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A need for sensitive, stable alpha hand and shoe monitoring equipment was met by a transistorized air proportional instrument. Many features incorporated in the design were first used in portable alpha survey meters for several years and have demonstrated reliability. The large-area air proportional detectors are unaffected by penetrating background radiations or rf or magnetic fields. They have a uniform surface response and 16% efficiency at 5 MeV. Novel pedestal-type packaging and transistorization resulted in a compact, efficient, and attractive instrument. Maintenance is much less than for scintillation-type counters.

INTRODUCTION

Background and environmental conditions in several locations at Berkeley preclude the use of scintillation-type alpha hand and shoe counters. A sensitive counter was needed that could operate in all background areas and not be affected by rf and magnetic fields.

DESIGN CONSIDERATIONS

Detector. The design of this instrument is a result of experience gained by using portable air proportional alpha survey meters. The choice of an alpha detector for the instrument was a simple one, for we had been using a suitable detector in the very locations where the hand and shoe counters were needed. Now all that was required was to enlarge the portable air proportional detector to the sizes required for hand and shoe monitoring without altering their characteristics. This was done and the results were very satisfactory.

Electronics. The design of the circuitry and alarm system was tailored to a philosophy that contamination on one's hands and shoes requires (a) complete monitoring of the person involved and (b) an investigation into why the person became contaminated. The awareness that contaminating conditions exist is the fundamental reason for our use of these instruments. Detection of contaminated personnel, of course, is of great importance, but locating the source of contamination is far more important. By helping to eliminate sources of contamination the hand and shoe monitor is serving its most valuable function. Because of this approach, we did not feel it necessary to complicate the circuitry by including a distinction between right and left extremities. We feel that anyone who has one extremity contaminated must be monitored from head to foot, and that the conventional left-right distinction is therefore superfluous.

Operation. Use of these instruments should be simple, the results should not require interpretation, and if possible the instrument should be attractive. Every effort should be made to encourage personnel to use the instruments voluntarily and frequently, thereby

* Work done under the auspices of the U. S. Atomic Energy Commission.

providing maximum protection. To simplify use of the counter, a photocell control was provided to turn the counter on when the hands are inserted, and the scaler is reset and the time started automatically. The alarm system controls two top-panel-mounted lights indicating either hand or shoe contamination or both. If neither light comes on during the counting period, no detectable contamination is present.

If the hands are withdrawn prior to the end of the counting period, the photocell turn-on circuit activates a warning light, advising the user to restart the count.

An audible pop is heard from a speaker for every alpha particle detected. This audio information helps confirm low-level contamination and makes higher-level contamination immediately apparent. Continuous audio also provides a means of checking the instruments background counting rate in a coarse but practical manner.

Figure 1 shows the first counter used for field testing.

DETECTORS

Structure. The basic physical dimensions of the air proportional detectors are the 1/4-in. depth of the U-shaped grooves and the 0.0005-in.-diameter of the tungsten wire anodes (see Fig. 2). The length of the groove is not important as long as the wire is not allowed to sag. The number of grooves cut parallel and spaced 1/32 in. apart is determined by the intended application; in fact, the detectors can be made to form 90° angles.

Characteristics. At sea level, any detector, regardless of size, starts counting at about 1700 volts. The plateau region extends from 1730 volts to 1780 volts and has a slope of approximately 10%. Breakdown occurs at about 1800 volts. Double aluminized Mylar (0.95 mg/cm^2) is used for covering the sensitive volume, and limits the efficiency to 16% at 5 MeV. It is fortunate that, regardless of size, all detectors operate at the same voltage, greatly simplifying the high-voltage distribution. Puncturing the Mylar cover does not necessarily affect the operation of these detectors, as they can operate without a cover.

CIRCUITRY

Four circuit boards plus a low-voltage supply and timer comprise the electronics. Three preamplifiers are on the input board. Both hand detectors feed one preamplifier, both shoe detectors feed the second, and a frisking probe feeds the third. The frisking probe counting rate is displayed on a meter mounted on the side of the instrument. The hand and shoe preamplifier outputs are fed to a second board containing two binary scalers. Both scalers have selectable outputs at 4 or 8 counts. The scaler outputs are fed to the third board, which contains two alarm relay latching circuits and an audio amplifier. The fourth board is the high-voltage supply, of the single-transistor type, identical to the supply on our portable survey meter. The low current requirements of air proportional detectors allows the use of such a simple inexpensive high-voltage supply. However, sufficient current is available to allow regulation by an 1800-volt voltage regulator.

OPERATIONAL EXPERIENCE

Test models have been in use for more than 2 years, and all manner of people have used them. The model shown in Fig. 1 has one design fault that has accounted for the major service need. One would think that the large, exposed shoe detectors would suffer the most damage; however, the hand detectors suffered the most damage, because of hot cigarette ashes and hand-held objects. If foreign matter is introduced into the sensitive volume or a flap of torn Mylar comes close to the anode wire, the detector becomes noisy and must be cleaned and re-covered. If a stock of detectors is on hand, this causes little down time, and service costs are modest. The main cause of electronic failure to date has been high reverse leakage in some of the high-voltage doubling diodes.

During the design period various combinations of counting period and alarm levels were tried. Keeping in mind that the counting period should be as short as possible, we determined that in 12 seconds it was possible to have an alarm level of four counts with at least 90% confidence. Four counts in 12 seconds corresponds to 125 disintegrations per minute, which we consider the minimum reliably detectable activity. This sensitive level is not affected by any background that is allowable for human occupancy, regardless of the type of radiation.

RESULTS

Our experience indicates that air proportional detectors of correct design are quite reliable. Their sensitivity, permanence, and versatility make them ideal detectors for hand and shoe monitors as well as many other laboratory detection needs.

If the hand detectors were placed vertically inside the cabinet, the damage to them would be virtually eliminated and one of the major causes of servicing would also be eliminated.

Fig. 1

Air Proportional Hand and Shoe Counter, Alpha Hand and Shoe Counter

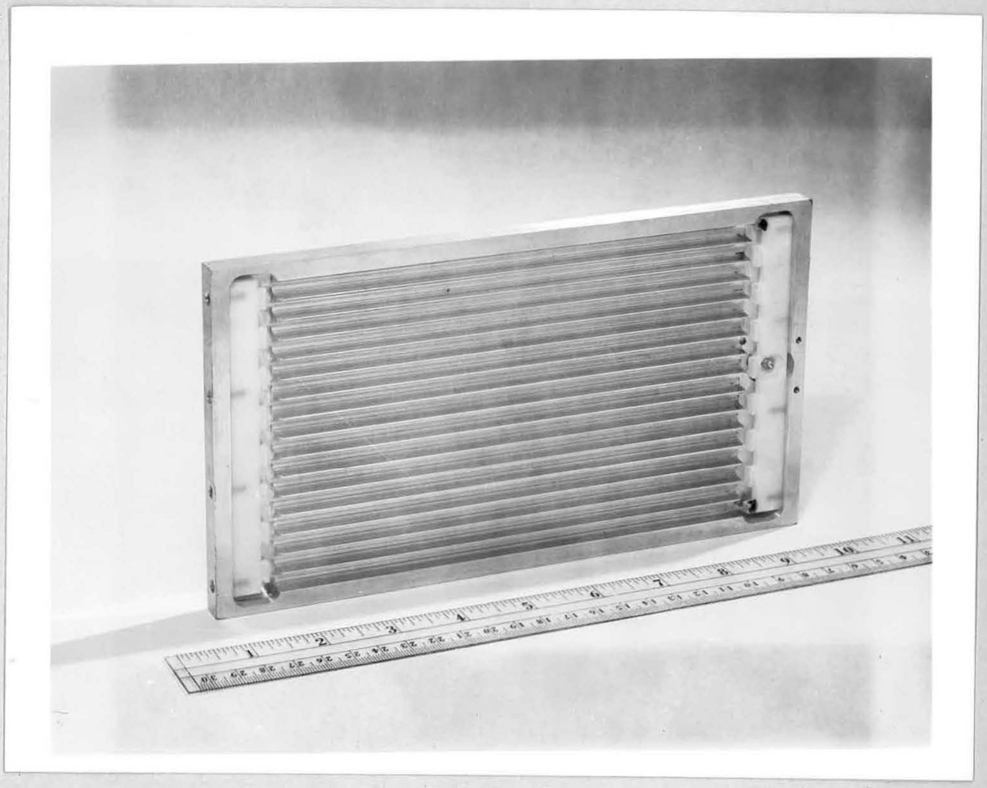

Fig. 2

Air Proportional Detector, Alpha Hand and Shoe Counter