. This circuitry generates a qualifier used in the ROM. The flow-charting that corresponds to a machine-instruction that can do indirect addressing has special activity to handle the occurrence of an indirect reference.

In the event of an interrupt request generated by the IOC, the BPC aborts the execution of the machine-instruction just fetched, and without incrementing the program counter, executes the following machine-instruction instead: JMP $10_8$,I. Register $10_8$ is the Interrupt Vector Register (IV) in the 10C. This is part of the means by which vectored interrupt is implemented. FIGS. **117**A–B illustrate interrupt operation.

In the event that an addressable register within the BPC is the object of a memory cycle, whether the memory cycle is originated by the BPC itself, or by an agency external to the BPC, a BPC Register Detection and Address Latch circuit detects that fact (by the value of the address) and latches the address, and also latches whether the operation is a read or a write. The result of this action is two-fold: First, it supplies qualifier information to the ROM so that micro-instructions necessary to the completion of the memory cycle may be issued. Secondly, it initiates action within the M-Section that aids in the handling of the various memory cycle control signals.

FIGS. **106–114** are waveforms that illustrate the various memory cycles that can occur.

The BPC can interrupt the execution of a machine-instruction to allow some other agency to use the IDA Bus. The BPC will do this whenever Bus Request ($\overline{\text{BR}}$) is active, and the BPC is not in the middle of a memory cycle. When these conditions are met, the BPC issues a signal called Bus Grant (BG) to inform the requesting agency that the IDA Bus is available, and the BPC also generates an internal signal called Stop (STP) that halts the operation of the decrementer in the I Register, and halts the change of the ROM statecounter. In addition, STP inhibits the decoding from the ROM of all but those micro-instructions needed to respond to memory cycles under the control of the M-Section. STP and BG are given until the requesting agency signals that its use of the IDA Bus is over by releasing $\overline{\text{BR}}$. This capability is the basis of Direct Memory Access, as implemented by the IOC. FIGS. **118** and **119**A–B illustrate the operation of Bus Request and Bus Grant. Communication Between the BPC and IOC.

Each major element in the microprocessor is connected to the IDA Bus and some related control lines. The IDA Bus allows elements of the system to both "send" and "receive" 16-bit words.

The term "chip" refers to any of the BPC, IOC, or EMC.

Consider this question: "Since there are some separate instructions for the IOC, and since the BPC is sort of the 'head processor' that does the fetching of instructions from memory, how is it that the IOC receives its instructions that the BPC Is not disturbed by fetching such an instruction?"

The answer is: All chips in the microprocessor are exposed to instructions via the IDA Bus as they are fetched. A chip will either execute an instruction, or idle until the next instruction fetch. An instruction can cause activity in more than one chip.

There is a signal called Sync, which is issued by common consent of all the chips in the microprocessor, and whose significance is that the next memory cycle is an instruction fetch. During that fetch, the instruction word appears on the IDA Bus. Each chip in the microprocessor looks at the word and puts it through an instruction decode process to determine if that chip needs to initiate some activity. If a chip recognizes a machine-instruction, it pulls Sync to ground and begins the activity.

More than one chip can recognize the same instruction, and this does happen (the RET *n*,P machine-instruction affects both the BPC and the IOC). While each chip is busy, it keeps Sync grounded, releasing it when its activity is completed. When all activity is complete, (i.e., Sync is allowed to go high by all chips), the BPC initiates the next instruction fetch. The other chips in the microprocessor can recognize this memory access as an instruction fetch because Sync has gone high.

If a chip is not affected by an instruction, it idles until either another Sync/instruction fetch, or, until some other mechanism causes the chip to respond. For instance, the IOC can be the object of a memory cycle required by the BPC's execution of a memory reference instruction (which the IOC had decoded as "not me").

Each element in the system decodes the addresses for which it contains addressable registers. To initiate a register memory cycle, an element of the microprocessor puts the address of the desired location on the IDA Bus, sets the Read/Write line high or low, and gives Start Memory. Then, elsewhere in the microprocessor the address is decoded and recognized, and an element of the microprocessor begins to function as memory. It is part of the system definition that whatever is on the IDA Bus when a Start Memory is given is an address of a memory (or register) location.

Here is a complete description of the entire process: An originator orginates a memory cycle by putting the address on the IDA Bus, setting the the Read/Write line, and giving a Start Memory. The respondent identifies itself as containing the object location of the memory cycle, and handles the data. If the originator is a sender (write) it puts and holds the data on the IDA Bus until the respondent acknowledges receipt by sending Memory Complete. If the originator is a receiver (read) the respondent obtains and puts the data onto the IDA Bus and then sends Memory Complete. The originator then has one clock time to capture the data; no additional acknowledgement is involved.

Description of the IOC

The IOC includes a register called the Peripheral Address Register (PA) which is used in establishing the select code currently in use. The bottom four bits of this register are brought out of the IOC as PA0 through PA3. Each Peripheral Interface decodes PA0–PA3 and thus determines if it is the addressed interface.

The peripheral address is established by storing the desired select code into PA with an ordinary memory reference instruction.

Flag, Status and Control

The peripheral interface is the source of the Flag and Status bits for the BPC instructions SFS, SFC, SSS, and SSC. Since there can be many interfaces, but only one each of Flag and Status, only the interface addresssed by the select code is allowed to ground these lines. Their logic is negative-true, and a result of this is that if the addressed peripheral is not present on the I/O Bus, Status and Flag are logically false.

$\overline{IC1}$ and $\overline{IC2}$ are two control lines that are sent to each peripheral interface by the IOC. The state of these two lines during the transfer of information can be decoded to mean something by the interface. Just what 'something' will be is subject to agreement between the firmware designer and the interface designer — it can be any thing they want, and might not be the same for different interfaces. These two lines act as a four position mode switch on the interface, controlled by the IOC during an I/O operation. I/O Bus Cycles.

An I/O Bus cycle is an exchange of a word between the IDA Bus and the IOD Bus. The information transfer between the processor and an interface is not of the handshake variety.

Timing diagrams for read and write I/O Bus cycles are shown in FIGS. 121 and 122. These cycles are initiated by standard (programmed) I/O instructions, interrupt, and by DMA.

For example, during a standard I/O instruction, an I/O Bus cycle is initiated by a reference to one of R4 through R7 in the IOC. One way that can be done is with a BPC memory reference instructions; for instance, STA R4 (for a write cycle), or LDA R4 (for a read cycle).

Consider a write I/O Bus cycle as illustrated in FIG. 121. This is initiated with a reference to one of R4–R7. The IOC sees this as an address between 4 and 7 on the IDA Bus while $\overline{STM}$ is low. The Read line is low to denote a write operation. The IOC enables the peripheral BIB's and specifies the direction. It also sets the control lines $\overline{IC1}$ and $\overline{IC2}$, according to which register was referenced. Meanwhile, the BPC has put the word that is to be written onto the IDA Bus. That word is felt at all peripheral interfaces. The interface that is addressed uses $\overline{DOUT}$ to understand it's to read something, and uses $\overline{IOSB}$ as a strobe for doing it. After $\overline{IOSB}$ is given, the IOC gives [Synchronized] Memory Complete ($\overline{SMC}$) and the process terminates. The BPC has written a word to the interface whose select code matched the number in the PA register.

A read I/O Bus cycle is similar, as shown in FIG. 122. Here the BPC expects to receive a word from the addressed peripheral interface. Read, $\overline{DOUT}$ and $\overline{BE}$ are different because the data is now moving in the other direction.

In either case, the critical control signals $\overline{SMC}$ and $\overline{IOSB}$ are given by the IOC, and their timing is fixed. There can be no delays due to something's not being ready, nor is there any handshake between the interface and the IOC.

It is the responsibility of the firmware not to initiate an I/O Bus cycle involving a device that is not ready. To do so will result in lost data, and there will be no warning that this has happened.

Place and Withdraw

The IOC includes some firmware-stack manipulation instructions. Two registers are provided as stack pointers: C and D. There are eight place and withdraw instructions for putting things into stacks and getting them out. Furthermore, the place and withdraw instructions can handle full 16-bit words, or pack 8-bit bytes in words of a stack. And last, there are provisions for automatic incrementing and decrementing of the stack pointer registers, C and D.

The mnemonics for the place and withdraw instructions are easy to decipher. All place instructions begin with P, and all withdraw instructions begin with W. The next character is a W or B, for word or byte, respectively. The next character is either a C or D, depending upon which stack pointer is to be used. There are eight combinations, and each is a legitimate instruction.

A PWD A,1 reads as follows: place the entire word of A into the stack pointed at by D, and increment the pointer before the operation. The instruction WWC B,D is read: Withdraw an entire word from the stack pointed at by C, put the word into B, and decrement the stack pointer D after the operation.

The place and withdraw instruction outwardly resembles the memory reference instructions of the BPC: a mnemonic followed by an operand that is understood as an address, followed by an optional 'behavior modifier'. The range of values that the operand may have is restricted, however. The value of the operand must be between 0 and 7, inclusive. Thus, the place and withdraw instructions can place from, or, withdraw into, the first eight registers. These are A, B, P, R, and R4 through R7. Therefore, the place and withdraw instructions can initiate I/O Bus cycles; they can do I/O.

The place and withdraw instructions automatically change the value of the stack pointer each time the stack is accessed. In the source text an increment or decrement is specified by including *a* ,I or *a* ,D respectively, after the operand.

Regardless of which of increments or decrement is specified, a place instruction will do the increment or decrement of the pointer prior to the actual place operation. Contrariwise, the withdraw instructions do the increment or decrement after actual withdraw operation. The reason for this is that it always leaves the stack with the pointer pointing at the new 'top-of-the-stack'.

Place and Withdraw for Bytes

The following explains how the place and withdraw instructions are used for placing and withdrawing bytes as opposed to complete words. First, the stack is always a stack composed of words. However, for byte operations bit 15 of the pointer register assumes added significance; it selects the left-half or right-half of the word on top of the stack. If bit 15 of the pointer register is a one, the left-half is selected. Also, only the right-half of the registers A, B, P, R, and R4–R7 are taken as the operands; the left halves are ignored.

Thus, the instructions place from, or, withdraw into, the right-half of the referenced register. The left-half of the destination register is cleared during a withdraw operation. The instructions place into, or withdraw from, the left or right half of the top of the stack, as determined by bit 15 of the pointer register. A place operation does not disturb the unreferenced half of the destination word in the stack, provided the memory entity properly utilizes the $\overline{\text{BYTE}}$ line. After each place or withdraw, bit 15 is automatically toggled, to provide a left-right-left-right-...sequence.

However, it is up to the firmware to see to it that bit 15 of the pointer register is properly set prior to beginning stack operations.

When incrementing the stack pointer, bit 15 automatically changes state each time. But, the address contained in the lower 15 bits increments only during the zero-to-one transition of bit 15. Similarly, when decrementing the transition of bit 15 from a one to a zero is accompanied by a decrement of the lower 15 bits.

The incrementing and decrementing schemes just described are only for increments and decrements brought about by *a*, I, or D following the operand of a Place or Withdraw instruction. Increments or decrements to the pointer register with ISZ or DSZ do not automatically toggle bit 15.

The place-byte instruction cannot be used to place bytes into the registers within the BPC, EMC, and IOC. The reason for this is that these chips do not utilize the $\overline{\text{BYTE}}$ line of the IDA Bus during references to their internal registers.

The $\overline{\text{BYTE}}$ line is a signal supplied by the IOC for use by an interested memory entity. The $\overline{\text{BYTE}}$ line indicates that whatever is being transferred to or from memory is a byte (8 bits) and that bit 15 of the address indicates righr or left half. It is up to the memory (if it is a 16-bit mechanism) to merge the byte in question with its companion byte in the addressed word.

In the case of a withdraw-byte the memory can supply the full 16-bit word (that is, ignore the BYTE line). The IOC will extract the proper byte from the full word and store it as the right-half of the referenced register; the left half of the referenced register is cleared. In the case of a place-byte, however, the IOC copies the entire referenced register into W, and outputs its right half as either the upper or lower byte (according to bit 15 of the address) in a full 16-bit word. The full word is transmitted to the memory, and the "other" byte is all zeros. Thus, in this case the memory must utilize the $\overline{\text{BYTE}}$ line.

The consequence of the above is that any byte-oriented stacks to be managed using the place instruction must not include registers in any of the BPC, EMC, or IOC; that is, C and D must not assume any value between 0 and $37_8$ inclusive for a place-byte instruction.

Standard I/O

Standard programmed I/O involves three activities:

(1) Setting the peripheral address
(2) Investigating the status of the peripheral
(3) Initiating an I/O Bus Cycle

Addressing the Peripheral

A peripheral is selected as the addressed peripheral by storing its octal select code into the register called PA (Peripheral Address — address $11_8$). Only the four least significant bits are used to represent the select code.

Checking Status

The addressed peripheral is allowed to control the Flag and Status lines. (That is, it is up to the interface to not ground Flag or Status unless it is the addressed interface). These lines have an electrically negative-true logic so that when floating they appear false (clear, or not set) for SFS, SFC, SSS, and SSC.

The basic idea (and it can be done in a variety of ways) is to use sufficient checks of Flag and Status before and amongst the I/O Bus Cycles such that there is no possibility of initiating an I/O Bus Cycle to a device that is not ready to handle it. One way to do this with standard I/O is to precede every Bus Cycle with the appropriate checks.

Initiating I/O Bus Cycles

An I/O Bus Cycle occurs once each time one of R4 - R7 ($4_8$ - $7_8$) is accessed as memory. An instruction that "puts" something into R4–R7 results in an output (write) I/O Bus Cycle. Conversely, an instruction that "gets" something from R4 - R7 results in an input (read) I/O Bus Cycle. However, there are no R4 through R7. The use of address 4–7 is just a device to get an I/O Bus Cycle started; they do not correspond to actual physical registers in the IOC.

The Interrupt System

The idea behind interrupt is that for certain kinds of peripheral activity, the calculator can go about other business once the I/O activity is initiated, leaving the bulk of the I/O activity to an interrupt service routine. When the peripheral is ready to handle another ration of data (it might be a single byte or a whole string of words) it requests an interrupt. When the micro-processor grants the interrupt, the firmware program currently being executed is automatically suspended, and there is an automatic JSM to an interrupt service routine that corresponds to the device that interrupted. The service routine used standard programmed I/O to accomplish its task. A RET O,P terminates the activity of the service routine and causes resumption of the suspended program.

Priority

The interrupt system allows even an interrupt service routine to be interrupted and is therefore a multi-level interrupt system, and it has a priority scheme to determine whether to grant or ignore an interrupt request.

The IOC allows two levels of interrupt, and has an accompanying two levels of priority. Priority is determined by select code; select codes O–$7_8$ are the lower level (priority level 1), and select codes $10_8$–$17_8$ are the higher level (priority level 2). Level 2 devices have priority over level 1 devices; that is, a disc driver operating at level 2 could interrupt a plotter operating at level 1, but not vice versa. Within a priority level all devices are of "equal" priority, and operation is of a first come-first served basis; a level 1 device cannot be interrupted by another level 1 device, but only by a level 2 device. Within a level priorities are not equal in the case of simultaneous requests by two or more devices within a level. In such an instance the device with the higher numbered select code has priority. With no interrupt service routine in progress, any interrupt will be granted.

Vectored Interrupts

Devices request an interrupt by pulling on one or two interrupt request lines ($\overline{IRL}$ and $\overline{IRH}$ — one for each priority level). The IOC determines the requesting select code by means of an interrupt poll, to be described in the next paragraph. If the IOC grants the interrupt it saves the existing select code located in PA, puts the interrupting select code in PA, and does a JSM-Indirect through an interrupt table to get to the interrupt service routine.

An interrupt poll is a special I/O Bus Cycle to determine which interface(s) is (are) requesting an interrupt. An interrupt poll is restricted to one level of priority at a time, and is done only when the IOC is prepared to grant an interrupt for that level.

The interfaces distinguish an Interrupt Poll Bus Cycle from an ordinary I/O Bus Cycle through the $\overline{INT}$ line being low. Also, during this Bus Cycle PA3 specifies which priority level the poll is for. An interface that is requesting an interrupt on the level being polled responds by grouding the *n*th I/O Data line of the I/O Bus, where *n* equals the device's select code modulo eight. If more than one device is requesting an interrupt, the one with the higher select code will have priority.

Automatic Peripheral Addressing

The IOC has a three-deep first-in last-out hardware stack. The top of the stack is the Peripheral Address register (PA-$11_8$). The stack is deep enough to hold the select code in use prior to any interrupts, plus the select codes for two levels of interrupt. When an interrupt is granted, the IOC automatically pushes the select code of the interrupting device (as determined by the interrupt poll) onto the stack. Thus the previous select code-in-use is saved, and the new select code-in-use becomes the one of the interrupting device.

Interrupt Table

It is the responsibility of the firmware to maintain an interrupt table of 16 consecutive words, starting at some RWM address whose four least significant bits are zeros. The firmward is also to see to it that the starting address of the table is stored in the IV register (Interrupt Vector register — $\mathbf{10_8}$), and that bit 15 of IV is set. (IV is the first of two levels in an indirect chain. For an address in the interrupt table to be taken indirectly, the previous address (IV) must have had bit 15 set.)

The words in the interrupt table contain the addresses of the interrupt service routines for the **16** different select codes. FIG. **123** depicts the interrupt table.

After the interrupt poll is complete the select code of the interrupting device is made to be the four least significant bits of the IV register. Thus IV now points at the word in the Interrupt Table which has the address of the appropriate interrupt service routine.

All that is needed now is a JSM IV, I, and the interrupt service routine will be under way. This is accomplished by the BPC as explained below.

Interrupt Process Summary

The IOC inspects the interrupt requests $\overline{IRL}$ and $\overline{IRH}$ during the time sync is given. Based on the priority of the interrupt requests, and the priority of any interrupt in progress, the IOC decides whether or not to grant an interrupt. If it decides to allow an interrupt it immediately pulls $\overline{INT}$ to ground, and also begins an interrupt poll.

The grounding of $\overline{INT}$ serves three purposes: It allows the interfaces to identify the forthcoming I/O Bus Cycle as an interrupt poll; it causes all th chips in the system, except the BPC, to abort their instruction decode process (which by this time is in progress) and return to their idle states; and it causes the BPC to abort its instruction decode and execute a JSM $\mathbf{10_8}$, I instead.

The IOC uses the results of the interrupt poll to form the interrupt vector, which is then used by the JSM $\mathbf{10_8}$, I. It also pushes the new select code onto the peripheral address stack, and puts itself into a configuration where all interrupt requests except those of a higher priority will be ignored.

Interrupt Service Routines

The majority of the interrupt activity described so far is accomplished automatically by the hardware. All the firmware has been responsible for has been the IV register, the maintenance of the interrupt table, and (probably) the initiation of the particular peripheral operation involved (plotting a point, backspace, finding a file, etc.). Such operations (initiated through a command given by simple programmed I/O) may involve many subsequent I/O Bus Cycles, done at odd time-intervals, and requested by the peripheral through an interrupt. It is the responsibility of the interrupt service routine to handle the I/O activity required by the peripheral without upsetting the routine that was interrupted.

The last things done by an interrupt service routine are to: (if necessary) shut off the interrupt mode of the interface; restore any saved values; and to execute a RET O,P.

The RET O part acts to return to the routine that was interrupted, so that its execution will continue. The P acts to pop the peripheral address stack and adjust the IOC's internal indicator of what priority level of interrupt is in progress. By popping the peripheral address stack, PA is set back to whatever it was prior to the most recent interrupt.

Disabling the Interrupt System

The interrupt system can be "turned off" by a DIR instruction. After this instruction is given the IOC will refuse to grant any interrupts whatsoever, until the interrupt system is turned back on with the instruction EIR. While the IOC won't grant any interrupts, the RET O,P works as usual so that interrupt service routines may be safely terminated, even while the interrupt system is turned off.

Pop On Turn-On

There is a signal called $\overline{POP}$ generated by the power supply. Its purpose is to initialize all the chips in the calculator system during turnon. $\overline{POP}$ leaves the IOC with the DMA and Pulse Count Modes turned off, and with the interrupt system turned off. The contents of the internal registers are random.

Direct Memory Access

Direct Memory Access is a means to exchange entire blocks of data between memory and peripherals. A block is a series of consecutive memory locations. Once started, the process is mostly automatic; it is done under control of hardware in the IOC, and regulated by the interface.

The DMA process transfers a word at a time, on a cycle-steal basis. This means that to transfer a word the IOC requests control of the IDA Bus with $\overline{BR}$, halting all other system activity for the duration of IOC control over the Bus, which is one memory cycle. When granted the Bus the IOC uses it to accomplish the necessary memory activity.

A transfer of a word is initiated at the request of the interface. To request a DMA transfer a device grounds the DMA Request line ($\overline{DMAR}$). Since there is only one channel of DMA hardware, and one DMA Request line, only one peripheral at a time may use DMA. A situation where two or more devices compete for the DMA channel must be resolved by the firmware, and it is absolutely forbidden for two or more devices to ground $\overline{\text{DMAR}}$ at the same time. (A data request for DMA is not like an interrupt request; there is no priority scheme, and no means for the hardware to select, identify and notify an interface as the winner of a race for DMA service.) Furthermore, a device must not begin requesting DMA transfers on its own; it must wait until instructed to do so by the firmware.

During a DMA transfer of a block of data the IOC knows the next memory location involved, whether input or output, which select code (and possibly) whether or not the transfer of the entire block is complete. This information is in registers in the IOC, which are set up by the firmware before the peripheral is told to begin DMA activity.

The DMA process is altogether independent of the operation of standard I/O and of the interrupt system, and except for cycle-stealing, does not interfere with them in any way.

Enabling and Disabling the DMA Mode

DMA transfers as described above are referred to as the DMA Mode. The DMA Mode can be disabled two ways: by a DDR (Disable Data Request), or by a PCM (Pulse Count Mode — described later). A DDR causes the IOC to simply ignore $\overline{\text{DMAR}}$; no more, no less. The instruction DMA (DMA Mode) causes the IOC to resume DMA Mode operation; DMA cancels DDR, and vice versa. DMA also cancels PCM, and vice versa. Also, DDR cancels PCM, and vice versa.

Also, the IOC turns on as if it has just been given a DDR. DDR (along with DIR) is useful during system initialization (or possible error recovery) routines, where it is unsafe to allow any system activity to proceed until the system is properly initialized (or restarted).

Register Set-Up

There are three registers that must be set up prior to the onset of DMA activity. These are shown in Table 4 below.

Table 4

| Name | Address | Meaning |
|---|---|---|
| DMAPA | $(=13_8)$ | DMA Peripheral Address |
| DMAMA | $(=14_8)$ | DMA Memory Address (and direction) |
| DMAC | $(=15_8)$ | DMA Count |

The four least significant bits of DMAPA specify the select code that is the peripheral side of the DMA activity. During an I/O Bus Cycle given in response to a DMA data request, the four least significant bits of DMAPA will determine the states of the PA lines, not the PA register.

DMAC can, if desired, be set to $n$-1, where $n$ is the number of words to be transferred. During each transfer the count in DMAC is decremented. During the last transfer the IOC automatically generates signals which the interface can use to recognize the last transfer. In the case of a transfer of unknown size, DMAC should be set to a very large count, to thwart the automatic termination mechanism. In such cases it is up to the interface to identify the last transfer.

DMAMA is set to the address of the first word in the block to be transferred. This is the lowest numbered address; after each transfer DMAMA is automatically incremented by the IOC. Bit 15 of DMAMA specifies input or output (relative to the processor); a zero specifies input and a one specifies output.

DMA Initiation

Once the three registers are set up, a "start DMA" command is given to the interface through standard programmed I/O. The "start DMA" command is an output I/O Bus Cycle with a particular combination of $\overline{\text{IC1}}$, $\overline{\text{IC2}}$, (and perhaps) a particular bit pattern in the transmitted word. The patterns themselves are subject to agreement between the firmware designer and the interface designer. Sophisticated peripherals using DMA in both directions will have two start commands, one for input and one for output. It's also possible that other information could be encoded in the start command (block size, for instance).

Data Request and Transfer

The interface exerts $\overline{\text{DMAR}}$ low whenever it is ready to exchange a word of data. When $\overline{\text{DMAR}}$ goes low the IOC requests control of the IDA Bus. When granted the Bus, the IOC initiates an I/O Bus Cycle with the PA lines controlled by DMA Peripheral Address, and does a memory cycle. (The order of these two operations depends upon the direction of the transfer).

Next the IOC increments DMA Memory Address and decrements DMA Count.

DMA Termination

There are two automatic termination mechanisms, each usable only when the block size is known in advance, and each based on the count in DMAC going negative. Recall that at the start of the operation part of DMAC is set to $n-1$, where $n$ is the size of the transfer in words.

During the transfer of the $n$th word, the IOC will signal the interface by temporarily exerting $\overline{\text{IC2}}$ high during the I/O Bus Cycle for that exchange. The interface can detect this and cease DMA operations.

The other means of automatic termination is detection by the interface of a signal called Count Minus ($\overline{\text{CTM}}$). $\overline{\text{CTM}}$ is generated by the IOC; it means that the count in the least significant 15 bits of DMAC has gone negative. $\overline{\text{CTM}}$ is a steady-state signal, given as soon as, and as long as, the count in DMAC is negative. $\overline{\text{CTM}}$ is generated by the IOC but is not utilized in the configuration employed in the hybrid microprocessor. That is, $\overline{\text{CTM}}$ never leaves the IOC.

For DMA transfers of unknown block size, the interface determines when the transfer is complete, and flags or interrupts the processor.

The Pulse Count Mode

The Pulse Count Mode is a means of using the DMA hardware to acknowledge, but do nothing about, some number of leading DMA requests. The Pulse Count Mode is initiated by a PCM, and resembles the DMA Mode, but without the memory cycle. The activities of the three registers DMAPA, DMAC and DMAMA remain as described for DMA Mode operation. The only difference is that no data is exchanged with memory; no memory cycle is given. (The IOC even requests the IDA Bus, but when granted it, releases it without doing the memory cycle).

A dummy I/O Bus Cycle is given, and DMAC decremented. Also, the automatic termination mechanisms still function; in fact, they are the object of the entire operation. The Pulse Count Mode is intended for applications like the following: Suppose it were desired to move a tape cassette a known number of files. The firmware puts the appropriate number into DMAC, gives PCM, and instructs the cassette to begin moving.

The cassette would give a DMA Request each time it encounters a file header. In this way the DMA hardware and the automatic termination mechanism count the number of files for the cassette. PCM cancels DMA and DDR. Both DMA and DDR cancel PCM.

Extended Bus Grant

Two of the signals of the IDA Bus are Bus Request ($\overline{\mathrm{BR}}$) and Bus Grant (BG). These two signals are used, for instance, during a DMA transfer. The IOC requests the IDA Bus (in order to do the necessary memory cycle) by grounding $\overline{\mathrm{BR}}$. When BG is given the IOC then knows to proceed.

Other entities can also request the IDA Bus. All chips in the system listen to Bus Request, and Bus Grant cannot go high until all chips consent to it; a 'wired and' does that. If two chips request the IDA Bus at the same time, the winner of BG is specified, and the loser is kept waiting by a daisy-chain priority scheme for the routing of Bus Grant. This is depicted in FIG. **124**.

As FIG. **124** shows, the IOC is the initial receiver of Bus Grant; if it's not who is requesting the Bus, then the tester gets Bus Grant next. If the tester is not requesting the Bus, then the next device in the chain has the chance to use Bus Grant. A device gives the next device its chance by passing along the signal EXBG (Extended Bus Grant). The requesting device understands EXBG as a Bus Grant, and refuses to send EXBG any further.

IOC Machine Instructions.

Assembly language machine instructions are three-letter mnemonics. Each machine instruction source statement corresponds to a machine operation in the object program produced by an assembler.

Notation used in requesting source statement is explained below:

| | |
|---|---|
| reg 0–7 | Register location. |
| reg 4–7 | Register location. |
| I | Increment indicator (for place and withdraw instructions); for BPC memory reference instructions it is an indirect addressing indicator. |
| D | Decrement indicator for place and withdraw instructions. |
| ,I/,D | The slash indicates that either item (but not both) may be used at this place in the source statement. |
| [] | Brackets indicate that the item contained within them is optional. |

Stack Group

The stack group manages first-in, last-out firmware stacks. The "place" instruction puts a word or a byte into a stack pointed at by C or D. The item that is placed is reg 0–7. The "withdraw" instructions remove a word or a byte from a stack pointed at by C or D. The removed item is written into reg 0–7.

After each place or withdraw instruction the stack pointer is either incremented or decremented, as specified in the source text by the optional I or D, respectively. In the absence of either an I or a D, the assembler defaults to I for place instructions, and D for withdraw instructions.

Place instructions increment or decrement the stack pointer prior to the placement, and withdraw instructions do it after the withdrawal. In this way the pointer is always left pointing at the top of the stack.

For byte operations bit 15 of the pointer register (C or D) indicates left or right half (one = left, zero = right). Stack instructions involving bytes toggle bit 15 at each increment or decrement; but the lower bits of the pointer increment or decrement only every other time.

The values of C and D for place-byte and withdraw-byte instructions must not be the address of any internal register for the BPC, EMC, or IOC. The place and withdraw instruction can also initiate I/O operations, so they are also listed under the I/O group. The stack group instructions are listed below.

PWC reg 0–7 [,I/,]

Place the entire word of reg into the stack pointed at by C.

PWD reg 0–7 [,I/,D]

Place the entire word of reg into the stack pointed at by D.

PBC reg 0–7 [,I/,D]

Place the right half of reg into the stack pointed at by C.

PBD reg 0–7 [,I/,D]

Place the right half of reg into the stack pointed at by D.

WWC reg 0–7 [,I/,D]

Withdraw an entire word from the stack pointed at by C, and put it into reg.

WWD reg 0–7 [,I/,D]

Withdraw an entire word from the stack pointed at by D, and put it into reg.

WBC reg 0–7 [,I/,D]

Withdraw a byte from the stack pointed at by C, and put it into the right half of reg.

WBD reg 0–7 [,I/,D]

Withdraw a byte from the stack pointed at by D, and put it into the right half of reg.

I/O Group

The states of $\overline{\mathrm{IC1}}$ and $\overline{\mathrm{IC2}}$ during the I/O Bus Cycles initiated by the instructions listed hereinafter depend upon which register is the operand of the instructions as shown in Table 5 below.

Table 5

| | $\overline{\mathrm{IC1}}$ | $\overline{\mathrm{IC2}}$ |
|---|---|---|
| R4 | 1 | 1 |
| R5 | 1 | 0 |
| R6 | 0 | 1 |
| R7 | 0 | 0 |

mem. ref. inst. reg 4–7 [,I]

Initiate an I/O Bus Cycle. Memory reference instructions 'reading' from reg cause intput I/O Bus Cycles; those 'writing' to reg cause output I/O Bus Cycles. In either case the exchange is between A or B and the interface addressed by the PA register (Peripheral Address Register - $11_8$); reg 4–7 do not really exist as physical registers within any chip on the IDA Bus.

stack inst. reg 4–7 [,I/,D]

Initiate an I/O Bus Cycle. Place instructions 'read' from reg, therefore they cause input I/O Bus Cycles. Withdraw instructions 'write' into reg, therefore they cause output I/O Bus Cycles. In either case the exchange is beween the addressed stack location and the interface addressed by PA.

Interrupt Group

The interrupt group instructions are listed below.

EIR

Enable the interrupt system. This instruction cancels DIR.

DIR

Disable the interrupt system. This instruction cancels EIR.

DMA Group

The DMA group instructions are listed below.

DMA

Enable the DMA mode. This instruction cancels PCM and DDR.

PCM

Enable and Pulse Count Mode. This instruction cancels DMA and DDR.

DDR

Disable Data Request. This instruction cancels the DMA Mode and the Pulse Count Mode.

IOC Machine-Instructon Bit Patterns

FIGS. 125A-C depict the bit patterns of the IOC machine-instructions.

Internal Description of the IOC

The IOC may be understood with reference to the detailed block diagram of FIGS. 126A-C. A DMP IDA micro-instruction provides communication from the IDA Bus to the internal $\overline{\text{IDC}}$ Bus in the IOC. A SET IDA micro-instruction provides communication from the IOC to the IDA Bus; SET IDA drives the IDA Bus according to the contents of the O Register, which in turn is set with a SET O micro-instruction.

As in the BPC, and Address Decode section and associated latches detect the appearance of an IOC-related register address. Such as event results in the address being latched and sent to the Bus Control ROM as qualifier information.

There are two main ROMs in the IOC. These are the Bus Control ROM and the Instruction Control ROM. The Bus Control ROM is responsible for generating and responding to activity between the IOC and the IDA and $\overline{\text{IOD}}$ busses. This class of activity consists of memory cycles, I/O Bus cycles, interrupt polls, interrupt requests, and requests for DMA. The instruction Control ROM is responsible for recognizing fetched IOC machine-instructions, and for implementing the algorithms that accomplish those instructions. Frequently, the Bus Control ROM will undertake activity on the behalf of the Instruction Control ROM. These two ROMs are physically merged, and share a common set of decodable micro-instructions.

However, each of the two ROMs has its own state-counter. For each ROM, the next state is explicitly decoded by each current state.

The I Register serves a function similar to that of the I Register of the BPC. It serves as a repository to hold the fetched machine-instruction and to supply that instruction to Instruction Decode. Instruction Decode generates Asynchronous Control Lines that are similar in function to those of the BPC. Instruction Decode also generates Instruction Qualifiers that represent the machine-instruction to the ROM mechanism.

The W Register is used primarily in conjunction with the execution of the place and withdraw machine-instructions. Each such instruction requires two memory cycles; one to get the data from the source, and one to transmit it to the destination. W serves as a place to hold the data in between those memory cycles.

The DMP W function is complex, and is implemented by a DMP W and Crossover Network. If the place or withdraw operation is for the entire word, the crossover function is not employed, and the pairs of signals OLB, DLB, and, OMB, DMB, work together to implement a standard 16-bit DMP W. However, a byte oriented place or withdraw instruction involves the dumping of only a single byte of W onto the $\overline{\text{IDC}}$ Bus. This is done in the following combinations: least-significant byte of W to most-significant half of the $\overline{\text{IDC}}$ Bus; least-significant byte of W to least-significant half of the $\overline{\text{IDC}}$ Bus; and, most-significant byte of W to least-significant half of the $\overline{\text{IDC}}$ Bus. The exact mode of operation during a DMP W is determined by W Register Control on the basis of the Asynchronous Control Lines from Instruction Decode.

Another use of W occurs during an interrupt. During an interrupt poll the response of the requesting peripheral(s) is loaded into the least-significant half of W. These eight bits represent the eight peripherals on the currently active (or enabled) level of interrupt. Each peripheral requesting interrupt service during the poll will have a one in its corresponding bit. This eight-bit pattern is fed to a Select Code Priority Resolver and 3 LSB Interrupt Vector Generator. That circuitry identifies the highest numbered select code requesting service (should there be more than one) and generates the three least-significant bits of binary code that correspond to that peripheral's select code. The next most-significant bit corresponds to the level at which the interrupt is being granted, and it is available from the interrupt circuitry in the form of the signal $\overline{\text{PHIR}}$.

The interrupt vector is made up of the three least-significant bits from W, as encoded by the priority resolver, the bit corresponding to $\overline{\text{PHIR}}$, and the 12 bits contained in the Interrupt Vector Register (IV). Thus, when an interrupt is granted the complete interrupt vector is placed on the $\overline{\text{IDC}}$ Bus by simultaneously giving the following micro-instructions: EPR, DMP, ISC, UIG, and DMP IV.

The C and D Registers are the pointer registers used for place and withdraw operations. Each of these registers is equipped with a 15-bit increment and decrement network for changing the value of the pointer. Whether to increment or decrement is controlled by the C and D Register Control circuit according to the Asynchronous Control Lines.

The DMA Memory Address (DMAMA) and DMA Count (DMAC) Registers are similar to the C and D Registers, except that DMAMA always increments, and that DMAC always decrements. In addition, the decrement for DMAC is a 16-bit decrement. These two registers are used in conjunction to identify the destination or source address in memory of each DMA transfer, and to keep a count of the number of such transfers so far.

Two separate mechanisms are provided for the storage of peripheral select codes. The DMAPA Register is a four-bit register used to contain the select code of any peripheral that is engaged in DMA.

The other mechanism is a three-level stack, also four bits wide, whose uppermost level is the Peripheral Address Register (PA). It is in this stack that peripheral select codes for both standard I/O and interrupt I/O are kept. The stack is managed by the interrupt circuitry.

The Peripheral Address Lines (PA Lines) reflect either the contents of DMAPA or PA, depending upon whether or not the associated I/O Bus cycles are for DMA or not, respectively. This selection is controlled by the DMA circuitry, and is implemented by the Peripheral Address Bus Controller.

Three latches control whether or not the Interrupt System is active or disabled, whether or not the DMA Mode is active or disabled, and, whether or not the Pulse Count Mode is active or disabled. Those latches are respectively controlled by these machine-instructions; EIR and DIR for the Interrupt System, and, DMA, PCM, and DDR for DMA-type operations.

The interrupt circuitry is controlled by a two-bit state-counter and ROM. The state-count is used to represent the level of interrupt currently in use. Requests for interrupt are made into qualifiers for the ROM of the interrupt controller. If the interrupt request can be granted it is represented by a change in state of that ROM, as well as by instructions decoded from that ROM and sent to the Interrupt Grant Network. This circuitry generates the $\overline{\text{INT}}$ signal used to cause an interrupt of the BPC, and, generates an INTQ qualifier that represents the occurrence of an interrupt to the main ROM mechanism in the IOC so that an interrupt poll can be initiated.

The DMA circuitry is similar in its method of control. It has a ROM controlled by a three-bit state-counter.

Description of the EMC

The Extended Math Chip (EMC) executes **15** macine-instructions. Eleven of these operate on BCD-Coded three-word mantissa data. Two operate on blocks of data of from 1 to 16 words. One is a binary multiply and one clears the Decimal Carry (DC) register.

Unless specified otherwise, the contents of the registers A, B, SE and DC are not changed by the execution of any of the EMC's instructions. The EMC communicates with other chips along the IDA Bus in a way similar to how the IOC communicates via the Bus.

Notation

A number of notational devices are employed in describing the operation of the EMC.

The symbols <...> denotes a reference to the actual contents of the named location.

$A_{0\text{-}3}$ and $B_{0\text{-}3}$ denote the four least significant bit-positions of the A and B registers, respectively. Similarly, $A_{4\text{-}15}$ denotes the 12 most-significant bit-positions of the A register. And by the previous convention, $<A_{0\text{-}3}>$ represents the bit pattern contained in the four least-significant bit-positions of A.

AR1 is the label of a four-word location in R/W memory: $77770_8$ through $77773_8$.

AR2 is the label of a four-word arithmetic accumulator register located within the EMC, and occupying register addresses $\mathbf{20}_8$ through $\mathbf{23}_8$.

SE is the label of the four-bit shift-extend register, located within the EMC. Although SE is addressable, and can be read from, and stored into, its primary use is as internal intermediate storage during those EMC instructions that read something from, or put something into, $A_{0\text{-}3}$. The address of SE is $\mathbf{24}_8$.

DC is the mnemonic for the one-bit decimal-carry register located within the EMC. DC is set by the carry output of the decimal adders of the EMC. Sometimes, in the illustrations of what the EMC instructions do, DC is shown as being part of the actual computation, as well as being a repository for overflow. In such cases the initial value of DC affects the result. However, DC will usually be zero at the beginning of such an instruction. The firmware sees to that by various means.

DC does not have a register address. Instead, it is the object of the BPC instructions SDS and SDC (Skip if Decimal Carry Set and Skip if Decimal Carry Clear), and the EMC instruction CDC (Clear Decimal Carry).

Data Format

The EMC can perform operations on twelve-digit, BCD-encoded, floating point numbers. Such numbers occupy four words of memory, and the various parts of a number are put into specific portions of the four words. FIG. **127** depicts this format.

The twelve mantissa digits are denoted by $D_1$ through $D_{12}$. $D_1$ is the most-significant digit, and $D_{12}$ is the least-significant digit. It is assumed that there is a decimal point between $D_1$ and $D_2$. $E_s$ and $M_s$ each represent positive and negative (signs) by zero and one, respectively.

EMC Machine Instructions

Assembly language EMC machine-instructions are three-letter mnemonics. Each machine instruction source statement corresponds to a machine operation in the object program produced by an assembler.

Notation used in representing source statements is explained below:

N Constant whose value is restricted to the range: $1 \leqq N \leqq 20_8 = 16_{10}$

The Four-Word Group

The four-word group instructions are listed below.

CLR N

Clear N words. This instruction clears N consecutive words, beginning with location < A >. Recall that: $1 \leqq N \leqq 16_{10}$.

```
                 0→location <A>
                 0→location <A>+1
                 •
                 •
                 •
                 0<location <A> + N−1
     XFR N
```

Transfer N words. This instruction transfers the N consecutive words beginning at location < A > to those beginning at < B >. Recall that: $1 \leqq N \geqq 16_{10}$.

```
          location <A>  → location <B>
       location <A>  +1 →location <B>+1
                        •
                        •
                        •
     location <A>+N-1 → location <B>+N-1
```

The Mantissa Shift Group

The mantissa shift group instructions are listed below.

MRX

Mantissa right shift of AR1 $r$ times, $r = <B_{0\text{-}3}>$, and $0 \leqq r \leqq 17_8 = 15_0$.

1st shift: $<A_{0\text{-}3}> \rightarrow D_1$; ... $<D_i> \rightarrow D_{i+1}$; ... $D_{12}$ is lost

$j$th shift: $0 \rightarrow D_1$; ... $<D_i> \rightarrow D_{i+1}$; ... $D_{12}$ is lost

$r$th shift: $0 \rightarrow D_1$; ... $<D_i> \rightarrow D_{i+1}$; ... $<D_{12}> \rightarrow A_{0\text{-}3}$; $0 \rightarrow DC$; $0 \rightarrow A_{4\text{-}15}$

Notice:

(1) The first shift does not necessarily shift in a zero; the first shift shifts in $<A_{0\text{-}3}>$.

(2) The last digit shifted out ends up as $<A_{0\text{-}s}>$.

(3) If only one digit-shift is done, (1) and (2) happen together.

(4) After (2), SE is the same as $<A_{0\text{-}s}>$.

(5) Any more than eleven shifts is wasteful.

MRY

Mantissa right shift of AR2 $<B_{0\text{-}3}>$ -times. Otherwise identical to MRX.

MLY

Mantissa left shift of AR2 one time.

$<A_{0\text{-}3}> \rightarrow D_{12}$; ... $<D_i> \rightarrow D_{i-1}$; ... $<D_1> \rightarrow A_{0\text{-}3}$; $0 \rightarrow DC$; $0 \rightarrow A_{4\text{-}15}$

At the conclusion of the operation SE equals $<A_{0\text{-}3}>$.

DRS

Mantissa right shift of AR1 one time.

$0 \rightarrow D_1; \ldots < D_i > \rightarrow D_{i+1}; \ldots < D_{12} > \rightarrow A_{0\text{-}3}; 0 \rightarrow DC; 0 \rightarrow A_{4\text{-}15}$

At the conclusion of the operation SE equals $< A_{0\text{-}3} >$.

NRM

Normalize AR2. The mantissa digits of AR2 are shifted left until $D_1 \neq 0$.

If the original $D_1$ is non-zero, no shifts occur. If twelve shifts occur, then AR2 equals zero, and no further shifts are done. The number of shifts is stored as a binary number in $B_{0\text{-}3}$.

i. $0 \rightarrow B_{4\text{-}15}$; # of shifts $\rightarrow B_{0\text{-}3}$

ii. For $0 \leqq < B_{0\text{-}3} > \leqq 11; 0 \rightarrow DC$

iii. If $< B_{0\text{-}3} > = 12; 1 \rightarrow DC$

The Arithmetic Group

The arithmetic group instructions are listed below.

CMX

Ten's complements of AR1. The mantissa of AR1 is replaced with its ten's complement, and DC is set to zero.

CMY

Ten's complement of AR2. The mantissa of AR2 is replaced with its ten's complement, and DC is set to zero.

CDC

Clear Decimal Carry. Clears the DC register; O → DC.

FXA

Fixed-point addition. The mantissas of AR1 and AR2 are added together, along with DC (as a $D_{12}$-digit), and the result is placed in AR2. If an overflow occurs, DC is set to one, otherwise, DC is set to zero at the completion of the addition.

During the addition the exponents are not considered, and are left strictly alone. The signs are also left completely alone.

$<AR1> = D_1\,D_2\,D_3 - - - D_{12}$
$<AR2> = D_1\,D_2\,D_3 - - - D_{12}$
$\underline{\qquad + \qquad\qquad <DC>} \leftarrow$ initial value of DC
(overflow)$\rightarrow$ "$D_0$"$D_1\,D_2\,D_3 - - - D_{12} \rightarrow AR2$
DC (final value of DC)
MWA

Mantissa Word Add. $< B >$ is taken as four BCD digits, and added, as $D_9$ through $D_{12}$, to AR2. DC is also added in as a $D_{12}$. The result is left in AR2. If an overflow occurs, DC is set to one, otherwise, DC is set to zero at the completion of the addition.

During the addition the exponents are not considered, and are left strictly alone, as are the signs. MWA is intended primarily for use in rounding routines.

$<B> = \text{———} D_9\,D_{10}\,D_{11}\,D_{12}$
$<AR2> = D_1 - - - D_9\,D_{10}\,D_{11}\,D_{12}$
$\underline{\qquad + \qquad\qquad <DC>} \leftarrow$ initial value of DC
(overflow)$\rightarrow$ "$D_0$" $D_1 - - - D_9\,D_{10}\,D_{11}\,D_{12} \rightarrow AR2$
DC (final value of DC)

FMP

Fast multiply. The mantissas of AR1 and AR2 are added together (along with DC as $D_{12}$) $< B_{0\text{-}3} >$ -times; the result accumulates in AR2.

The repeated additions are likely to cause some unknown number of overflows to occur. The number of overflows that occurs is returned in $A_{0\text{-}3}$.

FMP is used repeatedly to accumulate partial products during BCD multiplication. FMP operates strictly upon mantissa portions; signs and exponents are left strictly alone.

$<AR2> + ((<AR1>\cdot(<B_{0\text{-}3}>)) + DC \rightarrow AR$

| | |
|---|---|
| DC doesn't enter into these repeated additions except for the first one as shown at right. 0 → DC immediately after each overflow | Represents the initial value of DC. |

$0 \rightarrow DC, 0 \rightarrow A_{4\text{-}15}$, # of overflows$\rightarrow A_{0\text{-}3}$
MPY

Binary Multiply Using Booth's Algorithm. The (binary) signed two's complement contents of the A and B registers are multiplied together. The thirty-two bit product is also assigned two's complement number, and is stored back into A and B. B receives the sign and most-significant bits, and A the least-significant bits.

$$< A > \cdot < B > \rightarrow \overbrace{< B > < A} >$$

FDV

Fast Divide. The mantissas of AR1 and AR2 are added together until the first decimal overflow occurs. The result of these additions accumulates into AR2. The number of additions without overflow ($n$) is placed into B.

$$< AR2 > + < AR1 > + < DC > \rightarrow AR2$$

(repeatedly until overflow)

then

$$0 \rightarrow DC, 0 \rightarrow B_{4\text{-}15}, n \rightarrow B_{0\text{-}3}$$

FDV is used in floating-point division to find the quotient digits of a division. In general, more than one application of FDV is needed to find each digit of the quotient.

As with the other BCD instructions, the signs and exponents of AR1 and AR2 are left strictly alone. FIGS. 128A-C depict the bit patterns of the EMC machine-instructions.

Internal Description of the EMC

FIGS. 129A-C depict the internal block diagram of the EMC. The micro-instructions SET IDA and DMP IDA are the communication link between the external IDA bus and the internal $\overline{\text{IDM}}$ bus. An instruction is fetched by the BPC and placed on the IDA Bus. All chips connected to the bus decode it and act accordingly.

If the fetched instruction is not an EMC instruction, or if an interrupt request is made, the EMC ignores the instruction. Upon completion of the instruction by another chip or upon completion of the interrupt, the EMC examines the next instruction. If the instruction is an EMC instruction, it is executed and data effected by it are transferred via the IDA bus. At the appropriate point during the execution of the instruction, SYNC is given to indicate to other chips that it has finished using the IDA Bus and consequently to treat the next data that appears on IDA as an instruction.

The Word Pointer Shift Register points to the register to be effected by the DMPX/SETX or DMPY/SETY micro-instructions and the registers to be bussed to the Adder. It is also employed as a counter in some instructions.

Once data is on the $\overline{\text{IDM}}$ Bus, it can then be loaded into one of several registers by issuing the appropriate micro-instruction. The data paths between IDM and the X and Y registers can be controlled in two ways. One way is by issuing an explicit micro-instruction, e.g., SET Y2 would set the Y2 Register with the data on $\overline{\text{IDM}}$. Another way of accomplishing the same thing would be to issue a SET Y for a word pointer equal two.

The X Registers are used for all shifting operations, the direction being instruction dependent.

The Shift Extend Register is a four-bit addressable register used to hold a digit to be shifted into the X register or one that has been shifted out of X.

The Arithmetic Extend Register is a four-bit addressable (read-only) register used to accumulate a decimal digit for the FMP and FDV instructions and serves as a number-of-shifts accumulator in the NRM instruction.

The N Counter is used to indicate the number of words involved in the CLR and XFR instructions, the number of shifts in MRX, MRY, MLY and DRS, the multiplier digit in FMP, and a loop counter in MPY.

The Adder is capable of either binary or BCD addition with the complementer being capable of either one's or nine's complementation of the Y Register inputs. A carry-in signal is available from three sources for generating two's or ten's complement arithmetic.

The Decimal Carry Register is a one-bit register that can hold the carry-out of the Adder. ADR1 is the address of the AR1 operand; its two least significant bits are determined by the word pointer, e.g., WP0 => 00, WP1 => 01, etc.

The Address Decode ROM generates the control signals used for reading from or writing into a register in either the Extended Register Access (ERA) mode or the normal addressing mode of operation. Miscellaneous hardware has been added to enhance the execution of the two's complement binary multiply instruction (MPY).

## BUS CONTROL

The direction of data flow on the IDA bus is controlled by the bus control circuit of FIGS. **16** and **130**. Gate U**19** provides the basic definition of the direction of data flow. The direction of data flow is normally from the microprocessor to the memory since address is the first data on the IDA bus when the memory cycle starts. This condition is controlled by the STM signal into gate U**19** being logically false. Once the memory cycle starts, the Processor Driving (PDR) signal indicates that data flow is from processor to memory. In some instances, such as during direct memory access (DMA) operation, the PDR signal does not indicate the direction of data flow on the IDA bus. For this case, the Write (WRIT) signal is ANDed into U**19** to decide bus direction. Also, since the first thirty-two memory addresses are actually registers within the microprocessor, the Register Access Line (RAL) is used to prevent bus conflict when accessing register information. Finally, the Monitor Buffer Control (MBC) signal is also ANDed in to define bus direction during testing. The resulting output of U**19** is called the Stay Off Bus (SOB) signal since it indicates those times when the memory section is not allowed to be on the IDA bus. The bus control circuit also controls the direction of the bidirectional data buffer located within the hybrid microprocessor (processor buffer out, PBO, signal). Since the microprocessor buffer and the memory buffers normally operate in tandem (i.e., when the microprocessor buffer points out, the memory buffer points into memory, and when the memory buffer points out, the microprocessor buffer points into the microprocessor) the SOB signal is inverted by U17A and used to control the microprocessor's buffer.

The bus control circuit also decodes the upper three bits of the IDA bus (IDA**12** through IDA**14**) using a dual open-collector output 2-line to 4-line decoder (Texas Instruments device SN74LS156 or equivalent) as a one-of-eight decoder. The memory space is thus broken into 4096-word divisions. The memory map of FIG. **6** shows allocation of read-only and read/write memory in the memory space. The first three outputs of the decoder are wire-ORed together to indicate that the mainframe language ROM memory section is being accessed. The next three outputs of the decoder are also wired-ORed together with the two-pole switch S1 determining whether or not the upper two outputs are to be included in the wire-ORing. The resulting output determines which portion of the memory space is taken by the optional plug-in ROM memory section. The balance of the address space is assumed to be read/write memory. The boundary between the plug-in ROM and the read/write memory is determined by switch S1 which is set according to the amount of optional read/write memory that the calculator contains. The STM (Start Memory) signal is used to latch the outputs of the decoder into the latches U16A and U16B for the balance of the memory cycle since address information is only present on the IDA bus at the beginning of the memory cycle. The output of the latches is gated with the Stay Off Bus (SOB) signal to prohibit the memory section from placing data onto the IDA bus until permitted to do so. If the data to be read is located in the mainframe language ROM memory section, the bus control circuit releases the mainframe ROM buffer control (MFRBC) signal to allow the ROM to place data on the IDA bus and point the bidirectional buffer associated with the ROM from the memory to the microprocessor. Likewise, if the data to be read is located in the plug-in ROM memory section, the bus control circuit releases the plug-in ROM buffer control (PIRBC) signal. If the data, instead, is to be read from the read/write memory sections, the bus control simply removes the Stay Off Bus signal to allow the read/write memory to place the data on the IDA bus at its discretion.

## MEMORY TIMING AND CONTROL

The Memory Timing and Control block of FIG. **16** may be understood with reference to the detailed schematic diagram of FIG. **131**. This block comprises a small state counter, U21, which counts the number of states in the memory cycle. The counter initiates its sequence when the STM signal occurs if the memory cycle is referencing addresses located in the memory section (indicated by the RAL signal not being true). The counter is clocked on the rising edge of the phase two clock. On the first clock after the STM occurs, flip-flop U21A changes state and the STMROM signal is generated. Thus, the STM signal to the ROM is delayed by one-half of a state time to allow more address setup time as required by the ROM. On the next state time, the second flip-flop U21B is set provided that the Memory Busy (MEB) signal is not true. The Memory Busy signal is used to suspend the sequencing should the read/write memory be addressed and not be able to participate in the memory cycle immediately (such as being in a refresh cycle when the memory cycle starts). When the second flip-flop is set, the Unsynchronized Memory Complete (UMC) signal is generated to indicate to the microprocessor that the memory cycle is complete. FIG. 109 illustrates the timing associated with the memory cycle.

## READ-ONLY MEMORY

Both the plug-in ROM memory section and the mainframe language ROM memory section shown in the block diagram of FIG. 4 are composed of a number of N-channel MOS sixteen-kilobit integrated circuits. These devices are organized as 1024 words of 16 bits and contain their own dynamic address latches and mask-programmable address decode circuits. The organization of the read-only memory section is shown in FIG. 132. The mainframe language ROM memory section contains twelve such devices. The plug-in ROM modules contain either two or four such devices depending on the features which the ROM module contains. An example of the ROM circuitry used in all the read-only memory sections is shown in FIG. 133. The 16-bit IDA bus input/outputs are used for receiving the address information from the microprocessor and for outputting the data accessed. When the STM input is not true, the ROM assumes that memory address information is on the IDA bus and continually inspects IDA bits 10 through 14 to determine if it has been addressed. The device is designed such that power consumption when not addressed is approximately one-tenth the consumption when addressed. Therefore, the power consumption in the calculator is reduced by applying the power to the device only when it is addressed. Consequently, each ROM device has an associated "power pulse" circuit 211 which is turned on by the ROM address decode circuit (powered separately from the +12 volts input) only when the ROM is addressed. If the ROM detects its address, it exerts the power pulse (PWP) output which switches on the transistor and applies +12 volts to the voltage switch (VSW) input that powers the balance of the ROM circuit. The ROM latches the address information and starts its data access when the STM signal (STMROM) is exerted. The accessed data is placed on the IDA bus as soon as it is accessed (approximately 300 ns) provided the output drivers are not disabled (Output Data Disable, ODD) by the bus control circuit.

## READ/WRITE MEMORY

Both the basic read/write memory section and the optional read/write memory section shown in the block diagram of FIG. 4 are identical in structure. As shown in the detailed schematic diagram of FIG. 134, each section contains an address decoder U1 which examines the upper three bits of the address (IDA12 through IDA14) and generates one of three outputs depending on whether the address is 70K, 60K, or 50K octal. A jumper is used to select which address the memory section responds to thereby defining the memory section as the basic read/write section or the optional read/write section. The output of the address decoder is latched in U5 along with the balance of the address (U12, U14, U16) when the Start Memory (STM) signal occurs. The output of U5 is gated with the STM signal to generate the Request for service (REQ) signal which is sent to the read/write memory control circuit. The output of the address latches goes directly to the read/write memory devices with the exception of the lower six bits which first traverse a two-to-one data selector (U17 and U18). The other input of the data selector comes from the refresh address counter (U20 an U21). The lower six bits of the address are selected by a read/write memory control circuit (DATA SELECT) as determined by the read/write cycle being either a refresh cycle or a normal memory cycle. At the start of the refresh cycle, the read/write control circuit first increments the refresh address counter to advance it to the next memory address to be refreshed.

The read/write memory control circuit is shown in the detailed schematic diagram of FIG. 135. The state of the memory control is determined by the four flip-flops of devices U6 and U7. The flip-flops of U7 indicate that a refresh cycle is in progress. The waveforms associated with the control circuitry are shown in FIG. 136. The flip-flops are clocked on the positive-going edge of the phase two clock. When the STM signal occurs, flip-flop U6A will be set via U4A and U4B on the next clock provided neither flip-flop of U7 is set. The read/write memory devices are enabled (CEN) via U9A whenever either U6A or U6B are set. Whether the read/write memory devices perform a read or write operation is determined by gate U2A (RW). If the RW signal is a logical high, the read/write devices are in read mode. To generate the write mode, three conditions are necessary: the Write (WRIT) signal from the microprocessor must be logically true; a refresh cycle must not be in progress (U7A and U7B are not set); and the latch composed of gates U3C and U3D must be set (U3C output high). The latch is cleared by the Request (REQ) signal not being true. The latch is set at the beginning the next phase two clock following the setting of flip-flop U6B. If the memory cycle is a read cycle, the Output Buffer Enable (OBC) signal, which allows the output of the read/write memory devices to be placed on the IDA bus, is generated via U2C when the memory timing and control circuit removes the Stay Off Bus (SOB) signal.

The refresh cycle is initiated via gate U4B when the monostable U21 delay period has expired provided that the microprocessor is not requesting use of the memory. When the cycle is initiated, flip-flop U7A will be set which causes the read/write cycle by setting U6B via U4A and U4B on the next state time. Secondly, flip-flop U7A also generates the Memory Busy (MEB) signal via U2B and U3B to notify the memory timing and control circuit should the microprocessor start a memory cycle while the refresh cycle is in progress. Thirdly, flip-flop U7A also drives the RW signal, via U8B, to the read logic level as required by the read/write memory devices during the refresh cycle. The second flip-flop of the refresh cycle, U7B will be set the state time following the setting of flip-flop U6A to sustain the conditions required for the refresh cycle. When the read/write cycle has expired, indicated by flip-flop U6B resetting, the next state time flip-flop U7B resets thus terminating the refresh cycle.

The read/write memory devices, Texas Instruments devices TMS 4030 or equivalent, are shown in FIG. 137. The devices are organized as 4096 addresses of one bit. The read/write (RW) control signal determines if the operation is a read (RW high) or a write operation. If the cycle is a write cycle, the data written is accepted from the Data In (DIN) inputs. If the cycle is a read cycle, the data is presented at the Data Out (DOUT) outputs and will be placed onto the IDA bus when the Output Buffer Enable (OBE signal is generated by the read/write memory control. The read/write cycle is started when the Chip Enable (CEN) signal occurs provided that the devices have been selected by the

Chip Select (CS) signal. The memory section is capable of byte operation as determined by flip-flop U5 and gates U8C and U8D. The memory bus control signal Byte (BYTE) from the microprocessor indicates if the memory operation is to be a byte operation. If the Byte signal does not occur, both bytes are enabled. If the byte signal does occur, the address bit IDA15, latched in U5B when STM occurs, will determine which byte is being referenced.

## KDP CONTROL

Referring now to FIG. 138, there is shown a detailed schematic diagram of an I/O interface included within the KDP control block of FIG. 4. When the Initialize (INIT) signal on the I/O bus occurs, the power-up (PUP) signal is generated by the I/O interface and used throughout the KDP control circuitry to initialize the various flip-flops and counters. The I/O interface section contains the I/O operation decoder composed of the two three-to-eight decoders U21 and U29. The decoders are enabled whenever the KDP's peripheral address is detected by gate U17. Decoder U21 generates the read register 4 (R4) and read register 5 (R5) signals. The R4 signal is used to send the keycode information to the microprocessor. The R5 signal is used to send the KDP status information to the microprocessor. The status latch U53 as well as the gates to place the data on the I/O bus is located in the I/O interface section. Bit 0 indicates that the LED display unit contains 32 alphanumeric positions. Bit 1 indicates if the printer is out of paper. Bit 2 indicates that the printer is busy printing. Bit 3 indicates that the reset key on the keyboard has been depressed. Bit 4 indicates that the keyboard section is exerting the interrupt request signal (IRL).

The other decoder, U29, generates four register strobe signals, R4SB, W4SB, W5SB, and W6SB. The R4SB signal indicates to the keyboard scan control circuitry that the pending keycode has been accepted by the microprocessor. The W4SB signal loads the display character code from the microprocessor into the data register in the KDP memory section, causes the timing generator circuitry to generate the signals to store the character code in the read/write memory in the memory section, and causes the display control section to terminate displaying until all the new data has been received. The W6SB signal also loads the data register in the memory section with the printer character code, and causes the timing generator section to transfer the code to the read/write memory in the memory section. New printer data is not sent to the KDP control until the printer busy bit in the KDP status indicates to the microprocessor that the printer is no longer busy. The W5SB signal updates the "command register" of the KDP control. Bit 0 of the I/O command word generates the print (PRT) signal via gate U57A which sets the print command flip-flop located in the print control section. Bit 1 generates the display (DSP) signal via gate U51B which, similarly, set the display command flip-flop located in the display control section. Bit 2 is used to turn on an astable multivibrator (gates U30A and U30B) which produces the audio "beep" sound of the calculator. Bits 3 and 4 control the command register "run light" flip-flop U31A which turns on and off the "run light" located on the left side of the LED display unit. Since the flip-flop is JK type flip-flop, if both bits 3 and 4 are set, the run light will toggle to the opposite state. If bit 3 only is set, the run light will be turned off. If bit 4 only is set, the run light will be turned on. Similarly, bits 5 and 6 control the command register cursor flip-flop U31B which determines which type of cursor, insert or replace, symbol can be displayed in the LED display unit. If bit 5 only is set, the cursor will be the insert cursor. If bit 6 only is set, the cursor will be the replace cursor.

The switches on the calculator keyboard are single-pole, single-throw switches. The circuitry included within the KDP control block of FIG. 4 which scans for keyboard input and sends the information to the microprocessor via the I/O bus is shown in the detailed schematic diagram of FIG. 139. The keyboard scan counter U65A and U65B determines which key is being examined for closure. The counter is clocked at approximately a 2.5 KHz rate by an oscillator made of gates U37A and U37B and associated components. The lower four bits of the counter is decoded by U48 to select one of sixteen column select lines to the keyboard. The upper three bits of the counter are used by U57 to select one of eight row scan lines from the keyboard. Should the selected keyswitch be depressed, the column select output will be connected to the row select input and the output of the row selector (U57) will go to the logic low state indicating that a keyswitch closure has been detected.

When a key closure has been detected, flip-flop U27A will be set via inverter U36B. The complement output of flip-flop U27A inhibits the keyboard scan counter from counting further thereby saving the keycode for the key closure that was detected. The flip-flop also causes flip-flop U27B to become set via U39C. The output of flip-flop U27B then sets the latch U62 provided that an interrupt poll is not in progress (U56C). The output of the latch causes the low priority interrupt request (IRL) signal to the microprocessor to be set, thereby indicating that a key closure has been detected and that interrupt service is required. At the microprocessor's convenience the service routine is performed. The first operation of the service routine is to perform an interrupt poll to determine which I/O device is requesting service. The fact that the interrupt poll is taking place is indicated to the keyboard scan circuit by the Interrupt (INT) signal being exerted when peripheral address bit 3 (PA3) is logically false (poll of low level interrupt I/O devices). The keyboard scan circuit, since it has generated an interrupt request, responds by exerting the I/O bus data bit 0 (IOD0) which corresponds to its peripheral address via gate U61C. Upon determining that the keyboard scan circuit is interrupting, the microprocessor executes the keyboard service routine. During the service routine, an I/O cycle which reads R4 occurs. When the I/O cycle occurs, the keycode from the keyboard scan counter is placed on the I/O bus via the eight gates of U58 and U59. The I/O cycle also causes the Read Register 4 Strobe (R4SB) which U37C resets flip-flop U27B. The output of U27B will, in turn, set U27A, provided that the debounce counter U28 declares the key no longer closed, and thus allows the keyboard scanning to resume. The debounce counter is reset whenever a key closure occurs. As the key is released, the debounce counter will be reset each time a key bounce occurs until finally no further key bounce occurs and the debounce counter counts to the point that it enables gate U37D.

The keyboard scan circuit also has the automatic key repeat feature. The latch, composed of gates U39A and U39B is reset whenever no key closure is detected.

Likewise, the repeat counter **U47** is held reset as long as no key closure is detected. When a key closure is detected, the repeat counter is allowed to start counting (but starts counting over again each time that a key bounce occurs as the key is closing). When the repeat counter's output pin **1** goes high, the latch composed of gates **U39A** and **U39B** is set and the repeat feature is enabled by enabling gate **U39D**. Thereafter each time **U47** output pin **12** goes high, gate **U39D** will set flip-flop **U27B** thereby causing another interrupt request to occur. The delay time from the time the key is depressed to the time automatic repeating starts is determined by the time it takes after key closure, with no further bouncing, for **U47** output pin **1** to go high followed by output pin **12** going high. The frequency of key repeat is determined by the frequency at which **U47** output pin **12** toggles.

The keyboard also contains the Reset key which is handled separately from the keyboard scanning. When the Reset key is depressed, the KRST signal goes low and, after a time delay for key bounce caused by **C22**, **R49**, and **R50**, the input to inverter **U40B** goes low. The positive-going transition of inverter output **U40B** is differentiated by **C21** and **R47** to produce a pulse which becomes the I/O bus Reet (RESET) signal that reinitializes the microprocessor and I/O section. The output of the inverter, before the pulse formation, is sent to the KDP's status latch which the microprocessor can interrogate to determine if the initialization is a power-on initialization or a Reset key initialization.

The Shift and Shift Lock keys on the keyboard are handled separately from the scanning circuit. When either of the shift keys on the keyboard is depressed, the SHIFT signal resets the latch composed of gates **U46A** and **U45C** and sets flip-flop **U56B** which in turn will set I/O data bit 7 (IOD7) thereby indicating to the microprocessor that the shift key is depressed. If the shift lock key is depressed, the latch composed of gates **U46A** and **U45C** will be set to indicate that all further keycodes are shifted keycodes. The latch remains set until on the shift keys is depressed.

A KDP control timing generator included within the KDP control block of FIG. **4** is shown in the detailed schematic diagram of FIG. **140**. The 6 MHz clock from the I/O bus is divided by four by flip-flops **U66A** and **U62A** to produce the KDP clock and the gated T clock generated at the output of gates **U56A** and **U7C**. The gated clock is disabled via gate **U54B** whenever either flip-flops **U63B** or **U64B** are set. Flip-flop **U63B** is set on the next KDP clock after a printer data word (indicated by W6SB) is sent to the KDP control. Similarly, flip-flop **U64B** is set on the next KDP clock after a display data word (indicated by W4SB) is sent the KDP control. The two flip-flops disable the T clock for only one state time since the output of each flip-flop clears flip-flops **U63A** and **U63B**, respectfully. During the state time that the T clock is disabled, the R/W signal (gate **U55C**) goes low during the second half of the state time and is used by the memory section to store the data just received into the KDP read/write memory. The three signals PLC (printer load clock), DLC (display load clock), and SPA (select printer address) is used by the printer control, display control, and memory sections to produce the correct address for storing the data just received into the KDP read/write memory. When new display or printer data is not being received, th PR (printer) signal is used to control the SPA signal so that either display or printer data can be read from the KDP memory.

The upper portion of FIG. **140** shows the circuitry which generates the basic timing signals used by the printer control, display control, and memory sections. The waveforms generated by this circuitry is shown in the waveform timing diagram of FIG. **141**. Device **U35** is a four-bit binary counter with a synchronous load control input (Texas Instruments device SN74LS163). The PR (printer) signal is present for eight state times and absent for six state times. The last state ime before each transition of PR, the P7 signal is generated by gate **U46C** for the full state time and the T7 signal is generated by gate **U56B** during the last half of the state time. Each time that P7 occurs, the binary counter will be loaded with the data on the A through D inputs on the next state time. If the PR signal is not true, the counter will be set to zero the next state time. If the PR signal is true, the counter will be set to a decimal ten on the next state. The use of these timing signals will be discussed in the following sections.

A read/write memory section of the KDP control block of FIG. **4** is shown in the detailed schematic diagram of FIG. **142**. Central to the memory section is the KDP read/write memory which stores the display data By designing the display control section to automatically refresh the display, the capability to inform the calculator user of what the calculator program is doing via display messages while the program is running is possible. More importantly, the design provides the basic requirement of live keyboard, i.e., displaying keyboard actions and results while a program is running. The read/write memory device **U38** is Signetics device 82S09 which is capable of storing sixty-four 9-bit words The memory is divided into two halfs by the select printer address (SPA) signal on the A5 input of the device. Thus the lower half of the memory stores the 32-character codes for the LED display unit and the upper 16 locations of the upper half stores the 16-character codes for the thermal printer unit. The data from the I/O data bus to be stored in the memory is first saved in the register composed of **U43** and **U52**. The timing section then generates the R/W and SPA signals as necessary to transfer the data from the register into the proper location in the memory. When the KDP control is not receiving information from the I/O bus, the display and printer data in the read/write memory are alternately assessed to refresh the display. The printer data is only printed the one time after the print command is received by the I/O interface section. The address for the read/write memory is selected by the two-to-one data selector composed of **U13** and **U14**. The two inputs to the data selector are the display character address and character column select and the printer character address and character row select. The character address information is used to address the read/write memory. The column and row select is used to address the dot pattern read-only memory **U23**. The read-only memory is comprised of devices that are organized as 2048 words of eight bits. The dot patterns for both the display and the printer are stored in the ROM. The most significant bit of the address (PR) is used to select whether the dot pattern is for the display or for the printer. The next seven bits of address select one of **128** possible symbols. The lowest three bits of address select the desired column or row of the symbol. Column data is needed for the display unit; row information is needed for the printer unit. The timing section is designed such that when a printer character is being processed by the printer control section, the address to the read/write memory is the next display character to be processed and vice versa. As shown in the timing diagram of FIG. **141**, during the state times that the P7 signal occurs, the ROM is enabled (input CE of U23) and, as explained in the read-only memory section, the power pulse circuit composed of Q3 and associated components applies +12 volts to the main section of the ROM device. During the second half of the state time the T clock occurs and the ROM accesses the doat data addressed and presents it at the D outputs for use. At the end of the P7 state time the dot data is parallel loaded into the parallel-in/serial-out shift register composed of U22 and U18. During the following state times the dot data (DD) is shifted out of the shift register for use by the display or printer control sections. If the dot data is printer row data only five dot data bits are defined (five by seven printer matrix). For the display dot data, all seven bits are defined since the data is column information.

The most significant bit of the read/write memory is not used. The next most significant bit is used to inform the display control section that the cursor (CURSOR) is to be flashed in that character position. The outputs of the read/write memory are open-collector and require the external pull-up resistors to obtain the logic high state. This fact is used to advantage to generate the symbol for the insert cursor (character code zero). If the display symbol being accessed in the read/write memory is to have the cursor superimposed (read/write output bit 07 true), the display control section, if required, will cause the cursor enable (CE) signal to go high thereby switching off transistor Q4 and causing the output of the read/write memory to become the character code zero for the insert cursor.

A display control section of the KDP control block of FIG. **4** is shown in the detailed schematic diagram of FIG. **143**. When the first data character of a new group of display data is sent to the KDP control, the W4SB associated with the transaction is used to trigger one-shot U16. The output of U16 via gate U9A clears binary counters U3 and U6 thereby initializing the counters to the first display character address of the read/write memory in the memory section. Also, via gate U7A, the output clears flip-flops U15B and U15A. In turn, the output of flip-flop U15A disables the column scan decoder U2 which blanks the display, disables gate U4A which enables gate U10D and allows the display load clock (DLC) from the timing section to increment the binary counter to the next display character address each time that a new display data character is received, and disables the one-shot U16 from being triggered again on the next data transfer. The display control section remains in the mode of receiving display data with the display blanked until the DSP signal is received.

When the DSP signal, part of the command word, is received from the I/0 interface section, the binary counters U3 and U6 are again cleared to start the display scan at the first display character address. Also, the DSP signal sets flip-flop U15B which clears flip-flops U12B and U32B thereby re-starting the flash cycle for the cursor and allows flip-flop U15A to be set on the next T7 clock. Once flip-flop U15A is set, the display control switches from the mode of receiving new data to the mode of displaying the data. Assume for the moment that the cursor is not displayed, in which case gate U5A is enabled to pass the serial display dot data (DD) through to the display connector and hence to the display. The LED display unit is composed of eight display devices that contain four display not matrices per device. A detailed block diagram of the display unit of FIG. **4** is shown in FIG. **144**. The serial-in/parallel-out shift register (**332**) shifts in a new dot data bit each time that the clock signal occurs. When one column of dots for each character position has been received (244 bits), the scan line corresponding to the column data is enabled to cause the dots selected on those columns to light or not light according to the data in the shift register. The cycle is then repeated with each column in sequence. Counter U1 and decoder U2 determine which column is selected. The timing relationship between the waveforms that result from a display of all LED columns is shown in FIG. **145**. Since binary counter U3 starts with a count of zero at the beginning of the display cycle, both gates U5B and U9C will enable gate U4B. Gate U9B allows the T clOck to become the series of display clocks shown in the first three lines of FIG. **145**. The display size (SIZE) signal via gate U5B will disable the last sixteen series of display clocks (shown on line two) if the display is only a sixteen character display. The upper three bits of the binary counter U3 and decoding gate U9C further allow the display clocks only when the three bits are zeros. The balance of the time the column scan decoder U2 is allowed to operate. The divide-by-five column counter U1 determines which column is being scanned. It is not initialized as it makes no difference which column is scanned first since all columns will eventually be scanned. Each time that counter U3 "rolls over", the column counter U1 will be incremented to the next column.

The display cursor logic is shown at the upper left portion of FIG. **143**. The cursor flash frequency is determined by the astable multivibrator composed of gates U8A, U8B, and U8C which is divided by four by flip-flops U12B and U32B. When the Q-not output of flip-flops U32B is a logical high, the cursor symbol is enabled for disabling. The command register in the I/O interface section enables either gate U11A or U11B depending on whether the insert (INS) or replace (RPL) cursor is selected. As discussed in the memory section above, the cursor (CURSOR) output from the read/write memory indicates when the particular character being accessed from the read/write memory is to also have the flashing cursor. If the insert cursor is selected, the cursor enable (CE) signal is generated which forces the output of the read/write memory to assume the insert cursor code. If the replace cursor is selected, the flip-flop U12A is used to save the cursor signal so that it will be available when the character dot pattern is sent to the display unit. The replace cursor lights all dots in each column of the character matrix which is achieved by gate U11B disabling U5A when the cursor is to be displayed thereby forcing the serial display data to the state that lights all dots on the column.

A printer control section of the KDP control block of FIG. **4** is shown in the detailed schematic diagram of FIG. **146A**. Assume as an initial condition that flip-flops U44A and U44B and binary counter U33 have just been cleared by gate U54C. Since the output of flip-flop U44B is a low, decimal counters U24, U25, and U26 and flip-flop U32A wil be cleared, printer scan decoder U41 will be disabled, printer paper advance (ADV) solenoid will be de-energized via gate U7B, and gate U17B will be disabled thereby enabling gate U10B to pass the printer load clock (PLC). Hence, no printing action will occur and the printer control is in the data receiving mode. The binary counter U33 provides the printer character address to the read/write memory in the memory section. Each time that printer data is received by the KDP control, the timing section produces the printer load clock (PLC) to advance the binary counter U33 (via gate U10B) to the next printer character address so that the next address will be ready when the next printer character code is received. The PLC clock also clocks the other binary counters U26, U25, and U24 as well as flip-flop U32A but since the counters are connected in cascade (ripple carry output to enable inputs of next stage) none of the counters will change state because flip-flop U32A is clear. The printer control section will remain in the data receiving mode until the PRT command signal is received from the I/O interface section.

When the PRT signal is received, flip-flop U44A will be set and at the end of the next T7 clock flip-flop U44B will be set indicating that the printer control section is in the print mode. To understand the timing that the printer conrol section generates, it is first necessary to understand the requirements of the thermal printer unit. A block diagram of the thermal printer of FIG. 4 is shown in FIG. 147. The print head circuit comprises an off-the-shelf twenty-bit serial-in/parallel-out shift register whose inputs are DATA and CLOCK. The output of each group of five bits goes to a 5-of-20 demultiplexer. Each demultiplexer routes its five input bits to one of four print head positions. Each print head position contains five dot resistors which "burn" the paper to produce the printing. The four input scan signals (S1 through S4) determine which of the head positions the demultiplexer selects. The sequence of operation is for the printer control to send the dot information for the first, fifth, ninth, and thirteenth character positions and generate the first scan signal which "burns" the paper for the proper length of time. The procedure is then repeated for each of the other scan signals in sequence. When the four scans are completed, the paper advance solenoid which as been energized ("cocked") during the four scan operations is de-energized and a fifth time period is required to allow the paper to advance and settle.

Returning now to the printer control circuitry, FIGS. 148A–B show the timing relationship of various waveforms associated with the printer control circuitry of FIG. 146A. Binary counter U33 counts the sixteen character positions. Outputs QB and QC of decimal counter U25 determines which scan is taking place via scan decoder U41. Notice that the counter's output also goes to integrated circuit U34. Device U34 is a four-bit magnitude comparator which generates a positive-true output as output A=B whenever the four bits input at the A inputs is equal to the four bits input at the B inputs. The output is used to enable the T clocks to pass through gate U5C to become the printer clocks. Notice that inputs A0 and A1 are tied to a logic one. Consequently, inputs B0 and B1 can be used to shut off the clocks to the printer. The four gates U19A, U19B, U19C, and U7D combine logically with inputs B0 and B1 to form a disable function such that if any input to U19A, U19B, or U19C is a logic high, the clocks to the printer are disabled. Therefore, let each input to gates U19A, U19B, and U19C be taken to form a counter whose decimal count is shown in FIG. 148B. The state number associated with each count is shown immediately above the decimal count. The outputs which define the decimal count are the output from flip-flop U32A, the four outputs of U26, and the QA output of U25. Notice that the feedback generated by gates U5D and U46B causes the counting sequence to change from decimal count 11 to 16 during state numbers 12 and 13 and again from count 43 to 48 during state numbers 28 and 29. Note also that counter U26 is a decimal counter which causes the count to change from count 19 to 32 during state numbers 16 and 17 and again from count 43 to 48 during state numbers 28 and 29. Thus, the total number of states for one scan is 32.

Only during the first state (decimal count zero) are the T clocks allowed to pass through gate U5C to become the printer clocks. Binary counter U33 counts the sixteen character positions of the printer. For the first scan, input B2 and B3 of comparator U34 are both zero. Therefore, as the character counter U33 counts through the sixteen character positions, only the first, fifth, ninth, and thirteenth characters are sent to the printer. For the next scan, only the second, sixth, tenth, and fourteenth characters are sent to the printer. A similar pattern occurs for scans three and four. These waveforms for each scan are shown in FIG. 148A. After the character counter has counted through sixteen counts, flip-flop U32A will be set and via gate U19A further clocks to the printer will be disabled.

The scan signals are shown in FIG. 148B. The scan decoder U41 is enabled by flip-flop U44B, QD output of U24, and the burn control output (BCO). A printer burn control circuit within the KDP control block of FIG. 4 is shown in the detailed schematic diagram of FIG. 146B. Devices U50D, U50C, and associated components form an oscillator whose duty cycle depends on the unregulated +20 volts. The output of the oscillator turns switch Q4 on and off which in turn charges capacitor C27 through resistors R66 and R67. The higher the +20 volts, the slower that capacitor C27 will be charged. Devices U50B, Q15, Q16, and associated components form another oscillator which operates at a frequency of approximately one-tenth that of the U50D oscillator. The purpose of this oscillator is to discharge capacitor C27. The voltage across C27 is input through R67 to the non-inverting input of comparator U50A. The other input of the comparator is a reference voltage. The reference voltage can be modified by the print intensity adjustment, the print head thermister, and resistor R63 which is switched in when FET Q12 is turned-on. The output of the comparator U50A is the burn control output (BCO) signal which alternatively switches the printer scan signals on and off. The BCO signal is a negative-true signal whose duty cycle is inversely proportional to approximately the square of the unregulated +20 volts, thereby providing an almost constant power dissipation for the print head resistors. The print temperature control (PTC) signal from gate U7D of the printer control section modifies the duty cycle of the burn control to allow a fast rise time for the temperature of the print head resistors during state numbers 1 through 12 of the scan time followed by an approximately constant temperature for the print head resistors during the second portion of the scan period.

When the fourth scan is completed, the QD output of U25 will become set. The output disables the scan decoder U41, disables the current drive to the advance solenoid, and disables the counter feedback gate U46B. The paper then advances to the next line. The time allowed for the advance (40 state times) is longer than the scan time due to the disabling of the feedback gate U46B.

Decimal counter U24 is used to determine which row of the character is selected. For the first row, the dot information read out of the read/only memory section is all spaces. The next seven rows are the seven rows of the five-by-seven dot matrix. The last two rows are again all spaces to provide the separation between the characters on successive lines. For the last two rows, output QD of decimal counter U24 (counts eight and nine) will be a high thereby disabling the scan decoder during those two rows. At the end of the tenth row, the QD output will return to a logic low which via capacitor C16 clears flip-flops U44A and U44B ending the print mode.

## CASSETTE CONTROL

The cassette control circuitry of FIG. 4 provides the interface between the microprocessor and the cassette transport hardware. The control circuitry can be divided into four sections. One section is the I/O interface section which provides the interface between the I/O bus and the rest of the cassette control circuitry. Another section is the tape section which provides the motor drive electronics that causes the movement of the magnetic tape. A third section is the read electronics section which detects flux transitions on the magnetic tape and decodes it into bit serial digital data which is sent to the microprocessor. The delta distance code is used to represent digital information on the magnetic tape. This code represents a zero on the magnetic tape by a short distance between flux transitions and a one by a long distance between flux transitions. The fourth section is the write electronics section which encodes bit serial digital data from the microprocessor into a seires of flux transitions on the magnetic tape.

The cassette control I/O interface section is shown in the detailed schematic diagram of FIGS. 149A-C. The I/O interface section contains an I/O operation decoder composed of a dual three-to-eight decoder U3 and associated gates. The decoder is enabled whenever the peripheral address lines indicate peripheral address one and an interrupt (INT) poll is not occurring. One section of the decoder decodes the I/O read operations; the other section decodes the I/O write operations. A write to memory address seven (W7) clears the servo-fail flip-flop U7B and the cartridge out flip-flop U7A as shown in FIG. 149C. The servo-fail flip-flop is set by the servo section. The cartridge out flip-flop is set when the cartridge-in microswitch opens due to the cartridge being removed from the transport assembly. A write to memory address six (W6), which occurs during the last I/O DMA operation, sets the search complete flip-flop U9A and clears the DMA request enable flip-flop U9B. A write to memory address five (W5) latches the primary command information from the microprocessor into the eight-bit command latch U1 shown in FIG. 149B. The command latch is also cleared to its initial state by the Initialize (INIT) signal when the calculator is turned on. The figure shows the information assigned to each bit. A write to memory address four (W4) causes the bit serial data to be written on the magnetic tape (sent on I/O bus line IOD0) to be latched into flip-flop U13A and clears the flag flip-flop U13B.

A read of R6 (R6SB) causes the beginning/end of tape flip-flop U15A to be cleared. The flip-flop is set whenever a hole is detected in the magnetic tape as shown in FIG. 150. A hole is detected by allowing light to pass through the hole to reach a phototransistor. The signal from the phototransistor is applied to an op-amp U4 which compares the signal to a level which is approximately 30% of the peak level. The transistor Q4 changes the op-amp output to voltage levels compatible with the input requirements of the beginning/end of tape flip-flop.

A read of R5 (R5) causes the cassette status data, held stable by latch U16 of FIG. 149B, to be sent to the micropressor. The data assigned to each bit is shown in the figure. A read of R4 (R4SB) causes the data decoded from the magnetic tape (RDT) to be sent to the microprocessor (gate U12F) and clears the flag flip-flop U13B shown in FIG. 149C. The flag flip-flop is used to indicate the presence of either servo tach information (output of flip-flop U15B) or the presence of read data (RWF) from the magnetic tape as selected by the command bit 3 (TAC) of the command latch U1. Similarly, the I/O status (STS) signal is used to indicate either the presence of a gap on the magnetic tape (when in the normal mode as indicated by search/normal bit of the command latch U1) or the fact that the search operation has ended when in the search mode. The search operation is terminated (indicated by gate U6A) by either having a servo-fail signal (flip-flop U7B) or a cartridge out signal (flip-flop U7A) or a beginning/end of tape encounter (flip-flop U15A) or a normal completion caused by an I/O write operation to R6 setting the search complete flip-flop U9A. Conversely, if none of the four conditions have occurred and the run command (command bit 7) is true, the GO signal is generated via gate U5B which informs the servo section that the motor is to run.

The cassette control servo section is shown in the detailed schematic diagram of FIGS. 151A-C. The servo system is designed to provide tape speeds of +/− 22 ips and +/− 90 ips at +/− 5%. The transition between these speeds is at a constant acceleration of +/− 1200 in/sec/sec which corresponds to approximately 18 ms to accelerate from 0 to 22 ips. In addition to speed control, the servo section provides the tape moving (MVG), a tachometer pulses (TAC), and servo-fail detect (SFD) signals as status information for the microprocessor. The input signals from the I/O interface section are the GO signal which indicates that tape movement is to occur, the Fast (FST) signal which indicates the higher speed is desired, and the REVerse signal which indicates the direction of tape movement.

Referring to FIG. 151A, the reference generator composed of the input circuitry associated with U25A converts the digital input signals GO, FST, and REV to analog voltages for input to the controlled-slew-rate amplifier composed of U25A and U25B. The slew rate is a function of the voltage of the zeners diodes CR7 and CR8, resistor R49, and capacitor C29. The slew rate is approximately 100 v/sec. The steady-state voltage gain of the amplifier is either +1.5 or −1.5 as determined by the digital input REV signal. The steady state output voltage is 0, +/−2, or +/−7 volts depending, respectively, on whether GO is logically flase, GO is true and FST is false, or G is true and FST is true. The output voltage will be referred to as the "forcing function (Vff)". It is applied via R79 to the summing junction of the servo loop which is at the inverting input of U28B. The forcing function is also applied to the dead-band detector circuit.

The dead-band detector circuit is composed of the two voltage comparators U21C and U21D and associated components. Since these comparators operate from 0 to 5 volts, the forcing function is first level-shifted to provide compatibility with the comparators. If the shifted level is above the reference of U21D, the moving reverse (MRV) signal is generated. If the shifted level is below the reference level of U21C, the moving forward (MFD) signal is generated. If either the MRV or MFD signals are generated, the moving (MVG) signal is also generated. This signal indicates that the forcing function is indicating a motor speed of greater than 2 ips. The moving signal is used to light the run LED on the transport assembly which indicates to the user that the motor is operating and is sent to the status latch in the I/O interface section for use by the microprocessor. Also, the absence of the moving signal is used to turn off the drive to the motor to prevent the motor from creeping due to small offset voltages in the sytem.

The feedback voltage Vfb from the tachometer associated with the motor is also applied via R78 to the servo loop summing junction, as shown in FIG. 151B. The feedback voltage is proportional to the angular velocity of the motor and is generated by an optical tachometer, as shown in FIG. 151C. The optical tachometer consists of a light source, a 1000 line disk and a phototransistor. A signal (23 KHz at 22 ips) is amplified by the op-amp U3 and applied to the bidirectional one-shop (Signetics device 8T20 or equivalent shown in FIG. 151B) which generates 2 us pulses. These pulses occur on both polarities of the waveform such that the repetition rate of the output pulses is twice the input frequency (46 KHz at 22 ips). The pulses are applied to a second-order low pass filter, composed of L2 and C42, which has a bandpass of 2.25 KHz. The output of the filter is a positive DC voltage which is proportional to the angular velocity of the motor. (The ripple of the DC voltage does not have an adverse effect upon the motor speed since its frequency components are much higher than the bandwidth of the system.) The output of the filter is amplified by U28A with a gain of either +3 or −3 in a circuit configuration similar to the configuration used to generate the forcing function. The polarity of the gain in this case is determined by the MRV (moving reverse) and MFD (moving forward) signals generated by the dead-band detector circuit.

The feedback from the summing junction op-amp U28B is also applied to the summing junction. The feedback provides most of the open loop gain and introduces a zero at 5 Hz that matches the mechanical pole of the motor. The closed loop gain of Vfb/Vff is 0.6 with a bandwidth of approximately 200 Hz. The motor driver amplifier, composed of transistors Q3, Q4, Q9, and Q10 and associated components (shown in FIG. 151C), provides a voltage gain of 2.46 as determined by the feedback resistors R62 and R61. As mentioned earlier, the moving (MVG) signal from the dead-band detect circuit is used to disable the drivers if the moving signal is logically false to prevent the motor from creeping due to small offset voltages in the system as well as to insure stability during the zero speed crossover region. Also, the INIT signal is used to disable the drivers to prevent spurious movement of the tape during calculator turn-on and turn-off. The maximum average power dissipated from either darlington driver is 13 watts. This assumes a worse case duty cycle of 80% and a maximum average supply voltage of 23 volts.

The servo-fail detect circuit, composed of U21 and associated components, senses both the voltage to and current through the motor. Both the voltage and current sense inputs are filtered such that an overload condition is not detected during acceleration. The output of the circuit sets the servo-fail flip-flop in the I/O interface section which in turn causes the GO input signal to be removed thereby protecting the motor from overload.

The write electronics section of the cassette control block of FIG. 4 is shown in the detailed schematic diagram of FIG. 152. The inputs to the section come from the I/O interface section and are the bit to be encoded (BSD), the write command (WRT), the track to written on (TRKB), and the mode command (MOD). Outputs from the section are the flux transitions on the magnetic tape, and the read/write flag (RWF) to I/O interface flag flip-flop which indicates that another bit of data may be sent.

The encoder portion of the write electronics section is composed of flip-flops U30A and U30B, astable multivibrator U29, and one-shot U31B with associated gates. The section is initialized whenever the WRT signal is false. Both the data bit flip-flop U30A and the write data flip-flop U30B are preset by the WRT signal. Also, via gate U35C and open-collector inverter U34D, the WRT signal discharges the timing capacitor C50 associated with the astable multivibrator U29. The one-shot U31B is shared between the encoder and the decoder. Its other input (input A) is forced to the enable state during write operations by the WRT signal. When the WRT signal becomes true and the MOD signal is false, the output of the astable multivibrator is allowed to oscillate. The period of the first oscillation of the multivibrator is determined by C50, R87, and R88. When the first oscillation is complete, the one-shop U31B wil be triggered which signals the end of a data bit time. The output of the one-shot causes a flux transition on the magnetic tape by toggling the write data flip-flop U30B, loads the next data bit on the BSD line into data bit flip-flop U30A, and sets the I/O interface section flag flip-flop to indicate that another bit may now be sent by the microprocessor. The output of data bit flip-flop U30A determines the time constant of the astable multivibrator by either switching in or switching out resistor R88. The period of the astable is short if the flip-flop contains a zero and long if the flip-flop contains a one.

The output of the write data flip-flop U30B is sent to the magnetic tape read/write circuitry. The read/write head provides for two tracks on the tape; track A and track B. A high-voltage open-collector output BCD-to-decimal decoder U1 (Texas Instruments device SN7445 or equivalent) is used as a one-of-eight decoder to select the track, whether a read or write operation is to occur, and, if a write operation is selected, which direction current flow through the head is to occur. Hence, the decoder inputs are TRB (track B), WRT (write), and WDT (write data). The TRB signal determines the track by enabling outputs 4, 5, 6, and 7 or outputs 0, 1, 2, and 3. The WRT signal selects the "write" outputs 2, 3, 6, and 7 rather than the read outputs 0, 1, 4, and 5. Since the "read" outputs are not enabled, the four FET switches Q1 through Q4 are turned off and the read circuitry is disconnected from the tape head. (The regulated turn off bias for the switches is generated by a voltage doubler circuit located in the servo section.) When the WRT signal goes high, transistor Q5 is turned on which, in turn, turns on the current source composed of Q6 and associated resistors. The direction of current flow through the head from the current source to the decoder output is determined by the write data (WDT) signal input to the decoder. Each time the WDT signal changes levels the direction of the flux on the magnetic tape is reversed due to the current flow through the head changing directions. The Initialize (INIT) signal is logically ORed with the WRT signal (via CR4) to turn off the current source and prevent spurious write currents through the head during a calculator turn-on or turn-off.

The read electronics section of the cassette control block of FIG. 4 is shown in the detailed schematic diagram of FIGS. 153A–B. The inputs to the read electronics is the TRB (track B) signal which determines which track is to be read, the WRT (write) signal which disables the write section and enables the read section, the analog signal from the magnetic tape head, and the FST (fast) and MOD (mode) signals which determine the threshold level associated with the analog head signal. The outputs are the bit serial read data (RDT) to the I/O interface and the read/write flag (RWT) to the I/O interface flag flip-flop.

When information on the tape is being read, the BCD-to-decimal decoder U1 of FIG. 152 selects outputs 0 or 1 or outputs 4 or 5 thereby turning on FET switches Q1 and Q2 or switches Q3 and Q4, respectively. The appropriate tape read head is then connected to the pre-amplifier U2. The preamp provides a nominal gain of −20. Since the output from the read head can vary as much as +/−25%, the gain is adjusted by selecting R5 such that the output of the preamp is 300 mV PP. The bandwidth of the preamp is at least 110 KHz. The read waveform from the magnetic head contains predominate frequencies of 10.6 KHz and 17.6 KHz when the tape speed is at 22 ips for one's and zero's, respectively. A significant amount of information is contained in the 3rd harmonics of these waveforms. The frequency is increased to 72 KHz when the tape speed is at 90 ips. However, at 90 ips, only gap information (the absence of flux transitions) is being searched for and no data is recovered at that speed. The signal from the preamp is applied to the input of an active second-order Butterworth low pass filter composed of U17 and associated components. The filter has a bandwidth of 55 KHz which limits the noise susceptibility but at the same time does not increase the peak shift excessively. The filter has a gain of 6.7 which produces a nominal output of 2 Vpp. The output of the filter is applied to a differentiator (C14 and R5) and a threshold detector composed of U22 and associated components. The differentiator attenuates the signal (10.6 KHz) by a factor of 9, while the following amplifier U18 provides a gain of 9 and a low impedance output. The output of U18 is applied to a dual comparator U10 which detects a zero crossing condition. The two comparators are only enabled during the appropriate +/− threshold to increase the noise immunity. The output from the zero crossing detector is applied to the clock input of a D-type flip-flop U27 while the clear and D inputs are connected to the threshold (THD) signal from the threshold detector. This configuration prevents a glitch (multiple transitions) from occurring on the output of the flip-flop since the only way possible for the output to go high is for the clock input to go high while the THD signal is high. The only way for the output to go low is for the clear and D inputs to go low. The positive-going transition of the output of the flip-flop U27 indicates that a flux transistion (FTR) has occurred.

The input to the threshold detector is the amplified and filtered signal from active Butterworth filter. The threshold detector produces an output when the absolute value of the waveform exceeds either 10%, 45% or 30% of the nominal peak signal. The 10% level is used for reading at 22 ips, the 45% level is used for write verification and gap detection, and the 30% level is used for high speed gap search. Which level is selected is determined by the FST and MOD inputs at inverters U20E abnd U20F, respectively. The two transistors Q1 and Q2 connected in cascade perform the function of filtering the output of the threshold detector and insuring that the THD signal remains high for at least 100 ns thereby preventing noise from causing false outputs on the flux transition (FTR) signal out of the flip-flop U27.

The output of the threshold detector (THD) is also used to retrigger one-shots U43A and U43B shown in FIG. 153B. The first one-shot, U43A, has a period of approximately 125 us. If no flux transitions are detected for 125 us, the one-shot expires and sets the latch composed of gates U39A and U39B. The output of the latch (GAP) indicates to the microprocessor, via the I/O status control signal, that a gap condition exists. The output of the latch also inhibits the InterRecord Gap (IRG) one-shot U43B from being retriggered. The period of the interrecord gap one-shot is approximately 2.5 ms. If the latch has not been reset or if a flux transition after the latch is reset has not occurred by 2.5 ms, the one-shot expires and an interrecord gap condition is declared. The gap one-shot U43A also clears the four-bit binary counter U42. To prevent the possibility of noise in the system erroneously ending the gap condition, the latch is not allowed to reset until four flux transitions have been detected and counted by the binary counter U42. The gap one-shot also clears flip-flop U38A whose output is used to initialize the read decode circuitry. The first twelve flux transitions after a gap occurs always correspond to a digital zero on the magnetic tape. Hence the flip-flop U38A is not set again until twelve flux transitions have been counted by the binary counter U42.

The decoder is required to reliably retrieve information stored in the form of delta distance code from a tape which exhibits speed variations. The input to the decoder is a stream of pulses corresponding to flux transitions detected on the magnetic tape (FTR). The time between the pulses indicates whether the distance between flux transitions was a "long" or a "short" distance. Decoding the time between pulses into ones and zeros could be accomplished on an absolute basis of one were willing to allow the ratio between zero and one to be large enough that a zero would always be less than a specified time and a one would always be greater than a specified time when all possible variations in the system have been accounted for. This approach would reduce the amount of information which could be stored on the tape and is not acceptable. Instead, the decoder eliminates dependence upon the absolute time required for the tape to move a long or short distance by "tracking" the average tape speed. The ratio of the "long" time to the "short" time, not the actual time, is used in decoding the information. The decoder uses the time between previous FTR pulses to develop a reference voltage which is used for decoding. The reference voltage is developed across C59.

To understand how the reference voltage is established, a description of the decoder circuit configuration is first necessary. When the GAP signal occurs, flip-flop U38A is cleared and its output, the decoder initializing signal, clears the read data flip-flop U38B and turns on FET switch U33A to short out resistor R111. The reference capacitor C59 is driven by U36 which is part of the sample and hold circuit formed by FET switches U33B and U33D and sample and hold capacitor C58. The input to the sample and hold circuit comes from the ramp generator circuit formed by U32 and associated components. Notice that the output of the ramp generator can be applied directly to the sample and hold capacitor C58 via FET switch U33D but is first attenuated by the resistor divider R108 and R107 before it can be applied to the sample and hold capacitor via FET switch U33B. Notice, further, that the read data output (RDT) of the read data flip-flop U38B enables the attenuated signal FET switch U33B to update the sample and hold capacitor when RDT is a one or, similarly, enables the direct signal FET switch U33D when RDT is a zero. The ramp generator (U32) output, which is the signal sampled, is reset to zero by switch U33C whenever one-shot U31B is triggered.

When the end of a gap occurs, the following initializing action is generated. The positive-going edge of the first flux transition pulse (FTR) triggers the one-shot U31A which has a pulse width of approximately one microsecond. The one-shot pulse and the fact that the read data flip-flop U38B is being held clear by the decoder initializing signal U38A causes FET switch U33D to turn on and charge the sample and hold capacitor C58 to the voltage of the ramp generator output. In turn, the reference capacitor C59 will also be charged to the voltage of the sample and hold capacitor via U36 since the FET switch U33A is turned on by the decoder initializing signal. For the first flux transition, the ramp generator will be at its maximum value due to the long time of the gap signal. On the trailing edge of the one-shot U31A pulse, the second one-shot U31B is triggered and generates a four microsecond pulse which turns on FET switch U33C and resets the ramp generator. After the pulse terminates, the output of the ramp generator proceeds to become a ramp. The next flux transition occurs after a "short" time (twelve "short" times always follow a gap) and again the sample and hold capacitor is updated with the voltage of the ramp generator. This time the voltage of the ramp generator correctly corresponds to the "short" time or a digital zero on the magnetic tape. After twelve flux transitions the reference capacitor C59 has been initialized and the decoder initializing signal is terminated.

The time between the flux transitions now varies according to whether digital ones or zeros ("longs" or "shorts") are recorded on the magnetic tape. When a flux transition occurs, one-shot U31A is triggered and its output clocks the read data flip-flop U38B. The read data flip-flop is updated with the results of the comparison of the reference voltage to the attenuated output of the ramp generator by comparator U37. The output of the ramp generator is attenuated by R105 and R106 to produce a "short" voltage less than the reference voltage and a "long" voltage greater than the reference voltage. The read data output is used to select which FET switch, U33B for a "long" or U33D for a "short", updates the sample and hold capacitor C58. The ramp generator output is attenuated for the "long" time to produce the same sample and hold voltage as for the "short" time. The reference capacitor C59 voltage is allowed to track only the low frequency changes caused by tape speed variations since resistor R111 and capacitor C59 now filter the short term changes in the voltage of the sample and hold capacitor. The read data output is sent to the I/O interface section to become the bit serial data to the microprocessor. Each time that one-shot U31B resets the ramp generator, it also generates the read/write flag which sets the I/O interface flag flip-flop to indicate to the microprocessor that the bit serial data is ready.

## POWER SUPPLIES

The power supplies in the calculator consist of five regulated supplies, +12, +7, +5, −5, and −12 volts, and two unregulated supplies, +/−20 volts. These power supplies may be understood with reference to the block diagram of FIG. 4 and the detailed schematic diagrams of FIGS. 154A–C.

For the +12 volt supply of FIG. 154C, a reference voltage appears at pin 4 of U3 when a voltage of 10 to 40 volts is applied between pins 8 and 5. The reference voltage is also applied to the non-inverting input of the amplifier in U3. The output voltage from the supply is sensed by R9, R10, and R11 and applied to the inverting input of the amplifier in U3. Capacitor C11 is used to limit the frequency response of the U3 amplifier. The output of the U3 amplifier is further amplified by Q4. The output current of the supply is dropped across R13 and sensed by pins 10 and 1 of U3 to limit the output current to approximately 2.75 amps.

For the +7 volt supply, device U1 (National device LM309 or equivalent) is used. The device is designed to provide +5 volts between pins 3 and 2 when a voltage of +7 to +35 is applied between pins 1 and 2. By using a resistor divider R5 and R6, the terminal normally connected to ground is connected to a point which is at 2 volts, thus giving an output of +7 volts from the device. Resistor R8 is used to limit the power dissipation in U1.

The five volt supply of FIG. 154B is a switching regulator. The non-inverting input (pin 1) of the amplifier in U4 is connected via R15 to a +5 reference voltage developed from the +12 volt supply by resistors R14 and R16. The inverting input (pin 2) to the amplifier is connected to the supply output at L2. If the supply output voltage, as sensed at the inverting input of U4, falls below the reference voltage on the non-inverting input, the output of U4, amplified by Q6 and Q3, applies +20 volts to inductor L2. The tap on inductor L2 via R22 allows both Q3 and Q6 to saturate thereby increasing efficiency. When Q3 turns on, the reference voltage to the non-inverting input of U3 is raised by approximately 50 millivolts by resistor divider R17 and R15. When the output voltage at the inverting input of the U4 amplifier reaches the reference voltage at the non-inverting input, the amplifier turns off Q6 and Q3. Turning off Q3 causes the reference voltage on the non-inverting input of the amplifier to drop by about 20 millivolts. This hysterisis voltage introduces about 70 millivolts of ripple on the +5 volt supply which is filtered out by L1, C4, and C15. The current used to turn on Q6 and Q3 is limited by sensing the voltage across R19. If the +5 volt supply is suddenly pulled more than a diode and an emitter-base voltage drop below the reference voltage, transistor Q5 turns on and shuts off the drive transistor in U4. As long as there is any current flow out of the +5 volt supply, Q5 remains on and keeps the +5 volt supply shut down.

The −12 volt supply is developed by device U2 (National LM 320-12 or equivalent) in a manner similar to the +7 volt supply. The −5 volt supply is a zener regulated supply consisting of resistor R7 and zener CR8.

## CALCULATOR FIRMWARE

Operation of the calculator firmware may be understood with reference to FIGS. 5–15, the calculator firmware listing of routines and subroutines stored within the calculator read-only memory, and the flow chart of these routines and subroutines illustrates in FIGS. 155–182B.

Referring to FIG. 5, there is shown an overall block diagram of the portion of the calculator firmware residing in the mainframe language ROM 210 of FIG. 4. The address structure of the mainframe language ROM is depicted in FIG. 6 in relation to the remainder of the calculator memory. The location of each of the firmware components of FIG. 5 within the twelve individual ROM chips comprising the mainframe language ROM is shown in FIG. 7. The remaining portion of the calculator firmware resides in the various plug-in ROMs 230 of FIG. 4 that may be employed by the user for increasing the functional capability of the calculator.

A detailed listing of the routines and subroutines of instructions stored in the mainframe language ROM together with a listing of the routines and subroutines that may be stored in a general I/O plug-in ROM are provided hereinafter. In addition, as a preface to the listing of the routines and subroutines stored in read-only memory, a listing of the base page read-write memory is given. This listing of the base page read-write memory may be understood with reference to the memory map of FIG. 15. It will be seen that the base page portion of the read-write memory is employed for storing several words of information used by the calculator firmware. Included are all the working registers of the calculator, scratch pad locations used by the floating point math routines, locations for storing information regarding the current status of the magnetic tape cassette unit, and locations for storing information regarding the current position of the visual cursor associated with the output display unit.

## DETAILED LISTING OF ROUTINES AND SUBROUTINES OF INSTRUCTIONS

A complete assembly language listing of all of the routines and subroutines of instructions employed by the calculator is given below. The listing covers the read-write memory base page, the entire mainframe language read-only memory, and a general I/O plug-in read-only memory. Each page within the listing is numbered in sequence at the upper left-hand corner, and its page number within the specification as a whole is indicated at the bottom of the page. Each line of each page is separately numbered in the first column from the left-hand side of the page. This line numbering and paginating arrangement facilitates reference to different portions of the listing. Descriptive headings are variously provided throughout the listing to identify routines, subroutines, groups of constants, and plug-in ROM routines. Each instruction of each routine or subroutine and each constant stored in the mainframe langauge ROM or the general I/O plug-in ROM is represented in octal form in the third column from the left-hand side of the page. Each of these instructions may be understood in detail by referring to the detailed description of the microprocessor hereinabove. The octal address of the ROM location in which each such instruction or constant is stored is given in the second column from the left-hand side of the page.

Mnemonic labels serving as symbolic addresses or names are given in the fourth column from the left-hand side of the page. An asterisk in the fourth column indicates that particular line of the listing is merely a comment. A mnemonic code corresponding to a particular instruction is given in the fifth column from the left-hand side of the page. Operands that may be either labels or literals associated with each of the instructions are located in the sixth column from the left-hand side of the page. Explanatory comments are given in the remaining right-hand portion of each page.

```
Page 1                          BASE-PAGE READ-WRITE-MEMORY

00003000 76550                ORG 76550B
00004000                *     UNL
00005000                      SUP
00006000                *
00007000                *
00008000                *
00009000 76550          BINRY BSS 7           BINARY PROGRAM LINKS
00010000                *
00011000 76557          CBUFF BSS 80          COMPILE BUFFER
00012000 76677          CSTAK BSS 80          COMPILE STACK
00013000                *
00014000 77017          RMTBL BSS 19          ROM ADDRESS TABLE
00015000 77042          STEAL BSS 16          STOLEN RWM TABLE
00016000 77062          ROMWD BSS 1           ROM IN/OUT INFO
00017000 77063          NPROG BSS 1           NEW-PROGRAM FLAG
00018000 77064          IBUFF BSS 41          INPUT/OUTPUT BUFFER
00019000 77135          KBUFF BSS 41          KEYBOARD BUFFER
00020000                *
00021000 77206          IOTMP BSS 8           I/O DRIVER TEMPORARIES
00022000 77216          CSTMP BSS 17          CONTROL SUPERVISOR TEMPORARIES
00023000 77237          CMTMP BSS 14          COMPILER TEMPORARIES
00024000                *
00025000 77255          XCOMM BSS 1           INTERPRETER COMMUNICATIONS WORD
00026000 77256          MODE  BSS 1           CONTROL-SUPERVISOR MODE FLAG
00027000 77257          CSTAT BSS 1           CONTHOL STATE
00028000 77260          ERRBP BSS 1           ERROR BYPASS LINK
00029000                *
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BASE-PAGE READ-WRITE-MEMORY

```
00030000 77261             EXTMP BSS 12        INTERPRETER TEMPORARIES
00031000                   *
00032000 77275             IDXRW BSS 1         INDEXED RWM
00033000 77276             SAVEB BSS 1
00034000 77277             END$  BSS 1
00035000 77300             AP2   BSS 1
00036000 77301                   BSS 4         RESERVED FOR INDEX TABLE
00037000                   *
00038000 77305             OFWAM BSS 1         FIRST WORD ACTUAL RWM
00039000 77306             FWAM  BSS 1         FIRST WORD AVAILABLE RWM
00040000 77307             FWUP  BSS 1         FIRST WORD OF USER PROGRAM
00041000 77310             RMAX  BSS 1         MAXIMUM R-REGISTER ADDRESS
00042000 77311             VT1   BSS 1         FIRST WORD OF VALUE TABLE INFO
00043000 77312             VT2   BSS 1         FIRST WORD OF VALUE TABLE VALUES
00044000 77313             FWBA  BSS 1         FIRST WORD OF BINARY AREA
00045000 77314             TE    BSS 1         TRACE ON/OFF FLAG
00046000 77315             STYFG BSS 1         SECURE-PROGRAM FLAG
00047000 77316             CERR  BSS 1         COMPILE ERROR FLAG
00048000 77317             SWHRE BSS 1         SAVED WHERE
00049000                   *
00050000 77320             ESV   BSS 1         ERASE STRING VARIABLE TABLE
00051000 77321             STCHK BSS 1         STRING COMPARISON LINK
00052000 77322             STENT BSS 1         STRING ENTER LINK
00053000 77323             STEAS BSS 1         STRING ENTER ASSIGNMENT LINK
00054000 77324             AKOUN BSS 1         LINK TO PROCESS A STRING
00055000 77325             STRES BSS 1         STRING ASSIGNMENT FOR READ STAT
00056000 77326             STEFL BSS 1         STRING ENTER FLAG
00057000 77327             SEED  BSS 4         SEED FOR RANDOM-NUMBER GENERATOR
00058000 77333                   BSS 8         RESERVED FOR POST-RELEASE
00059000 77343             NOTRY BSS 1         MAXIMUM # OF TRIES AT READ OR SEARC
00060000 77344             AVFLG BSS 1         CASSETTE AUTOVERIFY FLAG
00061000 77345             CSCF  BSS 1         SELECT CODE OF CASSETTE
00062000 77346             FTRGT BSS 1         TARGET RECORD FOR PARALLEL SEARCH
00063000 77347             INTSR BSS 1         INTERRUPT SERVICE FLAG
00064000                   *
00065000 77350             AEBUF BSS 1         BUFFER EDIT POINTERS
00066000 77351             AEBFX BSS 1
00067000 77352             AEBFM BSS 1
00068000 77353             AEBFL BSS 1
00069000                   *
00070000 77354             DVTAB BSS 26        DECLARED VARIABLE TABLE
00071000 77406             DATAB BSS 26        DECLARED ARRAY TABLE
00072000 77440             ITABL BSS 16        INTERRUPT JUMP TABLE
00073000 77460             HPIT  BSS 7         HI-PRIORITY INTERRUPT SAVE AREA
00074000 77467             LPIT  BSS 7         LO-PRIORITY INTERRUPT SAVE AREA
00075000                   *
00076000 77476             ENR   BSS 4         ENTER REGISTER
00077000 77502             URES  BSS 4         USER RESULT REGISTER
00078000 77506             FLAGS BSS 1         FLAG REGISTER, 0-15 L-TO-R
00079000                   *
00080000 77507             ELINK BSS 1         END-STMT EXECUTION LINK
00081000 77510             .IOSR BSS 1         I/O-ROM SERVICE ROUTINE LINK
00082000 77511             MLBPL BSS 1         "MAIN LOOP" BYPASS LINK
00083000 77512             DLEN  BSS 1         DISPLAY LENGTH
00084000 77513             DBP   BSS 1         DISPLAY BEGIN POINTER
00085000 77514             CSELC BSS 1         CASSETTE SELECT CODE
00086000 77515             BUSFG BSS 1         FOR JN
00087000 77516             IOINT BSS 1         FOR JN
00088000 77517             RGFLG BSS 1         REGISTER ASSIGNMENT INFORMATION
00089000                   *
00090000 77520             PARG  BSS 1         P-ARGUMENT
00091000 77521             AP36  BSS 1         PRODUCTION 36 (FOR JO)
00092000 77522             AP37  BSS 1         PRODUCTION 37
00093000 77523             AP77  BSS 1         PRODUCTION 77
00094000 77524             AP78  BSS 1         PRODUCTION 78
00095000 77525             AP136 BSS 1         PRODUCTION 136
00096000 77526             APP#  BSS 1         P# EXECUTION
00097000 77527             APRET BSS 1         A.P. ROM'S PART OF 'RET' EXECUTION
00098000 77530             LOADL BSS 1         CASSETTE LDK OK LINK
00099000 77531             APRVC BSS 1         A.P. ROM'S CHECK FOR ()
00100000 77532             REFOR BSS 1         RESET FOR/NEXT BEFORE EXECUTE
00101000 77533             RLINK BSS 1         RUN-CMND EXECUTION LINK
00102000                   *
00103000 77534             RBUFF BSS 41        RESERVE KEYBOARD BUFFER
00104000 77605             LKTMP BSS 14
00105000 77623             LKFLG BSS 1         LIVE KEYBOARD ENABLE/DISABLE FLAG
00106000                   *
00107000 77624             ENSV  BSS 4         SAVE AREA FOR ENTER
00108000 77630             SVXCM BSS 1         SAVED XCOMM FOR ENTER
00109000                   *
00110000 77631                   BSS 2         FOR POST-RELEASE CHANGES
00111000                   *
00112000 77633             JSTAK BSS 33        JSM STACK
00113000                   *
00114000 77674                   BSS 1         FOR POST-RELEASE CHANGES
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00114100 77675           T26   BSS 1
00115000                 *
00116000 77676           CATMP BSS 11           CASSETTE TEMPORARIES
00117000                 *
00118000 77711           T1    BSS 1            SHARED TEMPORARIES
00119000 77712           T2    BSS 1
00120000 77713           T3    BSS 1
00121000 77714           T4    BSS 1
00122000 77715           T5    BSS 1
00123000 77716           T6    BSS 1
00124000 77717           T7    BSS 1
00125000 77720           T8    BSS 1
00126000 77721           T9    BSS 1
00127000 77722           T10   BSS 1
00128000 77723           T11   BSS 1
00129000 77724           T12   BSS 1
00130000 77725           T13   BSS 1
00131000 77726           T14   BSS 1
00132000 77727           T15   BSS 1
00133000 77730           T16   BSS 1
00134000 77731           T17   BSS 1
00135000 77732           T18   BSS 1
00136000 77733           T19   BSS 1
00137000 77734           T20   BSS 1
00138000 77735           T21   BSS 1
00139000 77736           T22   BSS 1
00140000 77737           T23   BSS 1
00141000 77740           T24   BSS 1
00142000 77741           T25   BSS 1
00143000                 *
00144000 77742           OP1   BSS 4            FLOATING-POINT TEMPORARY
00145000 77746           OP2   BSS 4            FLOATING-POINT TEMPORARY
00146000 77752           RES   BSS 4            RESULT FOR ALL FLOATING-POINT
00147000 77756           MRW1  BSS 10           MATH READ-WRITE
00148000 77770                 BSS 4            AR1
00149000 77774           MRW2  BSS 4            MATH READ-WRITE
00151000 00040                 ORG 40B
00152000                 *
00153000                 * SYSTEM STARTUP
00154000                 *
00155000 00040   164041  SYSS  JMP *+1,I
00156000 00041                 BSS 1
00158000                 *
00159000                 * CONSTANTS
00160000                 *
00161000 00042   000777  P511  DEC 511        JN JO
00162000         000042  B777  EQU P511
00163000 00043   000411  P265  DEC 265
00164000         000043  B411  EQU P265
00165000 00044   000400  P256  DEC 256     JB JN
00166000         000044  B400  EQU P256
00167000 00045   000377  P255  DEC 255     JB JN
00168000         000045  B377  EQU P255             MT
00169000 00046   000231  P153  DEC 153
00170000         000046  B231  EQU P153
00171000 00047   000230  P152  DEC 152
00172000         000047  B230  EQU P152
00173000 00050   000224  P148  DEC 148
00174000         000050  B224  EQU P148
00175000 00051   000202  P130  DEC 130
00176000         000051  B202  EQU P130
00177000 00052   000200  P128  DEC 128     JB       MT
00178000         000052  B200  EQU P128
00179000 00053   000177  P127  DEC 127     JB       MT
00180000         000053  B177  EQU P127             MT
00181000 00054   000176  P126  DEC 126     JB
00182000         000054  B176  EQU P126
00183000 00055   000175  P125  DEC 125     JB
00184000         000055  B175  EQU P125
00185000 00056   000174  P124  DEC 124     JB
00186000         000056  B174  EQU P124
00187000 00057   000173  P123  DEC 123     JB
00188000         000057  B173  EQU P123             MT
00189000 00060   000162  P114  DEC 114     JB
00190000         000060  B162  EQU P114
00191000 00061   000160  P112  DEC 112
00192000         000061  B160  EQU P112
00193000 00062   000153  P107  DEC 107     JB
00194000         000062  B153  EQU P107             MT
00195000 00063   000145  P101  DEC 101
00196000         000063  B145  EQU P101
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00197000 00064  000143  P99   DEC 99            JO MT
00198000 00065  000141  P97   DEC 97
00199000        000065  B141  EQU P97
00200000 00066  000140  P96   DEC 96    JB
00201000        000066  B140  EQU P96
00202000 00067  000135  P93   DEC 93
00203000        000067  B135  EQU P93
00204000 00070  000133  P91   DEC 91
00205000        000070  B133  EQU P91
00206000 00071  000105  P69   DEC 69    JB
00207000 00072  000101  P65   DEC 65
00208000        000072  B101  EQU P65
00209000 00073  000100  P64   DEC 64    JB      JO MT
00210000        000073  B100  EQU P64
00211000 00074  000077  P63   DEC 63    JB
00212000        000074  B77   EQU P63
00213000 00075  000075  P61   DEC 61
00214000        000075  B75   EQU P61
00215000 00076  000073  P59   DEC 59    JB
00216000        000076  B73   EQU P59
00217000 00077  000072  P58   DEC 58    JB
00218000        000077  B72   EQU P58
00219000 00100  000064  P52   DEC 52    JB
00220000        000100  B64   EQU P52
00221000 00101  000063  P51   DEC 51    JB
00222000        000101  B63   EQU P51            MT
00223000 00102  000061  P49   DEC 49
00224000        000102  B61   EQU P49
00225000 00103  000060  P48   DEC 48    JB
00226000        000103  B60   EQU P48
00227000 00104  000057  P47   DEC 47    JB
00228000        000104  B57   EQU P47
00229000 00105  000056  P46   DEC 46    JB
00230000        000105  B56   EQU P46
00231000 00106  000055  P45   DEC 45    JB
00232000        000106  B55   EQU P45
00233000 00107  000054  P44   DEC 44    JB
00234000        000107  B54   EQU P44
00235000 00110  000053  P43   DEC 43    JB
00236000        000110  B53   EQU P43
00237000 00111  000052  P42   DEC 42    JB
00238000        000111  B52   EQU P42
00239000 00112  000051  P41   DEC 41    JB
00240000        000112  B51   EQU P41
00241000 00113  000050  P40   DEC 40
00242000        000113  B50   EQU P40
00243000 00114  000044  P36   DEC 36
00244000        000114  B44   EQU P36
00245000 00115  000043  P35   DEC 35
00246000        000115  B43   EQU P35
00247000 00116  000042  P34   DEC 34    JB JN
00248000        000116  B42   EQU P34
00249000 00117  000040  P32   DEC 32    JB JN    MT
00250000        000117  B40   EQU P32
00251000 00120  000037  P31   DEC 31    JB
00252000        000120  B37   EQU P31
00253000 00121  000034  P28   DEC 28       JN    MT
00254000        000121  B34   EQU P28
00255000 00122  000032  P26   DEC 26    JB    JO
00256000 00123  000024  P20   DEC 20             MT
00257000 00124  000023  P19   DEC 19       JN    MT
00258000 00125  000022  P18   DEC 18
00259000 00126  000021  P17   DEC 17    JB JN
00260000 00127  000020  P16   DEC 16    JB JN JO MT
00261000        000127  B20   EQU P16
00262000 00130  000017  P15   DEC 15    JB JN    MT
00263000        000130  B17   EQU P15
00264000 00131  000016  P14   DEC 14    JB JN
00265000 00132  000015  P13   DEC 13    JB    JO
00266000 00133  000014  P12   DEC 12    JB JN JO MT
00267000 00134  000013  P11   DEC 11    JB    JO
00268000        000134  B13   EQU P11
00269000 00135  000012  P10   DEC 10    JB JN JO MT
00270000 00136  000011  P9    DEC 9
00271000 00137  000010  P8    DEC 8     JB JN JO MT
00272000        000137  B10   EQU P8
00273000 00140  000007  P7    DEC 7     JB JN JO MT
00274000 00141  000006  P6    DEC 6     JB    JO MT
00275000 00142  000005  P5    DEC 5     JB JN JO MT
00276000 00143  000004  P4    DEC 4     JB JN JO MT
00277000 00144  000003  P3    DEC 3     JB JN JO MT
00278000 00145  000002  P2    DEC 2     JB JN JO MT
00279000 00146  177776  M2    DEC -2    JB JN
00280000 00147  177775  M3    DEC -3    JB JN JO MT
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00281000 00150  177774  M4    DEC -4     JB JN JO MT
00282000 00151  177773  M5    DEC -5     JB JN JO
00283000 00152  177772  M6    DEC -6
00284000 00153  177771  M7    DEC -7     JB
00285000 00154  177770  M8    DEC -8        JN    MT
00286000 00155  177765  M11   DEC -11          JO
00287000 00156  177763  M13   DEC -13          JO
00288000 00157  177761  M15   DEC -15             MT
00289000 00160  177760  M16   DEC -16    JB JN JO MT
00290000 00161  177757  M17   DEC -17    JB
00291000 00162  177740  M32   DEC -32    JB JN    MT
00292000        000162  BM40  EQU M32
00293000 00163  177720  M48   DEC -48    JB
00294000 00164  177700  M64   DEC -64    JB    JO
00295000        000164  BM100 EQU M64
00296000 00165  177660  M80   DEC -80    JB
00297000 00166  177637  M97   DEC -97
00298000 00167  177600  M128  DEC -128            MT
00299000 00170  177400  M256  DEC -256   JB    JO MT
00300000 00171  160000  M8192 DEC -8192  JB
00301000                *
00302000 00172  000174  AONE  DEF *+2       JN JO    FLOATING-POINT ONE
00303000 00173  000177  APIE  DEF *+4          JO    FUDGED PI
00304000 00174  000000        OCT 000000
00305000 00175  010000  B10K  OCT 010000 JB    JO MT
00306000 00176  000000        OCT 000000
00307000 00177  000000  P0    OCT 000000 JB    JO
00308000 00200  030501        OCT 030501      3141
00309000 00201  054446        OCT 054446      5926
00310000 00202  051540        OCT 051540      5360
00311000                *
00312000 00203  000204  PTCN  DEF *+1
00313000 00204  154360  M10K  DEC -10000 JB
00314000 00205  176030  M1000 DEC -1000
00315000 00206  177634  M100  DEC -100   JB
00316000 00207  177766  M10   DEC -10    JB    JO
00317000 00210  000210  ENDTC DEF *
00318000                *
00319000 00211  077740  BXCAA OCT 77740  JB
00320000 00212  077700  EMAX  OCT 77700        JO
00321000        000212  B777X EQU EMAX   JB
00322000 00213  077577  TMASK OCT 77577
00323000 00214  077440  EOLB  OCT 77440  JB
00324000 00215  077400  BXCMM OCT 77400  JB
00325000 00216  076574  ZK2   OCT 76574
00326000 00217  076000  B76K  OCT 76000  JB
00327000 00220  071050  TRCC2 OCT 71050
00328000 00221  070000  B70K  OCT 70000        JO MT
00329000 00222  067000  B67K  OCT 67000           MT
00330000 00223  063000  B63K  OCT 63000  JB
00331000 00224  060000  B60K  OCT 60000  JB       MT
00332000 00225  052525  ALBPT OCT 52525  JB
00333000 00226  037440  QMRKB OCT 37440  JB
00334000 00227  020000  B20K  OCT 20000  JB
00335000 00230  010133  RK2   OCT 10133
00336000 00231  010050  RK1   OCT 10050
00337000 00232  007403  B7403 OCT 7403            MT
00338000 00233  004406  ZK3   OCT 4406
00339000 00234  004000  B4K   OCT 4000            MT
00340000 00235  003377  B3377 OCT 3377            MT
00341000 00236  002000  B2K   OCT 2000   JB       MT
00342000 00237  001000  B1K   OCT 1000            MT
00343000                *
00344000 00240  177701  ZAP   OCT 177701       JO
00345000        000167  BM200 EQU M128   JB    JO
00346000 00241  174000  BM2K  OCT -2000  JB
00347000 00242  170720  KF    OCT 170720
00348000 00243  170000  B170K OCT 170000 JB
00349000 00244  137777  XMASK OCT 137777 JB
00350000 00245  131400  IMCON OCT 131400
00351000 00246  126273  AMSE  OCT 126273          MT
00352000 00247  101175  ZK1   OCT 101175
00353000 00250  100377  BM377 OCT 100377          MT
00354000 00251  100200  UMASK OCT 100200
00355000                *
00356000 00252  000254  NB1   DEF *+2        SPECIAL PATTERN FOR NUMBER BUILDER
00357000 00253  077772  NB2   DEF 77772B
00358000 00254  000001  P1    DEC 1      JB JN JO MT
00359000 00255  177764  M12   DEC -12    JB    JO
00360000 00256  000000        DEC 0
00361000 00257  177777  M1    DEC -1     JB    JO MT
00362000 00260  000000        DEC 0
00363000 00261  000000        DEC 0
00364000                *
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00365000 00262  020040  TOBLN OCT 020040      TWO ASCII BLANKS
00366000 00263  100000  FLAG  OCT 100000
00367000 00264  040001  STTMP OCT 040001      STRING CONSTANT IN STACK
00368000 00265  100004  STWHR OCT 100004
00369000        000171  ARRAY EQU M8192       ENTIRE ARRAY
00370000        000221  EMPTY EQU 870K        EMPTY
00371000 00266  011401  FPTMP OCT 011401      FULL-PRECISION CONSTANT IN STACK
00372000 00267  110000  FVRWM OCT 110000      FULL-PRECISION VARIABLE IN RWM
00373000 00270  110402  FVRRA OCT 110402      FULL-PRECISION VARIABLE IN R
00374000                *
00375000 00271  062562  LKERM OCT 62562       LOWER-CASE "ERROR"
00376000 00272  071157        OCT 71157
00377000 00273  071040        OCT 71040
00378000                *
00379000                * POINTERS
00380000                *
00381000 00274  000053  AAEOL DEF B177        ADDRESS OF EOL
00382000 00275  077440  AITAB DEF ITABL       ADDRESS OF INTERRUPT TABLE
00383000 00276  077354  ADVTB DEF DVTAB       ADDRESS OF DECLARED VARIABLE TABLE
00384000 00277  077406  ADATB DEF DATAB       ADDRESS OF DECLARED ARRAY TABLE
00385000 00300  077632  AJSTK DEF JSTAK-1     ADDRESS OF JSM STACK
00386000 00301  077633  AJSMS DEF JSTAK
00387000 00302  176557  ACBFX DEF CBUFF,I     COMPILE BUFFER 1ST CHAR ADDRESS
00388000 00303  076557  ACBF  DEF CBUFF       COMPILE BUFFER STARTING ADDRESS
00389000 00304  076556  ACBUF DEF CBUFF-1     ADDRESS OF COMPILE BUFFER
00390000 00305  076676  ACLMT DEF CBUFF+79    COMPILE BUFFER UPPER LIMIT
00391000 00306  077135  AKBUF DEF KBUFF       KEYBOARD BUFFER
00392000 00307  177135  AKBFX DEF KBUFF,I     KEYBOARD BUFFER 1ST CHAR ADDRESS
00393000 00310  077134  AKBFM DEF KBUFF-1     KEYBOARD BUFFER STARTING ADDRESS - 1
00394000 00311  077205  AKBFL DEF KBUFF+40    KEYBOARD BUFFER ENDING ADDRESS
00395000 00312  000306  AKBST DEF AKBUF       KEYBOARD BUFFER POINTERS START.
00396000 00313  077064  AIBUF DEF IBUFF       I/O BUFFER
00397000 00314  177064  AIBFX DEF IBUFF,I     I/O BUFFER 1ST CHAR ADDRESS
00398000 00315  077063  AIBFM DEF IBUFF-1     I/O BUFFER STARTINF ADDRESS - 1
00399000 00316  077134  AIBFL DEF IBUFF+40    I/O BUFFER ENDING ADDRESS
00400000 00317  077066  AIBSL DEF IBUFF+2     I/O BUFFER STARTING ADDRESS + 2
00401000 00320  077070  AIOLM DEF IBUFF+4     I/O BUFFER STARTING ADDRESS .
00402000 00321  000313  AIBST DEF AIBUF       EDIT POINTERS STARTING ADDRESS
00403000 00322  077534  ARBUF DEF RBUFF
00404000 00323  077533  ARBFM DEF RBUFF-1
00405000 00324  076677  ASTK1 DEF CSTAK       COMPILE STACK STARTING ADDRESS
00406000 00325  176677  ACSTF DEF CSTAK,I
00407000        000305  ASTAK EQU ACLMT       ADDRESS OF COMPILE STACK - 1
00408000 00326  077016  ASLMT DEF CSTAK+79    COMPILE STACK UPPER LIMIT
00409000        000326  ATROM EQU ASLMT
00410000                *
00411000 00327  077017  AROMS DEF RMTBL       ADDRESS OF ROM ADDRESS TABLE
00412000 00330  076550  ABNRY DEF BINRY       ADDRESS OF BINARY HEADER
00413000 00331  000332  AMAIN DEF ARTBL       ADDRESS OF MAINFRAME HEADER
00414000 00332          ARTBL BSS 1           ADDRESS OF REVERSE COMPILE TABLE
00415000 00333          AMTBL BSS 1           ADDRESS OF MAINFRAME MNEMONIC TABLE
00416000                *
00417000 00334  000177  ADP0  DEF P0
00418000 00335  077711  ATMP  DEF T1      .   STARTING ADDRESS OF SHARED TEMP
00419000                *
00420000 00336  077742  AOP1  DEF OP1
00421000 00337  077746  AOP2  DEF OP2
00422000 00340  077752  ARES  DEF RES
00423000 00341  077476  AENR  DEF ENR
00424000 00342  077502  AURES DEF URES
00425000                *
00426000 00343  077414  SVRE  ABS DVTAB-1018+97
00427000        000326  STRK  EQU ASLMT
00428000                *
00429000 00344  077777  MAW   OCT 77777       MAXIMUM AVAILABLE WORD
00430000        000330  LWAM  EQU ABNRY       LAST WORD AVAILABLE RWM + 1
00431000                *
 0432000 00345  077770  ADR1  DEF AR1
 0433000        000127  ADR2  EQU P16


 0435000                *
 0436000                * USEFUL POINTERS AND EQUATES
00437000                *
00438000        077237  TKN   EQU CMTMP+0     TOKEN FOR PARSER
00439000        077240  BCD   EQU CMTMP+1     ASCII FOR PARSER
00440000        077241  OLDC  EQU CMTMP+2     USED BY SCANNER IN CASE OF ERROR
00441000        077242  ISTAR EQU CMTMP+3     IMPLIED-MULTIPLY FLAG
00442000                *
00443000        077254  STAKP EQU CMTMP+13    STACK POINTER
00444000                *
00445000        077237  GUIDE EQU CMTMP+0     PRIORITY/CLASS/CHARACTERS
00446000        077240  ASCII EQU CMTMP+1     CHARACTER ADDRESS
00447000                *
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00448000        077261  AP3   EQU EXTMP+0         RETURN LINK INFORMATION
00449000        077263  AP1   EQU EXTMP+2         TOP OF EXECUTION STACK
00450000        077264  LEND  EQU EXTMP+3         ADDRESS OF NEXT LINE TO BE EXECUTED
00451000        077265  HERE  EQU EXTMP+4         ADDRESS OF LINE BEING EXECUTED
00452000        077266  WHERE EQU EXTMP+5         ADDRESS FOR CS TO RESUME EXECUTION
00453000        077267  TRACE EQU EXTMP+6         CURRENT LINE TRACE INFORMATION
00454000        077270  SAVEC EQU EXTMP+7
00455000        077271  BASE  EQU EXTMP+8         ADDRESS IN DVTAB OR DATAB
00456000        077272  FAP1  EQU EXTMP+9
00457000        077273  OPND1 EQU EXTMP+10
00458000        077274  OPND2 EQU EXTMP+11
00459000                *
00460000        077222  L     EQU CSTMP+4
00461000        077610  KBFMT EQU LKTMP+3
00462000                *
00463000        000141  STRID EQU P6              ID OF STRING ROM
00465000                *
00466000                * ROUTINE ADDRESSES
00467000                *
00468000 00346          ACPLR BSS 1               COMPILER
00469000 00347          AREAD BSS 1               COMPILER INPUT READER
00470000 00350          AAPL1 BSS 1               APPLY-PRODUCTION RETURN TO COMPILER
00471000 00351          ASETC BSS 1               COMPILE ERROR
00472000 00352          ANUMB BSS 1               NUMBER-BUILDER
00473000 00353          ALBLN BSS 1               QUOTE SCANNER
00474000 00354          ALBCM BSS 1               QUOTE BUILDER
00475000 00355          AOUTS BSS 1               COMPILER BYTE WRITER
00476000                *
00477000 00356          ARCLR BSS 1               REVERSE COMPILER
00478000 00357          ADSRM BSS 1               DISPLAY ROM I.D. NUMBER
00479000                *
00480000 00360          ARSGT BSS 1               RESET HI-SPEED BRANCHES
00481000 00361          AINTI BSS 1               INTERPRETER 'RUN' ENTRY
00482000 00362          AFBAD BSS 1               FIND BYTE ADDRESS DIFFERENCE
00483000 00363          AINTT BSS 1               INTERPRETER 'CLL' ENTRY
00484000 00364          AINTK BSS 1               INTERPRETER 'CONTINUE' ENTRY
00485000 00365          AINTX BSS 1               INTERPRETER EXECUTION RETURN
00486000 00366          ARAP  BSS 1               FOR MATH ROUTINES
00487000 00367          ASTP  BSS 1               FOR END-STMT LINK
00488000 00370          ALLOC BSS 1               ALLOCATOR
00489000 00371          AOVTS BSS 1               EXECUTION STACK OVERFLOW TEST
00490000 00372          AASTR BSS 1               ASSIGNMENT TRACE
00491000 00373          ALNTR BSS 1               LINE NUMBER TRACE
00492000 00374          AFCI  BSS 1               FIND-BYTE INITIALIZATION ENTRY
00493000 00375          AFCC  BSS 1               FIND-BYTE CONTINUATION ENTRY
00494000 00376          ASFG  BSS 1               SET A FLAG
00495000 00377          AGNAM BSS 1               GET VARIABLE NAME
00496000 00400          ACLBL BSS 1               FIND LABEL LINE ADDRESS
00497000 00401          AADBA BSS 1               ADJUST BYTE ADDRESS ENTRY #1
00498000 00402          A.ADB BSS 1               ADJUST BYTE ADDRESS ENTRY #2
00499000                *
00500000                * 10K PAGE - CONTROL SUPERVISOR
00501000                *
00502000 00403          AMCLX BSS 1               MAIN LOOP ADDR+1
00503000 00404          AERR1 BSS 1               ERROR ROUTINE -- NO RETURN
00504000 00405          AERR2 BSS 1               ERROR ROUTINE -- RETURN P+2
00505000 00406          APEMI BSS 1               PLACE ERROR MESSAGE IN I/O BUFFER
00506000 00407          AEREX BSS 1               ERROR EXIT -- AFTER 'AERR2'
00507000 00410          AREJR BSS 1               INTERRUPT REJECT ROUTINE
00508000 00411          AXCMM BSS 1               XCOMM MANAGEMENT
00509000 00412          APLIR BSS 1               PLACE LINE NUMBER IN I/O BUFFER
00510000 00413          ACNDT BSS 1               COMMAND TABLE
00511000 00414          ACTFC BSS 1               CHECK TABLE FOR COMMAND
00512000 00415          ACONT BSS 1               IMMEDIATE EXECUTE CONTINUE
00513000 00416          AEXCK BSS 1               COMMAND EXECUTION
00514000 00417          AEXCL BSS 1               PLACE LINE BRIDGES ON COMPILED LINE
00515000 00420          AKYPR BSS 1               PROCESS A KEY
00516000 00421          AERCS BSS 1               CASSETTE RUN ENTRY
00517000 00422          AECIM BSS 1               IMMEDIATE CONTINUE
00518000 00423          ASCND BSS 1               COMMAND TABLE ADDRESS
00519000 00424          ASYER BSS 1               SYSTEM ERROR
00520000 00425          ACNIN BSS 1               CONTINUE INITIALIZATION
00521000 00426          AERSA BSS 1               LINK FOR ERASE-ALL
00522000 00427          AISTR BSS 1               PLACE KEYBOARD CHARACTER IN I/O BUF
00523000 00430          AISTX BSS 1               PLACE CHARACTER IN I/O BUFFER
00524000 00431          AEXST BSS 1               STATEMENT EXECUTION
00525000                *
00526000                * 12K PAGE - I/O SUPERVISOR
00527000                *
00528000 00432          ADSPC BSS 1               DISPLAY EDIT BUFFER WITH CURSOR
00529000 00433          ALDSP BSS 1               DISPLAY I/O BUFFER
00530000 00434          AKBSR BSS 1               KEYBOARD SERVICE ROUTINE
00531000 00435          ATRBF BSS 1               TRANSFER I/O BUFFER TO KEYBOARD BUF
00532000 00436          AEPON BSS 1               PRINT-ALL ROUTINE
00533000 00437          AEPNX BSS 1               LINK TO PRINT-ALL FOR ENP
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00534000 00440          ASVRG BSS 1             SAVE LOW PRIORITY A,B,E,O
00535000 00441          AKBR2 BSS 1             RESTORE LOW PRIORITY A,B,E,O
00536000 00442          ACPST BSS 1             CHECK PRINTER STATUS
00537000 00443          APRNT BSS 1             PRINT CHARACTERS ALREADY GIVEN
00538000 00444          A.PRN BSS 1             PRINT 16 CHARS FROM I/O BUFFER
00539000 00445          APNMR BSS 1             PRINT A NUMERIC VALUE
00540000 00446          AFBP  BSS 1             FIND DISPLAY BEGIN POINTER
00541000 00447          ASWIO BSS 1             SWAP POINTERS TO EDIT I/O BUFFER
00542000 00450          ACLBI BSS 1             CLEAR I/O BUFFER
00543000 00451          ACLEB BSS 1             CLEAR EDIT BUFFER
00544000 00452          AEDLB BSS 1             SET EOL IN EDIT BUFFER
00545000 00453          ACLCM BSS 1             CLEAR COMPILE BUFFER
00546000 00454          ARPRL BSS 1             ROM "POWER REDUCTION LOOP"
00547000 00455          ALKEX BSS 1             LINK TO LIVE-KEYBOARD-EXECUTION
00548000 00456          ALXER BSS 1             LINK TO LIVE-KEYBOARD EXECUTE ERROR
00549000 00457          ALXKY BSS 1             LINK TO LIVE-KEYBOARD EXECUTE KEY
00550000 00460          AKYTB BSS 1
00551000 00461          APRKB BSS 1             PRINT-ALL FROM KEYBOARD BUFFER
00552000 00462          APSTR BSS 1 (PSTRG)
00553000                *
00554000                * 22K PAGE
00555000                *
00556000 00463          AMUPH BSS 1             MOVE MAIN PROGRAM TO HIGHER MEMORY
00557000 00464          AMAMP BSS 1             MOVE MAIN PROGRAM TO LOWER MEMORY
00558000 00465          AMPUP BSS 1             MOVE PART OF MAIN PROGRAM HIGHER
00559000 00466          AMPML BSS 1             MOVE PART OF MAIN PROGRAM LOWER
00560000 00467          AMTHM BSS 1             MOVE RWM HIGHER
00561000 00470          AMTLM BSS 1             MOVE RWM LOWER
00562000 00471          AZRWM BSS 1             ZERO RWM
00563000 00472          AERAV BSS 1             ERASE ALL VARIABLES
00564000 00473          ALISK BSS 1             LIST A SPECIAL KEY
00565000 00474          AKEYN BSS 1             PUT SPECIAL KEY NUMBER IN I/O BUF
00566000 00475          AEDPT BSS 1             RESET EDIT POINTERS
00567000 00476          ATLNI BSS 1             PLACE LINE NUMBER IN I/O BUFFER
00568000 00477          ABTDA BSS 1             BINARY TO DECIMAL ASCII
00569000 00500          AEOLN BSS 1             FIND EOL IN I/O BUFFER
00570000 00501          AGNXT BSS 1             GET NEXT CHARACTER
00571000 00502          ATCHR BSS 1             TRANSFER CHARS
00572000 00503          ARNLO BSS 1             LINK TO TURN ON RUN LIGHT
00573000 00504          ARNLF BSS 1             LINK TO TURN OFF RUN LIGHT
00574000                *
00575000                * 26K PAGE
00576000                *
00577000 00505          APGET BSS 1 (PGET)      GET NEXT PARAMETER FOR "PRINT" LIST
00578000 00506          APNUM BSS 1 (PNUM)      PROCESS A NUMERIC ITEM
00579000 00507          AINTC BSS 1 (INTCK)     MAKE INTEGER FROM ASCII STRING
00580000 00510          AGLL  BSS 1 (GLENL)     GET LENGTH OF COMPILED LINE
00581000 00511          AGEOL BSS 1             FIND EOL IN COMPILE BUFFER
00582000 00512          AFLAD BSS 1 (FLADR)     FIND LINE ADDRESS
00583000 00513          AFLNA BSS 1             FIND LINE ADDR (TMP7)
00584000 00514          ASLLN BSS 1 (SLLN)      SET 'LNO' TO LAST LINE NUMBER OR -1
00585000 00515          ASTKI BSS 1             LINK TO LIVE-KEYBOARD INIT
00586000 00516          AREST BSS 1             LINK TO LIVE-KEYBOARD RESTORE
00587000 00517          ARENI BSS 1             INSERT LINE RENUMBER GTO/GSB
00588000 00520          AREND BSS 1             DELETE LINE RENUMBER GTO/GSB
00589000 00521          ASTKG BSS 1             STACK ROUTINE FOR GSB
00590000 00522          ADIGX BSS 1             GENERAL RANGE CHECK ROUTINE
00591000 00523          AGLNO BSS 1             GET LINE NUMBER OF CURRENT LINE
00592000                *
00593000 00524          AUNM  BSS 1             UNARY MINUS -- FILLED IN FROM 14K
00594000 00525          AADD  BSS 1             ADD
00595000 00526          ASUB  BSS 1             SUBTRACT
00596000 00527          AMUL  BSS 1             MULTIPLY
00597000 00530          ADIV  BSS 1             DIVIDE
00598000 00531          ASQR  BSS 1             SQRT
00599000 00532          AGE   BSS 1             >=
00600000 00533          AGT   BSS 1             >
00601000 00534          ALT   BSS 1             <
00602000 00535          ALE   BSS 1             <=
00603000 00536          AEQ   BSS 1             =
00604000 00537          ANE   BSS 1             #
00605000 00540          AAND  BSS 1             AND
00606000 00541          AOR   BSS 1             OR
00607000 00542          AXOR  BSS 1             XOR
00608000 00543          ANOT  BSS 1             NOT
00609000 00544          APRND BSS 1             P-ROUND
00610000 00545          ADRND BSS 1             D-ROUND
00611000 00546          ARERR BSS 1             RECOVERABLE MATH ERROR
00612000 00547          ARND  BSS 1             ROUND
00613000 00550          ATSUB BSS 1             USED BY RELATIONAL OPERATIONS
00614000 00551          AFLTC BSS 1             FULL-PRECISION EXPONENT RANGE CHECK
00615000 00552          AGET1 BSS 1             GET ONE MATH OPRND FROM STACK
00616000 00553          AGET2 BSS 1             GET TWO MATH OPNDS FROM STACK
00617000 00554          AADD1 BSS 1             ADD+1
00618000 00555          ASUB1 BSS 1             SUBTRACT+1
```

BASE-PAGE READ-ONLY-MEMORY

```
00619000 00556          AMUL1 BSS 1          MULTIPLY+1
00620000 00557          ADIV1 BSS 1          DIVIDE+1
00621000 00560          ADIV2 BSS 1          DIVIDE ENTRY FOR TRUNCATED QUOTIENT
00622000 00561          ASQR1 BSS 1          SQRT+1
00623000 00562          ATSU1 BSS 1          TSUB+1
00624000 00563          AFLTP BSS 1          CONVERT TO FLOATING-POINT
00625000                *
00626000 00564          ASTMA BSS 1          STMAX ENTRY -- FILLED IN FROM 24K-
00627000 00565          ASTM1 BSS 1          STMAX ENTRY
00628000                *
00629000 00566          ALST  BSS 1          LINK TO EXECUTE 'LIST'
00630000 00567          APRT  BSS 1          LINK TO EXECUTE 'PRT'
00631000 00570          ADSP  BSS 1          LINK TO EXECUTE 'DSP'
00632000 00571          ASPC  BSS 1          LINK TO EXECUTE 'SPC'
00633000 00572          ALSTK BSS 1          LINK TO EXECUTE 'LISTK'
00634000 00573          AKON  BSS 1          LINK TO EXECUTE 'KON'
00635000 00574          AKOF  BSS 1          LINK TO EXECUTE 'KOFF'
00636000 00575          AFXD  BSS 1          LINK TO EXECUTE 'FXD'
00637000 00576          AFLT  BSS 1          LINK TO EXECUTE 'FLT'
00638000 00577          AENT  BSS 1          LINK TO EXECUTE 'ENT'
00639000                *
00640000 00600          ACSTI BSS 1          CASSETTE INITIALIZATION
00641000 00601          ARFK  BSS 1          REWIND FROM KEYBOARD
00642000 00602          DMALO BSS 1          LINK TO DMA LOCKOUT ROUTINE
00643000 00603          ASTPA BSS 1          LINK TO SET CASSETTE P.A.
00644000 00604          AWTHR BSS 1          LINK TO WRITE RECORD
00645000 00605          ACMST BSS 1          LINK TO FIND RECORD
00646000 00606          ARDRC BSS 1          LINK TO READ RECORD
00647000                *
00648000 00607  001053  ABUMP DEF BUMP       BUMP PARAMETER POINTER (FAP1)
00649000 00610  001110  ACOUN DEF COUNT      COUNT PARAMETERS ON STACK
00650000 00611  001133  AGTAD DEF GETAD      GETAD SUBROUTINE
00651000 00612  001142  AGTIN DEF GETIN      GETIN SUBROUTINE
00652000                *
00653000 00613                BSS 2          FOR MORE LINKS IF NEEDED
```

BASE-PAGE SUBROUTINES

```
00655000                *
00656000                * UTILITIES
00657000                *

00659000                *
00660000                * SUBROUTINE TO GET OPERAND ABSOLUTE ADDRESS    W.F.C.
00661000                *
00662000                * ON EXIT:  A = UPDATED STACK POINTER
00663000                *           B = ABSOLUTE ADDRESS
00664000                *       SAVEB = OLD STACK POINTER
00665000                *
00666000 00615  005263  ABSAD LDB AP1        ENTER HERE TO USE AP1
00667000 00616  035276        STB SAVEB
00668000                *
00669000 00617  100001        LDA B,I
00670000 00620  050140        AND P7         GET INDEX NUMBER
00671000 00621  020632        ADA INDXP
00672000 00622  024145        ADB P2
00673000 00623  104001        LDB B,I        B = RELATIVE ADDRESS
00674000 00624  124000        ADB A,I        B = ABSOLUTE ADDRESS
00675000                *
00676000 00625  001276        LDA SAVEB
00677000 00626  020254        ADA P1
00678000 00627  100000        LDA A,I        A = LENGTH
00679000 00630  021276        ADA SAVEB      A = UPDATED POINTER
00680000 00631  170201        RET 1
00681000                *
00682000 00632  077275  INDXP DEF IDXRW      POINTER TO INDEXED RWM

00684000                *
00685000                * WAIT SUBROUTINE
00686000                *
00687000                * ON ENTRY: B = -DELAY IN MILLISECONDS
00688000                *
00689000 00633  000642  DELAY LDA TIME
00690000 00634  072100        RIA *
00691000 00635  001206        LDA IOTMP      TEST FOR STOP KEY
00692000 00636  010254        CPA P1
00693000 00637  170201        RET 1
00694000 00640  076173        RIB *-5
00695000 00641  170201        RET 1
00696000                *
00697000 00642  177130  TIME  OCT 177130
```

```
00699000                          *
00700000                          * CONVERT FLOATING NUMBER TO INTEGER    W.F.C.
00701000                          *
00702000                          * ON ENTRY:
00703000                          *
00704000                          *   A POINTS TO FLOATING NUMBER
00705000                          *
00706000                          * ON EXIT:
00707000                          *
00708000                          *   B HAS INTEGER VALUE
00709000                          *   O INDICATES OVERFLOW STATUS
00710000                          *
00711000                          *   AR2 HAS FRACTIONAL REMAINDER
00712000                          *
00713000                          * TEMPORARIES USED: T1,T2
00714000                          *
00715000 00643  000001                  LDA B          ALTERNATE ENTRY
00716000                          *
00717000 00644  004127            FIXPT LDB ADR2       ADDRESS OF AR2
00718000 00645  071403                  XFR 4          MOVE NUMBER TO AR2
00719000 00646  004177                  LDB P0         INITIALIZE RESULT
00720000 00647  173201                  SOC *+1,C
00721000 00650  000020                  LDA AR2        LOOK AT EXPONENT
00722000 00651  170405                  AAR 6
00723000 00652  020254                  ADA P1
00724000 00653  072417                  SZA FI3
00725000 00654  172426                  SAM FI4
00726000 00655  031711                  STA T1
00727000 00656  064664                  JMP FI2
00728000                          *
00729000 00657  024001            FI1   ADB B          2X
00730000 00660  035712                  STB T2
00731000 00661  024001                  ADB B          4X
00732000 00662  024001                  ADB B          8X
00733000 00663  025712                  ADB T2         10X
00734000 00664  000177            FI2   LDA P0
00735000 00665  075541                  MLY            SHIFT AR2 LEFT
00736000 00666  170040                  TCA            BUILD NEGATIVE NUMBER
00737000 00667  024000                  ADB A          ADD IN NEXT DIGIT
00738000 00670  055711                  DSZ T1
00739000 00671  064657                  JMP FI1
00740000                          *
00741000 00672  000021            FI3   LDA AR2+1
00742000 00673  170513                  SAR 12
00743000 00674  020151                  ADA M5
00744000 00675  172402                  SAM *+2        ROUND
00745000 00676  024257                  ADB M1
00746000                          *
00747000 00677  000020                  LDA AR2
00748000 00700  073402                  RLA *+2        TEST MANTISSA SIGN
00749000 00701  174040                  TCB            COMPLEMENT IF NECESSARY
00750000 00702  170201            FI4   RET 1
00752000                          *
00753000                          * BEEP SUBROUTINE
00754000                          *
00755000 00703  000177            BEEP  LDA P0
00756000 00704  030011                  STA PA
00757000 00705  000143                  LDA P4
00758000 00706  030005                  STA R5
00759000 00707  170201                  RET 1

00761000                          *
00762000                          * CLEAR I/O BUFFER AND PUT 'LAZY-T' AT LEFT END
00763000                          *
00764000 00710  140450            EOLIO JSM ACLBI,I
00765000 00711  000214                  LDA EOLB
00766000 00712  130313                  STA AIBUF,I
00767000 00713  170201                  RET 1

00769000                          *
00770000                          * MISCELLANY FOR JB
00771000                          *
00772000 00714  000721            ARET1 DEF RET1
00773000                          *
00774000 00715  000177            CLMOD LDA P0         SET MODE=0
00775000 00716  064720                  JMP STMOD
00776000 00717  000143            STELM LDA P4         SET MODE=4
00777000 00720  031256            STMOD STA MODE
00778000 00721  170201            RET1  RET 1
00779000                          *
00780000 00722  140404            ERLNF JSM AERR1,I    LINE NOT FOUND
00781000 00723  031461                  ASC 1,31
00782000                          *
```

```
00783000 00724  005315  SECCK LDB STYFG
00784000 00725  076474        SZB RET1
00785000 00726  140404  ERSEC JSM AERR1,I
00786000 00727  030064        ASC 1,04

00788000                *
00789000                * SOME COMMON ERRORS
00790000                *
00791000 00730  000731  AREPN DEF *+1
00792000 00731  140404  E29   JSM AERR1,I     ERROR, ROM MISSING AT EXECUTION
00793000 00732  031071        ASC 1,29
00794000                *
00795000 00733  140404  E32   JSM AERR1,I     ERROR, ILLEGAL DATA TYPE
00796000 00734  031462        ASC 1,32
00798000                *
00799000                * SUBROUTINE TO DO AN EXE A
00800000                *
00801000 00735  070430  EXEXA DIR             PREVENT INTERRUPT INTERFERENCE
00802000 00736  070000        EXE A
00803000 00737  064747        JMP SXCMM+3
00804000                *
00805000                * SUBROUTINE TO CLEAR BITS IN XCOMM
00806000                *
00807000                * ON ENTRY: B = MASK TO CLEAR BITS
00808000                *
00809000 00740  070430  CLXCM DIR             PREVENT INTERRUPT INTERFERENCE
00810000 00741  001255        LDA XCOMM
00811000 00742  050001        AND B
00812000 00743  064746        JMP SXCMM+2
00813000                *
00814000                * SUBROUTINE TO SET BITS IN XCOMM
00815000                *
00816000                * ON ENTRY: A = BITS TO BE INCLUDED
00817000                *
00818000 00744  070430  SXCMM DIR             PREVENT INTERRUPT INTERFERENCE
00819000 00745  061255        IOR XCOMM
00820000 00746  031255        STA XCOMM
00821000 00747  070420        EIR
00822000 00750  170201        RET 1

00824000                *
00825000                * SUBROUTINE TO GET NUMERIC PARAMETER
00826000                *
00827000                * ON ENTRY: FAP1 POINTS TO PARAMETER
00828000                *
00829000                * ON EXIT TO P+1: A = CLASS OF NON-NUMERIC ITEM ENCOUNT.
00830000                *
00831000                * ON EXIT TO P+2: B POINTS TO VALUE
00832000                *
00833000 00751  101272  NGET  LDA FAP1,I      GET 'WHAT' WORD
00834000 00752  172201        SAP *+1,C
00835000 00753  170513        SAR 12          GET CLASS
00836000 00754  010254        CPA P1          NUMERIC?
00837000 00755  064757        JMP *+2         YES
00838000 00756  170201        RET 1           NO
00839000                *
00840000 00757  005272        LDB FAP1
00841000 00760  040616        JSM ABSAD+1
00842000 00761  170202        RET 2
00844000                *
00845000                * INTEGER DIVIDE        W.F.C.
00846000                *
00847000                * ON ENTRY:
00848000                *
00849000                *   BA HAS DIVIDEND
00850000                *
00851000                *   JSM IDIV
00852000                *   DEF DIVISOR
00853000                *
00854000                * ON EXIT:
00855000                *
00856000                *   A = QUOTIENT
00857000                *   B = REMAINDER
00858000                *   O = OVERFLOW STATUS
00859000                *
00860000                * TEMPORARIES USED: T1,T2,T3,T4,T5,T6
00861000                *
00862000 00762  004177  SDIV  LDB P0          ALTERNATE ENTRY
00863000 00763  035711  IDIV  STB T1          SAVE HI DIVIDEND
00864000 00764  004146        LDB M2
00865000 00765  035712        STB T2          INITIALIZE QUOTIENT SIGN
00866000 00766  035713        STB T3          INITIALIZE REMAINDER SIGN
00867000 00767  004160        LDB M16
```

```
00868000 00770  035714        STB T4          INITIALIZE LOOP COUNTER
00869000                *
00870000 00771  144003        ISZ R,I
00871000 00772  104003        LDB R,I         ADDRESS OF DIVISOR ADDRESS
00872000 00773  104001        LDB B,I         ADDRESS OF DIVISOR
00873000 00774  104001        LDB B,I
00874000 00775  176003        SBP *+3         GET ABS OF DIVISOR
00875000 00776  045712        ISZ T2
00876000 00777  174040        TCB
00877000 01000  035715        STB T5          SAVE + DIVISOR
00878000 01001  174040        TCB
00879000 01002  035716        STB T6          SAVE - DIVISOR
00880000                *
00881000 01003  005711        LDB T1          TEST DIVIDEND SIGN
00882000 01004  176010        SBP DIV0
00883000 01005  045712        ISZ T2          COMPLEMENT DIVIDEND
00884000 01006  066007        JMP *+1         (ALLOW FOR SKIP)
00885000 01007  170040        TCA
00886000 01010  174140        CMB
00887000 01011  072002        RZA *+2
00888000 01012  024254        ADB P1
00889000 01013  045713        ISZ T3          SET REMAINDER SIGN -
00890000 01014  025716  DIV0  ADB T6          ADD - DIVISOR
00891000 01015  176034        SBP OVFL        SKIP IF OVERFLOW
00893000                *
00894000                * MAIN DIVIDE LOOP
00895000                *
00896000 01016  174600  DIV1  SBL 1           SHIFT LEFT
00897000 01017  172002        SAP *+2
00898000 01020  024254        ADB P1
00899000 01021  170600        SAL 1
00900000 01022  025715        ADB T5          ADD + DIVISOR
00901000 01023  066032        JMP DIV3
00902000 01024  073072  DIV2  SLA DIV1
00903000 01025  174600        SBL 1           SHIFT LEFT
00904000 01026  172002        SAP *+2
00905000 01027  024254        ADB P1
00906000 01030  170600        SAL 1
00907000 01031  025716        ADB T6          ADD - DIVISOR
00908000                *
00909000 01032  176402  DIV3  SBM *+2
00910000 01033  060254        IOR P1
00911000 01034  045714        ISZ T4          INCREMENT LOOP COUNTER AND TEST
00912000 01035  066024        JMP DIV2
00913000                *
00914000 01036  176002        SBP *+2         CORRECT NEGATIVE REMAINDER
00915000 01037  025715        ADB T5
00916000                *
00917000 01040  045712        ISZ T2          CORRECT QUOTIENT SIGN
00918000 01041  066050        JMP DIV5
00919000 01042  170040        TCA
00920000 01043  173201  DIV4  SOC *+1,C       ALL OK
00921000                *
00922000 01044  045713        ISZ T3
00923000 01045  170201        RET 1           RETURN POSITIVE REMAINDER
00924000 01046  174040        TCB
00925000 01047  170201        RET 1           RETURN NEGATIVE REMAINDER
00926000                *
00927000 01050  172073  DIV5  SAP DIV4
00928000                *
00929000 01051  173301  OVFL  SOC *+1,S       OVERFLOW, SET O-REGISTER
00930000 01052  170201        RET 1
00932000                *
00933000                * SUBROUTINE TO BUMP PARAMETER POINTER
00934000                *
00935000                * ON ENTRY: A = +- COUNT
00936000                *
00937000                * ON EXIT TO P+1:  NO MORE PARAMETERS
00938000                *
00939000                * ON EXIT TO P+2:  FAP1 = NEXT PARAMETER ADDRESS
00940000                *
00941000                * TEMPORARIES USED: T1,T2
00942000                *
00943000 01053  072415  BUMP  SZA BU2         SKIP IF NOTHING TO DO
00944000 01054  031711        STA T1
00945000 01055  172014        SAP BU3         WHICH WAY?
00946000                *
00947000 01056  005272        LDB FAP1        MOVE TO LEFT IF -
00948000 01057  100001  BU1   LDA B,I
00949000 01060  170603        SAL 4           LOOK AT PARAMETER LINK BIT
00950000 01061  172012        SAP BU4
00951000 01062  000001        LDA B
00952000 01063  020254        ADA P1
00953000 01064  124000        ADB A,I
00954000 01065  045711        ISZ T1
```

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```
00955000 01066  066057         JMP BU1           KEEP ON
00956000                 *
00957000 01067  035272         STB FAP1
00958000 01070  170202   BU2   RET 2             RETURN
00959000                 *
00960000 01071  005263   BU3   LDB AP1           MOVE TO RIGHT IF +
00961000 01072  015272         CPB FAP1
00962000 01073  170201   BU4   RET 1             RETURN
00963000                 *
00964000 01074  035712   BU5   STB T2            SAVE PREVIOUS LOCATION
00965000 01075  000001         LDA B
00966000 01076  020254         ADA P1
00967000 01077  124000         ADB A,I
00968000 01100  015272         CPB FAP1
00969000 01101  066103         JMP *+2
00970000 01102  066074         JMP BU5
00971000                 *
00972000 01103  005712         LDB T2
00973000 01104  035272         STB FAP1          MOVE FAP1 ONE POSITION
00974000 01105  055711         DSZ T1
00975000 01106  066071         JMP BU3           KEEP ON
00976000                 *
00977000 01107  170202         RET 2             RETURN
00979000                 *
00980000                 * SUBROUTINE TO COUNT PARAMETERS ON STACK
00981000                 *
00982000                 * ON EXIT:  A = # OF NUMERIC PARAMETERS
00983000                 *           B = # OF PARAMETERS
00984000                 *        FAP1 = LOCATION OF LEFTMOST PARAMETER
00985000                 *
00986000                 * TEMPORARIES USED: T1,T2
00987000                 *
00988000 01110  000177   COUNT LDA P0
00989000 01111  031711         STA T1            INITIALIZE A COUNT
00990000 01112  031712         STA T2            INITIALIZE B COUNT
00991000 01113  005263         LDB AP1
00992000 01114  100001   CO1   LDA B,I           GET "WHAT" WORD
00993000 01115  170600         SAL 1             LOOK AT CLASS
00994000 01116  172402         SAM *+2           SKIP IF NON-NUMERIC
00995000 01117  045711         ISZ T1
00996000 01120  045712         ISZ T2
00997000 01121  170602         SAL 3             LOOK AT PARAMETER LINK BIT
00998000 01122  172005         SAP CO2
00999000 01123  000001         LDA B
01000000 01124  020254         ADA P1
01001000 01125  124000         ADB A,I
01002000 01126  066114         JMP CO1           MORE PARAMETERS FOLLOW
01003000                 *
01004000 01127  035272   CO2   STB FAP1          INITIALIZE POINTER
01005000 01130  001711         LDA T1
01006000 01131  005712         LDB T2
01007000 01132  170201         RET 1             RETURN
01009000                 *
01010000                 * GET NUMERIC OPERAND ADDRESS
01011000                 *
01012000                 * ON EXIT:  B = OPERAND ADDRESS
01013000                 *         AP1 = UPDATED
01014000                 *
01015000 01133  040615   GETAD JSM ABSAD         GET OPERAND ABSOLUTE ADDRESS
01016000 01134  031263         STA AP1           UPDATE AP1
01017000                 *
01018000 01135  101276         LDA SAVEB,I       THE 'WHAT' WORD
01019000 01136  050221         AND B70K
01020000 01137  010175         CPA B10K
01021000 01140  170201         RET 1             RETURN IF NUMERIC
01022000                 *
01023000 01141  064733         JMP E32


01025000                 *
01026000                 * GET INTEGER PARAMETER
01027000                 *
01028000                 * ON EXIT:  B = INTEGER VALUE
01029000                 *
01030000 01142  042133   GETIN JSM GETAD         GET OPERAND ADDRESS
01031000 01143  040643         JSM FIXPT-1       CONVERT TO INTEGER
01032000 01144  173402         SOS *+2
01033000 01145  170201         RET 1
01034000                 *
01035000 01146  140404   E11   JSM AERR1,I       ERROR, INTEGER OUT OF RANGE
01036000 01147  030461         ASC 1,11

01038000                 *
01039000                 * WAIT EXECUTION
01040000                 *
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BASE-PAGE SUBROUTINES

```
01041000 01150  042142  XWAIT JSM GETIN         GET INTEGER PARAMETER
01042000 01151  176003        SBP *+3
01043000 01152  140404  E17A  JSM AERR1         ERROR, ILLEGAL WAIT PARAMETER
01044000 01153  030467        ASC 1,17
01045000                *
01046000 01154  174040        TCB
01047000 01155  040633        JSM DELAY         GO DELAY
01048000 01156  164365        JMP AINTX,I

01050000 01157                BSS 1             *** RESERVED FOR OK-PAGE CHECKSUM
01051000                      LST
09999000                      END

END OF PASS 2 NO ERRORS DETECTED
```

BASE-PAGE READ-WRITE-MEMORY

```
00003000 76550                ORG 76550B
00004000                      UNL
```

TABLES

```
02001000 01170                ORG 1170B
02002000                      UNS
02003000                *
02004000                * CLASS TABLE FOR COMPILER
02005000                *
02006000                *  LEFT BYTE = CHARACTER CLASS FOR INPUT SCANNER
02007000                * RIGHT BYTE = TOKEN CLASS FOR PARSER
02008000                *
02009000 01170  000000  CTBL  NOP       000
02010000 01171  000000        NOP       001
02011000 01172  000000        NOP       002
02012000 01173  000000        NOP       003
02013000 01174  000000        NOP       004
02014000 01175  000000        NOP       005
02015000 01176  000000        NOP       006
02016000 01177  000000        NOP       007
02017000 01200  000000        NOP       010
02018000 01201  000000        NOP       011
02019000 01202  000000        NOP       012
02020000 01203  000000        NOP       013
02021000 01204  000000        NOP       014
02022000 01205  000000        NOP       015
02023000 01206  000000        NOP       016
02024000 01207  000000        NOP       017
02025000 01210  000000        NOP       020
02026000 01211  000000        NOP       021
02027000 01212  000000        NOP       022
02028000 01213  000000        NOP       023
02029000 01214  000000        NOP       024
02030000 01215  000000        NOP       025
02031000 01216  000000        NOP       026
02032000 01217  000000        NOP       027
02033000 01220  000000        NOP       030
02034000 01221  000000        NOP       031
02035000 01222  000000        NOP       032
02036000 01223  000000        NOP       033
02037000 01224  000000        NOP       034
02038000 01225  000000        NOP       035
02039000 01226  000000        NOP       036
02040000 01227  003020        OCT 3020  037  6  16  I*
02041000 01230  000000        NOP       040
02042000 01231  000000        NOP       041         !
02043000 01232  001465        OCT 1465  042  3  53  "
02044000 01233  000400        OCT 0400  043  1      #
02045000 01234  000000        NOP       044         $
02046000 01235  000400        OCT 0400  045  1      %
02047000 01236  000400        OCT 0400  046  1      &
02048000 01237  000400        OCT 0400  047  1      '
02049000 01240  004002        OCT 4002  050  8   2  (
02050000 01241  003407        OCT 3407  051  7   7  )
02051000 01242  003006        OCT 3006  052  6   6  *
02052000 01243  003003        OCT 3003  053  6   3  +
02053000 01244  003014        OCT 3014  054  6  12  ,
02054000 01245  003012        OCT 3012  055  6  10  -
02055000 01246  002462        OCT 2462  056  5  50  .
02056000 01247  003013        OCT 3013  057  6  11  /
```

TABLES

```
02057000 01250  002062          OCT 2062  060   4  50  0
02058000 01251  002062          OCT 2062  061   4  50  1
02059000 01252  002062          OCT 2062  062   4  50  2
02060000 01253  002062          OCT 2062  063   4  50  3
02061000 01254  002062          OCT 2062  064   4  50  4
02062000 01255  002062          OCT 2062  065   4  50  5
02063000 01256  002062          OCT 2062  066   4  50  6
02064000 01257  002062          OCT 2062  067   4  50  7
02065000 01260  002062          OCT 2062  070   4  50  8
02066000 01261  002062          OCT 2062  071   4  50  9
02067000 01262  003015          OCT 3015  072   6  13  :
02068000 01263  003010          OCT 3010  073   6   8  ;
02069000 01264  000400          OCT 0400  074   1      <
02070000 01265  000400          OCT 0400  075   1      =
02071000 01266  000400          OCT 0400  076   1      >
02072000 01267  000000          NOP       077          ?
02073000 01270  000000          NOP       100          @
02074000 01271  001066          OCT 1066  101   2  54  A
02075000 01272  001066          OCT 1066  102   2  54  B
02076000 01273  001066          OCT 1066  103   2  54  C
02077000 01274  001066          OCT 1066  104   2  54  D
02078000 01275  001066          OCT 1066  105   2  54  E
02079000 01276  001066          OCT 1066  106   2  54  F
02080000 01277  001066          OCT 1066  107   2  54  G
02081000 01300  001066          OCT 1066  110   2  54  H
02082000 01301  001066          OCT 1066  111   2  54  I
02083000 01302  001066          OCT 1066  112   2  54  J
02084000 01303  001066          OCT 1066  113   2  54  K
02085000 01304  001066          OCT 1066  114   2  54  L
02086000 01305  001066          OCT 1066  115   2  54  M
02087000 01306  001066          OCT 1066  116   2  54  N
02088000 01307  001066          OCT 1066  117   2  54  O
02089000 01310  001066          OCT 1066  120   2  54  P
02090000 01311  001066          OCT 1066  121   2  54  Q
02091000 01312  001066          OCT 1066  122   2  54  R
02092000 01313  001066          OCT 1066  123   2  54  S
02093000 01314  001066          OCT 1066  124   2  54  T
02094000 01315  001066          OCT 1066  125   2  54  U
02095000 01316  001066          OCT 1066  126   2  54  V
02096000 01317  001066          OCT 1066  127   2  54  W
02097000 01320  001066          OCT 1066  130   2  54  X
02098000 01321  001066          OCT 1066  131   2  54  Y
02099000 01322  001066          OCT 1066  132   2  54  Z
02100000 01323  003001          OCT 3001  133   6   1  [
02101000 01324  004053          OCT 4053  134   8  43  SQR
02102000 01325  003404          OCT 3404  135   7   4  ]
02103000 01326  000400          OCT 0400  136   1      ^
02104000 01327  000000          NOP       137          _
02105000 01330  000000          NOP       140
02106000 01331  000400          OCT 0400  141   1      L.C. A
02107000 01332  000400          OCT 0400  142   1      L.C. B
02108000 01333  000400          OCT 0400  143   1      L.C. C
02109000 01334  000400          OCT 0400  144   1      L.C. D
02110000 01335  000400          OCT 0400  145   1      L.C. E
02111000 01336  000400          OCT 0400  146   1      L.C. F
02112000 01337  000400          OCT 0400  147   1      L.C. G
02113000 01340  000400          OCT 0400  150   1      L.C. H
02114000 01341  000400          OCT 0400  151   1      L.C. I
02115000 01342  000400          OCT 0400  152   1      L.C. J
02116000 01343  000400          OCT 0400  153   1      L.C. K
02117000 01344  000400          OCT 0400  154   1      L.C. L
02118000 01345  000400          OCT 0400  155   1      L.C. M
02119000 01346  000400          OCT 0400  156   1      L.C. N
02120000 01347  000400          OCT 0400  157   1      L.C. O
02121000 01350  000400          OCT 0400  160   1      L.C. P
02122000 01351  000400          OCT 0400  161   1      L.C. Q
02123000 01352  000400          OCT 0400  162   1      L.C. R
02124000 01353  000400          OCT 0400  163   1      L.C. S
02125000 01354  000400          OCT 0400  164   1      L.C. T
02126000 01355  000400          OCT 0400  165   1      L.C. U
02127000 01356  000400          OCT 0400  166   1      L.C. V
02128000 01357  000400          OCT 0400  167   1      L.C. W
02129000 01360  000400          OCT 0400  170   1      L.C. X
02130000 01361  000400          OCT 0400  171   1      L.C. Y
02131000 01362  000400          OCT 0400  172   1      L.C. Z
02132000 01363  004422          OCT 4422  173   9  18  PI
02133000 01364  000000          NOP       174
02134000 01365  003016          OCT 3016  175   6  14  GAZINTA
02135000 01366  000400          OCT 0400  176   1      SIGMA
02136000 01367  003031          OCT 3031  177   6  25  EOL
02138000                *
02139000                * MNEMONIC TABLE
02140000                *
02141000                *    L.H. = CLASS     R.H. = TOKEN
02142000                *
```

TABLES

```
02143000 01370  004063           OCT    4063 LC. P (65)
02144000 01371  003027           OCT    3027 TLIST (64)
02145000 01372  003027           OCT    3027 LISTK (63)
02146000 01373  004422           OCT    4422 RES  (62)
02147000 01374  003041           OCT    3041 LIST  (61)
02148000 01375  004063           OCT    4063 LC. R (60)
02149000 01376  003047           OCT    3047 =   (59)
02150000 01377  003047           OCT    3047 >   (58)
02151000 01400  003047           OCT    3047 <   (57)
02152000 01401  003047           OCT    3047 >=  (56)
02153000 01402  003047           OCT    3047 <=  (55)
02154000 01403  003047           OCT    3047 #   (54)
02155000 01404  003027           OCT    3027 LKE   (53)
02156000 01405  003027           OCT    3027 LKD   (52)
02157000 01406  003027           OCT    3027 AVE   (51)
02158000 01407  003027           OCT    3027 AVD   (50)
02159000 01410  003057           OCT    3057 VFY   (49)
02160000 01411  003035           OCT    3035 LDB   (48)
02161000 01412  003035           OCT    3035 LDK   (47)
02162000 01413  003035           OCT    3035 RCK   (46)
02163000 01414  003035           OCT    3035 LDM   (45)
02164000 01415  003035           OCT    3035 RCM   (44)
02165000 01416  003041           OCT    3041 LDP   (43)
02166000 01417  003030           OCT    3030 ENP   (42)
02167000 01420  003046           OCT    3046 LDF   (41)
02168000 01421  003046           OCT    3046 RCF   (40)
02169000 01422  003042           OCT    3042 MRK   (39)
02170000 01423  003054           OCT    3054 ERT   (38)
02171000 01424  003035           OCT    3035 FDF   (37)
02172000 01425  003054           OCT    3054 TRK   (36)
02173000 01426  003054           OCT    3054 SSC   (35)
02174000 01427  003036           OCT    303  IDF   (34)
02175000 01430  003021           OCT    302. XOR   (33)
02176000 01431  003027           OCT    3027 REW   (32)
02177000 01432  003027           OCT    3027 END   (31)
02178000 01433  003027           OCT    3027 BEEP (30)
02179000 01434  003054           OCT    3054 WAIT (29)
02180000 01435  003050           OCT    3050 RET   (28)
02181000 01436  003026           OCT    3026 DIM   (27)
02182000 01437  003060           OCT    3060 GSB   (26)
02183000 01440  003060           OCT    3060 GTO   (25)
02184000 01441  003060           OCT    3060 GSB+ (24)
02185000 01442  003060           OCT    3060 GSB- (23)
02186000 01443  003060           OCT    3060 GTO+ (22)
02187000 01444  003060           OCT    3060 GTO- (21)
02188000 01445  003030           OCT    3030 ENT   (20)
02189000 01446  004053           OCT    4053 FLG   (19)
02190000 01447  003055           OCT    3055 STP   (18)
02191000 01450  003055           OCT    3055 NOR   (17)
02192000 01451  003055           OCT    3055 TRC   (16)
02193000 01452  004051           OCT    4051 DRND (15)
02194000 01453  004051           OCT    4051 PRND (14)
02195000 01454  003052           OCT    3052 CMF   (13)
02196000 01455  003052           OCT    3052 CFG   (12)
02197000 01456  003052           OCT    3052 SFG   (11)
02198000 01457  003040           OCT    3040 JMP   (10)
02199000 01460  003035           OCT    3035 SPC   (09)
02200000 01461  003035           OCT    3035 FLT   (08)
02201000 01462  003035           OCT    3035 FXD   (07)
02202000 01463  003043           OCT    3043 NOT   (06)
02203000 01464  003024           OCT    3024 AND   (05)
02204000 01465  003021           OCT    3021 OR    (04)
02205000 01466  003045           OCT    3045 DSP   (03)
02206000 01467  003045           OCT    3045 PRT   (02)
02207000 01470  003054           OCT    3054 IF    (01)
02208000        001471  MNTBL EQU *
02209000 01471  064546           DEC   26982  I     F
02210000 01472  020201           DEC   08321        (01)
02211000 01473  070162           DEC   28786  P     R
02212000 01474  072040           DEC   29728  T
02213000 01475  101144           DEC  -32156  (02) D
02214000 01476  071560           DEC   29552  S     P
02215000 01477  020203           DEC   08323        (03)
02216000 01500  020157           DEC   08303        O
02217000 01501  071040           DEC   29216  R
02218000 01502  102040           DEC  -31712  (04)
02219000 01503  060556           DEC   24942  A     N
02220000 01504  062040           DEC   25632  D
02221000 01505  102556           DEC  -31378  (05) N
02222000 01506  067564           DEC   28532  O     T
02223000 01507  020206           DEC   08326        (06)
02224000 01510  020170           OCT 020170         X
02225000 01511  067562           OCT 067562   O     R
02226000 01512  020241           OCT 020241         (33)
02227000 01513  063170           DEC   26232  F     X
```

TABLES

```
02228000 01514  062040     DEC  25632  D
02229000 01515  103546     DEC -30874  (07) F
02230000 01516  066164     DEC  27764  L    T
02231000 01517  020210     DEC  08328       (08)
02232000 01520  071560     DEC  29552  S    P
02233000 01521  061440     DEC  25376  C
02234000 01522  104552     DEC -30358  (09) J
02235000 01523  066560     DEC  28016  M    P
02236000 01524  020212     DEC  08330       (10)
02237000 01525  071546     DEC  29542  S    F
02238000 01526  063440     DEC  26400  G
02239000 01527  105543     DEC -29853  (11) C
02240000 01530  063147     DEC  26215  F    G
02241000 01531  020214     DEC  08332       (12)
02242000 01532  061555     DEC  25453  C    M
02243000 01533  063040     DEC  26144  F
02244000 01534  106560     DEC -29328  (13) P
02245000 01535  071156     DEC  29294  R    N
02246000 01536  062216     DEC  25742  D    (14)
02247000 01537  062162     DEC  25714  D    R
02248000 01540  067144     DEC  28260  N    D
02249000 01541  107564     DEC -28812  (15) T
02250000 01542  071143     DEC  29283  R    C
02251000 01543  020220     DEC  08336       (16)
02252000 01544  067157     DEC  28271  N    O
02253000 01545  071040     DEC  29216  R
02254000 01546  110563     DEC -28301  (17) S
02255000 01547  072160     DEC  29808  T    P
02256000 01550  020222     DEC  08338       (18)
02257000 01551  063154     DEC  26220  F    L
02258000 01552  063623     DEC  26515  G    (19)
02259000 01553  062556     DEC  25966  E    N
02260000 01554  072040     DEC  29728  T
02261000 01555  112147     DEC -27545  (20) G
02262000 01556  072157     DEC  29807  T    O
02263000 01557  020055     DEC  08237       -
02264000 01560  112547     DEC -27289  (21) G
02265000 01561  072157     DEC  29807  T    O
02266000 01562  020053     DEC  08235       +
02267000 01563  113147     DEC -27033  (22) G
02268000 01564  071542     DEC  29538  S    B
02269000 01565  020055     DEC  08237       -
02270000 01566  113547     DEC -26777  (23) G
02271000 01567  071542     DEC  29538  S    B
02272000 01570  020053     DEC  08235       +
02273000 01571  114147     DEC -26521  (24) G
02274000 01572  072157     DEC  29807  T    O
02275000 01573  020231     DEC  08345       (25)
02276000 01574  063563     DEC  26483  G    S
02277000 01575  061040     DEC  25120  B
02278000 01576  115144     DEC -26012  (26) D
02279000 01577  064555     DEC  26989  I    M
02280000 01600  020233     DEC  08347       (27)
02281000 01601  073541     DEC  30561  W    A
02282000 01602  064564     DEC  26996  I    T
02283000 01603  020235     DEC  08349       (29)
02284000 01604  061145     DEC  25189  B    E
02285000 01605  062560     DEC  25968  E    P
02286000 01606  117145     DEC -24987  (30) E
02287000 01607  067144     DEC  28260  N    D
02288000 01610  117562     DEC -24718  (31) R
02289000 01611  062567     DEC  25975  E    W
02290000 01612  120151     OCT 120151  (32) I
02291000 01613  062146     DEC  25702  D    F
02292000 01614  020242     DEC  08354       (34)
02293000 01615  071563     DEC  29555  S    S
02294000 01616  061440     DEC  25376  C
02295000 01617  121564     DEC -23692  (35) T
02296000 01620  071153     DEC  29291  R    K
02297000 01621  020244     DEC  08356       (36)
02298000 01622  063144     DEC  26212  F    D
02299000 01623  063040     DEC  26144  F
02300000 01624  122545     DEC -23195  (37) E
02301000 01625  071164     DEC  29300  R    T
02302000 01626  020246     DEC  08358       (38)
02303000 01627  066562     DEC  28018  M    R
02304000 01630  065440     DEC  27424  K
02305000 01631  123562     DEC -22670  (39) R
02306000 01632  061546     DEC  25446  C    F
02307000 01633  020250     DEC  08360       (40)
02308000 01634  066144     DEC  27748  L    D
02309000 01635  063040     DEC  26144  F
02310000 01636  124562     DEC -22158  (41) R
02311000 01637  062564     OCT 062564  E    T
02312000 01640  020234     OCT 020234       (28)
```

TABLES

```
02313000 01641   066144          OCT 066144  L     D
02314000 01642   070040          OCT 070040  P
02315000 01643   125562          DEC -21646  (43)  R
02316000 01644   061555          DEC  25453  C     M
02317000 01645   020254          DEC  08364        (44)
02318000 01646   066144          DEC  27748  L     D
02319000 01647   066440          DEC  27936  M
02320000 01650   126562          DEC -21134  (45)  R
02321000 01651   061553          DEC  25451  C     K
02322000 01652   020256          DEC  08366        (46)
02323000 01653   066144          DEC  27748  L     D
02324000 01654   065440          DEC  27424  K
02325000 01655   127554          DEC -20628  (47)  L
02326000 01656   062142          DEC  25698  D     B
02327000 01657   020260          DEC  08368        (48)
02328000 01660   073146          DEC  30310  V     F
02329000 01661   074440          DEC  31008  Y
02330000 01662   130541          DEC -20127  (49)  A
02331000 01663   073144          DEC  30308  V     D
02332000 01664   131141          DEC -19871  (50)  A
02333000 01665   073145          DEC  30309  V     E
02334000 01666   131554          OCT 131554  (51)  L
02335000 01667   065544          OCT 065544  K     O
02336000 01670   020264          OCT 020264        (52)
02337000 01671   021666          OCT 021666  #     (54)
02338000 01672   036076          OCT 036076  <     >
02339000 01673   133076          OCT 133076  (54)  >
02340000 01674   036266          OCT 036266  <     (54)
02341000 01675   036075          OCT 036075  <     =
02342000 01676   133475          OCT 133475  (55)  =
02343000 01677   036267          OCT 036267  <     (55)
02344000 01700   037075          OCT 037075  >     =
02345000 01701   134075          OCT 134075  (56)  =
02346000 01702   037270          OCT 037270  >     (56)
02347000 01703   036271          OCT 036271  <     (57)
02348000 01704   037272          OCT 037272  >     (58)
02349000 01705   036673          OCT 036673  =     (59)
02350000 01706   066153          OCT 066153  L     K
02351000 01707   062440          OCT 062440  E
02352000 01710   132562          OCT 132562  (53)  R
02353000 01711   062563          OCT 062563  E     S
02354000 01712   137162          OCT 137162  (62)  R
02355000 01713   136154          OCT 136154  (60)  L
02356000 01714   064563          OCT 064563  I     S
02357000 01715   072040          OCT 072040  T
02358000 01716   065677          OCT 065677  K     (63)
02359000 01717   072154          OCT 072154  T     L
02360000 01720   064563          OCT 064563  I     S
02361000 01721   072300          OCT 072300  T     (64)
02362000 01722   070301          OCT 070301  P     (65)
02363000 01723   066151          OCT 066151  L     I
02364000 01724   071564          OCT 071564  S     I
02365000 01725   020275          OCT 020275        (61)
02366000 01726   062556          OCT 062556  E     N
02367000 01727   070040          OCT 070040  P
02368000 01730   125200          OCT 125200  (42)  \
02369000 01731   000000          NOP
```

TABLES FOR COMPILER -- PARSE TABLES

```
02371000                        *
02372000                        * EQUATES NEEDED BY PARSER
02373000                        *
02374000                000210  MAXR  EQU 136
02375000                000274  MAXL  EQU 188
02376000                000302  MAXP  EQU 194
02377000                              SUP

02379000 01732   002010  READX DEC  1032,1550,5141,9485,10799,11312,11985,12337
02380000 01742   031306        DEC  12998,13362,13875,14388,14989,15502,16439,17039
02381000 01752   042071        DEC  17465,17978,18491,19088,19601,20626,21057,21651
02382000 01762   053103        DEC  22083,22596,23188,23701,24215,24649,25162,25868
02383000 01772   063115        DEC  26189,26776,27290,27924,28900,1032,1550,3090
02384000 02002   012025        DEC  5141,9485,13362,14388,17978,21057,22083,23701
02385000 02012   061112        DEC  25162,25868,26189,26776,27422,27924,1032,1550
02386000 02022   006023        DEC  3091,5141,9485,13362,14388,17978,21057,22083
02387000 02032   056225        DEC  23701,25162,25868,26189,26776,27422,27924,1032
02388000 02042   003016        DEC  1550,5141,9485,13362,14388,17978,21057,22083
02389000 02052   056225        DEC  23701,25162,25868,26189,26776,27422,27924,1032
02390000 02062   022415        DEC  9485,13362,21057,22083,23701,25162,25868,26189
02391000 02072   066424        DEC  27924,1032,1550,5141,9485,13362,21057,22083
02392000 02102   056225        DEC  23701,25162,25868,26189,27924,14388,26776,27422
```

TABLES FOR COMPILER -- PARSE TABLES

```
02393000 02112  004502        DEC  2370,2371,25162,26189,26776,27441,27924,25162
02394000 02122  063115        DEC  26189,26776,27924,26776,23702,25163,26703,27942
02395000 02132  061112        DEC  25162,26189,26776,27440,27924,1161,27982,1162
02396000 02142  061112        DEC  25162,26189,27924,1032,1550,5141,9485,13362
02397000 02152  034064        DEC  14388,21057,22083,23701,25162,25868,26189,26776
02398000 02162  065436        DEC  27422,27924,1032,1550,5141,9485,13362,14388
02399000 02172  043072        DEC  17978,21057,22083,23701,25164,25868,26189,26777
02400000 02202  065436        DEC  27422,27924,1035,1036,1037,25816,27351,514
02401000 02212  001004        DEC  516,518,515,517,519,6853,7206,8748
02402000 02222  016047        DEC  7207,1032,1550,5141,9485,10799,11312,11985
02403000 02232  030061        DEC  12337,13362,13875,14388,14989,15502,16439,17039
02404000 02242  042071        DEC  17465,17978,18491,19088,19601,20626,21057,21651
02405000 02252  053103        DEC  22083,22596,23188,23701,24215,24649,25162,25868
02406000 02262  063115        DEC  26189, 6776,27422,27924,28900,2576,7208,20030
02407000 02272  005020        DEC  2576, 030,7209,1551,5142,20031,3089,5655
02408000 02302  004447        DEC  2343,6180,6283,6168,6169,6170,4301,12999
02409000 02312  017052        DEC  7722,9773,1032,1550,5141,9485,10799,11312
02410000 02322  027321        DEC  11985,12337,12998,13362,13875,14388,14989,15502
02411000 02332  040067        DEC  16439,17039,17465,17978,18491,19088,19601,20626
02412000 02342  051101        DEC  21057,21651,22083,22596,23188,23701,24215,24649
02413000 02352  061112        DEC  25162,25868,26189,26776,27422,27924,28900,6173
02414000 02362  014037        DEC  6175,13000,3854,6174,6177,6179,6693,3856
02415000 02372  014034        DEC  6172,3859,6172,2325,6172,2337,6172,3818
02416000 02402  014034        DEC  6172,2344,6172,3857,6284,3871,6284,8235
02417000 02412  014033        DEC  6171,10286,20301,4628
02419000 02416  007275  LOOKA DEC  3773,6333,9,3774,6334,10,4287,6335
02420000 02426  031277        DEC  12991,32,3776,6336,34,4313,13017,53
02421000 02436  010341        DEC  4321,13025,54,13037,56,4317,13021,60
02422000 02446  010322        DEC  4306,13010,61,12993,64,4315,13019,66
02423000 02456  010302        DEC  4290,12994,69,1094,274,1095,233,4319
02424000 02466  031337        DEC  13023,72,590,288,592,288,6737,286
02425000 02476  016123        DEC  7251,8787,206,7252,8788,239,7253,207
02426000 02506  016126        DEC  7254,240,4325,13029,88,2650,7258,20058
02427000 02516  000427        DEC  279,2651,251,2652,253,7261,230,7262
02428000 02526  000430        DEC  280,1631,5215,20063,249,1632,5216,252
02429000 02536  003141        DEC  1633,5217,250,3170,5730,254,3171,5731
02430000 02546  000377        DEC  255,3172,5732,256,6246,211,6247,212
02431000 02556  014150        DEC  6248,213,7787,329,6254,308,6255,222
02432000 02566  014163        DEC  6259,327,6773,299,6263,238,6264,220
02433000 02576  020200        DEC  8320,260,8321,261,8322,262,6275,226
02434000 02606  024204        DEC  10372,243,10373,244,4743,263,4744,264

02436000 02616  000000  APPLY DEC  0,109,-9532,195,106,112,87,-20790
02437000 02626  000311        DEC  201,-20788,203,4209,27354,28395,29298,31035
02438000 02636  075442        DEC  31522,-32448,-30512,-30031,4928,5440,5748,2226
02439000 02646  052512        DEC  21834,23371,-23220,14648,15670,16187,16704,17224
02440000 02656  042500        DEC  17728,18038,18610,19244,311,669,-9571,-20835
02441000 02666  000236        DEC  158,667,-9573,-20837,156,22714,185,23798
02442000 02676  000365        DEC  245,29944,247,31910,32423,165,7849,11434
02443000 02706  000250        DEC  168,8962,12035,257,7350,10935,181,22204
02444000 02716  000273        DEC  187,-30961,-25834,10506,265,25394,27972,-28448
02445000 02726  046361        DEC  19697,20210,13106,13618,14149,15157,267,31036
02446000 02736  037474        DEC  16188,321,675,-9565,-20829,164,671,30880
02447000 02746  100240        DEC  -32608,-9569,4768,5280,31905,32418,-20833,16032
02448000 02756  040240        DEC  16544,17568,89,8476,283,25395,20761,21274
02449000 02766  031463        DEC  13107,13619,285,171,172,12581,292,101
02450000 02776  044452        DEC  18730,297,173,105,13102,13615,301,214
02451000 03006  000257        DEC  175,28851,-31564,6265,1659,6780,2685,3707
02452000 03016  000172        DEC  122,176,16186,313,5247,126,-32532,16675
02453000 03026  042476        DEC  17726,317,184,227,231,174,108,82
02454000 03036  073350        DEC  30440,134
02456000 03040  000245  INDEX DEC  165,9232,9232,9232,9232,4881,7057,9232
02457000 03050  046620        DEC  19856,19856,9232,9232,9232,11274,12556,14083
02458000 03060  030414        DEC  12556,14465,14593,11274,11274,12556,12556,16131
02459000 03070  034605        DEC  14725,15364,17539,9232,17539,9232,9232,19856
02460000 03100  022020        DEC  9232,19856,9232,9232,9232,17539,17539,15873
02461000 03110  037001        DEC  15873,9232,11274,9232,9232,9232,16001,16131
02462000 03120  040205        DEC  16517,17153,17281,17409,9232,17539,9232,9232
02463000 03130  022020        DEC  9232,17935,17281,9232,9232,17935,17935,19856
02464000 03140  052601        DEC  21889,9232,11274,9232,9232,22017,22145,17539
02465000 03150  053402        DEC  22274,22529,22657,22785,11274,22913,23041,23169
02466000 03160  055401        DEC  23297,9232,23426,23426,23681,23681,23844,28419
02467000 03170  070202        DEC  28802,28419,28417,28417,29057,29057,29187,29186
02468000 03200  071002        DEC  29186,29570,29570,29570,29826,30081,30209,30337
02469000 03210  073401        DEC  30465,30594,30849,30977,31141,-29695,-29567,-29439
02470000 03220  106601        DEC  -29311,-29183,-29055,-28927,-28799,-28671,-28543,-28543
02471000 03230  110402        DEC  -28414,-28158,-27902,-27646,-27390,-27134,-26878,-26623
02472000 03240  114001        DEC  -26623,-26623,-26495,-26367,-26367,-26239,-26111,-26111
02473000 03250  000203        DEC  131,515,900,1411,1795,2179,2562,2819
02474000 03260  006203        DEC  3203,3586,3843,4227,4610,4866,5123,5506
02475000 03270  013202        DEC  5762,6018,6275,6659,7042,7298,7555,7940
02476000 03300  020402        DEC  8450,8706,8962,9218,9476,9987,10371,10755
02477000 03310  025603        DEC  11139,11523,11906,12162,12418,12674,12930,13186
02478000 03320  032202        DEC  13442,13698,13954,14210,14466,14722,14978,15234
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TABLES FOR COMPILER -- PARSE TABLES

```
02479000 03330  036202        DEC  15490,15746,16002,16258,-24695,-24694,-24672,-24670
02480000 03340  117700        DEC -24640,-23739,128,129,257,384,385,385
02481000 03350  001200        DEC  640,642,768,770,896,1024,1024,1025
02482000 03360  002000        DEC  1024,1024,1025,1025,1025,1025,1025,1025
02483000 03370  002000        DEC  1024,1025,1024,1025,1024,1025,1024,1025
02484000 03400  002000        DEC  1024,1025,1025,1024,1024,1024,1025,1025
02485000 03410  002001        DEC  1025,1028,1281,1281,1280,1281,1536,1536
02486000 03420  011402        DEC  4866,4866,5376,5378,5888,5890,6144,6145
02487000 03430  014400        DEC  6400,6402,6402,6402,6402,6656,6658,6658
02488000 03440  015600        DEC  7040,7042,7042,7424,7425,7425,7808,7810
02489000 03450  020000        DEC  8192,8194,8448,8448,8448,8450,8449,8453
02490000 03460  020403        DEC  8451,8448,8451,8960,8963,8961,10240,10240
02491000 03470  024502        DEC  10626,10626,11136,11138,12800,12800,12803,13056
02492000 03500  031403        DEC  13059,13824,13826,13952,13954,14080,14083,14083
02493000 03510  034000        DEC  14336,14338,14464,14466,14720,14722,14722,14848
02494000 03520  035002        DEC  14850,14976,14976,15360,15362,15490,15616,15618
02495000 03530  040400        DEC  16640,16642,16768,16768,17024,17026,17280,17280
02496000 03540  041600        DEC  17280,17283,17283,17792,17794,17920,17920,17922
02497000 03550  043200        DEC  18048,18050,18178,18306,18432,18560

02499000 03556                BSS 1            **** RESERVED FOR 2K-PAGE CHECKSUM ****

02501000 03557                BSS 5            RESERVED FOR TABLE EXPANSION
```

SYNTHESIZE JUMP TABLE

```
02503000                *
02504000                * SYNTHESIZE JUMP TABLE
02505000                *
02506000 03564  004543  SYNJP DEF APL1        1
02507000 03565  004543        DEF APL1        2
02508000 03566  004740        DEF OLABL       3
02509000 03567  004631        DEF OUT1        4
02510000 03570  004631        DEF OUT1        5
02511000 03571  004631        DEF OUT1        6
02512000 03572  004543        DEF APL1        7
02513000 03573  004543        DEF APL1        8
02514000 03574  004543        DEF APL1        9
02515000 03575  004543        DEF APL1        10
02516000 03576  004631        DEF OUT1        11
02517000 03577  004644        DEF IMSTZ       12
02518000 03600  004543        DEF APL1        13
02519000 03601  004627        DEF OUT2        14
02520000 03602  004631        DEF OUT1        15
02521000 03603  004672        DEF OEMTY       16
02522000 03604  004627        DEF OUT2        17
02523000 03605  004627        DEF OUT2        18
02524000 03606  004627        DEF OUT2        19
02525000 03607  004627        DEF OUT2        20
02526000 03610  005012        DEF BRSTR       21
02527000 03611  005021        DEF BRNUM       22
02528000 03612  004672        DEF OEMTY       23
02529000 03613  004627        DEF OUT2        24
02530000 03614  004672        DEF OEMTY       25
02531000 03615  004627        DEF OUT2        26
02532000 03616  004672        DEF OEMTY       27
02533000 03617  004627        DEF OUT2        28
02534000 03620  004672        DEF OEMTY       29
02535000 03621  004627        DEF OUT2        30
02536000 03622  004672        DEF OEMTY       31
02537000 03623  004627        DEF OUT2        32
02538000 03624  004627        DEF OUT2        33
02539000 03625  005041        DEF LITRL       34
02540000 03626  004663        DEF IMDSF       35
02541000 03627  004543        DEF APL1        36
02542000 03630  004627        DEF OUT2        37
02543000 03631  004627        DEF OUT2        38
02544000 03632  177521        DEF AP36,I      39   UDF CALL
02545000 03633  177522        DEF AP37,I      40   UDF CALL
02546000 03634  004627        DEF OUT2        41
02547000 03635  004627        DEF OUT2        42
02548000 03636  004672        DEF OEMTY       43
02549000 03637  004627        DEF OUT2        44
02550000 03640  004543        DEF APL1        45
02551000 03641  004543        DEF APL1        46
02552000 03642  004627        DEF OUT2        47
02553000 03643  004627        DEF OUT2        48
02554000 03644  004543        DEF APL1        49
02555000 03645  004627        DEF OUT2        50
02556000 03646  004543        DEF APL1        51
02557000 03647  004627        DEF OUT2        52
02558000 03650  004543        DEF APL1        53
```

SYNTHESIZE JUMP TABLE

```
02559000 03651  004627       DEF OUT2       54
02560000 03652  004543       DEF APL1       55
02561000 03653  004627       DEF OUT2       56
02562000 03654  004627       DEF OUT2       57
02563000 03655  004627       DEF OUT2       58
02564000 03656  004627       DEF OUT2       59
02565000 03657  004543       DEF APL1       60
02566000 03660  004627       DEF OUT2       61
02567000 03661  004627       DEF OUT2       62
02568000 03662  004543       DEF APL1       63
02569000 03663  004627       DEF OUT2       64
02570000 03664  004627       DEF OUT2       65
02571000 03665  004543       DEF APL1       66
02572000 03666  004543       DEF APL1       67
02573000 03667  004670       DEF UNARY      68
02574000 03670  004543       DEF APL1       69
02575000 03671  004627       DEF OUT2       70
02576000 03672  004543       DEF APL1       71
02577000 03673  004627       DEF OUT2       72
02578000 03674  004543       DEF APL1       73
02579000 03675  004703       DEF UNUMB      74
02580000 03676  004631       DEF OUT1       75
02581000 03677  004543       DEF APL1       76
02582000 03700  004627       DEF OUT2       77
02583000 03701  004675       DEF UROUN      78
02584000 03702  004623       DEF OUT4       79
02585000 03703  177523       DEF AP77,I     80   UDF FCN
02586000 03704  177524       DEF AP78,I     81   UDF FCN
02587000 03705  004631       DEF OUT1       82
02588000 03706  004623       DEF OUT4       83
02589000 03707  004627       DEF OUT2       84
02590000 03710  004543       DEF APL1       85
02591000 03711  004543       DEF APL1       86
02592000 03712  005037       DEF STRAS      87
02593000 03713  005037       DEF STRAS      88
02594000 03714  004543       DEF APL1       89
02595000 03715  004627       DEF OUT2       90
02596000 03716  004543       DEF APL1       91
02597000 03717  004744       DEF OSTRG      92
02598000 03720  004623       DEF OUT4       93
02599000 03721  004631       DEF OUT1       94
02600000 03722  004623       DEF OUT4       95
02601000 03723  004543       DEF APL1       96
02602000 03724  004627       DEF OUT2       97
02603000 03725  004543       DEF APL1       98
02604000 03726  004627       DEF OUT2       99
02605000 03727  004774       DEF ODIME     100
02606000 03730  004777       DEF ODIML     101
02607000 03731  004777       DEF ODIML     102
02608000 03732  004543       DEF APL1      103
02609000 03733  005077       DEF OSCOM     104
02610000 03734  004543       DEF APL1      105
02611000 03735  004627       DEF OUT2      106
02612000 03736  004543       DEF APL1      107
02613000 03737  004627       DEF OUT2      108
02614000 03740  004627       DEF OUT2      109
02615000 03741  004744       DEF OSTRG     110
02616000 03742  004747       DEF ESTRG     111
02617000 03743  004543       DEF APL1      112
02618000 03744  004543       DEF APL1      113
02619000 03745  004543       DEF APL1      114
02620000 03746  004627       DEF OUT2      115
02621000 03747  004627       DEF OUT2      116
02622000 03750  004543       DEF APL1      117
02623000 03751  004627       DEF OUT2      118
02624000 03752  004543       DEF APL1      119
02625000 03753  004627       DEF OUT2      120
02626000 03754  004543       DEF APL1      121
02627000 03755  004543       DEF APL1      122
02628000 03756  004543       DEF APL1      123
02629000 03757  004627       DEF OUT2      124
02630000 03760  004631       DEF OUT1      125
02631000 03761  004543       DEF APL1      126
02632000 03762  004543       DEF APL1      127
02633000 03763  004700       DEF ARREF     128
02634000 03764  004700       DEF ARREF     129
02635000 03765  004543       DEF APL1      130
02636000 03766  004627       DEF OUT2      131
02637000 03767  004631       DEF OUT1      132
02638000 03770  004543       DEF APL1      133
02639000 03771  004627       DEF OUT2      134
02640000 03772  004543       DEF APL1      135
02641000 03773  004627       DEF OUT2      136
02642000 03774  004627       DEF OUT2      137
02643000 03775  004627       DEF OUT2      138
02644000 03776  177525       DEF AP136,I   139   FOR =
02645000 03777  004631       DEF OUT1      140
```

```
02647000                  *
02648000                  * COMPILER              W.F.C.
02649000                  *
02650000                  * ON ENTRY:
02651000                  *
02652000                  *   KEYBOARD BUFFER CONTAINS SOURCE LINE
02653000                  *
02654000                  * ON EXIT:
02655000                  *
02656000                  *   COMPILE BUFFER CONTAINS COMPILED LINE
02657000                  *

02659000                  *
02660000                  * READER FOR SCANNER
02661000                  *
02662000                  * ON ENTRY:
02663000                  *
02664000                  *   C-REGISTER POINTS TO INPUT AREA
02665000                  *
02666000                  * ON EXIT:
02667000                  *
02668000                  *   A-REGISTER = CHARACTER
02669000                  *   B-REGISTER = CLASS FROM CTBL
02670000                  *
02671000                  *   CTBL WORD SAVED IN CT2
02672000                  *
02673000                  * BLANKS ARE IGNORED
02674000                  *
02675000 04000  074560  READ2 WBC A,I          GET NEXT CHARACTER
02676000 04001  050053        AND B177
02677000 04002  010117        CPA B40
02678000 04003  067000        JMP *-3          JUMP IF TO BE SKIPPED
02679000                  *
02680000 04004  007012        LDB ACTBL        GET CTBL ORIGIN
02681000 04005  024000        ADB A
02682000 04006  104001        LDB B,I          GET CTBL WORD
02683000 04007  035244        STB CT2
02684000 04010  174507        SBR 8            GET LEFT BYTE = CLASS
02685000 04011  170201        RET 1
02687000                  *
02688000                  * POINTERS AND EQUATES
02689000                  *
02690000 04012  001170  ACTBL DEF CTBL         ADDRESS OF CLASS TABLE
02691000 04013  003037  AINDX DEF INDEX-1      ADDRESS OF INDEX TABLE
02692000 04014  001731  AREED DEF READX-1      ADDRESS OF READ  TABLE
02693000 04015  002415  ALOOK DEF LOOKX-1      ADDRESS OF LOOK  TABLE
02694000 04016  002615  AAPLY DEF APPLY-1      ADDRESS OF APPLY TABLE
02695000 04017  103564  ASYJP DEF SYNJP,I      ADDRESS OF SYNTHESIZE JUMP TABLE
02696000                  *
02697000        077243  CT1   EQU CMTMP+4      TEMPORARY
02698000        077244  CT2   EQU CMTMP+5      TEMPORARY
02699000        077245  CT3   EQU CMTMP+6      TEMPORARY
02700000        077246  CT4   EQU CMTMP+7      TEMPORARY
02701000        077247  CT5   EQU CMTMP+8      TEMPORARY
02702000        077250  NLOOK EQU CMTMP+9      NO-LOOK-AHEAD-DONE
02703000        077251  STATE EQU CMTMP+10     PARSER STATE
02704000        077252  IX1   EQU CMTMP+11     INDEX1
02705000        077253  IX2   EQU CMTMP+12     INDEX2
02706000                  *
02707000        077772  ES    EQU 77772B       EXPONENT SIGN
02708000        077773  DC    EQU ES+1         DIGIT COUNTER
02709000        077774  SD    EQU ES+2         SIGNIFICANT-DIGITS FLAG
02710000        077775  M     EQU ES+3         PART OF EXPONENT
02711000        077776  EX    EQU ES+4         PART OF EXPONENT
02712000        077777  DP    EQU ES+5         DECIMAL-POINT FLAG

02714000                  *
02715000                  * SET C-REGISTER FOR COMPILATION ERROR
02716000                  *
02717000 04020  005241  SETCE LDB OLDC
02718000 04021  034016        STB C            RESTORE ANCIENT C
02719000                  *
02720000 04022  004016  SE1   LDB C            TENTATIVE CURSOR POSITION
02721000 04023  035316        STB CERR
02722000 04024  074560        WBC A,I          TEST FOR BLANK OR EOL
02723000 04025  050053        AND B177
02724000 04026  010117        CPA B40
02725000 04027  067022        JMP SE1          BLANK, KEEP LOOKING
02726000 04030  010053        CPA B177
02727000 04031  067033        JMP SE2          EOL, GO THE OTHER WAY
02728000 04032  164404        JMP AERR1,I
02729000                  *
02730000 04033  054016  SE2   DSZ C
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                                   COMPILER

02731000 04034  035316  SL3   STB CERR
02732000 04035  004016        LDB C
02733000 04036  074760        WBC A,D
02734000 04037  050053        AND B177
02735000 04040  010117        CPA B40         BLANK, KEEP LOOKING
02736000 04041  067034        JMP SF3
02737000 04042  164404        JMP AERR1,I

                              COMPILER  --  SCANNER

02739000                      *
02740000                      * SCANNER
02741000                      *
02742000                      * ON EXIT:
02743000                      *
02744000                      *   TKN = TOKEN (FROM CTBL)
02745000                      *   BCD = CHARACTER
02746000                      *
02747000 04043  004016  SCAN  LDB C
02748000 04044  035241        STB OLDC
02749000 04045  043000        JSM READ2       READ FROM INPUT
02750000 04046  031240        STA BCD
02751000 04047  000016        LDA C
02752000 04050  031243        STA CT1         SAVE C+1
02753000                      *
02754000 04051  001244  SC1   LDA CT2         RECALL CTBL INFORMATION
02755000 04052  050045        AND B377
02756000 04053  031237        STA TKN         SAVE TOKEN
02757000                      *
02758000 04054  027056        ADB AJ1
02759000 04055  164001        JMP B,I         BRANCH VIA JMP TABLE
02760000                      *
02761000 04056  104057  AJ1   DEF *+1,I       JUMP TABLE #1
02762000                      *
02763000 04057  004522        DEF E7       0  UNDEFINED CODE
02764000 04060  004125        DEF SL2      1  SPECIAL MNEMONIC
02765000 04061  004100        DEF TYPEL    2  LETTER
02766000 04062  004251        DEF SQ1      3  QUOTE
02767000 04063  004071        DEF TYPEN    4  DIGIT
02768000 04064  004071        DEF TYPEN    5  DECIMAL POINT
02769000 04065  004122        DEF TYPEA    6  SPECIAL CHARACTER
02770000 04066  004110        DEF TYPEB    7  SPECIAL CHARACTER
02771000 04067  004112        DEF TYPEC    8  SPECIAL CHARACTER
02772000 04070  004106        DEF TYPED    9  SPECIAL CHARACTER
02774000                      *
02775000                      * NUMERIC
02776000                      *
02777000 04071  001242  TYPEN LDA ISTAR       TEST I* FLAG
02778000 04072  072022        RZA TY1
02779000 04073  045242        ISZ ISTAR       SET IT
02780000 04074  043274        JSM SN1         CALL NUMBER BUILDER
02781000 04075  043020  E6    JSM SETCE       ERROR, SYNTAX ERROR IN NUMBER
02782000 04076  030066        ASC 1,06
02783000 04077  170201        RET 1


02785000                      *
02786000                      * LETTER
02787000                      *
02788000 04100  043000  TYPEL JSM READ2       LOOK AHEAD
02789000 04101  010114        CPA B44
02790000 04102  067225        JMP STL         JUMP IF FOLLOWED BY $
02791000 04103  074761        WBC B,D
02792000 04104  010070        CPA B133
02793000 04105  067240        JMP SSL         JUMP IF FOLLOWED BY [
02794000                      *
02795000                      *               FALL THRU
02796000                      *
02797000                      * SPECIAL CHARACTER
02798000                      *
02799000 04106  001242  TYPED LDA ISTAR       (EITHER SIDE OF I*)
02800000 04107  072005        RZA TY1
02801000 04110  045242  TYPEB ISZ ISTAR       (LEFT SIDE OF I*)
02802000 04111  170201        RET 1
02803000                      *
02804000 04112  001242  TYPEC LDA ISTAR       (RIGHT SIDE OF I*)
02805000 04113  072411        SZA TY2
02806000 04114  001241  TY1   LDA OLDC
02807000 04115  030016        STA C           RESTORE C
02808000 04116  000127        LDA P16
02809000 04117  031237        STA TKN         TKN FOR I*
02810000 04120  000120        LDA P31
02811000 04121  031240        STA BCD         BCD FOR I*
```

```
                      *
04122  000177  TYPEA LDA P0            (NEITHER SIDE OF I*)
04123  031242        STA ISTAR
04124  170201  TY2   RET 1
                      *
                      * TABLE SEARCH
                      *
04125  004017  SL2   LDB D
04126  035244        STB CT2           SAVE D
04127  004327        LDB AROMS
04130  035245        STB CT3           INITIALIZE 'TABLES' POINTER
                      *
04131  105245  TS1   LDB CT3,I         GET ADDRESS OF NEXT ROM
04132  045245        ISZ CT3
04133  076476        SZB TS1           JUMP IF ROM NOT PRESENT
04134  014257        CPB M1
04135  067223        JMP E3            JUMP IF END OF ALL TABLES
04136  024254        ADB P1
04137  104001        LDB B,I           PICK UP ROM TABLE ORIGIN ADDRESS
04140  014257        CPB M1
04141  067131        JMP TS1
04142  176202        SBP *+2,C
04143  140001        JSM B,I           OPTIONAL CALL ON ROM
                      *
04144  035712        STB T2
04145  034017        STB D
04146  074770        WBD A,D           SET D = ROM TABLE ADDRESS
                      *
04147  005243  TS2   LDB CT1
04150  034016        STB C
04151  074761        WBC B,D           SET C = START OF MNEMONIC
04152  074570  TS3   WBD A,I
04153  010117        CPA B40
04154  067152        JMP *-2           IGNORE BLANKS IN MNEMONIC TABLE
04155  031711        STA T1
04156  170607        SAL 8
04157  172612        SAM TS4,C         SKIP IF ENTRY CODE OR END-OF-TABLE
04160  074561        WBC B,I
04161  014117        CPB B40
04162  067160        JMP *-2           IGNORE BLANKS IN INPUT LINE
04163  015711        CPB T1
04164  067152        JMP TS3           JUMP IF CHARACTER MATCH
                      *
04165  074570        WBD A,I           FIND END OF TABLE ENTRY
04166  170607        SAL 8
04167  172076        SAP *-2
04170  067147        JMP TS2
                      *
04171  170507  TS4   SAR 8
04172  072002        RZA *+2
04173  067131        JMP TS1           JUMP IF END OF TABLE
04174  004000        LDB A
04175  174040        TCB
04176  025712        ADB T2            SUBTRACT OPCODE FROM TABLE ADDRESS
04177  104001        LDB B,I
04200  035237        STB TKN           TEMPORARILY SAVE CLASS/TOKEN VALUE
                      *
04201  004327        LDB AROMS
04202  174040        TCB
04203  025245        ADB CT3           CALCULATE ROM ID
04204  014125        CPB P18
04205  067211        JMP SL5           JUMP IF MAINFRAME
                      *
04206  170607        SAL 8             CORRECT BCD FOR OPTIONAL ROMS
04207  060001        IOR B
04210  067212        JMP *+2
                      *
04211  020053  SL5   ADA B177          CORRECT MAINFRAME BCD
04212  031240        STA BCD
                      *
04213  005244        LDB CT2
04214  034017        STB D             RESTORE D
                      *
04215  005237        LDB TKN           RECALL CLASS/TOKEN INFO
04216  176202        SBP *+2,C
04217  140001        JSM B,I           OPTIONAL CALL ON ROM
                      *
04220  035244        STB CT2
04221  174507        SBR 8
04222  067051        JMP SC1
                      *
04223  043020  E3    JSM SETCE         ERROR, MYSTERIOUS MNEMONIC
04224  030063        ASC 1,03
```

```
02898000                    *
02899000                    * STRING LETTER
02900000                    *
02901000 04225  000100  STL    LDA P52
02902000 04226  031237         STA TKN           TKN FOR STRING
02903000                    *
02904000 04227  043000         JSM READ2         LOOK AHEAD
02905000 04230  074761         WRC B,D
02906000 04231  005240         LDB BCD
02907000 04232  010070         CPA B133          [?
02908000 04233  024117         ADB B40           YES, OFFSET BCD
02909000 04234  174607         SBL 8
02910000 04235  024141         ADB STRID         ID OF STRING ROM
02911000 04236  035240         STB BCD
02912000                    *
02913000 04237  067122         JMP TYPEA

02915000                    *
02916000                    * SUBSCRIPTED LETTER
02917000                    *
02918000 04240  001242  SSL    LDA ISTAR
02919000 04241  072402         SZA *+2
02920000 04242  067114         JMP TY1
02921000                    *
02922000 04243  000102         LDA P49
02923000 04244  031237         STA TKN           TKN FOR SUBSCRIPTED
02924000                    *
02925000 04245  005240         LDB BCD
02926000 04246  024117         ADB B40
02927000 04247  035240         STB BCD           OFFSET BCD
02928000                    *
02929000 04250  170201         RET 1
02931000                    *
02932000                    * PROCESS QUOTE FIELD
02933000                    *
02934000                    * ON EXIT:
02935000                    *
02936000                    *   CT4 = BYTE COUNT
02937000                    *   CT5 = START OF STRING
02938000                    *
02939000 04251  000177  SQ1    LDA P0
02940000 04252  031242         STA ISTAR
02941000 04253  031246         STA CT4           INITIALIZE BYTE COUNT
02942000 04254  004016         LDB C
02943000 04255  035247         STB CT5           SAVE START OF STRING
02944000                    *
02945000 04256  074561  SQ2    WRC B,I           READ NEXT CHARACTER
02946000 04257  014116         CPB B42           "?
02947000 04260  067267         JMP SQ4           YES
02948000 04261  014053         CPB B177          EOL?
02949000 04262  067265         JMP E2            YES
02950000 04263  045246  SQ3    ISZ CT4           INCREMENT BYTE COUNT
02951000 04264  067256         JMP SQ2
02952000                    *
02953000 04265  043020  E2     JSM SETCE         ERROR, UNTERMINATED STRING
02954000 04266  030062         ASC 1,02
02955000                    *
02956000 04267  074561  SQ4    WRC B,I           READ NEXT CHARACTER
02957000 04270  014116         CPB B42           "?
02958000 04271  067263         JMP SQ3           YES, CONTINUE
02959000                    *
02960000 04272  074760         WRC A,D           BACK UP INPUT POINTER
02961000 04273  170201         RET 1
02963000                    *
02964000                    * NUMBER BUILDER
02965000                    *
02966000 04274  000252  SN1    LDA NB1
02967000 04275  004253         LDB NB2
02968000 04276  071405         XFR 6             INITIALIZE
02969000 04277  000127         LDA ADR2
02970000 04300  071603         CLR 4             CLEAR AR2
02971000                    *
02972000 04301  001240         LDA BCD
02973000 04302  004103         LDB B60
02974000 04303  035240         STB BCD
02975000                    *
02976000 04304  010105         CPA B56           .?
02977000 04305  067353         JMP SN4           YES
02978000 04306  010103  SN2    CPA B60           0?
02979000 04307  067312         JMP *+3           YES
02980000 04310  004254         LDB P1            NO, SET SD
02981000 04311  035774         STB SD
02982000                    *
02983000 04312  005777         LDB DP
```

COMPILER -- SCANNER

```
02984000 04313  025774         ADB SD
02985000 04314  025775         ADB M
02986000 04315  035775         STB M            UPDATE EXPONENT
02987000 04316  005774         LDB SD
02988000 04317  076406         SZB SN3          SKIP IF NO SIGNIFICANT DIGITS YET
02989000 04320  005773         LDB DC
02990000 04321  076504         SIB SN3          SKIP IF 12 SIGNIFICANT DIGITS NOW
02991000 04322  035773         STB DC
02992000 04323  050130         AND B17
02993000 04324  075541         MLY              MERGE IN NEW DIGIT
02994000                 *
02995000 04325  043000  SN3    JSM READ2        READ NEXT CHARACTER
02996000 04326  014143         CPB P4           DIGIT?
02997000 04327  067306         JMP SN2          YES
02998000 04330  010105         CPA B56          .?
02999000 04331  067360         JMP SN5          YES
03000000 04332  010063         CPA B145         EEX?
03001000 04333  067365         JMP SN7          YES
03002000 04334  001776  SNW    LDA EX           WRAP IT UP
03003000 04335  055772         DSZ ES
03004000 04336  170040         TCA
03005000 04337  021775         ADA M            FINAL EXPONENT
03006000 04340  071500         NRM
03007000 04341  072310         SOS *+8          SKIP IF FLOATING ZERO
03008000 04342  004000         LDB A
03009000 04343  176002         SAP *+2
03010000 04344  174040         TCB
03011000 04345  024206         ADB M100         OVERFLOW TEST
03012000 04346  176016         SAP E6A
03013000 04347  170605         SAL 6
03014000 04350  030020         STA AR2
03015000 04351  074761         WBC B,D          BACK UP C
03016000 04352  170203         RET 3            NORMAL RETURN
03018000 04353  055777  SN4    DSZ DP           SET DP FOR LEADING .
03019000 04354  043000         JSM READ2        READ NEXT CHARACTER
03020000 04355  014143         CPB P4           DIGIT?
03021000 04356  067306         JMP SN2          YES
03022000 04357  067364         JMP E6A          ERROR, ILLEGAL DECIMAL POINT
03023000                 *
03024000 04360  001777  SN5    LDA DP
03025000 04361  072076         RZA *-2
03026000 04362  055777         DSZ DP           SET DP
03027000 04363  067325         JMP SN3
03028000                 *
03029000 04364  170201  E6A    RET 1            ERROR RETURN
03030000                 *
03031000 04365  004016  SN7    LDB C
03032000 04366  035711         STB T1           SAVE C IN CASE OF MNEMONIC WITH E
03033000 04367  043000         JSM READ2        READ NEXT CHARACTER
03034000 04370  010106         CPA B55          -?
03035000 04371  067421         JMP SNM          YES
03036000 04372  010110         CPA B53          +?
03037000 04373  067423         JMP SN6          YES
03038000 04374  014143         CPB P4           DIGIT?
03039000 04375  067401         JMP SN9          YES
03040000 04376  005711         LDB T1           NO
03041000 04377  034016         STB C            FALSE ALARM, RESTORE C
03042000 04400  067334         JMP SNW
03043000                 *
03044000 04401  045240  SN9    ISZ BCD          SET E-FORMAT
03045000 04402  031711         STA T1           SAVE ASCII DIGIT
03046000 04403  001776         LDA EX
03047000 04404  004135         LDB P10          10*EX
03048000 04405  075617         MPY
03049000 04406  020163         ADA M48
03050000 04407  021711         ADA T1
03051000 04410  031776         STA EX           SAVE UPDATED EXPONENT SPEC
03052000 04411  020170         ADA M256         OVERFLOW TEST
03053000 04412  172052         SAP E6A
03054000 04413  043000         JSM READ2        READ NEXT CHARACTER
03055000 04414  014143         CPB P4           DIGIT?
03056000 04415  067402         JMP SN9+1        YES
03057000 04416  010105         CPA B56          .?
03058000 04417  067364         JMP E6A          YES, ERROR
03059000 04420  067334         JMP SNW
03060000                 *
03061000 04421  000257  SNM    LDA M1           - EXPONENT DETECTED
03062000 04422  031772         STA ES
03063000 04423  043000  SN6    JSM READ2        READ NEXT CHARACTER
03064000 04424  014143         CPB P4           DIGIT?
03065000 04425  067401         JMP SN9          YES
03066000 04426  067364         JMP E6A          NO
```

COMPILER -- MAIN SECTION

```
03068000 04427  177567  TCON1 ABS -MAXR-1
03069000 04430  177706  TCON2 ABS MAXR-MAXP
03070000 04431  000006  TCON3 ABS MAXP-MAXL


03072000                *
03073000                * STACKER
03074000                *
03075000 04432  005254  CPSTK LDB STAKP
03076000 04433  014326        CPB ASLMT
03077000 04434  067440        JMP E8
03078000                *
03079000 04435  045254        ISZ STAKP
03080000 04436  131254        STA STAKP,I
03081000 04437  170201        RET 1
03082000                *
03083000 04440  043020  E8    JSM SETCE        ERROR, OVERFLOW
03084000 04441  030070        ASC 1,08


03086000                *
03087000                * INITIALIZATION
03088000                *
03089000 04442  000257  CPLR  LDA M1
03090000 04443  031610        STA KBFMT        INDICATE COMPILE BUFFER IS OVERWRIT,
03091000 04444  001532        LDA REFOR
03092000 04445  072402        SZA *+2
03093000 04446  141532        JSM REFOR,I
03094000 04447  140453        JSM ACLCM,I      CLEAR COMPILE BUFFER
03095000                *
03096000 04450  004307        LDB AKBFX
03097000 04451  034016        STB C            POINT C TO KEYBOARD BUFFER
03098000 04452  004304        LDB ACBUF
03099000 04453  034017        STB D            POINT D TO COMPILE BUFFER ORIGIN
03100000 04454  000177        LDA P0
03101000 04455  031242        STA ISTAR        IMPLIED MULTIPLY FLAG
03102000 04456  031316        STA CERR         COMPILE ERROR FLAG
03103000 04457  000254        LDA P1
03104000 04460  031251        STA STATE        PARSER START STATE
03105000 04461  000305        LDA ASTAK
03106000 04462  031254        STA STAKP        STACK POINTER
03107000                *
03108000 04463  000257  LOOP1 LDA M1
03109000 04464  031250        STA NLOOK        SET NO-LOOK-AHEAD-DONE TRUE
03110000 04465  001251        LDA STATE
03111000 04466  023013  LOOP2 ADA AINDX        INDEX TABLE ORIGIN
03112000 04467  100000        LDA A,I          INDEX WORD
03113000 04470  004000        LDB A
03114000 04471  174506        SBR 7
03115000 04472  035252        STB IX1          B = INDEX1[STATE]
03116000 04473  050053        AND B177
03117000 04474  031253        STA IX2          A = INDEX2[STATE]
03119000 04475  001251        LDA STATE
03120000 04476  023427        ADA TCON1        (-MAXR-1)
03121000 04477  172033        SAP APPLT
03122000                *
03123000                * READ STATE
03124000                *
03125000 04500  001251        LDA STATE
03126000 04501  043432        JSM CPSTK        STACK PRESENT STATE
03127000                *
03128000 04502  045250        ISZ NLOOK        TEST NO-LOOK-AHEAD-DONE
03129000 04503  067505        JMP *+2
03130000 04504  043043        JSM SCAN         READ
03131000                *
03132000 04505  005252        LDB IX1          RECALL INDEX1
03133000 04506  027014        ADB AREED        OFFSET BY READ TABLE ORIGIN
03134000 04507  001253        LDA IX2          RECALL INDEX2
03135000 04510  020001        ADA B
03136000 04511  020257        ADA M1
03137000 04512  031243        STA CTI          LIMIT ADDRESS FOR TOKEN SEARCH
03138000                *
03139000 04513  100001  REA2  LDA B,I          GET COMPARISON TOKEN
03140000 04514  170510        SAR 9            A = READ1[J]
03141000 04515  011237        CPA TKN
03142000 04516  067524        JMP REA3         FOUND IT
03143000 04517  015243        CPB CTI          NO MATCH
03144000 04520  067522        JMP *+2          END OF TABLE, MUST BE ERROR
03145000 04521  076172        RIB REA2
03146000                *
03147000 04522  043020  E7    JSM SETCE        SYNTAX ERROR
03148000 04523  030067        ASC 1,07
03149000                *
03150000 04524  100001  REA3  LDA B,I
03151000 04525  050042        AND B777         A = READ2[J]
```

COMPILER -- MAIN SECTION

```
03152000 04526  031251        STA STATE
03153000              *
03154000 04527  001240        LDA BCD
03155000 04530  043432        JSM CPSTK        STACK BCD
03156000 04531  067463        JMP LOOP1
03158000 04532  023430  APPLT ADA TCON2        (MAXR-MAXP)
03159000 04533  172434        SAM PUSHT
03160000              *
03161000              * APPLY STATE
03162000              *
03163000 04534  005253        LDB IX2          RECALL INDEX2
03164000 04535  174600        SBL 1
03165000 04536  174040        TCB
03166000 04537  025254        ADB STAKP        A = MP
03167000 04540  035243        STB CT1
03168000 04541  023017        ADA ASYJP
03169000 04542  164000        JMP A,I          BRANCH TO SYNTHESIZE
03170000              *
03171000 04543  001243  APL1  LDA CT1
03172000 04544  031254        STA STAKP        UPDATE STACK POINTER
03173000 04545  020257        ADA M1
03174000 04546  100000        LDA A,I          A = PREVSTATE = J
03175000 04547  031243        STA CT1
03176000 04550  005252        LDB IX1          RECALL INDEX1
03177000 04551  027016        ADB AAPLY        APPLY TABLE ORIGIN
03178000              *
03179000 04552  100001  APL2  LDA B,I          APPLY TABLE WORD
03180000 04553  170510        SAR 9            A = APPLY1[I] = TEMP
03181000 04554  072404        SZA APL3         =0?
03182000 04555  011243        CPA CT1          =J?
03183000 04556  067560        JMP APL3         YES
03184000 04557  076173        RIB APL2
03185000              *
03186000 04560  100001  APL3  LDA B,I
03187000 04561  050042        AND B777         A = APPLY2[I]
03188000 04562  072003        RZA APL4
03189000 04563  000254        LDA P1           DONE WITH PARSE!
03190000 04564  170201        RET 1
03191000              *
03192000 04565  031251  APL4  STA STATE
03193000 04566  067466        JMP LOOP2
03195000 04567  023431  PUSHT ADA TCON3        (MAXP-MAXL)
03196000 04570  172020        SAP PUSH
03197000              *
03198000              * LOOK STATE
03199000              *
03200000 04571  045250        ISZ NLOOK        TEST NO-LOOK-AHEAD-DONE
03201000 04572  067574        JMP *+2
03202000 04573  043043        JSM SCAN         READ
03203000              *
03204000 04574  005252        LDB IX1          RECALL INDEX1
03205000 04575  027015        ADB ALOOK        LOOK TABLE ORIGIN
03206000              *
03207000 04576  100001  LOO2  LDA B,I          LOOK TABLE WORD
03208000 04577  170510        SAR 9            B = LOOK1[I] = TEMP
03209000 04600  072404        SZA LOO3         =0?
03210000 04601  011237        CPA TKN          =TOKEN?
03211000 04602  067604        JMP LOO3         YES
03212000 04603  076173        RIB LOO2
03213000              *
03214000 04604  100001  LOO3  LDA B,I
03215000 04605  050042        AND B777         A = LOOK2[I]
03216000 04606  031251        STA STATE
03217000 04607  067466        JMP LOOP2

03219000              *
03220000              * PUSH STATE
03221000              *
03222000 04610  001253  PUSH  LDA IX2
03223000 04611  043432        JSM CPSTK        STACK INDEX2
03224000 04612  000054        LDA B176
03225000 04613  043432        JSM CPSTK        STACK 'EMPTY'
03226000              *
03227000 04614  001252        LDA IX1          RECALL INDEX1
03228000 04615  031251        STA STATE
03229000 04616  067466        JMP LOOP2
```

COMPILER -- SYNTHESIZE PRELIMINARIES

```
03231000              *
03232000              * TOS OUTPUT
03233000              *
03234000 04617  055254  OUT6  DSZ STAKP        TOS-5
```

COMPILER -- SYNTHESIZE

```
03235000 04620  055254              DSZ STAKP
03236000 04621  055254  OUT5        DSZ STAKP          TOS-4
03237000 04622  055254              DSZ STAKP
03238000 04623  055254  OUT4        DSZ STAKP          TOS-3
03239000 04624  055254              DSZ STAKP
03240000 04625  055254  OUT3        DSZ STAKP          TOS-2
03241000 04626  055254              DSZ STAKP
03242000 04627  055254  OUT2        DSZ STAKP          TOS-1
03243000 04630  055254              DSZ STAKP
03244000                *
03245000 04631  101254  OUT1        LDA STAKP,I        TOS
03246000                *
03247000 04632  043637  OUT0        JSM OUTST          NORMAL BCD OUTPUT
03248000 04633  170507              SAR 8
03249000 04634  072402              SZA *+2            SKIP IF MAINFRAME
03250000 04635  043637              JSM OUTST
03251000 04636  067543              JMP APL1           RETURN

03253000                *
03254000                * BYTE WRITER SUBROUTINE
03255000                *
03256000                * ON ENTRY!
03257000                *
03258000                *   A-REGISTER = BYTE
03259000                *
03260000 04637  004017  OUTST LDB D
03261000 04640  014305        CPB ACLMT
03262000 04641  067440        JMP E8
03263000                *
03264000 04642  074550        PBD A,I
03265000 04643  170201        RET 1
03267000                *
03268000                * IMPLIED STORAGE
03269000                *
03270000 04644  001257  IMSTZ LDA CSTAT            CHECK CONTROLLER STATE
03271000 04645  010177        CPA P0
03272000 04646  067661        JMP E12              CANNOT STORE IT
03273000 04647  010142        CPA P5
03274000 04650  067655        JMP IM2              ENTER CONTINUATION
03275000                *
03276000 04651  000074  IM1   LDA B77
03277000 04652  043637        JSM OUTST            OUTPUT 'RES'
03278000 04653  000247        LDA ZK1
03279000 04654  067632        JMP OUT0             OUTPUT 'GAZINTA DSP' PAIR
03280000                *
03281000 04655  001517  IM2   LDA RGFLG
03282000 04656  072473        SZA IM1
03283000 04657  000216        LDA ZK2
03284000 04660  067632        JMP OUT0             OUTPUT 'ENR GAZINTA' PAIR
03285000                *
03286000 04661  043020  E12   JSM SETCE            ERROR, LINE CANNOT BE STORED
03287000 04662  030462        ASC 1,12

03289000                *
03290000                * IMPLIED DISPLAY FOR STRINGS
03291000                *
03292000 04663  001257  IMDSP LDA CSTAT            CHECK CONTROLLER STATE
03293000 04664  010177        CPA P0
03294000 04665  067661        JMP E12              CANNOT STORE IT
03295000 04666  000051        LDA B202
03296000 04667  067632        JMP OUT0             OUTPUT 'DSP'

03298000                *
03299000                * UNARY -
03300000                *
03301000 04670  000105  UNARY LDA B56
03302000 04671  067632        JMP OUT0             OUTPUT 'U-'

03304000                *
03305000                * EMPTY PARAMETER
03306000                *
03307000 04672  000054  OEMTY LDA B176
03308000 04673  043637        JSM OUTST            OUTPUT 'EMPTY'
03309000 04674  067631        JMP OUT1

03311000                *
03312000                * 'ROUND' STATEMENTS
03313000                *
03314000 04675  000107  OROUN LDA B54
03315000 04676  043637        JSM OUTST            OUTPUT ','
03316000 04677  067617        JMP OUT6
```

COMPILER -- SYNTHESIZE

```
                     *
                     * ARRAY REFERENCE
                     *
04700   000066  ARREF LDA B140
04701   043637        JSM OUTST       OUTPUT 'ENTIRE ARRAY'
04702   067623        JMP OUT4

                     *
                     * REAL NUMBER
                     *
04703   101254  ONUMB LDA STAKP,I
04704   004020        LDB AR2         TEST AR2 EXPONENT
04705   076405        SZB ON1
04706   020145        ADA P2          CORRECT CODE FOR NON-ZERO EXPUNENT
04707   043637        JSM OUTST
04710   000020        LDA AR2
04711   170405        AAR 6
04712   043637  ON1   JSM OUTST
                *
04713   000127        LDA ADR2
04714   004345        LDB ADR1
04715   071403        XFR 4           COPY NUMBER TO AR1
04716   004155        LDB M11
04717   075441        DRS             SHIFT AR1 RIGHT ONCE
04720   072002        RZA *+2
04721   076176        RIB *-2
04722   024257        ADB M1
04723   174400        ABR 1           B = -# OF BYTES TO MOVE
04724   076412        SZB ON3
04725   035711        STB T1
                *
04726   075541  ON2   MLY
04727   170603        SAL 4
04730   031712        STA T2
04731   075541        MLY
04732   061712        IOR T2
04733   043637        JSM OUTST       OUTPUT TWO PACKED DIGITS
04734   045711        ISZ T1
04735   067726        JMP ON2
                *
04736   000121  ON3   LDA B34
04737   067632        JMP OUT0
                *
                * STRING
                *
04740   000115  OLABL LDA B43         ENTRY FOR LABEL
04741   043752        JSM STRGF
04742   000075        LDA B75
04743   067632        JMP OUT0
                *
04744   000116  OSTRG LDA B42         ENTRY FOR LITERAL
04745   043752        JSM STRGF
04746   067543        JMP APL1

                *
                * SPECIAL STRING FOR ENT
                *
04747   000116  ESTRG LDA B42
04750   043752        JSM STRGF
04751   067627        JMP OUT2

04752   043637  STRGF JSM OUTST
04753   001246        LDA CT4
04754   043637        JSM OUTST       OUTPUT BYTE COUNT
04755   004016        LDB C
04756   035711        STB T1          SAVE C
04757   005247        LDB CT5
04760   034016        STB C           SET C TO BEGINNING OF STRING
                *
04761   074560  SF2   WBC A,I         GET BYTE
04762   010116        CPA B42         "?
04763   067766        JMP SF4         YES
04764   043637  SF3   JSM OUTST       STASH IT
04765   067761        JMP SF2
                *
04766   074560  SF4   WBC A,I         GET CHARACTER FOLLOWING "
04767   010116        CPA B42         "?
04770   067764        JMP SF3         YES
                *
04771   005711        LDB T1
04772   034016        STB C           RESTORE C
04773   170201        RET 1
```

```
03402000                    *
03403000                    * OUTPUT DIM OPERATORS
03404000                    *
03405000 04774  000070  ODIME LDA B133
03406000 04775  043637        JSM OUTST        OUTPUT DIM OPERATOR
03407000 04776  067631        JMP OUT1         OUTPUT LETTER
03408000                    *
03409000 04777  000070  ODIML LDA B133
03410000 05000  043637        JSM OUTST        OUTPUT DIM OPERATOR
03411000 05001  067623        JMP OUT4         OUTPUT LETTER
03413000                    *
03414000                    * BRANCH OUTPUT SUBROUTINE
03415000                    *
03416000 05002  005254  BRNCH LDB STAKP
03417000 05003  024146        ADB M2
03418000 05004  100001        LDA B,I
03419000 05005  031711        STA T1
03420000 05006  043637        JSM OUTST        OUTPUT THE BRANCH COMMAND
03421000 05007  000177        LDA P0
03422000 05010  043637        JSM OUTST        LEAVE TWO BLANK BYTES .
03423000 05011  067637        JMP OUTST

03425000                    *
03426000                    * STRING BRANCH
03427000                    *
03428000 05012  042002  BRSTR JSM BRNCH        OUTPUT THE BRANCH COMMAND
03429000 05013  001711        LDA T1
03430000 05014  010047        CPA B230
03431000 05015  067744        JMP OSTRG        OUTPUT THE LABEL ·
03432000 05016  010046        CPA B231
03433000 05017  067744        JMP OSTRG        OUTPUT THE LABEL
03434000                    *
03435000 05020  067522        JMP E7           ERROR, ILLEGAL BRANCH COMMAND

03437000                    *
03438000                    * NUMBER BRANCH
03439000                    *
03440000 05021  042002  BRNUM JSM BRNCH        OUTPUT THE BRANCH COMMAND
03441000 05022  001777        LDA DP
03442000 05023  072403        SZA *+3
03443000 05024  043020  E10   JSM SETCE        ERROR, ILLEGAL INTEGER
03444000 05025  030460        ASC 1,10
03445000                    *
03446000 05026  000114        LDA B44          OUTPUT 'INTEGER FOLLOWS'
03447000 05027  043637        JSM OUTST
03448000                    *
03449000 05030  040646        JSM FIXPT+2      OUTPUT THE INTEGER
03450000 05031  173473        SOS E10
03451000 05032  000001        LDA B
03452000 05033  170707        RAR 8
03453000 05034  043637        JSM OUTST
03454000 05035  170707        RAR 8
03455000 05036  067635        JMP OUT0+3

03457000                    *
03458000                    * STRING ASSIGNMENT
03459000                    *
03460000 05037  000233  STRAS LDA ZK3
03461000 05040  067632        JMP OUT0         OUTPUT 'GAZINTA STRING'
03463000                    *
03464000                    * LITERAL TRANSFER
03465000                    *
03466000 05041  101254  LITRL LDA STAKP,I
03467000 05042  043637        JSM OUTST        OUTPUT TOS
03468000 05043  170507        SAR 8
03469000 05044  072402        SZA *+2
03470000 05045  043637        JSM OUTST
03471000 05046  000121        LDA B34
03472000 05047  043637        JSM OUTST        OUTPUT 'COMMENT DELIMITER'
03473000 05050  074560  LI0   WBC A,I
03474000 05051  010076        CPA B73
03475000 05052  066062        JMP LI1          JUMP IF !
03476000 05053  010053        CPA B177
03477000 05054  066062        JMP LI1          JUMP IF EOL
03478000 05055  010116        CPA B42
03479000 05056  066066        JMP LI2          JUMP IF "
03480000 05057  010117        CPA B40
03481000 05060  066050        JMP LI0
03482000 05061  066047        JMP LI0-1
03483000                    *
03484000 05062  000121  LI1   LDA B34
03485000 05063  043637        JSM OUTST        OUTPUT 'COMMENT DELIMITER'
```

## COMPILER -- SYNTHESIZE

```
03486000 05064  074760             WBC A,D
03487000 05065  067543             JMP APL1
03488000                     *
03489000 05066  004016  L12        LDB C
03490000 05067  035241             STB OLDC
03491000 05070  043637             JSM OUTST
03492000 05071  074560             WBC A,I
03493000 05072  010116             CPA B42
03494000 05073  066047             JMP L10-1
03495000 05074  010053             CPA B177
03496000 05075  067265             JMP E2            ERROR, UNTERMINATED STRING
03497000 05076  066070             JMP L12+2

03499000                     *
03500000                     * OUTPUT SUBSCRIPT COMMA
03501000                     *
03502000 05077  000100  USCOM LDA B64
03503000 05100  067632             JMP OUT0          OUTPUT ',2'
```

## COMPILER -- FILL IN BASE-PAGE LINKS

```
03505000                     *
03506000                     * FILL IN BASE-PAGE LINKS
03507000                     *
03508000 00346                     ORG ACPLR
03509000 00346  004442             DEF CPLR
03510000 00347  004000             DEF READ2
03511000 00350  004543             DEF APL1
03512000 00351  004020             DEF SETCE
03513000 00352  004274             DEF SN1
03514000 00353  004251             DEF SQ1
03515000 00354  004752             DEF STRGF
03516000 00355  004637             DEF OUTS1
03517000                     *
03518000 00333                     ORG AMTBL
03519000 00333  001471             DEF MNTBL
03520000                     *
03521000                           END
END OF PASS 2 NO ERRORS DETECTED
```

## BASE-PAGE READ-WRITE-MEMORY

```
00003000 76550                     ORG 76550B
00004000                           UNL
```

## REVERSE COMPILER TABLE

```
02001000 15477                     ORG 15477B
02002000                     *
02003000                     * CLASS TABLE FOR REVERSE COMPILER
02004000                     *
02005000                     * FORMAT IS PPPP CCCC MMMMMMMM
02006000                     *
02007000                     *   P = PRIORITY
02008000                     *   C = CLASS
02009000                     *   M = MNEMONIC INFORMATION!
02010000                     *
02011000                     *
02012000                     *
02013000                     *
02014000                     *
02015000                     *
02016000 15477  000000  RTBL  NOP            000
02017000 15500  003400        OCT 003400     001  0  7  000  ROM
02018000 15501  003400        OCT 003400     002  0  7  000  ROM
02019000 15502  003400        OCT 003400     003  0  7  000  ROM
02020000 15503  003400        OCT 003400     004  0  7  000  ROM
02021000 15504  003400        OCT 003400     005  0  7  000  ROM
02022000 15505  003400        OCT 003400     006  0  7  000  ROM
02023000 15506  003400        OCT 003400     007  0  7  000  ROM
02024000 15507  003400        OCT 003400     010  0  7  000  ROM
02025000 15510  003400        OCT 003400     011  0  7  000  ROM
02026000 15511  003400        OCT 003400     012  0  7  000  ROM
02027000 15512  003400        OCT 003400     013  0  7  000  ROM
02028000 15513  003400        OCT 003400     014  0  7  000  ROM
02029000 15514  003400        OCT 003400     015  0  7  000  ROM
02030000 15515  003400        OCT 003400     016  0  7  000  ROM
```

REVERSE COMPILER TABLE

```
02031000 15516  003400       OCT 003400  017  0  7  000  ROM
02032000 15517  003400       OCT 003400  020  0  7  000  ROM
02033000 15520  003400       OCT 003400  021  0  7  000  ROM
02034000 15521  003400       OCT 003400  022  0  7  000  ROM
02035000 15522  000000       NOP         023
02036000 15523  000000       NOP         024
02037000 15524  000000       NOP         025
02038000 15525  000000       NOP         026
02039000 15526  000000       NOP         027
02040000 15527  000000       NOP         030
02041000 15530  000000       NOP         031
02042000 15531  000000       NOP         032
02043000 15532  000000       NOP         033
02044000 15533  002400       OCT 002400  034  0  5  000  LITERAL
02045000 15534  000000       NOP         035
02046000 15535  000000       NOP         036
02047000 15536  131400       OCT 131400  037 11  3  000  I*
02048000 15537  000000       NOP         040
02049000 15540  000000       NOP         041
02050000 15541  004000       OCT 004000  042  0  8  000  STRING FOLLOWS
02051000 15542  004000       OCT 004000  043  0  8  000  LABEL FOLLOWS
02052000 15543  005000       OCT 005000  044  0 10  000  INTEGER FOLLOWS
02053000 15544  000000       NOP         045
02054000 15545  000000       NOP         046                 &
02055000 15546  004000       OCT 004000  047  0  8  000  '
02056000 15547  000000       NOP         050
02057000 15550  000000       NOP         051
02058000 15551  111452       OCT 111452  052  9  3  052  *
02059000 15552  101453       OCT 101453  053  8  3  053  +
02060000 15553  021454       OCT 021454  054  2  3  054  ,1
02061000 15554  101455       OCT 101455  055  8  3  055  -
02062000 15555  121055       OCT 121055  056 10  2  055  U-
02063000 15556  111457       OCT 111457  057  9  3  057  /
02064000 15557  004400       OCT 004400  060  0  9  000  F NUMBER
02065000 15560  004400       OCT 004400  061  0  9  000  E NUMBER
02066000 15561  004400       OCT 004400  062  0  9  000  F NUMBER W/EXPONENT
02067000 15562  004400       OCT 004400  063  0  9  000  E NUMBER W/EXPONENT
02068000 15563  021454       OCT 021454  064  2  3  054  ,2
02069000 15564  000000       NOP         065
02070000 15565  000000       NOP         066
02071000 15566  000000       NOP         067
02072000 15567  000000       NOP         070
02073000 15570  000000       NOP         071
02074000 15571  031472       OCT 031472  072  3  3  072  I
02075000 15572  002073       OCT 002073  073  0  4  073  !
02076000 15573  000000       NOP         074
02077000 15574  002072       OCT 002072  075  0  4  072  I
02078000 15575  000000       NOP         076
02079000 15576  000000       NOP         077
02080000 15977  000000       NOP         100
02081000 15600  000501       OCT 000501  101  0  1  101  A
02082000 15601  000502       OCT 000502  102  0  1  102  B
02083000 15602  000503       OCT 000503  103  0  1  103  C
02084000 15603  000504       OCT 000504  104  0  1  104  D
02085000 15604  000505       OCT 000505  105  0  1  105  E
02086000 15605  000506       OCT 000506  106  0  1  106  F
02087000 15606  000507       OCT 000507  107  0  1  107  G
02088000 15607  000510       OCT 000510  110  0  1  110  H
02089000 15610  000511       OCT 000511  111  0  1  111  I
02090000 15611  000512       OCT 000512  112  0  1  112  J
02091000 15612  000513       OCT 000513  113  0  1  113  K
02092000 15613  000514       OCT 000514  114  0  1  114  L
02093000 15614  000515       OCT 000515  115  0  1  115  M
02094000 15615  000516       OCT 000516  116  0  1  116  N
02095000 15616  000517       OCT 000517  117  0  1  117  O
02096000 15617  000520       OCT 000520  120  0  1  120  P
02097000 15620  000521       OCT 000521  121  0  1  121  Q
02098000 15621  000522       OCT 000522  122  0  1  122  R
02099000 15622  000523       OCT 000523  123  0  1  123  S
02100000 15623  000524       OCT 000524  124  0  1  124  T
02101000 15624  000525       OCT 000525  125  0  1  125  U
02102000 15625  000526       OCT 000526  126  0  1  126  V
02103000 15626  000527       OCT 000527  127  0  1  127  W
02104000 15627  000530       OCT 000530  130  0  1  130  X
02105000 15630  000531       OCT 000531  131  0  1  131  Y
02106000 15631  000532       OCT 000532  132  0  1  132  Z
02107000 15632  025400       OCT 025400  133  2 11       DIM OPERATOR
02108000 15633  151134       OCT 151134  134 13  2  134  SQR
02109000 15634  000000       NOP         135  0  0  000  END OF #
02110000 15635  000000       NOP         136
02111000 15636  000000       NOP         137
02112000 15637  000452       OCT 000452  140  0  1  052  ENTIRE ARRAY
```

## REVERSE COMPILER TABLE

```
02113000 15640  171101      OCT 171101  141 15  2  101  A[
02114000 15641  171102      OCT 171102  142 15  2  102  B[
02115000 15642  171103      OCT 171103  143 15  2  103  C[
02116000 15643  171104      OCT 171104  144 15  2  104  D[
02117000 15644  171105      OCT 171105  145 15  2  105  E[
02118000 15645  171106      OCT 171106  146 15  2  106  F[
02119000 15646  171107      OCT 171107  147 15  2  107  G[
02120000 15647  171110      OCT 171110  150 15  2  110  H[
02121000 15650  171111      OCT 171111  151 15  2  111  I[
02122000 15651  171112      OCT 171112  152 15  2  112  J[
02123000 15652  171113      OCT 171113  153 15  2  113  K[
02124000 15653  171114      OCT 171114  154 15  2  114  L[
02125000 15654  171115      OCT 171115  155 15  2  115  M[
02126000 15655  171116      OCT 171116  156 15  2  116  N[
02127000 15656  171117      OCT 171117  157 15  2  117  O[
02128000 15657  171120      OCT 171120  160 15  2  120  P[
02129000 15660  171121      OCT 171121  161 15  2  121  Q[
02130000 15661  171122      OCT 171122  162 15  2  122  R[
02131000 15662  171123      OCT 171123  163 15  2  123  S[
02132000 15663  171124      OCT 171124  164 15  2  124  T[
02133000 15664  171125      OCT 171125  165 15  2  125  U[
02134000 15665  171126      OCT 171126  166 15  2  126  V[
02135000 15666  171127      OCT 171127  167 15  2  127  W[
02136000 15667  171130      OCT 171130  170 15  2  130  X[
02137000 15670  171131      OCT 171131  171 15  2  131  Y[
02138000 15671  171132      OCT 171132  172 15  2  132  Z[
02139000 15672  000573      OCT 000573  173  0  1  173  PI
02140000 15673  031575      OCT 031575  174  3  3  175  GAZINTA STRING
02141000 15674  031575      OCT 031575  175  3  3  175  GAZINTA
02142000 15675  000400      OCT 000400  176  0  1  000  EMPTY
02143000 15676  002177      OCT 002177  177  0  4  177  EOL
02144000 15677  011003      OCT 011003  200  1  2    3  IF
02145000 15700  011004      OCT 011004  201  1  2    4  PRT
02146000 15701  011004      OCT 011004  202  1  2    4  DSP
02147000 15702  041400      OCT 041400  203  4  3       OR
02148000 15703  051400      OCT 051400  204  5  3       AND
02149000 15704  061000      OCT 061000  205  6  2       NOT
02150000 15705  011000      OCT 011000  206  1  2       FXD
02151000 15706  011000      OCT 011000  207  1  2       FLT
02152000 15707  011000      OCT 011000  210  1  2       SPC
02153000 15710  011000      OCT 011000  211  1  2       JMP
02154000 15711  011000      OCT 011000  212  1  2       SFG
02155000 15712  011000      OCT 011000  213  1  2       CFG
02156000 15713  011000      OCT 011000  214  1  2       CMF
02157000 15714  161000      OCT 161000  215 14  2       PRND
02158000 15715  161000      OCT 161000  216 14  2       DRND
02159000 15716  011000      OCT 011000  217  1  2       TRC
02160000 15717  011000      OCT 011000  220  1  2       NOR
02161000 15720  011000      OCT 011000  221  1  2       STP
02162000 15721  151000      OCT 151000  222 13  2       FLG
02163000 15722  011000      OCT 011000  223  1  2       ENT
02164000 15723  003000      OCT 003000  224  0  6       GTO-
02165000 15724  003000      OCT 003000  225  0  6       GTO+
02166000 15725  003000      OCT 003000  226  0  6       GSB-
02167000 15726  003000      OCT 003000  227  0  6       GSB+
02168000 15727  003000      OCT 003000  230  0  6       GTO
02169000 15730  003000      OCT 003000  231  0  6       GSB
02170000 15731  011000      OCT 011000  232  1  2       DIM
02171000 15732  011000      OCT 011000  233  1  2       RET
02172000 15733  011000      OCT 011000  234  1  2       WAIT
02173000 15734  000400      OCT 000400  235  0  1       BEEP
02174000 15735  000400      OCT 000400  236  0  1       END
02175000 15736  000400      OCT 000400  237  0  1       REW
02176000 15737  041400      OCT 041400  240  4  3       XOR
02177000 15740  011000      OCT 011000  241  1  2       IDF
02178000 15741  011000      OCT 011000  242  1  2       SSC
02179000 15742  011000      OCT 011000  243  1  2       TRK
02180000 15743  011000      OCT 011000  244  1  2       EDF
02181000 15744  011000      OCT 011000  245  1  2       ERT
02182000 15745  011000      OCT 011000  246  1  2       MRK
02183000 15746  011000      OCT 011000  247  1  2       RCF
02184000 15747  011000      OCT 011000  250  1  2       LDF
02185000 15750  011000      OCT 011000  251  1  2       ENP
02186000 15751  011000      OCT 011000  252  1  2       LDP
02187000 15752  011000      OCT 011000  253  1  2       RCM
02188000 15753  011000      OCT 011000  254  1  2       LDM
02189000 15754  011000      OCT 011000  255  1  2       RCK
02190000 15755  011000      OCT 011000  256  1  2       LDK
02191000 15756  011000      OCT 011000  257  1  2       LDB
02192000 15757  011000      OCT 011000  260  1  2       VFY
02193000 15760  000400      OCT 000400  261  0  1       AVD
02194000 15761  000400      OCT 000400  262  0  1       AVE
02195000 15762  000400      OCT 000400  263  0  1       LKD
02196000 15763  000400      OCT 000400  264  0  1       LKE
02197000 15764  071400      OCT 071400  265  7  3       #
```

REVERSE COMPILER TABLE

```
02198000 15765  071400            OCT 071400  266  7  3        <=
02199000 15766  071400            OCT 071400  267  7  3        >=
02200000 15767  071400            OCT 071400  270  7  3        <
02201000 15770  071400            OCT 071400  271  7  3        >
02202000 15771  071400            OCT 071400  272  7  3        =
02203000 15772  151000            OCT 151000  273 13  2        L.C. R
02204000 15773  011000            OCT 011000  274  1  2        LIST
02205000 15774  000400            OCT 000400  275  0  1        RES
02206000 15775  000400            OCT 000400  276  0  1        LIST K
02207000 15776  000400            OCT 000400  277  0  1        TLIST
02208000 15777  151000            OCT 151000  300 13  2        L.C. P
```

REVERSE COMPILER

```
02210000 05106                    ORG 5106B
02211000                    *
02212000                    * REVERSE COMPILER
02213000                    *


02215000                    *
02216000                    * POINTERS AND EQUATES
02217000                    *
02218000        077241 LEFTE EQU CMTMP+2
02219000        077242 PRI   EQU CMTMP+3      INPUT PRIORITY
02220000        077243 LAST  EQU CMTMP+4      LATEST OUTPUT PRIORITY
02221000        077244 ARRBF EQU CMTMP+5      LEFT END OF BUFFER
02222000        077245 CODE  EQU CMTMP+6
02223000        077246 RT1   EQU CMTMP+7
02224000        077247 RT2   EQU CMTMP+8
02225000        077250 RT3   EQU CMTMP+9
02226000        077251 OFLAG EQU CMTMP+10     OUTPUT BUFFER OVERFLOW FLAG
02227000        077252 IMMFG EQU CMTMP+11     I* DUMP FLAG

02229000 05106               BSS 1            *** RESERVED FOR 4K-PAGE CHECKSUM
```

REVERSE COMPILER SUBROUTINES

```
02231000                    *
02232000                    * OUTPUT WRITER SUBROUTINE
02233000                    *
02234000 05107  000177 RCPAR LDA P0           SPECIAL ENTRY FOR PARENTHESES
02235000 05110  042142       JSM RCSTK
02236000 05111  000231       LDA RK1          STACK '('
02237000 05112  042142       JSM RCSTK
02238000 05113  000112       LDA B51          OUTPUT ')'
02239000                    *
02240000 05114  072422 RCOUT SZA RC02         SKIP IF NULL CHARACTER
02241000 05115  004016       LDB C
02242000 05116  035714       STB T4           SAVE C
02243000 05117  004316       LDB AIBFL
02244000 05120  034016       STB C            INITIALIZE DESTINATION
02245000 05121  024257       ADB M1
02246000 05122  034017       STB D            INITIALIZE SOURCE
02247000 05123  074771 RC01  WBD B,D
02248000 05124  074741       PBC B,D          MOVE A BYTE
02249000 05125  004017       LDB D
02250000 05126  015244       CPB ARRBF
02251000 05127  066131       JMP *+2
02252000 05130  066123       JMP RC01
02253000                    *
02254000 05131  005714       LDB T4
02255000 05132  034016       STB C            RESTORE C
02256000                    *
02257000 05133  074550       PBD A,I          INSERT NEW CHARACTER
02258000 05134  104316       LDB AIBFL,I
02259000 05135  014262       CPB TOBLN        OVERFLOW?
02260000 05136  170201 RC02  RET 1            NO
02261000 05137  004074       LDB B77          YES
02262000 05140  035251       STB OFLAG
02263000 05141  170201       RET 1
02265000                    *
02266000                    * STACKER SUBROUTINE
02267000                    *
02268000 05142  005254 RCSTK LDB STAKP
02269000 05143  014326       CPB ASLMT
02270000 05144  164424       JMP ASYER,I      STACK OVERFLOW
02271000                    *
02272000 05145  045254       ISZ STAKP
02273000 05146  131254       STA STAKP,I      STACK THE INFO
02274000 05147  170201       RET 1
```

REVERSE COMPILER SUBROUTINES

```
                     *
                     * MNEMONIC TABLE SCAN SUBROUTINE FOR REVERSE COMPILER
                     *
                     * ON ENTRY:
                     *
                     *    A-REGISTER = OPCODE
                     *    B-REGISTER = WORD ADDRESS OF TABLE
                     *
                     * ON EXIT:
                     *
                     *    GUIDE = CHARACTER COUNT INCLUDED
                     *    ASCII = CHARACTER POINTER TO RIGHT END OF MNEMONIC
                     *
                     *    A-REGISTER = GUIDE
                     *
05150  031711  TSCAN STA T1               SAVE OPCODE
05151  034017        STB D
05152  074770        WBD A,D              INITIALIZE CHARACTER POINTER
                     *
05153  000177  Y1    LDA P0
05154  031713        STA T3               INITIALIZE CHARACTER COUNT
05155  074570  Y2    WBD A,I
05156  170607        SAL 8
05157  172603        SAM *+3,C            SKIP IF OPCODE
05160  045713        ISZ T3
05161  066155        JMP Y2
                     *
05162  170507        SAR 8
05163  011711        CPA T1
05164  066166        JMP *+2              JUMP IF FOUND
05165  066153        JMP Y1
                     *
05166  001237        LDA GUIDE
05167  050170        AND M256
05170  061713        IOR T3
05171  031237        STA GUIDE            RECORD CHARACTER COUNT
                     *
05172  054017        DSZ D
05173  004017        LDB D
05174  035240        STB ASCII            RECORD CHARACTER POINTER
                     *
05175  170201        RET 1
                     *
                     * BACKWARD SCAN SUBROUTINE FOR REVERSE COMPILER
                     *
                     * ON RETURN TO P+1:  AT LH LIMIT
                     *
                     * ON RETURN TO P+2:  B-REGISTER HAS BYTE
                     *
05176  004304  RSCAN LDB ACBUF
05177  014016        CPB C
05200  170201        RET 1                AT LH LIMIT, DONE
                     *
05201  034017        STB D
05202  074571        WBD B,I              INITIALIZE FORWARD POINTER
                     *
05203  004017  RSCL  LDB D
05204  014016        CPB C
05205  066264        JMP RS2              JUMP IF C IS OK
05206  000017        LDA D
05207  074771        WBD B,D              BACK UP ONE SPACE
05210  004017        LDB D
05211  014016        CPB C
05212  066262        JMP RS1              JUMP IF C NOT OK
                     *
05213  031241        STA LEFTE            SAVE OLD D
05214  030017        STA D
05215  074570        WBD A,I              CONTINUE FORWARD SCAN
05216  031711        STA T1
05217  020332        ADA ARTBL
05220  100000        LDA A,I              GET RTBL WORD
05221  170507        SAR 8
05222  050130        AND B17              GET CLASS
05223  010142        CPA P5
05224  066253        JMP RS5              5 = LITERAL
05225  010141        CPA P6
05226  066257        JMP RS6              6 = GTO OR GSB
05227  010140        CPA P7
05230  066245        JMP RS3              7 = OPTIONAL ROM
05231  010137        CPA P8
05232  066240        JMP RS4              8 = CHARACTER STRING
05233  010136        CPA P9
05234  066253        JMP RS5              9 = REAL NUMBER
05235  010135        CPA P10
05236  066257        JMP RS6              10 = INTEGER NUMBER
                     *
05237  066203        JMP RSCL             NONE => ONE-BYTE CODE
```

REVERSE COMPILER SUBROUTINES

```
02365000                      *
02366000                      * CHARACTER STRING
02367000                      *
02368000 05240  074571  RS4    WBD B,I          GET LENGTH OF STRING
02369000 05241  174040         TCB
02370000 05242  076541         SIB RSCL
02371000 05243  074570         WBD A,I          SKIP TO END OF STRING
02372000 05244  066242         JMP *-2
02373000                      *
02374000                      * OPTIONAL-ROM CODE
02375000                      *
02376000 05245  074570  RS3    WBD A,I          SKIP SECOND CODE OF PAIR
02377000 05246  170607         SAL 8
02378000 05247  061711         IOR T1
02379000 05250  010043         CPA B411         IS IT API 'XXX' ?
02380000 05251  066240         JMP RS4          YES
02381000 05252  066203         JMP RSCL
02382000                      *
02383000                      * REAL NUMBER OR ENT LITERAL
02384000                      *
02385000 05253  074570  RS5    WBD A,I          LOOK FOR END OF IT
02386000 05254  010121         CPA B34
02387000 05255  066203         JMP RSCL
02388000 05256  066253         JMP *-3
02389000                      *
02390000                      * GTO OR GSB
02391000                      *
02392000 05257  074570  RS6    WBD A,I          SKIP R.S. BRANCH ADDRESS
02393000 05260  074570         WBD A,I
02394000 05261  066203         JMP RSCL

02396000                      *
02397000                      * NORMAL RETURNS
02398000                      *
02399000 05262  005241  RS1    LDB LEFTE
02400000 05263  034016         STB C            CORRECT C
02401000 05264  074761  RS2    WBC B,D
02402000 05265  170202         RET 2            RETURN WITH BYTE
```

REVERSE COMPILER -- MAIN SECTION

```
02404000                      *
02405000                      * INITIALIZATION
02406000                      *
02407000                      * ON ENTRY:
02408000                      *
02409000                      *   B-REGISTER HAS LOCATION FOR LEFT END
02410000                      *
02411000 05266  035244  RCLR   STB ARRBF        INITIALIZE LEFT-END POINTER
02412000 05267  000001         LDA B
02413000 05270  004450         LDB ACLBI
02414000 05271  024254         ADB P1           SPECIAL ENTRY INTO ACLBI,I
02415000 05272  140001         JSM B,I          TO CLEAR MOST OF I/O BUFFER
02416000 05273  000262         LDA TOBLN
02417000 05274  130316         STA AIBFL,I
02418000 05275  000117         LDA B40
02419000 05276  031251         STA OFLAG        INDICATE NO BUFFER OVERFLOW
02420000                      *
02421000 05277  000257         LDA M1
02422000 05300  031610         STA KBFMT        INDICATE COMPILE BUFFER IS OVERWRIT.
02423000 05301  001532         LDA REFOR
02424000 05302  072402         SZA *+2
02425000 05303  141532         JSM REFOR,I
02426000                      *
02427000 05304  140511         JSM AGEOL,I      LOOK FOR EOL
02428000 05305  066323         JMP RL1

02430000                      *
02431000                      * EXIT ROUTINE .
02432000                      *
02433000 05306  005244  RXIT   LDB ARRBF
02434000 05307  034017         STB D            INITIALIZE POINTER FOR OVERFLOW FLAG
02435000 05310  074570         WBD A,I
02436000 05311  001251         LDA OFLAG
02437000 05312  074750         PBD A,D          STORE OVERFLOW STATUS FLAG
02438000 05313  000214         LDA EOLB
02439000 05314  130316         STA AIBFL,I      FIX UP END OF I/O BUFFER
02440000                      *
02441000 05315  005531         LDB APRVC        IS API ROM IN?
02442000 05316  076402         SZB *+2          NO
02443000 05317  164001         JMP B,I          YES
02444000 05320  170201         RET 1
```

REVERSE COMPILER -- MAIN SECTION

```
02446000                   *
02447000                   * MAIN LOOP
02448000                   *
02449000 05321  042176  RLOOP JSM RSCAN        SCAN BACKWARDS
02450000 05322  066306        JMP RXIT         DONE
02451000                   *
02452000 05323  035245  RL1   STB CODE         SAVE BYTE
02453000 05324  024332        ADB ARTBL
02454000 05325  100001        LDA B,I
02455000 05326  031237        STA GUIDE        SAVE RTBL WORD
02456000 05327  004177        LDB P0
02457000 05330  035240        STB ASCII        INITIALIZE 'ASCII' TO "NO MNEMONIC"
02458000                   *
02459000 05331  005245        LDB CODE         RECALL CODE
02460000 05332  024167        ADB M128
02461000 05333  176405        SBM RL4          SKIP UNLESS MAINFRAME MNEMONIC
02462000 05334  000001        LDA B
02463000 05335  020254        ADA P1
02464000 05336  004333        LDB AMTBL
02465000 05337  042150        JSM TSCAN        GO GET MNEMONIC INFORMATION
02466000                   *
02467000 05340  170507  RL4   SAR 8
02468000 05341  050130        AND B17          GET CLASS
02469000 05342  022344        ADA AJ2
02470000 05343  164000        JMP A,I          BRANCH VIA JMP TABLE
02471000                   *
02472000 05344  105345  AJ2   DEF *+1,I        JUMP TABLE #2
02473000                   *
02474000 05345  100424        DEF ASYER,I  0   UNEXPECTED CODE
02475000 05346  005433        DEF RC2      1   OPERAND
02476000 05347  005470        DEF RC4      2   UNARY OPERATOR
02477000 05350  005470        DEF RC4      3   BINARY OPERATOR
02478000 05351  005427        DEF RC1      4   EOL
02479000 05352  005575        DEF ELOUT    5   LITERAL
02480000 05353  005433        DEF RC2      6   GTO OR GSB
02481000 05354  005361        DEF OPROM    7   OPTIONAL-ROM
02482000 05355  005545        DEF STOUT    8   CHARACTER STRING
02483000 05356  005610        DEF REOUT    9   REAL NUMBER
02484000 05357  005737        DEF INTOT   10   INTEGER NUMBER
02485000 05360  005321        DEF RLOOP   11   IGNORE
02487000                   *
02488000                   * CALL OPTIONAL-ROM FOR REVERSE COMPILER
02489000                   *
02490000                   * ON EXIT:
02491000                   *
02492000                   *   'GUIDE' = 'GUIDE' INFORMATION
02493000                   *   'ASCII' = CHARACTER POINTER TO RIGHT END OF MNEMONIC
02494000                   *
02495000 05361  004326  OPROM LDB ATROM
02496000 05362  025245        ADB CODE
02497000 05363  104001        LDB B,I          GET ROM PAGE ADDRESS
02498000 05364  076407        SZB E20A         SKIP IF ROM IS MISSING
02499000 05365  024254        ADB P1
02500000 05366  035246        STB RT1          COMPILE
02501000 05367  024254        ADB P1
02502000 05370  035247        STB RT2          REVERSE COMPILE
02503000 05371  104001        LDB B,I
02504000 05372  014257        CPB M1
02505000 05373  066772  E20A  JMP E20          ERROR, ROM MISSING
02506000                   *
02507000 05374  044016        ISZ C
02508000 05375  074760        WBC A,D          GET ROM'S RELATIVE CODE
02509000 05376  031250        STA RT3
02510000 05377  074761        WBC B,D
02511000                   *
02512000 05400  105247        LDB RT2,I
02513000 05401  176205        SBP *+5,C
02514000 05402  140001        JSM B,I          OPTIONAL CALL ON ROM
02515000 05403  066406        JMP *+3
02516000 05404  001237        LDA GUIDE        SPECIAL RETURN FOR STRING ROM
02517000 05405  066340        JMP RL4
02518000                   *
02519000 05406  001250        LDA RT3
02520000 05407  020257        ADA M1
02521000 05410  170700        RAR 1
02522000 05411  024000        ADB A
02523000 05412  176204        SBP *+4,C        SKIP IF LEFT HALF
02524000 05413  100001        LDA B,I
02525000 05414  170607        SAL 8
02526000 05415  066420        JMP *+3
02527000 05416  100001        LDA B,I
02528000 05417  050170        AND M256
02529000 05420  031237        STA GUIDE        SAVE 'GUIDE' INFORMATION
02530000                   *
```

```
02531000 05421  105246         LDB RT1,I
02532000 05422  176202         SBP *+2,C
02533000 05423  140001         JSM B,I        OPTIONAL CALL ON ROM
02534000                *
02535000 05424  001250         LDA RT3
02536000 05425  042150         JSM TSCAN      GO GET MNEMONIC INFORMATION
02537000 05426  066340         JMP RL4
02539000                *
02540000                * EOL CODE
02541000                *
02542000 05427  000305  RC1    LDA ASTAK
02543000 05430  031254         STA STAKP      RESET STACK POINTER
02544000 05431  000177         LDA P0
02545000 05432  031243         STA LAST       RESET 'LAST'
02546000                *
02547000                * OPERAND
02548000                *
02549000 05433  001237  RC2    LDA GUIDE
02550000 05434  005240         LDB ASCII
02551000 05435  042754         JSM NMOUT      OUTPUT OPERAND
02552000 05436  000177  RC2A   LDA P0
02553000 05437  031252         STA IMMFG
02554000                *
02555000 05440  004305  RC3    LDB ASTAK
02556000 05441  015254         CPB STAKP      STACK EMPTY?
02557000 05442  066321         JMP RLOOP      YES
02558000                *
02559000 05443  101254         LDA STAKP,I    RECALL STACKED 'GUIDE'
02560000 05444  055254         DSZ STAKP
02561000 05445  031237         STA GUIDE
02562000 05446  105254         LDB STAKP,I    RECALL STACKED 'ASCII'
02563000 05447  055254         DSZ STAKP
02564000 05450  010245         CPA IMCON      =131400B
02565000 05451  066455         JMP RC3A       JUMP IF IMPLIED MULTIPLY
02566000 05452  042754         JSM NMOUT      OUTPUT TOS
02567000 05453  000177         LDA P0
02568000 05454  031252         STA IMMFG      NOT IMPLIED MULTIPLY
02569000                *
02570000 05455  001237  RC3A   LDA GUIDE
02571000 05456  004000         LDB A
02572000 05457  170507         SAR 8
02573000 05460  050130         AND B17        A=CLASS
02574000                *
02575000 05461  174513         SBR 12         B=PRIORITY
02576000 05462  014140         CPB P7
02577000 05463  004137         LDB P8         CHANGE 7 TO 8
02578000 05464  035243         STB LAST       SET 'LAST'
02579000 05465  010144         CPA P3         BINARY OPERATOR?
02580000 05466  066321         JMP RLOOP      YES
02581000 05467  066440         JMP RC3        NO
02583000                *
02584000                * OPERATOR
02585000                *
02586000 05470  001237  RC4    LDA GUIDE
02587000 05471  170513         SAR 12         A=INPUT PRIORITY
02588000 05472  031242         STA PR1
02589000 05473  000305         LDA ASTAK
02590000 05474  011254         CPA STAKP      STACK EMPTY?
02591000 05475  066505         JMP RC5        YES
02592000 05476  101254         LDA STAKP,I
02593000 05477  170513         SAR 12         A=PR2
02594000 05500  010132         CPA P13
02595000 05501  000133         LDA P12        CHANGE 13 TO 12
02596000 05502  170140         CMA
02597000 05503  021242         ADA PR1        PR1-PR2-1
02598000 05504  172405         SAM RC6
02599000 05505  001242  RC5    LDA PR1
02600000 05506  170140         CMA
02601000 05507  021243         ADA LAST       LAST-PR1-1
02602000 05510  172406         SAM RC7
02603000 05511  042107  RC6    JSM RCPAR      STACK '(' AND OUTPUT ')'
02604000 05512  000177         LDA P0
02605000 05513  031252         STA IMMFG      COVERS CASE (2+3)4
02606000 05514  000254         LDA P1
02607000 05515  031243         STA LAST       SET 'LAST'
02608000                *
02609000 05516  001240  RC7    LDA ASCII      STACK INPUT INFORMATION
02610000 05517  042142         JSM RCSTK
02611000 05520  001237         LDA GUIDE
02612000 05521  042142         JSM RCSTK
02613000 05522  001242         LDA PR1        RECALL INPUT PRIORITY
02614000 05523  010131         CPA P14
02615000 05524  066530         JMP RC8
02616000 05525  010130         CPA P15
02617000 05526  066532         JMP RC9
```

REVERSE COMPILER -- MAIN SECTION

```
02618000 05527  066321         JMP RLOOP
02619000                *
02620000 05530  042107  RC8    JSM RCPAR        STACK '(' AND OUTPUT ')'
02621000 05531  066540         JMP RCOM
02622000                *
02623000 05532  000177  RC9    LDA P0
02624000 05533  042142         JSM RCSTK
02625000 05534  000230         LDA RK2          STACK '['
02626000 05535  042142         JSM RCSTK
02627000 05536  000067         LDA B135
02628000 05537  042114         JSM RCOUT        OUTPUT ']'
02629000 05540  000177  RCOM   LDA P0
02630000 05541  031252         STA IMMFG        COVERS CASE A[2]3
02631000 05542  000254         LDA P1
02632000 05543  031243         STA LAST         SET 'LAST'
02633000 05544  066321         JMP RLOOP
02635000                *
02636000                * SECTION TO OUTPUT A STRING IN LIST FORMAT
02637000                *
02638000 05545  000116  STOUT  LDA B42
02639000 05546  042114         JSM RCOUT        OUTPUT TRAILING QUOTE
02640000 05547  004016         LDB C
02641000 05550  035270         STB SAVEC        SAVE C
02642000 05551  044016         ISZ C
02643000 05552  074560         WBC A,I          GET LENGTH
02644000 05553  072415         SZA ST1
02645000 05554  031712         STA T2
02646000 05555  031713         STA T3
02647000                *
02648000 05556  074560         WBC A,I          FIND RIGHT-HAND END OF STRING
02649000 05557  055712         DSZ T2
02650000 05560  066556         JMP *-2
02651000 05561  074760         WBC A,D          POINT TO RIGHT-HAND END OF STRING
02652000                *
02653000 05562  074760         WBC A,D          READ A CHARACTER
02654000 05563  042114         JSM RCOUT        MOVE TO OUTPUT
02655000 05564  010116         CPA B42
02656000 05565  042114         JSM RCOUT        DUPLICATE IF "
02657000 05566  055713         DSZ T3
02658000 05567  066562         JMP *-5
02659000                *
02660000 05570  000116  ST1    LDA B42
02661000 05571  042114         JSM RCOUT        OUTPUT LEADING QUOTE
02662000 05572  005270         LDB SAVEC
02663000 05573  034016         STB C            RESTORE C
02664000 05574  066436         JMP RC2A


02666000                *
02667000                * SECTION TO OUTPUT LITERAL
02668000                *
02669000 05575  044016  ELOUT  ISZ C            SKIP PAST LEADING B34
02670000                *
02671000 05576  074560  EL1    WBC A,I          FIND RIGHT-HAND END OF LITERAL
02672000 05577  010121         CPA B34
02673000 05600  066602         JMP EL2
02674000 05601  066576         JMP EL1
02675000 05602  054016  EL2    DSZ C
02676000                *
02677000 05603  074760  EL3    WBC A,D          READ A CHARACTER
02678000 05604  010121         CPA B34
02679000 05605  066321         JMP RLOOP
02680000 05606  042114         JSM RCOUT        MOVE TO OUTPUT
02681000 05607  066603         JMP EL3
02683000                *
02684000                * SECTION TO OUTPUT A REAL NUMBER IN LIST FORMAT
02685000                *
02686000 05610  001252  REOUT  LDA IMMFG
02687000 05611  170140         CMA
02688000 05612  031252         STA IMMFG
02689000 05613  072002         RZA *+2
02690000 05614  042107         JSM RCPAR        DUMPING NUMBER WITH I* ACTIVE
02691000 05615  004016         LDB C
02692000 05616  035270         STB SAVEC        SAVE C
02693000 05617  000345         LDA ADR1
02694000 05620  030017         STA D
02695000 05621  071603         CLR 4            CLEAR AR1
02696000 05622  173201         SOC *+1,C
02697000                *
02698000 05623  074560         WBC A,I
02699000 05624  074560         WBC A,I          GET FORMAT INDICATOR
02700000 05625  010103         CPA B60
02701000 05626  173211         SOC RN2,C        JUMP IF F/NX
02702000 05627  010102         CPA B61
```

```
05630  173307        SOC RN2,S        JUMP IF E/NX
05631  010101        CPA B63
05632  173301        SOC *+1,S
                *
05633  074560        WBC A,I
05634  170607        SAL 8
05635  170401        AAR 2
05636  031770        STA AR1          SET UP EXPONENT
                *
05637  074560  RN2   WBC A,I          MOVE DIGITS TO AR1
05640  010121        CPA B34
05641  066644        JMP RN3A
05642  074550        PBD A,I
05643  066637        JMP RN2
                *
05644  005270  RN3A  LDB SAVEC
05645  034016        STB C            RESTORE C
                *
                * ENTER HERE IF NUMBER ALREADY IN AR1
                *
05646  001770        LDA AR1
05647  170405        AAR 6            LOOK AT EXPONENT
                *
05650  173022        SOC ROUTF        SKIP IF F-FORMAT
                *
05651  172002        SAP *+2          GET ABS OF EXPONENT
05652  170040        TCA
05653  040762  RN4   JSM SDIV         GET EXPONENT DIGIT
05654  000135        DEF P10
05655  024103        ADB B60          CONVERT TO ASCII
05656  031711        STA T1
05657  000001        LDA B
05660  042114        JSM RCOUT        MOVE TO OUTPUT
05661  001711        LDA T1
05662  072071        RZA RN4
05663  001770        LDA AR1
05664  172003        SAP *+3          TEST EXPONENT SIGN
05665  000106        LDA B55
05666  042114        JSM RCOUT        OUTPUT '-'
05667  000063        LDA B145
05670  042114        JSM RCOUT        OUTPUT 'EEX'
                *
05671  000177        LDA P0           FALL THROUGH TO F-SECTION
                *
05672  170140  ROUTF CMA
05673  031711        STA T1           SAVE K = 1'S COMPLEMENT OF EXP
05674  020133        ADA P12
05675  172010        SAP RF2
05676  031712        STA T2
05677  000103        LDA B60
05700  042114        JSM RCOUT        OUTPUT '0' TO LEFT OF DECIMAL
05701  045711        ISZ T1
05702  045712        ISZ T2
05703  066700        JMP *-3
05704  066727        JMP RF4
                *
05705  170040  RF2   TCA
05706  172021        SAP RF4
05707  004103        LDB B60
05710  035712        STB T2           SET INSIGNIFICANT-ZERO FLAG
05711  031713        STA T3           DIGIT COUNTER
05712  075441  RF3   DRS              SHIFT AR1 RIGHT
05713  060103        IOR B60          CONVERT TO ASCII
05714  011712        CPA T2
05715  066721        JMP *+4          DON'T OUTPUT INSIGNIFICANT ZEROS
05716  042114        JSM RCOUT
05717  000177        LDA P0
05720  031712        STA T2           RESET INSIGNIFICANT-ZERO FLAG
05721  045713        ISZ T3
05722  066712        JMP RF3
                *
05723  001712        LDA T2
05724  072003        RZA *+3
05725  000105        LDA B56
05726  042114        JSM RCOUT        OUTPUT '.'
                *
05727  001711  RF4   LDA T1           RECALL K
05730  172006        SAP RF6          DONE
05731  075441  RF5   DRS              SHIFT AR1 RIGHT
05732  060103        IOR B60          CONVERT TO ASCII
05733  042114        JSM RCOUT
05734  045711        ISZ T1           TEST FOR FINAL MSD
05735  066731        JMP RF5
                *
05736  066440  RF6   JMP RC3
```

REVERSE COMPILER -- MAIN SECTION

```
02790000                    *
02791000                    * SECTION TO OUTPUT AN INTEGER
02792000                    *
02793000 05737  004016  INTOT LDB C
02794000 05740  035270        STB SAVEC         SAVE C
02795000 05741  044016        ISZ C
02796000 05742  074560        WBC A,I           GET THE INTEGER
02797000 05743  170607        SAL 8
02798000 05744  074561        WBC B,I
02799000 05745  024000        ADB A
02800000 05746  140563        JSM AFLTP,I       CONVERT TO FLOATING
02801000 05747  000127        LDA ADR2
02802000 05750  004345        LDB ADR1
02803000 05751  071403        XFR 4             MOVE TO AR1
02804000 05752  173201        SOC *+1,C
02805000 05753  066544        JMP RN3A
02807000                    *
02808000                    * SUBROUTINE TO OUTPUT NORMAL CODES
02809000                    *
02810000                    * ON ENTRY:
02811000                    *
02812000                    *   A-REGISTER = 'GUIDE' INFORMATION
02813000                    *   B-REGISTER = 'ASCII' INFORMATION
02814000                    *
02815000 05754  050045  NMOUT AND B377
02816000 05755  076002        RZB NM1           SKIP IF MNEMONIC
02817000 05756  066114        JMP RCOUT         OUTPUT DIRECT CODE
02818000                    *
02819000 05757  031711  NM1   STA T1            INITIALIZE CHARACTER COUNTER
02820000 05760  000016        LDA C
02821000 05761  031270        STA SAVEC         SAVE C
02822000 05762  034016        STB C
02823000 05763  074760  NM2   WBC A,D           MOVE A CHARACTER
02824000 05764  042114        JSM RCOUT
02825000 05765  055711        DSZ T1
02826000 05766  066763        JMP NM2
02827000                    *
02828000 05767  005270        LDB SAVEC
02829000 05770  034016        STB C             RESTORE C
02830000 05771  170201        RET 1


02832000                    *
02833000                    * MISSING ROM
02834000                    *
02835000 05772  140405  E20   JSM AERR2,I       ERROR, MISSING ROM
02836000 05773  031060        ASC 1,20
02837000 05774  001245        LDA CODE
02838000 05775  004320  DSRMI LDB AIOLM
02839000 05776  140477        JSM ABTDA,I       INCLUDE ROM'S ID
02840000 05777  164407        JMP AEREX,I

02842000                    *
02843000                    * FILL IN BASE-PAGE LINKS
02844000                    *
02845000 00356                ORG ARCLR
02846000 00356  005266        DEF RCLR
02847000 00357  005775        DEF DSRMI
02848000                    *
02849000 00332                ORG ARTBL
02850000 00332  015477        DEF RTBL
02851000                    *
02852000                      END

END OF PASS 2 NO ERRORS DETECTED
```

BASE-PAGE READ-WRITE-MEMORY

```
00003000 76550                ORG 76550B
00004000                      UNL
```

INTERPRETER

```
02001000                    *
02002000                    * INTERPRETER
02003000                    *
02004000 06012                ORG 6012B
02005000                    *
02006000 06012  140404  E9    JSM AERR1,I       ERROR, WRONG CONTROL STATE
02007000 06013  030071        ASC 1,09
02008000 06014  177737  M33   DEC -33
```

```
               *
               * SUBROUTINE TO SKIP N LINES
               *
               * ON ENTRY: A = +- SKIP DISTANCE
               *           B = STARTING ADDRESS
               *
               * ON EXIT:  B = ADDRESS OF TARGET LINE
               *
               * TEMPORARIES USED: T2
               *
06015  072413  RELGO SZA XIT          SKIP IF NOTHING TO DO
06016  031712        STA T2
06017  172012        SAP FSKIP        WHICH WAY?
               *
06020  100001  BSKIP LDA B,I          BACKWARD IF -
06021  170507        SAR 8            BACKWARD LINK
06022  050053        AND B177
06023  170040        TCA
06024  072414        SZA E31          ERROR IF ZERO
06025  024000        ADB A
06026  045712        ISZ T2
06027  067020        JMP BSKIP
               *
06030  170201  XIT   RET 1            DONE
               *
06031  100001  FSKIP LDA B,I          FORWARD IF +
06032  050053        AND B177         FORWARD LINK
06033  072405        SZA E31
06034  024000        ADB A
06035  055712        DSZ T2
06036  067031        JMP FSKIP
               *
06037  170201        RET 1            DONE
               *
06040  064722  E31   JMP ERLNF        ERROR, NONEXISTENT LINE


               *
               * SUBROUTINE TO DETERMINE WHETHER B IS IN COMPILE BUFFER
               *
06041  000001  FINDB LDA B
06042  170140        CMA
06043  020330        ADA ABNRY        ABNRY-B-1
06044  172002        SAP *+2
06045  170201        RET 1            YES
06046  170202        RET 2            NO
               *
               * EXECUTION STACK OVERFLOW TEST
               *
               * ON ENTRY: A = # OF WORDS NEEDED
               *           B = 'WHAT'
               *
               * ON EXIT:  AP1 = UPDATED
               *           B = D = POINTS TO 'LENGTH'
               *
               * TEMPORARIES USED: T1,T2
               *
06047  000144  PHVAR LDA P3           SPECIAL ENTRY TO STACK VARIABLE
06050  004267        LDB FVRWM
06051  067054        JMP *+3
               *
06052  000140  PHCON LDA P7           SPECIAL ENTRY TO STACK CONSTANT
06053  004266        LDB FPTMP
               *
06054  031711  OVTST STA T1
06055  035712        STB T2
06056  170040        TCA
06057  005310        LDB RMAX
06060  174140        CMB
06061  021263        ADA AP1
06062  024000        ADB A            AP1-(RMAX+1)
06063  176003        SBP *+3
06064  140404  E40   JSM AERR1,I      ERROR, STACK OVERFLOW
06065  032060        ASC 1,40
               *
06066  031263        STA AP1
06067  020257        ADA M1
06070  030017        STA D
               *
06071  005712        LDB T2
06072  070551        PWD B,I          FILL IN 'WHAT'
06073  005711        LDB T1
06074  070551        PWD B,I          FILL IN 'LENGTH'
               *
06075  004017        LDB D
06076  170201        RET 1
```

```
02097000                        *
02098000                        * ASSIGNMENT TRACE
02099000                        *
02100000                        * ON ENTRY: A-REGISTER = SOURCE ADDRESS
02101000                        *           B-REGISTER = DESTINATION ADDRESS
02102000                        *
02103000                        * TEMPORARIES USED: T1,T2,T3,T4,T5,T6,T7,T8,T9,T11,T12
02104000                        * PLUS THOSE USED BY ACLBI,ABTDA,ATCHR,APSTR,APNUM,APNMR
02105000                        *
02106000 06077  071403  ASTRC XFR 4             TRANSFER THE NUMBER
02107000 06100  140551        JSM AFLTC,I       CHECK IF IN USER RANGE
02108000 06101  001267        LDA TRACE         TEST TRACE FLAG
02109000 06102  172031        SAP AS1           SKIP IF NO TRACING REQUIRED
02110000 06103  000016        LDA C
02111000 06104  031270        STA SAVEC         SAVE C
02112000                        *
02113000 06105  005762        LDB MRW1+4        (WAS SAVED BY AFLTC,I)
02114000 06106  140377        JSM AGNAM,I       GET VARIABLE NAME
02115000 06107  000075        LDA B75
02116000 06110  074550        PBD A,I           OUTPUT =
02117000 06111  000315        LDA AIBFM
02118000 06112  004017        LDB D
02119000 06113  140362        JSM AFBAD,I       GET CHARACTER COUNT
02120000 06114  004000        LDB A
02121000 06115  000314        LDA AIBFX
02122000 06116  030017        STA D
02123000 06117  000305        LDA ASTAK
02124000 06120  140502        JSM ATCHR,I
02125000 06121  000325        LDA ACSTF
02126000 06122  030017        STA D
02127000 06123  000315        LDA AIBFM
02128000 06124  031727        STA T15
02129000 06125  140462        JSM APSTR,I
02130000 06126  005723        LDB T11
02131000 06127  140506        JSM APNUM,I
02132000 06130  000000        NOP
02133000 06131  140445        JSM APNMR,I       PRINT THE VALUE ASSIGNED
02134000 06132  066444        JMP FTR2+1
02135000                        *
02136000 06133  170201  AS1   RET 1
02138000                        *
02139000                        * IF EXECUTION
02140000                        *
02141000 06134  140611  XIF   JSM AGTAD,I       GET OPERAND ADDRESS
02142000 06135  024254        ADB P1
02143000 06136  100001        LDA B,I           LOOK AT MANTISSA
02144000 06137  072037        RZA MLOOP         'TRUE'


02146000                        *
02147000                        * EOL EXECUTION
02148000                        *
02149000 06140  005264  XEOLN LDB LEND
02150000 06141  176202        SBP *+2,C
02151000 06142  067220        JMP XCGSB         GO COMPLETE GOSUB
02152000                        *
02153000 06143  001261  XE0   LDA AP3
02154000 06144  031263        STA AP1
02155000                        *
02156000 06145  034016  XEX   STB C
02157000 06146  074560        WBC A,I
02158000 06147  050053        AND B177          GET WLENGTH
02159000 06150  072431        SZA XE3
02160000 06151  100001        LDA B,I
02161000 06152  051314        AND TE
02162000 06153  050052        AND B200          GET STOPBIT
02163000 06154  072026        RZA XE4
02164000 06155  001255        LDA XCOMM
02165000 06156  061347        IOR INTSR
02166000 06157  072023        RZA XE4
02167000                        *
02168000 06160  034016  XE2   STB C             "CONTINUE" ENTERS HERE
02169000 06161  074560        WBC A,I
02170000 06162  050053        AND B177          GET WLENGTH OF LINE
02171000 06163  072416        SZA XE3
02172000                        *
02173000 06164  035265        STB HERE          SET CURRENT LINE
02174000 06165  020001        ADA B
02175000 06166  031264        STA LEND          SET NEXT LINE
02176000                        *
02177000 06167  101265  LNTRC LDA HERE,I
02178000 06170  051314        AND TE
02179000 06171  031267        STA TRACE         SAVE CURRENT LINE TRACE INFORMATION
02180000 06172  172004        SAP MLOOP
02181000 06173  067207        JMP XE6           GO TRACE LINE #
```

```
02183000                    *
02184000                    * ! EXECUTION
02185000                    *
02186000 06174  001261  XSEMI LDA AP3
02187000 06175  031263        STA AP1           CLEAR TOS
02188000                    *
02189000                    * MAIN LOOP
02190000                    *
02191000 06176  074560  MLOOP WBC A,I           GET BYTE
02192000 06177  022475        ADA ABTBL         ADD JUMP TABLE ORIGIN
02193000 06200  164000        JMP A,I

02195000                    *
02196000                    * RETURN TO CALLER
02197000                    *
02198000 06201  000117  XE3   LDA B40
02199000 06202  040744  XE4   JSM SXCMM         GO SET BITS IN XCOMM
02200000 06203  014334        CPB ADP0
02201000 06204  005317        LDB SWHRE
02202000 06205  035266        STB WHERE
02203000 06206  170201        RET 1

02205000                    *
02206000                    * LINE NUMBER TRACE
02207000                    *
02208000 06207  000016  XE6   LDA C
02209000 06210  031270        STA SAVEC         SAVE C
02210000                    *
02211000 06211  005265        LDB HERE
02212000 06212  140523        JSM AGLNO,I       GET LINE # OF CURRENT LINE
02213000 06213  140476        JSM ATLNI,I       PUT LINE # INTO I/O BUFFER
02214000 06214  000077        LDA B72
02215000 06215  074550        PBD A,I           FOLLOWED BY ":"
02216000 06216  042443        JSM FTR2          GO PRINT I/O BUFFER
02217000 06217  067176        JMP MLOOP
02219000                    *
02220000                    * COMPLETE GOSUB
02221000                    *
02222000 06220  035716  XCGSB STB T6            SAVE JUMP ADDRESS
02223000                    *
02224000 06221  001257        LDA CSTAT
02225000 06222  010254        CPA P1
02226000 06223  043041        JSM FINDB         IN COMPILE BUFFER?
02227000 06224  067227        JMP XCG0          YES
02228000 06225  140516        JSM AREST,I       UNSTACK
02229000 06226  140425        JSM ACNIN,I       INITIALIZE FOR CONTINUE
02230000                    *
02231000 06227  005261  XCG0  LDB AP3
02232000 06230  035263        STB AP1
02233000                    *
02234000 06231  000150        LDA M4            NEED 4 WORDS
02235000 06232  140521        JSM ASTKG,I       GO STACK OLD AP3,AP1
02236000 06233  031470  E38   ASC 1,38          ERROR, GOSUBS NESTED TOO DEEP
02237000                    *
02238000 06234  004257        LDB M1
02239000 06235  070551        PWD B,I           SAVE NULL PARM LIST ON TOS-2
02240000 06236  001257        LDA CSTAT
02241000 06237  073014        SLA XCG1          SKIP IF EXECUTING FROM USER PROGRAM
02242000 06240  005716        LDB T6
02243000 06241  043041        JSM FINDB         IN COMPILE BUFFER?
02244000 06242  067251        JMP *+7           YES
02245000 06243  001257        LDA CSTAT
02246000 06244  010254        CPA P1
02247000 06245  000145        LDA P2
02248000 06246  010144        CPA P3
02249000 06247  000141        LDA P6
02250000 06250  031257        STA CSTAT         UPDATE CSTAT IF NECESSARY
02251000 06251  004334        LDB ADP0
02252000 06252  067257        JMP XCG2          FAKE RETURN ADDRESS
02253000                    *
02254000 06253  005265  XCG1  LDB HERE
02255000 06254  100001        LDA B,I
02256000 06255  050053        AND B177
02257000 06256  024000        ADB A
02258000 06257  070551  XCG2  PWD B,I           SAVE RETURN ADDRESS ON TOS-3
02259000                    *
02260000 06260  005716        LDB T6            RECALL JUMP ADDRESS
02261000 06261  067145        JMP XEX
02263000                    *
02264000                    * RET EXECUTION
02265000                    *
02266000 06262  005263  XRETN LDB AP1
02267000 06263  024254        ADB P1
```

```
02268000 06264  035711          STB T1          SAVE POINTER
02269000                 *
02270000 06265  005261          LDB AP3
02271000 06266  034017          STB D
02272000 06267  070571          WWD B,I         RETRIEVE AP3 LINK
02273000 06270  014257          CPB M1
02274000 06271  067310          JMP E28         ERROR, NO MATCHING GSB
02275000                 *
02276000 06272  025300          ADB AP2
02277000 06273  035261          STB AP3         RESTORE OLD AP3
02278000 06274  070571          WWD B,I
02279000 06275  101711          LDA T1,I        GET LENGTH OF RETURN PARAMETER
02280000 06276  170040          TCA
02281000 06277  031712          STA T2
02282000 06300  024000          ADB A
02283000 06301  025300          ADB AP2
02284000 06302  035263          STB AP1         UPDATED AP1
02285000                 *
02286000 06303  070570          WWD A,I         UDF CALL?
02287000 06304  172402          SAM *+2         NO
02288000 06305  165527          JMP APRET,I     YES, LINK TO UDF ROM
02289000                 *
02290000 06306  070571          WWD B,I         GET RETURN ADDRESS
02291000 06307  067143          JMP XE0
02292000                 *
02293000 06310  140404   E28    JSM AERR1,I     ERROR, RET WITH NO MATCHING GSB
02294000 06311  031070          ASC 1,28
02296000                 *
02297000                 * STACK NUMBER
02298000                 *
02299000 06312  074560   NWEXP  WBC A,I         NUMBER WITH EXPONENT
02300000 06313  170607          SAL 8
02301000 06314  170401          AAR 2
02302000 06315  067317          JMP *+2
02303000 06316  000177   NNEXP  LDA P0          NUMBER WITHOUT EXPONENT
02304000 06317  031713          STA T3
02305000 06320  043052          JSM PHCON
02306000 06321  004144          LDB P3
02307000 06322  070551          PWD B,I         WHERE = RELATIVE 3
02308000 06323  020143          ADA P4
02309000 06324  071603          CLR 4
02310000 06325  001713          LDA T3
02311000 06326  070550          PWD A,I         SET EXPONENT
02312000 06327  074560   NN1    WBC A,I         GET DIGIT PAIR
02313000 06330  010121          CPA B34
02314000 06331  067176          JMP MLOOP
02315000 06332  074550          PBD A,I         STORE IN VALUE
02316000 06333  067327          JMP NN1


02318000                 *
02319000                 * STACK PI
02320000                 *
02321000 06334  043052   XPIE   JSM PHCON
02322000 06335  000144          LDA P3
02323000 06336  070550          PWD A,I         WHERE = RELATIVE 3
02324000 06337  024145          ADB P2
02325000 06340  000173          LDA APIE
02326000 06341  071403          XFR 4           TRANSFER 'PI' TO STACK
02327000 06342  067176          JMP MLOOP


02329000                 *
02330000                 * STACK ENR
02331000                 *
02332000 06343  043047   XENR   JSM PHVAR
02333000 06344  004341          LDB AENR
02334000 06345  070551          PWD B,I         WHERE = IN ENTER REGISTER
02335000 06346  067176          JMP MLOOP
02337000                 *
02338000                 * STACK USER RESULT ADDRESS
02339000                 *
02340000 06347  043047   XARES  JSM PHVAR
02341000 06350  004342          LDB AURES
02342000 06351  070551          PWD B,I         WHERE = IN USER RESULT REGISTER
02343000 06352  067176          JMP MLOOP


02345000                 *
02346000                 * STACK USER RESULT VALUE
02347000                 *
02348000 06353  043052   XVRES  JSM PHCON
02349000 06354  000144          LDA P3
02350000 06355  070550          PWD A,I         WHERE = RELATIVE 3
02351000 06356  024145          ADB P2
```

```
02352000 06357  000342        LDA AURES
02353000 06360  071403        XFR 4              TRANSFER VALUE TO STACK
02354000 06361  067176        JMP MLOOP


02356000                *
02357000                * STACK STRING
02358000                *
02359000 06362  074560  XSTRG WBC A,I            GET CHARACTER COUNT
02360000 06363  031713        STA T3
02361000 06364  020254        ADA P1
02362000 06365  170500        SAR 1
02363000 06366  020143        ADA P4             LENGTH
02364000 06367  004264        LDB STTMP          WHAT = STRING/CONSTANT
02365000 06370  043054        JSM OVTST
02366000 06371  004265        LDB STWHR
02367000 06372  070551        PWD B,I            WHERE = RELATIVE 4 (CHARACTER)
02368000 06373  005713        LDB T3
02369000 06374  070551        PWD B,I            BYTE COUNT
02370000 06375  174040        TCB
02371000 06376  067401        JMP XSTR2
02372000                *
02373000 06377  074560  XSTR1 WBC A,I            MOVE BYTES
02374000 06400  074550        PBD A,I
02375000 06401  076176  XSTR2 RIB XSTR1
02376000 06402  067176        JMP MLOOP
02378000                *
02379000                * STACK SUBSCRIPTED VARIABLE
02380000                *
02381000 06403  023465  XSSVR ADA SSRK           CALCULATE INDEX INTO DATAB
02382000 06404  100000        LDA A,I
02383000 06405  072003        RZA *+3
02384000 06406  140404  E27   JSM AERR1,I        ERROR, UNDEFINED ARRAY
02385000 06407  031067        ASC 1,27
02386000                *
02387000 06410  105263        LDB AP1,I          LOOK AT FIRST OPERAND
02388000 06411  014171        CPB ARRAY
02389000 06412  067470        JMP XS1            JUMP IF 'ENTIRE ARRAY'
02390000                *
02391000 06413  104000        LDB A,I
02392000 06414  035714        STB T4             SAVE #DIMS
02393000 06415  020254        ADA P1
02394000 06416  031271        STA BASE           SAVE INDEX INTO DOPE VECTOR
02395000 06417  140610        JSM ACOUN,I
02396000 06420  010001        CPA B
02397000 06421  067423        JMP *+2
02398000 06422  064733        JMP E32
02399000 06423  011714        CPA T4             # OF NUMERIC PARAMETERS
02400000 06424  067427        JMP *+3
02401000 06425  140404  E25   JSM AERR1,I        ERROR, DIMENSIONS DISAGREE
02402000 06426  031065        ASC 1,25
02403000                *
02404000 06427  000177        LDA P0
02405000 06430  031715  NEXTI STA T5             VARPART
02406000 06431  140612        JSM AGTIN,I        GET SUBSCRIPT
02407000 06432  125271        ADB BASE,I         ADD U[I]
02408000 06433  045271        ISZ BASE
02409000 06434  176432        SBM E26            SKIP IF OUT OF BOUNDS
02410000 06435  035716        STB T6             SAVE Q
02411000 06436  101271        LDA BASE,I         GET D[I]
02412000 06437  045271        ISZ BASE
02413000 06440  174140        CMB
02414000 06441  024000        ADB A              D[I]-Q-1
02415000 06442  176424        SBM E26
02416000                *
02417000 06443  005715        LDB T5             RECALL VARPART
02418000 06444  075617        MPY
02419000 06445  021716        ADA T6             VARPART*D[I]+Q
02420000 06446  173420        SOS E26
02421000 06447  055714        DSZ T4             ANY MORE PLANES?
02422000 06450  067430        JMP NEXTI          YES
02424000 06451  170601        SAL 2              4 WDS/REGISTER
02425000 06452  170040        TCA
02426000 06453  121271        ADA BASE,I         ADD CONSPART
02427000 06454  055263        DSZ AP1
02428000 06455  131263        STA AP1,I          WHERE = IN VALUE TABLE
02429000 06456  000144        LDA P3
02430000 06457  055263        DSZ AP1
02431000 06460  131263        STA AP1,I          LENGTH = 3
02432000 06461  000267        LDA FVRWM
02433000 06462  055263        DSZ AP1
02434000 06463  131263        STA AP1,I          WHAT = FULL/VARIABLE
02435000 06464  067176        JMP MLOOP
02436000                *
```

INTERPRETER

```
02437000 06465  167547  SSRK  ABS DATAB-141B+100000B-IBTBL
02438000                *
02439000 06466  140404  E26   JSM AERR1,I      ERROR, OUT OF BOUNDS
02440000 06467  031066        ASC 1,26

02442000 06470  104000  XS1   LDB A,I          IT WAS 'ENTIRE ARRAY'
02443000 06471  174600        SBL 1
02444000 06472  020254        ADA P1
02445000 06473  020001        ADA B            A = LOCATION OF ORGANIZATION DATA
02446000 06474  005263        LDB AP1
02447000 06475  024145        ADB P2
02448000 06476  104001        LDB B,I
02449000 06477  076402        SZB *+2
02450000 06500  064733        JMP E32
02451000                *
02452000 06501  005263        LDB AP1
02453000 06502  024145        ADB P2
02454000 06503  071401        XFR 2            TRANSFER 'ENTIRE ARRAY' INFORMATION
02455000 06504  100001        LDA B,I
02456000 06505  020144        ADA P3
02457000 06506  130001        STA B,I          POINT TO END OF AREA
02458000 06507  067176        JMP MLOOP


02460000                *
02461000                * STACK SIMPLE VARIABLE
02462000                *
02463000 06510  023521  XSVAR ADA SVRK         CALCULATE INDEX INTO DVTAB
02464000 06511  031271        STA BASE
02465000 06512  105271        LDB BASE,I       RECALL DVTAB ENTRY
02466000 06513  014177        CPB P0
02467000 06514  042033        JSM ALLO4        CALL ALLOCATOR IF UNALLOCATED
02468000 06515  043047        JSM PHVAR
02469000 06516  105271        LDB BASE,I
02470000 06517  070551        PWD B,I          WHERE = IN VALUE TABLE
02471000 06520  067176        JMP MLOOP
02472000                *
02473000 06521  167555  SVRK  ABS DVTAB-101B+100000B-IBTBL
02475000                *
02476000                * UNARY OPERATORS
02477000                *
02478000 06522  140524  XUNM  JSM AUNM,I
02479000 06523  067565        JMP RAPUP        WRAP UP
02480000                *
02481000 06524  140531  XSQR  JSM ASQR,I
02482000 06525  067565        JMP RAPUP        WRAP UP
02483000                *
02484000 06526  140543  XNOT  JSM ANOT,I
02485000 06527  067565        JMP RAPUP        WRAP UP

02487000                *
02488000                * BINARY OPERATORS
02489000                *
02490000 06530  140544  XPRND JSM APRND,I
02491000 06531  067565        JMP RAPUP        WRAP UP
02492000                *
02493000 06532  140545  XDRND JSM ADRND,I
02494000 06533  067565        JMP RAPUP        WRAP UP
02495000                *
02496000 06534  140540  XAND  JSM AAND,I
02497000 06535  067565        JMP RAPUP        WRAP UP
02498000                *
02499000 06536  140541  XLOR  JSM AOR,I
02500000 06537  067565        JMP RAPUP        WRAP UP
02501000                *
02502000 06540  140542  XXOR  JSM AXOR,I
02503000 06541  067565        JMP RAPUP        WRAP UP
02504000                *
02505000 06542  140533  XGTN  JSM AGT,I
02506000 06543  067565        JMP RAPUP        WRAP UP
02507000                *
02508000 06544  140536  XEQL  JSM AEQ,I
02509000 06545  067565        JMP RAPUP        WRAP UP
02510000                *
02511000 06546  140534  XLTN  JSM ALT,I
02512000 06547  067565        JMP RAPUP        WRAP UP
02513000                *
02514000 06550  140532  XGEQ  JSM AGE,I
02515000 06551  067565        JMP RAPUP        WRAP UP
02516000                *
02517000 06552  140535  XLEQ  JSM ALE,I
02518000 06553  067565        JMP RAPUP        WRAP UP
02519000                *
```

INTERPRETER

```
02520000 06554  140537  XNEQ  JSM ANE,I
02521000 06555  067565        JMP RAPUP          WRAP UP
02522000                *
02523000 06556  140530  XDIV  JSM ADIV,I
02524000 06557  067565        JMP RAPUP          WRAP UP
02525000                *
02526000 06560  140526  XSUB  JSM ASUB,I
02527000 06561  067565        JMP RAPUP          WRAP UP
02528000                *
02529000 06562  140527  XMPY  JSM AMUL,I
02530000 06563  067565        JMP RAPUP          WRAP UP
02531000                *
02532000 06564  140525  XADD  JSM AADD,I
02533000                *
02534000                *                        FALL THRU TO WRAP UP
02535000                *
02536000                * WRAP UP MATH OPERATIONS
02537000                *
02538000 06565  043052  RAPUP JSM PHCON
02539000 06566  000144        LDA P3
02540000 06567  070550        PWD A,I            WHERE = RELATIVE 3
02541000                *
02542000 06570  001752        LDA RES
02543000 06571  050164        AND M64
02544000 06572  010263        CPA FLAG           TEST FOR EXPONENT = -512
02545000 06573  143601        JSM E77,I
02546000 06574  004017        LDB D
02547000 06575  024254        ADB P1
02548000 06576  000340        LDA ARES
02549000 06577  071403        XFR 4
02550000 06600  067176        JMP MLOOP
02551000                *
02552000 06601  014000  E77   DEF 14000B

02554000                *
02555000                * NUMERIC ASSIGNMENT
02556000                *
02557000 06602  040615  XASN  JSM ABSAD
02558000 06603  031263        STA AP1            UPDATE AP1
02559000 06604  035712        STB T2             "TO" ADDRESS
02560000 06605  101276        LDA SAVEB,I
02561000 06606  170513        SAR 12
02562000 06607  010136        CPA P9
02563000 06610  067613        JMP *+3
02564000 06611  140404  E33   JSM AERR1,I        ERROR, STORE INTO ILLEGAL OPERAND
02565000 06612  031463        ASC 1,33
02566000                *
02567000 06613  101263        LDA AP1,I          LOOK AT "FROM" TYPE
02568000 06614  050221        AND B70K
02569000 06615  010175        CPA B10K
02570000 06616  067620        JMP *+2
02571000 06617  067611        JMP E33            ERROR, ILLEGAL DATA TYPE
02572000                *
02573000 06620  040615        JSM ABSAD          GET "FROM" ADDRESS
02574000 06621  000001        LDA B
02575000 06622  005712        LDB T2
02576000 06623  043077        JSM ASTRC          GO TRACE ASSIGNMENT
02577000 06624  067176        JMP MLOOP
02579000                *
02580000                * EXECUTE DIM OPERATOR
02581000                *
02582000 06625  074560  DIMOP WBC A,I            READ NEXT BYTE
02583000 06626  010141        CPA STRID
02584000 06627  067765        JMP DMSTR          GO DIM STRING
02585000                *
02586000 06630  020166        ADA M97
02587000 06631  172011        SAP D11            SKIP IF ARRAY VARIABLE
02588000                *
02589000                * SECTION FOR SIMPLE VARIABLE
02590000                *
02591000 06632  020343        ADA SVRE           CALCULATE INDEX INTO DVTAB
02592000 06633  031271        STA BASE
02593000 06634  105271        LDB BASE,I         RECALL DVTAB ENTRY
02594000 06635  076403        SZB *+3
02595000 06636  140404  E23   JSM AERR1,I        ERROR, SIMPLE VARIABLE
02596000 06637  031063        ASC 1,23
02597000                *
02598000 06640  042033        JSM ALLO4          CALL ALLOCATOR IF UNALLOCATED
02599000 06641  067760        JMP CLNUP
02600000                *
02601000                * SECTION FOR ARRAY VARIABLE
02602000                *
02603000 06642  020277  D11   ADA ADATB          CALCULATE INDEX INTO DATAB
02604000 06643  031271        STA BASE
```

```
02605000 06644  105271        LDB BASE,I     RECALL DATAB ENTRY
02606000 06645  076403        SZB *+3
02607000 06646  140404  E24   JSM AERR1,I    ERROR, ARRAY ALREADY DIMENSIONED
02608000 06647  031064        ASC 1,24
02609000                *
02610000 06650  000254        LDA P1
02611000 06651  031715        STA T5         S
02612000 06652  031716        STA T6         #DIMS
02613000 06653  004305        LDB ASTAK      INDEX INTO CSTAK (WORK AREA)
02614000 06654  034017        STB D
02615000                *
02616000 06655  101263  DI2   LDA AP1,I      LINK BIT INFORMATION
02617000 06656  031717        STA T7
02618000 06657  140612        JSM AGTIN,I    GET SUBSCRIPT
02619000 06660  035720        STB T8         U
02620000 06661  001717        LDA T7         RECALL LINK BIT INFORMATION
02621000 06662  170604        SAL 5
02622000 06663  172403        SAM *+3        SKIP IF LOWER BOUND SUPPLIED
02623000 06664  004257        LDB M1         ELSE USE DEFAULT
02624000 06665  067670        JMP *+3
02625000 06666  140612        JSM AGTIN,I    GET SUBSCRIPT
02626000 06667  174040        TCB            -L
02627000 06670  070551        PWD B,I        SAVE U[I]
02628000 06671  025720        ADB T8
02629000 06672  024254        ADB P1         U-L+1
02630000 06673  070551        PWD B,I        SAVE D[I]
02631000 06674  035720        STB T8         D
02633000 06675  001720        LDA T8         RECALL D
02634000 06676  020257        ADA M1         U-L
02635000 06677  173402        SOS *+2
02636000 06700  172002        SAP *+2
02637000 06701  067773  E22A  JMP E22        ERROR, ILLEGAL DIM SPEC
02638000                *
02639000 06702  001715        LDA T5         RECALL S
02640000 06703  075617        MPY
02641000 06704  031715        STA T5         S = S*D
02642000 06705  172421        SAM E39B
02643000 06706  076020        RZB E39B
02644000                *
02645000 06707  001717        LDA T7         RECALL LINK BIT INFORMATION
02646000 06710  170603        SAL 4
02647000 06711  172003        SAP *+3        SKIP IF END OF SPECS
02648000 06712  045716        ISZ T6         INCREMENT #DIMS
02649000 06713  067655        JMP DI2
02650000                *
02651000 06714  001716        LDA T6
02652000 06715  170600        SAL 1
02653000 06716  020144        ADA P3         2*#DIMS+3
02654000 06717  031717        STA T7         SIZE OF DOPE VECTOR
02655000                *
02656000 06720  001715        LDA T5
02657000 06721  004143        LDB P4
02658000 06722  075617        MPY
02659000 06723  031715        STA T5         SIZE OF VALUE AREA
02660000 06724  172402        SAM *+2
02661000 06725  076403        SZB *+3
02662000 06726  140404  E39B  JSM AERR1,I    ERROR, INSUFFICIENT MEMORY
02663000 06727  031471        ASC 1,39
02664000                *
02665000 06730  021717        ADA T7
02666000 06731  170040        TCA
02667000 06732  140370        JSM ALLOC,I    REQUEST THE SPACE
02668000 06733  030017        STA D          SAVE START OF AREA
02669000 06734  131271        STA BASE,I     SET DATAB ENTRY
02670000 06735  005716        LDB T6         #DIMS
02671000 06736  134000        STB A,I
02672000 06737  021717        ADA T7
02673000 06740  031717        STA T7         START OF VALUE AREA
02674000 06741  031312        STA VT2        UPDATE VT2
02675000 06742  174600        SBL 1
02676000 06743  174040        TCB
02677000 06744  035714        STB T4         COUNTER FOR TRANSFER
02678000 06745  004324        LDB ASTK1      RECALL ADDRESS OF WORK AREA
02679000 06746  100001  DI3   LDA B,I        MOVE A U-D PAIR
02680000 06747  070550        PWD A,I
02681000 06750  045714        ISZ T4
02682000 06751  076175        RIB DI3
02683000                *
02684000 06752  001717        LDA T7         CONSPART
02685000 06753  021715        ADA T5
02686000 06754  020150        ADA M4
02687000 06755  070550        PWD A,I
02688000 06756  001715        LDA T5         SIZE OF VALUE AREA
```

INTERPRETER

```
02689000 06757  070550             PWD A,I
02690000                    *
02691000 06760  074560  CLNUP WBC A,I           LOOK AT NEXT BYTE
02692000 06761  010107        CPA B54
02693000 06762  067764        JMP *+2           IGNORE ,1
02694000 06763  074760        WBC A,D
02695000 06764  067174        JMP XSEMI         CLEAR TOS AND CONTINUE

02697000                * 
02698000                * LINK TO DIM STRING
02699000                *
02700000 06765  020326  DMSTR ADA STRK
02701000 06766  104000        LDB A,I
02702000 06767  076404        SZB E22           ERROR, ROM MISSING
02703000 06770  000056        LDA B174
02704000 06771  104001        LDB B,I
02705000 06772  164001        JMP B,I
02706000                *
02707000 06773  140404  E22   JSM AERR1,I       ERROR, NO STRING ROM
02708000 06774  031062        ASC 1,22
02710000                *
02711000                * JMP
02712000                *
02713000 06775  007014  XJMP  LDB M33
02714000 06776  040740        JSM CLXCM         CLEAR XCOMM BIT 5
02715000 06777  140612        JSM AGTIN,I       GET INTEGER PARAMETER
02716000 07000  000001        LDA B
02717000 07001  005265        LDB HERE
02718000 07002  043015        JSM RELGO         EXECUTE SKIP
02719000 07003  001264        LDA LEND
02720000 07004  172402        SAM *+2           TEST FOR IMMEDIATELY PREVIOUS GSB
02721000 07005  067143        JMP XEO
02722000 07006  067220        JMP XCGSB

02724000                *
02725000                * FLAG
02726000                *
02727000 07007  140612  XFLG  JSM AGTIN,I       GET INTEGER PARAMETER
02728000 07010  176413        SBM E35           SKIP IF #<0
02729000 07011  024160        ADB M16
02730000 07012  176011        SBP E35           SKIP IF #>15
02731000 07013  000340        LDA ARES
02732000 07014  071603        CLR 4             CLEAR 'RES'
02733000 07015  042405        JSM EXEB
02734000 07016  051506        AND FLAGS         TEST THE DESIGNATED FLAG
02735000 07017  072403        SZA *+3
02736000 07020  000175        LDA B10K
02737000 07021  031753        STA RES+1         RES = 0 OR 1
02738000 07022  067565        JMP RAPUP
02739000                *
02740000 07023  140404  E35   JSM AERR1,I       ERROR, ILLEGAL FLAG REFERENCE
02741000 07024  031465        ASC 1,35

02743000                *
02744000                * SKIP LABEL
02745000                *
02746000 07025  074561  XLABL WBC B,I           GET LENGTH OF STRING
02747000 07026  174040        TCB
02748000 07027  066031        JMP XL1
02749000                *
02750000 07030  074560        WBC A,I           SKIP BYTES OF STRING
02751000 07031  076177  XL1   RIB *-1
02752000 07032  067176        JMP MLOOP

02754000                *
02755000                * ALLOCATE SIMPLE VARIABLE, FULL PRECISION
02756000                *
02757000 07033  000150  ALLO4 LDA M4
02758000 07034  140370        JSM ALLOC,I       MOVE MEMORY UP
02759000 07035  131271        STA BASE,I        UPDATE DVTAB
02760000 07036  170201        RET 1
02762000                *
02763000                * GTO AND GSB EXECUTION
02764000                *
02765000 07037  000263  XAGSB LDA FLAG          ABSOLUTE GSB
02766000 07040  066042        JMP *+2
02767000 07041  000177  XAGTO LDA P0            ABSOLUTE GTO
02768000 07042  031715        STA T5
02769000 07043  000257        LDA M1            INDICATE FORWARD
02770000 07044  031716        STA T6
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02771000 07045  005307              LDB FWUP          INDICATE ABSOLUTE
02772000 07046  066063              JMP XFER
02773000                     *
02774000 07047  000263       XPGSB  LDA FLAG          + GSB
02775000 07050  066052              JMP *+2
02776000 07051  000177       XPGTO  LDA P0            + GTO
02777000 07052  031715              STA T5
02778000 07053  000257              LDA M1            INDICATE FORWARD
02779000 07054  066061              JMP XM1
02780000                     *
02781000 07055  000263       XMGSB  LDA FLAG          - GSB
02782000 07056  066060              JMP *+2
02783000 07057  000177       XMGTO  LDA P0            - GTO
02784000 07060  031715              STA T5
02785000 07061  031716       XM1    STA T6
02786000 07062  005265              LDB HERE          INDICATE RELATIVE
02787000                     *
02788000 07063  035717       XFER   STB T7
02789000 07064  074560              WBC A,I           GET HI-SPEED WORD
02790000 07065  170607              SAL 8
02791000 07066  074561              WBC B,I
02792000 07067  024000              ADB A
02793000 07070  076410              SZB LOWSP         SKIP IF SEARCH NEEDED
02794000                     *
02795000                     * THIS SECTION DOES A HI-SPEED BRANCH
02796000                     *
02797000 07071  035264              STB LEND          SET GTO/GSB FLAG
02798000 07072  074560              WBC A,I
02799000 07073  010116              CPA B42           ALPHA?
02800000 07074  066025              JMP XLABL         YES
02801000 07075  074560              WBC A,I           NO, SKIP PAST INTEGER
02802000 07076  074560              WBC A,I
02803000 07077  067176              JMP MLOOP
02804000                     *
02805000                     * THIS SECTION DOES A LOW-SPEED BRANCH
02806000                     *
02807000 07100  007014       LOWSP  LDB M33
02808000 07101  040740              JSM CLXCM         CLEAR XCOMM BIT 5
02809000 07102  000016              LDA C             SAVE C FOR LATER FILL-IN
02810000 07103  031720              STA T8            OF HI-SPEED BRANCH ADDRESS
02811000 07104  074560              WBC A,I
02812000 07105  010114              CPA B44           NUMERIC?
02813000 07106  066112              JMP FINON         YES
02814000                     *
02815000 07107  074560              WBC A,I           GET BYTE COUNT
02816000 07110  042164              JSM FINDL         FIND LABELED LINE
02817000 07111  066122              JMP CN1
02819000                     *
02820000                     * SCAN FOR A LINE NUMBER
02821000                     *
02822000 07112  074560       FINON  WBC A,I           GET INTEGER
02823000 07113  170607              SAL 8
02824000 07114  074561              WBC B,I
02825000 07115  060001              IOR B
02826000 07116  045716              ISZ T6            TEST DIRECTION OF SEARCH
02827000 07117  170040              TCA
02828000 07120  005717              LDB T7
02829000 07121  043015              JSM RELGO
02830000                     *
02831000                     * FINAL PROCESSING
02832000                     *
02833000 07122  001257       CN1    LDA CSTAT
02834000 07123  010142              CPA P5
02835000 07124  067012              JMP E9            ERROR, WRONG CONTROL STATE
02836000                     *
02837000 07125  025715              ADB T5            INCLUDE GTO/GSB FLAG
02838000 07126  035264              STB LEND
02839000 07127  176425              SBM CN2           SKIP IF GSB
02840000 07130  010144              CPA P3
02841000 07131  067012              JMP E9            ERROR, WRONG CONTROL STATE
02842000 07132  010254              CPA P1
02843000 07133  043041              JSM FINDB         IN COMPILE BUFFER?
02844000 07134  066154              JMP CN2           YES
02845000 07135  000117              LDA B40           SET STOP BIT
02846000 07136  040744              JSM SXCMM
02847000 07137  001232              LDA CSTMP+12
02848000 07140  170501              SAR 2             TEST RUN-DONE BIT
02849000 07141  073405              RLA *+5
02850000 07142  140425              JSM ACNIN,I       CONTINUE INITIALIZATION
02851000 07143  004303              LDB ACBF
02852000 07144  035265              STB HERE
02853000 07145  140515              JSM ASTKI,I       DUMMY STACK FOR C.S.
02854000 07146  005264              LDB LEND
02855000 07147  035317              STB SWHRE
02856000 07150  001232              LDA CSTMP+12
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INTERPRETER

```
07151  050207        AND M10          CLEAR BITS 0 AND 3 OF JB'S CFLAG
07152  031232        STA CSTMP+12     (FETCH AND STEP BITS)
07153  140523        JSM AGLNO,I
07154  001257  CN2   LDA CSTAT
07155  073406        RLA *+6          DON'T FILL IN H.S. ADDRESS
07156  001720        LDA T8           RECALL PROGRAM LOCATION
07157  030017        STA D
07160  074751        PBD B,D          FILL IN HI-SPEED ADDRESS
07161  174407        ABR 8
07162  074751        PBD B,D
07163  067176        JMP MLOOP
               *
               * SUBROUTINE TO SCAN FOR AN ALPHAMERIC LABEL
               *
               * ON ENTRY: A = BYTE COUNT
               *                 C = POINTER TO FIRST BYTE
               *
               * TEMPORARIES USED: T1,T2,T3,T4,T9
               *
07164  031711  FINDL STA T1           SAVE BYTE COUNT
07165  000016        LDA C
07166  031721        STA T9           SAVE START OF REAL CHARACTERS
07167  005307        LDB FWUP         NOW SCAN PROGRAM
07170  035712  FN2   STB T2
07171  034017        STB D
07172  074570        WBD A,I
07173  050053        AND B177
07174  072002        RZA *+2
07175  067040        JMP E31          ERROR, END OF PROGRAM
07176  031713        STA T3           SAVE LENGTH OF THIS LINE
07177  074570        WBD A,I
07200  010115        CPA B43          DOES LABEL FOLLOW?
07201  066203        JMP *+2          YES
07202  066223        JMP FN5          NO
07203  074570        WBD A,I          GET BYTE COUNT
07204  011711        CPA T1           SAME LENGTH?
07205  066207        JMP *+2          YES
07206  066223        JMP FN5          NO
07207  010177        CPA P0           BOTH LABELS NULL?
07210  066221        JMP FN4          YES
07211  031714        STA T4           NO, INITIALIZE COMPARE-COUNTER
07212  074560  FN3   WBC A,I          REAL BYTE
07213  074571        WBD B,I          TEST BYTE
07214  010001        CPA B            MATCH?
07215  066217        JMP *+2          YES
07216  066223        JMP FN5          NO
07217  055714        DSZ T4           DECREMENT COMPARISON COUNTER
07220  066212        JMP FN3
               *
07221  005712  FN4   LDB T2           FOUND IT
07222  170201        RET 1
               *
07223  005712  FN5   LDB T2           NOT FOUND YET
07224  025713        ADB T3
07225  001721        LDA T9
07226  030016        STA C            RESTORE REAL BYTE POINTER
07227  066170        JMP FN2
               *
               * SUBROUTINE TO CHANGE STOP AND/OR TRACE INDICATOR BITS
               *
07230  000257        LDA M1
07231  031716  XSHT  STA T6
07232  035717        STB T7
07233  101263        LDA AP1,I
07234  031714        STA T4           SAVE LINK INFORMATION
07235  140612        JSM AGTIN,I      GET INTEGER PARAMETER
07236  176434        SRM E19
07237  035715        STB T5           SAVE FIRST PARAMETER
07240  001714        LDA T4           RECALL LINK INFORMATION
07241  170603        SAL 4
07242  172004        SAP GE1          SKIP IF DEFAULT SECOND PARAMETER
07243  140612        JSM AGTIN,I      GET INTEGER PARAMETER
07244  176426        SBM E19
07245  066247        JMP *+2
07246  005715  GE1   LDB T5
07247  001715        LDA T5
07250  170140        CMA
07251  020001        ADA B
07252  172020        SAP E19
07253  031715        STA T5           -# OF LINES
07254  000001        LDA B
07255  005307        LDB FWUP
07256  043015        JSM RELGO        GO FIND THE LINE
               *
```

```
02943000 07257  100001  XSNT1 LDA B,I
02944000 07260  051716        AND T6
02945000 07261  061717        IOR T7
02946000 07262  130001        STA B,I
02947000 07263  045715        ISZ T5             ANY MORE LINES TO BE DONE?
02948000 07264  066266        JMP *+2            YES
02949000 07265  067176        JMP MLOOP          NO
02950000                *
02951000 07266  050053        AND B177           GET WLENGTH
02952000 07267  072476        SZA *-2            END OF PROGRAM
02953000 07270  024000        ADB A
02954000 07271  066257        JMP XSNT1
02955000                *
02956000 07272  140404  E19   JSM AERR1,I        ERROR, BAD LINE NUMBER
02957000 07273  030471        ASC 1,19
02959000                *
02960000                * NOR EXECUTION
02961000                *
02962000 07274  105263  XNOR  LDB AP1,I          LOOK AT TOS
02963000 07275  014221        CPB EMPTY
02964000 07276  066302        JMP XNO2           JUMP IF NO PARAMETERS
02965000                *
02966000 07277  000213        LDA TMASK
02967000 07300  004177        LDB P0
02968000 07301  066231        JMP XSNT           GO CHANGE BITS
02969000                *
02970000 07302  000177  XNO2  LDA P0
02971000 07303  031267        STA TRACE
02972000 07304  031314        STA TE             DISABLE TRACING
02973000 07305  067176        JMP MLOOP


02975000                *
02976000                * STP EXECUTION
02977000                *
02978000 07306  105263  XSTP  LDB AP1,I          LOOK AT TOS
02979000 07307  014221        CPB EMPTY
02980000 07310  066316        JMP XST2           JUMP IF NO PARAMETERS
02981000                *
02982000 07311  040724        JSM SECCK          CHECK FOR SECURE PROGRAM
02983000 07312  000251        LDA UMASK
02984000 07313  031314        STA TE             ENABLE TRACING
02985000 07314  004052        LDB B200
02986000 07315  066230        JMP XSNT-1         GO CHANGE BITS
02987000                *
02988000 07316  000073  XST2  LDA B100
02989000 07317  040744        JSM SXCMM
02990000 07320  067176        JMP MLOOP


02992000                *
02993000                * TRC EXECUTION
02994000                *
02995000 07321  000251  XTRC  LDA UMASK
02996000 07322  031314        STA TE             ENABLE TRACING
02997000 07323  105263        LDB AP1,I          LOOK AT TOS
02998000 07324  014221        CPB EMPTY
02999000 07325  067176        JMP MLOOP          JUMP IF NO PARAMETERS
03000000                *
03001000 07326  040724        JSM SECCK          CHECK FOR SECURE PROGRAM
03002000 07327  004263        LDB FLAG
03003000 07330  066230        JMP XSNT-1         GO CHANGE BITS
03005000 07331  007460  FK1   DEF MFLAG
03006000 07332  007467  FK2   DEF SFLAG
03007000 07333  007471  FK3   DEF CFLAG


03009000                *
03010000                * COMPLEMENT FLAG
03011000                *
03012000 07334  001506  XCMF  LDA FLAGS
03013000 07335  105263        LDB AP1,I
03014000 07336  014221        CPB EMPTY
03015000 07337  066356        JMP ALLF1          JUMP IF ALL FLAGS
03016000                *
03017000 07340  006331        LDB FK1
03018000 07341  066362        JMP ALTER


03020000                *
03021000                * SET FLAG
03022000                *
03023000 07342  000257  XSFG  LDA M1
03024000 07343  105263        LDB AP1,I
03025000 07344  014221        CPB EMPTY
```

```
03026000 07345  066357              JMP ALLF2           JUMP IF ALL FLAGS
03027000                      *
03028000 07346  006332              LDB FK2
03029000 07347  066362              JMP ALTER


03031000                      *
03032000                      * CLEAR FLAG
03033000                      *
03034000 07350  000177  XCFG  LDA P0
03035000 07351  105263              LDB AP1,I
03036000 07352  014221              CPB EMPTY
03037000 07353  066357              JMP ALLF2           JUMP IF ALL FLAGS
03038000                      *
03039000 07354  006333              LDB FK3
03040000 07355  066362              JMP ALTER
03041000                      *
03042000 07356  170140  ALLF1 CMA
03043000 07357  031506  ALLF2 STA FLAGS
03044000 07360  042415              JSM FCHEK           GO CHECK FOR FLAG TRACING
03045000 07361  067176              JMP MLOOP
03047000 07362  035714  ALTER STB T4              SAVE SUBROUTINE ADDRESS
03048000 07363  000177              LDA P0
03049000 07364  031715              STA T5              INITIALIZE FLAG MASK
03050000                      *
03051000 07365  101263  NEXTF LDA AP1,I
03052000 07366  031716              STA T6              SAVE LINK INFORMATION
03053000 07367  140612              JSM AGTIN,I         GET INTEGER PARAMETER
03054000 07370  176414              SBM E35A            SKIP IF #<0
03055000 07371  024160              ADB M16
03056000 07372  176012              SBP E35A            SKIP IF #>15
03057000 07373  042405              JSM EXEB            POSITION MASK BIT
03058000 07374  061715              IOR T5
03059000 07375  031715              STA T5
03060000 07376  005716              LDB T6              RECALL LINK INFORMATION
03061000 07377  174603              SBL 4
03062000 07400  176465              SBM NEXTF           SKIP IF MORE PARAMETERS
03063000 07401  141714              JSM T4,I            GO CHANGE FLAGS
03064000 07402  042415              JSM FCHEK           GO CHECK FOR FLAG TRACING
03065000 07403  067176              JMP MLOOP
03066000                      *
03067000 07404  066023  E35A  JMP E35             ERROR, ILLEGAL FLAG MODIFIER REF


03069000                      *
03070000                      * SUBROUTINE TO FORM ROTATE INSTRUCTION AND EXECUTE IT
03071000                      *
03072000 07405  024242  EXEB  ADB KF
03073000 07406  000254              LDA P1
03074000 07407  070430              DIR                 PREVENT INTERRUPT INTERFERENCE
03075000 07410  070001              EXE B
03076000 07411  070420              EIR
03077000 07412  170201              RET 1
03079000                      *
03080000                      * SUBROUTINE TO CHECK FOR FLAG TRACING
03081000                      *
03082000 07413  042405  SYSFL JSM EXEB            SPECIAL ENTRY TO SET A SYSTEM FLAG
03083000 07414  042467              JSM SFLAG
03084000                      *
03085000 07415  001267  FCHEK LDA TRACE           TRACING ENABLED?
03086000 07416  172031              SAP FTR3            NO
03087000                      *
03088000 07417  000016              LDA C
03089000 07420  031270              STA SAVEC
03090000 07421  140450              JSM ACLBI,I         CLEAR I/O BUFFER
03091000 07422  002450              LDA FMSG
03092000 07423  004313              LDB AIBUF
03093000 07424  071406              XFR 7               "FLAGS:" MESSAGE
03094000 07425  140444              JSM A.PRN,I         GO PRINT IT
03095000 07426  140450              JSM ACLBI,I         CLEAR I/O BUFFER
03096000 07427  000160              LDA M16
03097000 07430  031713              STA T3              INITIALIZE COUNTER
03098000 07431  004315              LDB AIBFM
03099000 07432  034017              STB D               INITIALIZE BUFFER POINTER
03100000 07433  001506              LDA FLAGS
03101000 07434  004103  FTR1  LDB B60             ASSUME FLAG IS 'ZERO'
03102000 07435  172002              SAP *+2
03103000 07436  004102              LDB B61             NOPE, FLAG IS 'ONE'
03104000 07437  074551              PBD B,I
03105000 07440  170716              RAR 15
03106000 07441  045713              ISZ T3              TEST LOOP COUNTER
03107000 07442  066434              JMP FTR1
03108000                      *
03109000 07443  140444  FTR2  JSM A.PRN,I         GO PRINT FLAG CONFIGURATION
03110000 07444  040710              JSM EOLIO
```

```
03111000 07445  001270        LDA SAVEC
03112000 07446  030016        STA C
03113000 07447  170201  FTR3  RET 1            DONE!
03114000                *
03115000 07450  007451  FMSG  DEF *+1
03116000 07451  043114        ASC 7,FLAGS:  (0-15)
03118000                *
03119000                * SUBROUTINE TO COMPLEMENT DESIGNATED FLAG
03120000                *
03121000                * ON ENTRY:  A-REGISTER HAS FLAG MASK
03122000                *
03123000 07460  061506  MFLAG IOR FLAGS
03124000 07461  004000        LDB A
03125000 07462  001506        LDA FLAGS
03126000 07463  051715        AND T5
03127000 07464  170140        CMA
03128000 07465  050001        AND B
03129000 07466  066473        JMP C1


03131000                *
03132000                * SUBROUTINE TO SET DESIGNATED FLAG
03133000                *
03134000                * ON ENTRY:  A-REGISTER HAS FLAG MASK
03135000                *
03136000 07467  061506  SFLAG IOR FLAGS
03137000 07470  066473        JMP C1


03139000                *
03140000                * SUBROUTINE TO CLEAR DESIGNATED FLAG
03141000                *
03142000                * ON ENTRY:  A-REGISTER HAS FLAG MASK
03143000                *
03144000 07471  170140  CFLAG CMA
03145000 07472  051506        AND FLAGS
03146000 07473  031506  C1    STA FLAGS
03147000 07474  170201        RET 1
03149000 07475  107476  ABTBL DEF IBTBL,I      ADDRESS OF JUMP TABLE
03150000                *
03151000 07476  100424  IBTBL DEF ASYER,I 000
03152000 07477  027755        DEF CALLM   001 ROM #1
03153000 07500  027755        DEF CALLM   002 ROM #2
03154000 07501  027755        DEF CALLM   003 ROM #3
03155000 07502  027755        DEF CALLM   004 ROM #4
03156000 07503  027755        DEF CALLM   005 ROM #5
03157000 07504  027755        DEF CALLM   006 ROM #6
03158000 07505  027755        DEF CALLM   007 ROM #7
03159000 07506  027755        DEF CALLM   010 ROM #8
03160000 07507  027755        DEF CALLM   011 ROM #9
03161000 07510  027755        DEF CALLM   012 ROM #10
03162000 07511  027755        DEF CALLM   013 ROM #11
03163000 07512  027755        DEF CALLM   014 ROM #12
03164000 07513  027755        DEF CALLM   015 ROM #13
03165000 07514  027755        DEF CALLM   016 ROM #14
03166000 07515  027755        DEF CALLM   017 ROM #15
03167000 07516  027755        DEF CALLM   020 ROM #16
03168000 07517  027755        DEF CALLM   021 ROM #17
03169000 07520  027755        DEF CALLM   022 ROM #18
03170000 07521  100424        DEF ASYER,I 023
03171000 07522  100424        DEF ASYER,I 024
03172000 07523  100424        DEF ASYER,I 025
03173000 07524  100424        DEF ASYER,I 026
03174000 07525  100424        DEF ASYER,I 027
03175000 07526  100424        DEF ASYER,I 030
03176000 07527  100424        DEF ASYER,I 031
03177000 07530  100424        DEF ASYER,I 032
03178000 07531  100424        DEF ASYER,I 033
03179000 07532  100424        DEF ASYER,I 034 END OF #
03180000 07533  100424        DEF ASYER,I 035
03181000 07534  100424        DEF ASYER,I 036
03182000 07535  006562        DEF XMPY    037 I*
03183000 07536  100424        DEF ASYER,I 040
03184000 07537  100424        DEF ASYER,I 041
03185000 07540  006362        DEF XSTR    042 STRING FOLLOWS
03186000 07541  007025        DEF XLA     043 LABEL FOLLOWS
03187000 07542  100424        DEF ASYER,I 044
03188000 07543  100424        DEF ASYER,I 045
03189000 07544  100424        DEF ASYER,I 046
03190000 07545  100424        DEF ASYER,I 047
03191000 07546  100424        DEF ASYER,I 050
03192000 07547  100424        DEF ASYER,I 051
03193000 07550  006562        DEF XMPY    052 *
03194000 07551  006564        DEF XADD    053 +
03195000 07552  015446        DEF XCOMA   054 ,1
```

INTERPRETER

```
03196000 07553  006560          DEF XSUB     055 -
03197000 07554  006522          DEF XUNM     056 U-
03198000 07555  006556          DEF XDIV     057 /
03199000 07556  006316          DEF NNEXP    060 F-NUMBER
03200000 07557  006316          DEF NNEXP    061 E-NUMBER
03201000 07560  006312          DEF NWEXP    062 F-NUMBER W/EXP
03202000 07561  006312          DEF NWEXP    063 E-NUMBER W/EXP
03203000 07562  015446          DEF XCOMA    064 ,2
03204000 07563  100424          DEF ASYER,I  065
03205000 07564  100424          DEF ASYER,I  066
03206000 07565  100424          DEF ASYER,I  067
03207000 07566  100424          DEF ASYER,I  070
03208000 07567  100424          DEF ASYER,I  071
03209000 07570  015444          DEF XCOLN    072 :
03210000 07571  006174          DEF XSEMI    073 ;
03211000 07572  100424          DEF ASYER,I  074
03212000 07573  006174          DEF XSEMI    075 LABEL :
03213000 07574  100424          DEF ASYER,I  076
03214000 07575  006347          DEF XARES    077 RES (ADDRESS)
03215000 07576  100424          DEF ASYER,I  100 LITERAL
03216000 07577  006510          DEF XSVAR    101 A
03217000 07600  006510          DEF XSVAR    102 B
03218000 07601  006510          DEF XSVAR    103 C
03219000 07602  006510          DEF XSVAR    104 D
03220000 07603  006510          DEF XSVAR    105 E
03221000 07604  006510          DEF XSVAR    106 F
03222000 07605  006510          DEF XSVAR    107 G
03223000 07606  006510          DEF XSVAR    110 H
03224000 07607  006510          DEF XSVAR    111 I
03225000 07610  006510          DEF XSVAR    112 J
03226000 07611  006510          DEF XSVAR    113 K
03227000 07612  006510          DEF XSVAR    114 L
03228000 07613  006510          DEF XSVAR    115 M
03229000 07614  006510          DEF XSVAR    116 N
03230000 07615  006510          DEF XSVAR    117 O
03231000 07616  006510          DEF XSVAR    120 P
03232000 07617  006510          DEF XSVAR    121 Q
03233000 07620  006510          DEF XSVAR    122 R
03234000 07621  006510          DEF XSVAR    123 S
03235000 07622  006510          DEF XSVAR    124 T
03236000 07623  006510          DEF XSVAR    125 U
03237000 07624  006510          DEF XSVAR    126 V
03238000 07625  006510          DEF XSVAR    127 W
03239000 07626  006510          DEF XSVAR    130 X
03240000 07627  006510          DEF XSVAR    131 Y
03241000 07630  006510          DEF XSVAR    132 Z
03242000 07631  006625          DEF DIMOP    133 DIM OPERATOR
03243000 07632  006524          DEF XSQR     134 SQR
03244000 07633  100424          DEF ASYER,I  135
03245000 07634  100424          DEF ASYER,I  136
03246000 07635  100424          DEF ASYER,I  137
03247000 07636  027766          DEF XARRY    140 ENTIRE ARRAY
03248000 07637  006403          DEF XSSVR    141 A[
03249000 07640  006403          DEF XSSVR    142 B[
03250000 07641  006403          DEF XSSVR    143 C[
03251000 07642  006403          DEF XSSVR    144 D[
03252000 07643  006403          DEF XSSVR    145 E[
03253000 07644  006403          DEF XSSVR    146 F[
03254000 07645  006403          DEF XSSVR    147 G[
03255000 07646  006403          DEF XSSVR    150 H[
03256000 07647  006403          DEF XSSVR    151 I[
03257000 07650  006403          DEF XSSVR    152 J[
03258000 07651  006403          DEF XSSVR    153 K[
03259000 07652  006403          DEF XSSVR    154 L[
03260000 07653  006403          DEF XSSVR    155 M[
03261000 07654  006403          DEF XSSVR    156 N[
03262000 07655  006403          DEF XSSVR    157 O[
03263000 07656  006403          DEF XSSVR    160 P[
03264000 07657  006403          DEF XSSVR    161 Q[
03265000 07660  006403          DEF XSSVR    162 R[
03266000 07661  006403          DEF XSSVR    163 S[
03267000 07662  006403          DEF XSSVR    164 T[
03268000 07663  006403          DEF XSSVR    165 U[
03269000 07664  006403          DEF XSSVR    166 V[
03270000 07665  006403          DEF XSSVR    167 W[
03271000 07666  006403          DEF XSSVR    170 X[
03272000 07667  006403          DEF XSSVR    171 Y[
03273000 07670  006403          DEF XSSVR    172 Z[
03274000 07671  006334          DEF XPIE     173 PI
03275000 07672  006343          DEF XENR     174 ENR
03276000 07673  006602          DEF XASN     175 GAZINTA
03277000 07674  027771          DEF XEMTY    176 EMPTY
03278000 07675  006140          DEF XEOLN    177 EOL
03279000 07676  006134          DEF XIF      200 IF
03280000 07677  100567          DEF APRT,I   201 PRT
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03281000 07700  100570          DEF ADSP,I  202 DSP
03282000 07701  006536          DEF XLOR    203 OR
03283000 07702  006534          DEF XAND    204 AND
03284000 07703  006526          DEF XNOT    205 NOT
03285000 07704  100575          DEF AFXD,I  206 FXD
03286000 07705  100576          DEF AFLT,I  207 FLT
03287000 07706  027734          DEF XSPAC   210 SPC
03288000 07707  006775          DEF XJMP    211 JMP
03289000 07710  007342          DEF XSFG    212 SFG
03290000 07711  007350          DEF XCFG    213 CFG
03291000 07712  007334          DEF XCMF    214 CMF
03292000 07713  006530          DEF XPRND   215 PRND
03293000 07714  006532          DEF XDRND   216 DRND
03294000 07715  007321          DEF XTRC    217 TRC
03295000 07716  007274          DEF XNOR    220 NOR
03296000 07717  007306          DEF XSTP    221 STP
03297000 07720  007007          DEF XFLG    222 FLG
03298000 07721  023706          DEF XENT    223 ENT
03299000 07722  007057          DEF XMGTO   224 GTO-
03300000 07723  007051          DEF XPGTO   225 GTO+
03301000 07724  007055          DFF XMGSB   226 GSB-
03302000 07725  007047          DEF XPGSB   227 GSB+
03303000 07726  007041          DEF XAGTO   230 GTO
03304000 07727  007037          DEF XAGSB   231 GSB
03305000 07730  006176          DEF MLOOP   232 DIM
03306000 07731  006262          DEF XRETN   233 RET
03307000 07732  001150          DEF XWAIT   234 WAIT
03308000 07733  015475          DEF XBEEP   235 BEEP
03309000 07734  015452          DEF XEND    236 END
03310000 07735                  BSS 1       237 REW
03311000 07736  006540          DEF XXOR    240 XOR
03312000 07737                  BSS 1       241 IDF
03313000 07740                  BSS 1       242 SSC
03314000 07741                  BSS 1       243 TRK
03315000 07742                  BSS 1       244 FDF
03316000 07743                  BSS 1       245 ERT
03317000 07744                  BSS 1       246 MRK
03318000 07745                  BSS 1       247 RCF
03319000 07746                  BSS 1       250 LDF
03320000 07747  023704          DEF XENP    251 ENL
03321000 07750                  BSS 1       252 LDP
03322000 07751                  BSS 1       253 RCM
03323000 07752                  BSS 1       254 LDM
03324000 07753                  BSS 1       255 RCK
03325000 07754                  BSS 1       256 LDK
03326000 07755                  BSS 1       257 LDB
03327000 07756                  BSS 1       260 VFY
03328000 07757                  BSS 1       261 AVD
03329000 07760                  BSS 1       262 AVE
03330000 07761  100574          DEF AKOF,I  263 LKD
03331000 07762  100573          DEF AKON,I  264 LKE
03332000 07763  006554          DEF XNEQ    265 #
03333000 07764  006552          DEF XLEQ    266 <=
03334000 07765  006550          DEF XGEQ    267 >=
03335000 07766  006546          DEF XLTN    270 <
03336000 07767  006542          DEF XGTN    271 >
03337000 07770  006544          DEF XEQL    272 =
03338000 07771  015401          DEF XLCR    273 L.C. R
03339000 07772  100566          DEF ALST,I  274 LIST
03340000 07773  006353          DEF XVRES   275 RES (VALUE)
03341000 07774  100572          DEF ALSTK,I 276 LISTK
03342000 07775                  BSS 1       277 TLIST
03343000 07776  177526          DEF APP#,I  300 L.C. P


03345000 07777                  BSS 1           *** RESERVED FOR 6K-PAGE CHECKSUM


03347000                *
03348000                * FILL IN BASE-PAGE LINKS
03349000                *
03350000 00360                  ORG ARSGT
03351000 00360  015261          DEF RESTB
03352000 00361  015246          DEF INTI
03353000 00362  015370          DEF FBAD
03354000 00363  006145          DEF XEX
03355000 00364  006160          DEF XE2
03356000 00365  006176          DEF MLOOP
03357000 00366  006565          DEF RAPUP
03358000 00367  007316          DEF XSTZ
03359000 00370  015272          DEF MOVEM
03360000 00371  006054          DEF OVTST
03361000 00372  006077          DEF ASTRC
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                                        INTERPRETER

03362000 00373   006167              DEF LNTRC
03363000 00374   027614              DEF FCI
03364000 00375   027626              DEF FCC
03365000 00376   007413              DEF SYSFL
03366000 00377   027466              DEF GNAME
03367000 00400   007164              DEF FINDL
03368000 00401   015360              DEF ADBA
03369000 00402   015362              DEF .ADB

                                     LEFTOVERS

03371000 15246                       ORG 15246B

03373000                       *
03374000                       * INTERPRETER INITIALIZATION
03375000                       *
03376000 15246   005311  INII  LDB VT1
03377000 15247   035300        STB AP2
03378000 15250   024146        ADB M2           ONE BLANK WORD BETWEEN AP2 AND BOT.
03379000 15251   035263        STB AP1
03380000 15252   035261        STB AP3          SET UP EXECUTION STACK POINTERS
03381000                       *
03382000 15253   000257        LDA M1
03383000 15254   131261        STA AP3,I        MARK BOTTOM OF STACK
03384000                       *
03385000 15255   005307        LDB FWUP
03386000 15256   035265        STB HERE
03387000 15257   035266        STB WHERE
03388000                       *
03389000 15260   170201        RET 1

03391000                       *
03392000                       * SECTION TO RESET HI-SPEED BRANCH ADDRESSES
03393000                       *
03394000 15261   000050  RESTB LDA B224
03395000 15262   004152        LDB M6
03396000 15263   140374        JSM AFCI,I       INITIALIZE TEST BYTE
03397000 15264   140375  REST2 JSM AFCC,I
03398000 15265   170201        RET 1            END-OF-PROGRAM
03399000 15266   000177        LDA P0
03400000 15267   074550        PBD A,I
03401000 15270   074550        PBD A,I
03402000 15271   066264        JMP REST2
03405000                       *
03406000                       * MOVE MEMORY UP
03407000                       *
03408000                       * ON ENTRY: A = -# OF WORDS TO MOVE
03409000                       *
03410000                       * ON EXIT: A = NEW VT2 = START OF NEW SPACE
03411000                       *
03412000                       * TEMPORARIES USED: T1,T2,T3,T4
03413000                       *
03414000 15272   005263  MOVEM LDB AP1
03415000 15273   035711        STB T1
03416000 15274   024000        ADB A
03417000 15275   035712        STB T2
03418000 15276   031713        STA T3           SAVE -# OF WORDS TO MOVE
03419000 15277   000001        LDA B
03420000 15300   170040        TCA
03421000 15301   021310        ADA RMAX         RMAX-AP1
03422000 15302   172403        SAM *+3
03423000 15303   140404  E39   JSM AERR1,I      ERROR, ALLOCATION OVERFLOW
03424000 15304   031471        ASC 1,39
03425000                       *
03426000 15305   035263        STB AP1          UPDATE AP1
03427000 15306   005300        LDB AP2
03428000 15307   025713        ADB T3
03429000 15310   035300        STB AP2          UPDATE AP2
03430000 15311   005261        LDB AP3
03431000 15312   025713        ADB T3
03432000 15313   035261        STB AP3          UPDATE AP3
03433000 15314   005311        LDB VT1
03434000 15315   025713        ADB T3
03435000 15316   035311        STB VT1          UPDATE VT1
03436000 15317   005272        LDB FAP1
03437000 15320   025713        ADB T3
03438000 15321   035272        STB FAP1         UPDATE FAP1
03439000 15322   005625        LDB ENSV+1
03440000 15323   025713        ADB T3
03441000 15324   035625        STB ENSV+1       UPDATE STORED FAP1
03442000                       *
```

```
03443000 15325  000122        LDA P26
03444000 15326  031714        STA T4
03445000 15327  004277        LDB ADATB       UPDATE DATAB
03446000 15330  100001  M01   LDA B,I
03447000 15331  072403        SZA *+3         IGNORE IF UNALLOCATED
03448000 15332  021713        ADA T3
03449000 15333  130001        STA B,I         STORE UPDATED ENTRY
03450000 15334  055714        DSZ T4
03451000 15335  076173        RIB M01
03452000                *
03453000 15336  005711        LDB T1          RECALL OLD API
03454000 15337  015312  M02   CPB VT2
03455000 15340  066346        JMP M03         JUMP IF DONE
03456000                *
03457000 15341  100001        LDA B,I         MOVE ORGANIZATION DATA AND STACK
03458000 15342  024254        ADB P1
03459000 15343  131712        STA T2,I
03460000 15344  045712        ISZ T2
03461000 15345  066337        JMP M02
03462000                *
03463000 15346  001712  M03   LDA T2
03464000 15347  035712        STB T2
03465000 15350  031312        STA VT2         UPDATE VT2
03466000                *
03467000 15351  004177        LDB P0          ZERO THE NEW AREA
03468000 15352  011712  M04   CPA T2
03469000 15353  066356        JMP M05
03470000 15354  134000        STB A,I
03471000 15355  072175        RIA M04
03472000                *
03473000 15356  001312  M05   LDA VT2
03474000 15357  170201        RET 1

03476000                *
03477000                * ADJUST BYTE ADDRESS
03478000                *
03479000                * ON ENTRY: A-REGISTER = BYTE ADDRESS
03480000                *           B-REGISTER = COUNT
03481000                *
03482000                * ON EXIT:  A-REGISTER = NEW BYTE ADDRESS
03483000                *           B-REGISTER = UNALTERED
03484000                *
03485000 15360  172302  ADBA  SAP *+2,S       COMPLEMENT SIGN BIT
03486000 15361  172201        SAP *+1,C
03487000 15362  170716  .ADB  RAR 15          ADJUST ADDRESS
03488000 15363  020001        ADA B           ADD CHANGE
03489000 15364  170700        RAR 1           RESET ADDRESS
03490000 15365  172302        SAP *+2,S       COMPLEMENT SIGN BIT
03491000 15366  172201        SAP *+1,C
03492000 15367  170201        RET 1

03494000                *
03495000                * FIND BYTE ADDRESS DIFFERENCE
03496000                *
03497000                * ON ENTRY: A-REGISTER = LOWER BYTE ADDRESS
03498000                *           B-REGISTER = UPPER BYTE ADDRESS FOR POSITIVE
03499000                *
03500000                * ON EXIT:  A-REGISTER = CHARACTER COUNT
03501000                *
03502000 15370  172302  FBAD  SAP *+2,S
03503000 15371  172201        SAP *+1,C       COMPLEMENT THE SIGN BIT
03504000 15372  170716        RAR 15
03505000 15373  176302        SBP *+2,S
03506000 15374  176201        SBP *+1,C       COMPLEMENT THE SIGN BIT
03507000 15375  174716        RBR 15
03508000 15376  170040        TCA             MAKE NEG.
03509000 15377  020001        ADA B           A = BYTE DIFF
03510000 15400  170201        RET 1
03512000                *
03513000                * L.C. R EXECUTION
03514000                *
03515000 15401  140612  XLCR  JSM AGTIN,I     GET SUBSCRIPT
03516000 15402  176003        SBP *+3
03517000 15403  140404  E26A  JSM AERR1,I     ERROR, NEGATIVE R SUBSCRIPT
03518000 15404  031066        ASC 1,26
03519000 15405  000001        LDA B
03520000 15406  050224        AND B60K
03521000 15407  072034        RZA E39A
03522000                *
03523000 15410  174601        SBL 2
03524000 15411  024254        ADB P1
03525000 15412  001277        LDA END$
03526000 15413  020001        ADA B           A = ABSOLUTE ADDRESS
```

```
03527000 15414  170140         CMA
03528000 15415  021263         ADA AP1
03529000 15416  020152         ADA M6             A = AP1-(L+7)
03530000 15417  172424         SAM E39A
03531000 15420  055263         DSZ AP1
03532000 15421  135263         STB AP1,I          WHERE = RELATIVE R-REGISTER
03533000 15422  055263         DSZ AP1
03534000 15423  000144         LDA P3             LENGTH = 3
03535000 15424  131263         STA AP1,I
03536000 15425  000270         LDA FVRRA
03537000 15426  055263         DSZ AP1
03538000 15427  131263         STA AP1,I          WHAT = FULL/VARIABLE
03539000 15430  024144         ADB P3
03540000 15431  025277         ADB END$
03541000 15432  000001         LDA B
03542000 15433  170040         TCA
03543000 15434  021310         ADA RMAX           RMAX-(L+3)
03544000 15435  172005         SAP *+5
03545000 15436  001310         LDA RMAX
03546000 15437  020254         ADA P1
03547000 15440  035310         STB RMAX           UPDATE RMAX IF NECESSARY
03548000 15441  140471         JSM AZRWM,I        ZERO THE NEW AREA
03549000 15442  164365         JMP AINTX,I
03550000                 *
03551000 15443  066303   E39A  JMP E39            ERROR, OUT-OF-BOUNDS


03553000                 *
03554000                 * SET LINK BITS IN STACK
03555000                 *
03556000 15444  000236   XCOLN LDA B2K            ' ; => 2000B => BIT 10
03557000 15445  066447         JMP *+2
03558000                 *
03559000 15446  000234   XCOMA LDA B4K            , => 4000B => BIT 11
03560000 15447  161263         IOR AP1,I
03561000 15450  131263         STA AP1,I
03562000 15451  164365         JMP AINTX,I
03564000                 *
03565000                 * END    (EVENTUALLY ARRIVES AT XST2)
03566000                 *
03567000 15452  001257   XEND  LDA CSTAT
03568000 15453  010254         CPA P1
03569000 15454  066461         JMP XEN1
03570000 15455  010145         CPA P2
03571000 15456  066461         JMP XEN1
03572000 15457  140404   E9A   JSM AERR1,I        ERROR, WRONG CONTROL STATE
03573000 15460  030071         ASC 1,09
03574000                 *
03575000 15461  042246   XEN1  JSM INTI           DELETE EXECUTION STACK
03576000 15462  035264         STB LEND           IMPLIED GTO 0
03577000 15463  035317         STB SWHRE
03578000 15464  001257         LDA CSTAT
03579000 15465  010254         CPA P1
03580000 15466  140515         JSM ASTKI,I        DUMMY STACK FOR C.S. IF REQUIRED
03581000                 *
03582000 15467  000177         LDA P0
03583000 15470  031226         STA CSTMP+8        LNO=0
03584000 15471  001232         LDA CSTMP+12
03585000 15472  050207         AND M10            CLEAR BITS 0 AND 3 OF JB'S CFLAG
03586000 15473  031232         STA CSTMP+12       (FETCH AND STEP BITS)
03587000                 *
03588000 15474  165507         JMP ELINK,I        LINK TO WAIT FOR I/O COMPLETION


03590000                 *
03591000                 * BEEP EXECUTION
03592000                 *
03593000 15475  040703   XBEEP JSM BEEP
03594000 15476  164365         JMP AINTX,I
03596000 27466                 ORG 27466B


03598000                 *
03599000                 * SUBROUTINE TO GET VARIABLE NAME INTO I/O BUFFER
03600000                 *
03601000 27466  035723   GNAME STB T11
03602000 27467  174040         TCB
03603000 27470  035724         STB T12
03604000 27471  140450         JSM ACLBI,I        CLEAR I/O BUFFER
03605000 27472  004315         LDB AIBFM
03606000 27473  034017         STB D              INITIALIZE BUFFER POINTER
03607000                 *
03608000 27474  001311         LDA VT1
03609000 27475  170040         TCA
03610000 27476  021723         ADA T11            "TO"-VT1
```

```
03611000 27477  172020        SAP AST1       SKIP UNLESS R-REGISTER OR P-NUMBER
03612000 27500  001310        LDA RMAX
03613000 27501  170040        TCA
03614000 27502  021723        ADA T11        "TO"-RMAX
03615000 27503  172404        SAM GNA1       SKIP IF R-REGISTER
03616000 27504  000061        LDA B160       L.C. P
03617000 27505  074550        PBD A,I
03618000 27506  170201        RET 1
03619000                *
03620000 27507  000060  GNA1  LDA B162       L.C. R
03621000 27510  074550        PBD A,I
03622000 27511  001277        LDA END$
03623000 27512  170140        CMA
03624000 27513  021723        ADA T11
03625000 27514  170501        SAR 2          R# = ("TO"-END$-1)/4
03626000 27515  004017        LDB D
03627000 27516  164477        JMP ABTDA,I    OUTPUT SUBSCRIPT VALUE
03628000                *
03629000 27517  004276  AST1  LDB ADVTB
03630000 27520  035712        STB T2         INITIALIZE TABLE POINTER
03631000 27521  000122        LDA P26
03632000 27522  031713        STA T3         INITIALIZE COUNT
03633000 27523  000072        LDA B101
03634000 27524  005723        LDB T11        RECALL ACTUAL ADDRESS
03635000 27525  115712  AST2  CPB T2,I
03636000 27526  066612        JMP AST9+1     JUMP IF SIMPLE VARIABLE FOUND
03637000 27527  045712        ISZ T2
03638000 27530  055713        DSZ T3
03639000 27531  072174        RIA AST2
03640000                *
03641000                *                    FALL THRU IF ARRAY VARIABLE
03642000                *
03643000 27532  000072  AST4  LDA B101       INITIALIZE ASCII CHARACTER
03644000 27533  031712        STA T2
03645000 27534  004277        LDB ADATB
03646000 27535  035714        STB T4
03647000 27536  105714  AST5  LDB T4,I       GET DATAB ENTRY
03648000 27537  076417        SZB AST6       IGNORE IF ZERO
03649000 27540  035717        STB T7         T7 => #DIMS
03650000 27541  100001        LDA B,I
03651000 27542  170600        SAL 1          2*#DIMS
03652000 27543  024254        ADB P1
03653000 27544  024000        ADB A          B => LOCATION OF FIRST ELEMENT
03654000 27545  100001        LDA B,I
03655000 27546  021724        ADA T12        FIRST ELEMENT ADDRESS - ACTUAL ADD,
03656000 27547  172407        SAM AST6
03657000 27550  024254        ADB P1
03658000 27551  035721        STB T9         T9 => #WORDS
03659000 27552  104001        LDB B,I
03660000 27553  174040        TCB
03661000 27554  024000        ADB A          RELATIVE WORD - #WORDS
03662000 27555  176404        SBM AST7       SKIP IF IDENTIFIED
03663000                *
03664000 27556  045712  AST6  ISZ T2         IT ISN'T THE ONE
03665000 27557  045714        ISZ T4
03666000 27560  066536        JMP AST5
03667000                *
03668000 27561  170501  AST7  SAR 2          RELATIVE ELEMENT
03669000 27562  005712        LDB T2
03670000 27563  074551        PBD B,I        OUTPUT THE LETTER
03671000 27564  004070        LDB B133
03672000 27565  074551        PBD B,I        OUTPUT (
03673000 27566  055721        DSZ T9
03674000 27567  055721        DSZ T9
03675000 27570  040762  AST8  JSM SDIV
03676000 27571  177721        DEF T9,I       RELATIVE/D(J)
03677000 27572  055721        DSZ T9
03678000 27573  031720        STA T8
03679000 27574  101721        LDA T9,I
03680000 27575  055721        DSZ T9
03681000 27576  170040        TCA
03682000 27577  020001        ADA B          REMAINDER+L(J)
03683000 27600  004017        LDB D
03684000 27601  140477        JSM ABTDA,I    OUTPUT SUBSCRIPT VALUE
03685000 27602  005717        LDB T7
03686000 27603  015721        CPB T9         DONE?
03687000 27604  066611        JMP AST9
03688000 27605  000107        LDA B54        OUTPUT ,
03689000 27606  074550        PBD A,I
03690000 27607  001720        LDA T8
03691000 27610  066570        JMP AST8
03692000                *
03693000 27611  000067  AST9  LDA B135       OUTPUT )
03694000 27612  074550        PBD A,I
03695000 27613  170201        RET 1
```

```
03697000                    *
03698000                    * SUBROUTINE TO FIND A DESIGNATED BYTE IN THE PROGRAM
03699000                    *
03700000                    * INITIALIZATION: LDA (DESIRED BYTE)     (EXCEPT EOL)
03701000                    *                 LDB -# OF CONSECUTIVE BYTES
03702000                    *                 JSM FCI
03703000                    *
03704000                    * CONTINUATION:   JSM FCC
03705000                    *
03706000                    *   ON RETURN TO P+1: END-OF-PROGRAM
03707000                    *                P+2: B-REGISTER = D-REGISTER
03708000                    *
03709000                    * TEMPORARIES USED: T1,T2,T3,T4,T26
03710000                    *
03711000 27614  170040 FCI   TCA
03712000 27615  031711       STA T1            SAVE DESIRED BYTE
03713000 27616  035675       STB T26
03714000 27617  005307       LDB FWUP
03715000 27620  035712       STB T2            INITIALIZE WORD ADDRESS
03716000 27621  034017 FCI3  STB D
03717000 27622  074570       WBD A,I           SKIP OVER WLENGTH
03718000 27623  004017       LDB D
03719000 27624  035713       STB T3            INITIAL D-REGISTER SETTING
03720000 27625  170201       RET 1


03722000 27626  101712 FCC   LDA T2,I
03723000 27627  050053       AND B177
03724000 27630  072475       SZA *-3           END-OF-PROGRAM
03725000                *
03726000 27631  005713       LDB T3            RECALL LOCATION OF NEXT BYTE
03727000 27632  034017       STB D
03728000 27633  074570 RE0   WBD A,I           GET NEXT BYTE
03729000 27634  010053       CPA B177
03730000 27635  066667       JMP RE2           EOL FOUND
03731000                *
03732000 27636  031714       STA T4            SAVE CURRENT BYTE
03733000 27637  020332       ADA ARTBL
03734000 27640  100000       LDA A,I           GET RTBL WORD
03735000 27641  170507       SAR 8
03736000 27642  050130       AND B17           GET CLASS
03737000                *
03738000 27643  010142       CPA P5
03739000 27644  066712       JMP RE5           5 = LITERAL SYNTAX
03740000 27645  010141       CPA P6
03741000 27646  066702       JMP RE6           6 = GTO/GSB
03742000 27647  010140       CPA P7
03743000 27650  066724       JMP RE7           7 = OPTIONAL ROM
03744000 27651  010137       CPA P8
03745000 27652  066716       JMP RE8           8 = CHARACTER STRING
03746000 27653  010136       CPA P9
03747000 27654  066712       JMP RE5           9 = NUMBER
03748000                *
03749000 27655  005713 RE1   LDB T3            CURRENT POSITION
03750000 27656  000017       LDA D
03751000 27657  031713       STA T3            UPDATE POSITION
03752000 27660  034017       STB D
03753000                *
03754000 27661  001711       LDA T1            DESIRED BYTE?
03755000 27662  021714       ADA T4
03756000 27663  172450       SAM RE0           NO
03757000 27664  021675       ADA T26
03758000 27665  172046       SAP RE0           NO
03759000 27666  170202       RET 2             YES
03760000                *
03761000 27667  005712 RE2   LDB T2            RECALL WORD ADDRESS OF LINE
03762000 27670  100001       LDA B,I
03763000 27671  050053       AND B177          GET WLENGTH OF LINE
03764000 27672  024000       ADB A
03765000 27673  035712       STB T2
03766000 27674  101712       LDA T2,I
03767000 27675  050053       AND B177
03768000 27676  010177       CPA P0
03769000 27677  170201       RET 1             END-OF-PROGRAM
03770000                *
03771000 27700  042621       JSM FCI3
03772000 27701  066633       JMP RE0
03773000                *
03774000 27702  074570 RE6   WBD A,I           GTO/GSB
03775000 27703  074570       WBD A,I
03776000 27704  074570       WBD A,I           GET TYPE OF BRANCH
03777000 27705  010116       CPA B42
03778000 27706  066716       JMP RE8
03779000 27707  074570       WBD A,I
```

LEFTOVERS

```
03780000 27710  074570        WBD A,I
03781000 27711  066655        JMP RE1
03782000                *
03783000 27712  074570  RE5   WBD A,I           NUMBER OR LITERAL SYNTAX
03784000 27713  010121        CPA B34
03785000 27714  066655        JMP RE1
03786000 27715  066712        JMP *-3
03787000                *
03788000 27716  074571  RE8   WBD B,I           CHARACTER STRING, GET LENGTH
03789000 27717  174040        TCB
03790000 27720  076503        SIB *+3
03791000 27721  074570        WBD A,I
03792000 27722  066720        JMP *-2
03793000 27723  066655        JMP RE1
03794000                *
03795000 27724  074571  RE7   WBD B,I           OPTIONAL-ROM, GET SECOND CODE
03796000 27725  001714        LDA T4
03797000 27726  010136        CPA P9            IS IT THE UDF ROM?
03798000 27727  066731        JMP *+2           YES
03799000 27730  066655        JMP RE1           NO
03800000                *
03801000 27731  014254        CPB P1            IS IT A UDF NAME?
03802000 27732  066716        JMP RE8           YES
03803000 27733  066655        JMP RE1           NO
03805000                *
03806000                * SPACE EXECUTION
03807000                *
03808000 27734  101263  XSPAC LDA AP1,I         LOOK AT DATA TYPE
03809000 27735  010221        CPA EMPTY
03810000 27736  066744        JMP XSP1          JUMP IF NO PARAMETER
03811000                *
03812000 27737  140612        JSM AGTIN,I       GET INTEGER PARAMETER
03813000 27740  076413        SZB XSP2
03814000 27741  176004        SRP *+4
03815000 27742  140404  E17   JSM AERR1,I       ERROR, ILLEGAL SPACE COUNT
03816000 27743  030467        ASC 1,17
03817000                *
03818000 27744  004254  XSP1  LDB P1            DEFAULT
03819000 27745  035711        STB T1
03820000 27746  000254        LDA P1
03821000 27747  140571        JSM ASPC,I        GO SPACE ONCE
03822000 27750  001206        LDA IOTMP         GET KEYCODE
03823000 27751  055711        DSZ T1            COUNT EXHAUSTED?
03824000 27752  010254        CPA P1            STOP KEY?
03825000 27753  164365  XSP2  JMP AINTX,I       DONE!
03826000 27754  066746        JMP XSP1+2        KEEP SPACING


03828000                *
03829000                * CALL OPTIONAL-ROM FOR EXECUTION
03830000                *
03831000 27755  022765  CALLM ADA ROMK
03832000 27756  104000        LDB A,I           B = RMTBL ENTRY
03833000 27757  076403        SZB E29A          ERROR, ROM MISSING
03834000                *
03835000 27760  104001        LDB B,I
03836000 27761  014257        CPB M1
03837000 27762  064731  E29A  JMP E29           ERROR, ROM MISSING
03838000 27763  074560        WBC A,I           GET OPCODE
03839000 27764  164001        JMP B,I           CALL OPTIONAL-ROM
03840000                *
03841000 27765  167320  ROMK  DEF RMTBL-IBTBL-1,I
03843000                *
03844000                * STACK 'ENTIRE ARRAY'
03845000                *
03846000 27766  000143  XARRY LDA P4
03847000 27767  004171        LDB ARRAY         WHAT = ENTIRE ARRAY
03848000 27770  066773        JMP XEMTY+2


03850000                *
03851000                * STACK 'EMPTY'
03852000                *
03853000 27771  000144  XEMTY LDA P3
03854000 27772  004221        LDB EMPTY         WHAT = EMPTY
03855000 27773  140371        JSM AOVTS,I
03856000 27774  004177        LDB P0
03857000 27775  070551        PWD B,I           WHERE = ABSOLUTE 0
03858000 27776  164365        JMP AINTX,I

03860000 27777                BSS 1             *** RESERVED FOR 26K-PAGE CHECKSUM
```

LFFTOVERS

```
03862000 23704                  ORG 23704B

03864000                  *
03865000                  * PROLOGUE TO ENT EXECUTION
03866000                  *
03867000 23704  004127  XENP  LDB B20          SET PRINT FLAG
03868000 23705  066707        JMP *+2
03869000 23706  004177  XENT  LDB P0           CLEAR PRINT FLAG
03870000 23707  001232        LDA CSTMP+12     GET CONTROL SUPERVISOR FLAG (CFLAG)
03871000 23710  050161        AND M17
03872000 23711  060001        IOR B            SET BIT ACCORDING TO ENTER ENTRY.
03873000 23712  031232        STA CSTMP+12     UPDATE THE CONTROL SUPERVISOR FLAG .
03874000 23713  001257        LDA CSTAT        MAKE SURE PROPER MODE
03875000 23714  010145        CPA P2
03876000 23715  066720        JMP *+3
03877000 23716  140404  E13   JSM AERR1,I      ERROR, ILLEGAL MODE
03878000 23717  030463        ASC 1,13
03879000                  *
03880000 23720  000016        LDA C
03881000 23721  031624        STA ENSV         SAVE C
03882000 23722  140610        JSM ACOUN,I      SET UP FAP1
03883000 23723  164577        JMP AENT,I
03884000                  *
03885000                      END

END OF PASS 2 NO ERRORS DETECTED
```

BASE-PAGE READ-WRITE-MEMORY

```
00003000 76550                  ORG 76550B
00004000                        UNL
02000000                        LST
02001000                  *

02003000                  *
02004000                  *     BASE PAGE LINKS
02005000                  *
02006000 00041                  ORG SYSS+1
02007000 00041  010000          DEF .INT      INTERRUPT LINK
02008000                  *
02009000 00403                  ORG AMCLX
02010000 00403  010063          DEF MCLX      MAIN LOOP ADDR+1
02011000 00404  011000          DEF ERR1      ERROR ROUTINE - NO RETURN
02012000 00405  011067          DEF ERR2      ERROR ROUTINE - RETURN P+2
02013000 00406  011072          DEF PEMIO     PLACE ERROR MESSAGE IN I/O BUFFER
02014000 00407  011002          DEF EREXT     ERROR EXIT - AFTER 'AERR2'
02015000 00410  010776          DEF REJR      INTERRUPT REJECT ROUTINE
02016000 00411  011406          DEF ERUN7     XCOMM MANAGEMENT
02017000 00412  010722          DEF PLIRC     PLACE LINE NO. IN I/O BUFF
02018000 00413  110657          DEF CNDT,I    COMMAND TABLE (ADDR)
02019000 00414  010605          DEF CTFC8     CHECK TABLE FOR COMMAND
02020000 00415  011177          DEF CONEN     IMMEDIATE EXECUTE CONTINUE
02021000 00416  010437          DEF EXCK      COMMAND EXECUTION
02022000 00417  010551          DEF EXCSB     COMPILE A LINE
02023000 00420  010242          DEF KYPRC     PROCESS A KEY
02024000 00421  011400          DEF RUNSB     RUN INIT CALLED BY LDP
02025000 00422  011312          DEF ECIM      IMMEDIATE CONTINUE
02026000 00423  010654          DEF SCNDT     COMMAND TABLE TABLE START ADDR
02027000 00424  011065          DEF SYSER     SYSTEM ERROR
02028000 00425  010372          DEF CNINT     CONTINUE INITIALIZATION
02029000 00426  010013          DEF ERASA     ERASE ALL LINK
02030000 00427  011452          DEF ISTOR     PLACE KEYBOARD CHAR IN I/O BUFFER
02031000 00430  011453          DEF ISTOX     PLACE CHARACTER IN I/O BUFFER
02032000 00431  010477          DEF EXCST     STMT EXECUTION
02033000                  *
02034000 00577                  ORG AENT
02035000 00577  011105          DEF XENO      LINK TO EXECUTE 'ENT'
02036000                  *
```

CONTROL SUPERVISOR

```
02039000                  *
02040000                  *
02041000                  **********************************
02042000                  *                                *
02043000                  *     CONTROL SUPERVISOR
02044000                  *
02045000                  *
02046000                  *
```

```
02047000                *
02048000                *                                       *
02049000                **********************************
02050000                *
02051000                *
02052000                *           CNSP
02053000                *
02054000                *
02055000                *
02056000                *
02057000                *
02058000 10000                ORG 10000B
02059000                *  POWER ON ROUTINES;  CHECK RESET BIT
02060000                *  FINDS THE AMOUNT OF R/W MEM IN SYSTEM; ZEROES ALL R/W
02061000                *  MEMORY;  WAITS .5 SEC FOR THE CASSETTE
02062000                *  MAX ADDR OF R/W MEM= MAW = 77777B
02063000                *
02064000                *
02065000                *
02066000                *
02067000                *
02068000                *
02069000                *
02070000 10000  000177  .INT  LDA KPA      KEYB, SELECT CODE
02071000 10001  030017        STA D        SET FLAG FOR AUTO START ROUTINES
02072000 10002  030011        STA PA       SET PERIPHERAL ADDR
02073000 10003  000005        LDA R5       READ SYSTEM STATUS
02074000 10004  170502        SAR 3        POSITION POWER-ON BIT
02075000 10005  073402        RLA *+2      SKIP IF POWER ON
02076000                *
02077000 10006  067073        JMP RESET    RESET KEY WAS PRESSED
02078000                *
02079000 10007  004154        LDB M8       WAIT .5 SECONDS
02080000 10010  000263        LDA FLAG
02081000 10011  072100        RIA *
02082000 10012  076176        RIB *-2
02083000                *
02084000                ************************
02085000                *
02086000                *  ERASE ALL ENTRY
02087000                *
02088000                *      FIND AMOUNT OF MEMORY AVAILABLE
02089000 10013  000225  ERASA LDA ALBPI    ALTERNATE BIT PATTERN
02090000 10014  004217        LDB B76K     ASSUME AT LEAST 2K OF MEMORY
02091000 10015  034016  .INTL STB C        SAVE ADDRESS
02092000 10016  024241        ADB BM2K     CHECK NEXT LOWER 2K
02093000 10017  130001        STA B,I      WRITE ALTERNATE 1'S AND 0'S
02094000 10020  110001        CPA B,I      SEE IF WRITTEN
02095000 10021  067015        JMP .INTL    YES, SO KEEP LOOKING
02096000                *
02097000                *       CLEAR R/W MEMORY
02098000 10022  000177        LDA P0
02099000 10023  004016        LDB C        GET ADDR TO START CLEARING
02100000 10024  130001        STA B,I      ZERO MEMORY
02101000 10025  014344        CPB MAW      DONE?
02102000 10026  067030        JMP *+2      YES; GET OUT OF LOOP
02103000 10027  076175        RIB *-3      NO; LOOP
02104000 10030  004016        LDB C        GET C REG.
02105000 10031  035305        STB OFWAM    FIRST WORD OF ACTUAL R/W
02106000 10032  035306        STB FWAM     FIRST WORD OF AVAILABLE MEMORY (R/W)
02107000                *
02108000                *
02109000                *     RESET "JSM STACK" POINTER
02110000                *
02111000                *     SET DISPLAY LENGTH
02112000                *
02113000                *
02114000 10033  000300        LDA AJSTK    JSM STACK S/A-1
02115000 10034  030003        STA R        SET RET STACK POINTER
02116000                *
02117000 10035  004117        LDB P32
02118000 10036  000005        LDA R5       READ SYSTEM STATUS
02119000 10037  073002        SLA *+2      SKIP ON 32 CHAR DISP
02120000 10040  004127        LDB P16
02121000 10041  035512        STB DLEN     SET DISP LENGTH
02122000                *
02123000                *
02124000 10042  043137        JSM SRWLK    SET R/W LINKS,INIT OPTION ROMS
02125000 10043  140435        JSM ATRBF,I  TRANSFER I/O TO KBD BUFF
02126000 10044  040715        JSM CLMOD    SET MODE = 0 FOR ATRBF
02127000 10045  140435        JSM ATRBF,I  TRANS EOL TO RESERVE BUFF ALSO
02128000                *
02129000                *
02130000                *
```

CONTROL SUPERVISOR

```
02131000                    *       SET MEMORYPOINTERS
02132000                    *
02133000 10046  004330  SETMP LDB LWAM      LAST WORD OF AVAILABLE MEM.
02134000 10047  035311        STB VT1       SET VALUE TABLE POINTR
02135000 10050  035312        STB VT2       SET VALUE TABLE POINTR
02136000 10051  035313        STB FWBA      SET FIRST WORD OF BIN. AREA
02137000 10052  005306        LDB FWAM      FIRST WORD OF AVAILABLE R/W MEM.
02138000 10053  035307        STB FWUP      SET FIRST WORD OF USER PROGRAM
02139000 10054  035277        STB ENDS      NULL PROGRAM
02140000 10055  035310        STB RMAX      NO R-REGISTERS ALLOCATED
02141000 10056  042400        JSM RUNSB     INITIALIZE SO THAT A CONT IS LEGAL
02142000 10057  140514        JSM ASLLN,I   SET LNO TO LAST LINE NO. OR -1
02143000                    *
02144000                    *
02145000                    *     TURN-ON DISPLAY,ENABLE INTERRUPT
02146000                    *
02147000 10060  140433  SETM1 JSM ALDSP,I   DISPLAY INFO
02148000 10061  070420        EIR           ENABLE INTERRUPT
02149000                    *
02150000                    ************************************************************
02151000                    *
02152000                    *       MAIN CONTROL LOOP
02153000                    *
02154000                    *
02155000 10062  165511  MCL   JMP MLBPL,I  GO THRU MAIN LOOP BYPASS LINK
02156000 10063  140504  MCLX  JSM ARNLF,I  TURN OFF RUN LIGHT
02157000 10064  140454  MLCK JSM ARPRL,I   GET NEW KEY FLAG,DISTRIBUTE POWER
02158000 10065  172277        SAP MLCK,C   KEEP LOOKING IF FLAG IS NOT SET
02159000 10066  031207  MLK   STA .WMOD    RESET NEW KEY FLAG
02160000 10067  001206        LDA .WKC     GET KEY CODE
02161000 10070  043242        JSM KYPRC    PROCESS THE KEY
02162000 10071  140432  MCLI  JSM ADSPC,I  DISPLAY THE NEW KEY
02163000 10072  067062        JMP MCL      LOOP
02164000                    *
02165000                    *****************************************************************
02166000                    *
02167000                    *****************************************************************
02168000                    *
02169000                    *       SYSTEM RESET
02170000                    *
02171000                    *     AFTER SYSTEMRESET SYSTEM IS READY
02172000
02173000                    *  RESETS JSM STACK; RESETS STOLEN MEM PTR
02174000                    *  STRIPS EXECUTIONSTACK; CLEARS SYSTEM FLAGS
02175000                    *  CHECKS LINE BRIDGES OF PROGRAM;DISPLAYS LINE # .
02176000                    *  BEING EXECUTED
02177000                    *
02178000                    *
02179000 10073  000300  RESET LDA AJSTK    JSM STACK S/A-1
02180000 10074  030003        STA R        SET RET STACK POINTR
02181000 10075  001305        LDA OFWAM    FIRST WORD OF ACTUAL R/W
02182000 10076  031306        STA FWAM     RESET AVAILABLE MEM PTR
02183000 10077  001265        LDA HERE
02184000 10100  030017        STA D        SET FLAG FOR AUTO START ROUTINES
02185000 10101  140361        JSM AINTI,I  RESET EXECUTION STACK
02186000 10102  043137        JSM SRWLK    SET R/W LINKS,INIT OPTION ROMS
02187000 10103  001257        LDA CSTAT    SAVE CONTROL STATE
02188000 10104  031234        STA TMP4
02189000 10105  042040        JSM CLRST    CLEAR CSTAT, LEAVE A P0 IN "A"
02190000 10106  031232        STA CFLAG    RESET CONTROL FLAG
02191000 10107  031613        STA RENFG    CLEAR RENUMBER,REWIND FLAG
02192000 10110  031255        STA XCOMM    CLEAR ANY PENDING INTERRUPTS
02193000 10111  031623        STA LKFLG    ENABLE LIVE KBD
02194000 10112  031314        STA TE       CLEAR MASTER TRACE FLAG
02195000 10113  040717        JSM STELM    SET EOL MODE
02196000 10114  004344        LDB MAW      SEE IF PROGRAM STRUCTURE STILL INTACT
02197000 10115  140523        JSM AGLNO,I  SEARCH THROUGH LINE BRIDGES
02198000 10116  140514        JSM ASLLN,I  RESET LINE NO.
02199000                    *
02200000 10117  001234        LDA TMP4     PUT CORRECT LINE NUMBER IN DISPLAY
02201000 10120  072416        SZA NOLNN    SKIP IF STATE = 0
02202000 10121  005626        LDB ENSV+2   GET ENTER SAVED HERE
02203000 10122  010143        CPA P4       WAITING FOR ENTER
02204000 10123  067133        JMP RLINN    YES, PUT LINE # IN I/O BUFFER
02205000 10124  010142        CPA P5       EXECUTION IN ENTER?
02206000 10125  067133        JMP RLINN    YES
02207000 10126  005607        LDB LKTMP+2  GET SAVED WHERE FOR LIVE KBD
02208000 10127  010144        CPA P3       EXECUTION IN LIVE KBD?
02209000 10130  067133        JMP RLINN    YES, PUT LINE # IN I/O BUFFER
02210000 10131  073405        RLA NOLNN    SKIP IF STATE = 1
02211000 10132  004017        LDB D        STATE MUST BE 2 OR 6 SO USE HERE
02212000 10133  043421  RLINN JSM STEP4    PLACE LINE # IN I/O BUFFER
02213000 10134  000177        LDA P0       RESET CONTROL FLAG
02214000 10135  031232        STA CFLAG
```

CONTROL SUPERVISOR

```
02215000                   *
02216000 10136  067060  NOLNN  JMP SETM1   COMPLETE RESET INIT
02217000                *********************************************************************
02218000                *
02219000                *
02220000                *******************************************************************
02221000                *
02222000                *   SET R/W LINKS,SET INTERRUPT TABLE, INIT OPTION ROMS
02223000                *
02224000                *      ROUTINES SHARED BY POWER-ON AND RESET
02225000                *
02226000 10137  000367  SRWLK LDA ASTP      GET ADDR OF STOP ROUT.
02227000 10140  031507        STA ELINK     INIT. END-STMT LINK
02228000 10141  000406        LDA APEMI     ADDR OF COMMON ERROR SUBR.
02229000 10142  031260        STA ERRBP     SET LINK FOR NORMAL ERROR ROUT.
02230000 10143  000403        LDA AMCLX     MAIN LOOP ADDR+1
02231000 10144  031511        STA MLBPL     SET MAIN LOOP BYPASS LINK
02232000 10145  000714        LDA ARET1     TERMINATE RUN LINK WITH A RETURN
02233000 10146  031533        STA RLINK     SET RUN LINK FOR OPTION ROMS
02234000 10147  000112        LDA B51       SET FOR FIXED 2, FLOAT 9
02235000 10150  031217        STA .WPRT
02236000 10151  000730        LDA AREPN     SET ERROR ADDR FOR P# EXECUTION
02237000 10152  031526        STA APP#
02238000                *
02239000                *     SET INTERRUP  TABLE ON TURN-ON:
02240000                *
02241000                *     KEYBOARD LINKAND REJECT LINKS
02242000                *
02243000                *
02244000 10153  000275  SETIT LDA AITAB     GET INTERRUPT TABLE ADDR
02245000 10154  172701        SAM *+1,S     SET BIT 15 FOR INDIRECT
02246000 10155  030010        STA IV        SET INTERRUPT VECTOR POINTER
02247000 10156  000275        LDA AITAB     GET INTERRUPT TABLE ADDR
02248000 10157  004434        LDB AKBSR     KEYBOARD SERVICE ROUTINE ADDR
02249000 10160  134000        STB A,I       IN INTRPT TABLE
02250000 10161  004410        LDB AREJR     REJECT ROUTINE ADDR
02251000 10162  072101  SET1  RIA *+1       INCRM TABLE ADDR
02252000 10163  134000        STB A,I       FILL REST OF TABLE WITH REJECT ADDRESS
02253000 10164  012567        CPA LITAD     LAST INTERPT TABLE ADDR?
02254000 10165  067167        JMP STEDT     YES, DONE
02255000 10166  067162        JMP SET1      NO! SET ADDITIONAL ADDRS
02256000                *
02257000                ***************
02258000                *
02259000 10167  140447  STEDT JSM ASWIO,I  SET POINTERS TO EDIT I/O BUFFER
02260000 10170  140452        JSM AEOLB,I  PUT EOL IN BUFFER, RESET EDIT POINTERS
02261000                *
02262000                *
02263000                *************************************************************
02264000                *
02265000                *  SORFI  SET OPTION ROM TABLE
02266000                *
02267000                *********************
02268000                *
02269000 10171  140600  SORFI JSM ACSTI,I  CASSETTE INITIALIZATION
02270000                *
02271000                *             RESETOPTION ROM TABLE
02272000                *
02273000 10172  000327        LDA AROMS     S/A OF TABLE
02274000 10173  020254        ADA P1        SKIP OVER BINARY PROG LINK
02275000 10174  071617        CLR 16        CLEAR TABLE
02276000 10175  020127        ADA P16       SET MAIN SYSTEM ADDRESS
02277000 10176  004331        LDB AMAIN
02278000 10177  134000        STB A,I
02279000 10200  020254        ADA P1
02280000 10201  004257        LDB M1        SET END OF TABLE
02281000 10202  134000        STB A,I
02282000                *
02283000                *     INITIALIZE OPTION ROM TABLE
02284000                *
02285000 10203  006576        LDB ASYSM     START SEARCH AT SYSTEM ROM ADDR
02286000 10204  000001  RINT  LDA B         GET CURRENT ADDR
02287000 10205  020236        ADA B2K       LOOK AT NEXT HIGHER 1K
02288000 10206  011305        CPA OFWAM     START OF R/W!END OF ROM ADDR SPACE?
02289000 10207  067225        JMP ROMIN     INITIALIZE ROMS IF SO
02290000 10210  010224        CPA B60K      END OF ROM ADDRESSES?
02291000 10211  067225        JMP ROMIN     TABLE FILLED IF SO
02292000 10212  030001        STA B         SAVE POSSIBLE ROM S/A
02293000 10213  020143        ADA P4        GET ROM INIT ADDR
02294000 10214  100000        LDA A,I
02295000 10215  010257        CPA M1        ROM PRESENT?
02296000 10216  067204        JMP RINT      NO, CHECK NEXT ROM
02297000 10217  000001        LDA B         GET ROM S/A AGAIN
02298000 10220  020142        ADA P5        POINT TO ROM ID
```

```
10221  100000          LDA A,I       GET ROM ID
10222  020326          ADA ATROM     CALCULATE ADDR TO PUT ROM S/A
10223  134000          STB A,I       STORE ROM ADDR FOR THIS ID
10224  067204          JMP RINT      CHECK FOR ANOTHER ROM
                 *
                 *    INITIALIZE THE OPTION ROMS
                 *
10225  000327    ROMIN LDA AROMS     S/A OF OPTION ROM ADDR TABLE
10226  020127          ADA P16       START WITH THE HIGHEST ID ROM
10227  031227          STA TMP1      SAVE ROM TABLE PTR
10230  101227    RMIN1 LDA TMP1,I    GET ROM ADDR
10231  072404          SZA RMIN2     SKIP IF ROM NOT PRESENT
10232  020143          ADA P4        ROM INIT ADDR
10233  100000          LDA A,I       GET ADDRESS
10234  140000          JSM A,I       INIT THE ROM
10235  001227    RMIN2 LDA TMP1      DONE WITH ALL THE OPTION ROMS?
10236  010327          CPA AROMS
10237  170201          RET 1         YES
10240  055227          DSZ TMP1      NO, POINT TO NEXT ROM ADDR
10241  067230          JMP RMIN1
                 *
                 **********************************************************************************
                 *
                 *
                 ******************************************************************************
                 *
                 *      THE CONTROL SUPERVISOR DIRECTS ALL KEYCODES
                 *
                 *      LOADED BY THE KEYBOARD INTERRUPT ROUTINE TO THE
                 *
                 *      PROPER HANDLING ROUTINE.
                 *
                 *            ENTRY: A = KEY CODE
                 *
                 *
                 *     TABLE ADDR = BASE + MODE + 5(CN)
                 *      THE CONTENTS OF THE ADDR POINTS TO THE PROCESSING
                 *      ROUTINE. THIS TABLE OF ADDRESSES CAN BE CONSID
                 *     AS A MATRIX OF SIZE (5,21) WHERE EACH
                 *      ELEMENT IS FOUND BY (MODE,CN).
                 *      MODE IS THE CONTROL SUPERVISOR CONTROLLING FLAG.
                 *      CN IS THE CONTROL NUMBER FOUND IN MTABLE
                 *
                 ***********************************************************************
                 *
                 *  KEY PROCESSING TABLE    ENTRY    KYPRC:  A CONTAINS KEY
                 *
                 *
                 *      IF STATE = 2 OR 4 THEN ENTRY 3 IN THE TABLE IS USED
                 *      IF THIS ADDR IS ZERO THEN THE MODE ENTRY IS USED
                 *      THE MODE ENTRY IS ALLWAYS USED IF THE STATE IS ZERO
                 *      MODE IS 0,1,2,OR 4
                 *
                 *****************************************
                 *
10242  031235    KYPRC STA SKEY      SAVE NEW CODE
10243  020167          ADA BM200
10244  172002          SAP *+2       SPECIAL KEY?
10245  067250          JMP KYCN2     NO
10246  004126          LDB P17       SPECIAL KEY CN = B21
10247  067251          JMP PRG1
10250  043300    KYCN2 JSM SKCD      GET CONTROL # FROM MTABLE
                 *
10251  014135    PRG1  CPB P10       SEE IF RECALL KEY
10252  067261          JMP KYREC     YES
10253  001232          LDA CFLAG     NO,CLEAR BIT 5 OF CFLAG, AND MODIFY
10254  170705          RAR 6         IF BIT 5 IS SET LEAVE BIT 6 = 1
10255  172602          SAM LASRC,C   CLEAR BIT 5 IN ALL CASES
10256  073201          SLA LASRC,C   BIT 5 = 0 SO CLEAR BIT 6
10257  170711    LASRC RAR 10        REPOSITION FLAG
10260  031232          STA CFLAG     RESTORE FLAG
10261  001257    KYREC LDA CSTAT     IF STATE = 0 USE MODE ENTRY
10262  072404          SZA PRG2      INTO TABLE
10263  000144          LDA P3        STATE MUST BE 2 OR 4 SO USE ENTRY 3
10264  067267          JMP PRG4
10265  005227    PRG3  LDB TMP1      RESTORE B BEFORE RECALCULATE
10266  001256    PRG2  LDA MODE      USE MODE ENTRY
10267  035227    PRG4  STB TMP1      CALCULATE TABLE ADDR
10270  174601          SBL 2         MPY BY 4
10271  025227          ADB TMP1      B=5(CN)
10272  024000          ADB A         B=ENTRY# + 5(CN)
10273  026613          ADB .ATBL     B=ADDR,I  OF PROCESSING ROUTINE
10274  000177          LDA P0        IF ADDR = 0
10275  110001          CPA B,I
```

```
10276  067265         JMP PRG3     THEN USE MODE ENTRY
10277  164001         JMP B,I      #0 SO GO TO THE PROCESSING ROUTINE
              *
              *
              *****************************************************************
              *
              *
              *
              *        GET MTABLE CODE
              *
              *              ENTRY:    ASCII CODE IN "SKEY"
              *
              *                 EXIT:  CONTROL NUMBER IN B-REG.
              *
              *
10300  001235  SKCD   LDA SKEY     GET KEY CODE
10301  004460  SMTBL  LDB AKYTB    GET TABLE ADDR
10302  034016         STB C        SET C-REG
10303  074561  SMTB1  WBC B,I      GET UPPER HALF BYTE
10304  014045         CPB B377     END-OF-TABLE?
10305  067315         JMP SKCD1    YES
              *
10306  010001         CPA B        CODE FOUND?
10307  067312         JMP SMTB2    YES
10310  074561         WBC B,I      NO, BYPASS RIGHT-HALF
10311  067303         JMP SMTB1    CONTINUE
10312  074561  SMTB2  WBC B,I      GET MCODE
10313  174502         SBR 3        GET CONTROL NUMBER
10314  170201         RET 1
              *
10315  004134  SKCD1  LDB B13      MUST BE PROGRAMMING KEY
10316  170201         RET 1        CN = 13
              *
              *
10317  140404  ERILO  JSM AERR1,I  ILLEGAL OPERATION
10320  030065         ASC 1,05
              *
              *****************************************************************
              *
              *
              *         NEW KEY AFTER "EOL" MODE IS SET
              *
              *
10321  140451  PEOL   JSM ACLEB,I  CLEAR EDIT BUFFER
10322  040715         JSM CLMOD    RESET TO KBD MODE
              *
              *          ALPHANUMERIC KEYS
              *
10323  140427  P02    JSM AISTR,I  STORE CODE IN INPUT BUFF
10324  067325         JMP *+1      INPUT BUFF FULL! CHAR NOT STORED
10325  164446         JMP AFBP,I   FIND DISP BEGIN POINTR AND
              *
              *
              *          PRINT-ALL KEY
              *
              *
10326  140451  PALL   JSM ACLEB,I  CLEAR EDIT BUFFER
10327  001232         LDA CFLAG    GET CONTROL FLAG
10330  172705         SAM PALL1,S  PRINT ALL SET ?
10331  031232         STA CFLAG    NO; SET IT; UPDATE CONTROL FLAG
10332  003351         LDA ONMSG    GET "ON" MESSAGE
10333  131350         STA AEBUF,I  PLACE LINE NO. IN I/O BUFFER
10334  067342         JMP STPLL    DISPLAY ON/OFF MESSAGE
              *
10335  172601  PALL1  SAM *+1,C    CLEAR PRINT ALL
10336  031232         STA CFLAG    UPDATE CONTROL FLAG
10337  003346         LDA AOFF     ADDR OF "OFF" MESSAGE
10340  005350         LDB AEBUF    DESTINATION ADDR
10341  071401         XFR 2        TRANSFER "OFF" IN I/O BUFF
10342  040715  STPLL  JSM CLMOD    SET MODE = 0
10343  140432         JSM ADSPC,I  DISPLAY ON/OFF MESSAGE
10344  140452         JSM AEOLB,I  CLR EDIT BUFFER
10345  170202         RET 2        LEAVE MESSAGE IN DISPLAY
              *
              *
              *
10346  010347  AOFF   DEF *+1
10347  067546         OCT 67546    OF
10350  063040         OCT 63040    F BLANK
10351  067556  ONMSG  OCT 67556    ON
              *
              *
              *          RESULT KEY
```

```
                        *
                        *
10352  000060   RESK   LDA P114      GET LOWER CASE "R"
10353  043357          JSM RESSB     PLACE CODE IN I/O BUFF
10354  000063          LDA B145      GET LOWER CASE "E"
10355  043357          JSM RESSB     PLACE CODE IN I/O BUFF
10356  002571          LDA B163      GET LOWER CASE "S"
                        *
                        *
                        *
10357  031235   RESSB  STA SKEY      SAVE CODE
10360  067323          JMP P02       STORE CODE IN I/O BUFF + RETURN P+1
                        *
                        *
                        *        RESULT KEY - EOL MODE
                        *
                        *
10361  140451   REOL   JSM ACLEB,I   CLEAR EDIT BUFFER
10362  040715          JSM CLMOD     SET KBD MODE
10363  067352          JMP RESK
                        *
                        **********************************************************
                        *
                        *  CNINT  CONTINUE INITIALIZATION
                        *
                        *  CNINS  PRE CONTINUE INIT
                        *
                        *
                        *
                        *
                        *
                        *
                        *
                        ********************
                        *
10364  040717   CNINS  JSM STELM     SET MODE = 4
10365  140452          JSM AEOLB,I   CLR DISPLAY
10366  140433          JSM ALDSP,I
10367  000145          LDA P2        SET RUN STATE
10370  031257          STA CSTAT
10371  140503   CNINN  JSM ARNLO,I   TURN ON RUN LIGHT
                        *
10372  001232   CNINT  LDA CFLAG     SEE IF RUN ALREADY DONE
10373  170702          RAR 3         POSITION RUN BIT 2
10374  172406          SAM CRUND     SKIP IF DONE
10375  140361          JSM AINTI,I   NOT DONE, STRIP EXEC STACK
10376  140360          JSM ARSGT,I   RESET HI SPEED GTO/GSB'S
10377  000254          LDA P1        AND RESET HERE,WHERE
10400  031063          STA NPROG     SET FLAG FOR RLINK-CONTINUE INIT
10401  141533          JSM RLINK,I   ALLOW ROMS TO INIT
                        *
10402  001232   CRUND  LDA CFLAG
10403  050160          AND M16       CLEAR BITS 0-3 OF CFLAG
10404  060143          IOR P4        SET RUN DONE BIT 2
10405  031232          STA CFLAG     RESTORE FLAGS
10406  170201          RET 1
                        *
                        **********************************************************
                        *
                        *
                        *      STEP KEY EXECUTION
                        *  IF RUN DONE BIT IS CLEARED, DOES A CONTINUE INIT,
                        *                           AND DISPLAYS LINE # 0
                        *  IF RUN HAS BEEN DONE, CHECKS STEP DONE BIT OF CFLAG
                        *  EXECUTES LINE INDICATED BY WHERE (SETS A BIT IN XCOMM
                        *  SO IT WILL STOP AT THE END OF THE LINE) ! IF BIT NOT
                        *  SET DISPLAYS LINE # INDICATED BY WHERE
                        *
                        *
                        *
                        *
10407  001232   STEPK  LDA CFLAG     GET CONTROL FLAG
10410  170702          RAR 3         POSITION RUN FLAG (BIT 2)
10411  172022          SAP STEP1     "RUN" DONE ?
10412  073006          SLA STEP3     YES! STEP DONE BEFORE ?
10413  000052          LDA B200      YES! SET A STOP CONDITION
10414  031255          STA XCOMM     IN XCOMM
10415  043364          JSM CNINS     CONTINUE INIT
10416  005266          LDB WHERE     S/A OF LINE TO START EXECUTION
10417  067516          JMP EXCS2     START RUNNING THE PROGRAM
                        *
10420  005266   STEP3  LDB WHERE     GET ADDR OF NEXT LINE
10421  140523   STEP4  JSM AGLNO,I   AND FIND ITS LINE NO.
10422  140476   STEP2  JSM ATLNI,I   PLACE ITS NO. IN I/O BUFFER
```

```
10423  140475            JSM AEOPT,I   RESET EDIT PTRS
10424  000077            LDA COLLN     GET COLLON
10425  074550            PBD A,I       INCREM AND PLACE IN I/O BUFF
10426  140436            JSM AEPON,I   GO THRU PRINT ALL
10427  043402            JSM CRUND     SET CFLAG
10430  060133            IOR P12       SET STEP AND RUN FLAGS
10431  031232            STA CFLAG     UPDATE CONTROL FLAG
10432  064717            JMP STELM     SET EOL MODE AND RETURN P+1
                  *
10433  043371     STEP1  JSM CNINN     CONTINUE INIT WITH RUN LIGHT ON
10434  004177            LDB P0
10435  035226            STB LNO       SET FOR LINE 0
10436  067422            JMP STEP2     DISP NEXT LINE NO. AND EXIT
                  *
                  ****************************************************************
                  *
                  *
                  *      COMMAND EXECUTION
                  *
                  *      JUMP TO THE PROPER COMMAND ROUTINE IF
                  *
                  *      A COMMAND IS FOUND; OTHERWISE GO TO THE INTERPRETER
                  *
                  *
                  *
10437  140435     EXCK JSM ATRBF,I     TRANSFER BUFFERS
10440  000177            LDA P0
10441  031316            STA CERR       CLEAR COMPILE ERROR FLAG
10442  031255            STA XCOMM      CLEAR XCOMM
10443  140503            JSM ARNLO,I    TURN ON RUN LIGHT
10444  140461            JSM APRKB,I    GO THROUGH PRINT-ALL,KBD BUFFER
10445  000327            LDA AROMS      ADDR OF OPTION ROM TABLE
10446  031712            STA T2         AND SAVE THE ADDR
10447  101712     EXCK3  LDA T2,I       GET ROM ADDR
10450  072417            SZA EXCK2      SKIP IF THE ROM IS NOT PRESENT
10451  010331            CPA AMAIN      END OF TABLE?
10452  067471            JMP EXCK4      EXIT LOOP IF SO
10453  020144            ADA P3         POINT TO COMMAND ENTRY
10454  100000            LDA A,I        GET ROM WORD
10455  010257            CPA M1         ENTRY PRESENT?
10456  067467            JMP EXCK2      NO; GO TO NEXT ROM
10457  031714            STA T4         SAVE S/A OF COMMAND TABLE
10460  172701            SAM *+1,S      POINT TO UPPER HALF
10461  043604            JSM CTFC       CHECK TABLE FOR COMMAND
10462  067467            JMP EXCK2      NOT FOUND
10463  174040            TCB            MAKE OPCODE NEGATIVE
10464  025714            ADB T4         B = EXECUTION ROUTINE ADDR POINTR
10465  176701            SBM *+1,S      SET INDIRECT
10466  164001            JMP B,I        GO TO THE ROUTINE
                  *
10467  045712     EXCK2  ISZ T2         INC TABLE ADDR
10470  067447            JMP EXCK3      KEEP LOOKING
10471  000413     EXCK4  LDA ACNDT      ADDR OF MAIN FRAME COMMAND TABLE
10472  043604            JSM CTFC       CHECK TABLE FOR COMMAND
10473  067504            JMP EXCS1      NOT FOUND
                  *
10474  174040            TCB            FOUND; MAKE OPCODE NEGATIVE
10475  026570            ADB ASCDI      B= EXECUTION ROUTINE ADDR POINTER
10476  164001            JMP B,I        GO TO THE ROUTINE
                  *
                  *       STATEMENT EXECUTION
                  *
10477  001257     EXCST  LDA CSTAT      GET STATE VARIABLE
                  *
10500  010145            CPA P2         LIVE KBD EXECUTE?
10501  164457            JMP ALXKY,I    YES, USE LIVE KBD ROUTINES
                  *
10502  140435            JSM ATRBF,I    TRANSFER LINE TO KBD BUFFER
10503  140461            JSM APRKB,I    YES, SO GO THROUGH PRINTALL,KBD BUF
                  *
10504  140515     EXCS1  JSM ASTKI,I    STACK SYSTEM INFO
10505  001257            LDA CSTAT
10506  020254            ADA P1         STATES 0,2,4 BECOME
10507  031257            STA CSTAT      STATES 1,3,5
10510  000177            LDA P0         ALLOW IMPLIED STORAGE INTO RES REG
10511  031517            STA RGFLG
10512  043542            JSM EXCSS      COMPILE LINE, SET BRIDGES
10513  140503            JSM ARNLO,I    TURN ON RUN LIGHT
10514  001266            LDA WHERE      SAVE WHERE
10515  031317            STA SWHRE
10516  140364     EXCS2  JSM AINTK,I    GO TO INTERPRETER
10517  001257     EXCS4  LDA CSTAT      GET STATE VARIABLE
                  *
10520  010143            CPA P4         DONE WITH PRE ENTER?
```

```
10521  170201        RET 1         YES, RETURN TO IDLE LOOP
                    *
                    *
10522  140411        JSM AXCMM,I   GO AND WORK ON XCOMM
10523  067526        JMP ERSTP     JCB COMPLETE OR STOP
10524  005266        LDB WHERE     XCOMM CLEAR; GET S/A OF NEXT OP
10525  067516        JMP EXCS2     RESUME INTERPRETER ACTION
                    *
10526  001257  ERSTP LDA CSTAT     DON'T UNSTACK IF STATE # 2
10527  010145        CPA P2
10530  067534        JMP ERSS      STATE = 2 SO MUST BE A STOP CONDITION
10531  001317        LDA SWHRE     STATE #2 SO UNSTACK, RESTORE WHERE
10532  031266        STA WHERE
10533  066032        JMP EREX2     STATE #2 SO UNSTACK
                    *
10534  077003  ERSS  SLB STPPR     SKIP IF STP STMT OR END STMT
10535  043420        JSM STEP3     PUT LINE # IN DISPLAY
10536  066032        JMP EREX2     CHANGE STATE
                    *
10537  005266  STPPR LDB WHERE     GET ADDR OF NEXT LINE
10540  140523        JSM AGLNO,I   FIND LINE NO.
10541  066032        JMP EREX2     CHANGE STATE
                    *
                    *
                    ***************************************************************
                    *
                    *      COMPILE LINEAND CREATE LINE STRUCTURE
                    *
                    *   REDISPLAYS EDITBUFFER IF CURSOR IS SET
                    *            EXIT: B=COMPILE BUFF S/A
                    *
                    *
10542  001214  EXCSS LDA CRSP      SEE IF CURSOR SET
10543  072406        SZA EXCSB     DON'T REDISPLAY IF NOT
10544  000177        LDA P0        STRIP CURSOR FROM DISPLAY
10545  031214        STA CRSP
10546  140432        JSM ADSPC,I   DISPLAY LINE WITHOUT CURSOR
10547  004155        LDB M11       WAIT 11MS FOR DISPLAY
10550  040633        JSM DELAY
                    *
10551  140452  EXCSB JSM AEOLB,I   PUT EOL IN I/O BUFFER
10552  000214        LDA EOLB      GET EOL AND BLANK
10553  130311        STA AKBFL,I   STORE IN LAST WORD OF KEYBOARD BUFFER
10554  140346        JSM ACPLR,I   GO TO COMPILER
10555  140510        JSM AGLL,I    GET LENGTH OF LINE
10556  020254        ADA P1        INCLUDE END LINK
10557  020165        ADA M80       COMPILE BUFF = 80 W
10560  172404        SAM EXCK7     LENGTH < 80 W?
10561  072403        SZA EXCK7     NO; LENGTH = 80 W?
10562  140404  ERLLN JSM AERR1,I   NO; LINE TOO LONG
10563  030070        ASC 1,08
                    *
10564  044016  EXCK7 ISZ C         ADJUST POINTER
10565  004016        LDB C         GET C-REG
10566  176002        SBP *+2       POINTR = NEW WORD ?
10567  074760        WBC A,D       YES; POINT TO PREVIOUS WORD
10570  001234        LDA TMP4      GET LINE LENGT
10571  170607        SAL 8         POSITION IN UPPER HALF
10572  070540        PWC A,I       INCRM AND STORE END LINK
10573  004016        LDB C         GET C-REG
10574  024254        ADB P1        POINT TO NEXT WORD
10575  034017        STB D         SET START DESTIN. ADDR
10576  004303        LDB ACBF      END SOURCE ADDR
10577  140467        JSM AMTHM,I   SHIFT INFO HIGHER  ONE WORD
10600  001234        LDA TMP4      GET LENGTH OF LINE
10601  130303        STA ACBF,I    CREATE FRONT LINK
10602  004303        LDB ACBF      COMPILE BUFF S/A
10603  170201        RET 1
                    *
                    ***********************************************************
                    *     CHECK TABLE FOR COMMAND
                    *
                    *     ENTRY: A=TABLE POINTER
                    *  ACTFC ENTRY - B=-BUFF S/A
                    *
                    *     EXIT:   RET P+1 NOT FOUND
                    *
                    *             RET P+2 FOUND
                    *
                    *             B=OPCODE
                    *
                    *
10604  004307  CTFC  LDB AKBFX      ADDR OF KBD BUFFER
10605  030017  CTFCB STA D          SET TABLE PTR
```

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```
02719000 10606  035227         STB TMP1     SET BUFFER START ADDR
02720000 10607  005227  CTFC7  LDB TMP1     GET BUFFER START ADDR
02721000 10610  035222         STB L        FOR "GNEXT"
02722000 10611  140501  CTFC6  JSM AGNXT,I  GET CHAR FROM I/O BUFF
02723000 10612  074571         WBD B,I      GET CHAR FROM TABLE
02724000 10613  174706         RBR 7        POSITION END OF ENTRY BIT
02725000 10614  077015         SLB CTFC2    END OF ENTRY?
02726000 10615  001713         LDA T3       YES; GET COMPARE FLAG
02727000 10616  072411         SZA CTFC1    COMMAND FOUND?
02728000 10617  174601         SBL 2       YES; DROP TWO FLAG BITS
02729000 10620  174512         SBR 11       DROP END OF ENTRY BIT
02730000 10621  001222         LDA L       GET "L", GNEXT, POINTR
02731000 10622  030016         STA C
02732000 10623  074760         WRC A,D      DUMMY WITHDRAW AND DECRM
02733000 10624  000016         LDA C        GET POINTR
02734000 10625  031222         STA L        UPDATE "L" POINTR
02735000 10626  170202         RET 2
02736000                *
02737000 10627  176060  CTFC1  SBP CTFC7    END OF TABLE ?
02738000 10630  170201         RET 1        YES
02739000                *
02740000 10631  174710  CTFC2  RBR 9       REPOSITION CHAR IN LOWER HALF
02741000 10632  010001         CPA B        CHARS COMPARE ?
02742000 10633  067644         JMP CTFC5    YES
02743000 10634  000177         LDA P0       NO
02744000 10635  031713         STA T3       CLEAR COMPARE FLAG
02745000 10636  074571  CTFC3  WBD B,I      GET NEXT CHAR
02746000 10637  174706         RBR 7        POSITION END OF ENTRY BIT
02747000 10640  077076         SLB CTFC3    IS THIS THE OPCODE?
02748000 10641  176402         SBM CTFC4    YES; END OF TABLE?
02749000 10642  067607         JMP CTFC7    NO; CONT SEARCH
02750000 10643  170201  CTFC4  RET 1
02751000                *
02752000 10644  000254  CTFC5  LDA P1
02753000 10645  031713         STA T3       SET COMPARE FLAG
02754000 10646  067611         JMP CTFC6    CONT WITH SAME ENTRY
02755000                *
02756000                *
02757000                *      MAIN FRAME COMMAND ADDRESSES
02758000                *
02759000                *
02760000 10647  023775         DEF 237758   DEL LINE
02761000 10650  011321         DEF ECONT    CONTINUE
02762000 10651  023776         DEF 237768   ERASE
02763000 10652  010674         DEF FETCH    FETCH LINE
02764000 10653  011337         DEF ERUX     RUN
02765000                *
02766000                *      MAIN FRAME COMMAND TABLE
02767000                *
02768000 10654  000154  SCNDT  OCT 154      OL
02769000 10655  064563         OCT 64563    IS
02770000 10656  072206         OCT 72206    T OPCODE 6   LIST
02771000                *
02772000 10657  063145  CNDT   DEC 26213    FE
02773000 10660  072143         DEC 29795    TC
02774000 10661  064202         DEC 26754    H OPCODE 2 - FETCH
02775000 10662  062562         DEC 25970    ER
02776000 10663  060563         DEC 24947    AS
02777000 10664  062603         DEC 25987    E OPCODE 3 - ERASE
02778000 10665  062145         DEC 25701    DE
02779000 10666  066205         DEC 27781    L OPCODE 5 - DEL
02780000 10667  071165         DEC 29301    RU
02781000 10670  067201         DEC 28289    N OPCODE 1 - RUN
02782000 10671  061557         DEC 25455    CO
02783000 10672  067164         DEC 28276    NT
02784000 10673  142000         OCT 142000   OPCODE 4 - CONT  (EOT)
02785000                *
02786000                ****************************************************************
02787000                *      FETCH ONE LINE OF PROGRAM
02788000                *
02789000                *
02790000 10674  043761  FETCH  JSM FLIN     FETCH LINE INITIALIZATION
02791000 10675  140501         JSM AGNXT,I  GET NEXT CHAR FROM I/O BUFF
02792000 10676  010053         CPA EOL      LINE NO. GIVEN ?
02793000 10677  067720         JMP FETC4    NO
02794000 10700  140507         JSM AINTC,I  GET INTEGER
02795000 10701  035226  FETC5  STB LNO      SET LINE NO.
02796000 10702  001232  FETC3  LDA CFLAG    CLR FETCH, SPECIAL KEY BITS FROM CFLAG
02797000 10703  050150         AND M4       BITS 0,1
02798000 10704  031232         STA CFLAG
02799000 10705  140512         JSM AFLAD,I  FIND LINE ADDR
02800000 10706  067715         JMP FETC2    LINE NOT FOUND
02801000 10707  004254  FTCHX  LDB P1
02802000 10710  035256         STB MODE     SET FETCH MODE
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02803000 10711  005232         LDB CFLAG
02804000 10712  077301         SLB *+1,S    SET FETCH BIT OF CFLAG
02805000 10713  035232         STB CFLAG
02806000 10714  067722         JMP PLIRC    PLACE LINE NO. IN I/O BUFF
02807000                *
02808000 10715  040717  FETC2  JSM STELM    SET MODE = A
02809000 10716  140514         JSM ASLLN,I  RESET LNO
02810000 10717  164452         JMP AEOLB,I  PUT EOL IN BUFFER
02811000                *
02812000 10720  004177  FETC4  LDB P0       DEFAULT = LNO 0
02813000 10721  067701         JMP FETC5
02814000                *
02815000                *****************************************************************
02816000                *
02817000                *      PLACE LINE NO.IN I/O BUFF AND REV. COMPILE
02818000                *
02819000                *           ENTRY: A = ADDR OF LINE
02820000                *
02821000                *           EXIT: REV. COMPILED LINE IN I/O BUFF
02822000                *
02823000                *
02824000 10722  104000  PLIRC  LDB A,I      GET LINE BRIDGE
02825000 10723  174610         SRL 9
02826000 10724  174510         SBR 9        GET LINE LENGTH
02827000 10725  072101         RIA *+1      POINT TO SECOND WORD OF LINE
02828000 10726  030016         STA C        SET C-REG
02829000 10727  024000         ADB A
02830000 10730  024146         ADB M2       B = END SOURCE ADDR
02831000 10731  000303         LDA ACBF      COMPILE BUFF S/A
02832000 10732  030017         STA D        SET D-REG
02833000 10733  140470         JSM AMTLM,I  MOVE THE LINE INTO COMPILE BUFF
02834000 10734  140476         JSM ATLNI,I  TRANSFER LINE NO. TO I/O BUFF
02835000 10735  000077         LDA COLLN    GET COLLON
02836000 10736  074550         PBD A,I      INCRM AND PLACE IN I/O BUFF
02837000 10737  000117         LDA B40      GET BLANK
02838000 10740  074550         PBD A,I      INCRM AND PLACE IN I/O BUFF
02839000 10741  004017         LDB D        GET CHAR POINTR AND PASS TO REV. COMP.
02840000 10742  164356         JMP ARCLR,I  REVERSE COMPILE AND RETURN P+1
02841000                *
02842000                *****************************************************************
02843000                *      UP-ARROW
02844000                *
02845000                *      DECREMENT THECURRENT "LNO" AND
02846000                *
02847000                *      FETCH THE CORRESPONDING LINE
02848000                *
02849000                *
02850000 10743  043761  UPAR   JSM FLIN     FETCH LINE INIT
02851000 10744  005226         LDB LNO      GET CURRENT LINE NO.
02852000 10745  001232         LDA CFLAG    SEE IF FETCH BIT SET
02853000 10746  073002         SLA FRSAR    SKIP IF FIRST UP ARROW
02854000 10747  024257         ADB M1       DECREMENT LNO
02855000 10750  176450  FRSAR  SBM FETC4    SET LNO = 0 IF = -1
02856000 10751  035226         STB LNO      SET LINE COUNTER
02857000 10752  140512         JSM AFLAD,I  FIND S/A OF LINE
02858000 10753  140514         JSM ASLLN,I  LINE NOT FOUND SET LNO TO LAST LINE#
02859000 10754  067702         JMP FETC3    FETCH LINE
02860000                *
02861000                *
02862000                *      DOWN-ARROW
02863000                *
02864000                *      INCREMENT THECURRENT "LNO" AND
02865000                *
02866000                *      FETCH THE CORRESPONDING LINE
02867000                *
02868000                *
02869000 10755  043761  DNAR   JSM FLIN     FETCH LINE INIT
02870000 10756  045226         ISZ LNO      INCREM LINE NO.
02871000 10757  067760         JMP *+1
02872000 10760  067702         JMP FETC3    FETCH LINE
02873000                *
02874000                *
02875000                *       FETCH LINE INITIALIZATION
02876000                *
02877000                *          EXIT :   A=FWUP POINTER
02878000                *
02879000                *
02880000 10761  040724  FLIN   JSM SECCK    SEE IF PROGRAM IS SECURE
02881000 10762  140453         JSM ACLCM,I  CLEAR COMPILE BUFFER
02882000 10763  164475         JMP AEDPT,I  RESET EDIT POINTERS
02883000                *
02884000                *
02885000                *****************************************************************
02886000                *  STOP, REW IN ENTER OR LIVE KBD
```

CONTROL SUPERVISOR

```
                      *
                      *
10764  001235   PINEN LDA SKEY      GET KEYCODE
10765  010145         CPA P2        REWIND ?
10766  164601         JMP ARFK,I    YES, REWIND AND RETURN
                      *
10767  172701         SAM *+1,S     SET BIT 15 (INTERRUPTING KEY)
10770  040744         JSM SXCMM     IOR TO PRESENT XCOMM
10771  004132         LDB P13       SET FLAG 13
10772  140376         JSM ASFG,I
10773  140452         JSM AEOLB,I   CLR I/O BUFF, PUT EOL IN BUFF
10774  140503         JSM ARNLO,I   TURN ON RUN LIGHT
10775  066262         JMP XEN5      ABORT ENTER STMT
                      *
                      *
                      *       REJECTION ROUTINE FOR INTERRUPT THAT
                      *
                      *            DOES NOTHAVE A CORRECT INTRP. TABLE ENTRY
                      *
                      *
10776  140404   REJR  JSM AERR1,I   ILLEGAL INTERRUPT
10777  030061         ASC 1,01
                      *
                      *
                      *       ERROR MESSAGEGENERATOR WITHOUT RETURN
                      *
                      *       CALL SEQUENCE:  JSM AERR1,I
                      *
                      *                       ASC 1,XX WHERE XX=ERROR CODE
                      *
                      *       EXIT:           "ERROR XX" IN DISP BUFFER
                      *
                      *                       "JSM" STACK IS RESET
                      *
                      *
                      *
                      *
11000  070420   ERR1  EIR           ENABLE ALL INTERRUPTS
11001  141260         JSM ERRBP,I   GO THRU ERROR BYPASS LINK
11002  040717   EREXT JSM STELM     SET EOL MODE
11003  040703         JSM BEEP      GIVE ERROR BEEP
11004  042043         JSM EREX3     PUT LINE NO. IN DISPLAY   MAYBE
11005  000177   EREXX LDA P0        CLEAR RENUMBER FLAG,REWIND KEY FLAG
11006  031613         STA RENFG
11007  001067         LDA IBUFF+3   GET ERROR "XX"
11010  012566         CPA PRPRB     NO PRINTER OR NO PAPER ?
11011  066013         JMP EREX1     YES: BYPASS PRINT-ALL
11012  140436         JSM AEPON,I   GO THRU PRINT ALL
11013  001257   EREX1 LDA CSTAT     GET STATE VARIABLE
11014  010144         CPA P3        GO TO LIVE KBD ERROR PROCESSING IF
11015  164456         JMP ALXER,I   STATE = 3 OR 6
11016  010141         CPA P6
11017  164456         JMP ALXER,I
11020  042032         JSM EREX2       CHANGE STATE
                      *
11021  001257   EREX4 LDA CSTAT     GET CONTROL STATE
11022  010143         CPA P4        IF STATE = 4 THEN DON'T STRIP EXEC
11023  066026         JMP ERNOS
11024  001261         LDA AP3       SET AP1 BACK TO AP3
11025  031263   ERENT STA AP1
                      *
11026  000300   ERNOS LDA AJSTK     JSM STACK S/A-1
11027  030003         STA R         RESET JSM STACK PTR
11030  140433         JSM ALDSP,I     DISP ERROR MESSAGE
11031  165511         JMP MLBPL,I   GO TO IDLE(THRU MAIN BYPASS LINK)
                      ************************************************************
                      *
                      * EREX2  UNSTACKS AP1,AP3,  AND CHANGES STATE
                      *        1,3,5 TO 0,2,4  ;    2  TO 0
                      *             DOES NOT UNSTACK IF STATE = 0,2,4
                      *
                      ***************************
                      *
11032  001257   EREX2 LDA CSTAT     GET STATE VARIABLE
11033  073004         SLA EREX5     DO NOT UNSTACK IF = 0,2, OR 4
11034  020257         ADA M1        MAKE 1,3,5 = 0,2,4
11035  031257         STA CSTAT     RESTORE NEW STATE
11036  164516         JMP AREST,I   UNSTACK
                      *
11037  010145   EREX5 CPA P2        STATE = 2?
11040  000177   CLRST LDA P0        MAKE STATE = 0
11041  031257         STA CSTAT
11042  170201   ERNON RET 1
                      *
                      ************************************************************
```

```
                    *
                    * EREX3  PUTS "IN LINE #" IN I/O BUFFER IF STATE = 2 OR 6
                    *        OR IF THE RENUMBER GTO/GSB FLAG IS SET
                    *
                    ***************************
11043  001257       EREX3 LDA CSTAI     GET STATE VARIABLE
11044  010145             CPA P2        RUNNING PROGRAM?
11045  066052             JMP ELNO      YES, DSP LINE #
11046  010141             CPA P6        RUN PROG FROM LIVE KBD?
11047  066052             JMP ELNO      YES, DSP LINE #
11050  001613             LDA RENFG     RENUMBERING GTO'S AND GSB'S?
11051  073071             SLA ERNON     SKIP IF NOT
                    *
11052  002574       ELNO  LDA AELN1     GET "IN" MEAASGE
11053  031070             STA IBUFF+4
11054  002575             LDA AELN2     PUT IN I/O BUFFER
11055  031071             STA IBUFF+5
11056  005265             LDB HERE      GET CURRENT LINE ADDR
11057  140523             JSM AGLNO,I
11060  001307             LDA FWUP      SET S/A OF NEXT LINE TO BE THE FIRST LINE
11061  031266             STA WHERE     SET FOR CONTINUE ROUTINES
11062  006572             LDB AINLM     PTR FOR LINE NUMBER
11063  001226             LDA LNO       SET FOR ABTDA
11064  164477             JMP ABTDA,I   PLACE LINE NO. IN I/O BUFF
                    *
                    ****************************************************************
                    *
                    *  SYSTEM ERROR
                    *
                    ******************
                    *
11065  042000       SYSER JSM ERR1
11066  030060             ASC 1,00
                    *
                    ********************************************************************
                    *     ERROR MESSAGEGENERATOR WITH RETURN
                    *
                    *     CALL SEQUENCE:  JSM AERR2,I
                    *
                    *                          ASC 1,XX WHERE XX=ERROR CODE
                    *
                    *     EXIT:        "ERROR XX" IN DISP BUFFR
                    *
                    *                  RET P+2
                    *
                    *
11067  070420       ERR2  EIR           ENABLE INTERRUPTS
11070  141260             JSM ERRBP,I   PUT ERROR # IN I/O BUFFER
11071  170201             RET 1         RET 2
                    *
                    *
                    *      PLACE ERROR MESSAGE IN I/O BUFF
                    *
                    *
11072  140451       PEMIO JSM ACLEB,I   CLEAR I/ BUFFER
11073  002573             LDA AERMS     GET "ERROR" ADDR
11074  004313             LDB AIBUF     I/O BUFF S/A
11075  071403             XFR 4         TRANSFER "ERROR" TO I/O BUFF
11076  000003             LDA R         GET R-STACK POINTR
11077  020257             ADA M1        POINT TO "JSM AERRX" ENTRY IN STACK
11100  144000             ISZ A,I       POINT TO MESSAGE "XX" ADDR
11101  100000             LDA A,I       GET MESSAGE ADDR
11102  100000             LDA A,I       GET MESSAGE "XX" AND
11103  031067             STA IBUFF+3   STORE IN I/O BUFF
11104  170201             RET 1
                    *
                    *
                    *
                    *      ENTER STATEMENT EXECUTION
                    *
                    *            PRE-ENTER
                    *
                    *
11105  000143       XENO  LDA P4        SET ENTER STATE
11106  031257             STA CSTAT
11107  004244             LDB XMASK     CLEAR LIVE KBD BIT FROM XCOMM
11110  040740             JSM CLXCM
11111  031630             STA SVXCM
11112  000177             LDA P0        START WITH A CLEAR XCOMM
11113  031255             STA XCOMM
                    *
11114  040717       XENN  JSM STELM     SET EOL MODE
11115  140475             JSM AEDPT,I   RESET EDIT POINTERS
                    *
```

CONTROL SUPERVISOR

```
11116  001272        LDA FAP1
11117  104000        LDB A,I      LOOK AT NEXT PARAMETER
11120  174514        SBR 13
11121  014145        CPB P2       IS IT A STRING CONSTANT ?
11122  066133        JMP XEN1     YES
11123  014141        CPB P6       IS IT A STRING VARIABLE ?
11124  066173        JMP XEN9
                *
11125  005272        LDB FAP1     IT MUST BE NUMERIC
11126  040616        JSM ABSAD+1
11127  140377        JSM AGNAM,I  GET THE NAME
11130  000074  XEN8  LDA B77
11131  074550        PBD A,I      OUTPUT "?"
11132  066156        JMP XEN2
                *
11133  020144  XEN1  ADA P3
11134  104000        LDB A,I      GET LENGTH OF STRING CONSTANT
11135  076412        SZB XEN6     SKIP IF NULL STRING
11136  140451        JSM ACLEB,I  CLEAR I/O BUFFER
11137  001272        LDA FAP1
11140  020144        ADA P3
11141  104000        LDB A,I      B = LENGTH
11142  020254        ADA P1       A = SOURCE PTR
11143  172301        SAP *+1,S
11144  030017        STA D
11145  000315        LDA AIBFM    GET DESTINATION POINTR
11146  140502        JSM ATCHR,I  TRANSFER TO I/O BUFFER
11147  000254  XEN6  LDA P1
11150  140607        JSM ABUMP,I  SKIP PAST STRING CONSTANT
11151  000000        NOP
11152  105272        LDB FAP1,I   SEE IF NEXT PARAM IS A STRING VAR
11153  174514        SBR 13
11154  014141        CPB P6
11155  066174        JMP XEN15    YES, SO SET STRING ENTER FLAG
                *
11156  000177  XEN2  LDA P0       CLEAR STRING ENTER FLAG
11157  031326        STA STEFL
11160  001272  XEN3  LDA FAP1     SAVE FAP1,HERE
11161  031625        STA ENSV+1
11162  001265        LDA HERE
11163  031626        STA ENSV+2
11164  001267        LDA TRACE    SAVE TRACE FLAG
11165  031627        STA ENSV+3
11166  001232  XENPP LDA CFLAG    GET CONTROL FLAG
11167  170704        RAR 5        POSITION ENTER/PRINT FLAG BIT 4
11170  172002        SAP *+2      ENTER/PRINT?
11171  164437        JMP AEPNX,I  YES, PRINT PROMPT, RETURN P+1
11172  164436        JMP AEPON,I  NO, GO THROUGH PRINT-ALL
                *
11173  141322  XEN9  JSM STENT,I  GO TO STRING BLOCK FOR PROMPT
11174  000254  XEN15 LDA P1       SET STRING ENTER FLAG
11175  031326        STA STEFL
11176  066160        JMP XEN3
                *
                *
                *          POST-ENTER
                *
                *
11177  001257  CONEN LDA CSTAT    IGNORE KEY IF LIVE KBD
11200  010145        CPA P2
11201  066552        JMP BBEEP    LIVE KBD SO BEEP AND IGNORE
11202  001506        LDA FLAGS    CLEAR FLAG 13
11203  050151        AND M5
11204  031506        STA FLAGS
11205  005256        LDB MODE     SEE IF NOTHING ENTERED
11206  035233        STB TMP7     SAVE MODE
11207  014143        CPB P4       NOTHING IF MODE = 4
11210  140451        JSM ACLEB,I  CLEAR I/O BUFFER
11211  040715        JSM CLMOD    SET MODE = 0 SO I/O BUFFER IS COMP
11212  140503        JSM ARNLO,I  TURN ON RUN LIGHT
11213  140435        JSM ATRBF,I  TRANSFER LINE TO KBD BUFFER
11214  042166        JSM XENPP    SEE IF ENTER-PRINT
11215  001326        LDA STEFL    GET STRING ENTER FLAG
11216  010254        CPA P1       STRING ENTER?
11217  066274        JMP XEN10    YES
                *
11220  000257        LDA M1       FLAG THE ENTER REGISTER
11221  031476        STA ENR
11222  031517        STA RGFLG    DISABLE IMPLIED STORAGE INTO RES
11223  140515        JSM ASTKI,I  STACK SYSTEM INFO
11224  000142        LDA P5       SET STATE = 5
11225  031257        STA CSTAT
11226  043542        JSM EXCSS    COMPILE LINE, SET LINE BRIDGES
11227  140364  XENLP JSM AINTK,I  GO TO INTERPRETER
11230  140411        JSM AXCMM,I  SERVICE XCOMM
```

```
03140000 11231  066234        JMP *+3      RET1 STOP CONDITION
03141000 11232  005266        LDB WHERE    RET2 XCOMM SERVICED, CONTINUE EXEC
03142000 11233  066227        JMP XENLP
03143000 11234  140516        JSM AREST,I  UNSTACK SYSTEM INFO
03144000 11235  000143        LDA P4       SET STATE BACK TO 4
03145000 11236  031257        STA CSTAT
03146000 11237  042303        JSM RESPN    RESTORE FAP1
03147000 11240  005476        LDB ENR      CHECK ENR REGISTER
03148000 11241  014257        CPB M1
03149000 11242  066255        JMP XEN4     JUMP IF NOTHING ENTERED
03150000                *
03151000 11243  005272        LDB FAP1     "TO" ADDRESS
03152000 11244  040616        JSM ABSAD+1
03153000 11245  000341        LDA AENR     "FROM" ADDRESS
03154000 11246  140372        JSM AASTR,I  GO TRACE ASSIGNMENT
03155000 11247  042303  XEN11 JSM RESPN    RESTORE FAP1,HERE
03156000 11250  000254        LDA P1
03157000 11251  140607        JSM ABUMP,I  ADVANCE TO NEXT PARAMETER
03158000 11252  066260        JMP XEN55    END OF LIST
03159000 11253  066114        JMP XENN
03160000                *
03161000 11254  140452  XEN19 JSM AEOLB,I  PUT EOL IN I/O BUFFER
03162000 11255  004132  XEN4  LDB P13      SET FLAG 13
03163000 11256  140376        JSM ASFG,I
03164000 11257  066247        JMP XEN11
03165000                *
03166000 11260  000177  XEN55 LDA P0       CLEAR STOP KEY CODE
03167000 11261  031206        STA .WKC
03168000 11262  001630  XEN5  LDA SVXCM    RESTORE XCOMM
03169000 11263  040744        JSM SXCMM    IOR NEW XCOMM TO OLD XCOMM
03170000 11264  140433        JSM ALDSP,I  DISPLAY I/O BUFFER
03171000 11265  001624        LDA ENSV
03172000 11266  030016        STA C        RESTORE C
03173000 11267  042303        JSM RESPN    RESTORE HERE
03174000 11270  000145        LDA P2       SET RUN STATE
03175000 11271  031257        STA CSTAT
03176000 11272  140365        JSM AINTX,I  BACK TO INTERPRETER
03177000 11273  067517        JMP EXCS4    BACK TO NORMAL INTERPRETER CALLING LOOP
03178000                *
03179000 11274  001233  XEN10 LDA TMP7     GET OLD MODE
03180000 11275  010143        CPA P4       NOTHING ENTERED?
03181000 11276  066254        JMP XEN19    SET FLAG 13 IF SO
03182000 11277  042303        JSM RESPN    RESTORE FAP1
03183000 11300  141323        JSM STEAS,I  GO TO STRING ROM FOR ASSIGNMENT
03184000 11301  140452        JSM AEOLB,I  PUT EOL IN I/O BUFFER
03185000 11302  066247        JMP XEN11    ADVANCE TO NEXT PARAMETER
03186000                *
03187000                *
03188000                *       RESTORE POINTERS
03189000                *
03190000                *
03191000 11303  001626  RESPN LDA ENSV+2
03192000 11304  031265        STA HERE     RESTORE HERE
03193000 11305  001625        LDA ENSV+1
03194000 11306  031272        STA FAP1     RESTORE FAP1
03195000 11307  001627        LDA ENSV+3
03196000 11310  031267        STA TRACE
03197000 11311  170201        RET 1
03198000                *
03199000                ***********************************************************
03200000                *       EXECUTION OF CONTINUE
03201000                *
03202000                *
03203000                *
03204000                *     "ECIM" IS THEIMMEDIATE EXECUTE ENTRY
03205000                *
03206000 11312  043364  ECIM  JSM CNINS    CONTINUE INIT
03207000 11313  005266        LDB WHERE    GET S/A OF NEXT LINE
03208000 11314  035227        STB TMP1     AND SAVE IT
03209000                *
03210000 11315  000177  ECON3 LDA P0       CLEAR XCOMM
03211000 11316  031255        STA XCOMM
03212000 11317  005227        LDB TMP1     RECALL S/A OF LINE
03213000 11320  067516        JMP EXCS2    GO TO MAIN RUN LOOP
03214000                *
03215000                *  CONTINUE COMMAND(FROM A SPECIFIED LINE)
03216000                *
03217000 11321  042344  ECONT JSM ERN.X    CHECK FOR LINE NO. GIVEN
03218000 11322  066312        JMP ECIM     NO LINE # GIVEN
03219000 11323  043364        JSM CNINS    CONTINUE INIT
03220000 11324  066315        JMP ECON3
03221000                *
03222000                *
03223000                *       EXECUTION OFRUN COMMAND
```

```
                      *
                      *
                      *
                      *    "ERUN" IS THE IMMEDIATE EXECUTE ENTRY
                      *
11325  005307  ERUN   LDB FWUP      GET S/A OF USER PROG
11326  035227         STB TMP1      AND SAVE IT
11327  140503  ERUN1  JSM ARNLO,I   TURN ON RUN LIGHT
11330  040717         JSM STELM     SET MODE =4
11331  140452         JSM AEOLB,I   CLR DISPLAY
11332  140433         JSM ALDSP,I
11333  000145         LDA P2        SET RUN STATE
11334  031257         STA CSTAT
11335  042400         JSM RUNSB     RUN INIT
11336  066315         JMP ECON3
                      *
                      *  RUN COMMAND (FROM A SPECIFIED LINE)
                      *
11337  005307  ERUX   LDB FWUP      GET FIRST WORD OF USER PROGRAM
11340  035227         STB TMP1      AND SAVE IT
11341  042344         JSM ERN.X     CHECK FOR LINE NO. GIVEN
11342  066327         JMP ERUN1
11343  066327         JMP ERUN1     RET 2  LINE # GIVEN
                      *
                      *
                      *
                      *       GET LINE NO. (IF GIVEN) AND S/A OF LINE
                      *
                      *  EXIT  :  RET 1     LINE # OR LABEL NOT GIVEN
                      *           RET 2     S/A OF LINE IN TMP1
                      *
                      *
11344  140501  ERN.X  JSM AGNXT,I   GET NEXT CHARACTER FROM I/O BUFFER
11345  010053         CPA EOL       START LINE GIVEN ?
11346  170201         RET 1         NO
11347  010116         CPA B42       QUOTE?
11350  066357         JMP ERLBL     LABEL IF SO
                      *
11351  140507  ERUX1  JSM AINTC,I   BUILD A BINARY NUMBER
11352  035233         STB TMP7      AND SAVE IT
11353  140513         JSM AFLNA,I   FIND S/A OF LINE GIVEN
11354  064722         JMP ERLNF     LINE NOT FOUND
11355  031227  ERADR  STA TMP1      SAVE S/A OF LINE
11356  170202         RET 2
                      *
11357  000214  ERLBL  LDA EOLB      PUT EOL IN I/O BUFFER
11360  130311         STA AKBFL,I
11361  074760         WBC A,D       DUMMY WITHDRAW TO DEC C
11362  000016         LDA C         SET PTR IN CASE OF AN ERROR
11363  031241         STA OLDC
11364  074560         WBC A,I       SET C BACK TO FIRST CHAR
11365  140353         JSM ALBLN,I   FIND LABEL LENGTH
11366  000303         LDA ACBF      COMPILE LABEL IN COMPILE BUFFER
11367  030017         STA D         SET PTR
11370  140354         JSM ALBCM,I   COMPILE LABEL
11371  000303         LDA ACBF
11372  020254         ADA P1        PT TO START OF COMPILED LABEL
11373  030016         STA C         SET PTR
11374  074560         WBC A,I       GET LENGTH OF LABEL
11375  140400         JSM ACLBL,I   GET S/A OF LINE IN B
11376  035227         STB TMP1      SET START ADDRESS
11377  170202         RET 2
                      *
                      *
                      *       RUN COMMAND SUBR.
                      *
                      *
                      *
11400  140472  RUNSB  JSM AERAV,I   ERASE VARIABLES,RESET EXECUTION STACK
11401  140360         JSM ARSGT,I   RESET HISPEED GTO/GSB'S
11402  043402         JSM CRUND     SET CFLAG
11403  000177         LDA P0
11404  031063         STA NPROG     SET FOR RLINK  RUN INIT
11405  165533         JMP RLINK,I   GO THRU LINK FOR OPTION BLOCKS
                      *
                      ****************************************************
                      *
                      *
                      *       "XCOMM" MANAGEMENT
                      *
                      *            PROCESS INTERRUPTING KEYS
                      *
                      *            DIRECT OPTION BLOCK INTERRUPTS AND
                      *
```

CONTROL SUPERVISOR

```
03308000                  *          LIVE KEYBORAD ACTIVITY
03309000                  *
03310000                  *            EXIT: RET P+1    STOP STATEMENT
03311000                  *
03312000                  *                  RET P+2    XCOMM ALL CLEAR
03313000                  *
03314000                  *
03315000 11406  001255    ERUN7 LDA XCOMM     GET INTERPRETER FLAG
03316000 11407  172402          SAM *+2       INTERRUPTING KEY ?
03317000 11410  066432          JMP ERUN6     NO
03318000 11411  170500          SAR 1         POSITION REW BIT
03319000 11412  073010          SLA ERUN2     IF CLEAR THEN MUST BE STOP KEY
03320000 11413  140601          JSM ARFK,I    REWIND THE TAPE
03321000 11414  070430          DIR           DISABLE INTERRUPTS
03322000 11415  001255          LDA XCOMM     SEE IF STOP KEY ALSO
03323000 11416  073404          RLA ERUN2     SKIP IF BIT 0 SET, STOP KEY CODE
03324000 11417  004211          LDB BXCAA     SAVE BITS 5 TO 14
03325000 11420  040740          JSM CLXCM
03326000 11421  066406          JMP ERUN7     CHECK XCOMM AGAIN
03327000                  *
03328000 11422  004254    ERUN2 LDB P1        SET STOP KEY INDICATOR
03329000 11423  070430    ERNX1 DIR
03330000 11424  001255          LDA XCOMM     SAVE ONLY BIT 13 OF XCOMM
03331000 11425  050227          AND B20K
03332000 11426  031255          STA XCOMM
03333000 11427  070420          EIR
03334000 11430  140475          JSM AEDPT,I   RESET EDIT PTRS
03335000 11431  064717          JMP STELM     SET MODE = 4 AND RETURN
03336000                  *
03337000 11432  170600    ERUN6 SAL 1         POSITION BIT 14
03338000 11433  172003          SAP ERUN8     SKIP IF NOT LIVE KEYBOARD
03339000 11434  140455          JSM ALKEX,I   LIVE KEYBOARD EXECUTION
03340000 11435  066406          JMP ERUN7     CHECK XCOMM AGAIN
03341000                  *
03342000 11436  170600    ERUN8 SAL 1         POSITION BIT 13
03343000 11437  172003          SAP ERUN9     SKIP IF NOT INTERRUPT SERV. ROUTINE
03344000 11440  141510          JSM .IOSR,I   GIVE CONTROL TO SYSTEM I/O ROM
03345000 11441  066406          JMP ERUN7     CHECK XCOMM AGAIN
03346000                  *
03347000 11442  072002    ERUN9 RZA *+2       SKIP IF XCOMM NOT CLEAR
03348000 11443  170202          RET 2
03349000                  *
03350000 11444  001255          LDA XCOMM     SEE IF NEW HIGHER ORDER BITS WERE SET
03351000 11445  170507          SAR 8         GET BITS 8-15
03352000 11446  072040          RZA ERUN7     BITS SET, SERVICE THEM
03353000                  *
03354000 11447  005255          LDB XCOMM     POSITION BIT 7 FOR RETURN
03355000 11450  174706          RBR 7
03356000 11451  066423          JMP ERNX1
03357000                  *
03358000                  *
03359000                  ******************************************************************
03360000                  *
03361000                  *      ROUTINE TO REPLACE - STORE KEYCODES
03362000                  *
03363000                  *    IN THE EDIT BUFF AREA
03364000                  *
03365000                  *          ENTRY: COD   N "SKEY"
03366000                  *
03367000                  *         EXIT:
03368000                  *
03369000                  *                 B=I/O CURRENT POINTR
03370000                  *
03371000                  *                  RET P+1 EDIT BUFF FULL: CHAR NOT STORED
03372000                  *
03373000                  *                 RET P+2   CHAR STORED
03374000                  *
03375000                  *                           AND "IOCP" POINTER INCREMENTED
03376000                  *
03377000                  *
03378000 11452  001235    ISTOR LDA SKEY      GET CODE
03379000 11453  031715    ISTOX STA T5        SAVE CODE
03380000 11454  005213          LDB OLCP      GET OLD CURRENT POINTR
03381000 11455  014257          CPB M1        FORWARD CURSOR PASS MADE ?
03382000 11456  045213          ISZ OLCP      YES: SET OLCP = 0
03383000 11457  066460          JMP *+1
03384000 11460  005215          LDB IOCP      GET I/O BUFF CURRENT PTR
03385000 11461  042535          JSM CKFUL     SEE IF BUFFER IS FULL
03386000 11462  064703          JMP BEEP      BEEP AND RETURN IF BUFF IS FULL
03387000 11463  005214    IST02 LDB CRSP      GET CURSOR POINTR
03388000 11464  176421          SRM IST05     SKIP IF INSERT CURSOR SET
03389000 11465  005215    IST06 LDB IOCP      NO: GET I/O BUFF CURRENT POINTR
03390000 11466  034016          STB C         SET C-REG
03391000 11467  074540          PRC A,I       INCRM POINTR AND STORE CODE
03392000 11470  004016          LDB C
```

```
11471  035215        STB IOCP     UPDATE POINTR
11472  015213        CPB OLCP     "IOCP" = PREVIOUS CURRENT POINTR?
11473  066531        JMP IST04    YES
11474  005214        LDB CRSP     GET CURSOR POINTR
11475  001214        LDA CRSP     GET CURSOR POINTR
11476  072403        SZA IST03    SKIP IF CURSOR NOT SET
11477  050074        AND B77      SAVE CURSOR COUNT
11500  011512        CPA DLEN     CURSOR AT LAST DISP POSITION ?
11501  170202  IST03 RET 2        YES; DO NOT INCRM
               *
11502  076101        RIB *+1      MOVE CURSOR TO NEXT CHAR
11503  035214        STB CRSP     UPDATE CURSOR POINTR
11504  170202        RET 2
               *
11505  005213  IST05 LDB OLCP     GET OLD CURRENT POINTER
11506  042535        JSM CKFUL    SEE IF BUFFER IS FULL
11507  064703        JMP BEEP     RETURN AND BEEP IF BUFFER IS FULL
11510  015215        CPB IOCP     OLCP = IOCP ?
11511  066526        JMP IST08    YES
11512  034016        STB C        SET SOURCE POINTR
11513  034017        STB D        SET DESTINATION POINTR
11514  074571        WBD B,I
11515  004017        LDB D        GET OLCP+1
11516  035213        STB OLCP     UPDATE OLD CURRENT POINTR
11517  074571        WBD B,I      D = OLCP + 2
11520  074761  IST07 WBC B,D      GET BYTE AND DECRM
11521  074751        PBD B,D      DECRM AND PLACE BYTE
11522  004016        LDB C        GET SOURCE POINTR
11523  015215        CPB IOCP     ALL CHARS BETWEEN IOCP AND
11524  066465        JMP IST06    OLCP SHIFTED RIGHT ONCE ?
11525  066520        JMP IST07    NO; CONT TRANSFER
               *
11526  042531  IST08 JSM IST04    RESET "CRSP" AND "OLCP"
11527  066530        JMP *+1
11530  066465        JMP IST06    STORE CHAR IN I/O BUFF
               *
11531  004177  IST04 LDB P0
11532  035214        STB CRSP     CLEAR CURSOR POINTR
11533  035213        STB OLCP     CLEAR PREVIOUS CURRENT POINTR
11534  170202        RET 2
               *
               ******************
               *
               *  CKFUL  SERVICE ROUTINE THAT CHECKS THE EDIT BUFFER
               *         TO SEE IF THIS CHAR IS THE BEEP CHAR
               *         OR IF THE BUFFER IS FULL   RET 1 IF FULL
               *         BEEPS IF THIS IS THE BEEP CHAR
               *        IF BUFF IS NOT FULL RET2 WITH T5 IN A
               *        DOES NOT DESTROY B
               *
               ***************
               *
11535  035236  CKFUL STB TMP8     SAVE ADDRESS
11536  001353        LDA AEBFL
11537  020257        ADA M1       LAST ALLOWED CHAR ADDRESS
11540  140362        JSM AFBAD,I  SEE IF BUFFER FULL
11541  172010        SAP ISRET    FULL IF RESULT IS POSITIVE
11542  001353        LDA AEBFL    GET BEEP CHAR ADDR
11543  020154        ADA M8
11544  005236        LDB TMP8     GET CHAR ADDR AGAIN
11545  014000        CPB A
11546  040703        JSM BEEP     YES
11547  001715        LDA T5       NO
11550  170202        RET 2        TAKE BUFF NOT FULL RETURN
11551  170201  ISRET RET 1
               *
               ******************
               *
11552  040703  BBEEP JSM BEEP     IGNORE THIS KEY
11553  170202  BACEL RET 2        DON'T DISPLAY I/O BUFFER
               *
               *
               *
               ***********************************************************
               *
               *  UP OR DOWN ARROWIN LIVE KBD
11554  000143  WTLKB LDA P4
11555  011257        CPA CSTAT    BEEP IF ENTER
11556  066552        JMP BBEEP    ENTER SO BEEP AND RETURN
11557  011256        CPA MODE
11560  170202        RET 2
11561  140432        JSM ADSPC,I  DUMMY DISPLAY
11562  140432        JSM ADSPC,I  DISPLAY BUFFER
11563  006577        LDB M800     WAIT 800 MS
```

```
03477000 11564  040633        JSM DELAY
03478000 11565  170202        RET 2
03479000                *
03480000                ***************************************************************
03481000                *
03482000                *  CONSTANTS
03483000                *
03484000 11566  030465  PRPRB OCT 30465    ASCII 15
03485000 11567  077457  LITAD DEF ITABL+15 LAST ENTRY IN INTERRUPT TABLE
03486000 11570  110654  ASCOI DEF SCNDT+1  COMMAND TABLE ADDR
03487000 11571  000163  P115  DEC 115
03488000 11572  077071  AINLM DEF IBUFF+5  START ADDR FOR LINE NUMBER OF ERROR
03489000 11573  000271  AERMS DEF LKERM    PTR TO LOWER CASE "ERROR"
03490000 11574  020151  AELN1 OCT 20151    BLANK I
03491000 11575  067040  AELN2 OCT 67040    N BLANK
03492000 11576  022000  ASYSM DEF 22000B   STOP ADDR OF ROM SEARCH
03493000 11577  176340  M800  DEC -800
03494000                *
03495000                ****************************************************************
03496000                *
03497000                *     THIS TABLE CONTAINS THE ADDRESS OF THE
03498000                *
03499000                *     PROCESSING ROUTINES
03500000                *
03501000                *            MODE = 0 KEYBOARD ENTRY
03502000                *
03503000                *                   1 FETCH
03504000                *
03505000                *                   2 EDIT
03506000                *
03507000                *                3   NEVER
03508000                *
03509000                *                   4 END OF LINE
03510000                *
03511000                *
03512000                *    BSS 'S TO BE FILLED IN BY THE 12K AND 22K PAGES
03513000                *
03514000                *
03515000 11613                ORG 11613B
03516000 11613  111607  .ATBL DEF .TB3-5,I        TABLE BASE - 5  (FIRST CN = 1)
03517000                *
03518000                *         EXECUTE (1)
03519000                *
03520000 11614  010437  .TB3  DEF EXCK
03521000 11615  010317        DEF ERILO
03522000 11616  010437        DEF EXCK
03523000 11617  010477        DEF EXCST
03524000 11620  010437        DEF EXCK
03525000                *
03526000                *         STORE    (2)
03527000                *
03528000 11621                BSS 1
03529000 11622  010317        DEF ERILO
03530000 11623                BSS 1
03531000 11624  011552        DEF BBEEP
03532000 11625                BSS 1
03533000                *
03534000                *      INSERT/REPLACE CHAR (3)
03535000                *
03536000 11626                BSS 3
03537000 11631  000000        DEF 0
03538000 11632  011553        DEF BACEL
03539000                *
03540000                *         CLEAR    (4)
03541000                *
03542000 11633                BSS 5
03543000                *
03544000                *       DELETE CHAR (5)
03545000                *
03546000 11640                BSS 3
03547000 11643  000000        DEF 0
03548000 11644  011553        DEF BACEL
03549000                *
03550000                *         STEP      (6)
03551000                *
03552000 11645  010407        DEF STEPK
03553000 11646  010407        DEF STEPK
03554000 11647  010407        DEF STEPK
03555000 11650  011552        DEF BBEEP
03556000 11651  010407        DEF STEPK
03557000                *
03558000                *           RIGHT ARROW (7)
03559000                *
03560000 11652                BSS 3
```

CONTROL SUPERVISOR

```
03561000 11655  000000          DEF 0
03562000 11656                  BSS 1
03563000                 *
03564000                 *          LEFT ARROW (10)
03565000                 *
03566000 11657                  BSS 3
03567000 11662  000000          DEF 0
03568000 11663                  BSS 1
03569000                 *
03570000                 *      DOWN-ARROW  (11)
03571000                 *
03572000 11664  010755          DEF DNAR
03573000 11665  010755          DEF DNAR
03574000 11666  010755          DEF DNAR
03575000 11667  011554          DEF WTLKB
03576000 11670  010755          DEF DNAR
03577000                 *
03578000                 *            RECALL ( 12 )
03579000                 *
03580000 11671                  BSS 3
03581000 11674  000000          DEF 0          SHOLUD BE BSS 1!!!!!!!!!!!!!!!!!!
03582000 11675                  BSS 1
03583000                 *
03584000                 *          PROGRAMMABLE (13)
03585000                 *
03586000 11676  010323          DEF P02
03587000 11677  010321          DEF PEOL
03588000 11700  010323          DEF P02
03589000 11701  000000          DEF 0
03590000 11702  010321          DEF PEOL
03591000                 *
03592000                 *    UP-ARROW (14)
03593000                 *
03594000 11703  010743          DEF UPAR
03595000 11704  010743          DEF UPAR
03596000 11705  010743          DEF UPAR
03597000 11706  011554          DEF WTLKB
03598000 11707  010743          DEF UPAR
03599000                 *
03600000                 *      BACK  (15)
03601000                 *
03602000 11710                  BSS 3
03603000 11713  000000          DEF 0
03604000 11714  011553          DEF BACEL
03605000                 *
03606000                 *      FORWARD  (16)
03607000                 *
03608000 11715                  BSS 3
03609000 11720  000000          DEF 0
03610000 11721  011553          DEF BACEL
03611000                 *
03612000                 *      PROG. INTERRUPTING KEYS (17)
03613000                 *
03614000 11722                  BSS 3
03615000 11725  010764          DEF PINEN
03616000 11726                  BSS 1
03617000                 *
03618000                 *        TYPING-AIDS  (20)
03619000                 *
03620000 11727                  BSS 5
03621000                 *
03622000                 *      SPECIAL KEYS  (21)
03623000                 *
03624000 11734                  BSS 5
03625000                 *
03626000                 *        PRINT ALL  (22)
03627000                 *
03628000 11741  010326          DEF PALL
03629000 11742  010326          DEF PALL
03630000 11743  010326          DEF PALL
03631000 11744  000000          DEF 0
03632000 11745  010326          DEF PALL
03633000                 *
03634000                 *      LINE INSERT  (23)
03635000                 *
03636000 11746                  BSS 1
03637000 11747  010317          DEF ERILO
03638000 11750                  BSS 1
03639000 11751  011552          DEF BBEEP
03640000 11752                  BSS 1
03641000                 *
03642000                 *        RUN  (24)
03643000                 *
03644000 11753  011325          DEF ERUN
03645000 11754  011325          DEF ERUN
```

```
03646000 11755  011325        DEF ERUN
03647000 11756  011552        DEF BBEEP
03648000 11757  011325        DEF ERUN
03649000                *
03650000                *     CONTINUE (25)
03651000                *
03652000 11760  011312        DEF ECIM
03653000 11761  011312        DEF ECIM
03654000 11762  011312        DEF ECIM
03655000 11763  011177        DEF CONEN
03656000 11764  011312        DEF ECIM
03657000                *
03658000                *      LINE DELETE  (26)
03659000                *
03660000 11765  011552        DEF BBEEP
03661000 11766                BSS 1
03662000 11767  011552        DEF BBEEP
03663000 11770  011552        DEF BBEEP
03664000 11771  011552        DEF BBEEP
03665000                *
03666000                *      RESULT (27)
03667000                *
03668000 11772  010352        DEF RESK
03669000 11773  010361        DEF REOL
03670000 11774  010352        DEF RESK
03671000 11775  000000        DEF 0
03672000 11776  010361        DEF REOL
03673000                *
03674000                **********************************************************************
03675000                *
03676000 11777                BSS 1         CHECK SUM !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
03677000                *
03678000                *********************
03679000                *
03680000                *     DEFINITIONS
03681000                *
03682000                *
03683000        000263  MAXLN EQU FLAG
03684000        011571  B163  EQU P115
03685000        000170  BUHM  EQU M256
03686000        000122  B32   EQU P26
03687000        000052  STPMS EQU B200
03688000        000263  TRCMS EQU FLAG
03689000        000077  COLLN EQU B72
03690000        000053  EOL   EQU D177
03691000        000177  KPA   EQU P0
03692000        000116  QUOTE EQU B42
03693000        077467  LPSVA EQU LPIT
03694000        077470  LPSVB EQU LPIT+1
03695000        077471  LPSVC EQU LPIT+2
03696000        077473  LPSVE EQU LPIT+4
03697000        077474  LPSVO EQU LPIT+5
03698000        000045  DCMND EQU B377
03699000        000236  CTCNT EQU B2K
03700000        077216  CST   EQU CSTMP
03701000        077216  SIOCP EQU CST
03702000        077217  .WPRT EQU CST+1
03703000        077220  M     EQU CST+2
03704000        077221  PLADD EQU CST+3
03705000        077223  TMP6  EQU CST+5
03706000        077224  K     EQU CST+6
03707000        077225  TMP2  EQU CST+7
03708000        077226  LNU   EQU CST+8
03709000        077227  TMP1  EQU CST+9
03710000        077230  TMP5  EQU CST+10
03711000        077231  TMP3  EQU CST+11
03712000        077232  CFLAG EQU CST+12
03713000        077233  TMP7  EQU CST+13
03714000        077234  TMP4  EQU CST+14
03715000        077235  SKEY  EQU CST+15
03716000        077236  TMP8  EQU CST+16
03717000        077206  .WKC  EQU IOTMP
03718000        077207  .WMOD EQU IOTMP+1
03719000        077210  DTMP1 EQU IOTMP+2
03720000        077211  DTMP2 EQU IOTMP+3
03721000        077212  SPKN  EQU IOTMP+4
03722000        077213  OLCP  EQU IOTMP+5
03723000        077214  CRSP  EQU IOTMP+6
03724000        077215  IOCP  EQU IOTMP+7
03725000        077613  RENFG EQU LKTMP+6
03726000        000433  DISP  EQU ALDSP
03727000                *
03728000                *
03729000                *
03730000                      END

END OF PASS 2 NO ERRORS DETECTED
```

```
00003000 76550               ORG 76550B
00004000                     UNL
02000000                     LST
02001000              *

02003000              *
02004000              *      BASE PAGE LINKS
02005000              *
02006000 00432               ORG ADSPC
02007000 00432  012140       DEF DISPC    DISP INFO WITH CURSOR
02008000 00433  012135       DEF DISP     DISPLAY ROUTINE - NO RESET JSM STACK
02009000 00434  012000       DEF KBSRV    KEYBOARD SERVICE ROUTINE
02010000 00435  013430       DEF TRBUF    TRANSFER I/O TO KEYBOARD BUFFER
02011000 00436  013123       DEF EPON     PRINT-ALL ROUTINE
02012000 00437  013126       DEF EPNX     PRINT-ALL LINK FOR ENTER PRINT
02013000 00440  012044       DEF SVRG     SAVE LOW PRIORITY A,B,E,O
02014000 00441  012012       DEF KBSR2    RESTORE LOW PRIORITY A,B,E,O
02015000 00442  012503       DEF CPST     CHECK PRINTER STATUS
02016000 00443  012524       DEF PRNT     PRINT CHARS ALREADY GIVEN TO HARDW.
02017000 00444  012514       DEF .PRNT    PRINT 16 CHARS FROM I/O BUFF
02018000 00445  012606       DEF PNUMR    PRINT A NUMERIC VALUE
02019000 00446  013010       DEF FBP      FIND DISP BEGIN POINTER
02020000 00447  013716       DEF SWIOP    SWAP PARAM TO EDIT I/O BUFFER
02021000 00450  013506       DEF CLBIO    CLEAR I/O BUFFER
02022000 00451  013465       DEF CLEBF    CLEAR EDIT BUFFER
02023000 00452  013511       DEF EOLEB    SET EOL IN EDIT BUFFER
02024000 00453  013515       DEF CLCMB    CLEAR COMPILE BUFFER
02025000 00454  013165       DEF RPRL     ROM POWER REDUCTION LOOP
02026000 00455  013575       DEF LKBEX    LIVE KBD EXECUTION
02027000 00456  013622       DEF LEXER    LIVE KBD EXEC ERROR ROUTINES
02028000 00457  013570       DEF LEXKY    LIVE KBD EXECUTE KEY PROCESSING ROUT
02029000 00460  113722       DEF K1.I     KEY CONTROL CODE TABLE
02030000 00461  013117       DEF EPKBD    PRINT-ALL FROM KBD BUFFER
02031000 00462  012672       DEF PSTRG    PRINT A STRING
02032000              *
02033000 00566               ORG ALST
02034000 00566  012174       DEF LIST     LINK TO EXECUTE 'LIST'
02035000 00567  012554       DEF EPRT     LINK TO EXECUTE 'PRT'
02036000 00570  012742       DEF EDIS     LINK TO EXECUTE 'DSP'
02037000 00571  012540       DEF PLDX     LINK TO EXECUTE 'SPC'
02038000 00572  012333       DEF LISTK    LINK TO EXECUTE "LISTK"
02039000 00573  013526       DEF ELKE     LIVE KBD ENABLE
02040000 00574  013531       DEF ELKD     LIVE KBD DISABLE
02044000              *
02045000 11614               ORG 11614B
02046000              *
02047000 11614               BSS 5        EXECUTE
02048000 11621               BSS 5        STORE
02049000 11626               BSS 5        INSERT/REPLACE
02050000              *
02051000 11633  013345       DEF CLEAR    CLEAR KEY
02052000 11634  013345       DEF CLEAR
02053000 11635  013345       DEF CLEAR
02054000 11636  013353       DEF CLEEN
02055000 11637  013345       DEF CLEAR
02056000              *
02057000 11640  013363       DEF DLCH     DELETE CHARACTER
02058000 11641  013363       DEF DLCH
02059000 11642  013363       DEF DLCH
02060000 11643               BSS 2
02061000              *
02062000 11645               BSS 5        STEP
02063000 11652               BSS 5        RIGHT ARROW
02064000 11657               BSS 5        LEFT ARROW
02065000 11664               BSS 5        DOWN ARROW
02066000              *
02067000 11671  013241       DEF RECL     RECALL
02068000 11672  013241       DEF RECL
02069000 11673  013241       DEF RECL
02070000 11674  013241       DEF RECL
02071000 11675  013241       DEF RECL
02072000              *
02073000 11676               BSS 5        PROG KEYS  ALPHA NUMERIC
02074000 11703               BSS 5        UP ARROW
02075000 11710               BSS 5        BACK
02076000 11715               BSS 5        FORWARD
02077000 11722               BSS 5        STOP,REW
02078000              *
02079000 11727  013043       DEF LTID     TYPING AIDS
02080000 11730  013043       DEF LTID
02081000 11731  013043       DEF LTID
02082000 11732  013043       DEF LTID
02083000 11733  013043       DEF LTID
02084000              *
02085000 11734               BSS 5        SPECIAL KEYS
02086000 11741               BSS 5        PRINT-ALL
02087000 11746               BSS 5        LINE INSERT
```

CONTROL SUPERVISOR LINKS

```
02088000 11753                 BSS 5       RUN
02089000 11760                 BSS 5       CONTINUE
02090000 11765                 BSS 5       LINE DELETE
02091000 11772                 BSS 5       RESULT KEY
02092000                 *
```

I/O SUPERVISOR

```
02095000                 *
02096000                 *
02097000                 ************************
02098000                 *                      *
02099000                 *   I/O SUPERVISOR
02100000                 *
02101000                 *
02102000                 *
02103000                 *                      *
02104000                 ************************
02105000                 *
02106000                 *
02107000                 *         IOSP
02108000                 *
02109000                 *
02110000                 *
02111000                 *
02112000                 *
02113000 12000                 ORG 12000B
02114000                 *
02115000                 *
02116000                 *
02117000                 *
02118000                 *
02119000                 *
02120000                 *
02121000                 *
02122000                 *
02123000                 *
02124000                 *
02125000                 *
02126000                 *
02127000 12000  043044   KBSRV JSM SVRG       SAVE REGISTERS
02128000 12001  000004         LDA R4         GET KEY CODE
02129000 12002  031207         STA .WMOD      SAVE KEYBOARD CODE
02130000 12003  043061         JSM KCASC      KEYCODE CONVERSION TO ASCII
02131000 12004  031206         STA .WKC       SAVE CODE
02132000 12005  005257         LDB CSTAT      GET STATE
02133000 12006  076022         RZB KBSR5      SKIP IF NOT IDLE STATE
02134000 12007  001207   KBSR6 LDA .WMOD
02135000 12010  172701         SAM *+1,S      SET NEW KEY FLAG
02136000 12011  031207         STA .WMOD
02137000 12012  001472   KBSR2 LDA LPSVD      RESTORE C,D
02138000 12013  030017         STA D
02139000 12014  001471         LDA LPSVC
02140000 12015  030016         STA C
02141000 12016  001473         LDA LPSVE      GET E REG. INFO
02142000 12017  177201         SEC *+1,C      CLEAR E REG.
02143000 12020  073002         SLA *+2        SKIP IF LSB =0
02144000 12021  177301         SEC *+1,S
02145000 12022  173201         SOC *+1,C      CLEAR O REG.
02146000 12023  172002         SAP *+2
02147000 12024  173301         SOC *+1,S
02148000 12025  005470         LDB LPSVB      RESTORE B REGISTER
02149000 12026  001467         LDA LPSVA      RESTORE A REGISTER
02150000 12027  170300   KBSR3 RET 0,P        RETURN AND TURN-ON INTERRUPT
02151000                 *
02152000 12030  014143   KBSR5 CPB P4         ENTER STATE ?
02153000 12031  067007         JMP KBSR6      YES
02154000                 *
02155000 12032  020147   KBSR1 ADA M3
02156000 12033  172005         SAP KBSR4      SKIP IF NOT AN INTERRUPTING KEY
02157000 12034  001206         LDA .WKC       IOR KEYCODE INTO XCOMM
02158000 12035  172701         SAM *+1,S      SET BIT 15 ALSO
02159000 12036  040744         JSM SXCMM
02160000                 *
02161000 12037  067012         JMP KBSR2      RESTORE REGISTERS
02162000                 *
02163000 12040  001623   KBSR4 LDA LKFLG      GET LIVE KEYB. FLAG
02164000 12041  073451         RLA KBSR2      SKIP IF LIVE KBD NOT ENABLED
02165000                 *
02166000 12042  042533         JSM LKPRC      GO TO THE LIVE KBD PROC ROUTINES
02167000                 *
02168000 12043  067012         JMP KBSR2      RESTORE REGISTERS
```

I/O SUPERVISOR

```
                   *
                   *
                   *       SAVE-REGISTERS SUBR.
                   *
                   *           LOW PRIORITY: A,B,E,O
                   *
                   *
12044  031467  SVRG  STA LPSVA    LOW PRIORITY SAVE "A" TEMPORARY
12045  035470        STB LPSVB    LOW PRIORITY SAVE "B" TEMPR.
12046  000177        LDA P0
12047  177002        SEC *+2      SKIP IF CLEAR
12050  000254        LDA P1
12051  173002        SOC *+2      SKIP IF CLEAR
12052  172301        SAP *+1,S
12053  031473        STA LPSVE    SAVE O,E REGISTERS
12054  000016        LDA C
12055  031471        STA LPSVC    SAVE C-REG.
12056  000017        LDA D
12057  031472        STA LPSVD    SAVE D-REG.
12060  170201        RET 1
                   *
                   *
                   *     KEYCODE CONVERSION TO ASCII
                   *
                   *        ENTRY:    A-REG = KEYCODE
                   *
                   *        EXIT:     A-REG = ASCII CODE
                   *
                   *  SEE CONVERSION TABLES CONTAINED IN THE DOCUMENTATION FOR
                   *  THE I/O SUPERVISOR
                   *
                   *
12061  170607  KCASC SAL 8        KEYCODE IN UPPER HALF
12062  172002        SAP *+2      SKIP IF UNSHIFTED
12063  067112        JMP KCAS3    SHIFTED
12064  170507        SAR 8        KEYCODE IN LOWER HALF
                   *
                   *     UNSHIFTED KEY CONVERSION
                   *
12065  004000        LDB A        NO! SAVE KEYCODE
12066  174040        TCB          MAKE NEG
12067  024073        ADB B100
12070  176015        SBP KCAS6    SKIP IF KEYCODE <101!NO CONVERSION
12071  026760        ADB B31
12072  176413        SRM KCAS6    SKIP IF KEYCODE > 131
12073  006223        LDB KTBL1    GET TABLE ADDR (UNSHIFTED)
12074  020164        ADA BM100    GET CODE 1 - 31B
12075  177301  KCAS4 SEC *+1,S    SET E-REG.
12076  073002        SLA *+2
12077  177201        SEC *+1,C    CLEAR E-REG. IF L.S.BIT OF A=1
12100  170300        SAR 1        BECAUSE OF TWO CODES PER WORD
12101  024000        ADB A        B = ADDR OF CODES
12102  100001        LDA B,I      GET CODES
12103  177005        SEC KCAS1    SKIP FOR LOWER HALF
12104  170507        SAR 8        A = CODE
12105  010066  KCAS6 CPA B140     IS THIS THE ENTER EXPONENT KEY?
12106  000063        LDA B145     YES, MAKE IT A SMALL E
12107  170201        RET 1        NO, LEAVE ALONE
                   *
12110  050045  KCAS1 AND B377     A = CODE
12111  170201        RET 1
                   *
                   *     SHIFTED KEY CONVERSION
                   *
12112  170507  KCAS3 SAR 8        KEYCODE IN LOWER HALF
12113  050053        AND B177     DROP BIT 7
12114  010055        CPA B175     GAZINTA?
12115  170201        RET 1        YES
                   *
12116  010057        CPA B173     PI ?
12117  067133        JMP KCAS2    YES
12120  004000        LDB A        GET KEYCODE
12121  174040        TCB          MAKE NEG.
12122  024110        ADB B53
12123  176062        SBP KCAS6    SKIP IF KEYCODE < 54
                   *
12124  026761        ADB B65
12125  176404        SHM KCAS7    SKIP IF KEYCODE > 140
12126  006167        LDB KTBL2    GET TABLE ADDR (SHIFTED)
12127  022756        ADA BM54     GET CODE 0 - 64B
12130  067075        JMP KCAS4    GET UPPER CASE CODE
12131  020162  KCAS7 ADA BM40     GET UPPER CASE ALPHA
12132  170201        RET 1
                   *
```

I/O SUPERVISOR

```
02253000 12133  000056  KCAS2 LDA B174     GET VERTICAL BAR
02254000 12134  170201        RET 1
02255000                *
02256000                ************************************************************
02257000                *
02258000                * DISP  DISPLAY INFO WITHOUT CURSOR
02259000                * DISPLAYS CONTENTS OF I/O BUFFER REGARDLESS OF POSITION
02260000                * OF EDIT BUFFER POINTERS
02261000                *
02262000                *
02263000                ********************
02264000                *
02265000 12135  004150  DISP  LDB M4       SET FOR ENTRY WITHOUT CURSOR
02266000 12136  000314        LDA AIBFX    DISPLAY I/O BUFFER
02267000 12137  067144        JMP NOCUR    DISPLAY WITH OUT CURSOR
02268000                *
02269000                *************************************************************
02270000                *
02271000                * DISPC  DISPLAY WITH CURSOR  USES T1 DISPLAYS STARTING AT
02272000                * CHARACTER INDICATED BY DBP  SETS THE CURSOR IF CRSP#0
02273000                * BIT 15 OF CRSP ISSET IF INSERT CURSOR, BITS 0-14
02274000                * CONTAIN A CHARACTER OFFSET FROM DBP-1 TO SET THE CURSOR
02275000                *
02276000                *************************
02277000                *
02278000 12140  001214  DISPC LDA CRSP     GET CURSOR POINTER
02279000 12141  050074        AND B77      SAVE ONLY OFFSET COUNT
02280000                *
02281000 12142  004000        LDB A        SET CURSOR OFFSET
02282000 12143  001513        LDA DBP      GET START OF DISPLAY ADDR
02283000 12144  030016  NOCUR STA C        SAVE IT FOR THE TRANSFER
02284000 12145  140401        JSM AADBA,I  ADJUST BYTE ADDRESS
02285000 12146  030001        STA B        SET CURSOR ADDRESS
02286000 12147  000177        LDA OPA      GET DISPLAY SELECT CODE
02287000 12150  030011        STA PA       SET PERPHERAL ADDRESS
02288000 12151  001512        LDA DLEN     GET LENGTH OF DISPLAY
02289000 12152  031711        STA T1       SAVE LOOP COUNTER
02290000                *                  B CONTAINS THE ADDR OF THE CHAR
02291000 12153  074560  LDH   WBC A,I      GET BYTE AND INC PTR
02292000 12154  014016        CPB C        CURSOR POSITION?
02293000 12155  067157        JMP *+2      YES
02294000 12156  067166        JMP NOPOS    NO
02295000                *
02296000 12157  005214        LDB CRSP     GET CURSOR
02297000 12160  176403        SBM INCUR    TO SEE WHICH TYPE OF CURSOR
02298000 12161  004073        LDB B100     REPLACE CURSOR
02299000 12162  067164        JMP *+2
02300000 12163  004117  INCUR LDB B40      INSERT CURSOR
02301000 12164  034005        STB R5       SET CURSOR INDICATOR
02302000 12165  060052        IOR B200     SET CURSOR BIT ON BYTE TO DISPLAY
02303000                *
02304000 12166  030004  NOPOS STA R4       SEND CHAR TO DISPLAY
02305000 12167  055711        DSZ T1       DONE?
02306000 12170  067153        JMP LDH      NO, CONTINUE
02307000 12171  000145        LDA P2       TRIGGER THE DISPLAY
02308000 12172  030005        STA R5
02309000 12173  170201        RET 1        YES SO RETURN
02310000                *
02311000                *
02312000                *
02313000                *     LIST MAIN PROGRAM
02314000                *  PERIPHERAL LIST ENTRY IS LISTP.  PLADD MUST BE SET TO
02315000                *  ADDRRESS OF A RETURN FOR A MAINFRAME LIST. OTHERWISE IT
02316000                *  CONTAINS THE ADDRESS OF THE PERIPHERAL LIST ROUTINE.
02317000                *  ROUTINE MUST DO A RET2 WHEN IT IS DONE.  OTHERWISE THE
02318000                *  PROGRAM WILL ALSO LIST TO THE INTERNAL PRINTER
02319000                *
02320000                *
02321000                *
02322000                *
02323000                *
02324000                *
02325000                *
02326000                *
02327000                *
02328000                *
02329000                *
02330000                *
02331000                *
02332000                *
02333000                *
02334000                *
02335000 12174  140610  LIST  JSM ACOUN,I  COUNT PARAMETERS ON STACK
02336000 12175  004714        LDB ARET1    SET FOR A RETURN
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```
12176  035221  LISTP STB PLADD    SET FOR MAIN FRAME LIST
12177  005257        LDB CSTAT    SEE IF STATE 1,3, OR 5
12200  077005        SLB NOCOM    IF SO THEN SET C TO POINT
12201  004274        LDB AAEOL    EOL AND SET LEND TO POINT TO ZERO
12202  034016        STB C
12203  004334        LDB ADP0
12204  035264        STB LEND
12205  043603  NOCOM JSM INTIO    INIT FOR LIST OUTPUT
12206  004177        LDB P0       SET LINE # = LOWER LIMIT
12207  035216        STB SIOCP    CLEAR CHECKSUM WORD
12210  035233        STB TMP7
12211  004263        LDB MAXLN    MAX LINE NO.
12212  035223        STB TMP6     SET DEFAULT UPPER LIMIT
12213  072412        SZA LIST3    PARAMETERS GIVEN?
12214  043327        JSM LGINM    GET LINE NUMBER
12215  173411        SOS LSSSS    LINE CANNOT EXIST IF OVERFLOW
12216  035233        STB TMP7     SET BEGIN OF LIST
12217  000254        LDA P1
12220  140607        JSM ABU[illegible],I ADVANCE TO NEXT PARAMETER
12221  067225        JMP LIST3    END OF PARAMETER LIST
12222  043327        JSM LGINM
12223  173402        SOS LIST3    LIST TO END OF PROG IF OVERFLOW
12224  035223        STB TMP6     SET UPPER LIMIT
12225  140513  LIST3 JSM AFLNA,I  FIND LINE ADDR
12226  067302  LSSSS JMP LIST5    LINE NOT FOUND
12227  040724        JSM SECCK    SEE IF PROG IS SECURE
12230  043533        JSM PLEAD    GIVE PAPER LEADER
12231  140453  LIST1 JSM ACLCM,I  CLEAR COMPILE BUFF
12232  140513        JSM AFLNA,I  FIND LINE ADDRESS
12233  067270        JMP LIST2    NOT FOUND, MUST BE DONE
12234  005233        LDB TMP7     SET LNO FOR ATLNO ROUTINE
12235  035226        STB LNO
12236  140412        JSM APLIR,I  PLACE LINE NO. IN I/O BUFF
12237  001206        LDA .WKC     GET KEY CODE
12240  010254        CPA P1       IS IT HTE STOP KEY?
12241  067270        JMP LIST2    YES, ABORT OPERATION
               *
12242  000314        LDA AIBFX    I/O BUFF S/A
12243  030016        STA C        SET PTR
12244  000165        LDA M80      SET 80 CHAR COUNTER
12245  031711        STA T1
12246  074560  LLOOP WBC A,I      GET CHARACTER
12247  005711        LDB T1       GET CHAR COUNT
12250  075617        MPY          MPY CHAR * CHAR COUNT
12251  005233        LDB TMP7     GET LINE #
12252  024254        ADB P1       ACCOUNT FOR LINE ZERO
12253  075617        MPY          MPY LINE # * CHAR * CHAR COUNT
12254  021216        ADA SIOCP    ADD SUM SO FAR
12255  031216        STA SIOCP    SET NEW SUM
12256  045711        ISZ T1       INC COUNTER
12257  067246        JMP LLOOP    NOT DONE SO KEEP GOING
               *
12260  000177        LDA P0       SET INDICATOR FOR PERIPHERAL ROUTINE
12261  141221        JSM PLADD,I  GIVE PERIPHERAL CONTROL
12262  043353        JSM PIOB     PRINT ONE LINE
12263  001233        LDA TMP7     GET LAST PRINTED LINE NO.
12264  011223        CPA TMP6     LISTING COMPLETE ?
12265  067270        JMP LIST2    YES
12266  045233        ISZ TMP7     INCRM LINE NO.
12267  067231        JMP LIST1    CONT
               *
12270  140450  LIST2 JSM ACLBI,I  CLEAR I/O BUFFER
12271  002763        LDA BLAST    GET A BLANK, ASTERIK
12272  130313        STA AIBUF,I  PUT IN I/O BUFFER
12273  004314        LDB AIBFX    PUT # IN I/O BUFFER
12274  001216        LDA SIOCP    GET CHECKSUM
12275  050344        AND MAW      MAKE POSITIVE
12276  140477        JSM ABTDA,I  PUT IN I/O BUFFER
12277  141221        JSM PLADD,I  GIVE PERIPHERAL CONTROL
12300  043514        JSM .PRNT    PRINT CHECKSUM
12301  043533        JSM PLEAD    GIVE PAPER LEADER
12302  140450  LIST5 JSM ACLBI,I  CLEAR I/O BUFF
               *
12303  001307        LDA FWUP     CALCULATE MEMORY USED BY PROGRAM
12304  170040        TCA
12305  021277        ADA ENDS     MEMORY BETWEEN ENDS AND FWUP
12306  072403        SZA LNULP    SKIP IF A NULL PROGRAM
12307  020254        ADA P1       ADD 1 WORD FOR BRIDGES
12310  170600        SAL 1        MAKE BYTES
12311  004315  LNULP LDB AIBFM    S/A TO PUT NUMBER
12312  140477        JSM ABTDA,I  CONVERT TO ASCII
               *
12313  001310        LDA RMAX     CALCULATE AVAILABLE MEMORY
12314  020254        ADA P1       ADJUST ADDR
12315  170040        TCA
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12316  021263        ADA AP1      B= AVAILABLE WORDS
12317  170600        SAL 1        MAKE BYTES
12320  004320        LDB AIOLM    S/A TO PUT NUMBER
12321  140477        JSM ABTDA,I  MAKE ASCII AND PLACE IN I/O BUFF
12322  140436        JSM AEPON,I  GO THROUGH PRINTALL
              *
12323  043135        JSM DISP     DISPLAY # OF REGISTERS LEFT
12324  067600        JMP RESIO    RESTORE AFTER LIST
              *
12325  140404 ERLNW  JSM AERR1,I  LINE NO. WRONG
12326  030471        ASC 1,19
              *
12327  040751 LGTNM  JSM NGET     GET NEXT PARAMETER
12330  067325        JMP ERLNW    WRONG TYPE
12331  000001        LDA B        A= POINTER
12332  064644        JMP FIXPT    FLOAT TO FIXED
              *
              *
              ****************
              *
              * LISTK:  SYSTEM COMMAND TO LIST ALL DEFINED KEYS IN NUMERICAL ORDER
              *
              ****************
              *
12333  000177 LISTK  LDA P0       START WITH F0
12334  031212        STA SPKN
12335  043603        JSM INTIO    INIT FOR LISTING
12336  001206 LSTK1  LDA .WKC     CHECK FOR STOP KEY
12337  010254        CPA P1       STOP KEY IF = 1
12340  067347        JMP LSTK2    =1 SO ABORT OPERATION
12341  140473        JSM ALISK,I  LIST KEY <SPKN> IF IT IS DEFINED
12342  045212        ISZ SPKN     BUMP THE KEY NUMBER
12343  004122        LDB P26
12344  015212        CPB SPKN     IF  F26 IS THE NEXT KEY THEN ALL KEYS HAVE BEEN
12345  067347        JMP LSTK2    LISTED, SO PUT EOL IN THE DISP AND RETURN
12346  067336        JMP LSTK1    OTHERWISE KEEP LISTING UNTIL ALL KEYS ARE DONE.
12347  000144 LSTK2  LDA P3
12350  140571        JSM ASPC,I   GIVE 3 PAPER LINE FEEDS
12351  040710        JSM EOLIO    CLEAR I/O BUFFER, PLACE EOL IN 1ST CHAR.
12352  067600        JMP RESIO    RESTORE AFTER LISTING AND RETURN TO INTERPRETER
              *
              *
              *
              *
              *      PRINT CONTENTS OF I/O BUFFER
              *  *H
              *  12 CHARACTERS ARE SEND TO THE PRINTER HARDWARE, THEN THE NEXT 4
              *  CHARACTERS ARE SEARCHED FROM RIGHT TO LEFT FOR A +  -  *  /
              *  ;  ,  OR SPACE AND THE LINE IS BROKEN AT THIS SPOT IF ANY ARE
              *  FOUND.  OTHERWISE 16 CHARACTERS ARE PRINTED.  THIS CONTINUES
              *  UNTIL THE LAST NON BLANK CHARACTER IS PRINTED
              *
              *
12353  000314 PIO8   LDA AIBFX    GET I/O BUFF ADDR
12354  030017        STA D        SET SOURCE POINTER
12355  000133        LDA P12      12 CHARS
12356  031227 PIO89  STA TMP1     SET COUNTER
12357  043463        JSM PCOUT    OUTPUT CHARS
12360  001210        LDA DTMP1    GET "EOL" FLAG
12361  072404        SZA PIO82    END OF LINE FOUND ?
12362  000143        LDA P4       YES
12363  031227        STA TMP1     SET COUNT FOR 4 BLANKS
12364  067456        JMP SHLP     FILL BUFF, PRINT LINE AND RETURN P+1
              *
12365  000017 PIO82  LDA D        GET I/O BUFF POINTR
12366  031225        STA TMP2     AND SAVE IT
12367  000142        LDA P5       LOOK AT NEXT 5 CHARACTERS
12370  031231        STA TMP3     SET COUNTER
12371  074570 PIO81  WBD A,I      GET CHAR AND INCRM
12372  010053        CPA EOL      END-OF-LINE?
12373  067453        JMP PIO88    YES
12374  055231        DSZ TMP3     DONE?
12375  067371        JMP PIO81    NO
              *
12376  074770        WBD A,D      DUMMY WITHDRAW,DEC
12377  000017        LDA D        GET I/O BUFF POINTR
12400  030016        STA C        SET C=REG
12401  074760        WBC A,D      DUMMY WITHDRAW AND DECREM
12402  000143        LDA P4       MAX OF 4 CHARS
12403  031231        STA TMP3     SET COUNTER
12404  074760 PIO83  WBC A,D      GET CHAR AND DECREM
12405  010110        CPA B53      +?
12406  067441        JMP PIO84    YES
12407  010106        CPA B55      -?
12410  067441        JMP PIO84    YES
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~~02507000 12411  010111         CPA B52      *?~~
02508000 12412  067441         JMP PIOB4    YES
02509000 12413  010104         CPA B57      /?
~~02510000 12414  067441         JMP PIOB4    YES~~
02511000 12415  010117         CPA B40      BLANK?
02512000 12416  067441         JMP PIOB4    YES
~~02513000 12417  010076         CPA B73      ;?~~
02514000 12420  067441         JMP PIOB4    YES
02515000 12421  010107         CPA B54      ,?
~~02516000 12422  067441         JMP PIOB4    YES~~
02517000 12423  055231         DSZ TMP3     DONE?
02518000 12424  067404         JMP PIOB3    NO
~~02519000 12425  000143  PIOB6  LDA P4       NO BREAK POINT FOUND~~
02520000 12426  043527         JSM SPIB     SET COUNT AND OUTPUT CHARS
02521000 12427  043524  PIOX2  JSM PRNT     PRINT LINE
~~02522000 12430  043503  PIOX3  JSM CPST     CHECK PRINTER STATUS~~
02523000 12431  074570         WBD A,I      GET NEXT CHAR
02524000 12432  010053         CPA EOL      END OF LINE MARK ?
~~02525000 12433  170201         RET 1        YES ; DONE WITH THIS LINE~~
02526000                *
02527000 12434  074770         WBD A,D      NO; READJUST SOURCE POINTR
~~02528000 12435  000117         LDA B40      GET BLANK~~
02529000 12436  030006         STA R6       INDENT THE LINE
02530000 12437  000134         LDA P11      GET READY FOR 11 MORE CHARS
~~02531000 12440  067356         JMP PIOB9    OUTPUT MORE LINES~~
02532000                *
02533000 12441  001231  PIOB4  LDA TMP3     NO. OF ADDITIONAL CHARS
~~02534000 12442  043527         JSM SPIB     SET COUNT AND OUTPUT CHARS~~
02535000 12443  001231         LDA TMP3     A = NO. OF CHARS OUTPUT ABOVE 12
02536000 12444  010143         CPA P4       A = 4, LINE COMPLETE
~~02537000 12445  067427         JMP PIOX2    PRINT LINE~~
02538000 12446  170040         TCA          MAKE NEGATIVE
02539000 12447  020143         ADA P4       A = NO. OF CHARS TO REACH 16
~~02540000 12450  031227         STA TMP1     SET CHAR COUNTR~~
02541000 12451  043456         JSM SBLP     FILL BUFF AND PRINT LINE
02542000 12452  067430         JMP PIOX3    OUTPUT MORE LINES
02543000                *
02544000 12453  000143  PIOB8  LDA P4       GET ALL REMAINING CHARS
02545000 12454  043527         JSM SPIB     SET COUNT,RESET SOURCE POINTR,OUTPUT CHARACTERS
02546000 12455  067524         JMP PRNT     PRINT LINE + RETURN P+1
02547000                *
02548000                *
02549000                ******************************************************************
02550000                *
02551000                *    PRINT UTILITY ROUTINES
02552000                *
02553000                *********************************
02554000                *
02555000                *       SEND BLANKS AND PRINT 16 CHARS
02556000                *
02557000                *              ENTRY: "TMP1" = NO. OF BLANKS
02558000                *
02559000                *
02560000 12456  000117  SBLP   LDA B40      GET BLANK
02561000 12457  030006  SBLP1  STA R6       TO PRINTER HARDWARE
02562000 12460  055227         DSZ TMP1     DONE ?
02563000 12461  067457         JMP SBLP1    NO
02564000 12462  067524         JMP PRNT     PRINT LINE + RETURN P+1
02565000                *
02566000                *
02567000                *      PRINTER CHARACTER OUTPUT
02568000                *
02569000                *       ENTRY:  TMP1 = NO. OF CHARS
02570000                *
02571000                *
02572000 12463  043503  PCOUT  JSM CPST     CHECK PRINTER STATUS
02573000 12464  000177  PCOU1  LDA P0
02574000 12465  031210         STA DTMP1    CLEAR "EOL" FLAG
02575000 12466  074570  PCOU2  WBD A,I      GET CHAR AND INCREM.
02576000 12467  010053         CPA EOL      END OF LINE ?
02577000 12470  067475         JMP PCOU3    YES; DO NOT COUNT THE EOL CHAR
02578000 12471  030006         STA R6       TO PRINTER HARDWARE
02579000 12472  055227         DSZ TMP1     DONE?
02580000 12473  067466         JMP PCOU2    NO
02581000 12474  170201         RET 1        YES
02582000                *
02583000 12475  045210  PCOU3  ISZ DTMP1    SET "EOL" FLAG
02584000 12476  000117         LDA B40      GET BLANK
02585000 12477  030006  PCOU4  STA R6       TO PRINTER HARDWARE
02586000 12500  055227         DSZ TMP1     DONE ?
02587000 12501  067477         JMP PCOU4    NO; LOOP
02588000 12502  170201  PCOUX  RET 1
02589000                *
02590000                *
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```
02591000                       *      CHECK PRINTERSTATUS
02592000                       *
02593000                       *
02594000 12503  000177  CPST   LDA PPA      GET PRINTER SEL. CODE
02595000 12504  030011         STA PA       SET PERIPHERAL ADDR
02596000 12505  000005  CPST1  LDA R5       GET PRINTER STATUS
02597000 12506  050141         AND P6       SAVE PRINTER BUSY AND OUT OF PAPER BITS
02598000 12507  072473         SZA PCOUX    OK; PROCEED
02599000 12510  170501         SAR 2        POSITION BUSY BIT
02600000 12511  073474         RLA CPST1    IF BUSY SKIP AND CHECK AGAIN
02601000 12512  140404  ERPRT  JSM AERR1,I  NO PRINTER OR NO PAPER
02602000 12513  030465         ASC 1,15
02603000                       *
02604000                       *
02605000                       *        OUTPUT 16 CHARS FROM I/O BUFF TO PRINTER
02606000                       *
02607000                       *            ENTRY: I/O BUFF SET
02608000                       *
02609000                       *
02610000 12514  004314  .PRNT  LDB AIBFX    I/O BUFF S/A
02611000 12515  034016         STB C        SET C-REG
02612000 12516  043503         JSM CPST     CHECK PRINTER STATUS
02613000 12517  000127         LDA P16      CHAR COUNT
02614000 12520  031211         STA DTMP2    SET COUNTER
02615000 12521  074566  .PRN1  WBC R6,I     SEND BYTE TO HARDWARE, INC PTR
02616000 12522  055211         DSZ DTMP2    ALL CHARS OUT ?
02617000 12523  067521         JMP .PRN1    NO; LOOP
02618000                       *
02619000                       *
02620000                       *      PRINT ONE LINE
02621000                       *
02622000                       *      ENTRY: HARDWARE LOADED WITH 16 CHARS
02623000                       *
02624000                       *
02625000 12524  000254  PRNT   LDA P1       PRINT COMMAND
02626000 12525  030005         STA R5       PRINT LINE
02627000 12526  170201         RET 1
02628000                       *
02629000                       *
02630000                       *       SET CHAR COUNT AND OUTPUT CHARS
02631000                       *
02632000                       *            ENTRY: A= CHAR COUNT
02633000                       *
02634000                       *
02635000 12527  031227  SPIB   STA TMP1     SET CHAR COUNT
02636000 12530  001225         LDA TMP2     RECALL I/O BUFF POINTR
02637000 12531  030017         STA D        RESET SOURCE POINTER
02638000 12532  067464         JMP PCOU1    OUTPUT CHARS  + RETURN P+1
02639000                       *
02640000                       ******************************************************************
02641000                       *
02642000                       *
02643000                       *         GIVE PAPER LINE FEEDS
02644000                       *
02645000                       *            ENTRY "PLDX": A = NO. OF LINE FEEDS
02646000                       *    PLEAD ENTRY ASSUMES PLADD IS SET TO THE ADDRESS OF A RETURN
02647000                       *    OR THE ADDRESS OF THE PERIPHERAL LIST ROUTINE
02648000                       *    A WILL CONTAIN A -3 SO THAT THE PERIPHERAL LIST ROUTINE
02649000                       *    WILL KNOW HOW MANY LINE FEEDS TO ISSUE
02650000                       *
02651000                       *
02652000                       *
02653000 12533  000147  PLEAD  LDA M3       SET INDICATOR FOR PERIPHERAL ROUTINES
02654000 12534  141221         JSM PLADD,I  ALLOW PERIP CHANCE TO SPACE, RET2 IF PRESENT
02655000 12535  067537         JMP *+2      NOT THERE SO SPACE PRINTER
02656000 12536  170201         RET 1        PERIP SPACED, RETURN
02657000 12537  000144         LDA P3
02658000 12540  031211  PLDX   STA DTMP2    LINE FEED COUNT
02659000 12541  004127  PLEA2  LDB P16
02660000 12542  035210         STB DTMP1    SET CHAR COUNTR
02661000 12543  043503         JSM CPST     CHECK PRINTER STATUS
02662000 12544  000117         LDA B40      GET BLANK
02663000 12545  030006  PLEA1  STA R6       TO PRINTER HARDWARE
02664000 12546  055210         DSZ DTMP1    DONE ?
02665000 12547  067545         JMP PLEA1    NO; CONT
02666000 12550  043524         JSM PRNT     PRINT ONE LINE
02667000 12551  055211         DSZ DTMP2    DONE ?
02668000 12552  067541         JMP PLEA2    NO; PRINT ANOTHER LINE
02669000 12553  170201  PLEA3  RET 1
02670000                       *
02671000                       ******************************************************************
02672000                       *
02673000                       *
02674000                       *      PRINT STATEMENT EXECUTION
```

```
                     *
                     *
12554   043603  EPRT  JSM INTIO    INIT FOR OUTPUT
12555   043634        JSM PCLIO    CLR I/O BUFFER,RESET STRING FLAG
12556   000263        LDA FLAG     FOR "PGET"
12557   140505        JSM APGET,I  GET FIRST PARAMETER
12560   067577        JMP EPRT4    NO PARAMETERS
12561   176002  EPRT2 SAP *+2      SKIP IF OK
12562   067754        JMP ERUND    UNDEFINED OR WRONG CLASS
12563   072403        SZA EPRT1    SKIP ON NUMERIC
12564   043672        JSM PSTRG    PRINT STRING
12565   067567        JMP EPRT3
12566   043606  EPRT1 JSM PNUMR    PRINT NUMERIC
12567   000254  EPRT3 LDA P1       FOR "PGET"
12570   140505        JSM APGET,I  GET NEXT PARAMETER
12571   067573        JMP *+2      LIST EXHAUSTED
12572   067561        JMP EPRT2    CONTINUE
12573   001727        LDA T15      GET STRING FLAG
12574   010315        CPA AIBFM    STRING PENDING?
12575   067577        JMP *+2      NO
12576   043514        JSM .PRNT    PRINT STRING
12577   040710  EPRT4 JSM EOLIO    CLEAR I/O BUFF AND SET EOL IN I/O BUFF
                *
12600   001234  RESIO LDA TMP4     RESTORE C REGISTER
12601   030016        STA C
12602   164365        JMP AINTX,I  BACK TO INTERPRETER
                *
                *
                **********************************************************
                *
                *  IOINT    INIT ROUTINE FOR ANY ROUTINE THAT USES THE I/O BUFFER
                *           FOR I/O  LIST PROG,LIST KEYS, DISP STMT, PRT STMT
                *           PLIST
                *
                ***********************
                *
12603   004016  INTIO LDB C        SAVE C
12604   035234        STB TMP4
12605   170201        RET 1
                *
                *
                *     PRINT NUMERIC
                *
                *     ENTRY: B = CHAR COUNT
                *
                *            D = BYTE ADDR OF FIRST CHAR
                *
                *  USES T15 AS A FLAG   IF IT IS NOT SET TO AIBFM THEN IT ASSUMES
                *  THAT A STRING IS PENDING SO THE ROUTINE WILL TRY TO
                *  PUT THE NUMERIC ON THE SAME LINE. ASSUMES THAT THE STRING LENGTH
                *  IS IN OTMP1.
                *
                *  USES .WPRT TO DECIDE WHAT THE FIX/FLT SETTING OF THE NUMBER IS
                *  IF THE NUMBER HAS REVERTED TO FLOAT 10 OR 11 THEN IT WILL
                *  USE THE LENGTH OF THE NUMBER TO DETECT THIS - LENGTH OF 17 =
                *  FLOAT 10,  LENGTH OF 18 = FLOAT 11 .
                *
12606   035712  PNUMR STB T2       SAVE NO. OF CHARS
12607   001727        LDA T15      GET STRING FLAG
12610   010315        CPA AIBFM    STRING ON SAME LINE?
12611   067613        JMP *+2      NO
12612   067644        JMP PNUM2    YES
12613   024161        ADB M17
12614   176424        SBM PNUM3    NO. OF CHAR < = 16?
12615   001217  PNUM9 LDA .WPRT    NO; GET FXD/FLT SPEC.
12616   050130        AND B17      GET FLT SPEG.
12617   020144        ADA P3       ACCOUNT FOR SIGN, DIGIT, DEC. POINT
12620   031713        STA T3       SAVE CHAR COUNT OF FIRST NUM. PART
12621   004000        LDB A        GET NO. OF CHARS
12622   043736        JSM RJNM     RIGHT JUSTIFY NUM.
12623   005713        LDB T3       GET CHAR COUNT
12624   140502        JSM ATCHR,I  TRANSFER CHARACTERS
12625   043514        JSM .PRNT    PRINT ONE LINE
12626   140450        JSM ACLBI,I  CLEAR I/O BUFF
12627   000313        LDA AIBUF    I/O BUFF S/A
12630   020142        ADA P5       A = START POINTR FOR EXPONENT PART
12631   004143        LDB P4       EXPONENT INFO OF 4 CHARS
12632   140502  PNUM4 JSM ATCHR,I  TRANSFER CHARACTERS
12633   043514  PCLII JSM .PRNT    PRINT ONE LINE
12634   140450  PCLIO JSM ACLBI,I  CLEAR I/O BUFFER
12635   000315        LDA AIBFM    A/S OF I/O BUFF
12636   031727        STA T15      RESET STRING FLAG
12637   170201        RET 1
                *
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12640   005712  PNUM3 LDB T2       GET NO. OF CHARS
12641   043736        JSM RJNM     RIGHT JUSTIFY NUM.
12642   005712  PNUM5 LDB T2       GET NO. OF NUM. CHARS
12643   067632        JMP PNUM4
                *
12644   001210  PNUM2 LDA DTMP1    GET NO. OF STRING CHARS
12645   021712        ADA T2       ADD NO. OF NUM. CHARS
12646   020161        ADA M17
12647   172471        SAM PNUM3    SKIP IF SUM <=16 CHARS
                *
12650   001712        LDA T2       GET LENGTH OF NUMBER
12651   010126        CPA P17      IS IT FLOAT 10?
12652   067660        JMP PNUM7    YES
12653   010125        CPA P18      IS IT FLOAT 11?
12654   067660        JMP PNUM7    YES
12655   043514  PNUM6 JSM .PRNT    PRINT STRING LINE
12656   140450        JSM ACLBI,I  CLEAR I/O BUFF
12657   067640        JMP PNUM3    TRANSFER AND PRINT NUM.
                *
                *********************
                *
                *  ORIGINALLY IT WAS INTENDED TO PUT THE MANTISSA ON THE SAME LINE
                *  AS THE STRING IF IT WOULD FIT AND THE CHARACTERISTIC ON THE
                *  NEXT LINE IF THE NUMBER WAS FLOAT 10 OR 11
                *  TO MAKE THIS WORK PROPERLY CHANGE THE ADA P3 AND ADA M17
                *  INSTRUCTIONS TO ADA M10, ADA M11
                *
12660   021210  PNUM7 ADA DTMP1    ADD NO. OF STRING CHAR TO FLOAT SPEC
12661   020144        ADA P3       ACCOUNT FOR SIGN, DIGIT, DEC. POINT
12662   020161        ADA M17
12663   172002        SAP *+2      SKIP IF SUM > 16 CHARS
12664   067615        JMP PNUM9    SUM <= 16 CHARS
12665   043514        JSM .PRNT    PRINT STRING LINE
12666   140450        JSM ACLBI,I  CLEAR I/O BUFF
12667   067615        JMP PNUM9    TRANSFER AND PRINT NUM.
                *
                **************************
                *
12670                 BSS 2        POST RELEASE CORECTIONS
                *
                **************************
                *
                *
                *     PRINT STRING
                *
                *     ENTRY: B = CHAR COUNT
                *
                *            D = BYTE ADDR OF FIRST CHAR
                *
                *                 IF T15 # AIBFM  OLD STRING IS STILL PENDING
                *
                *     EXIT:   IF STRING LENGTH MOD 16 WAS NOT 0 THEN
                *     T15 WILL NOT BE SET TO AIBFM, AND THE LAST PART OF THE
                *     STRING WILL NOT BE PRINTED.  DTMP1 WILL CONTAIN THE LENGTH
                *     OF THE REMAINING STRING THAT WAS LEFT IN THE I/O BUFFER
                *
                *     IN ORDER TO PRINT A STRING BY ITSELF THE FOLLOWING SEQUENCE
                *     SHOULD BE USED
                *     LDA AIBFM
                *     STA T15
                *     JSM APSTR,I
                *     JSM A.PRN,I  PRINT THE REST OF THE STRING
                *
                *
                *
                *
12672   035210  PSTRG STB DTMP1    SAVE NO. OF CHARS
12673   001727        LDA T15      GET STRING FLAG
12674   010315        CPA AIBFM    OLD STRING PENDING ?
12675   067677        JMP PSTR4    NO
12676   043633        JSM PCLII    PRINT STRING,CLR I/O BUFFER,RESET STRING FLAG
12677   005210  PSTR4 LDB DTMP1    GET NO. OF CHARS (NEW STRING)
12700   076406        SZB PSTR2    SKIP ON A NULL STRING
12701   024160        ADB M16
12702   176007        SBP PSTR6    SKIP IF NO. OF CHARS >= 16
12703   000315        LDA AIBFM    I/O BUFF S/A
12704   005210        LDB DTMP1    GET CHAR COUNT
12705   140502        JSM ATCHR,I  TRANSFER CHARS
12706   000016  PSTR2 LDA C        GET DESTINATION POINTR
12707   031727        STA T15      SET STRING INCOMPLETE FLAG
12710   170201        RET 1        NUM. MAY FOLLOW
                *
12711   140450  PSTR6 JSM ACLBI,I  CLEAR I/O BUFF
12712   000177        LDA P0
```

```
12713  031714        STA T4       INIT. LINE CHAR COUNTER
12714  000315        LDA AIBFM    I/O BUFF S/A
12715  030016        STA C
12716  001210  PSTR5 LDA DTMP1    STRING CHAR COUNT
12717  072004        RZA PSTR3    DONE?
12720  001714        LDA T4       YES: ALL STRING OUT
12721  031210        STA DTMP1    SAVE REMAINDER COUNT
12722  067706        JMP PSTR2    SAVE STRING POINTR
12723  074570  PSTR3 WBD A,I      GET ONE CHAR AND INCRM
12724  074540        PBC A,I      INCRM AND STORE CHAR
12725  055210        DSZ DTMP1    DECRM STRING COUNT
12726  067727        JMP *+1
12727  045714        ISZ T4       INCRM LINE CHAR COUNT
12730  001714        LDA T4       GET ITS VALUE
12731  010127        CPA P16      16 CHARS OUT?
12732  067734        JMP *+2      YES
12733  067716        JMP PSTR5    NO
12734  043514        JSM .PRNT    PRINT 16 CHARS
12735  067711        JMP PSTR6
               *
               *
               *
               *     RIGHT JUSTIFYNUMERIC
               *
               *     ENTRY: B = NO. OF CHARS IN NUM.
               *
               *       EXIT: A = DESTINATION POINTER
               *
               *
12736  024160  RJNM  ADB M16      B= ADJUST COUNT
12737  174040        TCB          MAKE NEGATIVE
12740  000315        LDA AIBFM    I/O BUFF S/A
12741  164401        JMP AADBA,I  ADJUST ADDR
               *
               *
               *
               *     DISP STATEMENT EXECUTION
               *   A BLANK IS PLACED BETWEEN EACH FIELD IN THE DISPLAY STMT
               *   AN ERROR IS ISSUED IF THE DISPLAY FIELD WILL NOT FIT IN 80 CHA
               *
               *
12742  043603  EDIS  JSM INTIO    INIT FOR I/O
12743  140450        JSM ACLBI,I  CLEAR I/O BUFFER
12744  000315        LDA AIBFM
12745  030016        STA C        SET DESTINATION REG.
12746  000165        LDA M80
12747  031227        STA TMP1     SET 80 CHAR MAX COUNT
12750  000263        LDA FLAG     FOR FIRST ACESS OF "PGET"
12751  140505  EDIS2 JSM APGET,I  GET ONE PARAMETER
12752  066005        JMP EDIS5    LIST EXHAUSTED
12753  176003        SBP *+3      SKIP IF OK
12754  140404  ERUND JSM AERR1,I  UNDEFINED OR WRONG CLASS
12755  030470        ASC 1,18
               *
12756  076425        SZB EDIS6    SKIP IF COUNT IS ZERO
12757  035225        STB TMP2     SAVE PARAMETER CHAR COUNT
12760  005227        LDB TMP1     GET COUNT
12761  000016        LDA C        GET CURRENT BUFFER POINTR
12762  010315        CPA AIBFM    IS THIS THE FIRST PARAMETER ?
12763  067765        JMP EDIS1    YES
12764  024254        ADB P1       COUNT FOR ONE BLANK
12765  025225  EDIS1 ADB TMP2     ADD PARAMETER CHAR COUNT
12766  035227        STB TMP1     UPDATE COUNT
12767  076404        SZB EDIS3    BUFF EXACT FIT?
12770  176403        SBM *+3      NO: BUFF OVERFILL?
12771  140404  ERBOV JSM AERR1,I  YES: ERROR
12772  031467        ASC 1,37
               *
12773  004016  EDIS3 LDB C        GET CURRENT BUFF POINTR
12774  014315        CPB AIBFM    IS THIS THE FIRST PARAMETER?
12775  067777        JMP EDIS4    YES
12776  074560        WBC A,I      DUMMY INC
12777  074570  EDIS4 WBD A,I      GET CHAR AND INCRM
13000  074540        PBC A,I      INCRM AND PLACE IN I/O BUFF
13001  055225        DSZ TMP2     ALL CHARS TRANSFERRED?
13002  067777        JMP EDIS4    NO: CONT
13003  000254  EDIS6 LDA P1       FOR NEXT ACCESS OF "PGET"
13004  067751        JMP EDIS2    LOOK FOR NEXT PARAMETER
13005  043135  EDIS5 JSM DISP     DISP INFO
13006  140436        JSM AEPON,I  GO THRU PRINT ALL
13007  067600        JMP RESIO    RESTORE AFTER I/O
               *
               *     FIND DBP ( DISP BEGIN POINTR )
               *
               *      EXIT:      RET P+1   DISP BEGIN POINTR SET
               *
               *
13010  001215  FBP   LDA IOCP      GET CURRENT I/O BUFF POINTR
13011  005512        LDB DLEN      GET DISP LENGTH
13012  035711        STB T1        SET COUNTER
13013  030016        STA C         SET C-REG
13014  001214        LDA CRSP      GET CURSOR POINTR
13015  072406        SZA FBP1      SKIP IF CURSOR NOT SET
13016  050074        AND B77       GET CURSOR POSITION
13017  011512        CPA DLEN      CURSOR AT END OF DISP ?
13020  066022        JMP *+2       YES: FIND DISP BEGIN POINTR
13021  170201        RET 1         NO: DO NOT CHANGE DBP
               *
13022  055711        DSZ T1    IF CORSOR IS ON DLEN, REPLACE THAT CHAR AND SHIFT
13023  004016  FBP1  LDB C         GET C-REG
13024  015352        CPB AEBFM     BEGIN OF EDIT BUFFER ADDR -1
13025  066037        JMP FBP2      YES
13026  015513        CPB DBP       PTR = DISPLAY BEGIN BUFFER?
13027  170201        RET 1         YES, DON'T MOVE DBP BACKWARD
13030  074760        WBC A,D       WITHDRAW ONE BYTE AND DECREM.
13031  055711        DSZ T1        DECRM COUNTER: DONE?
13032  066023        JMP FBP1      NO: CONTINUE
13033  074560  FBP3  WBC A,I       YES: INCRM POINTER
13034  004016        LDB C         GET C-REG
13035  035513        STB DBP       SET DISP BEGIN POINTR
13036  170201        RET 1
               *
13037  005512  FBP2  LDB DLEN      GET DISP LENGTH
13040  015711        CPB T1        COUNTER CHANGED?
13041  066511        JMP EOLEB     NO: CLEAR EDIT BUFFER,GIVE EOL AND RETURN
13042  066033        JMP FBP3      ADJUST POINTR
               *
               *
               *     LOAD TYPE-AIDIN DISPLAY
               *
               *     ENTRY:  CODE IN "SKEY"
               *
               *     EXIT:  ASCII CHARS OF TYPE-AID IN EDIT BUFFER
               *     EDIT BUFFER IS CLEARED AND MODE SET TO ZERO BEFORE
               *     TYPE AID IS PUT IN THE FIRST PART OF EDIT BUFFER
               *
               *             "DBP"POINTS TO FIRST CHAR
               *
               *
13043  140451  LTID  JSM ACLEB,I   CLEAR EDIT BUFFER
13044  040715        JSM CLMOD     SET KBD MODE
13045  042057        JSM STTM      SEARCH TABLE FOR MNEMONIC
13046  074570  LTID1 WBD A,I       GET ONE CHAR
13047  140430        JSM AISTX,I   STORE IN I/O BUFF
13050  066051        JMP *+1       "IST02" RETURNS ON P+2
13051  045227        ISZ TMP1      DONE?
13052  066046        JMP LTID1     NO: CONT
13053  000117        LDA B40       GET SPACE
13054  140430        JSM AISTX,I   STORE IN I/O BUFF
13055  066056        JMP *+1        "IST02" RETURNS ON P+2
13056  170201        RET 1         YES
               *
               *
               *     SEARCH TABLE OF TYPE-AID MNEMONICS
               *
               *     ENTRY:  CODE IN "SKEY"
               *
               *            EXIT: D = FIRST CHAR PTR
               *
               *             TMP1=NEG. LENGTH
               *
               *
13057  002076  STTM  LDA TTM       S/A OF TABLE
13060  030017        STA D         SET D REG
13061  005235        LDB SKEY      GET ASCII CODE
13062  074570  STTM2 WBD A,I       GET BYTE AND INC
13063  060170        IOR M256      CONFIGURE COMPLETE NEG. LENGTH
13064  031227        STA TMP1      AND SAVE IT
13065  074570        WBD A,I       GET ASCII CODE AND INC
13066  014000        CPB A         CODE FOUND?
13067  170201        RET 1         YES
               *
13070  010045        CPA B377      NO: END OF TABLE ?
13071  140424        JSM ASYER,I   YES,ERROR
13072  074570  STTM1 WBD A,I       NO: BYPASS THIS ENTRY
13073  045227        ISZ TMP1      DONE?
13074  066072        JMP STTM1     NO: CONT
13075  066062        JMP STTM2     NEXT ENTRY
```

```
                      *
                      *
                      *     TABLE OF TYPE-AID MNEMONICS
                      *
                      *     EACH ENTRY ISCOMPOSED OF:
                      *
                      *     -LENGTH (OF MNEMONIC)
                      *
                      *     KEY ASCII CODE
                      *
                      *     MNEMONIC ASCII CHARACTERS
                      *
                      *
13076  113077  TTM    DEF *+1,I
13077  176033         OCT 176033      -4,33
13100  066151         DEC 27753     LI
13101  071564         DEC 29556     ST
13102  175435         OCT 175435    -5,35
13103  062562         DEC 25970     ER
13104  060563         DEC 24947     AS
13105  062775         OCT 62775     E,-3
13106  017162         OCT 17162     36,R
13107  061546         OCT 61546     CF
13110  176437         OCT 176437    -3,37
13111  066144         OCT 66144     LD
13112  063373         OCT 63373     F,-5
13113  016146         OCT 16146     34,F
13114  062564         DEC 25972     ET
13115  061550         DEC 25448     CH
13116  177777         DEC -1        END-OF-TABLE
                      *
                      *
                      *     PRINT ALL EXECUTION
                      *
                      *  EPKBD ENTRY:  PRINT KEYBOARD BUFFER(KBUFF) IF PRINT-ALL IS
                      *  SET (BIT 15 OF CFLAG)
                      *
                      *  EPON ENTRY:  PRINT I/O BUFFER(IBUFF) IF PRINT-ALL IS SET
                      *
                      *  EPNX ENTRY: PRINT I/O BUFFER REGARDLESS OF PRINT-ALL BIT
                      *
                      *  IN ALL CASES THE RESPECTIVE BUFFERS ARE PRINTED 16 CHAR AT A
                      *  TIME UNTIL NO NON BLANK (OTHER THAN EOL)  CHARACTERS REMAIN
                      *  IN THE BUFFER
                      *
                      *
13117  000307  EPKBD  LDA AKBFX     SET KBD BUFF S/A
13120  005232         LDB CFLAG
13121  176406         SBM EPPP      SKIP IF PRINT-ALL SET
13122  170201         RET 1
                      *
13123  001232  EPON   LDA CFLAG     GET CONTROL FLAG
13124  172402         SAM EPNX      PRINT-ALL?
13125  170201         RET 1         NO
                      *
13126  000314  EPNX   LDA AIBFX     I/O BUFFER S/A
13127  031222  EPPP   STA L         SET "GNEXT" POINTR
13130  030017         STA D         SET D-REG
13131  140442  EPON1  JSM ACPST,I   CHECK PRINTER STATUS
13132  004127         LDB P16
13133  035735         STB T21       SET 16 CHAR COUNTR
13134  140501  EPON3  JSM AGNXT,I   GET NEXT CHAR (BLANKS IGNORED)
13135  010053         CPA EOL       END OF INFO ?
13136  066150         JMP EPON4     YES: COMPLETE WITH BLANKS
13137  074576         WBD R6,I      SEND CHAR TO HARDWARE
13140  055735         DSZ T21       16 CHARS OUT ?
13141  066145         JMP EPON2     NO
13142  140443         JSM APRNT,I   YES: PRINT ONE LINE
13143  000017         LDA D         RESTORE L POINTER
13144  066127         JMP EPPP      PRINT MORE LINES
13145  004017  EPON2  LDB D         GET CURRENT SOURCE POINTR
13146  035222         STB L         UPDATE "GNEXT" POINTR
13147  066134         JMP EPON3     LOOP
                      *
13150  000017  EPON4  LDA D         SEE IF BUFFER WAS EMPTY
13151  010314         CPA AIBFX
13152  066160         JMP EPON6     I/O BUFFER WAS EMPTY
13153  010307         CPA AKBFX
13154  066160         JMP EPON6     KBD BUFFER WAS EMPTY
13155  000127         LDA P16       SEE IF LINE TO PRINT IS NULL
13156  011735         CPA T21
13157  170201         RET 1         YES, DONE
13160  000117  EPON6  LDA B40       GET A BLANK
13161  030006  EPON5  STA R6        SEND A BLANK TO PRINTER HARDWARE
```

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```
13162   055735         DSZ T21       DONE?
13163   066161         JMP EPONS     NO
13164   164443         JMP APRNT,I   PRINT ONE LINE
                *
                *
                *       ROM POWER REDUCTION LOOP
                *
                *          EXIT: RET P+1 CURSOR SET
                *
                *
                *
13165   001207  RPRL   LDA .WMOD     GET NEW KEY FLAG
13166   170201         RET 1
                *
                *
                ****************************************************************
                *
                *  KEYCODE CONVERSION TABLES
                *
                *          EOL (LAZY T)) 177
                *
                *
                *          KEYCODES     54 - 140 (SHIFTED)
                *
13167   013170  KTBL2  DEF *+1
13170   036055         OCT 36055     , - : < -
13171   037057         OCT 37057     . / : > /
13172   023441         OCT 23441     0 1 : ' !
13173   021043         OCT 21043     2 3 : " #
13174   022045         OCT 22045     4 5 : $ %
13175   023100         OCT 23100     6 7 : & @
13176   055535         OCT 55535     8 9 : [ ]
13177   000073         OCT 73         NULL ; : NULL ;
13200   000075         OCT 75        NULL = : NULL =
13201   000072         OCT 72        NULL ? : NULL :
13202   000214         OCT 214       NULL SK0 : NULL SK12
13203   106616         OCT 106616    SK1 SK2 : SK13 SK14
13204   107620         OCT 107620    SK3 SK4 : SK15 SK16
13205   110622         OCT 110622    SK5 SK6 : SK17 SK18
13206   111624         OCT 111624    SK7 SK8 : SK19 SK20
13207   112626         OCT 112626    SK9 SK10 : SK21 SK22
13210   113400         OCT 113400    SK11 NULL : SK23 NULL
13211   030061         OCT 30061     P0 P1 : P0 P1
13212   031063         OCT 31063     P2 P3 : P2 P3
13213   032065         OCT 32065     P4 P5 : P4 P5
13214   033067         OCT 33067     P6 P7 : P6 P7
13215   034071         OCT 34071     P8 P9 : P8 P9
13216   027054         OCT 27054     . , : . ,
13217   000000         OCT 0         NULL NULL : NULL NULL
13220   000000         OCT 0         NULL NULL : NULL NULL
13221   056000         OCT 56000     ^ NULL : SQR NULL
13222   057400         OCT 57400     ENTER EXP. NULL : UNDERSCORE NULL
                *
                *          KEYCODES      101 - 131 (UNSHIFTED)
                *
13223   013224  KTBL1  DEF *+1
13224   000200         OCT 200       NULL SK0
13225   100602         OCT 100602    SK1 SK2
13226   101604         OCT 101604    SK3 SK4
13227   102606         OCT 102606    SK5 SK6
13230   103610         OCT 103610    SK7 SK8
13231   104612         OCT 104612    SK9 SK10
13232   105400         OCT 105400    SK11 NULL
13233   030061         OCT 30061     P0 P1
13234   031063         OCT 31063     P2 P3
13235   032065         OCT 32065     P4 P5
13236   033067         OCT 33067     P6 P7
13237   034071         OCT 34071     P8 P9
13240   027054         OCT 27054     . ,
                *
                ****************************************************************
                *
                *
                *       RECALL KEY
                *
                *  SETS MODE = 0, SETS DBP TO START OF EDIT BUFFER, CLEARS CURSOR
                *  IF LAST KEY WAS RECALL(BIT 5 OF CFLAG) THEN KBUFF AND RBUFF
                *  ARE SWAPPED
                *  SETS BITS 5,6 OF CFLAG(RECALL BITS)
                *
                *  THE KBD BUFFER IS TRANSFERRED TO THE I/O  BUFFER UNLESS
                *  STATE = 2 (LIVE KBD)
                *
                *  IOCP AND OLCP ARE SET TO THE CHAR AFTER THE LAST NON-BLANK
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```
                         *  CHAR IN THE RECALLED LINE
                         *
                         *  IF THE COMPILE ERROR FLAG (CERR) IS SET THEN IOCP, DBP, AND
                         *  CRSP ARE SET SO THE CURSOR WILL BE DISPLAYED ON THE PROPER
                         *  CHAR IN THE EDIT BUFFER
                         *  CERR SHOULD ALWAYS POINT INTO THE KBD(KBUFF) BUFFER
                         *  AN OFFSET IS CALCULATED FROM THE START OF THIS BUFFER
                         *  USING THE ABSOLUTE ADDR IN CERR.  IOCP, DBP ARE THEN
                         *  THEN SET TO THEIR CORRECT ADDRESSES IN THE EDIT BUFFER
                         *  USING THIS OFFSET.  NOTE IF IN LIVE KBD THEN THE EDIT BUFFER
                         *  IS THE KBD BUFFER, OTHERWISE IT IS THE I/O BUFFER
                         *  AN ADDITIONAL TEST IS MADE TO INSURE THE THE CURSOR IS NOT
                         *  ON THE 81ST CHAR. IF SO IT IS PUT ON THE 80TH CHAR
                         *
                         *
13241   040715  RECL  JSM CLMOD     SET KBD MODE
13242   001351        LDA AEBFX     SET DISPLAY BEGIN PTR
13243   031513        STA DBP
13244   000177        LDA P0        CLEAR CURSOR POINTER
13245   031214        STA CRSP
13246   001232        LDA CFLAG
13247   170704        RAR 5         SEE IF PREVIOUS KEY = RECALL
13250   073017        SLA RNORE     DON'T SWAP BUFFERS IF NOT
                         *
13251   000306        LDA AKBUF     S/A OF KBD BUFFER
13252   030016        STA C         SET POINTER
13253   000322        LDA ARBUF     S/A OF RESERVE BUFFER
13254   030017        STA D
13255   000112        LDA P41       41 WORDS TO TRANSFER
13256   031711        STA T1        SET COUNTER
13257   070760  RLOOP WWC A,D       GET A WORD FROM KBD BUFFER
13260   070771        WWD B,D       GET A WORD FROM RESERVE BUFFER
13261   070541        PWC B,I       PUT WORD IN KBD BUFFER
13262   070550        PWD A,I       PUT WORD IN RESERVE BUFFER
13263   044016        ISZ C         BUMP BUFFER POINTERS
13264   044017        ISZ D
13265   055711        DSZ T1        SEE IF DONE
13266   066257        JMP RLOOP     CONTINUE IF NOT
                         *
13267   001232  RNORE LDA CFLAG     GET CONTROL FLAG AGAIN
13270   060066        IOR B140      SET BIT 5,6
13271   031232        STA CFLAG     RESTORE CONTROL FLAG
13272   001257        LDA CSTAT     SEE IF LIVE KBD KEY
13273   010145        CPA P2
13274   066300        JMP RELKB     YES, DO NOT TRANSFER KBD TO I/O BUFFER
13275   000306        LDA AKBUF     TRANSFER KBD TO I/O BUFFER
13276   004315        LDB AIBFM
13277   042447        JSM TRBX
                         *
13300   140500  RELKB JSM AEOLN,I   GET ADDR OF LAST CHARACTER
13301   031213  RELLL STA OLCP     SET PTRS
13302   031215        STA IOCP
                         *
13303   005316        LDB CERR      GET COMPILE ERROR FLAG
13304   076432        SZB RECEX     SKIP IF NOT SET
                         *
13305   000310        LDA AKBFM     KBD BUFF S/A
13306   140362        JSM AFBAD,I   FIND BYTE OFFSET OF ERROR POSITION
13307   031214        STA CRSP      SET CURSOR OFFSET
13310   004177        LDB P0        CLEAR COMPILE ERROR FLAG
13311   035316        STB CERR
13312   001352        LDA AEBFM     GET EDIT BUFF S/A
13313   005214        LDB CRSP      ERROR BYTE OFFSET
13314   024257        ADB M1        MAKE RELATIVE TO BUFF S/A
13315   140401        JSM AADBA,I   FIND ABSOLUTE ADDR OF ERROR
                         *
13316   031215  REC10 STA IOCP      SET PTR TO ERROR POSITION
13317   005353        LDB AEBFL     SEE IF CURSOR PAST LAST POSSIBLE CHAR
13320   024257        ADB M1
13321   015215        CPB IOCP
13322   066342        JMP REC11     YES, SET TO LAST POSSIBLE CHAR
13323   005213        LDB OLCP      SEE IF CURSOR >= OLCP
13324   140362        JSM AFBAD,I
13325   020257        ADA M1
13326   172004        SAP RELCR     OUT IF NOT
13327   001215        LDA IOCP      SET OLCP = 1 CHAR PAST IOCP
13330   004254        LDB P1
13331   042415        JSM DLCH4     SET OLCP
                         *
13332   005214  RELCR LDB CRSP      SEE IF ERROR OFFSET > OLEN
13333   174040        TCB
13334   025512        ADB OLEN
13335   176402        SBM RECL3     B= OLEN - ERROR OFFSET
13336   170201  RECEX RET 1
                         *
```

```
13337  001512  RECL3 LDA OLEN      SET CURSOR TO LAST DISPLAY POSITION
13340  031214        STA CRSP
13341  164446        JMP AFBP,I    FIND DISPLAY BEGIN PTR AND RETURN P+1
                *
13342  176301  RECI1 SHP *+1,S     ADDR OF LAST POSSIBLE CHAR
13343  000001        LDA B
13344  066316        JMP REC10     SET OLCP,IOCP
                *
                *
                ******************************************************************
                *
                *
                *  CLEAR KEY  MODE = 0,1,2
                *  SETS MODE =0: CLEARS EDIT BUFFER, RESETS EDIT PTRS
                *  IF FETCH BIT OF CFLAG(BIT 1) IS SET THE SPECIAL
                *  KEY NUMBER IS DISPLAYED
                *
                *
                *
                *
                *
13345  140452  CLEAR JSM AEOLB,I   PUT EOL IN DISPLAY
13346  040715        JSM CLMOD     SET MODE = 0
13347  001232        LDA CFLAG     GET CONTROL FLAG
13350  170500        SAR 1         POSITION SPECIAL KEY FLAG - BIT 1
13351  073006        SLA CLMMD     CLEAR MODE IF SPECIAL NOT TO BE DEFINED
13352  164474        JMP AKEYN,I   DISPLAY KEY #,PUT EOL IN I/O BUFFER, RET 2-NO DISP
                *
                *
                ********************
                *
                * CLEAR KEY IN ENTER (STATE=4), OR LIVE KBD (STATE=2)
                * IF ENTER A QUESTION MARK IS PUT IN THE I/O BUFFER
                * AND THE MODE IS SET TO 4
                *
                *
13353  140452  CLEEN JSM AEOLB,I   PUT EOL IN EDIT BUFFER
13354  040715        JSM CLMOD     SET MODE = 0
13355  001257        LDA CSTAT     RETURN IF LIVE KBD
13356  010145        CPA P2
13357  170201  CLMMD RET 1         STATE = 2 SO MUST BE LIVE KBD
13360  000226        LDA QMRKB     GET "?" AND BLANK
13361  130313        STA AIBUF,I   AND PLACE IN I/O BUFFER
13362  064717        JMP STELM     SET MODE = 4, RETURN
                *
                *
                *
                *     DELETE CHARACTER EXECUTION
                *
                *     ENTRY: INFO IN I/O BUFF
                *
                *
13363  001214  DLCH  LDA CRSP      GET CURSOR POINTR
13364  072002        RZA *+2       SET ?
13365  170201        RET 1         NO
                *
13366  001215        LDA IOCP      GET I/O BUFF CURRENT POINTR
13367  011213        CPA OLCP      SEE IF AT LAST CHARACTER
13370  066420        JMP DLCH2     YES
13371  004254        LDB P1
13372  140401        JSM AADBA,I   GET IOCP + 1 ADDR
13373  011213        CPA OLCP      CURSOR ON LAST ENTERED CHAR?
13374  066420        JMP DLCH2     YES
13375  005353        LDB AEBFL     GET END OF BUFFER ADDR
13376  176301        SBP *+1,S     PT TO FIRST BYTE
13377  001215        LDA IOCP      GET IOCP AGAIN
13400  030017        STA D         SET DESTIN. POINTR
13401  030016        STA C         SET SOURCE POINTR
13402  074560        WBC A,I       DUMMY WITHDRAW: ADJUST POINTR
13403  074560        WBC A,I       POINT TO "DELETE CHAR" +1
13404  074560  DLCH1 WBC A,I       GET FIRST CHAR AND INCRM
13405  074550        PBD A,I       INCRM AND STORE CHAR
13406  014016        CPB C         LAST CHAR TAKEN?
13407  066411        JMP *+2       YES
13410  066404        JMP DLCH1     NO: TRANSFER NEXT CHAR LEFT
13411  000117        LDA B40       SET LAST CHAR = BLANK
13412  074740        PBC A,D
13413  001213        LDA OLCP      GET OLD CURRENT POINTER
13414  004257        LDB M1
13415  140401  DLCH4 JSM AADBA,I   UPDATE OLD CURRENT POINTER
13416  031213  DLCH3 STA OLCP      UPDATE OLD CURRENT POINTR
13417  170201        RET 1
                *
13420  000117  DLCH2 LDA B40       GET BLANK
```

I/O SUPERVISOR

```
13421  005215        LDB IOCP     GET I/O BUFF CURRENT POINTR
13422  034016        STB C        SET C-REG
13423  074540        PBC A,I      INCRM AND DELETE CURSOR CHAR
13424  000177        LDA P0
13425  031214        STA CRSP      CLEAR CURSOR POINTR
13426  000257        LDA M1       SET FORWARD PASS FLAG
13427  066416        JMP DLCH3    CLEAR DLCP POINTR
                *
                ******************************************************************
                *
                *  ATRBF TRANSFER BUFFERS
                *
                *  CLEARS COMPILE ERROR FLAG
                *  IF MODE = 4  LEAVES BUFFERS ALONE
                *  SETS MODE = 4, RETURNS IF LIVE KBD
                *  ALSO LEAVES BUFFERS ALONE IF LAST KEY WAS RECALL
                *
                *  TRANSFERS KBD BUF  ; TO RBUFF(RESERVE BUFFER)
                *  AND THEN TRANSFER.  /O BUFFER TO KBD BUFFER
                *
                *
                *
13430  000177  TRBUF LDA P0       CLEAR COMPILE ERROR FLAG
13431  031316        STA CERR
13432  001256        LDA MODE     LEAVE BUFFERS ALONE IF MODE = 4
13433  010143        CPA P4
13434  170201        RET 1
13435  040717        JSM STELM    SET MODE = 4
13436  001257        LDA CSTAT    DON'T TRANS FER TO LIVE KBD IF STATE = 2
13437  010145        CPA P2
13440  170201  TREC  RET 1
13441  001232        LDA CFLAG    DON'T TRANSFER IF LAST KEY = RECALL
13442  170705        RAR 6
13443  073475        RLA TREC     RETURN IF BIT IS SET
13444  042462        JSM KBREB    TRANSFER KBD BUFF TO RESERVE BUFF
13445  000313  TRB2  LDA AIBUF    I/O BUFF S/A
13446  004310        LDB AKBFM    KBD BUFF S/A
13447  030016  TRBX  STA C        SET SOURCE ADDR
13450  034017        STB D        SET DESTINATION ADDR
13451  000112        LDA P41      BUFF LENGTH
13452  031230        STA TMP5     SET COUNTR
13453  070560  TRB3  WWC A,I      GET WORD AND INCRM
13454  070550        PWD A,I      PLACE WORD AND INCRM
13455  055230        DSZ TMP5     DONE ?
13456  066453        JMP TRB3     NO
13457  170201        RET 1
                *
                ******************
                *
                *  KBREB   TRANSFER KDB BUFFER(KBUFF=LIVE KBD BUFFER) TO
                *  RESERVE BUFFER
                *
                ********************
                *
13460  000177  KBTRB LDA P0       CLR ERROR CURSOR FLAG
13461  031316        STA CERR     USED BY LIVE KBD
                *
13462  000306  KBREB LDA AKBUF    KBD BUFF S/A
13463  004323        LDB ARBFM    RESERVE BUFF S/A
13464  066447        JMP TRBX     TRANSFER AND RETURN
                ***************************************************************************
                *
                *
                * CLEBF- ACLEB   CLEAR EDIT BUFFER TO BLANKS, RESET EDIT PTRS IOCP
                *   OLCP, DBP, CRSP
                *
                *  IF MODE = 4 AND IN LIVE KBD , KBD BUFFER IS TRANSFERED TO RESERVE
                *  TO RESERVE BUFFER.  TEST FOR LIVE KBD DONE BY COMPARING
                *  ERROR BYPASS LINK (ERRBP) TO LIVE KBD ERROR ROUTINE
                *  MIGHT BE BETTER TO CHECK FOR STATE = 2
                *
                *
                *  CLBF1 ENTRY A= START ADDR-1
                *              B= LAST ADDR
                *  MEMORY BETWEEN A-1 AND B INCLUSIVELY IS CLEARED TO BLANKS
                *
                *
                *
13465  001256  CLEBF LDA MODE      IF MODE = 4 AND THIS IS A LIVE
13466  010143        CPA P4        KBD KEY THEN TRANSFER LIVE KBD
13467  066471        JMP *+2       BUFFER TO RESERVE BUFFER BEFORE
13470  066474        JMP CLBF3     THE LIVE KBD BUFFER IS CLEARED
13471  001260        LDA ERRBP     LIVE KBD KEY IF BYPASS LINK IS SET
13472  012520        CPA ALKER
```

```
13473  042460        JSM KBTRB    CONDITIONS MET SO TRANSFER
                *
13474  140475  CLBF3 JSM AEDPT,I  RESET EDIT POINTERS
13475  005353        LDB AEBFL    LAST EDIT BUFF ADDR
13476  030016  CLBF1 STA C        SET C REG
13477  000262  CLBF2 LDA TOBLN    TWO BLANKS
13500  070540        PWC A,I      CLEAR 1 WORD
13501  000016        LDA C        GET WORD POINTER
13502  172601        SAM *+1,C    CLEAR BIT 15
13503  010001        CPA B        DONE ?
13504  170201        RET 1        YES
                *
13505  066477        JMP CLBF2    NO! CONT
                *
                *****************************************************************
                *
                *
                *    CLEAR I/O BUFFER LEAVE EDIT PTRS ALONE
                *
13506  000315  CLBIO LDA AIBFM    START ADDR
13507  004316        LDB AIBFL    STOP ADDR
13510  066476        JMP CLBF1    CLEAR BUFF AND RETURN
                *
                *
                ****************************************************************
                *
                * AEOLB-EOLEB  SAMEAS ACLEB-CLEBF EXCEPT THAT IT SETS AN EOL
                * AS THE FIRST CHAR OF THE EDIT BUFFER.
                *
                *
13511  042465  EOLEB JSM CLEBF
13512  000214  EOLBB LDA EOLB     CLEAR I/O BUFF, SET PTRS, PUT EOL IN EDIT BUFF
13513  131350        STA AEBUF,I
13514  170201        RET 1
                *
                ***************************************************************
                *
                * CLCMB  CLEAR COMPILE BUFFER
                *
                *******************
                *
13515  000304  CLCMB LDA ACBUF    COMPILE BUFF S/A -1
13516  004305        LDB ACLMT    STOP ADDR
13517  066476        JMP CLBF1
                *
                *
```

LIVE KEYBOARD ROUTINES

```
                *******************************************************
                *
                *
                *    LIVE KEYBOARD
                *
                *
                *******************************************************
                *
                *
                * EQUATES
                *
                *
       077605  LKR   EQU LKTMP+0  DEDICATED WORD TO SAVE R
       077606  BPLNK EQU LKTMP+1  DEDICATED WORD TO SAVE ERROR BYPASS LINK
       077607  LWHER EQU LKTMP+2  DEDICATED WORD TO SAVE WHERE
                *
       077611  LXCMM EQU LKTMP+4  DEDICATED WORD TO SAVE XCOMM
       077613  RENFL EQU LKTMP+6  RENUMBER OF GTO AND GSB FLAG
                *      LKTMP+7 TO +13    SAVE TEMPORARIES USED BY LIVE KBD KEY PROC
                *
                *
                * ADDRESSES
                *
                *
13520  013646  ALKER DEF LKERR    LIVE KEYBOARD ERROR TRAPPING ROUTINE ADDRESS
13521  100271  ALKEM DEF LKERM,I  ADDRESS OF THE FIRST CHARACTER OF THE ERROR MESSAGE
13522  077614  ASVLK DEF LKTMP+7  START ADDR TO SAVE TEMPS
13523  077227  ACST9 DEF CSTMP+9  START ADDR OF CONTROL SUP TEMPS TO SAVE
13524  077350  AEBST DEF AEBUF    START ADDR OF R/W EDIT PTRS
                *
                *
                * CONSTANTS
                *
```

LIVE KEYBOARD ROUTINES

```
03513000                  *
03514000 13525  040000   XBIT  OCT 040000   SET ONLY BIT 14 OF XCOMM
03515000                  *
03516000                  ****************
03517000                  *
03518000                  * LKE:  LIVE KEYBOARD ENABLE.
03519000                  *
03520000                  ****************
03521000                  *
03522000 13526  000177   ELKE  LDA P0       CLEAR LIVE KBD DISABLE FLAG
03523000 13527  031623   ELK1  STA LKFLG
03524000 13530  164365         JMP AINTX,I  RETURN TO INTERPRETER
03525000                  *
03526000                  ****************
03527000                  *
03528000                  * LKD:  LIVE KEYBOARD DISABLE
03529000                  *
03530000                  ****************
03531000                  *
03532000 13531  000254   ELKD  LDA P1       DISABLE LIVE KBD
03533000 13532  066527         JMP ELK1
03534000                  *
03535000                  ****************
03536000                  *
03537000                  *  LKPRC: PROCESS A KEY, EXTENSION OF KDB INT SERV ROUTINE
03538000                  *         ROUTINE IN "IOSP".
03539000                  *  ALLOWS LIVE KBD ONLY IF STATE = 2
03540000                  *  BEEPS OTHERWISE
03541000                  *
03542000                  *  SAVES TEMPS T1-T5, TMP1,TMP5! ALSO USES TMP8 BUT
03543000                  *  DOESN'T SAVE IT
03544000                  *
03545000                  *  USES ERRBP TO TRAP KEY ERRORS, SAVES R IN CASE OF AN ERROR
03546000                  *  AND SETS EDIT POINTERS TO EDIT KDB(KBUFF) BUFFER
03547000                  *
03548000                  ****************
03549000                  *
03550000 13533  001257   LKPRC LDA CSTAT    IGNORE KEY IF STATE #2
03551000 13534  010145         CPA P2       =2?
03552000 13535  066537         JMP *+2      YES
03553000 13536  064703         JMP BEEP     IGNORE KEY,BEEP, AND RETURN
03554000                  *
03555000 13537  000335         LDA ATMP     SAVE T1-T5 IN LKTMP+7,13
03556000 13540  006522         LDB ASVLK
03557000 13541  071404         XFR 5
03558000 13542  002523         LDA ACST9    SAVE TMP1,TMP5
03559000 13543  024142         ADB P5
03560000 13544  071401         XFR 2        TMP8 ALSO USED BUT NOT SAVED/RESTORED
03561000                  *
03562000 13545  000003         LDA R        SAVE RETURN PTR IN CASE OF AN ERROR
03563000 13546  031605         STA LKR
03564000 13547  001260         LDA ERRBP    SAVE ERROR BYPASS LINK  FOR DAISY CHAIN
03565000 13550  031606         STA BPLNK
03566000 13551  002520         LDA ALKER    SET ERROR LINK FOR LIVE KBD PROCESSING
03567000 13552  031260         STA ERRBP
03568000                  *
03569000 13553  000312         LDA AKBST    SWAP LIVE KBD POINTERS
03570000 13554  006524         LDB AEBST    INTO EDIT POINTERS
03571000 13555  071403         XFR 4
03572000                  *
03573000 13556  001206         LDA .WKC     PUT KEYCODE IN A
03574000 13557  140420   LKNRL JSM AKYPR,I   PROCESS THE KEY
03575000                  *
03576000 13560  042562         JSM LKDSP    RET1  DISPLAY BUFFER WITH DELAYS
03577000 13561  066704         JMP KREST    RET 2  DON'T DISPLAY ANYTHING
03578000                  *
03579000 13562  004155   LKDSP LDB M11      WAIT 11 MILLISECONDS
03580000 13563  040633         JSM DELAY
03581000 13564  140432         JSM ADSPC,I  COMPLETE PREVIOUS DISPLAY
03582000 13565  140432         JSM ADSPC,I  DISPLAY EDIT BUFFER
03583000 13566  004156         LDB M13      WAIT ANOTHER 13 MILLISECONDS
03584000 13567  064633         JMP DELAY
03585000                  *
03586000                  *************************************************************
03587000                  *
03588000                  *
03589000                  *  EXECUTE IN LIVE KBD. SET BIT 14 IN XCOMM
03590000                  *
03591000                  *
03592000 13570  000214   LEXKY LDA EOL8     SET FOR ECECUTION OF THE LINE
03593000 13571  130311         STA AKBFL,I
03594000 13572  002525         LDA XBIT     SET XCOMM FOR EXECUTION
03595000 13573  040744         JSM SXCMM
03596000 13574  170202         RET 2        DON'T DISPLAY ANYTHING
```

LIVE KEYBOARD ROUTINES

```
                      *
                      ****************
                      *
                      * LKBEX:  EXECUTE THE LIVE KEYBOARD BUFFER CONTENTS
                      *         (ACCESSED BY A JSM FROM THE XCOMM SERVICE ROUTINE.)
                      *  STACKS (PUTS A FAKE BOTTOM OF STACK ON THE EXECUTION STACK)
                      *  CHANGES THE STATE TO 3. SAVES R AND WHERE(NEEDED FOR RESUMING
                      *  FROM XCOMM SERVICE ROUTINE) CLEARS BIT 14 FROM XCOMM. SAVES
                      *  THIS XCOMM, CLEARS DISPLAY, EXECUTES LIVE KBD LINE
                      *
                      *  AN ERROR MESSAGE WILL BE LEFT IN THE DISPLAY FOR .5 SEC
                      *  SO IT CAN BE VIEWED
                      *
                      *
                      ****************
                      *
13575   140515  LKBEX JSM ASTKI,I  STACK
13576   000144        LDA P3       SET LIVE KBD EXEC STATE
13577   031257        STA CSTAT
13600   000003        LDA R        SAVE RETURN PTR IN CASE OF AN ERROR
13601   031605        STA LKR
13602   001266        LDA WHERE    SAVE WHERE WORD ALSO
13603   031607        STA LWHER
                      *
13604   004244        LDB XMASK    CLEAR LIVE KBD BIT IN XCOMM
13605   040740        JSM CLXCM
13606   031611        STA LXCMM
13607   000177        LDA P0       CLEAR XCOMM BEFORE STARTING
13610   031255        STA XCOMM
                      *
13611   042117        JSM EPKBD    GO THROUGH PRINTALL
13612   042465        JSM CLEBF    CLEAR I/O BUFFER, RESET PTRS
13613   043135        JSM DISP     CLEAR DISPLAY
13614   140417        JSM AEXCL,I  COMPILE LINE
                      *
13615   140364  LKBE2 JSM AINTK,I  INTERPRET THE LINE
                      *
13616   140411        JSM AXCMM,I  WANTS TO BE SERVICED SO GO SERVICE XCOMM,
13617   066626        JMP LEXRR    P+1: STOP CONDITION, ABORT EXECUTION
13620   005266        LDB WHERE    P+2: XCOMM HAS BEEN SERVICED,CONTINUE
13621   066615        JMP LKBE2
                      *
13622   042641  LEXER JSM LKRES    DISPLAY ERROR MESSAGE,RES XCOMM,CLR .WKC
13623   006762        LDB M512     WAIT 512 MS FOR DISPLAY
13624   040633        JSM DELAY
13625   066627        JMP LXERR
                      *
13626   042641  LEXRR JSM LKRES    DISPLAY ERROR MESSAGE, RES XCOMM, CLR .WKC
13627   001607  LXERR LDA LWHER    REPLACE WHERE WORD
13630   031266        STA WHERE
13631   001605        LDA LKR      RESTORE JSM STACK PTR
13632   030003        STA R
13633   140516        JSM AREST,I  RESTORE AFTER EXECUTION
13634   004155        LDB M11      WAIT FOR DISPLAY
13635   040633        JSM DELAY
13636   000145        LDA P2       SET STATE BACK TO 2
13637   031257        STA CSTAT
13640   170201        RET 1
                      *
                      *
13641   001611  LKRES LDA LXCMM    RESTORE XCOMM
13642   031255        STA XCOMM
13643   000177        LDA P0       CLEAR KEY CODE FOR WAIT ROUTINE
13644   031206        STA .WKC
13645   164433        JMP ALDSP,I  DISPLAY ERROR MESSAGE OR RESULT
                      *
                      *
                      *
                      ****************
                      *
                      * LKERR:  ERROR HANDLING ROUTINE FOR LIVE KEYBOARD EXECUTION.
                      *
                      ****************
                      *
13646   040717  LKERR JSM STELM    SET EOL MODE
13647   040703  LKER1 JSM BEEP
13650   000177        LDA P0       SET PERIP ADDR TO THE PRINTER/DSP
13651   030011        STA PA
13652   002521        LDA ALKEM    POINT C TO THE FIRST CHARACTER OF THE ERROR MESSAGE.
13653   030016        STA C
13654   004141        LDB P6
13655   074560  LKER2 WBC A,I      SEND "ERROR " TO THE DISPLAY
13656   030004        STA R4
13657   054001        DSZ B
```

```
13660  066655        JMP LKER2
13661  000003        LDA R         GET JSM STACK PTR
13662  020257        ADA M1        PT TO JSM AERR1 ENTRY ON STACK
13663  144000        ISZ A,I
13664  100000        LDA A,I       PT TO MESSAGE XX ON STACK
13665  100000        LDA A,I       GET MESSAGE XX
13666  170707        RAR 8
13667  030004        STA R4        SEND THE FIRST CHARACTER OF THE ERROR NUMBER
13670  170707        RAR 8
13671  030004        STA R4        SEND THE SECOND CHARACTER OF THE ERROR NUMBER.
13672  000117        LDA B40       FILL OUT THE REST OF THE DISPLAY WITH BLANKS.
13673  005512        LDB DLEN
13674  024154        ADB M8
13675  030004  LKER3 STA R4
13676  054001        DSZ B
13677  066675        JMP LKER3
13700  000145        LDA P2        TRIGGER THE DISPLAY
13701  030005        STA R5
13702  001605        LDA LKR       RESTORE STACK POINTER
13703  030003        STA R
               *
13704  001606  KREST LDA BPLNK     RESTORE ERROR BYPASS LINK
13705  031260        STA ERRBP
13706  042716        JSM SWIOP     RESTORE EDIT PTRS SO PT TO I/O BUFFER
13707  002522        LDA ASVLK     RESTORE TEMPS T1-T5
13710  004335        LDB ATMP
13711  071404        XFR 5
13712  020142        ADA P5        RESTORE TMP1,TMP5
13713  006523        LDB ACST9
13714  071401        XFR 2
13715  170201        RET 1
               *
               ***********************************************************
               *
               *  SWIOP  SWAPS THE ROM PTRS FOR THE I/O BUFFER INTO THE
               *         READ-WRITE EDIT POINTER LOCATIONS
               *         AND SETS THE ERROR BYPASS LINK FOR  NORMAL PROCESSING
               *
               **********************
               *
13716  000321  SWIOP LDA AIBST     TRANSFER EDIT PTRS FOR I/O BUFFER
13717  006524        LDB AEBST
13720  071403        XFR 4
13721  170201        RET 1
               *
               *
               *
               *
               *     MTABLE
               *
               *     CONSTRUCTED BY CODE CLASS AND CONTROL NUMBER
               *
               *     CLASS: BITS 0-2
               *
               *     CONTROL NUMBER (CN) BITS 3-7
               *
               *     ASCII CODE: BITS 8-15
               *
               *
               *
13722  000572  K1    OCT 572       STOP: 1,17,2
13723  001172  K2    OCT 1172      REWIND: 2,17,2
13724  003673  K7    OCT 3673      RESULT: 7,27,3
13725  004233  K10   OCT 4233      LINE INSERT: 10,23,3
13726  004663  K11   OCT 4663      LINE DELETE: 11,26,3
13727  005013  K12   OCT 5013      EXECUTE: 12,1,3
13730  005523  K13   OCT 5523      RECALL: 13,12,3
13731  006243  K14   OCT 6243      RUN: 14,24,3
13732  006423  K15   OCT 6423      STORE: 15,2,3
13733  007103  K16   OCT 7103      L.ARROW: 16,10,3
13734  007473  K17   OCT 7473     R.ARROW: 17,7,3
13735  010113  K20   OCT 10113     D.ARROW: 20,11,3
13736  010543  K21   OCT 10543     U.ARROW: 21,14,3
13737  011043  K22   OCT 11043     CLEAR: 22,4,3
13740  011623  K23   OCT 11623     PRINT ALL: 23,22,3
13741  012153  K24   OCT 12153     BACK: 24,15,3
13742  012563  K25   OCT 12563     FORWARD: 25,16,3
13743  013033  K26   OCT 13033     INSERT: 26,3,3
13744  013453  K27   OCT 13453     DELETE: 27,5,3
13745  014063  K30   OCT 14063     STEP: 30,6,3
13746  014653  K31   OCT 14653     CONTINUE: 31,25,3
13747  015604  K33   OCT 15604    LIST: 33,20,4
13750  016204  K34   OCT 16204    FETCH: 34,20,4
13751  016604  K35   OCT 16604    ERASE: 35,20,4
```

LIVE KEYBOARD ROUTINES

```
13752  017204  K36   OCT 17204      RECORD: 36,20,4
13753  017604  K37   OCT 17604      LOAD: 37,20,4
13754  177777        OCT -1         END-OF-TABLE
                *
                *
                ***********************************************************************
                *
                *  CONSTANTS
                *
13755  000131  P89   DEC 89
13756  177724  M44   DEC -44
13757  054501  LMT1  OCT 54501
13760  000031  B31   OCT 31
13761  000065  B65   OCT 65
13762  177000  M512  DEC -512
13763  025040  BLAST OCT 25040      ASCII ASTERIK, BLANK
                *
                *
                *
                *
                ***********************************************************************
                *
                *     DEFINITIONS
                *
                *
       013755  B131  EQU P89
       013756  BM54  EQU M44
       000263  MAXLN EQU FLAG
       000077  COLLN EQU B72
       000053  EOL   EQU B177
       000177  DPA   EQU P0
       000177  PPA   EQU P0
       000116  QUOTE EQU B42
       077467  LPSVA EQU LPIT
       077470  LPSVB EQU LPIT+1
       077471  LPSVC EQU LPIT+2
       077472  LPSVD EQU LPIT+3
       077473  LPSVE EQU LPIT+4
       077216  CST   EQU CSTMP
       077216  SIOCP EQU CST
       077217  .WPRT EQU CST+1
       077220  M     EQU CST+2
       077221  PLADD EQU CST+3
       077223  TMP6  EQU CST+5
       077224  K     EQU CST+6
       077225  TMP2  EQU CST+7
       077226  LNO   EQU CST+8
       077227  TMP1  EQU CST+9      TMP1,TMP5 MUST BE IN THIS ORDER
       077230  TMP5  EQU CST+10
       077231  TMP3  EQU CST+11
       077232  CFLAG EQU CST+12
       077233  TMP7  EQU CST+13
       077234  TMP4  EQU CST+14
       077235  SKEY  EQU CST+15
       077206  .WKC  EQU IOTMP
       077207  .WMOO EQU IOTMP+1
       077210  DTMP1 EQU IOTMP+2
       077211  DTMP2 EQU IOTMP+3
       077212  SPKN  EQU IOTMP+4
       077213  OLCP  EQU IOTMP+5
       077214  CHSP  EQU IOTMP+6
       077215  IOCP  EQU IOTMP+7
                *
                *
                ***********************************************************************
                *
13777                ORG 13777B
13777                BSS 1          CHECKSUM!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
                *
                ********************
                *
                     END

END OF PASS 2 NO ERRORS DETECTED
```

INTERNAL FULL PRECISION MATH ROUTINES

```
*
* FULL PRECISION NUMBER:  INTERNAL FORMAT
*
*
*   EEEE EEEE EEXX XXXS   10 BIT 2'S COMPL. EXP., 5 DON'T CARE BITS
*                         MANTISSA SIGN (0=+ 1=-)
*                         EXP. RANGE = -511 TO +511
```

INTERNAL FULL PRECISION MATH ROUTINES

```
                     *     D1 . D2    D3    D4     BCD DIGITS 1-4
                     *
                     *
                     *     D5    D6    D7    D8     BCD DIGITS 5-8
                     *
                     *
                     *     D9    D10   D11   D12    BCD DIGITS 9-12
                     *
                     ****************
                     *


                     *
                     * EQUATES
                     *
            077752   RESE  EQU RES        FULL PRECISION RESULT REGISTER
            077753   RESM1 EQU RES+1
            077754   RESM2 EQU RES+2
            077755   RESM3 EQU RES+3
            077756   ZE    EQU MRW1       FULL PRECISION MATH TEMPORARY
            077757   ZM1   EQU MRW1+1
            077760   ZM2   EQU MRW1+2
            077761   ZM3   EQU MRW1+3
            077762   MT1   EQU MRW1+4
            077763   MT2   EQU MRW1+5
            077764   MT3   EQU MRW1+6
            077765   MT4   EQU MRW1+7
            077766   MT5   EQU MRW1+8
            077767   MT6   EQU MRW1+9
            000345   AR1A  EQU ADR1       ADDRESS OF AR1
            077770   AR1E  EQU AR1        EXPONENT WORD OF AR1
            077771   AR1M1 EQU AR1E+1     1ST MANTISSA WORD OF AR1
            077772   AR1M2 EQU AR1E+2     2ND MANTISSA WORD OF AR1
            077773   AR1M3 EQU AR1E+3     3RD MANTISSA WORD OF AR1
            077774   RNDT2 EQU MRW2       NORMALIZE COUNT FOR COMPARISON IN ROUND
            077775   RNDT1 EQU MRW2+1     SHIFT COUNTER FOR ROUND
            077776   NRMFL EQU MRW2+2     NORMALIZATION FLAG FOR ROUND
            077777   STBIT EQU MRW2+3     "STICKY BIT" FOR ROUND
            000127   AR2A  EQU ADR2       ADDRESS OF AR2
            000020   AR2E  EQU AR2        EXPONENT WORD OF AR2
            000021   AR2M1 EQU AR2E+1     1ST MANTISSA WORD OF AR2
            000022   AR2M2 EQU AR2E+2     2ND MANTISSA WORD OF AR2
            000023   AR2M3 EQU AR2E+3     3RD MANTISSA WORD OF AR2
            000175   BCD1  EQU B10K       BCD 1000
     14000                 ORG 14000B
                     *
     14000  066070   E77L  JMP E77        ERROR 77 LINK:  MUST BE AT 14000B.
     14001  014301   E99M  OCT 014301     E99 -  (USED BY ERROR 73)
     14002  100030   A01FF ABS AR2E-AR1E SQUARE ROOT USES THIS
     14003  002400   BCD.5 OCT 02400      BCD 0500
     14004  077756   ZA    DEF ZE         ADDRESS OF FULL PREC. MATH TEMPORARY -- Z
     14005  077774   WPTR2 DEF AR1E+4     ADDRESS OF THE WORD BELOW AR1 (D9-D12) -- RNDT2


     14006           CHKSM BSS 1          CHECKSUM WORD FOR ADDRESSES:  14000-15777.


                     *
                     ****************
                     *
                     * INTERNAL MATH GENERAL ENTRY CONDITIONS:
                     *
                     *
                     *   DESCRIPTIONS OF THE OPERANDS ARE ON THE TOP OF THE EXECUTION
                     *   STACK.  EACH BINARY IMATH ROUTINE USES "GET2" TO POINT OPND2
                     *   TO THE OPERAND ON THE TOP OF THE STACK AND OPND1 TO THE SECOND
                     *   OPERAND ON THE TOP OF THE STACK.  EACH UNARY IMATH ROUTINE
                     *   USES "GET1" TO POINT OPND1 TO THE OPERAND ON THE TOP OF THE STACK.
                     *   AR1 IS RESET BY GET1 AND GET2 TO ELIMINATE THE OPERANDS
                     *   FROM THE EXECUTION STACK.
                     *
                     *   DON'T USE AR1, AR2, OR Z(MRW1+0 THRU MRW1+3)
                     *   TO STORE OPERANDS IN WHEN CALLING THESE IMATH ROUTINES.
                     *


                     *
                     ****************
                     *
                     * INTERNAL MATH GENERAL EXIT CONDITIONS:
                      *
                      *
                      *    THE RESULT OF EACH IMATH ROUTINE IS PLACED IN THE BASEPAGE
                      *    RESULT LOCATION "RES" AS A FULL PRECISION NUMBER.  THERE IS NO
                      *    GUARANTY THAT THE EXPONENT IS IN THE USER'S RANGE OF -99 TO +99
                      *    USE "FLTCK" TO VERIFY THIS CONDITION BEFORE MAKING THE RESULT
                      *    AVAILABLE TO THE USER.
                      *
                      *
                      ****************
                      *
                      * GET1:  ROUTINE TO UNSTACK ONE OPERAND FOR UNARY OPERATORS
                      * GET2:  ROUTINE TO UNSTACK TWO OPERANDS FOR BINARY OPERATORS
                      *
                      * ENTRY CONDITIONS:
                      *   THE "WHAT/WHERE" INFORMATION FOR THE OPERANDS MUST BE ON THE
                      *   TOP OF THE EXECUTION STACK, POINTED TO BY AP1.
                      *
                      * EXIT CONDITIONS:
                      *   OPND1 WILL CONTAIN THE VALUE ADDRESS OF THE FULL PRECISION
                      *   OPERAND 1.
                      *   OPND2 WILL CONTAIN THE VALUE ADDRESS OF THE FULL PRECISION
                      *   OPERAND 2.
                      *
                      * TEMPORARIES:  SAVEB
                      *
                      ****************
                      *
14007   043011  GET2  JSM GET1       UNSTACK THE SECOND OPERAND FROM THE TOP OF STACK.
14010   035274        STB OPND2      SAVE THE ADDRESS OF THE SECOND OPERAND IN OPND2.
14011   140611  GET1  JSM AGTAD,I    DEMAND A NUMERIC ON TOP OF STACK OR GIVE ERROR 32.
14012   000001        LDA B          RETURN THE ADDRESS IN BOTH A & B.
14013   035273        STB OPND1
14014   170201  GRET1 RET 1
```

```
                      *
                      ****************
                      *
                      * ZAR2:  TEST THE MANTISSA OF AR2 FOR ZERO/NON-ZERO
                      *
                      * ENTRY CONDITIONS:
                      *   AR2 CONTAINS THE NUMBER TO BE CHECKED
                      *
                      * EXIT CONDITIONS:
                      *   RET 1 IF AR2 = 0
                      *   RET 2 IF AR2 # 0
                      *
                      ****************
                      *
14015   000021  ZAR2  LDA AR2M1
14016   060022        IOR AR2M2
14017   060023        IOR AR2M3
14020   072474        SZA GRET1
14021   170202        RET 2
                      *
                      ****************
                      *
                      * FUNM:  FULL PRECISION UNARY MINUS
                      *
                      *   RES = - <OPND1>
                      *
                      * SPECIAL EXIT CONDITIONS:
                      *   OPND2 POINTS TO Z WHICH CONTAINS -(ARGUMENT)
                      *
                      * TEMPORARIES:  Z
                      *
                      ****************
                      *
14022   043011  FUNM  JSM GET1       COPY THE ARGUMENT INTO Z.  CHANGE
14023   043026        JSM CHS        THE SIGN OF Z.  LOAD A WITH THE ADDRESS
14024   003004        LDA ZA         OF Z.  JUMP TO THE ROUTINE THAT
14025   06605[illegible]        JMP STANY      WILL CHECK FOR ZERO AND STORE THE RESULT.
                      *
                      ****************
                      *
                      * CHS:  FULL PRECISION CHANGE SIGN
                      *
                      *   OPND2 = - <A>
                      *
                      * ENTRY CONDITIONS:
```

INTERNAL FULL PRECISION MATH ROUTINES

```
                *   A CONTAINS THE ADDRESS OF THE ARGUMENT
                *
                * EXIT CONDITIONS:
                *   OPND2 CONTAINS THE ADDRESS OF Z WHICH CONTAINS -(<A>)
                *
                * TEMPORARIES:  Z
                *
                ****************
                *
14026  007004   CHS   LDB ZA        B CONTAINS THE ADDRESS OF THE RESULT LOC.
14027  035274         STB OPND2     POINT OPND2 TO THE RESULT
14030  071403         XFR 4         COPY THE ARGUMENT INTO Z
14031  001756         LDA ZE        GET THE MANTISSA SIGN OF Z AND
14032  073302         SLA *+2,S     MAKE IT NEGATIVE.  LEAVE IT IF IT WAS POSITIVE
14033  073201         SLA *+1,C     OTHERWISE MAKE THE MANTISSA SIGN POSITIVE
14034  031756         STA ZE        THEN STORE IT
14035  170201         RET 1         AND RETURN
                *
                ****************
                *
                * FSUB:  FULL PRECISION SUBTRACTION
                *
                *   RES = <OPND1> + (-<OPND2>)
                *
                * SPECIAL EXIT CONDITIONS:
                *   OPND2 CONTAINS THE ADDRESS OF Z WHICH CONTAINS -(SUBTRAHEND)
                *
                * TEMPORARIES:  Z, MT1
                *
                ****************
                *
14036  043007   FSUB  JSM GET2
14037  001274         LDA OPND2
14040  043026         JSM CHS       CHANGE THE SIGN OF THE SUBTRAHEND.
14041  067043         JMP FADD+1    AND ENTER THE FULL PRECISION ADDITION ROUTINE.


                *
                ****************
                *
                * FADD:  FULL PRECISION ADDITION
                *
                *   RES = <OPND1> + <OPND2>
                *
                * TEMPORARIES:  MT1
                *   OPND1 & OPND2 CANNOT POINT TO AR1 & AR2.
                *
                ****************
                *
14042  043007   FADD  JSM GET2      GET 2 OPERANDS OFF OF THE STACK
14043  101273         LDA OPND1,I   CALCULATE THE EXPONENT OFFSET, AND SAVE IT
14044  170405         AAR 6         FOR LATER USE
14045  105274         LDB OPND2,I
14046  174405         ABR 6
14047  174040         TCB
14050  020001         ADA B
14051  031762         STA MT1       SAVE THE OFFSET IN A MATH TEMPORARY.
14052  004345         LDB AR1A      IF THE EXPONENT OFFSET IS NEGATIVE THEN OPND2
14053  172405         SAM *+5       IS LARGER THAN OPND1
14054  001273         LDA OPND1     TRANSFER THE LARGER OPERAND TO AR1 AND
14055  071403         XFR 4         THE SMALLER OPERAND TO AR2
14056  001274         LDA OPND2     NOTE:
14057  067063         JMP *+4       LARGE AND SMALL REFER ONLY TO EXPONENT SIZE
14060  001274         LDA OPND2     AND DO NOT IMPLY ANYTHING ABOUT MANTISSA
14061  071403         XFR 4         SIZE OR SIGN.
14062  001273         LDA OPND1
14063  004127         LDB AR2A
14064  071403         XFR 4
14065  000021         LDA AR2M1     IF THE SMALLER OPERAND IS ZERO
14066  072411         SZA STAR1     STORE THE LARGER (AR1) AS THE RESULT
14067  001771         LDA AR1M1     IF THE LARGER OPERAND IS ZERO THEN
14070  072424         SZA STSMA     STORE THE SMALLER (AR2) AS THE RESULT.
14071  001762         LDA MT1       RECALL THE EXPONENT OFFSET
14072  172002         SAP *+2       MAKE THE OFFSET
14073  170040         TCA           POSITIVE
14074  004000         LDB A         SET B UP FOR A RIGHT SHIFT OF AR2.
14075  020156         ADA M13       IF THE OFFSET IS 12 OR LESS
14076  172403         SAM *+3       THEN CONTINUE AND PREPARE AR2.
14077  000345   STAR1 LDA AR1A      OTHERWISE STORE THE LARGER
14100  066050         JMP STANY
14101  076403         SZB *+3       IF B = 0 DON'T ROUND
14102  000177         LDA P0        SHIFT IN A ZERO
14103  043137         JSM FRND      USE THE FAST, NON-STICKY BIT ROUND.
14104  071700         CDC
```

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02392000 14105  001770         LDA AR1E       ADD THE SIGNS OF THE TWO MANTISSAS TOGETHER
02393000 14106  020020         ADA AR2E       IF THEY ARE DIFFERENT, SUBTRACT
02394000 14107  073413         RLA .SUB       OTHERWISE, ADD THE MANTISSAS.
02395000                *
02396000 14110  071200  .ADD   FXA            ADD THE TWO MANTISSAS
02397000 14111  072304         SOS *+4
02398000 14112  001770         LDA AR1E       IF NO CARRY IS GENERATED THEN THE AR1
02399000 14113  030020         STA AR2E       EXPONENT IS THE RESULT EXPONENT
02400000 14114  066047  STSMA  JMP STAR2      STORE AR2 AS THE RESULT
02401000                *
02402000 14115  000254         LDA P1         IF A DECIMAL CARRY OCCURS SHIFT A ONE INTO
02403000 14116  004254         LDB P1         AR2 AND SET B TO INCREMENT THE AR1 EXPONENT.
02404000 14117  043137         JSM FRND       CALL THE FAST, NON-SHITTY BIT ROUNDING ROUTINE.
02405000 14120  004073         LDB P64
02406000 14121  066041         JMP UAR2E      JUMP TO THE UPDATE AR2 EXPONENT ROUTINE
02407000                *
02408000 14122  043015  .SUB   JSM ZAR2       IF AR2 IS ZERO AFTER ALIGNING
02409000 14123  067077         JMP STAR1      THEN STORE AR1 AS THE RESULT.
02410000 14124  071040         CMY            OTHERWISE, COMPLEMENT AR2 AND
02411000 14125  071200         FXA            ADD THE MANTISSAS
02412000 14126  072303         SOS *+3        IF THERE WAS A CARRY, AR2 IS THE RESULT.  IF THERE
02413000 14127  071040         CMY            WAS NO CARRY, AR2 IS THE 10'S COMP. OF THE RESULT
02414000 14130  045770         ISZ AR1E       AND THE SIGN OF AR1 IS OPPOSITE OF THE RESULT SIGN.
02415000 14131  071500         NRM            NORMALIZE AND MAKE THE NO. OF SHIFTS
02416000 14132  014133         CPB P12        BUG SHEET #1700:  CHECK FOR ZERO (B=12) BEFORE
02417000 14133  004177         LDB P0         TRYING TO UPDATE THE EXPONENT IN UAR2E.
02418000 14134  174040         TCB            NEGATIVE THEN ALIGN IT WITH THE
02419000 14135  174605         SBL 6          EXPONENT OF AR1 AND
02420000 14136  066041         JMP UAR2E      JMP TO UPDATE THE AR2 EXPONENT

02422000                *
02423000                * FRND:  FAST, NON-STICKY BIT ROUNDING ROUTINE FOR FADD.
02424000                *
02425000                * A = DIGIT TO SHIFT IN.
02426000                * B = NO. OF DIGITS TO SHIFT OUT.  B CANNOT BE ZERO.
02427000                *
02428000 14137  075500  FRND   MRY            SHIFT AR2 RIGHT <B> PLACES.
02429000 14140  020151         ADA M5
02430000 14141  172404         SAM *+4        ROUND UP ?
02431000 14142  004254         LDB P1         YES.
02432000 14143  071700         CDC
02433000 14144  071000         MWA
02434000 14145  170201         RET 1
02436000                *
02437000                ****************
02438000                *
02439000                * FMPY:  FULL PRECISION MULTIPLICATION
02440000                *
02441000                *   RES = <OPND1> * <OPND2>
02442000                *
02443000                * TEMPORARIES:  MT1, MT2, MT3, MT4, MT5, "ROUND"
02444000                *   OPND1 CANNOT POINT TO AR1 OR AR2.
02445000                *
02446000                ****************
02447000                *
02448000                * MPMPY:  MULTIPLE PRECISION MULTIPLICATION
02449000                *
02450000                *   RES =  <OPND1>    *    <OPND2>
02451000                *         (N DIGITS)    (12 DIGITS)
02452000                *
02453000                *   NOTE:  N MUST BE AN EVEN MULTIPLE OF 4.
02454000                *
02455000                * ENTRY CONDITIONS:  (MPMPY)
02456000                *   1. OPND1 CONTAINS THE ADDRESS OF THE MULTIPLIER
02457000                *   2. OPND2 CONTAINS THE ADDRESS OF THE MULTIPLICAND
02458000                *   3. A = -(N-2)
02459000                *   4. B = (N/4) + 1
02460000                *
02461000                * NO SPECIAL EXIT CONDITIONS
02462000                *
02463000                * TEMPORARIES:  SAME AS FOR FMPY.
02464000                *
02465000                ****************
02466000                *
02467000 14146  043007  FMPY   JSM GET2      GET 2 OPERANDS OFF OF THE STACK
02468000 14147  000207         LDA M10       A:  LOOP DIGIT COUNTER FOR FULL PRECISION MULTIPLIER.
02469000 14150  004143         LDB P4        B:  LENGTH OF A FULL PRECISION MULTIPLIER (4 WORDS)
02470000 14151  025273  MPMPY  ADB OPND1
02471000 14152  031763         STA MT2       INITIALIZE THE LOOP DIGIT COUNTER
02472000 14153  035762         STB MT1       INITIALIZE THE WORD POINTER
02473000 14154  001274         LDA OPND2     TRANSFER THE MULTIPLICAND TO AR1
02474000 14155  004345         LDB AR1A
02475000 14156  071403         XFR 4
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```
14157  000177         LDA P0
14160  031777         STA STBIT    CLEAR THE "STICKY BIT".
14161  031774         STA RNDT2    CLEAR THE NO. OF DIGITS TO SHIFT OUT FOR ROUND LATER.
14162  005273         LDB OPND1    NOTE:  THE MULTIPLIER MUST BE CHECKED FOR ZERO UNLES
14163  024254         ADB P1       CPB M2 JMP FALSE, IS INSERTED AFTER STB MT2 IN MNXTW
14164  110001         CPA B,I      IF THE MULTIPLIER IS ZERO
14165  066032         JMP FALSE       THEN ZERO IS THE RESULT.
14166  011771         CPA AR1M1    IF THE MULTIPLICAND IS ZERO
14167  066032         JMP FALSE       THEN ZERO IS THE RESULT.
14170  000127         LDA AR2A     CLEAR THE ACCUMULATOR (AR2)
14171  071603         CLR 4
14172  055762  MNXTW  DSZ MT1      DECREMENT THE WORD POINTER
14173  105762         LDB MT1,I    GET THE NEXT 4 MULTIPLIER DIGITS
14174  076012         RZB MNXT.    ARE THEY ALL ZERO ?
14175  000023         LDA AR2M3    YES, UPDATE THE "STICKY BIT" WITH THE
14176  061777         IOR STBIT    LAST FOUR DIGITS IN AR2.
14177  031777         STA STBIT
14200  000177         LDA P0
14201  004143         LDB P4       THEN SHIFT OUT THE LAST FOUR DIGITS.
14202  075500         MRY
14203  025763         ADB MT2      AND INCREMENT THE LOOP DIGIT COUNTER BY 4
14204  035763         STB MT2
14205  067172         JMP MNXTW    NOW CHECK THE NEXT 4 DIGITS.
14206  000143  MNXT.  LDA P4       SET THE WORD DIGIT COUNT TO 4.
14207  031764         STA MT3
14210  071700  MNXTD  CDC
14211  075000         FMP          ACCUMULATE:  AR2 = AR2 + B<0-3> * AR1 + DC
14212  035765         STB MT4      SAVE MULTIPLIER DIGITS IN TEMPORARY WHILE
14213  004254         LDB P1       AR2 IS SHIFTED RIGHT ONE DIGIT.
14214  075500         MRY
14215  061777         IOR STBIT    UPDATE THE "STICKY BIT" WITH THE
14216  031777         STA STBIT    DIGIT SHIFTED OUT OF AR2 INTO A.
14217  005765         LDB MT4      THEN RESTORE THE MULTIPLIER DIGITS
14220  174503         SBR 4        AND SHIFT THE NEXT ONE INTO B<0-3>.
14221  045763         TSZ MT2      INCREMENT THE LOOP DIGIT COUNTER.
14222  067224         JMP *+2      AFTER (N-2) DIGITS HAVE BEEN PROCESSED, EXIT
14223  067227         JMP LSTWO    THE LOOP TO FINISH THE LAST TWO DIGITS.
14224  055764         DSZ MT3      DECREMENT THE DIGIT COUNT AND LOOP IF NOT ZERO
14225  067210         JMP MNXTD
14226  067172         JMP MNXTW
14227  071700  LSTWO  CDC
14230  075000         FMP          PROCESS THE (N-1)TH DIGIT (D2).
14231  004254         LDB P1
14232  075500         MRY          SHIFT AR2 RIGHT ONE DIGIT.
14233  031766         STA MT5      SAVE SHIFTED OUT DIGIT WHILE PROCESSING MULTIPLIER DI
14234  105762         LDB MT1,I    GET THE NTH DIGIT (D1) READY AND
14235  174513         SBP 12       MULTIPLY BY IT
14236  071700         CDC
14237  075000         FMP          (A = DECIMAL CARRY, IF ANY)
14240  004254         LDB P1       SET UP B FOR RIGHT SHIFT OR ROUNDING
14241  035776         STB NRMFL    SET THE "NRM" FLAG FOR ROUNDING
14242  072005         RZA D1#0     IF NO OVERFLOW, CONTINUE, OTHERWISE GO TO D1#0
14243  001766  D1=0   LDA MT5      LOAD A WITH THE JUST SHIFTED OUT DIGIT
14244  043611         JSM DECID+1  ENTER THE ROUNDING ROUTINE MIDWAY.
14245  004177         LDB P0       SET UP B FOR AR2 EXP. UPDATE
14246  067255         JMP MEXIT    AND JUMP TO THE ROUTINE THAT DOES IT.
14247  075500  D1#0   MRY          RIGHT SHIFT AR2 TO RECOVER THE HIGH ORDER DIGIT IN A
14250  001766         LDA MT5      RECALL THE PREVIOUSLY SHIFTED OUT DIGIT AND
14251  061777         IOR STBIT    ADD IT TO THE "STICKY BIT" AND THEN
14252  031777         STA STBIT    PUT IT BACK IN THE STICKY BIT
14253  043610         JSM DECID    ENTER THE ROUNDING ROUTINE MID-WAY.
14254  004073         LDB P64      INCREMENT THE MULTIPLIER EXPONENT.
14255  173201  MEXIT  SOC *+1,C    CLEAR THE OVERFLOW INDICATOR.
14256  024020         ADB AR2E     DON'T FORGET THE POSSIBLE EXPONENT INCREMENT IN DECI
14257  125273         ADB OPND1,I  B=THE EXP. MODIFIER FOR THE EXPONENT UPDATE IN UAR2E
14260  173003         SOC *+3      IF OVERFLOW OCCURRED PUT THE CORRECT
14261  125274         ADB OPND2,I  MANTISSA SIGN IN B<0> AND GO TO
14262  066065         JMP E76      THE INTERMEDIATE RESULT OVERFLOW ERROR.
14263  066041         JMP UAR2E    NOW UPDATE THE AR2 EXPONENT WITH AR1E & B.
                *
                ****************
                *
                * FDVD:  FULL PRECISION DIVISION
                *
                *   RES = <OPND1> / <OPND2>
                *
                * DVDNR:  ALTERNATE ENTRY POINT TO TRUNCATE THE QUOTIENT INSTEAD
                * (A=0)   OF ROUNDING IT.  USE BASEPAGE LINK ADIV2.
                *
                * SPECIAL EXIT CONDITIONS:
                *   RES = +/- 9.99999999999 E 511 IF DIVISOR=0 & FLAG 14=1.
                *
                * TEMPORARIES:  D, Z, MT1, MT2, MT3, MT4, MT5
                *   OPND1 CANNOT POINT TO AR1.
                *   OPND2 CANNOT POINT TO AR2.
```

INTERNAL FULL PRECISION MATH ROUTINES

```
                    *     DIVIDEND EXPONENT MAY NOT BE -512 OR THE RESULT EXPONENT
                    *     WILL BE WRONG IF THE (LDB M64) AT READY-1 IS EXECUTED.
                    *
                    ****************
                    *
14264  043007  FDVD  JSM GET2
14265  003441        LDA JSM.R     PUT THE INSTRUCTION, JSM .ROUN, IN D IF THE
14266  030017  DVUNR STA D         QUOTIENT IS TO BE ROUNDED.  D=0 FOR TRUNCATION.
14267  001273        LDA OPND1     COPY THE DIVIDEND INTO AR2
14270  004127        LDB AR2A
14271  071403        XFR 4
14272  001274        LDA OPND2     COPY THE DIVISOR INTO AR1
14273  004345        LDB AR1A
14274  071403        XFR 4
14275  003004        LDA ZA        INITIALIZE THE QUOTIENT WORD POINTER
14276  031763        STA MT2       AND CLEAR THE QUOTIENT TEMPORARY (WHICH
14277  071604        CLR 5         INCLUDES MT1)
14300  000177        LDA P0        CLEAR A FOR COMPARISONS TO FOLLOW
14301  004020        LDB AR2E      LOAD THE EXPONENT WORD OF AR2 FOR ITS SIGN
14302  011771        CPA AR1M1     IF THE DIVISOR IS ZERO
14303  067405        JMP E66       CHECK FLAG 14 FOR ERROR 66 -- DIVISION BY ZERO
14304  010021        CPA AR2M1     IF THE DIVIDEND IS ZERO
14305  066032        JMP FALSE     THEN STORE ZERO AS THE QUOTIENT
14306  071040        CMY           COMPLEMENT THE DIVIDEND
14307  000257        LDA M1        INITIALIZE THE FDV COUNT TO -1
14310  004127        LDB P16       INITIALIZE THE TOTAL DIGIT COUNT TO 16
14311  035764        STB MT3
14312  045763  DNXTW ISZ MT2       BUMP THE QUOTIENT WORD POINTER
14313  004143        LDB P4        SET THE WORD DIGIT COUNTER TO 4
14314  035765        STB MT4
14315  174603  DNXTD SRL 4         CLEAR LOCATION FOR NEXT CALCULATED DIGIT
14316  135763        STB MT2,I     SAVE THE QUOTIENT DIGITS
14317  031766        STA MT5       STORE THE FDV COUNT
14320  071700  FDVLP CDC
14321  075041        FDV
14322  125763        ADB MT2,I     UPDATE THE NEW QUOTIENT DIGIT
14323  024254        ADB P1        INCREMENT THE NEW QUOTIENT DIGIT
14324  135763        STB MT2,I     SAVE THE QUOTIENT DIGITS
14325  045766        ISZ MT5       INCREMENT THE FDV COUNT AND LOOP IF NON-ZERO
14326  067320        JMP FDVLP
14327  043015        JSM ZAR2      JUMP OUT OF THE MAIN LOOP IF AN EXACT
14330  067351        JMP PFQUO     QUOTIENT HAS BEEN FOUND (DIVIDEND=0)
14331  071040        CMY           OTHERWISE RESTORE THE DIVIDEND
14332  071200        FXA           TO ITS LAST POSITIVE VALUE.
14333  105763        LDB MT2,I     DECREMENT AND SAVE THE LAST CALCULATED DIGIT
14334  024257        ADB M1        NOTE:  THIS MUST BE DONE IN B ( NOT DSZ )
14335  135763        STB MT2,I           BECAUSE OF POSSIBLE JUMP TO "DONE".
14336  071040        CMY           COMPLEMENT THE DIVIDEND AGAIN
14337  000177        LDA P0
14340  075541        MLY           SHIFT THE DIVIDEND LEFT ONE DIGIT
14341  020207        ADA M10       COMPUTE THE NEXT FDV COUNT
14342  055764        DSZ MT3       DECREMENT THE TOTAL DIGIT COUNT
14343  172402        SAM *+2       THIS SHOULD ALWAYS JUMP *+2
14344  067353        JMP DONE      DECREMENT THE WORD DIGIT COUNTER
14345  055765        DSZ MT4
14346  067315        JMP DNXTD     JUMP BACK TO DIGIT LOOP IF NON-ZERO
14347  067312        JMP DNXTW     JUMP BACK TO THE WORD LOOP
                *
14350  174603        SBL 4
14351  055765  PFQUO DSZ MT4       ALIGN THE DIGITS OF THE LAST WORD
14352  067350        JMP *-2
                *
14353  135763  DONE  STB MT2,I     STORE THE LAST DIGITS NOW THAT THEY ARE ALIGNED.
14354  003004        LDA ZA
14355  004127        LDB AR2A      PREPARE TO ROUND THE QUOTIENT
14356  071403        XFR 4
14357  071500        NRM           BUT FIRST CHECK FOR A ZERO IN THE FIRST QUOTIENT
14360  001762        LDA MT1       DIGIT.  IF ONE EXISTS, LEFT SHIFT THE ENTIRE QUOTIENT
14361  076407        SZB READY     (A = D13 D14 D15 D16)
14362  170513        SAR 12        AND USE D13 AS D12
14363  060023        IOR AR2M3
14364  030023        STA AR2M3
14365  001762        LDA MT1       A = D13 D14 D15 D16
14366  170603        SAL 4         A = D14 D15 D16 0
14367  004164        LDB M64       B = EXPONENT OF -1
                *
14370  125273  READY ADB OPND1,I
14371  034020        STB AR2E      AR2E = EXPONENT OF DIVIDEND (WITH NORMALIZATION
14372  170713        RAR 12        OFFSET IF NECESSARY)
14373  030024        STA SE        SE = D13 OF QUOTIENT
14374  050160        AND M16       A<4-15> = UNUSED DIGITS (STICKY BIT)
14375  004177        LDB P0        A<0-2> = UNBIASED, UN-NORM, B=DIGITS TO SHIFT=0
14376  070017        EXE 0         ROUND OR NOT BASED ON ENTRY POINT.
14377  004020        LDB AR2E
```

INTERNAL FULL PRECISION MATH ROUTINES

```
14400  001770        LDA AR1E      COMPLEMENT THE EXPONENT OF THE DIVISOR
14401  170040        TCA
14402  020145        ADA P2
14403  031770        STA AR1E
14404  066041        JMP UAR2E     JUMP TO THE UPDATE AR2E ROUTINE.
                *
                * ERROR 66 -- DIVISION BY ZERO
                *
14405  140564  E66   JSM ASTMA,I   STORE +/-9.99999999999 E 511 AS THE RESULT.
14406  042073        JSM ERROR
14407  033066        ASC 1,66
                *
                ****************
                *
                * FSQR:  FULL PRECISION SQUARE ROOT
                *
                *   RES = SQR <OPND1>
                *
                * SPECIAL EXIT CONDITIONS:
                *   RES = SQR(ABS(RADICAND))  IF RADICAND<0 & FLAG 14=1
                *
                * TEMPORARIES:  MT1, MT2, MT3, MT4, MT5, MT6, "ROUND"
                *
                ****************
                *
14410  043011  FSQR  JSM GET1
14411  001273        LDA OPND1     COPY THE RADICAND INTO AR1
14412  004345        LDB AR1A
14413  071403        XFR 4
14414  000127        LDA AR2A      CLEAR AR2
14415  071603        CLR 4
14416  001771        LDA AR1M1
14417  072002        RZA *+2       IF THE RADICAND IS ZERO
14420  066032        JMP FALSE     THEN STORE ZERO AS THE RESULT
14421  004142        LDB P5        AR2 = 5 * AR1
14422  071700        CDC           THIS IS NECESSARY SINCE DC COULD BE SET.
14423  075000        FMP
14424  004254        LDB P1        SHIFT AR2 RIGHT ONCE TO PICK UP THE HIGH ORDER
14425  074500        MRY           DIGIT FROM THE FMP.  DIVIDE BY 2 IS THE SAME AS
14426  031777        STA STBIT       (SAVE THE SHIFTED OUT DIGIT IN THE "STICKY BIT")
14427  000177        LDA P0        MULTIPLY BY 5 AND DIVIDE BY 10.
14430  005770        LDB AR1E      IF THE EXPONENT IS EVEN THEN RIGHT SHIFT AR2
14431  174610        SBL 9         ONE MORE DIGIT.
14432  176405        SBM FSQR1
14433  000177        LDA P0        THEN SHIFT AR2 RIGHT ONCE
14434  004254        LDB P1
14435  075500        MRY           AND PUT THE NEW SHIFTED OUT DIGIT IN SE FOR ROUNDING
14436  001777        LDA STBIT
14437  170602  FSQR1 SAL 3         A<3-15> = STICKY BIT, A<0-2> IS THE SPECIFICATION
14440  004177        LDB P0
14441  043564  JSM.R JSM .ROUN     RO [illegible] AR2 BASED ON SE AND THE "STICKY BIT"
14442  000345        LDA AR1A      INITIALIZE THE RESULT WORD POINTERS 1 & 2
14443  020254        ADA P1        TO THE SECOND WORD OF THE WORKING REGISTER (AR1)
14444  031763        STA MT2          RESULT WORD POINTER 1
14445  031764        STA MT3          RESULT WORD POINTER 2
14446  071603        CLR 4         CLEAR 4 WORDS STARTING AT AR1M1 INCLUDING RNDT2
14447  001770        LDA AR1E      DIVIDE THE AR1 EXPONENT BY 2 & CLEAR THE SIGN
14450  031765        STA MT4          (SAVE THE SIGN FOR ERROR 67 TEST LATER)
14451  170400        AAR 1         & STORE IN THE AR1 EXPONENT WORD.
14452  050240        AND ZAP
14453  031770        STA AR1E
14454  003003        LDA BCD.5     INITIALIZE THE "FIVE" WORD TO BCD 0500
14455  031766        STA MT5
14456  000175        LDA BCD1      INITIALIZE THE "N" WORD TO BCD 1000
14457  031767        STA MT6
14460  001767  BLOOP LDA MT6       IF THE LOW ORDER BCD DIGIT OF THE "N"
14461  073002        SLA *+2       WORD IS 1
14462  045764        ISZ MT3       THEN INCREMENT THE RESULT WORD POINTER # 2
14463  170703        RAR 4         ROTATE THE "N" WORD RIGHT 1 BCD DIGIT.
14464  031767        STA MT6       AND STORE.
14465  001766        LDA MT5       MASK OUT THE LAST
14466  170140        CMA           FIVE FROM THE WORKING
14467  151763        AND MT2,I     REGISTER
14470  131763        STA MT2,I     AND STORE IT.
14471  001766        LDA MT5       IF THE LOW ORDER BCD DIGIT OF THE
14472  073002        SLA *+2       "FIVE" WORD IS A FIVE
14473  045763        ISZ MT2       THEN INCREMENT THE RESULT WORD POINTER # 1
14474  170703        RAR 4         ROTATE THE "FIVE" WORD RIGHT 1 BCD DIGIT.
14475  031766        STA MT5       AND STORE.
14476  121763        ADA MT2,I     PLACE THE NEXT FIVE IN THE WORKING REGISTER
14477  131763        STA MT2,I     POINTED TO BY WORD POINTER # 1
14500  105764        LDB MT3,I     LOAD THE WORD POINTED TO BY RESULT POINTER # 2
14501  071040        CMY           COMPLEMENT AR2
14502  000135        LDA P10       INITIALIZE THE INCREMENT COUNTER TO 10
14503  031762        STA MT1
```

INTERNAL FULL PRECISION MATH ROUTINES

```
02732000 14504  135764  SLOOP STB MT3,I    UPDATE THE RESULT WORD POINTED TO BY # 2
02733000 14505  071700        CDC
02734000 14506  071200        FXA          AR2 = AR2 + AR1 (RESULT REG.)
02735000 14507  025767        ADB MT6      INCREMENT THE PROPER DIGIT OF B WITH THE "N" WORD
02736000 14510  055762        DSZ MT1      DECREMENT THE COUNTER AND EXIT LOOP IF ZERO
02737000 14511  072773        SDC SLOOP    LOOP IF NO OVERFLOW, OTHERWISE EXIT LOOP
02738000 14512  071040        CMY          COMPLEMENT AR2 (NOW IN ORIGINAL FORM)
02739000 14513  043015        JSM ZAR2     EXIT THE BIG LOOP (BLOOP) IF A PERFECT SQUARE ROOT
02740000 14514  067524        JMP PFSQR    HAS BEEN FOUND, OTHERWISE CONTINUE IN LOOP.
02741000 14515  071200        FXA          RESTORE AR2 AND
02742000 14516  000177        LDA P0
02743000 14517  075541        MLY          LEFT SHIFT IT ONE BCD DIGIT
02744000 14520  001764        LDA MT3      IF 12 DIGITS HAVE BEEN CALCULATED,
02745000 14521  013005        CPA WPTR2    THEN EXIT
02746000 14522  067545        JMP LSTLP    FROM THE BIG LOOP,
02747000 14523  067460        JMP BLOOP    OTHERWISE, CONTINUE TO LOOP.
02748000 14524  005763  PFSQR LDB MT2      A PERFECT SQUARE ROOT HAS BEEN FOUND
02749000 14525  027002        ADB ADIFF    SO INCREMENT THE LEAST SIGNIFICANT
02750000 14526  001766        LDA MT5      DIGIT, A FIVE, OF AR2 BY FIVE
02751000 14527  130001        STA B,I      AND THEN LEFT
02752000 14530  071700        CDC
02753000 14531  071200        FXA          SHIFT AR2 ONCE.
02754000 14532  000177        LDA P0       SHIFT IN A ZERO.
02755000 14533  075541        MLY
02756000 14534  072406        SZA FSQR2    IF A DIGIT WAS SHIFTED OUT OF AR2 INTO A,
02757000 14535  004254        LDB P1
02758000 14536  075500        MRY          THEN SHIFT IT BACK IN
02759000 14537  004073        LDB P64      AND
02760000 14540  042041        JSM UAR2E    INCREMENT THE EXPONENT USING UAR2E.
02761000 14541  067554        JMP E67      AND THEN CHECK FOR ERROR 67 BEFORE RETURNING
02762000 14542  173201  FSQR2 SOC *+1,C    OTHERWISE, STORE THE RESULT (AR2) AND
02763000 14543  042043        JSM UAR2E+2
02764000 14544  067554        JMP E67      CHECK FOR ERROR 67 BEFORE RETURNING.
02765000 14545  000345  LSTLP LDA AR1A     TRANSFER AR1 TO AR2 SO A LEFT SHIFT CAN BE DONE
02766000 14546  004127        LDB AR2A
02767000 14547  071403        XFR 4
02768000 14550  101764        LDA MT3,I    POSITION THE LAST DIGIT IN A<0-3>
02769000 14551  170513        SAR 12
02770000 14552  075541        MLY          SHIFT AR2 LEFT ONCE.
02771000 14553  042047        JSM STAR2    STORE AR2 AS THE RESULT.
02772000                *
02773000                * ERROR 67 -- SQUARE ROOT OF A NEGATIVE NUMBER
02774000                *
02775000 14554  001765  E67   LDA MT4      RECALL THE ORIGINAL EXPONENT WORD
02776000 14555  073003        SLA *+3      IF THE MANTISSA WAS POSITIVE THEN RETURN
02777000 14556  042673        JSM ERROR    ELSE, CHECK FLAG 14 FOR ERROR 67
02778000 14557  033067        ASC 1,67
02779000 14560  170201        RET 1        USED BY *-3 ONLY.  NOT USED BY E67.
02781000                *
02782000                ****************
02783000                *
02784000                * ROUND:  GENERALIZED ROUNDING ROUTINE
02785000                *
02786000                * ENTRY CONDITIONS:  (ALSO SEE TABLE BELOW)
02787000                *   THE NUMBER TO BE ROUNDED MUST BE IN AR2
02788000                *   B CONTAINS EITHER:
02789000                *     1.)  THE NUMBER OF THE DIGIT TO BE ROUNDED (0-12)   OR
02790000                *     2.)  THE NUMBER OF DIGITS TO BE SHIFTED OUT (12-0)
02791000                *   A<0> = 1 IF B CONTAINS THE NUMBER OF THE DIGIT TO BE ROUNDED
02792000                *          0 IF B CONTAINS THE NUMBER OF DIGITS TO BE SHIFTED OUT
02793000                *   A<1> = 1 IF AR2 IS TO BE NORMALIZED BEFORE RETURNING
02794000                *          0 IF AR2 IS NOT TO BE NORMALIZED BEFORE RETURNING
02795000                *   A<2> = 1 IF A 4-5 ROUND IS DESIRED (BIASED)
02796000                *          0 IF AN UNBIASED ROUND IS DESIRED
02797000                *   A<3-15> = 0
02798000                *
02799000                * EXIT CONDITIONS:
02800000                *   AR2 CONTAINS THE ROUNDED RESULT
02801000                *
02802000                * TEMPORARIES:  "ROUND" -- (STBIT, NRMFL, RNDT1, RNDT2)
02803000                *
02804000                ***************************************************
02805000                *   *          *           *                     *
02806000                * 0 * UNBIASED * UN-NORM.  * B=DIGITS TO SHIFT   *
02807000                *   *          *           *                     *
02808000                ***************************************************
02809000                *   *          *           *                     *
02810000                * 1 * UNBIASED * UN-NORM.  * B=DIGIT TO ROUND    *
02811000                *   *          *           *                     *
02812000                ***************************************************
02813000                *   *          *           *                     *
02814000                * 2 * UNBIASED *     NORM. * B=DIGITS TO SHIFT   *
02815000                *   *          *           *                     *
02816000                ***************************************************
```

```
                       *   *           *           *                    *
                       * 3 * UNBIASED  *     NORM. * B=DIGIT TO ROUND   *
                       *   *           *           *                    *
                       **********************************************
                       *   *           *           *                    *
                       * 4 *    4-5    * UN-NORM.  * B=DIGITS TO SHIFT  *
                       *   *           *           *                    *
                       **********************************************
                       *   *           *           *                    *
                       * 5 *    4-5    * UN-NORM.  * B=DIGIT TO ROUND   *
                       *   *           *           *                    *
                       **********************************************
                       *   *           *           *                    *
                       * 6 *    4-5    *     NORM. * B=DIGITS TO SHIFT  *
                       *   *           *           *                    *
                       **********************************************
                       *   *           *           *                    *
                       * 7 *    4-5    *     NORM. * B=DIGIT TO ROUND   *
                       *   *           *           *                    *
                       **********************************************
14561   170603  ROUND  SAL 4        ENTRY POINT TO CLEAR <SE> BEFORE STARTING TO ROUND.
14562   030024         STA SE       CLEAR THE 4 BIT SHIFT EXTEND REGISTER
14563   170503         SAR 4
14564   073003  .ROUN  SLA *+3      ENTRY POINT FOR FSQR TO ROUND ON <SE>.
14565   174040         TCB          COMPUTE THE NUMBER OF DIGITS TO BE SHIFTED OUT
14566   024133         ADB P12      SAVE IT
14567   035775         STB RNDT1
14570   174040         TCB          MAKE THE NUMBER OF DIGITS TO BE SHIFTED OUT .
14571   035774         STB RNDT2    NEGATIVE AND SAVE FOR COMPARISON WITH NRM RESULTS
14572   170500         SAR 1        SAVE THE NRM/DON'T NRM FLAG FOR LATER
14573   031776         STA NRMFL
14574   170500         SAR 1        SETUP THE "STICKY BIT".  ZERO IMPLIES
14575   031777         STA STBIT    UNBIASED ROUND.  NON-ZERO IMPLIES 4-5 ROUND.
14576   076512         STB DECID    IF NO. DIGITS TO SHIFT = 0, BASE THE ROUND ON SE
14577   004254         LDB P1       SET UP B FOR 1 DIGIT RIGHT SHIFT ON AR2
14600   170603  SHIFT  SAL 4        SHIFT AR2 RIGHT 1 DIGIT AND BRING IN A ZERO
14601   075500         MRY
14602   055775         DSZ RNDT1    WHEN THE PROPER NO. OF DIGITS HAVE BEEN SHIFTED
14603   067605         JMP *+2      GET OUT OF THE LOOP.AND ROUND ON SE AND THE
14604   067610         JMP DECID    "STICKY BIT".
14605   021777         ADA STBIT    UPDATE THE "STICKY BIT"
14606   031777         STA STBIT
14607   067600         JMP SHIFT
14610   000024  DECID  LDA SE       IF THE LAST DIGIT SHIFTED OUT IS 0,1,2,3,4
14611   020151         ADA M5       THEN DON'T ROUND UP.  IF THE LAST DIGIT IS
14612   172424         SAM NORM?    6,7,6,9 THEN ALWAYS ROUND UP.
14613   072007         RZA RNDUP
14614   001777         LDA STBIT    IF THE LAST DIGIT IS 5 AND THE "STICKY BIT"
14615   072005         RZA RNDUP    IS NON-ZERO THEN ROUND UP. IF THE "STICKY
14616   000023         LDA AR2M3    BIT" IS ZERO THEN MAKE THE CURRENT D12 OF
14617   073301         SLA *+1,S    AR2 ODD (SINCE ODD DOESN'T PROPAGATE A CARRY).
14620   030023         STA AR2M3    AND SEE IF AR2 IS TO BE NORMALIZED
14621   067636         JMP NORM?
14622   071700  RNDUP  CDC          GET READY TO ADD 1 TO AR2 ON THE D12 LEVEL AND
14623   071000         MWA          WATCH FOR AN OVERFLOW CONDITION.
14624   072712         SDC NORM?    IF NO CARRY THEN CHECK FOR NORMALIZATION.
14625   000001         LDA B        B HAS BEEN 1 SINCE (SHIFT-1)
14626   075500         MRY          MAKE THE AR2 MANTISSA A FULL PRECISION ONE.
14627   173201  INCEX  SOC *+1,C    NOW GET READY TO CHECK FOR EXPONENT OVERFLOW
14630   000020         LDA AR2E     ADD 1 TO THE EXPONENT AND IF OVERFLOW DOES
14631   020073         ADA P64      NOT OCCUR THEN CHECK FOR NORMALIZATION.
14632   030020         STA AR2E
14633   173003         SOC NORM?
14634   004020         LDB AR2E     GET THE SIGN OF THE AR2 MANTISSA AND
14635   066065         JMP E76      CHECK FLAG 14 FOR ERROR 76 -- INTERM. RES. OVERFLOW
14636   001776  NORM?  LDA NRMFL    RECALL THE NORMALIZATION FLAG AND OBEY IT.
14637   073207         SLA RTN,C    IN THE PROCESS, CLEAR IT TO PREVENT INFINITE
14640   031776         STA NRMFL    LOOPING IF A NEW HIGH ORDER DIGIT WAS CREATED.
14641   071500         NRM
14642   014133         CPB P12      IF AR2=0 THEN DON'T INCREMENT THE EXPONENT
14643   170201         RET 1        BUT RATHER, RETURN
14644   025774         ADB RNDT2    CHECK TO SEE IF A NEW HIGH ORDER DIGIT WAS
14645   076062         RZB INCEX    CREATED.  IF SO, INCREMENT THE EXPONENT.
14646   170201  RTN    RET 1
                *
                ****************
                *
                * TSUB:  COMPARISON ROUTINE FOR THE RELATIONAL OPERATORS.
                *
                * SPECIAL EXIT CONDITIONS:
                *
                *    <B> = 0 IF (OPND1) = (OPND2)
                *    <B> = 1 IF (OPND1) > (OPND2)
                *    <B> = 3 IF (OPND1) < (OPND2)
                *
```

INTERNAL FULL PRECISION MATH ROUTINES

```
                      * TEMPORARIES:  MT1, MT2
                      *   (TEMPORARIES FOR STCHK ARE NOT INCLUDED HERE)
                      *
                      ****************
                      *
14647  101263  TSUB   LDA AP1,I
14650  050221         AND B70K
14651  004000         LDB A        B = CLASS OF OPERAND 2
14652  001263         LDA AP1      READ DOWN THE STACK TO THE WHAT WORD FOR
14653  020254         ADA P1       OPERAND 1.
14654  100000         LDA A,I
14655  021263         ADA AP1
14656  100000         LDA A,I
14657  050221         AND B70K     A = CLASS OF OPERAND 1
14660  010175         CPA B10K     IF OPERAND 1 IS NON-NUMERIC CALL THE STRINGS ROM.
14661  067663         JMP *+2      OTHERWISE CHECK OPERAND 2.
14662  067665         JMP TSUB$
14663  014175         CPB B10K     IF OPERAND 2 IS NON-NUMERIC CALL THE STRINGS ROM.
14664  067674         JMP TSUB#    OTHERWISE BOTH ARE NUMERIC SO GO TO TSUB#.
                      *
14665  001321  TSUB$  LDA STCHK    IF STCHK = 0 OR STCHK,1 = -1 THE STRINGS ROM IS
14666  072404         SZA E16      NOT PRESENT SO GIVE ERROR 16.
14667  105321         LDB STCHK,I  OTHERWISE BRANCH TO THE STRINGS ROM FOR THE
14670  044001         ISZ B        COMPARISON.
14671  165321         JMP STCHK,I
                      *
                      * ERROR 16:  STRINGS ROM MISSING FOR STRING RELATIONAL COMPARISON OR
                      *            ILLEGAL ARGUMENT(S) FOR RELATIONAL COMPARISON.
                      *
14672  140404  E16    JSM AERR1,I  NON-RECOVERABLE ERROR.
14673  030466         ASC 1,16


14674  043007  TSUB#  JSM GET2     FETCH THE TWO NUMERIC OPERANDS.
14675  000016         LDA C
14676  031763         STA MT2      SAVE C IN MT2.
14677  101273         LDA OPND1,I  IF THE MANTISSA SIGNS ARE THE SAME MORE
14700  121274         ADA OPND2,I  TESTING IS NEEDED TO DETERMINE THE RELATION.
14701  073007         SLA TSUB1
14702  101273         LDA OPND1,I  THE SIGNS ARE DIFFERENT SO THE NEGATIVE OPERAND
14703  073403         RLA B=3      IS SMALLER.
14704  004254  B#1    LDB P1       (OPND1) > (OPND2)
14705  067762         JMP RESTC
14706  004144  B=3    LDB P3       (OPND1) < (OPND2)
14707  067762         JMP RESTC
14710  001273  TSUB1  LDA OPND1    MANTISSA SIGNS ARE ALIKE, CHECK FOR ZEROS.
14711  030016         STA C
14712  020254         ADA P1
14713  100000         LDA A,I      A = 1ST MANTISSA WORD OF (OPND1)
14714  005274         LDB OPND2
14715  034017         STB D
14716  024254         ADB P1
14717  104001         LDB B,I      B = 1ST MANTISSA WORD OF (OPND2)
14720  072003         RZA TSUB2
14721  076065         RZB B=3      A=0, B#0  (OPND1) < (OPND2)
14722  067761         JMP B=0      A & B ARE ZERO.  (OPND1) = (OPND2) = 0
14723  076461  TSUB2  SZB B=1      A#0, B=0  (OPND1) > (OPND2)
14724  101273         LDA OPND1,I  A & B ARE NOT ZERO.  NOW WE MUST CHECK THE
14725  170405         AAR 6        EXPONENTS.
14726  105274         LDB OPND2,I  (THE ARITHMETIC SHIFTS ARE NEEDED TO PREVENT
14727  174405         ABR 6        OVERFLOW IN THE FOLLOWING ADDITION.)
14730  174040         TCB
14731  020001         ADA B        A = (OPND1E) - (OPND2E)
14732  172007         SAP TSUB4
14733  004144  B=3?   LDB P3       ABS(OPND1) < ABS(OPND2)
14734  101273  TSUB3  LDA OPND1,I  NOW CHECK THE MANTISSA SIGN OF EITHER ONE
14735  073025         SLA RESTC    (THEY'RE THE SAME).  IF THEY ARE NEGATIVE
14736  024150         ADB M4       THEN THE RELATION IS REVERSED.
14737  174040         TCB
14740  067762         JMP RESTC
14741  072403  TSUB4  SZA TSUB5    THE EXPONENTS ARE EQUAL, CHECK THE MANTISSAS.
14742  004254  B=1?   LDB P1       ABS(OPND1) > ABS(OPND2)
14743  067734         JMP TSUB3
14744  074560  TSUB5  WBC A,I      DUMMY WITHDRAWS TO POINT TO (D1,D2) BYTES.
14745  074570         WBD A,I
14746  000141         LDA P6       THERE ARE SIX PAIRS OF DIGITS TO CHECK.
14747  031762         STA MT1
14750  074561  TSUB6  WBC B,I
14751  074570         WBD A,I
14752  174040         TCB
14753  020001         ADA B        A = (OPND2 DIGIT PAIR) - (OPND1 DIGIT PAIR)
14754  072403         SZA TSUB7    IF THEY ARE EQUAL, KEEP CHECKING.
14755  172056         SAP B=3?     ABS(OPND1) < ABS(OPND2)
14756  172464         SAM B=1?     ABS(OPND1) > ABS(OPND2)
```

INTERNAL FULL PRECISION MATH ROUTINES

```
14757  055762  TSUB7 DSZ MT1       HAVE ALL 6 DIGIT PAIRS BEEN TESTED ?
14760  067750        JMP TSUB6     NO, KEEP CHECKING.
14761  064177  B=0   LDB P0        YES, THE NUMBERS ARE EQUAL.
14762  061763  RESTC LDA MT2
14763  030016        STA C         RESTORE C FROM MT2.
14764  170201        RET 1
               *
               ****************
               *
               * FULL PRECISION LOGICAL OPERATORS:  AND, OR, XOR, NOT
               *
               * SPECIAL EXIT CONDITIONS:
               *    RES = 1 FOR TRUE
               *    RES = 0 FOR FALSE
               *
               ****************
               *
14765  043007  XOR   JSM GET2
14766  045273        ISZ OPND1
14767  045274        ISZ OPND2
14770  101273        LDA OPND1,I
14771  105274        LDB OPND2,I
14772  072410        SZA AND2      A = FALSE
14773  066031        JMP FEQ+1     A = TRUE


14774  043007  AND   JSM GET2
14775  045273        ISZ OPND1     IF OPERAND 1 IS TRUE AND OPERAND 2 IS TRUE
14776  105273        LDB OPND1,I   THEN RESULT = TRUE
14777  076433        SZB FALSE     B = FALSE
15000  045274  AND1  ISZ OPND2     B = TRUE
15001  105274        LDB OPND2,I
15002  066036  AND2  JMP FNEQ+1


15003  043007  OR    JSM GET2
15004  045273        ISZ OPND1     IF OPERAND 1 IS TRUE THEN DON'T BOTHER WITH OPERAND 2
15005  105273        LDB OPND1,I   RESULT = TRUE.  BUT IF OPERAND 1 IS FALSE, OPERAND 2
15006  076031        RZB TRUE      MUST BE TRUE TO MAKE RESLT = TRUE.
15007  066000        JMP AND1      B = FALSE


15010  043011  NOT   JSM GET1
15011  045273        ISZ OPND1     IF OPERAND 1 IS TRUE, RES = FALSE
15012  105273        LDB OPND1,I   IF OPERAND 1 IS FALSE, RES = TRUE
15013  066031        JMP FEQ+1
               *
               ****************
               *
               * FULL PRECISION RELATIONAL OPERATORS:  =, #, <, <=, >, >=
               *
               * SPECIAL EXIT CONDITIONS:
               *    RES = 1 FOR TRUE
               *    RES = 0 FOR FALSE
               *
               * TEMPORARIES:  MT1, MT2
               *
               ****************
               *
15014  043647  FLT   JSM TSUB      PERFORM COMPARISON
15015  024147        ADB M3        CHECK B<0 FOR "LESS THAN"
15016  066031        JMP FEQ+1


15017  043647  FLTE  JSM TSUB      PERFORM COMPARISON
15020  076417        SZB TRUE      CHECK B=0 FOR "OR EQUAL"
15021  066015        JMP FLT+1     JUMP TO CHECK "LESS THAN"


15022  043647  FGT   JSM TSUB      PERFORM COMPARISON
15023  024257        ADB M1        CHECK B>0 FOR "GREATER THAN"
15024  066031        JMP FEQ+1


15025  043647  FGTE  JSM TSUB      PERFORM COMPARISON
15026  076411        SZB TRUE      CHECK B=0 FOR "OR EQUAL"
15027  066023        JMP FGT+1     JUMP TO CHECK "GREATER THAN"


15030  043647  FEQ   JSM TSUB      PERFORM COMPARISON
15031  076406        SZB TRUE      CHECK B=0 FOR "EQUAL"
```

INTERNAL FULL PRECISION MATH ROUTINES

```
15032  000340  FALSE LDA ARES      CLEAR THE RESULT REGISTER.
15033  071603        CLR 4
15034  170201        RET 1

15035  043647  FNEQ  JSM TSUB      PERFORM COMPARISION
15036  076474        SZB FALSE     CHECK B#0 FOR "NOT EQUAL"

15037  000172  TRUE  LDA AONE      STORE 1 AS THE RESULT
15040  066050        JMP STANY
               *
               ****************
               *
               * FULL PRECISION RESULT VERIFICATION AND STORING ROUTINES
               *
               * ENTRY CONDITIONS:  (TO "UAR2E")
               *     B CONTAINS IN THE EXPONENT POSITION THE CORRECTION TO BE MADE
               *     TO AR1E BEFORE STORING IN AR2E
               *
               * EXIT CONDITIONS:
               *   IF <B> + AR1E IS IN RANGE (-511 TO 511) THEN STORE IN AR2E AND
               *   TRANSFER AR2 TO RES
               *
               *   IF OVERFLOW OCCURS:  STORE +/- 9.99999999999 E 511 AS THE RESULT
               *   IF UNDERFLOW OCCURS: STORE 0 AS THE RESULT
               *
               * TEMPORARIES:  NONE
               ****************
               *
15041  173201  UAR2E SOC *+1,C     CLEAR THE OVERFLOW BIT, THEN
15042  000001        LDA B         ADD AR1E TO <B> AND CLEAR
15043  021770        ADA AR1E      OUT BITS 1-5 AND STORE IN AR2E
15044  050240        AND ZAP
15045  030020        STA AR2E
15046  173407        SOS OV/UN     IF OVER/UNDERFLOW DID OCCUR THEN GIVE AN ERROR.
15047  000127  STAR2 LDA AR2A
15050  004340  STANY LDB ARES
15051  071403        XFR 4
15052  005753        LDB RESM1
15053  076457        SZB FALSE
15054  170201        RET 1         THIS IS THE NORMAL RET TO THE INTERPRETER FROM IMATH
               *
               *
               * EXPONENT OVERFLOW OR UNDERFLOW HAS OCCURRED.
               *
15055  174401  OV/UN ABR 2         OFFSET AR1E AND B, THEN RECOMPUTE TO DETERMINE
15056  001770        LDA AR1E      WHETHER OVERFLOW OR UNDERFLOW TOOK PLACE.
15057  170401        AAR 2
15060  024000        ADB A
15061  176407        SBM E77       IF B<0 THEN UNDERFLOW OCCURRED.
15062  000020        LDA AR2E
15063  073002        SLA *+2       B>0:  OVERFLOW.  SET B<0> IF AR2 MANTISSA IS
15064  077301        SLB *+1,S     NEGATIVE.
               *
               * ERROR 76 -- INTERMEDIATE RESULT OVERFLOW
               *
15065  140564  E76   JSM ASTMA,I   STORE +/-9.99999999999 E 511 AS THE RESULT
15066  042073        JSM ERROR
15067  033466        ASC 1,76
               *
               * ERROR 77 -- INTERMEDIATE RESULT UNDERFLOW
               *
15070  042032  E77   JSM FALSE     STORE ZERO AS THE RESULT
15071  042073        JSM ERROR
15072  033467        ASC 1,77
               *
               ****************
               *
               * RECOVERABLE ERROR ROUTINE FOR INTERNAL MATH
               *
               * ENTRY CONDITIONS:
               *    RES MUST CONTAIN THE DEFAULT VALUE.
               *
               * CALLING SEQUENCE:
               *    JSM ERROR
               *    ASC 1,??
               *
               * EXIT CONDITIONS:
               *    FLAG 15 IS SET, AND TRACED IF TRACING IS ENABLED.
               *    IF FLG 14 = 1:  BUMP JSM STACK AND RETURN TO PREVIOUS CALL
               *    IF FLG 14 = 0:  JMP AERR1,I -- GIVE THE DESIGNATED ERROR MESSAGE.
               *
               * TEMPORARIES:  NONE
```

```
                     *
                     ****************
                     *
15073  004130  ERROR LDB P15          CALL A SUBROUTINE TO SET FLAG 15 AND
15074  140376        JSM ASFG,I       TRACE THE SETTING IF TRACING IS ENABLED.
15075  001506        LDA FLAGS
15076  170500        SAR 1            TEST FLAG 14.
15077  073402        RLA SET
15100  164404  CLR   JMP AERR1,I      FLG 14 = 0:  GIVE DESIGNATED ERROR MESSAGE.
15101  054003  SET   DSZ R            FLG 14 = 1:  BUMP THE JSM STACK
15102  170201  RETN1 RET 1            AND RETURN TO THE PREVIOUS JSM.
                     *
                     ****************
                     *
                     * FLTCK:  FULL PRECISION EXPONENT USER RANGE CHECK.
                     *
                     * ENTRY CONDITIONS:
                     *    B CONTAINS THE ADDRESS OF THE FULL PRECISION NUMBER TO BE CHECKED.
                     *
                     * EXIT CONDITIONS:
                     *    EXPONENT IN RANGE (-99,99):  RET 1
                     *
                     *    EXPONENT > 99 AND FLG 14 = 1:  +/- 9.99999999999 E 99
                     *    EXPONENT > 99 AND FLG 14 = 0:  ERROR 74 -- OVERFLOW
                     *
                     *    EXPONENT < -99 AND FLG 14 = 1:  0
                     *    EXPONENT < -99 AND FLG 14 = 0:  ERROR 75 -- UNDERFLOW
                     *
                     * TEMPORARIES:  MT1
                     *
                     *    WARNING !!!     ASSIGNMENT TRACING DEPENDS ON HAVING <B>
                     *                    SAVED IN MT1 BY THIS ROUTINE.
                     *
                     ****************
                     *
15103  035762  FLTCK STB MT1          SAVE THE ADDRESS OF THE FULL PRECISION NUMBER
15104  100001        LDA B,I          LOAD THE EXPONENT WORD OF THE NUMBER BEING CHECKED
15105  004000        LDB A            CHECK THE EXPONENT TO INSURE THAT IT IS WITHIN
15106  170405        AAR 6            THE RANGE (-99,99)
15107  172402        SAM *+2
15110  170040        TCA              MAKE THE EXPONENT NEGATIVE
15111  020064        ADA P99
15112  172070        SAP RETN1        IF THE EXP. IS IN RANGE, B SHOULD BE >= 0
15113  176412        SBM E75
                     *
                     * ERROR 74 -- FULL PRECISION OVERFLOW
                     *
15114  140564  E74   JSM ASTMA,I      STORE +/-9.99999999999 E 99 AS THE RESULT
15115  001752        LDA RESE
15116  053001        AND E99M
15117  031752        STA RESE
15120  000340        LDA ARES
15121  005762        LDB MT1
15122  071403        XFR 4
15123  042073        JSM ERROR
15124  033464        ASC 1,74
                     *
                     * ERROR 75 -- FULL PRECISION UNDERFLOW
                     *
15125  001762  E75   LDA MT1          CLEAR THE FULL PRECISION NUMBER TO ZERO.
15126  071603        CLR 4
15127  042073        JSM ERROR
15130  033465        ASC 1,75
                     *
                     ****************
                     *
                     * PRND: POWER-OF-TEN ROUNDING FUNCTION
                     *
                     * DRND: DIGIT POSITION ROUNDING FUNCTION
                     *
                     *    4/5 ROUNDING IS USED.  (LIKE IN THE DISPLAY)
                     *
                     * ENTRY CONDITIONS:
                     *    OPERAND 1 IS THE NUMBER TO BE ROUNDED
                     *    OPERAND 2 IS THE ROUNDING SPECIFICATION
                     *
                     * TEMPORARIES: MT1, "ROUND"
                     *
                     ****************
                     *
15131  043007  PRND  JSM GET2
15132  001274        LDA OPND2
15133  040644        JSM FIXPT        B = POWER OF TEN ROUNDING SPEC.
15134  101273        LDA OPND1,I      CONVERT IT TO DIGIT-TO-ROUND SPEC.
15135  170405        AAR 6
```

## INTERNAL FULL PRECISION MATH ROUTINES

```
03235000 15136  020254        ADA P1
03236000 15137  174040        TCB
03237000 15140  024000        ADB A        B = DIGIT-TO-ROUND SPEC.
03238000 15141  044020        ISZ AR2E     CHANGE THE SIGN OF THE ROUNDING SPEC.
03239000 15142  000000        NOP          NEEDED IN CASE OF (E-1 -) WITH 5 DON'T CARE BITS=1
03240000 15143  066147        JMP DRND1    JUMP INTO THE DRND ROUTINE.


03242000 15144  043007  DRND  JSM GET2
03243000 15145  001274        LDA OPND2
03244000 15146  040644        JSM FIXPT    B = DIGIT-TO-ROUND.

03246000 15147  035762  DRND1 STB MT1      SAVE THE DIGIT-TO-ROUND INFO.
03247000 15150  001273        LDA OPND1    A = ADDRESS OF NO. TO BE ROUNDED.
03248000 15151  004020        LDB AR2E     B = SIGN OF ROUNDING SPEC.
03249000 15152  173004        SOC DRND2    INTEGER OVERFLOW ?
03250000 15153  077402        RLB STZER    YES, CHOOSE THE PROPER DEFAULT VALUE BASED ON
03251000 15154  066050  STARG JMP STANY          THE SIGN OF THE ROUNDING SPEC.
03252000 15155  066032  STZER JMP FALSE

03254000 15156  004127  DRND2 LDB AR2A     TRANSFER THE NO. TO BE ROUNDED TO AR2.
03255000 15157  071403        XFR 4
03256000 15160  005762        LDB MT1      B = DIGIT-TO-ROUND SPEC.
03257000 15161  176474        SBM STZER    IF B<0, STORE ZERO AS THE RESULT.
03258000 15162  024255        ADB M12
03259000 15163  176071        SBP STARG    IF B>=0, STORE THE ARGUMENT AS THE RESULT.
03260000 15164  000140        LDA P7
03261000 15165  005762        LDB MT1
03262000 15166  043561        JSM ROUND    ROUND THE ARGUMENT
03263000 15167  066047        JMP STAR2    STORE THE ROUNDED ARGUMENT.
```

## UTILITY ROUTINES ACCESSED BY BASE PAGE LINKS

```
03265000                *
03266000                ****************
03267000                *
03268000                * FLTPT:  CONVERT B TO FLOATING POINT FORMAT IN AR2
03269000                *
03270000                * ON ENTRY: B-REGISTER = INTEGER
03271000                *
03272000                * ON EXIT:  AR2 CONTAINS FLOATING NUMBER
03273000                *
03274000                * TEMPORARIES USED: T1
03275000                *
03276000                ****************
03277000                *
03278000 15170  000127  FLTPT LDA AR2A     CLEAR AR2 REGISTER
03279000 15171  071603        CLR 4
03280000 15172  076432        SZB FLRET    IF B=0, GET OUT
03281000 15173  176003        SBP *+3      IF B<0,
03282000 15174  174040        TCB          MAKE B>0
03283000 15175  044020        ISZ AR2E     AND RECORD MANTISSA SIGN
03284000 15176  000203        LDA PTCN
03285000 15177  031711        STA T1       T1 = START OF POWERS OF TEN TABLE
03286000 15200  000257  FLTP1 LDA M1       A = INITIAL COUNT, -1
03287000 15201  020254        ADA P1       INCREMENT COUNT
03288000 15202  125711        ADB T1,I     B = B-10**N
03289000 15203  176076        SBP *-2      IF B STILL >0, KEEP LOOPING
03290000 15204  075541        MLY          B<0, SO SAVE COUNT AS NEXT DIGIT
03291000 15205  101711        LDA T1,I     GET LAST POWER OF TEN
03292000 15206  170040        TCA          MAKE IT POSITIVE
03293000 15207  024000        ADB A        AND RESTORE B TO LAST POS. VALUE
03294000 15210  010135        CPA P10      IS A=10?
03295000 15211  066214        JMP *+3          YES, DONE; B HAS UNITS COUNT
03296000 15212  045711        ISZ T1       NO, MOVE TO NEXT POWER OF TEN
03297000 15213  066200        JMP FLTP1    AND GO AGAIN
03298000 15214  000001        LDA B        PUT UNITS IN A
03299000 15215  075541        MLY          AND INCLUDE IT
03300000 15216  071500        NRM
03301000 15217  174040        TCB
03302000 15220  024134        ADB P11      EXPONENT = 11 - B
03303000 15221  174605        SBL 6            POSITION EXPONENT
03304000 15222  024020        ADB AR2E         INCLUDE SIGN
03305000 15223  034020        STB AR2E         STORE FINAL EXPONENT WORD
03306000 15224  170201  FLRET RET 1
```

FILL IN BASE PAGE BSS'S

```
03308000 00524                  ORG AUNM
03309000                  *
03310000 00524  014022          DEF FUNM
03311000 00525  014042          DEF FADD
03312000 00526  014036          DEF FSUB
03313000 00527  014146          DEF FMPY
03314000 00530  014264          DEF FDVD
03315000 00531  014410          DEF FSQR
03316000 00532  015025          DEF FGTE
03317000 00533  015022          DEF FGT
03318000 00534  015014          DEF FLT
03319000 00535  015017          DEF FLTE
03320000 00536  015030          DEF FEQ
03321000 00537  015035          DEF FNEQ
03322000 00540  014774          DEF AND
03323000 00541  015003          DEF OR
03324000 00542  014765          DEF XOR
03325000 00543  015010          DEF NOT
03326000 00544  015131          DEF PRND
03327000 00545  015144          DEF DRND
03328000 00546  015073          DEF ERROR
03329000 00547  014561          DEF ROUND
03330000 00550  014647          DEF TSUB
03331000 00551  015103          DEF FLTCK
03332000 00552  014011          DEF GET1
03333000 00553  014007          DEF GET2
03334000 00554  014043          DEF FADD+1
03335000 00555  014037          DEF FSUB+1
03336000 00556  014147          DEF FMPY+1
03337000 00557  014265          DEF FDVD+1
03338000 00560  014266          DEF DVDNR
03339000 00561  014411          DEF FSQR+1
03340000 00562  014675          DEF TSUB#+1
03341000 00563  015170          DEF FLTPT
03343000                        END

END OF PASS 2 NO ERRORS DETECTED
```

---- CASSETTE OPERATING SYSTEM ----

```
02002000                  *
02003000                  *
02004000                  *
02005000                  *
02006000 07775                  ORG 77758          LINK TO EXECUTE "TLIST"
02007000 07775  016236          DEF ETLIS
02008000                  *
02009000                  *
02010000                  *
02011000 00601                  ORG ARFK
02012000 00601  016336          DEF RWFKB          REWIND FROM KEYBOARD
02013000 07735                  ORG 77358
02014000 07735  016334          DEF EREW           LINK TO EXECUTE 'REW'
02015000 07737                  ORG 7737B
02016000 07737  016037          DEF IOF            LINK TO EXECUTE 'IOF'
02017000 07742                  ORG 7742B
02018000 07742  016100          DEF FDF            LINK TO EXECUTE "FDF"
02019000 07743  016327          DEF ERSTP          LINK TO EXECUTE 'ERT'
02020000 07744  016000          DEF EMARK          LINK TO EXECUTE 'MRK'
02021000 07745  016633          DEF RCF            LINK TO EXECUTE 'RCF'
02022000 07746  017051          DEF LDF            LINK TO EXECUTE 'LDF'
02023000 07750                  ORG 7750B
02024000 07750  017042          DEF LDP1           LINK TO EXECUTE 'LDP'
02025000 07751  016432          DEF RCMEM          LINK TO EXECUTE 'RCM'
02026000 07752  016470          DEF LDMEM          LINK TO EXECUTE 'LDM'
02027000 07753  016117          DEF RCK            LINK TO EXECUTE 'RCK'
02028000 07754  016132          DEF LDK            LINK TO EXECUTE 'LDK'
02029000 07755  016543          DEF LDB            LINK TO EXECUTE 'LDB'
02030000 07756  016206          DEF VFY            LINK TO EXECUTE 'VFY'
02031000 00603                  ORG ASTPA
02032000 00603  017605          DEF CFD
02033000 00604  017460          DEF WTRR
02034000 00606                  ORG ARDRC
02035000 00606  017635          DEF RDREC
02036000                  *
02037000                  *
02038000                  *
02039000 21770                  ORG 21770B
02040000 21770  016347          DEF ERDS0
02041000 21771  017566          DEF GTPR2          LINK TO GTPR2
02042000 21772  017665          DEF STPRA
02043000                  *
02044000                  *
02045000 00600                  ORG ACSTI
02046000 00600  023750          DEF CSTIN          LINK TO CASSETTE INITIALIZATION ROUTINE
```

```
*
*
*
*
****************************************
*
*             CASSETTE
*             OPERATING
*             SYSTEM
*
*
****************************************
*
*
*
*
*
*
*      INSTRUCTIONS FOR RECORDING OR LOADING CASSETTE FILES
*
*
*     TO WRITE A RECORD :
*
*          1). JSM ASTPA,I   -   SET PERIPHERAL ADDRESS
*                         AND COMPLETE ANY PENDING FINDS
*          2). T13 (RECNO) = FILE NUMBER
*          3). CATMP+8 (MBPTR) = STARTING ADDRESS (LOWEST MEMORY ADDRESS
*     TO BE RECORDED)
*          4). OP1+1 (LWMD) = ENDING ADDRESS ( HIGHEST MEMORY ADDRESS
*     TO BE RECORDED)
*          5). MRW1+1 (RELTH) = RECORD LENGTH ( LWMD - MBPTR + 1 )
*
*          FILE TYPES :
*          NULL                     => 0
*          BINARY                   => 1
*          NUMERIC DATE             => 2
*          MIXED STRING AND NUMERIC => 3
*          MEMORY                   => 4
*          KEYS                     => 5
*          USER PROGRAMS            => 6
*
*
*          6). MRW1+3 ( RECTP ) = TYPE
*          7). JSM AWTRR,I   -   WRITE THE RECORD
*          8). ENABLE THE INTERRUPT
*          NOTE: THE C REGISTER IS SAVED IN T21. IF ALTERED,
*                 THE C REGISTER SHOULD BE RESTORED FROM T21 AT THIS
*                 POINT.
*
*     TO READ A RECORD :
*
*          1). JSM ASTPA,I   -   SET THE PERIPHERIAL ADDRESS
*          2). RECNO = FILE NUMBER
*          3). JSM ACHST,I   -   POSITION THE TAPE AT FILE
*          4). MBPTR = STARTING ADDRESS
*          5). JSM ARDRC,I   -   READ THE RECORD
*          6). ENABLE INTERRUPT
*          NOTE: THE C REGISTER IS SAVED IN T21. IF ALTERED,
*                 THE C REGISTER SHOULD BE RESTORED FROM T21 AT THIS
*                 POINT.
*
*     NOTE : NO CHECK IS MADE BY THE TAPE OPERATING SYSTEM FOR ADEQUATE
*          ROOM IN MEMORY OR FOR PROPER FILE TYPE.  THE FILE
*          HEAD INFORMATION
*          IS VALID AFTER THE CALL TO ACHST.  THREE ATTEMPTS
*          ARE MADE
*          AT READING A FILE IF ERRORS ARE ENCOUNTERED,
*          WITH A FOURTH READ FOR RECOVERY.
*
*
*
*
*
*          THE CASSETTE OPERATING SYSTEM IS BASICALLY SELF CONTAINED
*          IT CALLS THE FOLLOWING ROUTINES EXTERNAL TO ITS PAGES:
*                 (16K, 20K)
*          ABUMP, FIXPT-1, ACOUN, NGET, AERR1,AERR2, AFLNA, AFLTP
*          AMPUP, AMAMP, ARSGT, ACLBI, A.PRN, EOLIO, ABTDA, AASTR
*          DMALO, ADSRM, ALDSP, ALLOC, ACNIN, AERCS, ASSLN, AERAV
*          AMPUP, AMPML, AZRWM, ABSAD+1, ASPC
*
*          THE FOLLOWING TEMPORARIES ARE USED AT SOME POINT IN THE
*          CASSETTE SYSTEM :
*          T1 THROUGH T23, MRW1 THROUGH MRW1+9, OP1 THROUGH OP1 + 2
************************************************************************
```

---- CASSETTE OPERATING SYSTEM ----

```
02133000                *              NOTE : THE C REGISTER IS SAVED IN TEMPORARY T21 ON ENTRY
02134000                *                     TO ANY STATEMENT EXECUTION VIA THE INTERPRETURE
02135000                *                     AND IS RESTORED ON EXIT
02136000                *
02137000                ************************************************************************
02138000                *
02139000                *
02140000                *          STANDARD PROCEEDURE #1
02141000                *          THIS PROCEEDURE IS USED BY MOST ROUTINES TO GET THE FIRST
02142000                *          ENTERED PARAMETER FROM THE STACK ( THE FILE NUMBER ).
02143000                *
02144000                *          THE FILE NUMBER IS GOTTEN FROM THE RUN TIME EXECUTION STACK
02145000                *          IT RESIDES AS EITHER A 7 WORD ENTRY IF NUMERIC OR A THREE WORD
02146000                *          ENTRY IF A SIMPLE VARIABLE OR ARRAY ELEMENT.
02147000                *         THIS PARAMETER CAN BE OBTAINED BY THE FOLLOWING CODE:
02148000                *
02149000                *          JSM ACOUN,I         THIS SETS FAP1 (FLOATING POINTER IN
02150000                *                               STACK)
02151000                *          JSM NGET            THIS WILL ATTEMPT TO GET A NUMERIC PARAMETER
02152000                *                              IT WILL RETURN P+1 IF A NONNUMERIC IS EN-
02153000                *                              COUNTERED AT FAP1. IT WILL RETURN P+2 IF
02154000                *                              THE PARAMETER AT FAP1 IS NUMERIC
02155000                *          JMP ERR55
02156000                *          JSM FIXPT-1        FIXPT WILL RETURN THE ENTERED FLOATING POINT
02157000                *                             NUMBER AS A BINARY NUMBER IN REGISTER B
02158000                *
02159000                *
02160000                *           THE FILE NUMBER NEED NOT BE SUPPLIED, THE DEFAULT IS ZERO
02161000                *           HOWEVER IF ANYTHING OTHER THAN A NUMERIC PARAMETER IS ENTERED
02162000                *           ERROR 55 IS GIVEN.
02163000                *
02164000                *           SUCCESIVE PARAMETERS AFTER THE FIRST ARE OBTAINED BY CALLING
02165000                *           BMP1 TO MOVE THE EXECUTION STACK POINTER (FAP1) BY ONE ENTRY
02166000                *           THEN CALLING NGET TO OBTAIN THE PARAMETER
02167000                *
02168000                *
02169000                *          EMARK IS THE CASSETTE MARK COMMAND
02170000                *
02171000                *
02172000                *
02173000                *          TEMPORARIES USED :  NOREC (T10), MSIZE (T11), FLAGA
02174000                *
02175000                *
02176000                *          ROUTINES CALLED : GTPAR, LDXI, MRKA, ERDS0, BMP1, NGET, FIXPT
02177000                *                                ASYER, AERR1
02178000                *
02179000                *
02180000                *
02181000                *
02182000                *             ON EXIT :  MARK COMPLETE
02183000                *
02184000                *
02185000                *
02186000 16000                    ORG 16000B
02187000 16000  042565  EMARK JSM GTPAR            GET THE FIRST PARAMETER
02188000 16001  035722        STB NOREC            ON RETURN B HAS THE NUMBER OF FILES
02189000 16002  042732        JSM BMP1             MOVE THE EXECUTION STACK POINTER BY ONE
02190000 16003  140424        JSM ASYER,I          MISSING PARAMETER
02191000 16004  040751        JSM NGET             GET THE NUMERIC PARAMETER ON STACK
02192000 16005  067726        JMP ERR55            NON-NUMERIC ENTRY ENCOUNTERED
02193000 16006  040643        JSM FIXPT-1          CONVERT PARAMETER TO FIXED POINT NUMBER
02194000 16007  173427        SOS MARK8            IF OVERFLOW - ERROR
02195000 16010  176423        SBM MKER1            IF NEG ERROR
02196000 16011  024254        ADB P1               ROUND THE BYTE COUNT UP
02197000 16012  173424        SOS MARK8            SEE IF OVERFLOW
02198000 16013  174500        SAR 1                MAKE BYTE COUNT A WORD COUNT
02199000 16014  076414        SZB MRK12            IF SIZE IS ZERO - CHECK FOR REQ. TO REWRITE
02200000                *                          HEAD
02201000 16015  001722        LDA NOREC            WE KNOW MSIZE#0 SO IF NOREC=0, ERROR
02202000 16016  072414        SZA MRK13
02203000 16017  035720  MRK11 STB MSIZE            B CONTAINS MAX SIZE
02204000 16020  142771  MARK7 JSM MRKA,I           MARK THE TAPE
02205000 16021  043347        JSM ERDS0            CHECK FOR ERORS
02206000                *                          IF MRK ERRORS, THE LOADING OF THE RETURN
02207000                *                          VARIABLE INFO. IS DONE IN ERDS0, WHICH THEN
02208000                *                          DOES A RETURN 5
02209000 16022  001676  MARK9 LDA CRECN            SET THE RETURN VARIABLE FOR A SUCCESSFUL MARK
02210000 16023  020257        ADA M1
02211000 16024  031756  MRK10 STA FLAGA
02212000 16025  042655        JSM LDXI             LOAD THE (X)
02213000 16026  067464        JMP INTN1
02214000 16027  067464        JMP INTN1
02215000 16030  001722  MRK12 LDA NOREC            SEE IF BOTH PARAMETERTS ARE ZERO
```

```
02216000 16031  072466        SZA MRK11         IF BOTH ZERO REWRITE HEAD
02217000 16032  067726  MRK13 JMP ERR55         IF NOT GIVE ERROR
02218000 16033  066603  MKER1 JMP ERR53         INVALID PARAMETER ON CASSETTE COMMAND
02219000 16034  140404  ERR48 JSM AERR1,I       MARK FAILED
02220000 16035  032070        ASC 1,48
02221000 16036  066535  MARK8 JMP ERR11         ERROR 11 - OVERFLOW ERROR
02222000                *
02223000                *
02224000                *
02225000                *     IDENTIFY FILE STATEMENT RETURNS FILE NUMBER, FILE TYPE,
02226000                *     FILE CURRENT SIZE (IN BYTES), FILE CAPACITY (IN BYTES)
02227000                *     AND TRACK (0 OR 1)
02228000                *     THIS COMMAND NORMALLY RESULTS IN LITTLE OR NO TAPE MOTION ON
02229000                *     EXECUTION. THE TAPE IS ALWAYS POSITIONED IN THE INTER FILE
02230000                *     GAP IMMEDIATELY PRECEEDING THE FILE WHOSE HEADER WAS JUST READ.
02231000                *
02232000                *     IF THE TAPE POSITION IS UNKNOWN TO THE SYSTEM,
02233000                *     (AS AT TURN ON OR RESET, OR ON INSERTION OF A DIFFERENT CART.)
02234000                *     THE COMMAND MUST HAVE AT LEAST ONE PARAMETER. THE TAPE WILL
02235000                *     SEARCH IN REVERSE FOR A FILE HEADER
02236000                *
02237000                *     TEMPORARIES USED : NONE
02238000                *
02239000                *
02240000                *     ROUTINES CALLED : CFD, CNULL, IDRA, ERDSO,  LDXI, LDX2
02241000                *                       LDX3, AERR1, ASYER
02242000                *
02243000                *
02244000                *
02245000                *
02246000 16037  042605  IDF   JSM CFD           COMPLETE ANY FINDS
02247000 16040  001705        LDA TPOS          GET THE CURRENT TAPE POSITION
02248000 16041  010127        CPA P16           ARE WE LOST
02249000 16042  067075        JMP IDF2          YES LOST
02250000 16043  000005        LDA R5            CHECK TO SEE IF THE CARTRIDGE IS PULLED
02251000 16044  170501        SAR 2             AND CHECK IF TAPE IS LOST
02252000 16045  073002        SLA *+2
02253000 16046  067075        JMP IDF2          LOST, SEE IF AT LEAST ONE PARAMETER IS ENTERED
02254000 16047  142777  IDF7  JSM IDRA,I        IDENTIFY THIS RECORD
02255000 16050  043347        JSM ERDS0         CHECK FOR ERRORS
02256000 16051  042611  IDF5  JSM CNULL         CHECK FOR ANY PARAMETERS
02257000 16052  067464        JMP INTN1         ENABLE GHE INTERRUPT AND EXIT
02258000 16053  005676        LDB CRECN         GET THE VALUE FOR THE FIRST PARAMEYER
02259000 16054  042660        JSM LDX2          AT LEAST ONE PARAMETER
02260000 16055  140424        JSM ASYER,I       IF HERE SOMETHING WENT WRONG !!
02261000 16056  005701        LDB RTYPE
02262000 16057  042654        JSM LDX3          TRANSFER RTYPE TO (,X)
02263000 16060  067464        JMP INTN1         ENABLE THE INTERRUPT AND EXIT
02264000 16061  005700        LDB CSIZE
02265000 16062  174600        SBL 1             MAKE WORD COUNT A BYTE COUNT
02266000 16063  042654        JSM LDX3          TRANSFER CSIZE TO NEXT (,X)
02267000 16064  067464        JMP INTN1         ENABLE THE INTERRUPT AND EXIT
02268000 16065  005677        LDB ASIZE
02269000 16066  174600        SBL 1             MAKE WORD COUNT A BYTE COUNT
02270000 16067  042654        JSM LDX3          TRANSFER ASIZE TO NEXT (,X)
02271000 16070  067464        JMP INTN1         ENABLE THE INTERRUPT AND EXIT
02272000 16071  001707        LDA FLG1          GET THE COMPLEMENT OF THE TRACK
02273000 16072  170140        CMA               COMPLEMEMT
02274000 16073  050254        AND P1            CLEAR ALL BUT THE TRACK BIT
02275000 16074  067024        JMP MRK10         LOAD THE RETURN VARIABLE
02276000 16075  042611  IDF2  JSM CNULL         CHECK FOR THE NULL PARAMETER
02277000 16076  067404        JMP ERR45         NO PARAMETERS ENTERED SO ERROR
02278000 16077  067047        JMP IDF7          AT LEAST ONE NUMERIC PEARAMETER - CONTINUE
02279000                *
02280000                *
02281000                *
02282000                *     FDF IS THE CASSETTE FIND FILE COMMAND
02283000                *
02284000                *
02285000                *
02286000                *     TEMPORARIES USED : MRW1+6(FLG2)
02287000                *
02288000                *     ROUTINES CALLED : GTPR2, ACHST, STPRA, DMALO, STOPC
02289000                *
02290000                *
02291000                *
02292000 16100  042665  FDF   JSM STPRA         SET THE PERIPHERIAL ADDRESS
02293000 16101  142766        JSM STOPC,I       STOP THE CASSETTE
02294000 16102  042566        JSM GTPR2         GET THE FILE NUMBER
02295000 16103  005514  FDF1  LDB CSELC         PREPARE TO CALL DMA LOCKOUT
02296000 16104  140602        JSM DMALO,I
02297000 16105  067103        JMP FDF1          DMA REFUSED TRY AGAIN
02298000 16106  070430        DIR               WE HAVE DMA , CONTINUE
02299000 16107  034011        STB PA            SET THE PA
02300000 16110  000177        LDA P0
```

```
16111   030013         STA DMAPA           CLEAR DMAPA ( THE DMA FLAG) IN CASE DRIVERS
                *                          HAVE ERROR
16112   031345         STA CSCF            FORGET ANY PREVIOUS FINDS
16113   000254         LDA P1              SET UP THE HARDWARE FIND
16114   031764         STA FLG2
16115   140605         JSM ACHST,I         DO THE FIND
16116   067466         JMP INTEN
                *
                *
                *
                *
                *
                *
                *
                *      RCK IS THE CASSETTE RECORD KEYS COMMAND
                *
                *
                *      TEMPORARIES USED : MRW1+3(RECTP), OP1+1(LWMD)
                *
                *      ROUTINES CALLED : GTPAR, CALTH , WTRR
                *
                *
                *
16117   042565  RCK    JSM GTPAR           GET THE FILE NUMBER
16120   000142         LDA P5              KEYS ARE TYPE FIVE
16121   031761         STA RECTP
16122   001306         LDA FWAM            THIS IS THE START OF THE RECORD
16123   031706         STA MBPTR
16124   005307         LDB FWUP
16125   024257         ADB M1              THIS IS THE END OF THE RECORD
16126   035743         STB LWMD
16127   042626         JSM CALTH           CALCULATE THE LENGTH
16130   042460         JSM WTRR            WRITE THE RECORD
16131   067464         JMP INTN1           ENABLE THE INTERRUPT AND EXIT
                *
                *
                *      LDK IS THE CASSETTE  LOAD KEYS COMMAND
                *           LOADING BEGINS AT THE FWAM AND OVERLAYS ANY KEYS ALREADY
                *           DEFINED.
                *
                *
                *      TEMPORARIES USED : OP1*1 (LWMD), FLAGA (MRW1)
                *                         TVAR1 ( OP1+2)
                *
                *      ROUTINES CALLED : PCALL, STVFY, NEWSZ, AMAMP, AMUPH, RDREC
                *                               CKKBE, ARSGT, SSCHK
                *
                *
16132   042427  LDK    JSM STVFY           MUST SEE IF THE STATE IS LEGAL
16133   000142         LDA P5              KEYS ARE TYPE FIVE
16134   042710         JSM PCALL           PRELIMINARY CALL FOR LOADS
16135   001307         LDA FWUP
16136   031756         STA FLAGA           REMEMBER STARTING POINT TO UPDATE REG C,
                *                          HERE, LEND
16137   001306         LDA FWAM            THIS IS THE START OF THE LOAD
16140   031706         STA MBPTR
16141   042646         JSM NEWSZ           CALCULATE MBPTR + CSIZE TO B -1 TO A
16142   034017         STB D               SET POINTERS TO MOVE MEMORY
16143   174040         TCB
16144   025307         ADB FWUP            WHICH DIRECTION AND HOW FAR ?
16145   176010         SBP LDK1            SKIP IF MUST MOVE LOWER
16146   001307         LDA FWUP
16147   170040         TCA                 SET POINTERS TO MOVE PROGRAMMING
16150   021310         ADA RMAX
16151   020017         ADA D
16152   030017         STA D
16153   140463         JSM AMUPH,I         MOVE PROGRAM TO HIGHER MEMORY
16154   067156         JMP LDK7
16155   140464  LDK1   JSM AMAMP,I         MOVE MEMORY LOWER
16156   042736  LDK7   JSM CKKHE           SEE IF THERE IS A PROGRAM RUNNING
16157   067161         JMP LDK3            YES A PROGRAM IS RUNNING
16160   067204         JMP LDK2            NO PROGRAM RUNNING
16161   001756  LDK3   LDA FLAGA           INITIAL POSITION OF THE START OF THE PROGRAM
16162   170040         TCA
16163   021307         ADA FWUP            THIS IS THE OFFSET TO THE C REG BECAUSE OF
                *                          THE MOVING OF THE MEMORY
16164   031744         STA TVAR1           REMEMBER THE OFFSET
16165   005735         LDB SVC             MUST RESET REG C, 'HERE', AND 'LEND'(SVC=C)
16166   024000         ADB A
16167   035735         STB SVC
16170   005265         LDB HERE
16171   024000         ADB A
16172   035265         STB HERE
```

---- CASSETTE OPERATING SYSTEM ----

```
16173  005264       LDB LEND
16174  024000       ADB A
16175  035264       STB LEND
16176  000177       LDA P0              SET THE FLAG FOR ADJUSTMENT OF GSB RETURNS
16177  031063       STA NPROG
16200  042376       JSM SSCHK           THIE ROUTINE WILL ADJUST THE GSB RETURNS
16201  140360       JSM ARSGT,I         RESET THE HS GTO ADDRESSES
16202  042635       JSM RDREC           READ THE RECORD
16203  067464       JMP INTN1           ENABLE THE INTERRUPT AND EXIT
16204  042635  LDK2 JSM RDREC           READ THE RECORD
16205  066257       JMP LDF18           NO PROGRAM SO CLEAR RUN BIT, EXIT
              *
              *
              *
              *     VFY IS THE CASSETTE VERIFY COMMAND, IT MUST BE THE FIRST
              *     CASSETTE STATEMENT AFTER A RECORD OR LOAD STATEMENT
              *          OR ITS PARAMETERS MAY BE DESTROYED
              *
              *
              *     ON ENTRY : THE INFORMATION FOR THE TAPE TO BE VERIFIED AGAINST
              *                IT'S COUNTERPART IN MEMORY
              *
              *     ON EXIT : VERIFY COMPLETE UNLESS ERROR 44 OCCURES - VERIFY FAILED
              *
              *
              *
              *
              *     TEMPORARIES USED : RECNO
              *
              *     ROUTINES CALLED : CFD, ACOUN, VREC, CNULL, LDX2, ASYER
              *
              *
16206  042605  VFY  JSM CFD             COMPLETE ANY PENDING FINDS
16207  001676       LDA CRECN           MUST DO THIS IN CASE
16210  020257       ADA M1              RECNO IS CHANGED , TPOS = 2 ON ENTRY
16211  031725       STA RECNO           RESTORE THE TARGET RECORD NUMBER
16212  140610       JSM ACOUN,I         SET FAP1
16213  043227       JSM VREC            VERIFY THE RECORD
16214  067223       JMP VFY1            NO  ERROR RETURN
16215  042611  VFY2 JSM CNULL           CHECK FOR THE NULL PARAMETER
16216  066511       JMP ERR44           NO NUMERIC PARAMETER SO GIVE ERROR
16217  004254       LDB P1              ERROR - VERIFY HAS FAILED
16220  042660  VFY3 JSM LDX2            LOAD NEXT XI
16221  140424       JSM ASYER,I         BAD NEWS IF GET HERE
16222  067464       JMP INTN1           ENABLE THE INTERRUPT AND EXIT
16223  042611  VFY1 JSM CNULL           SEE IF WE HAVE A RETURN VARIABLE
16224  067464       JMP INTN1           NO NUMERIC RETURN VARIABLE SO DONE
16225  004177       LDB P0
16226  067220       JMP VFY3            LOAD THE RETURN VARIABLE
              *
              *
              *
              *     VREC DOES A VERIFY ON THE CURRENT FILE NUMBER
              *
              *
              *     TEMPORARIES USED : INSTR (T11)
              *
              *     ROUTINES CALLED : ACHST, RBDYA, ERDS0
              *
              *
              *
16227  140605  VREC JSM ACHST,I         REPOSITION THE TAPE
16230  002744       LDA CPBCD           CPB PTR,I COMMAND FOR VERIFY
16231  031723       STA INSTR
16232  142775       JSM RBDYA,I         DO THE VERIFY
16233  043347       JSM ERDS0           CHECK FOR ERRORS
16234  170201       RET 1
16235  170202       RET 2               CONTINUE RETURN FROM ERDS0
              *
              *
              ****************
              *
              * TLIST:  STATEMENT TO LIST FILE DESCRIPTIONS
              *
              ****************
              *
              *     ROUTINES CALLED : CFD, IDRA, ERDS0, ACLBI, A.PRN, ACHST
              *                       ASPC, EOLIO, ABTOA
              *
              *     TEMPORARIES USED : RECNO
              *
              *
16236  042605  ETLIS JSM CFD           COMPLETE ANY PENDING FINDS
16237  142777       JSM IDRA,I          IDENTIFY CURRENT TAPE POSITION
16240  043347       JSM ERDS0           CHECK FOR ERRORS
```

```
16241  140450        JSM ACLBI,I         CLEAR THE I/O BUFFER
16242  003320        LDA HEAD1           TRANSFER THE TRACK NO. HEADING TO THE BUFFER
16243  004313        LDB AIBUF
16244  071401        XFR 2
16245  001707        LDA FLG1            GET THE CURRENT TRACK NUMBER
16246  170140        CMA
16247  050254        AND P1
16250  063323        IOR BZ
16251  130317        STA TLPTR,I         AND FILL IN THE TRACK NO.
16252  140444        JSM A.PRN,I         THEN PRINT THE LINE.
                *
                * START OF MAIN TLIST LOOP
                *
16253  001676        LDA CRECN           SET UP THE TARGET RECORD NUMBER
16254  031725        STA RECNO
16255  070420  TLIS1 EIR                 TURN ON INTERRUPT FOR STOP FLAG
16256  001206        LDA .WKC            CHECK THE "STUP FLAG" BEFORE EACH NEW IDF.
16257  010254        CPA P1
16260  067312        JMP TLIS3           AND GET OUT IF IT IS SET.
16261  070430        DIR                 TURN OFF INTERRUPTS
                *
16262  001514        LDA CSELC           SET THE PERIPHERAL ADDRESS OF THE CASSETTE.
16263  030011        STA PA
16264  140605        JSM ACHST,I         FIND THE NEXT FILE AND READ THE HEADER.
                *
16265  140450  TLIS6 JSM ACLBI,I         CLEAR THE I/O BUFFER FOR THE NEXT LINE.
16266  003326        LDA BNOBK           GET THE # SIGN FOR FILE NUMBER
16267  130313        STA AIBUF,I         PUT AT START OF LINE
16270  001676        LDA CRECN
16271  004314        LDB AIBFX
16272  043317        JSM DMPNO
                *
16273  140444        JSM A.PRN,I         PRINT THE FILE NUMBER LINE
16274  140450        JSM ACLBI,I         CLEAR THE I/O BUFFER
16275  001701        LDA RTYPE           GET THE RECORD TYPE
16276  004314        LDB AIBFX
16277  043317        JSM DMPNO
                *
16300  001700        LDA CSIZE
16301  007324        LDB CS
16302  043316        JSM DMPNO-1
                *
16303  001677        LDA ASIZE
16304  007325        LDB AS
16305  043316        JSM DMPNO-1
                *
16306  140444        JSM A.PRN,I         PRINT THE LINE IN THE I/O BUFFER
                *
16307  045725        ISZ RECNO           GET READY TO FIND THE NEXT FILE.
16310  001677        LDA ASIZE           IF THE NULL F.NOT BEEN REACHED, KEEP TLISTING.
16311  072044        RZA TLIS1
                *
16312  000144  TLIS3 LDA P3              PRINT THREE BLANK LINES
16313  140571        JSM ASPC,I          PRINT THE BLANK LINES.
16314  040710        JSM EOLIO
16315  067464        JMP INTN1           ENABLE THE INTERRUPT AND EXIT
                *
                * SUBROUTINES FOR TLIST
                *
16316  170600        SAL 1
16317  164477  DMPNO JMP ABTDA,I         BUILD THE NO. IN <A> IN THE I/O BUFFER STARTING
                *                        AT CHARACTER ADDRESS <B> + 1
                *
                *
                * TLIST CONSTANTS AND EQUATES.
                *
                *
16320  016321  HEAD1 DEF *+1
16321  072162        DEC 29810           T  R
16322  065440        DEC 27424           K  BLANK
16323  020060  BZ    OCT 020060          ASCII: BLANK, ZERO
       000317  TLPTR EQU AIBSL           POINTER FOR TRACK DIGIT
16324  177066  CS    DEF IBUFF+2,I
16325  177071  AS    DEF IBUFF+5,I
       077206  .WKC  EQU IOTMP
16326  021440  BNOBK OCT 21440
                *
                *
                *      ERST IS THE CASSETTE ERASE COMMAND
                *
                *
                *
                *      TEMPORARIES USED : NONE
```

```
                      *
                      *     ROUTINES CALLED : GTPAR, ERSA, ERDSO
                      *
                      *
                      *
                      *
16327  042565  ERSTP JSM GTPAR          GET THE FILE NUMBER
16330  140605        JSM ACHST,I        POSITION THE TAPE
16331  142776        JSM ERSA,I         DO THE ERASE
16332  043347        JSM ERDSO          CHECK FOR ERRORS
16333  067464        JMP INTN1          ENABLE THE INTERRUPT AND EXIT
                      *
                      *
                      *
                      *     THE REWIND COMMAND SETS THE HARDWARE IN REVERSE , HS MODE
                      *     AND SEARCHES FOR THE BEGINNING OF TAPE.  ONCE INITIATED, THE
                      *     REWIND OPERATION TERMINATES BY ITSELF
                      *
                      *
                      *
                      *     TEMPORARIES USED : NONE
                      *
                      *     ROUTINES CALLED BY THIS ROUTINE : STPRA, REWA, ERDSO
                      *
                      *
                      *
                      *
16334  043340  EREW  JSM EREW1
16335  067464        JMP INTN1          EXECUTION HERE IF NOT AN IMMEDIATE EXECUTE KEY
16336  000263  RWEKB LDA FLAG           SET FLAG THAT THIS IS A HARDWARE SIM. REWIND
16337  031613        STA LKTMP+6
                      *
                      *
                      *
                      *
16340  042665  EREW1 JSM STPRA          SET THE PA
16341  142772        JSM REWA,I         REWIND TAPE
16342  043347        JSM ERDSO          CHECK FOR HARDWARE ERRORS
16343  070420  ERD21 EIR
16344  000177        LDA P0             CLEAR THE HARDWARE SIM. REWIND FLAG
16345  031613        STA LKTMP+6
16346  170201        RET 1
                      *
                      *
                      *
                      *
                      *          ERDSO IS CALLED WHEN THE CASSETTE DRIVERS SOFTWARE ENCOUNTERS
                      *      AN ERROR.  THIS ERROR IS LOGGED AS A ONE (SET BIT ) AT THE PROPE-
                      *     BIT LOCATION IN ERRWD.  ERDSO DECODES THE WORD ( BIT 15, BIT 14,
                      *     ETC. TO BIT 5 ) AND THE PROPER ERROR IS DISPLAYED OR SOME OTHER
                      *     ACTION IS TAKEN.
                      *
                      *     NOTE: IF THIS ROUTINE IS CALLED WITH BITS 0-4 SET OR ERRWD
                      *     =0, THE SYSTEM WILL HANG UP OR FAIL
                      *
                      *
                      *     ON ENTRY : ERRWD HAS BIT(S) SET CORRESPONDING TO THE ERROR(S)
                      *                WHICH OCCURED
                      *
                      *
                      *     ON EXIT : RETURNS IF FURTHER ACTION MUST BE TAKEN, AS LOADING
                      *               AN OPTIONAL PARAMETER
                      *               OTHERWISE THE RETURN IS TO CONTROL SUPERVISOR VIA AERR1
                      *
                      *
                      *
                      *     TEMPORARIES USED : ERRWD (MRW1+5), LDTRS (MR1W+4)
                      *                FLAGA (MRW1)
                      *
                      *
                      *     ROUTINES CALLED : AERR1, PTBRA, LDXI
                      *
                      *
                      *
                      *
                      *
                      *
16347  004135  ERDSO LDB P10
16350  001763        LDA ERRWD          GET ERROR WORD
16351  172404  ERD1  SAM ERD2           SKIP IF BIT 15 SET
16352  024257        ADB M1             COUNT IF NO ERROR BIT SET
16353  170600        SAL 1              MOVE NEXT BIT TO MSB
16354  067351        JMP ERD1           CONTINUE
16355  003360  ERD2  LDA ERADD          GET THE JMP TABLE ADDRESS
16356  020001        ADA B              CALCULATE THE OFFSET
16357  164000        JMP A,I            JUMP THROUGH THE JMP TABLE
```

```
16360  016361  ERADD DEF *+1
                *
16361  067404        JMP ERR45
16362  067417        JMP ERD11
16363  067415        JMP ERR47
16364  067406        JMP ERDS9
16365  067403        JMP ERD14
16366  067430        JMP ERR65
16367  067401        JMP ERR42
16370  067373        JMP ERR43
16371  067373        JMP ERR43
16372  067375        JMP ERR41
16373  140404  ERR43 JSM AERR1,I          POWER DOWN, SERVO FAILED, UNEXPECTED HOT OR EC
                *                         BITS 15,13,12
16374  032063        ASC 1,43
16375  001613  ERR41 LDA LKTMP+6          IF THIS IS SET WE GIVE NO ERROR
16376  172445        SAM ERD21            RETURN 1
16377  140404        JSM AERR1,I          CARTRIDGE OUT
                *                         BIT 14
16400  032061        ASC 1,41
16401  140404  ERR42 JSM AERR1,I          CARTRIDGE PROTECTED
                *                         BIT 11
16402  032062        ASC 1,42
                *                         BIT 9 IS VERIFY ERROR
16403  170202  ERD14 RET 2                ERROR - VERIFY HAS FAILED LOAD (,X)
16404  140404  ERR45 JSM AERR1,I          EXECUTION OF IDF WITHOUT PARAMETERS OR MRK
                *                         WHILE THE TAPE IS LOST
                *                         BIT 5
16405  032065        ASC 1,45
16406  055762  ERDS9 USZ LDTRS            COUNT THIS TRY AT LOADING, SEE IF DONE
16407  170202        RET 2                TRY AGAIN
16410  001701  ERD20 LDA RTYPE            IF TYPE IS PROGRAM MUST PATCH BRIDGS
16411  010141        CPA P6
16412  166770        JMP PTBRA,I          PATCH UP LINE BRIDGES AND DO RETURN
16413  140404  ERR46 JSM AERR1,I          PARTITION ERROR - RECOVERY CYCLE IS COMPLETE
16414  032066        ASC 1,46             PARTITION ERROR, BIT 8 OF ERRWD
                *
                *
16415  140404  ERR47 JSM AERR1,I          HEAD READ ERROR
                *                         BIT 7
16416  032067        ASC 1,47
16417  005676  ERD11 LDB CRECN            MARK WAS UNSUCCESSFUL , LOAD (,X)   BIT 6
                *
16420  024257        ADB M1               THE (,X)
16421  174040        TCB
16422  035756        STB FLAGA
16423  042655        JSM LDXI             LOAD THE (,X) PARAMETER
16424  067034        JMP ERR48            NO (,X) PRESENT SO GIVE ERROR
16425  170205        RET 5                ENABLE THE INTERRUPT AND EXIT
16426  140404  ERR49 JSM AERR1,I          FILE TOO SMALL
16427  032071        ASC 1,49
                *
16430  140404  ERR65 JSM AERR1,I          FILE NOT FOUND, BIT 10
16431  033065        ASC 1,65
                *
                *
                *
                *
                *
                *     RCMEM  RECORDS ON THE CASSETTE THE ENTIRE READ/WRITE
                *            MEMORY INCLUDING SELECTED REGISTERS
                *
                *            SYNTAX : L.C. RCM (FILE #)
                *
                *     ON ENTRY : CONTROL IS HERE IF RCM IS ENCOUNTEWRED BY
                *                THE INTERPRETURE. THE FILE NUMBER IS
                *                OPTIONAL BUT IF PRESENT IT IS ON THE RUN-
                *                TIME EXECUTION STACK AND IS GOTTEN BY THE
                *                "STANDARD PROCEDURE 1 "
                *
                *
                *
                *
                *
                *     ON EXIT: DUMP COMPLETE UNLESS ERRORS ARE ENCOUNTERED
                *
                *
                *
                *     TEMPORARIES USED : RECTP (MRW1+3), SEFLG (MRW1+2)
                *                        TVAR3, SVC, T22, T23
                *
                *
                *     ROUTINES CALLED : GTPAR, STPRL, WTRR, BINUI
                *
                *
                *
16432   000003  RCMEM LDA R             SAVE THE RETURN STACK POINTER
16433   130324        STA ASTK1,I       STORE ON COMPILE STACK
16434   042565        JSM GTPAR         GET THE FILE NUMBER
16435   042622        JSM STPRL         SET UP MEMORY RECORD ADDRESSES
16436   000143        LDA P4
16437   031761        STA RECTP
16440   001062        LDA ROMWD         GET THE 'ROMS PRESENT ON SYSTEM' WORD
16441   031742        STA TVAR3         PREPARE TO PUT IT IN THE HEADER
16442   000254        LDA P1
16443   031736        STA T22           SET FLAG FOR BINARY
16444   100327        LDA AROMS,I       SAVE THE BINARY "PRESENT" LINK
16445   031737        STA T23
16446   043607        JSM BINUI         UNINITIALIZE THE BINARY PROGRAM
                *
16447   004324  RCM3  LDB ASTK1         THESE GO INTO THE COMPILE STACK
16450   034016        STB C             SET THE POINTER
16451   001735        LDA SVC           SAVE REG C (SVC=C)
16452   070540        PWC A,I           SAVE THE OLD C REGISTER ( STILL IN A )
16453   000301        LDA AJSMS         33 WORDS , STARTIMG HERE MUST BE SAVED
16454   030017        STA D             SET UP THE POINTER
16455   004162        LDB M32           SET THIS COUNTER TO ONE LESS THAN THE
                *                       ABS. VALUE OF THE NUMBER OF WORDS TO BE
                *                       TRANSFERED
16456   070570  RCM2  WWD A,I
16457   070540        PWC A,I
16460   076176        RIB RCM2
16461   042460        JSM WTRR          WRITE THE RECORD
16462   001737        LDA T23           RESTORE THE BINARY LINK
16463   130327        STA AROMS,I
                *
                *
                *
                *     THIS ROUTINE ENABLES THE INTERRUPT BEFORE THE CASOS RETURNS CONTRO
                *     THIS ROUTINE IS THE LAST ROUTINE EXECUTED BY ANY STATEMENT SERVICE
                *     ROUTINE
                *
                *
                *     ON ENTRY : ENTRY AT INTN1 IF MUST RESTORE THE C REGISTER AT
                *                COMPLETION
                *                ENTRY AT INTEN IF NEED ONLY ENABLE INTERRUPT AND
                *                RETURN TO INTERPRETURE
                *
                *
                *
16464   001735  INTN1 LDA SVC           RESTORE THE C REGISTER
16465   030016  INTN2 STA C
16466   070420  INTEN EIR
16467   164365        JMP AINTX,I
                *
                *
                *
                *
                *     LDMEM  LOADS THE ENTIRE USER ACCESSABLE READ/WRITE MEMORY
                *            SPACE
                *
                *     SYNTAX : L.C. LDM (<FILE NUMBER>)
                *
                *
                *
                *     ON ENTRY : CONTROL HERE IF LDM IS RECOGNIZED BY THE INTERPRETURE
                *                THE FILE NUMBER IS GOTTEN FROM THE RUN-TIME EXECUTION
                *                STACK BY "STANDARD PROCEDURE #1" DETAILED AT THE
                *                START OF THE LISTING
                *
                *
                *     TEMPORARIES USED : T1, SVC
                *
                *     ROUTINES CALLED : PCALL, STPRL, CHSIZ, RDREC
                *                       AERR2, ADSRM, ALDSP
                *
                *
                *
                *
16470   000143  LDMEM LDA P4            MEMORY IS TYPE 4
16471   042710        JSM PCALL         PRELIMINARY CALL FOR LOADS
16472   042622        JSM STPRL         SET UP MEMORY LOAD (START AND END ADDRESS)
16473   000126        LDA P17           SET COUNTER FOR ROM ID
16474   031711        STA T1
16475   001704        LDA EX2           GET THE OLD ROM WORD
16476   005062        LDB ROMWD         GET THE NEW ROM WORD
16477   073007  LDM7  SLA LDM5          SKIP LSB A = 0 = ROM GONE
16500   077014        SLB ERR52         SKIP IF B=0= ROM GONE
```

```
02805000 16501   170500  LDM8   SAR 1              LOOK AT THE NEXT BIT
02806000 16502   174500         SBR 1
02807000 16503   055711         DSZ T1             SEE IF DONE WITH ROMWD. THERE ARE ALWAYS
02808000 16504   067477         JMP LDM7           2 EXTRA PASSES TO ZERO THE COUNTER BUT THEY
02809000                 *                         ARE ZERO
02810000 16505   067517         JMP LDM10
02811000 16506   077073  LDM5   SLB LDM8           SKIP LSB = 0 = ROM ABSENT
02812000 16507   140405  ERR51  JSM AERR2,I        ERROR - ROM #T1 IS PRESENT BUT WAS NOT
02813000 16510   032461         ASC 1,51           PRESENT AT RCM
02814000 16511   001711  LDM9   LDA T1             ROM ID TO REGISTER A
02815000 16512   070420         EIR
02816000 16513   164357         JMP ADSRM,I        DISPLAY ROM ID CODE
02817000 16514   140405  ERR52  JSM AERR2,I        ERROR = ROM #T1 IS NOT PRESENT BUT SHOULD BE !!
02818000 16515   032462         ASC 1,52
02819000 16516   067511         JMP LDM9
02820000 16517   042724  LDM10  JSM CHSIZ          SEE IF IT WILL FIT
02821000 16520   001700         LDA CSIZE          MUST CALC. AJSMS-CSIZE AS START OF LOAD
02822000 16521   170040         TCA                IN CASE MEMORY IS LARGER THAN FILE
02823000 16522   020301         ADA AJSMS
02824000 16523   031706         STA MBPTR
02825000 16524   042635         JSM RDREC          READ THE RECORD
02826000 16525   140433         JSM ALDSP,I        DISPLAY I/O BUFFER
02827000 16526   000324         LDA ASTK1
02828000 16527   030017         STA D
02829000 16530   070571         WWD R,I            GET REGISTER R FROM THE COMPILE STACK
02830000 16531   034003         STB R
02831000 16532   070570         WWD A,I
02832000 16533   031735         STA SVC            GET THE C REGISTER AND SAVE IT (SVC=C)
02833000 16534   004300         LDB AJSTK          THE REST OF THE WORDS GO HERE AND HIGHER
02834000 16535   034016         STB C
02835000 16536   004162         LDB M32            SET THIS COUNTER TO ONE LESS THAN THE
02836000                 *                         ABS. VALUE OF THE NUMBER OF WORDS TO BE
02837000                 *                         TRANSFERED
02838000 16537   070570  LDM1   WWD A,I
02839000 16540   070540         PWC A,I            RESTORE THE JSM RETURN SYACK
02840000 16541   076176         RIB LDM1
02841000 16542   067464         JMP INTN1          ENABLE THEINTERRUPT AND EXIT
02842000                 *
02843000                 *
02844000                 *
02845000                 *
02846000                 *
02847000                 *      LDB IS THE CASSETTE LOAD BINARY PTOGRAMS COMMAND
02848000                 *
02849000                 *      SYNTAX L.C. LDB (<FILE NUMBER>)
02850000                 *
02851000                 *
02852000                 *      ON ENTRY : CONTROL HERE IF INTERPRETURE RECOGNIZES LDB
02853000                 *                 STATEMENT. THE FILE NUMBER IS ON THE RUN-TIME
02854000                 *                 EXECUTION STACK AND CAN BE GOTTEN BY "STANDARD
02855000                 *                 PROCEEDURE #1"
02856000                 *
02857000                 *
02858000                 *
02859000                 *      TEMPORARIES USED : T22
02860000                 *
02861000                 *      ROUTINES CALLED : PCALL, BINSZ, RDREC, AERR1, BINUI, ALLOC
02862000                 *
02863000                 *
02864000                 *
02865000                 *
02866000 16543   000254  LDB    LDA P1             BINARY PROGRAMS ARE TYPE 1
02867000 16544   042710         JSM PCALL          PRELIMINARY CALL FOR OADS
02868000                 *                         PCALL WILL GET THE FILE NUMBER, POSITION
02869000                 *                         THE TAPE, CHECK FOR TYPE =1 (BINARY)
02870000 16545   043602         JSM BINSZ          LWAM - CSIZE + 5 TO A
02871000 16546   005313         LDB FWBA           THIS IS THE FIRST WORD OF THE BINARY AREA
02872000 16547   174040         TCB
02873000 16550   020001         ADA B
02874000 16551   172415         SAM LDB1           BINARY PROGRAM WILL NOT FIT IN MEMORY
02875000 16552   043602  LVBN2  JSM BINSZ
02876000 16553   031706         STA MBPTR
02877000 16554   000177         LDA P0
02878000 16555   031736         STA T22            CLEAR THIS FLAG FOR BINARY
02879000 16556   043607         JSM BINUI          UNINITILIZE THE BINARY PROGRAM
02880000 16557   042635         JSM RDREC          READ THE RECORD
02881000 16560   000330         LDA LWAM           GET THE ADDRESS OF THE BINARY PROGRAM LINKS
02882000 16561   130327         STA AROMS,I        ADD THE BINARY'S ADDRESS TO THE TABLE
02883000 16562   020143         ADA P4             POINT AT THE INITIALIZATION ENTRY
02884000 16563   100000         LDA A,I            GET THE ADDRESS OF THE INITIALIZATION ROUTINE
02885000 16564   140000         JSM A,I            RUN THE INITIALIZATION ROUTINE
02886000 16565   067464         JMP INTN1          ENABLE THE INTERRUPT AND EXIT
02887000 16566   001313  LDB1   LDA FWBA           SEE IF THE VALUE TABLE IS EMPTY
```

---- CASSETTE OPERATING SYSTEM ----

```
16567  011311        CPA VT1            IF EMPTY, WE CAN TRY TO ALOCATE SPACE
16570  067573        JMP LDB2           IT IS EMPTY
16571  140404  ERR54 JSM AERR1,I        BINARY PROGRAM WILL NOT FIT
16572  032464        ASC 1,54
16573  021700  LDB2  ADA CSIZE          CALCULATE THE AMOUNT OF MEMORY REQUIRED
16574  170040        TCA
16575  020140        ADA P7             ALLOW FOR 7 WORD ID TABLE
16576  020330        ADA LWAM
16577  140370        JSM ALLOC,I        MOVE THE EXECUTION STACK
16600  031313        STA FWBA           A RETURNS WITH THE FIRST WORD AVAIL.
16601  067552        JMP LVBN2
               *
               *
               *     BINSZ CALCULATES LWAM - CSIZE TO REGISTER A
               *
               *
               *     TEMPORARIES USED : NONE
               *
               *     ROUTINES CALLED : NONE
               *
               *
               *
16602  001700  BINSZ LDA CSIZE
16603  170040        TCA
16604  020330        ADA LWAM
16605  020140        ADA P7
16606  170201  BNSZ1 RET 1
               *
               *
               *
               *     BINUI IS A ROUTINE TO ALLOW THE BINARY PROGRAM TO
               *     "CLEAN UP" AFTER ITSELF WHEN IT IS REMOVED FROM THE SYSTEM
               *     AS ON AN RCM OR LDB STATEMENT
               *
               *
               *
16607  100327  BINUI LDA AROMS,I        SEE IF BINARY PRESENT
16610  072476        SZA BNSZ1
16611  020141        ADA P6
16612  100000        LDA A,I            GET THE ADDRESS
16613  164000        JMP A,I            DO THE UNINITIALIZATION AND RETURN
               *
               *
               *
               *
               *
               *     THIS IS THE RECORD PROG. AND DATA STATEMENT.
               *
               *
               *     TEMPORARIES USED : RELTH, FLAGA, LWMD
               *                        RECTP, SEFLG, TVAR3
               *
               *     ROUTINES CALLED : GTPAR, BMP1, GWTWH, CHNP2, NGET
               *                       CALTH, CHNTP
               *                       CHSEC, ASYER, REGCK, RCFB, AERR1
               *
16614  043715  RCFZ  JSM REGCK          IS THIS AN R - REGISTER ?
16615  067631        JMP RCP11          NOT AN R - REGISTER
16616  067620        JMP RCF4           DONE ONLY ONE R - REGISTER
16617  067625        JMP RCFK           LEGAL SET OF TWO R - REGISTERS
16620  001277  RCF4  LDA END$           ONLY ONE R - REG ENTERED
16621  020254        ADA P1
16622  031706        STA MBPTR
16623  001756        LDA FLAGA
16624  020144        ADA P3
16625  031743  RCFK  STA LWMD
               *
16626  000145        LDA P2             DATA IS TYPE 2
16627  031761        STA RECTP
16630  067704        JMP RCP10
16631  043741  RCP11 JSM RCFB           SIMPLE VARIABLE , ARRAY OR STRING
16632  067704        JMP RCP10          DONE
               *
               *
               *
               *     THIS IS THE ENTRY TO THE CODE FOR THE RCF STATEMENT
               *
               *
16633  042565  RCF   JSM GTPAR          GET THE FILE NUMBER
16634  000257        LDA M1             SET FIRST FLAG
16635  031757        STA RELTH
16636  000177        LDA P0
16637  031742        STA TVAR3          CLEAR THIS VARIABLE FOR EX2 (STRING COUNT)
16640  042732        JSM BMP1           MOVE THE STACK POINTER BY ONE
16641  067672        JMP RCP1           NO MORE PARAMETERS - MUST BR PROGRAM RECORD
```

---- CASSETTE OPERATING SYSTEM ----

```
02973000 16642  042703         JSM GWTWH        GET THE WHAT AND WHERE WORD
02974000 16643  035756         STB FLAGA        SAVE THE 'WHERE' WORD
02975000 16644  035706         STB MBPTR
02976000 16645  172467         SAM RCFZ         SKIP IF THE PARAMETER IS A VARIABLE
02977000 16646  042517         JSM CHNP2        CHECK OUT THIS PARAMETER
02978000                *                       IF HERE WE DO NOT HAVE A VARIABLE SO
02979000                *                       RECORD THE USER PROGRAM
02980000 16647  140424         JSM ASYER,I      NO MORE PARAMETERS - MAY NEVER HAPPEN
02981000 16650  067707         JMP RCP2         NON-NUMERIC RETURN
02982000 16651  064722         JMP ERLNF        COULD NOT FIND LINE ADDRESS
02983000 16652  031706  RCFJ   STA MBPTR        THIS IS THE START OF THE RECORD
02984000 16653  042515         JSM CHNTP
02985000 16654  067674         JMP RCP4         NO MORE PARAMETERS
02986000 16655  067711         JMP RCP5         A NON-NUMERIC PARAMETER AS 'SE'
02987000 16656  067663         JMP RCP6         LINE ADDRESS COULD NOT BE FOUND, ADDRESS SET
02988000                *                       TO ENDS
02989000 16657  004000         LDB A            B IS THE ADDRESS OF LN2
02990000 16660  100001         LDA B,I          GET THE LINE BRIDGE
02991000 16661  050053         AND B177         CLEAR THE HIGH ORDER BITS
02992000 16662  020001         ADA B            MAKE ADDRESS OF NEXT LINE BRIDGE
02993000 16663  031743  RCP6   STA LWMD         THIS IS THE LAST ADDRESS TO BE RECORDED
02994000 16664  042732  RCP9   JSM BMP1         MOVE FAP1
02995000 16665  067676         JMP RCP7         NO MORE PARAMETERS - DONE
02996000 16666  040751         JSM NGET         SEE IF IT IS A NUMBER, IT SHOULD NOT BE
02997000 16667  067713         JMP RCP8         OK COULD BE "SE" OR "DB"
02998000 16670  140404  ERR58  JSM AERR1,I      INVALID OR MISSING 'SE'
02999000 16671  032470         ASC 1,58
03000000 16672  001307  RCP1   LDA FWUP         THIS IS THE STARTING ADDRESS OF THE RECORD
03001000 16673  031706         STA MBPTR
03002000 16674  001277  RCP4   LDA ENDS         SET UP END ADDRESS
03003000 16675  031743         STA LWMD
03004000 16676  000141  RCP7   LDA P6           USER'S PROGRAM IS TYPE 6
03005000 16677  031761         STA RECTP
03006000 16700  001760         LDA SEFLG        SEE IF CALCULATOR ALREADY SECURE
03007000 16701  072003         RZA RCP10        IF NOT ZERO, DO NOT USE SYSTEM SECURE FLAG
03008000 16702  001315         LDA STYFG        IF "SE" NOT REQUESTED USE THIS AS THE SECURITY
03009000 16703  031760         STA SEFLG
03010000 16704  042626  RCP10  JSM CALTH        CALCULATE RECORD LENGTH
03011000 16705  042460         JSM WTRR         WRITE THE RECORD
03012000 16706  067464         JMP INTN1        ENABL ETHE INTERRUPT AND EXIT
03013000 16707  042541  RCP2   JSM CHSEC        CHECK FOR SECURITY REQUEST
03014000 16710  067672         JMP RCP1
03015000 16711  042541  RCP5   JSM CHSEC        CHECK TO SEE IF SECURE REQUEST
03016000 16712  067674         JMP RCP4
03017000 16713  042541  RCP8   JSM CHSEC        CHECK SECURITY REQUEST
03018000 16714  067676         JMP RCP7
03019000                *
03020000                *
03021000                *    THIS ROUTINE CHECKS TO SEE IF THE PARAMETER ENTERED WAS AN
03022000                *         R - REGISTER
03023000                *
03024000                *       ON EXIT : RET 1 =PARAMETER WAS NOT AN R - REGISTER
03025000                *                 RET 2 =NO MORE PARAMETERS
03026000                *                 RET 3 =ANOTHER R-REGISTER
03027000                *               A=ADDRESS OF THE LAST WORD OF THIS R-REGISTER
03028000                *
03029000                *    TEMPORARIES USED : FLAGA (MRW1)
03030000                *
03031000                *    ROUTINES CALLED : REG., BMP1, GWTWH
03032000                *
03033000                *
03034000                *
03035000                *
03036000 16715  043735  REGCK  JSM REG.         IS THIS AN R - REGISTER ?
03037000 16716  170201         RET 1            NOT AN R - REGISTER
03038000 16717  042732         JSM BMP1         MOVE THE STACK POINTER BY ONE
03039000 16720  170202         RET 2            NO MORE PARAMETERS
03040000 16721  042703         JSM GWTWH        GET THE WHAT AND WHERE WORDS
03041000 16722  001756         LDA FLAGA
03042000 16723  170040         TCA
03043000 16724  020001         ADA B            IS B < FLAGA ?
03044000 16725  172003         SAP RCF5         SKIP IF B< FLAGA
03045000 16726  140404  ERR55  JSM AERR1,I      ILLEGAL PARAMETER
03046000 16727  032465         ASC 1,55
03047000 16730  043735  RCF5   JSM REG.         IS THIS AN R - REGISTER ?
03048000 16731  067726         JMP ERR55        NOT AN R - REFISTER
03049000 16732  000001         LDA B            YES AN R - REGISTER
03050000 16733  020144         ADA P3
03051000 16734  170203         RET 3
03052000                *
03053000                *
03054000                *
03055000                *    REG. CHECKS FOR THIS ENTRY BEING AN R - REGISTER
```

```
03056000                   *
03057000                   *
03058000 16735  042703  REG.  JSM GWTWH          GET THE WHAT WORD AND ABSOLUTE ADDRESS
03059000 16736  010270        CPA FVRHA          IS IT AN R-REGISTER?
03060000 16737  170202        RET 2              YES
03061000 16740  170201        RET 1              NO
03062000                   *
03063000                   *
03064000                   *
03065000                   *
03066000                   *    THIS ROUTINE CHECKS FOR S. VAR, ARRAYS, OR STRINGS ENTERED IN
03067000                   *         A RCF OR LDF STATEMENT.
03068000                   *
03069000                   *
03070000                   *
03071000                   *    ON ENTRY : ONLY SIMPLE VARIABLES, ARRAY ELEMENTS, ENTIRE
03072000                   *               ARRAYS  OR ENTIRE STRINGS ARE ALLOWED IF ANYTHING
03073000                   *               ELSE ERROR 55 IS GIVEN
03074000                   *
03075000                   *
03076000                   *    ON EXIT : THE NECESSARY CHECKS HAVE BEEN MADE AND THE DRIVER
03077000                   *          PARAMETERS ARE SET UP TO LOAD
03078000                   *
03079000                   *    TEMPORARIES USED : RELTH (MRW1+1), FLAGA (MRW1), LWMD(  (OP1+1)
03080000                   *            TVAR1, TVAR3, RECTP
03081000                   *
03082000                   *
03083000                   *    ROUTINES CALLED : BMP1, GWTWH, AERR1, CTYPE
03084000                   *
03085000                   *
03086000                   *
03087000                   *
03088000 16741  000305  RCFB  LDA ASTAK          SET THE POINTER TO THE COMPILE STACK
03089000 16742  031744        STA TVAR1
03090000 16743  000145        LDA P2
03091000 16744  031761        STA RECTP          DATA IS TYPE 2
03092000 16745  101272  RCFB9 LDA FAP1,I         MUST CHECK FOR VARIABLE
03093000 16746  172402        SAM RCF6
03094000 16747  067726        JMP ERR55          INVALID DATA LIST ON RCF OR LDF
03095000 16750  052750  RCF6  AND SATMP          CLEAR OUT THE LINK BITS
03096000 16751  010267        CPA FVRWM          IS THIS A S. VAR. OR ARRAY ELEMENT?
03097000 16752  066020        JMP RCFD           HERE IF SIMPLE VARIABLE OR ARRAY ELEMENT
03098000                   *
03099000                   *    THIS CODE IS FOR ARRAYS AND STRINGS
03100000                   *
03101000 16753  042452        JSM CTYPE          CHECK THE TYPE OF THIS ENTRY
03102000 16754  067775        JMP RCF3           THIS ENTRY NOT A STRING
03103000 16755  045742        ISZ TVAR3          THIS IS A STRING SO COUNT IT
03104000 16756  004144.       LDB P3
03105000 16757  035761        STB RECTP          SET TYPE TO 'MIXED DATA' IF STRING ENCOUNTERED
03106000 16760  001272        LDA FAP1           GET THE "WHAT" WORD
03107000 16761  020142        ADA P5             POINT AT THE STRING ADDRESS WORD
03108000 16762  100000        LDA A,I
03109000 16763  005744        LDB TVAR1          GET THE POINTER TO THE COMPILE STACK
03110000 16764  071402        XFR 3              TRANSFER THE FIRST THREE WORDS OF THE STRING'S
03111000                   *                     ORGANIZATION DATA
03112000 16765  024144        ADB P3             UPDATE THE POINTER
03113000 16766  035744        STB TVAR1
03114000 16767  104000        LDB A,I            GET THE STRING LENGTH
03115000 16770  024000        ADB A              CALCULATE THE LAST ADDRESS + 1
03116000 16771  045757        ISZ RELTH          IS THIS THE FIRST ENTRY ?
03117000 16772  066013        JMP RCF10          NO , NOT THE FIRST ENTRY
03118000 16773  024257        ADB M1             YES THE FIRST ENTRY
03119000 16774  066010        JMP RCF11          CONTINUE
03120000 16775  010171  RCF3  CPA ARRAY          IF HERE WE MUST HAVE AN ARRAY
03121000 16776  066000        JMP RCF8
03122000 16777  067726        JMP ERR55          UNKNOWN JUNK ENTERED
03123000 17000  001272  RCF8  LDA FAP1           MUST CALCULATE THE LAST ADDRESS TO BE LOADED
03124000 17001  020144        ADA P3             POINT A AT THE NO. OF WORDS TO BE RECORDED
03125000 17002  100000        LDA A,I            GET THE NO. OF WORDS TO BE RECORDED
03126000 17003  170040        TCA
03127000 17004  020254        ADA P1             B HAS THE ENDING ADDRESS
03128000 17005  020001        ADA B              CALCULATE THE ADDRESS OF THE START OF THE RECO
03129000 17006  045757        ISZ RELTH          IS THIS THE FIRST ONTRY
03130000 17007  066012        JMP RCF1           NO
03131000 17010  035743  RCF11 STB LWMD           THIS IS THE LAST WORD TO BE RECORDED
03132000 17011  066016        JMP RCFH
03133000 17012  024254  RCF1  ADB P1             SEE IF CONTIGUOUS
03134000 17013  015706  RCF10 CPB MBPTR
03135000 17014  066016        JMP RCFH
03136000 17015  066036        JMP ERR56          NOT CONTIGUOUS ERROR
03137000 17016  031706  RCFH  STA MBPTR
03138000 17017  066025        JMP RCFA
03139000 17020  045757  RCFD  ISZ RELTH          IS THIS THE FIRST ENTRY ?
03140000 17021  066032        JMP RCF2           NOT THE FIRST ENTRY
```

---- CASSETTE OPERATING SYSTEM ----

```
17022  001756        LDA FLAGA          YES - FIRST ENTRY
17023  020144        ADA P3
17024  031743        STA LWMD
17025  042732  RCFA  JSM BMP1           MOVE THE STACK POINTER BY ONE
17026  170201        RET 1              NO MORE PARAMETERS
17027  042703        JSM GWTWH          GET THE WHAT AND WHERE WORDS
17030  035756        STB FLAGA          SAVE THIS ADDRESS
17031  067745        JMP RCFBB
17032  001756  RCF2  LDA FLAGA          HERE IF NOT THE FIRST S. VARIABLE ENTRY
17033  020143        ADA P4
17034  011706        CPA MBPTR          CHECK FOR CONTIGUITY
17035  066040        JMP RCF7
17036  140404 ERR56  JSM AERR1,I        NOT CONTIGUOUS ERROR
17037  032466        ASC 1,56
17040  020150  RCF7  ADA M4             UPDATE MBPTR
17041  066016        JMP RCFH
                *
                *
                *
                *     LDP IS THE CASSETTE LOAD PROGRAMS STATEMENT, IT WILL
                *     CAUSE THE LOADED PROGRAM TO RUN AFTER LOADING
                *
                *
                *     TEMPORARIES USED : SEE LDF STATEMENT
                *
                *     ROUTINES CALLED : SEE LDF STATEMENT
                *
                *
                *
17042  000254  LDP1  LDA P1
17043  031761        STA RECTP          SET FLAG TO INDICATE THAT THE
17044  042565        JSM GTPAR          COMMAND IS A LOAD NOT A LINK
17045  140605        JSM ACHST,I        FIND THE FILE
17046  000141        LDA P6             FILE TYPE MUST BE A PROGRAM
17047  042714        JSM CHTP1
17050  066206        JMP LDP            IT IS PROGRAM
                *
                *
                *
                *     LDF IS THE CASSETTE LOAD FILE STATEMENT, FOR PROGRAMS AND DATA.
                *
                *     TEMPORARIES USED : RELTH, FLAGA, LWMD
                *
                *     ROUTINES CALLED : GTPAR, ACHST, CHTP1, BMP1, GWTWH, REGCK, RRMAX
                *                       NEWSZ, CALTH, RDREC, PRGLD, CHSIZ, AERR1, CTYPE
                *                       CKKBE, CHNT3, ACOUN
                *
                *
                *     FIRST CHECK FILE TYPE -- MUST BE :  6 = USER'S PROGRAM
                *                                         2 = NUMERIC DATA
                *                                         3 = MIXED STRING AND NUMERIC
                *
                *
                *
17051  042565  LDF   JSM GTPAR          GET THE FILE NUMBER
17052  000257        LDA M1             THIS MARKS THE FACT THAT
17053  031757        STA RELTH          WE HAVE ENTERED THIS ROUTINE
17054  140605        JSM ACHST,I
17055  001701        LDA RTYPE          SEE WHICH TYPE RECORD THIS IS
17056  010141        CPA P6             A PROGRAM FILE ?
17057  066202        JMP LDPX           YES A PRO GRAM FILE
17060  010145        CPA P2             IS THIS A NUMERIC DATA FILE ?
17061  066064        JMP LDF7           YES A NUMERIC DATA FILE
17062  000144        LDA P3             IS THIS A MIXED DATA FILE ?
17063  042714        JSM CHTP1          CHECK THE TYPE
                *
                *     LOAD DATA BEGINS HERE
                *
17064  042732  LDF7  JSM BMP1           MOVE THE STACK POINTER BY ONE
17065  066120        JMP LDF4           NO VARIABLES ENTERED - LOAD R0 ON
17066  042703        JSM GWTWH          GET THE WHAT ANT WHERE WORDS
17067  035756        STB FLAGA          SAVE THE ADDRESS
17070  035706        STB MBPTR
17071  043715        JSM REGCK          SEE IF THIS IS AN R - REG
17072  066100        JMP LDF27          NOT AN R-REGISTER
17073  066075        JMP LDF6           NO MORE PARAMETERS-ONLY ONE R-REG ENTERED
17074  066131        JMP LDF5           LOAD THIS
17075  042436  LDF6  JSM RRMAX          RESET THE RMAX POINTER , ONLY ONE R-REG.
                *                         ENTERED , LOAD FROM HERE ON
17076  042646        JSM NEWSZ
17077  066131        JMP LDF5
17100  043741 LDF27  JSM RCFB           TAKE CARE OR S. VARIABLES, ARRAYS AND STRINGS
17101  042626        JSM CALTH          CALCULATE THE LENGTH OF THE RECORD
```

---- CASSETTE OPERATING SYSTEM ----

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17102  042724        JSM CHSIZ         CHECK TO SEE IF THE RECORD WILL FIT
17103  005701        LDB RTYPE
17104  014144        CPB P3            IF THE FILE TYPE IS MIXED DATA , THE CSIZE MUST
17105  066114        JMP LDF8          MUST EQUAL THE ROOM IN MEMORY
17106  001700        LDA CSIZE
17107  170040        TCA
17110  021743        ADA LWMD          THIS IS BEING DONE TO FORCE A SHORT DATA FILE
17111  020254        ADA P1            TO BE LOADED INTO A LARGER ARRAY , WITH THE
17112  031706        STA MBPTR         FIRST ELEMENTS ALIGNING PROPERLY
17113  066134        JMP LDF2
17114  010177  LDF8  CPA P0            IF A=0 WE HAVE AN EXACT FIT
17115  066146        JMP LDF9          OK , CONTINUE
17116  140404  ERRSA JSM AERR1,I       ILLEGAL SET OF STRINGS IN DATA LIST
17117  051460        ASC 1,S0
17120  001701  LDF4  LDA RTYPE         MUST BE SURE THE DATA TO BE LOADED INTO
17121  020146        ADA M2            R-REGISTERS IS NUMERIC
17122  072074        RZA ERRSA         NOT NUMERIC IF SKIP - STRING
17123  001277        LDA ENDS          ONLY ONE REG PARAMETER OR NO PARAMETERS ON
17124  020254        ADA P1            LOAD COMMAND SO LOAD AT R0 ON
17125  031706        STA MBPTR
17126  042436        JSM RRMAX         RESET THE RMAX POINTER
17127  001263        LDA AP1           GET THE TOP OF THE EXECUTION STACK
17130  020257        ADA M1
17131  031743  LDF5  STA LWMD
17132  042626        JSM CALTH         CALCULATE THE EXPECTED LENGTH
17133  042724        JSM CHSIZ         SEE IF THE MEMORY SPACR IS LARGE ENOUGH
17134  042646  LDF2  JSM NEWSZ         MUST SET LWMD SO THAT ONLY CSIZE SECTION
17135  031743        STA LWMD          OF ARRAY HAS "???????" INSERTED
               *
               *
17136  005706  QUMRK LDB MBPTR         GET THE LOAD POINT
17137  002751  QSTM1 LDA QMRKS         GET THE ADDRESS OF THE QUESTION MARKS
17140  071403        XFR 4             WRITE THEM IN
17141  024052        ADB P128          ADJUST TO NEXT PARTITION
17142  001743        LDA LWMD          SEE IF WE ARE DONE
17143  170040        TCA
17144  020001        ADA B
17145  172472        SAM QSTM1         SKIP IF WE KEEP GOING
17146  042635  LDF9  JSM RDREC         READ THE RECORD
17147  000305        LDA ASTAK         GET THE ADDRESS OF THE TOP OF THE COMPILE STACK
17150  031744        STA TVAR1
17151  140610        JSM ACOUN,I       RESET FAP1 IN THE EXECUTION STACK
               *                       POINT AT FILE NUMBER (IF ANY)
17152  042732  LDP31 JSM BMP1          GET THE NEXT ENTRY
17153  066176        JMP LDF30         DONE = NO MORE ENTRIES
17154  042452        JSM CTYPE         WHAT TYPE IS THIS ENTRY ?
17155  066152        JMP LDP31         TYPE # STRING
17156  055704        DSZ EX2           TYPE = STRING , COUNT IT
17157  066160        JMP *+1           ALLOW FOR SKIP
17160  001272        LDA FAP1          GET THE "WHAT" WORD ADDRESS
17161  020142        ADA P5            POINT AT ADDRESS OF STRING
17162  100000        LDA A,I           GET ADDRESS
17163  004144        LDB P3            SET UP COUNTER
17164  035711        STB T1
17165  104000  LDP32 LDB A,I           GET ONE STRING ID WORD
17166  020254        ADA P1
17167  115744        CPB TVAR1,I       DOES THIS NEW O.D. WORD COMP WITH THAT EXPECTE
17170  066172        JMP *+2           YES
17171  066116        JMP ERRSA         NO - ERROR , THIS FILE CONTAINS AN IMPRIPER
               *                       STRING
17172  045744        ISZ TVAR1
17173  055711        DSZ T1
17174  066165        JMP LDP32         NOT DONE YET
17175  066152        JMP LDP31         DONE WITH THIS STRING
17176  001704  LDF30 LDA EX2           ARE ALL STRINGS DONE ON THIS FILE ?
17177  010177        CPA P0
17200  067464        JMP INTN1         YES, DONE
17201  066116        JMP ERRSA         ERROR - THIS FILE CONTAINS AN IMPROPER STRING.
               *
               *     LOAD DATA ENDS HERE
               *
               *
               *     LOAD PROGRAMMING BEGINS HERE
               *
               *     ROUTINES CALLED ONLY BY PROG. LOAD CODE :
               *               AFLNA, ARSGT, CLRDB, CHNTP, ACNIN, AERCS, ASSLN
               *
               *     TEMPORARIES USED : RECTP, TVAR2
               *
               *
               *
               *
17202  004177  LDPX  LDB P0            SEE IF AN LDF FROM KEYBOARD
17203  042736        JSM CKKBE
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3308000 17204  004263        LDB FLAG            YES A RUNNING PROGRAM , SET FLAG
3309000 17205  035761        STB RECTP           THIS FLAG DISI, LDP/LDF(PROG)/LDF(KEYBRD)
3310000               *
3311000 17206  042427  LDP   JSM STVFY           MUST CHECK IF THE STATE IS LEGAL
3312000 17207  042515  LDP18 JSM CHNTP           CHECK THE NEXT PARAMETER
3313000 17210  066246        JMP LDP10           NO MORE PARAMETERS
3314000 17211  067726        JMP ERR55           NON-NUMERIC PARQMETER ENCOUNTERED
3315000 17212  066242        JMP LDP51           LINE ADDRESS NOT FOUND
3316000 17213  031706  LDP19 STA MBPTR           START LOADING HERE
3317000 17214  031766        STA TVAR2           EXECUTE FROM HERE POSSIBLY
3318000 17215  042515        JSM CHNTP           GET THE STARTING LINE NUMBER
3319000 17216  066251        JMP LDP11           NO STARTING LINE NUMBER
3320000 17217  067726        JMP ERR55           NON-NUMERIC PARAMETER
3321000 17220  066221        JMP *+1             COULD NOT FIND LINE'S ADDRESS
3322000 17221  042270        JSM PRGLD           LOAD THE PROGRAM
3323000 17222  140513        JSM AFLNA,I         FIND THE LINE'S ADDRESS OF LINE IN TMP7
3324000 17223  066262        JMP ERR61           ERROR LINE NOT FOUND
3325000 17224  031766        STA TVAR2           SAVE THIS ADDRESS FROR THE RUN
3326000 17225  001761        LDA RECTP           SEE IF AN LDF FROM PROGRAM
3327000 17226  072411        SZA LDF16           SKIP IF AN LDF FROM KEYBOARD
3328000 17227  073426        RLA LDP41           LDP IF SKIP-DO A RUN OPERATION
3329000 17230  140360  LDF14 JSM ARSGT,I         RESET THE HS GTO ADDRESSES
3330000 17231  000145  LDF15 LDA P2              SET THE STATE TO "RUNNING PROGRAM"
3331000 17232  031257        STA CSTAT
3332000 17233  005766        LDB TVAR2           THIS IS THE "RUN" POINT
3333000 17234  035264        STB LEND            SET THE CONTINUE POINT FOR INTERP.
3334000 17235  000274        LDA AAEOL           SET ADDRESS OF EOL FOR INTERPRETURE
3335000 17236  067465        JMP INTN2           THIS WILL LOAD A INTO C
03336000 17237  042264  LDF16 JSM CLRDB          CLEAR THE RUN BIT OF CFLAG
03337000 17240  140425        JSM ACNIN,I        DO CONTINUE INITIALIZATION
03338000 17241  066231        JMP LDF15          DO A CONTINUE
03339000 17242  024254  LDP51 ADB P1             B HAS LAST LINE NUMBER OF PROGREAM
03340000 17243  015233        CPB TMP7           IS B WITHIN ONE OF LINE NUMBER IN TMP7?
03341000 17244  066213        JMP LDP19          YES SO CONTINUE
03342000 17245  064722        JMP ERLNF          BAD LINE NUMBER
03343000 17246  001307  LDP10 LDA FWUP
03344000 17247  031706        STA MBPTR          THIS IS THE LOAD POINT
03345000 17250  031766        STA TVAR2          THIS IS THE EXECUTION POINT
03346000 17251  042270  LDP11 JSM PRGLD          LOAD THE PROGRAM
03347000 17252  001761        LDA RECTP          DO WE HAVE AN LDF FROM KEYBOARD
03348000 17253  072404        S7A LDF18          SKIP IF YES
03349000 17254  172454  LDF13 SAM LDF14          IF THIS IS AN LDP OR AN LDF FROM
03350000               *                         KEYBOARD, SKIP IFLDF FROM KEYBOARD
03351000 17255  140421  LDP41 JSM AERCS,I        IMITIALIZE THE RUN
03352000 17256  066231        JMP LDF15
03353000 17257  042264  LDF18 JSM CLRDB          CLEAR THE "RUN" BIT OF CFLAG
03354000 17260  140514        JSM ASLLN,I        RESET LNO
03355000 17261  067464        JMP INTN1          DONE, RETURN
03356000 17262  140404  ERR61 JSM AERR1,I        LINE NOT FOUND-IGNORE LINE NUMBER IN DISPLAY
03357000 17263  033061        ASC 1,61
03358000               *
03359000               *
03360000               *
03361000               *
03362000               *     CLRDB CLEARS THE "RUN" BIT OF CFLAG
03363000               *
03364000               *
03365000               *
03366000 17264  001232  CLRDB LDA CFLAG
03367000 17265  050151        AND M5              THE BIT IN QUESTION IS BIT 2
03368000 17266  031232        STA CFLAG
03369000 17267  170201        RET 1
03370000               *
03371000               *
03372000               *
03373000               *     PRGLD LOADS USER'S PROGRAMMING
03374000               *
03375000               *     ON ENTRY : MBPTR SET UP; TAPE POSITIONED
03376000               *
03377000               *     ON EXIT : USER'S PROGRAMMING IS LOADED IF NO ERRORS OCCURED
03378000               *
03379000               *
03380000               *     TEMPORARIES USED : FLAGA, RECTP, TVAR1
03381000               *
03382000               *
03383000               *     ROUTINES CALLED : RDREC, AZRWM, AMPML, SSCHK, AERR1, AERAV, NEWSZ
03384000               *                       AMPUP, ASSLN
03385000               *
03386000               *
03387000               *
03388000 17270  001761  PRGLD LDA RECTP           IS THIS  AN LDF FROM PROGRAM
03389000 17271  172004        SAP PRG17           SKIP IF NOT LDF FROM PROGRAM
03390000 17272  000254        LDA P1              SET THIS FOR JUMP THROUGH LOADL
03391000 17273  031063        STA NPROG           TO ALERT ROMS
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03392000 17274  042376        JSM SSCHK          CHECK FOR GSB OVERLAYS AND JMP LOADL
03393000 17275  074560  PRG17 WBC A,I            MUST NOT ALLOW ANY STATEMENTS AFTER  LDF
03394000 17276  010053        CPA B177           SINCE THEY WILL NOT BE EXECUTED
03395000 17277  066302        JMP PRGL7
03396000 17300  140404  ERR50 JSM AERR1,I
03397000 17301  032460        ASC 1,50
03398000                *
03399000 17302  101706  PRGL7 LDA MBPTR,I        GET THE BRIDGE THAT NEEDS TO BE CHANGED LATER
03400000 17303  050215        AND BXCMM          CLEAR LOW ORDER BITS, TRACE BIT AND STOP BIT
03401000 17304  031756        STA FLAGA          SAVE THE BRIDGE HALF
03402000 17305  001761        LDA RECTP          IF LDP DO ERASE VARIABLES
03403000 17306  073002        SLA PRG13
03404000 17307  140472        JSM AERAV,I        ERASE THE VARIABLES
03405000 17310  042646  PRG13 JSM NEWSZ          CALCULATE MBPTR + CSIZE -1
03406000 17311  170040        TCA                SEE IF WE NEED TO MOVE THE R-REGISIERS
03407000 17312  021277        ADA ENDS           BY CHECKING IF MBPTR+CSIZE-1>ENDS
03408000 17313  172012        SAP PRG11          SKIP IF WE MOVE THE R-REGISTERS LOWER
03409000 17314  042646        JSM NEWSZ          CALC. MBPTR+CSIZE-1 -> A
03410000 17315  005277        LDB ENDS           CALC. (MBPTR+CSIZE-1)+(RMAX-ENDS) AS NEW RMAX
03411000 17316  174040        TCB
03412000 17317  025310        ADB RMAX
03413000 17320  020001        ADA B
03414000 17321  030017        STA D
03415000 17322  005277        LDB ENDS           AND ENDS AS THE LAST WORD TO BE MOVED
03416000 17323  140465        JSM AMPUP,I        MOVE THE R-REGISTERS HIGHER, RESET ENDS, RMAX
03417000 17324  066333        JMP PRG15
03418000 17325  001277  PRG11 LDA ENDS           MUST MOVE R-REG LOWER
03419000 17326  020254        ADA P1
03420000 17327  030016        STA C
03421000 17330  042646        JSM NEWSZ
03422000 17331  034017        STB D
03423000 17332  140466        JSM AMPML,I        MOVE R-REG LOWER, RESET ENDS, RMAX
03424000 17333  005277  PRG15 LDB ENDS           THIS IS THE END OF THE LOAD
03425000 17334  001706        LDA MBPTR          SET START AND END ADDRESSES
03426000 17335  140471        JSM AZRWM,I        ZERO THIS AREA
03427000 17336  000177        LDA P0             SET THIS TO DETECT PARTITION ERROR
03428000 17337  031744        STA TVAR1
03429000 17340  001706        LDA MBPTR          SEE IF THE SECURITY FLAG NEEDS UPDATING
03430000 17341  011307        CPA FWUP
03431000 17342  066345        JMP PRGL3          UPDATE SECURITY FLAG
03432000 17343  001315        LDA STYFG          IS SECURE ?
03433000 17344  072003        RZA PRGL4          SKIP IF CALCULATOR IS SECURE ALREADY
03434000 17345  001703  PRGL3 LDA EXISF          UPDATE THE SECURITY FLAG
03435000 17346  031315        STA STYFG
03436000 17347  042635  PRGL4 JSM RDREC          READ THE RECORD
03437000 17350  101277  PRG16 LDA ENDS,I         MAKE SURE THE LAST LINE BRIDGE IS SET RIGHT
03438000 17351  050167        AND M128           CLEAR LOW ORDER BITS (NO PROG. BELOW)
03439000                *                        AND SAVE THE STOP BIT
03440000 17352  131277        STA ENDS,I         RESTORE THE LINE BRIDGE
03441000 17353  101706        LDA MBPTR,I        GET NEW LINE BRIDGE
03442000 17354  050250        AND BM377          CLEAR HIGH ORDER BITS
03443000 17355  061756        IOR FLAGA          COMBINE THE BRIDGE SECTIONS
03444000 17356  131706        STA MBPTR,I        RESTORE THE CORRECTED LINE BRIDGE
03445000                *
03446000                *     THIS CODE IS TO CLEAR OUT THE TRACE AND STOP BITS
03447000                *
03448000 17357  005704        LDB EX2            GET THE CLEAR - SAVE DEBUG BITS FLAG
03449000 17360  077412        RLB PRGL5          IF THE BIT IS SET KEEP THE DEBUG BITS
03450000 17361  005706        LDB MBPTR          START HERE TO CLEAR OUT THE DEBUG BITS
03451000 17362  100001  PRGL6 LDA B,I            GET THE LINE BRIDGE
03452000 17363  050213        AND TMASK          MASK OFF THE TRACE AND STOP BITS
03453000 17364  130001        STA B,I            RESTORE THE LINE BRIDGE
03454000 17365  015277        CPB ENDS           ARE WE DONE WITH PROGRAM?
03455000 17366  066372        JMP PRGL5          YES DONE
03456000 17367  050053        AND B177           GET THE BRIDGE'S LINK DOWN TO CALC.
03457000 17370  024000        ADB A              THE NEXT LINE'S ADDRESS
03458000 17371  066362        JMP PRGL6          CONTINUE
03459000 17372  055744  PRGL5 DSZ TVAR1          IF TVAR1=1 AT THIS POINT, A PARTITION ERROR
03460000                *                        HAS OCCURED
03461000 17373  170201  PRG10 RET 1
03462000 17374  140514        JSM ASLLN,I        RESET LNO
03463000 17375  067413        JMP ERR46          PARTITION ERROR IN USER'S PROGRAM - RECOVERY
03464000                *
03465000                *
03466000                *
03467000                *
03468000                *     SSCHK CHECKS THROUGH THE GSB STACK FOR THE RETURNS
03469000                *
03470000                *     IS NPROG=1 IT IS TO CHECK FOR GSB RETURN OVERLAYS IF THE
03471000                *     PRESENT FILE IS LOADED OVER THE CURRENT PROGRAM
03472000                *     IF AN OVERLAY CONDITION IS ENCOUNTERED, ERROR 63 IS GIVEN
03473000                *
03474000                *     IF NPROG=0 IS TO ADJUST THE RETURNS ON THE GSB STACK BY THE
03475000                *     OFFSET IN TVAR1
03476000                *
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```
                      *     TEMPORARIES USED : TVAR1
                      *
                      *     ROUTINES CALLED : LNKSB
                      *
                      *
                      *
17376   001261  SSCHK LDA AP3           GET THE TOP OF THE STACK
17377   104000  SSCH3 LDB A,I           GET THE OLD AP2
17400   014257        CPB M1            IF THIS ENTRY IS A M1, WE ARE DONE
17401   066764        JMP LNKSB         IF DONE JUMP THROUGH LOAD=LINK
17402   020144        ADA P3            LOOK AT THE RETURN ADDRESS
17403   104000        LDB A,I
17404   014334        CPB ADR0          SEE IF WE HAVE A GSB FROM KEYBOARD
17405   066423        JMP SSCH1         BYPASS TEST IF TRUE
17406   055063        DSZ NPROG         IF NPROG=1 WE HAVE AN OVERLAY TEST CONDITION
17407   066417        JMP SSCH2         DO THE NECESSARY ADJUSTMENT
17410   045063        ISZ NPROG         RESET THE FLAG
17411   176601        SBM *+1,C         CLEAR THIS ADDRESS FOR THE API ROM
17412   174040        TCB
17413   025706        ADB MBPTR
17414   176007        SBP SSCH1
17415   140404  ERR63 JSM AERR1,I
17416   033063        ASC 1,63
17417   045063  SSCH2 ISZ NPROG         RESET THE FLAG
17420   066421        JMP *+1
17421   025744        ADB TVAR1
17422   134000        STB A,I
17423   020147  SSCH1 ADA M3            MUST RETURN TO OLD AP3 AND CONTINUE
17424   100000        LDA A,I
17425   021300        ADA AP2           ADD IN OFFSET TO ADJUST FOR RELATIVE ADDRESS
17426   066377        JMP SSCH3
                      *
                      *
                      *
                      *
                      *
                      *     STVFY  CHECKS WHETHER THE STATE IS RIGHT FOR THE
                      *     CASSETTE OPERATION IN QUESTION
                      *
                      *
17427   001257  STVFY LDA CSTAT         GET THE "STATE" INDICATOR
17430   010254        CPA P1            STATE=1 IS LEGAL
17431   170201        RET 1
17432   010145        CPA P2            STATE=2 IS LEGAL
17433   170201        RET 1
17434   140404  ERR64 JSM AERR1,I       ANY OTHER STATE IS ILLEGAL
17435   033064        ASC 1,64
                      *
                      *
                      *
                      *     RRMAX RESETS THE RMAX POINTER AFTER R - REGISTERS HAVE BEEN LOADE
                      *
                      *
                      *     ON ENTRY : MBPTR SET, CSIZE SET, REGISTERS NOT LOADED YET
                      *
                      *
                      *     ON EXIT : RMAX UPDATED IF MBPTR + CSIZE - 1 > RMAX
                      *               ELSE RMAX LEFT AS WAS
                      *
                      *
                      *     TEMPORARIES USED : NONE
                      *
                      *     ROUTINES CALLED : NEWSZ
                      *
                      *
                      *
17436   042646  RRMAX JSM NEWSZ
17437   004000        LDB A
17440   170040        TCA
17441   021310        ADA RMAX
17442   172006        SAP RMX1
17443   001263        LDA AP1           GET TOP OF STACK POINTER
17444   170040        TCA
17445   020001        ADA B             SEE IF WE HAVE MEMORY OVERFLOW
17446   172003        SAP RMX2          SKIP IF OVERFLOW
17447   035310        STB RMAX
17450   170201  RMX1  RET 1
17451   066730  RMX2  JMP ERR62         MEMORY OVERFLOW ERROR
                      *
                      *
                      *     CTYPE CHECKS THE TYPE OF THE ENTRY IN THE EXECUTION STACK
                      *           AND SPECIFIES STRING OR NON-STRING ON EXIT
                      *
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---- CASSETTE OPERATING SYSTEM ----

```
03560000                      *
03561000                      *      ON ENTRY : FAP1 POINTS TO THE ENTRY IN QUESTION
03562000                      *
03563000                      *      ON EXIT : RET 1 = NON-STRING ENTRY AT FAP1
03564000                      *                RET 2 = STRING ENTRY AT FAP1
03565000                      *
03566000                      *
03567000                      *      TEMPORARIES USED : NONE
03568000                      *
03569000                      *      ROUTINES CALLED : GWTWH
03570000                      *
03571000                      *
03572000                      *
03573000 17452  042703  CTYPE JSM GWTWH           GET THE WHAT WORD
03574000 17453  012747        CPA B151K           CHECK FOR A STRING
03575000 17454  170202        RET 2
03576000 17455  012746-       CPA B150K           CHECK FOR A STRING
03577000 17456  170202        RET 2
03578000 17457  170201        RET 1               NON-STRING
03579000                      *
03580000                      *
03581000                      *      WTRR WRITE A RECORD ON THE CASSETTE.
03582000                      *
03583000                      *      ON ENTRY* STARTING MEMORY ADDRESS IN  'MBPTR'
03584000                      *                    FILE NUMBER IN "RECNO=T13"
03585000                      *                    LENGTH OF RECORD IN WORDS IN 'RELTH'
03586000                      *                    FINAL SECURITY STATUS IN 'SEFLG'
03587000                      *                    FINAL RECORD TYPE IN      'RECTP'
03588000                      *          ON EXIT : RGCORD IS WRITTEN IF NO ERRORS AND TAPE
03589000                      *                    POSITION IS IN BODY OF CURRENT RECORD
03590000                      *                    THIS COMMAND IS ENTIRELY UNDER BPC CONTROL
03591000                      *
03592000                      *
03593000                      *      TEMPORARIES USED : RELTH (MRW1*1), RECTP (MRW1*3), TVAR3 (OP1)
03594000                      *                         SEFLG (MRW1*2)
03595000                      *      ROUTINES CALLED : CPTP, ERDS0, ACHST, WTRA, VREC ,AERR1, ERDS0
03596000                      *
03597000                      *
03598000                      *
03599000                      *
03600000 17460  142773  WTRR  JSM CRTP,I          IS THE CARTRIDGE PROTECTED?
03601000 17461  043347        JSM ERDS0           YES, GENERATE ERROR AND TERMINATE
03602000 17462  001757        LDA RELTH
03603000 17463  020146        ADA M2              MUST CHECK FOR NOTHING TO LOAD FOR KEYS AND
03604000 17464  172427        SAM ERR59           PROGRAM
03605000 17465  140605        JSM ACHST,I
03606000 17466  001757        LDA RELTH
03607000 17467  170040        TCA
03608000 17470  021677        ADA ASIZE           IF THE RESULT IS POSITIVE, FILE WILL FIT
03609000 17471  172002        SAP WTRR2
03610000 17472  067426        JMP ERR49           FILE WILL NOT FIT ERROR
03611000 17473  001757  WTRR2 LDA RELTH           SET UP THE RECORD LENGTH
03612000 17474  031700        STA CSIZE
03613000 17475  001761        LDA RECTP           SETUP THE RECORD TYPE
03614000 17476  031701        STA RTYPE
03615000 17477  001742        LDA TVAR3           MUST REMEMBER THIS FOR RCF,LDF AND ROMWD
03616000 17500  031704        STA EX2
03617000 17501  001760        LDA SEFLG           UPDATE SECURITY FLAG
03618000 17502  031703        STA EX1SF
03619000                      *                   AUTO - VERIFY
03620000 17503  142774        JSM WTRA,I          WRITE THE RECORD
03621000 17504  043347        JSM ERDS0           CHECK FOR ERRORS
03622000 17505  001344        LDA AVFLG           IS AUTOVERIFY ON -> -1 = NO, ZERO = YES
03623000 17506  172402        SAM WTRR1
03624000 17507  043227        JSM VREC            VERIFY THE RECORD
03625000 17510  170201  WTRR1 RET 1
03626000 17511  140404  ERR44 JSM AERR1,I         VERIFY FAILED
03627000 17512  032064        ASC 1,44
03628000 17513  140404  ERR59 JSM AERR1,I         NOTHING TO RECORD
03629000 17514  032471        ASC 1,59
03630000                      *
03631000                      *
03632000                      *
03633000                      *
03634000                      *
03635000                      *
03636000                      *
03637000                      *
03638000                      *      CHNTP BUMPS THE EXECUTION STACK POINTER, FAP1,CHECKS FOR
03639000                      *            ANOTHER PARAMETER ON THE STACK. IF A PARAMETER, GET IT.
03640000                      *            IF THE PARAMETER IS NUMERIC, EVALUATE IT (MAKE IT FIXPT)
03641000                      *            IF NON-NUMERIC, RET 2
03642000                      *            THEN FIND THE LINE ADDRESS CORRESPONDING TO THE NUMERIC
03643000                      *            PARAMETER.
03644000                      *
```

```
03645000                  *
03646000                  *       ON ENTRY : EXEC. STACK POINTER POINTS AT THE PREVIOUS PARAMETER
03647000                  *                  ENTRY
03648000                  *        ON EXIT:  RET 1 IF NO MORE PARAMETERS.
03649000                  *                  RET 2 IF THE PARAMETER ON THE STACK WAS NON-NUMERIC
03650000                  *                  RET 3 : IF THE LINE ADDRESS COULD NOT BE FOUND, A=ENDS
03651000                  *                  RET 4 : IF THE LINE ADDRESS COULD BE FOUND, THEN REG A
03652000                  *                  CONTAINS THE ADDRESS OF THE LINE'S BRIDGE
03653000                  *
03654000                  *
03655000                  *
03656000                  *       TEMPORARIES USED : NONE
03657000                  *
03658000                  *       ROUTINES CALLED : BMP1, NGET, FIXPT-1, AFLNA, AERR1
03659000                  *
03660000                  *
03661000                  *
03662000 17515  042732  CHNTP JSM BMP1
03663000 17516  170201        RET 1             RETURN IF NO MORE PARAMETERS ON STACK
03664000 17517  040751  CHNP2 JSM NGET          GET THE PARAMETER
03665000 17520  170202        RET 2             NON-NUMERIC PARAMETER ON STACK
03666000 17521  040643        JSM FIXPT-1       CONVERT THE NUMBER TO A FIXED POINT NUMBER
03667000 17522  173413        SOS ERR11         OVERFLOW ERROR
03668000 17523  176414        SRM ERR19         IF LINE NUMBER IS NEGATIVE - ERROR
03669000 17524  035233        STB TMP7
03670000 17525  076404        S7B CHNP3         IF ZERO START AT FWUP ALWAYS
03671000 17526  140513        JSM AFLNA,I       FIND THE LINE ADDRESS
03672000 17527  066533        JMP CHNP4         LINE ADDRESS COULD NOT BE FOUND
03673000 17530  170204        RET 4             RESTORE A AND RETURN
03674000 17531  001307  CHNP3 LDA FWUP          START HERE
03675000 17532  170204        RET 4
03676000 17533  001277  CHNP4 LDA ENDS          LINE ADDRESS NOT FOUND SO SET A TO ENDS
03677000 17534  170203        RET 3
03678000 17535  140404  ERR11 JSM AERR1,I       FIXED POINT OVERFLOW ERROR
03679000 17536  030461        ASC 1,11
03680000 17537  140404  ERR19 JSM AERR1,I       BAD LINE NUMBER
03681000 17540  030471        ASC 1,19
03682000                  *
03683000                  *
03684000                  *        CHSEC GETS THE 'SE' OR 'DB' STRING FROM THE EXECUTION STACK, AND
03685000                  *              CHECKS FOR VALIDITY, IF VALID THEN SEFLG IS SET TO -1
03686000                  *              OR TVAR3=1, OTHERWISE THEY ARE LEFT UNCHANGED
03687000                  *              THIS ROUTINE IS CALLED BY THE RCF ROUTINE
03688000                  *
03689000                  *
03690000                  *        ON ENTRY : FAP1 POINTS TO SUSPECTED ENTRY IN EXECUTION STACK
03691000                  *
03692000                  *        ON EXIT : SEFLG OR TVAR3 IS SET IF NO ERRORS OCCURED.
03693000                  *                  THEY ARE NOT ALTERED IF ERRORS OCCURED
03694000                  *
03695000                  *
03696000                  *        TEMPORARIES USED : NONE
03697000                  *
03698000                  *        ROUTINES CALLED : GWTWH
03699000                  *
03700000                  *
03701000                  *
03702000 17541  042703  CHSEC JSM GWTWH         GET THE WHAT AND WHERE
03703000 17542  170513        SAR 12            LOOK AT THE CLASS
03704000 17543  010143        CPA P4            IF A=4 WE ARE OK
03705000 17544  066546        JMP CHSE1
03706000 17545  067670  SEDBE JMP ERR58         INVALID "SE" OR "DB" PARAMETER
03707000 17546  034017  CHSE1 STB D             B POINYS TO STRING
03708000 17547  074570        WBD A,I           GET THE FIRST CHARACTER
03709000 17550  170607        SAL 8
03710000 17551  074571        WBD B,I           GET THE SECOND CHARACTER
03711000 17552  060001        IOR B             MAKE COMPOSITE WORD
03712000 17553  020246        ADA AMSE          ADD IN -"SE"
03713000 17554  072004        RZA CHSEE         SKIP IF INVALID "SE"
03714000 17555  000257        LDA M1            SET SECURE
03715000 17556  031760        STA SEFLG
03716000 17557  170201        RET 1
03717000 17560  020232  CHSEE ADA B7403         DO WE HAVE A "DB" REQUEST
03718000 17561  072064        RZA SEDBE         SKIP IF ERROR
03719000 17562  000254        LDA P1            A "DB" REQUEST SO MARK IT
03720000 17563  031742        STA TVAR3
03721000 17564  170201        RET 1
03722000                  *
03723000                  *        GTPAR GETS THE FIRST PARAMETER ON THE EXECUTION STACK
03724000                  *
03725000                  *         ON EXIT :  B AND RECNO CONTAIN THE FIRST PARAMETER
03726000                  *                    IF THERE IS NO PARAMETER ENTERED, ZERO IS ASSUMED
03727000                  *
```

```
                       *
                       *
                       *       TEMPORARIES USED : RECNO, SEFLG
                       *
                       *       ROUTINES CALLED : NGET, FIXPT-1, CFD, CNULL, AERR1
                       *
                       *
17565   042605   GTPAR JSM CFD              COMPLETE ANY PENDING FINDS
17566   042611   GTPR2 JSM CNULL            CHECK FOR THE NULL PARAMETER AND CALL COUNT
17567   066601         JMP GTPR5            WE HAVE A NULL SO LOAD OR RECORD AT  FILE 0
17570   040751   GTPR1 JSM NGET             GET THE FIRST PARAMETER
17571   067726   GTPR4 JMP ERR55            IF WE GET HERE - BAD ERROR !!!!
17572   040643   GTPR3 JSM FIXPT-1          CONVERT FROM FLOAT TO FIXED
17573   173442         SOS ERR11            OVERFLOW ERROR
17574   176407         SBM ERR53            IF MINUS - ERROR
17575   035725   GTPR6 STB RECNO
17576   000177         LDA P0               CLEAR THE SECURITY FLAG TEMPORARY
17577   031760         STA SEFLG
17600   170201   BMP2  RET 1
17601   004177   GTPR5 LDB P0               WE HAVE A NULL SO SET FILE TO 0
17602   066575         JMP GTPR6            CONTINUE
17603   140404   ERR53 JSM AERR1,I          CASSETTE PARAMETER IS NEGATIVE
17604   032463         ASC 1,53
                       *
                       *
                       *
                       *       THIS ROUTINE WILL SET THE PA FOR THE CASSETTE AND
                       *       COMPLETE ANY PENDING FINDS ON THE SELECT CODE*
                       *       CSELC
                       *
                       *
                       *
17605   042665   CFD   JSM STPRA
17606   142767         JSM CFDA,I
17607   043347         JSM ERDS0
17610   170201         RET 1
                       *
                       *
                       *
                       *       CNULL CHECKS THE ENTERED PARAMETER FOR THE NULL , IF NULL
                       *       THEN - RET 1
                       *       ELSE - RET 2
                       *
                       *
                       *       TEMPORARIES USED : NONE
                       *
                       *       ROUTINES CALLED : ACOUN
                       *
                       *
                       *
17611   140610   CNULL JSM ACOUN,I          SET FAP1 AND COUNT THE PARAMETERS ENTERED
17612   010177         CPA P0               IF A=0 WE HAVE NO NUMERIC PARAMETERS
17613   066615         JMP CNLL1            IF NO NUMERIC WE MUST SEE IF NULL
17614   170202         RET 2
17615   101272   CNLL1 LDA FAP1,I           GET "WHAT"
17616   170513         SAR 12               LOOK AT CLASS
17617   010140         CPA P7               SEE IF NULL
17620   170201         RET 1                NULL PARAMETER OK
17621   067726         JMP ERR55            NOT NUMERIC AND NOT NULL SO ERROR
                       *
                       *
                       *
                       *       STPRL SETS UP POINTERS FOR RECORD AND LOAD MEMORY STATEMENTS
                       *
                       *       ON EXIT : STARTING ADDRESS IS SET UP
                       *                 ENDING ADDRESS IS SET UP
                       *
                       *
                       *
                       *       TEMPORARIES USED : LWMD (OP1+1)
                       *
                       *       ROUTINES CALLED : NONE
                       *
                       *
                       *
17622   000300   STPRL LDA AJSTK            THIS IS THE END OF MEMORY DUMP (JSM STACK+1)
17623   031743         STA LWMD
17624   001305         LDA OFWAM            THIS IS THE PERMANENT START OF USER'S MEMORY SP
17625   031706         STA MBPTR
                       *
                       *
                       *       CALTH  CALCULATES THE LEGTH IN WORDS OF A SECTION OF MEMORY
                       *                 (LWMD - MBPTR + 1)
                       *
```

```
3812000                  *     ON ENTRY: MBPTR CONTAINS THE STARTING ADDRESS
3813000                  *                LWMD CONTAINS THE ENDING ADDRESS
3814000                  *
3815000                  *     ON EXIT:  LENGTH IN RELTH
3816000                  *
3817000                  *
3818000                  *     TEMPORARIES USED : LWMD (OP1+1), RELTH (MRW1+1)
3819000                  *
3820000                  *     ROUTINES CALLED : NONE
3821000                  *
3822000                  *
3823000                  *
3824000 17626  001743  CALTH LDA LWMD
3825000 17627  005706        LDB MBPTR          CALCULATE THE RECORD LENGTH AS:
3826000 17630  174040        TCB
3827000 17631  020001        ADA B              LWMD - MBPTR + 1
3828000 17632  020254        ADA P1
3829000 17633  031757        STA RELTH          STORE RESULT IN RELTH
3830000 17634  170201        RET 1
3831000                  *
3832000                  *
3833000                  *
3834000                  *
3835000                  *
3836000                  *     RDREC SETS THE NUMBER  OF TRIES AT READING, WITH RECOVERY IF
3837000                  *     ERRORS ARE ENCOUNTERED.
3838000                  *
3839000                  *
3840000                  *     ON ENTRY : ALL POINTERS ARE SET UP FOR READING A RECORD
3841000                  *                AND THE TAPE IS POSITIONED PROPERLY
3842000                  *
3843000                  *
03844000                 *     ON EXIT : THE RECORD IS READ
03845000                 *               IF ERRORS OCCURED, RECOVERY HAS BEEN ATTEMPTED
03846000                 *
03847000                 *
03848000                 *     TEMPORARIES USED : LDTRS (MRW1+4), INSTR (T11)
03849000                 *
03850000                 *     ROUTINES CALLED : ACHST, RBDYA, ERDS0
03851000                 *
03852000                 *
03853000                 *
03854000                 *
03855000 17635  001343  RDREC LDA NOTRY          SET THE NUMBER OF READ TRIES
03856000 17636  031762        STA LDTRS
03857000 17637  002745        LDA STBCD          STB PTR,I COMMAND FOR LOADING
03858000 17640  031723        STA INSTR
03859000 17641  140605  RDRC1 JSM ACHST,I        REPOSITION THE TAPE
03860000 17642  142775        JSM RBDYA,I        READ THE RECORD
03861000 17643  043347        JSM ERDS0          CHECK FOR ERRORS
03862000 17644  170201        RET 1              SUCCESSFUL READ
03863000 17645  066641        JMP RDRC1          READ ERROR - DO AGAIN
03864000                 *
03865000                 *
03866000                 *     NEWSZ CALCULATES (MBPTR+CSIZE TO B) -1 TO A
03867000                 *
03868000                 *
03869000                 *     ON ENTRY : MBPTR AND CSIZE ARE SET UP
03870000                 *
03871000                 *     ON EXIT : CALCULATION IS DONE
03872000                 *
03873000                 *     TEMPORARIES USED : NONE
03874000                 *
03875000                 *     ROUTINES CALLED : NONE
03876000                 *
03877000                 *
03878000                 *
03879000 17646  005706  NEWSZ LDB MBPTR
03880000 17647  001700  NWSZ1 LDA CSIZE
03881000 17650  020001        ADA B
03882000 17651  004000        LDB A
03883000 17652  020257        ADA M1
03884000 17653  170201        RET 1
03885000                 *
03886000                 *
03887000                 *
03888000                 *
03889000                 *     LDXI CHECKS FOR (,X) PARAMETER, CONVERTS FLAGA TO FLOAT, AND
03890000                 *          TRANSFERS THE FLOATING POINT NUMBER TO (,X)
03891000                 *
03892000                 *
03893000                 *
03894000                 *     ON ENTRY : FAP1 POINTS AT PREVIOUS 'WHAT' WORD
03895000                 *                FLAGA CONTAINS THE FIXED POINT NUMBER TO BE CONVERTED.
```

```
                          *
                          *      ON EXIT :   RET 1 - NO MORE PARAMETERS
                          *                  RET 2 - TRANSFER COMPLETE
                          *
                          *
                          *      TEMPORARIES USED : FLAGA (MRW1)
                          *
                          *      ROUTINES CALLED : BMP1, AFLTP, GWTWH, AASTR
                          *
                          *
                          *
17654   035756   LDX3   STB FLAGA
17655   042732   LDXI   JSM BMP1            MOVE THE STACK POINTER
17656   170201          RET 1               RETURN IF NO MORE PARAMETERS
17657   005756          LDB FLAGA           GET THE NUMBER
17660   140563   LDX2   JSM AFLTP,I         CONVERT TO FLOATING POINT NUMBER
17661   042703          JSM GWTWH           GET THE WHAT AND WHERE WORD
17662   000127          LDA ADR2            SOURCE ADDRESS
17663   140372          JSM AASTR,I         TRACE THE ASSIGNMENT
17664   170202          RET 2               DONE - FULL PRECISION TRANSFER
                          *
                          *
                          *      STPRA SETS THE PERIPHERIAL ADDRESS FOR THE CASSETTE
                          *      AND DISABLES THE INTERRUPT SYSTEM
                          *
                          *
                          *      ON ENTRY : CSELC CONTAINS THE CURRENT SELECT CODE FOR CASSETTES
                          *
                          *      ON EXIT : PA = CSELC
                          *                INTERRUPT IS DISABLED
                          *
                          *
                          *      TEMPORARIES USED : SVC, FLG2
                          *
                          *      ROUTINES CALLED : NONE
                          *
                          *
17665   070430   STPRA  DIR                 MUST CHECK TO SEE IF DMA IS NOT USED
17666   000013          LDA DMAPA           IF DMAPA IS ZERO WE CAN PROCEED
17667   072405          SZA STPA1           IF THE DMAPA IS ZERO THEN DMA IS AVAILABLE
17670   011345          CPA CSCF            IF DMA IS BUSY BUT A CASSETTE IS USING IT, WE
17671   066674          JMP STPA1           CAN PROCEED
17672   070420          EIR                 WE MUST WAIT FOR DMA TO COMPLETE
17673   066665          JMP STPRA
17674   001514   STPA1  LDA CSELC           GET THE CASSETTE'S SELECT CODE
17675   030011          STA PA
17676   000016          LDA C               SAVE THE C REGISTER
17677   031735          STA SVC
17700   000177          LDA P0
17701   031764          STA FLG2            CLEAR THE FIND SELECT FLAG
17702   170201          RET 1
                          *
                          *
                          *      GWTWH GETS THE "WHAT" AND THE "WHERE" WORDS FROM THE EXEC. STACK
                          *
                          *      ON ENTRY : FAP1 IS POINTING AT THE "WHAT " WORD DESIRED
                          *
                          *      ON EXIT : REGISTER A CONTAINS THE "WHAT " WORD
                          *                REGISTER B CONTAINS THE "WHERE" WORD
                          *
                          *
                          *      TEMPORARIES USED : ABSAD
                          *
                          *      ROUTINES CALLED : NONE
                          *
                          *
                          *
17703   005272   GWTWH  LDB FAP1            SET B TO POINT AT PROPER ENTRY
17704   040616          JSM ABSAD+1         GET THE ABSOLUTE ADDRESS OF THE ENTRY
17705   101272          LDA FAP1,I          GET THE WHAY WORD
17706   052750          AND SATMP           CLEAR OUT THE LINK BITS
17707   170201          RET 1
                          *
                          *
                          *      PCALL IS A ROUTINE OF COMMON CODE USED BY SEVERAL LOAD ROUTINES
                          *
                          *
                          *      ON ENTRY : REGISTER A CONTAINS THE DESIRED RECORD TYPE
                          *
                          *      ON EXIT : 1). PA IS SET TO CSELC
                          *                2). DESIRED RECORD NUMBER IS IN RECNO
                          *                3). RECORD DESIRED IS FOUND IF NO ERRORS
                          *                4). CHECKS FOR A PROGRAM ON THE TAPE AT RECNO
                          *                5). VERIFIES THAT TYPE MATCHES
                          *
```

---- CASSETTE OPERATING SYSTEM ----

```
                      *
                      *      TEMPORARIES USED : RECTP (MRW1+3)
                      *
                      *      ROUTINES CALLED : GTPAR, CHST, AERR1
                      *
                      *
                      *
17710   031761  PCALL STA RECTP          REG A HAS THE DESIRED RECORD TYPE ON ENTRY
17711   042565        JSM GTPAR          GET THE LFILE NUMBER
17712   140605        JSM ACHST,I        DO A BPC FIND
17713   001761  CHTYP LDA RECTP          MUST CHECK TO SEE IF TYPE IS RIGHT
17714   011701  CHTP1 CPA RTYPE
17715   170201  PCLL1 RET 1              TYPE OK
17716   001701        LDA RTYPE          SEE IF THERE IS ANYTHING TO LOAD
17717   072403        SZA ERR60          IF TYPE IS ZERO THEN CSIZE=0 TOO
17720   140404  ERR57 JSM AERR1,I        FILE TYPE MISMATH ERROR
17721   032467        ASC 1,57
17722   140404  ERR60 JSM AERR1,I        NOTHING TO LOAD ERROR
17723   033060        ASC 1,60
                      *
                      *
                      *
                      *
                      *      CHSIZ WILL CHECK THE SIZE OF THE RECORD TO BE READ IN TO SEE
                      *            IF THERE IS ROOM IN MEMORY
                      *            IF THERE IS NO ROOM, ERROR 62 IS GIVEN
                      *
                      *
                      *      ON ENTRY : RECORD HAS BEEN FOUND SO HEAD VARIABLES ARE SET.
                      *                 RELTH OF RECORD TO LOAD HAS BEEN CALCULATED
                      *
                      *
                      *      ON EXIT : RETURN TO CALLING ROUTINE, IF CSIZE <=RELTH
                      *                GIVES ERROR 62 IF CSIZE > RELTH AND TERMINATES LOAD
                      *
                      *
                      *      TEMPORARIES USED : RELTH (MRW1+1)
                      *
                      *      ROUTINES CALLED : AERR1
                      *
                      *
                      *
                      *
                      *
17724   001700  CHSIZ LDA CSIZE          GET FILE SIZE FROM HEAD
17725   170040        TCA
17726   021757        ADA RELTH          SUBTRACT CSIZE FROM ROOM IN MEMORY
17727   172066        SAP PCLL1
                      *                  IF THE RESULT IS POSITIVE
17730   140404  ERR62 JSM AERR1,I        FILE WILL NOT FIT - MEMORY OVERFLOW
17731   033062        ASC 1,62           NO ROOM IN MEMORY
                      *
                      *
                      *      BMP1 MOVES THE EXECUTION STACK POINTER BY ONE ENTRY
                      *
                      *      ON ENTRY : A CALL TO SUBROUTINE 'COUNT' MUST PROCEED A CALL TO
                      *                 BMP1
                      *
                      *
                      *      ON EXIT : THE POINTER ( FAP1 ) IS MOVED
                      *                ONE PARAMETER TO THE RIGHT
                      *           IF RET 2, IF RET 1, NO MORE PARAMETERS ON THE STACK
                      *
                      *
                      *      TEMPORARIES USED : NONE
                      *
                      *      ROUTINES CALLED : ABUMP
                      *
                      *
                      *
                      *
                      *
                      *
17732   000254  BMP1  LDA P1
17733   140607        JSM ABUMP,I
17734   170201        RET 1              NO MORE PARAMETERS
17735   170202        RET 2              FAP1 IS MOVED
                      *
                      *
                      *
                      *      CKKBE CHECKS THE SYSTEM TO SEE IF THIS COMMAND WAS A KEYBOARD
                      *            ENTRY OR A PROGRAM STATEMENT
                      *
                      *      CSTAT = 1 => KEYBOARD EXECUTION
```

---- CASSETTE OPERATING SYSTEM ----

```
04064000                  *          * 2 => RUNNING PROGRAM
04065000                  *
04066000                  *     ON ENTRY : CSTAT CONTAINS SYSTEM STATE
04067000                  *
04068000                  *     THIS ROUTINE IS ONLY CALLED BY LDK AND LDF/LDPOF
04069000                  *     PROGRAM FILES. THESE CALLING ROUTINES CALL STVFY
04070000                  *     WHICH GUARANTEES THAT CSTAT = 1 OR 2
04071000                  *     ON EXIT : RET 1 = PROGRAM LINE IS EXECUTING
04072000                  *               RET 2 = KEYBOARD EXECUTION
04073000                  *
04074000                  *
04075000                  *
04076000                  *     TEMPORARIES USED : NONE
04077000                  *
04078000                  *     ROUTINES CALLED : NONE
04079000                  *
04080000                  *
04081000                  *
04082000                  *
04083000                  *
04084000 17736  001257  CKKBE LDA CSTAT             GET THE STATE
04085000 17737  010145        CPA P2                IS IT A KEYBOARD EXECUTION
04086000 17740  170201        RET 1                 THIS IS PROGRAM EXECUTION
04087000 17741  000334        LDA ADP0              KEYBOARD EXECUTION
04088000 17742  031264        STA LEND              MUST CANCEL ALL PENDING GTO/GSB'S
04089000 17743  170202        RET 2
04090000                  *
04091000                  *
04092000                  *
04093000                  *            DEFINITIONS
04094000                  *
04095000                  *
04096000        077756  FLAGA EQU MRW1             TEMPORARY STORAGE
04097000        077757  RELTH EQU MRW1+1
04098000        077760  SEFLG EQU MRW1+2
04099000        077761  RECTP EQU MRW1+3
04100000        077742  TVAR3 EQU OP1              CARRIES THE END OF THE MEMORY SECTION
04101000        077765  TVAR4 EQU MRW1+7
04102000        077743  LWMD  EQU OP1+1
04103000        077744  TVAR1 EQU OP1+2            TEMPORARY STORAGE
04104000        077735  SVC   EQU T21              DEDECATED TO SAVING THE C REGISTER
04105000        077766  TVAR2 EQU MRW1+8           TEMPORARY STORAGE
04106000        077226  LNO   EQU CSTMP+8          FOR CALLING AFLNA
04107000        077762  LDTRS EQU MRW1+4           NUMBER OF TRIES AT NORMAL LOAD
04108000        077232  CFLAG EQU CSTMP+12         CFLAG IS FOR CONTROL SUPERVISOR
04109000        077233  TMP7  EQU CSTMP+13
04110000 17744  115733  CPBCD CPB T19,I            COMPARE INSTRUCTION FOR RBODY
04111000 17745  135733  STBCD STB T19,I            STORE COMMAND FOR RBODY
04112000 17746  150000  B150K OCT 150000
04113000 17747  151000  B151K OCT 151000
04114000 17750  171777  SATMP OCT 171777
04115000 17751  021774  QMRKS OCT 21774
04116000                  *
04117000                  *
04118000                  *
04119000                  *
04120000                  *     ROUTINE LINKS
04121000                  *
04122000                  *
04123000                  *
04124000 17763                ORG 17763B
04125000 17763                BSS 1                   THIS IS THE CHECKSUM WORD
04126000 17764  165530  LNKSB JMP LOADL,I             THIS IS A READ/WRITE LINK FOR THE CHAIN
04127000 17765  170201  LKSBR RET 1                   RETURN USED BY ALL USERS OF THIS LINK
04128000 17766          STOPC BSS 1                   LINK TO STOP CASSETTE
04129000 17767          CFDA  BSS 1                   LINK TO COMPLETE FIND ROUTINE
04130000 17770          PTBRA BSS 1
04131000 17771          MRKA  BSS 1                   LINK TO EXECUTE 'MRK'
04132000 17772          REWA  BSS 1                   LINK TO EXECUTE 'REW'
04133000 17773          CRTP  BSS 1                   LINK TO EXECUTE 'CARTP'
04134000 17774          WTRA  BSS 1                   LINK TO EXECUTE 'WTR'
04135000 17775          RBDYA BSS 1                   LINK TO EXECUTE 'RBODY'
04136000 17776          ERSA  BSS 1                   LINK TO EXECUTE 'ERS'
04137000 17777          IDRA  BSS 1                   LINK TO EXECUTE 'IDR'
04138000                  *
04139000                  *
04140000                  *

                              *****RAM WORDS*****

04142000                  *
04143000                  *-----CASSETTE DEDICATED RAM
04144000                  *
04145000        077676  CRECN EQU CATMP               RECORD NUMBER (PART OF HEAD)
```

```
                                 *****RAM WORDS*****

04146000        077677  ASIZE EQU CATMP+1           ABSOLUTE SIZE
04147000        077700  CSIZE EQU CATMP+2           CURRENT SIZE
04148000        077701  RTYPE EQU CATMP+3           RECORD TYPE
04149000        077702  RRWNO EQU CATMP+4           RECORD REWRITE NUMBER
04150000        077703  EXISF EQU CATMP+5           SECURITY FLAG #0=SECURE 0=UNSECURE
04151000        077704  EX2   EQU CATMP+6           USED FOR FWUP IN RKM
04152000        077705  TPOS  EQU CATMP+7           TAPE POSITION INDICATOR
04153000        077706  MBPTR EQU CATMP+8           POINTS TO BODY SECTION
04154000        077763  ERRWD EQU MRW1+5            LOGS ERRORS
04155000        077764  FLG2  EQU MRW1+6            BITS 1-15 ARE ALWAYS ZERO
04156000                *                           BIT ZERO SET= HARDWARE FIND
04157000                *                           BIT ZERO CLR = BPC FIND
04158000                *
04159000                *     SHARED TEMPORARIES
04160000                *
04161000                *-----------------------
04162000                *
04163000                *-----  PARTITION HEAD
04164000                *
04165000        077767  PRCTR EQU MRW1+9            PARTITION COUNTER
04166000        077714  PARNO EQU T4                PARTITION NUMBER
04167000        077715  PARLN EQU T5                PARTITION LENGTH
04168000        077716  PRWNO EQU T6                PARTITION REWRITE NUMBER
04169000        077717  TEMP1 EQU T7                USED IN WAIT AND NCODE
04170000        077720  MSIZE EQU T8                HOLDS THE ABSOLUTE SIZE OF THE RECORDS TO MARK
04171000        077721  CHSUM EQU T9                USED FOR ALL CHECKSUM CALCULATIONS
04172000        077721  TDIST EQU CHSUM             TARGET-STARTING RECORD NUMBER
04173000        077722  NOREC EQU T10               NUMBER OF RECORDS TO MARK
04174000        077723  INSTR EQU T11               HOLDS AN INSTRUCTION (STR,COMPR)
04175000        077724  FPASS EQU T12               COUNTS NUMBER OF ATTEMPTS TO FIND
04176000        077725  RECNO EQU T13               TARGET RECORD NUMBER
04177000        077726  MRKSZ EQU T14               NUMBER OF WORDS NCODE WRITES ON MARK
04178000                *
04179000                *
04180000                *       FLG1 : BITS 1*- 14  ARE ALWAYS ZERO
04181000                *                BIT  0     SET MEANS TRACK A
04182000                *                           CLEAR MEANS TRACK B
04183000                *
04184000                *
04185000        077707  FLG1  EQU CATMP+9           MARK SETS THIS BEFORE ENTERING IDR, ANDTHIS
04186000                *                           REMEMBERS THE TRACK
04187000                *
04188000                *
04189000                *          COUNTERS
04190000                *
04191000                *
04192000        077730  RHCTR EQU T16               USED IN REWRITE OF RECORD HEAD
04193000        077730  PHCTR EQU T16               PARTITION HEAD COUNTER
04194000        077731  WCTR  EQU T17               WORD COUNTER USED IN PARTITION BODY
04195000        077732  RWCTR EQU T18               COUNTS WORDS IN S RECORD
04196000                *
04197000                *            POINTERS
04198000
04199000        077733  PTR   EQU T19               GENERA  PURPOSE MOVING POINTER
04200000        077734  BDPTR EQU T20               MOVING BODY POINTER
04201000                *
04202000                *

                     ***** CASSETTE INITIALIZATION ****

04204000                *
04205000                *
04206000                *
04207000                *
04208000 23750                ORG 23750B
04209000 23750  000254  CSTIN LDA P1
04210000 23751  031514        STA CSELC             SET CAST. SELECT CODE
04211000 23752  030011        STA PA                SET CAST. PERIPHERAL ADDR
04212000 23753  000127        LDA P16
04213000 23754  031705        STA CATMP+7           SET CAST. TO "LOST"
04214000 23755  000006        LDA R6                CLEAR "BEGIN/END" OF TAPE
04215000 23756  030007        STA R7                CLEAR "SERVO FAILED, CARTRIDGE OUT"
04216000 23757  000045        LDA P255
04217000 23760  030005        STA R5                OUTPUT STOP COMMAND
04218000 23761  000254        LDA P1
04219000 23762  031707        STA CATMP+9           SET TRACK 0
04220000 23763  000143        LDA P4
04221000 23764  031343        STA NOTRY             SET NO. OF HEAD AND SEARCH TRIES
04222000 23765  000177        LDA P0
04223000 23766  031345        STA CSCF
04224000 23767  031344        STA AVFLG             ENABLE AUTO VERIFY
04225000 23770  030013        STA DMAPA             DMA AVAILABLE
04226000 23771  002774        LDA LKSRA             SET UP THE LINK ADDRESS FOR THE OPTION
04227000 23772  031530        STA LOADL             ROMS
04228000 23773  170201        RET 1
04229000 23774  017765  LKSRA ABS LKSBR             ADDRESS OF THE LINK RETURN
04230000                      END

END OF PASS 2 NO ERRORS DETECTED
```

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                              BASE-PAGE READ-WRITE-MEMORY

00003000 76550                ORG 76550B
00004000                      UNL
02000000 00602                ORG DMALO
02001000 00602  023724        DEF DMAL.
02002000 00605                ORG ACHST
02003000 00605  021712        DEF CHST
02004000                *
02005000                *
02006000                *       LINKS TO INTERPRETURE
02007000                *
02008000 07740                ORG 7740B
02009000 07740  021653        DEF SSC           LINK TO EXECUTE "SSC"
02010000 07741  021667        DEF TRKCH         LINK TO EXECUTE "TRK"
02013000 07757                ORG 7757B
02014000 07757  021717        DEF AVD           LINK TO EXECUTE "AVD"
02015000 07760  021715        DEF AVE           LINK TO EXECUTE "AVE"
02016000                *
02017000                *
02018000                *
02019000                *
02020000                *
02021000                *
02022000 17766                ORG 17766B
02023000                *
02024000                *
02025000                *     ROUTINE LINKS TO CASOS
02026000                *
02027000                *
02028000                *
02029000 17766  021701        DEF STOPC         LINK TO STOPC
02029100 17767  021352        DEF CFD           LINK TO CFD
02030000 17770  021607        DEF PTBRG         LINK TO EXECUTE THE BRIDGE PATCH ROUTINE
02031000 17771  020736        DEF MRK           LINK TO MRK
02032000 17772  021414        DEF REW           LINK TO REW
02033000 17773  020465        DEF CARTP         LINK TO CART. PROTECT
02034000 17774  021227        DEF WTR           LINK TO WRITE
02035000 17775  020034        DEF RBODY         LINK TO READ
02036000 17776  021450        DEF ERS           LINK TO ERASE
02037000 17777  021131        DEF IOR           LINK TO IDENTIFY
02038000                *
02039000                *

                              ******** TITLE PAGE *********

02041000                *
02042000                ************************************************************************
02043000                *
02044000                *       9825 TAPE CARTRIDGE DRIVERS
02045000                *
02046000                *       VERSION  FORVU
02047000                *
02048000                *
02049000                *
02050000                ************************************************************************
02051000                *
02052000                *
02055000                *
02056000                *
02057000                *
02058000                *----------LIST OF ABBREVIATIONS
02059000                *
02060000                *
02061000                *    BET  -- BEGINNING OR END OF TAPE (HRDW STATUS BIT 0).
02062000                *    BOT  -- BEGINNING OF TAPE.
02063000                *    COT  -- CARTRIDGE OUT (HRDW STATUS BIT 2).
02064000                *    DIR  -- TAPE DIRECTION.
02065000                *    EOT  -- END OF TAPE.
02066000                *    EVTM -- END OF VALID TAPE MARK (6" OF GAP).
02067000                *    EWA  -- ENABLE WRITE AMPLIFIER.
02068000                *    HS   -- HIGH SPEED (90 INCHES/SEC).
02069000                *    IPG  -- INTER-PARTITION GAP (APPROX. .018").
02070000                *    IRG  -- INTER-RECORD GAP (1") ALSO HRDW STATUS BIT 4.
02071000                *    LS   -- LOW SPEED (22 INCHES/SEC)
02072000                *    MVG  -- MOVING LINE (HRDW STATUS BIT 5).
02073000                *    PHEAD-- PARTITION HEAD(3 WORDS + CHSUM).
02074000                *    POF  -- POWER OFF (HRDW STATUS BIT 3).
02075000                *    RBODY-- RECORD BODY.
02076000                *    RHEAD-- RECORD HEAD.
02077000                *    SCH  -- SEARCH (HRDW CMD BIT 1).
02078000                *    SFL  -- SERVO FAILURE (HRDW STATUS BIT 1).
02079000                *    THI  -- HIGH READ THRESHOLD.
02080000                *    THOLD-- READ THRESHOLD.
02081000                *    TLO  -- LOW READ THRESHOLD.
02082000                *    TOS  -- TAPE OPERATING SYSTEM
02083000                *    WPR  -- WRITE PROTECTED (HRDW STATUS BIT 7).
```

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                             *****RDHED*****

02085000 20000                     ORG 20000B
02086000                    *-----SUBROUTINE  RDHED
02087000                    *
02088000                    *     THIS ROUTINE READS A RECORD HEAD(LENGTH
02089000                    * DEFND BY "HDLN") AND STORES IT INTO MEMORY( RHPTR
02090000                    * DEFINES WHERE IN MEMORY).
02091000                    *
02093000 20000  115733  CPINS CPB PTR,I
02100000 20001  001343  RDHED LDA NOTRY      SET NOTRY
02105000 20002  031731        STA WCTR       ATTEMPTS TO READ THE HEAD
02106000 20003  000057  ERDHD LDA RLFDH      READ DATA CMD AT HI THRESHOLD
02107000 20004  043715        JSM CMDW       START GOING;WAIT TIL UP TO SPEED
02108000 20005  002736        LDA RHPTR      SET PTR TO THE FIRST
02109000 20006  031733        STA PTR        WORD OF THE RECORD HEAD
02110000 20007  043271        JSM INGAP      FIND REC GAP; COULD BE IN DATA
02111000 20010  043261        JSM INDTA      FIND PREAMBLE
02112000 20011  043720        JSM RSTHD      SETS DATA MODE & PROPER THOLD
02113000 20012  043234        JSM PAMBL      GET SYNC'D WITH THE TAPE
02114000                    *
02115000                    *****READ RECORD HEAD
02116000                    *
02117000 20013  000177  .DC10 LDA ZERO       INITIALIZE THE CHECKSUM
02118000 20014  031721        STA CHSUM      FOR READING THE REC HEAD
02119000 20015  000137        LDA HDLN       INITIALIZE THE
02120000 20016  031730        STA RHCTR      RECORD HEAD COUNTER
02121000 20017  043242  .DC13 JSM GETWD      GET NEW WORD
02122000 20020  067204        JMP .DC6
02123000 20021  055730        DSZ RHCTR      DONE WITH HEAD?
02124000 20022  067024        JMP *+2        NO
02125000 20023  067031        JMP .DC1       YES
02130000 20024  135733  STINS STB PTR,I
02132000 20025  025721        ADB CHSUM
02133000 20026  035721        STB CHSUM      UPDATE HEAD CHECKSUM
02134000 20027  045733        ISZ PTR        MOVE HEAD PTR
02135000 20030  067017        JMP .DC13
02136000 20031  015721  .DC1  CPB CHSUM      READ HEAD CORRECTLY?
02137000 20032  170202        RET 2          YES; EXIT WITH TAPE STILL MOVING
02138000 20033  067204        JMP .DC6       HEAD CHSUM ERROR

                             *****RBODY*****

02140000                    *
02141000                    *-----SUBROUTINE RBODY
02142000                    *
02143000                    *   THIS ROUTINE READS THE BODY OF A RECORD.SET
02144000                    *   INSTR= STB PTR,I INSTR TO STORE BODY INTO MEMORY
02145000                    *   INSTR= CPB PTR,I INSTR TO COMPARE BODY WITH MEMORY
02146000                    *
02147000 20034  043001  RBODY JSM RDHED      READ THE RECORD HEAD
02148000 20035  170201        RET 1          HEAD READ ERROR
02149000 20036  001706        LDA MBPTR      GET MASTER BODY PTR (POINTS TO
02150000                    *                1ST WORD IN MEMORY FOR THE BODY)
02151000 20037  031734        STA BDPTR      AND INIT THE REF POINTER.
02152000 20040  021700        ADA CSIZE      FORM MAX ADDR ALLOWED
02153000 20041  170040        TCA            AND STORE ITS NEG FOR USE IN
02154000 20042  031732        STA RWCTR      DETERMINING WHEN TO STOP READING
02155000 20043  001725        LDA RECNO      GET TARGET RECORD NUMBER.
02156000 20044  011676        CPA CRECN      IS IT THE SAME AS THIS RECORD?
02157000 20045  067047        JMP *+2        YES
02158000 20046  067222        JMP .DC99      NO;WE HAVE THE WRONG RECORD!
02159000 20047  000177        LDA ZERO
02160000 20050  031767        STA PRCTR      SET PARTION CTR=0; 1ST PART IS 0
02161000                      IFZ
02162000 20051  031727        STA DLFLG      CLEAR THE DUMMY LINE FLAG.
02163000                      XIF
02164000                    *
02165000                    *-----NOW INIT. ITEMS NEC TO READ EACH PARTITION
02166000                    *
02167000 20052  000150  .DC4  LDA M4         -4=NO. OF WORDS IN PHEAD
02168000 20053  031730        STA PHCTR      COUNTING THE PHEAD CHSUM
02169000 20054  002737        LDA PHPTR      PHPTR POINTS TO STORAGE AREA
02170000 20055  031733        STA PTR        FOR THE PHEAD
02171000 20056  043724        JSM SHTHD      PUT HRDW IN READ,DATA,THI MODE
02172000                    *                               THI IS IMPT FOR IPG DETECTION!
02173000                    *
02174000                    *-----MUST GET BY THE POSTAMBLE INTO THE PGAP
02175000                    *
02176000 20057  000177        LDA ZERO
02177000 20060  031721        STA CHSUM      INIT. CHECK SUM REGISTER
02178000 20061  076600        SSC *          STAY HERE UNTIL FIND IPG
02179000 20062  076605  .DC18 SSC *+5        SKIP WHEN IN DATA
02180000 20063  000005        LDA R5         GET STATUS
02181000 20064  170503        SAR 4          GET THE IRG BIT
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                             *****HBODY*****
02182000 20065  073075          SLA *-3       SKIP IF STILL PARTITION GAP
02183000 20066  067224          JMP .DC89     HIT AN IRG
02184000                  *
02185000                  *----- JUST LEFT AN IPG
02186000                  *
02187000 20067  043720          JSM RSTHD     SETS DATA MODE & PROPER THOLD
02188000 20070  043234          JSM PAMBL     GET BY PREAMBLE
02189000 20071  043242    .DC40 JSM GETWD     GET REST OF PARTITION
02190000 20072  067215          JMP .DC17     HIT IPG
02191000 20073  045730          ISZ PHCTR     HAVE I READ LAST WD IN PHEAD?
02192000 20074  067076          JMP *+2       NO! THEN STORE IT
02193000 20075  067103          JMP .DC2      ALL DONE WITH P HEAD
02194000 20076  135733          STB PTR,I     STORE 1 WORD OF PHEAD
02195000 20077  025721          ADB CHSUM     ADD IN CHSUM
02196000 20100  035721          STB CHSUM     SAVE CHSUM
02197000 20101  045733          ISZ PTR       MOVE PTR FOR NEXT STORE
02198000 20102  067071          JMP .DC40     GET NEXT WD OF PHEAD
02199000                  *
02200000                  *-----FINISHED READING PHEAD! CHECK FOR ERRORS
02201000                  *
02202000 20103  015721    .DC2  CPB CHSUM     B REG HAS TAPE-READ CHSUM
02203000 20104  067106          JMP *+2
02204000 20105  067215          JMP .DC17     PHEAD CHSUM ERROR
02205000                  *
02206000                  *-----CHECK PARTITION RE-WRITE NUMBER. IT MUST AGREE
02207000                  *     WITH THE ONE IN THE RECORD HEAD. IF IT DOESN'T
02208000                  *     THEN WE HAVE AN OLD PARTITION
02209000                  *
02210000 20106  001702          LDA RRWNO
02211000 20107  011716          CPA PRWNO
02212000 20110  067112          JMP *+2
02213000 20111  067224          JMP .DC89     HIT AN OLD PARTITION
02214000                  *
02215000                  *-----CHECK TO SEE IF WE SKIPPED ANY PARTITIONS
02216000                  *
02217000                        IFZ
02218000 20112  001714    .DC11 LDA PARNO     GET CURRENT PARTITION NUMBER
02219000 20113  011767          CPA PRCTR     SAME AS EXPECTED PART NUMBER?
02220000 20114  067121          JMP .DC12     YES--NO ERROR
02221000 20115  001723          LDA INSTR     CAN'T ALTER MEMORY IF THIS IS
02222000 20116  013000          CPA CPINS     A VERIFY. SKIP IF NOT VERIFY!
02223000 20117  067231          JMP VFYER      VERIFY--EXIT NOW!
02224000 20120  042463          JSM ERLN      IF PRGM, THIS INSERTS A DUMMY
02225000                  *                   LINE OF *'S,AND LOGS A READ BODY ERROR.
02226000 20121  001714    .DC12 LDA PARNO     CURRENT PARTITION NUMBER
02227000 20122  020254          ADA ONE       PLUS 1 EQUALS
02228000 20123  031767          STA PRCTR     NEW EXPECTED PARTITION NUMBER.
02229000                        XIF
02230000                  *
02231000                  *-----MUST COMPUTE THE STARTING ADDR FOR STORING THE
02232000                  *     COMING PARTITION BODY. BDPTR IS THE REFERENCE
02233000                  *     PTR FOR PROGRAM STORAGE. PTR IS THE MOVING PTR
02234000                  *     IF IT IS A DATA RECORD, A RELATIVE ADDR IS
02235000                  *     COMPUTED USING THE PARTITION NO. (PARNO) AND
02236000                  *     THE PARTITION LENGTH (128 WDS FOR DATA).
02237000                  *
02238000 20124  001734          LDA BDPTR     GET REF PTR VALUE
02239000 20125  031733          STA PTR       INIT. MOVING PTR
02240000 20126  005715          LDB PARLN     INITIALIZE THE WORD COUNTER FOR
02241000 20127  035731          STB WCTR      READING THE PARTITION BODY.
02242000 20130  020001          ADA B         FORM MAX ADDR USED FOR BODY
02243000 20131  021732          ADA RWCTR     STORE AND DET IF IT EXCEEDS LMT.
02244000 20132  172002          SAP *+2       0=LAST PARTITION! >0=ERROR
02245000 20133  067137          JMP *+4       OK TO READ
02246000 20134  031732          STA RWCTR     SAVE FACT THAT THIS COULD BE
02247000 20135  072402          SZA *+2       THE LAST PARTITION. SKIP IF SO!
02248000 20136  067224          JMP .DC89     ERROR--EXCEED ALLOWED MEM SPACE
02249000                  *
02250000                  *-----NOW CHECK TO SEE IF THIS IS A DATA RECORD
02251000                  *
02252000 20137  001701          LDA RTYPE     GET REC TYPE
02253000 20140  010141          CPA PRGM      IS THIS A PROGRAM RECORD?
02254000 20141  067146          JMP *+5       IT IS PROGRAM! NO ADDR COMPUTE.
02255000 20142  001714          LDA PARNO     GET PARTITION NO.
02256000 20143  170606          SAL 7         MULT BY PAR. SIZE (128)
02257000 20144  021706          ADA MBPTR     ADD IN BODY SECTION BASE ADDR
02258000 20145  031733          STA PTR
02259000                  *
02260000                  *****READ THE PARTITION BODY
02261000                  *
02262000 20146  000177          LDA ZERO      GET A 0
02263000 20147  031721          STA CHSUM     INIT THE CHSUM WORD
02264000 20150  072600          SFC *         GUAR THAT I IGNORE 1 FLAG WHICH
02265000 20151  000004          LDA R4        COULD BE THE EXTRA BIT OF CHSUM
02266000 20152  043234          JSM PAMBL     GET IN SYNC AGAIN WE ARE
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```
                              *****RBODY*****

02267000                      *                     GETTING BY THE PROCESSING PREAMBLE
02268000 20153  043242   .DC3   JSM GETWD       READ 1 WD OF THE PARTITION BODY
02269000 20154  067215          JMP .DC17       HIT GAP
02270000 20155  001723          LDA INSTR       GET THE INSTRUCTION (EITHER A
02271000                 *                      STORE,I FOR LOAD CMDS; OR A
02272000                 *                      COMPARE,I FOR VERIFY CMDS)
02273000 20156  070000          EXE A           EXECUTE THE A REG AS AN INSTRUCTION
02274000 20157  067161          JMP *+2         IF STORE WAS EXECUTED,ALWAYS
02275000                 *                      HIT THIS INSTR. BUT IF CPB, ONLY
02276000                 *                      IF COMPARE WAS CORRECT.
02277000 20160  067231          JMP VFYER       COMPARE ERROR
02278000 20161  025721          ADB CHSUM       ADD IN CHSUM
02279000 20162  035721          STB CHSUM       SAVE CHSUM
02280000 20163  045733          ISZ PTR         MOVE PTR; READY FOR NEXT WORD
02281000 20164  055731          DSZ WCTR        COUNT WORD; ALL DONE WITH BODY?
02282000 20165  067153          JMP .DC3        NO; GET ANOTHER WORD
02283000                 *
02284000                 *-----DONE READING THE PARTITION BODY;
02285000                 *
02286000                 *-----NOW LET'S CHECK FOR A READ ERROR
02287000                 *
02288000                 *
02289000 20166  043242   .DC30  JSM GETWD       GET PARTITION BODY CHECKSUM
02290000 20167  067215          JMP .DC17       FOUND GAP
02291000 20170  015721          CPB CHSUM       COMPUTED CHECKSUM (CHSUM)=
02292000                 *                      TAPE-READ CHECKSUM (IN B REG) ?
02293000 20171  067173          JMP *+2         NO ERROR; KEEP GOING
02294000 20172  067215          JMP .DC17       BODY CHSUM ERROR
02295000                 *
02296000                 *-----TAPE IS IN POSTAMBLE NOW; NEXT WE MUST SEE IF
02297000                 *      THERE IS MORE TO READ.
02298000                 *
02299000 20173  001733          LDA PTR         IT'S AT 1 POS. BEYOND LAST WD
02300000                 *                      STORED. THUS NEXT PART. BODY
02301000                 *                      WORD GOES THERE.
02302000 20174  031734          STA BDPTR       UPDATE PROG. REF. PTR
02303000 20175  001732          LDA RWCTR       GET CTR TO SEE IF DONE WITH REC
02304000 20176  072402          SZA .DC35       A 0 MEANS ALL DONE
02305000 20177  067052          JMP .DC4        MORE TO READ
02306000                 *
02307000                 *-----DONE READING THIS RECORD
02308000                 *
02309000 20200  045676   .DC35  ISZ CRECN       NEXT REC IS PRESENT + 1
02310000 20201  000145          LDA TWO         SET TPOS TO "WE KNOW
02311000 20202  031705   .DC36  STA TPOS        THE NO. OF THE NEXT REC"
02312000                 *                      STSAF WILL STOP THE TAPE
02313000 20203  067705          JMP STSAF       THIS WILL COMBINE HRDW AND SFTW
02314000                 *                      STATUS AND DO A RET 1 IF AN
02315000                 *                      ERROR WAS FOUND; RET 2 IF OK.

                         *****READ ERROR SECTION*****

02317000                 *
02318000                 *****ERROR RECOVERY SECTION AND ERROR LOGGING
02319000                 *
02320000                 *
02321000                 *----INSTR :  DEFINES OPERATION OF RBODY
02322000                 *
02323000                 *      1.) INSTR=STINS----MEANS READ MODE
02324000                 *      2.) INSTR=CPINS----MEANS VERIFY MODE
02325000                 *
02326000                 *-----GET TO .DC6 FOR
02327000                 *           1.)REC HEAD CHSUM ERROR
02328000                 *           2.)GAP DETECTED DURING REC HEAD READ
02329000                 *
02330000 20204  043450   .DC6   JSM BCKUP       GET READY FOR ANOTHER TRY OR
02331000 20205  043456          JSM STPED       GET LEFT OF ERROR; STOP TAPE
02332000 20206  055731          DSZ WCTR        ANOTHER TRY?
02333000 20207  067003          JMP ERDHD       YES--READ HEAD;DON'T RESET WCTR!
02334000 20210  000052          LDA RHERR       READ ERROR IN RECORD HEAD
02335000 20211  031763          STA ERRWD       REMEMBER THE ERROR
02336000 20212  000127          LDA D16         SET TAPE POSITION
02337000 20213  031705          STA TPOS        TO "LOST".
02338000 20214  067705          JMP STSAF       COMBINE ERRORS AND EXIT
02339000                 *
02340000                 *-----NOTICE THAT REC HEAD ERRORS ARE FATAL
02341000                 *-----NO RECOVERY IS ATTEMPTED
02342000                 *
02343000                 *-----GET TO .DC17 FOR
02344000                 *           1.)UNEXPECTED GAP (IN PHEAD OR PBODY)
02345000                 *           2.)CHSUM ERROR    (IN PHEAD OR PBODY)
02346000                 *
02347000 20215  001723   .DC17  LDA INSTR       CHECK THE MODE
02348000 20216  013000          CPA CPINS       OF RBODY
02349000 20217  067231          JMP VFYER       VERIFY!
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                           *****READ ERROR SECTION*****
02350000                   *-----ERLN WILL LOG A READ BODY ERROR IN ERRWD!
02351000 20220  042463           JSM ERLN      RECOVERY--INSERT A DUMMY LINE
02352000 20221  067052           JMP .DC4      GET THE NEXT PARTITION
02353000                   *
02354000                   *-----WE HAVE THE WRONG RECORD
02355000                   *
02356000 20222  000236     .DC99 LDA NRERR     WRONG RECORD
02357000 20223  067232           JMP LOGER     LOG ERROR & POSITION TAPE.
02358000                   *
02359000                   *----GET TO .DC89 FOR
02360000                   *
02361000                   *         1.)HITTING AN OLD PARTITION (FATAL ERROR)
02362000                   *         2.)DETECTION OF AN IRG (FATAL ERROR)
02363000                   *         3.)EXCEED MEMORY LIMIT (FATAL ERROR)
02364000                   *
02365000 20224  000044     .DC89 LDA RBERR     LOG ERROR
02366000 20225  031763           STA ERRWD     = READ BODY
02367000 20226  001723           LDA INSTR     FIND OUT WHICH
02368000 20227  013024           CPA STINS     MODE RBODY IS IN
02369000 20230  067200           JMP .DC35     READ! STOP TAPE AND EXIT
02370000 20231  000237     VFYER LDA VYERR     VERIFY! LOG A VERIFY
02371000 20232  031763     LOGER STA ERRWD     ERROR
02372000 20233  067200           JMP .DC35     STOP TAPE AND EXIT

                                 *****PREAMBLE*****

02374000                   *
02375000                   *-----SUBROUTINE PAMBL
02376000                   *
02377000                   *
02378000                   *-----THIS ROUTINE IS USED TO GET SYNC'D WITH THE
02379000                   *  TAPE. IT RECEIVES SERIAL DATA BITS FROM THE
02380000                   *  HRDW DECODER. IT ASSUMES THE PREAMBLE ON THE TAPE
02381000                   *  IS A STRING OF ZEROS ENDING IN A ONE. PAMBL WAITS
02382000                   *  FOR A ONE TO MEAN END OF PREAMBLE.  THIS ROUTINE
02383000                   *  WILL NOT GET STUCK IN GAP.
02384000                   *
02385000 20234  076602     PAMBL SSC *+2       CHECK FOR GAP FIRST
02386000 20235  170201           RET 1         GAP DETECTED--ERROR
02387000 20236  072676           SFC *-2       SKIP IF DECODER NOT READY
02388000 20237  000004           LDA R4        GET DATA BIT AND CLR FLG
02389000 20240  073074           SLA PAMBL     SKIP IF DATA BIT IS A ZERO
02390000 20241  170201           RET 1         FOUND A 1--END OF PREAMBLE

02392000                   *
02393000                   *-----SUBROUTINE  GETWD (FORMS 16 BIT WORDS)
02394000                   *
02395000                   *
02396000                   *-----THIS ROUTINE FORMS 16 BIT WORDS FROM THE BIT
02397000                   *  SERIAL DECODER. THE BITS ENTER AT 0 BIT AND ARE
02398000                   *  MOVED UP TO THE SIGN BIT. THIS ROUTINE IGNORES
02399000                   *  ONE BIT BEFORE FORMING WORDS.
02400000                   *
02401000                   *      NORMAL EXIT: WORD DONE  (P+2)
02402000                   *      ERROR  EXIT: HIT IPG    (P+1)
02403000                   *
02404000 20242  072600     GETWD SFC *         IGNORE 1 BIT
02405000 20243  000004           LDA R4        CLR FLAG! DON'T WANT TO SEE IT TWICE
02406000 20244  004254           LDB ONE       WHEN THIS MOVES TO SIGN BIT.
02407000                   *                   THE WORD IS DONE!
02408000 20245  072203     NBIT  SFS *+3       NEXT BIT READY?
02409000 20246  076677           SSC *-1       NO--ARE WE IN GAP?
02410000 20247  170201           RET 1         YES--ERROR
02411000 20250  000004           LDA R4        GET THE BIT AND CLR THE FLG.
02412000 20251  050254           AND ONE       MASK ALL BITS EXCEPT B0
02413000 20252  176404           SAM ENDWD     END OF WORD?
02414000 20253  174600           SAL 1         NO
02415000 20254  024000           ADB A         STORE BIT
02416000 20255  067245           JMP NBIT      GET ANOTHER BIT
02417000 20256  174600     ENDWD SAL 1
02418000 20257  024000           ADB A         STORE FINAL BIT
02419000 20260  170202           RET 2         NORMAL RETURN

                                ******INDTA******

02421000                   *
02422000                   *-----SUBROUTINE INDTA (FIND A DATA REGION)
02423000                   *
02424000                   *-----THIS ROUTINE LOOKS FOR A DATA REGION. BIT 4 OF
02425000                   *  THE STATUS REG (R5) IS THE IRG BIT: 0=DATA; 1=GAP
02426000                   *  THIS ROUTINE MUST ALSO WATCH FOR ERRORS WHICH CAN
```

```
                      ******INDTA******
                      *  STOP THE SYSTEM BECAUSE DATA DETECTION REQUIRES
                      *  THE TAPE TO BE MOVING.
                      *
20261   000005  INDTA LDA RS          GET STATUS
20262   050130        AND ERMSK       ALLOWS COT,SFL & BET TO BE TESTD
20263   072402        SZA *+2         IS POF=COT=SFL=BET=0?(NO ERRORS)
20264   170201        RET 1           NO; WE HAVE A HRDW ERROR
20265   000005        LDA RS          YES;HRDW OK; GET STATUS AGAIN
20266   170503        SAR 4           GET BIT 4.
20267   073472        RLA INDTA       SKIP IF STILL IN AN IRG
20270   170201        RET 1

                      *
                      *-----SUBROUTINE  INGAP (FINDS IRG)
                      *
                      *-----INGAP LOOKS FOR INTER-RECORD GAPS. IT USES
                      *  THE IRG BIT (BIT 4) OF THE STATUS WORD;
                      *  IRG=1 MEANS INTER-REC. GAP; IRG=0 MEANS DATA.
                      *
20271   000005  INGAP LDA R5          GET STATUS
20272   170503        SAR 4           GET BIT 4
20273   073076        SLA INGAP       SKIP IF STILL IN DATA
20274   170201        RET 1           NORMAL RETURN

                      *****ENCODER*****

                      *
                      *-----SUBROUTINE NCODE
                      *
                      *-----THIS ROUTINE WILL WRITE A RECORD HEAD AND
                      * BODY FOR AN EXISTING RECORD.(MRK CREATES RECORDS)
                      * IT WILL WRITE THE RECORD IN "PARTIITION" FORM.
                      *
                      *
                      *****WRITE RECORD HEAD
                      *
20275   000057  NCODE LDA RLFDH       TELL HRDW TO READ,LS,FWD
                      *               THOLD=HI FOR GAP DETECTION
20276   043715        JSM CMDW        START GOING;WAIT TIL UP TO SPEED
20277   043271        JSM INGAP       COULD START IN DATA BEFORE GAP;
20300   043261        JSM INDTA       FIND THE RECORD PREAMBLE.
                      *
                      *----- DELAY TURN-ON OF WRITE AMP
                      *
20301   000177  NCEP1 LDA ZERO
20302   031714        STA PARNO       1ST PARTITION IS NO. 0
20303   030004        STA R4          DEF DATA LINE BEFORE WRITE DATA
20304   031721        STA CHSUM       INIT. CHECKSUM
20305   000074        LDA WLFDD       GIVE THE HRDW A
20306   043730        JSM OUTCM       WRITE CMD.(33 MICROS SFTW DELAY)
                      *
                      *------INIT. FOR WRITING THE RECORD
                      *
20307   001702        LDA RRWNO
20310   031716        STA PRWNO       SET PART RE-WR # = REC RE-WR #
20311   005706        LDB MBPTR
20312   035734        STB BDPTR       SET BDPTR TO LOC TO BE WRITTEN
20313   002736        LDA RHPTR       SET PTR TO POINT AT THE
20314   031733        STA PTR         FIRST WORD OF THE RECORD HEAD.
20315   000137        LDA HDLN        SET RECORD HEAD CTR TO HDLN-1
20316   020257        ADA M1          BECAUSE LOOP AT .NC10 DOES NOT
20317   031730        STA RHCTR       INCLUDE WRITING RHEAD CHSUM.
20320   004254        LDB ONE         MAKE TEMP1 POSITVE BEC THAT
20321   035717        STB TEMP1       MEANS MORE REC TO WRITE.
                      *
                      *-----NOW WRITE THE RECORD HEAD.
                      *
20322   043421        JSM PUTWD       B REG=1; WRITE PREAMBLE.
20323   105733  .NC10 LDB PTR,I       GET HEAD WORD
20324   043421        JSM PUTWD       WRITE THE WORD ON TAPE
20325   025721        ADB CHSUM       UPDATE THE
20326   035721        STB CHSUM       CHSUM
20327   045733        ISZ PTR         ADVANCE THE PTR TO NEXT RHEAD WD
20330   055730        DSZ RHCTR       COUNT WORD JUST WRITTEN; DONE?
20331   067323        JMP .NC10       NOT YET; GET NEXT WORD
20332   002737  .NC3  LDA PHPTR       DONE WITH RHEAD; NOW INITIALIZE
20333   031733        STA PTR         PTR FOR PHEAD
20334   043421        JSM PUTWD       B REG HAS CHSUM; PUT IT ON TAPE;
20335   004254        LDB ONE         SET B=1
20336   043421        JSM PUTWD       WRITE POSTAMBLE
20337   001701        LDA RTYPE
20340   072002        RZA *+2
```

*****ENCODER*****

```
02507000 20341  067414         JMP MARKO     RTYPE=0; DO MARK
02508000 20342  001717         LDA TEMP1     DONE YET?
02509000 20343  172002         SAP *+2       SKIP IF NOT DONE WRITING
02510000 20344  067407         JMP .NC11     HAVE FINISHED THIS RECORD
02511000                *
02512000                *------WRITE AN IPG
02513000                *
02514000 20345  000101  .NC1   LDA WLFTG     WRITE GAP--FOR IPG
02515000 20346  043730         JSM OUTCM     COULD DESTROY EAST BIT OF POSTAM
02516000 20347  000177         LDA ZERO
02517000 20350  031721         STA CHSUM
02518000 20351  000147         LDA M3
02519000 20352  031730         STA PHCTR     UPDATE PARTITION HEAD CTR
02520000                *
02521000                *------FOR NOW, DATA AND PROG PARLN ARE TREATED THE SAME
02522000                *
02523000 20353  042523         JSM PTCLC     WRITE AN IPG & COMPUTE PART LENGTH
02524000 20354  000177         LDA ZERO
02525000 20355  030004         STA R4        WANT DATA LINE TO BE 0 WHEN EWA
02526000 20356  000074         LDA WLFDD     GET READY TO WRITE DATA AGAIN
02527000 20357  043730         JSM OUTCM
02528000 20360  004254         LDB ONE
02529000 20361  043421         JSM PUTWD     WRITE PREAMBLE
02530000                *
02531000                *------ WRITE PARTITION HEAD
02532000                *
02533000 20362  105733  .NC13  LDB PTR,I
02534000 20363  043421         JSM PUTWD     WRITE PARTITION HEAD
02535000 20364  025721         ADB CHSUM     UPDATE THE
02536000 20365  035721         STB CHSUM     CHSUM
02537000 20366  045733         ISZ PTR
02538000 20367  045730         ISZ PHCTR
02539000 20370  067362         JMP .NC13     STILL PART. HEAD TO ENCODE
02540000 20371  043421         JSM PUTWD     WRITE HEAD CHECKSUM
02541000                *
02542000                *****NOW HANDLE PARTITION BODY
02543000                *
02544000 20372  004254         LDB ONE
02545000 20373  043421         JSM PUTWD     WRITE PROC. PREAMBLE
02546000 20374  000177         LDA ZERO
02547000 20375  031721         STA CHSUM     RESET CHECKSUM
02549000 20376  105734  .NC14  LDB BOPTR,I   GET BODY WORD
02554000 20377  043421         JSM PUTWD     WRITE PARTITION BODY
02555000 20400  025721         ADB CHSUM     UPDATE THE
02556000 20401  035721         STB CHSUM     CHSUM
02557000 20402  045734         ISZ BOPTR
02558000 20403  055731         DSZ WCTR
02559000 20404  067376         JMP .NC14     MORE TO WRITE
02560000 20405  045714         ISZ PARNO     INC PARNO FOR NEXT PAR. WRITE
02561000 20406  067332         JMP .NC3      CHECK FOR ADDIT PARTITIONS
02562000 20407  043726  .NC11  JSM STPCA     OUTPUT A STOP CMD TO THE HRDW.
02563000 20410  000145         LDA TWO       SET TAPE POS INDICATOR TO "WE
02564000 20411  031705         STA TPOS      KNOW THE # OF NEXT REC";
02565000 20412  045676         ISZ CRECN     INCR TO NEXT REC.
02566000 20413  170201         RET 1         NORMAL RETURN
02567000                *
02568000                *------ IT IS A MARK COMMAND
02569000                *
02570000 20414  004257  MARKO  LDB M1        GET ALL ONES WORD FOR TAPE
02571000 20415  043421         JSM PUTWD
02572000 20416  055731         DSZ WCTR
02573000 20417  067414         JMP MARKO
02574000 20420  170201         RET 1         NORMAL RETURN
02576000                *
02577000                *------SUBROUTINE  PUTWD  (WRITES 16 BIT WORD)
02578000                *
02579000                *      WRITES THE B-REG ONTO TAPE SIGN BIT FIRST
02580000                *      ASSUMES BIT  0 GOES TO BIT SERIAL ENCODER
02581000                *      IT ALWAYS WRITES AN EXTRA 1 ON THE TAPE TO
02582000                *      ALLOW EXTRA PROCESSING TIME AT THE END OF A
02583000                *      WORD.
02584000                *
02585000 20421  000157  PUTWD  LDA M15       SET BIT CTR
02586000 20422  072600  .NC30  SFC *         WAIT TIL ENCODER IS READY
02587000 20423  174716         RBR 15        GET B15 INTO B0
02588000 20424  034004         STB R4        GIVE HRDW ENC B0
02589000 20425  072175         RIA .NC30     SKIP IF NOT DONE WITH THE WORD
02590000                *---RIA INSTR WILL LEAVE A=1 WHEN DONE!
02591000 20426  072600         SFC *         WAIT FOR ENCODER
02592000 20427  030004        STA R4        OUTPUT EXTRA BIT=1
02593000 20430  170201         RET 1
02594000                *
02595000                *----ON EXIT,B REG HAS WORD WRITTEN ON THE TAPE
02596000                *
```

```
                        *******./GAP******

                   *
                   *-----WGAP (WRITES GAP;ASSUMES B HAS NO. OF TACH PULSES)
                   *
20431  000101  WGAP  LDA WLFTG     PUT HRDW INTO WRITE,LS,
20432  043730        JSM OUTCM     FWD,TAC,GAP MODE
20433  072600  .WGP1 SFC *         LOW SPEED; TACH PULSE?
20434  000004        LDA R4        CLR TAC
20435  076502        SIB *+2       YES;ARE WE DONE?
20436  067433        JMP .WGP1     NO; KEEP COUNTING
20437  170201        RET 1         NORMAL RETURN

                   *
                   *-----SUBROUTINE WGAPH (WRITE GAP AT HS)
                   *
20440  000124  WGAPH LDA WHFTG     PUT HRDW INTO WRITE,HS,
20441  043730        JSM OUTCM     FWD,TAC,GAP MODE
20442  000005        LDA R5        GET HRDW STATUS
20443  050130        AND ERMSK     CHECK FOR HRDW ERRORS
20444  072476        SZA *-2       SKIP IF NONE
20445  010254        CPA ONE       IS HRDW ERROR=BET?
20446  067545        JMP HOLE      YES--DETERMINE POSITION.
20447  067705        JMP STSAF     NO--ERROR

                        *****BC.UP*****

                   *
                   *-----SUBROUTINE BCKUP
                   *
                   *    THIS ROUTINE WILL TURN THE TAPE AROUND AND
                   *  POSITION THE TAPE IN   THE FIRST GAP IT SEES.
                   *  IT IS DESIGNED PRIMARILY FOR GETTING BACK IN
                   *  FRONT OF A RECORD AFTER READING ITS HEAD.
                   *
20450  043475  BCKUP JSM TURN      THIS TURNS THE TAPE
20451  043261  BUP1  JSM INDTA     ALLOWS TURN TO HAVE 1 GAP +
                   *               1 DATA SECTION UNCERTAINTY.
20452  043271        JSM INGAP     FIND AN INTER-RECORD GAP
20453  002734        LDA SETLN     THIS WILL WAIT A SETTLING
20454  043525        JSM WAIT      DISTANCE.
20455  067726        JMP STPCA     STOP CASSETTE & EXIT

                   *
                   *-----SUBROUTINE STPED
                   *
                   *    THIS ROUTINE WILL WAIT UNTIL THE CASSETTE
                   *  COMES TO A DEAD STOP.
                   *
20456  043726  STPED JSM STPCA     OUTPUT A STOP CMD TO THE HRDW
20457  000005  STPW LDA R5         GET HRDW STATUS
20460  170504        SAR 5         PUT MVG BIT INTO LSB
20461  073476        RLA *-2       SKIP IF STILL MOVING
20462  002727        LDA COAST     WAIT UNTIL IT'S DONE
20463  072100        RIA *         COASTING (ABOUT 1.5 MSEC)
20464  170201        RET 1         EXIT

                        *****CARTP*****

                   *
                   *-----SUBROUTINE CARTP
                   *
                   *    THIS CHECKS TO SEE IF A CARTRIDGE IS WRITE
                   *  PROTECTED. ONLY CALL THIS ROUTINE WHEN YOU WISH
                   *  TO WRITE ON THE TAPE BECAUSE IT GENERATES AN
                   *  ERROR IF THE CARTRIDGE IS WRITE PROTECTED.
                   *
20465  043635  CARTP JSM STSBF     CHECK HRDW STATUS
20466  170201        RET 1         ERROR
20467  000005        LDA R5        LOAD HRDW STATUS REG.
20470  170506        SAR 7         MOVE WPR BIT INTO LSB
                   *               IF WPR=0, START WITH NO ERRORS
20471  073003        SLA .C        SKIP IF IT IS OK TO WRITE
20472  004234        LDB WPERR     ERROR--WRITE NOT ALLOWED
20473  035763        STB ERRWD     LOG ERROR=WRITE NOT ALLOWED!
20474  067705  .C    JMP STSAF     COMBINE ERRORS & EXIT
```

```
                          *******TURN*****

02670000                  *
02671000                  *-----TURN(REVERSES TAPE DIR; POS=.1-.3" FROM ENTRY)
02672000                  *
02673000                  *  ENTRY POINTS: 1.) TURN--IF FINAL SPEED=LS
02674000                  *                2.) .T7--IF FINAL SPEED=ENTRY SPEED=HS
02675000                  *
02676000 20475  000117  TURN  LDA D32       SPEED BIT(5)=1 (LS)
02677000 20476  061710        IOR CUCMD     NOW HAVE LS
02678000 20477  050057        AND RLFDH     SET THOLD=HI (BIT 2 = 0 IN SFTW)
02679000 20500  043730        JSM OUTCM
02680000 20501  002730  .T7   LDA TACLS     THIS GIVES A
02681000 20502  043525        JSM WAIT      BUFFER ZONE=.22" BEFORE TURNING
02682000 20503  001710        LDA CUCMD     GET PRESENT HRDW CMD
02683000 20504  170703  .T1   RAR 4         GET DIR BIT
02684000 20505  073302        SLA *+2,S     THESE 2 INSTRUCTIONS
02685000 20506  073201        SLA *+1,C     REVERSE BUT 0 OF A REG
02686000 20507  170713        RAR 12        GET CORRECT ORIENT.
02687000 20510  043730        JSM OUTCM     TURN THIS THING AROUND
02688000 20511  004177        LDB ZERO      TAC CTR INIT.
02689000                  *
02689100                  *-----NOW COUNT TAC PULSES (IN B) WHILE DECELERATING
02689200                  *
02689300 20512  072603  .T2   SFC *+3       TAC PULSE?
02690000 20513  076501        SIB *+1       YES; COUNT IT
02691000 20514  000004        LDA R4        CLR FLG
02692000 20515  000005        LDA R5        NO TAC PULSE; GET HRCW STATUS
02693000 20516  170504        SAR 5          GET 10% OF SPD BIT
02694000 20517  073473        RLA .T2       SKIP IF STILL MOVING
02695000 20520  174040        TCB
02696000                  *
02697000                  *-----NOW COUNT TAC PULSES WHILE ACCELERATING (COUNT
02698000                  *     SAME NUMBER NOW AS WHEN DECELERATING
02699000                  *
02700000 20521  072600  .T5   SFC *         WAIT HERE FOR TAC PULSE
02701000 20522  000004        LDA R4        CLR FLAG
02702000 20523  076176        RIB .T5       COUNT DOWN 1; SKIP IF MORE TAC
02703000                  *                 PULSES TO COUNT.
02704000 20524  170201        RET 1         ALL DONE


                          *******WAIT*****

02706000                  *
02707000                  *-----WAIT(NUMBER IN A REG-NEGATIVE-GIVES AMT OF
02708000                  *           TAC PULSES WAITED)
02709000                  *
02710000                  *           483 TAC PULSES (TO SFTW) = 1 INCH OF TAPE
02711000                  *
02712000 20525  031717  WAIT  STA TEMP1     SAVE LENGTH OF THIS WAIT
02713000 20526  001710        LDA CUCMD     GET CURRENT HRDW CMD
02714000 20527  052742        AND TACMD     NOW PUT THE HRDW INTO TAC
02715000 20530  043730        JSM OUTCM     MODE; MUST COUNT TAC PULSES.
02716000 20531  072600        SFC *         WAIT FOR TAC PULSE
02717000 20532  030004        STA R4        CLR FLG
02718000 20533  045717        ISZ TEMP1     COUNT TAC PULSE; DONE?
02719000 20534  067531        JMP *-3       NOT YET; KEEP COUNTING
02720000 20535  170201        RET 1         ALL DONE
02722000                  *
02723000                  *-----MSBET(MEASURE A DISTANCE OR DETECT BET)
02724000                  *
02725000                  *  ENTRY:  DISTANCE IN B REG (NEGATIVE NO.)
02726000                  *
02727000                  *  EXIT :  RET 1--BET OCCURRED-B REG HAS PARTIAL CNT
02728000                  *          RET 2--THE DISTANCE WAS MEASURED
02729000                  *
02730000 20536  000005  MSBET LDA R5        GET HRDW STATUS
02731000 20537  073405        RLA .BETM     SKIP IF BET OCCURRED
02732000 20540  072600        SFC *         WAIT FOR TAC PULSE
02733000 20541  000004        LDA R4        CLR FLG
02734000 20542  076174        RIB MSBET     SKIP IF NOT DONE
02735000 20543  170202        RET 2         DIST. HAS BEEN MEASURED
02736000 20544  170201  .BETM RET 1         BET OCCURRED


                          *******HOLE*****

02738000                  *
02739000                  *-----HOLE(DETERMINES TAPE POSITION WHEN HIT HOLE)
02740000                  *
02741000 20545  000005  HOLE  LDA R5        GET HRDW STATUS; MOVE STATUS DIR
02742000 20546  170501        SAR 2         TO SAME POSITION AS CMD DIR BIT.
02743000 20547  050127        AND D16       ISOLATE DIRECTION BIT
```

```
                    *******HOLE*****

20550  062744         IOR RHRTL       PUTS HRDW INTO TAC MODE.HS AND
20551  043730         JSM OUTCM       OPPOSITE DIRECTION.
               * THE DIR IS OPPOSITE BEC CMD & STATUS ARE OP SENSE
20552  004006         LDB R6          CLR BET
20553  006723         LDB .M30I       GO FOR 30 INCHES OF TAPE OR A
20554  043536         JSM MSBET       BET.  WHICH EVER COMES FIRST
20555  067557         JMP .MDL        HIT BET--GET TO MAIN DECODE LOOP
20556  067630         JMP .EHOL       CAN'T FIND "ENTRY" HOLE
20557  000006  .MDL   LDA R6          CLR BET
20560  006723         LDB .M30I       GO 30 INCHES OF TAPE OR UNTIL
20561  043536         JSM MSBET       BET OCCURS.
20562  067607         JMP .DDIS       HIT BET--DECODE THE DIST TRVLED!
20563  043501         JSM .T7         WENT 30 IN.--IN VALID TAPE! TURN
20564  006724         LDB .M24I       GO FOR 24 IN. WATCH
20565  043536         JSM MSBET       FOR HOLES!
20566  067630         JMP .EHOL       ERROR--HIT UNEXPECTED HOLE
20567  006725         LDB .M12I       GO FOR 12 IN. I EXPECT TO HIT A
20570  043536         JSM MSBET       HOLE BEFORE THEN!
20571  067573         JMP *+2         FOUND HOLE! CONTINUE RECOVERY
20572  067630         JMP .EHOL       ERROR--MISSED A HOLE
20573  000006         LDA R6          CLR BET
20574  043475         JSM TURN        TURN AROUND--EXIT AT LOW SPEED
20575  002733         LDA DLYA        GUAR I GET BY THE HOLE I JUST
20576  043525         JSM WAIT        SENSED! (IN VALID DATA NOW)
20577  043726         JSM STPCA       OUTPUT A STOP CMD TO THE HRDW.
20600  004006         LDB R6          CLR BET
20601  004137         LDB D8          SET B TO REWIND POSITION. SET
20602  170503         SAR 4           TPOS BASED ON DIR BIT
20603  073402         RLA *+2         SKIP IF DIR=FWD=REWIND
20604  004127         LDB D16         AT EOT!
20605  035705         STB TPOS        SAVE THE TAPE POSITION
20606  170202         RET 2
               *
               *-----DECODE THE DISTANCE BETWEEN HOLES
               *
20607  026722  .DDIS  ADB .P30I       FORM POS # = DIST TRAVELED
20610  000001         LDA B           PUT A COPY IN A
20611  026726         ADB .MQTI       DID WE GO 1/4 INCH?
20612  176004         SBP .DD1        SKIP IF NO!
20613  002745  .BOT   LDA RHFTL       AT BOT
20614  043730         JSM OUTCM       THUS GO FWD TO
20615  067557         JMP .MDL        GO TO MAIN DECODING LOOP.
20616  022725  .DD1   ADA .M12I       DID WE GO 12 INCHES?
20617  172402         SAM *+2         SKIP IF YES
20620  067557         JMP .MDL        NEED MORE DECODING
20621  004006         LDB R6          CLR BET! WE WENT 1 FOOT
20622  006726         LDB .MQTI       GO AT LEAST 1/4 INCH OR
20623  043536         JSM MSBET       UNTIL BET
20624  067613         JMP .BOT        HIT BET--THUS 2 HOLES 1/4"!ATBOT
20625  002744  .EOT   LDA RHRTL       AT EOT! GO REVERSE TO FIND
20626  043730         JSM OUTCM       VALID TAPE.
20627  067557         JMP .MDL        DO MORE DECODING!
               *
               *-----ERRORS DETECTED BY HOLE
               *
20630  000175  .EHOL LDA HOERR       HIT EXTRA HOLE OR MISSED ONE!
20631  031763         STA ERRWD       LOG ERROR
20632  000127         LDA D16         SET POSITION
20633  031705         STA TPOS        TO LOST!
20634  067705         JMP STSAF       COMBINE ERRORS AND EXIT
               *                      STSAF WILL STOP THE TAPE

                    ******STSBF******


               *
               *-----STSBF(HRDW STATUS CHECK BEFORE EXEC)
               *
20635  000177  STSBF  LDA ZERO
20636  031763         STA ERRWD       NEW INSTR.  START WITH NO ERRORS
20637  000005  STSNI  LDA R5          GET HRDW STATUS
20640  170504         SAR 5           PUT MVG BIT INTO LSB
20641  073476         RLA *-2         SKIP IF SPEED > 2 INCHES/SEC
20642  043456  STSNP  JSM STPED        GET CASSETTE DEAD STOPPED
20643  000005  STSBH  LDA R5          GET HRDW STATUS
20644  170701         RAR 2           GET COT INTO LSB
20645  073011         SLA .BF1        SKIP IF CART. WASN'T PULLED
20646  030007         STA R7          CART WAS REMOVED! CLR COT
20647  000006         LDA R6          CLR BET
20650  000127         LDA D16         SET TAPE POSITION
20651  031705         STA TPOS        TO LOST
20652  000005         LDA R5          GET HRDW STATUS
20653  170701         RAR 2           PUT COT INTO LSB
20654  073002         SLA *+2         SKIP IF WE HAVE A NEW CART
20655  067705         JMP STSAF       NO CART IN MACHINE
```

```
                                   ******STSAF******

02826000 20656  170716  .BF1  RAR 15           GET SFL INTO LSB
02827000 20657  073014        SLA .BF2         SERVO OK? (SFL=0 FOR YES)
02828000 20660  000127        LDA D16          SET TAPE POSITION INDICATOR
02829000 20661  031705        STA TPOS         TO LOST.
02830000                *-------------THE SERVO FAIL COULD BE LEFT FROM PREV USER CMD
02831000 20662  000146        LDA M2           NOW  WAIT
02832000 20663  004254        LDB ONE          FOR .4 SECONDS
02833000 20664  076100        RIB *            BEFORE CLEARING
02834000 20665  072176        RIA *-2          SFL BIT.
02835000 20666  030007        STA R7           TRY CLEARING SFL
02836000 20667  000005        LDA R5           GET HRDW STATUS
02837000 20670  170700        RAR 1            GET SFL BIT INTO LSB
02838000 20671  073002        SLA *+2          SERVO STILL BAD?
02839000 20672  067705        JMP STSAF        YES; COMBINE ERRORS
02840000 20673  170701  .BF2  RAR 2            GET POF BIT INTO LSB
02841000 20674  073004        SLA .BF3         IS POWER ON? (SKIP IF YES)
02842000 20675  000127        LDA D16          SET TAPE POSITION
02843000 20676  031705        STA TPOS         TO LOST
02844000 20677  067705        JMP STSAF        COMBINE ERRORS AND EXIT
02845000 20700  170714  .BF3  RAR 13           GET BET INTO LSB.
02846000 20701  073003        SLA *+3          BET? (SKIP IF NO)
02847000 20702  043545        JSM HOLE         YES; HOLE WILL FIX THAT
02848000 20703  067705        JMP STSAF        COMBINE ERRORS & EXIT
02849000 20704  170202        RET 2            HRDW OK! EXIT
02851000                *
02852000                *-----SUBROUTINE STSAF
02853000                *
02854000                *     THIS ROUTINE COMBINES SOFTWARE ERRORS AND
02855000                *  HARDWARE ERRORS INTO A SINGLE ERROR WORD CALLED
02856000                *     ERRWD: THIS WORD CAN BE EXAMINED FROM MSB TO
02857000                *  LSB AND THE MOST SEVERE ERROR WILL BE DETECTED
02858000                *  FIRST.
02859000                *
02860000 20705  043726  STSAF JSM STPCA        STOP THE TAPE.
02861000 20706  000005        LDA R5           GET THE HRDW STATUS
02862000 20707  170613        SAL 12           MOVE 4 HRDW ERROR BITS TO MSB.
02863000 20710  061763        IOR ERRWD        INCLUDE SOFTWARE ERRORS
02864000 20711  031763        STA ERRWD        SAVE FOR POSSIBLE FUTURE USE
02865000 20712  072402        SZA *+2          AND ERRORS? (0=NO ERRORS)
02866000 20713  170201        RET 1            YES!
02867000 20714  170202        RET 2            NO!
```

```
                                   *****CMDW*****

02869000                *
02870000                *-----SUBROUTINE CMDW
02871000                *
02872000                *     THIS ROUTINE OUTPUTS THE A REG TO THE HRDW
02873000                * AS A CMD. THEN IT COUNTS ENOUGH TAC PULSES TO
02874000                * GUARANTEE THAT THE TAPE REACHES LOW SPEED: ONLY
02875000                * THE A REG IS USED.
02876000                *
02877000 20715  043730  CMDW  JSM OUTCM        OUTPUT CMD
02878000 20716  002730  CMDW1 LDA TACLS        COUNT ENUF TACS TO REACH LS
02879000 20717  067525        JMP WAIT         COUNT DISTANCE & EXIT

02881000                *
02882000                *-----SUBROUTINE OUTCM (GIVES HRDW A CMD).
02883000                *
02884000                *     ENTRY POINTS:
02885000                *
02886000                *  1). RSTHD-- SET READ THOLD HI(VFY) OR LO(LOAD).
02887000                *  2). SHTHD-- SET READ THOLD HI(ACCUR. GAP DETECT).
02888000                *  3). STPCA-- OUTPUT A STOP CMD TO THE HRDW.
02889000                *  4). OUTCM-- OUTPUT THE A REG AS A HRDW CMD.
02890000                *
02891000                *
02892000 20720  000053  RSTHD LDA RLFDL        GET CMD FOR A NORMAL READ
02893000 20721  005723        LDB INSTR        CHECK TO SEE IF CMD IS A
02894000 20722  017024        CPB STINS        READ OR A VERIFY!
02895000 20723  067730        JMP OUTCM        IT IS A READ
02896000 20724  000057  SHTHD LDA RLFDH        IT IS VERIFY! SET THOLD TO HI
02897000 20725  067730        JMP OUTCM        AND OUTPUT THE CMD.
02898000 20726  002746  STPCA LDA STOP         GET THE STOP CMD & INCLUDE THE
02899000 20727  061710        IOR CUCMD        DIRECTION OF PREV CMD.
02900000 20730  073201  OUTCM SLA *+1,C        CLR THE TRACK BIT
02901000 20731  061707        IOR FLG1         INCLUDE CURRENT TRACK
02902000 20732  050045        AND KPMSK        B0-7 UNCHNG'D;B8=0
02903000 20733  031710        STA CUCMD        SAVE THE CMD.
02904000 20734  030005        STA R5           TELL HRDW
02905000 20735  170201        RET 1            ALL DONE
```

```
                                   ******MARK*****

02907000                         *
02908000                         *-----MARK  SUBROUTINE
02909000                         *
02910000                         *        INPUTS:  NOREC=NUMBER OF RECORDS
02911000                         *                 MSIZE=ABSOLUTE SIZE IF EACH RECORD
02912000                         *
02913000 20736  043465   MRK     JSM CARTP      CHECK TO SEE IF CART. IS PROT'ED.
02914000 20737  170201           RET 1          ERROR--THIS CART IS PROTECTED!
02915000 20740  001705           LDA TPOS       CHECK TO SEE IF WE MUST
02916000 20741  170500           SAR 1          READ A RECORD HEAD TO
02917000 20742  073003           SLA *+3        DETERMINE POSITION. (SKIP = NO)
02918000 20743  042210           JSM IDR1       YES--TPOS=21 GO FWD & FIND A REC
02919000 20744  170201           RET 1          ERROR WHEN I TRIED TO READ RHEAD
02920000                         *
02921000                         *-----AT THIS POINT, TPOS SHOULD BE 1, 8, OR 16
02922000                         *
02923000                         *
02924000                         *-----INITIALIZATION
02925000                         *
02926000 20745  000177           LDA ZERO
02927000 20746  031701           STA RTYPE      RECORD TYPE=0 FOR EMPTY RECORD
02928000 20747  031700           STA CSIZE      CURRENT SIZE=0 WHEN MARKED
02929000 20750  031702           STA RRWNO      RE-WRITE NUMBER STARTS AT 0
02930000                         *
02931000                         *-----COMPUTE ACTUAL MARKING LENGTH
02932000                         *
02933000 20751  001720           LDA MSIZE      GET BUFFERED ABS SIZE
02934000 20752  031677           STA ASIZE      DEF PART OF REC HEAD
02935000 20753  170506           SAR 7          DIVIDE BY 128
02936000 20754  030001           STA B          NO. OF FULL PARTITIONS
02937000 20755  001677           LDA ASIZE
02938000 20756  050053           AND MSKL7      MASK OFF LOW 7 BITS
02939000 20757  072402           SZA *+2
02940000 20760  076501           SIB *+1        ADD 1 FOR PARTIAL PARTITION
02941000 20761  000001           LDA B          GET NP=NUMBER OF PARTITIONS
02942000 20762  170602           SAL 3          NP*8
02943000 20763  174600           SBL 1          NP*2
02944000 20764  020001           ADA B          A REG=NP*10=POH (PAR OVERHEAD)
02945000 20765  021677           ADA ASIZE      FORM TOTWD
02946000 20766  004000           LDB A          SAVE IN B
02947000 20767  174502           SBR 3          FORM VARSL=TOTWD*12.5%
02948000 20770  020001           ADA B          A REG =1.125*TOTWD
02949000 20771  020140           ADA SLKRH      MARKING SIZE = 1.125*TOTWD +
02950000                         *              RECORD HEAD SLACK!
02951000 20772  031726           STA MRKSZ      SAVE THIS FOR NCODE
02952000 20773  031731           STA WCTR       SET UP THE WORD COUNTER
02953000 20774  005722          LDB NOREC       GET # OF REC TO BE MARKED.
02954000                         *
02955000                         *----DETERMINE WHERE TO START MARKING THE TAPE
02956000                         *
02957000 20775  001705   .MRK6   LDA TPOS       GET PRESENT TAPE POSITION
02958000 20776  010137           CPA D8         ARE WE AT REWIND?
02959000 20777  066023           JMP .MRK8      YES
02960000 21000  010254           CPA ONE        DO WE KNOW WHERE WE ARE?
02961000 21001  066034           JMP .MRK2      YES--START MARKING FROM THAT REC
02962000 21002  000117           LDA MPERR      NO--ERROR--CAN'T MARK WHEN
02963000 21003  031763           STA ERRWD      POSITION IS UNKNOWN
02964000 21004  067705           JMP STSAF      COMBINE ERRORS AND EXIT
02965000                         *
02966000                         *-----SPECIAL CASE:  RE-MARK A RECORD HEAD.
02967000                         *
02968000                         *    THIS OPTION SHOULD ONLY BE USED WHEN YOU CAN'T
02969000                         *  READ A RECORD HEAD. THE MRK MODULE RECOGNIZES
02970000                         *  THIS CASE BY NOREC=0. MSIZE MUST ALSO BE 0. BUT THE
02971000                         *  TOS DOES THIS CHECK. THE HEAD IS REWRITTEN WITH AN
02972000                         *  ABSOLUTE SIZE OF 1 WORD.
02973000                         *
02974000                         *    SUPPOSE YOU WISH TO REMARK THE HEAD OF
02975000                         *  RECORD X:
02976000                         *         1)IF X=0, THEN DO A REWIND. OTHERWISE DO
02977000                         *  A FIND X.
02978000                         *         2)NOW DO A MARK CMD WITH "NUMBER OF
02979000                         *  RECORDS" PARAMETER = 0 AND "RECORD SIZE" PARAMETER = 0!
02980000                         *
02981000 21005  004257   .MRK5   LDB M1         NEEDED IN CASE AT REWIND.
02982000 21006  000137           LDA D8         WRITE 8WDS OF "BODY" AFTER RE-
02983000 21007  031731           STA WCTR       MARKING THE HEAD.(MIN. AT ORGNAL
02984000 21010  011705           CPA TPOS       MARK IS 18WDS). AT REWIND?
02985000 21011  035676           STB CRECN      YES: THIS -1 GOES TO 0--NXT INST
02986000 21012  045676           ISZ CRECN      RE-MARKING NEXT REC IN FWD DIR!
02987000 21013  066014           JMP *+1        SLACK SINCE CRECN=-1 IS POSSIBLE
02988000                         IFZ
02989000 21014  000254           LDA ONE        FORCE NEW ABSOLUTE
02990000 21015  031677           STA ASIZE      SIZE TO BE 1 WORD.
```

```
02991000                     XIF
02992000                *
02993000                *----WE ARE IN THE IRG OF THE RECORD PRECEDING THE
02994000                * RECORD THAT MUST BE RE-MARKED.
02995000                *
02996000 21016  000057       LDA RLFDH      GO LS,,FWD. WE MUST GET OUT OF
02997000 21017  043715       JSM CMDW       THIS IRG SINCE INCODE KEYS OFF OF
02998000 21020  043261       JSM INDTA      THE IRG.
02999000 21021  043275       JSM NCODE      RE-MARK THE REC HEAD(RTYPR=0!)
03000000 21022  067200       JMP .DC35      STOP;SET TPOS; EXIT!
03001000                *
03002000                ********** MARK FROM REWIND **********
03003000                *
03004000                *
03005000                *-----WRITE 'DEAD ZONE' AT BOT
03006000                *
03007000 21023  076462  .MRK8 SZB .MRK5     B=NOREC! NOREC=0 IS SPECIAL!
03008000 21024  000074       LDA WLFDD      WRITE,LS,FWD,DATA,DATA AND
03009000 21025  043715       JSM CMDW       START GOING;WAIT TIL UP TO SPEED
03010000 21026  000177       LDA ZERO
03011000 21027  031676       STA CRECN      1ST REC IS 0
03012000 21030  002735       LDA DEADZ      SET WCTR TO THE NUMBER OF ALL
03013000 21031  031731       STA WCTR       ONES WORDS IN THE "DEADZONE".
03014000                *
03014100                * NOTE: HRDW IN WRT, TAC, DATA; SHOULD BE IN
03014200                *     WRT, DATA, DATA. RESULT IS A
03014300                *     LONGER DEAD ZONE.
03014400                *
03014500 21032  043414       JSM MARK0      WRITE THE DEAD ZONE
03015000 21033  066042       JMP .MRK3      GET INTO MAIN MARK LOOP
03016000                *
03017000                *----IN IRG OF INITIAL MARKING RECORD
03018000                *
03019000 21034  076451  .MRK2 SZB .MRK5     B=NOREC! NOREC=0 IS SPECIAL!
03020000 21035  043275       JSM NCODE      RE-WRITE HEAD&BODY OF 1ST REC.
03021000 21036  045676  .MRK7 ISZ CRECN
03022000 21037  055722       DSZ NOREC      ANY MORE RECORDS TO MARK?
03023000 21040  066042       JMP *+2        YES
03024000 21041  066052       JMP .MRK1      NO-DONE
03025000 21042  001726  .MRK3 LDA MRKSZ     SET WCTR TO NUMBER OF ALL ONES
03026000 21043  031731       STA WCTR       WORDS IN THE RECORD BODY.
03027000 21044  006733       LDB IRGLN
03028000 21045  043431       JSM WGAP       WRITE AN IRG
03029000 21046  000005       LDA R5         GET HRDW STATUS
03030000 21047  073431       RLA .MRK4      SKIP IF BET OCCURRED
03031000 21050  043301       JSM NCEP1      AN ENTRY POINT OF NCODE!PREAMBLE
03032000 21051  066036       JMP .MRK7      MUST CHECK FOR MORE RECORDS
03033000                *
03034000                *-----NOW MARK THE EXTRA RECORD (ASIZE=0)
03035000                *
03036000 21052  000177  .MRK1 LDA ZERO
03037000 21053  031677       STA ASIZE      SET ABSOLUTE SIZE=0
03038000 21054  000123       LDA P20        WRITE 20WDS OF BODY! THIS HELPS
03039000 21055  031731       STA WCTR       BACKING UP IF RUN INTO EOT!
03040000 21056  006733       LDB IRGLN
03041000 21057  043431       JSM WGAP       WRITE IRG
03042000 21060  043301       JSM NCEP1      WRITE THE EXTRA RECORD
03043000 21061  006731       LDB EVTLN
03044000 21062  043431       JSM WGAP       WRITE END OF VALID TAPE
03045000                *
03046000                *-----GET BACK TO EXTRA RECORD
03047000                *
03048000 21063  000057       LDA RLFDH      NOW PUT HRDW INTO READ
03049000 21064  043730       JSM OUTCM      MODE.(THOLD=HI FOR GAP DETECT)
03050000 21065  043475       JSM TURN       TURN AROUND
03051000 21066  000005       LDA R5         LOAD HRDW STATUS.
03052000 21067  073411       RLA .MRK4      SKIP IF WE HIT A HOLE.
03053000 21070  002733  .MRK9 LDA IRGLN     NOW WAIT 1" TO MAKE
03054000 21071  043525       JSM WAIT       SURE I'M IN THE EVTM!
03055000 21072  043451       JSM BUP1       THIS GETS ME INTO THE GAP OF
03056000                *                   THE 1ST REC BEFORE THE EVTM
03057000 21073  043705       JSM STSAF      COMBINE HRDW & SFTW ERRORS
03058000 21074  170201       RET 1          AN ERROR WAS FOUND! EXIT
03059000 21075  000145       LDA TWO        INDICATE WE KNOW THE REC
03060000 21076  031705       STA TPOS       NUMBER OF OUR CURRENT POSITION.
03061000 21077  170202       RET 2          YES
03062000                *
03063000                *------HIT BET BEFORE DONE! FIND LAST RECORD BUT
03064000                *------LEAVE AN EVTLN FROM EOT
03065000                *
03066000 21100  043545  .MRK4 JSM HOLE      GET BACK INTO VALID DATA.
03067000 21101  170201       RET 1          HOLE HAD ERROR
03068000 21102  014137       CPB D8         TPOS IN B! AT BOT?
03069000 21103  067630       JMP .EHOL      YES--LOG A BET ERROR & EXIT.
```

```
                              ******MARK*****

03070000                    *
03071000                    *----AT EOT; LEAVE BUFFER AREA
03072000                    *
03073000 21104  002743            LDA RHRDL     GO HS,REV READY
03074000 21105  043730            JSM OUTCM     FOR GAP DETECTION.
03075000 21106  002731            LDA EVTLN
03076000 21107  043525            JSM WAIT      GET EVT DIST FROM EOT
03077000 21110  042177            JSM IDR6      FIND THE LAST GOOD RECORD
03078000 21111  170201            RET 1         IDR HAD TROUBLE--ERROR EXIT
03079000                    *
03080000                    *----MAKE SURE NEW EXTRA REC IS AN EMPTY REC;
03081000                    *
03082000 21112  001701      .MRKB LDA RTYPE     GET REC TYPE
03083000 21113  072407            SZA .MRKA     SKIP IF EMPTY REC
03084000 21114  001676            LDA CRECN     IT'S NOT EMPTY; MUST HAVE
03085000 21115  020254            ADA ONE       BACKED UP TOO FAR. FIND
03086000 21116  031725            STA RECNO     THE NEXT RECORD
03087000 21117  042244            JSM .DF1      IN THE FWD DIRECTION
03088000 21120  170201            RET 1         FIND ROUTINE HAD AN ERROR
03089000 21121  066112            JMP .MRKB     CHECK THIS RECORD
03090000                    *
03091000                    *----REWRITE THIS REC HEAD AS THE EXTRA (NULL) REC.
03092000                    *  THEN WRITE GAP UNTIL EOT. THEN GET BACK TO THE
03093000                    *  EXTRA RECORD, READ ITS HEAD, BACKUP TO ITS GAP
03094000                    *  AND EXIT
03095000                    *
03096000 21122  001676      .MRKA LDA CRECN     MUST SET RECNO = NULL RECORD
03097000 21123  031725            STA RECNO     SO THAT AFTER ERASING THE REST
03098000 21124  042452            JSM .ERS1     OF THE TRK, WE GET BACK TO IT;
03099000 21125  170201            RET 1         HAD ERROR
03100000 21126  000073            LDA MKERR     LOG ERROR =
03101000 21127  031763            STA ERRWD     MARK DIDN'T FIT
03102000 21130  067705            JMP STSAF     COMBINE ERRORS AND EXIT;


                              ******IDR*****


03104000                    *
03105000                    *     IDR(DETERMINE PRESENT TAPE POSITION)
03106000                    *
03107000 21131  043635      IDR   JSM STSHF     CHECK HRDW
03108000 21132  170201            RET 1         SOMETHING IS WRONG
03109000 21133  001705            LDA TPOS
03110000 21134  010254            CPA ONE       WAS PREVIOUS INSTRUCT A FIND?
03111000 21135  170202            RET 2         YES; ALL DONE THEN
03112000 21136  010145            CPA TWO       DO WE KNOW REC NO.?
03113000 21137  066210            JMP IDR1      YES--GO FWD AND READ THE RHEAD.
03114000 21140  010137            CPA OB        AT REWIND?
03115000 21141  066143            JMP IDR10     YES
03116000 21142  066175            JMP IDR4      NO--I'M LOST
03117000                    *
03118000                    *-----AT REWIND, IS THE TRACK BLANK?
03119000                    *
03120000 21143  000057      IDR10 LDA RLFDH     TELL HRDW TO READ,LS,FWD,DATA,
03121000 21144  043730            JSM OUTCM     THOLD=HI; WAIT 2.5"
03122000 21145  002732            LDA INDED     FROM LP TO GUARANTEE I REACH
03123000 21146  043525            JSM WAIT      THE "DEADZONE" (IF PRESENT).
03124000 21147  000005            LDA R5        GET STATUS
03125000 21150  170503            SAR 4         GET IRG BIT INTO LSB
03126000 21151  073002            SLA *+2
03127000 21152  066220            JMP IDR5      HIT GAP--MUST BE VIRGIN TAPE
03128000 21153  006725            LDB .M12I     12" IS ENUF TO HIT REC 0!
03129000 21154  072600      IDR20 SFC *
03130000 21155  000004            LDA R4        CLR TAC
03131000 21156  076102            RIB *+2       LOOKED FAR ENOUGH?
03132000 21157  066220            JMP IDR5      YES; NO GAP YET; BLANK TAPE
03133000 21160  000005            LDA R5        NO; HAVE WE HIT GAP?
03134000 21161  170503            SAR 4         GET IRG BIT INTO LSB
03135000 21162  073072            SLA IDR20     NO GAP; KEEP GOING
03136000 21163  003024      IDR8  LDA STINS     SET UP ENTRY SO
03137000 21164  031723            STA INSTR     THAT "RDHED" READS THE
03138000 21165  043001            JSM RDHED     RHEAD AT LOW THRESHOLD
03139000 21166  170201            RET 1         TROUBLE READING THE REC HEAD
03140000 21167  043450      IDR7  JSM BCKUP     GET BACK TO GAP OF REC IDR'D
03141000 21170  043705            JSM STSAF     COMBINES HRDW & SFTW ERRORS
03142000 21171  170201            RET 1         AN ERROR OCCURRED--EXIT
03143000 21172  000254            LDA ONE       SET TAPE POSITION INDICATOR MEAN
03144000 21173  031705            STA TPOS      "WE KNOW ALL ABOUT THIS RECORD"
03145000 21174  170202            RET 2         EXIT
03146000                    *
03147000                    *-----LOST--TAPE POSITION UNKNOWN
03148000                    *
03149000 21175  002743      IDR4  LDA RHRDL     GO HS,REV LOOKING
03150000 21176  043715            JSM CMDW      FOR A REC; GUAR. I HIT 22IPS.
03151000 21177  043261      IDR6  JSM INDTA     FIND A DATA REGION.
```

```
                              ******IDR*****

03152000 21200  043271          JSM INGAP      FIND GAP (RECORD)
03153000 21201  000005          LDA R5         CHECK FOR HOLE BEFORE
03153100 21202  073411          RLA IDR9       "JSM TURN" CHANGES TAPE DIR. (HOLE*JMP IDR9)
03153200 21203  043475          JSM TURN       MUST TURN TO BE ABLE TO READ HED
03154000 21204  043271          JSM INGAP      GIVES TURN 1 REC UNCERTAINTY.
03155000 21205  000005          LDA R5         GET HROW STATUS
03156000 21206  073405          RLA IDR9       SKIP IF WE HIT A HOLE
03157000 21207  066163          JMP IDR8       DIDN'T HIT BET; THUS WE HAVE
03158000                 *                     FOUND A RECORD!
03159000                 *
03160000                 *-----TPOS=2; GO HS FWD TO GET THE REC HEAD
03161000                 *
03162000 21210  001676   IDR1   LDA CRECN      SET THE TARGET REC = CURRENT
03163000 21211  031725          STA RECNO      REC (SPECIAL FOR TPOS=2); FIND
03164000 21212  066244          JMP .DF1       THE REC AND EXIT!
03165000                 *
03166000                 *      HIT A HOLE
03167000                 *
03168000 21213  043545   IDR9   JSM HOLE
03169000 21214  170201          RET 1          HOLE HAD ERROR
03170000 21215  014137          CPB D8         TPOS IN B; AT BOT?
03171000 21216  066143          JMP IDR10      YES
03172000 21217  066175          JMP IDR4       AT EOT; STILL LOOK FOR A REC
03173000                 *
03174000                 *      BLANK TRACK
03175000                 *
03176000 21220  000236   IDR5   LDA NRERR      ERROR--NO RECORD FOUND
03177000 21221  031763          STA ERRWD      LOG "BLANK TRACK" ERROR
03178000 21222  000127          LDA D16        SET TAPE POSITION
03179000 21223  031705          STA TPOS       TO "LOST"
03180000                 *                     STSAF WILL STOP THE TAPE
03181000 21224  067705          JMP STSAF      COMBINE ERRORS AND EXIT


                              *****WTR*****

03183000                 *
03184000                 ******WTR(WRITE A RECORD)
03185000                 *
03186000                 *
03187000                 **********HOW TO USE WTR**********
03188000                 *
03189000                 *      JSM CARTP      IS CART PROTECTED?
03190000                 *      JMP CASER      YES-WRITING IS AN ERROR!
03191000                 *      JSM DFND       FINDS THE RECORD STORED IN RECNO
03192000                 *      JMP CASER      CASSETTE ERROR
03193000                 *
03194000                 *--BLOCK OF SYSTEM CODE WHICH:
03195000                 *          1. CHECKS SIZE,TYPE AND REC "SECUREDNESS"
03196000                 *          2. MODIFY REC HEAD (NEW CSIZE,TYPE,ETC)
03197000                 *      JSM WTR        WRITES THE RECORD
03198000                 *      JMP CASER      CASSETTE ERROR
03199000                 *      JMP NXTCM      GET NEXT COMMAND
03200000                 *
03201000                 *----IN DATA REGION BEFORE THIS RECORD OR IN ITS GAP
03202000                 *
03203000                 *
03204000                 *-----ENTRY POINT "WTRC" IS FOR CLEARING A FILE.
03205000                 * IT ASSUMES RTYPE IS SET TO ZERO. THEN IT WILL
03206000                 * REWRITE THE REC HEAD AND ONLY 1 WORD OF JUNK BODY!
03207000                 *
03208000 21225  000254   WTRC   LDA ONE        MUST DEFINE WCTR=NO. OF WORDS
03209000 21226  031731          STA WCTR       OF BODY IF RTYPE = 0.
03210000 21227  045702   WTR    ISZ RRWNO      INCREMENT THE RECORD RE-WRITE #
03211000 21230  043275          JSM NCODE      WRITE THE RECORD
03212000                 *                     STSAF WILL STOP THE TAPE
03213000 21231  067705          JMP STSAF      COMBINE ERRORS & EXIT


                              *****RDR*****

03215000                 *
03216000                 *-----RDR(READ A RECORD)
03217000                 *
03218000                 *
03219000                 **********HOW TO READ A RECORD**********
03220000                 *
03221000                 *--PUT THE RECORD NO. INTO "RECNO".
03222000                 *
03223000                 *      JSM DFND       FINDS THE RECORD
03224000                 *      JMP CASER      CASSETTE ERROR!
03225000                 *
```

```
                         *****RDR*****
03226000          *--BLOCK OF SYSTEM CODE WHICH:
03227000          *
03228000          *        1. CHECKS RECORD'S SIZE (FIT INTO MEMORY?)
03229000          *        2. CHECKS RECORD'S TYPE
03230000          *        3. IS THIS RECORD SECURED
03231000          *        4. DOES MEMORY NEED TO BE MOVED
03232000          *        5. SET MBPTR TO LOC FOR 1ST WORD OF BODY
03233000          *        6. SET INSTR = "STINS" (STORE INTO MEMORY INSTRUCTION).
03234000          *
03235000          *     JSM RBODY     READ THE REC BODY INTO MEMORY.
03236000          *     JMP CASER     CASSETTE ERROR!
03237000          *
03238000          *-----RECORD LOADED!
03239000          *


03241000          *
03242000          *-----VFY(VERIFY A RECORD AGAINST MEMORY)
03243000          *
03244000          *
03245000          **********HOW TO VERIFY A RECORD**********
03246000          *
03247000          *--THE CALLING SEQUENCE IS THE SAME AS FOR READING
03248000          *  A RECORD EXCEPT REPLACE
03249000          *
03250000          *         6. SET INST: *  "STINS" (STORE INTO MEMORY INSTRUCTION).
03251000          *
03252000          *  WITH
03253000          *
03254000          *         6. SET INSTR = "CPINS" (COMPARE MEMORY INSTRUCTION).

                         *****FIND*****

03256000                  *
03257000                  *****SUBROUTINE DFND(DUAL FIND:BPC CONTROL OR HRDW)
03258000                  *
03259000                  *     INPUTS:  1.)RECNO : TARGET RECORD NUMBER
03260000                  *              2.)FLG3  : SET = HRDW FIND
03261000                  *                         CLR = BPC FIND
03262000                  *
03263000                  *     RETURN:   RET 1     ERROR
03264000                  *               RET 2     NORMAL
03265000                  *
03266000 21232  043635   DFND  JSM STSBF      CHECK HARDWARE
03267000 21233  170201         RET 1          ERROR
03268000 21234  001705         LDA TPOS       CHECK PRESENT
03269000 21235  010145         CPA TWO        TAPE POSITION
03270000 21236  066244         JMP .DF1       OK--KNOW WHERE WE ARE
03271000 21237  042131         JSM IDR        FIND OUR PRESENT POSITION
03272000 21240  170201         RET 1          ERROR
03273000 21241  001676         LDA CRECN      GET CURRENT REC NO.
03274000 21242  011725         CPA RECNO      IS IT SAME AS TARGET?
03275000 21243  170202         RET 2          YES--ALL DONE
03277000 21244  001343   .DF1  LDA NOTRY
03282000 21245  031724         STA FPASS      ALLOW NOTRY CHANCES TO FIND REC
03283000                  *-----------COMPUTE DIST TO TARGET
03284000 21246  005676   .FND6 LDB CRECN      COMPUTE TARGET REC NO. (RECNO)-
03285000 21247  174040         TCB            CURRENT REC NO.(CRECN) IN B. B
03286000 21250  025725         ADB RECNO      HAS # GAPS TO TARGET.(NOT
03287000                  *                   COUNTING GAP OF CRECN)
03288000 21251  176407         SBM .SCHR      B NEGATIVE = SEARCH REVERSE
03289000 21252  002745         LDA RHFTL      SRCH FWD AT
03290000 21253  043715         JSM CMDW       START GOING:WAIT TIL UP TO SPEED
03291000 21254  043271         JSM INGAP      MUST OVERCOME UNCERTAINTY IN
03292000 21255  043261         JSM INDTA      POSITION DUE TO TPOS=2.
03293000 21256  076006         RZB .DF2       SKIP IF NOT AT TARGET. DIST TO
03294000                  *                   TARGET CAN BE 0 RECORDS IF
03295000                  *                   TPOS=2,YET NOT REALLY AT TARGET!
03296000 21257  066327         JMP .DF3       AT TARGET--FINISH OFF THE ACCESS
03297000                  *                   THE JSM INDTA (LOC=*-2) IS NEC
03298000                  *                   TO FINISH OFF THIS ACCESS!
03299000 21260  174040   .SCHR TCB            MAKE TARGET DIST POSITIVE
03300000 21261  002744         LDA RHRTL      SEARCH REVERSE
03301000 21262  043715         JSM CMDW       START GOING:WAIT TIL UP TO SPEED
03302000 21263  043261         JSM INDTA      COULD WAKE UP IN IRG:NO COUNT IT
03303000                  *
03304000                  *-----IS FND BPC OR HRDW CONTROLLED?
03305000                  *
03306000 21264  001764   .DF2  LDA FLG2       DETERMINE WHO CONTROLS THE SRCH!
03307000 21265  073023         SLA .FND9      SKIP IF BPC CONTROLLED SEARCH.
03308000                  *
```

```
                                   *****FIND*****

03309000                    *-----PARALLEL SEARCH
03310000                    *
03311000 21266  001514           LDA CSELC     GET CASSETTE SELECT-CODE
03312000 21267  031345           STA CSCF      SAVE SC OF CASSETTE DOING A FIND
03313000 21270  030013           STA DMAPA     ALSO SET DMA PER. ADDR.
03314000 21271  000247           LDA M30K      MUST SET DMA MEMORY ADDR REG
03315000                         IFZ
03316000 21272  030014           STA DMAMA     TO "OUTPUT" VALUE.
03317000                         XIF
03318000 21273  024257           ADB M1        DMA HRDW NEED DISTANCE TO TARGET
03319000 21274  034015           STB DMAC      REC-1; STORE THAT IN DMA CTR.
03320000 21275  070440           DMA           ENABLE DMA HRDW TO COUNT IRGS
03321000 21276  001710           LDA CUCMD     GET THE CURRENT HRDW CMD
03322000 21277  050147           AND M3        ENABLE SCH BIT
03323000 21300  043730           JSM OUTCM     GIVE HRDW PAR. SEARCH CMD (FIND)
03324000 21301  000127           LDA D16       SET TAPE POSITION
03325000 21302  031705           STA TPOS      TO LOST!
03326000 21303  001707           LDA FLG1      GET CURRENT TRK
03327000 21304  170616           SAL 15        SO WE CAN
03328000 21305  061725           IOR RECNO     SAVE TRK AND TARGET REC NUMBER
03329000 21306  031346           STA FTRGT     FOR THIS FIND.
03330000 21307  170202           RET 2
03331000                    *
03332000                    *-----BPC CONTROL (MUST BE PART OF RDR OR WTR)
03333000                    *
03334000                    *
03335000                    *-----B REG IS NUMBER OF RECS TO TARGET
03336000                    *
03337000 21310  002732      .FND9 LDA EVTDT    INIT WCTR TO # OF TAC PULES IT
03338000 21311  031731           STA WCTR      TAKES TO RECOG AN EVTM!
03339000 21312  043271           JSM INGAP     FIND A REGION OF GAP
03340000 21313  000005      .FND7 LDA R5       GET HRDW STATUS
03341000 21314  170503           SAR 4         MOVE IRG BIT INTO LSB
03342000 21315  073010           SLA .FND8     SKIP IF INTO DATA
03343000 21316  072600           SFC *         WAIT FOR TAC (IN TAC BEC FND4+1)
03344000 21317  030004           STA R4        CLR FLG
03345000 21320  045731           ISZ WCTR      HAVE WE DETECTED AN EVTM?
03346000 21321  066313           JMP .FND7     NOT YET
03347000 21322  000127           LDA D16       SET TAPE POSITION INDICATOR
03348000 21323  031705           STA TPOS      TO LOST!
03349000 21324  066347           JMP .FND0
03350000 21325  054001      .FND8 DSZ B        COUNT GAP; SKIP IF AT TARGET
03351000 21326  066310           JMP .FND9     NOW GET READY FOR NEXT GAP.
03352000                    *
03353000                    *----GOING HS & IN A DATA REGION. IT IS BEFORE THE
03354000                    * GAP IF SEARCH DIR=REV; AFTER IF SEARCH DIR=FWD!
03355000                    *
03356000 21327  043475      .DF3  JSM TURN     TURNAROUND & GO LS
03357000 21330  043261           JSM INDTA     GIVES TURN A GAP + DATA UNCERT.
03358000 21331  001710           LDA CUCMD
03359000 21332  170612           SAL 11        WANT TO DETERMINE CUR DIR
03360000 21333  172404           SAM .FND5     DON'T TURN IF DIR=FWD!
03361000 21334  043271           JSM INGAP     GET INTO TARGET RECORD'S IRG.
03362000 21335  043716           JSM CMDW1     GO INTO THE GAP ABOUT .22", THEN
03363000 21336  043475           JSM TURN
03364000                    *
03365000                    *----VERIFY ACCESS NOW!
03366000                    *
03367000 21337  042163      .FND5 JSM IDR8     NOW READ THE HEAD
03368000 21340  170201           RET 1         IDR HAD A PROBLEM
03369000 21341  043456      .FND2 JSM STPED    GET CASSETTE TO A DEAD STOP
03370000 21342  001676           LDA CRECN     YES; FIND RIGHT RECORD?
03371000 21343  011725           CPA RECNO
03372000 21344  170202           RET 2         FOUND RIGHT RECORD
03373000 21345  055724           DSZ FPASS     NO; ALL FIND PASSES DONE?
03374000 21346  066246           JMP .FND6     NO; TRY AGAIN
03375000 21347  000236      .FND0 LDA NRERR    LOG ERROR =
03376000 21350  031763           STA ERRWD     RECORD CAN'T BE FOUND
03377000 21351  067705           JMP STSAF     COMBINE ERRORS AND EXIT
03378000                    *                  STSAF WILL STOP THE TAPE
03380000                    *
03381000                    *-----THIS ROUTINE COMPLETES A FIND COMMAND SINCE
03382000                    * THE HRDW ONLY GETS YOU WITHIN 4". THIS ROUTINE
03383000                    * WILL ONLY COMPLETE A FIND IF THE CURRENT TRK AND
03384000                    * SC ARE THE SAME AS WHEN THE FIND WAS STARTED.
03385000                    *
03386000 21352  001514      CFD   LDA CSELC    GET CURRENT SC
03387000 21353  011345           CPA CSCF      SAME AS FIND SC?
03388000 21354  066356           JMP *+2       YES
03389000 21355  170202           RET 2         NO--DONHT COMPLETE THE FIND.
03390000 21356  000005           LDA R5        WAIT FOR THE TAPE TO
03391000 21357  170504           SAR 5         STOP MOVING BEFORE
03392000 21360  073476           RLA *-2       CLEARING DMAPA!
03393000 21361  000177           LDA ZERO      SET CSCF TO ZERO MEANING THE
03394000 21362  031345           STA CSCF      FIND WILL BE COMPLETED!
```

```
                              *****FIND*****

03395000 21363  030013          STA DMAPA     MAKE THE DMA HRDW AVAIL.
03396000 21364  001346          LDA FTRGT     GET TARGET ADDR: TRK & REC NUM.
03397000 21365  005707          LDB FLG1      GET CURRENT TRK
03398000 21366  077403          RLB .CTKA     SKIP IF CURRENTLY ON TRK "A"
03399000 21367  172003          SAP .CFD      CURRENT TRK="B=!SKIP=FIND ON "B"
03400000 21370  170202          RET 2         FIND TRK # CURRENT TRK! EXIT
03401000 21371  172277    .CTKA SAP *-1,C     CURRENT TRK="A"!SKIP=FIND IS NOT
03402000 21372  031725    .CFD  STA RECNO     SAVE TARGET REC #! MSB=0!
03403000 21373  000005          LDA R5        NOW CHECK TO
03404000 21374  170501          SAR 2         SEE IF CART WAS PULLED OUT.
03405000 21375  073002          SLA *+2       SKIP IF SAME CART IN MACHINE
03406000 21376  067635          JMP STSBF     NEW CART--CHECK STATUS & EXIT
03407000 21377  043635          JSM STSBF     CLR ERRWD! CHECK STATUS
03408000                  *                   ALSO WAIT FOR HRDW TO STOP.
03409000 21400  170201          RET 1         HRDW STATUS ERROR
03410000 21401  000005          LDA R5        CHECK THE DIRECTION
03411000 21402  170505          SAR 6         WE SEARCHED ON THE FIND
03412000 21403  073406          RLA .CFD1     SKIP IF SRCH'D REV
03413000 21404  000064          LDA RLRTH     FWD! WE'RE ON WRONG SIDE OF REC
03414000 21405  043730          JSM OUTCM     TELL HRDW TO
03415000 21406  002740          LDA CFDF      BACK UP CFDF NUMBER OF TAC
03416000 21407  043525          JSM WAIT      PULSES. THIS PUTS ME IN FRONT OF
03417000 21410  043475          JSM TURN      THE DESIRED REC. NOW TURNAROUND
03418000                  *                   BEC WE MUST GO FWD TO READ HEAD
03419000 21411  042163    .CFD1 JSM IOR8      GO READ THE RECORD HEAD
03420000 21412  066413          JMP *+1       ERROR--GIVE DFND A CHANCE
03421000                  *                            IT CAN RECOVER FROM HOLES!
03422000 21413  066232          JMP DFND      CLEAR OUT ANY ERRORS IOR8 HAD.
03423000                  *                   THEN FINISH THE FIND AND EXIT!


                              *****REWIND*****


03425000                  *
03426000                  *----SUBROUTINE REW
03427000                  *
03428000                  *-----THIS ROUTINE WILL REWIND THE TAPE TO
03429000                  *  BEG. OF TAPE. IT IS AN UNATTENDED REWIND.
03430000                  *
03431000 21414  042701    REW   JSM STOPC     STOP THE CASSETTE
03432000 21415  043635          JSM STSBF     CHECK THE HRDW STATUS
03433000 21416  170201          RET 1         ERROR--BAD HRDW STATUS
03434000 21417  002744    REW1  LDA RHRTL     GO HS,REV TO
03435000 21420  043730          JSM OUTCM     REACH BEG. OF TAPE
03436000 21421  006723          LDB .M301     WAIT 30 IN.(> MAX. DIST BETW
03437000 21422  043536          JSM MSBET     HOLES) OR WAIT FOR A HOLE
03438000 21423  066427          JMP .REW1     HIT A HOLE--ANALYZE IT
03439000 21424  000137    .REW2 LDA D8        THIS VALUE OF TPOS ALLOWS IDF
03440000 21425  031705          STA TPOS      (KPF CMD) TO BE EXECUTED NEXT!
03441000                  *                   ALSO IMPT FOR TRK CMD!
03442000 21426  170202          RET 2         REWIND HAS BEEN DONE
03443000 21427  043545    .REW1 JSM HOLE      FIND OUR POSITION
03444000 21430  170201          RET 1         HOLE FOUND TROUBLE
03445000 21431  014137          CPB D8        TPOS IN B! AT BOT?
03446000 21432  067705          JMP STSAF     YES--EXIT
03447000 21433  066417          JMP REW1      AT EOT. GO HS, REV TO BOT.

03449000                  *
03450000                  *-----SUBROUTINE TRK
03451000                  *
03452000                  *-----THIS ROUTINE WILL SWITCH TRACKS. IT WILL SET
03453000                  *  TPOS TO LOST IF NEW TRK IS DIFFERENT FROM THE
03454000                  *  OLD TRACK. IT ASSUMES THAT THE A REGISTER HAS:
03455000                  *      0 FOR TRACK 0 = TRACK A  (CMD BIT TRB=1)
03456000                  *      1 FOR TRACK 1 = TRACK B  (CMB BIT TRB=0)
03457000                  *
03458000                  *              NOTE:
03459000                  *                     TRK DOES NOT CLEAR ERRWD SINCE NO
03460000                  *                     ERRORS ARE POSSIBLE WHEN SWITCHING
03461000                  *                     TRACKS. THUS ERRWD IS NOT VALID.
03462000                  *
03463000 21434  005707    TRK   LDB FLG1      GET CURRENT TRACK.
03464000 21435  073003          SLA TRK0      SKIP IF NEW TRK=A
03465000 21436  077211    TRK1  SLB TRKE,C    NEW TRK=B!SKIP IF PRESENT TRK=B
03466000 21437  066441          JMP *+2       PRESENT TRK=A ! LSB OF B WAS
03467000                  *                   CLR'ED SO IT IS SET FOR TRK B
03468000 21440  077707    TRK0  RLB TRKE,S    NEW TRK=A!SKIP IF PRESENT TRK=A
03469000 21441  035707          STB FLG1      PRESENT TRK=B! LSB OF B IS SET
03470000 21442  001705          LDA TPOS      GET CURRENT TAPE POSITION
03471000 21443  010137          CPA D8        ARE WE AT REWIND?
03472000 21444  066447          JMP TRKE      YES! DON'T CHANGE TPOS
03473000 21445  000127          LDA D16       SET TAPE POSITION INDICATOR TO
03474000 21446  031705          STA TPOS      LOST SINCE WE SWITCHED TRACKS!
03475000 21447  170201    TRKE  RET 1         TRACK SWITCH COMPLETED.
```

*****ERASE*****

```
                         *
                         *-----SUBROUTINE ERS (TOS POSITIONS THE TAPE)
                         *
                         *
                         *-----THIS ROUTINE WILL ERASE AN ENTIRE TRACK OF THE
                         * TAPE. IT ASSUMES THE TOS HAS POSITIONED THE TAPE
                         * IN THE IRG OF THE STARTING RECORD. THAT RECORD HEAD
                         * WILL BE REWRITTEN TURNING IT INTO THE "NULL" RECORD
                         * AND ALL HIGHER RECORD NUMBERS ON THAT TRACK WILL BE
                         * ERASED.
                         *
21450  043465   ERS      JSM CARTP      IS THIS CARTRIDGE PROTECTED?
21451  170201            RET 1          YES--CAN'T ERASE THEN--ERROR
21452  000177  .ERS1     LDA ZERO       SET THESE ITEMS TO ZERO:
21453  031700            STA CSIZE      CURRENT SIZE
21454  031701            STA RTYPE      RECORD TYPE
21455  031677            STA ASIZE      ABSOLUTE SIZE
21456  042225            JSM WTRC       RE-WRITE THE RECORD HEAD
21457  170201            RET 1          ERROR
21460  043440            JSM WGAPH      WRITE GAP UNTIL EOT
21461  170201            RET 1          ERROR
21462  066232            JMP DFND       THIS GUAR. THAT WE GET BACK TO
                *                       THE NEWLY CREATED NULL FILE!
```

********* ERLN *********

```
                *
                *
                *
                *     ERLN IS THE ROUTINE THAT PLACES A DUMMY LINE IN THE USER'S
                *          PROGRAM WHEN A PARTITION HAS BEEN DELETED BECAUSE OF ERROR
                *
                *
                *     ON ENTRY : BDPTR POINTS AT THE FIRST LINE BRIDGE OF THE
                *                BAD PARTITION
                *
                *
                *     TEMPORARIES USED : ERRWD, RTYPE, BDPTR, DLFLG
                *
                *     ROUTINES CALLED : NONE
                *
                *
21463  000044   ERLN  LDA RBERR             READ BODY ERROR
21464  031763         STA ERRWD
21465  001701         LDA RTYPE             SEE IF USER'S PROGRAM
21466  010141         CPA P6                ONLY CONCERNED WITH IT
21467  066477         JMP ERLN1
21470  010145         CPA P2                SEE IF IT IS A DATA (NUMERIC) FILE
21471  066473         JMP *+2               YES, NUMERIC DATA SO INSERT ???????
21472  170201         RET 1
21473  005734         LDB BDPTR             GET THE POINT TO INSERT THE QUESTION MARK
21474  002773         LDA QMRKS             GET ADDRESS OF THE QUESTION MARKS
21475  071403         XFR 4                 TRANSFER THEM TO THE DATEM
21476  170201   ERLN2 RET 1
21477  001727   ERLN1 LDA DLFLG             MUST CHECK TO SEE IF THIS PARTITION HAS
21500  073776         RLA ERLN2,S           EVEN HAD STARS
21501  031727         STA DLFLG             NO IT HASN'T SO PUT IN DUMMY LINE
21502  000141         LDA P6                SET THE LOWER LINE BRIDGE OF THE DUMMY LINE
21503  131734         STA BDPTR,I
21504  045734         ISZ BDPTR             SET THIS POINTER TO THE DUMMY LINE'S LOCATION
21505  005734         LDB BDPTR
21506  002515         LDA QUSTA             GET ADDRESS OF THE DUMMY LINE
21507  071404         XFR 5                 TRANSFER THE DUMMY LINE
21510  024142         ADB P5
21511  000235         LDA B3377             SET UP THE UPPER DUMMY LINE'S BRIDGE
21512  130001         STA B,I
21513  035734         STB BDPTR             RESET BDPTR
21514  170201         RET 1
                *
                *
                *     THIS WILL BE THE LOCATION OF THE DUMMY LINE TEMPLATE
                *
                *
                *
21515  021516   QUSTA DEF QUST              ADDRESS OF THE DUMMY LINE
21516  021007   QUST  OCT 21007             QUOTE - 'COUNT'
21517  025052   STST1 OCT 25052             STAR - STAR
21520  025052   STST2 OCT 25052             STAR - STAR
21521  025052   STST3 OCT 25052             STAR - STAR
21522  025177   STEOL OCT 25177             STAR - EOL
```

```
***** PTCLC **********

                     *
                     *
                     *
                     *     PTCLC IS THE ROUTINE THAT CALCULATES THE PARTITIONS LENGTHS
                     *          IF THE FILE BEING RECORDED IS ANYTHING OTHER THAN A
                     *          USER'S PROGRAM FILE THE PARTITIONS ARE ALWAYS 128 WORDS
                     *          LONG. IF THE FILE BEING RECORDED IS A USER'S PROGRAM
                     *          FILE THE PARTITION IS AS CLOSE TO 128 WORDS IN LENGTH
                     *          AS POSSIBLE WITH A WHOLE NUMBER OF LINES BEING INCLUDED
                     *
                     *     ON ENTRY : LWMD CONTAINS THE LAST ADDRESS TO BE RECORDED OF THIS
                     *          FILE
                     *          BOPTR POINTS AT THE LOCATION IN MEMORY WHERE THE NEXT
                     *          PARTITION WILL START RECORDING
                     *
                     *     ON EXIT : PARLN IS SET WITH THE LENGTH OF THE NEXT PARTITION
                     *          WCTR IS SET WITH THE LENGTH OF THE NEXT PARTITION
                     *          TEMP1 IS SET TO -1 IF THIS NEXT PARTITION IS THE LAST
                     *          PARTITION IN THE CURRENT FILE
                     *
                     *     TEMPORARIES USED BY THIS ROUTINE : T1, T2, A, B, C, D,
                     *
                     *     ROUTINES CALLED BY THIS ROUTINE : NONE
                     *
                     *
21523  001743  PTCLC LDA LWMD       GET THE ENDING ADDRESS
21524  005734        LDB BOPTR      GET THE CURRENT RECORDING POSITION
21525  174040        TCB
21526  020001        ADA B          THIS IS THE LENGTH OF THE NEXT PATTITION IF IT IS TH
21527  031712        STA T2         LAST SO SAVE IT
21530  004052        LDB P128       SEE IF TI IS THE LAST PARTITION
21531  174040        TCB
21532  020001        ADA B
21533  172402        SAM *+2        IF THE RESULT IS MINUS THIS IS THE LAST PARTITION
21534  066542        JMP PTCL2      NOTH THE LAST PARTITION SO CHECK FILE TYPE
21535  045712        ISZ T2         YES TH LAST PARTITION SO CORRECT THE LENGTH
21536  000257        LDA M1
21537  031717        STA TEMP1      SET TH 'LAST' FLAG
21540  001712        LDA T2         THIS IS THE LENGTH OF THE LAST PARTITION
21541  066571        JMP PTCL9
21542  001701  PTCL2 LDA RTYPE      SEE IF IT IS A USER'S TYPE PROGRAM
21543  010141        CPA P6
21544  066547        JMP PTCL3      YES A USER'S TYPE PROGRAM SO DO LONG PARTITION
                     *              LENGTH CALCULATION
21545  000052        LDA P128       NOT USER'S TYPE PROGRAM SO PARTITION LENGTH IS 128 W
21546  066571        JMP PTCL9
21547  000177  PTCL3 LDA P0
21550  030016        STA C          THIS IS THE NEXT PARTITIONS LENGTH
21551  000157        LDA M15        AT 20 US. PER LINE IT WILL TAKE ABOUT 15 LINES TO
                     *              ACCUMULATE 300 US. FOR THE IPG LENGTH
21552  030017        STA D          THIS IS THE LINE COUNTER
21553  001734        LDA BOPTR      GET THE CURRENT RECORD POSITIN
21554  004000        LDB A
21555  100000  PTCL6 LDA A,I        GET THAT LINE BRIDGE
21556  050053        AND B177       CLEAR HIGH ORDER BITS
21557  020016        ADA C          ADD THE RIGHT HALF OF THE LINE BRIDGE IN TO GET TO T
                     *              NEXT LINE BRIDGE
21560  030016        STA C
21561  020167        ADA M128       SEE IF DONE WITH THIS PARTITION
21562  172402        SAM *+2        IF MINUS THEN THE PARTITION IS NOT LONG ENOUGH YET
21563  066574        JMP PTCL7      DONE WITH PARTITION LENGTH CALCULATION
21564  000016        LDA C          GET THE PARTITION LENGTH
21565  020001        ADA B          ADD IT THO THE BOPTR
21566  044017        ISZ D          COUNT THIS LINE IF IT GOES POSITIVE WE DON'T HAVE TO
                     *              WAIT FOR ANY TAC PULSES AFTER THE CALCUL
21567  066555        JMP PTCL6
21570  066555        JMP PTCL6      ALLOW FOR SKIP
21571  004257  PTCL9 LDB M1         WE MUST WAIT FOR 300 US. BEFORE EXITING
21572  034017        STB D
21573  066575        JMP PTCL8      SO SET THE ILNE COUNTER NEGATINE
21574  000016  PTCL7 LDA C          GET THE PARTITION LENGTH
21575  031731  PTCL8 STA WCTR       THE NEXT PARTITION'S LENGTH IS IN A
21576  031715        STA PARLN
21577  000017        LDA D          GET THE LINE COUNT
21600  172006        SAP PTC10      IF LINE COUNT OS POSITIVE WE NEED COUNT NO TAC PULSE
21601  000146        LDA M2         MUST WAIT 300 US. BETWEEN PARTITIONS
21602  004004        LDB R4         CLEAR TAC LINE
21603  072600        SFC *
21604  072176        RIA *-2
21605  000004        LDA R4         CLEAR TAC LINE
21606  170201  PTC10 RFT 1
                     *
```

***** BRIDGE PATCH *****

```
03639000                *
03640000                *
03641000                *
03642000                *     THIS CODE IS EXECUTED AFTER LOADING A USER'S PROGRAM TO PATCH UP
03643000                *          DANGLING LINE BRIDGES IN CASE OF AN ERROR
03644000                *     THIS ROUTINE IS INVOKED AFTER A RECOVERY CYCLE IS COMPLETED
03645000                *     FOR A USER'S PROGRAM.   THIS CALL ONLY OCCURES IF ERLN HAS
03646000                *     BEEN EXECUTED BY THE DRIVERS AND AT LEAST ONE DUMMY LINE HAS
03647000                *     BEEN INSERTED INTO THE USER'S PROGRAM (BECAUSE A PARTITION IS DELE
03648000                *
03649000                *     THE SEARCH BEGINS AT FWUP AND PATCHES ALL BRIDGES IN THE
03650000                *     PROGRAM FROM FWUP TO ENDS
03651000                *
03652000                *     NOTE : THE FIRST WORD TO BE RECORDED ON A PARTITION IS THE LINE
03653000                *            BRIDGE OF THE FOLLOWING LINE. IE. THE LAST WORD OF A
03654000                *            PARTITION IS NOT A LINE BRIDGE EXCEPT IN THE CASE OF THE
03655000                *            LAST PARTITION IN THE PROGRAM
03656000                *
03657000                *
03658000                *
03659000 21607  005307  PTBRG LDB FWUP             GET THE START OF THE PROGRAM
03660000 21610  015734  PTBR2 CPB BDPTR            SEE IF THIS IS WHERE BDPTR POINTS
03661000 21611  066624        JMP PTBR3            YES IT POINTS HERE
03662000 21612  024254        ADB P1               NOT HERE SO ADJUST GUESS
03663000 21613  015734        CPB BDPTR            DOES IT POINT HERE ?
03664000 21614  066622        JMP PTBR5            YES IT POINTS HERE
03665000 21615  024257        ADB M1               RESET 'GUESS'
03666000 21616  100001        LDA B,I              GET LINE BRIDGE
03667000 21617  050053        AND B177             CLEAR HIGH ORDER BITS
03668000 21620  024000        ADB A
03669000 21621  066610        JMP PTBR2
03670000 21622  024257  PTBR5 ADB M1               RESET FOR ENDS
03671000 21623  066627        JMP PTBR4
03672000 21624  100001  PTBR3 LDA B,I
03673000 21625  072102        RIA *+2              IF ZERO DO NOT SKIP
03674000 21626  042463        JSM ERLN             PUT IN ERROR LINE OF STARS
03675000 21627  001277  PTBR4 LDA ENDS             MOVE THE R-REGISTERS LOWER
03676000 21630  020254        ADA P1
03677000 21631  030016        STA C
03678000 21632  024254        ADB P1
03678100 21633  034017        STB D
03678200 21634  140466        JSM AMPML,I          MOVE R-REGISTERS LOWER, RESET ENDS, RMAX
03678300 21635  045744        ISZ TVAR1            SET FLAG FOR ERROR 46
03678400 21636  005307        LDB FWUP             START AT THE TOP OF THE PROGRAM SINCE THE
03679000                *                          BRIDGES LINKING UP ARE NOT OUT OF
03680000                *                          ORDER
03681000 21637  100001        LDA B,I              GET THIS FIRST LINE BRIDGE
03682000 21640  050053  PTBR1 AND B177             GET ITS LINK DOWN
03683000 21641  024000        ADB A                CALCULATE THE NEXT BRIDGES ADDRESS
03684000 21642  170607        SAL 8                MOVE TO LEFT HALF OF BRIDGE
03685000 21643  031756        STA FLAGA            SAVE THIS BRIDGE LINK
03686000 21644  100001        LDA B,I              GET THE NEXT INE BRIDGE
03687000 21645  050053        AND B177             CLEAR THE HIGH ORDER BITS
03688000 21646  061756        IOR FLAGA            INCLUDE THE SAVED BRIDGE HALF
03689000 21647  130001        STA B,I              RESTORE THIS LINE'S BRIDGE
03690000 21650  015277        CPB ENDS             ARE WE DONE YET ?
03691000 21651  170201        RET 1                YES DONE
03692000 21652  066640        JMP PTBR1            NOT DONE CONTINUE
03693000                *
03694000        077756  FLAGA EQU MRW1
03695000        077744  TVAR1 EQU OP1+2
03696000                *
03697000                *     END OF BRIDGE PATCH ROUTINE
03698000                *
```

```
03700000                *
03701000                *
03702000                *     SSC IS THE CASSETTE SET SELECT CODE COMMAND
03703000                *
03704000                *
03705000                *
03706000                *     TEMPORARIES USED : T1 (NTRK)
03707000                *
03708000                *     ROUTINES CALLED : GTPAR, TRKA, ERDSO
03709000                *
03710000 21653  142771  SSC   JSM GTPR2,I          GET THE DESIRED SELECT CODE
03711000 21654  000001        LDA B
03712000 21655  020257        ADA M1
03713000 21656  172415        SAM ERR17            IF X IS LESS THAN ONE - ERROR
03714000 21657  020157        ADA M15              SUBTRACT 16 FROM A
```

```
                              ***** BRIDGE PATCH *****

715000 21660  172013         SAP ERR17          IF THE RESULT IS ZERO OR POSITIVE - ERROR
716000 21661  015514         CPB CSELC
717000 21662  066677         JMP SSC3
718000 21663  000127         LDA P16            SELECT CODE CHANGE
719000 21664  031705         STA TPOS           SO SET 'LOST' CONDITION
720000 21665  035514         STB CSELC          IF X WITHIN RANGE - ALTER SELECT CODE
721000 21666  066677         JMP SSC3
725000                 *
726000                 *
727000                 *     TRK1 IS THE CASSETTE TRACK CHANGE COMMAND
728000                 *
729000                 *                    *
730000                 *
731000                 *
732000                 *     TEMPORARIES USED : T1 (NTRK)
733000                 *
734000                 *     ROUTINES CALLED : GTPAR, ERR1, TRKA, ERDS0
735000                 *
736000                 *
737000                 *
738000                 *
739000 21667  142771   TRKCH JSM GTPR2,I        GET THE DESIRED TRACK
740000 21670  076405         SZB TRCK1          IF THE TRACK IS ZERO - CHANGE
741000 21671  014254         CPB P1             IS IT TAACK ONE ?
742000 21672  066675         JMP TRCK1          YES CHANGE
743000 21673  140404   ERR17 JSM AERR1,I        BOUNDRY ERROR
744000 21674  030467         ASC 1,17
3745000 21675  000001  TRCK1 LDA B
3746000 21676  042434        JSM TRK            CHANGE THE TRACKS
3746100 21677  070420  SSC3  EIR                ENABLE THE INTERRUPT AND EXIT
3746200 21700  164365        JMP AINTX,I


                              ----- STOPC AND CHST -----


3748000                *
3749000                *
3750000                *
3751000                *     THIS ROUTINE WILL STOP THE CASSETTE ON THE CURRENT
3752000                *     SELECT CODE  IT THEN CLEARS DMAPA AND CSCF SO THE FIND IS
3753000                *     FORGOTTEN, IT THEN FALLS THROUGH TO SET THE PA
3754000                *
3755000                *
3756000                *
3757000 21701  001514  STOPC LDA CSELC          SEE IF THE FIND IS ON THIS SC
3758000 21702  011345        CPA CSCF
3759000 21703  066705        JMP *+2            YES A FIND HERE SO STOP IT
3760000 21704  170201        RET 1              NO FIND ON THIS SC
3761000 21705  043726        JSM STPCA          STOP THE CASSETTE AND REMOVE FROM SEARCH
3762000 21706  000177        LDA P0             MODE THEN FORGET THE FIND
3763000 21707  030013        STA DMAPA
3764000 21710  031345        STA CSCF
3765000 21711  170201        RET 1
3796000                *
3797000                *
3798000                *
3799000                *
3800000                *     CHST EXECUTES A BPC FIND OR INITIATES A HARDWARE FIND OPERATOPN
3801000                *
3802000                *     ON ENTRY : ENTRY AT CHST : RECNO CONTAINS THE TARGET RECORD NUMBER
3803000                *                                A BPC FIND IS ECECUTED
3804000                *                ENTRY AT CHST1 : RECNO CONTAINS THE TARGET RECORD NUMBE
3805000                *                                  IF FLG2 = 1, A HARDWARE FIND IS INITIA
3806000                *                IF NO ERRORS OCCURED
3807000                *
3808000                *
3809000                *     ON EXIT : IF A BPC FIND WAS INITIATED, THE TAPE IS POSITIONED
3810000                *               IN THE RECORD GAP PRECEEDING THE HEAD OF THE FILE NUMBER
3811000                *               IN RECNO, TPOS = 1
3812000                *               IF A HARDWARE FIND WAS INITIATED, THE TAPE IS MOVING IN
3813000                *               THE PROPER DIRECTION AT HIGH SPEED UNDER DMA PULSE COUNT
3814000                *               CONTROL, TPOS = 2
3815000                *
3816000                *
3817000                *     TEMPORARIES USED : FLG2 (MRW1+6)
3818000                *
3819000                *     ROUTINES CALLED : STPRA, DUFNQ, ERDS0
3820000                *
3821000                *
3822000                *
3823000                *
3824000 21712  042232  CHST  JSM DFND           DO THE FIND
3825000 21713  142770        JSM ERDS0,I        CHECK FOR ERRORS
3826000 21714  170201        RET 1
```

***** AVE AND AVD *****

```
03826110                   *
03826120                   *
03826130                   *
03826140                   *
03826150                   *
03826160                   *      AVE IS THE CASSETTE AUTOVERIFY ENABLE COMMAND
03826170                   *
03826180                   *
03826190                   *      TEMPORARIES USED : NONE
03826200                   *
03826210                   *      ROUTINES CALLED : NONE
03826220                   *
03826230                   *
03826240 21715    000177   AVE    LDA P0
03826250 21716    066720          JMP AVD1
03826260                   *
03826270                   *
03826280                   *      AVD IS THE CASSETTE AUTOVERIFY DISABLE COMMAND
03826290                   *
03826300                   *
03826310                   *      TEMPORARIES USED : NONE
03826320                   *
03826330                   *      ROUTINES CALLED : NONE
03826340                   *
03826350                   *
03826360                   *
03826370                   *
03826380                   *
03826390 21717    000257   AVD    LDA M1
03826400 21720    031344   AVD1   STA AVFLG
03826410 21721    164365          JMP AINTX,I
```

*****ROM CON *****

```
03828000                   *
03829000                   *-------- ROM CONSTANTS
03830000                   *
03831000                   *
03832000          000177   ZERO   EQU P0
03833000          000254   ONE    EQU P1
03834000          000145   TWO    EQU P2
03835000          000144   THREE  EQU P3
03836000          000143   D4     EQU P4
03837000          000137   D8     EQU P8
03838000          000133   D12    EQU P12
03839000          000127   D16    EQU P16
03840000          000117   D32    EQU P32
03841000          000052   D128   EQU P128
03842000          000247   M30K   EQU ZK1         USED IN FIND! GIVES BUFFER DMAMA
03843000 21722    034232   .P30I  DEC 14490       USED IN HOLE TO CALC DIST TRVLED
03844000 21723    143546   .M30I  DEC -14490      30" OF TAPE
03845000 21724    152152   .M24I  DEC -11158      USED TO GET BACK TO LP & EW
03846000 21725    161663   .M12I  DEC -7245       DIST THOLD IN HOLE
03847000 21726    177416   .MWTI  DEC -242        DIST THOLD IN HOLE
03848000 21727    176422   COAST  DEC -750
03849000 21730    177626   TACLS  DEC -106        REACH 22 IPS
03850000 21731    171611   EVTLN  DEC -3191       WRITE AN EVTM
03851000 21732    175507   EVTDT  DEC -1209       DETECT AN EVTM
03852000 21733    177035   IRGLN  DEC -483        WRITE IRG
03853000 21734    177620   SETLN  DEC -112        10 MSEC OF SETTLING
03854000 21735    000325   DEADZ  DEC 213         6" BUFFER BETW LP & IRG 0 (WRDS)
03855000          000130   ERMSK  EQU P15         ERROR MASK
03856000          000141   PRGM   EQU P6
03857000                   *                      TO DISTUISH DATA FROM PROGRAMS
03858000          021732   INDED  EQU EVTDT
03859000 21736    077676   RHPTR  DEF CRECN       POINTS TO RECORD HEAD
03860000 21737    077714   PHPTR  DEF PARNO       POINTS TO PARTITION HEAD
03861000 21740    174373   CFDF   DEC -1797       RECOVERY DISTANCE FOR FIND IF SEARCH IN FWD
03862000 21741    175412   CFDR   DEC -1270       RECOVERY DISTANCE IF FIND SEARCHES IN REVERSE
03863000          000053   RLFDL  EQU B177        READ,LS,FWD,DATA,TLO
03864000          000137   HDLN   EQU P8          DEFINE HEAD LENGTH TO BE SEVEN WORDS + 1 (CHSUM)
03865000          021733   DLYA   EQU IRGLN       USED IN HOLE TO GET VALID PE
03866000          000140   SLKRH  EQU P7          MRK SLACK FOR REC HEAD
03867000          000053   MSKL7  EQU RLFDL       ALLOWS ME TO LOOK AT LOW 7 BITS
03868000          000045   KPMSK  EQU B377        GUAR B8 OF HARWARE COMMANDS IS ZERP
03869000 21742    000167   RLFTL  OCT 167         READ,LS,FWD,TAC,TLO
03870000          021742   TACMD  EQU RLFTL
03871000 21743    000117   RHRDL  OCT 117         READ,HS,REV,DATA,TLO
03872000 21744    000107   RHRTL  OCT 107         READ,HS,REV,TAC,TLO
03873000 21745    000127   RHFTL  OCT 127         READ,HS,FORWARD,TAC,TLO
03874000          000074   WLFDD  EQU B77         WHT,LS,FWD,DATA,DATA
03875000          000101   WLFTG  EQU B63         WHT,LS,FND,TAC,GAP
```

```
                        *****ROM CON *****

03876000          000124  WHFTG EQU P19        WRT,HS,FWD,TAC,GAP
03877000          000057  RLFDH EQU B173       READ,LS,FWD,DATA,THI
03878000          000057  RLFTH EQU RLFDH      READ,LS,FWD,TAC,THI
03879000          000062  RLRDH EQU B153       READ,LS,REV,DATA,THI
03880000          000064  RLRTH EQU P99        READ ,LS,REV,TAC,THI
03881000 21746    000303  STOP  OCT 303        STOP,READ,FST,REV,TAC,NOI,,WRONG--TLO,TRB
03882000                  *                    TLO,TRB
03883000          000117  MPERR EQU P32        ERROR -- MRK POSITION UNKNOWN
03884000          000073  MKERR EQU P64       ERROR--MARK DOES NOT FIT
03885000          000052  RHERR EQU P128      ERROR--RECORDING HEAD
03886000          000044  RBERR EQU B400      ERROR--READING BODY
03887000          000236  NRERR EQU B2K       ERROR--RECORD NOT FOUND OR NO RECORD
03888000          000234  WPERR EQU B4K       ERROR--ILLEGAL WRT: CART. PROT'D
03889000          000237  VYERR EQU B1K       ERROR--VERIFY FAILED
03890000          000175  HOERR EQU B10K      ERROR - HOLE PATTERN UNKNOWN
03891000 21770                  ORG 21770B
03892000 21770            ERDSU BSS 1
03892100 21771            GTPR2 BSS 1
03893000 21772            STPRA BSS 1

                        ----- QUESTION MARKS!! -----

03895000                  *
03896000                  *
03897000                  *     THESE CONSTANTS REPRESENT A FLOATING POINT QUESTION MARK
03898000                  *
03899000                  *
03900000 21773                  ORG 21773B
03901000 21773    021774  QMRKS DEF *+1
03902000 21774    000000        DEC 0
03903000 21775    177777        DEC -1
03904000 21776    177777        DEC -1
03905000 21777    177777        DEC -1

                        ******** DMALO **********

03940000                  *
03941000                  *
03942000                  *     ALL DEVICES USING DMA MUST CALL THIS ROUTINE. UPON RELEASE OF
03943000                  *     DMA, THE CALLING DEVICE MUST CLEAR ( SET TO ZERO ) THE DMA
03944000                  *     LOCKOUT FLAG.( DMA LOCKOUT FLAG = DMAPA )
03945000                  *
03946000                  *
03947000                  *     TYPICAL CODE SEQUENCE FOR THE INTERRUPT ROUTINE OF THE DEVICE
03948000                  *     DESIRING DMA :
03949000                  *
03950000                  *
03951000                  *     SERVICE ROUTINE
03952000                  *
03953000                  *(SAVE REGISTERS, ETC.)
03954000                  *      LDB P7            PERIPHERIAL ADDRESS OF DEVICE = 7
03955000                  *      JSM DMALO         REQUEST DMA HARDWARE
03956000                  *      JMP *-2           REQUEST REFUSED - TRY AGAIN
03957000                  *(SET DMAMA)             SET THE DMA REGISTERS
03958000                  *(SET DMAC)
03959000                  *      DMA               ENABLE DMA (OR PCM)
03960000                  *(RESTORE REGISTERS, ETC.)
03961000                  *      RET 0,P           DONE
03962000                  *
03963000                  *
03964000                  *     A PART OF THIS ROUTINE MUST ALSO BE EXECUTED TO RELEASE THE
03965000                  *     DMA HARDWARE WHEN THE DMA OPERATION IS FINISHED BY THE DEVICE
03966000                  *
03967000                  *
03968000                  *     EXAMPLE :
03969000                  *
03970000                  *(PRELIMINARY CODE)
03971000                  *      LDA P0            CLEAR DMA LOCKOUT FLAG
03972000                  *      STA DMAPA
03974000                  *      RET 0,P
03975000                  *
03976000                  *
03977000                  *     ON ENTRY : REGISTER B CONTAINS THE PERIPHERIAL ADDRESS OF THE
03978000                  *                DEVICE REQUESTING  DMA
03979000                  *
03980000                  *
03981000                  *     ON EXIT : 1). RET 1 = DMA BUSY MUST WAIT
03982000                  *               2). RET 2 = DMA GRANTED AND DMAPA = CONTENTS OF REGISTER
03983000                  *
03984000                  *
03985000                  *     TEMPORARIES USED : NONE
```

******** DMALO *********

```
                     *
                     *      ROUTINES CALLED : NONE
                     *
                     *
                     *
23724                       ORG 237248
23724  070430  DMAL. DIR
23725  000013        LDA DMAPA          SEE IF THE DMA IS FREE
23726  072416        SZA DMAL2          SKIP IF DMA IS FREE
23727  011345        CPA CSCF           IF DMA NOT = ZERO IS A CASSETTE DOING A FIND ?
23730  066733        JMP *+3            YES A CASSETTE IS DOING A FIND
23731  070420  DMAL1 EIR
23732  170201        RET 1
23733  001345        LDA CSCE           SEE IF THE CASSETTE IS DONE
23734  030011        STA PA
23735  000005        LDA R5             DO THIS BY CHECKING THE 'MOVING' BIT
23736  170504        SAR 5
23737  073472        RLA DMAL1          SKIP IF BUSY
23740  170602        SAL 3              MUST CLEAR "SEARCH" BIT IN
23741  170140        CMA                CASSETTE TO PREVENT ANY
23742  062747        IOR STOP1          FURTHER DMA REQUESTS
23743  030005        STA R5
23744  034013  DMAL2 STB DMAPA          DMA IS FREE SO SET UP THE DMAPA
23745  070420        EIR
23746  170202        RET 2
23747  000357  STOP1 OCT 357            STOP CASSETTE AND CLEAR SEARCH BIT
                     *
                     *
                     *
                     *
                     *
```

*****RAM WORDS*****

```
                     *
                     *-----CASSETTE DEDICATED RAM
                     *
       077676  CRECN EQU CATMP          RECORD NUMBER (PART OF HEAD)
       077677  ASIZE EQU CATMP+1        ABSOLUTE SIZE
       077700  CSIZE EQU CATMP+2        CURRENT SIZE
       077701  RTYPE EQU CATMP+3        RECORD TYPE
       077702  RRWNO EQU CATMP+4        RECORD REWRITE NUMBER
       077703  EXISF EQU CATMP+5        SECURITY FLAG #0=SECURE 0=UNSECURE
       077704  EX2   EQU CATMP+6        USED FOR FWUP IN RKM
       077705  TPOS  EQU CATMP+7        TAPE POSITION INDICATOR
                     *
                     *
                     *      TPOS TAKES ON THE FOLLOWING VALUES:
                     *
                     *      TPOS=1  -> IN GAP PROCEEDING RECORD CRECN
                     *      TPOS=2  -> IN RECORD BODY OF CRECN-1
                     *      TPOS=8  -> AT REWIND
                     *      TPOS=16 -> LOST, HEAD INFO INVALID
                     *
                     *
       077706  MBPTR EQU CATMP+8        POINTS TO BODY SECTION
       077710  CUCMD EQU CATMP+10       CURRENT HARDWARE COMMAND
       077763  ERRWD EQU MRW1+5         LOGS ERRORS
       077764  FLG2  EQU MRW1+6         BITS 1-15 ARE ALWAYS ZERO
                     *                  BIT ZERO SET= HARDWARE FIND
                     *                  BIT ZERO CLR = BPC FIND
                     *
                     *    SHARED TEMPORARIES
                     *
                     *-----------------------
                     *
       077743  LWMD  EQU OP1+1
       077735  SVC   EQU T21            DEDECATED TO SAVING THE C REGISTER
                     *-----  PARTITION HEAD
                     *
       077767  PRCTR EQU MRW1+9
       077727  DLFLG EQU T15
       077714  PARNO EQU T4             PARTITION NUMBER
       077715  PARLN EQU T5             PARTITION LENGTH
       077716  PRWNO EQU T6             PARTITION REWRITE NUMBER
       077717  TEMP1 EQU T7             USED IN WAIT AND NCODE
       077720  MSIZE EQU T8             HOLDS ABSOLUTE SIZE OF RECORDS TO MARK
       077721  CHSUM EQU T9             USED FOR ALL CHECKSUM CALCULATIONS
       077721  TDIST EQU CHSUM          TARGET-STARTING RECORD NUMBER
       077722  NOREC EQU T10            NUMBER OF RECORDS TO MARK
       077723  INSTR EQU T11            HOLDS AN INSTRUCTION (STR,COMPR)
       077724  FPASS EQU T12            COUNTS NUMBER OF ATTEMPTS TO FIND
       077725  RECNO EQU T13            TARGET RECORD NUMBER
```

```
                              *****RAM WORDS*****

04066000         077726  MRKSZ EQU T14            NUMBER OF WORDS NCODE WRITES ON MARK
04067000                 *
04068000                 *
04069000                 *       FLG1 ! BITS 1 - 15  ARE ALWAYS ZERO
04070000                 *              BIT  0       SET MEANS TRACK A
04071000                 *                           CLEAR MEANS TRACK 8
04072000                 *
04073000                 *
04074000         077707  FLG1  EQU CATMP+9        MARK SETS THIS BEFORE ENTERING IDR, ANDTHIS
04075000                 *                        REMEMBERS THE TRACK
04076000                 *
04077000                 *
04078000                 *      COUNTERS
04079000                 *
04080000                 *
04081000         077730  RHCTR EQU T16
04082000         077730  PHCTR EQU T16            PARTITION HEAD COUNTER
04083000         077731  WCTR  EQU T17            WORD COUNTER USED IN PARTITION BODY
04084000         077732  RWCTR EQU T18            COUNTS WORDS IN S RECORD
04085000                 *
04086000                 *       POINTERS
04087000                 *
04088000         077733  PTR   EQU T19            GENERAL PURPOSE MOVING POINTER
04089000         077734  BDPTR EQU T20            MOVING BODY POINTER
04090000                 *
04091000                 *
04092000                 *
04093000                 *
04094000                       END

END OF PASS 2 NO ERRORS DETECTED


                              BASE-PAGE READ-WRITE-MEMORY

00003000 76550                ORG 76550B
00004000                      UNL
02000000                      LST
02001000                *


02003000                *
02004000                *     BASE PAGE LINKS
02005000                *
02006000 00463                ORG AMUPH
02007000 00463  022641        DEF MUPHI    MOVE MAIN PROGRAM TO HIGHER MEM.
02008000 00464  022662        DEF MAMPL    MOVE MAIN PROGRAM TO LOWER MEMORY
02009000 00465  022646        DEF MPUPH    MOVE PART OF MAIN PROG. HIGHER
02010000 00466  022665        DEF MPMLM    MOVE PART OF MAIN PROG. LOWER
02011000 00467  022627        DEF MTHIM    MOVE RWM HIGHER
02012000 00470  022700        DEF MTLOM    MOVE RWM LOWER
02013000 00471  022716        DEF ZRWM     ZERO RWM
02014000 00472  022761        DEF ERAS4    ERASE ALL VARIABLES
02015000 00473  022460        DEF LSTS1    LIST A SPECIALKEY
02016000 00474  022431        DEF FETS3    PUT SPECIAL KEY NUMBER IN I/O BUFFER
02017000 00475  023506        DEF EDPTR    RESET EDIT POINTERS
02018000 00476  023514        DEF TLNIO    PUT LINE NUMBER IN I/O BUFFER
02019000 00477  023517        DEF TLNX     CONVERT FROM BINARY TO DECIMAL ASCII
02020000 00500  023561        DEF EOLNN    FIND END OF LINE IN I/O BUFFER
02021000 00501  023601        DEF GNEXT    GET NEXT CHARACTER
02022000 00502  023630        DEF TCHR     TRANSFER CHARACTERS
02023000 00503  023617        DEF RNLON    TURN ON RUN LIGHT
02024000 00504  023623        DEF RNLOF    TURN OFF RUN LIGHT


                              CONTROL SUPERVISOR LINKS

02028000                *
02029000 11614                ORG 11614B
02030000                *
02031000 11614                BSS 5        EXECUTE
02032000                *
02033000 11621  022000        DEF STOR     STORE
02034000 11622                BSS 1
02035000 11623  022051        DEF STEDT
02036000 11624                BSS 1
02037000 11625  022000        DEF STOR
02038000                *
02039000 11626  023477        DEF INRE     INSERT/REPLACE CHAR
02040000 11627  023477        DEF INRE
02041000 11630  023477        DEF INRE
02042000 11631                BSS 2
02043000                *
02044000 11633                BSS 5        CLEAR KEY
02045000 11640                BSS 5        DELETE CHAR
02046000 11645                BSS 5        STEP
02047000                *
02048000 11652  023333        DEF RHAR     RIGHT ARROW
```

CONTROL SUPERVISOR LINKS

```
11653  023340          DEF RHAR7
11654  023333          DEF RHAR
11655                  BSS 1
11656  023332          DEF RHRM4
               *
11657  023364          DEF LAKE       LEFT ARROW
11660  023427          DEF LFAR
11661  023364          DEF LAKE
11662                  BSS 1
11663  023363          DEF LFRM4
               *
11664                  BSS 5          DOWN ARROW
11671                  BSS 5          RECALL
11676                  BSS 5          PROG KEYS
11703                  BSS 5          UP ARROW
               *
11710  023122          DEF BACK       BACK
11711  023147          DEF BACK2
11712  023122          DEF BACK
11713                  BSS 2
               *
11715  023174          DEF FORW       FORWARD
11716  023234          DEF FORW2
11717  023174          DEF FORW
11720                  BSS 2
               *
11722  023637          DEF PINK       STOP, REW
11723  023637          DEF PINK
11724  023637          DEF PINK
11725                  BSS 1
11726  023637          DEF PINK
               *
11727                  BSS 5          TYPING AIDS
               *
11734  022273          DEF SPKMO      SPECIAL KEYS
11735  022315          DEF EXESK
11736  022315          DEF EXESK
11737  022315          DEF EXESK
11740  022315          DEF EXESK
               *
11741                  BSS 5          PRINT-ALL
               *
11746  022164          DEF INLK       INSERT LINE
11747                  BSS 1
11750  022164          DEF INLK
11751                  BSS 1
11752  022164          DEF INLK
               *
11753                  BSS 5          RUN
11760                  BSS 5          CONTINUE
               *
11765                  BSS 1          LINE DELETE
11766  023113          DEF LDELF
11767                  BSS 3
               *
11772                  BSS 5          RESULT
               *
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
               *
               *
               ***********************************************
               *
               *    CONTROL AND I/O SUPERVISOR ROUTINES
               *
               *
               *
               ***********************************************
               *
               *
               *         EDMM
               *
               *
               *
               *
22000                  ORG 22000B
               *
               *
               *       STORE (KEYBOARD MODE)
               *
               *
22000  043233  STOR    JSM EDIN       EDIT INITIALIZATION (RET P+1; A=CFLAG)
```

```
02131000 22001  170700        RAR 1        POSITION STORE-KEY AND FETCH-LINE BITS
02132000 22002  073002        SLA *+2      KEY TO BE DEFINED ?
02133000 22003  067526        JMP STKEY    YES
02134000 22004  172002        SAP STOR6    REPLACE OLD LINE ?
02135000 22005  067052        JMP STD1     YES
02136000 22006  043151  STOR6 JSM ISSBR    NULL PROGRAM OR REFERENCE TO LAST LINE ?
02137000 22007  067054        JMP STEDX    NO
02138000                *
02139000 22010  043245  STOR7 JSM CRCL     COMPILE, REV. COMPILE, GET LINE LENGTH
02140000 22011  043255        JSM COVF     CHECK FOR OVERFLOW
02141000 22012  101277        LDA ENDS,I   GET LAST BRIDGE
02142000 22013  050215        AND BXCMM    SAVE ONLY REVERSE LINK
02143000 22014  061234  STOR4 IOR TMP4     INCLUDE LENGTH OF PRESENT LINE
02144000 22015  131277  STOR2 STA ENDS,I   LINE BRIDGE CREATED
02145000 22016  005277        LDB ENDS     GET END OF USER PROGRAM POINTR
02146000 22017  015310        CPB RMAX     R-REGS GIVEN ?
02147000 22020  024257        ADB M1       NO; B = ENDS-1
02148000 22021  024254        ADB P1       B = OLD FIRST WORD OF R-REGS (B=ENDS IF NO R-REGS GIV
02149000 22022  001310        LDA RMAX     MAX R-REG USED
02150000 22023  030016        STA C        SET START SOURCE ADDR
02151000 22024  021234        ADA TMP4     A = NEW RMAX VALUE
02152000 22025  030017        STA D        SET START DESTINATION ADDR
02153000 22026  031310        STA RMAX     UPDATE MAX R-REG POINTR
02154000 22027  140467        JSM AMTHM,I  MOVE R-REGS TO HIGHER MEMORY
02155000 22030  001277  STOX1 LDA ENDS     GET DESTINATION ADDR
02156000 22031  072101        RIA *+1      POINT TO SECOND WORD OF LINE
02157000 22032  043265        JSM TLCM     TRANSFER LINE TO MEMORY
02158000 22033  001277        LDA ENDS     GET E/A OF PROG
02159000 22034  021234        ADA TMP4     ADD LENGTH OF NEW LINE
02160000 22035  031277        STA ENDS     UPDATE POINTR
02161000 22036  001234        LDA TMP4     GET LENGTH OF LINE
02162000 22037  170607        SAL 8        PLACE IN UPPER HALF
02163000 22040  131277        STA ENDS,I   LAST BRIDGE CREATED
02164000 22041  045226  STOR5 ISZ LNO      INCRM LINE NO.
02165000 22042  067043        JMP *+1      NEEDED FOR FIRST LINE NO.
02166000 22043  140476  STOR3 JSM ATLNI,I  TRANSFER LINE NO. TO I/O BUFFER
02167000 22044  140475        JSM AEDPT,I  RESET I/O PTRS
02168000 22045  000053        LDA EOL      END OF LINE MARKER
02169000 22046  074550        PBD A,I      INCRM AND PLACE IN I/O BUFF
02170000 22047  000146        LDA M2       CLR FETCH BIT 0
02171000 22050  067242        JMP STCFG    SET CFLAG
02172000                *
02173000                *
02174000                *
02175000                *
02176000                *
02177000                *
02178000                *      STORE-(EDIT-MODE)
02179000                *
02180000                *
02181000 22051  043233  STEDT JSM EDIN     EDIT INITIALIZATION
02182000 22052  043056  STD1  JSM STED     STORE NEW LINE
02183000 22053  067043        JMP STOR3    GIVE LINE NO.
02184000                *
02185000 22054  043060  STEDX JSM STED5    STORE NEW LINE
02186000 22055  067041        JMP STOR5    INCRM LINE NO. AND DISP IT
02187000                *
02188000 22056  140512  STED  JSM AFLAD,I  FIND LINE ADDR
02189000 22057  140424        JSM ASYER,I  LINE SHOULD EXIST
02190000 22060  031225  STED5 STA TMP2     SAVE S/A OF LINE
02191000 22061  100000        LDA A,I      GET LINE BRIDGE
02192000 22062  050053        AND B177     GET OLD LINE LENGTH
02193000 22063  031227        STA TMP1     AND SAVE IT
02194000 22064  101225        LDA TMP2,I   GET LINE BRIDGE AGAIN
02195000 22065  050052        AND STPMS    PRESERVE STOP BIT
02196000 22066  031730        STA T16      AND SAVE IT
02197000 22067  043245        JSM CRCL     COMPILE, REV. COMPILE, GET LINE LENGTH
02198000 22070  001234        LDA TMP4     GET LENGTH
02199000 22071  170040        TCA          MAKE NEG.
02200000 22072  021227        ADA TMP1     A=OLD LENGTH-NEW LENGTH
02201000 22073  072403        SZA STED2    SKIP IF OLD = NEW
02202000 22074  172003        SAP STED1    NEW > OLD ?
02203000 22075  067111        JMP STED4    YES
02204000                *
02205000                *      REPLACE OLD LINE BY NEW; OLD = NEW
02206000                *
02207000 22076  067127  STED2 JMP STED6
02208000                *
02209000                *      REPLACE OLD LINE BY NEW; OLD > NEW
02210000                *
02211000 22077  043133  STED1 JSM STDIN    SET STOP BIT IN LINE BRIDGE
02212000 22100  043127        JSM STED6    TRANSFER LINE TO MEMORY
02213000 22101  005225        LDB TMP2     S/A OF OLD/NEW LINE
02214000 22102  025227        ADB TMP1     B = S/A OF NEXT LINE
02215000 22103  045234        ISZ TMP4     INC TMP4 DUE TO STED6
02216000 22104  043141        JSM STREL    SET REVERSE LINK IN BRIDGE
02217000                *
02218000                *      CLOSE-UP GAP
02219000                *
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
22105  070570        WWD A,I     DUMMY; POINT TO START DESTIN. ADDR
22106  005227        LDB TMP1    GET ADDR OF NEXT LINE
22107  034016        STB C       SET START SOURCE ADDR
22110  164466        JMP AMPML,I MOVE PART OF PROG. TO LOWER MEM. + RET P+1
                *
                *    REPLACE OLD LINE BY NEW; OLD < NEW
                *
22111  170040  STED4 TCA         MAKE DIFF. NEG.
22112  031715        STA T5      SAVE DIFFERENVE
22113  101225        LDA TMP2,I  GET LINE BRIDGE
22114  050053        AND B177    GET OLD LINE LENGTH
22115  021225        ADA TMP2    FIND S/A OF NEXT LINE
22116  004000        LDB A       B=END SOURCE ADDR
22117  001310        LDA RMAX    MAX. R-REG. POINTR
22120  021715        ADA T5      POINT TO NEW ADDR
22121  030017        STA D       SET START DESTINATION ADDR
22122  140465        JSM AMPUP,I MOVE PART OF MAIN PROG. TO HIGHER MEM.
22123  043133        JSM STDIN   SET STOP BIT IN LINE BRIDGE
22124  005225        LDB TMP2    S/A OF LINE
22125  025234        ADB TMP4    POINT TO S/A OF NEXT LINE
22126  043141        JSM STREL   SET REVERSE LINK IN BRIDGE
22127  001225  STED6 LDA TMP2    S/A OF NEW LINE
22130  072101        RIA *+1     POINT TO SECOND WORD
22131  055234        DSZ TMP4    DISCOUNT NEW LINE BRIDGE
22132  067265        JMP TLCM    TRANSFER LINE TO MEM. AND RET P+1
                *
                *
22133  101225  STDIN LDA TMP2,I  GET LINE BRIDGE
22134  050170        AND BUHM    SAVE UPPER HALF
22135  061234        IOR TMP4    INCLUDE LENGTH OF LINE
22136  061730        IOR T16     INCLUDE STOP BIT
22137  131225        STA TMP2,I  NEW LINE BRIDGE
22140  170201        RET 1
                *
                *
                * STREL  SETS REVERSE LINK IN LINE BRIDGE
                *        BRIDGE ADDR IN B
                *        LINE LENGTH IN TMP4
                *
                *      USES TMP1
                *
22141  035227  STREL STB TMP1    SAVE BRIDGE ADDR
22142  100001        LDA B,I     GET BRIDGE
22143  050250        AND BM377   SAVE TRACE,STOP BITS  , FORWARD LINK
22144  005234        LDB TMP4    GET LENGTH OF LINE
22145  174607        SBL 8       POSITION IN UPPER BYTE
22146  060001        IOR B       SET BITS IN A
22147  131227        STA TMP1,I  SET NEW BRIDGE
22150  170201        RET 1
                *
                *
                *
                *
                *    CHECK FOR NULL PROGRAM OR REFERENCE TO LAST LINE
                *
                *        EXIT: RETP+1    NOT FOUND
                *
                *              RETP+2    FOUND
                *
                *
22151  140512  ISSBR JSM AFLAD,I FIND LINE ADDR
22152  067162        JMP ISSB1   LINE NOT FOUND
22153  104000        LDB A,I     GET LINE BRIGE
22154  174610        SBL 9
22155  174510        SBR 9       GET LINE LENGTH
22156  020001        ADA B       POINT TO S/A OF NEXT LINE
22157  011277        CPA END$    LAST LINE ?
22160  170202        RET 2       YES
                *
22161  170201        RET 1
                *
22162  140514  ISSB1 JSM ASLLN,I SET LNO TO LAST LINE
22163  170202        RET 2       RET 2  LAST LINE OR NULL PROGRAM
                *
                *
                *      INSERT LINE- KEYBOARD MODE
                *
                *
22164  043233  INLK  JSM EDIN    EDIT INITIALIZATION
22165  073412        RLA INLK2   SKIP IF FETCH BIT IS SET
22166  001307        LDA FWUP    NULL PROGRAM?
22167  011277        CPA END$
22170  067010        JMP STOR7   YES, TREAT AS A STORE
22171  001226        LDA LNO     IS LNO = -1?
22172  010257        CPA M1
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
22173  067226         JMP INLK1      YES, NOT REFERENCE TO LAST LINE
22174  043151         JSM ISSBR      NULL PROG. OR REFERENCE TO LAST LINE ?
22175  067226         JMP INLK1      NO
22176  067010         JMP STOR7      YES: TREAT IT AS A STORE
22177  043245   INLK2 JSM CRCL       COMPILE, REV. COMPILE, GET LINE LENGTH
22200  043255         JSM COVF       CHECK FOR OVERFLOW
22201  140512   INLK3 JSM AFLAD,I    FIND LINE ADDR
22202  140424         JSM ASYER,I    LINE SHOULD EXIST
22203  031225         STA TMP2       SAVE S/A OF REFERENCE LINE
22204  004000         LDB A          SET BRIGE ADDR FOR STREL
22205  101225         LDA TMP2,I     GET LINE BRIDGE
22206  031715         STA T5         SAVE OLD BRIDGE
22207  043141         JSM STREL      SET REVERSE LINK IN LINE BRIDGE
22210  001310         LDA RMAX       MAX. R-REG. POINTR
22211  021234         ADA TMP4       A = START DESTINATION ADDR
22212  030017         STA D          SET D-REG
22213  005225         LDB TMP2       END SOURCE ADDR
22214  140465         JSM AMPUP,I    MOVE PART OF USER PROG. TO HIGHR MEM.
22215  001715         LDA T5         GET REF. LINE BRIDGE AGAIN
22216  050215         AND BXCMM      SAVE ONLY REVERSE LINK
22217  061234         IOR TMP4       INCLUDE LENGTH OF NEW LINE
22220  131225         STA TMP2,I     BRIDGE OF NEW LINE
22221  043127         JSM STED6      TRANSFER LINE TO MEMORY
22222  001226         LDA LNO        GET LINE NUMBER
22223  031721         STA T9         SET FOR RENUMBER ROUTINES
22224  140517         JSM ARENI,I    ADJUST GTO'S AND GSB'S
22225  067043         JMP STOR3      GIVE LINE NO.
                *
22226  043245   INLK1 JSM CRCL       COMPILE REV COMPILE, GET LINE LENGTH
22227  043255         JSM COVF       CHECK FOR OVERFLOW
22230  045226         ISZ LNO        ADJUST LINE NO.
22231  067232         JMP *+1
22232  067201         JMP INLK3      INSERT LINE
                *
                *
                *       EDIT INITIALIZATION
                *
                *         EXIT: RET P+1    A = CFLAG
                *
                *
22233  140435   EDIN  JSM ATRBF,I    TRANSFER INFO FROM I/O TO KEYB. BUFF
22234  140461         JSM APRKB,I    GO THROUGH PRINTALL
22235  000214         LDA EOLB       GET EOL AND BLANK
22236  130311         STA AKBFL,I    STORE IN LAST WORD OF KBD BUFFER
22237  000254         LDA P1
22240  031517         STA RGFLG      ASSIGNMENT TO RES. REG. NOT ALLOWED
22241  000151         LDA M5         CLR RUN DONE BIT 2
                *
22242  051232   STCFG AND CFLAG
22243  031232         STA CFLAG
22244  170201   COV1  RET 1
                *
                *
                *      COMPILE, REV. COMPILE, GET LINE LENGTH SUBR.
                *
                *
22245  140346   CRCL  JSM ACPLR,I    GO TO COMPILER, COMPILE KBD BUFFER
22246  004317         LDB AIBSL      I/O BUFF START OF LINE (ALLOW FOR LINE NO. AND COLL
22247  140356         JSM ARCLR,I    REVERSE COMPILE TO CHECK LINE LENGTH
22250  001251         LDA OFLAG      GET REV COMPILE OVERFLOW FLAG
22251  010117         CPA B40        IS IT A BLANK?
22252  164510         JMP AGLL,I     YES, NO OVERFLOW,GET LINE LENGTH,RETURN
                *
22253  140404         JSM AERR1,I    LINE TOO LONG
22254  031061         ASC 1,21
                *
                *
                *       CHECK FOR OVER-FLOW
                *
                *               ENTRY: TMP4 = LENGTH NEEDED
                *
                *          "COVX" ENTRY: A = POSSIBLE ADDR OF RMAX
                *
                *
22255  001234   COVF  LDA TMP4       GET LENGTH
22256  021310         ADA RMAX       A=NEW MAX R-REG ADDR
22257  170040   COVX  TCA            MAKE NEGATIVE
22260  021263         ADA AP1        TOP OF EXECUTION STACK
22261  072402         SZA ERMOV      GIVE AN ERROR IF NO MEM AVAILABLE
22262  172062         SAP COV1       NO OVERFLOW IF RESULT IS POSITIVE
22263  140404   ERMOV JSM AERR1,I    MEMORY OVERFLOW
22264  032060         ASC 1,40
                *
```

```
02388000                     *
02389000                     *      TRANSFER LINEFROM COMPILE BUFF TO MEMORY
02390000                     *
02391000                     *              ENTRY: A=DESTINATION ADDR
02392000                     *
02393000                     *                     TMP4=LINE LENGTH
02394000                     *
02395000                     *
02396000 22265  004303 TLCM  LDB ACBF     ADDR OF COMPILE BUFF
02397000 22266  034016       STB C        SET C-REG
02398000 22267  030017       STA D        SET D-REG
02399000 22270  025234       ADB TMP4     B = ACBF + LINE LENGTH
02400000 22271  024257       ADB M1       B = LAST SOURCE ADDR
02401000 22272  164470       JMP AMTLM,I  TRANSFER LINE INTO MEM. AND RETURN P+1
02403000                     *
02404000                     *
02405000                     * SPECIAL KEYS SOFTWARE
02406000                     *
02407000                     *
02408000                     *
02409000                     *
02410000                     *
02411000                     *
02412000                     *

02414000                     ****************
02415000                     *
02416000                     * SPKM0:  MODE 0 ENTRY POINT FOR SPECIAL KEYS
02417000                     *
02418000                     ****************
02419000                     *
02420000 22273  043307 SPKM0 JSM SVKEY    SAVE KEY NUMBER
02421000 22274  000423       LDA ASCND    SEARCH THE I/O BUFFER FOR MAINFRAME COMMANDS
02422000 22275  004314       LDB AIBFX    GET COMMAND FROM I/O BUFFER
02423000 22276  140414       JSM ACTFC,I  INCLUDING THE NON-COMMAND "LIST".
02424000 22277  067316       JMP EXEKK    P+1:NO COMMAND FOUND,MUST BE KEY EXECUTION
02425000 22300  014145       CPB P2       P+2:  COMMAND FOUND, B = OP CODE
02426000 22301  067407       JMP FETSK    OP CODE 2:  FETCH
02427000 22302  014144       CPB P3
02428000 22303  067436       JMP .ERSK    OP CODE 3: ERASE
02429000 22304  014141       CPB P6       OP CODE 6: LIST
02430000 22305  067457       JMP LSTSK
02431000 22306  067316       JMP EXEKK
02432000                     *
02433000                     * COMMAND FOUND BUTNOT ONE THAT THE SPECIAL KEYS SOFTWARE HANDLES.
02434000                     * SO DEFAULT TO KEYEXECUTION.
02435000                     *
02436000                     ******************
02437000                     *
02438000 22307  001212 SVKEY LDA SPKN     SAVE THE CURRENT KEY NUMBER
02439000 22310  031714       STA T4
02440000 22311  001235       LDA SKEY     REPLACE IT WITH THE NUMBER OF THE KEY TO BE EXECUTED
02441000 22312  020167       ADA BM200
02442000 22313  031212       STA SPKN
02443000 22314  170201       RET 1
02444000                     *
02445000                     *
02446000                     *
02447000                     ****************
02448000                     *
02449000                     * EXESK:  KEY EXECUTION
02450000                     *
02451000                     ****************
02452000                     *
02453000 22315  043307 EXESK JSM SVKEY    SET KEY NUMBER
02454000                     *
02455000 22316  000166 EXEKK LDA M97      CLR RECALL BITS 5,6
02456000 22317  043242       JSM STCFG
02457000 22320  043571       JSM FINDK    HAS THE KEY BEEN DEFINED?
02458000 22321  067401       JMP E30      P+1: KEY IS NOT DEFINED, GIVE ERROR 30
02459000 22322  172701       SAM *+1,S    P+2:  KEY FOUND, LET T3 = CHAR ADDR OF
02460000 22323  031713       STA T3       KEY DEFINITION,  SAVE ADDR
02461000 22324  001256       LDA MODE     IF "EOL" OR "FETCH"
02462000 22325  010254       CPA P1       MODE, THEN CLEAR
02463000 22326  140451       JSM ACLEB,I  THE EDIT BUFFER BEFORE
02464000 22327  010143       CPA P4       TRANSFERRING
02465000 22330  140451       JSM ACLEB,I  THE KEY DEFINITION
02466000 22331  001713       LDA T3       GET KEY ADDR
02467000 22332  030017       STA D        SET POINTER
02468000 22333  043615       JSM PLUCK    WITHDRAW THE FIRST CHARACTER
02469000 22334  000000       NOP          (THERE IS ALWAYS A FIRST CHARACTER)
02470000 22335  031713       STA T3       SAVE THE FIRST CHAR AS THE IEX/CONT FLAG
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
22336  010111        CPA B52
22337  067351        JMP EXES2     FIRST CHARACTER IS "*" , DON'T TRANSFER IT
22340  010104        CPA B57
22341  067351        JMP EXES2     FIRST CHARACTER IS "/", DON'T TRANSFER IT.
               *
22342  004017  EXES1 LDB D
22343  035712        STB T2        SAVE OLD PTR
22344  140430        JSM AISTX,I   TRANSFER THE FIRST CHAR TO THE I/O BUFF
22345  067377        JMP E34   P+1: I/O BUFFER FULL, CHAR NOT TRANSFERED
22346  140446        JSM AFBP,I    UPDATE THE DISP POINTER
22347  005712        LDB T2
22350  034017        STB D         RESTORE CHAR POINTR
22351  043615  EXES2 JSM PLUCK     GET THE NEXT CHAR
22352  067354        JMP EXES3     P+1:  END OF KEY DEFINITION REACHED
22353  067342        JMP EXES1     P+2:  GOT ANOTHER CHARACTER, TRANSFER IT TO I/O BUF
               *
22354  001714  EXES3 LDA T4        RESTORE THE CURRENT KEY NUMBER
22355  031212        STA SPKN
               *
22356  040715        JSM CLMOD     SET KEY ENTRY MODE
22357  005257        LDB CSTAT     B = CONTROL STATE.
22360  001713        LDA T3        RECALL THE IEX/CONT FLAG
22361  010111        CPA B52       "*" ?
22362  067366        JMP EXES4     IMMEDIATE EXECUTE KEY
22363  010104        CPA B57       "/" ?
22364  067371        JMP EXES5     IMMEDIATE CONTINUE KEY.
               *
22365  170201        RET 1         EXIT FOR TYPING AIDS
               *
22366  014177  EXES4 CPB P0        EXIT FOR IEX KEYS
22367  164416        JMP AEXCK,I   COMMAND EXECUTION
22370  164431        JMP AEXST,I   STATEMENT EXECUTION FOR STATE = 2,4
               *
22371  014177  EXES5 CPB P0        EXIT FOR ICONT KEYS.
22372  164422        JMP AECIM,I   CSTAT=0:  NORMAL CONTINUE
22373  014145        CPB P2        IF LIVE KBD DISPLAY BUFFER
22374  140415        JSM ACONT,I   BEEP, RETURN P+2
22375  164415        JMP ACONT,I   CSTAT#0:  "ENTER" CONTINUE.
22376  170201        RET 1
               *
22377  043403  E34   JSM SKERR     SPECIAL KEY ERROR
22400  031464        ASC 1,34      ERROR 34, DISPLAY BUFFER OVERFLOW
               *
22401  043403  E30   JSM SKERR     SPECIAL KEY NOT DEFINED, ERROR 30
22402  031460        ASC 1,30
               *
22403  140435  SKERR JSM ATRBF,I   TRANSFER I/O BUFF TO KBD BUFF
22404  001714        LDA T4        RESTORE CURRENT KEY NUMBER
22405  031212        STA SPKN
22406  164404        JMP AERR1,I   GO TO ERROR ROUTINE
               *
               ****************
               *
               * FETSK:  FETCH A SPECIAL KEY
               *
               ****************
               *
22407  001232  FETSK LDA CFLAG     SET BIT ONE OF CFLAG TO INDICATE "KEY TO BE STORED"
22410  060145        IOR P2
22411  031232        STA CFLAG
               *
22412  140451        JSM ACLEB,I   CLEAR I/O BUFF T BLANKS AND RESET PTRS
               *
22413  043571        JSM FINDK     HAS THE KEY BEEN DEFINED ?
22414  067431        JMP FETS3     P+1: NO,DISPLAY LOWER CASE "F#"
22415  172701        SAM *+1,S     P+2:  YES, DISPLAY THE KEY DEFINITION
22416  030017        STA D         D = ADDRESS OF FIRST DEFINITION CHARACTER
22417  043615  FETS1 JSM PLUCK     GET A CHARACTER FROM THE KEY DEFINITION
22420  164436        JMP AEPON,I   P+1: END OF DEFINITION REACHED
22421  140430        JSM AISTX,I   P+2:  TRANSFER THE CHARACTER TO THE I/O BUFFER
22422  164436        JMP AEPON,I   P+1: I/O BUFFER FULL SHOULD NEVER OCCUR
22423  067417        JMP FETS1     GET NEXT CHAR
               *
               * ROUTINE TO PUT LOWER CASE "F#" IN THE I/O BUFFER
               *    (I/O BUFFER MUST BE CLEARED TO BLANKS ON ENTRY)
               *
22424  004223  FETS2 LDB B63K      STORE A LOWER CASE"F" AS THE FIRST CHARACTER
22425  134313        STB AIBUF,I
22426  001212        LDA SPKN      GET KEY NUMBER FOR ABTDA
22427  004314        LDB AIBFX     THE ASCII KEY NUMBER TO THE MESSAGE
22430  164477        JMP ABTDA,I
               *
22431  043424  FETS3 JSM FETS2     PUT F# IN DISPLAY
22432  140436        JSM AEPON,I   GO THROUGH PRINT-ALL
22433  140433        JSM ALDSP,I   DISPLAY F#
22434  140452        JSM AEOLB,I   PUT EOL IN EDIT BUFFER
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
02557000 22435  170202            RET 2         SKIP OVER DISPLAY OF I/O BUFFER IN IDLE LOOP
02558000                    *
02559000                    ****************
02560000                    *
02561000                    * ERASK:  ERASE A SPECIAL KEY
02562000                    *
02563000                    ****************
02564000                    *
02565000 22436  043750      .ERSK JSM ERS10     CLR BITS 0-3 OF CFLAG, PUT EOL IN EDIT BUFF
02566000                    *
02567000 22437  043571      .ERS1 JSM FINDK     PUT "EOL" IN THE 1ST CHAR.  IS THE KEY DEFINED ?
02568000 22440  170201            RET 1         P+1:  NO, CANT VERY WELL STORE IT !!
02569000 22441  035741            STB T25       P+2:  YES, NOW  FIND WHERE IT ENDS.
02570000 22442  030017            STA D         D = ADDRESS OF SECOND CHARACTER IN DEFINITION
02571000                    *
02572000 22443  043615      .ERS2 JSM PLUCK     GET ANOTHER CHAR
02573000 22444  067446            JMP .ERS3     P+1: FOUND THE END OF THE KEY DEFINITION
02574000 22445  067443            JMP .ERS2     P+2: KEEP GETTING CHARS UNTIL THE END IS FOUND
02575000                    *
02576000 22446  004017      .ERS3 LDB D
02577000 22447  176601            SBM *+1,C
02578000 22450  034016            STB C         C IS THE WORD ADDRESS OF THE FIRST
02579000 22451  005741            LDB T25       WORD FOLLOWING THE KEY DEFINITION.
02580000 22452  034017            STB D         D IS THE WORD ADDRESS OF THE BEGINNING OF THE KEY
02581000 22453  010045            CPA B377      IF B377 OR 80 WAS THE NEXT CHARACTER,
02582000 22454  067656      .ERS4 JMP MPKML     MOVE PART OF KEYS AND ALL MAINLINE TO
02583000 22455  072477            SZA .ERS4     LOWER MEMORY AND RETURN P+1
02584000 22456  164464            JMP AMAMP,I   ELSE MOVE ONLY MAINLINE TO LOWER MEM, & RET P+1.
02585000                    *
02586000                    ****************
02587000                    *
02588000                    * LSTSK:  LIST A SPECIAL KEY
02589000                    *
02590000                    ****************
02591000
02592000 22457  140475      LSTSK JSM AEDPT,I   RESET I/O PTRS
02593000                    *
02594000 22460  000147      LSTS1 LDA M3        CLR BIT 1 OF CFLAG TO GET OUT OF KEY MODE
02595000 22461  043242            JSM STCFG
02596000                    *
02597000 22462  043571            JSM FINDK     HAS THE KEY BEEN DEFINED ?
02598000 22463  064710            JMP EOLIO     P+1: NO, DISPLAY EOL AND RETURN
02599000 22464  172701            SAM *+1,S     P+2:  YES, SAVE STARTING CHARACTER ADDRESS
02600000 22465  031737            STA T23
02601000                    *
02602000 22466  140450            JSM ACLBI,I   CLR I/O BUFFER
02603000 22467  140444            JSM A.PRN,I   PRINT A BLANK LINE
02604000 22470  043424            JSM FETS2     PUT "F#" IN THE I/O BUFFER
02605000                    *
02606000 22471  004017            LDB D         GET CHAR ADDR OF LAST DIGIT OF KEY #
02607000 22472  034016            STB C         SET PTR
02608000 22473  000134            LDA P11       COMPUTE THE NUMBER OF CHARACTERS LEFT IN THE
02609000 22474  176402            SBM *+2       FIRST LINE AFTER "F#":
02610000 22475  020254            ADA P1
02611000 22476  031711            STA T1
02612000                    *
02613000 22477  004077            LDB P58
02614000 22500  074541            PBC B,I       PUSH ":"
02615000 22501  004117            LDB B40
02616000 22502  074541            PBC B,I       PUSH " "
02617000 22503  001737            LDA T23       SET UP THE BYTE POINTR FOR THE KEY DEFIN.
02618000 22504  030017            STA D
02619000                    *
02620000 22505  043615      LSTS2 JSM PLUCK     GET THE NEXT KEY DEFINITION CHARACTER
02621000 22506  067521            JMP LSTS3     P+1:  END OF DEFINITION REACHED
02622000 22507  074540            PBC A,I       P+2:  NOW PUT IT IN THE I/O BUFFER
02623000 22510  055711            DSZ T1        HAS THE PRINT LINE BEEN FILLED ?
02624000 22511  067505            JMP LSTS2     NO, GET ANOTHER CHARACTER.
02625000                    *
02626000 22512  140444            JSM A.PRN,I   YES, PRINT THE LINE
02627000 22513  140450            JSM ACLBI,I   CLR I/O BUFFER TO BLANKS
02628000 22514  000130            LDA P15
02629000 22515  031711            STA T1        PREPARE TO BUILD THE NEXT LINE, ONE BLANK
02630000 22516  000314            LDA AIBFX     FOLLOWED BY 15 CHARACTERS.
02631000 22517  030016            STA C
02632000 22520  067505            JMP LSTS2
02633000                    *
02634000 22521  001711      LSTS3 LDA T1        HAVE ANY CHARACTERS BEEN STORED IN THE NEXT LINE
02635000 22522  010130            CPA P15       TO BE PRINTED ?
02636000 22523  067525            JMP *+2       NO, DON'T PRINT THE I/O BUFFER FULL OF BLANKS
02637000 22524  140444            JSM A.PRN,I   YES, PRINT THE LAST LINE
02638000 22525  064710      CIOEL JMP EOLIO     CLEAR I/O BUFF, SET EOL IN I/O BUFF AND RETURN P+1
02639000                    *
02640000                    ****************
02641000                    *
02642000                    * STKEY:  STORE A SPECIAL KEY
```

```
                    *
                    ****************
                    *
22526  043437  STKEY JSM .ERS1      ERASE OLD KEY FIRST
22527  001215        LDA IOCP       GET CURRENT BUFFER PTR
22530  005214        LDB CRSP       USE OLCP IF CURSOR IS SET
22531  076402        SZB *+2        SKIP IF NOT SET
22532  001213        LDA OLCP       CURSOR IS SET, USE OLCP
22533  010315        CPA AIBFM      THE I/O BUFFER WITH THE FIRST CHARACTER ADDRESS.
22534  067570        JMP STKE4      THE BUFF IS EMPTY, NOTHING TO STORE; RETURN
                    *
22535  031215        STA IOCP       I/O BUFFER.  IF AN ODD NUMBER
22536  172004        SAP STKE2      OF CHARACTERS ARE PRESENT, PUSH A B0 ONTO THE
22537  000177        LDA P0         END OF THE DEFINITION.
22540  140430        JSM AISTX,I
22541  000000        NOP            (THERE WILL ALWAYS BE ROOM FOR THE B0)
                    *
22542  000315  STKE2 LDA AIBFM      LENGTH OF KEY DEFINITION (WORDS) = (IOCP - AIBFM + 1)
22543  170040        TCA
22544  021215        ADA IOCP
22545  020254        ADA P1
22546  031734        STA T20        SAVE THE LENGTH FOR LATER USE.
                    *
22547  021310        ADA RMAX       SET UP THE DESTINATION ADDRESS FOR MAINLINE
22550  030017        STA D          PROGRAM AREA.
22551  140463        JSM AMUPH,I    MOVE ALL OF USER MAIN PROGRAM TO HIGHER MEMORY.
                    *
22552  005734        LDB T20        CALCULATE THE STARTING ADDRESS OF THE NEWLY
22553  174040        TCB            CREATED KEY AREA.
22554  025307        ADB FWUP
22555  000170        LDA M256       BUILD THE KEY HEADER (B377, KEY NO.) IN A
22556  061212        IOR SPKN       AND STORE IT AS THE FIRST WORD OF THE KEY DEFINITION
22557  130001        STA B,I
                    *
22560  000313        LDA AIBUF      USE D AS A WORD POINTER INTO THE I/O BUFFER AND
22561  030017        STA D          TRANSFER THE REST OF THE KEY DEFINITION TO ITS
22562  055734        DSZ T20        NEW HOME.
                    *
22563  044001  STKE3 ISZ B          BUMP THE KEY AREA WORD POINTER
22564  070570        WWD A,I        GET THEN NEXT WORD OUT OF THE I/O BUFFER
22565  130001        STA B,I        AND TRANSFER IT TO THE KEY AREA.
22566  055734        DSZ T20        ALL WORDS TRANSFERRED ?
22567  067563        JMP STKE3      NO, KEEP GOING.
                    *
22570  067750  STKE4 JMP ERS10      CLR BITS 0-3 OF CFLAG,PUT EOL IN EDIT BUFFER
                    *
                    ****************
                    *
                    * FINDK:  DETERMINEWHETHER KEY F<SPKN> IS DEFINED.
                    *   P+1:  KEY F<SPKN> IS NOT DEFINED
                    *   P+2:  KEY F<SPKN> IS DEFINED, AND
                    *         A = WORD STARTING ADDRESS OF THE KEY DEFINITION
                    *         B = WORD STARTING ADDRESS OF THE KEY HEADER (B377, KEY NO.)
                    *
                    ****************
                    *
22571  001306  FINDK LDA FWAM       IF FWAM = FWUP THEN NO KEYS ARE DEFINED.
22572  011307        CPA FWUP
22573  170201        RET 1
                    *
22574  030017        STA D          ASSUME THAT THE LEFT BYTE OF FWAM,I MUST BE B377.
22575  005307        LDB FWUP       THE NEXT BYTE WITHDRAWN WILL BE THE KEY NO. OF
22576  176301        SBP *+1,S      THE FIRST KEY.  B = CHAR. ADDRESS OF FWUP'S LEFT BYTE
                    *
22577  074570  FIND1 WBD A,I        CHECK TO SEE IF THE KEY JUST FOUND IS THE ONE
22600  011212        CPA SPKN       BEING SEARCHED FOR.
22601  067610        JMP FIND3      YES, SET UP A & B AND RETURN P+2.
                    *
22602  014017  FIND2 CPB D          HAS THE BEGINNING OF MAINLINE PROGRAMMING BEEN FOUND
22603  170201        RET 1          YES, THE KEY F<SPKN> IS NOT DEFINED.
22604  074570        WBD A,I        KEEP LOOKING FOR THE START OF THE NEXT KEY.
22605  010045        CPA B377
22606  067577        JMP FIND1      FOUND THE START OF THE NEXT KEY, CHECK KEY NO.
22607  067602        JMP FIND2      CHECK FOR THE END OF THE KEY AREA.
                    *
22610  000017  FIND3 LDA D          A = ADDRESS OF DEFINITION
22611  172601        SAM *+1,C
22612  004000        LDB A
22613  024257        ADB M1         B = ADDRESS OF HEADER
22614  170202        RET 2
                    *
                    ****************
                    *
                    * PLUCK:  WITHDRAW (WBD A,I) THE NEXT CHARACTER FROM THE KEY DEFINITION.
                    *   P+1:  END OF DEFINITION REACHED (A = B377, B0, OR THE FIRST
                    *         BYTE OF THE MAINLINE PROGRAM AREA)
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                     *     P+2:  A = NEXT DEFINITION BYTE
                     *
                     ****************
                     *
22615  074570  PLUCK WBD A,I      WITHDRAW THE NEXT BYTE
22616  010045        CPA B377     IF IT IS THE START OF A NEW KEY THEN WE'RE DONE.
22617  170201  PLUC1 RET 1
22620  005307        LDB FWUP     IF WE JUST WITHDREW THE FIRST BYTE OF THE MAINLINE
22621  014017        CPB D        PROGRAM AREA, WE'RE DONE.
22622  067625        JMP *+3
22623  072474        SZA PLUC1    MUST TEST 0 AFTER 1ST BYTE OF FWUP BECAUSE IT WILL
22624  170202        RET 2
22625  000257        LDA M1       ALWAYS BE ZERO AS THE LINK OF LINE ZERO.
22626  170201        RET 1
                     *     MOVE A BLOCK OF INFO TO HIGHER MEMORY
                     *
                     *            ENTRY: C=START SOURCE ADDR
                     *
                     *                   D=START DESTINATION ADDR
                     *
                     *                   B=END SOURCE ADDR
                     *
                     *
22627  070570  MTHIM WWD A,I      DUMMY; INCRM DESTIN. POINTR
22630  024257        ADB M1       ADJUST END ADDR
22631  000016  MTHM1 LDA C        GET WORD POINTR
22632  172601        SAM *+1,C    CLEAR BIT 15
22633  030016        STA C        AND UPDATE C-REG.
22634  010001        CPA B        CURRENT = END ADDR ?
22635  067712        JMP MTLM2    YES; CLEAR BIT 15 OF D-REG, AND RETURN P+1
                     *
22636  070760        WWC A,D      FETCH ONE WORD AND DECRM
22637  070750        PWD A,D      DECRM. AND PLACE ONE WORD
22640  067631        JMP MTHM1    LOOP
                     *
                     *
                     *     MOVE ALL OF USER MAIN PROGRAM TO HIGHER MEMORY
                     *
                     *
                     *
                     *            ENTRY: D=START DESTINATION ADDR
                     *
                     *            CHECK FOR MEMORY OVERFLOW
                     *
                     *
22641  005307  MUPHI LDB FWUP     FIRST WORD OF USER PROGRAM ADDR
22642  043646        JSM MPUPH    MOVE TO HIGHER MEMORY
22643  000017  MSTFW LDA D        LAST DESTINATION ADDR
22644  031307        STA FWUP     UPDATE START OF USER PROGRAM POINTR
22645  170201        RET 1
                     *
                     *
                     *     MOVE PART OF USER MAIN PROGRAM TO HIGHER MEMORY
                     *
                     *            ENTRY: D=START DESTINATION ADDR
                     *
                     *                   B=END SOURCE ADDR
                     *
                     *            CHECK FOR MEMORY OVERFLOW
                     *
                     *
22646  001310  MPUPH LDA RMAX     ADDR OF MAX R-REG USED
22647  030016        STA C        SET START SOURCE ADDR
22650  000017        LDA D        START DESTINATION ADDR
22651  031712        STA T2       SAVE POINTR
22652  043257        JSM COVX     CHECK FOR MEMORY OVERFLOW
22653  043627        JSM MTHIM    MOVE TO HIGHER MEMORY
22654  001712        LDA T2
22655  067670        JMP MSTPT    SET ENDS,RMAX
                     *
                     *     MOVE PART OF KEYS AND MAIN PROGRAM LOWER
                     *
                     *            ENTRY: C=START SOURCE ADDR
                     *
                     *                   D=START DESTINATION ADDR
                     *
                     *
22656  005307  MPKML LDB FWUP     START OF MAIN PROGRAM
22657  024257        ADB M1       POINT TO END OF KEYS
22660  043700        JSM MTLOM    MOVE PART OF KEYS LOWER
                     *
                     *     D=NEW FWUP-1
                     *
22661  044017        ISZ D        POINT TO NEW FWUP AND PROCEED TO "MAMPL"
                     *
```

```
02815000                 *
02816000                 *      MOVE ALL MAINPROGRAM TO LOWER MEMORY
02817000                 *
02818000                 *                ENTRY: D=START DESTINATION ADDR
02819000                 *
02820000                 *
02821000 22662  001307   MAMPL LDA FWUP      GET START SOURCE ADDR
02822000 22663  030016         STA C         GET C-REG
02823000 22664  043643         JSM MSTFW     UPDATE START OF PROG PTR
02824000                 *
02825000                 *
02826000                 *      MOVE PART OF USER MAIN PROGRAM TO LOWER MEMORY
02827000                 *
02828000                 *                ENTRY: C=START SOURCE ADDR
02829000                 *
02830000                 *                       D=START DESTINATION ADDR
02831000                 *
02832000                 *
02833000 22665  005310   MPMLM LDB RMAX      MAX. R-REG USED
02834000 22666  043700         JSM MTLOM     MOVE TO LOWER MEMORY
02835000 22667  000017         LDA D         SET PTR
02836000 22670  005310   MSTPT LDB RMAX      OLD MAX R-REG
02837000 22671  174040         TCB           MAKE NEG.
02838000 22672  024000         ADB A         B = - PTR CHANGE
02839000 22673  025277         ADB ENDS      FIND NEW END OF PROG. ADDR
02840000 22674  035277         STB ENDS      UPDATE THE POINTR
02841000 22675  004000         LDB A         GET LAST DESTINATION ADDR
02842000 22676  035310         STB RMAX      UPDATE MAX. R-REG USED
02843000 22677  170201         RET 1
02844000                 *
02845000                 *
02846000                 *      MOVE A BLOCK OF INFO TO LOWER MEMORY
02847000                 *
02848000                 *                ENTRY: C=START SOURCE ADDR
02849000                 *
02850000                 *                       D=START DESTINATION ADDR
02851000                 *
02852000                 *                       B=END SOURCE ADDR
02853000                 *
02854000                 *                  EXIT: D=LAST DESTINATION ADDR
02855000                 *
02856000                 *
02857000 22700  070770   MTLOM WWD A,D       DUMMY: DECRM DESTIN. POINTR
02858000 22701  024254         ADB P1        ADJUST END ADDR
02859000 22702  000016   MTLM1 LDA C         GET WORD POINTR
02860000 22703  172601         SAM *+1,C     CLEAR BIT 15
02861000 22704  030016         STA C         AND UPDATE C-REG.
02862000 22705  010001         CPA B         CURRENT = END ADDR ?
02863000 22706  067712         JMP MTLM2     YES
02864000                 *
02865000 22707  070560         WWC A,I       FETCH ONE WORD AND INCRM
02866000 22710  070550         PWD A,I       INCRM AND PLACE ONE WORD
02867000 22711  067702         JMP MTLM1     LOOP
02868000 22712  000017   MTLM2 LDA D         GET D-REG.
02869000 22713  172601         SAM *+1,C     CLEAR BIT 15
02870000 22714  030017         STA D         AND UPDATE D-REG.
02871000 22715  170201         RET 1
02872000                 *
02873000                 *
02874000                 *      ZERO R/W MEMORY SEGMENT
02875000                 *
02876000                 *      ENTRY: A = START ADDR
02877000                 *
02878000                 *             B = END ADDR
02879000                 *       EXIT: B=P0, A= END ADR
02880000                 *
02881000                 *
02882000 22716  035711   ZRWM  STB T1        SAVE END ADDR
02883000 22717  004177         LDB P0        CLEAR B-REG
02884000 22720  134000   ZRWM1 STB A,I       ZERO ONE WORD
02885000 22721  011711         CPA T1        DONE?
02886000 22722  170201         RET 1         YES
02887000                 *
02888000 22723  072175         RIA ZRWM1     NO: CONT
02889000                 *
02890000                 *
02891000                 *
02892000                 *
02893000                 *      ERASE MAIN PROGRAM
02894000                 *
02895000                 *
02896000 22724  140501   ERAS  JSM AGNXT,I   GET NEXT CHAR.
02897000 22725  030017         STA D         SET FLAG FOR AUTO START ROUTINES
02898000 22726  010053         CPA EOL       EOL MARK?
02899000 22727  067740         JMP ERAS2     YES: ERASE MAIN PROG.
02900000 22730  010065         CPA B141      A ?
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
22731  164426        JMP AERSA,I   YES, GO THROUGH PARTIAL SYSTEM START-UP
22732  010062        CPA B153      K ?
22733  067753        JMP ERAS3     YES, ERASE KEYS
22734  012652        CPA B166      V ?
22735  067746        JMP ERAS5     YES,ERASE VARIABLES
22736  140404  ERCNR JSM AERR1,I   COMMAND NOT RECOGNIZED
22737  030470        ASC 1,18
               *
               *     ERASE
               *
22740  001307  ERAS2 LDA FWUP      FIRST WORD OF USER PROG POINTER
22741  031277        STA END$      SET FOR NULL PROGRAM
22742  031310        STA RMAX      AND NO R-REGISTERS
22743  000177        LDA P0        CLEAR SECURE FLAG
22744  031315        STA STYFG
22745  131277        STA END$,I    CLEAR FIRST LINE BRIDGE
               *
               *     ERASE VARIABLES
               *
22746  043761  ERAS5 JSM ERAS4     ERASE VARIABLES
               *
22747  140514  ERAS9 JSM ASLLN,I   SET LNO = -1 OR LAST LINE #
22750  140452  ERS10 JSM AEOLB,I   PUT EOL IN I/O BUFFER, RESET EDIT PTRS
22751  000160        LDA M16       CLR BITS 0-3 OF CFLAG
22752  067242        JMP STCFG     SET CFLAG
               *
               *      ERASE KEYS
               *
22753  001306  ERAS3 LDA FWAM      GET S/A OF KEYS
22754  011307        CPA FWUP      NULL KEYS?
22755  067747        JMP ERAS9     YES, DONE
22756  030017        STA D         SET D TO START OF KEYS
22757  043662        JSM MAMPL     MOVE ALL MAIN PROG LOWER, MOVE FWUP
22760  067747        JMP ERAS9
               *
               *
               *
               *  ERASE V SUBROUTINE
               *
22761  001277  ERAS4 LDA END$      END OF USER PROG. POINTR
22762  031310        STA RMAX      RESET R-REGS
22763  005313        LDB FWBA      FIRST WORD OF BIN PROG AREA
22764  035311        STB VT1       RESET VALUE TABLE AREA
22765  035312        STB VT2       RESET VALUE TABLE AREA
22766  000276        LDA ADVTB     S/A OF VARIABLE TABLE
22767  004276        LDB ADVTB     S/A OF VAIABLE TABLE
22770  024101        ADB P51       POINT TO E/A OF VARIABLE TABLE
22771  043716        JSM ZRWM      ZERO VARIABLE TABLE AREA
22772  035506        STB FLAGS     CLEAR USER FLAGS
22773  140361        JSM AINTI,I   RESET AP1,AP2,AP3 POINTERS
22774  001320  ERSX1 LDA ESV       GET LINK TO STRING BLOCK
22775  072402        SZA *+2       SKIP IF NOT DEFINED
22776  141320        JSM ESV,I     ERASE STRING VARIABLE TABLE
22777  170201        RET 1
               *
               *
               *
               *****************************************************************
               *
               *  DELETE   COMMAND
               *
               *     DEL #1, (#2),(*)          DELETES LINES #1 THROUGH #2 INCLUSIVELY
               *     IF THE * IS PRESENT, NO PRESCAN IS DONE BY THE RENUMBERING
               *     ROUTINES
               *      T9=LN1; T7=LN2; T20= S/A OF LN1; T2= S/A OF LN2
               *      T19 = S/A OFLN2 +1
               *      ENTRY: L MUST POINT TO FIRST CHAR AFTER "DEL" IN I/O OR
               *              KBD BUFFER
               *      EXIT: LNO = #1 - 1
               *
               ********************
               *
23000  000254  DELL  LDA P1        SET FOR PRESCAN BY DEFAULT
23001  031731        STA T17
23002  140501        JSM AGNXT,I   GET NEXT CHAR FROM BUFFER
23003  140507        JSM AINTC,I   BUILD A BINARY NUMBER
23004  035721        STB T9        LOWER LINE NO.
23005  035717        STB T7        HIGHER LINE NO.
23006  010107        CPA B54       IS NEXT CHAR A COMMA?
23007  066073        JMP DELL2     YES,GET NEXT NUMBER
               *
23010  010053  DELL1 CPA EOL       END OF BUFFER?
23011  066014        JMP DEL10     CONTINUE IF SO
23012  140404  ERLNB JSM AERR1,I   TOO MANY PARAMETERS- ERROR
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```
23013  030471        ASC 1,19       BAD LINE NUMBERS
                   *
23014  001721  DEL10 LDA T9         SEE IF LN1>LN2
23015  031233        STA TMP7       SET FOR AFLNA
23016  170040        TCA
23017  021717        ADA T7         A = LN2 - LN1
23020  172472        SAM ERLNB      ERROR IF MINUS
23021  140513        JSM AFLNA,I    FIND ADDR OF FIRST LINE, LINE # IN TMP7
23022  064722        JMP ERLNF      ERROR IF LINE NOT FOUND
23023  031734        STA T20        SET ADDR OF FIRST LINE
23024  001717        LDA T7         GET LN2
23025  031233        STA TMP7       SET FOR AFLNA
23026  140513        JSM AFLNA,I    FIND ADDR OF LAST LINE
23027  066065        JMP DELL3      NOT FOUND, DELETE REST OF PROGRAM
23030  031712  DELL4 STA T2         SET S/A OF LN2
23031  100000        LDA A,I        GET BRIDGE LENGTH
23032  050053        AND B177
23033  021712        ADA T2         ADD ADDR OF BRIDGE
23034  031733  DELL5 STA T19        SET S/A OF LN2+1
23035  001721        LDA T9         SET LNO TO FIRST LINE # -1
23036  020257        ADA M1
23037  031226        STA LNO
                   *
23040  001731        LDA T17        WAS * A PARAMETER?
23041  072404        SZA DELL6      SKIP PRESCAN IF SO
23042  000254        LDA P1         SET FOR PRESCAN
23043  031613        STA RENFG
23044  140520        JSM AREND,I    PRESCAN FOR DELETED DESTINATIONS
23045  000177  DELL6 LDA P0         SET FOR ACTUAL RENUMBERING
23046  031613        STA RENFG
23047  140520        JSM AREND,I    RENUMBER GTO/GSB'S
                   *
23050  101734        LDA T20,I      GET BRIDGE OF LN1
23051  050215        AND BXCMM      SAVE ONLY REVERSE BRIDGE LENGTH
23052  031731        STA T17        SAVE IT
23053  101733        LDA T19,I      GET FIRST BRIDGE OF LN2+1
23054  050250        AND BM377      SAVE ONLY TRACE,STOP BITS AND FORWARD BRIDGE LENGTH
23055  061731        IOR T17        SET BACKWARD LENGTH OF LN1-1
23056  131733        STA T19,I      SET NEW BRIDGE
                   *
23057  001734        LDA T20        SHIFT USER'S PROGRAM TO THIS LOCATION
23060  030017        STA D
23061  001733        LDA T19        S/A TO SHIFT FROM
23062  030016        STA C
23063  043665        JSM MPMLM      MOVE MEMORY
                   *
23064  067750        JMP ERS10      CLR BITS 0-3 OF CFLAG, PUT EOL IN I/O BUFF,RET1
                   *
23065  140514  DELL3 JSM ASLLN,I    SET LNO TO LAST LINE
23066  001226        LDA LNO        SET FOR RENUMBER ROUTINES
23067  031717        STA T7
23070  001277        LDA ENDS       SET ADDR OF LN2+1
23071  071600        CLR 1          CLR LAST LINE BRIDGE
23072  066034        JMP DELL5
                   *
23073  140501  DELL2 JSM AGNXT,I    GET NEXT PARAMETER
23074  010111        CPA B52        IS IT A *?
23075  066107        JMP DEL90      YES
23076  140507        JSM AINTC,I    BUILD THE LINE NUMBER
23077  035717        STB T7         SET LINE #
23100  010107        CPA B54        NEXT PARAMETER A COMMA?
23101  066103        JMP DEL91      YES
23102  066010        JMP DELL1      NO
                   *
23103  140501  DEL91 JSM AGNXT,I    GET NEXT PARAMETER
23104  010111        CPA B52        IS IT A *?
23105  066107        JMP DEL90      YES, NO PRESCAN
23106  066012        JMP ERLNB      NO, ILLEGAL PARAMETER
23107  000177  DEL90 LDA P0         ASTERIK FOUND, NO PRESCAN
23110  031731        STA T17
23111  140501        JSM AGNXT,I    MAKE SURE NO MORE PARAMETERS
23112  066010        JMP DELL1
                   *
                   **************************************************************
                   *
                   *  LINE DELETE KEY
                   *
                   *************************
                   *
23113  040717  LDELF JSM STELM      SET MODE = 4
23114  000254        LDA P1         SET FOR PRESCAN
23115  031731        STA T17
23116  001226        LDA LNO        SET LN1,LN2
23117  031721        STA T9
```

```
03069000 23120  031717        STA T7
03070000 23121  066014        JMP DEL10
03071000                *
03072000                *
03073000                *
03074000                *     BACK KEY EXECUTION
03075000                *
03076000                *     MOVE CURSOR TO THE LEFT ONCE
03077000                *
03078000                *
03079000                *
03080000 23122  001214  BACK  LDA CRSP      GET CURSOR POINTR
03081000 23123  072015        RZA BACK1     IS CURSOR SET ?
03082000 23124  001215        LDA IOCP      NO; I/O BUFF CURRENT POINTR
03083000 23125  031213        STA OLCP      SET  CURSOR DROP POSITION
03084000 23126  042254        JSM CCTR      COUNT NO. OF CHARS FROM DBP TO IOCP
03085000 23127  066131        JMP BACX2
03086000 23130  170201        RET 1         BUFF EMPTY
03087000                *
03088000 23131  042264  BACX2 JSM BCSR      POSITION OF LAST CHAR >= TO DISP LENGTH ?
03089000 23132  066134        JMP *+2       NO
03090000 23133  066155        JMP BACX4     YES
03091000 23134  001711        LDA T1        CHAR COUNT FROM "CCTR" SUBR.
03092000 23135  072010        RZA BACX5     SET CRSP IF NOT 0
03093000 23136  042241        JSM FORW8     SET CRSP = 1
03094000 23137  066167        JMP BACX9     DEC IOCP,DEC DBP, RETURN
03095000                *
03096000 23140  050074  BACK1 AND B77       SAVE CURSOR COUNT
03097000 23141  010254        CPA P1        CURSOR ON FIRST POSITION?
03098000 23142  066164        JMP BACK7     YES
03099000                *
03100000 23143  001214        LDA CRSP      GET CURSOR POINTR AGAIN
03101000 23144  020257        ADA M1        BACK-UP CURSOR ONCE
03102000 23145  031214  BACX5 STA CRSP      UPDATE CURSOR POINTR
03103000 23146  066330        JMP DIOCP     DECRM I/O BUFF CURRENT POINTR + RETURN P+1
03104000                *
03105000 23147  042273  BACK2 JSM FMSE      FIND EOL AND SET EDIT MODE
03106000 23150  042254        JSM CCTR      COUNT NO. OF CHARS FROM DBP TO IOCP
03107000 23151  066153        JMP BACK3     BUFF NOT EMPTY
03108000 23152  066241        JMP FORW8     SET CRSP TO FIRST POSITION
03109000                *
03110000 23153  042264  BACK3 JSM BCSR      POSITION OF LAST CHAR >= DISP LENGTH ?
03111000 23154  066161        JMP BACK4     NO
03112000 23155  035214  BACX4 STB CRSP      YES; SET CURSOR POINTR ON LAST DISP CHAR
03113000 23156  024146        ADB M2        B = DLEN-2
03114000 23157  001513        LDA DBP       DISP BEGIN POINTER
03115000 23160  066360        JMP DKCPX     UPDATE IOCP POINTR AND RETURN P+1
03116000                *
03117000 23161  045711  BACK4 ISZ T1        CURSOR ON LAST CHAR+1
03118000 23162  001711        LDA T1        GET CURSOR POSITION
03119000 23163  066503        JMP INRE2     SET CRSP
03120000                *
03121000 23164  001513  BACK7 LDA DBP       GET DISP BEGIN POINTR
03122000 23165  011351        CPA AEBFX     EQUAL TO S/A OF EDIT BUFF?
03123000 23166  170201        RET 1         YES
03124000                *
03125000 23167  042330  BACX9 JSM DIOCP     DEC IOCP POINTER
03126000 23170  004257        LDB M1
03127000 23171  001513  BACK9 LDA DBP       GET DISPLAY BEGIN POINTER
03128000 23172  140401        JSM AADBA,I   DECRM DBP POINTR
03129000 23173  066466        JMP RHAR8     SET DBP POINTER
03130000                *
03131000                *
03132000                *     FORWARD KEY EXECUTION
03133000                *
03134000                *     MOVE CURSOR TO THE RIGHT ONCE
03135000                *
03136000                *
03137000 23174  000262  FORW  LDA TOBLN     CLR EOL FROM END OF LINE
03138000 23175  131353        STA AEBFL,I
03139000 23176  001213        LDA OLCP      GET FLAG FOR FORW CURSOR PASS
03140000 23177  010257        CPA M1        SET ?
03141000 23200  170201        RET 1         YES; DO NOT RESTART CURSOR
03142000                *
03143000 23201  001214        LDA CRSP      GET CURSOR POINTR
03144000 23202  072417        SZA FORW1     SKIP IF CURSOR NOT SET
03145000 23203  050074        AND B77       SAVE CURSOR COUNT
03146000 23204  011512        CPA DLEN      CURSOR ON LAST POSITION?
03147000 23205  066243        JMP FORW4     YES
03148000                *
03149000 23206  005214        LDB CRSP      GET CURSOR POINTR
03150000 23207  176601        SBM *+1,C     CLEAR INSERT CURSOR BIT
03151000 23210  024257        ADB M1        ADJUST CURSOR COUNT FOR ADDR CALCULATION
03152000 23211  001513        LDA DBP       GET DISP BEGIN POINTR
```

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```
03153000 23212  140401         JSM AADBA,I  FIND BYTE ADDR OF CURSOR POSITION
03154000 23213  011213         CPA OLCP     IS IT ON THE LAST CHAR ENTERED?
03155000 23214  066226         JMP FORW5    YES
03156000                *
03157000 23215  001214         LDA CRSP     GET CURSOR POINTR AGAIN
03158000 23216  020254         ADA P1       FORWAR CURSOR ONCE
03159000 23217  031214         STA CRSP     UPDATE CURSOR POINTR
03160000 23220  066326         JMP INCP     INCRM I/O BUFF CURRENT POINTR +RETURN P+1
03161000                *
03162000 23221  001215  FORW1  LDA IOCP     GET I/O BUFF CURRENT POINTR
03163000 23222  011352         CPA AEBFM    BUFF EMPTY?
03164000 23223  170201         RET 1        YES
03165000                *
03166000 23224  031213         STA OLCP     SET OLD CURRENT POINTR
03167000 23225  066235         JMP FOR10    SET IOCP
03168000                *
03169000 23226  042326  FORW5  JSM INCP     INC I/O BUFF CURRENT POINTER
03170000 23227  000177  FORW9  LDA P0
03171000 23230  031214         STA CRSP     DROP CURSOR (LAST ENTERED CHAR + 1)
03172000 23231  000257         LDA M1
03173000 23232  031213         STA OLCP     SET FLAG FOR FORW CURSOR PASS
03174000 23233  170201         RET 1
03175000                *
03176000 23234  042273  FORW2  JSM FMSE     FIND EOL AND SET EDIT MODE
03177000 23235  004257  FOR10  LDB M1
03178000 23236  001513         LDA DBP      GET DISP BEGIN POINTR
03179000 23237  140401         JSM AADBA,I  FIND IOCP POINTR (DBP-1)
03180000 23240  031215  FORW3  STA IOCP     SET I/O BUFF CURRENT POINTR
03181000                *
03182000 23241  000254  FORW8  LDA P1       SET CURSOR ON FIRST CHAR
03183000 23242  066503         JMP INRE2    SET CRSP, CURSOR POINTER
03184000                *
03185000 23243  001513  FORW4  LDA DBP      GET DISP BEGIN POINTR
03186000 23244  005512         LDB DLEN     GET DISP LENGTH
03187000 23245  024257         ADB M1       ADJUST "B" FOR ADDR CALCULATION
03188000 23246  140401         JSM AADBA,I  FIND BYTE ADDR OF CURSOR CHAR
03189000 23247  011213         CPA OLCP     IS IT THE LAST CHAR ENTERED?
03190000 23250  042227         JSM FORW9    RESET OLCP,CRSP
03191000 23251  042326         JSM INCP     INC CURRENT I/O BUFF PTR
03192000 23252  004254         LDB P1       INC DBP AND RETURN
03193000 23253  066171         JMP BACK9
03194000                *
03195000                *
03196000                *
03197000                *
03198000                *      CHAR COUNTER
03199000                *         FIND NO. OF CHARS FROM DBP TO IOCP
03200000                *
03201000                *      EXIT: RET P+1 T1=CHAR COUNT
03202000                *
03203000                *            RET P+2 I/O BUFF EMPTY
03204000                *
03205000                *
03206000 23254  005215  CCTR   LDB IOCP     I/O BUFF CURRENT POINTR
03207000 23255  015352         CPB AEBFM    EDIT BUFF EMPTY?
03208000 23256  170202         RET 2        YES
03209000                *
03210000 23257  001513         LDA DBP      DISP BEGIN POINTR
03211000 23260  140362         JSM AFBAD,I  FIND BYTE ADDR DIFF
03212000 23261  020254         ADA P1       ADJUST CHAR COUNT
03213000 23262  031711         STA T1       AND SAVE IT
03214000 23263  170201  CCTRX  RET 1
03215000                *
03216000                *
03217000                *      FIND POSITIONOF LAST CHAR IN I/O BUFF
03218000                *
03219000                *         ENTRY: T1=CHAR COUNT
03220000                *
03221000                *         EXIT: RET P+1  POSITION OF LAST CHAR < DLEN
03222000                *
03223000                *               RET P+2 POSITION OF LAST CHAR >= DLEN; B=DLEN
03224000                *
03225000                *
03226000 23264  005711  BCSR   LDB T1       GET CHAR COUNT
03227000 23265  174040         TCB          MAKE NEG.
03228000 23266  025512         ADB DLEN     ADD DISP LENGTH
03229000 23267  176402         SBM *+2      IOCP OFF DISP LENGTH ?
03230000 23270  076073         RZB CCTRX    NO, SKIP IF IOCP < DLEN
03231000 23271  005512         LDB DLEN     IOCP = DLEN
03232000 23272  170202         RET 2
03233000                *
03234000                *
03235000                *      FIND LINE NO. AND COLLON AND REPLACE THEM WITH BLANKS
03236000                *
```

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```
03237000                  *      FIND EOL MARKAND REPLACE IT WITH BLANK
03238000                  *
03239000                  *      SET EDIT MODE
03240000                  *
03241000                  *          SET "OLCP" POINTER
03242000                  *
03243000                  *                  ENTRY: LINE IN I/O BUFF (FETCH MODE)
03244000                  *
03245000                  *
03246000 23273  001351  FMSE  LDA AEBFX    EDIT BUFF S/A
03247000 23274  030016        STA C        SET C-REG
03248000 23275  074560  FMSE2 WBC A,I      GET CHAR AND INCRM
03249000 23276  010077        CPA COLLN    COLLON ?
03250000 23277  066301        JMP FMSE9    YES
03251000 23300  066275        JMP FMSE2    NO
03252000 23301  074560  FMSE9 WBC A,I      DUMMY WITHDRAW TO DELETE "?"
03253000 23302  000262  FMSE3 LDA TOBLN    GET BLANKS
03254000 23303  074740        PBC A,D      DECRM. AND PLACE BLANK IN I/O BUFF
03255000 23304  004016        LDB C
03256000 23305  015351        CPB AEBFX    EDIT BUFF FRONT END FILLED WITH BLANKS?
03257000 23306  066310        JMP FMSE5    YES
03258000 23307  066302        JMP FMSE3    NO: LOOP
03259000 23310  074561  FMSE5 WBC B,I      GET BYTE AND INCRM
03260000 23311  014053        CPB EOL      EOL MARKER FOUND ?
03261000 23312  066314        JMP FMSE6    YES
03262000 23313  066310        JMP FMSE5    CONT
03263000 23314  074761  FMSE6 WBC B,D      DUMMY WITHDRAW AND DECRM.
03264000 23315  074761        WBC B,D        "     "     "    "
03265000 23316  004016        LDB C        GET BYTE ADDR  OF LAST CHAR
03266000 23317  035215        STB IOCP     SET I/O BUFF CURRENT POINTR
03267000 23320  074540        PBC A,I      REPLACE EOL WITH BLANK
03268000 23321  130316        STA AIBFL,I  REPLACE EOL AT END OF LINE WITH A BLANK
03269000 23322  000016        LDA C
03270000 23323  031213        STA OLCP     SAVE CURSOR DROP POSITION
03271000 23324  000145        LDA P2
03272000 23325  064720        JMP STMOD    SET MODE AND RETURN
03273000                  *
03274000                  *
03275000                  *        INCREMENT I/O BUFFER CURRENT POINTER
03276000                  *
03277000                  *
03278000 23326  004254  INCP  LDB P1
03279000 23327  066357        JMP RHAXX
03280000                  *
03281000                  *
03282000                  *         DECREMENTI/O BUFFER CURRENT POINTER
03283000                  *
03284000                  *
03285000 23330  004257  DIOCP LDB M1
03286000 23331  066357        JMP RHAXX
03287000                  *
03288000                  *
03289000                  *      RIGHT ARROW EXECUTION
03290000                  *
03291000                  *      ENTRY: LINE OF CODE IN EDIT BUFFER
03292000                  *
03293000                  *
03294000 23332  042453  RHRM4 JSM LFRHI    INIT FOR ARROWS WHEN MODE =4
03295000 23333  001214  RHAR  LDA CRSP     GET CURSOR POINTER
03296000 23334  072004        RZA RHAR7    CURSOR SET ?
03297000 23335  001215        LDA IOCP     NO: GET I/O BUFF CURRENT POINTR
03298000 23336  011352        CPA AEBFM    EDIT BUFFER EMPTY?
03299000 23337  170201        RET 1        YES
03300000                  *
03301000 23340  042474  RHAR7 JSM GFDL     GET 1/4 OF DISP LENGTH
03302000 23341  042447        JSM LRASX    INITL. SUBR. FOR LEFT/RIGHT ARROW
03303000 23342  000016  RHAR2 LDA C        BEGGINNING OF BUFFER?
03304000 23343  011351        CPA AEBFX
03305000 23344  066350        JMP RHAR1    YES,EXIT LOOP
03306000 23345  074760        WBC A,D      NO,KEEP MOVING TO THE LEFT
03307000 23346  055227        DSZ TMP1     HAVE WE SHIFTED LEFT DLEN/4 CHARACTERS?
03308000 23347  066342        JMP RHAR2    NO, KEEP GOING
03309000 23350  000016  RHAR1 LDA C        SET DISPLAY BEGIN POINTER
03310000 23351  031513        STA DBP
03311000 23352  001214  RHAR6 LDA CRSP     IS THE CURSOR SET?
03312000 23353  072407        SZA RHSXX    NO,RETURN
03313000 23354  042474  RHAR4 JSM GFDL     GET 1/4 OF DISP LENGTH
03314000 23355  174040        TCB          MAKE NEG.
03315000 23356  025227        ADB TMP1     B = COUNTER VALUE - DLEN/4
03316000 23357  001215  RHAXX LDA IOCP     GETBYTE ADDR I/O CURRENT POINTR
03317000 23360  140401  DKCPX JSM AADBA,I  ADJUST BYTE ADDR
03318000 23361  031215  RHSET STA IOCP     UPDATE I/O CURRENT POINTER
03319000 23362  170201  RHSXX RET 1
03320000                  *
```

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```
03321000                    *
03322000                    *     LEFT ARROW EXECUTION (KEYB./EDIT MODE)
03323000                    *
03324000                    *     ENTRY; LINE OF CODE IN EDIT BUFFER
03325000                    *
03326000                    *
03327000 23363  042453  LFRM4 JSM LFRHI      INIT FOR ARROWS WHEN MODE = 4
03328000 23364  001214  LAKE  LDA CRSP       GET CURSOR POINTER
03329000 23365  072004        RZA LAKE7      CURSOR SET ?
03330000 23366  001215        LDA IOCP       NO; GET I/O BUFF CURRENT POINTR
03331000 23367  011352        CPA AEBFM      EDIT BUFF EMPTY?
03332000 23370  170201  LAKXX RET 1          YES
03333000                *
03334000 23371  042445  LAKE7 JSM LRASR      INITL. SUBR. FOR LEFT/RIGHT ARROW
03335000 23372  001214        LDA CRSP       CURSOR POINTR
03336000 23373  072003        RZA LAKE1      SET ?
03337000 23374  001215        LDA IOCP       NO; GET I/O BUFF CURRENT POINTR
03338000 23375  066377        JMP LAKE9
03339000 23376  001213  LAKE1 LDA OLCP       GET OLD I/O BUFF CURRENT POINTR
03340000 23377  031230  LAKE9 STA TMP5       SET PTR
03341000 23400  055227  LAKE2 DSZ TMP1       DONE ?
03342000 23401  066413        JMP LAKE3      NO ;
03343000 23402  042470        JSM AJDBP      YES; ADJUST DISP BEGIN POINTR
03344000 23403  001214  LAKE5 LDA CRSP       GET CURSOR POINTR
03345000 23404  072002        RZA *+2        SET ?
03346000 23405  170201        RET 1          NO
03347000                *
03348000 23406  001227        LDA TMP1       GET COUNTR VALUE
03349000 23407  170040        TCA            MAKE NEG.
03350000 23410  042474        JSM GFDL       GET 1/4 OF DISP LENGTH
03351000 23411  024000        ADB A          B = DLEN/4 - COUNTER VALUE
03352000 23412  066357        JMP RHAXX      UPDATE I/O CURRENT POINTR AND RETURN P+1
03353000                *
03354000 23413  074560  LAKE3 WBC A,I        INC C
03355000 23414  000016        LDA C
03356000 23415  005230        LDB TMP5       STOP IF C>= IOCP OR OLCP+1
03357000 23416  140362        JSM AFBAD,I
03358000 23417  172061        SAP LAKE2      SKIP IF CONDITION NOT MET
03359000                *
03360000 23420  042474  LAKE4 JSM GFDL       GET 1/4 OF DISPLAY LENGTH
03361000 23421  174040        TCB            MAKE NEG
03362000 23422  025227        ADB TMP1       B= COUNTER VALUE - DLEN/4
03363000 23423  176027        SBP LRSXX      SKIP IF EOL WITHIN DLEN
03364000 23424  174040        TCB            B = POSITION CHANGE OF DISP BEGIN POINTR
03365000 23425  042471        JSM AJDBX      ADJUST DISP BEGIN POINTR
03366000 23426  066403        JMP LAKE5      NO; ADJUST IOCP IF NEEDED
03367000                *
03368000                *
03369000                *     LEFT ARROW EXECUTION (FETCH MODE)
03370000                *
03371000                *     ENTRY; LINE OF CODE IN EDIT BUFFER
03372000                *
03373000                *
03374000 23427  042445  LFAR  JSM LRASR      INITL. SUBR. FOR LEFT/RIGHT ARROW
03375000 23430  074560  LFAR2 WBC A,I        GET BYTE AND INCRM
03376000 23431  055227        DSZ TMP1       DONE?
03377000 23432  066434        JMP LFAR1      NO
03378000 23433  066470        JMP AJDBP      YES; ADJUST DISP BEGIN POINTR AND RETURN P+1
03379000                *
03380000 23434  010053  LFAR1 CPA EOL        END OF LINE MARKER?
03381000 23435  066437        JMP *+2        YES
03382000 23436  066430        JMP LFAR2      NO; CONT
03383000 23437  042474  LFR4  JSM GFDL       GET 1/4 OF DISP LENGTH
03384000 23440  174040        TCB            MAKE NEG.
03385000 23441  025227        ADB TMP1       B = COUNTER VALUE-DLEN/4
03386000 23442  176010        SBP LRSXX      SKIP IF EOL WITHIN DLEN
03387000                *
03388000 23443  174040        TCB            B = POSITION CHANGE OF DBP POINTR
03389000 23444  066471        JMP AJDBX      ADJUST DISP BEGIN POINTR AND RETURN P+1
03390000                *
03391000                *
03392000                *     LEFT/RIGHT ARROW SERVICE SUBR
03393000                *
03394000                *         SET TMP1 = DLEN + DLEN/4; C = DBP
03395000                *
03396000                *
03397000 23445  042474  LRASR JSM GFDL       GET 1/4 OF DISP LENGTH
03398000 23446  025512        ADB DLEN       B = DLEN + DLEN/4
03399000 23447  035227  LRASX STB TMP1       SET CHAR COUNTER
03400000 23450  001513        LDA DBP        GET DISP BEGIN POINTR
03401000 23451  030016        STA C          SET C REG
03402000 23452  170201  LRSXX RET 1
03403000                *
```

```
                      *******************
                      *
                      * LFRHI  INIT FOR LEFT-RIGHT ARROWS
                      *
                      **********
                      *
23453  140447  LFRHI JSM ASWIO,I   SET EDIT POINTERS FOR I/O BUFFER
23454  140500        JSM AEOLN,I   SET BUFFER POINTERS
23455  031213        STA OLCP
23456  031215        STA IOCP
                      *
23457  005512        LDB DLEN      SEE IF DBP>IOCP-DLEN
23460  174500        SBR 1         MAKE A WORD COUNT
23461  025513        ADB DBP
23462  024257        ADB M1
23463  140362        JSM AFBAD,I   FIND BYTE DIFFERENCE
23464  172466        SAM LRSXX     IF <0 THEN OK
23465  001351  RHAR9 LDA AEBFX     SET DISPLAY BEGIN POINTER
23466  031513  RHAR8 STA DBP
23467  170201        RET 1
                      *
                      *
                      *
                      *      ADJUST DISP BEGIN POINTR
                      *
                      *         TO THE RIGHT BY DLEN/4 POSITIONS
                      *
                      *
23470  042474  AJDBP JSM GFDL      GET 1/4 OF DISP LENGTH
23471  001513  AJDBX LDA DBP       GET DISP BEGIN POINTR
23472  140401        JSM AADBA,I   ADJUST BYTE ADDR (DBP POINTR)
23473  066466        JMP RHAR8     UPDATE DISP BEGIN POINTR AND RETURN P+1
                      *
                      *
                      *        GET 1/4 OF DISP LENGTH
                      *
                      *            EXIT: B = DLEN/4
                      *
                      *
23474  005512  GFDL  LDB DLEN      GET DISP LENGTH
23475  174501        SBR 2         B = DLEN/4
23476  170201        RET 1
                      *
                      *
                      **************************************************************
                      *
                      *INRE  INSERT/REPLACE CURSOR KEY
                      *
                      **********************
                      *
23477  001214  INRE  LDA CRSP      GET CURSOR PTR
23500  072002        RZA *+2       SET?
23501  170201        RET 1         NO
                      *
23502  172203        SAP INRE1,C   SKIP IF NOT SET,CLR INS. CURSOR
23503  031214  INRE2 STA CRSP      UPDATE CURSOR PTR
23504  170201        RET 1
                      *
23505  172376  INRE1 SAP INRE2,S   SET INSERT CURSOR
                      *
                      ***************************************************************
                      *
                      ***************************************************************
                      *
                      *  EDPTR   RESET EDIT POINTERS
                      *
                      ****************************
                      *
23506  000177  EDPTR LDA P0        RESET OLD CURRENT PTR,,CURSOR PTR
23507  031213        STA OLCP
23510  031214        STA CRSP
23511  042465        JSM RHAR9     RESET DISPLAY BEGIN POINTER,DBP
23512  001352        LDA AEBFM     SET CURRENT PTR
23513  066361        JMP RHSET     SET IOCP, I/O BUFF CURRENT POINTER
                      *
                      *
                      ***************************************************************
                      *
                      *  CONVERT BINARY TO DECIMAL AND
                      *
                      *      TRANSFER LINE NO. TO I/O BUFF
                      *
                      *         TLNIO ENTRY:  LINE NO. IN LNO
                      *
```

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```
                      *       ABTDA OR "TLNX" ENTRY  BIN NO. IN A
                      *
                      *                                  B = DESTINATION CHAR POINTR-1
                      *
                      *            EXIT: D=LAST CHAR OF LINE NO. IN I/O BUFF
                      *
                      *
23514  140450  TLNIO JSM ACLBI,I  CLR I/O BUFF, LEAVE PTRS ALONE
23515  001226        LDA LNO      GET LINE NO.
23516  004315        LDB AIBFM    I/O BUFF ADDR-1
23517  034017  TLNX  STB D        SET D-REG
23520  172004        SAP TLNT2    SKIP IF NO. IS POSITIVE
23521  004106        LDB B55      GET MINUS SIGN
23522  074551        PBD B,I      INCRM AND PLACE IN DISP BUFF
23523  170040        TCA          MAKE NO. POSITIVE
23524  031220  TLNT2 STA M        SAVE BINARY INFO.
23525  000203        LDA PTCN     ADDR OF POWERS OF 10 CONSTANTS
23526  031713        STA T3
23527  000177        LDA P0       USED TO SUPRESS LEADING ZEROS
23530  031222        STA L        COUNT OF LINE NO. CHARS
23531  042545        JSM CBA2     GET FIRST DEC. ASCII DIGIT
23532  074550  TLNT1 PBD A,I      INCRM AND PLACE DIGIT IN DISP BUFF
23533  001713        LDA T3       T3 + POINTR
23534  010210        CPA ENDTC    CONVERSION FINISHED?
23535  170201        RET 1        YES
                      *
23536  042540        JSM CBA      NO: CONTINUE
23537  066532        JMP TLNT1
                      *
                      *    SERVICE SUBR.
                      *
                      *    CONVERT BINARY TO ASCII DECIMAL
                      *               ENTRY: M=BINARY INFO
                      *
                      *                       T3=POWERS OF TEN TABLE ADDR
                      *
                      *               EXIT: ONE ASCII DIGIT
                      *
                      *
23540  000103  CBA   LDA B60
23541  045713  CBA4  ISZ T3            INCRM TABLE POINTR
23542  005713        LDB T3            GET ADDR
23543  014210        CPB ENDTC         COMPUTING LAST DIGIT?
23544  066557        JMP CBA5              YES
23545  005220  CBA2  LDB M             GET BINARY NO.
23546  125713  CBA1  ADB T3,I          SUBTRACT NUMBER OF CURRENT TENS POSITION DIGIT
23547  176404        SBM CBA3          IF MINUS OVERFLOW: END DIVIDE
23550  035220        STB M             NO OVERFLOW: SAVE DIGIT
23551  020254        ADA P1
23552  066546        JMP CBA1          LOOP
23553  072466  CBA3  SZA CBA4          OVERFLOW: IF ZERO, NO NON-ZERO DIGIT FOUND
23554  060103  CBA6  IOR B60           MAKE ASCII
23555  045222        ISZ L             INCRM CHAR COUNT
23556  170201        RET 1
                      *
23557  001220  CBA5  LDA M             LAST DIGIT: THUS M=BCD DIGIT
23560  066554        JMP CBA6
                      *
                      *
                      *
                      ***********************************************************
                      *
                      *  EOLNN  FIND ADDR OF LAST CHARACTER IN EDIT BUFFER
                      *         ADDRESS RETURNED IN A
                      *
                      *****************
                      *
23561  001353  EOLNN LDA AEBFL    END OF BUFFER
23562  020257        ADA M1       START AT LAST CHARACTER
23563  030016        STA C        SET PTR
23564  005352        LDB AEBFM    BEGIN OF BUFF PTR
23565  074760  REND  WBC A,D      GET A CHARACTER
23566  010117        CPA B40      IS IT A BLANK
23567  066571        JMP *+2      YES, SEE IF BEGGINNING OF BUFF
23570  066574        JMP RSTPP    NO, SEE IF EOL CHAR
23571  014016        CPB C        IS THIS THE BEGGINING OF BUFFER?
23572  066577        JMP RSTT     YES, SO EXIT
23573  066565        JMP REND     NO, KEEP LOOKING
23574  010053  RSTPP CPA EOL      SEE IF EOL
23575  066577        JMP *+2      YES SO DON'T MOVE PTR
23576  074561  RSTP  WBC B,I      DUMMY WITHDRAW TO INC C
23577  000016  RSTT  LDA C        GET NON-BLANK CHAR ADDR
23600  170201        RET 1
                      *
                      *
```

CONTROL AND I/O SUPERVISOR SERVICE ROUTINES

```
                      *
                      *
                      *     GET NEXT CHARACTER FROM BUFFER
                      *
                      *         SPACES ARE IGNORED
                      *
                      *     ENTRY:  L = POINTER TO NEXT CHAR
                      *
                      *     EXIT:   A = ASCII CHAR: IF FOUND
                      *
                      *             A = EOL: IF END OF BUFF FOUND
                      *     END OF BUFF = END OF I/O BUFF OR END OF KDB BUFFER
                      *
                      *             L = L+1
                      *
                      *
23601   005222  GNEXT LDB L          GET CHAR POINTER
23602   034016        STB C          SET C-REG
23603   074560  GNE1  WBC A,I        GET CHAR
23604   004016        LDB C          GET POINTER
23605   014316        CPB AIBFL      END OF I/O BUFFER?
23606   066615        JMP GNOPR      YES
23607   014311        CPB AKBFL      END OF KBD BUFFER
23610   066615        JMP GNOPR      YES
                *
23611   010117        CPA B40        SPACE?
23612   066603        JMP GNE1       YES, KEEP LOOKING
                *
23613   035222  GNE3  STB L          SET POINTER
23614   170201        RET 1
                *
23615   000053  GNOPR LDA EOL        SET EOL IN SINCE END OF BUFFER
23616   066613        JMP GNE3       RETURN WITH L SET
                *
                ************************************************************
                *
                *  RNLON   TURN ON RUN LIGHT
                *
                ***********************
                *
23617   000177  RNLON LDA P0         SET PERIPHERAL ADDR TO ZERO
23620   030011        STA PA
23621   000137        LDA B10        TURN ON RUN LIGHT
23622   066626        JMP RSETL
                *
                ************************************************************
                *
                *  RNLOF  TURN OFF RUN LIGHT
                *
                *******************
                *
23623   000177  RNLOF LDA P0         SET PERIPHERAL ADDR
23624   030011        STA PA
23625   000127        LDA B20        TURN OFF RUN LIGHT
23626   030005  RSETL STA R5
23627   170201        RET 1
                *
                ************************************************************
                *
                * TCHR  TRANSFER CHARACTERS
                *
                *
                *    ENTRY:  D  =  SOURCE CHAR PTR
                *            A  =  DESTINATION CHAR PTR -1
                *            B  =  CHARACTER COUNT
                *
                ************************
                *
23630   035711  TCHR  STB T1         SET CHAR COUNT
23631   030016        STA C          SET DESTINATION ADDR
23632   074570  TCHR1 WBD A,I        GET CHAR AND INC
23633   074540        PBC A,I        INC AND STORE CHAR
23634   055711        DSZ T1         DONE?
23635   066632        JMP TCHR1      NO
23636   170201        RET 1          YES
                *
                *
                *
                *
                *     STOP, REW KEYS
                *
                *
23637   005235  PINK  LDB SKEY      GET KEY CODE
23640   014145        CPB P2        REW KEY?
```

```
03657000 23641  164601          JMP ARFK,I   YES, REWIND AND RETURN
03658000                  *
03659000 23642  001232          LDA CFLAG    NO, MUST BE STOP KEY
03660000 23643  170701          RAR 2        POSITION SPECIAL KEY BIT
03661000 23644  172602          SAM *+2,C    KEY TO BE DEFINED?
03662000 23645  170201          RET 1        NO
03663000                  *
03664000 23646  170715          RAR 14       REPOSITION CLEARED SPECIAL KEY BIT
03665000 23647  031232          STA CFLAG    REPLACE IT
03666000 23650  040715          JSM CLMOD    SET MODE = 0
03667000 23651  164452          JMP AEOL8,I  PUT EOL IN I/O BUFFER, RETURN
03668000                  *
03669000                  *
03670000                  *
03671000                  *
03672000                  *  CONSTANTS
03673000                  *
03674000 23652  000166    P118  DEC 118
03675000                  *
03676000                  *
03677000                  *
03678000                  *     DEFINITIONS
03679000                  *
03680000                  *
03681000        023652    B166  EQU P118
03682000        000263    MAXLN EQU FLAG
03683000        000170    BUHM  EQU M256
03684000        000122    B32   EQU P26
03685000        000052    STPMS EQU B200
03686000        000263    TRCMS EQU FLAG
03687000        000077    COLLN EQU B72
03688000        000053    EOL   EQU B177
03689000        000177    KPA   EQU P0
03690000        000116    QUOTE EQU B42
03691000        077467    LPSVA EQU LPIT
03692000        077470    LPSVB EQU LPIT+1
03693000        077471    LPSVC EQU LPIT+2
03694000        077473    LPSVE EQU LPIT+4
03695000        077474    LPSVD EQU LPIT+5
03696000        000236    CTCNT EQU B2K
03697000        077216    CST   EQU CSTMP
03698000        077216    SIOCP EQU CST
03699000        077217    .WPRT EQU CST+1
03700000        077220    M     EQU CST+2
03701000        077221    PLADD EQU CST+3
03702000        077223    TMP6  EQU CST+5
03703000        077224    K     EQU CST+6
03704000        077225    TMP2  EQU CST+7
03705000        077226    LNO   EQU CST+8
03706000        077227    TMP1  EQU CST+9
03707000        077230    TMP5  EQU CST+10
03708000        077231    TMP3  EQU CST+11
03709000        077232    CFLAG EQU CST+12
03710000        077233    TMP7  EQU CST+13
03711000        077234    TMP4  EQU CST+14
03712000        077235    SKEY  EQU CST+15
03713000        077206    .WKC  EQU IOTMP
03714000        077207    .WMOD EQU IOTMP+1
03715000        077210    DTMP1 EQU IOTMP+2
03716000        077211    DTMP2 EQU IOTMP+3
03717000        077212    SPKN  EQU IOTMP+4
03718000        077213    OLCP  EQU IOTMP+5
03719000        077214    CRSP  EQU IOTMP+6
03720000        077215    IOCP  EQU IOTMP+7
03721000        077613    RENFG EQU LKTMP+6
03722000        000433    DISP  EQU ALDSP
03723000        077251    OFLAG EQU CMTMP+10
03724000                  *
03725000                  *
03726000                  *      ROUTINE LINKS
03727000                  *
03728000                  *
03729000 23775                  ORG 23775B
03730000 23775  066000          JMP DELL     DELETE COMMAND
03731000 23776  067724          JMP ERAS     ERASE COMMAND
03732000                  *
03733000                  ***********************************************************************
03734000                  *                                  *
03735000 23777                  BSS 1        CHECKSUM
03736000                  *
03737000                  ***************
03738000                  *
03739000                        END
END OF PASS 2 NO ERRORS DETECTED
```

BASE-PAGE READ-WRITE-MEMORY

```
0003000 76550                    ORG 76550B
0004000                          SUP
0005000                   *
0006000                   *
0007000                   *
0008000 76550             BINRY BSS 7          BINARY PROGRAM LINKS
0009000                   *
0010000 76557             CBUFF BSS 80         COMPILE BUFFER
0011000 76677             CSTAK BSS 80         COMPILE STACK          MUST BE AFTER CBUFF
0012000                   *
0013000 77017             RMTBL BSS 19         ROM ADDRESS TABLE      MUST BE AFTER CSTAK
0014000 77042             STEAL BSS 16         STOLEN RWM TABLE
0015000 77062             ROMWD BSS 1          ROM IN/OUT INFO
0016000 77063             NPROG BSS 1          NEW-PROGRAM FLAG
0017000 77064             IBUFF BSS 41         INPUT/OUTPUT BUFFER
0018000 77135             KBUFF BSS 41         KEYBOARD BUFFER
0019000                   *
0020000 77206             IOTMP BSS 8          I/O DRIVER TEMPORARIES
0021000 77216             CSTMP BSS 17         CONTROL SUPERVISOR TEMPORARIES
0022000 77237             CMTMP BSS 14         COMPILER TEMPORARIES
0023000                   *
0024000 77255             XCOMM BSS 1          INTERPRETER COMMUNICATIONS WORD
0025000 77256             MODE  BSS 1          CONTROL-SUPERVISOR MODE FLAG
0026000 77257             CSTAT BSS 1          CONTROL STATE
0027000 77260             ERRBP BSS 1          ERROR BYPASS LINK
0028000                   *
0029000 77261             EXTMP BSS 12         INTERPRETER TEMPORARIES
0030000                   *
0031000 77275             IDXRW BSS 1          INDEXED RWM
0032000 77276             SAVEB BSS 1
0033000 77277             ENDS  BSS 1
0034000 77300             AP2   BSS 1
0035000 77301                   BSS 4          RESERVED FOR INDEX TABLE
0036000                   *
0037000 77305             OFWAM BSS 1          FIRST WORD ACTUAL RWM
0038000 77306             FWAM  BSS 1          FIRST WORD AVAILABLE RWM
0039000 77307             FWUP  BSS 1          FIRST WORD OF USER PROGRAM
0040000 77310             RMAX  BSS 1          MAXIMUM R-REGISTER ADDRESS
0041000 77311             VT1   BSS 1          FIRST WORD OF VALUE TABLE INFORMATION
0042000 77312             VT2   BSS 1          FIRST WORD OF VALUE TABLE VALUES
0043000 77313             FWBA  BSS 1          FIRST WORD OF BINARY AREA
0044000 77314             TE    BSS 1          TRACE ON/OFF FLAG
0045000 77315             STYFG BSS 1          SECURE-PROGRAM FLAG
0046000 77316             CERR  BSS 1          COMPILE ERROR FLAG
0047000 77317             SWHRE BSS 1          SAVED WHERE
0048000                   *
0049000 77320             ESV   BSS 1          ERASE STRING VARIABLE TABLE
0050000 77321             STCHK BSS 1          STRING COMPARISON LINK
0051000 77322             STENT BSS 1          STRING ENTER LINK
0052000 77323             STEAS BSS 1          STRING ENTER ASSIGNMENT LINK
0053000 77324             AKOUN BSS 1          LINK TO PROCESS A STRING
0054000 77325             STRES BSS 1          STRING ASSIGNMENT FOR READ STATEMENT
0055000 77326             STEFL BSS 1          STRING ENTER FLAG
0056000 77327             SEED  BSS 4          SEED FOR RANDOM-NUMBER GENERATOR
0057000 77333                   BSS 8          RESERVED FOR POST-RELEASE INTER-ROM LINKS
0058000 77343             NOTRY BSS 1          MAXIMUM # OF TRIES AT READ OR SEARCH
0059000 77344             AVFLG BSS 1          CASSETTE AUTOVERIFY FLAG
0060000 77345             CSCF  BSS 1          SELECT CODE OF CASSETTE IN PARALLEL SEARCH
0061000 77346             FTRGT BSS 1          TARGET RECORD FOR PARALLEL SEARCH
0062000 77347             INTSR BSS 1          INTERRUPT SERVICE FLAG
0063000                   *
0064000 77350             AEBUF BSS 1          BUFFER EDIT POINTERS
0065000 77351             AEBFX BSS 1
0066000 77352             AEBFM BSS 1
0067000 77353             AEBFL BSS 1
0068000                   *
0069000 77354             DVTAB BSS 26         DECLARED VARIABLE TABLE
0070000 77406             DATAB BSS 26         DECLARED ARRAY TABLE
0071000 77440             ITABL BSS 16         INTERRUPT JUMP TABLE -- ADDRESS MUST END IN 0000
0072000 77460             HPIT  BSS 7          HI-PRIORITY INTERRUPT SAVE AREA
0073000 77467             LPIT  BSS 7          LO-PRIORITY INTERRUPT SAVE AREA
0074000                   *
0075000 77476             ENR   BSS 4          ENTER REGISTER
0076000 77502             URES  BSS 4          USER RESULT REGISTER
0077000 77506             FLAGS BSS 1          FLAG REGISTER, 0-15 L-TO-R
0078000                   *
0079000 77507             ELINK BSS 1          END-STMT EXECUTION LINK
0080000 77510             .IOSR BSS 1          I/O-ROM SERVICE ROUTINE LINK
0081000 77511             MLBPL BSS 1          "MAIN LOOP" BYPASS LINK
0082000 77512             DLEN  BSS 1          DISPLAY LENGTH
0083000 77513             DBP   BSS 1          DISPLAY BEGIN POINTER
0084000 77514             CSELC BSS 1          CASSETTE SELECT CODE
0085000 77515             BUSFG BSS 1          FOR JN
0086000 77516             IOINT BSS 1          FOR JN
0087000 77517             RGFLG BSS 1          REGISTER ASSIGNMENT INFORMATION
```

BASE-PAGE READ-WRITE-MEMORY

```
00088000                    *
00089000 77520              PARG  BSS 1              P-ARGUMENT
00090000 77521              AP36  BSS 1              PRODUCTION 36 (FOR JO)
00091000 77522              AP37  BSS 1              PRODUCTION 37
00092000 77523              AP77  BSS 1              PRODUCTION 77
00093000 77524              AP78  BSS 1              PRODUCTION 78
00094000 77525              AP136 BSS 1              PRODUCTION 136
00095000 77526              APP#  BSS 1              P# EXECUTION
00096000 77527              APRET BSS 1              A.P. ROM'S PART OF 'RET' EXECUTION
00097000 77530              LOADL BSS 1              CASSETTE LDK OK LINK
00098000 77531              APRVC BSS 1              A.P. ROM'S CHECK FOR ()
00099000 77532              REFOR BSS 1              RESET FOR/NEXT BEFORE EXECUTE
00100000 77533              RLINK BSS 1              RUN-CMND EXECUTION LINK
00101000                    *
00102000 77534              RBUFF BSS 41             RESERVE KEYBOARD BUFFER
00103000 77605              LKTMP BSS 14
00104000 77623              LKFLG BSS 1              LIVE KEYBOARD ENABLE/DISABLE FLAG
00105000                    *
00106000 77624              ENSV  BSS 4              SAVE AREA FOR ENTER
00107000 77630              SVXCM BSS 1              SAVED XCOMM FOR ENTER
00108000                    *
00109000 77631                    BSS 2              FOR POST-RELEASE CHANGES  (ARE SAVED WITH RCM)
00110000                    *
00111000 77633              JSTAK BSS 33             JSM STACK
00112000                    *
00113000 77674                    BSS 1              FOR POST-RELEASE CHANGES  (NOT SAVED WITH RCM)
00114000 77675              T26   BSS 1
00115000                    *
00116000 77676              CATMP BSS 11             CASSETTE TEMPORARIES
00117000                    *
00118000 77711              T1    BSS 1              SHARED TEMPORARIES
00119000 77712              T2    BSS 1
00120000 77713              T3    BSS 1
00121000 77714              T4    BSS 1
00122000 77715              T5    BSS 1
00123000 77716              T6    BSS 1
00124000 77717              T7    BSS 1
00125000 77720              T8    BSS 1
00126000 77721              T9    BSS 1
00127000 77722              T10   BSS 1
00128000 77723              T11   BSS 1
00129000 77724              T12   BSS 1
00130000 77725              T13   BSS 1
00131000 77726              T14   BSS 1
00132000 77727              T15   BSS 1
00133000 77730              T16   BSS 1
00134000 77731              T17   BSS 1
00135000 77732              T18   BSS 1
00136000 77733              T19   BSS 1
00137000 77734              T20   BSS 1
00138000 77735              T21   BSS 1
00139000 77736              T22   BSS 1
00140000 77737              T23   BSS 1
00141000 77740              T24   BSS 1
00142000 77741              T25   BSS 1
00143000                    *
00144000 77742              OP1   BSS 4              FLOATING-POINT TEMPORARY
00145000 77746              OP2   BSS 4              FLOATING-POINT TEMPORARY
00146000 77752              RES   BSS 4              RESULT FOR ALL FLOATING-POINT OPERATIONS
00147000 77756              MRW1  BSS 10             MATH READ-WRITE
00148000 77770                    BSS 4              AR1
00149000 77774              MRW2  BSS 4              MATH READ-WRITE

00151000 00040                    ORG 40B
00152000                    *
00153000                    * SYSTEM STARTUP       *
00154000                    *
00155000 00040      164041  SYSS  JMP *+1,I
00156000 00041                    BSS 1
00158000                    *
00159000                    * CONSTANTS
00160000                    *
00161000 00042      000777  P511  DEC 511          JN JO
00162000            000042  B777  EQU P511
00163000 00043      000411  P265  DEC 265
00164000            000043  B411  EQU P265
00165000 00044      000400  P256  DEC 256       JB JN
00166000            000044  B400  EQU P256
00167000 00045      000377  P255  DEC 255       JB JN
00168000            000045  B377  EQU P255                MT
00169000 00046      000231  P153  DEC 153
00170000            000046  B231  EQU P153
00171000 00047      000230  P152  DEC 152
00172000            000047  B230  EQU P152
```

```
00173000 00050  000224  P148  DEC 148
00174000        000050  B224  EQU P148
00175000 00051  000202  P130  DEC 130
00176000        000051  B202  EQU P130
00177000 00052  000200  P128  DEC 128   JB       MT
00178000        000052  B200  EQU P128
00179000 00053  000177  P127  DEC 127   JB       MT
00180000        000053  B177  EQU P127           MT
00181000 00054  000176  P126  DEC 126   JB
00182000        000054  B176  EQU P126
00183000 00055  000175  P125  DEC 125   JB
00184000        000055  B175  EQU P125
00185000 00056  000174  P124  DEC 124   JB
00186000        000056  B174  EQU P124
00187000 00057  000173  P123  DEC 123   JB
00188000        000057  B173  EQU P123           MT
00189000 00060  000162  P114  DEC 114   JB
00190000        000060  B162  EQU P114
00191000 00061  000160  P112  DEC 112
00192000        000061  B160  EQU P112
00193000 00062  000153  P107  DEC 107   JB
00194000        000062  B153  EQU P107           MT
00195000 00063  000145  P101  DEC 101
00196000        000063  B145  EQU P101
00197000 00064  000143  P99   DEC 99          JO MT
00198000 00065  000141  P97   DEC 97
00199000        000065  B141  EQU P97
00200000 00066  000140  P96   DEC 96    JB
00201000        000066  B140  EQU P96
00202000 00067  000135  P93   DEC 93
00203000        000067  B135  EQU P93
00204000 00070  000133  P91   DEC 91
00205000        000070  B133  EQU P91
00206000 00071  000105  P69   DEC 69    JB
00207000 00072  000101  P65   DEC 65
00208000        000072  B101  EQU P65
00209000 00073  000100  P64   DEC 64    JB    JO MT
00210000        000073  B100  EQU P64
00211000 00074  000077  P63   DEC 63    JB
00212000        000074  B77   EQU P63
00213000 00075  000075  P61   DEC 61
00214000        000075  B75   EQU P61
00215000 00076  000073  P59   DEC 59    JB
00216000        000076  B73   EQU P59
00217000 00077  000072  P58   DEC 58    JB
00218000        000077  B72   EQU P58
00219000 00100  000064  P52   DEC 52    JB
00220000        000100  B64   EQU P52
00221000 00101  000063  P51   DEC 51    JB
00222000        000101  B63   EQU P51            MT
00223000 00102  000061  P49   DEC 49
00224000        000102  B61   EQU P49
00225000 00103  000060  P48   DEC 48    JB
00226000        000103  B60   EQU P48
00227000 00104  000057  P47   DEC 47    JB
00228000        000104  B57   EQU P47
00229000 00105  000056  P46   DEC 46    JB
00230000        000105  B56   EQU P46
00231000 00106  000055  P45   DEC 45    JB
00232000        000106  B55   EQU P45
00233000 00107  000054  P44   DEC 44    JB
00234000        000107  B54   EQU P44
00235000 00110  000053  P43   DEC 43    JB
00236000        000110  B53   EQU P43
00237000 00111  000052  P42   DEC 42    JB
00238000        000111  B52   EQU P42
00239000 00112  000051  P41   DEC 41    JB
00240000        000112  B51   EQU P41
00241000 00113  000050  P40   DEC 40
00242000        000113  B50   EQU P40
00243000 00114  000044  P36   DEC 36
00244000        000114  B44   EQU P36
00245000 00115  000043  P35   DEC 35
00246000        000115  B43   EQU P35
00247000 00116  000042  P34   DEC 34    JB JN
00248000        000116  B42   EQU P34
00249000 00117  000040  P32   DEC 32    JB JN    MT
00250000        000117  B40   EQU P32
00251000 00120  000037  P31   DEC 31    JB
00252000        000120  B37   EQU P31
00253000 00121  000034  P28   DEC 28       JN    MT
00254000        000121  B34   EQU P28
00255000 00122  000032  P26   DEC 26    JB    JO
00256000 00123  000024  P20   DEC 20             MT
00257000 00124  000023  P19   DEC 19       JN    MT
```

BASE-PAGE READ-ONLY-MEMORY

```
00258000 00125  000022  P18   DEC 18
00259000 00126  000021  P17   DEC 17      JB JN
00260000 00127  000020  P16   DEC 16      JB JN JO MT
00261000        000127  B20   EQU P16
00262000 00130  000017  P15   DEC 15      JB JN    MT
00263000        000130  B17   EQU P15
00264000 00131  000016  P14   DEC 14      JB JN
00265000 00132  000015  P13   DEC 13      JB    JO
00266000 00133  000014  P12   DEC 12      JB JN JO MT
00267000 00134  000013  P11   DEC 11      JB    JO
00268000        000134  B13   EQU P11
00269000 00135  000012  P10   DEC 10      JB JN JO MT
00270000 00136  000011  P9    DEC 9
00271000 00137  000010  P8    DEC 8       JB JN JO MT
00272000        000137  B10   EQU P8
00273000 00140  000007  P7    DEC 7       JB JN JO MT
00274000 00141  000006  P6    DEC 6       JB    JO MT
00275000 00142  000005  P5    DEC 5       JB JN JO MT
00276000 00143  000004  P4    DEC 4       JB JN JO MT
00277000 00144  000003  P3    DEC 3       JB JN JO MT
00278000 00145  000002  P2    DEC 2       JB JN JO MT
00279000 00146  177776  M2    DEC -2      JB JN
00280000 00147  177775  M3    DEC -3      JB JN JO MT
00281000 00150  177774  M4    DEC -4      JB JN JO MT
00282000 00151  177773  M5    DEC -5      JB JN JO
00283000 00152  177772  M6    DEC -6
00284000 00153  177771  M7    DEC -7      JB
00285000 00154  177770  M8    DEC -8         JN    MT
00286000 00155  177765  M11   DEC -11           JO
00287000 00156  177763  M13   DEC -13           JO
00288000 00157  177761  M15   DEC -15              MT
00289000 00160  177760  M16   DEC -16     JB JN JO MT
00290000 00161  177757  M17   DEC -17     JB
00291000 00162  177740  M32   DEC -32     JB JN    MT
00292000        000162  BM40  EQU M32
00293000 00163  177720  M48   DEC -48     JB
00294000 00164  177700  M64   DEC -64     JB    JO
00295000        000164  BM100 EQU M64
00296000 00165  177660  M80   DEC -80     JB
00297000 00166  177637  M97   DEC -97
00298000 00167  177600  M128  DEC -128             MT
00299000 00170  177400  M256  DEC -256    JB    JO MT
00300000 00171  160000  M8192 DEC -8192   JB
00301000                *
00302000 00172  000174  AONE  DEF *+2        JN JO    FLOATING-POINT ONE
00303000 00173  000177  APIE  DEF *+4           JO    FUDGED PI
00304000 00174  000000        OCT 000000
00305000 00175  010000  B10K  OCT 010000 JB     JO MT
00306000 00176  000000        OCT 000000
00307000 00177  000000  P0    OCT 000000 JB     JO
00308000 00200  030501        OCT 030501       3141
00309000 00201  054446        OCT 054446       5926
00310000 00202  051540        OCT 051540       5360
00311000                *
00312000 00203  000204  PTCN  DEF *+1
00313000 00204  154360  M10K  DEC -10000 JB
00314000 00205  176030  M1000 DEC -1000
00315000 00206  177634  M100  DEC -100    JB
00316000 00207  177766  M10   DEC -10     JB    JO
00317000 00210  000210  ENDTC DEF *
00318000                *
00319000 00211  077740  BXCAA OCT 77740   JB
00320000 00212  077700  EMAX  OCT 77700         JO
00321000        000212  B777X EQU EMAX    JB
00322000 00213  077577  TMASK OCT 77577
00323000 00214  077440  EOLB  OCT 77440   JB
00324000 00215  077400  BXCMM OCT 77400   JB
00325000 00216  076574  ZK2   OCT 76574
00326000 00217  076000  B76K  OCT 76000   JB
00327000 00220  071050  TRCC2 OCT 71050
00328000 00221  070000  B70K  OCT 70000         JO MT
00329000 00222  067000  B67K  OCT 67000            MT
00330000 00223  063000  B63K  OCT 63000   JB
00331000 00224  060000  B60K  OCT 60000   JB       MT
00332000 00225  052525  ALBPT OCT 52525   JB
00333000 00226  037440  QMRKB OCT 37440   JB
00334000 00227  020000  B20K  OCT 20000   JB
00335000 00230  010133  RK2   OCT 10133
00336000 00231  010050  RK1   OCT 10050
00337000 00232  007403  B7403 OCT 7403             MT
00338000 00233  004406  ZK3   OCT 4406
00339000 00234  004000  B4K   OCT 4000             MT
00340000 00235  003377  B3377 OCT 3377             MT
00341000 00236  002000  B2K   OCT 2000    JB       MT
00342000 00237  001000  B1K   OCT 1000             MT
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00343000                   *
00344000 00240  177701  ZAP   OCT 177701        JO
00345000        000167  BM200 EQU M128    JB    JO
00346000 00241  176000  BM2K  OCT -2000   JB
00347000 00242  170720  KF    OCT 170720
00348000 00243  170000  B170K OCT 170000  JB
00349000 00244  137777  XMASK OCT 137777  JB
00350000 00245  131400  IMCON OCT 131400
00351000 00246  126273  AMSE  OCT 126273           MT
00352000 00247  101175  ZK1   OCT 101175
00353000 00250  100377  BM377 OCT 100377           MT
00354000 00251  100200  UMASK OCT 100200
00355000                *
00356000 00252  000254  NB1   DEF *+2           SPECIAL PATTERN FOR NUMBER BUILDER
00357000 00253  077772  NB2   DEF 77772B
00358000 00254  000001  P1    DEC 1       JB JN JO MT
00359000 00255  177764  M12   DEC -12     JB    JO
00360000 00256  000000        DEC 0
00361000 00257  177777  M1    DEC -1      JB    JO MT
00362000 00260  000000        DEC 0
00363000 00261  000000        DEC 0
00364000                *
00365000 00262  020040  TOBLN OCT 020040        TWO ASCII BLANKS
00366000 00263  100000  FLAG  OCT 100000
00367000 00264  040001  STTMP OCT 040001        STRING CONSTANT IN STACK
00368000 00265  100004  STWHR OCT 100004
00369000        000171  ARRAY EQU M8192         ENTIRE ARRAY
00370000        000221  EMPTY EQU B70K          EMPTY
00371000 00266  011401  FPTMP OCT 011401        FULL-PRECISION CONSTANT IN STACK
00372000 00267  110000  FVRWM OCT 110000        FULL-PRECISION VARIABLE IN RWM
00373000 00270  110402  FVRRA OCT 110402        FULL-PRECISION VARIABLE IN R-REGISTER AREA
00374000                *
00375000 00271  062562  LKERM OCT 62562         LOWER-CASE "ERROR"
00376000 00272  071157        OCT 71157
00377000 00273  071040        OCT 71040
00378000                *
00379000                * POINTERS
00380000                *
00381000 00274  000053  AAEOL DEF B177          ADDRESS OF EOL
00382000 00275  077440  AITAB DEF ITABL         ADDRESS OF INTERRUPT TABLE
00383000 00276  077354  ADVTB DEF DVTAB         ADDRESS OF DECLARED VARIABLE TABLE
00384000 00277  077406  ADATB DEF DATAB         ADDRESS OF DECLARED ARRAY TABLE
00385000 00300  077632  AJSTK DEF JSTAK-1       ADDRESS OF JSM STACK
00386000 00301  077633  AJSMS DEF JSTAK
00387000 00302  176557  ACBFX DEF CBUFF,I       COMPILE BUFFER 1ST CHAR ADDRESS
00388000 00303  076557  ACBF  DEF CBUFF         COMPILE BUFFER STARTING ADDRESS
00389000 00304  076556  ACBUF DEF CBUFF-1       ADDRESS OF COMPILE BUFFER
00390000 00305  076676  ACLMT DEF CBUFF+79      COMPILE BUFFER UPPER LIMIT
00391000 00306  077135  AKBUF DEF KBUFF         KEYBOARD BUFFER
00392000 00307  177135  AKBFX DEF KBUFF,I       KEYBOARD BUFFER 1ST CHAR ADDRESS
00393000 00310  077134  AKBFM DEF KBUFF-1       KEYBOARD BUFFER STARTING ADDRESS - 1
00394000 00311  077205  AKBFL DEF KBUFF+40      KEYBOARD BUFFER ENDING ADDRESS
00395000 00312  000306  AKBST DEF AKBUF         KEYBOARD BUFFER POINTERS STARTING ADDRESS
00396000 00313  077064  AIBUF DEF IBUFF         I/O BUFFER
00397000 00314  177064  AIBFX DEF IBUFF,I       I/O BUFFER 1ST CHAR ADDRESS
00398000 00315  077063  AIBFM DEF IBUFF-1       I/O BUFFER STARTINF ADDRESS - 1
00399000 00316  077134  AIBFL DEF IBUFF+40      I/O BUFFER ENDING ADDRESS
00400000 00317  077066  AIBSL DEF IBUFF+2       I/O BUFFER STARTING ADDRESS + 2
00401000 00320  077070  AIOLM DEF IBUFF+4       I/O BUFFER STARTING ADDRESS FOR "LINE" MESSAGE
00402000 00321  000313  AIBST DEF AIBUF         EDIT POINTERS STARTING ADDRESS
00403000 00322  077534  ARBUF DEF RBUFF
00404000 00323  077533  ARBFM DEF RBUFF-1
00405000 00324  076677  ASTK1 DEF CSTAK         COMPILE STACK STARTING ADDRESS
00406000 00325  176677  ACSTF DEF CSTAK,I
00407000        000305  ASTAK EQU ACLMT         ADDRESS OF COMPILE STACK - 1
00408000 00326  077016  ASLMT DEF CSTAK+79      COMPILE STACK UPPER LIMIT
00409000        000326  ATROM EQU ASLMT
00410000                *
00411000 00327  077017  AROMS DEF RMTBL         ADDRESS OF ROM ADDRESS TABLE
00412000 00330  076550  ABNRY DEF BINRY         ADDRESS OF BINARY HEADER
00413000 00331  000332  AMAIN DEF ARTBL         ADDRESS OF MAINFRAME HEADER
00414000 00332          ARTBL BSS 1             ADDRESS OF REVERSE COMPILE TABLE
00415000 00333          AMTBL BSS 1             ADDRESS OF MAINFRAME MNEMONIC TABLE
00416000                *
00417000 00334  000177  ADP0  DEF P0
00418000 00335  077711  ATMP  DEF T1            STARTING ADDRESS OF SHARED TEMPORARIES
00419000                *
00420000 00336  077742  AOP1  DEF OP1
00421000 00337  077746  AOP2  DEF OP2
00422000 00340  077752  ARES  DEF RES
00423000 00341  077476  AENR  DEF ENR
00424000 00342  077502  AURES DEF URES
00425000                *
00426000 00343  077414  SVRE  ABS DVTAB-1018+97
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BASE-PAGE READ-ONLY-MEMORY

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00427000        000326  STRK  EQU ASLMT
00428000                *
00429000 00344  077777  MAW   OCT 77777      MAXIMUM AVAILABLE WORD
00430000        000330  LWAM  EQU ABNRY      LAST WORD AVAILABLE RWM + 1
00431000                *
00432000 00345  077770  ADR1  DEF AR1
00433000        000127  ADR2  EQU P16

00435000                *
00436000                * USEFUL POINTERS AND EQUATES
00437000                *
00438000        077237  TKN   EQU CMTMP+0    TOKEN FOR PARSER
00439000        077240  BCD   EQU CMTMP+1    ASCII FOR PARSER
00440000        077241  OLDC  EQU CMTMP+2    USED BY SCANNER IN CASE OF ERROR
00441000        077242  ISTAR EQU CMTMP+3    IMPLIED-MULTIPLY FLAG
00442000                *
00443000        077254  STAKP EQU CMTMP+13   STACK POINTER
00444000                *
00445000        077237  GUIDE EQU CMTMP+0    PRIORITY/CLASS/CHARACTERS
00446000        077240  ASCII EQU CMTMP+1    CHARACTER ADDRESS
00447000                *
00448000        077261  AP3   EQU EXTMP+0    RETURN LINK INFORMATION
00449000        077263  AP1   EQU EXTMP+2    TOP OF EXECUTION STACK
00450000        077264  LEND  EQU EXTMP+3    ADDRESS OF NEXT LINE TO BE EXECUTED
00451000        077265  HERE  EQU EXTMP+4    ADDRESS OF LINE BEING EXECUTED
00452000        077266  WHERE EQU EXTMP+5    ADDRESS FOR CS TO RESUME EXECUTION
00453000        077267  TRACE EQU EXTMP+6    CURRENT LINE TRACE INFORMATION
00454000        077270  SAVEC EQU EXTMP+7
00455000        077271  BASE  EQU EXTMP+8    ADDRESS IN DVTAB OR DATAB
00456000        077272  FAP1  EQU EXTMP+9
00457000        077273  OPND1 EQU EXTMP+10
00458000        077274  OPND2 EQU EXTMP+11
00459000                *
00460000        077222  L     EQU CSTMP+4
00461000        077610  KBFMT EQU LKTMP+3
00462000                *
00463000        000141  STRID EQU P6         ID OF STRING ROM
00465000                *
00466000                * ROUTINE ADDRESSES
00467000                *
00468000 00346          ACPLR BSS 1          COMPILER
00469000 00347          AREAD BSS 1          COMPILER INPUT READER
00470000 00350          AAPL1 BSS 1          APPLY-PRODUCTION RETURN TO COMPILER
00471000 00351          ASETC BSS 1          COMPILE ERROR
00472000 00352          ANUMB BSS 1          NUMBER-BUILDER
00473000 00353          ALBLN BSS 1          QUOTE SCANNER
00474000 00354          ALBCM BSS 1          QUOTE BUILDER
00475000 00355          AOUTS BSS 1          COMPILER BYTE WRITER
00476000                *
00477000 00356          ARCLR BSS 1          REVERSE COMPILER
00478000 00357          ADSRM BSS 1          DISPLAY ROM I.D. NUMBER
00479000                *
00480000 00360          ARSGT BSS 1          RESET HI-SPEED BRANCHES
00481000 00361          AINTI BSS 1          INTERPRETER 'RUN' ENTRY
00482000 00362          AFBAD BSS 1          FIND BYTE ADDRESS DIFFERENCE
00483000 00363          AINTT BSS 1          INTERPRETER 'CLL' ENTRY
00484000 00364          AINTK BSS 1          INTERPRETER 'CONTINUE' ENTRY
00485000 00365          AINTX BSS 1          INTERPRETER EXECUTION RETURN
00486000 00366          ARAP  BSS 1          FOR MATH ROUTINES
00487000 00367          ASTP  BSS 1          FOR END-STMT LINK
00488000 00370          ALLOC BSS 1          ALLOCATOR
00489000 00371          AOVTS BSS 1          EXECUTION STACK OVERFLOW TEST
00490000 00372          AASTR BSS 1          ASSIGNMENT TRACE
00491000 00373          ALNTR BSS 1          LINE NUMBER TRACE
00492000 00374          AFCI  BSS 1          FIND-BYTE INITIALIZATION ENTRY
00493000 00375          AFCC  BSS 1          FIND-BYTE CONTINUATION ENTRY
00494000 00376          ASFG  BSS 1          SET A FLAG
00495000 00377          AGNAM BSS 1          GET VARIABLE NAME
00496000 00400          ACLBL BSS 1          FIND LABEL LINE ADDRESS
00497000 00401          AADBA BSS 1          ADJUST BYTE ADDRESS ENTRY #1
00498000 00402          A.ADB BSS 1          ADJUST BYTE ADDRESS ENTRY #2
00499000                *
00500000                * 10K PAGE - CONTROL SUPERVISOR
00501000                *
00502000 00403          AMCLX BSS 1          MAIN LOOP ADDR+1
00503000 00404          AERR1 BSS 1          ERROR ROUTINE -- NO RETURN
00504000 00405          AERR2 BSS 1          ERROR ROUTINE -- RETURN P+2
00505000 00406          APEMI BSS 1          PLACE ERROR MESSAGE IN I/O BUFFER
00506000 00407          AEREX BSS 1          ERROR EXIT -- AFTER 'AERR2'
00507000 00410          AREJR BSS 1          INTERRUPT REJECT ROUTINE
00508000 00411          AXCMM BSS 1          XCOMM MANAGEMENT
00509000 00412          APLIR BSS 1          PLACE LINE NUMBER IN I/O BUFFER AND REVCOMP
00510000 00413          ACNDT BSS 1          COMMAND TABLE
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00414    ACTFC BSS 1            CHECK TABLE FOR COMMAND
00415    ACONT BSS 1            IMMEDIATE EXECUTE CONTINUE
00416    AEXCK BSS 1            COMMAND EXECUTION
00417    AEXCL BSS 1            PLACE LINE BRIDGES ON COMPILED LINE
00420    AKYPR BSS 1            PROCESS A KEY
00421    AERCS BSS 1            CASSETTE RUN ENTRY
00422    AECIM BSS 1            IMMEDIATE CONTINUE
00423    ASCND BSS 1            COMMAND TABLE ADDRESS
00424    ASYER BSS 1            SYSTEM ERROR
00425    ACNIN BSS 1            CONTINUE INITIALIZATION
00426    AERSA BSS 1            LINK FOR ERASE-ALL
00427    AISTR BSS 1            PLACE KEYBOARD CHARACTER IN I/O BUFFER
00430    AISTX BSS 1            PLACE CHARACTER IN I/O BUFFER
00431    AEXST BSS 1            STATEMENT EXECUTION
         *
         * 12K PAGE - I/O SUPERVISOR
         *
00432    ADSPC BSS 1            DISPLAY EDIT BUFFER WITH CURSOR
00433    ALDSP BSS 1            DISPLAY I/O BUFFER
00434    AKBSR BSS 1            KEYBOARD SERVICE ROUTINE
00435    ATRBF BSS 1            TRANSFER I/O BUFFER TO KEYBOARD BUFFER
00436    AEPON BSS 1            PRINT-ALL ROUTINE
00437    AEPNX BSS 1            LINK TO PRINT-ALL FOR ENP
00440    ASVRG BSS 1            SAVE LOW PRIORITY A,B,E,O
00441    AKBR2 BSS 1            RESTORE LOW PRIORITY A,B,E,O
00442    ACPST BSS 1            CHECK PRINTER STATUS
00443    APRNT BSS 1            PRINT CHARACTERS ALREADY GIVEN TO HARDWARE
00444    A.PRN BSS 1            PRINT 16 CHARS FROM I/O BUFFER
00445    APNMR BSS 1            PRINT A NUMERIC VALUE
00446    AFBP  BSS 1            FIND DISPLAY BEGIN POINTER
00447    ASWIO BSS 1            SWAP POINTERS TO EDIT I/O BUFFER
00450    ACLBI BSS 1            CLEAR I/O BUFFER
00451    ACLEB BSS 1            CLEAR EDIT BUFFER
00452    AEOLB BSS 1            SET EOL IN EDIT BUFFER
00453    ACLCM BSS 1            CLEAR COMPILE BUFFER
00454    ARPRL BSS 1            ROM "POWER REDUCTION LOOP"
00455    ALKEX BSS 1            LINK TO LIVE-KEYBOARD EXECUTION
00456    ALXER BSS 1            LINK TO LIVE-KEYBOARD EXECUTE ERROR ROUTINE
00457    ALXKY BSS 1            LINK TO LIVE-KEYBOARD EXECUTE KEY PROCESSING
00460    AKYTB BSS 1
00461    APRKB BSS 1            PRINT-ALL FROM KEYBOARD BUFFER
00462    APSTR BSS 1 (PSTRG)
         *
         * 22K PAGE
         *
00463    AMUPH BSS 1            MOVE MAIN PROGRAM TO HIGHER MEMORY
00464    AMAMP BSS 1            MOVE MAIN PROGRAM TO LOWER MEMORY
00465    AMPUP BSS 1            MOVE PART OF MAIN PROGRAM HIGHER
00466    AMPML BSS 1            MOVE PART OF MAIN PROGRAM LOWER
00467    AMTHM BSS 1            MOVE RWM HIGHER
00470    AMTLM BSS 1            MOVE RWM LOWER
00471    AZRWM BSS 1            ZERO RWM
00472    AERAV BSS 1            ERASE ALL VARIABLES
00473    ALISK BSS 1            LIST A SPECIAL KEY
00474    AKEYN BSS 1            PUT SPECIAL KEY NUMBER IN I/O BUFFER
00475    AEOPT BSS 1            RESET EDIT POINTERS
00476    ATLNI BSS 1            PLACE LINE NUMBER IN I/O BUFFER
00477    ABTDA BSS 1            BINARY TO DECIMAL ASCII
00500    AEOLN BSS 1            FIND EOL IN I/O BUFFER
00501    AGNXT BSS 1            GET NEXT CHARACTER
00502    ATCHR BSS 1            TRANSFER CHARS
00503    ARNLO BSS 1            LINK TO TURN ON RUN LIGHT
00504    ARNLF BSS 1            LINK TO TURN OFF RUN LIGHT
         *
         * 26K PAGE
         *
00505    APGET BSS 1 (PGET)     GET NEXT PARAMETER FOR "PRINT" LIST
00506    APNUM BSS 1 (PNUM)     PROCESS A NUMERIC ITEM
00507    AINTC BSS 1 (INTCK)    MAKE INTEGER FROM ASCII STRING
00510    AGLL  BSS 1 (GLENL)    GET LENGTH OF COMPILED LINE
00511    AGEOL BSS 1            FIND EOL IN COMPILE BUFFER
00512    AFLAD BSS 1 (FLADR)    FIND LINE ADDRESS
00513    AFLNA BSS 1            FIND LINE ADDR (TMP7)
00514    ASLLN BSS 1 (SLLN)     SET 'LNO' TO LAST LINE NUMBER OR -1
00515    ASTKI BSS 1            LINK TO LIVE-KEYBOARD INITIALIZATION
00516    AREST BSS 1            LINK TO LIVE-KEYBOARD RESTORE
00517    ARENI BSS 1            INSERT LINE RENUMBER GTO/GSB
00520    AREND BSS 1            DELETE LINE RENUMBER GTO/GSB
00521    ASTKG BSS 1            STACK ROUTINE FOR GSB
00522    ADIGX BSS 1            GENERAL RANGE CHECK ROUTINE
00523    AGLNO BSS 1            GET LINE NUMBER OF CURRENT LINE
         *
00524    AUNM  BSS 1            UNARY MINUS -- FILLED IN FROM 14K-PAGE (IMATH)
00525    AADD  BSS 1            ADD
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                         BASE-PAGE READ-ONLY-MEMORY

00595000 00526          ASUB  BSS 1          SUBTRACT
00596000 00527          AMUL  BSS 1          MULTIPLY
00597000 00530          ADIV  BSS 1          DIVIDE
00598000 00531          ASQR  BSS 1          SQRT
00599000 00532          AGE   BSS 1          >=
00600000 00533          AGT   BSS 1          >
00601000 00534          ALT   BSS 1          <
00602000 00535          ALE   BSS 1          <=
00603000 00536          AEQ   BSS 1          =
00604000 00537          ANE   BSS 1          #
00605000 00540          AAND  BSS 1          AND
00606000 00541          AOR   BSS 1          OR
00607000 00542          AXOR  BSS 1          XOR
00608000 00543          ANOT  BSS 1          NOT
00609000 00544          APRND BSS 1          P-ROUND
00610000 00545          ADRND BSS 1          D-ROUND
00611000 00546          ARERR BSS 1          RECOVERABLE MATH ERROR
00612000 00547          ARND  BSS 1          ROUND
00613000 00550          ATSUB BSS 1          USED BY RELATIONAL OPERATIONS
00614000 00551          AFLTC BSS 1          FULL-PRECISION EXPONENT RANGE CHECK
00615000 00552          AGET1 BSS 1          GET ONE MATH OPRND FROM STACK
00616000 00553          AGET2 BSS 1          GET TWO MATH OPNDS FROM STACK
00617000 00554          AADD1 BSS 1          ADD+1
00618000 00555          ASUB1 BSS 1          SUBTRACT+1
00619000 00556          AMUL1 BSS 1          MULTIPLY+1
00620000 00557          ADIV1 BSS 1          DIVIDE+1
00621000 00560          ADIV2 BSS 1          DIVIDE ENTRY FOR TRUNCATED QUOTIENT
00622000 00561          ASQR1 BSS 1          SQRT+1
00623000 00562          ATSU1 BSS 1          TSUB+1
00624000 00563          AFLTP BSS 1          CONVERT TO FLOATING-POINT
00625000                *
00626000 00564          ASTMA BSS 1          STMAX ENTRY -- FILLED IN FROM 24K-PAGE (MOBA)
00627000 00565          ASTM1 BSS 1          STMAX ENTRY
00628000                *
00629000 00566          ALST  BSS 1          LINK TO EXECUTE 'LIST'
00630000 00567          APRT  BSS 1          LINK TO EXECUTE 'PRT'
00631000 00570          ADSP  BSS 1          LINK TO EXECUTE 'DSP'
00632000 00571          ASPC  BSS 1          LINK TO EXECUTE 'SPC'
00633000 00572          ALSTK BSS 1          LINK TO EXECUTE 'LISTK'
00634000 00573          AKON  BSS 1          LINK TO EXECUTE 'KON'
00635000 00574          AKOF  BSS 1          LINK TO EXECUTE 'KOFF'
00636000 00575          AFXD  BSS 1          LINK TO EXECUTE 'FXD'
00637000 00576          AFLT  BSS 1          LINK TO EXECUTE 'FLT'
00638000 00577          AENT  BSS 1          LINK TO EXECUTE 'ENT'
00639000                *
00640000 00600          ACSTI BSS 1          CASSETTE INITIALIZATION
00641000 00601          ARFK  BSS 1          REWIND FROM KEYBOARD
00642000 00602          DMALO BSS 1          LINK TO DMA LOCKOUT ROUTINE
00643000 00603          ASTPA BSS 1          LINK TO SET CASSETTE P.A.
00644000 00604          AWTRR BSS 1          LINK TO WRITE RECORD
00645000 00605          ACHST BSS 1          LINK TO FIND RECORD
00646000 00606          ARDRC BSS 1          LINK TO READ RECORD
00647000                *
00648000 00607  001053  ABUMP DEF BUMP       BUMP PARAMETER POINTER (FAP1)
00649000 00610  001110  ACOUN DEF COUNT      COUNT PARAMETERS ON STACK
00650000 00611  001133  AGTAD DEF GETAD      GETAD SUBROUTINE
00651000 00612  001142  AGTIN DEF GETIN      GETIN SUBROUTINE
00652000                *
00653000 00613                BSS 2          FOR MORE LINKS IF NEEDED

                         BASE-PAGE SUBROUTINES

00655000                *
00656000                * UTILITIES
00657000                *

00659000                *
00660000                * SUBROUTINE TO GET OPERAND ABSOLUTE ADDRESS    W.F.C.
00661000                *
00662000                * ON EXIT:  A = UPDATED STACK POINTER
00663000                *           B = ABSOLUTE ADDRESS
00664000                *       SAVEB = OLD STACK POINTER
00665000                *
00666000 00615  005263  ABSAD LDB AP1        ENTER HERE TO USE AP1
00667000 00616  035276        STB SAVEB
00668000                *
00669000 00617  100001        LDA B,I
00670000 00620  050140        AND P7         GET INDEX NUMBER
00671000 00621  020632        ADA INDXP
00672000 00622  024145        ADB P2
00673000 00623  104001        LDB B,I        B = RELATIVE ADDRESS
00674000 00624  124000        ADB A,I        B = ABSOLUTE ADDRESS
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               *
00625  001276        LDA SAVEB
00626  020254        ADA P1
00627  100000        LDA A,I        A = LENGTH
00630  021276        ADA SAVEB      A = UPDATED POINTER
00631  170201        RET 1
               *
00632  077275  INDXP DEF IDXRW      POINTER TO INDEXED RWM

               *
               * WAIT SUBROUTINE
               *
               * ON ENTRY! B = -DELAY IN MILLISECONDS
               *
00633  000642  DELAY LDA TIMF
00634  072100        RIA *
00635  001206        LDA IOTMP      TEST FOR STOP KEY
00636  010254        CPA P1
00637  170201        RET 1
00640  076173        RIB *-5
00641  170201        RET 1
               *
00642  177130  TIME  OCT 177130
               *
               * CONVERT FLOATING NUMBER TO INTEGER    W.F.C.
               *
               * ON ENTRY!
               *
               *   A POINTS TO FLOATING NUMBER
               *
               * ON EXIT!
               *
               *   B HAS INTEGER VALUE
               *   O INDICATES OVERFLOW STATUS
               *
               *   AR2 HAS FRACTIONAL REMAINDER
               *
               * TEMPORARIES USED: T1,T2
               *
00643  000001        LDA B          ALTERNATE ENTRY
               *
00644  004127  FIXPT LDB ADR2       ADDRESS OF AR2
00645  071403        XFR 4          MOVE NUMBER TO AR2
00646  004177        LDB P0         INITIALIZE RESULT
00647  173201        SOC *+1,C
00650  000020        LDA AR2        LOOK AT EXPONENT
00651  170405        AAR 6
00652  020254        ADA P1
00653  072417        SZA FI3
00654  172426        SAM FI4
00655  031711        STA T1
00656  064664        JMP FI2
               *
00657  024001  FI1   ADB B          2X
00660  035712        STB T2
00661  024001        ADB B          4X
00662  024001        ADB B          8X
00663  025712        ADB T2         10X
00664  000177  FI2   LDA P0
00665  075541        MLY            SHIFT AR2 LEFT
00666  170040        TCA            BUILD NEGATIVE NUMBER
00667  024000        ADB A          ADD IN NEXT DIGIT
00670  055711        DSZ T1
00671  064657        JMP FI1
               *
00672  000021  FI3   LDA AR2+1
00673  170513        SAR 12
00674  020151        ADA M5
00675  172402        SAM *+2        ROUND
00676  024257        ADB M1
               *
00677  000020        LDA AR2
00700  073402        RLA *+2        TEST MANTISSA SIGN
00701  174040        TCB            COMPLEMENT IF NECESSARY
00702  170201  FI4   RET 1
               *
               * BEEP SUBROUTINE
               *
00703  000177  BEEP  LDA P0
00704  030011        STA PA
00705  000143        LDA P4
00706  030005        STA R5
00707  170201        RET 1
```

```
                     *
                     * CLEAR I/O BUFFER AND PUT 'LAZY-I' AT LEFT END
                     *
00710   140450   EOLIO JSM ACLBI,I
00711   000214         LDA EOLB
00712   130313         STA AIBUF,I
00713   170201         RET 1

                     *
                     * MISCELLANY FOR JB
                     *
00714   000721   ARET1 DEF RET1
                     *
00715   000177   CLMOD LDA P0          SET MODE=0
00716   064720         JMP STMOD
00717   000143   STELM LDA P4          SET MODE=4
00720   031256   STMOD STA MODE
00721   170201   RET1  RET 1
                     *
00722   140404   ERLNF JSM AERR1,I     LINE NOT FOUND
00723   031461         ASC 1,31
                     *
00724   005315   SECCK LDB STYFG
00725   076474         SZB RET1
00726   140404   ERSEC JSM AERR1,I
00727   030064         ASC 1,04

                     *
                     * SOME COMMON ERRORS
                     *
00730   000731   AREPN DEF *+1
00731   140404   E29   JSM AERR1,I     ERROR, ROM MISSING AT EXECUTION TIME
00732   031071         ASC 1,29
                     *
00733   140404   E32   JSM AERR1,I     ERROR, ILLEGAL DATA TYPE
00734   031462         ASC 1,32
                     *
                     * SUBROUTINE TO DO AN EXE A
                     *
00735   070430   EXEXA DIR             PREVENT INTERRUPT INTERFERENCE
00736   070000         EXE A
00737   064747         JMP SXCMM+3
                     *
                     * SUBROUTINE TO CLFAR BITS IN XCOMM
                     *
                     * ON ENTRY:  B = MASK TO CLEAR BITS
                     *
00740   070430   CLXCM DIR             PREVENT INTERRUPT INTERFERENCE
00741   001255         LDA XCOMM
00742   050001         AND B
00743   064746         JMP SXCMM+2
                     *
                     * SUBROUTINE TO SET BITS IN XCOMM
                     *
                     * ON ENTRY:  A = BITS TO BE INCLUDED
                     *
00744   070430   SXCMM DIR             PREVENT INTERRUPT INTERFERENCE
00745   061255         IOR XCOMM
00746   031255         STA XCOMM
00747   070420         EIR
00750   170201         RET 1

                     *
                     * SUBROUTINE TO GET NUMERIC PARAMETER
                     *
                     * ON ENTRY: FAP1 POINTS TO PARAMETER
                     *
                     * ON EXIT TO P+1:  A = CLASS OF NON-NUMERIC ITEM ENCOUNTERED
                     *
                     * ON EXIT TO P+2:  B POINTS TO VALUE
                     *
00751   101272   NGET  LDA FAP1,I      GET 'WHAT' WORD
00752   172201         SAP *+1,C
00753   170513         SAR 12          GET CLASS
00754   010254         CPA P1          NUMERIC?
00755   064757         JMP *+2         YES
00756   170201         RET 1           NO
                     *
00757   005272         LDB FAP1
00760   040616         JSM ABSAD+1
00761   170202         RET 2
```

```
                        *
                        * INTEGER DIVIDE        W.F.C.
                        *
                        * ON ENTRY:
                        *
                        *   BA HAS DIVIDEND
                        *
                        *   JSM IDIV
                        *   DEF DIVISOR
                        *
                        * ON EXIT:
                        *
                        *   A = QUOTIENT
                        *   B = REMAINDER
                        *   O = OVERFLOW STATUS
                        *
                        * TEMPORARIES USED: T1,T2,T3,T4,T5,T6
                        *
00762  004177  SDIV  LDB P0         ALTERNATE ENTRY FOR POSITIVE SINGLE-PRECISION
00763  035711  IDIV  STB T1         SAVE HI DIVIDEND
00764  004146        LDB M2
00765  035712        STB T2         INITIALIZE QUOTIENT SIGN
00766  035713        STB T3         INITIALIZE REMAINDER SIGN
00767  004160        LDB M16
00770  035714        STB T4         INITIALIZE LOOP COUNTER
                        *
00771  144003        ISZ R,I
00772  104003        LDB R,I        ADDRESS OF DIVISOR ADDRESS
00773  104001        LDB B,I        ADDRESS OF DIVISOR
00774  104001        LDB B,I
00775  176003        SBP *+3        GET ABS OF DIVISOR
00776  045712        ISZ T2
00777  174040        TCB
01000  035715        STB T5         SAVE + DIVISOR
01001  174040        TCB
01002  035716        STB T6         SAVE - DIVISOR
                        *
01003  005711        LDB T1         TEST DIVIDEND SIGN
01004  176010        SBP DIV0
01005  045712        ISZ T2         COMPLEMENT DIVIDEND
01006  066007        JMP *+1        (ALLOW FOR SKIP)
01007  170040        TCA
01010  174140        CMB
01011  072002        RZA *+2
01012  024254        ADB P1
01013  045713        ISZ T3         SET REMAINDER SIGN -
01014  025716  DIV0  ADB T6         ADD - DIVISOR
01015  176034        SBP OVFL       SKIP IF OVERFLOW
                        *
                        * MAIN DIVIDE LOOP
                        *
01016  174600  DIV1  SBL 1          SHIFT LEFT
01017  172002        SAP *+2
01020  024254        ADB P1
01021  170600        SAL 1
01022  025715        ADB T5         ADD + DIVISOR
01023  066032        JMP DIV3
01024  073072  DIV2  SLA DIV1
01025  174600        SBL 1          SHIFT LEFT
01026  172002        SAP *+2
01027  024254        ADB P1
01030  170600        SAL 1
01031  025716        ADB T6         ADD - DIVISOR
                        *
01032  176402  DIV3  SBM *+2
01033  060254        IOR P1
01034  045714        ISZ T4         INCREMENT LOOP COUNTER AND TEST
01035  066024        JMP DIV2
                        *
01036  176002        SBP *+2        CORRECT NEGATIVE REMAINDER
01037  025715        ADB T5
                        *
01040  045712        ISZ T2         CORRECT QUOTIENT SIGN
01041  066050        JMP DIV5
01042  170040        TCA
01043  173201  DIV4  SOC *+1,C      ALL OK
                        *
01044  045713        ISZ T3
01045  170201        RET 1          RETURN POSITIVE REMAINDER
01046  174040        TCB
01047  170201        RET 1          RETURN NEGATIVE REMAINDER
                        *
01050  172073  DIV5  SAP DIV4
                        *
01051  173301  OVFL  SOC *+1,S      OVERFLOW, SET O-REGISTER
01052  170201        RET 1
```

BASE-PAGE SUBROUTINES

```
               *
               * SUBROUTINE TO BUMP PARAMETER POINTER
               *
               * ON ENTRY: A = +- COUNT
               *
               * ON EXIT TO P+1:  NO MORE PARAMETERS
               *
               * ON EXIT TO P+2:  FAP1 = NEXT PARAMETER ADDRESS
               *
               * TEMPORARIES USED: T1,T2
               *
01053  072415  BUMP  SZA BU2        SKIP IF NOTHING TO DO
01054  031711        STA T1
01055  172014        SAP BU3        WHICH WAY?
               *
01056  005272        LDB FAP1       MOVE TO LEFT IF -
01057  100001  BU1   LDA B,I
01060  170603        SAL 4          LOOK AT PARAMETER LINK BIT
01061  172012        SAP BU4
01062  000001        LDA B
01063  020254        ADA P1
01064  124000        ADB A,I
01065  045711        ISZ T1
01066  066057        JMP BU1        KEEP ON
               *
01067  035272        STB FAP1
01070  170202  BU2   RET 2          RETURN
               *
01071  005263  BU3   LDB AP1        MOVE TO RIGHT IF +
01072  015272        CPB FAP1
01073  170201  BU4   RET 1          RETURN
               *
01074  035712  BU5   STB T2         SAVE PREVIOUS LOCATION
01075  000001        LDA B
01076  020254        ADA P1
01077  124000        ADB A,I
01100  015272        CPB FAP1
01101  066103        JMP *+2
01102  066074        JMP BU5
               *
01103  005712        LDB T2
01104  035272        STB FAP1       MOVE FAP1 ONE POSITION
01105  055711        DSZ T1
01106  066071        JMP BU3        KEEP ON
               *
01107  170202        RET 2          RETURN
               *
               * SUBROUTINE TO COUNT PARAMETERS ON STACK
               *
               * ON EXIT:  A = # OF NUMERIC PARAMETERS
               *           B = # OF PARAMETERS
               *        FAP1 = LOCATION OF LEFTMOST PARAMETER
               *
               * TEMPORARIES USED: T1,T2
               *
01110  000177  COUNT LDA P0
01111  031711        STA T1         INITIALIZE A COUNT
01112  031712        STA T2         INITIALIZE B COUNT
01113  005263        LDB AP1
01114  100001  C01   LDA B,I        GET "WHAT" WORD
01115  170600        SAL 1          LOOK AT CLASS
01116  172402        SAM *+2        SKIP IF NON-NUMERIC
01117  045711        ISZ T1
01120  045712        ISZ T2
01121  170602        SAL 3          LOOK AT PARAMETER LINK BIT
01122  172005        SAP C02
01123  000001        LDA B
01124  020254        ADA P1
01125  124000        ADB A,I
01126  066114        JMP C01        MORE PARAMETERS FOLLOW
               *
01127  035272  C02   STB FAP1       INITIALIZE POINTER
01130  001711        LDA T1
01131  005712        LDB T2
01132  170201        RET 1          RETURN
               *
               * GET NUMERIC OPERAND ADDRESS
               *
               * ON EXIT:  B = OPERAND ADDRESS
               *         AP1 = UPDATED
               *
01133  040615  GETAD JSM ABSAD      GET OPERAND ABSOLUTE ADDRESS
01134  031263        STA AP1        UPDATE AP1
               *
01135  101276        LDA SAVEB,I    THE 'WHAT' WORD
```

BASE-PAGE SUBROUTINES

```
01019000 01136  050221        AND B70K
01020000 01137  010175        CPA B10K
01021000 01140  170201        RET 1              RETURN IF NUMERIC
01022000                *
01023000 01141  064733        JMP E32

01025000                *
01026000                * GET INTEGER PARAMETER
01027000                *
01028000                * ON EXIT:   B = INTEGER VALUE
01029000                *
01030000 01142  042133  GETIN JSM GETAD         GET OPERAND ADDRESS
01031000 01143  040643        JSM FIXPT-1       CONVERT TO INTEGER
01032000 01144  173402        SOS *+2
01033000 01145  170201        RET 1
01034000                *
01035000 01146  140404  E11   JSM AERR1,I       ERROR, INTEGER OUT OF RANGE
01036000 01147  030461        ASC 1,11

01038000                *
01039000                * WAIT EXECUTION
01040000                *
01041000 01150  042142  XWAIT JSM GETIN         GET INTEGER PARAMETER
01042000 01151  176003        SBP *+3
01043000 01152  140404  E17A  JSM AERR1,I       ERROR, ILLEGAL WAIT PARAMETER
01044000 01153  030467        ASC 1,17
01045000                *
01046000 01154  174040        TCB
01047000 01155  040633        JSM DELAY         GO DELAY
01048000 01156  164365        JMP AINTX,I

01050000 01157                BSS 1             *** RESERVED FOR OK-PAGE CHECKSUM ***
01051000                      LST
```

MATH OPTION BLOCK - A: OVERHEAD

```
01238000                *
01239000                * FULL PRECISION NUMBER:  INTERNAL FORMAT
01240000                *
01241000                *
01242000                *   EEEE EEEE EEXX XXXS   10 BIT 2'S COMP. EXP., 5 DON'T CARE BITS
01243000                *                         MANTISSA SIGN (0=+ 1=-)
01244000                *                         EXP. RANGE = -511 TO +511
01245000                *    D1 . D2   D3   D4    BCD DIGITS 1-4
01246000                *
01247000                *
01248000                *    D5   D6   D7   D8    BCD DIGITS 5-8
01249000                *
01250000                *
01251000                *    D9   D10  D11  D12   BCD DIGITS 9-12
01252000                *
01253000                ****************
01254000                *
01255000                *
01256000                * EQUATES
01257000                *
01258000                *
01259000        077742  OP1E  EQU OP1
01260000        077743  OP1M1 EQU OP1+1
01261000        077747  OP2M1 EQU OP2+1
01262000        077752  RESE  EQU RES          FULL PRECISION RESULT REGISTER
01263000        077753  RESM1 EQU RES+1
01264000        077755  RESM3 EQU RES+3
01265000        000345  AR1A  EQU ADR1         ADDRESS OF AR1
01266000        077770  AR1E  EQU AR1          EXPONENT WORD OF AR1
01267000        000127  AR2A  EQU ADR2         ADDRESS OF AR2
01268000        000020  AR2E  EQU AR2          EXPONENT WORD OF AR2
01269000        000021  AR2M1 EQU AR2E+1       1ST MANTISSA WORD OF AR2
01270000        000022  AR2M2 EQU AR2E+2       2ND MANTISSA WORD OF AR2
01271000        000023  AR2M3 EQU AR2E+3       3RD MANTISSA WORD OF AR2
01272000        000175  BCD1  EQU B10K         BCD 1000
01273000        077762  MT1   EQU MRW1+4       OPMPY
01274000                *
01275000                * T1 THRU T13 ARE USED EXCLUSIVELY FOR THE CORDIC DIGIT STACK
01276000                *
01277000        000335  ADSTK EQU ATMP         ADDRESS OF THE TOP OF THE DIGIT STACK (T1) - Q(J)'S
01278000        077726  DIGIT EQU T14          POINTER TO THE CORDIC DIGIT STACK
01279000        077727  CTEMP EQU T15          TEMP. USED ONLY TO PRESERVE C DURING STMT. EXECUTION
01280000        077730  UFLAG EQU T16          TEMP. USED ONLY TO PRESERVE THE USER'S FLAG WORD
```

```
       077731  SHIFT EQU T17      SHIFT FACTOR FOR Y IN PH2 AND PH4
       077732  DJ    EQU T18      INCREMENT/DECREMENT FOR SHIFT
       077733  PTR   EQU T19      POINTS TO ALFAS, BETAS, CONVERSION CONSTANTS, (CSV)
       077734  EXP&1 EQU T20      USED TO HOLD THE EXPONENT VALUE OF THE ARGUMENT
       077735  SIGN  EQU T21      USED TO HOLD THE MANTISSA SIGN OF THE ARGUMENT
       077736  OCTNT EQU T22      USED TO SPECIFY THE OCTANT OF THE TANGENT ARGUMENTS.
       077737  CNTR1 EQU T23      GENERAL PURPOSE COUNTER
       077740  LOOPW EQU T24      COUNTER USED MAINLY FOR LOOPING
       077741  FLAGS EQU T25      GENERAL TEMPORARY FOR SECONDARY FUNCTIONS
       077042  UNITS EQU STEAL    STOLEN RWM WORD DEDICATED TO MOB(A) AT 24K
               *
               ****************
               *
               * MAINFRAME - OPTION BLOCK INTERFACE
               *
               ****************
               *
24000                ORG 24000B
               *
24000  024237        DEF EXECA    ADDRESS OF THE EXECUTION ROUTINE
24001  024176        DEF COMPA    ADDRESS OF THE COMPILE TABLE
24002  024247        DEF RCOMA    ADDRESS OF THE REVERSE COMPILE TABLE
24003  177777        DEC -1       NO COMMAND TABLE IN THIS BLOCK
24004  025304        DEF INITA    ADDRESS OF THE INITIALIZATION ROUTINE (EDEG)
24005  000017        DEC 15       MATH OPTION BLOCK - A  ROM ID=15
               *
24006          CHKSM BSS 1        CHECKSUM FOR ADDRESSES:  24000-25777


               *
               *
               * CONSTANTS, LINKAGES
               *
               *
               *
24007  024122  ABETA DEF BETAS
24010  024116  ALFAA DEF ALFA.
24011  024146  BETAA DEF BETA.
24012  024152  ALN10 DEF LN10
24013  042427  JADD  JSM ADD      JADD IS USED BY "PYTHA"
24014  024066  API/2 DEF CPI/2
24015  024016  DEG   DEF *+1      DEGREE CONVERSION CONSTANTS
24016  062145        OCT 062145   LOWER CASE "DEG "
24017  063440        OCT 063440
24020  000200  C360  OCT 000200   E2 +
24021  033000        OCT 033000   3600
24022  000000        OCT 000000   0000
24023  000000        OCT 000000   0000
24024  000100  C45   OCT 000100   E1 +
24025  042400        OCT 042400   4500
24026  000000        OCT 000000   0000
24027  000000        OCT 000000   0000
24030  177600  CR/D  OCT 177600   E-2+   PI/180  9820 USED 180/PI = 5.729 5779 5128
24031  013505        OCT 013505   1745   FUDGED TO WORK WELL FOR ATN.
24032  031222        OCT 031222   3292
24033  051000        OCT 051000   5200
               *
               * CR/D IS USED BY THE RANDOM NO. GENERATOR AS A SEED.
               * DO NOT MOVE IT WITHOUT CHANGING ITS ADDRESS ON THE 26K PAGE.
               *


24034  024035  GRAD  DEF *+1      GRADIAN CONVERSION CONSTANTS
24035  063562        OCT 063562   LOWER CASE "GRAD"
24036  060544        OCT 060544
24037  000200  C400  OCT 000200   E2 +
24040  040000        OCT 040000   4000
24041  000000        OCT 000000   0000
24042  000000        OCT 000000   0000
24043  000100  C50   OCT 000100   E1 +
24044  050000        OCT 050000   5000
24045  000000        OCT 000000   0000
24046  000000        OCT 000000   0000
24047  177600  CR/G  OCT 177600   E-2+   PI/200  9820 USED 200/PI = 6.366 1977 2365
24050  012560        OCT 012560   1570   FUDGED TO WORK WELL FOR ATN.
24051  074543        OCT 074543   7963
24052  023200        OCT 023200   2680
```

```
01359000 24053  024054  RAD   DEF *+1      RADIAN CONVERSION CONSTANTS
01360000 24054  071141        OCT 071141   LOWER CASE "RAD "
01361000 24055  062040        OCT 062040
01362000 24056  000000  C2PI  OCT 000000   E0 +
01363000 24057  061203        OCT 061203   6283
01364000 24060  014123        OCT 014123   1853
01365000 24061  003440        OCT 003440   0720    CORRECT VALUE IS 0718 (OCT 003430)
01366000 24062  177700  CPI/4 OCT 177700   E-1+
01367000 24063  074123        OCT 074123   7853
01368000 24064  114026        OCT 114026   9816
01369000 24065  032000        OCT 032000   3400    CORRECT VALUE IS 3397 (OCT 031627)
01370000 24066  000000  CPI/2 OCT 000000   E0 +    THIS VALUE IS BASED ON THE FUDGED PI(60)
01371000 24067  012560        OCT 012560   1570
01372000 24070  074543        OCT 074543   7963
01373000 24071  023200        OCT 023200   2680    CORRECT VALUE IS 2679 (OCT 023171)
01375000                *
01376000                *
01377000                * ATN CONSTANTS
01378000                *
01379000                *
01380000 24072  000000  ALFAS OCT 000000   E0 +    ATN 1
01381000 24073  003605        OCT 003605   0785
01382000 24074  034601        OCT 034601   3981
01383000 24075  061500        OCT 061500   6340
01384000                *
01385000 24076  000000        OCT 000000   E0 +    ATN .1
01386000 24077  004626        OCT 004626   0996
01387000 24100  064145        OCT 064145   6865
01388000 24101  022221        OCT 022221   2491
01389000                *
01390000 24102  000000        OCT 000000   E0 +    ATN .01
01391000 24103  004631        OCT 004631   0999
01392000 24104  113146        OCT 113146   9666
01393000 24105  064147        OCT 064147   6867
01394000                *
01395000 24106  000000        OCT 000000   E0 +    ATN .001
01396000 24107  004631        OCT 004631   0999
01397000 24110  114626        OCT 114626   9996
01398000 24111  063147        OCT 063147   6667
01399000                *
01400000 24112  000000        OCT 000000   E0 +    ATN .0001
01401000 24113  004631        OCT 004631   0999
01402000 24114  114631        OCT 114631   9999
01403000 24115  113147        OCT 113147   9667
01404000                *
01405000 24116  000000  ALFA. OCT 000000   E0 +    ATN .00001
01406000 24117  004631        OCT 004631   0999
01407000 24120  114631        OCT 114631   9999
01408000 24121  114627        OCT 114627   9997
01410000                *
01411000                *
01412000                * NATURAL LOG CONSTANTS
01413000                *
01414000                *
01415000 24122  000000  BETAS OCT 000000   E0 +    LN 2
01416000 24123  003223        OCT 003223   0693
01417000 24124  012161        OCT 012161   1471
01418000 24125  100126        OCT 100126   8056
01419000                *
01420000 24126  000000        OCT 000000   E0 +    LN 1.1
01421000 24127  004523        OCT 004523   0953
01422000 24130  010027        OCT 010027   1017
01423000 24131  114004        OCT 114004   9804
01424000                *
01425000 24132  000000        OCT 000000   E0 +    LN 1.01
01426000 24133  004625        OCT 004625   0995
01427000 24134  001460        OCT 001460   0330
01428000 24135  102462        OCT 102462   8532
01429000                *
01430000 24136  000000        OCT 000000   E0 +    LN 1.001
01431000 24137  004631        OCT 004631   0999
01432000 24140  050003        OCT 050003   5003
01433000 24141  031410        OCT 031410   3308
01434000                *
01435000 24142  000000        OCT 000000   E0 +    LN 1.0001
01436000 24143  004631        OCT 004631   0999
01437000 24144  112400        OCT 112400   9500
01438000 24145  001463        OCT 001463   0333
01439000                *
01440000 24146  000000  BETA. OCT 000000   E0 +    LN 1.00001
01441000 24147  004631        OCT 004631   0999
01442000 24150  114520        OCT 114520   9950
01443000 24151  000003        OCT 000003   0003
01444000                *
01445000 24152  000000  LN10  OCT 000000   E0 +    LN 10
```

MATH OPTION BLOCK - A1  OVERHEAD

```
24153  021402          OCT 021402    2302
24154  054120          OCT 054120    5850
24155  111231          OCT 111231    9299    9820 USED 9300 (OCT 111400)
                 *
                 ****************
                 *
                 * COMPILE TABLE
                 *
                 ****************
                 *                        I* TKN  MNEMONIC
24156  003027          OCT 003027         6 23   GRAD      (END)
24157  003027          OCT 003027         6 23   RAD       (END)
24160  003027          OCT 003027         6 23   DEG       (END)
24161  003027          OCT 003027         6 23   UNITS     (END)
24162  003027          OCT 003027         6 23   CSV       (END)
24163  003011          OCT 003011         6  9   ^         (^)
24164  004053          OCT 004053         8 43   LOG       (SQR)
24165  004053          OCT 004053         8 43   TN^       (SQR)
24166  004053          OCT 004053         8 43   ACS       (SQR)
24167  004053          OCT 004053         8 43   ASN       (SQR)
24170  004053          OCT 004053         8 43   COS       (SQR)
24171  004053          OCT 004053         8 43   SIN       (SQR)
24172  004053          OCT 004053         8 43   LN        (SQR)
24173  004053          OCT 004053         8 43   EXP       (SQR)
24174  004053          OCT 004053         8 43   ATN       (SQR)
24175  004053          OCT 004053         8 43   TAN       (SQR)
24176  072141    COMPA DEC 29793     T  A
24177  067201          DEC 28289     N (1)
24200  060564          DEC 24948     A  T
24201  067202          DEC 28290     N (2)
24202  062570          DEC 25976     E  X
24203  070203          DEC 28803     P (3)
24204  066156          DEC 27758     L  N
24205  102163          DEC -31629   (4) S
24206  064556          DEC 26990     I  N
24207  102543          DEC -31389   (5) C
24210  067563          DEC 28531     O  S
24211  103141          DEC -31135   (6) A
24212  071556          DEC 29550     S  N
24213  103541          DEC -30879   (7) A
24214  061563          DEC 25459     C  S
24215  104164          DEC -30604   (8) T
24216  067136          OCT 67136     N  ^
24217  104554          DEC -30356   (9) L
24220  067547          DEC 28519     O  G
24221  105136          OCT 105136  (10) ^
24222  105543          OCT 105543  (11) C
24223  071566          OCT 071566    S  V
24224  106165          OCT 106165  (12) U
24225  067151          OCT 067151    N  I
24226  072163          OCT 072163    T  S
24227  106544          OCT 106544  (13) D
24230  062547          OCT 062547    E  G
24231  107162          OCT 107162  (14) R
24232  060544          OCT 060544    A  D
24233  107547          OCT 107547  (15) G
24234  071141          OCT 071141    R  A
24235  062220          OCT 062220     D (16)
24236  100000          OCT 100000    EOT
                 *
                 ****************
                 *
                 * MAIN EXECUTION ROUTINE
                 *
                 * ON ENTRY:  <A> CONTAINS THE ROM'S INTERNAL CODE
                 *
                 ****************
                 *
24237  022757    EXECA ADA EXTBL     ADD THE EXECUTION JUMP TABLE ADDRESS
24240  100000          LDA A,I       A = ADDRESS OF THE STATEMENT'S EXECUTION ROUTINE.
24241  004016          LDB C         SAVE C IN A TEMPORARY DEDICATED TO ITS USE.
24242  035727          STB CTEMP
24243  140000          JSM A,I       PERFORM THE STATEMENT EXECUTION
24244  001727          LDA CTEMP     RESTORE C
24245  030016          STA C
24246  164366          JMP ARAP,I    STACK RES ON THE EXEC. STACK & RETURN TO INTERPRETER
                 *
                 ****************
                 *
                 * REVERSE COMPILE TABLE
                 *
                 *    MNEMONIC (OPERATOR PRIORITY, CLASS)
                 *
                 ****************
                 *
```

MATH OPTION BLOCK - A: OVERHEAD

```
01534000 24247   161342  RCOMA OCT 161342   TAN (14,2)    ATN (14,2)
01535000 24250   161342        OCT 161342   EX' (14,2)    LN  (14,2)
01536000 24251   161342        OCT 161342   SI   14,2)    COS (14,2)
01537000 24252   161342        OCT 161342   ASN (14,2)    ACS (14,2)
01538000 24253   151342        OCT 151342   TN^ (13,2)    LOG (14,2)
01539000 24254   141401        OCT 141401   ^     (12,3)  CSV ( 0,1)
01540000 24255   000401        OCT 000401  UNITS( 0,1)    DEG ( 0,1)
01541000 24256   000401        OCT 000401   RAD ( 0,1)    GRAD( 0,1)
```

MATH OPTION BLOCK - A: EXECUTION

```
01543000                 *
01544000                 ****************
01545000                 *
01546000                 * TAN EXECUTION
01547000                 *
01548000                 ****************
01549000                 *
01550000 24257  000177   ETAN  LDA P0
01551000 24260  031741   TAN1  STA FLAGS    SIN(FLAGS=AOP1), COS(FLAGS=AONE), TAN(FLAGS=0)
01552000 24261  000177         LDA P0
01553000 24262  031734         STA EXP&1
01554000 24263  031735         STA SIGN
01555000 24264  042313         JSM GET1A    OP1 = ARG
01556000 24265  001742         LDA OP1E     SAVE THE ORIGINAL MANTISSA SIGN IN (SIGN)
01557000 24266  073202         SLA *+2,C    AND MAKE THE ARGUMENT POSITIVE
01558000 24267  045735         ISZ SIGN
01559000 24270  031742         STA OP1E
01560000                 *
01561000                 * PRE-SCALE THE ARGUMENT IN THE USER'S UNITS.
01562000                 *
01563000 24271  000145         LDA P2       SET UP CNTR1 FOR TWO PASSES THROUGH THE LOOP
01564000 24272  031737         STA CNTR1    TO REDUCE THE ARGUMENT TO THE FIRST OCTANT
01565000 24273  005042         LDB UNITS
01566000 24274  024145         ADB P2       DETERMINE WHICH SET OF REDUCTION CONSTANTS TO USE.
01567000 24275  035733   TAN2  STB PTR      SAVE THE REDUCTION CONSTANT ADDRESS.
01568000 24276  000177         LDA P0
01569000 24277  031736         STA OCTNT    CLEAR OCTNT BEFORE REDUCING TO FIRST OCTANT.
01570000 24300  035274   TAN2A STB OPND2
01571000 24301  000336         LDA AOP1
01572000 24302  031273         STA OPND1
01573000 24303  042367         JSM XFRRS    FIX FOR BUG SHEET #349.
01574000 24304  140562         JSM ATSU1,I  COMPARE OP1 (ARGUMENT) WITH THE REDUCTION CONSTANT
01575000 24305  014144         CPB P3
01576000 24306  067332         JMP TAN2B
01577000 24307  000336         LDA AOP1     OP1 >= REDUCTION CONSTANT, KEEP REDUCING.
01578000 24310  005733         LDB PTR
01579000 24311  031273         STA OPND1
01580000 24312  035274         STB OPND2
01581000 24313  000177         LDA P0
01582000 24314  140560         JSM ADIV2,I
01583000 24315  001755         LDA RESM3    FIRST PASS REDUCTION TO FULL CIRCLE:
01584000 24316  050170         AND M256       ARG' = ARG - UCV * INT (ARG/UCV)
01585000 24317  031755         STA RESM3
01586000 24320  042350         JSM INRES    SECOND PASS REDUCTION TO FIRST OCTANT:
01587000 24321  001753         LDA RESM1      ARG'' = ARG' - FOV * INT (ARG'/FOV)
01588000 24322  170513         SAR 12
01589000 24323  031736         STA OCTNT
01590000 24324  001733         LDA PTR
01591000 24325  042437         JSM AXRES
01592000 24326  042432         JSM O1MRS
01593000 24327  042472         JSM RS.01    OP1  = ARG' OR ARG''
01594000 24330  005733         LDB PTR
01595000 24331  067300         JMP TAN2A    GO BACK & COMPARE OP1 WITH REDUCTION CONSTANT AGAIN.
01596000 24332  005733   TAN2B LDB PTR      OP1 < REDUCTION CONSTANT, DON'T NEED TO REDUCE.
01597000 24333  024143         ADB P4
01598000 24334  055737         DSZ CNTR1
01599000 24335  067275         JMP TAN2     LOOP AGAIN IF THIS IS THE FIRST PASS.
01600000                 *
01601000                 * CHECK FOR A PI/4 MULTIPLE INSIDE THE UNIT CIRCLE.
01602000                 *
01603000 24336  035733         STB PTR
01604000 24337  001736         LDA OCTNT
01605000 24340  005743         LDB OP1M1    IS THE PRE-SCALED ARGUMENT ZERO ?
01606000 24341  076010         RZB TAN3     NO, CONTINUE
01607000 24342  050144   TAN2C AND P3       YES, NOW DETERMINE THE CORRECT RESULT.
01608000 24343  010177         CPA P0
01609000 24344  066355         JMP CLRES    OCTANT = 0 OR 4:  RESULT = 0
01610000 24345  010145         CPA P2
01611000 24346  067471         JMP E687     OCTANT = 2 OR 6:  TRY TO GIVE ERROR 68
01612000 24347  043635         JSM RES=1    OCTANT = 1,3,5,7:  RESULT = +/-1
01613000 24350  067457         JMP TAN14    FIND OUT AT TAN14 WHETHER IT SHOULD BE + OR - 1.0
```

```
                      *
                      * FINALIZE THE ARGUMENT
                      *
24351   073006  TAN3   SLA TAN4     IF OCTANT IS EVEN THEN USE THE ARGUMENT
24352   001733         LDA PTR      WHICH IS IN THE FIRST OCTANT
24353   020150         ADA M4
24354   004336         LDB AOP1
24355   042434         JSM SUB      OTHERWISE USE PI/4 - ARGUMENT
24356   042472         JSM RS.01
                      *
                      * CONVERT ARGUMENT TO RADIANS
                      *
24357   001733  TAN4   LDA PTR
24360   013014         CPA API/2    IF CURRENT UNITS = RADIANS, NO CONVERSION NEEDED.
24361   067372         JMP TAN5     SO SKIP THE CONVERSION.
24362   042457         JSM SFG14    BUG SHEET #1788.
24363   001733         LDA PTR
24364   004336         LDB AOP1
24365   042440         JSM MPY      CONVERT TO RADIANS
24366   042455         JSM RSTFL
24367   001736         LDA OCTNT    *BUG SHEET #1528: THIS CHECKS FOR ZERO AS A
24370   005753         LDB RESM1    *RESULT OF UNDERFLOW ON CONVERSION TO DEG &
24371   076451         SZB TAN2C    *GRADS TO RADIANS.
                      *
                      * START OF ACTUAL TANGENT COMPUTATION.
                      *
24372   042470  TAN5   JSM RS.A2    AR2 = RES
24373   000020         LDA AR2E
24374   072004         RZA TAN7     IS THE EXPONENT = 0 ?
24375   000164  TAN6   LDA M64      YES, SET THE EXPONENT TO -1
24376   030020         STA AR2E
24377   067403         JMP TAN8
24400   042404  TAN7   JSM RAR21    RIGHT SHIFT AR2 ONE DIGIT
24401   000020         LDA AR2E
24402   072473         SZA TAN6     IF THE SHIFT ROUNDED AR2 TO ONE, SET THE EXP. TO -1
24403   020073  TAN8   ADA P64      SAVE (EXP + 1)
24404   004000         LDB A
24405   170405         AAR 6
24406   020141         ADA P6
24407   072402         SZA TAN9
24410   172004         SAP TAN10
24411   042474  TAN9   JSM RS.02
24412   042512         JSM OP1=1
24413   067442         JMP TAN11
24414   035734  TAN10  STB EXP&1
24415   031737         STA CNTR1    SAVE THE COUNT FOR "PHASE I"
24416   031740         STA LOOP#    SAVE THE COUNT FOR "PHASE II"
24417   170601         SAL 2
24420   170040         TCA          COMPUTE THE ADDRESS OF THE FIRST TRIG CONSTANT TO USE
24421   023007         ADA ABETA
24422   031733         STA PTR
24423   042514         JSM PH1      CALL "PHASE I"
24424   002722         LDA CDC
24425   030016         STA C
24426   002521         LDA CMY
24427   030017         STA D
24430   000135         LDA P10
24431   004146         LDB M2
24432   055726         DSZ DIGIT
24433   042543         JSM PH2      CALL "PHASE II"
24434   042466         JSM 02.A2    AR2 = OP2
24435   042700         JSM PH3.E    GET EXPONENT FOR Z
24436   042507         JSM A2.02    OP2 = AR2
24437   042464         JSM 01.A2    AR2 = OP1
24440   042700         JSM PH3.E
24441   042504         JSM A2.01    OP1 = AR2
24442   001736  TAN11  LDA OCTNT    OCTNT<0> = OCTNT<1> IMPLIES OCTANTS 0, 3, 4, OR 7.
24443   170500         SAR 1
24444   021736         ADA OCTNT
24445   073007         SLA TAN12
24446   001734         LDA EXP&1    TAN = X/Y
24447   170040         TCA
24450   031734         STA EXP&1
24451   000336         LDA AOP1
24452   004337         LDB AOP2
24453   067456         JMP TAN13
24454   000337  TAN12  LDA AOP2     TAN = Y/X
24455   004336         LDB AOP1
24456   042443  TAN13  JSM DVD
24457   001736  TAN14  LDA OCTNT    OCTNT<1> = 1 IMPLIES QUADRANTS II OR IV.
24460   170500         SAR 1
24461   073002         SLA TAN15
24462   045735         ISZ SIGN
24463   001735  TAN15  LDA SIGN
24464   050254         AND P1
```

MATH OPTION BLOCK - A: EXECUTION

```
24465  061734         IOR EXP&1
24466  021752         ADA RESE
24467  031752  TAN16  STA RESE
24470  170201         HET 1
               *
               * SIN, COS, OR TAN ARGUMENT LIES ON THE Y-AXIS.
               *
24471  005741  E68?   LDB FLAGS
24472  076412         SZB E68       TAN BEING CALCULATED ?
24473  054003         DSZ R         NO.  SIN OR COS.  RETURN TO EXECA, NOT SIN1.
24474  014172         CPB AONE      COS BEING CALCULATED ?
24475  066355  RES=0  JMP CLRES     YES.  COS(90) = COS(270) = 0
24476  043635         JSM RES=1     NO, SIN.
24477  001736         LDA OCTNT
24500  170501         SAR 2
24501  021735         ADA SIGN      CALCULATE THE CORRECT SIGN FOR SIN.
24502  050254         AND P1
24503  067467         JMP TAN16
               *
               * ERROR 68:  TAN (N*PI/2), N ODD.  DEG, RAD, OR GRAD.
               *
24504  005735  E68    LDB SIGN
24505  042373         JSM STMAX     RES = +/-9,99999999999 E 511
24506  140546         JSM ARERR,I
24507  033070         ASC 1,68
               *
               ****************
               *
               * ATN EXECUTION
               *
               ****************
               *
24510  043512  EATN   JSM ATN0      CALCULATE ATN IN RADIANS, LEAVE ANSWER IN RES
24511  066315         JMP CTOCU     CONVERT TO CURRENT UNITS


24512  140552  ATN0   JSM AGET1,I   GET THE ARGUMENT IN FULL PRECISION
24513  024254         ADB P1        IS THE ARGUMENT 0 ?
24514  100001         LDA B,I
24515  072460         SZA RES=0     YES, ATN 0 = 0.
24516  101273  ATN1   LDA OPND1,I   SAVE THE EXPONENT WORD
24517  031735         STA SIGN
24520  172431         SAM ATN2.     IF THE EXPONENT IS POSITIVE
24521  005273         LDB OPND1     LET ARG = 1 / ARG
24522  042226         JSM ONE/B
24523  000340         LDA ARES
24524  031273         STA OPND1     UPDATE THE OPND1 ADDRESS
24525  101273  ATN2   LDA OPND1,I   SAVE THE EXPONENT
24526  172423         SAM ATN2.
24527  001042         LDA UNITS     ARGUMENT = +1 OR -1 EXACTLY.  (1/1 = 1)
24530  020141         ADA P6
24531  054003         DSZ R         CANCEL RETURN FROM CALL TO ATN0.
24532  043630         JSM ATN7
24533  001735         LDA SIGN
24534  073007         SLA ATNRT
24535  001727         LDA CTEMP
24536  030016         STA C
24537  074760         WBC A,D
24540  074760         WBC A,D
24541  010137         CPA P8        ACS ?
24542  067544         JMP *+2       YES.
24543  170201  ATNRT  RFT 1
24544  004147         LDB M3
24545  140563         JSM AFLTP,I
24546  042504         JSM A2.01
24547  000340         LDA ARES
24550  066440         JMP MPY
24551  170405  ATN2.  AAR 6
24552  031734         STA EXP&1
24553  020142         ADA P5        IF THE EXPONENT IS LESS THAN -5, GO TO ATN4.
24554  172007         SAP ATN3
24555  001273         LDA OPND1
24556  042505         JSM XFR01
24557  001742         LDA OP1E      FIX FOR BUG SHEET # 572
24560  050146         AND M2
24561  031742         STA OP1E      OP1 = ABS(ARGUMENT)
24562  067616         JMP ATN4
24563  000335  ATN3   LDA ADSTK     CLEAR THE DIGIT STACK (Q0-Q12) TO ZERO
24564  071614         CLR 13
24565  020133         ADA P12       INITIALIZE THE DIGIT STACK POINTER
```

MATH OPTION BLOCK - A: EXECUTION

```
24566  031726        STA DIGIT
24567  004132        LDB P13
24570  035740        STB LOOP#
24571  001273        LDA OPND1
24572  042510        JSM XFRO2     SET Y0 = ARGUMENT
24573  002521        LDA CMY
24574  030016        STA C
24575  002722        LDA CDC
24576  030017        STA D
24577  001734        LDA EXP&1     A = -2*EXP&1
24600  170600        SAL 1
24601  170040        TCA
24602  004145        LDB P2        B = 2
24603  042543        JSM PH2       CALL "PHASE II"
24604  001734        LDA EXP&1
24605  170040        TCA
24606  020140        ADA P7
24607  007010        LDB ALFAA
24610  042635        JSM PH3       CALL "PHASE III"
24611  001734        LDA EXP&1
24612  170605        SAL 6
24613  020020        ADA AR2E
24614  030020        STA AR2E
24615  042504        JSM A2.01     OP1 = AR2
24616  001735  ATN4  LDA SIGN
24617  172410        SAM ATN6
24620  003014        LDA API/2
24621  042434  JSUB  JSM SUB
24622  001735  ATN5  LDA SIGN
24623  050254        AND P1
24624  061752        IOR RESE
24625  031752        STA RESE
24626  170201        RET 1
24627  000336  ATN6  LDA AOP1      RES = OP1
24630  042367  ATN7  JSM XFRRS
24631  067622        JMP ATN5
               *
               *****************
               *
               * EXP EXECUTION
               *
               *****************
               *
24632  042313  FEXP  JSM GET1A     OP1 = ARG
24633  001743  EXP0  LDA OP1M1     IS THE ARGUMENT ZERO ?
24634  072003        RZA EXP2
24635  000172  EXP1  LDA AONE      YES, EXP(0) = 1
24636  066367        JMP XFRRS
               *
               * EXP1 AND EXP1+1 ARE ALSO USED AS "RES=1".
               *
24637  001742  EXP2  LDA OP1E      SAVE EXPONENT AND MANTISSA SIGN
24640  031735        STA SIGN
24641  073201        SLA *+1,C     CLEAR THE MANTISSA SIGN AND RESTORE IT.
24642  031742        STA OP1E
24643  004177        LDB P0        CLEAR THE EXPONENT STORAGE WORD
24644  035734        STB EXP&1
24645  170405        AAR 6         MAKE THE EXPONENT AN INTEGER WORD
24646  172007        SAP EXP3      IS THE EXPONENT NEGATIVE ?
24647  170040        TCA           YES
24650  004000        LDB A
24651  024255        ADB M12
24652  176063        SBP EXP1      IF ABS(ARG) < 1E-11, RETURN 1 AS THE RESULT
24653  042464        JSM 01.A2     AR2 = OP1
24654  067710        JMP EXP6
24655  020150  EXP3  ADA M4        IS THE ARGUMENT >= 10,000 ?
24656  172411        SAM EXP5      NO, CONTINUE.
24657  001735        LDA SIGN      YES, OVERFLOW OR UNDERFLOW HAS OCCURRED.
24660  073404  EXP4  RLA E77       GIVE THE PROPER DEFAULT VALUE.
24661  042372  E76   JSM STMAX-1   OVERFLOW! RES=9.99999999999 E511
24662  140546        JSM ARERR,I
24663  033466        ASC 1,76
24664  042355  E77   JSM CLRES     UNDERFLOW! RES=0
24665  140546        JSM ARERR,I
24666  033467        ASC 1,77
               *
               * PRESCALE ARGUMENT TO THE RANGE [1, LN 10)
               *
24667  000336  EXP5  LDA AOP1
24670  042145        JSM LOG2      RES = ARG / LN10
24671  042350        JSM INRES     RES = INT (ARG / LN10)
24672  000340        LDA ARES
24673  040644        JSM FIXPT     CONVERT TO AN INTEGER FOR THE EXPONENT OF THE RESULT.
24674  043750        JSM EXSUB     MAKE SURE IT IS A VALID EXPONENT.
24675  067657        JMP EXP4-1      P+1: EXPONENT OUT OF RANGE.
```

MATH OPTION BLOCK - A1 EXECUTION

```
01866000 24676  035734         STB EXP&1      P+2: IN RANGE, USE LATER AS EXPONENT OF RESULT.
01867000 24677  003012         LDA ALN10
01868000 24700  042437         JSM AXRES     RES = LN10 * INT(ARG/LN10)
01869000 24701  000336         LDA AOP1
01870000 24702  042433         JSM AMRES     RES = ARG - LN10 * INT(ARG/LN10)
01871000 24703  042470         JSM RS.A2     AR2 = RES
01872000 24704  042422         JSM ZAR2      IF THE FRACTIONAL PART OF THE POWER IS ZERO
01873000 24705  067710         JMP EXP6      THEN SET RES=1 AND CONTINUE AT EXP9.
01874000 24706  043635         JSM RES=1
01875000 24707  067741         JMP EXP9
01876000                *
01877000                * COMPUTE EXP (1, LN 10)
01878000                *
01879000 24710  004020  EXP6   LDB AR2E
01880000 24711  176004         SAP EXP7      IF EXPONENT = 0, DON'T SHIFT
01881000 24712  174405         ABR 6
01882000 24713  174040         TCB           IF EXPONENT < 0, RIGHT SHIFT -EXPONENT DIGITS
01883000 24714  042405         JSM RAR2H     AND ROUND
01884000 24715  003007  EXP7   LDA ABETA
01885000 24716  031733         STA PTR
01886000 24717  000141         LDA P6
01887000 24720  031737         STA CNTR1
01888000 24721  042514         JSM PH1       CALL "PHASE I"
01889000 24722  000140         LDA P7        TRANSFER D1-D7 OF AR2 TO Q6-Q12
01890000 24723  031737         STA CNTR1
01891000 24724  004254         LDB P1
01892000 24725  075541  EXP8   MLY           SHIFT OUT A DIGIT
01893000 24726  131726         STA DIGIT,I   STORE IT IN THE NEXT QJ
01894000 24727  045726         ISZ DIGIT     BUMP THE QJ POINTER
01895000 24730  055737         DSZ CNTR1     MORE TO TRANSFER ?
01896000 24731  067725         JMP EXP8      YES.
01897000 24732  000172         LDA AONE      NO, CONTINUE TO PREPARE FOR "PHASE IV"
01898000 24733  042477         JSM XFRA2     AR2 = 1
01899000 24734  000133         LDA P12       TWOJ INITIAL VALUE
01900000 24735  004257         LDB M1        DJ INITIAL VALUE
01901000 24736  055726         DSZ DIGIT
01902000 24737  042705         JSM PH4       CALL "PHASE IV"
01903000 24740  042366         JSM A2.RS     RES = AR2
01904000 24741  001734  EXP9   LDA EXP&1
01905000 24742  031752         STA RESE      PUT THE PROPER EXPONENT ON IT
01906000 24743  001735         LDA SIGN
01907000 24744  073003         SLA EXP10
01908000 24745  004340         LDB ARES      RES = 1 / RES
01909000 24746  042226         JSM ONE/B
01910000 24747  170201  EXP10  RET 1


01912000                *
01913000                ****************
01914000                *
01915000                * EXSUB: SUBROUTINE USED BY EXP AND TNA
01916000                *
01917000                ****************
01918000                *
01919000 24750  000001  EXSUB  LDA B
01920000 24751  172402         SAM *+2
01921000 24752  170040         TCA
01922000 24753  020042         ADA P511      ABS(B) > 511 ?
01923000 24754  172473         SAM EXP10     INVALID EXPONENT, RETURN P+1.
01924000 24755  174605         SAL 6         VALID EXPONENT RANGE, POSITION B AS AN EXPONENT.
01925000 24756  170202         RET 2
01927000                *
01928000                ****************
01929000                *
01930000                * LN EXECUTION
01931000                *
01932000                ****************
01933000                *
01934000 24757  140552  ELN    JSM AGET1,I   FETCH THE ARGUMENT
01935000 24760  001273  LNV    LDA OPND1
01936000 24761  042477         JSM XFRA2     AR2 = ARGUMENT
01937000 24762  000020         LDA AR2E      IF THE ARGUMENT < 0, GIVE ERROR 69
01938000 24763  073203         SLA LN1,C
01939000 24764  042022         JSM E69       TRY TO GIVE ERROR 69, DEFAULT VALUE IS LN(ABS(ARG))
01940000 24765  000020         LDA AR2E
01941000 24766  031734  LN1    STA EXP&1     SAVE THE EXPONENT WORD IN EXP&1
01942000 24767  000021         LDA AR2M1     IF THE ARGUMENT = 0, GIVE ERROR 70
01943000 24770  072005         RZA LN2
01944000                *
01945000                * ERROR 70: LN(0) OR LOG(0)
01946000                *
01947000 24771  004254  E70    LDB P1        LN(0) OR LOG(0) = - 9.99999999999 E 511
01948000 24772  042373         JSM STMAX
```

```
24773  140546        JSM ARERR,I  ERROR 70:  LN(0) OR LOG(0)
24774  033460        ASC 1,70
24775  000335  LN2   LDA ADSTK    CLEAR THE DIGIT STACK AND INITIALIZE THE
24776  071614        CLR 13       DIGIT STACK POINTER
24777  020133        ADA P12
25000  031726        STA DIGIT
25001  000177        LDA P0
25002  004254        LDB P1
25003  042705        JSM PH4      CALL "PHASE IV"
25004  000140        LDA P7
25005  007011        LDB BETAA
25006  042635        JSM PH3      CALL "PHASE III"
25007  042504        JSM A2.01    OP1 = AR2 = LN(ARGUMENT MANTISSA)
25010  005734        LDB EXP&1
25011  174405        ABR 6
25012  024254        ADB P1
25013  140563        JSM AFLTP,I  AR2 = FLOATING POINT EQUIVALENT OF (EXP&1 + 1)
25014  003012        LDA ALN10
25015  004127        LDB AR2A
25016  042440        JSM MPY      RES = (EXP&1 + 1) * LN10
25017  000340        LDA ARES
25020  004336        LDB AOP1
25021  066434        JMP SUB      RES = ((EXP&1 + 1)*LN(10)) - LN(ARGUMENT MANTISSA)
               *
               * ERROR 69:  LN OR LOG OF A NEGATIVE NUMBER
               *
25022  030020  E69   STA AR2E     SET UP THE DEFAULT RESULT AS LN(ABS(ARG))
25023  140546        JSM ARERR,I
25024  033071        ASC 1,69
               *
               ****************
               *
               * COS EXECUTION
               *
               ****************
               *
25025  000172  ECOS  LDA AONE      SET UP A FOR CALCULATION OF COSINE.
25026  066030        JMP SIN1      ENTER THE SINE ROUTINE


               *
               ****************
               *
               * SIN EXECUTION
               *
               ****************
               *
25027  000336  ESIN  LDA AOP1      SET UP A FOR CALCULATION OF SINE.
25030  043260  SIN1  JSM TAN1      SAVE A IN A TEMPORARY FLAG AND CALCULATE THE TANGENT
25031  042457        JSM SFG14     SAVE THE USER'S FLAGS AND SET FLAG 14
25032  001741        LDA FLAGS     SIN = TAN / SQR(1 + TAN*TAN)
25033  007013        LDB JADD      COS =  1  / SQR(1 + TAN*TAN)
25034  042323        JSM PYTHA
25035  001752        LDA RESE
25036  170405        AAR 6         FIXED IN MOBA #119:
25037  010177        CPA P0        EXPONENT=0?  (IMPLIES RES=1 OR RES=0)
25040  031755        STA RESM3     YES, FORCE THE LAST 4 DIGITS TO BE ZERO.
25041  042455        JSM RSTFL     RESTORE THE USER'S FLAGS.
25042  001753        LDA RESM1
25043  072413        SZA SIN2
25044  001736        LDA OCTNT     GET THE QUADRANT FROM THE OCTANT INFORMATION.
25045  170500        SAR 1
25046  010177        CPA P0
25047  170201        RET 1         IF THE ARGUMENT WAS IN QUADRANT I, RETURN
25050  010144        CPA P3
25051  170201        RET 1         IF THE ARGUMENT WAS IN QUADRANT IV, RETURN
25052  001752        LDA RESE      OTHERWISE THE ARGUMENT WAS IN QUADRANTS II OR III
25053  073302        SLA *+2,S     AND THE SIGN OF THE RESULT NEEDS TO BE CHANGED.
25054  073201        SLA *+1,C
25055  031752        STA RESE
25056  170201  SIN2  RET 1
               *
               ****************
               *
               * ACS EXECUTION
               *
               ****************
               *
25057  042065  EACS  JSM ASN1      CALCULATE RES = ASN (ARG)
25060  003014        LDA API/2     ACS = PI/2 - ASN (ARG)
25061  042433        JSM AMRES
25062  066315        JMP CTOCU     CONVERT THE RESULT TO CURRENT UNITS
```

MATH OPTION BLOCK - A: EXECUTION

```
                *
                ****************
                *
                * ASN EXECUTION
                *
                ****************
                *
25063  042065  EASN  JSM ASN1     CALCULATE RES = ASN (ARG) = ATN (ARG/SQR(1-ARG*ARG))
25064  066315        JMP CTOCU    CONVERT THE RESULT TO CURRENT UNITS
                *
25065  042313  ASN1  JSM GET1A    FETCH THE ARGUMENT
25066  042367        JSM XFRRS    RES = ARG
25067  042457        JSM SFG14    SET FLAG 14 FOR POSSIBLE 1/0 IN PYTHA
25070  000336        LDA AOP1
25071  007621        LDB JSUB
25072  042323        JSM PYTHA    RES = ARG/SQR(1-ARG*ARG)
25073  042455        JSM RSTFL    RESTORE THE USER'S FLAGS
25074  042472        JSM RS.01    OP1 = RES
25075  035273        STB OPND1    SET OPND1 TO NEW ARGUMENT ADDRESS
25076  067513        JMP ATN0+1   ENTER ATN ROUTINE JUST AFTER THE ARG HAS BEEN FETCHE
                *
                ****************
                *
                * TN^ EXECUTION
                *
                ****************
                *
25077  043635  ETN^  JSM RES=1    ASSUME THAT THE POWER IS AN INTEGER (SAVES WORDS)
25100  042313        JSM GET1A    OP1 = ARG.  CONVERT THE ARG TO INTEGER FORMAT IN B.
25101  040644        JSM FIXPT    ON RETURN:  AR2 = FRACTIONAL PART OF ARG.
25102  042422        JSM ZAR2     WAS THERE A FRACTIONAL PART ?
25103  066113        JMP TN^4     YES, COMPUTE TN^(ARG) = EXP(ARG*LN10)
                *
                * COMPUTE   TN^(INTEGER)       OR  1E-511 < ABS(ARG) < 1E11
                *
25104  173003        SOC TN^2     CHECK FOR OVERFLOW ON CONVERSION TO INTEGER.
25105  101273  TN^1  LDA OPND1,I  A = MANTISSA SIGN OF POWER.
25106  067660        JMP EXP4     GIVE APPROPRIATE RESULT.
25107  043750  TN^2  JSM EXSUB    CHECK B FOR BEING A VALID EXPONENT.
25110  066105        JMP TN^1       P+1:  OUT OF RANGE, GIVE PROPER DEFAULT.
25111  035752        STB RESE       P+2:  EXPONENT IN RANGE.  PUT IT ON A MANTISSA OF 1
25112  170201  TN^3  RET 1
                *
                * COMPUTE   EXP(ARG*LN10)            1E-511 < ABS(ARG) < 1E11
                *
25113  001273  TN^4  LDA OPND1
25114  007012        LDB ALN10
25115  042440        JSM MPY      RES = ARG * LN10
25116  042472  TN^5  JSM RS.01    USE OP1 AS THE ARGUMENT FOR EXP.
25117  067633        JMP EXP0     LET EXP0 FINISH THE TASK.
                *
                ****************
                *
                * LOG EXECUTION
                *
                ****************
                *
25120  140552  ELOG  JSM AGET1,I  FETCH THE ARGUMENT
25121  024254        ADB P1
25122  100001        LDA B,I
25123  010177        CPA P0       IF THE ARGUMENT IS ZERO, GIVE ERROR 70.
25124  067771        JMP E70      BUG SHEET #1787 (LOG(0)=-4.34E511)
25125  170040        TCA
25126  020175        ADA BCD1
25127  024254        ADB P1
25130  160001        IOR B,I
25131  024254        ADB P1
25132  160001        IOR B,I
25133  072010        RZA LOG1     IS THE MANTISSA EXACTLY 1 ?
25134  105273        LDB OPND1,I  YES, RETURN THE ARGUMENT'S EXPONENT AS THE RESULT
25135  174405        ABR 6
25136  140563        JSM AFLTP,I  CONVERT THE EXP. TO A FLOATING POINT NUMBER IN AR2
25137  042366        JSM A2.RS    RES = AR2
25140  101273        LDA OPND1,I  WAS THE ARGUMENT < 0 ?
25141  073051        SLA TN^3
25142  066022        JMP E69      YES, TRY TO GIVE AN ERROR 69
25143  043760  LOG1  JSM LN0      CALCULATE LN(ARG)
25144  000340        LDA ARES     LOG(ARG) = LN(ARG) / LN(10)
25145  007012  LOG2  LDB ALN10
25146  066443        JMP DVD      LET DVD FINISH THE TASK.
                *
                ****************
                *
                * ^ EXECUTION
                *
```

MATH OPTION BLOCK - A: EXECUTION

```
2121000                     *       THE BASIC STANDARD (DOC.NO. X3J2/74) HAS RESOLVED:  0^0 = 1
2122000                     *       THE 9820/21 RETURNS 0
2123000                     *       THE 9830 GIVES ERROR 53
2124000                     *  THIS ROUTINE RETURNS 1 AS ITS DEFAULT VALUE
2125000                     *  AFTER TRYING TO GIVE ERROR 73.
2126000                     *
2127000                     ****************
2128000                     *
2129000 25147  000177  E^     LDA PO
2130000 25150  031741         STA FLAGS     CLEAR THE RESULT MANTISSA SIGN TEMPORARY.
2131000 25151  140553         JSM AGET2,I   FETCH THE BASE AND POWER
2132000 25152  001274         LDA OPND2
02133000 25153  031736        STA OCTNT     SAVE OPND2 DURING LN0
02134000 25154  001273        LDA OPND1
02135000 25155  042505        JSM XFRO1     OP1 = BASE
02136000 25156  035273        STB OPND1     OPND1 = AOP1
02137000 25157  001743        LDA OP1M1     IS THE BASE ZERO ?
02138000 25160  072010        RZA ^2        NO, CONTINUE
02139000 25161  105274        LDB OPND2,I   YES, CHECK THE MANTISSA SIGN OF THE POWER.
02140000 25162  077002        SLB ^1
02141000 25163  067661        JMP E76       POWER < 0,  ERROR 76: DEFAULT = +9.99999999999 E511
02142000 25164  045274  ^1    ISZ OPND2
02143000 25165  111274        CPA OPND2,I
02144000 25166  066750        JMP E73       POWER=0, 0^0 IS AN ERROR AS OF 7/28/75, CHECK FLG 14.
02145000 25167  066355        JMP CLRES     POWER > 0: RETURN 0
02146000                *
02147000 25170  000172  ^2    LDA AONE      OP2=1,  OP1=BASE (FROM ABOVE)
02148000 25171  042510        JSM XFRO2
02149000 25172  001274        LDA OPND2
02150000 25173  040644        JSM FIXPT     B = POWER
02151000 25174  173402        SOS *+2       INTEGER OVERFLOW, USE EXP(POWER*LN(BASE))
02152000 25175  042422        JSM ZAR2      IS THE POWER AN INTEGER NUMBER ?
02153000 25176  066234        JMP ^6        NO, THERE IS A FRAC. PART, USE EXP(POWER*LN(BASE))
02154000 25177  035741        STB FLAGS     YES, IT IS AN INTEGER.  SAVE IT IN FLAGS UNTIL LATE=
02155000 25200  176002        SBP *+2       (THIS PIECE HAS BEEN TESTED FOR POWER = -32768)
02156000 25201  174040        TCB           [.999^(-32768) = 1/((.999^16384)^2)]
02157000 25202  035736        STB OCTNT     OCTNT = ABS(POWER)
02158000 25203  077005  ^3    SLB ^4        IF BIT N IS ONE MULTIPLY THE ACCUMULATOR (OP2)
02159000 25204  000336        LDA AOP1      BY BASE^(2^N).
02160000 25205  004337        LDB AOP2
02161000 25206  042440        JSM MPY
02162000 25207  042474        JSM RS.02
02163000 25210  001736  ^4    LDA OCTNT     SHIFT THE POWER RIGHT TO THE NEXT BIT POSITION
02164000 25211  170500        SAR 1         AND EXIT THE LOOP IF NO BITS REMAIN SET.
02165000 25212  031736        STA OCTNT
02166000 25213  072407        SZA ^5        OTHERWISE,
02167000 25214  000336        LDA AOP1      UPDATE THE BASE REGISTER.
02168000 25215  004336        LDB AOP1      OP1 = OP1 * OP1
02169000 25216  042440        JSM MPY
02170000 25217  042472        JSM RS.01
02171000 25220  005736        LDB OCTNT     RECALL THE POWER AND KEEP LOOPING.
02172000 25221  066203        JMP ^3
02173000 25222  000337  ^5    LDA AOP2
02174000 25223  042367        JSM XFRRS     RES = OP2
02175000 25224  001741        LDA FLAGS     IF THE ORIGINAL POWER WAS POSITIVE, RES CONTAINS THE
02176000 25225  172033        SAP ^RET      CORRECT ANSWER.  OTHERWISE RETURN 1/RES AS THE RESULT
02177000 25226  100001  ONE/B LDA B,I       IF THE DIVISOR HAS AN EXPONENT OF -512 IT WOULD
02178000 25227  050164        AND M64       UNDERFLOW TO ZERO, SO 1/0 GENERATES ERROR 76
02179000 25230  010263        CPA FLAG      WITH A DEFAULT OF +9.99999999999 E511.
02180000 25231  067661        JMP E76
02181000 25232  000172        LDA AONE      IF NOT, RES = 1/<B>
02182000 25233  066443        JMP DVD
02183000                *
02184000                * CALCULATE   EXP(POWER*LN(BASE))
02185000                *
02186000 25234  005742  ^6    LDB OP1E
02187000 25235  077211        SLB ^7,C      IS THE BASE POSITIVE ?
02188000 25236  035742        STB OP1E      NO, MAKE THE BASE POSITIVE
02189000 25237  001274        LDA OPND2     AND MAKE SURE THE POWER IS AN INTEGER
02190000 25240  040644        JSM FIXPT     B=INT(POWER), PARITY ONLY, AR2=FRAC(POWER)
02191000 25241  000001        LDA B         IF THE POWER WAS ODD, THE FINAL RESULT WILL BE
02192000 25242  050254        AND P1        NEGATIVE (IF ERROR 72 DOESN'T OCCUR).  FLAGS
02193000 25243  031741        STA FLAGS     CONTAINS THE PROPER MANTISSA SIGN FOR THE RESULT.
02194000 25244  042422        JSM ZAR2      IS AR2 = 0 ?
02195000 25245  042753        JSM E72       NO, ISSUE AN ERROR MESSAGE IF FLAG 14 = 0
02196000 25246  043760  ^7    JSM LN0       YES,(RET 2 FROM ZAR2), BASE > 0, RES = LN(BASE)
02197000                *
02198000                * BUG SHEET #1758:  (TN^(-200))^(TN^510) GIVES ERROR 76, OVERFLOW,
02199000                * BECAUSE POWER*LN10 OVERFLOWS HERE.  COULD USE SFG14 & RSTFL
02200000                * AROUND THE <LDA OCTNT, JSM AXRES> TO IGNORE THE OVERFLOW BUT WE
02201000                * DECIDED NOT TO FIX IT SO CLOSE TO RELEASE.
02202000                *
02203000 25247  001736        LDA OCTNT     RECALL OPND2.
02204000 25250  042437        JSM AXRES     RES = POWER * LN(BASE)
02205000 25251  042116        JSM TN^5
```

MATH OPTION BLOCK - A: EXECUTION

```
25252  001753         LDA RESM1     IF THE MANTISSA IS ZERO DON'T MAKE IT NEGATIVE.
25253  010177         CPA P0        BUG SHEET #1775
25254  066355         JMP CLRES     RES = 0
25255  001752         LDA RESE
25256  061741         IOR FLAGS     PUT THE PROPER SIGN ON THE RESULT.
25257  031752         STA RESE
25260  170201  AHET   RET 1
```

```
                      REP 2
25261  000000         OCT 0         WORD RESERVED FOR POST-RELEASE CORRECTIONS.
25262  000000         OCT 0         WORD RESERVED FOR POST-RELEASE CORRECTIONS.
               *
               ****************
               *
               * CSV EXECUTION - CLEAR ALL ALLOCATED SIMPLE VARIABLES
               *
               ****************
               *
25263  000276  ECSV   LDA ADVTB
25264  031733         STA PTR       PTR = ADDRESS OF THE SIMPLE VARIABLE TABLE
25265  000122         LDA P26
25266  031737         STA CNTR1     CNTR1 = 26 (LENGTH OF THE SIMPLE VARIABLE TABLE)
25267  101733  CSV1   LDA PTR,I     A = ADDRESS OF THE NEXT SIMPLE VARIABLE
25270  072402         SZA CSV2      IF A = 0: THE VARIABLE IS NOT ALLOCATED
25271  071603         CLR 4         IT IS ALLOCATED SO CLEAR IT.
25272  045733  CSV2   ISZ PTR       BUMP THE SIMPLE VARIABLE TABLE POINTER
25273  055737         DSZ CNTR1     ANOTHER VARIABLE TO BE PROCESSED ?
25274  066267         JMP CSV1      YES
25275  170201         RET 1         NO, RETURN
```

```
               *
               ****************
               *
               * UNITS EXECUTION
               *
               ****************
               *
25276  140450  EUNIT  JSM ACLBI,I   CLEAR THE I/O BUFFER TO BLANKS
25277  001042         LDA UNITS     TRANSFER THE CURRENT UNITS MESSAGE TO THE I/O BUFFER
25300  004313         LDB AIBUF
25301  071401         XFR 2
25302  140433         JSM ALDSP,I   DISPLAY THE I/O BUFFER.
25303  164436         JMP AEPON,I   CHECK FOR PRINT-ALL.  IMPLIED RETURN.
```

```
               *
               ****************
               *
               * DEG, RAD, GRAD EXECUTION
               *
               ****************
               *
25304  003015  EDEG   LDA DEG       SET DEGREES (ALSO USED FOR INITIALIZATION)
25305  066311         JMP GRAD1
25306  003053  ERAD   LDA RAD       SET RADIANS
25307  066311         JMP GRAD1
25310  003034  EGHAD  LDA GRAD      SET GRADS
25311  031042  GRAD1  STA UNITS     AS THE CURRENT UNITS AND
25312  170201         RET 1         RETURN WITHOUT DISPLAYING CURRENT UNITS.
```

MATH OPTION BLOCK - A: UTILITY ROUTINES

```
               *
               ****************
               *
               * GET1A:  THIS SUBROUTINE SAVES 4-6 WORDS
               *
               * EXIT CONDITIONS:
               *    OP1 = ARGUMENT
               *    A   = OPND1
               *    B   = AOP1
               *
               ****************
               *
25313  140552  GET1A  JSM AGET1,I   FETCH THE ARGUMENT
25314  066505         JMP XFR01     OP1 = ARGUMENT
```

```
                     *
                     ****************
                     *
                     * CTOCU - CONVERT RES TO CURRENT UNITS
                     *
                     * ENTRY: RES IS IN RADIANS
                     * EXIT : RES IS IN CURRENT UNITS
                     *
                     * THIS IS A THIRD LEVEL SUBROUTINE
                     * EXTERNALS: DVD
                     *
                     ****************
                     *
25315  005042  CTOCU LDB UNITS
25316  017053        CPB RAD      IF CURRENT UNITS = RADIANS, NO CONVERSION NEEDED
25317  170201        RET 1        SO SKIP THE CONVERSION
25320  000340        LDA ARES
25321  024135        ADB P10
25322  066443        JMP DVD
                     *
                     ****************
                     *
                     * PYTHA -  RES = ((RES) OR (1)) / SQR(1 +/- RES*RES)
                     *
                     * ENTRY:  RES = ARGUMENT
                     *
                     * SIN:  A=AOP1  B=JADD
                     * COS:  A=AONE  B=JADD
                     * ASN:  A=AOP1  B=JSUB
                     * ACS:  A=AOP1  B=JSUB
                     *
                     * THIS IS A THIRD LEVEL SUBROUTINE
                     * TEMPORARIES:  C, D
                     * EXTERNALS:  MPY, ADD, SUB, SQR, DVD
                     *
                     * EXTERNALS FOR EM4:  RSTFL, STMAX, ARERR(I)
                     *
                     ****************
                     *
25323  030016  PYTHA STA C
25324  034017        STB D         SAVE A AND B FOR LATER USE
25325  042472        JSM RS.01     OP1 = RES
25326  042440        JSM MPY       RES = RES * RES
25327  000172        LDA AONE
25330  004340        LDB ARES
25331  070017        EXE D         RES = 1 +/- RES * RES
25332  001752        LDA RESE      CHECK THE RESULT EXPONENT FOR ASN, ACS
25333  073410        RLA E71
25334  000340        LDA ARES      RES = SQR(1 +/- RES * RES)
25335  042453        JSM SQR
25336  000016        LDA C
25337  004340        LDB ARES
25340  042443        JSM DVD       RES = ((RES) OR (1)) / SQR(1 +/- RES * RES)
25341  004340        LDB ARES
25342  170201        RET 1
                     *
                     * ERROR 71:  ACS OR ASN OF ARGUMENT <-1 OR >1
                     *
25343  042455  E71   JSM RSTFL     RESET THE USERS FLAGS  AND THEN TEST THE REAL FLG 14.
25344  005742        LDB OP1E      IF FLAG 14 IS SET THE DEFAULT RESULT IS ASN OR
25345  042373        JSM STMAX     ACS OF (SGN(ARG)*1)
25346  140546        JSM ARERR,I   ERROR 71:  ACS OR ASN ARG > 1 OR < -1.
25347  033461        ASC 1,71
                     *
                     ****************
                     *
                     * INRES - RES = INT(RES)
                     *
                     * THIS IS A SECOND LEVEL SUBROUTINE
                     * IT USES ONLY AR2.
                     *
                     ****************
                     *
25350  042470  INRES JSM RS.A2     AR2 = RES
25351  001752        LDA RESE      IF THE EXPONENT IS NEGATIVE, RETURN ZERO
25352  170405        AAR 6
25353  004000        LDB A
25354  176004        SBP *+4
25355  000340  CLRES LDA ARES
25356  071603        CLR 4
25357  170201        RET 1
25360  024155        ADB M11       IF THE EXPONENT IS >= 11, RETURN THE ARGUMENT
25361  176076        SBP *-2
25362  174040        TCB           B = NO. OF DIGITS TO RIGHT SHIFT OUT OF AR2
25363  000177        LDA P0
```

```
25364  075500         MRY           PERFORM THE RIGHT SHIFT
25365  071500         NRM           NORMALIZE THE RESULT
                *
25366  000127  A2.RS  LDA AR2A
25367  004340  XFRRS  LDB ARES
25370  071403  XFRET  XFR 4
25371  170201         RET 1

                *
                ***************
                *
                * STMAX:  RES = +/- 9.99999999999 E 511
                *
                * ENTRY POINT STMAX-1: STORE + 9.99999999999 E 511 IN RES.
                *
                * ENTRY POINT STMAX:   STORE + 9.99999999999 E 511 IN RES IF B<0>=0
                * ENTRY POINT STMAX:   STORE - 9.99999999999 E 511 IN RES IF B<0>=1
                *
                ***************
                *
25372  004177         LDB P0
25373  000127  STMAX  LDA AR2A
25374  071603         CLR 4
25375  044023         ISZ AR2M3
25376  071040         CMY
25377  000212         LDA EMAX
25400  030020         STA AR2E
25401  077002         SLB *+2
25402  044020         ISZ AR2E
25403  066366         JMP A2.RS
                *
                ***************
                *
                * RAR2 - ROUND AR2
                *
                * THIS IS A SECOND LEVEL SUBROUTINE
                * SEE THE MAINFRAME ROUNDING ROUTINE FOR TEMPORARIES
                *
                ***************
                *
25404  004254  RAR21  LDB P1        ENTRY POINT FOR 1 DIGIT SHIFT AND ROUND.
25405  000177  RAR2B  LDA P0        ENTRY POINT FOR <B> DIGIT SHIFT AND ROUND.
25406  164547         JMP ARND,I    USE THE RET 1 FROM ARND,I TO RETURN.
                *
                ***************
                *
                * ROUND:  FASTER SHIFT & ROUND THAN RAR2B
                *         B = NO. OF DIGITS TO RIGHT SHIFT
                *
                ***************
                *
25407  000001  ROUND  LDA B
25410  050160         AND M16
25411  072402         SZA *+2
25412  004132         LDB P13
25413  000177         LDA P0
25414  075500  FRND   MRY
25415  020151         ADA M5
25416  172403         SAM *+3
25417  004254         LDB P1
25420  071000         MWA
25421  170201  RETN1  RET 1
                *
                ***************
                *
                * ZAR2 - CHECK FOR AR2 = 0
                *
                *   RET 2 IF AR2 = 0
                *   RET 1 IF AR2 # 0
                *
                * THIS IS A FIRST LEVEL SUBROUTINE
                * IT USES NO TEMPORARIES
                *
                ***************
                *
25422  000021  ZAR2   LDA AR2M1
25423  060022         IOR AR2M2
25424  060023         IOR AR2M3
25425  072074         RZA RETN1
25426  170202         RET 2
```

```
               *
               ****************
               *
               * CALLS TO +-*/ ROUTINES
               *
               * ENTRY CONDITIONS:
               *   CALL WITH JSM XXX
               *   A = OPND1
               *   B = OPND2
               *
               * EXIT CONDITIONS:
               *   RETURNS TO CALLING ROUTINE USING THE RETURN FROM THE IMATH ROUTINE
               *
               * THESE ARE SECOND LEVEL SUBROUTINES
               * SEE THE MAINFRAME MATH ROUTINES FOR TEMPORARIES USED.
               *
               ****************
               *
25427  031273  ADD    STA OPND1
25430  035274         STB OPND2
25431  164554         JMP AADD1,I
               *
25432  000336  O1MRS  LDA AOP1      ENTRY POINT FOR RES=OP1-RES
25433  004340  AMRES  LDB ARES      ENTRY POINT FOR RES=<A>-RES
25434  031273  SUB    STA OPND1
25435  035274         STB OPND2
25436  164555         JMP ASUB1,I
               *
25437  004340  AXRES  LDB ARES      ENTRY POINT FOR RES=<A>*RES
25440  031273  MPY    STA OPND1
25441  035274         STB OPND2
25442  164556         JMP AMUL1,I
               *
25443  031273  DVD    STA OPND1
25444  035274         STB OPND2
25445  024254         ADB P1
25446  100001         LDA B,I
25447  072003         RZA DVD1
25450  105273         LDB OPND1,I  DIVISOR = 0:  RES = +/-9.99999999999 E511
25451  066373         JMP STMAX
25452  164557  DVD1   JMP ADIV1,I
               *
25453  031273  SQR    STA OPND1     (COULD BE MOVED INTO PYTHA)
25454  164561         JMP ASQR1,I
               *
25455  001730  RSTFL  LDA UFLAG     RESTORE THE USER'S FLAGS
25456  066462         JMP CAF1
               *
               * SFG14 USES UFLAG
               *
25457  001506  SFG14  LDA FLAGS     SAVE THE USER'S FLAGS AND SET FLAG 14
25460  031730         STA UFLAG
25461  060145         IOR P2
25462  031506  CAF1   STA FLAGS
25463  170201         RET 1
               *
               ****************
               *
               * TRANSFER SUBROUTINES FOR OP1, OP2, RES, AR1, AR2
               *
               * GENERAL FORM OF LABEL:  FF.TT,  WHERE FF=FROM AND TT=TO
               *
               ****************
               *
25464  000336  O1.A2  LDA AOP1
25465  066477         JMP XFRA2
               *
25466  000337  O2.A2  LDA AOP2
25467  066477         JMP XFRA2
               *
25470  000340  RS.A2  LDA ARES
25471  066477         JMP XFRA2
               *
25472  000340  RS.O1  LDA ARES
25473  066505         JMP XFRO1
               *
25474  000340  RS.O2  LDA ARES
25475  066510         JMP XFRO2
               *
25476  000345  A1.A2  LDA AR1A
25477  004127  XFRA2  LDB AR2A
25500  066370         JMP XFRET
               *
25501  000127  A2.A1  LDA AR2A
25502  004345  XFRA1  LDB AR1A
```

```
25503  066370        JMP XFRET
                *
25504  000127  A2.01 LDA AR2A
25505  004336  XFR01 LDB AOP1
25506  066370        JMP XFRET
                *
25507  000127  A2.02 LDA AR2A
25510  004337  XFR02 LDB AOP2
25511  066370        JMP XFRET
                *
25512  000172  OP1=1 LDA AONE
25513  066505        JMP XFR01
```

MATH OPTION BLOCK - A: "CORDIC" SUBROUTINES

```
                *
                ********************
                *
                * PH1 - "PHASE I":  CORDIC SUBROUTINE USED BY TAN & EXP
                *
                * TAN:  SUMMATION EQUATION
                *
                * EXP:  SUMMATION EQUATION
                *
                ****************
                *
                * INITIAL VALUES
                *
                *          TAN                EXP
                *
                * PTR     ABETA-4*CNTR1     ABETA
                * CNTR1    1-6                6
                *
                ****************
                *
25514  000335  PH1   LDA ADSTK     SET UP THE DIGIT STACK
25515  031726        STA DIGIT
25516  071605        CLR 6         CLEAR Q0 - Q5 TO ZERO
                *
25517  001733  PH1.A LDA PTR       MOVE NEXT CONSTANT TO AR1
25520  042502        JSM XFRA1
                *
25521  071040  CMY   CMY           DETERMINE THE NEXT QJ
25522  075041        FDV
25523  135726        STB DIGIT,I   SAVE QJ
                *
25524  071040        CMY           RESTORE THE REMAINDER
25525  071200        FXA
25526  000177        LDA P0
25527  075541        MLY           LEFT SHIFT THE REMAINDER 1 DIGIT
                *
25530  042422        JSM ZAR2      IS AR2 = 0 ?
25531  066534        JMP PH1.B     NO
                *
25532  145726        ISZ DIGIT,I   YES, INCREMENT THE LAST QJ
25533  170201        RET 1
                *
25534  045726  PH1.B ISZ DIGIT     BUMP THE QJ POINTER
25535  001733        LDA PTR
25536  020143        ADA P4
25537  031733        STA PTR       BUMP THE CONSTANT ADDRESS
25540  055737        DSZ CNTR1     MORE CONSTANTS ?
25541  066517        JMP PH1.A
25542  170201        RET 1         NO
                *
                ****************
                *
                * PH2 - "PHASE II":  CORDIC SUBROUTINE USED BY TAN & ATN
                *
                * TAN:  Y = Y + X
                *       X = X - 10^(-2J) * Y
                *
                * ATN:  Y = Y - X
                *       X = X + 10^(-2J) * Y
                *
                ****************
                *
                * INITIAL VALUES
                *
                *        TAN   ATN
                *
                * SHIFT    10    -2*EXP&1   USED FOR SHIFTING Y IN THE 2ND EQUATION
                * DJ       -2     2         INCREMENT/DECREMENT FOR SHIFT
```

MATH OPTION BLOCK - A: "CORDIC" SUBROUTINES

```
                * C       CDC   CMY
                * D       CMY   CDC
                * LOOP#   1-6    13
                *
                ****************
                *
25543  031731   PH2    STA SHIFT     SHIFT = SHIFT FACTOR FOR Y
25544  035732          STB DJ        DJ = INCREMENT/DECREMENT FOR TWOJ
                *
25545  042512          JSM OP1=1     SET X0 = 1
                *
25546  001732          LDA DJ
25547  010146          CPA M2        TAN ?
25550  066603          JMP PH2.D     YES
                *
25551  042466   PH2.A  JSM O2.A2     NO, AR2 = OP2
25552  070016          EXE C         CDC FOR TAN,  CMY FOR ATN
25553  000336          LDA AOP1      AR1 = OP1
25554  042502          JSM XFRA1
25555  071200          FXA           Y = Y +/- X
25556  001732          LDA DJ
25557  010146          CPA M2        TAN ?
25560  066566          JMP PH2.B     YES
25561  072705          SDC PH2.B     OVERFLOW ?
                *
25562  042422          JSM ZAR2      YES, IS AR2 = 0 ?
25563  066607          JMP PH2.E     NO
                *
25564  155726          DSZ DIGIT,I   YES
25565  170201          RET 1
                *
25566  070016   PH2.B  EXE C         CDC FOR TAN;  CMY FOR ATN
25567  042366          JSM A2.RS     NO OVERFLOW, RES = AR2
25570  042466          JSM O2.A2     AR2 = OP2
                *
25571  005731          LDB SHIFT     RIGHT SHIFT AR2 "SHIFT" PLACES AND ROUND
25572  042407          JSM ROUND     LEAVE IN UNNORMALIZED FORM IN AR2.
                *
25573  070017          EXE D         CMY FOR TAN,  CDC FOR ATN
25574  071200          FXA           X = X -/+ 10^(-2J) * Y
25575  042504          JSM A2.O1     OP1 = AR2
25576  042474          JSM RS.O2     OP2 = RES
                *
25577  155726          DSZ DIGIT,I   QJ = QJ -1;  QJ = 0 ?
25600  066551          JMP PH2.A     NO
25601  066607          JMP PH2.E     YES;  QJ IS NEVER ZERO FOR ATN.
                *
25602  042466   PH2.C  JSM O2.A2     AR2 = OP2
                *
25603  042404   PH2.D  JSM RAR21     RIGHT SHIFT AR2 ONE PLACE AND ROUND.
                *
25604  042507          JSM A2.O2     OP2 = AR2
                *
25605  101726          LDA DIGIT,I   QJ = 0 ?
25606  072043          RZA PH2.A     NO
                *
25607  001731   PH2.E  LDA SHIFT     YES, QJ=0
25610  021732          ADA DJ
25611  031731          STA SHIFT     SHIFT = SHIFT + DJ
                *
25612  055740          DSZ LOOP#     LOOP# = LOOP# -1;  LOOP# = 0 ?
25613  066615          JMP PH2.F     NO
25614  170201          RET 1         YES
                *
25615  055726   PH2.F  DSZ DIGIT     DIGIT = DIGIT - 1
                *
25616  001732          LDA DJ
25617  010146          CPA M2        TAN ?
25620  066602          JMP PH2.C     YES
                *
25621  001747          LDA OP2M1     NO, D1 OF OP2 = 0 ?
25622  170513          SAR 12
25623  072405          SZA PH2.G     YES
                *
25624  042464          JSM O1.A2     AR2 = OP1
25625  042404          JSM RAR21     RIGHT SHIFT AR2 ONE PLACE AND ROUND.
25626  042504          JSM A2.O1     OP1 = AR2
25627  066551          JMP PH2.A
                *
25630  042466   PH2.G  JSM O2.A2     AR2 = OP2
25631  000177          LDA P0
25632  075541          MLY           LEFT SHIFT AR2 ONE PLACE.
25633  042507          JSM A2.O2     OP2 = AR2
25634  066551          JMP PH2.A
```

```
                *
                ****************
                *
                * PH3 - "PHASE III":  CORDIC SUBROUTINE USED BY ATN & LN
                *
                *   ATN:  SUMMATION EQUATION
                *
                *   LN :  SUMMATION EQUATION
                *
                ****************
                *
                * INITIAL VALUES
                *
                *        ATN    LN
                *
                * LOOP# 7-12     7
                * PTR   ALFAA  BETAA
                *
                ****************
                *
25635  031740   PH3    STA LOOP#
25636  170040          TCA
25637  020132          ADA P13
25640  031737          STA CNTR1
25641  035733          STB PTR
                *
25642  000127          LDA AR2A
25643  071603          CLR 4
                *
25644  000335          LDA ADSTK
25645  031726          STA DIGIT
25646  004254          LDB P1
                *
25647  101726   PH3.A  LDA DIGIT,I  TRANSFER LOW ORDER DIGITS TO AR2
25650  170040          TCA
25651  075500          MRY
25652  045726          ISZ DIGIT
25653  055740          DSZ LOOP#
25654  066647          JMP PH3.A
                *
25655  000177          LDA P0
25656  075500          MRY
                *
25657  001733          LDA PTR
                *
25660  031733   PH3.B  STA PTR
25661  042502          JSM XFRA1
                *
25662  105726          LDB DIGIT,I
25663  174040          TCB
25664  075000          FMP
25665  045726          ISZ DIGIT
                *
25666  004254          LDB P1
25667  055737          DSZ CNTR1
25670  066672          JMP *+2
25671  066676          JMP PH3.D
                *
25672  042414          JSM FRND
25673  001733   PH3.C  LDA PTR
25674  020150          ADA M4
25675  066660          JMP PH3.B
                *
25676  072402   PH3.D  SZA PH3.E
25677  042414          JSM FRND
25700  071500   PH3.E  NRM          NOTE: THIS SUBROUTINE IS CALLED FROM "TAN10" TWICE.
25701  174040          TCB
25702  174605          SBL 6
25703  034020          STB AR2E
25704  170201          RET 1
                *
                ****************
                *
                * PH4 - "PHASE IV":  CORDIC SUBROUTINE USED BY EXP & LN
                *
                * RECURRENCE EQUATION:  Y = Y + 10^(-J) * Y
                *
                * EXP:  Y0 = 1
                * LN:   Y0 = ARGUMENT
                *
                ****************
                *
                * INITIAL VALUES
                *
                *        EXP    LN
```

MATH OPTION BLOCK - A: "CORDIC" SUBROUTINES

```
02787000                      * DIGIT  ADSTK + 12
02788000                      * SHIFT   12     0
02789000                      * DJ      =1     1
02790000                      * AR2      1   ARG
02791000                      *
02792000                      ****************
02793000                      *
02794000 25705  031731  PH4    STA SHIFT    SAVE THE SHIFT FACTOR (J, NOT 2J)
02795000 25706  035732         STB DJ       SAVE THE SHIFT FACTOR INCREMENT/DECREMENT
02796000 25707  000132         LDA P13
02797000 25710  031740         STA LOOP#    LOOP IN PH4 13 TIMES
02798000 25711  042501         JSM A2.A1    AR1 = AR2
02799000 25712  001732  PH4.A  LDA DJ
02800000 25713  010254         CPA P1       LN ?
02801000 25714  066717         JMP PH4.C    YES
02802000 25715  101726  PH4.B  LDA DIGIT,I  NO, EXP:  IS QJ = 0 ?
02803000 25716  072410         SZA PH4.E
02804000 25717  005731  PH4.C  LDB SHIFT    NO, QJ # 0
02805000 25720  076402         SZB PH4.D    IF TWOJ=0, DON'T RIGHT SHIFT AND ROUND
02806000 25721  042407         JSM ROUND    RIGHT SHIFT AR2 "SHIFT" PLACES AND ROUND
02807000 25722  071700  PH4.D  CDC
02808000 25723  071200         FXA          AR2 = Y + 10^(-J) * Y
02809000 25724  072711         SDC PH4.F    OVERFLOW ?
02810000 25725  042476         JSM A1.A2    YES, AR2 = AR1 (RESTORE TO PREVIOUS VALUE)
02811000 25726  001731  PH4.E  LDA SHIFT    INCREMENT/DECREMENT THE SHIFT FACTOR
02812000 25727  021732         ADA DJ
02813000 25730  031731         STA SHIFT
02814000 25731  055726         DSZ DIGIT
02815000 25732  055740         DSZ LOOP#    DECREMENT THE LOOP COUNTER
02816000 25733  066712         JMP PH4.A
02817000 25734  170201         RET 1
02818000 25735  155726  PH4.F  DSZ DIGIT,I  NO OVERFLOW, DECREMENT QJ
02819000 25736  000000         NOP          DON'T TEST FOR QJ=0 NOW (ITS DONE AT PH4.B)
02820000 25737  042501         JSM A2.A1    AR1 = AR2
02821000 25740  066715         JMP PH4.B
02823000                       UNS
02824000                       REP 7
         25741  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.
         25742  000000         OCT 0        WORD RESERVED FUR POST-RELEASE CORRECTIONS.
         25743  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.
         25744  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.
         25745  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.
         25746  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.
02825000 25747  000000         OCT 0        WORD RESERVED FOR POST-RELEASE CORRECTIONS.


02827000                      *
02828000                      * ERROR 73:  0^0
02829000                      *
02830000 25750  043635  E73    JSM RES=1    DEFAULT VALUE IS 1
02831000 25751  140546         JSM ARERR,I
02832000 25752  033463         ASC 1,73


02834000                      *
02835000                      * ERROR 72:  NEGATIVE BASE TO A NON-INTEGER POWER
02836000                      *
02837000 25753  000177  E72    LDA P0       IF FLAG 14 = 1, RETURN TO E^.2 TO CALCULATE
02838000 25754  031741         STA FLAGS    (ABS(BASE))^POWER
02839000 25755  140546         JSM ARERR,I  ERROR 72:  NEGATIVE BASE TO A NON-INTEGER POWER
02840000 25756  033462         ASC 1,72
```

MATH OPTION BLOCK - A: MISC.

```
02842000                      *
02843000                      *
02844000                      * EXECUTION JUMP TABLE
02845000                      *
02846000                      *
02847000 25757  025757  EXTBL  DEF *
02848000 25760  024257         DEF ETAN
02849000 25761  024510         DEF EATN
02850000 25762  024632         DEF EEXP
02851000 25763  024757         DEF ELN
02852000 25764  025027         DEF ESIN
02853000 25765  025025         DEF ECOS
02854000 25766  025063         DEF EASN
02855000 25767  025057         DEF EACS
02856000 25770  025077         DEF ETN^
02857000 25771  025120         DEF ELOG
```

```
                                MATH OPTION BLOCK - A:  MISC.
02858000 25772  025147          DEF EA
02859000 25773  025263          DEF ECSV
02860000 25774  025276          DEF EUNIT
02861000 25775  025304          DEF EDEG
02862000 25776  025306          DEF ERAD
02863000 25777  025310          DEF EGRAD

02865000        024635  RES=1 EQU EXP1
02866000        025722  CDC   EQU PH4.D     CONSTANT USED BY PH2.
02867000        025304  INITA EQU EDEG

02869000                * FILL IN BASEPAGE LINKS TO STMAX.

02871000 00564                  ORG ASTMA
02872000 00564  025373          DEF STMAX
02873000 00565  025372          DEF STMAX-1

02875000                        END
END OF PASS 2 NO ERRORS DETECTED

                              MATH OPTION BLOCK B (MB16) -

02058000                * FULL PRECISION NUMBER:  INTERNAL FORMAT

02060000                *   EEEE EEEE EEXX XXXS   10 BIT 2'S COMP. FXP.. 5 UNUSED BITS.
02061000                *                         MANTISSA SIGN (0=+ 1=-)
02062000                *                         EXP. RANGE = -511 TO +511
02063000                *    D1 . D2   D3   D4    BCD DIGITS 1-4

02065000                *    D5   D6   D7   D8    BCD DIGITS 5-8

02067000                *    D9   D10  D11  D12   BCD DIGITS 9-12
02069000                *
02070000                ****************
02071000                *
02072000                * READ/WRITE AREAS

02074000        077042  UNITS EQU STEAL   DEDICATED WORD FOR MOBA
02075000        077043  SEEDL EQU STEAL+1    DEDICATED WORD FOR MOBB IS USED TO STORE RUN LINK
02076000        077752  RESE  EQU RES       FULL PRECISION RESULT REGISTER
02077000        077753  RESM1 EQU RES+1
02078000        077754  RESM2 EQU RES+2
02079000        077755  RESM3 EQU RES+3
02080000                *
02081000        077756  ZE    EQU MRW1      FULL PRECISION MATH TEMPORARY
02082000        077757  ZM1   EQU MRW1+1
02083000        077760  ZM2   EQU MRW1+2
02084000        077761  ZM3   EQU MRW1+3
02085000                *
02086000        077762  MT1   EQU MRW1+4
02087000        077763  MT2   EQU MRW1+5
02088000        077764  MT3   EQU MRW1+6
02089000        077765  MT4   EQU MRW1+7
02090000        077766  MT5   EQU MRW1+8
02091000        077767  MT6   EQU MRW1+9
02092000                *
02093000        000345  AR1A  EQU ADR1      ADDRESS OF AR1
02094000        077770  AR1E  EQU AR1       EXPONENT WORD OF AR1
02095000        077771  AR1M1 EQU AR1E+1    1ST MANTISSA WORD OF AR1
02096000        077772  AR1M2 EQU AR1E+2    2ND MANTISSA WORD OF AR1
02097000        077773  AR1M3 EQU AR1E+3    3RD MANTISSA WORD OF AR1
02098000                *
02099000        077774  RNDT2 EQU MRW2      NORMALIZE COUNT FOR COMPARISON IN ROUND
02100000        077775  RNDT1 EQU MRW2+1    SHIFT COUNTER FOR ROUND
02101000        077776  NRMFL EQU MRW2+2    NORMALIZATION FLAG FOR ROUND
02102000        077777  STBIT EQU MRW2+3    "STICKY BIT" FOR ROUND
02103000                *
02104000        000127  AR2A  EQU ADR2      ADDRESS OF AR2
02105000        000020  AR2E  EQU AR2       EXPONENT WORD OF AR2
02106000        000021  AR2M1 EQU AR2E+1    1ST MANTISSA WORD OF AR2
```

```
02107000          000022  AR2M2 EQU AR2E+2   2ND MANTISSA WORD OF AR2
02108000          000023  AR2M3 EQU AR2E+3   3RD MANTISSA WORD OF AR2
02109000                  *
02110000                  *
02111000          000175  BCD1  EQU B10K     BCD 1000
02112000                  *
02113000                  *  EQU'S FOR SUBROUTINE TO FIN D LOCATION OF FIRST ELEMENT
02114000                  *  OF AN ARRAY, NUMBER OF ELEMENTS IN H THE ARRAY , AND
02115000                  *  IT'S PRECISSION
02116000          077734  VAL   EQU T20    LOCATION OF FIRST ELEMENT OF AN ARRAY
02117000          077733  VALN  EQU T19    NUMBER OF ELEMENTS OF THE ARRAY
02119000                  *
02120000                  ****************
02121000                  *
02122000                  * EQUATES

02124000                  *

02126000                  *
02127000                  ****************
02128000                  *
02129000                  * MAINFRAME - OPTION BLOCK INTERFACE

02131000 26000   026053         DEF EXECB    ADDRESS OF THE EXECUTION ROUTINE
02132000 26001   026032         DEF COMPB    ADDRESS OF THE COMPILE TABLE
02133000 26002   026016         DEF RCTBL   ADDRESS OF TH E REVERS E COMPILE TABLE
02134000 26003   177777         DEC -1     NO COMMAND TABLES
02135000 26004   026007         DEF INITB    ADDRESS OF THE INITIALIZATION ROUTINE
02136000 26005   000016         DEC 14     MOBB ROM ID
02138000                  *
02139000                  ****************
02140000                  *
02141000                  * CONSTANTS, LINKAGES

02143000                  *
02144000 26006   077327  ASEED DEF SEED    ADDRESS OF SEED

02146000                  *
02147000                  ****************
02148000                  *
02149000                  * INITIALIZATION
02150000                  *
02151000                  * ACCESSED BY JSM

02153000                  *
02154000                  *   STEAL 5 R/W WORDS POINT AT FIRST ONE BY SEED
02155000                  *  RESERVE 4 WORDS OF R/W MEMORY AS A SEED FOR RANDOM
02156000                  *  NUMBERS GENERATION
02157000                  *   THE LAST STOLEN WORD WILL CONTAIN RLINK CONTENTS FOR RESETTING
02158000                  *   SEED OF RANDOM GENERATOR ON RUN
02159000                  *
02160000 26007   000133  INITB LDA P12
02161000 26010   061062        IOR ROMWD     ROMWD BITS FOR MOBA,MOBB
02162000 26011   031062        STA ROMWD
02163000                  *
02164000                  *
02165000 26012   003075  INTO  LDA ACR/D
02166000 26013   007006  INTN  LDB ASEED
02167000 26014   071403        XFR 4     STORE PI/2 AS A DEFAULT SEED(INITIAL SEED)
02168000 26015   170201  IEND  RET 1

02171000                  *
02172000                  ****************
02173000                  *
02174000                  * COMMAND TABLE
02175000                  *
02176000                  * ACCESSED BY LOOK-UP
```

```
                    *
                    * COMMAND EXECUTION ROUTINES ACCESSED BY JSM

                    *
                    ****************
                    *
                    * REVERSE COMPILE
                    *
                    * ACCESSED BY JSM
                    *   A = ROM'S INTERNAL CODE
                    *   B = ROM'S ID CODE
                    *
                    * MUST RETURN:
                    *   ASCII = CHARACTER POINTER TO RIGHT HAND END OF MNEMONIC.
                    *   GUIDE = AAAA BBBB AAAA BBBB
                    *           AAAA = OPERATOR PRIORITY
                    *           BBBB = CLASS:
                    *                  1 : OPERAND
                    *                  2 : UNARY OPERATOR
                    *                  3 : BINARY OPERATOR

                    *
                    ****************
                    *
                    * REVERSE COMPILE TABLE

                    *                                            CC PP  CC PP
                    *
26016  161342 RCTBL OCT 161342   ABS  , SGN   14  2 , 14  2
26017  161342       OCT 161342   INT  , FRC  14  2 , 14  2
26020  161223       OCT 161223   RND  , MOD   14  2 ,  9  3
26021  161342       OCT 161342   MAX  , MIN  14  2 , 14  2
                    *
                    ****************
                    *
                    * COMPILE TABLE

                    *                                  CLASS  TOKEN
26022  004032       OCT 004032     8      26    MIN
26023  004032       OCT 004032     8      26    MAX
26024  003013       OCT 003013     6      11    MOD
26025  004053       OCT 004053     8      43    RND
26026  004053       OCT 004053     8      43    FRC
26027  004053       OCT 004053     8      43    INT
26030  004053       OCT 004053     8      43    SGN
26031  004053       OCT 004053     8      43    ABS
                    *
                    *  THE FOLLOWING IS A LOWER CASE MNEMONIC TABLE
                    *
26032  060542 COMPB DEC  24930     A   B
26033  071601       DEC  29569     S  (1)
26034  071547       DEC  29543     S   G
26035  067202       DEC  28290     N  (2)
26036  064556       DEC  26990     I   N
26037  072203       DEC  29827     T  (3)
26040  063162       DEC  26226     F   R
26041  061604       DEC  25476     C  (4)
26042  071156       DEC  29294     R   N
26043  062205       DEC  25733     D  (5)
26044  066557       DEC  28015     M   O
26045  062206       DEC  25734     D  (6)
26046  066541       DEC  28001     M   A
26047  074207       DEC  30855     X  (7)
26050  066551       DEC  28009     M   I
26051  067210       DEC  28296     N  (8)
26052  100000       OCT 100000     END OF TABLE
                    *
                    ****************
                    *
                    * MAIN EXECUTION ROUTINE
                    *
                    * ACCESSED BY JMP
                    *
                    * EXIT BY JMP AINTX,I FROM "EXIT"
```

MATH OPTION BLOCK 8 (MB16)

```
26053  023057  EXECB ADA ETBL
26054  100000        LDA A,I
26055  140000        JSM A,I      EXECUTE THE STATEMENT
26056  164366        JMP ARAP,I    GO TO RAP UP ROUTINE


                     *
                     * EXECUTION JUMP TABLE
                     *
26057  026057  ETBL  DEF *
26060  026402        DEF EABS
26061  026367        DEF ESGN
26062  026431        DEF EINT
26063  026315        DEF EFRAC
26064  026210        DEF ERND
26065  026244        DEF EMOD
26066  026104        DEF EMAX0
26067  026102        DEF EMIN


                     *
                     *
                     * CONSTANTS DEFINITION TABLE
                     *
                     *
26070  026071  A29   DEF *+1
26071  000100        OCT 000100    29. IS USED AS A MULTIPLIER FOR RANDOM NUMBER
26072  024400        OCT 024400
26073  000000        OCT 000000
26074  000000        OCT 000000
26075  024030  ACR/D OCT 24030    ADRESS OF PIE/180 ON J0 PAGE AS OF 9/10/75
26076  177767  M9    DEC -9
                     *
                     *
26077  077711  FT1A  DEF T1   ADDRESS OF T1
26100  077715  FT5A  DEF T5    ADDRESS OF T5
26101  077721  FT9A DEF T9
                     *
                     *
                     *******                       *******
                     *
                     *  SHARED TEMPORARIES BLOCK ADDRESSES*
                     *                                   *
                     *******                       *******
                     *
                     *
                     *
                     *
                     *  EQU'S AND CONSTANTS FOR FFM
                     *
       077217  .WPRT EQU CSTMP+1
                     *
                     *
                     *   THIS ROUTINE IS THE MAIN ) MAX/MIN EXECUTION
                     *   FOR EACH ELEMENT IN THE LIST OF PARAMETERS; IT FINDS THE
                     *    VALUE OF VAL AND VALN FOR THAT ELEMENT
                     *   WHEN LIST EXHAUSTED IT RETURNS THE VALUE OF MAX/MIN IN <RES>
                     *
                     *
                     *
26102  000257  EMIN  LDA M1
26103  067105        JMP *+2
26104  000254  EMAX0 LDA P1
26105  031716        STA T6   INDICATOR OF A MAX OR MIN IS T6 BEING +1 OR -1
26106  000254        LDA P1
26107  031717        STA T7   T7 INDICATES THE NUMBER OF TIMES WE ENTER MAXX
                     *
26110  140610        JSM ACOUN,I    COUNT PARAMETERS; FAP1 POINTS TO FIRST
26111  001272        LDA FAP1
26112  031722        STA T10    SAVE FAP1
                     *
26113  040751  EMAX1 JSM NGET     GET THE FIRST PPARAMETER IF SIMPLE VARIABLE
26114  067125        JMP EMAX3    FIND THE ARRAYS LOCATION AND NUMBER OF VARIABLES
                     *
                     *
                     *  WE HAVE A SINGLE ELEMENT ONLY IF NGET RETURNS TO NEXT LOCATION
                     *  (P+2); B POINTS TO THE EQUIVALENT FULL PRECISSION VALUE
                     *
                     *  WE SHOUL STORE THE FOLLOWING VALUES
```

MATH OPTION BLOCK 8 (MB16)

```
              *     VAL = 8
              *     VALN=  1
              *
26115 035734        STB VAL
26116 000254        LDA P1
26117 031733        STA VALN
              *
26120 043137  EMAX2 JSM MAXX    FIND THE MAX/MIN OF THE ARRAY
26121 000254        LDA P1      TO BUMP ONE PARAMETER AT A TIME
26122 140607        JSM ABUMP,I    BUMP ONE PARAMETER; IF NO MORE RET P+1
26123 067127        JMP MEXIT      *
              * IF ANY AT ALL RET P+2 ; GO BACK TO NGET
26124 067113        JMP EMAX1
              *
              *
26125 043171  EMAX3 JSM VMAX     FIND VAL; VALN; AND VALP
26126 067120        JMP EMAX2
              *
26127 001274  MEXIT LDA OPND2
26130 004340        LDB ARES
26131 071403        XFR 4     TRANSFER <T1,..T4> WHICH CONTAINS ANSWER FOUND
              *THROUGH  USING MAXX ROUTINE TO <RES>
26132 001722        LDA I10
26133 031263        STA AP1      AP1 POINTS TO FIRST ELEMENT ON STACK
26134 040615        JSM ABSAD     TO UPDATE AP1(UNSTACK)
26135 031263        STA AP1      A CONTAINS AP1 AFTER UNSTACKING ALLL & TRANSFER TO A.
              *
26136 170201        RET 1
              *
              *
              *********************************
              *
              *  MAX/MIN SUBROUTINE     ********
              *
              ***********           ***********
              *
              *  ASSUME THAT VAL CONTAINS THE ADDR. OF FIRST ELEMENT OF THE ARRAY
              *              VALN ''       THE NUMBER OF ELEMENTS OF THE ARRAY
              *
              *  <T1,.. T4 > CONTAINS THE FIRST ELEMENT OF THE ARRAY ON
              *  ENTRING MAXX; LATER ON IT WILL CONTAIN THE MAX/MIN AFTER
              *  EACH STEP OF COMPARISON DURING LOOKING FOR MAX/MIN
              *
              *  PROCEDURE:  SIMPLE LINEAR SEARCH ALGORITHM IS USED
              *              AT  START WE ASSUME THAT THE FIRST ELEMENT OF THE
              *             ARRAY IS THE MAX/MIN ELEMENT.
              *            WE COMPARE THAT ELEMENT WITH EACH ELEMENT OF THE
              *           ARRAY; IF WE FIND A LARGER/SMALLER ELEMENT E; WE REPALCE
              *          THE MAX/MIN BY THAT ELEMENT;PROCEED TILL YOU EXHAUST
              *     ALL THE ELEMENTS IN THE ARRAY.
              *
26137 055717  MAXX  DSZ T7   IF T7 WAS 1 MEANS THAT THIS IS THE FIRST TIME WE ENTER
26140 067151        JMP MAX4   WE ASSUME A MAX/MIN ALREADY IN OPND2
              *
26141 001734        LDA VAL     POINT TO FIRST ELEMENT TO BE CHECKED
26142 031274        STA OPND2    POINT TO ELEMENT AS MAX/MIN
              *  PRECISSION
              *  THIS <T1,..T4> IS ASSUMED TO BE MAX/MIN UNLESS THE MAXX SUB
              *  ROUTINE CONTINUES
              *MAX1 IS WHERE WE SHOULD START IF WE ARE ENTRING THE SUBROUTINE
              *  AFTER THE FIRST TIME
              *
26143 055733  MAX1  DSZ VALN IF VALN IS 0 ; LIST IS ALREADY EXHAUSTED
26144 067146        JMP *+2
26145 067170        JMP MOUT   FOUND THE MAX/MIN; CONTINUE AT MOUT
              *
26146 005734        LDB VAL
26147 024150        ADB M4    DECREMENT POINTER TO GET NEXT FLT. NUMBER
26150 035734        STB VAL
26151 005734  MAX4  LDB VAL
26152 035273        STB OPND1    POINT TO CURRENT ELEMENT AS OPND1
              *
26153 140562        JSM ATSU1,I   COMPARE NEW ELEMENT WITH ASSUMED MAX/MIN
              *
              *
              *  IF NEW = OLD    B=0
              *  IF NEW>  OLD    B=1
              *  IF NEW < OLD    B=3
              *
26154 076467        SZB MAX1        OLD = NEW KEEP OLD
26155 001716        LDA T6
26156 010257        CPA M1
26157 067165        JMP MIN1       T6 INDICATES THAT WE ARE HANDLING A MIN
              *  AT MIN1
```

MATH OPTION BLOCK B (MB16)

```
02419000                  *
02420000                  *  OTHERWISE WE ARE HANDLING A MAX NEXT
02421000                  *
02422000 26160  014144          CPB P3
02423000 26161  067143          JMP MAX1   NEW < OLD KEEP OLD
02424000                  *
02425000                  *
02426000 26162  001273    MAX2  LDA OPND1
02427000 26163  031274          STA OPND2  NEW > OLD  SAVE AS NEW MAX
02428000                  *
02429000 26164  067143          JMP MAX1      CONSIDER NEXT ELEMENT
02430000                  *
02431000                  *  THE CASE OF HANDLING A MIN
02432000                  *
02433000 26165  014254    MIN1  CPB P1
02434000 26166  067143          JMP MAX1    NEW > OLD ; SAVE OLD
02435000 26167  067162          JMP MAX2
02436000                  *
02437000 26170  170201    MOUT RET 1


02439000                  *
02440000                  *
02441000                  *  VMAX IS A SUBROUTINE TO FIND STARTING ADDRESS AND NUMBER OF
02442000                  *   WORDS ( 4 TIMES THE NUMBER OF ELEMENTS OF AN ARRAY)
02443000                  *
02444000 26171  001272    VMAX  LDA FAP1
02445000 26172  104000          LDB A,I
02446000 26173  174513          SBR 12    GET TYPE
02447000 26174  014131          CPB P14    ENTIRE ARRAY?
02448000 26175  067177          JMP *+2
02449000 26176  064733          JMP E32       EXPECTING NUMERIC DATA
02450000                  *
02451000 26177  020145          ADA P2
02452000 26200  104000          LDB A,I   B CONTAINS A POINTER TO STARTING ADDRESS
02453000 26201  024147          ADB M3
02454000 26202  035734          STB VAL
02455000 26203  020254          ADA P1
02456000 26204  104000          LDB A,I
02457000 26205  174501          SBR 2   DIVIDE BY 4
02458000 26206  035733          STB VALN    IS THE NUMBER OF ELEMENTS IN THE ARRAY
02459000 26207  170201          RET 1
02461000                  *
02462000                  *
02463000                  ************************************
02464000                  *
02465000                  *  RANDOM VALUE FUNCTION   ***********
02466000                  *
02467000                  ************************************
02468000                  *
02469000                  * ERND IS THE NAME: RND IS KEY  MNEMONIC
02470000                  *
02471000                  *  ENTRY : RND X
02472000                  *
02473000                  *  EXIT  : A RANDOM NUMBER BETWEEN 0 AND 1
02474000                  *
02475000                  *  PROCEDURE: 1. IF RND  THE FRACTIONAL PART OF 29*SEED IS
02476000                  *                             MULTIPLIED BY 29; THEN IT'S FRACTIONAL
02477000                  *                            PART IS TAKEN TO BE THE NEW SEED AND
02478000                  *                           THE RANDOM NUBER.
02479000                  *                 2. IF RND(X)   THE ARG. X IS TAKEN AS SEED AND CONTINUE
02480000                  *                          AS IN 1.
02481000                  *  REMARK:
02482000                  *         DUE TO THE POSSIBLITY OF D11,D12 OF THE RANDOM NUMBER
02483000                  *         BEING ZERO DUE TO FRACTIONAL SEPARATION D5,D6 ARE
02484000                  *         PACKED IN PLACE OF D11,D12 OF THE NUMBER
02485000                  *
02486000 26210  140552    ERND  JSM AGET1,I       GET THE OPERAND
02487000 26211  101273          LDA OPND1,I       EXPONENT WORD
02488000 26212  073005          SLA HERO     IS ARG.>=0
02489000                  *
02490000 26213  001273          LDA OPND1
02491000 26214  007006          LDB ASEED
02492000 26215  071403          XFR 4           <OPND1> TO <SEED>
02493000 26216  157006          DSZ ASEED,I    REMOVE MANTISSA SIGN
02494000                  *
02495000 26217  007006    HERO  LDB ASEED     ADDRESS OF SEED
02496000 26220  043234          JSM ERND1      ERND1 ROUTINE FINDS THE FRAC OF SEED * 29
02497000                  *
02498000 26221  005754          LDB RESM2
02499000 26222  174507          SBR 8
```

MATH OPTION BLOCK B (MB16)

```
02500000 26223  035727          STB T15      TO REPLACE THE LAST TWO DIGITS ORF RANDOM NUMBER
02501000                 *
02502000 26224  004340          LDB ARES
02503000 26225  043234          JSM ERND1       "        "       "       "    "    2  AR2     "  "
02504000                 *
02505000                 * NOW WE HAVE A RANDOM NUMBER AND A NEW SEED WITH THE
02506000                 *  POSSIBLITY OF 10 DIGIT MANTISSA INSTEAD OF 12
02507000                 *  TO FIX THAT WE WILL REPLACE D11D12 BY D6D7
02508000                 *
02509000 26226  001755          LDA RESM3
02510000 26227  050170          AND M256     MAKE SURE THAT D11,D12 ARE 0
02511000 26230  021727          ADA T15
02512000 26231  031755          STA RESM3
02513000 26232  000340          LDA ARES
02514000 26233  067013          JMP ININ          STOR NEW SEED
02515000                 *
02516000                 *
02517000                 *  SUBROUTINE ERND1
02518000                 *   TO MULTIPLY NUMBER SPECIFIED (POINTED TO) BY A
02519000                 *   BY 29. AND FIND THE FRACTIONAL PART I OF THE PRODUCT
02520000                 *   <RES> CONTAINS THE ANSWER
02521000                 *
02522000 26234  035273  ERND1 STB OPND1
02523000 26235  003070          LDA A29
02524000 26236  031274          STA OPND2      TO MULTIPLY BY 29.
02525000 26237  140556          JSM AMUL1,I
02526000 26240  000340          LDA ARES
02527000 26241  031273          STA OPND1
02528000 26242  043333          JSM IFREE     FIND FRACTIONAL PART IN <AR2>
02529000 26243  067326          JMP EFRA1     PUT FRACTION IN <RES>
02531000                 *
02532000                 *
02533000                 *****************************
02534000                 *
02535000                 *  MODULO VALUE FUNCTION
02536000                 *
02537000                 ************           *********
02538000                 *
02539000                 *  EMOD IS THE NAME ; MOD IS THE KEYB MNEMONIC
02540000                 *
02541000                 *  ENTRY : X MOD Y ; WHERE X, AND Y ARE INTEGERS; Y IS CALLED
02542000                 *                                THE BASE
02543000                 *
02544000                 *  EXIT  : THE RISIDUE OF DIVIDING X BY Y ; DEFINED AS:
02545000                 *                 X MOD Y = X- INT(X/Y)*Y
02546000                 *
02547000                 *
02548000                 *  GET X AND Y AS <OPND1> AND <OPND2> RESPECTIVLY
02549000                 *
02550000 26244  140553  EMOD   JSM AGET2,I
02551000 26245  001273          LDA OPND1
02552000 26246  007077          LDB FT1A
02553000 26247  071403          XFR 4        TRANFER X TO <T1...T4>
02554000                 *
02555000 26250  001274          LDA OPND2
02556000 26251  007100          LDB FT5A
02557000 26252  071403          XFR 4        TRANSFER Y TO <T5...T9>
02558000                 *
02559000                 *
02560000                 *
02561000                 *
02562000                 *  START THE MODULO SEARCH ROUTINE
02563000                 *  DIFFERENTIATE BETWEEN TWO TYPES OF VALUES FOR X
02564000                 *
02565000                 *       1. X WITH EXP.<9
02566000                 *       2. X WITH EXP.>9
02567000                 *
02568000                 *  IN THE FIRST CASE X MOD Y= X- INT(X/Y)*Y
02569000                 *
02570000                 *  IN THE SECOND CASE ; THE DEFINITION IF APPLIED WITHOUT SCALING
02571000                 *  WILL CAUSE ERROR DUE TO THE LIMITED NUMBER OF DIGITS IN THE
02572000                 *  MANTISSA. FOR THIS SITUATION WE ARE GOING TO FIND X/Y
02573000                 *  AND IF THE QUOTIENT HAS EXP.>8; WE WILL REDUCE THE LAST THREE
02574000                 *  DIGITS OF THAT QUOTIENT TO ZEROS AND REDUCE THE EXPONENT TO 8
02575000                 *  MULTIPLY THE BASE Y BY THAT AMOUNT (SCALED_QUOTIENT).
02576000                 *  SUBTRACT THE RESULT FROM THE ORIGNAL X AND REPLACE X BY
02577000                 *  THAT VALUE ; CONTINUE THIS SCALING TILL YOU REACH A SAFE VALUE
02578000                 *  FOR X TO APPLY THE DEFINITION OF MOD ON.
02579000                 *
02580000                 *
02581000 26253  140557  MSTA   JSM ADIV1,I     X/Y
02582000 26254  005716          LDB T6
02583000 26255  076411          SZB MZERO      IF Y=0;RETURN ZERO
02584000 26256  001752          LDA RESE
02585000 26257  170405          AAR 6
02586000 26260  005715          LDB T5
```

MATH OPTION BLOCK B (MB16)

```
02587000 26261  176003          SBP MSTA.
02588000 26262  010042          CPA B777      IS EXP(X)-EXP(Y)>=511
02589000 26263  067266          JMP MZERO      RETURN ZERO! OTHERWISE MACHINE WILL TAKE FOREVER TO
02590000                  *
02591000 26264  023076    MSTA. ADA M9
02592000 26265  172410          SAM MCONT      EXP DIFF<9!SAFE TO USE X-INT(X/Y)Y
02593000                  *
02594000                  *   GIVE A ZERO FOR ANSEWER
02595000                  *
02596000                  *
02597000                  *
02598000 26266  000340    MZERO LDA ARES
02599000 26267  071603          CLR 4         RETURN A ZERO
02600000 26270  170201          RET 1
02601000                  *
02602000 26271  001273    MODT  LDA OPND1
02603000 26272  004340          LDB ARES
02604000 26273  071403          XFR 4          RETURN X=XMODY
02605000 26274  170201          RET 1
02606000                  * COUNT THE MODULO ACCORDING THE GOLDEN, RULE
02607000                  *  X MOD Y = X- INT(X/Y)*Y
02608000                  *
02609000 26275  000340    MCONT LDA ARES
02610000 26276  007101          LDB FT9A
02611000 26277  071403          XFR 4
02612000 26300  035273          STB OPND1
02613000 26301  043432          JSM EINT.      FIND INTEGER PART
02614000                  *
02615000 26302  000340          LDA ARES
02616000 26303  031273          STA OPND1
02617000 26304  003100          LDA FT5A
02618000 26305  031274          STA OPND2
02619000 26306  140556    MCON1 JSM AMUL1,I
02620000 26307  000340          LDA ARES
02621000 26310  031274          STA OPND2
02622000 26311  003077          LDA FT1A
02623000 26312  031273          STA OPND1
02624000 26313  140555          JSM ASUB1,I
02625000 26314  170201          RET 1
02627000                  *
02628000                  *
02629000                  *
02630000                  *   FRACTION VALUE FUNCTION
02631000                  *   EFRAC IS THE NAME ! KEYB MNEMONIC IS FRAC
02632000                  *
02633000                  *   ENTRY IS A SINGLE ARG.
02634000                  *   EXIT IS THE FRACTIONAL PART IN THE MATHEMATICAL,(NOT ARITHMETIC)
02635000                  *   SENSE
02636000                  *
02637000                  *   THIS FUNCTION USES SUBROUTINE FREEK TO ACCOMPLISH FRACTION
02638000                  *   SEPARATION OF ABSOLUTE VALUE
02639000                  *
02640000                  *
02641000 26315  043332    EFRAC JSM FREEK      GO TO FRACTION SEPARATION ROUTINE
02642000 26316  000020    EEFR  LDA AR2E
02643000 26317  073007          SLA EFRA1    IF MANTISSA IS>= 0 ! GO TO EFRAC ROUTINE
02644000                  *
02645000                  *  ADD TO FRACTION 1.
02646000                  *
02647000 26320  000172          LDA AONE
02648000 26321  031273          STA OPND1
02649000 26322  000127          LDA AR2A
02650000 26323  031274          STA OPND2
02651000 26324  140554          JSM AADD1,I
02652000 26325  170201          RET 1
02653000 26326  000127    EFRA1 LDA AR2A
02654000 26327  004340          LDB ARES
02655000 26330  071403          XFR 4
02656000 26331  170201          RET 1
02658000                  * SUBROUTINE FREEK
02659000                  *
02660000                  *
02661000                  *  FOR FRACTIONAL VALUE SEPARARTION
02662000                  *
02663000                  *
02664000                  * ENTRY : ARG. ON TOP OF EXECUTION STACK
02665000                  * EXIT  : FRACTIONAL VALUE
02666000                  *
02667000                  *
02668000                  *
02669000 26332  140552    FREEK JSM AGET1,I
02670000 26333  001273    IFREE LDA OPND1
02671000 26334  004127          LDB AR2A
02672000 26335  071403          XFR  4           TRANSFER ARG. TO <AR2>
```

```
26336  004020        LDB AR2E
26337  176424        SBM NOACT    ARG. IS ALREADY A FRACTION ; NO INTEGER
                *                 PART TO REMOVE
26340  174505        SBR  6
                *
26341  000255        LDA M12
26342  020001        ADA B       EXP-12
26343  172021        SAP NOFRC   IF EP-12>=0  THER IS NO FRACTION PART
26344  024254        ADB  P1
26345  000177  LEFT  LDA P0
26346  075541        MLY       SHIFT MANTISSA LEFT TO REMOVE ONE DIGIT OF
                *                    INTEGER PART
26347  024257        ADB  M1
26350  076075        RZB LEFT    CONTINUE IN THE LOOP OF SHIFTING LEFT
26351  071500        NRM
26352  014133        CPB P12      A CASE OF ALL ZEROS MANTISSA
26353  067364        JMP NOFRC     RETURN A ZERO
26354  174040        TCB
26355  024257        ADB M1
26356  174605        SBL 6
26357  000020        LDA AR2E
26360  050254        AND P1    TO SAVE THE MANTISSA SIGN
26361  060001        IOR B    TO INCLUDE THE SIGN OF THE MANTISS WITH FRACTION
26362  030020        STA AR2E    NEW EXPONENT WORD
26363  170201  NOACT RET 1
                *
26364  000127  NOFRC LDA AR2A
26365  071603        CLR 4       ANSWER IS 0.
26366  170201        RFT 1
                *
                *
                *
                * RETURN SIGN FUNCTION
                * ESGN IS THE NAME ; SGN IS KEYB NEUMONIC
                *       ENTRY: ARGUMENT ON TOP OF EXECUTION SIACK
                *       EXIT : +1: IF ARG WAS FOUND POSITIVE
                *              0.0  IF ARG WAS FOUND TO BE ZERO
                *              -1  : IF ARG WAS FOUND TO BE NEGATIVE
                *
                *
                *
26367  140552  ESGN JSM AGET1,I     GET ONE OPERAND
26370  000172        LDA AONE
26371  004340        LDB ARES
26372  071403        XFR 4     STORE 1. IN <RES>
                *
26373  101273        LDA OPND1,I     LOAD EXPONENT WORD
26374  050254        AND P1          GET MANTISS SIGN
26375  031752        STA RESE        IT IS THE SIGN OF <RES> TTOO
                *
26376  045273        ISZ OPND1
26377  101273        LDA OPND1,I      THE FIRST WORD OF MANTISS A IN A
26400  072007        RZA EABSE     IF IT WAS NOT A ZERO RETURN
                *
26401  067266        JMP MZERO        CLEAR <RES>
                *
                *
                *
                * ABSOLUTE VALUE FUNCTION
                *
                * EABS IS THE NAME ; ABS IS THE KEYB NEUMONIC
                *****
                **
                * ENTER*: ARG. ON TOP OF EXECUTIO STACK
                * EXIT   : ABSOLUTE VALUE
                *
                *
                *
26402  140552  EABS  JSM AGET1,I
26403  043271        JSM MODT      OPND1 INT O RES
                *
26404  001752        LDA RESE   GET THE EXPONENT
26405  050146        AND M2     REMOVE THE MANTISSA SIGN
26406  031752        STA RESE
26407  170201  EABSE RET 1


                *
                ****************
                *
                *  INTEGER EXECUTION VALUE FUNCTION
                *
                *  EDINT IS THE NAME ; DINT IS THE KEYB MNEMONIC
```

```
02758000                      *
02759000                      *
02760000                      *  ENTRY 1 IS THE SINGLE ARG.
02761000                      *  EXIT  :  THE INTEGER PART OF THE EQUIVALENT ABSOLUTE VALUE
02762000                      *
02763000                      *
02765000                      *
02766000                      *
02767000 26410  105273  IDINT  LDB OPND1,I
02768000 26411  174405  DINT1  ABR  6
02769000 26412  176002         SRP *+2
02770000 26413  067266  DINT2  JMP MZERO       CLEAR <RES>
02771000 26414  024155         ADB M11       IF THE EXPONENT IS >= 11, RETURN THE ARGUMENT.
02772000 26415  176402         SRM *+2
02773000 26416  067271  DINT3  JMP MODT       OPND1 INTO <RES>
02774000 26417  174040         TCB           B = NO. OF DIGITS TO RIGHT SHIFT OUT OF AR2.
02775000 26420  035762         STB MT1
02776000 26421  001273         LDA OPND1
02777000 26422  004127         LDB AR2A      TRANSFER THE ARGUMENT TO AR2
02778000 26423  071403         XFR 4
02779000 26424  005762         LDB MT1
02780000 26425  000177         LDA P0
02781000 26426  075500         MRY           PERFORM THE RIGHT SHIFT.
02782000 26427  071500  DINT4  NRM
02783000 26430  067326         JMP EFRA1      <AR2> INTO <RES>
02785000                      *
02786000                      *
02787000                      *
02788000                      *  INTEGER VALUE FUNCTION
02789000                      *  THIS IS THE INTFGER VALUE ACCORDING TO THE MATHEMATICAL
02790000                      *  DEFINITION AS (THE FLOOR ACCORDING TO APL NOTATION)
02791000                      *
02792000                      *
02793000                      *  ENTRY : A SINGLE ARG.
02794000                      *  EXIT  : THE LARGES  INTEGER SMALLER OR EQUAL TO ARG.
02795000                      *
02796000                      *
02797000 26431  140552  EINT   JSM AGET1,I     GET ARG.
02798000 26432  043410  EINT.  JSM IDINT        GO TO DECIMAL SEPARATION ROUTINE
02799000 26433  001273         LDA OPND1
02800000 26434  031274         STA OPND2      POINT TO ARG. AS OPND2
02801000 26435  000340         LDA ARES
02802000 26436  031273         STA OPND1     POINT TO DINT AS OPND1
02803000                      *  IF THE ARG WAS POSITIVE DINT=INT I GO TO INT1
02804000                      *
02805000                      *   IF THE INTEGER IS ZRO WE SHOULD CHECK IF THE ARG. WAS A ZERO
02806000                      *   OR IT WAS A FRACTION WITH ABS. VALUE <1
02807000 26437  140562         JSM ATSU1,I     FIND DINT-ARG
02808000 26440  076406         SZB INT1     IF ARG WAS INTEGER INT=DINT
02809000 26441  014144         CPB P3
02810000 26442  067446         JMP INT1
02811000 26443  000172         LDA AONE     POINT TO FL 1.
02812000 26444  031274         STA OPND2
02813000 26445  140555         JSM ASUB1,I   ADD -1. TO DINT TO GET INT
02814000 26446  170201  INT1   RET 1
02816000                       END

END OF PASS 2 NO ERRORS DETECTED
```

BASE-PAGE READ-WRITE-MEMORY

```
00003000 76550                 ORG 76550B
00004000                       UNL
02000000                       LST
02001000                      *
02003000 00505                 ORG APGET
02004000 00505  026476         DEF PGET
02005000 00506  026571         DEF PNUM
02006000 00507  027034         DEF INTCK
02007000 00510  026755         DEF GLENL
02008000 00511  026765         DEF GLEOL
02009000 00512  026773         DEF FLADR
02010000 00513  026775         DEF FLINA
02011000 00514  027025         DEF SLLN
02012000 00515  027101         DEF STKEX
02013000 00516  027116         DEF UNSTK
02014000 00517  027216         DEF AJINS
02015000 00520  027262         DEF AJDEL
02016000 00521  027132         DEF STKPT
02017000 00522  027062         DEF DIGXX    DIGIT CHECK ROUTINE
02018000 00523  027170         DEF GLNUM    GET LINE NUMBER
02019000                      *
02020000 00575                 ORG AFXD
02021000 00575  026714         DEF EFIX
02022000 00576  026717         DEF EFLT
```

CONTROL AND I/O SUPERVISOR ROUTINES

```
02025000                   ************************************************************
02026000 26476                   ORG 26476B
02027000                   *
02028000                   *** GET NEXT PARAMETER FROM PRINT LIST ***
02029000                   *
02030000                   *   ENTRY: LDA FLAG
02031000                   *          JSM PGET     TO GET FIRST PARAMETER
02032000                   *
02033000                   *          LDA N     N=# PLACES TO BUMP FAP1 (N=1 FOR NEXT
02034000                   *                    PARAMETER), N>=0
02035000                   *          JSM PGET     TO GET SUBSEQUENT PARAMETERS
02036000                   *
02037000                   *   EXIT:  RETURN P+1 : PARAMETER LIST EXHAUSTED
02038000                   *          RETURN P+2 : NEXT PARAMETER FETCHED
02039000                   *           A= 0:NUMERIC, 1:STRING
02040000                   *           B= CHARACTER COUNT
02041000                   *           D= BYTE ADDRESS OF FIRST CHARACTER
02042000                   *
02043000                   *              IF B=-1, BUILDING OUTPUT STRING WAS NOT POSSIBLE
02044000                   *                   A=PARAMETER CLASS
02045000                   *
02046000 26476  005217  PGET  LDB .WPRT     SET FIX/FLT INDICATOR
02047000 26477  035216        STB SIOCP
02048000 26500  172003        SAP PGETN
02049000 26501  140610        JSM ACOUN,I
02050000 26502  067505        JMP PGETO
02051000 26503  140607  PGETN JSM ABUMP,I
02052000 26504  170201        RET 1         RETURN 1 IF LIST EXHAUSTED
02053000 26505  040751  PGETO JSM NGET      GET NEXT NUMBER
02054000 26506  067645        JMP PGETC     IT WASN'T NUMERIC, SO CHECK IT FOR STRING
02055000                   *
02056000                   *** THIS SECTION PROCESSES A NUMERIC ITEM
02057000                   *
02058000                   *
02059000                   *
02060000 26507  000001  PNNUM LDA B
02061000 26510  004336        LDB AOP1      PUT THE VALUE IN OP1
02062000 26511  071403        XFR 4
02063000 26512  035273        STB OPND1     SAVE ADDRESS FOR ROUND ROUTINE
02064000 26513  000254        LDA P1
02065000 26514  031713        STA T3        SET INITIAL COUNT TO 1
02066000 26515  140551        JSM AFLTC,I   CHECK FOR RANGE E+/-99
02067000 26516  000305        LDA ASTAK     GET ADDRESS-1 OF COMPILE STACK
02068000 26517  030017        STA D         AND INITIALIZE BUFFER POINTER
02069000 26520  105273        LDB OPND1,I   GET EXPONENT WORD
02070000 26521  043671        JSM PSIGN     AND DUMP THE +/- CHARACTER
02071000 26522  001216        LDA SIOCP      GET THE FIXED/FLOAT FLAG
02072000 26523  172002        SAP *+2       IS IT FIXED?
02073000 26524  067574        JMP PFLT      NO, PROCESS FLT FORMAT
02074000 26525  174405        ABR 6         B=EXPONENT
02075000 26526  035712        STB T2
02076000 26527  170503        SAR 4         A=N(FIXED)
02077000 26530  050130        AND P15
02078000 26531  031711        STA T1
02079000 26532  020001        ADA B         A = N+E
02080000 26533  022464        ADA M14       CHECK FOR COUNT >= 15
02081000 26534  172405        SAM PFIX       NO, DO A FIXPT OUTPUT
02082000 26535  005216        LDB SIOCP      YES, CHECK IF FLT REVERSION IS OK
02083000 26536  174600        SBL 1          POSITION BIT14 FOR CHECK
02084000 26537  001216        LDA SIOCP      GET FIX/FLT WORD JUST IN CASE
02085000 26540  176034        SBP PFLT       IF OK, REVERT TO FLOAT
02086000                   *
02087000                   *** THIS SECTION BUILDS A FIXED POINT NUMBER
02088000                   *
02089000 26541  005711  PFIX  LDB T1        B=N
02090000 26542  174040        TCB           SET B=-N FOR PROUND ROUTINE
02091000 26543  173201        SOC *+1,C     CLEAR OVF FOR ROUND ROUTINE
02092000 26544  000544        LDA APRND
02093000 26545  020144        ADA P3
02094000 26546  140000        JSM A,I       JUMP IN AT PRND+3
02095000 26547  000340        LDA ARES
02096000 26550  004127        LDB AOR2
02097000 26551  071403        XFR 4         PUT ROUNDED RESULT IN AR2
02098000 26552  104001        LDB B,I       GET EXPONENT WORD
02099000 26553  174405        ABR 6         B=EXPONENT
02100000 26554  176011        SBP PFIX1     IF B POS, ALL OK
02101000 26555  174040        TCB           OTHERWISE, SHIFT E+1 ZEROS
02102000 26556  000001        LDA B         INTO AR2
02103000 26557  170503        SAR 4
02104000 26560  072402        SZA *+2       IF B>15
02105000 26561  004133        LDB P12       USE 12
02106000 26562  000177        LDA P0        SET UP A FOR MRY
02107000 26563  075500        MRY           AND SHIFT IN B ZEROS
02108000 26564  004177        LDB P0        SET B=0 FOR NO CHARACTERS BEFORE DP
02109000 26565  024254  PFIX1 ADB P1        SET ONE MORE LEADING DIGIT
```

```
26566  043676        JSM PDUMP   OUTPUT THE NUMBER TO BUFFER
26567  005713        LDB T3      GET CHARACTER COUNT
26570  067641        JMP POUT    AND GET OUT
                *
                *
                *    ROUTINE TO PROCESS A NUMERIC ITEM
                *
26571  001217  PNUM  LDA .WPRT    SET FIX/FLT INDICATOR
26572  031216        STA SIOCP
26573  067507        JMP PNNUM
                *
                *
                *** THIS SECTION BUILDS A FLOATING POINT NUMBER
                *
                *
26574  050130  PFLT  AND P15     SAVE N(FLOAT)
26575  031711        STA T1
26576  001273        LDA OPND1
26577  004127        LDB ADR2
26600  071403        XFR 4       PUT THE NUMBER IN AR2 FOR ROUNDING
26601  000140        LDA P7      SET FOR ROUND TYPE
26602  005711        LDB T1
26603  024254        ADB P1      SET FOR ROUND ON DIGIT N+1
26604  140547        JSM ARND,I  AND DO IT.
26605  100127        LDA ADR2,I  GET EXPONENT WORD
26606  170405        AAR 6       A=EXPONENT
26607  020206        ADA M100    CHECK FOR ROUND OVERFLOW
26610  172404        SAM *+4     IF A<0, THEN E<100 AND ALL IS OK
26611  000336        LDA AOP1
26612  004127        LDB ADR2
26613  071403        XFR 4       IF A=0, USE ORIGINAL NUMBER
26614  004254        LDB P1      SET FOR 1 CHAR, BEFORE DP
26615  043676        JSM PDUMP   OUTPUT MANTISSA TO BUFFER
26616  000063        LDA B145     B145= ASCII LOWER CASE E  FOR EXPONENT
26617  074550        PBD A,I     OUTPUT THE "E"
26620  104127        LDB ADR2,I      GET EXPON, WORD
26621  174716        RBR 15       POSITION EXP, SIGN BIT FOR TEST
26622  043671        JSM PSIGN   OUTPUT A +/-
26623  000257        LDA M1      SET A FOR EXPONENT COUNT
26624  174700        RBR 1
26625  174405        ABR 6
26626  176002        SBP *+2
26627  174040        TCB
26630  024207        ADB M10     SUBTRACT 10
26631  020254        ADA P1      AND INCREMENT COUNT
26632  176076        SBP *-2     UNTIL B GOES NEGATIVE
26633  020103        ADA P48     MAKE COUNT IN A AN ASCII NUMBER
26634  074550        PBD A,I     AND SEND 10'S DIGIT
26635  024077        ADB P58     RESTORE LAST 10, AND MAKE ASCII
26636  074551        PBD B,I     AND SEND UNITS DIGIT
26637  004143        LDB P4      SET COUNT TO 4 FOR "E+XX"
26640  025713        ADB T3      ADD IN PREVIOUS COUNT
26641  000325  POUT  LDA ACSTF   SET D TO FIRST BYTE
26642  030017        STA D       OF COMPILER STACK BUFFER
26643  000177        LDA P0      SET FOR NUMERIC RESULT
26644  170202        RET 2       AND GET OUT!!!
                *
                *** THIS SECTION CHECKS A NON-NUMERIC FOR A STRING
                *
26645  101272  PGETC LDA FAP1,I   GET ORIGINAL WHAT WORD
26646  010221        CPA NWWD     SEE IF NUMERIC
26647  170201        RET 1        EMPTY LIST IF SO
26650  004000        LDB A        AND COPY INTO B
26651  174601        SBL 2        CHECK BIT 13
26652  176003        SBP PSTR     IF ZERO, THIS IS A STRING
26653  004257        LDB M1       SET B=-1 FOR "SOMETHING ROTTEN IN DENMARK"
26654  170202        RET 2        AND GIVE IT UP
                *
                *** THIS PROCESSES A STRING
                *
26655  172005  PSTR SAP PSTRC    IF A POS,STRING CONSTANT
26656  141324        JSM AKOUN,I  IF A NEG,CALL ON STRING ROM FOR WHERE,COUNT
                *                 ADDRESS OF KOUNT IN SROM
26657  030017  PSTRE STA D       SET BYTE ADDR OF START OF STRING
26660  000254        LDA P1       SET A FOR STRING RESULT
26661  170202        RET 2
                *
26662  001272  PSTRC LDA FAP1
26663  020144        ADA P3       POINT TO LENGTH
26664  104000        LDB A,I      B = COUNT OF CHARACTERS
26665  020257        ADA M1         PT TO WHERE WORD
26666  100000        LDA A,I        GET WHERE WORD
26667  021272        ADA FAP1       FIND ADDR OF FIRST CHAR
```

```
26670  067657         JMP PSTRE
                *
                *** SUBROUTINES
                *
26671  000117  PSIGN  LDA P32      A=ASCII BLANK
26672  077002         SLB *+2      IF MANTISSA POSITIVE, KEEP BLANK
26673  000106         LDA P45      OTHERWISE, USE MINUS
26674  074550         PBD A,I      OUTPUT IT
26675  170201         RET 1
                *
26676  043704  PDUMP  JSM PDUMB    DUMP B LEADING DIGITS
26677  005711         LDB T1       GET N
26700  076413         SZB PRET1    IF N=0, NO DECIMAL OR DIGITS FOLLOW
26701  000105         LDA P46      IF N>0, SEND DECIMAL POINT
26702  074550         PBD A,I
26703  045713         ISZ T3       AND BUMP COUNT
26704  000177  PDUMB  LDA P0         SET FOR MLY TO SHIFT IN ZEROS
26705  075541         MLY            SHIFT OUT NEXT DIGIT
26706  020103         ADA P48      MAKE IT ASCII
26707  074550         PBD A,I      SEND IT
26710  045713         ISZ T3       AND BUMP COUNT
26711  054001         DSZ B        LOOP UNTIL B=0
26712  067704         JMP PDUMB
26713  170201  PRET1  RET 1
                *
                *
                *       FIXED AND FLOAT EXECUTION
                *
                *
26714  001217  EFIX   LDA .WPRT      GET CURRENT .WPRT
26715  172201         SAP *+1,C      SET FIXED
26716  067721         JMP EFIX1
26717  001217  EFLT   LDA .WPRT      GET CURRENT .WPRT
26720  172301         SAP *+1,S      SET FOR FLOAT
26721  031217  EFIX1  STA .WPRT      PUT IT BACK FOR NOW
26722  140610         JSM ACOUN,I    HOW MANY PARAMETERS
26723  040751         JSM NGET       ONE: FIND IT
26724  067751         JMP NONUM      NOT NUMERIC,GIVE AN ERROR IF NOT NULL
26725  000001         LDA B          OK, MOVE IT TO A
26726  040644         JSM FIXPT      AND MAKE AN INTEGER
26727  173405         SOS ERFFL      OUT OF RANGE; GIVE ERROR
26730  176404         SBM ERFFL      OUT OF RANGE
26731  000001         LDA B
26732  020255         ADA M12        TEST FOR > 11
26733  172403         SAM *+3      OK ,  CONT.
26734  140404  ERFFL  JSM AERR1,I    GIVE ERROR 17
26735  030467         ASC 1,17
                *
26736  001217         LDA .WPRT
26737  172004         SAP EFL3       FIX/FLT ?
26740  050160         AND M16        PUT B INTO
26741  060001         IOR B          FLOAT POSITION
26742  067747         JMP EFL2       AND CLEAN UP
26743  170703  EFL3   RAR 4
26744  050160         AND M16      PUT B INTO
26745  060001         IOR B        FIXED POSITION
26746  170713         RAR 12
26747  031217  EFL2   STA .WPRT     PUT FINAL VALUE BACK
26750  164365  EFOUT  JMP AINTX,I   BACK TO INTERPRETER
                *
26751  010140  NONUM  CPA P7        IS IT THE NULL PARAMETER?
26752  164365         JMP AINTX,I   YES, RETURN TO INTERPRETER
26753  140404  ERUND  JSM AERR1,I   NON-NUMERIC PARAMETER
26754  030470         ASC 1,18
                *
                *
                *      GET LENGTH OFLINE
                *
                *                    ENTRY: INFO IN COMPILE BUFF
                *
                *       EXIT: TMP4 =LINE LENGTH+1  =A
                *
                *
26755  043765  GLENL  JSM GLEOL     FIND EOL ADDRESS
26756  004016  GLEN2  LDB C         GET HIGH CHAR POINTR
26757  000302         LDA ACBFX
26760  140362         JSM AFBAD,I   FIND BYTE ADDR DIFF
26761  020142         ADA P5        ROUND UP, ADD 2 WORDS
26762  170500         SAR 1         MAKE WORDS
26763  031234         STA TMP4      SAVE LINE LENGTH
26764  170201         RET 1
                *
                ************************************************************
                *
```

CONTROL AND I/O SUPERVISOR ROUTINES

```
02277000                * GLEOL   GET EOL ADDR IN COMPILE BUFF
02278000                *         EXIT  B CONTAINS 177B+ C POINTS TO BYTE BEFORE EOL
02279000                *
02280000                *********************
02281000                *
02282000 26765  000305  GLEOL LDA ACLMT     END ADDR OF COMPILER
02283000 26766  030016        SYA C         SET POINTER
02284000 26767  074761  GLEN1 WBC B,D       GET A BYTE
02285000 26770  014053        CPB EOL       END OF LINE?
02286000 26771  170201        RET 1         YES, RETURN
02287000 26772  067767        JMP GLEN1     NO, CONTINUE
02288000                *
02289000                ***************************************************************
02290000                *
02291000                * FLADR,FLINA  FINDLINE ADDRESS
02292000                *              FLADR ENTRY   LINE NO. IN LNO
02293000                *              FLINA ENTRY   LINE NO. IN TMP7
02294000                *
02295000                *              EXITLNO CHANGED TO -1 IF A NULL PROGRAM
02296000                *                     RET P+2    A= S/A OF LINE
02297000                *
02298000                *                     RET P+1    LINE NOT FOUND OR NULL PROGRAM
02299000                *                     B CONTAINS LAST LINE NO. OR -1
02300000                *                                K ALSO CONTAINS LNIE # IF NOT A NULL PROG
02301000                *
02302000                *********************
02303000                *
02304000 26773  005226  FLADR LDB LNO        GET LINE NO.
02305000 26774  035233        STB TMP7       SAVE IT
02306000 26775  001307  FLINA LDA FWUP       FIRST WORD OF USER PROGRAM
02307000 26776  011277        CPA END$       NULL PROGRAM?
02308000 26777  066023        JMP SLLN1      SET LNO = -1 IF A NULL PROG
02309000 27000  004177        LDB P0
02310000 27001  035224        STB K          INITIALIZE LINE COUNT
02311000 27002  104000  FLAD1 LDB A,I        GET LINE BRIDGE
02312000 27003  174610        SBL 9
02313000 27004  174510        SBR 9          GET LENGTH OF LINE
02314000 27005  035722        STB T10        AND SAVE IT
02315000 27006  024000        ADB A          B = S/A OF NEXT LINE
02316000 27007  015277        CPB END$       END OF PROGRAM?
02317000 27010  066017        JMP FLAD2      YES
02318000 27011  005224        LDB K         GET LINE NO.
02319000 27012  015233        CPB TMP7       LINE FOUND?
02320000 27013  170202        RET 2          YES
02321000                *
02322000 27014  045224        ISZ K         INCREM LINE COUNT
02323000 27015  021722        ADA T10        A = S/A OF NEXT LINE
02324000 27016  066002        JMP FLAD1      CONT
02325000 27017  005224  FLAD2 LDB K        GET LINE NO.
02326000 27020  015233        CPB TMP7       LINE FOUND?
02327000 27021  170202        RET 2          YES
02328000 27022  170201        RET 1
02329000                *
02330000 27023  004257  SLLN1 LDB M1
02331000 27024  066032        JMP SLLN2      SET LNO TO -1
02332000                *
02333000                *
02334000                *     SET "LNO" TO VALUE OF LAST LINE NO.
02335000                *
02336000                *     IF NULL PROG;SET "LNO" = -1
02337000                *
02338000                *
02339000 27025  000263  SLLN  LDA MAXLN     MAX LINE NO.
02340000 27026  031226        STA LNO
02341000 27027  043773        JSM FLADR     SET LNO TO -1 OR LAST LINE NO.
02342000 27030  066032        JMP SLLN2     LINE SHOULD NOT BE FOUND
02343000 27031  140424        JSM ASYER,I   E[illegible] IF FOUND
02344000 27032  035226  SLLN2 STB LNO       SET LNO
02345000 27033  170201        RET 1
02346000                *
02347000                *
02348000                *     BUILD AN INTEGER AND CHECK THE MAX. VALUE
02349000                *
02350000                *     ENTRY;  A = FIRST CHAR
02351000                *
02352000                *
02353000                *     EXIT;   B = INTEGER
02354000                *
02355000                *          "L" GNEXT POINTR HAS BEEN ADVANCED
02356000                *
02357000                *
02358000 27034  004177  INTCK LDB P0
02359000 27035  035224        STB K          INITIALIZE PARTIAL RESULT
02360000 27036  042061        JSM DIGCK      FIRST CHAR A DIGIT?
```

CONTROL AND I/O SUPERVISOR ROUTINES

```
27037  066047         JMP ERINT    NO
27040  042061   INTC1 JSM DIGCK    IS IT A DIGIT?
27041  066057         JMP INTC2    NO
27042  001224         LDA K        GET PARTIAL RESULT
27043  035224         STB K        SAVE LATEST DIGIT
27044  004135         LDB P10      MULTIPLY PARTIAL RESULT
27045  075617         MPY          BY 10
27046  076403         SZB *+3      INTEGER WITHIN "A" ?
27047  140404   ERINT JSM AERR1,I  NO! ERROR
27050  030461         ASC 1,11
                *
27051  172476         SAM ERINT    SKIP ON "A" TOO LARGE
27052  021224         ADA K        ADD LATEST DIGIT
27053  172474         SAM ERINT    SKIP ON OVERFLOW
27054  031224         STA K        SAVE PARTIAL RESULT
27055  140501         JSM AGNXT,I  GET NEXT CHARACTER
27056  066040         JMP INTC1    CONT
27057  005224   INTC2 LDB K        GET INTEGER
27060  170201         RET 1
                *
                *
                *     CHECK FOR A DIGIT
                *
                *      DIDCK ENTRY  A= CHARACTER
                *      DIGXX ENTRY B = LOW LIMIT(LOWER HALF) AND HIGH LIMIT
                *                       (UPPER HALF) WITH A= CHARACTER
                *
                *     EXIT:   RET P+1 NOT FOUND
                *
                *             RET P+2 FOUND! ASCII IN A! DIGIT IN B
                *
                *
27061  006465   DIGCK LDB DLIMT      GET DIGIT LIMITS
27062  035221   DIGXX STB PLADD      SAVE LIMITS
27063  174507         SBR 8          GET UPPER LIMIT
27064  174140         CMB            ONES COMPLEMENT
27065  024000         ADB A          ADD ASCII CODE
27066  176012         SBP DIG1       SKIP IF CODE EXCEEDS UPPER LIMIT
27067  005221         LDB PLADD      GET LIMITS
27070  174707         RBR 8
27071  174507         SBR 8          GET LOWER LIMITS
27072  174040         TCB            MAKE NEG.
27073  024000         ADB A          ADD ASCII CODE
27074  176404         SBM DIG1       SKIP IF CODE LESS THAN LOWER LIMIT
27075  004000         LDB A          CODE WITHIN LIMITS
27076  024163         ADB M48        GET BINARY DIGIT
27077  170202         RET 2
                *
27100  170201   DIG1  RET 1
                *
                *
                **********************************************************************
                *
                * STKEX   STACK INFO BEFORE EXECUTION
                *
                *******************
                *
27101  000147   STKEX LDA M3       PUT RELATIVE AP3,AP1
27102  042132         JSM STKPT    ON THE EXECUTION STACK
27103  032060         ASC 1,40     STACK OVERFLOW ERROR #
27104  001264         LDA LEND     PUT LEND ON THE STACK ALSO
27105  070550         PWD A,I
27106  000017         LDA D        GET STACK PTR
27107  050344         AND MAW      CLEAR BIT 15
27110  020147         ADA M3       PT TO LOCATION TO PUT -1 ON STACK
27111  004257         LDB M1
27112  134000         STB A,I      PUT -1 ON STACK  NEW BOTTOM OF STACK
27113  031261         STA AP3      SET NEW STACK POINTERS
27114  031263         STA AP1
27115  170201         RET 1
                *
                **********************************************************************
                *
                * UNSTK   UNSTACK INFO AFTER EXECUTION
                *
                *********************
                *
27116  101261   UNSTK LDA AP3,I    STRIP OFF GOSUBS
27117  010257         CPA M1       BY LOOKING FOR -1
27120  066124         JMP UNST1
27121  021300         ADA AP2      MAKE AN ABSOLUTE ADDRESS
27122  031261         STA AP3      *-1 SO KEEP LOOKING
27123  066116         JMP UNSTK
27124  001261   UNST1 LDA AP3      GET PTR
27125  020254         ADA P1       BUMP PAST THE -1
```

CONTROL AND I/O SUPERVISOR ROUTINES

```
27126  042160        JSM UNSPT     UNSTACK RELATIVE AP3,AP1
27127  070770        WWD A         GET LEND FROM THE STACK
27130  031264        STA LEND
27131  170201        RET 1
              *
              ************************************************************
              *
              *  STKPT   ROUTINE THAT PUTS AP3, AP1 ON THE EXECUTION
              *          STACK.   CALLED BY
              *                            LDA M#
              *                            JSM ASTKG,I
              *                               ASC 1,ERROR #
              *
              *          WHERE M# IS THE NEG OFFSET FROM AP1 TO PUT THE
              *          RELATIVE AP3.   IF STACK OVERFLOW OCCURS
              *          JMP AERR1,I IS EXECUTED.  ON RETURN D POINTS
              *         TO WHERE AP1 IS LOCATED ON THE STACK.  AP3,
              *          AP1 POINTS TO THE AP3 ON THE STACK (NEW TOP
              *          OF THE STACK)
              *
              ************************
              *
27132  021263 STKPT ADA AP1       A NOW POINTS TO LOCATION TO PUT AP3
27133  020257       ADA M1        ALLOW AN EXTRA WORD AND SET FOR TRANSFER
27134  005310       LDB RMAX      SEE IF MEM OVERFLOW
27135  174140       CMB           -STACK LIMIT
27136  024000       ADB A
27137  176002       SBP STK1      NO OVERFLOW IF RESULT POSITIVE
              *
27140  164404       JMP AERR1,I   OVERFLOW ERROR
              *
27141  030017 STK1  STA D         SET THANSFER POINTER
27142  001300       LDA AP2       POINTERS SHOULD BE RELATIVE TO AP2
27143  170040       TCA           SO SUBTRACT AP2
              *
27144  005261       LDB AP3       TRANSFER AP3
27145  024000       ADB A
27146  070551       PWD B,I
              *
27147  005263       LDB AP1       TRANSFER AP1
27150  024000       ADB A
27151  070551       PWD B,I
              *
27152  000017       LDA D         A NOW POINTS TO AP1 ON STACK
27153  050344       AND MAW       CLEAR BIT 15 OF A
27154  020257       ADA M1        POINT TO AP3 ON STACK
27155  031261       STA AP3       SET PTRS TO NEW TOP OF STACK
27156  031263       STA AP1
27157  170202       RET 2         NO OVER FLOW SO RETURN P+2
              *
              ***************************************************************
              *
              *  UNSPT   ROUTINE TO RESTORE AP3,AP1 FROM STACK
              *          WHEN CALLED A POINTS TO AP3 ON STACK, AFTERWARDS,
              *          D POINTS TO WORD AFTER AP1 ON STACK
              *
              ********************
              *
27160  030017 UNSPT STA D         SET STACK POINTER
              *
27161  070570       WWD A,I       GET RELATIVE AP3 FROM STACK
27162  021300       ADA AP2       MAKE AN ABSOLUTE ADDRESS
27163  031261       STA AP3
              *
27164  070570       WWD A,I       GET AP1
27165  021300       ADA AP2
27166  031263       STA AP1
              *
27167  170201       RET 1         D NOW POINTS TO WORD AFTER AP1
              *
              *
              ************************************************************
              *
              * AGLNO GET LINE #
              *
              *                   ENTRY:  B CONTAINS ADDR OF LINE
              *
              *                   EXIT:  LINE NO. IN LNO
              *
              ***************************
              *
27170  035732 GLNUM STB T18       SAVE ADDR
27171  000177       LDA P0        SET LNO = 0 INITIALLY
```

```
27172  031226        STA LNO
27173  005307        LOB FWUP      START SEARCH AT BEGGINNING OF PROGRAM
               *
27174  001277  GLN2  LDA END$      SEE IF PAST END OF PROGRAM
27175  170040        TCA
27176  020001        ADA B         ADD CURRENT ADDR
27177  172407        SAM GLN1      OK IF NEG RESULT
27200  072004        RZA GLERR     ERROR IF >0
27201  100001        LDA B,I       =0 SO END OF PROGRAM
27202  050053        AND B177      GET LAST LINE LINK
27203  072404        SZA GLRT      ERROR IF NOT ZERO
               *
27204  140404  GLERR JSM AERR1,I   ERROR, LINE BRIDGES MESSED UP
27205  030464        ASC 1,14
               *
27206  015732  GLN1  CPB T18       FOUND IT?
27207  170201  GLRT  RET 1         YES
27210  045226        ISZ LNO       NO KEEP SEARCHING
27211  100001        LDA B,I       GET LINE BRIDGE
27212  050053        AND B177      LOOK ONLY AT LINE LENGTH
27213  024000        ADB A         ADD TO CURRENT ADDRESS
27214  072470        SZA GLERR     ERROR IF LENGTH = 0
27215  066174        JMP GLN2
               *
               *

                     ********GTO AND GSB ADJUSTING ROUTINES*********

               *
               *
               *
               *
               *
               *
               *     AJGTU ADJUSTS GTO AND GSB DESTINATIONS AFTER AN INSERT
               *     OR DELETE LINE OPERATION
               *
               *
               *     ON ENTRY : ENTRY AT AJINS IS FOR GTO MODIFICATION AFTER AN INSERT
               *                ENTRY AT AJDEL IS FOR GTO MODIFICATION BEFORE A DELETE
               *                T9 = LN1 IF THIS IS A INSERT
               *                T7 = LN2 IF THIS IS A DELETE
               *                ERRORS :
               *                                  ON DELETE THE DELETION OF A GTO'S
               *             DESTINATION IS ERROR 36
               *
               *
               *     ON EXIT : RET 1 IF THE GTOS AND GSBS ARE ADJUSTED
               *               ELSE RETURN THROUGH AERR1
               *
               *
               *     TEMPORARIES USED : T11, T6, T7, T9, T2, T15, T17, LNO
               *
               *                      LKTMP+6 (DFLAG)
               *     ROUTINES CALLED : AERR1, ARLNO, ARLNF, AFCI, AFCC, AGLNO
               *
               *
               *
               *
               *     ADJUSTMENT CRITERIA :
               *
               *     FORMAT OF GTO/GSB :
               *
               *     *****  *****  *****  *****  *****  *****
               *    OPCODE  H.S. GTO       44     GTO # IF
               *    OCTAL   ADDRESS        42     <---- 44
               *     224-   (0 IF UNSET)   '44= NUMERIC
               *     231                    42= STRING FOLLOWS
               *
               *
               *     INSERT CASE :
               *
               *      INSERT OPERATES BY SCANNING THE PROGRAM 6 TIMES FOR EACH
               *     OF THE 6 GTO/GSB CODES. WHEN A GTO/GSB CODE IS FOUND, THE LINE
               *     NUMBER OF THE ASSOCIATED LINE IS CALCULATED, VIA SUBROUTINE,
               *     AS A REFERENCE. THE GTO/GSB DESTINATION IS ALSO GENERATED
               *     BY TAKING THE TWO BYTES AFTER THE 44 IS FOUND AND MAKING
               *     THESE TWO BYTES A NUMBER. THIS INFORMATION IS THE INPUT TO THE
               *     ADJUSTMENT ROUTINES WHICH DECIDE, BASED ON THE TYPE OF GTO/GSB
               *     ENCOUNTERED (I,-, ASB,) THE VALUE OF THE GTO/GSB, AND THE
               *     LINE NUMBER OF THE LINE CONTAINING THE GTO/GSB.
               *
               *     THE FOLLOWING RULES APPLY TO INSERTS :
               *
```

```
                                  ********GTO AND GSB ADJUSTING ROUTINES*********

                           *      1). '+' RELATIVE : IF LN1>LNO AND LNO+K>=LN1 OR
                           *      2). '-' RELATIVE : LN1<=LNO AND LNO-K<=LN1 OR
                           *      3). ABSOLUTE    :  K<=LN1
                           *      THEN K+1-->K, ELSE DO NO ADJUSTMENT
                           *
                           *
                           *       DELETE CASE : A PRESCAN IS MADE OF THE PROGRAM, IF DFLAG =1.
                           *      DURING THE PRESCAN , THE GTO/GSB DESTINATIONS ARE CHECKED TO
                           *      BE SURE THAT WHEN THE DELETION TAKES PLACE (IT HASN'T YET) , THE
                           *      DESTINATION OF SOME GTO/GSB WILL NOT DISAPPEAR, UNLESS
                           *      THE SOURCE IS DELETED. IF ANY DESTINATIONS ARE DELETED,
                           *      ERROR 36 IS GIVEN AND NO ADJUSTMENT OR DELETION IS DONE. IF
                           *      THE PRESCAN IS SUCCESSFUL (ERRORLESS), THE ADJUSTMENT IS
                           *      MADE AND THE LINES ARE DELETED
                           *      THE SAME 6 PASSES THROUGH THE PROGRAM ARE MADE FOR THE 6
                           *      GTO/GSB CODES AS FOR THE INSERT CASE.
                           *      RULES FOR DELETIONS :
                           *      IF NO '*' IS ENTERED WITH THE DEL
                           *
                           *      '+' RELATIVE : LNO<LN1, LN2<LNO+K, LN1<=LNO+K OR
                           *      '-' REIATIVE : LN2<LNO, LN2>=LNO-K, LN1>LNO-K OR
                           *          ABSOLUTE : LN2>=K
                           *
                           *      THEN ADJUST : K-(LN2-LN1+1) -> K
                           *
                           *      ERROR CONDITIONS OR NON-ADJUSTMENT CONDITIONS ARE THE
                           *      REMAINING ALTERNATIVES.
                           *
                           *      IF DFLAG IS SET - PRESCAN - DO NO ADJUSTMENT, GIVE ERROR
                           *      IF DFLAG IS CLEAR (NO '*' ) AND AN ERROR CONDITION OCCURS
                           *      THEN ADJUST ARTIFICIALLY AS FOLLOWS :
                           *
                           *      '+' RELATIVE : LN1-LNO -> K
                           *      '-' RELATIVE : LNO-(LN2+1) -> K
                           *          ABSOLUTE : LN1 -> K
                           *
                           *
                           *
                           *
                           *      THIS SECTION IS FOR  INSERTS
                           *
27216  042413  AJINS JSM SETUP              SAVE THE NECESSARY VARIABLES
27217  042427  AJGT2 JSM TRLND              GET THE LINE INTO THE I/O BUFFER
27220  066401        JMP AJG30              RESTORE TEMP , TURN OFF RUN LIGHT RETURN
27221  042442        JSM FGTO               FIND THE NEXT GTOO
27222  066235        JMP AJGT4              A '-' FOUND
27223  066250        JMP AJGT6              A '+' FOUND
27224  174040        TCB                    ABSOLUTE GTO/GSB
27225  025721        ADB T9                 IS K>=LN1 ?
27226  174040        TCB
27227  176002        SBP *+2                SKIP IF YES
27230  066217        JMP AJGT2              NO SO CONTINUE
27231  005716  AJGT5 LDB T6                 ADJUST GTO FOR INSERT
27232  024254        ADB P1
27233  042421        JSM ASLN               RESTOE  THE LINE
27234  066217        JMP AJGT2              OK TO CONTINUE
27235  005226  AJGT4 LDB LNO                GET LN1
27236  174040        TCB
27237  025721        ADB T9
27240  176057        SBP AJGT2              DO NOTHING HERE, LN1>LNO
27241  005716        LDB T6                 GET THE GTO NUMBER
27242  174040        TCB                    LNO -B<=LN1 = LN1-(LNO -B)>=0
27243  025226        ADB LNO
27244  174040        TCB
27245  025721        ADB T9
27246  176063        SBP AJGT5              SKIP IFTRUE
27247  066217  AJGT7 JMP AJGT2              NEED NOT ADJUST THIS GTO
27250  005721  AJGT6 LDB T9                 IS LN1>LNO  ?
27251  174040        TCB
27252  025226        ADB LNO                IE. IS LNO -LN1<0
27253  176074        SBP AJGT7              NO IF SKIP
27254  001721        LDA T9                 IS LNO +B>=LN1  =
27255  170040        TCA                    LNO +B-LN1>=0
27256  021226        ADA LNO
27257  021716        ADA T6
27260  172467        SAM AJGT7              NO, DO NO ADJUSTMENT
27261  066231        JMP AJGT5              YES, AJUST GTO
                           *
                           *      THIS CODE IS FOR DELETIONS
                           *
27262  042413  AJDEL JSM SETUP              SAVE THE NECESSARY VARIABLES
27263  042427  AJG32 JSM TRLND              GET NEXT GTO/GSB TYPE IN T11
27264  066401        JMP AJG30              RESTORE TEMPS, TURN OFF RUN LIGHT AND RETURN
27265  001721        LDA T9                 IF GTO/GSB LINE IS INCLUDED-
```

********GTO AND GSB ADJUSTING ROUTINES*********

```
27266  170040        TCA                      IN DELETED ECTION-NEED NOT
27267  021226        ADA LNO                  PROCESS IT
27270  172405        SAM AJG31
27271  001226        LDA LNO                  THAT IS IF LN1<=LNO<=LN2
27272  170040        TCA                      IF TRUE GO ON TO NEXT LINE
27273  021717        ADA T7
27274  172067        SAP AJG32
27275  042442  AJG31 JSM FGTO                 FIND THE NEXT GTO
27276  066323        JMP AJG11                WE HAVE A '-'
27277  066343        JMP AJG12                WE HAVE A '+'
27300  174040        TCB                      K>LN2 =   /WE HAVE ABSOLUTE GTO GSB
27301  025717        ADB T7                   LN2-K<0
27302  176406        SBM AJG10                SKIP IF TRUE, MUST ADJUST
27303  001721        LDA T9                   IS K>=LN1 = K-LN1>=0 ?
27304  170040        TCA
27305  021716        ADA T6
27306  172455        SAM AJG32                SKIP IF FALSE
27307  066376        JMP ERGTA                ERROR-DESTINATION GONE
27310  001613  AJG10 LDA UFLAG                IF THIS FLAG IS SET WE DO NO ADJUSTMENT
               *                              THIS IS A PRESCAN
27311  073452        RLA AJG32                SKIP IF A PRESCAN
27312  001721        LDA T9                   VALID GTO/GSB FOR DELETE
27313  170040        TCA
27314  021717        ADA T7                   SO K=K-(LN2-LN1+1)
27315  020254        ADA P1
27316  170040        TCA
27317  005716        LDB T6
27320  024000        ADB A
27321  042421  AJG33 JSM ASLN                 REPLACE ADJUSTED NUMBER IN LINE
27322  066263  AJG16 JMP AJG32                OK SO CONTINUE
27323  005226  AJG11 LDB LNO                  IS LN2<LNO  ?
27324  174040        TCB                      OR LN2-LNO <0 ?
27325  025717        ADB T7
27326  176074        SBP AJG16                SKIP IF NEED DO NO ADJUSTMENT
27327  005716        LDB T6                   GET THE NUMBER
27330  174040        TCB                      IS IS LN2>=LNO -K ?
27331  025226        ADB LNO                  OR IS LN2-(LNO-K)>=0 ?
27332  174040        TCB
27333  025717        ADB T7
27334  176466        SBM AJG16                SKIP IF FALSE, DO NO ADJUSTMENT
27335  005716        LDB T6                   GET THE NUMBER AGAIN
27336  025721        ADB T9                   IS LN1 <= LNO -K ?
27337  174040        TCB                      OR LNO -(K+LN1)>=0 ?
27340  025226        ADB LNO
27341  176447        SBM AJG10                SKIP IF OK TO ADJUST GTO OR GSB
27342  066363        JMP ERGTM                ERROR-DESTINATION GONE
27343  005717  AJG12 LDB T7                   IS LNO <LN2 OR LNO -LN2<0 ?
27344  174040        TCB
27345  025226        ADB LNO
27346  176054        SBP AJG16                SKIP IF FALSE, DO NO ADJUSTMENT
27347  005721        LDB T9                   GET THE LINE NUMBER
27350  174040        TCB                      LN1<=LNO+K
27351  025716        ADB T6
27352  025226        ADB LNO
27353  176447        SBM AJG16                SKIP IF FALSE DO NO ADJUSTMENT
27354  005716        LDB T6                   GET THE NUMBER AGAIN
27355  025226        ADB LNO                  LN2<LNO +K  OR LN2-(LNO +K)<0
27356  174040        TCB
27357  025717        ADB T7
27360  176402        SBM *+2
27361  066371  AJG15 JMP ERGTP                ERROR-DESTINATION GONE
27362  066310        JMP AJG10
27363  042404  ERGTM JSM ERRR2                SEE IF WE ADJUST OR GIVE ERROR
27364  005717        LDB T7                   ADJUST, SO LN-(LN2+1) -> K
27365  024254        ADB P1
27366  174040        TCB
27367  025226        ADB LNO
27370  066321        JMP AJG33
27371  042404  ERGTP JSM ERRR2                SEE IF WE ADJUST OR GIVE ERROR
27372  005226        LDB LNO                  ADJUST, SO K=LN
27373  174040        TCB                      K=LN1-LNO
27374  025721        ADB T9
27375  066321        JMP AJG33
27376  042404  ERGTA JSM ERRR2                SEEE IF WE ADJUST OR GIVE ERROR
27377  005721        LDB T9
27400  066321        JMP AJG33
               *
               *
27401  001731  AJG30 LDA T17
27402  031226        STA LNO
27403  164504        JMP ARNLF,I              TURN OFF THE RUN LIGHT, RETURN
27404  001613  ERRR2 LDA DFLAG                IF LSB IS SET WE GIVE ERROR BECAUSE GTO
               *                              GSB DESTINATION WILL BE GONE IF DELETE IS
               *                              ALLOWED
```

```
                 ********GTO AND GSB ADJUSTING ROUTINES*********

27405  073021         SLA ASLN1
27406  001232  ERR36  LDA CFLAG          CLEAR FETCH BIT FOR UP ARROW ROUTINES
27407  073201         SLA *+1,C
27410  031232         STA CFLAG
27411  140404         JSM AERR1,I        GTO DESTINATION GONE
27412  031466         ASC 1,36
               *
               *
               *      SETUP WILL TURN ON RUN LIGHT, SET VARIABLES TO CALL AFCI
               *      AND AFCC, AND SAVE LNO
               *
               *
               *
               *
27413  140503  SETUP  JSM ARNLO,I        TURN ON THE RUN LIGHT
27414  001226         LDA LNO
27415  031731         STA T17
27416  000050         LDA B224
27417  004152         LDB M6             THIS IS TO GET ALL 6 GTO/GSB CODES
27420  164374         JMP AFCI,I         INITILIZE THE BYTE SEARCH ROUTINE
               *
               *
               *
               *      ASLN WILL REPLACE THE TWO BYTES THAT MAKE UP THE GTO/GSB
               *      DESTINATION WITH THE NUMBER THAT IS IN THE B REGISTER
               *
               *      ON ENTRY : B HAS THE NUMBER TO REPLACE THE BYTES IN THE GTO/GSB
               *                 D POINTS TO THE BYTE IMMEDIATELY AFTER THE SECOND
               *                 BYTE OF THE GTO/GSB NUMBER IN THE COMPILED LINE
               *
               *      ON EXIT : THE GTO/GSB DESTINATION IS MODIFIED
               *
               *
               *      TEMPORARIES USED : NONE
               *
               *      ROUTINES CALLED : NONE
               *
               *
               *
27421  000001  ASLN   LDA B
27422  050045         AND B377           CLEAR THE H.O. BYTE
27423  074750         PBD A,D
27424  174507         SRR 8              GET THE H.O. BYTE
27425  074751         PBD B,D            REPLACE THE H.O. BYTE
27426  170201  ASLN1  RET 1
               *
               *      TRLIN FINDS THE NEXT GTO/GSB OF TYPE "44" IN THE PROGRAM AND KEEP
               *      TRACK OF HERE AND LNO  IN THE PROCESS
               *
               *      ON ENTRY : D POINTS TO THE NEXT BYTE TO BE EXAMINED
               *
               *      ON EXIT : RET 1 IF ENDS IS ENCOUNTERED
               *                RET 2 IF A TYPE "44" GTO/GSB IS ENCOUNTERED
               *                      THEN D POINTS TO FIRST BYTE AFTER THE GTO/GSB
               *                      OPCODE
               *
               *      TEMPORARIES USED: T11, HERE, A, B, D, LNO ,
               *
               *      ROUTINES CALLED: NONE
               *
               *
27427  140375  TRLND  JSM AFCC,I         FIND THE NEXT BYTE OF TYPE IN T11
27430  170201         RET 1              RET 1 IMPLIES EOP FOUND
27431  005712         LDB T2             FIND THE LINE NUMBER OF ADDRESS IN T2
27432  035265         STB HERE           REMEMBER THIS ADDRESS
27433  140523         JSM AGLNO,I        GET THE LINE NUMBER OF THE LINE
27434  044017         ISZ D              LINE NUMBER RETURNED IN LNO
27435  074570         WBD A,I            GET TO THE DESTINATION BYTES
27436  074570         WBD A,I
27437  022463         ADA BM44           SEE IF WE HAVE A NUMERIC GTO/GSB
27440  072067         RZA TRLND          NON-NUMERIC SO SKIP
27441  170202  GTOP   RET 2              FOUND GTO/GSB
               *
               *
               *
               *
               *
               *      FTGO FORMS THE INTEGER NUMBER REPRESENTING THE GTO/GSB DESTINATIO
               *      AND STORES IT IN T6, FGTO ALSO DET. THE TYPE OF GTO/GSB
               *
               *      ON ENTRY : D POINTS TO FIRST BYTE OF THE GTO/GSB DESTINATION
               *           INTEGER
               *
               *      ON EXIT : RET 1 = GTO/GSB "-" ENCOUNTERED
               *                RET 2 = GTO/GSB "+" ENCOUNTERED
```

```
                       *              RET 3 = NONE OF THE ABOVE=>GTO/GSB ABSOLUTE ENCOUNTERED
                       *              IN EACH CASE THE POINTER, D,POINTS AT THE
                       *              FIRST BYTE AFTER THE SECOND BYTE OF THE DEST. NUMBER
                       *
                       *
                       *    TEMORARIES USED : T6, T11
                       *
                       *    ROUTINES CALLED : NONE
                       *
                       *
      27442  074571    FGTO  WBD B,I           MAKE NUMBER FROM TWO BYTES
      27443  174607          SBL 8             AFTER "44" IN GTO/GSB
      27444  074570          WBD A,I           FIELD
      27445  060001          IOR B
      27446  004000          LDB A
      27447  035716          STB T6            SAVE IN T6 AND B FOR RETURN
      27450  001714          LDA T4            MUST DETERMINE WHICH TYPE OF GTO/GSB
      27451  022462          ADA BM224
      27452  072454          SZA ASLN1         WE HAVE A GTO/GSB REL. -
      27453  020257          ADA M1
      27454  072465          SZA GTOP          WE HAVE A GTO RELATIVE "+"
      27455  020257          ADA M1
      27456  072450          SZA ASLN1         WE HAVE A GSB RELATIVE -
      27457  020257          ADA M1
      27460  072461          SZA GTOP          WE HAVE A GSB RELATIVE "+"
      27461  170203          RET 3             HERE IF ABSOLUTE GTO OR GSB
                       *
                       *
                       *
                       ***********************************************************
                       *
                       *  CONSTANTS
                       *
      27462  177554    BM224 OCT -224
      27463  177734    BM44  OCT -44
      27464  177762    M14   DEC -14
      27465  034460    DLIMT OCT 34460      BITS 9-0
                       *
                       *
                       *
                       ***************************************************************
                       *
                       *    DEFINITIONS
                       *
                       *
             000221    NWWD  EQU B70K
             000263    MAXLN EQU FLAG
             000170    BUHM  EQU M256
             000122    B32   EQU P26
             000052    STPMS EQU B200
             000263    TRCMS EQU FLAG
             000077    COLLN EQU B72
             000053    EOL   EQU B177
             000177    KPA   EQU P0
             000116    QUOTE EQU B42
             000045    DCMND EQU B377
             000236    CTCNT EQU B2K
             077216    CST   EQU CSTMP
             077217    .WPRT EQU CSTMP+1
             077216    SIOCP EQU CST
             077220    M     EQU CST+2
             077221    PLADD EQU CST+3
             077223    TMP6  EQU CST+5
             077224    K     EQU CST+6
             077225    TMP2  EQU CST+7
             077226    LNO   EQU CST+8
             077227    TMP1  EQU CST+9
             077230    TMP5  EQU CST+10
             077231    TMP3  EQU CST+11
             077232    CFLAG EQU CST+12
             077233    TMP7  EQU CST+13
             077234    TMP4  EQU CST+14
             077235    SKEY  EQU CST+15
             077207    .WMOD EQU IOTMP+1
             077210    DTMP1 EQU IOTMP+2
             077211    DTMP2 EQU IOTMP+3
             077212    SPKN  EQU IOTMP+4
             077213    OLCP  EQU IOTMP+5
             077214    CRSP  EQU IOTMP+6
             077215    IOCP  EQU IOTMP+7
             000433    DISP  EQU ALDSP
             077613    DFLAG EQU LKTMP+6
                       *
```

```
                              ********GTO AND GSB ADJUSTING ROUTINES*********

02948000                   ***************************************************************
02949000                   *
02950000 27777                   ORG 27777B
02951000 27777                   BSS 1          CHECKSUM!!!!!!!!!!!!!!!!!!!!!!!!!
02952000                   *
02953000                   **********************
02954000                   *
02955000                   *
02956000                         END

END OF PASS 2 NO ERRORS DETECTED

                                 BASE-PAGE READ-WRITE-MEMORY

00003000 76550                   ORG 76550B
00004000                         UNL


02001000                   *
02002000                   *****                       I/O ROM
02003000                   *
02004000                   *                                      (FINAL RELEASE VERSION)
02005000                   *
02006000                   *     USING BPAGE!
02007000                   *
02008000                         UNS
02009000 32000                   ORG 32000B
02010000                   *
02011000 32000   032030          DEF EXEC    EXECUTION LINK WORD
02012000 32001   032053          DEF COMP    COMPILE LINK WORD
02013000 32002   032103          DEF RCOMP   REVERSE COMPILE LINK WORD
02014000 32003   177777          DEC -1      NO COMMAND TABLE
02015000 32004   032110          DEF INIT    INITIALIZATION ROUTINE
02016000 32005   000014          DEC 12      ROM ID=12


02018000                   *
02019000                   *  THE RELATIVE OP CODES ARE AS FOLLOWS!
02020000                   *
02021000                   *     1  FMT   FORMAT
02022000                   *     2  WRT   WRITE
02023000                   *     3  RED   READ
02024000                   *     4  WTC   WRITE CONTROL
02025000                   *     5  WTB   WRITE BYTE
02026000                   *     6  RDB   READ BYTE
02027000                   *     7  RDS   READ STATUS
02028000                   *     8  CONV  CONVERSION TABLE
02029000                   *     9  LIST# LIST TO PERIPHERAL

                                      FORMATTED I/O ROM

02031000                   *
02032000                   *   LINKS
02033000                   *
02034000 32006   033250           DEF GSCFN   LINK TO GET SELECT CODE/FMT NUMBER ROUTINE
02035000 32007   033341           DEF BUSET   LINK TO SET UP THE HP-IB ROUTINE
02036000 32010   033573           DEF REDST   LINK TO READ STATUS ROUTINE
02037000 32011   032273           DEF ANFMT   LINK TO PROCESS NEXT FORMAT ROUTINE
02038000 32012   033162           DEF ERD81   LINK TO STACK A RESULT ROUTINE
02039000 32013   032136     .RET1 DEF SLINK   ADDRESS OF A RET 1 (HELP ROUTINE)
02040000 32014   033450           DEF SEND    ADDRESS OF NORMAL OUTPUT ROUTINE
02041000 32015   033532           DEF READ    ADDRESS OF NORMAL INPUT ROUTINE


02043000                   *
02044000                   *   TABLE OF EXECUTION ROUTINE ADDRESSES
02045000                   *
02046000 32016   132016     ETBL  DEF *,I
02047000 32017   032202           DEF EFMT
02048000 32020   032532           DEF EWRT
```

```
32021  032702        DEF ERED
32022  033376        DEF EWTC
32023  032673        DEF EWTB
32024  033157        DEF ERDB
32025  033177        DEF ERDS
32026  033211        DEF ECONV
32027  033655        DEF ELIST


                *
                *   GENERAL EXECUTION ROUTER
                *
                *   ENTRY:  A CONTAINS THE ROM'S RELATIVE CODE
                *
32030  031717  EXEC  STA STMT     SAVE ORIGINAL RELATIVE CODE
32031  023016        ADA ETBL     CONSTRUCT AND
32032  031724        STA ASTMT    SAVE EXECUTION ADDRESS
32033  000016        LDA C
32034  031734        STA CSAVE    SAVE C POINTER
32035  043137        JSM PTSET    SET UP POINTERS TO STOLEN R/W
32036  141724        JSM ASTMT,I GO TO THE EXECUTION ROUTINE
32037  001734        LDA CSAVE    RESTORE C VALUE
32040  030016        STA C
32041  164365        JMP AINTX,I WHEN DONE, RETURN TO MAIN SYSTEM
                *
                *   MNEMONIC AND CODE TABLE FOR COMPILER
                *
                *   CODEWORD FORMAT:
                *      BITS 14-8 = CLASS (IMPLIED MULTIPLY)
                *      BITS  7-0 = TOKEN (PARSER DIRECTOR)
                *
32042  003041        OCT 3041     6 33 LIST# (LST)
32043  003052        OCT 3052     6 42 CONV  (SFG)
32044  004032        OCT 4032     8 26 RDS   (FCN)
32045  004032        OCT 4032     8 26 RDB   (FCN)
32046  003045        OCT 3045     6 37 WTB   (PRT)
32047  003052        OCT 3052     6 42 WTC   (SFG)
32050  003045        OCT 3045     6 37 RED   (PRT)
32051  003045        OCT 3045     6 37 WRT   (PRT)
32052  003070        OCT 3070     6 56 FMT   (FREE FIELD)
                *
32053  063155  COMP  DEC  26221   F   M
32054  072040        DEC  29728   T
32055  100567        DEC -32393  (1)  W
32056  071164        DEC  29300   R   T
32057  020202        DEC  08322      (2)
32060  071145        DEC  29285   R   E
32061  062040        DEC  25632   D
32062  101567        DEC -31881  (3)  W
32063  072143        DEC  29795   T   C
32064  020204        DEC  08324      (4)
32065  073564        DEC  30580   W   T
32066  061040        DEC  25120   B
32067  102562        DEC -31374  (5)  R
32070  062142        DEC  25698   D   B
32071  103162        DEC -31118  (6)  R
32072  062163        DEC  25715   D   S
32073  103543        DEC -30877  (7)  C
32074  067556        DEC  28526   O   N
32075  073040        DEC  30240   V
32076  104154        DEC -30612  (8)  L
32077  064563        DEC  26995   I   S
32100  072040        DEC  29728   T
32101  021611        OCT  21611   #  (9)
32102  100000        OCT 100000   *** END OF TABLE MARKER ***
                *
                *   REVERSE COMPILE TABLE
                *
                *   EACH BYTE OF THE REVERSE COMPILE TABLE SUPPLIES
                *   THE FOLLOWING INFORMATION:
                *      BITS 7-4 = PRIORITY
                *      BITS 3-0 = CLASS
                *
32103  000422  RCOMP OCT 000422     FMT   0,1     WRT   1,2
32104  011022        OCT 011022     RED   1,2     WTC   1,2
32105  011342        OCT 011342     WTB   1,2     RDB  14,2
32106  161022        OCT 161022     RDS  14,2     CONV  1,2
32107  011000        OCT 011000     LIST# 1,2


                *   THE FOLLOWING TABLE GIVES THE STRUCTURE OF THE
                *   ROM'S STOLEN WORDS, RELATIVE TO "FSPTR":
                *
```

FORMATTED I/O ROM

```
02132000                 *     0-9    BYTE POINTERS TO "FMT N" FOR N=0,9
02133000                 *      10    BYTE POINTER TO EXECUTED FMT STATEMENT
02134000                 *      11    CVTBL  POINTER TO END OF CONVERSION TABLE
02135000                 *      12    SFEAT  SPECIAL FEATURES (EXTIO)
02136000                 *      13    HLINK  LINK TO HELP ROUTINES IN OTHER ROMS
02137000                 *      14    WRTIC  LINK TO SEND ROUTINE (WRITE INTERCEPT)
02138000                 *      15    REDIC  LINK TO READ ROUTINE (READ INTERCEPT)
02139000                 *      16    RUNLK  NEXT LINK IN "RUN" DAISEY CHAIN
02140000                 *      17    LODLK  NEXT LINK IN "LOAD" DAISEY CHAIN
02141000                 *   18-27    BYTE-PAIR CONVERSION TABLE (ASCII/CONVERTED)
```

```
02143000                 ********** NOTE ON ERRORS **********
02144000                 *
02145000                 *   THIS ROM WAS ORIGINALLY CALLED "FORMATTED I/O".
02146000                 *   THE NAME WAS CHANGED TO "GENERAL I/O" AND THUS,
02147000                 *   THE ERRORS ARE NOW GIVEN AS G1-G9.  PROGRAM
02148000                 *   LABLES AND COMMENTS, HOWEVER, ARE STILL IN TERMS
02149000                 *   OF F1-F9, DUE TO THE OLD NAME.
02150000                 *
02151000                 ***********************************
02153000                 *
02154000                 *   INITIALIZATION
02155000                 *
02156000                 *   RESERVE 28 WORDS OF R/W MEMORY; SET NULL FORMAT
02157000                 *   FOR ALL FORMATS; SET UP RUN-LINK, LOAD-LINK, AND
02158000                 *   ROM'S INTERNAL LINKS.
02159000                 *
02160000 32110  001306  INIT  LDA FWAM    GET CURRENT STOLEN WORD BOUNDARY
02161000 32111  031045        STA FSPTR   AND SAVE AS ADDRESS OF THIS ROM'S WORDS
02162000 32112  071614        CLR 13      CLEAR FORMATS, CONVERSIONS, AND FEATURES
02163000 32113  020132        ADA P13     POINT TO LINKS AREA
02164000 32114  004000        LDB A
02165000 32115  002721        LDA IVALS   TRANSFER INITIAL VALUES
02166000 32116  071402        XFR 3
02167000 32117  024144        ADB P3      POINT TO END OF AREA
02168000 32120  001533        LDA RLINK
02169000 32121  130001        STA B,I     SAVE CURRENT LINK IN RUN CHAIN
02170000 32122  003144        LDA FRLNK   GET FMT RUN ROUTINE ADDRESS
02171000 32123  031533        STA RLINK   AND PUT IT IN THE CHAIN
02172000 32124  024254        ADB P1      POINT TO NEXT STOLEN LOCATION
02173000 32125  001530        LDA LOADL   GET THE CURRENT LINK IN THE LOAD
02174000 32126  130001        STA B,I     DAISEY CHAIN AND SAVE IT
02175000 32127  003154        LDA FLLNK   GET FMTIO LOAD LINK ADDRESS
02176000 32130  031530        STA LOADL   AND PUT IT IN THE CHAIN
02177000 32131  024134        ADB P11     POINT BEYOND STOLEN AREA
02178000 32132  035306        STB FWAM    AND SET THIS AS NEW BOUNDARY
02179000 32133  001062        LDA ROMWD
02180000 32134  060117        IOR B40     LOG IN FMTIO ROM  (BIT 5)
02181000 32135  031062        STA ROMWD
02182000 32136  170201  SLINK RET 1       INITIALIZATION COMPLETE
```

```
02184000                 *
02185000                 *   THIS ROUTINE SETS UP POINTERS TO STOLEN WORDS
02186000                 *   AND LINK WORDS FOR USE
02187000                 *
02188000 32137  001045  PTSET LDA FSPTR   GET STOLEN WORDS LOCATION
02189000 32140  020134        ADA P11     POINT TO FEATURES/LINKS
02190000 32141  006726        LDB .TREG   AND MOVE THEM INTO T-REGISTERS
02191000 32142  071404        XFR 5       WHERE THEY'RE MORE ACCESSABLE
02192000 32143  170201        RET 1
02194000                 *
02195000                 *   THIS ROUTINE SETS ALL FORMATS TO NULL
02196000                 *   WHENEVER A "RUN" IS EXECUTED, AND THEN
02197000                 *   CONTINUES ALONG THE DAISY CHAIN.
02198000                 *
02199000 32144  032145  FRLNK DEF *+1
02200000 32145  000257        LDA M1
02201000 32146  031610        STA KBFMT   RESET ANY PENDING KEYBOARD FORMATS
02202000 32147  001045        LDA FSPTR   GET ADDRESS OF START OF FORMAT TABLE
02203000 32150  071612        CLR 11      RESET FORMATS
02204000 32151  020127  CHAIN ADA P16     POINT TO NEXT RLINK IN CHAIN
02205000 32152  100000        LDA A,I     GET THE ADDRESS
02206000 32153  164000        JMP A,I     AND CONTINUE EXECUTION THERE.
```

```
02208000 32154  032155  FLLNK DEF *+1
02209000 32155  001045        LDA FSPTR   GET ADDRESS OF FORMAT POINTERS TABLE
02210000 32156  020136        ADA P9      POINT TO FORMAT 9
```

```
02211000 32157  005063  FLLN0 LDB NPROG   GET LOAD KEYS/PROGRAM FLAG
02212000 32160  076410        SZB FLKEY   IF KEYS, GO TO KEY OFFSET ROUTINE
02213000 32161  104000        LDB A,I     GET NEXT FORMAT POINTER
02214000 32162  176601        SRM *+1,C   STRIP OF LEFT/RIGHT BIT (15)
02215000 32163  174040        TCB         MAKE NEGATIVE ABSOLUTE ADDRESS
02216000 32164  025706        ADB PROFS   ADD IN OFFSET TO NEW PROGRAM
02217000 32165  176011        SBP FLLN2   IF B>0, FORMAT WAS NOT REPLACED
02218000 32166  004177        LDB P0      ELSE, FORMAT IS GONE SO RESET
02219000 32167  067175        JMP FLLN1   AND GO TO FORMAT RESET
02220000                *
02221000 32170  104000  FLKEY LDB A,I     GET NEXT FORMAT POINTER
02222000 32171  016722        CPB .SFMT   IF STANDARD FORMAT,
02223000 32172  067176        JMP FLLN2   NO ADDRESS CORRECTION REQUIRED
02224000 32173  076403        SZB FLLN2   IF ZERO, NO FORMAT WAS SET
02225000 32174  025744        ADB KYOFS   ELSE, ADD IN KEY PROGRAM OFFSET
02226000 32175  134000  FLLN1 STB A,I     AND PUT BACK NEW ADDRESS
02227000 32176  011045  FLLN2 CPA FSPTR   DID WE JUST DO THE LAST ONE?
02228000 32177  072152        RIA CHAIN   YES; GET OUT
02229000 32200  020257        ADA M1      NO; POINT TO NEXT FORMAT POINTER
02230000 32201  067157        JMP FLLN0   AND GO AROUND AGAIN
```

FORMATTING ROUTINES

```
02232000                *
02233000                *    FORMAT STATEMENT EXECUTION
02234000                *
02235000                *    THIS SECTION SETS A POINTER TO THE PROPER FORMAT
02236000                *    STATEMENT IN THE FORMAT POINTER TABLE
02237000                *
02238000 32202  074560  EFMT  WBC A,I     BYPASS THE BEGINNING OF FORMAT CHARACTE
02239000 32203  042527        JSM CSAV    SAVE PTR TO FIRST FMT BYTE
02240000 32204  043466        JSM FNBLD   TRY TO BUILD A FORMAT NUMBER
02241000                *
02242000 32205  035720        STB FMT.N   SAVE B AS POSSIBLE FORMAT NUMBER
02243000 32206  005716        LDB T6      B = POINTER TO START OF FMT STATEMENT
02244000 32207  010107        CPA C.COM   DID COMMA TERMINATE FNBLD?
02245000 32210  004016        LDB C       YES; POINT TO SPECS FOLLOWING FMT N.
02246000 32211  010121        CPA C.EFM   EMPTY FORMAT?
02247000 32212  006722        LDB .SFMT   YES; USE STANDARD FORMAT
02248000 32213  000177        LDA P0
02249000 32214  015716        CPB T6      IS B STILL EQUAL TO CSAVE?
02250000 32215  031720        STA FMT.N   YES; THIS MUST BE FMT 0
02251000 32216  001720        LDA FMT.N   IN ANY CASE, GET FMT NUMBER
02252000 32217  020207        ADA M10
02253000 32220  172403        SAM *+3     IF FMT.N<10, ALL IS WELL
02254000 32221  140404  ER.F1 JSM AERR1,I OTHERWISE, ***** ERROR F1 *****
02255000 32222  043461        ASC 1,G1    BAD FORMAT REFERENCE
02256000 32223  001257        LDA CSTAT   CHECK CURRENT STATE
02257000 32224  073005        SLA EFMTP   IF LSB(A)=0, FORMAT IS IN PROGRAM
02258000 32225  001720        LDA FMT.N   ELSE, FMT IS FROM KEYBOARD EXECUTION
02259000 32226  031610        STA KBFMT   SO SAVE ITS NUMBER IN BASE PAGE WORD
02260000 32227  000135        LDA P10     AND SET THIS AS A SPECIAL FORMAT
02261000 32230  067232        JMP *+2     SKIP TO PROCESS AS DUMMY FMT 10
02262000 32231  001720  EFMTP LDA FMT.N   GET FORMAT NUMBER
02263000 32232  021045        ADA FSPTR   OFFSET TO FORM POINTER ADDRESS FOR SAVE
02264000 32233  134000        STB A,I     AND PUT BYTE POINTER IN STOLEN TABLE
02265000                *
02266000                *    THIS SECTION MOVES C TO END OF FMT + 1
02267000                *
02268000 32234  074760        WBC A,D     BACK UP POINTER IN CASE OF NULL FORMAT
02269000 32235  074560  GTEFM WBC A,I     LOOK AT NEXT CHARACTER
02270000 32236  010121        CPA C.EFM   IF IT WAS END OF FORMAT (34B)
02271000 32237  170203        RET 3       THEN EXIT (BYPASS C RESET)
02272000 32240  067235        JMP GTEFM   OTHERWISE, CONTINUE TO SCAN
02274000                *
02275000                *    THIS ROUTINE SETS UP INITIAL VALUES FOR
02276000                *    SCANNING THE FORMAT STATEMENT:
02277000                *
02278000                *    REP.C = 1
02279000                *    Z.CSP = 100000 (NO SUPRESSION SET)
02280000                *    .BFMT = C = START OF FORMAT
02281000                *
02282000 32241  001045  FMSET LDA FSPTR   GET LOCATION OF FORMAT POINTER TABLE
02283000 32242  005232        LDB CFLAG   CHECK THE CONTINUE FLAG
02284000 32243  174501        SBR 2       FOR THE RUN-DONE BIT (1 = FORMATS VALID)
02285000 32244  077402        RLB *+2     IF FORMATS VALID, GO ON
02286000 32245  071611        CLR 10      ELSE, RESET ALL FMTS EXCEPT KEYBOARD FMT
02287000 32246  004136        LDB P9
02288000 32247  141737        JSM HLINK,I GIVE EXTIO A CHANCE TO DO ITS FMSET
02289000 32250  005720        LDB FMT.N   GET THE FORMAT NUMBER
02290000 32251  000001        LDA B       AND KEEP IN A FOR LATER TEST
02291000 32252  015610        CPB KBFMT   IS THIS FORMAT PENDING FROM KEYBOARD?
02292000 32253  004135        LDB P10     YES; USE FMT 10 INSTEAD (KYBD FORMAT)
```

```
32254  025045         ADB FSPTR   ADD IN OFFSET TO FORMAT TABLE
32255  104001         LDB B,I     GET TABLE ENTRY FOR FORMAT N
32256  076003         RZB *+3     IF NON-ZERO, FORMAT IS VALID
32257  072042         RZA ER.F1   IF NO FMT SET AND FMT.N >0, GIVE ERROR
32260  006722         LDB .SFMT   IF FMT.N=0, USE STANDARD FORMAT
32261  035720         STB .BFMT   SAVE AS STARTING ADDRESS OF FORMAT
32262  000254         LDA P1
32263  031732         STA REP.C   INITIALIZE REP.C TO 1
32264  000263  ZCSET  LDA FLAG
32265  031726         STA Z.CSP   SET FOR NO SUPRESSION, # DATA SPECS = 0
32266  034016  CSET   STB C       SET BYTE POINTER FOR <SPEC> FETCH
32267  170201         RET 1       SETUP COMPLETE
               *
               *   THIS SECTION SCANS THE FORMAT FOR NEXT SPECIFICATION
               *
               *   IF TEXT SPEC, IT EXECUTES IT!
               *     X = SPACE      / = CR/LF      Z = SUPRESS CR/LF
               *     "......" = LITERAL
               *
               *   IF DATA SPEC, RETURNS TO CALLING ROUTINE
               *     F   = FIXED POINT
               *     E   = FLOATING POINT
               *     FZ  = FIXED POINT WITH LEADING ZEROS
               *     B   = BINARY
               *     C   = CHARACTER STRING

32270  001725  NFMT   LDA RW.SN   GET LAST SPEC TYPE
32271  055732         DSZ REP.C   IF REPEAT COUNT WAS 1, GET NEXT SPEC
32272  170201         RET 1       OTHERWISE, RETURN LAST SPEC
               *
               *   ENTRY TO BYPASS REP.C CHECK; FORCE NEXT SPEC
               *
32273  043466  ANFMT  JSM FNBLD   GET REP.C IF ANY
32274  076004         RZB *+4     IF REPETITION COUNT >0, GO ON
32275  005715         LDB TS      WAS THE COUNT AN EXPLICIT ZERO?
32276  076027         RZB ER.F2   IF SO, REP.C=0 IS DUMB!
32277  004254         LDB P1      OTHERWISE, USE DEFAULT REP.C = 1
32300  035732         STB REP.C   AND SAVE IT
               *
               *   NOW CHECK CHARACTER WHICH TERMINATED NUMBER BUILDER
               *   TO DETERMINE TYPE OF <SPEC>
               *
32301  010121         CPA C.EFM   IF END OF FORMAT,
32302  067433         JMP E.EFM   GO TO END OF FORMAT ROUTINE
32303  004254         LDB P1      SET B=1 IN CASE <SPEC>="E"
32304  012731         CPA C.F     IF SPEC BEGINS WITH F
32305  067327         JMP S.F     SET UP NUMERIC OUTPUT
32306  010063         CPA C.E     IF "E",
32307  067335         JMP S.E     SET UP FLOATING SPEC
32310  010064         CPA C.C     IF "C",
32311  067361         JMP S.C     SET UP FOR STRING
32312  012730         CPA C.B     IF "B"
32313  067367         JMP S.B     SET UP FOR BINARY
32314  012732         CPA C.X     IF "X"
32315  067373         JMP E.X     EXECUTE SPACE ROUTINE
32316  010104         CPA C.LF    IF "/"
32317  067421         JMP E.LF    ECECUTE LINE FEED ROUTINE
32320  010116         CPA C.QT    IF LITERAL
32321  067402         JMP E.QT    EXECUTE A LITERAL
32322  012733         CPA C.Z     IF "Z"
32323  067425         JMP E.Z     SET TO SUPRESS CR/LF
               *
               *   NO VALID FORMAT RECOGNIZED
               *
32324  141737  FHELP  JSM HLINK,I ASK FOR HELP
32325  140404  ER.F2  JSM AERR1,I NO LUCK! ***** ERROR F2 *****
32326  043462          ASC 1,G2    IMPROPER FORMAT SPECIFICATION
               *
               *   THIS SECTION PROCESSES SPECIFICATIONS FORM FORMAT
               *
               *   <SPEC> STARTS WITH "F" = F,FZ.
               *
32327  004177  S.F    LDB P0      B = 0 IF FZ
32330  074560         WBC A,I     LOOK AT NEXT CHARACTER
32331  012733         CPA C.Z     IF Z
32332  067335         JMP S.E     STORE TYPE 0
32333  074760         WBC A,D     OTHERWISE, BACK UP THE BYTE POINTER
32334  004145         LDB P2      AND SET FOR FIXED-TYPE FORMAT
               *
               *   AT THIS POINT, B = 0(FZ), 1(E), 2(F)
               *
32335  174700  S.E    RBR 1       B = FZ(000000), F(000001), E(100000)
32336  035727         STB FFFLG   SAVE TYPE IN FIX/FLT FLAG
```

FORMATTING ROUTINES

```
32337  043514          JSM  DW.D     DEMAND W.D
                *
                *   THIS SECTION SETS UP FWPRT FOR PROPER FORMATTING
                *
32340  001217          LDA  .WPRT    GET CURRENT FIX/FLT SETTING JUST IN CASE
32341  005730          LDB  DP       B=SPECIFIED DECIMAL POINT SETTING
32342  176406          SBM  S.FI     IF B<0, USE CURRENT FIX/FLT SETTING
32343  024255          ADB  M12      CHECK DP FOR RANGE [0,11]
32344  176004          SBP  S.FI     IF DP>11, USE CURRENT FIX/FLT SETTING
32345  001730          LDA  DP       IF IN RANGE, GET DP
32346  170603          SAL  4        PUT THIS SETTING IN FIX AND FLT BITS
32347  061730          IOR  DP       OF WORD FOR NEW .WPRT
32350  050045  S.FI    AND  B377     KEEP ONLY FIX/FLT SETTING VALUES
32351  061727          IOR  FFFLG    AND SET FIX/FLT BIT (15) TO PROPER STATE
32352  060224          IOR  B60K     SET BIT 14 TO PREVENT FLOAT REVERSION
32353  031216  S.NUM   STA  FWPRT    USE THIS FOR FXD/FLT INDICATOR
32354  001725          LDA  RW.SN
32355  073201          SLA  *+1,C    SET FOR NUMBER REQUIRED
32356  031725  S.RET   STA  RW.SN    AND SAVE FOR FUTURE USE
32357  045726          ISZ  Z.CSP    LOG IN OCCURANCE OF DATA SPEC
32360  170201          RET  1        AND GET OUT
                *
                *   THIS SECTION SETS UP FOR STRING
                *
32361  043466  S.C     JSM  FNBLD    GET REP.C
32362  035731          STB  FW       SET FIELD WIDTH
32363  043522          JSM  TRMCK    CHECK FOR PROPER TERMINATION
32364  001725          LDA  RW.SN    GET TYPE WORD
32365  073301          SLA  *+1,S
32366  067356          JMP  S.RET
                *
                *   THIS SECTION SETS UP FOR FMT B (16-BIT BINARY NUMBER)
                *
32367  074560  S.B     WBC  A,I      GET THE NEXT BYTE
32370  043522          JSM  TRMCK    AND CHECK FOR PROPER TERMINATION
32371  000257          LDA  M1       SET .WPRT FOR BINARY FORMAT
32372  067353          JMP  S.NUM    AND EXIT THROUGH NUMERIC SPEC SETUP
                *
                *   PROCESS <SPEC> = X
                *
32373  000117  E.X     LDA  P32      GET AN ASCII SPACE
32374  042417          JSM  IO1C     AND READ/WRITE IT
32375  055732          DSZ  REP.C    IF REPEAT COUNT > 1,
32376  067373          JMP  E.X      LOOP UNTIL DONE
32377  074560          WBC  A,I      GET NEXT CHARACTER FROM FMT
32400  043522  E.XTC   JSM  TRMCK    AND CHECK FOR PROPER TERMINATION
32401  067273          JMP  ANFMT    IF OK, FORCE NEXT SPEC
                *
                *   PROCESS <SPEC> = "....."
                *
32402  000016  E.QT    LDA  C        GET CURRENT FORMAT LOCATION
32403  031727          STA  QTADD    AND SAVE IN CASE OF REPEAT COUNT
32404  001727  E.QTL   LDA  QTADD    GET ADDRESS OF START OF QUOTE
32405  030016          STA  C        AND RESET BYTE POINTER FOR ANOTHER PASS
32406  074560  E.QTN   WBC  A,I      GET NEXT CHARACTER FROM LITERAL
32407  010116          CPA  C.QT     IF QUOTE MARK
32410  067413          JMP  DQTCK    CHECK FOR DOUBLE QUOTE
32411  042417  E.QTQ   JSM  IO1C     READ/WRITE ONE CHARACTER
32412  067406          JMP  E.QTN    LOOP FOR NEXT CHARACTER
                *
32413  074560  DQTCK   WBC  A,I      LOOK AT CHARACTER FOLLOWING QUTOTE
32414  010116          CPA  C.QT     IS IT ANOTHER QUOTE
32415  067411          JMP  E.QTQ    YES, TAKE IT
32416  055732          DSZ  REP.C    NO, MUST BE END. IF REP.C >1,
32417  067404          JMP  E.QTL    THEN RESET TO START OF LITERAL
32420  067400          JMP  E.XTC    DONE! EXIT THROUGH TERM CHECK
                *
                *   PROCESS <SPEC> = /
                *
32421  043446  E.LF    JSM  ECRLF    READ/WRITE A CR/LF
32422  055732          DSZ  REP.C    IF REPEAT COUNT > 1,
32423  067421          JMP  E.LF     CONTINUE TO LOOP
32424  067377          JMP  E.XTC-1  WHEN DONE, EXIT THROUGH TERM CHECK
                *
                *   PROCESS <SPEC> = Z
                *
32425  001726  E.Z     LDA  Z.CSP    GET SUPRESSION FLAG
32426  172201          SAP  *+1,C    CLEAR CR/LF BIT (15)
32427  031726          STA  Z.CSP    PUT BACK SUPRESSION FLAG
32430  067377          JMP  E.XTC-1  WHEN DONE, EXIT THROUGH TERM CHECK
```

```
                      *
                      *   THIS ROUTINE HANDLES AND END-OF-FORMAT
                      *
                      *   IF A CONVERSION SPEC WAS ENCOUNTERED, RESET TO START
                      *   OF FORMAT FOR RESCAN. OTHERWISE, TERMINATE RED/WRT.
                      *   IN ANY CASE, RED/WRT A CR/LF UNLESS SUPRESSION SET.
                      *
32431   031726  NOSUP STA Z.CSP    REPLACE SUPRESSION FLAG
32432   043446        JSM ECRLF    READ/WRITE A CR/LF
                      *
32433   001726  E.EFM LDA Z.CSP    GET SUPRESSION FLAG
32434   172675        SAM NOSUP,C  IF BIT(15) SET, DO A CR/LF
32435   072407        SZA EFMX     IF NO DATA SPECS, TERMINATE
32436   001721        LDA NPCNT    GET PARAMETER COUNT
32437   010254        CPA P1       LAST PARAMETER PROCESSED?
32440   067444        JMP EFMX     YES! DONE, SO GET OUT
32441   005720        LDB .BFMT    NO! GET POINTER TO BEGINNING OF FORMAT,
32442   043264        JSM ZCSET    AND RESET FOR ANOTHER SCAN
32443   067273        JMP ANFMT    GO FOR NEXT FORMAT
32444   054003  EFMX  DSZ R        CANCEL JSM TO THIS ROUTINE
32445   170201        RET 1


                      *
                      *   THIS ROUTINE READS/WRITES A CR/LF
                      *
32446   004135  ECRLF LDB P10
32447   141737        JSM HLINK,I GIVE EXTIO A CHANCE TO EXPAND CR/LF
32450   001725        LDA RW.SN    GET THE READ/WRITE FLAG
32451   172405        SAM RCRLF    IF READ, GO TO READ CR/LF
32452   000132  WCRLF LDA A.CR     GET AN ASCII CR
32453   042421        JSM WRTAC    AND OUTPUT IT
32454   000135        LDA A.LF     GET AN ASCII LF
32455   066421        JMP WRTAC    AND OUTPUT IT (IMPLIED RETURN)
                      *
32456   000042  RCRLF LDA P511
32457   031714        STA T4       SET CUTOFF COUNT FOR OUTPUT-ONLY DEVICE
32460   042425  CKFLF JSM REDAG    READ NEXT CHARACTER
32461   010135        CPA A.LF     LINE FEED?
32462   170201        RET 1        YES! GET OUT
32463   055714        DSZ T4       NO! COUNT EXHAUSTED?
32464   067460        JMP CKFLF    NO! TRY AGAIN
32465   066004        JMP ER.F7    READ 511 CHARS WITH NO LF! GIVE ERROR
                      *
                      *   SUBROUTINE TO BUILD A NUMBER FROM FORMAT STATEMENT
                      *
                      *   ENTRY! C POINTS TO NEXT FORMAT CHARACTER
                      *    EXIT! B = INTEGER
                      *          A = CHARACTER TERMINATING NUMBER
                      *         T5 = COUNT OF EXPLICIT DIGITS FOUND
                      *
32466   004177  FNBLD LDB P0       INITIALIZE TO ZERO
32467   035712        STB T2       NUMBER BUILDING REGISTER
32470   035715        STB T5       COUNT OF DIGITS FOUND
32471   173201        SOC *+1,C    CLEAR OVERFLOW INDICATOR
32472   074560  FNBLN WBC A,I      GET THE NEXT CHARACTER FROM FORMAT
32473   042051        JSM DIGCK    IS IT A DIGIT?
32474   067502        JMP FNBL1    YES! PROCESS IT
32475   005715        LDB T5       NO! WERE THERE ANY DIGITS
32476   076002        RZB *+2      IF YES, RETURN THE VALUE BUILT
32477   141737        JSM HLINK,I  IF NO, TRY FOR VARIABLE VALUE
32500   005712        LDB T2       B = NUMBER BUILT
32501   170201        RET 1        DONE.
                      *
32502   045715  FNBL1 ISZ T5       LOG IN A DIGIT FOUND
32503   001712        LDA T2       GET THE NUMBER BUILT SO FAR (N)
32504   020000        ADA A
32505   020000        ADA A
32506   021712        ADA T2
32507   020000        ADA A
32510   021714        ADA T4       T4 = DIGIT JUST FOUND (D) IN RANGE [0,9]
32511   031712        STA T2       N = 10*N + D
32512   173060        SOC FNBLN    IF NO OVERFLOW, TRY FOR ANOTHER DIGIT
32513   067325        JMP ER.F2    OTHERWISE, GIVE BAD INTEGER ERROR


                      *
                      *   BUILD A NUMBER IN THE FORM W.D
                      *
                      *   ENTRY! C POINTS TO W.D IN FORMAT STATEMENT
                      *    EXIT! FW = W OR * (NO W GIVEN)
                      *          DP = D OR -1 (NO .D GIVEN)
                      *
```

FORMATTING ROUTINES

```
02543000 32514  043466  DW.D  JSM FNBLD   BUILD A NUMBER
02544000 32515  035731        STB FW      SAVE FIELD WIDTH
02545000 32516  004257        LDB M1      SET TO CURRENT FIX/FLT JUST IN CASE
02546000 32517  010105        CPA C.DP    DECIMAL POINT FOLLOWS?
02547000 32520  043466        JSM FNBLD   YES; BUILD D VALUE
02548000 32521  035730        STB DP      NO, USE -1; SAVE RESULT IN DP
02550000                *
02551000                *   CHECK FORMAT FOR PROPER TERMINATION
02552000                *   <SPEC> MUST BE FOLLOWED BY COMMA OR END-OF-FORMAT
02553000                *
02554000 32522  010107  TRMCK CPA C.COM   WAS TERMINATOR COMMA?
02555000 32523  170201        RET 1       YES; ALL IS WELL; GO BACK
02556000 32524  010121        CPA C.EFM   END OF FORMAT?
02557000 32525  067530        JMP F.END   YES; LOG THIS FACT
02558000 32526  004145        LDB P2      LOOKS BAD; SET UNRECOGNIZED TERMINATOR
02559000 32527  067324        JMP FHELP   AND ASK FOR HELP
02560000                *
02561000 32530  074760  F.END WBC A,D     BACK UP SO SCAN WILL FIND EFM CHARACTER
02562000 32531  170201        RET 1       AND PROCESS THIS SPEC
```

WRITE EXFCUTION

```
02565000                *
02566000                *   WRT <SC>,<FMT#>,<PARAMETER LIST>
02567000                *
0256H000 32532  000177  EWRT  LDA P0      SET FOR WRITE OPERATION
02569000 32533  042250        JSM GSCFN   AND SET UP SC, FMT#; CHECK HARDWARE
02570000 32534  043241        JSM FMSET   SET UP FORMAT FOR WRITE
02571000 32535  043270  WLOOP JSM NFMT    DEMAND NEXT FORMAT
02572000 32536  073002        SLA *+2     IF BIT(0)=0, NUMBER REQUIRED
02573000 32537  067645        JMP SWRT    OTHERWISE, DO A STRING WRITE
02574000                *
02575000                *   OUTPUT A NUMERIC ITEM
02576000                *
02577000 32540  001216  NWRT  LDA FWPRT   LOOK AT FORMATTED .WPRT AND
02578000 32541  010257        CPA M1      IF IT IS -1,
02579000 32542  067653        JMP BWRT    OUTPUT UNDER BINARY FORMAT
02580000 32543  043604        JSM NPGET   TRY FOR NEXT PARAMETER
02581000 32544  010254        CPA P1      GOT IT; WAS IT STRING?
02582000 32545  067642        JMP FREST   YES; DO A FREE STRING
02583000 32546  001727        LDA FFFLG   LOOK AT <SPEC> TYPE
02584000 32547  072402        SZA *+2        IF A=0 (FZ SPEC) SET LEADING ZEROS
02585000 32550  000160        LDA M16        IF A#0 SET LEADING BLANKS
02586000 32551  020103        ADA B60
02587000 32552  031746        STA LCHR    SAVE ASCII CODE IN LEADING CHARACTER
02588000 32553  074570        WBD A,I     LOOK AT FIRST CHARACTER (-/SPACE)
02589000 32554  073006        SLA NWRTP   IF BLANK (BIT0=0), OK
02590000 32555  074770        WBD A,D     IF MINUS (BIT0=1), RESET D
02591000 32556  024254        ADB P1      RESET COUNT
02592000 32557  001727        LDA FFFLG   PARM. IS NEGATIVE; CHECK FOR FMT FZ
02593000 32560  072002        RZA NWRTP   IF NOT FZ FORMAT, GO ON
02594000 32561  067613        JMP ER.F3   DON'T ALLOW FZ FORMAT WITH MINUS NUMBER
02595000 32562  000071  NWRTP LDA A.E     SET FOR LC. E TO UC. E CONVERSION
02596000 32563  043635        JSM ESETN   AND SET NCC = COUNT + 1
02597000 32564  001731  SWRT1 LDA FW      A = FIELD WIDTH
02598000 32565  024257        ADB M1      B = #CHARACTERS
02599000 32566  174040        TCB
02600000 32567  024000        ADB A       B = FW - #CHARS
02601000 32570  176007        SBP NWRT1   IF B>=0, OUTPUT B LEADING CHARACTERS
02602000 32571  004000        LDB A       OTHERWISE, SET B = FW
02603000 32572  076405        SZB NWRT1   ALLOW FOR FREE-FIELD WIDTH
02604000 32573  000114        LDA C.DOL   GET ASCII $
02605000 32574  031746        STA LCHR    SET $ AS LEADING CHARACTER
02606000 32575  000254        LDA P1      A = #CHARACTERS, B = # LEADING CHARS
02607000 32576  031750        STA NCC     SET FOR NOTHING AFTER LEADING CHARACTER
02608000 32577  024254  NWRT1 ADB P1      B = NUMBER LEADING CHARACTERS + 1
02609000 32600  035747        STB LCNT    SAVE IN LEAD COUNT
02610000 32601  043617        JSM DLCHR   DUMP LEADING CHARACTERS
02611000 32602  043626        JSM DCSTR   DUMP THE CHARACTER STRING
02612000 32603  067535        JMP WLOOP   GO BACK FOR NEXT SPEC.
02614000 32604  000254  NPGET LDA P1      SET TO GET NEXT PARAMETER
02615000 32605  004505        LDB APGET   GET ADDRESS OF PARAMETER GET ROUTINE
02616000 32606  024145        ADB P2      OFFSET FOR ALTERNATE ENTRY
02617000 32607  140001        JSM B,I     AND GO THERE;  MORE PARAMETERS?
02618000 32610  067433        JMP E.EFM   NO; EXIT THROUGH CR/LF CHECK
02619000 32611  055721        DSZ NPCNT   YES; BUMP PARAMETER COUNT
02620000 32612  176007        SBP DLRET   IF B>0, ALL OK SO RETURN
02621000 32613  140404  ER.F3 JSM AERR1,I ***** ERROR F3 *****
02622000 32614  043463        ASC 1,G3    BAD PARAMETER
```

```
02624000                *
02625000                *   ROUTINE TO DUMP LEADING CHARACTERS
02626000                *
```

WRITE EXECUTION

```
               *    LCHR = LEADING CHARACTER CODE (ASCII)
               *    LCNT = LEADING CHARACTER COUNT + 1
               *
32615  001746        LDA LCHR    GET ASCII CHARACTER
32616  042417        JSM IO1C    AND SEND IT
32617  055747  DLCHR DSZ LCNT    DO IT AGAIN?
32620  067615        JMP *-3     YES
32621  170201  DLRET RET 1       NO
               *
               *    ROUTINE TO DUMP A CHARACTER STRING
               *
               *    NCC  = NUMBER OF CHARACTER COUNT + 1
               *    ECHR = CHARACTER TO DUMP FOR L.C. E
               *
32622  074570  DCSTN WBD A,I     GET THE NEXT BYTE FROM THE STRING
32623  010063        CPA C.E     IS IT A L.C. E?
32624  001751        LDA ECHR    USE EITHER AN U.C. E OR A L.C. E
32625  042421        JSM WRTAC   OUTPUT THE CHARACTER
32626  055750  DCSTR DSZ NCC     MORE CHARACTERS IN THE STRING?
32627  067622        JMP DCSTN   YES; DUMP THE NEXT ONE
32630  170201        RET 1       NO; DONE.


32631  000254  BUMP1 LDA P1
32632  164607        JMP ABUMP,I

               *
               *    THIS ROUTINE SETS THE CHARACTER TO BE DUMPED
               *    FOR AN "E", AND SAVES NCC = B+1
               *
32633  000063  ESETS LDA C.E     STRING ENTRY; LEAVE L.C. "E" ALONE
32634  024254        ADB P1      ADD 1 TO B FOR NCC COUNT
32635  031751  ESETN STA ECHR    NUMERIC ENTRY; A=U.C. "E"
32636  035750        STB NCC     B = COUNT OF CHARACTERS + 1
32637  170201        RET 1
               *
               *    THIS ROUTINE OUTPUTS A FREE STRING FROM THE PARAMETER
               *    LIST WHEN A NUMERIC ITEM WAS EXPECTED
               *
32640  000177  FRESA LDA P0
32641  043605        JSM NPGET+1 RE-GET PARAMETER IN ASCII FORM
32642  043633  FREST JSM ESETS   SET ECHR AND NCC FOR STRING OUTPUT
32643  043626        JSM DCSTR   AND DUMP THE CHARACTER STRING
32644  067540        JMP NWRT    TRY AGAIN FOR A NUMERIC PARAMETER
               *
               *    OUTPUT A STRING
               *
32645  043604  SWRT  JSM NPGET   FETCH THE NEXT PARAMETER
32646  072445        SZA ER.F3   IF A=0, NUMERIC ITEM. BAD SHOW!
32647  000117        LDA B40
32650  031746        STA LCHR    SET LEADING CHARACTER TO BLANK
32651  043633        JSM ESETS   SET ECHR AND NCC FOR STRING OUTPUT
32652  067564        JMP SWRT1   AND LET NUMERIC OUTPUT FINISH UP
               *
               *    OUTPUT A BINARY FORMATTED NUMBER
               *
32653  043631  BWRT  JSM BUMP1   POINT TO NEXT PARAMETER
32654  043433        JSM E.EFM   IF NONE, LET E.EFM FINISH UP
32655  040751        JSM NGET    DEMAND NUMERIC VALUE
32656  067640        JMP FRESA   NON-NUMERIC; TRY FOR FREE STRING
32657  055721        DSZ NPCNT   DECREMENT PARAMETER COUNT
32660  043663        JSM BOFIX   MAKE AN INTEGER
32661  141740        JSM WRTIC,I AND SEND IT
32662  067535        JMP WLOOP   GO BACK FOR MORE
               *
               *    THIS ROUTINE MAKES A BINARY NUMBER FROM
               *    FLOATING POINT NUMBER (OCT/DEC)
               *
32663  000001  BOFIX LDA B       A POINTS TO NUMBER TO BE FIXED
32664  004141        LDB P6      SET FOR POSSIBLE OCTAL CONVERSION
32665  141737        JSM HLINK,I AND GIVE OCTAL ROUTINE A CHANCE
32666  040644        JSM FIXPT   IF NO HELP, CALL ON DECIMAL FIX-POINT
32667  173002        SOC *+2     IF NO OVERFLOW, GO ON
32670  067613  JERF3 JMP ER,F3   OTHERWISE, GIVE OVERFLOW ERROR
32671  000001        LDA B       A = B = RESULT
32672  170201        RET 1


               *
               *    WTB <SC>, <BYTE LIST>
               *
```

WRITE EXECUTION

```
                        *     FAKE A "FMT Z, 65535B" AND LET EWRT PROCESS IT
                        *
32673   000177   EWTB   LDA P0      SET FOR OUTPUT OPERATION
32674   031726          STA Z.CSP   RESET FOR SUPRESS/NO DATA SPECS
32675   042250          JSM GSCFN   AND GET THE SELECT CODE
32676   000257          LDA M1
32677   031732          STA REP.C   SET FOR 65535 REPEATS OF "FMT B"
32700   031216          STA FWPRT   SET FORMAT ,WPRT TO "BINARY"
32701   067535          JMP WLOOP   ENTER "EWRT" AT NEXT FORMAT CALL
```

READ EXECUTION

```
                        *
                        *   RED <SC>,<FMT.N>, <VARIABLE LIST>
                        *
32702   000263   ERED   LDA FLAG    SET READ INDICATOR
32703   042250          JSM GSCFN   AND SET UP SELECT CODE, FORMAT NUMBER
32704   043241          JSM FMSET   INITIALIZE FORMAT
32705   031722          STA RTFLG   CLEAR READ-TERMINATE FLAG
                        *
                        *   FREE-FIELD READ = FMT Z, 32767 FZ*.0
                        *
                        *   SET Z=SUPRESS, DP=0, FW=0, REP.C=0
                        *
32706   002727          LDA .T14    SET POINTER TO TEMPS, JUST IN CASE
32707   014722          CPB .SFMT   IS THIS A FREE-FIELD FORMAT?
32710   071604          CLR 5       YES; DO FREE-FIELD SETUP
                        *
                        *   READ THE NEXT PARAMTER
                        *
32711   043270   RCONT  JSM NFMT    DEMAND NEXT FORMAT
32712   043631          JSM BUMP1   POINT TO NEXT PARAMETER
32713   043433          JSM E.EFM   LIST EXHAUSTED; FINISH UP
32714   055721          DSZ NPCNT   GOT IT; BUMP PARAMETER COUNT
32715   101272          LDA FAP1,I  GET TYPE (WHAT WORD)
32716   172005          SAP ER.F5   IF PARAMETER IS A CONSTANT, CAN'T READ!
32717   040751          JSM NGET    CHECK TYPE OF THIS PARAMETER
32720   066060          JMP SRED    NON-NUMERIC; TRY FOR A STRING
32721   001725          LDA RW.SN   NUMERIC; SEE IF FMT IS FOR A NUMERIC
32722   073013          SLA NRED    YES IT IS; DO A NUMERIC READ
32723   140404   ER.F5  JSM AERR1,I ***** ERROR F5 *****
32724   043465          ASC 1,G5    WRONG READ PARAMETER TYPE
```

```
                        *
                        *   ROUTINES TO ABORT SINGLE PARAMETER OR READ LIST
                        *
32725   043733   REDX   JSM REDXX   SET FLAG 13 TO TELL PARAMETER ABORTED
32726   001722   RLOOP  LDA RTFLG   CHECK THE READ-TERMINATE FLAG
32727   073062          SLA RCONT   IF CLEAR, GO ON TO READ NEXT PARAMETER
32730   001721          LDA NPCNT   ELSE, SEE IF ALL PARAMS. DONE
32731   010254          CPA P1      IF READ/WRITE LIST COMPLETED
32732   170201          RET 1       DON'T SET FLAG 13
32733   004132   REDXX  LDB P13     SET B FOR FLAG 13 SETTING
32734   164376          JMP ASFG,I  SET THE FLAG (IMPLIED RETURN)
                        *
                        *   INPUT A NUMERIC ITEM
                        *
32735   001216   NRED   LDA FWPRT
32736   010257          CPA M1      IS FXD/FLT FLAG = -1?
32737   066144          JMP BRED    YES; THIS IS A BINARY READ
                        *
32740   000305          LDA ASTAK
32741   030017          STA D       SET TO USE CSTAK FOR INPUT BUFFER
32742   001731          LDA FW
32743   031747          STA TFW     SET TEMP-FW FOR COUND DOWN
32744   042527          JSM CSAV    SAVE C SINCE ANUMB WILL KILL IT
32745   042025          JSM REDFC   READ FIRST INPUT CHARACTER
32746   010107          CPA C.COM   IS IT A ","?
32747   067725          JMP REDX    YES; ABORT THIS PARAMETER
32750   010135   NREDO  CPA A.LF    LINE FEED (12B)?
32751   067725          JMP REDX    NO NUMERIC DATA FOUND; SKIP THIS VALUE
32752   172477          SAM *-1     FW RAN OUT BEFORE NUMERIC DATA
32753   042045          JSM NSTCK   GOT BYTE; NUMERIC TYPE?
32754   067757          JMP NRED1   YES; START NUMBER BUFFER
32755   042021          JSM REDNC   NO; TRY THE NEXT CHARACTER
32756   067750          JMP NREDO   AND TEST IT
                        *
32757   042015   NRED1  JSM STK1C   STACK A NUMERIC TYPE CHARACTER AND READ
32760   172405          SAM NRBLS   IF FW EXHAUSTED, GO TO NUMBER SCANNER
```

```
32761  005731        LDB FW      FREE FIELD READ?
32762  076075        RZB NREDI   NO; KEEP READING
32763  042035        JSM NUMCK   YES; STILL READING NUMERIC TYPES?
32764  067757        JMP NREDI   YES; CONTINUE UNTIL NON-NUMERIC TYPE
32765  074550 NRBLS  PBD A,I     STACK A DELIMITER IN CASE FW ENDED READ
32766  004325        LDB ASTKF
32767  034016        STB C       SET C TO START OF BUFFER
32770  000177        LDA P0
32771  031751        STA MSGN    RESET THE MANTISSA-SIGN INDICATOR
32772  074560 NRBLI  WBC A,I     CHECK THE FIRST BYTE READ
32773  042047        JSM DDPCK   WAS IT A DIGIT OR DECIMAL POINT?
32774  066002        JMP NRBLD   YES; GO TO THE NUMBER BUILDER
32775  010106        CPA A.MIN   NO; A MINUS SIGN?
32776  045751        ISZ MSGN    YES; LOG IN A MINUS SIGN
32777  042041        JSM NUMDK   NO; WAS IT AN "E"?
33000  067772        JMP NRBLI   NO; GO ON CHECKING
33001  066004        JMP ER.F7   YES; THAT WILL NEVER DO; GIVE ERROR.
                  *
33002  031240 NRBLD  STA BCD     "NUMB" EXPECTS FIRST CHARACTER HERE
33003  140352        JSM ANUMB,I AND CALL ON THE NUMBER BUILDER
33004  140404 ER.F7  JSM AERRI,I NUMBER BUILDER CAME UP CRAPS; ERROR F7
33005  043467        ASC 1,G7    BAD INPUT DATA
33006  000021        LDA AR2+1   LOOK AT FIRST MANTISSA WORD
33007  072404        SZA NRBLP   IF ZERO, SKIP "-" CHECK TO AVOID "-0"
33010  001751        LDA MSGN    CHECK THE MANTISSA-SIGN INDICATOR
33011  073002        SLA *+2     IF POSITIVE, GO ON
33012  044020        ISZ AR2     IF NEGATIVE, SET MANTISSA SIGN
33013  042523 NRBLP  JSM CGET    IT IS SAFE TO RESTORE C NOW
33014  066146        JMP BREDI   AND EXIT THROUGH STORAGE ROUTINE
                  *
                  *   THIS ROUTINE SAVES A CHARACTER AND READS ANOTHER ONE
                  *
                  *   ON EXIT, A IS THE CODE READ UNLESS TFW IS EXHAUSTED,
                  *   IN WHICH CASE A = -1.
                  *
33015  004017 S KIC  LDB D       LOOK AT BUFFER POINTER
33016  016742        CPB ASLMM   END OF BUFFER?
33017  066004        JMP ER.F7   YES; ERROR (160 NUMERICS IS RIDICULOUS)
33020  074550        PBD A,I     NO; SAVE THIS CHARACTER
                  *
33021  000257 REDNC  LDA M1      SET TO END-OF-FIELD (EOF) JUST IN CASE
33022  055747        DSZ TFW     IF FIELD WIDTH NOT EXHAUSTED,
33023  066025        JMP REDFC   READ A CHARACTER
33024  170201        RET 1       OTHERWISE, RETURN WITH -1
33025  042425 REDFC  JSM REDAC   INPUT THE NEXT CHARACTER
33026  010132        CPA A.CR    ASCII CR?
33027  066025        JMP REDFC   YES; IGNORE THIS CHARACTER
33030  010136        CPA A.SKP   ASCII SKIP CODE?
33031  067446        JMP ECRLF   READ TO NEXT RECORD AND RETURN WITH A.LF
33032  010135        CPA A.LF    LINE FEED WITHOUT PRECEEDING SKIP?
33033  045722        ISZ RTFLG   YES; SET READ TERMINATE FLAG!
33034  170201        RET 1       RETURN WITH A = CHARACTER


                  *
                  *   THIS ROUTINE CHECKS FOR "NUMERIC" TYPE CHARACTERS
                  *
                  *   0-9, DECIMAL POINT, E, +, AND - ARE ALLOWED CHARACTERS
                  *   ALL OTHERS ARE NON-NUMERIC AND ACT AS DELIMITERS
                  *
33035  010071 NUMCK  CPA A.E     ASCII E?
33036  000063        LDA C.E
33037  010063        CPA C.E     ALLOW L.C. OR U.C. "E" FOR EXPONENT
33040  170201        RET 1
33041  010117 NUMDK  CPA B40     BLANK?
33042  170201        RET 1
33043  010110        CPA A.PLS   ASCII +?
33044  170201        RET 1
33045  010106 NSTCK  CPA A.MIN   ASCII -?
33046  170201        RET 1
33047  010105 DDPCK  CPA C.DP    ASCII .?
33050  170201        RET 1
33051  004000 DIGCK  LDB A
33052  024163        ADB M48     B = A-48
33053  035714        STB T4      T4 = DIGIT IN RANGE [0,9]
33054  176403        SBM *+3     IF B<0, A:[0,47], NOT AN DIGIT
33055  024207        ADB M10     B = A-58
33056  176472        SBM DIGCK-1 IF B>0, A>58, NOT A DIGIT
33057  170202        RET 2       NON-NUMERIC TYPE; RET P+2
                  *
                  *   INPUT A STRING ITEM
                  *
33060  101272 SRED   LDA FAP1,I  GET THE TYPE WORD FOR THIS PARAMETER
33061  012743        CPA STR.S   IS IT A SIMPLE STRING?
33062  066070        JMP SREDO   YES; PROCESS IT
```

READ EXECUTION

```
02874000 33063  012744        CPA STR.A   IS IT A SIMPLE STRING FROM AN ARRAY?
02875000 33064  066070        JMP SREDO   YES! PROCESS IT
02876000 33065  004132        LDB P13     NONE OF THE ABOVE! SET FOR SUBSCRIPTED
02877000 33066  141737        JSM HLINK,I STRING TYPE AND ASK FOR HELP
02878000 33067  067723        JMP ER.F5   NONE! GIVE BAD READ PARAMETER ERROR
02879000               *
02880000 33070  005272  SREDO LDB FAP1    GET STACK POINTER
02881000 33071  024145        ADB P2      POINT TO WHERE WORD
02882000 33072  100001        LDA B,I     GET BYTE POINTER TO FIRST CHARACTER
02883000 33073  030017        STA D       AND SET UP D FOR CHARACTER STUFFING
02884000 33074  074770        WBD A,D     BACK UP POINTER SINCE PBD INCRMS. FIRST
02885000 33075  024145        ADB P2      POINT TO POINTER TO CURRENT LENGTH
02886000 33076  100001        LDA B,I     GET THE POINTER
02887000 33077  031746        STA .LEN    AND SAVE THIS POINTER TO UPDATE LENGTH
02888000 33100  071600        CLR 1       SET STRING LENGTH TO ZERO
02889000 33101  024254        ADB P1      POINT TO POINTER TO ORGANIZATION DATA
02890000 33102  100001        LDA B,I
02891000 33103  020145        ADA P2
02892000 33104  100000        LDA A,I     A = LEN (DIMENSIONED LENGTH)
02893000 33105  031750        STA R.LIM   SET THIS AS INITIAL READ COUNT LIMIT
02895000               *
02896000               *   THIS SECTION SETS UP FOR STRING READ
02897000               *
02898000               *   FREE STRING (RW.SN=EVEN):  R.LIM=LEN    R.AFT=1
02899000               *   FREE FIELD  (FW=0)      :  R.LIM=LEN    R.AFT=1
02900000               *   FORMATTED, FW>L         :  R.LIM=LEN    R.AFT=FW-LEN+1
02901000               *   FORMATTED, FW<L         :  R.LIM=FW     R.AFT=1
02902000               *
02903000 33106  004177        LDB P0
02904000 33107  035751        STB FFR     SET INITIALLY TO FREE-FIELD READ
02905000 33110  001725        LDA RW.SN   IS THIS A FREE-STRING (NUMBER EXPECTED)?
02906000 33111  073012        SLA SRED1   YES! R.LIM IS OK! SET R.AFT=1
02907000 33112  001731        LDA FW      NO! SET A = FW
02908000 33113  072410        SZA SRED1   IF FW=0, R.LIM IS OK! SET R.AFT=1
02909000 33114  045751        ISZ FFR     NO! SET TO FORMATTED READ
02910000 33115  005750        LDB R.LIM   A = FW
02911000 33116  174040        TCB
02912000 33117  024000        ADB A       B = FW - LEN
02913000 33120  176003        SBP SRED1   IF FW>=LEN, R.LIM IS OK! SET R.AFT
02914000 33121  031750        STA R.LIM   OTHERWISE, SET R.LIM = FW
02915000 33122  004177        LDB P0      AND R.AFT = 1
02916000 33123  024254  SRED1 ADB P1      OFFSET COUNT BY 1 FOR DSZ COUNTDOWN
02917000 33124  035747        STB R.AFT   SET NUMBER OF BYTES TO BYPASS AFTER READ
02918000               *
02919000 33125  042425  SREDN JSM REDAC   READ THE NEXT BYTE FROM THE PERIPHERAL
02920000 33126  005751        LDB FFR     IS THIS A FREE-FIELD READ
02921000 33127  077405        RLB SREDC   NO! ONLY TERMINATE ON R.LIM
02922000 33130  010132        CPA A.CR    YES! WAS CHARACTER A CARRIAGE-RETURN?
02923000 33131  066125        JMP SREDN   IF SO, FREE-FIELD IGNORES THEM
02924000 33132  010135        CPA A.LF    WAS THE CHARACTER A LINE-FEED?
02925000 33133  067712  SREDF JMP RCONT+1 YES! TERMINATE AND TRY AGAIN FOR NUMERIC
02926000               *
02927000 33134  074550  SREDC PBD A,I     PUT THE CHARACTER IN THE STRING
02928000 33135  145746        ISZ .LEN,I  INCREMENT THE CURRENT LENGTH COUNT
02929000 33136  055750        DSZ R.LIM   HAVE WE READ TO THE LIMIT?
02930000 33137  066125        JMP SREDN   NO! READ THE NEXT STRING CHARACTER
02931000 33140  043617        JSM DLCHR   YES! READ PAST ANY REMAINING FIELD-WIDTH
02932000 33141  005725        LDB RW.SN   CHECK WHETHER THIS WAS FREE-FIELD
02933000 33142  077071        SLB SREDF   IT WAS, SO TRY AGAIN FOR NUMERIC
02934000 33143  067726        JMP RLOOP   IT WAS FORMATTED, SO GO TO NEXT FORMAT
02936000               *
02937000               *   INPUT A BINARY FORMATTED NUMBER
02938000               *
02939000 33144  141741  BRED  JSM REDIC,I READ ONE BYTE
02940000 33145  042153        JSM BOFLT   MAKE A FULL-PRECISION NUMBER
02941000 33146  005272  BRED1 LDB FAP1
02942000 33147  040616        JSM ABSAD+1
02943000 33150  000127        LDA ADR2    SET UP SOURCE AND DESTINATIONS
02944000 33151  071403        XFR 4       AND SAVE RESULT
02945000 33152  067726        JMP RLOOP   GO BACK FOR MORE


02947000               *
02948000               *  BUILD A DECIMAL OR OCTAL FLOATING NUMBER
02949000               *
02950000 33153  004142  BOFLT LDB P5      SET FOR POSSIBLE OCTAL CONVERSION
02951000 33154  141737        JSM HLINK,I AND GIVE OCTAL ROUTINE A CRACK
02952000 33155  004000        LDB A       B IS VALUE TO FLOAT
02953000 33156  164563        JMP AFLTP,I EXIT THROUGH FLOAT-POINT ROUTINE
02955000               *
02956000               *  RDB (<SC>)        FUNCTION
02957000               *
02958000 33157  000263  ERDB  LDA FLAG
02959000 33160  042250        JSM GSCFN   BUILD AND SET UP SELECT CODE
```

## READ EXECUTION

```
02960000 33161  141741        JSM REDIC,I READ A BYTE
02961000 33162  042153  ERDB1 JSM BOFLT   BUILD A FLOATING NUMBER
02962000 33163  000127        LDA ADR2
02963000 33164  004340        LDB ARES
02964000 33165  071403        XFR 4       PUT THE RESULT IN RES
02965000 33166  054003        DSZ R       CANCEL MAIN EXECUTION RETURN
02966000 33167  001734        LDA CSAVE
02967000 33170  030016        STA C       AND RESTORE VALUE OF C
02968000 33171  055721        DSZ NPCNT   HOW MANY FUNCTION PARAMETERS?
02969000 33172  067613        JMP ER.F3   MORE THAN ONE! GIVE ERROR!
02970000 33173  005272        LDB FAP1    GET THE STACK POINTER
02971000 33174  040616        JSM ABSAD+1 FORM ADDRESS OF BOTTOM OF STACK
02972000 33175  031263        STA AP1     AND RESET AP1
02973000 33176  164366        JMP ARAP,I  CAUSE I'M GOING OUT THE BACK DOOR.
```

```
02975000                *
02976000                *   RDS (<SC>)          FUNCTION
02977000                *
02978000 33177  000257  ERDS  LDA M1      SET TO BYPASS BUS SETUP
02979000 33200  042250        JSM GSCFN   BUILD AND SET UP SELECT CODE
02980000 33201  005723        LDB DN.SC   LOOK AT THE CARD TYPE SPECIFIED
02981000 33202  176003        SBP *+3     IF CARD STATUS REQUIRED, GO ON
02982000 33203  004144        LDB P3      ELSE, SET FOR HP-IB SERIAL POLL
02983000 33204  066302        JMP SHELP   AND GO TO EXTIO (OR ERROR F4)
02984000 33205  172255        SAP ERDB1,C IF GPIO CARD, RETURN STATUS BYTE
02985000 33206  004143        LDB P4      GIVE EXTIO A CHANCE TO RETURN
02986000 33207  141737        JSM HLINK,I EXTENDED HP-IB STATUS BYTES
02987000 33210  066162        JMP ERDB1,  AND RETURN VALUE OF MAIN STATUS BYTE
```

## CONVERSION-TYPE STATEMENTS

```
02990000                *
02991000                *   CONV <ASCII>,<FOREIGN>, ... <ASCII>,<FOREIGN>
02992000                *
02993000                *   SET UP CODE CONVERSION TABLE
02994000                *
02995000 33211  000177  ECONV LDA P0
02996000 33212  042236        JSM ECONX   CLEAR CONVERSION WORD TO NULL
02997000 33213  024141        ADB P6      FORM ADDRESS OF START CONVERSION TABLE
02998000 33214  034017        STB D       AND SET D TO PLACE BYTES
02999000 33215  140610        JSM ACOUN,I HOW MANY PARAMETERS?
03000000 33216  072420        SZA ECONX   NONE! CLEAR CONV FLAG AND GET OUT
03001000 33217  073003        SLA *+3     AN EVEN NUMBER, SO GO ON
03002000 33220  140404  ER.F6 JSM AERR1,I ODD NUMBER! ***** ERROR F6 *****
03003000 33221  043466        ASC 1,G6    IMPROPER CONVERSION PARAMETER
03004000 33222  022736        ADA M21     IF NUMBER OF PARAMETERS > 20,
03005000 33223  172075        SAP ER.F6   GIVE ERROR (TABLE ONLY HOLDS 10 PAIRS)
03006000                *
03007000 33224  040751  ECONL JSM NGET    DEMAND A NUMERIC VALUE
03008000 33225  066220        JMP ER.F6   NON-NUMERIC, GIVE ERROR G6
03009000 33226  043663        JSM BOFIX   MAKE INTEGER USING DEC/OCT FLAG
03010000 33227  074551        PBD B,I     PLACE THE BYTE IN CONV TABLE
03011000 33230  174506        SBR 7       MORE THAN SEVEN BITS?
03012000 33231  076067        RZB ER.F6   YES! NOT ALLOWED
03013000 33232  043631        JSM BUMP1   TRY FOR ANOTHER PARAMETER
03014000 33233  066235        JMP *+2     NONE! TABLE COMPLETE
03015000 33234  066224        JMP ECONL   MORE! LOOP TO BUILD TABLE
03016000 33235  000017        LDA D       GET ADDRESS OF LAST TABLE ENTRY
03017000 33236  004134  ECONX LDB P11     SET TO SAVE ADDRESS IN CVTBL (STOLEN)
03018000 33237  025045        ADB FSPTR
03019000 33240  130001        STA B,I     SET CVTBL WITH CONTENTS OF A
03020000 33241  170201        RET 1       DONE! GET OUT
```

```
03022000 33242  031723  SCRDS STA DN.SC   SAVE A AS SELECT CODE/DEVICE NUMBER
03023000 33243  030011        STA PA      AND SET THE PERIPHERAL ADDRESS REGISTEE
03024000 33244  050045        AND B377    KEEP ONLY THE SELECT CODE PART
03025000 33245  020161        ADA M17     IS IT IN THE RANGE [0,16]?
03026000 33246  172035        SAP ER.F4   NO! GIVE BAD SC ERROR
03027000 33247  066573        JMP REDST   YES, EXIT THROUGH READ-STATUS ROUTINE
03030000                *
03031000                *   THIS ROUTINE DOES THE INITIAL SELECT-CODE SETUP
03032000                *
03033000                *   ALLOWED SC FORMATS:  S.F, SS.F, SDD.F, SSDD.F
03034000                *   WHERE SS=SELECT CODE, DD=DEVICE NUMBER (HPIB)
03035000                *   AND .F=FORMAT REFERENCE NUMBER
03036000                *
03037000                *   ENTRY:  A = 0 (WRITE), 100000 (READ), 177777 (STATUS)
03038000                *
```

SELECT CODE SET UP ROUTINES

```
03039000                    *    ON EXIT:  DN.SC = GPIO/HPIB FLAG (BIT 15)
03040000                    *                      DEVICE NUMBER (BITS 14-8)
03041000                    *                      SELECT CODE (BITS 7-0)
03042000                    *              FMT.N = FORMAT NUMBER
03043000                    *
03044000                    *    HARDWARE CHECKED FOR VALID CONFIGURATION AND SET
03045000                    *
03046000 33250  031725  GSCFN STA RW.SN   SAVE READ/WRITE FLAG
03047000 33251  140610        JSM ACOUN,I SET TO FIRST PARAMETER
03048000 33252  035721        STB NPCNT   SAVE NUMBER OF PARAMETERS
03049000 33253  040751        JSM NGET    DEMAND A NUMERIC VALUE
03050000 33254  172325        SAP HLP11,S IF NON-NUMERIC, ASK FOR HELP
03051000 33255  000001  GSCX  LDA B       A = ADDRESS OF SC PARAMETER
03052000 33256  004127        LDB ADR2    TRANSFER PARAMETER TO AR2-REGISTER
03053000 33257  071403        XFR 4
03054000 33260  000020        LDA AR2     LOOK AT THE EXPOPNENT WORD
03055000 33261  073422        RLA ER.F4   IF MANTISSA IS NEGATIVE, GIVE ERROR
03056000 33262  170405        AAR 6       A = EXPONENT (E)
03057000 33263  020254        ADA P1      A = (E+1)
03058000 33264  004132        LDB P13     SE! FOR 13 SHIFTS JUST IN CASE
03059000 33265  172405        SAM GSCF1   IF E<-1, SC=0.0 SO USE 13 SHIFTS
03060000 33266  170040        TCA
03061000 33267  020133        ADA P12     ELSE, SET A = 11-E
03062000 33270  004000        LDB A       INTO B AS NUMBER OF PLACES TO SHIFT
03063000 33271  176412        SBM ER.F4   IF B<0, E>11! TOO BIG, GIVE ERROR
03064000 33272  000177  GSCF1 LDA P0      SET TO SHIFT IN ZEROS
03065000 33273  031733        STA EXTBA   CLEAR EXTENDED BUS ADDRESSING (FOR EXTIC
03066000 33274  075500        MRY         POSITION DP TO FOLLOW DIGIT 12
03067000 33275  031720        STA FMT.N   ANY DIGIT AFTER DP IS FORMAT NUMBER
03068000 33276  000001        LDA B       A = 11-E (PLACES SHIFTED)
03069000 33277  174502        SBR 3       SEE IF #SHIFTS WAS LESS THAN 8
03070000 33300  076005        RZB GSCF2   NO, WE HAD 4 DIGITS OR LESS
03071000 33301  004134  HLP11 LDB P11     AND CALL ON EXTIO FOR HELP
03072000 33302  141737  SHHLP JSM HLINK,I THROUGH THE HELP LINK WORD
03073000 33303  140404  ER.F4 JSM AERR1,I NO HELP, GIVE ***** ERROR F4 *****
03074000 33304  043464        ASC 1,G4    BAD SELECT CODE PARAMETER
03075000 33305  000023  GSCF2 LDA AR2+3   GET 4-DIGITS OF SC PARAMETER
03076000 33306  030021        STA AR2+1   SET THEM FOR THE NUMBER BUILDER
03077000 33307  042372        JSM BLD2D   BUILD AN INTEGER OUT OF FIRST 2 DIGITS
03078000 33310  035723        STB DN.SC   AND SAVE THESE FOR NOW
03079000 33311  042372        JSM BLD2D   BUILD AN INTEGER OUT OF NEXT 2 DIGITS
03080000 33312  000001        LDA B       A = LOW DIGITS
03081000 33313  005723        LDB DN.SC   B = HIGH DIGITS
03082000 33314  076013        RZB GSC2    IF B>0, THIS IS 3- OR 4-DIGIT SC (HPIB)
03084000                    *
03085000                    *   2-DIGIT SC (GPIO)
03086000                    *
03087000 33315  042242        JSM SCRDS   CHECK SELECT CODE AND READ STATUS
03088000 33316  077422        RLB GSC1    IF READ STATUS ONLY, QUIT HERE
03089000 33317  042650        JSM CKPA    WHAT IS THE PA SET TO?
03090000 33320  066517        JMP SENDI   PA=0! EXIT THROUGH BUFFER SETUP
03091000 33321  066303  JERF4 JMP ER.F4   PA=1! DON'T ALLOW RED/WRT TO CASSETTE
03092000 33322  001745        LDA STBYT   PA>1! GET THE STATUS BYTE
03093000 33323  172403        SAM JERF9     IF HP-IB CARD, NOT RIGHT!
03094000 33324  050103        AND B60     KEEP ONLY THE IDENTIFIER BITS (5-4)
03095000 33325  072013        RZA GSC1    IF CARD IS THERE, DONE.
03096000 33326  066364  JERF9 JMP ER.F9   NO CARD, OR TYPE 00 (NON-STANDARD) CARC
03097000                    *
03098000                    *   4-DIGIT SC (HPIB)
03099000                    *
03100000 33327  020162  GSC2  ADA M32     IS DN IN RANGE (0,31)?
03101000 33330  172071        SAP JERF4   NO! GIVE ERROR
03102000 33331  020117        ADA P32     YES! RESTORE A = DN
03103000 33332  170607        SAL 8       POSITION DN BITS
03104000 33333  060001        IOR B       INCLUDE SC BITS
03105000 33334  062740        IOR BSMSK   AND SET HPIB FLAG BITS
03106000 33335  042242        JSM SCRDS   CHECK SC AND READ STATUS
03107000 33336  172026        SAP ER.F9   IF NOBODY OR GPIO, CONFIGURATION ERROR
03108000 33337  014257        CPB M1      IF RW.SN=-1, SKIP BUS SETUP
03109000 33340  170201  GSC1  RET 1       AND GET OUT
03111000                    *
03112000                    *   THIS SECTION SETS UP THE HPIB BY
03113000                    *
03114000                    *      SEND UNIVERSAL UNLISTEN COMMAND
03115000                    *      DECLAIR CALCULATOR TALKER/LISTNER (BASED ON RW.SN)
03116000                    *      DECLARE DEVICE AS  LISTNER/TALKER
03117000                    *
03118000 33341  001723  BUSET LDA DN.SC   LOOK AT THE GPIO/HP-IB FLAG
03119000 33342  004133        LDB P12     SET B FOR HELP LINK, JUST IN CASE
03120000 33343  141737        JSM HLINK,I GIVE EXTIO CHANCE FOR SECONDARY ADDRESS
03121000 33344  170507        SAR 8       KEEP ONLY DEVICE NUMBER HALF
03122000 33345  012737        CPA NOSET   IF DN=31 (11011111)
03123000 33346  170201        RET 1       LEAVE THE BUS SETUP AS IS
03124000 33347  030022        STA AR2+2   DN<31! SAVE TALK ADDRESS FOR LATER
03125000 33350  000074        LDA UNL     GET UNIVERSAL UNLISTEN COMMAND
```

## SELECT CODE SET UP ROUTINES

```
03126000 33351  042366            JSM BUSR6   AND SEND IT
03127000 33352  001743            LDA BUSDN   GET HP-IB'S BUS DEVICE NUMBER
03128000 33353  176002            SBP *+2     IF WRITE, THIS IS ALREADY TALK ADDRESS
03129000 33354  020066            ADA B140    OTHERWISE, FORM A LISTEN ADDRESS
03130000 33355  042366            JSM BUSR6   AND SEND IT
03131000 33356  000022            LDA AR2+2   GET SPECIFIED DEVICE NUMBER
03132000 33357  176402            SBM *+2     IF READ, THIS IS ALREADY TALK ADDRESS
03133000 33360  020066            ADA B140    OTHERWISE, FORM A LISTEN ADDRESS
03134000 33361  042366            JSM BUSR6   SEND IT
03135000 33362  042627            JSM WAIT    BUS IS CONFIGURED! WAIT FOR READY
03136000 33363  076206            SSS BUSRT   AND IF STATUS SET, ALL WENT WELL
03137000 33364  140404      ER.F9 JSM AERR1,I IF NOT, ***** ERROR F9 *****
03138000 33365  043471            ASC 1,G9    IMPROPER HARDWARE CONFIGURATION
03139000                    *
03140000                    *  SEND A COMMAND TO THE HPIB
03141000                    *
03142000 33366  042627      BUSR6 JSM WAIT    WAIT FOR BUS TO GO READY
03143000 33367  030006      EWTC1 STA R6      OUTPUT CONTROL BYTE
03144000 33370  005725      RDSTX LDB RW.SN   AND B = READ/WRITE FLAG
03145000 33371  170201      BUSRT RET 1       FOR NEXT PASS
```

◆

```
03147000                    *
03148000                    *  BUILD A 2-DIGIT NUMBER FROM AR2
03149000                    *
03150000 33372  000145      BLD2D LDA P2
03151000 33373  031711            STA T1      SET FOR 2-DIGITS LEFT TO BUILD
03152000 33374  004177            LDB P0      INITIALIZE THE ACCUMULATOR
03153000 33375  064664            JMP FI2     AND LET "FIXPT" FINISH UP
03155000                    *
03156000                    *   WTC <SC>, <BYTE>
03157000                    *
03158000 33376  000257      EWTC  LDA M1      SET FOR CHECK ONLY
03159000 33377  042250            JSM GSCFN   BUILD AND SET UP SELECT CODE
03160000 33400  172464            SAM ER.F9   DO NOT ALLOW WTC TO HP-IB CARD
03161000 33401  072463            SZA ER.F9   NO CARD PLUGGED IN
03162000 33402  043631            JSM BUMP1   POINT TO BYTE PARAMETER
03163000 33403  067613            JMP ER.F3   NO PARAMETER; GIVE ERROR
03164000 33404  040751            JSM NGET    FETCH THE PARAMETER
03165000 33405  067613            JMP ER.F3   NON-NUMERIC
03166000 33406  043663            JSM BOFIX   MAKE A FIX-POINT NUMBER
03167000 33407  052741            AND CMASK   MASK OUT INTERRUPT RELATED BITS (7-4)
03168000 33410  042650            JSM CKPA    CHECK THE PERIPHERAL ADDRESS
03169000 33411  066463            JMP EWTC0   PA=0; SET ALTERNATE KDP CHIP BY R7 OUT
03170000 33412  066303            JMP ER.F4   PA=1; CANNOT WRITE CONTROL TO CASSETTE!
03171000 33413  030005            STA R5      PA>1! OUTPUT CONTROL REGISTER
03172000 33414  050170            AND LMASK   ANY BITS IN LEFT BYTE?
03173000 33415  072454            SZA BUSRT   NO; WE ARE DONE! GET OUT.
03174000 33416  066367            JMP EWTC1   YES! SEND SECONDARY DATA THROUGH R6
```

## GENERAL INPUT/OUTPUT ROUTINES

```
03176000                    *
03177000                    *   GENERAL INPUT/OUTPUT ROUTER
03178000                    *
03179000                    *   ENTRY:  OUTPUT CODE IN A
03180000                    *   EXIT:   INPUT CODE IN A
03181000                    *
03182000                    *    IOIC:  INPUT/UOTPUT BASED ON CURRENT READ/WRITE FLAG
03183000                    *   WRTAC:  OUTPUT A THROUGH CONVERSION TABLE
03184000                    *   REDAC:  INPUT THROUGH CONVERSION TABLE TO A
03185000                    *
03186000 33417  005725      IOIC  LDB RW.SN   LOOK AT READ/WRITE FLAG
03187000 33420  176405            SBM REDAC   IF BIT(15) SET, READ
03188000                    *
03189000 33421  005735      WRTAC LDB CVTBL   CHECK FOR CONVERSION
03190000 33422  076402            SZB WRTA    IF ZERO, NO CONVERSION ACTIVE
03191000 33423  042431            JSM CVSCH   IF NOT, SEARCH CONV TABLE
03192000 33424  165740      WRTA  JMP WRT1C,I GO TO SEND ROUTINE THROUGH LINK WORD
03193000                    *
03194000 33425  141741      REDAC JSM RED1C,I GO TO READ ROUTINE THROUGH LINK WORD
03195000 33426  050053            AND B177    KEEP ONLY 7 BITS
03196000 33427  005735            LDB CVTBL   CHECK FOR CONVERSION
03197000 33430  076412            SZB CVRET   IF ZERO, NO CONVERSION ACTIVE
03198000 33431  005045      CVSCH LDB FSPTR
03199000 33432  024125            ADB P18     FORM ADDRESS OF START OF CONV TABLE
03200000 33433  035711            STB CVTBS   SET TABLE POINTER
03201000 33434  105711      CVNXT LDB CVTBS,I GET NEXT TABLE ENTRY
```

```
33435  174507         SBR 8       KEEP ONLY "CONVERT FROM" CODE
33436  014000         CPB A       DOES IT MATCH BYTE IN A?
33437  066445         JMP CVMAT   YES; WE HAVE A MATCH
33440  005711         LDB CVTBS   CHECK POINTER
33441  015735         CPB CVTBL   WAS THAT THE LAST ENTRY?
33442  170201  CVRET  RET 1       YES; LEAVE A ALONE AND GET OUT
33443  045711         ISZ CVTBS   NO; BUMP TABLE POINTER
33444  066434         JMP CVNXT   AND TEST THE NEXT ENTRY
33445  101711  CVMAT  LDA CVTBS,I RECOVER THE PAIR THAT MATCHED
33446  050053         AND B177    KEEP THE CONVERTED-CODE BYTE ONLY
33447  170201         RET 1       AND RETURN WITH THIS VALUE
               *
               *   GENERAL OUTPUT ROUTINE
               *
33450  031714  SEND   STA T4      SAVE OUTPUT CODE
33451  004011         LDB PA      LOOK AT SC
33452  076416         SZB SEND0   IF SC=0, GO TO PRT/DSP INTERNAL
               *
               *   PERIPHERAL SEND ROUTINE
               *
33453  076202  SENDP  SSS *+2     IF STATUS SET, ALL IS WELL
33454  042623         JSM PONCK   OTHERWISE, CHECK FOR DOWN PERIPHERAL
33455  005723         LDB DN.SC   LOOK AT DEVICE NUMBER
33456  176407         SBM WHPIB   IF BIT 15 SET, USE HP-IB PROTOCOL
33457  004005         LDB R5      GET GPIO STATUS BYTE
33460  174501         SBR 2
33461  042553         JSM INVDC   INVERT DATA IF INVERT BIT SET
33462  042465         JSM WHPIB   CALL SR TO OUTPUT DATA
33463  030007  EWICO  STA R7
33464  170201         RET 1

33465  042627  WHPIB  JSM WAIT    WAIT FNR READY
33466  030004         STA R4      OUTPUT DATA BYTE
33467  170201         RET 1
               *
               *   INTERNAL PRINTER/DISPLAY SEND ROUTINE
               *
33470  010132  SEND0  CPA A.CR    IF CARRIAGE RETURN
33471  170201         RET 1       IGNORE IT
33472  042525         JSM DCSAV   SAVE CURRENT C & D REGISTERS
33473  005722         LDB .IOBL   GET POINTER TO I/O BUFFER
33474  014315         CPB AIBFM   IS THIS THE FIRST CHARACTER?
33475  140450         JSM ACLBI,I YES; CLEAR THE BUFFER
33476  001714         LDA T4      RECOVER OUTPUT BYTE
33477  010135         CPA A.LF    IS IT A LINE FEED?
33500  066511         JMP SENDB   YES; DUMP THE BUFFER
33501  005722         LDB .IOBL   GET POINTER TO IOBUF
33502  014316         CPB AIBFL   IF IT POINTS TO LAST WORD
33503  170201         RET 1       BUFFER IS FULL
33504  034017         STB D       IF NOT, SET UP FOR NEXT PLACE
33505  074550         PBD A,I     NO; STACT IT ON THE BUFFER
33506  004017         LDB D       GET UPDATED D
33507  035722         STB .IOBL   AND UPDATE BUFFER POINTER
33510  066521         JMP DCGET   AND RESTORE C AND D
               *
33511  001723  SENDB  LDA DN.SC   CHECK THE PRINT/DISP FLAG
33512  072003         RZA SND16   IF SC=16, SEND TO PRINTER
33513  140433         JSM ALDSP,I IF SC=0, SEND TO DISPLAY
33514  066517         JMP SENDI   RESET C, D, AND .IOBL
33515  140444  SND16  JSM A.PRN,I SEND IOBUF TO PRINTER
33516  040710         JSM EOLIO   CLEAR IOBUF TO LAZY-T
33517  004315  SENDI  LDB AIBFM
33520  035722         STB .IOBL   RESET POINTER TO IOBUF
33521  005715  DCGET  LDB T5
33522  034017         STB D       RESET D
33523  005716  CGET   LDB T6
33524  067266         JMP CSET    RESET C

33525  004017  DCSAV  LDB D
33526  035715         STB T5
33527  004016  CSAV   LDB C
33530  035716         STB T6
33531  170201         RET 1
               *
               *   GENERAL INPUT ROUTINE
               *
33532  004011  READ   LDB PA      GET SELECT CODE
33533  076005         RZB READ1   IF SC>0, DO NORMAL READ
33534  001717         LDA STMT    IF SC=0, SEE IF THIS IS A RDB(0)
```

GENERAL INPUT/OUTPUT ROUTINES

```
03284000 33535  010141        CPA P6      RDB TYPE?
03285000 33536  066562        JMP RDB0    YES; EXECUTE RDB0 ROUTINE
03286000 33537  066303        JMP ER.F4   READ FROM SC=0 NOT ALLOWED
03287000 33540  001723  READ1 LDA DN.SC   CHECK GPIO/HPIB FLAG
03288000 33541  076202        SSS *+2     MAKE SURE DEVICE IS WELL
03289000 33542  042623        JSM PDNCK   IF NO, CHECK FOR DOWN PERIPHERAL
03290000 33543  042627        JSM WAIT
03291000 33544  172412        SAM RHPIB   IF HP-IB, DO HP-IB INPUT PROTOCOL
03292000 33545  000004        LDA R4      DEMAND A DATA BYTE
03293000 33546  030007        STA R7      AND TRIGGER COMMAND
03294000 33547  042627        JSM WAIT    WAIT FOR READY
03295000 33550  000004        LDA R4      AND TAKE IN BYTE
03296000 33551  004005        LDB R5      GET GPIO STATUS BYTE
03297000 33552  174502        SBR 3
03298000 33553  077002  INVDC SLB *+2     IF INVERT INPUT DATA BIT SET,
03299000 33554  170140        CMA         INVERT BITS IN A
03300000 33555  170201        RET 1
03301000                *
03302000 33556  000004  RHPIB LDA R4      REQUEST DATA BYTE
03303000 33557  042627        JSM WAIT    WAIT FOR READY FLAG
03304000 33560  000006        LDA R6      PULL IN GOOD DATA
03305000 33561  170201        RET 1
```

```
03307000                *
03308000                *  THIS ROUTINE DOES A RDB(0) BY WAITING FOR A KEY TO BE
03309000                *  PRESSED AND THEN RETURNING ITS KEY-CODE
03310000                *
03311000 33562  002570  RDB0  LDA RBINT   GET ADDRESS OF RDB INTERRUPT ROUTINE
03312000 33563  005440        LDB ITABL   SAVE CURRENT KEYBOARD SERVICE ADDRESS
03313000 33564  031440        STA ITABL   PUT INTERCEPT ADDRESS IN TABLE
03314000 33565  066565        JMP *       HOLD HERE FOR INTERRUPT
03315000 33566  035440        STB ITABL   WHEN INTERRUPT IS SERVICED, PUT BACK
03316000 33567  170201        RET 1       KEYBOARD SERVICE ADDRESS AND RETURN
03317000                *
03318000                *  THIS ROUTINE SERVICES THE KEYBOARD INTERRUPT
03319000                *
03320000 33570  033571  RBINT DEF *+1
03321000 33571  000004        LDA R4      ON INTERRUPT, TAKE IN NEW KEYCODE
03322000 33572  170301        RET 1,P     AND RETURN TO INSTRUCTION AFTER "JMP *"
03324000                *
03325000                *  READ STATUS
03326000                *
03327000                *  THIS ROUTINE CHECKS STATUS OF AN INTERFACE CARD
03328000                *  EXIT CONDITIONS:
03329000                *
03330000                *  A = 0 : NOBODY HOME
03331000                *  A > 0 : GPIO CARD, A = STATUS BYTE
03332000                *  A < 0 : HPIB CARD, A = STATUS BYTE
03333000                *                     BUSDN = CALCULATOR BUS ADDRESS
03334000                *
03335000 33573  070430  REDST DIR         THIS MUST TAKE <100USEC FOR HP-IB
03336000 33574  000005        LDA R5      READ THE STATUS BYTE (OR HP-IB DEMAND)
03337000 33575  042650        JSM CKPA    CHECK THE PA REGISTER
03338000 33576  066607        JMP REDSR   PA=0; DO NO MORE
03339000 33577  066607        JMP REDSR   PA=1; DO NO MORE
03340000 33600  004000        LDB A       KEEP A COPY FOR RETURNING
03341000 33601  050103        AND B60     MASK TO KEEP ONLY CARD-TYPE BITS
03342000 33602  010103        CPA B60     IF TYPE BITS=3, THIS IS HP-IB
03343000 33603  066612        JMP HPRDS   SO DO HP-IB STATUS PROTOCOL
03344000 33604  000001        LDA B       A=STATUS BYTE
03345000 33605  076602  REDSS SSC *+2     IF STATUS BIT IS SET,
03346000 33606  060044        IOR B400    SET BIT(8) OF STATUS WORD
03347000 33607  070420  REDSR EIR         IF NO, GPIO; RE-ENABLE INTERRUPT
03348000 33610  031745        STA STBYT   SAVE THE STATUS BYTE
03349000 33611  066370        JMP RDSTX   AND GO BACK  (IMPLIED RETURN)
03350000                *
03351000                *  HPIB RETURNS ITS BUS ADDRESS AND UP TO 3 STATUS BYTES
03352000                *
03353000 33612  042627  HPRDS JSM WAIT    WAIT FOR HPIB TO GET STATUS
03354000 33613  000005        LDA R5
03355000 33614  004336        LDB AOP1    GET ADDRESS OF STATUS BYTE STACK
03356000 33615  014337  HPRNS CPB AOP2    DID WE GET THE FOURTH ONE?
03357000 33616  172371        SAP REDSR,S YES; SET HP-IB BIT (15) AND EXIT.
03358000 33617  072600        SFC *       NO; WAIT FOR READY INDICATION
03359000 33620  000006        LDA R6      AND GET NEXT STATUS BYTE
03360000 33621  130001        STA B,I     PUT IT ON THE STACK
03361000 33622  076173        RIB HPRNS   BUMP POINTER IN B AND GO AGAIN
03363000                *
03364000                *  IF STATUS IS CLEAR, GIVE AN ERROR AFTER GIVING
03365000                *  HELP-LINK A CHANCE TO CORRECT THE PROBLEM
03366000                *
```

GENERAL INPUT/OUTPUT ROUTINES

```
33623  004137  PDNCK LDB P8        SET FOR DOWN PERIPHERAL
33624  141737        JSM HLINK,I   AND TRY FOR HELP
33625  140404  ER.F8 JSM AERR1,I   IF NONE, GIVE  ***** ERROR F8 *****
33626  043470        ASC 1,G8      PERIPHERAL DOWN.
```

```
                     *
                     *   THIS ROUTINE WAITS FOR A BUSY DEVICE TO GO READY
                     *
                     *   AFTER GIVING HELP-LINK A CHANCE FOR EXTENDED OPTIONS
                     *   IT WILL UNCONDITIONALLY WAIT FOR APPROXIMATELY TWO
                     *   SECONDS FOR DEVICE TO GO READY.  THEN IT WILL
                     *   CONTINUE TO WAIT, BUT WILL NOW ABORT ON SEEING THE
                     *   STOP KEY PRESSED.
                     *
33627  005257  WAIT  LDB CSTAT     IF RED/WRT IS FROM KEYBOARD,
33630  077413        RLB WAITS     SKIP 2-SECOND GRACE PERIOD
33631  072216        SFS WAITR     IF FLAG IS SET (READY), RETURN AT ONCE.
33632  004140        LDB P7        SET FOR WAIT INTERCEPT
33633  141737        JSM HLINK,I   AND GIVE HELP-LINK A CHANCE TO EXTEND
33634  004234        LDB B4K       THE WAIT OPTIONS! IF NO HELP,
33635  035711        STB T1        SET TIME CONSTANT 1
33636  004170  WAITC LDB M256      SET TIME CONSTANT 2
33637  072210        SFS WAITR     IF DEVICE HAS COME READY, EXIT WAIT
33640  076177        RIB *-1       ELSE, CONTINUE TO COUNT DOWN CONSTANT 2
33641  055711        DSZ T1        THEN COUNT DOWN CONSTANT 1
33642  066636        JMP WAITC     UNTIL IT TOO GOES TO ZERO
33643  005206  WAITS LDB IOTMP     TIME IS UP! BEGIN TO MONITOR KEY-FLAG
33644  014254        CPB P1        STOP KEY PRESSED?
33645  066625        JMP ER.F8     YES! ABORT AND GIVE USER INDICATION
33646  072675        SFC WAITS     NO; CONTINUE TO WAIT IF STILL BUSY
33647  170201  WAITR RET 1         FINALLY READY! EXIT
```

```
                     *
                     *   CHECK PA-REGISTER FOR VALUE OF 0, 1, OR >1
                     *
33650  004011  CKPA  LDB PA        GET THE PERIPHERAL ADDRESS
33651  076476        SZB WAITR     IF PA=0, RETURN P+1
33652  014254        CPB P1        IF PA=1, RETURN P+2
33653  170202        RET 2
33654  170203        RET 3         IF PA>1, RETURN P+3
```

PERIPHERAL LISTER

```
                     *
                     *   LIST #<SC>, <START LINE>, <END LINE>
                     *
33655  000177  ELIST LDA P0        SET FOR WRITE OPERATION
33656  042250        JSM GSCFN     SET UP SELECT CODE PARAMETER
33657  043631        JSM BUMP1     MAKE FAP1 POINT TO LINE# PARAMETER(S)
33660  000000        LDA A         NOOP! RETURNS HERE IF NO LINE NUMBERS
33661  004566        LDB ALST      GET ADDRESS OF MAINFRAME LIST ROUTINE
33662  134003        STB R,I       AND MAKE IT THE RETURN DESTINATION
33663  005734        LDB CSAVE
33664  034016        STB C         RESTORE VALUE OF C
33665  006674        LDB APLST     B = ADDRESS OF PERIPHERAL LIST ROUTINE
33666  000011        LDA PA        CHECK THE PERIPHERAL ADDRESS CODE
33667  010177        CPA P0        IS SELECT CODE 0 OR 16?
33670  007013        LDB .RET1     YES! DUMMY SHOULD HAVE USED LIST!!!
33671  001721        LDA NPCNT     GET COUNT OF PARAMETERS
33672  020257        ADA M1        TAKE OFF 1 FOR SELECT CODE PARAMETER
33673  170202        RET 2         AND GO TO LIST ROUTINE FOR EXECUTION
                     *
                     *  EACH LINE COMES HERE FOR OUTPUT TO PERIPHERAL
                     *
33674  033675  APLST DEF *+1
33675  031732        STA REP.C     A = 0(LINE), >0(CHECKSUM), -3(CR/LF)
33676  072403        SZA PLST1     IF PROGRAM LINE, DUMP UNCONDITIONALLY
33677  001720        LDA FMT.N     ELSE, SEE IF FMT.N WAS GIVEN
33700  072020        RZA PLSTR     IF YES, SUPRESS CKSUM AND CR/LF'S
33701  043137  PLST1 JSM PTSET     RESET LINKS IN CASE STRING ROM WAS CALL
33702  000214        LDA EOLB      GET AN END-OF-LINE CHARACTER
33703  130316        STA AIBFL,I   AND TERMINATE IOBUFF IN CASE OF CKSUM
33704  000314        LDA AIBFX     GET ADDRESS OF START OF I/O BUFFER
33705  030017        STA D         AND SET BYTE POINTER
33706  001732        LDA REP.C     CHECK TYPE INDICATOR
```

## PERIPHERAL LISTER

```
33707  172406        SAM PLST3    IF LEADER, DUMP 3 CR/LF'S
33710  074570  PLSTC WBD A,I      GET NEXT BYTE OF LINE
33711  010053        CPA EOL      END OF LINE MARKER?
33712  066717        JMP PLSTE    YES: FINISH UP
33713  042421        JSM WRTAC    OUTPUT THE CHARACTER
33714  066710        JMP PLSTC    GO BACK FOR MORE CHARACTERS
33715  043446  PLST3 JSM ECRLF    PROVIDE 3 CR/LF'S FOR LEADER/TRAILER
33716  043446        JSM ECRLF
33717  043446  PLSTE JSM ECRLF    OUTPUT A CR/LF TO END LINE
33720  170202  PLSTR RET 2        AND RETURN P+2 TO LIST ROUTINE
```

## CONSTANTS AND EQUATES

```
                *
                *   CONSTANTS
                *
33721  032013   IVALS DEF .RET1    INITIAL VALUES OF LINK WORDS
33722  033723   .SFMT DEF *+1      POINTER TO STANDARD FORMAT FOR WRITE
33723  016064         OCT 16064      #  4
33724  063061         OCT 63061      F  1
33725  034034         OCT 34034      8  #     (#=34B = FMT DELIMITER)
33726  077735   .TREG DEF T21
33727  077726   .T14  DEF T14
       000121   C.EFM EQU B34      END OF FORMAT CHARACTER
       000107   C.COM EQU B54      ASCII COMMA
       000105   C.DP  EQU B56      ASCII DECIMAL POINT
33730  000142   C.B   OCT 142      B  BINARY
33731  000146   C.F   OCT 146      F  F,FZ
       000063   C.E   EQU B145     E  EXPONENT
       000064   C.C   EQU P99      C  CHARACTERS
33732  000170   C.X   OCT 170      X  SPACE
       000104   C.LF  EQU B57      /  CR/LF
       000116   C.QT  EQU B42      "  LITERAL
33733  000172   C.Z   OCT 172      Z  SUPRESS CR/LF
       000132   A.CR  EQU P13      ASCII CR
       000135   A.LF  EQU P10      ASCII LF
       000114   C.DOL EQU B44      ASCII $
33734  001750   P1000 DEC 1000
33735  000025   P21   DEC 21
33736  177753   M21   DEC -21
       000074   UNL   EQU B77      HP-IB UNIVERSAL UNLISTEN COMMAND
33737  000337   NOSET OCT 337      DN=31 BYPASS INDICATOR
       000023   AR2M3 EQU 23B      AR2 MANTISSA WORD #3
       000053   EOL   EQU B177     END-OF-LINE INDICATOR
       077226   LNO   EQU CSTMP+8 LINE NUMBER FOR INTERPRETER
       077223   TMP6  EQU CSTMP+5
       077206   .WKC  EQU IOTMP    KEY-CODE FROM KEYBOARD
       000071   A.E   EQU P69      ASCII E
       000325   ASTKF EQU ACSTF
       000106   A.MIN EQU B55      ASCII MINUS SIGN
       000110   A.PLS EQU B53      ASCII PLUS SIGN
       000136   A.SKP EQU P9       ASCII SKIP CODE
       000170   LMASK EQU M256     MASK TO KEEP LEFT BYTE
33740  140000   BSMSK OCT 140000   HP-IB TALK MASK
33741  177457   CMASK OCT 177457   BIT MASK FOR WTC
33742  077015   ASLMM DEF CSTAK+78
       077744   KYOFS EQU OP1+2    KEY-PROGRAM OFFSET
       077706   PROFS EQU CATMP+8 PROGRAM OFFSET
       077232   CFLAG EQU CSTMP+12
33743  154000   STR.S OCT 154000 TYPE WORD: ENTIRE SIMPLE STRING
33744  155400   STR.A OCT 155400 TYPE WORD: ENTIRE STRING FROM ARRAY
                *
                *
                *   EQUATES
                *
       077045   FSPTR EQU STEAL+3 POINTER TO ROM'S STOLEN WORDS
                *
       077711   CVTBS EQU T1       TEMPORARY FOR CONVERSION TABLE SEARCH
       077717   STMT  EQU T7       ROM'S OP-CODE FOR EXECUTINE STATEMENT
       077720   .BFMT EQU T8       POINTER TO BEGINNING OF FMT FOR RESCAN
       077721   NPCNT EQU T9       NUMBER-OF-PARAMETERS COUNT
       077722   .IOBL EQU T10      POINTER TO START OF I/O BUFFER
       077723   DN.SC EQU T11      DEVICE NUMBER/SELECT CODE INDICATOR
       077724   ASTMT EQU T12      ADDRESS OF STATEMENT BEING EXECUTED
       077725   RW.SN EQU T13      READ/WRITE, STRING/NUMBER INDICATOR
       077726   Z.CSP EQU T14      SUPRESSION/SPEC COUNT INDICATOR
       077727   FFFLG EQU T15      FIX/FLT FLAG
       077730   DP    EQU T16      DECIMAL POINT SETTING FROM  W.D
       077731   FW    EQU T17      FIELD-WIDTH SPECIFICATION FROM W.D
       077732   REP.C EQU T18      REPETITION COUNT
       077733   EXTBA EQU T19      EXTENDED BUS ADDRESSING INDICATOR
```

CONSTANTS AND EQUATES

```
03521000        077734  CSAVE EQU T20     SAVED C-VALUE FOR RETURN TO INTERPRETER
03522000        077735  CVTBL EQU T21     ACTIVE CONVERSION TABLE INDICATOR
03523000        077736  SFEAT EQU T22     SPECIAL FEATURES INDICATOR (FOR EXTIO)
03524000        077737  HLINK EQU T23     HELP LINK WORD (EXTIO AND OTHER ROMS)
03525000        077740  WRTIC EQU T24     WRITE LINK WORD (GENERAL OUTPUT INTERCEE
03526000        077741  REDIC EQU T25     READ LINK WORD (GENERAL INPUT INTERCEPT)
03527000        077743  BUSDN EQU OP1+1   CALCULATOR'S DEVICE NUMBER ON HP-IB
03528000        077745  STBYT EQU OP1+3   MAIN STATUS BYTE FROM HP-IB OR GPIO
03529000        077746  LCHR  EQU OP2     LEADING CHARACTER FOR FORMATTED OUTPUT
03530000        077747  LCNT  EQU OP2+1   LEADING CHARACTER COUNT
03531000        077750  NCC   EQU OP2+2   NUMBER OF CHARACTERS COUNT
03532000        077751  ECHR  EQU OP2+3   CHARACTER TO REPLACE L.C. "E" FOR OUTPUT
03533000        077747  TFW   EQU LCNT    TEMPORARY FIELD-WIDTH FOR COUNT DOWN
03534000        077722  RTFLG EQU .IOBL   READ TERMINATE FLAG
03535000        077746  .LEN  EQU LCHR    POINTER TO STRING LENGTH REGISTER
03536000        077750  R.LIM EQU NCC     READ LIMIT FOR STRING INPUT
03537000        077747  R.AFT EQU LCNT    NUMBER OF CHARACTERS TO READ AFTER INPUT
03538000        077751  FFR   EQU ECHR    FREE-FIELD READ INDICATOR
03539000        077751  MSGN  EQU ECHR    MANTISSA SIGN FOR NUMERIC INPUT
03540000        077724  DN    EQU ASTMT   DEVICE NUMBER ON HP-IB FOR BUSET
03541000        077727  QTADD EQU FFFLG   BEGINNING OF QUOTE ADDRESS FOR RESTART
03542000        077720  FMT.N EQU .BFMT   FORMAT NUMBER
03543000        077217  .WPRT EQU CSTMP+1 MAINFRAME FIX/FLT INDICATOR
03544000        077216  FWPRT EQU CSTMP   FORMATTED FIX/FLT INDICATOR


03546000 33777                 ORG 33777B
03547000 33777                 BSS 1       ********** CHECKSUM WORD **********
03548000                *
03549000                       END      ***** END OF FMTIO ROM *****

END OF PASS 2 NO ERRORS DETECTED
```

Referring to FIG. 2, there is shown a calculator keyboard. The standard Alphanumeric keys having upper and lower cases are used to enter numbers, commands, and statements. The rest of the keyboard is divided into System Command keys, Display Control keys, Line and Character editing keys, Special function keys having upper and lower case functions and Calculator Control keys.

## SYSTEM COMMAND KEYS

Referring to the upper left portion of FIG. 3, the System Command keys are shown. A RESEt key returns the calculator and I/O cards to the power-on state without erasing programs on variables. RESET is executed automatically when it is pressed. All calculator activity is aborted and the line number of the current location in a program is displayed if a program is running. The RESET key is used to reset the calculator when no other key will bring the calculator to a ready state. Referring to FIG. 155, a flow chart illustrating the RESET subroutine is shown.

A print all key labelled PRT ALL, sets a print all mode on or off. When it is pressed once, the word "on" appears in the display. When it is pressed again, the word "off" appears in the display. In print all mode, executed lines and stored lines are printed. Displayed results are also printed. While a program is running in print all mode, all displayed messages and error messages are printed.

A REWIND key rewinds the tape cartridge to its beginning. Other statements and commands can be executed immediately without waiting for a cassette to completely rewind. If REWIND is pressed while a program is running or while a line is executing from the keyboard, the cartridge rewinds at the end of the current line.

A STEP key is used for stepping through a program, one line at a time. Each time it is pressed, another program line is executed. The line number of the next line to be executed is displayed. The first time STEP is pressed after running a program, the line number of the line to be executed is displayed. The next time STEP is pressed, that line is executed.

An ERASE key is used to erase all or part of the read/write memory, for example:

| | | | |
|---|---|---|---|
| ERASE | A | EXECUTE | Erases the entire calculator memory. |
| ERASE | V | EXECUTE | Erases the variables only. |
| ERASE | K | EXECUTE | Erases all the special function keys. |
| ERASE | EXECUTE | | Erases the program and variables. |
| ERASE | fn | | Erases the special function key represented by "n." |

A LOAD Key is used to load programs and data from the tape cartridge. For example:

| | | | |
|---|---|---|---|
| LOAD | 3 | EXECUTE | Loads the program from file 3 into the calculator. |

The display shows ldf (for "load file") when this key is pressed.

A RECORD key is used to record programs and data on the tape cartridge. Before recording on the tape cartridge, files must be marked. Assuming, for example that the files have been marked, a user actuates the sequence

| | | |
|---|---|---|
| RECORD 6 | EXECUTE | To record the calculator program on file 6 of the tape cartridge. |

A LIST key is used to list programs, sections of programs, all special function keys, or individual special function keys. For example:

| | | | |
|---|---|---|---|
| LIST | EXECUTE | | Lists the entire program. |
| LIST | K | EXECUTE | Lists all defined special function keys in numerical order. |
| LIST | $f_4$ | | Lists special function key, "$f_4$." |
| LIST | 9, 1 3 | EXECUTE | Lists the program from line 9 to 13, inclusive. |

A flow chart illustrating the LIST subroutine is shown in FIG. **156**A-B.

## DISPLAY CONTROL KEYS

Referring to the top central portion of FIG. **156**A–B, the Display Control keys are shown. An Up Arrow key ↑ moves the line with the next lower-valued line number into the display. If a stop is executed from a program, or if a line number is in the display, Up Arrow brings that line into the display. After a program error, the Up Arrow key ↑ brings the line containing the error into the display for editing. This key is used in live keyboard mode, explained in greater detail hereinafter, to display the line being typed-in for about one second. By holding Up Arrow down, the display remains.

A Down Arrow key ↓ moves the line with the next higher-valued line number into the display. If there are no more lines in the program, Down Arrow clears the display and allows new program lines to be appended to the end of the program. This key is also used to display the line being typed-in for about one second in live keyboard mode. By holding Down Arrow down, the display remains.

A Left Arrow key ← moves the line in the display to the left. A Right Arrow key → moves the line to the right. These allow all the characters in a line to be displayed. Each time one is pressed, the displayed line moves a quarter of the display size, 8 characters for a 32-character display, for example. If a cursor is in the display, it remains in the same place when the Left Arrow key is pressed.

## EDITING KEYS

Referring to the top central portion of FIG. 3, the Editing keys are shown. There are two types of editing keys; Line Editing keys and Character Editing keys.

### Line Editing Keys

A FETCH key is used to bring program lines into the display and to fetch special functions keys. For example:

| | | | |
|---|---|---|---|
| FETCH | 2 0 | EXECUTE | Brings line 20 into the display. |
| FETCH | $f_4$ | | Accesses special function key $f_4$. If $f_4$ is defined, its definition is displayed. Otherwise, "$f_4$" is displayed. |

A line DELETE key is used to delete the program line in the display from the read/write memory. If no program line is in the display, the calculator beeps and the DELETE key is ignored. To delete a program line, a user fetches the line into the display and presses DELETE. When a line is deleted from a program, the address of all relative and absolute go to and go sub statements are renumbered to reflect the deletion.

The INSERT line key is used to insert a new line in front of a fetched line. The fetch command, the Up Arrow, or Down Arrow keys are used to fetch a line into the display. For example:

| | | | |
|---|---|---|---|
| Press: | FETCH 2 0 | EXECUTE | Brings line 20 into the display. |
| Type-in: | prt "A+",35 | | |
| Press: | INSERT | | This inserts the typed-in line in place of old line 20. All higher numbered lines and old line 20 are incremented by one. |

when a line is inserted into a program, the branching addressing of all relative and absolute go to and go sub statements are renumbered to reflect the insertion. The line number assigned to the new line is the same line number used in the fetch command.

A RECALL key is used to bring back into the display, one of the two previous keyboard entries. Recall can be used in live keyboard mode, and in an enter (ent) statement. Recall also can be used after errors resulting from a keyboard operation to recall the line containing the error. For many errors, a flashing cursor indicates the location of the error in the line.

Referring to FIG. **157** a flow chart illustrating the positioning of the flashing cursor at the location of a syntax error is shown. When the user enters a line to be stored or executed, the line is read from left to right. If an error is detected, the reading process is stopped at the location of the error.

There are cases where the pointer used by the reading process is pointing to a blank space. In this event, an attempt is made to move the error cursor to some non-blank character. First the cursor is moved to the right until a non-blank character or the end of the line is found. If the end of the line is found, the cursor is moved back to the left until a non-blank character is found.

Referring to FIG. **158**A, double buffering allows the user to observe the last two lines that were stored or executed from the keyboard. These lines are stored in a two level stack and are brought into the display by the

RECALL key. Pressing the RECALL key recalls the most recent keyboard line, and a consecutive RECALL brings the previous keyboard line into the display. Additional RECALL's cause the two keyboard lines to be displayed alternately.

Referring to FIG. **158B**, there is shown a diagram of the buffering scheme employed. As characters are typed, they are entered into the I/O buffer and displayed. When the line is executed, the KBD buffer is transferred to the REB buffer and the I/O buffer is transferred to the KBD buffer. The result of the executed line is placed in the I/O buffer and displayed.

When the RECALL key is pressed, the KBD buffer is transferred to the I/O buffer and displayed. Consecutive pressings of the RECALL key causes the KBD and KEB buffers to be swapped, and the new contents of the KBD buffer to be transferred to the I/O buffer and displayed

Referring to FIG. **158B**, consecutive pressings of the EXECUTE, STORE or INSERT line keys cause the line in the KBD buffer to be re-executed or stored, but the buffers are not transferred. Also, if one of these keys are pressed after a line has been recalled, the contents of the KBD buffer are executed or stored, and the buffers are again not transferred. The buffering scheme thereby stacks the last two different lines that were executed or stored.

## The Character Editing Keys

Lines which are fetched into the display using the ↑ Up Arrow, ↓ Down Arrow, RECALL or FETCH command, and lines which are typed into the display can be edited using the character editing keys. Two flashing cursors are associated with these keys: the replace cursor and the insert cursor.

A BACK key moves the flashing replace cursor or the flashing insert cursor from its current position in the line in the display toward the beginning (left) of the line. If the cursor is not visible, BACK causes the cursor to appear on the right-most character in the line.

A forward key labelled FWD moves the flashing replace cursor or the flashing insert cursor from its current position in the line in the display, towards the last character in the line. For a line which has just been fetched into the display, pressing FWD causes the flashing cursor to appear on the left-most character in the display.

A character delete key, labelled DELETE, is used to delete individual characters which are under the insert or replace cursor. This is not the same key as the line delete key explained previously.

An insert/replace key labelled INS/RPL is used to change the flashing replace cursor to a flashing insert cursor and vice versa. When the insert cursor is flashing, any characters entered from the keyboard are inserted to the left of the cursor.

When the replace cursor is flashing, any character entered replaces the existing display character at the location of the cursor.

Referring to FIG. **159A–L**, a detailed flow chart illustrating the line editing subroutines is shown. The user can type and edit 80-character lines from the keyboard as described hereinbefore. As the keys are typed, they are placed in the I/O buffer at a position indicated by the I/O buffer pointer. This buffer is displayed after each keystroke, so that the new characters can be seen.

Referring to FIG. **159A**, if the back key is pressed, the I/O buffer pointer is decremented and the cursor pointer is set to the position indicated by the buffer pointer. Referring to FIG. **159B–D**, pressing the forward kay causes these two pointers to be incremented. The INS/RPL key toggles the cursor type flag as shown in FIG. **159E**. The displayed cursor is then changed from the replace to the insert cursor or vice-versa.

Referring to FIG. **159F**, if a programming key is pressed when the replace cursor is set, the key is placed in the I/O buffer at the position of the buffer pointer, and both the buffer and the cursor pointers are incremented. If the insert cursor was set, the character at the position of the buffer pointer and those to the right of the pointer are shifted right one character position. A normal replace sequence is then performed.

The delete character key routine illustrated by a flow chart in FIG. **159G** shifts the characters to the right of the cursor pointer left one character. This shift overwrites the character under the cursor thereby deleting it from the display.

Referring to FIGS. **159H** and **159I**, left arrow routines illustrated therein increment the buffer pointer and the display begin pointer by one-fourth of the display size. Referring to FIG. **159J**, the right arrow routines illustrated therein decrement these pointers by the same amount.

Referring to FIG. **159K**, once a program has been stored, the line editing keys are used to insert delete, or modify in the program. To modify a line, the line must first be brought into the display by the fetch command, or the up or down arrow keys. The user then edits the line and stores it thereby replacing the old line. Referring to FIG. **159L**, in order to insert a line in the program, the line that is to follow the inserted line is fetched. The new line is then typed. This line is inserted into the program by pressing the line insert key.

Lines can be deleted from the stored program by the delete command or the line delete key. To delete a line using the line delete key, the line must first be brought into the display. The pressing of the line delete key will then delete this line from the program.

## CALCULATOR CONTROL KEYS

Referring to the lower left and lower central portions of FIG. **3**, the Calculator Control keys are shown. A RUN key runs the program in the calculator from line zero. This key is an immediate execute key which means that "run" is executed automatically when the key is pressed. All variables, flags, and subroutine pointers are cleared when the run key is pressed. A red indicator at the left end of the display indicates a running program.

A STORE key stores individual program lines. Also, when a special function key is fetched and defined, STORE is used to store the key's definition. A program ine can be a single statement or several statements :eparated by semicolons. When an error occurs in storng a line, RECALL brings that line into the display. A lashing cursor usually shows where the error was en:ountered in the line.

The SHIFT or SHIFT LOCK keys shown in the ower left portion of FIG. 3 are used to obtain shifted :eyboard characters such as #, √ and the like. When ;HIFT LOCK is pressed, a small light above the shift ock key lights. To release SHIFT LOCK a user presses ;HIFT.

Referring to the lower central portion of FIG. 3, a ;TOP key terminates the execution of a program at the :nd of the current line. The number of the next line to »e executed in the program is displayed. When STOP is »ressed, enter, list, tlist, and wait statements are aborted »ut the rest of the line is executed. When STOP is »ressed in an enter statement, flag 13 is set and the enter tatement is terminated.

If STOP is pressed while doing a live keyboard operıtion, the operation is stopped, but the program contin1es. Pressing STOP a second time stops the program.

Referring to the right lower portion of FIG. 3, an :XXECUTE key executes the single or multi-statenent line which is in the display. The two most recently :xecuted (or stored) keyboard entries are temporarily tored and can be recalled by pressing RECALL once »r twice. The result of a numeric keyboard operation vhich is not asigned to a variable is stored in Result. ?ressing EXECUTE displays the result, and stores the esult in Result. Pressing the execute key again repeats he same operation.

Although multiple expressions are allowed, only the esult of the last expression in the line is stored in Result. :n print-all mode, both results are printed.

Referring to the lower central portion of FIG. 3, a :ONTINUE key is used to automatically continue a »rogram from where it was stopped. When a line num»er is in the display, CONTINUE continues from that ine number, except after RESET has been pressed, or ıfter editing the program. In an enter statement, CONΓINUE is pressed after entering data. If no data is en:ered and CONTINUE is pressed, the variable main:ains its previous value and flag 13 is set. When an error »ccurs in a program, pressing CONTINUE causes the »rogram to continue execution at program line zero.

Referring to the lower right portion of FIG. 3, a RESULT key is used to access the result of a numeric :eyboard operation which was not assigned to a variıble. A value which is stored in result is also displayed.

The value in result can be assigned to variables. For :xample:

| | | |
|---|---|---|
| es→A | EXECUTE | Store result in A. |
| ;/res→B | EXECUTE | Store 5 divided by result in B. |

In a program, values cannot be assigned to result; but :he value in result can be assigned to variables or used in :omputations. For example:

| | |
|---|---|
| 1: res + 2 → A | This assigns the value of result +2 to a variable, A. |

Referring to the central right portion of FIG. 3, a clear key is shown. The CLEAR key clears the display. If the CLEAR key is pressed while in the enter mode, a question mark (?) appears in the display, indicating that an entry is still expected. If this key is pressed after a special function key has been fetched, the key number (e.g., $f_8$) appears in the display.

The Assignment Operator key is located below the CLEAR key and is used to assign values to variables. The Assignment Operator key is labelled → but is not the same as the similarly labelled right arrow key used for display control described hereinbefore. For example:

| | | |
|---|---|---|
| √5 → X | EXECUTE | This stores the square root of 5 in x. |

To enter the approximate value of π the Π key located to the immediate left of the RUN key is pressed. The value entered is 3.14159265360.

The ENTER EXP key located to the immediate right of the RUN key enters a lower case e, into the display, representing an exponent of base 10. The unshifted E key can also be used in place of ENTER EXP.

## SPECIAL FUNCTION KEYS

There are 24 special function keys, 12 unshifted and 12 shifted. Referring to the upper right portion of FIG. 3, the special function keys are labelled $f_0$ through $f_{11}$ and can be used as typing aids, one line immediate execute keys or as immediate continue keys.

To define a special function key a user presses the FETCH key and the special function key to be defined. Then he enters a line in the display. He presses the STORE key to store the definition of the key and to exit key mode.

If a user decides that he is not going to store anything under a key, the STOP key can also be used to exit key mode. For example:

| | |
|---|---|
| Press: FETCH | "$f_0$" is displayed if the key was not previously defined. |
| Type-in: prt | Enters "prt" in the display. |
| Press: STORE | This stores "prt" under $f_0$, for use as a typing aid. |

### Immediate Execute Keys

If a line which is stored under a special function key is preceded by an asterisk, it is an immediate execute key. The asterisk key is shown in the right portion of FIG. 3. When the key is pressed, the contents corresponding to the special function key are appended to the display and the line in the display is executed automatically. For example:

| | |
|---|---|
| Press: FETCH SHIFT $f_1$ | Accesses $f_{13}$ (shifted $f_1$). |
| Type-in: *prt "$\pi$", $\pi$ | The asterisk makes this an immediate execute key. |
| Press: STORE | This stores the line entered in the display under $f_{13}$. |

Whenever SHIFT $f_1$ is pressed and the display is clear, the literal "$\pi$", followed by its approximate value is printed automatically.

## Immediate Continue Keys

If a line to be stored as a special function key is preceded by a slash (/), it is an immediate continue key for use with the enter statement. The slash key is shown in the right portion of FIG. 3. When the slash key is pressed, the contents of the key are appended to the display and the continue command is executed automatically. Immediate continue keys are used to enter often used values in enter statements. For example:

| | |
|---|---|
| Press: FETCH $f_5$ | Fetches special function key $f_5$. |
| Type-in: /2.71828182846 | This enters the approximate value of e, the base of the natural logarithms, into the display. |
| Press: STORE | This stores the line in the display under $f_5$. |

Whenever an enter statement is waiting for a value and the $f_5$ key is pressed, the approximate value for *e* (i.e., 2.71828182846) **is entered and the program continues.**

## Keys with Multiple Statements

By separating statements using semicolons, several statements are stored under one special function key. As an example, suppose a user wants to convert inches to centimeters. The following line is stored under special function key, $f_1$.

Press: FETCH $f_1$
Type-in: *→R; dsp R, "in.+", 2.54R, "cm."
Press: STORE

Then key-in a number, such as 6, and press $f_1$. The display will show:

6.00 in. + 15.2 cm.

## PROGRAMMING STATEMENTS, FUNCTIONS, AND OPERATORS

The statements, functions, and operators explained herein are all programmable and can also be executed in calculator mode.

Statements can be programmed or executed. Operators and functions must be part of a statement in order to be programmed. This means that operations, such as 10+32 or $\sqrt{63}$, which can be executed from the keyboard, must be part of a statement in order to be programmed. Thus, 10+32→X or $\sqrt{63}$ → B, are valid statements.

## SYNTAX CONVENTIONS

The instructions explained hereinafter use the syntax conventions shown in the table below.

## FORMAL SYNTAX CONVENTIONS

| | |
|---|---|
| array | The array name with an asterisk in brackets specifies an entire array (i.e.: R[*]). |
| brackets [] | items within brackets are optional. |
| coloring | colored items or colored items in dot matrix must appear as shown. |
| character | a letter, a number, or a symbol. |
| constant | a number within the storage range of the calculator. |
| expression | a constant (like 16.4), a variable (i.e.: X or B[8] or r3) or an expression such as (8 ↑ 4 or 6<A+B). |
| integer | an integer constant from −32768 through 32767 (i.e.: −10 or 301). |
| letter | an alphabetic character from a through z and from A through Z. |
| line number | an integer from 0 through 32767. |
| n | an integer from 0 through 15. |
| text | a series of characters within quotation marks. |
| variable | a simple variable (i.e.: A or Q), an array variable (i.e.: E[5]), or an r-variable (i.e.: r12). |
| absolute or labelled go sub | gsb line number or label. |
| absolute or labelled go to | gto line number or label. |
| absolute value | abs expression |
| addition | expression + expression |
| and | expression and expression |
| arccosine | acs expression |
| arcsine | asn expression |
| arctangent | atn expression |
| assignment | expression → variable |
| auto verify disable | avd |
| auto verify enable | ave |
| base ten logarithm | log expression |
| beep | beep |
| clear flag | cfg [n][ , n]... |
| complement flag | cmf [n][ , n]... |
| continue | cont [line number or lable] |
| cosine | cos expression |
| degrees | deg |

-continued

| | |
|---|---|
| delete | del line number [ , line number][ ,* ] |
| digit rounding | drnd (expression , expression ) |
| dimension | dim ____________ |
| display | dsp [text or expression [ , text or expression]...] |
| division | expression / expression |
| end | end |
| enter | ent [text , ] variable [ , [text , ] variable...] |
| enter print | enp [text , ]variable[ ,[text , ] variable...] |
| equal to | expression = expression |
| erase | erase [a or k or v or special function key] |
| erase tape | ert expression |
| exclusive or | expression xor expression |
| exponential | exp expression |
| exponentiation | expression ↑ expression |
| fetch | fetch [line number] |
| find file | fdf [expression] |
| fixed | fxd [expression] |
| flag | flg n |
| float | flt [expression] |
| fraction | frc expression |
| grads | grad |
| greater than | expression > expression |
| greater than or equal to | expression > = expression<br>expression = > expression |
| identify file | idf [variable[ , variable[ , variable [ , variable[ , variable]]]]] |
| implied multiply | ( expression ) ( expression ) |
| integer | int expression |
| jump | jmp expression |
| less than | expression < expression |
| less than or equal to | expression < = expression<br>expression = < expression |
| list program | list [line number[ , line number] |
| list special function key | list special function key |
| list special function keys | list k |
| live keyboard disable | lkd |
| live keyboard enable | lke |
| load binary | ldb [expression] |
| load file (data) | ldf [expression[ , variable [ , variable...]]] |
| load file (program) | ldf [expression[ , expression[,expression]]] |
| load keys | ldk [expression] |
| load memory | ldm [expression] |
| load program | ldp [expression[ , expression[ , expression]]] |
| mark | mrk expression , expression[, variable] |
| maximum value | max (expression or array[ , expression or array]...) |
| minimum value | min ( expression or array[ , expression or array]...) |
| modulus | expression mod expression |
| multiplication | expression * expression |
| natural logarithm (base e) | ln expression |
| normal | nor [line number[ , line number]] |
| not | not expression |
| not equal to | expression # expression<br>expression < > expression<br>expression > < expression |
| or | expression or expression |
| power of ten rounding | prnd ( expression , expression ) |
| print | prt [text or expression[ , text or expression]...] |
| radians | rad |
| random number | rnd [ — ] expression |
| record file (data) | rcf [expression[ , variable[ , variable...]]] |
| record file (program) | rcf [expression[ , constant[ , expression]]] |
| record keys | rck [expression] |
| record memory | rcm [expression] |
| relative go sub | gsb + line number<br>gsb − line number |
| relative go to | gto + line number<br>gto − line number |
| return | ret |
| rewind | rew |
| run | run [line number or label] |
| set flag | sfg [n][ , n]... |
| set select code | ssc expression |
| sign | sgn expression |
| sine | sin expression |
| space | spc [expression] |
| square root | √ expression |
| stop | stp [line number[ , line number]] |
| subtraction (negative) | [expression] − expression |
| tangent | tan expression |
| tape list | tlist |
| ten to the power | tn ↑ expression |
| trace | trc [line number[ , line number]] |

-continued

| | |
|---|---|
| track | trk expression |
| units (angular) | units |
| verify | vfy [variable] |
| wait | wait expression |

The calculator uses three types of variables: simple variables, array variables, and *r*-variables. As variables are allocated, they are initially assigned the value 0.

### Simple Variables

There are twenty-six simple variables, A through Z. A simple variable must appear in upper case. Each simple variable can be assigned one value. Simple variables may appear in a dimension (dim) statement to reserve memory for them, but this is not required.

| Examples: | |
|---|---|
| ϕ: dim A | Reserves 1 memory location for the simple variable A. This line is not required. |
| 1: 12 → A | Assigns the value 12 to A. |
| 2: prt A | Prints the value of A on the printer. |

### Array Variables

There are twenty-six arrays, named A through Z. Array names are followed by square brackets which enclose the subscripts of the array.

An array must be declared in a dimension statement. This reserves memory for the array, and initializes all elements in the array to zero. Each subscript of an array can be specified either by specifying the upper bound, in which case the lower bound is assumed to be one, or by specifying both the upper and lower bounds as more fully described hereinafter.

An array can have any size and any number of subscripts within the limits of the calculator memory size and line length.

| Ex. 1: | |
|---|---|
| ϕ: dim Q[10,10] | Reserves 100 memory locations for array Q. |
| 1: 3→Q[1,1] | Q[1,1] is assigned the value 3. |
| 2: 5→Q | The value 5 is assigned to the simple variable [. There is no connection between the simple variable Q and array Q[10,10]. |
| 3: 2→Q[1,Q] | Q[1,Q] is assigned the value 2. |
| Ex. 2: | |
| ϕ: 7→Z | 7 is assigned to Z. |
| 1: dim X[−4:ϕ,Z] | X is dimensioned by a 5 by 7 array. The lower and upper bound of the first array dimension are specified. |
| 2: 3.4→X[−4,1] | Assigns values. |
| 3: ϕ→X[ϕ,Z] | |

### *r*-variables

*r*-variables are specified by a lower case *r* followed by a value or expression. When an *r*-variable is encountered, memory is reserved for all lower-valued *r*-variables which have not been allocated. As *r*-variables are allocated, they are assigned the value 0. Thus if *r*10 is assigned a value, *r*0 through *r*9 are automatically allocated and assigned the value zero if they have not been previously allocated.

*r*-variables are stored in a different area in memory which is not contiguous with array or simple variables. Due to this, *r*-variables cannot be mixed with simple or array variables in record file (rcf) and load file (ldf) statements, rcf and ldf statements being more fully described hereinafter. Also, *r*-variables cannot appear in a dimension statement.

| Examples: | |
|---|---|
| ϕ: 4→rϕ | 4 is assigned to r-variable 0. |
| 1: 2→rrϕ | 2 is assigned to r-variable 4. rϕ=4, therefore 2 → r4. This is known as indirect storage. |

Arrays are allocated dynamically by providing an expandable region in read-write-memory to hold the array information. Referring to FIG. **160A**, the total space requirements for the new array are calculated and checked against available unused read-write-memory at the time the calculator user's program requests that the array be made present. If the new array will fit, the region designated to hold array information is expanded and the new space thus obtained is reserved for the new array or an error message is emitted.

## MULTI-DIMENSIONAL ARRAYS, VARIABLE BOUNDS

Since read-write-memory is essentially a one-dimensional storage medium, the elements of a multi-dimensional array are mapped into a linear sequence of consecutive storage locations.

The bounds being specifiable at run-time falls out naturally, because the DIM statement is executed as part of the program as opposed to being statically examined before the program is run.

### Algorithm for Subscript Address Calculations

Let the array have the declaration:
dim $A[L_1:U_1,L_2:U_2, \ldots ,L_N:U_N]$
Define $D_k = U_k - L_k + 1 \qquad Q_k = -L_k$
Then

$$S = \prod_{i=1}^{N} D_i$$

is the number of elements. FIG. **160B** is a flow chart illustrating the subroutine for calculation of $D_k$ and $Q_k$.

Let the reference be of the form:
$A[X_1, X_2, \text{---}, X_N]$
Then the iterative calculation:

```
$V = 0$
FOR $I = 1$ to N
$Q' = X_I + Q_I$
2F $Q' < 0$ or $Q' - D_I \geqq 0$ Then out-of-bounds
$V = V^* D_I + Q'$
NEXT I
```

will calculate the relative location of the element. FIG. **160C** is a flow chart of the subroutine for calculating the relative location of $[X_1, X_2 \ldots, X_N]$.

Due to the fact that the $X_I$ are stacked in order of increasing I, the optimum algorithm will process them in order of decreasing I. This has the same effect as the leftmost subscript varying the most rapidly. This is consistent with IBM Fortran IV and HP 2100-series Fortran IV.

In the case of a simple variable, the address and the variable correspond uniquely, so the name of the variable is known immediately. In the case of an array variable, the actual subscripts of the array must be reconstructed from the address given. Since the address was arrived at originally from a simple iterative calculation, the inverse of this iteration reproduces the desired subscripts. Referring to FIG. 160D, a flow chart of the subroutine for reconstructing the $X_i$ in the reference $A[X_I, ... X_N]$ from the relative address is shown.

The subscript address iteration is of the form:

$V_{new} = V_{old} * D_I + (X_I - L_I)$

$V_{new}$, $D_I$, $L_I$ is known and $V_{old}$ and $X_I$ is to be determined.

The division algorithm gives:

$V_{new}/D_I = V_{old} + (X_I - L_I)/D_I$

hence the quotient is the $V_{old}$, and since it is known that the starting $V_{new}$ was in-bounds, from the bounds conditions:

$(S_I - L_I) = Q'_I, Q_I' \geqq O, Q_I' < D_I$

the remainder is the $(X_I - L_I)$. The algorithm is

```
V = relative element
FOR I = N to 1
calculate $V/D_I$ = Quotient + Remainder/$D_I$
V ← Quotient
subscript = Remainder + $L_I$
NEXT I
```

## NUMBER FORMATS

Numbers can be displayed or printed in floating-point format (scientific notation) or in fixed format. The calculator's internal representation of numbers is unaffected by number formats, therefore, accuracy is not changed.

When the calculator is turned on, RESET is pressed, or erase *a* is executed, the number format is fixed 2 (fxd2), except for very large numbers. Then, the calculator temporarily reverts to float 9.

## THE FIXED STATEMENT

Syntax:

fxd number of decimal places

The fixed (fxd) statement sets the format for printing or displaying numbers. In fixed format, the number of digits to appear to the right of the decimal point is specified. Fixed 0 through fixed 11 can be specified.

When a number is too large to fit in the fixed format, the number format temporarily reverts to the previously set floating-point format. Thus, for any number A:

$A = N * 10^E$

where: $1 \leqq N < 10$, or $N=0$

The nuumber reverts to the previously set floating format if:

$D + E \geqq 14$

where:

D = Number of decimal places specified in the fixed statement.

E = exponent of the number.

For numbers too small to fit in the fixed format setting, zeros are printed or displayed for all decimal places with a minus sign if the number is negative.

Two distinct rounding functions are available to the user. prnd is used to round a number to a specified power of ten. For example, dollar figures can be rounded to the nearest penny or $10^{-2}$. The user specifies the number to be rounded and the power of ten is the argument list as follows:

prnd (43.271, −2) which results in a value of 43.27.

The other rounding function, drnd, is used to round a number to a specified precision indicated by the number of digits to be retained. The number to be rounded is represented as:

$\pm$ D1.D2 D3 ... D12 $*10^{exponent}$

The user specifies the argument and the number of digits to be retained in the argument list as follows:

drnd (−127.3276,6) which results in a value of −127.328.

In each rounding function one or both arguments may be any valid arithmetic expression. Referring to FIG. 161, a flow chart of the prnd and drnd function is given.

## THE FLOAT STATEMENT

Syntax:

flt number of decimal places

The float (flt) statement sets floating point format which is scientific notation. When working with very large or very small numbers, floating point format is most convenient. Float 0 through float 11 can be specified.

A number output in floating point format has the form:

−D.D...D e−DD

The first non-zero digit of a number is the first digit displayed. If the number is negative, a minus sign precedes tthis digit; if the number is positive or zero, a space precedes this digit. A decimal point follows the first digit; except in flt O. Some digits may follow the decimal point; the number of digits being determined by the specified floating point format (e.g., in float-5, five digits follow the decimal point).

When the character "e" appears, followed by a minus sign or space (for non-negative exponents) and two-digits, the two digits represent the exponent as a positive or negative power of ten.

## ROUNDING

A number is rounded before being displayed or printed if there are more digits to the right of the decimal point than the number format allows. The rounding is performed as follows: The first excess digit is checked; if its value is 5 or greater, the digit immediately preceding it is incremented by one; if its value is less than 5, the digit is truncated.

## THE DISPLAY STATEMENT

dsp [any combination of text or expressions]

The display (dsp) statement displays values or text on the calculator display. Commas are used to separate variables or text. The number of characters that can be viewed at one time is limited by the display size but all characters can be displayed and viewed using the display control keys, Left Arrow key and Right Arrow key.

Values and text which are displayed remain in the display until another display operation clears it, or until a print statement is executed.

### Displaying Quotes

Quotes are used to indicate text. To display quotes within text, it is necessary to press the quote key twice for each quote to be displayed.

Example 1:

Enter: dsp "Say" "Hi""to her."

Press: EXECUTE

Display: Say "Hi" to her. FIG. **162** is a flow chart of the quote recognition subroutine which allows a user to place a quote mark inside a string delimited by quote marks.

## THE PRINT STATEMENT

Syntax:

prt [any combination of text or expressions]

The print (prt) statement is used to print values or text on the calculator printer.

Examples:

| Statement | Output | |
|---|---|---|
| prt 6 | | 6.φφ |
| prt "One",1 | One | 1.φφ |
| prt "This one" | This one | |

If an expression is to be printed, such as:

prt 6*7→X

the expression is evaluated and the equivalent value is printed (and also stored in X in this example).

If no value or text is specified, such as:

prt

then no operation takes place.

When printing lines of text and values, the printout follows this format:

A literal followed by a numeric is printed on the same line if it fits; otherwise the literal is printed and the numer is printed on the next line.

Literals separated by commas begin on a new line and fold over on successive lines if they are longer than 16 characters.

Numerics separated by commas are printed one per line unless the format is flt **10** or flt **11** which require two lines.

## THE ENTER STATEMENT

Syntax:

end [prompt, ] variable [, [prompt, ] variable ...]

The enter (ent) statement is used to assign values to variables from the keyboard as a program runs. The variable can be a simple variable, array variable, or an *r*-variable.

When an enter statement is encountered in a program, a user keys in a number and presses CONTINUE.

When many items are entered from the keyboard, it is often helpful to have a message called a "prompt" displayed representing the variable being assigned a value. For instance:

| | Example | Display |
|---|---|---|
| φ: | ent "Amount",<br>A | Amount |
| 1: | ent "Temperat<br>ure",T | Temperature |

If no literal prompt is given, the calculator uses the name of the variable as the prompt.

If a null quote field is given as a prompt, such as **10**: ent"",A the calculator retains any previously displayed message, unless a print operation is between the display statement and the enter statement. This is useful for variable prompts using the display statement. For example:

6:

7: 1974→Y; fxd 0

8: dsp "Aug,", Y

9: ent "",A

10:

The display shows Aug, 1974 when a value is to be entered for "A".

A user can calculate values from the keyboard while the program waits in the enter statement. This is done simply by entering the calculation and pressing the EXECUTE key. If the value to be entered is the result of the "execute" operation, a user presses RECALL or RESULT (for numerics) then presses CONTINUE. Pressing EXECUTE immediately followed by pressing CONTINUE causes a default condition as if CONTINUE were pressed without entering a value.

A user can also enter expressions such as $\sqrt{5}$, and press CONTINUE. The calculation is performed automatically before the result is entered.

Complex lines can be entered as the response to an enter statement. For example, assume the following program is entered by a user.

0: ent B

1: ent A

2: prt A

3: end

When the display is "B?" a user enters a value for B. Then when the display is "A?" a user enters **20**; if B>**20**; **40**. The user then presses CONTINUE. If the value that is entered for B is greater than **20**, then "**40**"is printed, otherwise "**20**" is printed.

If CONTINUE is pressed without entering a value, the variable maintains is previous value and flag **13** is set.

To terminate a program during an enter statement, a user presses STOP. The program line is completed before the calculator stops.

Commands are not allowed during an enter statement.

Referring to FIGS. **163A–F**, the string constant prompts and the addresses of the enter variables are placed on the execution stack and the pre-enter routines are called when the statement is executed by the interpreter. These routines take the information off the stack and calculate the prompt that should be displayed. When the interpreter executes an enterprint statement (enp), it sets a bit in CFLAG so that the pre-enter routine will print as well as display the prompt.

After the prompt is constructed and placed in the I/O buffer, control is transferred back to the main idle loop. The user can then type characters using the normal I/O buffer editing routines. If the execute key is pressed, the normal execution loop is used to execute the line in the I/O buffer.

When the continue key is pressed, the post-enter routines are called ti interpret the entered line and assign the resulting value to the enter variable. If nothing is entered, or if no result is obtained from the line, the enter variable is left unchanged and flag **13** is set. After the line is processed, the next enter variable is taken from the execution stack, and the process is repeated. After the parameter list is exhausted, control is transferred back to the interpreter to continue processing the rest of the user program.

## THE ENTER PRINT STATEMENT

Syntax:

enp [prompt, ]variable [, [prompt, ] variable...]

The enter print (enp) statement is the same as the enter statement except that prompts and the entered values are printed and displayed as they are encountered.

For example, assume the following short program is entered to calculate the area of a circle:

```
0: enp "radius",
   R
1: πRR→A
2: prt "area",A
3: end
```

If 2 is entered for R when the program is run, the print-out will be:

```
radius
2
area     12.57
```

## THE SPACE STATEMENT

Syntax:

spc [number of lines]

The space (spc) statement causes the printer to output the number of blank lines indicated by the expression. The number of lines can be an expression with a range of 0 through 32767. If no parameter is specified, one blank line is output.

Examples

| | |
|---|---|
| spc A + B | Space the number of lines specified by A + B. |
| spc 5 | Space 5 lines. |
| spc | Space one line. |

## THE BEEP STATEMENT

Syntax:

beep

The beep statement causes the calculator to output an audible sound.

Example:

The calculator normally beeps, displays error 67, and stops when the argument of the square root (√ ) function is negative. In the following short program the value entered for A is tested. If it is negative, the calculator still beeps and displays a message, but the program continues entering values.

```
0: fxd 4
1: "beg.":ent
"Argument",A
2: if A>0;gto
   "error"
3: prt rA;gto
   "beg."
4: "error":beep
5: dsp "r of
   neg. no."
6: wait 2000;
   gto "beg."
```

## THE WAIT STATEMENT

Syntax:

wait number of milliseconds

The wait statement causes a program to pause the specified number of milliseconds. The wait statement is often used with the display or enter statements to display a message for a specified time. The number of milliseconds can be an expression.

Since the wait statement takes time to be executed, small values in the wait statement are actually longer than a millisecond.

The maximum wait is around 32 seconds which is specified by the value of 32767.

Examples:

| | |
|---|---|
| wait 2000 | pause for 2 seconds |
| wait (2*I) | pause for (2*I) milliseconds |

## BINARY I/O OPERATIONS

Binary I/O operations are available to read and write individual data characters, and to transmit or receive control information using interface status lines. Binary I/O operations do not reference format or conversion statements. The data I/O modes and status line meanings are determined by the interface card.

## THE WRITE BINARY STATEMENT

Syntax:

wtb select code,expression$_1$,expression$_2$,...

This statement outputs the 16-bit binary-equivalent result of each expression in the list. The usable range for each expression is an integer from 32767 through −32768. If the interface handles data in an 8-bit fashion, such as the HP-IB Interface or the byte mode with the HP 98032A, only the eight least-significant bits of each integer are output.

## THE READ BINARY FUNCTION

Syntax:

rdb [select code]

Read binary is a function that inputs one 16-bit character and stores its integer-decimal value. If the interface handles data in an 8-bit fashion, only the eight least-significant bits are read.

Referring to FIG. 164, a flow chart of the read binary subroutine is shown. A user places the calculator in a special input mode in which the next key pressed, except for the RESET key, terminates the mode and returns the key code for that key to the program. Using the select code 0 for the calculator keyboard and display, as discussed hereinafter, the syntax is rdb(0). The keycode for the next user actuated key is returned for the value of the function thereby allowing a user to redefine one or more of the keyboard keys.

## THE READ STATUS FUNCTION

Syntax:

rds [select code]

This function reads the current status information transmitted from the specified device and returns a decimal equivalent number.

### KDP Status Bits

Status information from the calculator's keyboard, display and printer is combined into an 8-bit byte. Although most of the bits are primarily for internal use only, two bits, bits 1 and 2, have programming uses in that Bit 1 indicates "1" whenever the printer is out of paper and Bit 2 indicates "1" whenever the printer is busy.

## THE WRITE CONTROL STATEMENT

Syntax:

wtc (select code),expression

This statement outputs a binary number to control functions on the Interface Card. One number is allowed with each statement. Control bits 0, 1 and 5 are used to drive interface output lines CTL0, CTL1, and RESET. CLT0 and CTL1 are optional peripheral control lines, while RESET is used to initialize the peripheral to its power-up state. A preset signal is automatically given when the calculator is switched on or when RESET is pressed. The interface ignores bits 2 and 3. Bits 4, 6 and 7 are usable when the Extended I/O ROM is in use.

## HP INTERFACE BUS

The HP Interface Bus, HP-IB hereafter, is described in U.S. Pat. No. 3,810,103 and in the January, 1975, Hewlett-Packard Journal, Vol. 26, Number 5. It has a serial-byte bus structure which permits bi-directional communication between multiple devices. When a controller such as a calculator is used, up to 14 HP-IB compatible devices can be controlled via one interface card.

Instruments are controlled or programmed and data transmitted between devices on the bus. This is possible since each device connected to the bus has the potential of being a "talker" (sends data) or a "listener" (receives data) and has a unique talk and/or listen address by which a controller interrogates or communicates with the instrument. A unique threewire handshake technique allows the communication to take place at a speed determined only by the specific instruments being addressed. Slower devices will not slow down the communication speed of the bus as long as they are not addressed.

The interface system consists of 16 lines which are used to carry all data and control information. The bus structure is organized into three sets of signal lines: data bus, 8 signal lines; handshake or control, 3 signal lines, and general interface management, 5 signal lines.

The data bus carries 8-bit data and control messages in bit parallel, byte serial form. The messages are transmitted bi-directionally and asynchronously. The handshake and management lines are used to control data transfer and timing on the bus. When the General I/O ROM is used, the handshake and management lines are controlled automatically, permitting the calculator to communicate with one instrument at a time. For complete control of all bus functions, the Extended I/O ROM is required.

## THE STOP STATEMENT

Syntax:
stp

The stop statement stops program execution at the end of the line in which it is executed. Executing the stop statement in a keyboard line stops the keyboard line only.

When the stop statement is executed in a program, the line number of the next line to be executed is displayed. Pressing the CONTINUE key continues the program from the line number in the display. Pressing the STEP key "steps" from the displayed line number one line at a time. If any editing is performed after the program stops, pressing the CONTINUE key causes the program to continue from line O.

The stop statement can also be used for editing.

## THE END STATEMENT

Syntax:
end

The end statement is usually the last line in a program. It causes the program to stop. The end statement resets the program line counter to line 0 and resets all go sub return pointers as explained more fully hereafter. The end statement cannot be executed during an enter statement, no can it be executed in live keyboard mode.

## HIERARCHY

In a statement containing functions, arithmetic operations, relational operations, logical operations, imbedded assignments, or flag operations, there is an order in which the statement is executed. This order is called the hierarchy, which is for the preferred embodiment:

| | |
|---|---|
| highest priority | functions, flag references, r-registers |
| | ↑ (exponentiation) |
| | implied multiply |
| | unary minus |
| | * / mod |
| | + − |
| | all relational operators (=,>,<,<=,>=,#) |
| | not |
| | and |
| lowest priority | or xor |

Expressions within parenthesis are given highest priority. Expressions within innermost parenthesis are evaluated first. If an assignment is within parenthesis, this rule does not always hold true. If operations are on the same level in the hierarchy, then they are evaluated from left to right as in : A*B*C*D.

## SIGNIFICANT DIGITS

All numbers are stored internally with 12 significant digits regardless of the number format being used.

## OPERATORS

The four groups of mathematical or logical symbols, called operators, are: the assignment operator, arithmetic operators, relational operators, and logical operators.

### Assignment Operator

Syntax:
expression → variable

The assignment key, labelled → and shown below the CLEAR key in FIG. 3, is used to assign values to variables.

Examples:

| | |
|---|---|
| 1.4 → A | The value 1.4 is assigned to the variable A. |
| B → A | The value of B is assigned to the variable A. |

To assign the same value to many variables, the assignment operator is used as in this example:

32 →A → B→ X → r4

Multiple assignments can also take the form:

(25→ A) +1 →B which is the same as 25→ A ; A +1→ B

It should be noted that 25→ A +1→ B is not allowed; parenthesis are required for imbedded assignments.

Assignments can be imbedded within a statement such as

if (A+1→ A) >5.

This allows the assignment and the comparison to be made in a single statement.

### Arithmetic Operators

The six arithmetic operators are given below:

| Key label | Function | Example |
|---|---|---|
| + | Add (if unary, no operation) | A+B or +A |
| − | Subtract (if nuary, change sign) | A−B or −A |
|  | Multiply | A*B |
|  | Divide | A÷B |
| ↑ | Exponentiate | $A^B$ |
| mod | Modulus | A mod B is the remainder of A÷B when A and B are integers.<br>A−int (A/B)*B |

In addition to the "*" symbol for multiplication, implied multiplication is also possible. In the following instances, implied multiplication takes place:

- Two variables together (i.e.: AB).
- A variable next to a value (i.e.: 5A).
- A variable or value next to parenthesis [i.e.: 5(A+B)].
- Parenthesis next to parenthesis [i.e.: (A+B)(X+Y)].
- A variable, value, or parenthesis preceding a function name (i.e.: 32 sinA).

For example:

|  |  |
|---|---|
| AB → X | A times B is stored in X. |
| 2C → R | 2 times C is stored in R. |
| X5 → Y | X times 5 is stored in Y |
| (5)5→ X | 5 times 5 is stored in X. |
| A(B+C)→ B | A times the sum B+C is stored in B. |
| (D+F)(R+T)→ T | The sum of D+F times the sum of R+T is stored in T. |
| 5 abs B | 5 times the absolute value of B. |

### Relational Operators

There are six relational operators shown in the following table.

| Key label | Function |
|---|---|
| = | equal to |
| > | Greater than |
| < | less than |
| => or >= | greater than or equal to |
| =< or <= | less than or equal to |
| # or <> or >< | not equal to |

The result of a relational operation is either a one if the relation is true or a zero if it is false. Thus if A is less than B, then the relational expression A >= B, is true and results in a value of one. All comparisons are made to 12 significant digits.

The relational operators can be used in assignment statements, if statements and other statements which allow expressions as arguments. For example:

|  |  |
|---|---|
| A=B → C | Assignment statement. If A and B are equal, a 1 is stored in C; otherwise, a 0 is stored in C. |
| if A>B;... | If statement. If A is greater than B, then continue in the line; but if A is less than or equal to B, go to the next line. |
| jmp A>3 | Jump statement. If A is greater than 3, jump 1 line, otherwise jump to the beginning of the line (jmp 0). |
| prt A*(A>B)+B*(A<B) | Print statement. If A is greater than B, A is printed. If A is less than B, then B is printed. If A equals B, then "0" is printed. |

### Logical Operators

The four logical operators, AND, OR, XOR (exclusive or), and NOR, are useful for evaluating Boolean expressions. Any value other than zero, false, is evaluated as true. The result of a logical operation is either zero or one as shown in the table below.

| Operation | Syntax | truth table |  |  |
|---|---|---|---|---|
| AND | expression and expression | A | B | A and B |
|  |  | F | F | 0 |
|  |  | F | T | 0 |
|  |  | T | F | 0 |
|  |  | T | T | 1 |
| OR | expression or expression | A | B | A or B |
|  |  | F | F | 0 |
|  |  | F | T | 1 |
|  |  | T | F | 1 |
|  |  | F | F | 1 |
| XOR<br>(exclusive OR) | expression xor expression | A | B | AxorB |
|  |  | F | F | 0 |
|  |  | F | T | 1 |
|  |  | T | F | 1 |
|  |  | T | T | 0 |
| NOT | not expression | A |  | not A |
|  |  | F |  | 1 |
|  |  | T |  | 0 |

## MATH FUNCTIONS AND STATEMENTS

Simple or complex problems are solved using the nineteen math functions and four math statements which are explained hereinafter and the six math operators explained hereinbefore.

Parenthesis are necessary when a "+" or "−" sign precedes the argument. In the following examples of Functions, parenthesis are shown only where they are required.

| Syntax | Description | Examples (fxd 5) |
|---|---|---|
| √ expression | The square root function returns the square root of an expression which is non-negative. | √64 = 8.00000<br>√π = 1.77245 |
| abs expression | The absolute value function determines the absolute value of the expression. | abs (−3.09) - 3.09000<br>abs 330.1 - 330.10000 |
| sgn expression | The sign function returns a −1 for negative expression, 0 if the expression equals 0, and 1 for a positive expression. | sgn (−18) = −1.00000<br>sgn 0 = 0.00000<br>sgn 34 = 1.00000 |
| int expression | The integer function returns the largest integer less than or equal to the expression. This is often referred to as the "floor" integer | int 2.718 = 2.00000<br>int (−3.24) = 04.00000 |

-continued

| Syntax | Description | Examples (fxd 5) |
|---|---|---|
| | value of the expression (see programming hints). | |
| frc expression | The fraction function gives the fractional part of a number. It is defined by: <expression> −int <expression> | frc 2.718 = .71800<br>frc (−3.24) = .76000 |
| prnd (expression, rounding specification | The power-of-ten rounding function returns the value of the argument rounded to the power-of-ten position indicated by the rounding specification. The argument remains unchanged. | prnd (127.375, -2) = 127.38000<br>127.375 is rounded to the nearest hundredth $10^{-2}$). |
| drnd (expression, number of digits) | The digit round function rounds the argument to the number of digits specified. The leftmost significant digit is digit number 1. The argument remains unchanged. | drnd (73.0625,5 = 73.06300<br>drnd (−65023,1) = −70000.00000<br>drnd (.055,1) = 0.6000 |
| min (list of expressions and arrays) | The min function returns the smallest value in the list. An entire array can be specified by using an asterisk, such as B[*]. | 0: dim A[3];2→A[1]<br>1: 9→A[2];3→A[3]<br>min (A[*]) = 2.00000<br>min (2,−3,−3,4) = 3.00000 |
| max (list of expressions and arrays) | The max function returns the largest value in the list. An entire array can be specified by using an asterisk, such as B[*]. | 0: dim A[3]; 2→A[1]<br>1: 9→A[2]; 3→A[3]<br>max (A[*]) = 9.00000<br>max (5,4,−3,8) = 8.00000 |
| rnd expression | The random number function generates a pseudo-random number in the range 0≦ rnd expression <1. The starting seed for the function is π/180 (which is .0174532925200). This seed is initialized when the calculator is turned on, erase a is executed, or RESET is pressed. If the expression is negative, then the expression becomes the new seed. To obtain other good seeds, use an expression between 0 and −1: The more non-zero digits in the value, the better. Last digits of 1,3,7 or 9 are preferable. | rnd 1 = .67822<br>rnd (−.827) = .50700 |

## Exponential and Logarithmic Functions

The math errors and default values associated with the log, and ln (natural log) functions are explained in detail hereinafter in the section on Math Errors.

| Syntax | Description | Examples (fxd 5) |
|---|---|---|
| ln expression | The natural logarithm function calculates the logarithm (base e) of a positive valued expression | ln 8001 = 8.98732<br>ln .0026 = −5.95224 |
| exp expression | The exponential function raises the constant, naperian $e_1$ to the power of the computed expression The range of the argument is from −227.95 through 230.25. | exp 1 = 2.71828<br>exp (−3) = .04979 |
| log expression | The common logarithm function calculates the logarithm (base 10) of a positive valued expression. | log 305.2 = 2.48458<br>log .0049 = −2.30980 |
| tn ↑ expression | The ten to the power function raises the constant, 10, to the power of the computed expression. The range of the argument is from −99.0000000002 through 99.9999999997. This function executes faster than 10 ↑ expression. | 5 tn ↑ 2 = 500.00000<br>tn ↑ (−3) = .00100 |

## Trigonometric Functions and Statements

The six trigonometric functions are all calculated in the currently set angular units. Three trigonometric statements explained in this section are used to set the angular units. Math errors and default values associated with the tan, asn, and acs functions are covered in detail hereinafter in the section on Math Errors.

Referring to FIG. 164, a flow chart illustrating how the calculator prescales trigonometric arguments is shown. The calculator reduces arguments to the first octant (0–45°) from any original value. The argument is reduced in its own units, that is in degrees, radians, or grads. First the argument is reduced to the unit circle (0–360°) by eliminating all full multiples of 360. The remainder is then reduced to the first octant and converted to radians.

Degrees are set when the calculator is switched on, erase a is executed, or RESET is pressed. To change the angular units, a user executes one of the following statements;

**69** corresponds to l*n* or log of a neative number. The default is in (abs(argument)) or log (abs(argument)), respectively. For example:

l*n* (−**301**) = **5.70711**

| Syntax | Description |
|---|---|
| deg | Specifies degrees for all calculations which involve angles. A degree is 1/360th of a circle. |
| rad | Specifies radians for all calculations which involve angles. There are 2π radians in a circle. |
| grad | Specifies grads for all calculations which involve angles. A grad is 1/400th of a circle. |
| units | Displays the current angular units |

| Syntax | Description | Examples (fxd 5) |
|---|---|---|
| sin expression | The sine function determines the sine of the angle represented by the expression in the current angular units. | deg; sin 45 = 0.70711<br>rad; sin (π/6) = 0.50000<br>grad; sin (−70) = −0.89101 |
| cos expression | The cosine function determines the cosine of the angle represented by the expression in the current angular units. | deg; cos 45 = .70711<br>rad; cos (π/6) = .86603<br>grad; cos (−70) = .45399 |
| tan expression | The tangent function determines the tangent of the angle represented by the expression in the current angular units. | deg; tan 45 = 1.00000<br>rad; tan (π/4) = 1.00000<br>grad; tan 50 = 1.00000 |
| asn expression | The arc sine function returns the principal value of the arcsine of the expression in the current angular units. The range of the argument is −1 through +1. The range of the result is −π/2 to +π/2(radians). | deg; asn .8 = 53.13010<br>rad; asn .8 = 0.92730<br>grad; asn .8 = 59.03345 |
| acs expression | The arccosine function returns the principal value of the arccosine of the expression in the current angular units. The range of the argument is −1 through +1. The range of the result is 0 to π (radians). | deg; acs (−.4) = 113.57818<br>rad; asn .8 = 1.98231<br>grad; acs (−.4) = 126.19798 |
| atn expression | The arctnagent function calculates the principal value of the arctangent of the expression in the current angular units. The range of the result is −π/2 to +π/2 (radians). | deg; atn 20 = 87.13759<br>rad; atn 20 = 1.52084<br>grad; atn 20 = 96.81955 |

## MATH ERRORS

The numerals **66** through **76** are automatically displayed in response to the occurrence of a math error and flag **15** is set. When flag **14** is set, math operations which normally cause an error to be displayed, result in a default value.

When printing, displaying or storing default values of ± 9.99999999999e511, the value is automatically converted to ± 9.99999999999399.

**66** is displayed in response to division by zero. The default value is 9.99999999999e511 if the dividend is negative. For example:

−9.5/0 = −9.999999999993511

A mod B with B equal to zero. The default value is 0. For example.

32 mod 0 = 0

**67** corresponds to the square root of a negative number. The default value is √(abs(argument)). For example:

√(−36) = 6.

**68** corresponds to the: tangent of (*n**π/2 radians; tangent of (n*90°); tangent of (*n**100 grads); wherein *n* is an odd integer. The default value is 9.99999999999e511 if *n* is positive; and −9.99999999999e511 if *n* is negative.

log (−.**001**) = −**3.00000**

**70** corresponds to ln or log of zero. The default value is −9.99999999999e511.

**71** corresponds to asn or acs of a number less than −1 or greater than 1. The default value is (asn (sgn(argument)) or acs (sgn)argument)), respectively. For example (in degrees):

asn (−10) = asn (−1) = −90

acs (1.6) = acs (1) = 0

**72** corresponds to a negative base to a non-integer power. The default value is (abs(base)) ↑ (non-integer power). For example:

(−36) ↑ (.5) = **6**

**73** corresponds to zero to the zero power (0 ↑ 0). The default value is 1.

**74** represents full-precision overflow. The default value is 9.99999999999e99 or −9.99999999999e99.

**75** represents full-precision underflow. The default value is zero. For example:

(1e−66) * (4e−35) → A

A will equal 0

**76** represents an intermediate result underflow. The default value is 9.99999999999e511 or −9.99999999999e511. For example:

(1e 99) ↑ 6 = 9.99999999999e511

(−13 99) ↑ 6 = −9.99999999999e511

77 represents an intermediate result underflow. The default value is zero. For example:

(1e−10) ↑ 60 = 0

## BRANCHING STATEMENTS

There are three statements used for branching: the go to (gto) statement, the jump (jmp) statement, and the go sub (gsb) statement.

The following three types of branching may be used for both go to and go sub statements:

| | |
|---|---|
| Absolute Branching - | branch to a specified line number (such as gto 10). |
| Relative Branching - | branch forward or backward in the program specified number of lines relative to the current line (such as gsb - 3). |
| Labelled Branching - | branch to an indicated label (such as gto "First"). |

### Line Renumbering

Line numbers are automatically renumbered when a program line is inserted or deleted. As lines are inserted or deleted in a program, the line number of any relative or absolute go to or go sub statements is changed to reflect the insertion or deletion. The entire program is checked before any deletion is made. If the line being deleted is the destination of a relative or absolute go to or go sub statement, an error is displayed and no deletion occurs unless an asterisk (*) is used in the delete commmand, the delete command being more fully described hereinafter.

### Labels

Labels are characters within quotes located at the beginning of a line, after a gto or gsb statement, or after a run or continue command. Labels at the beginning of a line must be followed by a colon.

Labels are used for branching, the label in the gto or gsb statement is compared to the line labels in the program until a match is found. Then, at the end of the line, a branch is made to the line containing the label. When a branch is made to a label, the program is scanned beginning at line O until a matching label is found.

## THE GO TO STATEMENT

The go to (gto) statement causes program control to transfer to the location indicated. There are three types of branching used with the gto statement, absolute, relative, and labelled.

### Absolute Go To

Syntax:
gto line number

An absolute go to statement is used to branch to the indicated line number. The line number must be a number. Inserting an absolute go to statement at line zero causes the line number of the go to statement to be incremented by one.

When an absolute go to statement is executed from the keyboard, the program line counter is set to the specified line number. To view the line, a user presses the ↑ Display key.

### Relative Go To

Syntax:
gto + number of lines
gto − number of lines

A relative go to statement is used to branch forward (+) or backward (−) the specified number of lines, relative to the current line number. The line number must be a value.

### Labelled Go To

Syntax:
gto label

A labelled go to statement is used to branch to the indicated label (see section on labels). This is the most convenient type of branching since no line numbers have to be considered.

Example:
gto "beg." go to the line labelled by "beg."

### Multiple Go To Statements

Multiple go to statements in a line are used for N-way branching, described hereinafter, when used with an if statement.

## THE JUMP STATEMENT

Syntax:
jmp number of lines

The jump (jmp) statement allows branching from the current line number by the number of lines specified. This statement is similar to the relative go to statement except that the number of lines can be an expression. If the number of lines is positive, the branch is forward in the program. If the number of lines is zero, the branch is to the beginning of the current line. If the number of lines is negative, the branch is backward in the program. If the number of lines is not an integer, then it is rounded as follows:

- The value is rounded to the next greater integer if the fractional part is 0.5 or larger.
- The fractional part is truncated if its value is less than 0.5.

The jump statement executes slower than the go to statement.

The jump statement can only be at the end of a line, otherwise error φ7 is displayed.

## THE GO TO SUBROUTINE AND RETURN STATEMENTS

The go to subroutine (gsb) statement allows branching to subroutine portions of a program. A return pointer is set up when the go sub statement is executed. The return pointer points to the line below the line containing the go sub statement. The return (ret) statement returns the program execution to the pointer location. The return statement must be the last statement executed in the subroutine and must be the last statement in a line. The depth of go sub nesting is limited only by the amount of available memory.

There are three types of go sub statements: absolute, relative, and labelled.

### Absolute Go Sub

Syntax:
gsb line number

An absolute go sub statement is used to go to the subroutine at the specified line number. The line number must be a number.

Inserting a gsb line number at line zero causes the line number of the go sub statement to be incremented by one.

### Relative Go Sub

Syntax:
gsb + number of lines
gsb − number of lines

A relative go sub statement provides forward (+) or backward (−) subroutine branching the specified number of lines, relative to the current line number. The number of lines must be a number.

### Labelled Go Sub

Syntax:
gsb label

A labelled go sub statement is used to branch to the subroutine at the indicated label. This is the most convenient form of go sub branching since no line numbers need to be considered.

When branching to a label, a comparison is made on all characters in the label.

### Multiple Go Sub Statements

Multiple go sub statements in a line are used for N-way branching when used with the if statement, described hereinafter.

The gsb statement is useful where the same routine will be done many times in a program and called from different places in the main program.

### Calculated Gosub Branching

Using the jump statement and the go sub statement, calculated branching to subroutines is possible. This form of subroutine branching is called the calculated go sub and has the form:

gsb line number, number of lines, or label; jmp expression

The line number or label in the gsb is ignored and the calculator branches to the subroutine designated by the computed jump expression. If a 3 is entered in line zero of the following program, for example, the program branches to the subroutine at line 4.

```
0: ent N
1: gsb "X";jmp N
2: prt "end"
3: "X":end
4: prt "subl";
   ret
5: prt "sub2";
   ret
6: prt "sub3";
   ret
```

The calculator automatically adjusts the gto and gsb destinations when program lines are inserted or deleted so that gto xx or gsb xx statement line number (xx) always point at the same line regardless of lines being inserted or deleted in the program.

This feature is desirable since all line numbers in a program are implicit. Therefore if a line is inserted, all lines after that line are associated with a line number one greater than before the insert.

This feature operates under the following editing operations:

| | |
|---|---|
| 1- | FETCH line no.<br>EXECUTE<br>enter line from keyboard<br>INSERT |
| 2- | FETCH line no.<br>DELETE |
| 3- | del <line no.1>[,line no.2][,*] |

-continued

| |
|---|
| EXECUTE |

Referring to FIG. 166, detailed flow charts are given illustrating the manner in which the calculator adjusts gto and gsb destinations. If an attempt is made to delete lines, the first step is to prescan the program to be sure that none of the gto or gsb statements reference the deleted lines. If the deleted lines are referenced, an error is given and the delete operation is terminated before any lines are deleted or any gto/gsb's are adjusted.

If the lines that are to be deleted are not gto/gsb destinations, then the adjustment is made and the deletion takes place. If the deletion is "del line no. 1,*"or" to del line no.1, line no.2,*", no prescan is made nor are any errors generated. All gto/gsb's whose destinations are deleted have their destinations adjusted to point at the first line after the deleted section.

## THE IF STATEMENT

Syntax:
if expression

The if statement is used to branch based on a logical decision. When an if statement is encountered, the expression following it is evaluated. If the computed expression is zero (false), program control resumes at the next program line (unless the preceding statement was a go to or go sub statement as explained hereinafter under n-way branching. If the computed expression is any other value, it is considered true, and the program continues in the same line. The if statement is nost often used with expressions containing relational operators or flags.

## N-WAY BRANCHING

The if statement used with a go to or go sub statement makes it possible to branch to any of several locations. This type of branching is referred to as n-way branching, and has the following forms:

gto... ; if... ; gto...
or
gsb... ; if... ; gsb...

If the first if statement is false, then the branch is determined by the first go to or go sub statement. If the first if statement is true, the second go to or go sub statement determines the branch.

## FLAGS

Flags are programmable indicators that can have a value of one or zero. When a flag is set, its value is one; when it s cleared, its value is zero. A flag's value can be complemented by the complement flag (cmf) statement. There are 16 flags, numbered 0 through 15. The following flags can have special meanings:

Flag 13 — is automatically set if the continue key is pressed without entering data in an enter statement or if the stop key is pressed in an enter statement. Flag 13 is automatically cleared when data is supplied in an enter statement.

Flag 14 — when flag 14 is set, the calculator ignores math errors such as division by zero and supplies a default value.

Flag 15 — is automatically set whenever a math error occurs, regardless of the state of flag 14.

## THE SET FLAG STATEMENT

Syntax:

sfg [flag number,...]

The set flag (sfg) statement sets the value of the specified flags in the list to one. The flag number can be a value or an expression. If sfg is executed alone, all flags (0 through 15) are set.

Examples:

| | |
|---|---|
| sfg 2 | Set flag 2. |
| sfg (A+1) | Set the flag designated by (A+1). |
| sfg 1,X | Set flag 1 and the flag designated by X. |

## THE CLEAR FLAG STATEMENT

Syntax:

cfg [flag number,...]

The clear flag (cfg) statement clears the specified flags in the list to zero. The flag number can be a value or expression. If cfg alone is executed, all flags (0 through 15) are cleared.

Examples:

| | |
|---|---|
| cfg 14 | Clear flag 14. |
| cfg (flg 2) | Clear the flag designated by the value of flag 2 (either flag one or flag zero will be cleared). |
| cfg 11, 12 | Clear flags 11 and 12. |

## THE COMPLEMENT FLAG STATEMENT

Syntax:

cmf [flag number,...]

The complement flag (cmf) statement changes the value of the flags specified. If a set flag is complemented, its new value is zero. If a cleared flag is complemented, its new value is one. A value or expression can be used for the flag number. To complement flags 0 through 15, the complement flag statement without parameters is executed.

Examples:

| | |
|---|---|
| cmf 1 | Complement flag 1. |
| cmf (X−1) | Complement the flag designated by (X−1). |
| cmf 3,4,5 | Complement flags 3,4, and 5. |

## THE FLAG FUNCTION

Syntax:

flg flag number

The flag (flg) function is used to check the value of a flag. The result of the flag function is zero or one. One indicates a set flag; zero indicates a cleared flag. Examples:

| | |
|---|---|
| 4: if flg2;jmp 5 | If flag 2 is set, jump 5 lines. |
| 5: flg15→A | If flag 15, is set 1→A; if flag 15 is cleared, 0→A. |

## THE DIMENSION STATEMENT

dim item [ , item, ...]

item may be: simple variable

array variable [subscript [ , subscript, ...]]

The dimension (dim) statement reserves memory for simple and array variables, and initializes the indicated variables to zero. r-variables are not allowed in a dimension statement.

Variables in the list allocate memory in the order that they appear if they have not already been allocated. Thus, all the variables dimensioned in any one dimension statement are stored in a contiguous block of memory.

In the dimension statement, the subscripts of an array can e specified by an expression. For example:

```
0: ent N,I,r2
1: dim A[N,I],
  B[r2],C[3,2*N]
```

Dimension statements may appear anywhere in a program but the same dimension statement can only be executed once. The number of dimension statements is limited by memory size. The number of subscripts and the size of subscripts is limited by memory size and line length.

### Specifying Bounds for Subscripts

The upper and lower bounds for the subscripts of an array can be specified. The lower bound must be specified before the upper bound and separated by a colon. For example:

```
0: dim S[−3:0,
  4:6]
```

The above statement reserves the same amount of memory as:

```
0: dim X[4,3]
```

The elements of array, S, are referenced as:

| | | |
|---|---|---|
| S[−3,4] | S[−3,5] | S[−3,6] |
| S[−2,4] | S[−2,5] | S[−2,6] |
| S[−1,4] | S[−1,5] | S[−1,6] |
| S[0,4] | S[−,5] | S[0,6] |

If a lower bound is not specified, as in X[4,3], it is assumed to be 1, the same as X[1:4:4,1:3].

## THE CLEAR SIMPLE VARIABLES STATEMENT

Syntax:

csv

The clear simple variables (csv) statement clears any allocated simple variables from A through Z to zero. The clear simple variables statement does not de-allocate variables. Therefore, an error results when the following line is executed:

```
7→A; CSV; dim A
```

## THE LIST STATEMENT

Syntax:

list [line number 1 [, line number 2]]

list special function key

list k

The list statement is used to obtain a printed listing of a program, section of a program, or special keys. If no parameter follows the list statement, the entire program is listed. If one line number is specified, the program is listed from that line to the end. If two line numbers ae specified, then the program segment between the two line numbers, inclusive, is listed. To list all the special function keys, execute lisk k (for list keys). When list is followed by pressing an individual special function key, then only that key is listed. The list statement must be stored as the last statement in a line.

Examples:

| | |
|---|---|
| list | Lists the entire program. |
| list 10,15 | List lines 10 through 15 |
| list 4,4 | List line 4. |

-continued

| | |
|---|---|
| list k | List the special function keys. |
| list f12 | List special function key $f_{12}$ (shift $f_0$). |

At the end of a listing, a checksum is printed. This checksum is useful for detecting interchanged or omitted lines and characters. This is because any difference in the programs generates a different checksum. In the following two programs, only the characters "rt" in line 1 are interchanged. Note that the checksums are different, the checksums being the bottom five digit numbers preceded by an asterisk.

```
φ: ent N              φ: ent N
1: prt "sprt.         1: prt "sptr.
 of ",N                of",N
2: prt "              2: prt "
 is",rN                is",rN
3: end                3: end
*3φ418                *3φ414
```

## Used and Remaining Memory

After a list operation, two values are displayed. The first value is the total length of the program in bytes where a byte is 8 bits. To store the program, a file must be marked at least that long. The second value is the remaining memory in bytes.

## EDITING

The first step in editing is to find the lines which require changes. This is done in several ways. One way is to step through a program by pressing the step key one time for each line to be executed and checking the results after each executed program line.

Another way is to use the trace (trc), stop (stp), and normal (nor) statements. When program lines are traced, variables and flags which are assigned values are printed. This allows a user to monitor program activity in individual program lines. Using the stop statement, the program is stopped whenever a specified program line is encountered. The normal statement is used to terminate tracing and stopping. More information on the stop, trace and normal statements is explained hereinafter under editing statements.

To modify characters within a line, a user presses the FETCH key followed by the line number of the line requiring the change and then presses the execute key. The line will appear in the display. A user next presses either BACK if the change is closer to the end of the display or FWD is the change is closer to the front. Once a flashing cursor is over the location needing correction, a user either inserts characters, deletes characters, or writes over the existing characters. To insert characters, the INS/RPL key is pressed. This changes the flashing cursor to a flashing insert cursor. Characters are inserted at the left of this cursor. To delete characters, the DELETE key is pressed for each character to be deleted.

To modify lines within a program, the FETCH key or the ↑ and ↓ keys are used to bring the line into the display. To delete the line, the line DELETE key is pressed.

If the line being deleted is a line referenced by a relative or absolute go to or go sub statement, an error 36 will occur. A user can either execute the delete (del) command with the optional asterisk (*) parameter, explained more fully hereinafter, or adjust the line reference in the go to or go sub statement accessing that line.

To insert a line, a user fetches the line where the inserted line is to be located, types the line into the display and presses the line INSERT key to store it. All the lines from the fetched line on are automatically renumbered (incremented by one). The line reference of go to or go sub statements are also incremented if necessary.

## EDITING STATEMENTS

The trace (trc) statement, stop (stp) statement, and normal (nor) statement are also used for editing programs. The three statements have dual roles in that their action depends upon whether any parameters are specified.

## THE TRACE STATEMENT

Syntax:

trc [beginning line number [, ending line number ]]

The trace (trc) statement monitors the activity of a running program. In trace mode, line numbers, any value assignments, and flags are printed as encountered in a running program.

An entire program, sections of a program, or individual lines in a program can be traced. To trace an entire program, the first line number is set to 0 and the second line number is set greater than or equal to the line number of the last line in the program. To trace a block of line numbers, trc followed by the beginning and ending line number in the block is executed. To trace a single line, trc followed by that one line number is executed.

The trace statement, when followed by parameters, sets a trace flag at each indicated line of the program. When the normal (nor) statement is executed without parameters, these line trace flags remain set, but trace mode is disabled. By executing the trace statement again, those flagged lines again are traced. To clear the line flags, the normal statement followed by the line numbers of the lines which are traced is used.

Example: Assume the following program is entered.

| | |
|---|---|
| φ: trc 1,12 | Traces lines 1 through 12. |
| nor | Disables tracing. |
| trc | Traces lines 1 through 12. |
| nor 3 | Clears trace flag at line 3; and tracing continues on lines 1, 2, and 4–12. |
| nor | Disables tracing. |

## THE STOP STATEMENT

Syntax:

stp line number [, line number]

This stop (stp) statement is used to set stop flags at the beginning of program lines. When a program reaches a line with a stop flag set (and when the master flag is set), the program stops at the beginning of that line.

When only the first line number is specified, a stop flag at the beginning of that line is set. If the program reaches the beginning of that line, execution stops. When a block of lines is specified by two line numbers, the stop flags at the beginning of all the lines in that block are set. If execution reaches any line in that block the program stops at the beginning of that line.

The normal statement followed by a line number or two line numbers clears the individual line stop flags.

## THE NORMAL STATEMENT

Syntax:

nor [line number **1** [ , line number **2**]]

The normal (nor) statement clears stop and trace flags. Tracing and stopping are terminated if nor is executed without line numbers, but individual stop and trace flags are not cleared on the program lines. The trace or stop flag at a line is cleared and overall tracing continues if nor is followed by the line number. When nor is followed by two line numbers, the trace and stop line flags of all the lines in the block are cleared.

All the trace and stop line flags are cleared if nor is followed by the beginning and ending line numbers of the program.

## OPERATION OF TRACE, STOP, AND NORMAL

To effectively use the trace, stop, and normal statements, the internal operation should be understood. There is one master flag which enables and disables overall tracing and stopping. In addition, each line has two flags. The trace flag enables and disables tracing of the line. The stop flag enables and disables selective stopping at the line.

Executing any of the following statements sets the master flag which enables tracing and selective stopping:

stp with parameters
trc with parameters
trc without parameters

The normal (nor) statement without parameters clears the master flag which disables tracing and stopping.

The line trace flags are set by executing trc with parameters. The line stop flags are set by executing stp with parameters. The line trace and stop flags are cleared by executing nor with parameters.

The trace and stop flags are recorded on the tape cartridge by including the optional debug ("DB") parameter in the record file (rcf) statement as explained more fully hereinafter.

## COMMANDS

Commands differ from statements in that they can only be executed from the keyboard. Commands cannot be stored as part of a program.

## THE RUN COMMAND

Syntax:

run [line number or label]

The run command clears all variables, flags, and return pointers to go subs, then starts program execution. If a line number is specified, the program begins execution at the specified line number. If a label is specified, execution begins at the specified label in the program.

## THE CONTINUE COMMAND

Syntax:

cont [line number or label]

The continue (cont) command continues the program without altering variables, flags, or go sub return pointers. If no line number is specified, the program continues from the current position of the program line counter. If a line number is specified, the program continues at that line. If an edit or error has taken place since a previous "run" or "continue", continue without parameters causes execution at line **0**.

## THE DELETE LINE COMMAND

Sytax:

del line number **1** [ , line number **2**][,*]

The delete (del) command is used to delete lines or sections of programs. When one line number is specified, only that line is deleted. When two line numbers are specified, all lines in the block are deleted. del **0**, **9999** is executed to delete an entire program, and leave the variables.

Examples:

| | |
|---|---|
| del 28 | Delete line 28. |
| del 13, 20 | Delete lines 13 through 20. |
| del 18, 9999 | Delete program from line 18 to the end (this does not affect variables). |

If the optional asterisk (*) parameter is specified, any go to or go sub statements which reference delected lines are adjusted to reference the first line after the delected section.

## THE ERASE COMMAND

Syntax:

erase [a or v or k or special function key]

The erase command is used to erase programs, variables, and special function keys as shown below.

| Command | Meaning |
|---|---|
| erase | Erases program and variables when executed. |
| erase a | Erases all when executed. |
| erase v | Erases all variables when executed. |
| erase k | Erases all special function keys when executed. |
| erase fn | Erases the special function key indicated by fn. |

## THE FETCH COMMAND

Syntax:

fetch [line number or special function key]

The fetch command brings individual program lines into the display. This is useful for editing lines or for viewing individual program lines. Fetching a special function key displays the definition of the key or "f" followed by the key number if the key is undefined. Executing fetch alone, fetches line **0**.

## LIVE KEYBOARD

The calculator's live keyboard mode provides additional power for executing single or multi-statement lines while a program is running. Among other things, a user can perform math operations, monitor program activity, and alter program flow in live keyboard mode. Two statements described hereinafter permit the live keyboard mode to be turned on or off. While a program is running, a live keyboard operation is executed by keying the live keyboard operation into the display and pressing the execute key. At the end of the current program line, the live keyboard line is executed, the live keyboard operation being executed entirely before the program continues.

If the running program uses the display, keys which are pressed in live keyboard mode will disappear from the display but the line which is typed in is saved and is viewed by pressing RECALL.

If the running program continually uses the display, keys which are typed in will keep disappearing, even if

RECALL is pressed. A user presses either ↑ or ↓ to view the line for about one second. When either of these keys is held down, the display remains and the running program halts until the key is released. For example, assume the following program is running in the calculator:

```
0: dps "Live Keyboard"; wait 100
1: gto 0
```

When the following line is entered from live keyboard, it will not be visible:

```
prt (√25→A)
```

By pressing ↑ or ↓ the line will be displayed for about one second.

When the execute key is pressed, the line will be executed and 5 will be stored in A and printed.

Results of calculations performed in live keyboard disappear from the display if a running program uses the display. A special function key can be defined to preserve the displayed result long enough to be viewed as in this example:

press: FETCH $f_0$
type-in: *; wait 1000
press: STORE

If a user, for example, types in a calculation such as 5*6, and presses $f_0$ instead of the execute key, the result of the calculation remains in the display for about one second.

## LIVE KEYBOARD MATH

Any math operations can be executed from live keyboard. Thus, when a program is running and a few figures need to be calculated, a user merely keys in the operation and presses execute.

## STATEMENTS IN LIVE KEYBOARD

If a user desires a listing of the current program, he presses the LIST key then presses execute.

To check a variable in the program, a user keys in the variable name, such as A or B[4] and presses execute. The value of the variable will be displayed.

To change a variable from live keyboard, one enters the new value and assigns it to the variable to be changed. For example, to reset a counter such as C + 1 → C to 0, a user keys in 0 → C and presses execute.

## SUBROUTINES FROM LIVE KEYBOARD

Parts of a program can be executed from live keyboard as subroutines using the gsb statement. For example, the following section of a running program is used to calculate the factorial of a number, N.

```
11: "factorial":
12: if frc(N)>0
  or N>0;prt N,
  "no factorial";
  ret
13: if N=0;prt
  N,"factorial=",
  1;ret
14: 1→C→F
15: if C=N+1;
  prt N,"factoria
  1=",F;ret
16: C*F→F;C+1→C;
  gto 15
```

By assigning a value to N (such as 4 → N), and then executing gsb "factorial" from live keyboard, the values of N and N factorial are printed, and the program continues.

Control is returned to the display in live keyboard mode whenever return (ret), stop (stp), including stop flags, or end is executed after the gsb statement, but the main program continues running. A second stop will stop the main program.

## SPECIAL FUNCTION KEYS IN LIVE KEYBOARD

Although the special function keys $f_0$ through $f_{23}$ cannot be defined from live keyboard, they can be used from live keyboard. In the following example, the special function keys are used to alter the flow of a running program.

Assume, for example, the special function keys are defined as follows:

| f0 : | f1 : | f2 : |
|---|---|---|
| * → F | *2 → F | *3 → F |

Assume further that the program is:

```
0: "wait":dsp
  "waiting";wait
500;jmp F
1: gto "first"
2: gto "second"
3: gto "third"
4: "first":prt
  "first";0→F;
  gto "wait"
5: "second":prt
  "second";0→F;
  gto "wait"
6: "third":prt
"third";o→F;
  gto "wait"
```

When the program is run, "waiting" is displayed until one of the immediate execute special function keys is pressed and the program then branches to the line where either "first", "second", or "third" is printed. Although this is a simple example, it shows how program flow is altered in live keyboard mode.

## ERRORS IN LIVE KEYBOARD

Commands are not allowed in live keyboard mode. Commands executed in live keyboard cause error 3 to be displayed. Also, the following keys cause an audible beep when pressed and are ignored in live keyboard mode:

| STEP | LINE DELETE | INSERT | RUN | STORE | CONTINUE |
|---|---|---|---|---|---|

The go to and end statements cause error 9 to be displayed in live keyboard mode. The following cartridge statements, described more fully hereinafter, are not allowed in live keyboard mode: load program (1dp), load key (1dk), and load file (1df) of a program file.

## THE LIVE KEYBOARD ENABLE STATEMENT

Syntax:

```
lke
```

Live keyboard enable (lke) turns on the live keyboard. The calculator is in live keyboard mode when it is turned on and when RESET is pressed. To disable live keyboard, the live keyboard disable (lkd) statement is used.

Example:

lke Enable live keyboard.

## THE LIVE KEYBOARD DISABLE STATEMENT

Syntax:

lkd

The live keyboard disable (lkd) turns off the live keyboard. This is useful when a program is running which the user doesn't want disturbed. A user can execute a live keyboard enable (lke) statement from a program to enable live keyboard when this statement is executed.

Referring to FIGS. 176A-B, the keys typed by the user during live keyboard are entered into the KBD buffer under interrupt control. The normal I/O buffer editing routines are utilized by setting editing pointers to edit the KBD buffer during the processing of the live keyboard key. The use of the KBD during live keyboard allows the running program to use the I/O buffer for normal programmed I/O without interfering with the live keyboard line that is being edited.

Referring to FIGS. 168A-B, any error that occurs during the processing of a live keyboard key is trapped using the error by-pass link, so that the normal operation of the running program is not affected.

Referring to FIGS. 169A-B, a bit is set in the interpreter communication word (XCOMM) if the live keyboard key was the execute key, or a special key with an immediate execute character. At the end of each program line, the interpreter checks XCOMM and returns if any bit is set. AXCMM is then called to process the bits in XCOMM. If the live keyboard bit is set (bit 14), the live keyboard execution routines are called. These routines save the necessary pointers to enable the resumption of the current user program, and call the interpreter to execute the line in the KBD buffer. After the line is executed, the pointers are restored and the execution of the running program is resumed.

Errors encountered during the execution of a live keyboard line are detected by the error routines. Live keyboard execution clean-up is performed when an error occurs so that the user program is not affected by live keyboard errors.

## GSB IN LIVE KEYBOARD MODE

The user can execute a line that contains a subroutine call from the keyboard while a program is running. The processing of this line is the same as the normal live keyboard execution except that the interpreter changes the state of the system during the execution of the subroutine. The state of the system is indicated by the word CSTAT. The values that CSTAT can have are as follows:

0. idle or key entry
1. execution of a keyboard line
2. running a program
3. live keyboard execution
4. enter statement-waiting or key entry
5. execution of a line during an enter statement
6. execution of a subroutine from live keyboard.

The state is changed from 2 to 3 by the live keyboard processing routines and from 3 to 6 by the interpreter when it encounters a subroutine call.

Referring to FIG. 169B, the live keyboard execution routines utilize an interpreter (AINTK)-XCOMM service routine (AXCMM) loop similar to that of the normal execution loop. Thus, the execution of a live keyboard subroutine is essentially the same as the execution of a user program, except that the state is 6 rather than 2. This state value of 6 is used by the error routines to trap the live keyboard errors and by the keyboard interrupt service routine to disable live keyboard.

## TAPE CARTRIDGE OPERATIONS

Referring to FIGS. 170A-D, the information structure of a tape is shown. FIG. 170A shows the format for an individual file on the tape. All files that are recorded are made up of partitions of length greater than or equal to 256 bytes to allow a user recovery of at least part of his file if a read error occurs on attempting to read the file.

The following file types have partitions of length 256 bytes exactly: (1) key files, (2) memory files, (3) binary program files, (4) and data files, including numeric data or string data.

User program files are unique in that the partition length is such that a partition is always made up of some integral number of complete program lines. This feature allows the user to recover complete program lines from those partitions that are correctly read if a read error occurs.

While a file is being recorded, a routine illustrated by the flow charts shown in FIGS. 171A-B is called as the cassette hardware writes the inner partition gaps illustrated in FIG. 170B. The length of the next partition is calculated in bytes and the last partition is determined. This routine execution is simply a matter of returning 256 in all cases except program (user) files. If the file is user programmed, the partition length is calculated by adding line lengths until the count is ≧ 256 bytes.

Referring to the flow chart shown in FIGS. 172A-B, in loading there are two special cases. One is numeric data in which the first single floating point number in a partition is filled with code that will list or display ?.??????????e00, if the calculator is in flt 11, for example, thereby indicating that this partition of data is questionable if an error occurs in the partition.

The other special case is user programming. An entire partition of lines is replaced in memory by a single line of stars, "********", if an error is detected while loading that particular partition. Thus a user can determine from the lines surrounding this line of stars which lines need to be replaced.

At the end of an erroneous load a routine is invoked which determines where the end of the program is, since the current size information in the file header is useless in an error situation. This routine then goes on to patch up line bridges, illustrated in FIG. 173, that are also in error since several lines have been replaced by a single line of stars and the program itself has shrunk.

The following program is run to initialize a new tape cartridge:

```
0: trk 0;rew;
  mrk 1,1;ert 0
1: trk 1;rew;
  mrk 1,1;ert 0
2: end
```

This program marks one null file on track 0 and track 1 as file 0. Then, each track is erased except for the single null file on each track. This insures that no residue noise from the manufacturing process remains on the tape.

## POSITIONING THE TAPE

The tape position is unknown whenever a tape cartridge is inserted into the tape drive, the track changed, RESET pressed, or erase a executed. Any tape cartridge statement except identify file (idf) (without parameters) and mark (mrk) will position the tape for the system. Once the tape is positioned, both mrk and idf can be used. The lowest file number on each track is file zero.

## THE REWIND STATEMENT

Syntax:

rew

The rewind (rew) statement is used to rewind the tape cartridge to its beginning. This statement has the same function as the rewind key.

Rewinding the tape is a parallel process and other operations can take place while the tape rewinds.

## THE TRACK STATEMENT

Syntax:

trk track number

The track (trk) statement sets track **0** or track **1** of the tape cartridge. When the track statement is executed, any following cassette operations are performed on that track. Track **0** is automatically set whenever the machine is switched on, RESET is pressed, or erase a is executed. The track does not change when the cartridge is removed. The track number can be an expression with a value of 0 or 1.

Unless a subsequent track statement specifies track **1**, cassette operations will be performed on track **0**.

## THE ERASE TAPE STATEMENT

Syntax:

ert    file number

The erase tape (ert) statement is used to erase everything on the current track starting from the file number specified following a mark statement, described hereinafter. After the erase operation, the tape is positioned at the file specified and one null file is marked. The null file is used as a starting point when marking more files.

The file number can be an expression.

Example:

Assume a cassette has the structure shown in FIG. **170C** on track **1**:

To erase everything on track **1** beginning at file **3** to the end, the following program is used:

```
0: trk 1
1: ert 3
2: end
```

After running this program, the tape's structure is as shown in FIG. **170D**.

Track **0** is not altered.

## THE IDENTIFY FILE STATEMENT

Syntax:

idf    [ file number [ , file type [ , current file size [ , absolute file size [ , track number ]]]]]

The identify file (idf) statement is used to identify the parameters of the next file in the forward direction. All five of the parameters are return variables whereby a value is returned to the variable specified when the statement is executed. All of the parameters are optional. If one variable is specified, such as: idf A, then only the file number is returned. Two variables must be specified to get the file type; three variables to get the current file size in bytes; four variables to get the absolute file size in bytes; and five variables to get the track number.

The file type can be one of the following:

| | |
|---|---|
| 0 | null file |
| 1 | binary program |
| 2 | numeric data |
| 3 | string or string and numerics (String ROM required) |
| 4 | memory file (from rcm statement) |
| 5 | key file |
| 6 | program file |

The return parameters can be any variable type (simple, array, or r-variable). If the tape position is unknown, at least one return variable must be specified or error **45** will occur. At the end of the identify file statement, the tape is positioned before the file's header.

Example:

| | |
|---|---|
| idf A,B,C,D,E | Identify the current file and return the file number, file type, current file size, absolute file size, and track number to A,B,C,D, and E, respectively. |

## THE FIND FILE STATEMENT

Syntax:

fdf    [ file number ]

The find file (fdf) statement is used to find the specified file on the current track of the tape cartridge. The tape is positioned at the beginning of the file specified. The file number can be an expression. The find file statement without parameters finds file **0**. If a file number which does not exist is specified, the next cartridge statement executed [except find file (fdf) or rewind (rew)] results in error **65**.

Other statements can be executed while the find file statement is executing.

Examples:

| | |
|---|---|
| fdf 8 | Find file 8. |
| fdf A[3] | Find the file specified by the value of A[3]. |

## THE SET SELECT CODE STATEMENT

Syntax:

ssc    select code

The set select code (ssc) statement is used to specify the select code of an external tape drive. Select code **1** specifies the select code of the internal tape drive, which is automatically set when the power is switched on, erase *a* is executed or RESET is pressed.

## THE TAPE LIST STATEMENT

Syntax:

tlist

The tape list (tlist) statement is used to identify the files on the tape cartridge. The tape's current position and track, file number, file type, current file size in bytes, and absolute file size are automatically printed. The file type can be one of the following.

| | |
|---|---|
| 0 | null file |
| 1 | binary program |
| 2 | numeric data |
| 3 | string or mixed string and numeric data |

-continued

| | |
|---|---|
| | (the String ROM must be present or loading this file will display error 50.) |
| 4 | memory file (from rcm statement) |
| 5 | key file |
| 6 | program file |

If the stop key is pressed while a tlist is being executed, the tlist terminates. Otherwise it will halt when the null file is reached.

A convenient way to determine the current track setting is to execute "tlist" then press the STOP key,.

## THE MARK STATEMENT

Syntax:

mark number of files, file size in bytes [ , return variable]

The mark (mrk) statement reserves file space on the tape cartridge. One file more than the number of files specified is marked. This file is the null file and is used as the starting point when marking more files. The null file has an absolute size of zero. Although it is not required, it is a good idea to execute the erase tape (ert) statement following the mark statement to clear the current track beginning at the null file. This should be done to avoid problems with accidental access of invalid files on the tape cartridge. The file size is specified in bytes. If an odd number of bytes is specified, one more byte is automatically marked. For example, if **111** bytes are specified, **112** bytes are marked.

In order to mark files, the position of the tape must be known. If the position is unknown, execute a find file (fdf) statement to position the tape where you are going to start marking.

The number of files and the file size can both be expressions. If a return variable is specified, the file number of the last usable file marked is stored in it. If the value of the return variable is positive, all the files specified are marked. If the value is negative, an end-of-tape (eot) condition occurred before all the requested files were marked.

Example:

A tape is to be re-marked for 3 files with a length of 320 bytes each on track 0. The following short program performs this operation.

| | |
|---|---|
| 0: rew | Rewind the cassette. |
| 1: trk 0 | Set to track 0. |
| 2: mrk 3,320,X | Mark 3 files, 320 bytes long. |
| 3: ert X+1 | Erase the rest of track 0. |
| 4: end | End the program. |

## DETERMINING SIZE TO MARK A FILE

When marking a file for a program which is currently in the calculator, a user executes a "list **9999**." The number in the left hand portion of the display is exactly the number of bytes needed to record the program. It is advisable to mark the file larger so that any future program changes that may increase the program size can still be accommodated on the file.

Data files require **8** bytes for each data element to be recorded. For example, to record data which is stored in the variables A and B, mark a file **16** bytes long.

Special function key files require **1** byte for each character under the keys, plus **2** bytes for each defined key. If the number of bytes for each key is odd, a user adds one byte. The sum is the minimum size to mark the file.

For a memory file (using rcm) a user marks the file for the size of available calculator memory.

## THE RECORD FILE STATEMENT

The record file (rcf) statement is used to store both data and programs. The syntax for each is explained below.

## RECORDING PROGRAMS

Syntax:

rcf [ file number [, beginning line number [ , ending line number ]]] [ , "SE" or "DB" ]

To record a program or a section of a program the record file (rcf) statement is used. The file is assumed to be file zero if no file number is specified. The entire program is recorded on the specified file if no line numbers are specified. The program from a line number to the end is recorded if the beginning line number is specified. A program section is recorded from the first line number to the second line number, inclusive, if both line numbers are specified.

The file number and ending line number parameters can both be expressions, but the beginning line number must be a number. If "SE" (for secure) follows at the end of a statement, the program is secured when stored on tape. When the secured program is loaded back into the calculator, the program cannot be listed or displayed, but can be re-recorded on a tape cartridge.

When "DB" (for debug) follows at the end of a statement, any trace or stop flags are stored with the program.

The tape file must be marked before recording a program. The file size must be greater than or equal to the size of the program being recorded.

Example:

7: rcf **8,3** Record the program on file **8**, starting at line **3** through the end.

## RECORDING DATA

Syntax:

rcf file number, data list

The record file (rcf) statement is used to record data. The list can consist of simple variables, array variables, or r-variables. But, r-variables cannot be mixed with simple and array variables in the same statement. The file number can be an expression.

To record an entire array, the array name is followed by an asterisk in brackets. For example:

S[*] Refers to the entire S array.

Simple and array variables must be contiguous in the calculator memory. That means that they must appear in the data list in the same order as allocated. If the variables appear in a dimension (dim) statement, they must appear in the same order in the rcf statement.

Example:

| | |
|---|---|
| 0: dim A[10,10] | The array A is allocated 100 variables (800 bytes). |
| 1: 0→X | The variable X is allocated 1 variable (8 bytes). |
| 2: X+1→X | Doesn't affect memory allocated to X. |
| 3: 1→I | The variable I is allocated 1 variable (8 bytes). |
| 4: rcf 5,A[*],X, | The array A, and variables X and I are recorded in the same order as allocated (contiguously) on file 5 (total of 102 numbers or 816 bytes). |

If r-variable is specified in the data list, all r-variables from $r_0$ to that r-variable are recorded. If two r-variables are specified, all r-variables from the first through the second are recorded.

### Considerations for Recording Data

The variables listed must be listed in the same order as they are allocated in memory when recording data on a tape cartridge.

Example:

```
0: ent A
1: 2*A→B
2: dim C,X,Y,Z,
   .
   .
   .
15: rfc A,B,C,X,
    Y,Z
```

In the above example program, the variables A and B are allocated outside a dimension statement. Variables C,X,Y, and Z are allocated in a dimension statement. Line **15** would cause error **56** to be displayed if B were allocated before A in the program since the variables must be listed in the same order as they are allocated. It is sometimes difficult to know the order in which variables are allocated because lines are not necessarily executed in numerical order. It is strongly recommended that when variables are to be recorded on a single file they be allocated in a dimension statement.

## THE LOAD PROGRAM STATEMENT

Syntax:

ldp [file number [, line number$_1$ [, line number$_2$]]]

The load program (ldp) statement is used to load a program from a specified file on the current track and run it automatically. The automatic run implies that all variables are erased, all go sub return pointers are cleared, and all flags are cleared.

When a file number only is given, the program is loaded from that file, beginning at line zero, and the program automatically runs from line zero. When the file number and the first line number are specified, the program is loaded from that file, beginning at the specified line number and runs from that line number. When all three parameters are specified, the program is loaded from the specified file number beginning at the first specified line number and begins running at the second specified line number. If no parameters are specified, zeros are assumed for all three. All three parameters can be expressions.

This statement is not allowed in live keyboard mode or during an enter statement.

Examples:

| | |
|---|---|
| ldp 2 EXECUTE | Load the program from file 2 beginning at line 0 and run from line 0. |
| ldp 8,2 EXECUTE | Load the program from file 8 beginning at line 2 and run from line 2. |
| ldp 16,3,0 EXECUTE | Load the program from file 16 beginning at line 3 and run from line 0. |

## THE LOAD FILE STATEMENT

The load file (ldf) statement is used to load both data and program files into the calculator memory.

### LOADING PROGRAMS

Syntax:

ldf [file number [, line number$_1$ [, line number$_2$]]]

The load file (ldf) statement loads programs from a specified file on the current track into the calculator memory.

This statement is executed from the keyboard as follows. The program on file zero is loaded, beginning at line **0** if no parameters are given.

The file identified by a file number is loaded beginning at line **0** when the file number is given. If the file number and a line number are specified, then that file is loaded beginning at the specified line number. When all three parameters are given, the specified file is loaded beginning at the first line number, and the program automatically continues at the second line number with all variables being preserved.

This statement is executed in a program as follows: When no parameters are specified, the program on file zero is loaded beginning at line zero and the program automatically continues at line zero. When the file number is specified, then the program is loaded from the specified file beginning at line zero and continues at line zero. When the file number and a line number are given, the specified file is loaded beginning at the specified line number and the program continues from that line number. When all three parameters are given, the statement is executed the same as from the keyboard. That is, a "continue" is performed from the second line number. All three parameters can be expressions.

This statement is not allowed in live keyboard to load a program file or during an enter statement.

### LOADING DATA

Syntax:

ldf [ file number [ , data list ]]

The load file (ldf) statement loads data from the specified file on the current track. The data list contains the names of variables separated by commas. Simple and array variables cannot be in the same ldf statement as r-variables.

If no list is specified, data begins filling the r-variables from $r_0$ until all the data has been loaded. If one r-variable is specified, the data beings filling r-variables from that r-variable until all the data has been loaded into higher r-variables. If two r-variables are specified, the data starts filling from the first location specified (lower r-variable) to the second, higher, r-variable. If there is more data than available or specified r-variables, no data is loaded.

When simple or array variables are specified, data begins filling the first variable until all variables have assigned values. If there is more data than variables, no data is loaded. If there is less data than variables, the data is loaded until all data is used. Variables must be contiguous.

Examples:

| | |
|---|---|
| ldf 4,r0,r10 | Load data file 4 starting from $r_0$ to $r_{10}$. |
| ldf r12,a,b[*] | Load the data file designated by $r_{12}$ into the variable A and array B. |

While that part of memory to be recorded or loaded is uniquely specified by the rcf or ldp statements, the ldf statement will cause loading into program area or variable area depending on the file accessed, not on the ldf statement itself.

### Array and r-variable Storage

r-variables are recorded in the opposite order of array variables. Thus, if r-variables are recorded, then loaded back into an array, they will be in the opposite order.

## THE RECORD KEYS STATEMENT

Syntax:
rck [file number]

The record keys (rck) statement is used to record all the special function keys on the specified file on the current track. If the file number is omitted, file zero is assumed. The file number can be an expression. The specified file must be marked before the record keys statement is executed.

Examples:

| | |
|---|---|
| rck 2 | Record the special function keys on file 2. |
| rdk A[12] | Record the special function keys on the file designated by the 12th element of array A. |

## THE LOAD KEYS STATEMENT

Syntax:
ldk [ file number ]

The load keys (ldk) statement is used to load the special function keys exactly as they were recorded from the specified file on the current track. If the file number is omitted, file zero is assumed. The file number can be an expression. Executing the load keys statement from the keyboard causes go sub return pointers to be reset and causes the program counter to reset to line zero. This statement is not allowed in live keyboard or during an enter statement.

Example:
ldk 4 Load the special function keys from file 4.

## THE LOAD MEMORY STATEMENT

Syntax:
ldm [file number]

The load memory (ldm) statement is used to load a previously recorded memory file. When the load operation is complete, the calculator is in the same state it was in when memory was recorded.

If a program was running when the record memory (rcm) statement was executed, that program will continue with the next statement after the record memory (rcm) statement when the load memory statement is executed.

The record memory and load memory statements are especially useful when executed from live-keyboard or from a special function key to "freeze" the state of the system without interrupting the running program.

The file number can be an expression.

Referring to FIG. 174, a flow chart of the ldm subroutine is shown.

## THE RECORD MEMORY STATEMENT

Syntax:
rcm [file number ]

The record memory (rcm) statement records the entire read-write memory in its current state on the specified file on the current track of the tape cartridge.

If the file number is omitted, file 0 is assumed. The file number can be an expression.

Referring to FIG. 175, a flow chart of the rcm subroutine is shown. The record memory statement records all user read/write memory space, variable area, and enough system and optional memory to insure that the calculator system can be brought back to the state it was at rcm upon the execution of the corresponding ldm statement. Also recorded is a special "ROM present" indicator to allow the ldm statement to guarantee that the option ROMs are the same. Likewise, the ldm statement loads the enter read/write memory space and places the calculator system in the same stte it was at rcm.

The statements rcm and ldm are executable in all calculator states, i.e. during program execution, idle (keyboard entry), live keyboard, and when a program stops for an ent statement.

This feature is particularly useful to provide a backup of the system periodically during a long program execution for example, or in case of power failure or the like. It is also convenient if done during live keyboard to "freeze" the system state at a particular point during execution.

At the termination of the execution of ldm the calculator is in the same execution state as it was at the end of the corresponding rcm statement that created the tape file.

On ldm a check is made by the calculator of all option ROMs present on the system to be sure they are the same as the option ROMs on the system when the rcm statement was executed. If this test fails, the user is told via one of two displayed error messages. One of these says that the ROM whose load number is displayed is present now but was not at rcm time. The other message says that the ROM whose load number is displayed was present at rcm time but is not present now. This is accomplished by requiring each ROM to set a bit in a rom-word (ROMWD) when they are initialzed. This rom-word is recorded in a special word in the record head of the memory file at rcm time. At ldm time the rom-word in the recore head is compared, bit by bit, against the corresponding rom-word in memory to determine the presence or absence of ROMs. If a difference is encountered, the operation is aborted. This guarantees that the calculator will work properly after ldm,

## THE LOAD BINARY PROGRAM STATEMENT

Syntax:
ldb [<file number>]

The load binary program (ldb) statement loads binary programs, a binary program being a machine language program which cannot be listed or displayed, into the calculator's read/write memory from the specified file on the current track of the tape cartridge. Binary programs can be loaded over other binary programs of equal or greater length at any time.

If no file number is specified, file 0 is assumed. The file number can be an expression.

Example:
ldb 2 Load the binary program from file 2.

Certain rules must be followed when loading binary programs since binary programs occupy a special place in memory.

Any binary program can be loaded at any time from the keyboard or a running program if no simple or array variables are allocated provided there is room in memory for it.

Once simple or array variables are allocated, a binary program cannot be loaded unless space has been allocated for it by a previous binary program load.

It is suggested that before any simple or array variables are refereced, the largest binary program file that the program will need be loaded so that variables can be allocated and binary programs loaded without concern about room for the binary program.

## FILE VERIFICATION

File verification is used to compare a tape file against the calculator memory to detect recording errors without losing the information in memory.

File verification requires a stronger tape signal than load thereby increasing confidence that a file will load properly at a later time.

The calculator returns to automatic file verification when the calculator is turned on, erase a executed, or RESET pressed. The auto verify disable (avd) statement turns file verification off and the auto verify enable (ave) statement turns automatic file verification on. The verify (vfy) statement allows one to verify files repeatedly under program control.

When the calculator is in auto-verify mode, all record statements are followed by an automatic verify operation.

## THE VERIFY STATEMENT

Syntax:

vfy [return variable]

The verify (vfy) statement is used to compare tape files with the calculator memory. The value of the return variable is 0 after the operation if the calculator memory is identical to the tape file. The return variable is one if the two are different. Error **44** occurs if the memory and tape file are not identical and no return variable is specified.

The return variable can be either a simple, array, or r-variable.

The verify statement provides added user confidence in a recording, even though a record operation is usually followed by an automatic verification.

This statement is also useful when a badly worn tape is being used. In this case, a user preferably turns off auto-verify and uses the verify statement. If the verify fails, the user performs the record operation again.

## TAPE CARTRIDGE ERRORS

When an error **46** is displayed, a user should first clean the tape head and drive wheel and execute the statement which caused the error again a few times. If an error still occurs, the next step depends on the type of file being loaded.

If an error **46** is displayed while loading a program file, one or more program lines may be lost. The place where this error occurred is indicated by a line of asterisks (*) inserted in the program at the place where the program lines are missing. These lines can be replaced by referring to a previous listing. Go to and go sub statement addresses are adjusted during this editing. Thus, it may be necessary to readjust the to to and go sub addresses after inserting the lost lines.

If an error **46** is displayed while loading numeric data, the partitions in question are marked by a single number in that partition being replaced by "?.???" (in float **11** format). A partition in a numeric data file always contains 32 numbers. With one entry replaced by "?.???", there are 31 numbers remaining which may be incorrect. For r-variables, the 31 higher numbered r-variables may be incorrect. For simple and array variables, a user should determine the order in which the variables in question were allocated. From the element that is replaced by "?.???", a user preferably searches from right to left in the dimension statement to locate the error. For an array, the first element in the lost partition will have the largest subscripts. Decreasing the leftmost subscript first for an array reveals the missing values.

### File Header Read Error

If a file head read error (error **47**) occurs, a user should preferably procede as follows:

1. Clean the tape head and drive wheel.
2. Execute the statement that caused the error again.
3. If, after steps 1 and 2, the error still occurs, a user should remark the tape-file header. Remarking a file header, however, is a "last resort" operation. All data and programs on a file with a re-marked header is lost and that file can no longer be used.

To remark the head of file N (file which cannot be loaded) a user executes:

| | |
|---|---|
| fdf N-1 | Positions the tape. |
| mrk 0,0 | Re-marks file header. |

for file **0**, execute:

| | |
|---|---|
| rew | Positions the tape. |
| mrk 0,0 | Re-marks file header. |

After the file header has been re-marked the absolute size of the file is 2 **bytes.**

### Error Messages

When an error occurs, the calculator makes a soft beep and the word "error" followed by a number appears in the display. The number references an error message that will help pinpoint the cause of the error.

If an error message is displayed during an attempt to run a program, the program line number where the error occurs is referenced.

A complete list of the error messages is given in the Table below.

## ERRORS

An error in a program resets the program counter to line **0**. Pressing CONTINUE will continue the program from line **0**.

**00** System error.

**01** Unexpected peripheral interrupt. Only occurs when a peripheral is being used. Press reset key to recover.

**02** Unterminated text. The line of text must have an ending quote. This error results in a cursor being displayed showing the location of the error.

**03** Mnemonic is unknown. This error is usually caused by typing errors, such as go to instead of gto; or by executing a command in live-keyboard mode or in an enter statement. This error results in a cursor being displayed showing the location of the error.

**04** System is secured. This error is generally caused by trying to list or fetch lines in a secured program.

**05** Operation not allowed — line cannot be stored or executed with line number. This can be caused by pressing execute, store, or line insert with a fetched line in the display.

**06** Syntax error in number. A cursor showing the location of the error is displayed.

**07** Syntax error in input line. For example: gto prt 5. A cursor showing the location of the error is displayed.

[ Internal representation of the line is too long (gives cursor sometimes).

**09** The go to (gto), go sub (gsb) or end statement is not allowed in the present context. For example, executing an end statement during an ent statement.

**10** The go to or go sub statement requires an integer. For example:

gto 23.4 is not allowed

A cursor showing the location of the error is displayed.

**11** Integer out of range or integer required. Must be between −32768 or +32767. For example:

spc 50000 integer out of range

del A integer required.

**12** The line cannot be stored. It can only be executed. For example:

2 + 2 EXECUTE is OK, but

2 + 2 STORE is not allowed

A cursor showing the location of the error is displayed.

**13** Enter (ent) statement is not allowed in present context. For example, ent X is not allowed from the keyboard; only from a program.

**14** Program structure destroyed. This can be caused by pressing the reset key while a program is being modified or shifted. It is advisable to record data ten execute erase a to recover.

**15** Printer out of paper or printer failure.

**16** The String ROM is not present for a string comparison or an argument in a relational comparison is not allowed. For example, if the String ROM is not in the calculator:

if "B" < "A"

results in error **16**.

**17** Parameter is out of range. For example:

wait −5

fxd 15

**18** Parameter is not allowed. For example:

erase Z

**19** Bad line number. For example:

del 10,5

**20** A ROM is missing. As a result, the line cannot be reconstructed. This error usually occurs when FETCH ↑, ↓ or list is executed.

**21** Line is too long to store. This can occur when blanks or parenthesis are automatically added. For example, parenthesis are automatically added when storing the line: tan 2 → A, which will appear in a listing as: tan (2) → A.

**22** Dimension specification is not allowed. For example, this error occurs when the lower bound of an array is greater than the upper bound. If the String ROM is not in the calculator and a string is dimensioned, this error results.

**23** The simple variable has already been alloctèd. For example:

2 → X. dim A[5], X

**24** The array has already been dimensioned. For example:

dim A[4], B[5], A[6]

**25** Dimensions of array disagree with subscripts. For example:

dim X[2,7]; 1 → X[5]

**26** Subscripts of array are out of bounds. For example:

dim A[12]; 2 → A[58]

**27** Undefined array. The array must first appear in a dimension (dim) statement.

**28** The return (ret) statement has no matching gsb statement.

**29** The line cannot be executed because a ROM is missing. For example; the plt statement is attempted with no Plotter ROM present in the calculator.

**30** Special function key has not been defined.

**31** Nonexistent program line. For example, gto 900 in a 5 line program.

**32** The data type is not allowed. A number is required.

**33** Data types don't match in an assignment statement.

**34** Display overflow due to pressing a special function key.

Only 80 characters can be entered into the display.

**35** Flag reference not allowed. There is no such flag. For example:

sfg 18

**36** Attempt to delete the destination of a gto or gsb statement. Operation not performed.

**37** Display buffer overflow caused by display (dsp) statement.

**38** Insufficient memory for go sub (gsb) statement.

**39** Insufficient memory for variable allocation or binary program. No allocation takes place.

**40** Insufficient memory for operation as in, for example, storing a line with insufficient memory.

**41** No cartridge is in the tape transport.

**42** Tape cartridge is write protected. A user should slide record tab to other position for recording.

**43** Unexpected Beginning-Of-Tape (BOT) marker, or End-Of-Tape (EOT) marker encountered; or a tape transport failure.

**44** File verification has failed.

**45** Attempted execution of idf statement without parameters when tape position is unkown, or mrk statement when tape position is unknown.

**46** Read error of file body. The partition containing the error is lost.

**47** Read error of file head.

**48** The End-Of-Tape (EOT) was encountered before the specified number of files were marked.

**49** File is too small.

**50** The 1df statement for a program file must be the last statement in the line.

**51** A ROM is present but was not when the record memory (rcm) statement was executed. A user should remove the ROM indicated by one of the numbers below and re-execute the load memory (1dm) statement.

| Number | ROM |
|---|---|
| 1 | Binary Program |
| 6 | String |
| 8 | Extended I/O |
| 9 | Advanced Programming |
| 10 | Matrix |
| 11 | Plotter |
| 12 | General I/O |

**52** The ROM indicated by a number from the previous table was present when the record memory (rcm) statement was executed, but is now missing. A user should insert the indicated ROM and re-execute the load memory (1dm) statement.

**53** File number or mrk parameter is negative. For example:

mrk −12,300

**54** Binary program to be loaded is larger than the allocated memory for the present binary program and variables.

**55** Illegal or missing parameter in one of the cartridge statements.

**56** Data list is not contiguous in memory for one of the cartridge statements.

**57** Improper file type. For instance, this can occur when trying to load a program from a data file or key file.

**58** Invalid parameter on rcf statement; "SE" or "DB" expected.

**59** Attempt to record a program, data, or special function keys which do not exist.

**60** Attempt to load an empty file or the null file (type=0).

**61** Parameter out of range in the track (trk) or set select code (ssc) statements. Track 0 or 1, and select codes 1 through 15 are allowed.

**62** Specified memory space is smaller than cartridge file size.

**63** Cartridge load operation would overlay gsb return address in program; load not executed.

**64** Attempt to execute 1dk, 1df (program file), or 1dp during live keyboard or enter statement.

**65** File not found. File specified in the previous find file (fdf) statement does not exist.

**66** Division by zero. Default = + or −9.99999999999e511. A mod B with B equal to zero. Default = 0.

**67** Square root of a negative number.

Default = √(abs(argument)).

**68** Tan (n*π/2 radians);
Tan (n*90°);
Tan (n*100 grads);
where *n* is an odd integer.

Default= +9.99999999999e511, for n>0.

Default= −9.99999999999e511, for n<0.

**69** ln or log of a negative number. Default = ln (abs(argument)) or log (abs(argument)).

**70** ln or log of zero. Default = −9.99999999999e511.

**71** adn or acs of number less than −1 or greater than +1. **Default = asn (sgn(argument)) or acs (sgn(argument)).**

**72** Negative base to a non-integer power. Default = (abs(base)) ↑ (non-integer power).

**73** Zero to the zero power (0 ↑ 0). Default = 1.

**74** Full-precision overflow. Default = + or −9.99999999999e99).

**75** Full-precision underflow. Default = 0.

**76** Intermediate result overflow. Default = + or −9.99999999999e511.

**77** Intermediate result underflow. Default = 0.

## FORMATTED I/O OPERATIONS

Referring to FIG. 4, the I/O Bus transfers data between the calculator processor and peripheral devices. All incoming data is transferred through the processor before it is stored in memory.

As shown in FIG. 4 each external device is connected to the calculator via an appropriate interface card and cable. An interface card plugs into any of the I/O slots in the calculator's back panel. Plug-in ROM cards become part of the calculator's memory.

ROMs which can be used with the calculator include, for example, a String ROM, an Advanced Programming ROM, a Matrix ROM, a Plotter ROM, a General I/O ROM and an Extended I/O ROM.

The String ROM enables the calculator to recognize and operate on letters and words ("strings") in much the same way that it recognizes and operates on numbers. Some of the capabilities which are provided include: single strings and string arrays, numerical value of a string of digits, concatenation, displaying or printing all special characters, and packing and unpacking floating point numbers in strings.

The Advanced Programming ROM extends the programming capabilities of the Calculator. For/next looping, split and integer precision number storage, multiparameter functions and subroutines, and the cross reference statement are some of the operations provided by the Advanced Programming ROM.

The Matrix ROM extends the language to include statements for manipulating matrices and arrays. Addition, subtraction, multiplication, and division of arrays, as well as inversion, transposition, and determinants of matrices are some of the capabilities provided by this ROM.

The Plotter ROM enables the Calculator to control a plotter. Axes can be drawn and labelled; functions can be plotted; and with a unique "typewriter" mode, characters of varying size can be printed. More than one plotter can be operated at the same time.

The General I/O ROM provides basic I/O capability with formatting. Peripherals can be controlled using this ROM. Basic control of the HP-Interface Bus, explained in greater detail hereinafter and referred to hereafter as HP-IB, and status checking are also provided.

The Extended I/O ROM extends the I/O capability of the calculator by providing complete HP-IB control.

Features include Bit manipulation and testing, autostarting, error trapping, and interrupt service routines.

## GENERAL I/O ROM

The General I/O ROM operations are given below:

| Operaton | Description |
|---|---|
| Write | Output data or character strings to specified device. |
| Read | Request and input data or character strings. |
| Format | Specify numeric specs and edit specs for both read and write statements. |
| Conversion | Set up a character conversion table for read and write statements. |
| Write Binary | Output 16-bit binary numbers. |
| Read Binary | Input 16-bit binary numbers. |
| Write Control | Output binary status codes via an Interface Card. |
| Read Status | Check interface or peripheral status information. |
| List | Output program listings to external device. |

External devices share the same I/O bus used by internal peripheral devices and internal peripherals respond to some General I/O operations in addition to their specific commands. Since all external devices are "party-lined" on the same bus, each device is assigned a unique address, or select code, so that the correct device responds to each I/O operation.

For all external peripherals, the select code is an integer number from 2 through 15 which is specified in each I/O operation and decoded by the corresponding interface card. Two digits are added to the select code parameter to address peripherals via a Hewlett-Packard Interface Bus, described for example in the January, 1975, Hewlett-Packard Journal, Vol. 26, Number 5, and in U.S. Pat. No. 3,810,103 entitled Data Transfer Control Apparatus, issued May 7, 1974. Each interface card has a switch permitting the user to set any one of the codes. A list of preferred assignment codes for use with typical peripheral devices is given below.

| SELECT CODE | ASSIGNMENT | EXAMPLE HEWLETT-PACKARD PERIPHERAL DEVICES |
|---|---|---|
| 0 | Calculator Keyboard and Display | — |
| 1 | Calculator Tape Drive | — |
| 2 | Paper Tape Punch | HP 9884A,98032A Interface |
| 3 | Paper Tape Reader | HP 9883A |
| 4 | Digitizer | HP 9864A |
| 5 | Plotter | HP 9862A |
| 6 | Printer | HP 9866B, HP 9871A |
| 7 | HP-Interface Bus | HP 98034A Interface |
| 8 through 15 | Unassigned | special peripherals |
| 16 | Calculator Printer | — |

Each internal peripheral has a fixed select code which is automatically specified by standard calculator statements (display, print, etc.). Both the display and the keyboard respond to select code **0**, the tape drive responds to select code **1**, and the printer responds to select code **16**.

The select code can be specified in the form of either a constant, a variable, or an expression.

### Input-Output Format

The I/O bus connecting the processor with internal and external peripherals contains 16 lines. Data is transmitted in a 16-bit parallel, character-serial fashion at certain times, while interface or peripheral status codes are transmitted at other times. The I/O operations send and receive data in standard 8-bit ASCII code. The calculator sends and receives one 8-bit character at a time. The parity (most-significant) bit is not used with formatted I/O operations.

### Peripheral Interrupt

Since the General I/O ROM is intended for use in systems where the calculator is the controlling device, there is no provision for peripheral interrupt operation, for example whereby, an external device can call for an I/O operation, or the like. The calculator must be in complete control of each device while that device is involved in data transfer.

## THE WRITE STATEMENT

Syntax:

wrt select code [.format no.], parameter$_1$, parameter$_2$, . . .

The write statement outputs the characters, signs, and decimal point of each parameter to the peripheral specified by the select code. Each parameter in the list can consist of either a numeric expression, text, or a string name (when the String ROM is in use). The value of each parameter is output in a free-field format, unless a format statement is in effect. The format number parameter can be an integer from 0 to 9 and references a similarly numbered format statement, described hereinafter.

### Delimiters

A delimiter is a character that is used to either separate one expression from another inside a list or to terminate a list. The space (sp) and the carriage-return line-feed (CR/LF) are delimiters that are automatically output during the execution of each write statement. The space is used to separate items within the list, and the CR/LF is used to terminate the list.

### Free-Field (Default) Format

The free-field output format is automatically set whenever either the calculator is switched on, or RESET is pressed. Each write statement references the free-field format until a format statement is executed and then the specifications in the format statement override free-field.

The free-field format causes each numeric expression to be output and right justified in an 18-character field. A CR/LF is given after each four expressions are output and again after the last parameter is output. The form in which expressions appear is determined by the current fixed or float setting. A number that is too large to be output under the current fixed-point specification is output under the previous floating-point specification Characters within quotes and strings are output as "free text" wherein the 18-character fields are not used.

## THE READ STATEMENT

Syntax:

red select code[.format no.], parameter$_1$,parameter$_2$, . . .

The read statement inputs and stores data from a specified peripheral. The calculator keyboard can not be used to input data with the read statement. The number of parameters in the list indicates how many data items to read. Each parameter consists of either a variable name or a string variable name if the String ROM is in use. Each numeric data item consists of the digits 0 through 9, plus and minus signs, a decimal point, and an

"E" character. All other characters are treated as input delimiters. The data item itself assumes the same form as any number entered from the keyboard.

The format number parameter can be used to reference any of ten format statements. If a format number is not specified, and if a format statement has not been previously executed, a free-field input format is automatically used.

### Free-Field Format

The free-field input format is set whenever either the calculator is switched on or RESET is pressed. Using free-field allows reading numerical data in virtually any form, provided that each item is followed by at least one non-numeric character delimiter. For each parameter in the list, the calculator ignores all input non-numeric character delimiters until one of the characters listed above is read. Then, after reading the data item, reading any non-numeric character terminates and stores the data item.

The calculator cannot input non-numeric characters unless a string variable is specified when free-field is used. All characters are input until either the dimensional string length is filled or a CR/LF is read. Reading a CR/LF automatically terminates the read operation. All non-numeric characters preceding a data item (except "E") are ignored.

Reading successive commas causes the corresponding variable to be skipped and flag **13** to be set. A SKP (HT) causes the calculator to skip all characters until a LF has been read. Whenever a LF is read (and it does not correspond to a preceding HT) the statement is terminated and flag **13** is set. An upper- or lower-case "E" character, when part of any of the following forms, causes the preceding data item to be raised by the power of 10 indicated: (data item)E(one or two digits); (data item)E(a + or -and one or two digits); (data item)E(a space and one or two digits). For example, any of the following data items will be read as the number "1234".

**1.234E3**

**1.234E 3**

**1.234E+3**

The CR is always ignored (skipped over) during a read operation.

## FORMAT STATEMENTS

Use of format statements provides the most-flexible and complete control of write and read statements. A format statement must be programmed before the I/O statement referencing it and provides a list of specifications for use by the I/O statement. As the I/O statement is executed, it references the last-encountered unnumbered format statement rather than free-field.

### The Format Syntax

Syntax:

fmt [format no.,] $\text{spec}_1,\text{spec}_2, \ldots$

The format number parameter is used to identify the statement for successive write or read statements. Each format number must be an integer from **0** to **9**. If the format number is not specified, format number **0** is assumed.

### Output Numeric Specifications

Numeric specifications determine the form in which each numeric parameter is output. A numeric specification determines whether the number is output in fixed point or floating point, the number of digits to the right of the decimal point, and the field width in which the number appears.

These numeric specifications are available:

Syntax:

| | |
|---|---|
| [r]fw.d | Specifies fixed-point format. |
| [r]ew.d | Specifies exponential (scientific) format. |
| [r]fzw.d | Specifies fixed-point format with leading zeros in each field. |

w indicates total field width (in characters). If w is omitted, leading spaces are deleted from the field.

d indicates the number of digits to the right of the decimal point. If d is omitted, the current fxd or flt setting is used.

r is an optional repeat factor.

(w,d, and r must be constants).

A numeric specification such as **f8.2** specifies a fixed-point number with two digits to the right of the decimal point. The number appears (right-justified) in an eight-character field. If d is **0**, the decimal point is not output. A number output under a numeric specification is always rounded according to the number of decimal places specified.

Some guidelines should be observed in selecting w and d. Signs, decimal points, and exponents are part of the number and must fit in the field width specified by w. For floating-point outputs, w should be greater than or equal to d+7.

In general, if a fixed-point specification cannot be met, either because w is not large enough or because the number is simply too large, the field is filled with dollar signs.

### Output Edit Specifications

Edit specifications are used to control the placement of output data and to output character strings:

Syntax:

| | |
|---|---|
| [r]X | Outputs a blank character space. |
| [r]/ | Outputs a CR/LF for a printer. |
| [r]"text" | Outputs the ASCII characters within quotes. |
| Z | Suppresses the automatic CR/LF output after each write statement. |
| [r]b | Outputs the binary equivalent of the corresponding decimal number in the write statement. |
| [r]cw | Specifies the field width for a string variable to be output. |

Any combination of specifications can appear in the same format statement when each item is separated by a comma. Most of the specifications can be duplicated *r* number of times by using the repeat factor.

### Input Numeric Specifications

Numeric specifications are used to determine which characters are input from a data input string, and in what form the data will appear. When a format statement is referenced by a read statement, the read operation is not terminated until a LF character is read (unless the edit specification Z is used as discussed above). A general input conversion specification syntax is:

| | |
|---|---|
| [r]f w | r is the number of consecutive times the specification is to be used (if r is 1 it may be omitted).<br>w is the width of the data field to be read. |

A numeric specification such as **f10** for example calls for reading ten numeric characters; all non-numerics which precede a numeric are counted but not entered. If an "E" is read, a number of the form 1E dd is entered.

### Input Edit Specifications

The following edit specifications can be used to increase input format flexibility:

### Automatic Delimiter Syntax

fmt z, f w

This spec causes the calculator to read only the number of characters specified in the next conversion spec. The READ operation is automatically terminated after the characters are read, without the need of a LF character.

### Skip Character Syntax

fmt [r] x

This spec causes the calculator to skip (not count) r number of characters.

### Skip Data Syntax

fmt [r]/

The calculator skips all data which precedes r number of CR/LF characters.

### Input Strings Syntax

fmt [r]c w

The calculator inputs w number of characters into a specified string variable (String ROM). All characters are entered until either the string is filled, or w characters are read, or a LF is read.

## THE CONVERSION STATEMENT

Syntax:

conv [code$_1$, code$_2$[,code$_3$,code$_4$]], . . .

The conversion statement sets up a character replacement table for use with read and write statements. Up to 10 pairs of decimal codes can be specified at a time. Each new conversion statement cancels the previous table and sets up the new one. A conversion statement with no parameters cancels any previous table.

## THE LIST STATEMENT

A select code parameter can be used with the list statement when the General I/O ROM is plugged in, enabling program listings on a peripheral output device. The new list syntax is:

list [#select code][,line no.]

## THE BUS CARD

The Interface provides HP-IB capability for the Calculator. The bus card buffers all data and control instructions between the calculator and instruments on the bus. The interface is preset to respond to select code 7.

Each instrument on the bus is connected, for example, through a 16-wire cable.

## HP-IB ADDRESSES

The General I/O ROM provides simplified control of instruments via the HP-IB by using a select code parameter containing a three- or four-digit integer. Referring to FIG. 176, a flow chart for the HP-IB Transparency Routine is given. The first one or two digits specifies the bus card select code, while the last two digits represent the address of the instrument on the bus.

Instruments having HP-IB capability are assigned unique 7-bit ASCII characters for talker and listener addresses. The calculator uses the address characters to indicate which instrument is to talk (send data) or listen (receive data). For example, here are the addresses preferably assigned for some Hewlett-Packard instruments:

| Hewlett-Packard | HP-IB Address | |
|---|---|---|
| Instrument Type | Talker | Listener |
| 98034A Interface | U | 5 |
| 3490A Multimeter | V | 6 |
| 9871A (Opt. 001) Printer | | ! |
| 59309A Digital Clock | P | φ |

The 9871A Printer is only a listener; it does not transmit data, so it has no talker address.

Using an ASCII tale the five least-significant bits of each character's binary form are converted to a decimal value:

| Hewlett-Packard | Address | |
|---|---|---|
| Instrument | Character | 5-bit Value |
| 98034A Interface | U | 21 |
| | 5 | 21 |
| 3490A Multimeter | V | 22 |
| | 6 | 22 |
| 9871A Printer | ! | 1 |
| 59309A Clock | P | 16 |
| | φ | 16 |

The 5-bit value for talker-listener instruments is the same number.

These numbers are used as the HP-IB address code in select code parameters of General I/O operations. The HP-IB address code must always contain two digits; if the 5-bit value is a one-digit number (e.g., 9), a leading zero must be used (e.g., 09).

This addressing method permits using General I/O operations via the HP-IB.

Instruments designated as listeners on the bus are controlled by using write and write binary statements. The address-code parameter just described must be used in each I/O operation.

For most applications, read and format statements are used to input data via the HP-IB. The format statement must be appropriate to the data string that the device sends to the calculator.

Many devices output leading non-numeric characters in their output data strings. The format statement must account for any leading non-numeric characters so that the read statement can interpret the numeric information.

## GENERAL I/O ERROR MESSAGES

In case of error, the calculator displays one of the following error messages.

| | |
|---|---|
| error G1 | Incorrect Format Numbers:<br>. Format number in format statement >9.<br>. Referenced format number not set. |
| error G2 | Referenced Format Statement has an error:<br>. Incorrect format specification.<br>. Numeric overflow in format statement. |
| error G3 | Incorrect I/O Parameters:<br>. Parameter not number or string.<br>. Negative parameter with fZ numeric specification.<br>. Numeric parameter with credit specification.<br>. Binary parameter >(± 32767).<br>. More than one parameter for read binary or read status function.<br>. Missing a non-numeric parameter for write control statement. |
| error G4 | Incorrect Select Code: |

-continued

| | |
|---|---|
| | . Select code is non-numeric or >4 digits. |
| | . Select code is >2 digits for read status. |
| | . Select code is not in range from 0 through 16. |
| | . Select code 1 allowed only for read status. |
| | . HP-IB address not in range from 0 through 31. |
| | . Read from select code ϕ not allowed. |
| error G5 | Incorrect Read Parameter: |
| | . Constant in read list. |
| | . String not filed by read operation. |
| | . Numeric parameter references c format specification. |
| error G6 | Incorrect Numeric (format) Specification. |
| error G7 | Unacceptable Input Data: |
| | . More than one decimal point or "E" read. |
| | . 511 characters read without LF. |
| | . E with no leading digit. |
| | . More than 158 numeric characters read. |
| error G3 | Perpheral Device Down: |
| | . Incorrect status bits. |
| | . STOP cancelled operation. |
| error G9 | Interface Hardware Problem: |
| | . Improper HP-IB operation. |
| | . Empty I/O slot. |
| | . Wrong select code set on 98032A card. |
| | . Write Control addressed to wrong card. |

GENERAL I/O SYNTAX

The following are the general Syntax Conventions used:

| | |
|---|---|
| rackets [ ] | Items within brackets are optional. |
| oloring | Colored items must appear as shown. |
| xpression | A constant (like 16.4), a variable (like X or B[8]or r3) or an expression like ↑ 4 or 6<A+B). |
| elect code format | cc[dd] cc = device or interface select code.<br>dd = optional HP-IB address code (Must be two digits). |
| ext | A series of characters within quotation marks. |
| ariable. | A simple variable (e.g., A or Q), an array variable (e.g., E[5]), an r-variable (e.g., 412), or a string variable name (A$). |

| tatement | Syntax |
|---|---|
| onversion | conv[code$_1$, code$_2$[,code$_3$,code$_4$]], . . .<br>Ten pairs of ASCII-decimal codes are allowed. |
| ormat | fmt[format no.,] spec$_1$[,spec$_2$],]]]<br>C≦ format no. ≦ |
| ist | list[#select code]<br>Other list parameters remain as defined. |
| ead | red select code [,format no.],variable$_1$ [,variable$_2$], . . . |
| ead Binary function) | rdb(select code) |
| ead Status function) | rds(select code) |
| Vrite | wrt select code [,format no.],expression or text$_1$ [,expression or text$_2$], . . . |
| Vrite Binary | wtb select code,expression$_1$[,expression$_2$], . . . |
| Vrite Control | wtc select code,expression |

We claim:

1. An electronic calculator comprising:

memory means including a first area for storing a program of one or more lines of one or more alphanumeric statements per line and a second area for storing a single line of one or more alphanumeric statements;

keyboard input means for entering one or more lines of one or more alphanumeric statements per line into the memory means;

processing means coupled to said memory means and keyboard input means for executing lines of one or more alphanumeric statements per line; and

output display means coupled to said processing means for visually displaying alphanumeric information, including the results of execution of lines of alphanumeric statements, to the user;

said keyboard input means including a run control key for initiating execution by said processing means of a program of one or more lines of alphanumeric statements stored in said first area of said memory means; and an execute control key for initiating execution by said processing means of a single line of one or more alphanumeric statements entered from said keyboard input means and stored in said second area of said memory means;

said processing means including logic means operative for enabling entry of a line of one or more alphanumeric statements from said keyboard input means during execution of a program stored in said first area of said memory means, said logic means further including means responsive to subsequent actuation of said execute control key, during execution of said program, for temporarily halting execution of said program, for initiating execution by said processing means of said entered line of one or more alphanumeric statements and for causing the results to be visually displayed on said output display means, said logic means further including means responsive to an indication by said processing means that execution of said entered line has been completed for causing said processing means to resume execution of said program.

2. An electronic calculator as in claim 1 wherein:

said keyboard input means includes one or more keys for entering a list statement;

said calculator includes printer means coupled to said processing means for printing one or more lines of alphanumeric statements; and

said logic means is operative for enabling entry of the list statement from said keyboard input means into said second area of said memory means during execution of a program stored in said first area of said memory means, said logic means further including means responsive to subsequent actuation of said execute control key, during execution of said program, for temporarily halting execution of said program, for initiating execution by said processing means of the list statement to cause the lines of alphanumeric statements comprising said program to be printed by said printer means and for then causing said processing means to resume execution of said program.

3. An electronic calculator as in claim 1 wherein:

said keyboard input means includes one or more keys for entering a program variable assignment statement; and

said logic means is operative for enabling entry of the program variable assignment statement during execution of a program stored in said first area of said memory means, said logic means further including means responsive to subsequent actuation of said execute control key, during execution of said program, for temporarily halting execution of said program, for initiating exeuction by said processing means of the program variable assignment statement to cause a designated numeric value to be associated with a selected program variable and for then causing said processing means to resume execution of said program.

4. An electronic calculator as in claim 1 wherein:

said keyboard input means includes one or more keys for entering a program variable interrogation statement; and

said logic means is operative for enabling entry of the program variable interrogation statement during execution of a program stored in said first area of said memory means, said logic means further including means responsive to subsequent actuation of said execute control key, during execution of said program, for temporarily halting execution of said program, for initiating execution by said processing means of the program variable interrogation statement to cause the current value of a selected program variable to be visually displayed on said output display means, and for then causing said processing means to resume execution of said program.

5. An electronic calculator as in claim 1 wherein

said second area of said memory means comprises buffer storage means for temporarily storing the single line of one or more alphanumeric statements entered from said keyboard input means during execution of a program stored in said first area of said memory means;

said keyboard input means includes a plurality of alphanumeric keys, each associated with an alphanumeric character, for entering lines of one or more alphanumeric statements;

said output display means is operative for visually displaying said single line of one or more alphanumeric statements as it is being entered from said keyboard input means during execution of a program stored in said first memory means; and

said logic means is responsive to actuation of any one of said alphanumeric keys during execution by said processing means of a program stored in said first area of said memory means for momentarily interrupting execution of said program by said processing means to permit entry of the associated alphanumeric character into said buffer storage means.

6. An electronic calculator as in claim 5 wherein said logic means is responsive to actuation of said execute control key, during execution by said processing means of the program stored in said first area of said memory means, for momentarily interrupt execution of that program and for initiating execution by said processing means of the single line of one or more alphanumeric statements then stored in said buffer storage means.

7. An electronic calculator as in claim 1 wherein said logic means is responsive to execution by said processing means of a keyboard disable statement stored in said second area of said memory means or stored as part of a program in said first area of said memory means for subsequently inhibiting the entry of alphanumeric statements from said keyboard input means during the time that a program stored in said first area of said memory means is being executed.

8. An electronic calculator as in claim 7 wherein said logic means is responsive to execution by said processing means of a keyboard enable statement, stored as part of a program in said first area of said memory means, following execution of a keyboard disable statement for subsequently enabling the entry of alphanumeric statements from said keyboard input means during the time that a program stored in said first area of said memory means is being executed.

* * * * *

## UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 1 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 15, "driven" should be --given--;

Column 4, line 46, "languagte" should be --language--;

Column 6, line 35, "01" should be --Ø1--;

Column 6, line 48, "24A-B" should be --25A-B--;

Column 7, delete lines 53-55;

Column 7, line 66, "25-B" should be --25A-B--;

Column 11, line 48, "FIG. 172" should be --FIG. 162--;

Column 12, line 37, "astored" should be --stored--;

Column 14, line 13, "reducnbg" should be --reducing--;

Column 14, line 59, "FIG. 15" should be --FIG. 16--;

Column 15, line 20, "perpheral" should be --peripheral--;

Column 15, lines 61 and 62,""memory cycle"]" should be --"memory cycle"--;

Column 16, line 44, "BOC'S" should be --BPC'S--;

Column 16, line 44, "evolve" should be --involve--;

Column 17, line 58, "77000 -" should be --$77000_8$- --;

Column 19, line 28, "operated" should be --operand--;

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. 4,075,679 Page 2 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 19, line 45, "such" should be --much--;

Column 20, line 16, "(1)" should be --(I)--;

Column 23, line 21, "egister" should be --register--;

Column 24, lines 20, 22, 23, 25, and 31, "1OC" should be --IOC--;

Column 24, line 34, "requiest" should be --request--;

Column 26, line 62, "addreses" should be --addresses--;

Column 27, line 32, "PBC" should be --BPC--;

Column 27, line 43, "1OC" should be --IOC--;

Column 28, line 22, "Is" should be --is--;

Column 29, lines 15 and 16, "PAO" should be --PAØ--;

Column 31, line 43, "righr" should be --right--;

Column 39, line 23, "as" should be --an--;

Column 44, line 4, "<AR2>+((<AR1>" should be --<AR2>+((<AR1>)--;

Column 44, line 4, "+DC→AR" should be --+DC→AR2--;

Column 47, line 68, "U20 an U21" should be --U20 and U21--;

Column 49, lines 28 and 54, "Bit 0" should be --Bit Ø--;

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 3 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 49, line 58, "set" should be --sets--;

Column 49, line 65, "is JK" should be --is a JK--;

Column 50, line 7, "switches on" should be --switches used on--;

Column 50, line 47, "bit 0" should be --bit Ø--;

Column 50, line 47, "(IODO)" should be --(IODØ)--;

Column 51, line 26, "Reet" should be --Reset--;

Column 51, line 54, "is sent the KDP" should be --is sent to the KDP--;

Column 51, line 67, "th" should be --the--;

Column 52, line 11, "ime" should be --time--;

Column 54, line 4, "not" should be --dot--;

Column 54, line 20, "clOck" should be --clock--;

Column 55, line 60, "AO" should be --AØ--;

Column 55, lines 61 and 63, "BO" should be --BØ--;

Column 57, line 64, "IODO" should be --IODØ--;

Column 58, line 63, "G" should be --GO--;

Column 61, line 26, "O" should be --Ø--;

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 4 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 61, line 56, "U10" should be --U19--;

Column 597, line 35, "FIG. 2" should be --FIG. 3--;

Column 597, line 47, "RESEt" should be --RESET--;

Column 597, line 49, "on" should be --or--;

Column 600, line 37, "when" should be --When--;

Column 602, line 11, "kay" should be --key--;

Column 603, line 25, "EXXECUTE" should be --EXECUTE--;

Column 609, line 62, "value 0" should be --value Ø--;

Column 609, line 62, "r10" should be --r1Ø--;

Column 609, line 63, "r0" should be --rØ--;

Column 610, line 56, "V=0" should be --V=Ø--;

Column 611, line 65, "prnd" should be --Prnd--;

Column 612, line 24, "Float 0" should be --Float Ø--;

Column 612, line 31, "tthis" should be --this--;

Column 613, line 42, "end" should be --ent--;

Column 614, line 33, "maintains is" should be --maintains its--;

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 5 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 614, line 56, "ti" should be --to--;

Column 617, line 3, "0" should be --Ø--;

Column 617, lines 4 and 5, "CTL0" should be --CTLØ--;

Column 619, line 50, "A>=B" should be --A<=B--;

Column 622, line 63, "(0-45$^{o}$)" should be --(Ø-45$^{o}$)--;

Column 622, line 66, "(0-360$^{o}$)" should be --(Ø-360$^{o}$)--;

Column 623, line 52, "9.99999999999399" should be --9.99999999999e99--;

Column 623, line 56, "9.999999999993511" should be --9.99999999999e511--;

Column 624, line 1, "neative" should be --negative--;

Column 628, line 52, "s" should be --is--;

Column 628, line 54, "0" should be --Ø--;

Column 629, line 18, "0" should be --Ø--;

Column 629, line 36, "0" should be --Ø--;

Column 630, line 16, "Specifying Bounds for Subscripts" should be underscored;

Column 630, line 35, "X[1:4:4,1:3] should be --X[1:4,1:3]--;

Column 630, line 57, "ae" should be --are--;

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 6 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 633, line 68, "0" should be --Ø--;

Column 635, line 7, "dps" should be --dsp--;

Column 637, line 15, "176A-B" should be --167A-B--;

Column 644, line 46, "beings" should be --begins--;

Column 645, line 22, "rdk A[12]" should be --rck A[12]--;

Column 646, line 41, "recore" should be --record--;

Column 649, line 10, "[" should be --08--;

Column 649, line 41, "ten" should be --then--;

Column 650, line 23, "alloc ted" should be --allocated--;

Column 653, line 57, "0" should be --Ø--;

Column 656, line 67, "f10" should be --f1Ø--;

Column 659, line 14, "error G3" should be --error G8--;

Column 659, line 66, the semicolon should be a comma;

Column 660, line 13, after "statement" insert --stored in said second area of said memory means,--;

Column 661, line 23, after "first" insert --area of said--; and

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,075,679 Page 7 of 7

DATED : February 21, 1978

INVENTOR(S) : Chris J. Christopher et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 662, lines 7 and 8, cancel "interrupt execution of that program" and substitute --interrupting execution of said program by said processing means--.

**Signed and Sealed this**

*Twenty-fifth* Day of *March 1980*

[SEAL]

*Attest:*

SIDNEY A. DIAMOND

*Attesting Officer* *Commissioner of Patents and Trademarks*