THE 1P21

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What photomultiplier has a cathode that is deeply buried, poorly shaped, and partly obstructed by a wire grill? What photomultiplier has a cathode that is unusually uneven in sensitivity? What photomultiplier is designed with its anode and cathode electrodes adjacent to each other both inside and outside of the envelope? And, finally, what photomultiplier is generally so noisy that it was used by the British during World War II for generating noise to jam German radio?

The answer to all of these questions is, of course, the early 1P21 photomultiplier. The secondary electron emission multiplication principle on which all photomultipliers operate was first applied by Vladimir Zworykin at the Radio Corporation of America in the early 1930's. The principle was essential not only for the efficient use of the simple photocathode but also for the further development of the then infant art and technology of television. The first commercial embodiment of the photomultiplier was called the 931A by RCA and it looked exactly like the later 1P21. Its appearance is unique in the art. The RCA decision makers must have pondered over this freak, basically linearly formatted device; RCA makes "tubes," so how can this thing be made to look like a tube? There followed a tour-de-force of electronic engineering. The linear multiplication train was successfully wrapped tightly around a central axis; this brought the anode and cathode electrodes close together inside the envelope, thus encouraging ionic feedback. Not to worry. A mica divider was placed between the critical electrodes and voilá! a few of these devices, which now looked like any other RCA "tube," and a small one at that, actually had a low enough noise level to compete successfully with much more elaborate and expensive diode photocell circuitry. Furthermore, the 931A was almost totally non-microphonic, a virtue of great importance that is now so commonly accepted that problems with microphonic noise have been forgotten.

Now, what about the 1P21? We have identified the Model T of the multiplier world; what about the Model A? It was known that, very roughly, one out of 50 931A's gave really outstanding low noise performance; it has been suspected that this came to the attention of the engineers at RCA and that these engineers arranged for production-line tests to segregate the "good" specimens of the 931A. Such tubes were then called 1P21's and were placed on the market with a price about five times that of the 931A, or about $50 compared with about $10. However, only one in about ten 1P21's was good enough for astronomical photometry and other highly critical uses, so no matter how you got your quality photomultiplier, it would cost about $500. It is interesting to note that the cheapest Model T automobile, in its heyday of, say, 1917, cost about half this much.

Astronomers plagued the radio stores shortly after the war when the 931A and the 1P21 (sometimes called the IP21 by the lesser informed) became commonly available. We would make friends with the proprietor and then ask to "test" his stock of photomultipliers. Testing took the form of either invading the store with noise-level equipment or of persuading the proprietor to allow temporary use of the tubes off premises, where much more thorough testing could be accomplished. If the investigator found a "good" cell (low noise), he would buy it and return the "duds." This practice led to an underground of informed astronomers. "Don't try the so-and-so radio store. Such-and-such an astronomer has already worked over the stock." Of course, even further in the background were other scientists also looking for unusual tubes and helping spoil the astronomer's game. The stock of some stores was worked over so much that the paper of the tube boxes actually became dogeared.

Somewhat later RCA made a series of changes in the 1P21 as a result of an experimental campaign to improve the tube. The photocathode became rust-colored instead of metallic blue, with improved red-sensitivity, probably from including oxidation during cathode preparation. In addition, ceramic insulators were substituted for some of the mica, and a superior insulating material was used for the base. These changes, along with others less obvious, made it apparent that RCA was now deliberately making 1P21 photomultipliers instead of getting them by selection.

Of course, the astronomer was never satisfied. The acid test was performance in the cooled state. Though the 1P21 lived up to RCA's specifications when operated at room temperature, only a small percentage of them gave that heartwarming, wonderful response to cooling in which the dark noise disappeared almost entirely, to the point where the residual cathode current was indicated to be only ten to fifty electrons per second. A "good" photomultiplier was still expensive to acquire!

The availability of the 1P21 quickly led to an enormous expansion of photoelectric photometry by astronomers. The multiplier principle had made the measurement of very faint light relatively straightforward. Moreover, the intervention of the war produced a breed of young scientists who were no longer intimidated by electronic circuits and who forged ahead in the field with a speed limited only by the availability of money to finance the progress. These newcomers were almost totally uninformed about the old-fashioned equipment employed prior to the war. Hence, many, even most of the newcomers were unaware of the fact that a large portion of the success of the 1P21 was caused by the remarkable nature of its photocathode. Though the so-called "alloy" photocathodes had been discovered about ten years before the appearance of the 931A, their use had not penetrated the field very rapidly until they appeared in photomultipliers. These photocathodes, based upon combinations of the semi-metals antimony and bismuth with the alkali metals cesium, potassium and rubidium, were at least ten times more efficient than the photosensitive surfaces previously employed. In addition, they were relatively easy to make and they would tolerate considerable abuse. Alloy cathodes represent almost all photoemissive surfaces in routine use today.

Modern photomultipliers generally have semi-transparent cathodes and a long shape indicative of the linear nature of the multiplier structure. Many different makes and varieties are available, costing from hundreds to thousands of dollars. However, the 1P21 abides; the Model A of the multiplier world has lasted longer and has been, in its own way, more successful than its vehicular brother of my metaphor. Such endurance can be explained only by a supremely good adaptation of the product to its use.

DR. GERALD E. KRON

Dr. Kron was the first to use the 1P21 in astronomy. During World War II he obtained a couple of good 1P21 photomultipliers, "liberated" a strip chart recorder, and designed and built a good DC amplifier. Immediately after the war, he applied this now classic combination of equipment to stellar photometry at Lock Observatory. His paper "Application of the Multiplier Phototube to Astronomical Photoelectric Photometry," Ap.J. 103, in 1946, alerted the astronomical community to this new development and ushered in the modern era of photoelectric photometry. (Photograph by Jeffery Hopkins.)