AN ALPHA, BETA, GAMMA
HAND AND SHOE COUNTER -
MODEL II

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JUNE 2, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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By

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Instrument Research and Development
Physics and Instrument Research and Development Operation

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INTRODUCTION

At the present time, the hand and shoe personnel monitors at Hanford comprise two separate instruments. One instrument, called a Four-Fold, monitors alpha contamination on the hands and has a warning level sensitivity of approximately 1000 d/m with air-proportional probes for detectors. The second instrument, called a Five-Fold, monitors beta-gamma contamination on the hands and shoes, and has a warning level set to be exceeded by a fifty millimicrocurie uranium nitrate source distributed over an area eight by four inches. The Five-Fold utilizes G. M. tubes as detectors. Each instrument requires a 15 second count period. From long experience, the Five-Fold instruments have proved to be reasonably reliable; however, the Four-Fold instruments have an inherently poor sensitivity and have required excessive maintenance.

An experimental combination alpha, beta, gamma hand and shoe counter was developed previously using alpha scintillation detectors and G. M. tube beta-gamma detectors. (1) This instrument utilized an analog-type circuitry with a light-indicated-type readout. The instrument performed well in laboratory tests, but in the field testing it was found that the maintenance costs were too great, the instrument was too large physically, and the circuitry was unnecessarily extensive and complex.

Consequently, it was decided to redesign the instrument as a compact, simplified, register readout instrument no larger than the present Five-Fold. The instrument was called Model II.

(1) Spear, W. G., M. O. Rankin and R. A. Harvey, A Combined Alpha, Beta, Gamma Hand and Shoe Counter, HW-43550, November 29, 1956.
SUMMARY

The combined alpha, beta, gamma hand and shoe counter uses alpha scintillation detectors and beta-gamma G. M. tube detectors. Total monitoring time per individual is 15 seconds. The alpha probe portion sensitivity is such that the instrument will indicate above warning level for a 250 d/m Pu alpha source distributed over an area eight by four inches. The beta-gamma sensitivity is the same as for the Five-Fold; approximately twice warning level for a fifty millimicrocurie uranium nitrate source distributed over a similar area. There are five register readouts: alpha left hand, beta-gamma left hand, beta-gamma shoes, beta-gamma right hand, and alpha right hand.

In addition to these, two separately operated cable-connected probes are attached to the instrument. These probes are activated separately from the main instrument, and each in turn drives a loudspeaker. One probe monitors clothing and shoes for alpha contamination, and it will detect spot alpha sources with activities as low as 100 d/m. The other probe is a single 1B85 metal-wall G. M. tube with a response similar to a standard portable G. M. This probe is used to monitor clothing, etc., for possible beta-gamma contamination. While one individual is using the main hand and shoe counter, a second may be using the cable-connected probes. Except for the supply of power, the cabled probes and speaker operate independently of the main instrument, and can be used for as long a time as necessary.

If strategically located, such a combination instrument with the described external probes can replace the Four-Fold, Five-Fold and Cart-Poppy instruments.

DISCUSSION

Figure 1 shows the complete electronic circuit diagram (Hanford Drawing H-4-39117).

The main instrument probes, which are shown mechanically in detail on Hanford Drawing H-4-2684, are of two types. The hand probes, four in number, each contains ten R.C.A. Type 931-A multiplier phototubes and four
metal-wall-type 1B85 G. M. tubes. The probe box face, five by nine inches, is covered by a 0.005 inch-thick cellophane sheet sprayed on the outer side with a zinc sulfide fluor. The mixture and spray method has been previously described.\(^2\) The cellophane, in turn, is covered with one layer of 0.2 mg/cm\(^2\) aluminum dutch leaf and one layer of 0.9 mg/cm\(^2\) double-aluminum coated Mylar for a light tight cover. The Mylar is protected by a wire-mesh or pierced-metal screen. Each probe is completely light tight.

A Pu alpha particle penetrates the light shield and strikes the zinc sulfide causing emission of light which is received by phototubes mounted to "view" the cellophane sheet. The average probe geometry over the five by nine inch active area is about 15 per cent. The background count per probe is approximately one count, and hence, one register in 15 seconds. Since the probes are paired, the average register count, alpha, for each hand is one to two registers in 15 seconds. Each probe will indicate about six registers in 15 seconds for a 250 d/m alpha source distributed over the probe face.

The beta-gamma portion of each of the four hand probes consists of four metal-wall 1B85 G. M. tubes or the equivalent sized halogen-quenched tubes. These tubes are stagger-located in the probe, one at each end and two nearer the center, resulting in a reasonably good geometrical relationship. These tubes have a sensitivity as stated.

Each of the two shoe probes consists of eight metal-wall 1B85 G. M. tubes. These adequately detect, with a sensitivity the same as the hand probes, beta-gamma contamination over a 14 by 5 inch area. The shoe probes are paired together to drive one amplifier, and the beta-gamma sections of the two probes for each hand are paired similarly, as are the alpha sections of the two probes for each hand. A total of five amplifier circuits are required.

One amplifier, multivibrator, and internal scaling circuit is required for each of the three beta-gamma channels. The two alpha channels are the same except they do not require scaling circuitry. Each of the five complete channel circuits is fabricated on a plug-in subchassis, facilitating maintenance and replacement.

All of the five amplifiers are the same and are shown on the attached print. Each consists of an input pulse selector-discriminator and three 6AK5 pulse amplifiers in cascade.

The input sensitivity is one millivolt and the input-equivalent noise level is 500 microvolts. No extensive feedback is required since the usual input pulse level is above 25 millivolts. The amplifier voltage gain is approximately 1000. Discrimination of pulses is quite easy since the usual signal to noise ratio is better than 20 to 1. The resultant positive pulses from the amplifier serve to trigger a cathode-coupled multivibrator which produces 80 volt magnitude pulses. For the alpha channels, this multivibrator pulse is coupled directly from the subchassis to the register deck where the pulses drive the 2D21 thyratron register drive tubes. For each input alpha-caused pulse, the register is once-activated.

The beta-gamma channels use the same type amplifier and multivibrator circuit as the alpha channels. However, the general beta-gamma background per G. M. tube is about 40 c/m or 10 counts in 15 seconds. Since each set of hand probes has eight total G. M. tubes, this means a background, in the usual case, of about 80 counts in 15 seconds per register. The shoe probes, having 16 G. M. tubes total, have a usual background of about 160 counts in 15 seconds. Obviously, a scaling-down can be employed to have a reasonable count on each register. For exceedingly simple circuitry, the best scaling can be done in a single GC-10B gas tube which is a single glow transfer decade scaler. These tubes, as shown schematically on the print, allow scaling down of 10:1 if one tube is used or 100:1 if two such tubes are used in series. Both types are shown on the print and both work satisfactorily. The 10:1 scale-down circuit employs two less tubes than the 100:1 circuit. If the 100:1 scale-down is used, the register indicated background counts would be about one register for each of the hand beta-gamma registers, and two registers for the shoes in 15 seconds. The method presently incorporated in the described instrument is a scale-down of only 10:1 (the Five-Fold uses
an 8:1 binary scale-down). The savings amount to a total of six tubes, three vacuum and three glow-transfer scaling tubes. A 10:1 scale-down would give, approximately, 8 to 10 registers per hand and 12 to 16 registers for the shoe probes in 15 seconds under the assumed background conditions of a single G. M. tube giving about 40 c/m average.

The multivibrator, following the amplifier for each beta-gamma channel, drives a dual-triode pulse shaping circuit which in turn drives the GC-10B scaling tube. If 100:1 scale-down is used, the first GC-10B. Output pulses from the tenth element of the GC-10B are plus 30 to 40 volts in magnitude.

The register-drive circuits, five in number, are driven by the output multivibrator of the two alpha channels, and the GC-10B outputs from the three beta-gamma channels. Each register drive circuit uses a 2D21 thyratron and a separate biasing circuit to eliminate thyratron interaction. The bias voltage is negative 12 to 15 volts and is supplied by a miniature crystal diode doubler circuit operated from the 6.3 volt winding of the power transformer. The thyratrons are normally cut off, and an input positive pulse of 15 to 20 volts in magnitude serves to trigger them. Part of the plate load of the 2D21 is the driving coil of the Sodeco register, and the 1.0 MFD capacitor to ground from the 2D21 plate serves to prolong the firing time long enough, 100 milliseconds, to activate the register. One register digit appears for each 2D21 input pulse.

The timing circuit, also shown on the print, is set for a 15 second operation although this may be varied, if required, from five to sixty seconds. The timing, switching and relay circuit is self-explanatory. Initial instrument activation is caused by movement of either of the outer two hand probes. This action energizes the hand probe microswitch which starts the timer, energizing the count relay and count light. The hand probe switch is a momentary contact type since the timer incorporates a holding coil. At the end of the count period, the timer times out and de-energizes the count
relay. The hand probe switch cannot be reactivated until the reset button controlling the reset relay is pushed. This resets the timer, energizes the ready light, and resets the scaling tubes and Sodeco registers. The instrument is then ready for the next individual. The two externally-connected probes are independent and are activated by a simple on-off switch on the side of the instrument. The main counter does not have to be activated to allow external probe usage.

Three commercial and one Hanford fabricated power supplies are used. The B+ and filament power supply is a Lambda Model 32, and the two high voltage power supplies, one for phototubes and one for G. M. tubes, are J. Fluke Model 403-M supplies. The phototube power requirements are +1400 VDC at 0.4 milliamperes, and the normal G. M. tube requirements are +950 VDC at 0.1 milliamperes. Individual probe high voltage adjustments are available through the 5.0 megohm series rheostats provided. These allow each probe to be set at the proper high voltage to obtain the best signal-to-noise ratio, and are set with the aid of an oscilloscope attached to the signal output connector of the probe. Once set, these rheostats need not be readjusted unless some tubes in the probes are changed. The controls are not critical in adjustment since the alpha signal-to-noise ratio is so high, and the G. M. tubes have 80 to 100 volt plateaus.

Figure 2 shows the combined alpha, beta, gamma instrument in its present form and Figure 3 illustrates the size comparison of the new instrument to the Four-Fold on the left and the Five-Fold on the right. The new instrument is the same size as the Five-Fold single purpose beta-gamma instrument. The new combined instrument is a 20 per cent reduction in size from the original, Model I, combined instrument.
CONCLUSIONS

The new instrument has now operated successfully in general building use for eight weeks. It has been operated approximately 75 to 100 times per day during this period. The total maintenance time for eight weeks was about fifteen minutes for adjustments. Only three or four minor recalibration adjustments were necessary and no components have failed. It is thought that the new, Model II, combined instrument can be a satisfactory replacement for the Four-Fold and Five-Fold counters. The alpha sensitivity of the combined instrument is about four times better than that of the Four-Fold.

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FIGURE 2
Combined Alpha, Beta, Gamma
Hand and Shoe Counter - Model II
FIGURE 3
From Left to Right: Four-Fold, New Combined Model II Instrument, Five-Fold
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