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DP-1080

AEC RESEARCH AND DEVELOPMENT REPORT

AN ALPHA-COUNTING HAND AND FOOT MONITOR

W. J. WOODWARD

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Instruments
(TID-4500)

AN ALPHA-COUNTING HAND AND FOOT MONITOR

by

William J. Woodward

Approved by

D. E. Waters, Manager
Laboratory Operations & Services Division

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E. I. DU PONT DE NEMOURS & COMPANY
SAVANNAH RIVER LABORATORY
AIKEN, S. C. 29801

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ABSTRACT

An instrument was developed for detection of alpha contamination on hands and feet. A practical alpha foot monitor was made possible by improvements in the aluminum-coated film used to cover the scintillation detectors. In the instrument, scintillation detectors are connected to counters made from standardized plug-in circuits developed at the Savannah River Laboratory.

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INTRODUCTION

Scintillation counters are used to monitor alpha activity at the Savannah River Laboratory (SRL) because these counters are very sensitive and are superior to air proportional counters in a humid climate. Operating procedures prescribe that persons working with alpha-emitting isotopes monitor their hands and feet. This is usually accomplished with a "poppy" scintillation probe which requires changing the instrument from one hand to the other as well as balancing on one foot while probing the other. Fixed alpha detectors are used to monitor hands but not feet because scintillation detectors develop light leaks in the very thin metal (or metallized plastic) radiation window causing gross errors in the count or complete saturation of the system.

Recent improvements in vacuum depositing aluminum on "Mylar"* have made it possible to produce very thin films having several coats of aluminum on each side. This improved film contains few small light leaks while it remains thin enough to pass alpha particles. An experimental foot monitor was made with two scintillation detectors covered with 0.00025-in.-thick triple-aluminized "Mylar". After a few existing light leaks were photo-opaqued, the foot monitor was used for several months. Operation was satisfactory, and routine cleaning of the "Mylar" surface did no appreciable damage.

The success of the initial experiment prompted construction of an experimental alpha hand and foot monitor, which was tested in service in the laboratory's main corridor. Experience gained from this test (about 6 months) was used in construction of the prototype monitor described below.

* Du Pont trademark for its polyester film.

DESCRIPTION

The instrument is contained in a standard electronic cabinet rack with a platform in front (Figure 1) and holes for the user's hands as he stands on two grilles in the platform (Figure 2). Glow-transfer counter tubes display the count from the hands and feet (from 0 to 99) and the counting time in seconds (Figure 3).

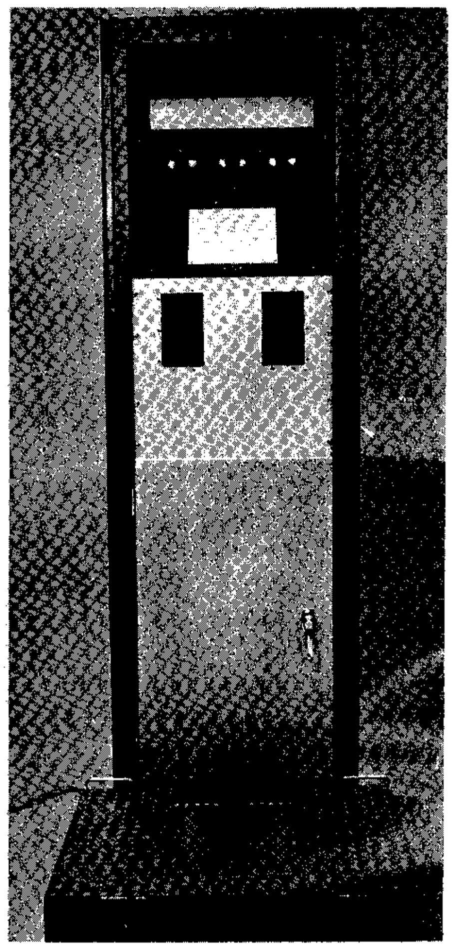


FIG. 1 ALPHA HAND AND FOOT MONITOR

FIG. 2 MONITOR IN USE

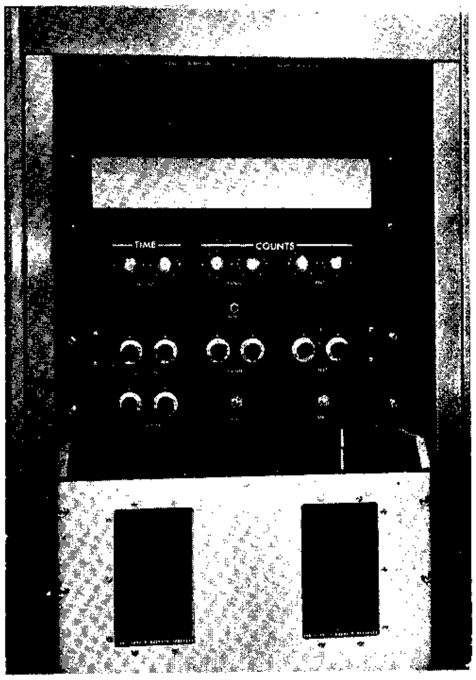


FIG. 3 DISPLAY PANEL WITH CONTROL COVER REMOVED

A backlighted status panel indicates one of the following counting conditions at all times:

READY FOR SERVICE

COUNTER IN OPERATION

CHECK INCOMPLETE - RESET AND RESTART

CHECK O.K.

DECONTAMINATION REQUIRED

A removable, locked panel conceals controls for setting the counting time, the total cycle time, and the alarm trip settings for hands and feet, plus discriminator adjustments for both counting channels.

A count is started when the user's hands are pressed gently toward each other. Subsequent logic operations are performed electronically and with relays.

The counting channels use transistorized plug-in circuits developed at SRL. Power supplies are solid-state except for the gas regulator tubes in the high voltage supply.

An essential consideration in designing was ease of maintenance. Power supply switches, fuses, and indicators are just inside the front door of the cabinet (Figure 4). The platform contains the scintillator box, which may be lifted out of its spring suspension (Figure 5). The platform cover is hinged and rests on its handles in the open position for easy closure. All

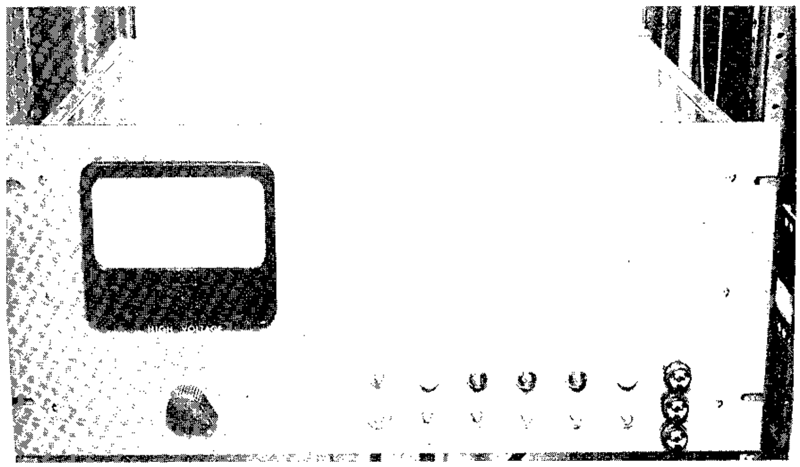


FIG. 4 POWER SUPPLY CHASSIS AS SEEN THROUGH OPEN FRONT DOOR

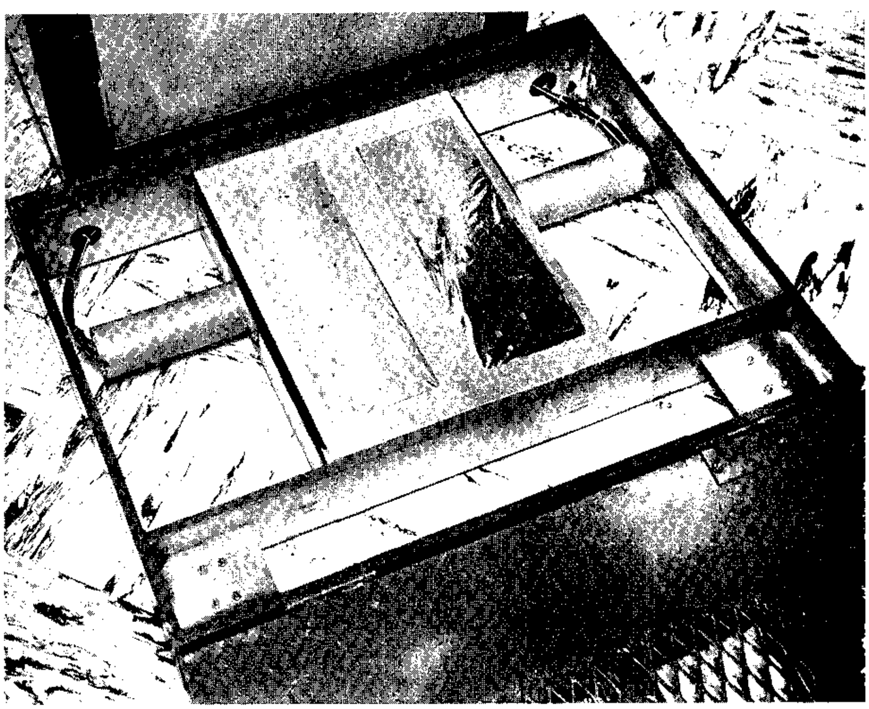


FIG. 5 FOOT PLATFORM, COVER OPEN TO SHOW SCINTILLATOR BOX

interconnecting cables and plug-in components are accessible through the rear door (Figure 6). Figure 7 shows the rear of the hand chute (cover open) and the hand scintillator box (partially removed).

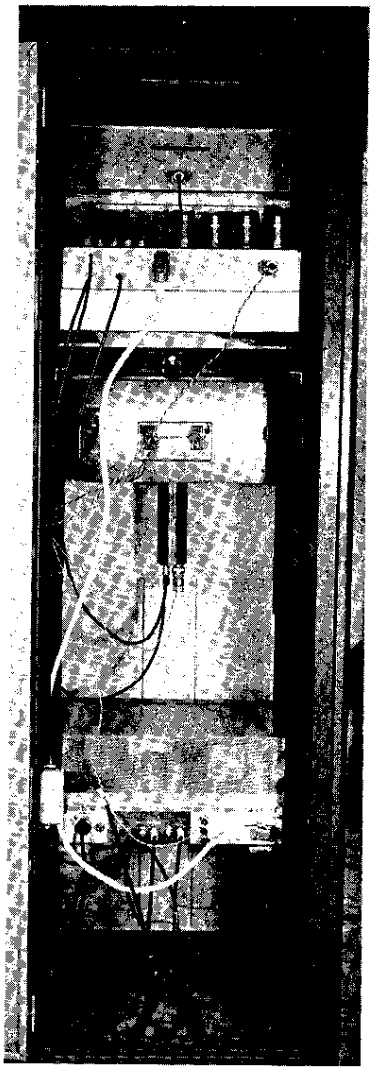


FIG. 6 REAR VIEW WITH DOOR OPEN

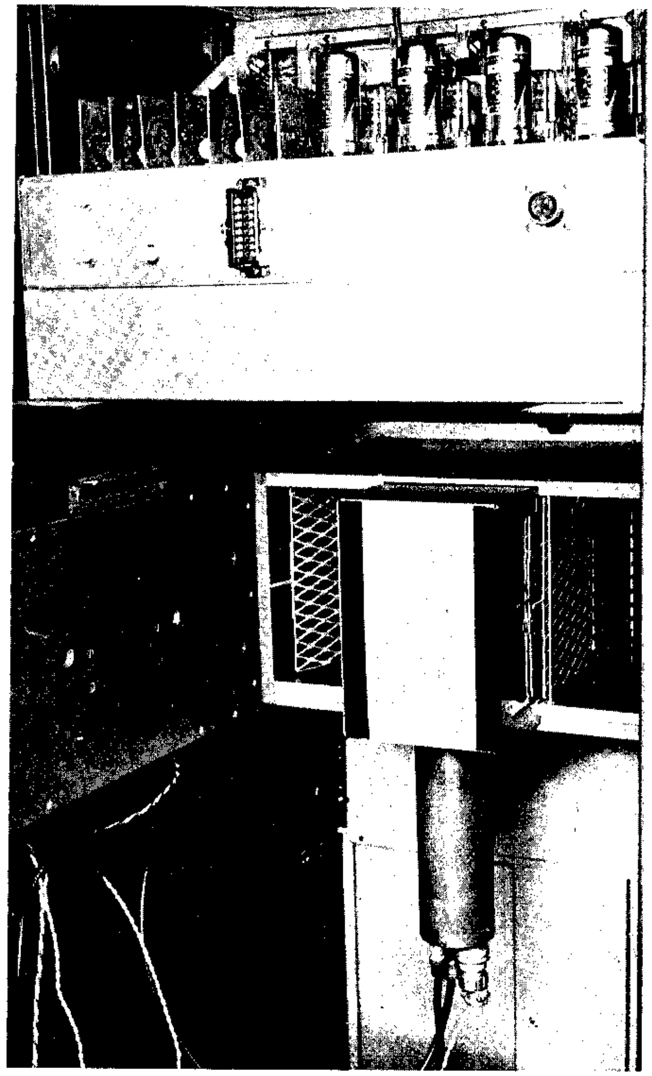


FIG. 7 HAND CHUTE, SHOWING REAR DOOR OPEN AND SCINTILLATOR BOX PARTIALLY REMOVED

The component most frequently serviced is the indicator lamp group behind the status panel. The entire lamp box may be removed from its snap-in retainer with one hand, as shown in Figure 8. The standard screw-base candelabra bulbs are easily replaced.

FIG. 8 REPLACEMENT OF INDICATOR LAMPS

The readout counter tubes are also easy to replace because all six of the numbered bezels are mounted on a rectangular panel held in place by four thumb screws (see Figure 3). With this panel removed, tubes can be removed easily.

Figure 9 shows the plug-in components on the display chassis. All the round relays are alike and have 8 pins, while all the square ones are alike and have 11 pins, which prevents interchange. The plug-in circuits are notched to fit keyed sockets to prevent interchange.

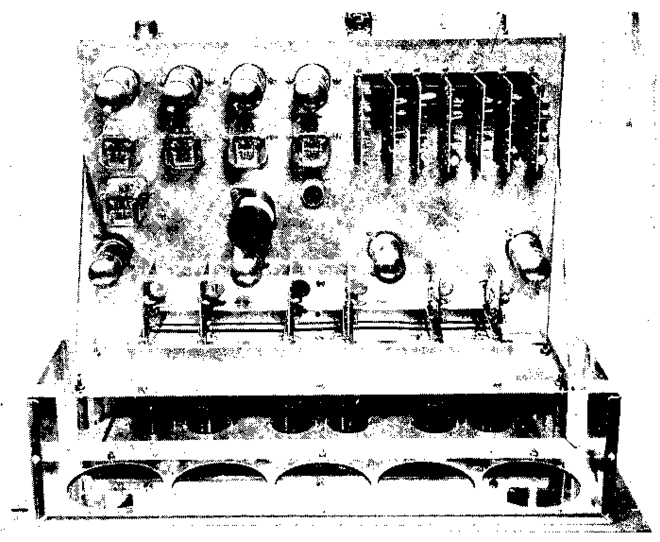


FIG. 9 TOP VIEW OF DISPLAY CHASSIS WITH LAMP BOX REMOVED

The underside of the display chassis is shown in Figure 10, and Figures 11 and 12 show the power supply chassis. Brackets support both chassis, even when the front mounting screws are removed. Each chassis slides forward on its brackets for removal. Cabinet doors have lift-off hinges, and casters on the monitor allow easy movement.

Power for the monitor is supplied through a rubber-covered cable to a duplex receptacle inside the cabinet. One receptacle provides a disconnect point for the monitor, the other may be used for calibration or test equipment.

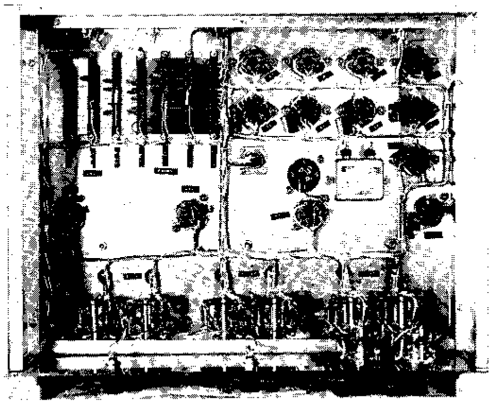


FIG. 10 BOTTOM VIEW OF DISPLAY CHASSIS

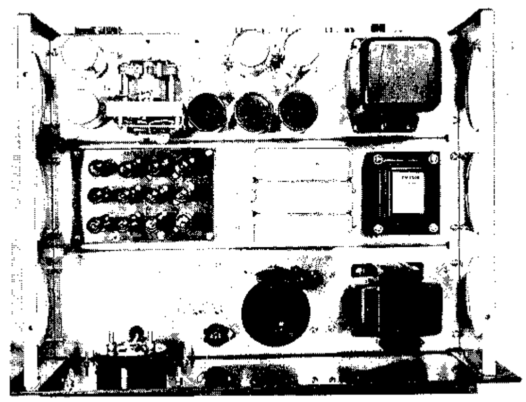


FIG. 11 TOP VIEW OF POWER SUPPLY CHASSIS

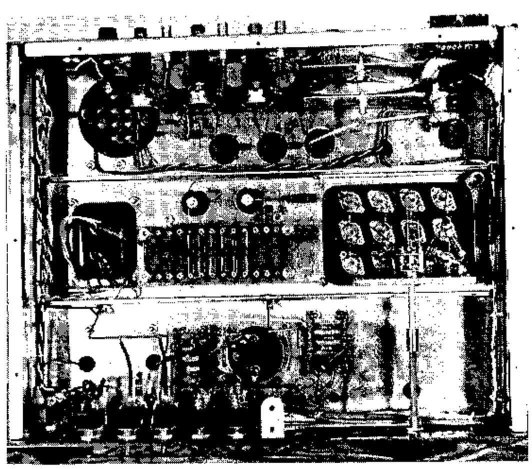


FIG. 12 BOTTOM VIEW OF POWER SUPPLY CHASSIS

POWER SUPPLY

Power for all operations is converted from a single-phase, 115-volt, 60-cps input to the required pulse and DC voltages in the power supply chassis (Figure 13). Three transformers are used; their primaries are individually fused.

Transformer T1 drives a voltage-doubling rectifier followed by a series string of gas regulator tubes. Regulated, negative high voltage is switch-selected in steps of (nominally) 105 volts from -315 to -1260, plus a zero (or grounded) position. This voltage (indicated on the front panel meter) is fed to the photomultiplier probes through adjustable resistors and connectors J9, J10, and J11. Each probe has a resistance of 2.8 megohms, so the voltage may be reduced about 30% of supply (for balancing) with the series adjustment. T1 also provides 6.3 volts AC to the probes via J12, J13, and J14.

T2 supplies +425 volts to the decade counting tubes from a half-wave rectifier and pi filter. A one-megohm bleeder is provided for safety, and the switched output is indicated on the front panel by a red neon indicator.

T2 also supplies a half-wave rectifier, filter, and zener regulator which provides -150 volts for the counting tube driver circuits. An amber neon indicator shows this switched output, and in the "off" position, a 5000-ohm, 10-watt resistor is connected as a dummy load to prevent the zener regulator from overheating.

A third tap on T2 provides AC drive to a half-wave rectifier, filter, and zener regulator that provides +39 volts to the amplifier, discriminator, and univibrator circuits through one output, and to relay circuits through another. The positive leads and grounds are divided after the +39 volt, "on-off" switch, which also has a dummy load resistor (750-ohm, 10-watt) for zener protection in the "off" position. A voltage divider from the -150 volt supply provides a negative bias on the +39 volt red neon indicator, as the 39 volts is less than the ignition potential of the neon bulb. Even though both the +39 volt and -150 volt indicators will go out if the -150 volt supply fails, neon indicators are used because they are superior to incandescent lamps.

Power for the display panel lamps and associated logic relays is +110 volts from a regulated supply driven by T3. A full-wave bridge rectifier feeds a series- regulator transistor that has a filtered, zener-regulated base voltage. The transistor uses the chassis as a heat sink. The +110 volt output is switched, which is shown by a red neon indicator. The ground for this output is

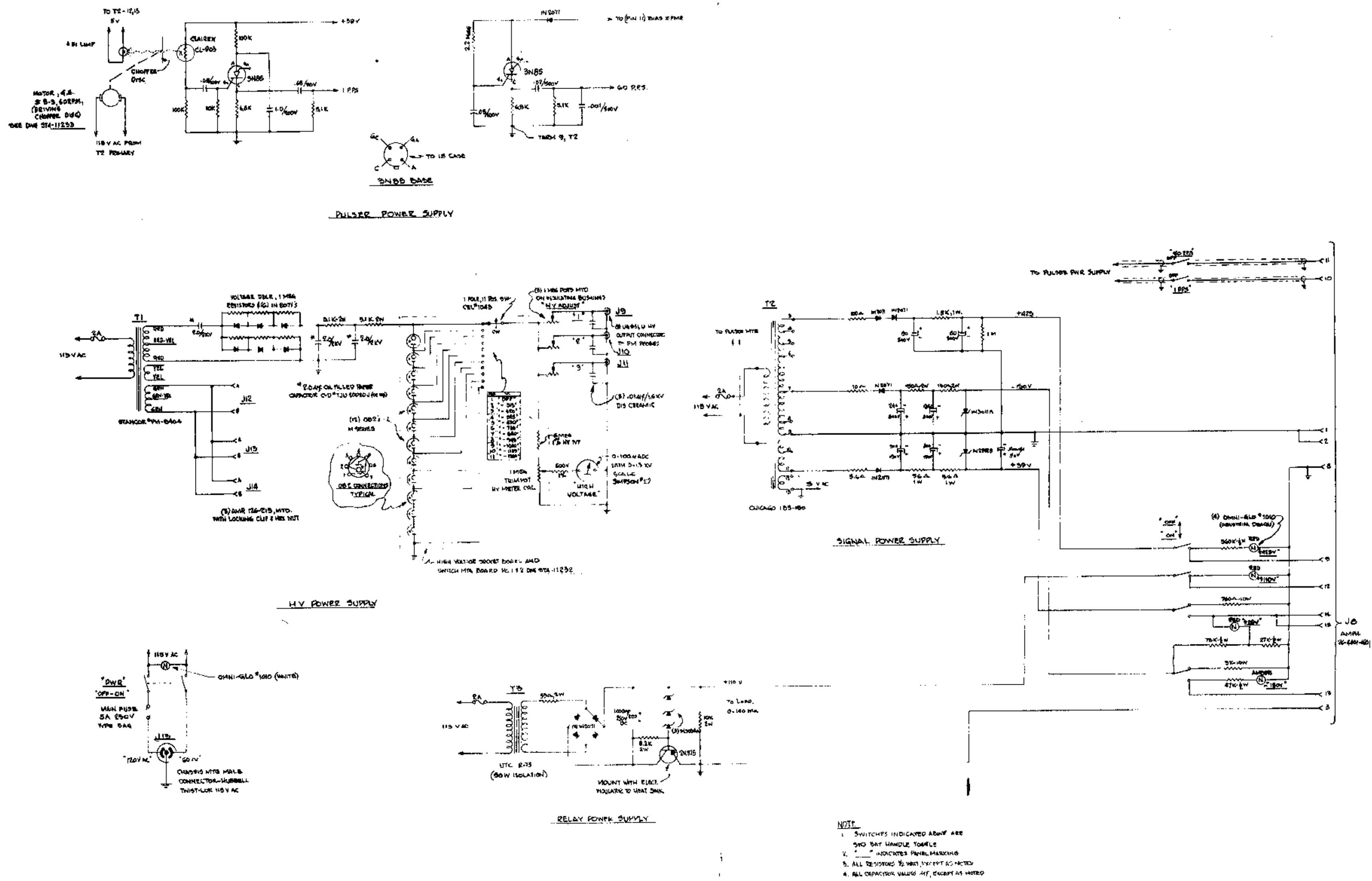


FIG. 13 SCHEMATIC OF POWER SUPPLY

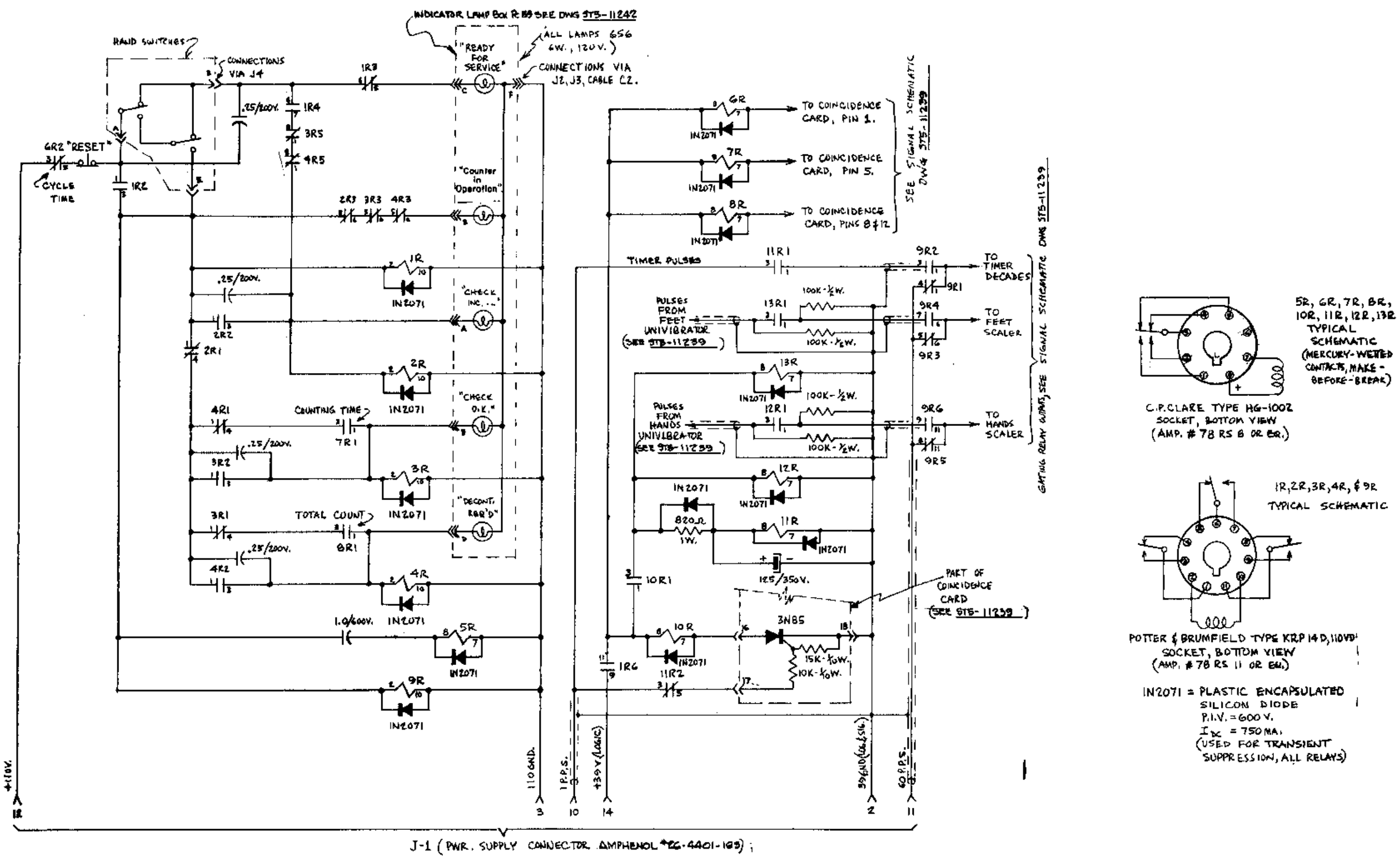
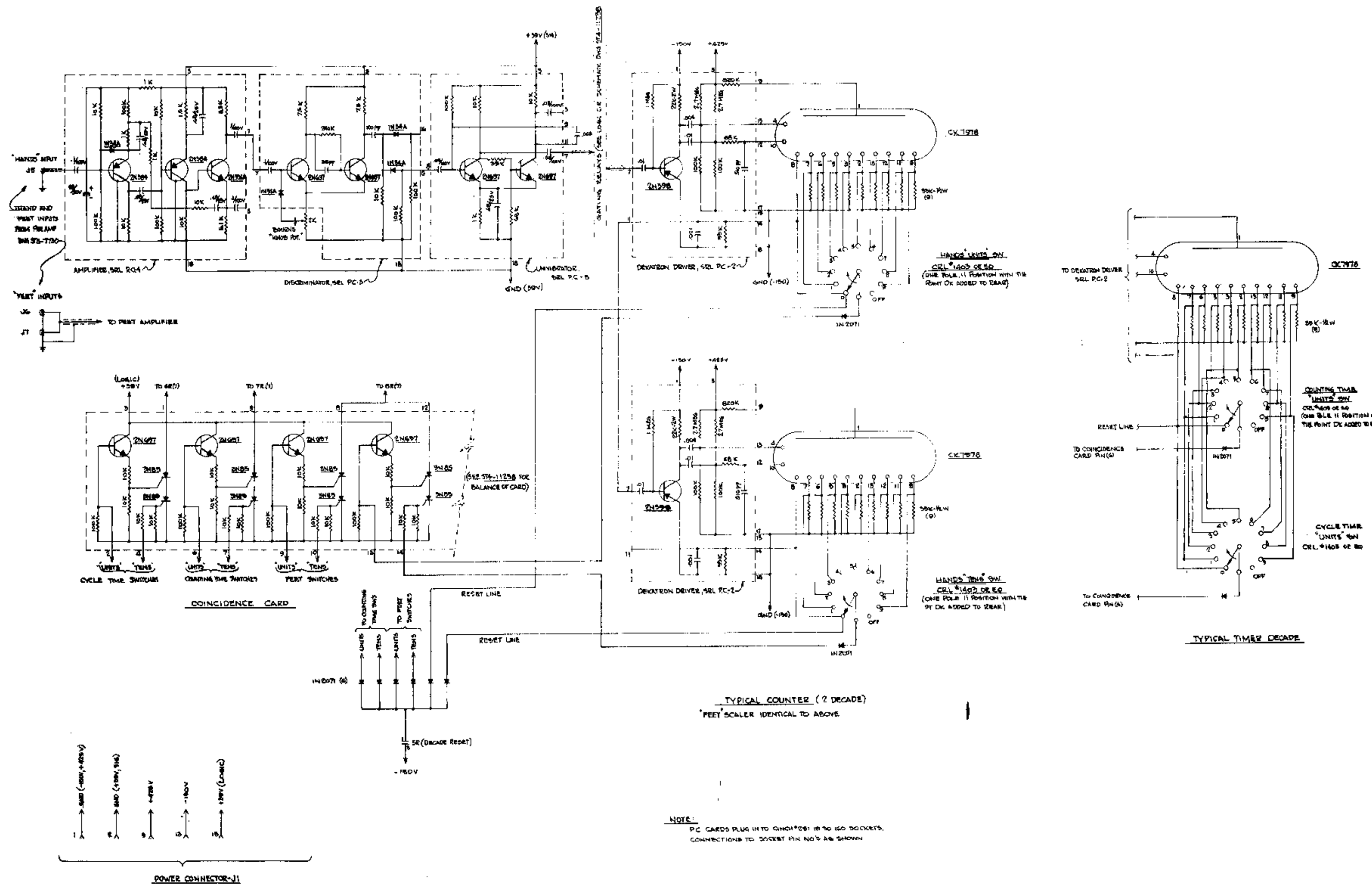


FIG. 14 SCHEMATIC OF LOGIC CIRCUIT



NOTE:
PC CARDS PLUG IN TO CINCH 281 18 TO 160 SOCKETS, CONNECTIONS TO SOCKET PIN NO'S AS SHOWN

FIG. 15 SIGNAL SCHEMATIC

tacts 11R2 isolate the silicon switch from the circuit.) Thus, the timer indicates one second only after exactly one second of counting time has elapsed. All of the operations described thus far take place within about one second after activation of the hand switches.

After counting has begun, one of three things happens: the count proceeds until the preset counting time has elapsed, or it proceeds until a preset count is reached that trips the alarm, or the count is stopped by releasing either hand switch.

If the timer reaches its preset count before either of the counting decades trips the alarm, the monitor reads out CHECK O.K. Counting time is preset by switch-selecting a cathode on each of the timer counting tubes, as shown in Figure 15. The COUNTING TIME switch dials are numbered to correspond to the cathodes, and the switch wipers are connected to a stacked pair of silicon-controlled switches (SCS) on the coincidence card (Figure 16). The TENS decade switch is resistance-coupled to the lower SCS, and the UNITS decade switch is coupled to a transistor that drives the upper SCS. (The driver transistor reduces loading on the UNITS decade so that its zero cathode can reliably drive the TENS decade.) Positive cathode voltage pulses at these two coincidence inputs with as little as one microsecond of overlap will cause both SCS units to conduct, energizing relay 7R. Contacts 7R1 (Figure 14) close to energize relay 3R and light the CHECK O. K. indicator lamp. Contacts 3R1 open the alarm indicator circuit, 3R2 seal the relay on, and 3R5 open the CHECK INCOMPLETE circuit. The hand switches may be released after the CHECK O. K. lamp comes on, and the instrument will return to its original (standby) state when the RESET button is pressed, or when contacts 6R2 open momentarily. Relay 6R operates like 7R except that another pair of SCS units is used, and the CYCLE TIME switches preset the time.

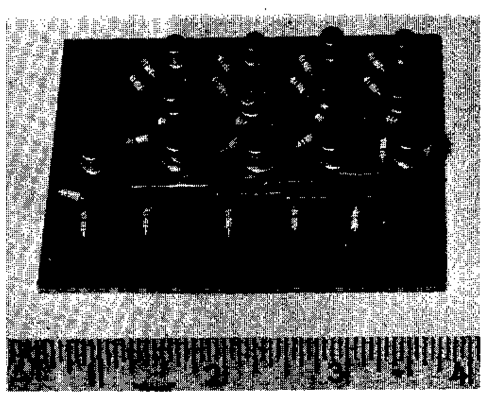


FIG. 16 COINCIDENCE CIRCUIT PLUG-IN CARD

A pair of selector switches is also used in each of the counting channel readouts, with cathodes of the UNITS and TENS tubes connected through the switches to SCS pairs for HANDS and FEET. These SCS pairs have a common relay, 8R, so that if the preset count is reached in either the HANDS or FEET decades before the preset time has elapsed, the relay will be energized. This closes contacts 8R1 which turn on the DECONTAMINATION REQUIRED lamp and energize relay 4R. Contacts 4R1 open the CHECK O.K. circuit, 4R2 seal the relay on, 4R3 open the COUNTER IN OPERATION lamp circuit, and 4R5 open the CHECK INCOMPLETE. Reset to standby is accomplished as before.

If either hand switch is released before a check is complete, relay 2R is energized through contacts 1R4, 3R5, and 4R5. The CHECK INCOMPLETE lamp is also turned on. Contacts 2R1 open the CHECK O.K. and DECONTAMINATION REQUIRED circuits, while 2R2 seal the relay on. Reset is again accomplished as before.

When the instrument is reset to standby, relay 1R is deenergized, which opens voltage supply circuits to all relays and turns on the READY FOR SERVICE lamp. Counters and timers are returned to 60 PPS operation to prevent counter tubes from developing a "favored" cathode. Discharge of the time delay capacitor across 11R is aided by a diode shunting the series resistor.

All signal-handling relays are of the mercury-wetted contact type to eliminate spurious pulses due to contact bounce. All relays are plug-in types, and all relay coils are shunted by diodes for arc suppression and SCS protection.

Signal pulses to be counted come from photomultiplier tubes of the venetian-blind dynode type with two-inch (nominal) end window photocathodes. One of these is mounted with its window just inside the bottom of the hand scintillator box, on either side of which is a zinc sulfide coated plastic screen covered with two layers of 0.00015-inch-thick aluminized "Mylar". Scintillations from the zinc sulfide are converted to electrical pulses by the tube, which plugs directly into a preamplifier assembly.[1] The preamplifier is a stacked emitter follower circuit that drives the HANDS counting channel.

The foot scintillation box has two zinc sulfide screens in its top, and two photomultiplier tubes in its sides to detect scintillations from the screens. Their preamplifier outputs are fed to a common connection at the input of the FEET counting channel.

Each counting channel consists of a series of transistorized plug-in circuit cards.[2] The input card is an amplifier with a gain of 100. Output pulses from the amplifier go to a discriminator circuit that has an adjustable threshold control on the front panel. Discriminator output is a fast-rising, narrow pulse that triggers a univibrator circuit which supplies shaped pulses to the counting tube driver circuits via the gating relays. The driver cards, two per channel, contain the bias and pulse transfer networks for the counting tubes. These tubes are mounted so that cathode glow in each is displayed within a bezel that is numbered 0 through 9 around the tube end. The tubes thus serve as a readout (to the user of the instrument) at the same time they are acting as counters and logic outputs.

The readout-display panel is recessed to make it easier to read and to shield it from ambient light. This shadow-box effect is enhanced by white lettering and lighted displays on a flat black background.

SERVICE HISTORY

The alpha hand and foot monitor has been in continuous service for over a year. The only recurring trouble is in the READY FOR SERVICE lamp, which burns out every two to three months. Dust that collects on the foot section can be either blown away or removed with a vacuum cleaner with no damage to the "Mylar" covers. Since the original 0.00025-inch-thick "Mylar" was replaced with two 0.00015-inch-thick layers, coincidence of pinholes is so rare that opaquing is unnecessary.

REFERENCES

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2. W. J. Woodward. Plug-In Circuits. USAEC Report DP-1079, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, S. C. (1966).