DP-1176

AEC RESEARCH AND DEVELOPMENT REPORT

A FOUR-CHANNEL MONITOR FOR AIRBORNE RADIOACTIVE CONTAMINANTS

W. J. WOODWARD

DUPONT
REG. U. S. PAT. OFF.

Savannah River Laboratory

Aiken, South Carolina

LEGAL NOTICE

Printed in the United States of America
Available from
Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U. S. Department of Commerce
Springfield, Virginia 22151
Price: Printed Copy $3.00; Microfiche $0.65

DP-1176

Instruments
(TID-4500)

A FOUR-CHANNEL MONITOR FOR AIRBORNE RADIOACTIVE CONTAMINANTS

by

William J. Woodward

Approved by

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

November 1968

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

CONTRACT AT(07-2)-1 WITH THE
UNITED STATES ATOMIC ENERGY COMMISSION

ABSTRACT

An instrument was developed to monitor continuously four locations for airborne radioactive contaminants. Each monitoring channel contains five plug-in circuit boards connected to form a count rate meter with five ranges and variable time constant.

CONTENTS

LIST OF FIGURES

INTRODUCTION

At the Savannah River Laboratory, air from rooms where radioactive materials are handled is continuously drawn through paper filters. Particulate matter collected on the filters is monitored for radioactivity. The filters are changed periodically and monitored; however, to provide early warning of any airborne contaminants it is desirable to monitor the filters continuously. Therefore, an instrument (Figure 1) was designed and built to continuously monitor airborne contaminants by accepting signals from four scintillation detectors.

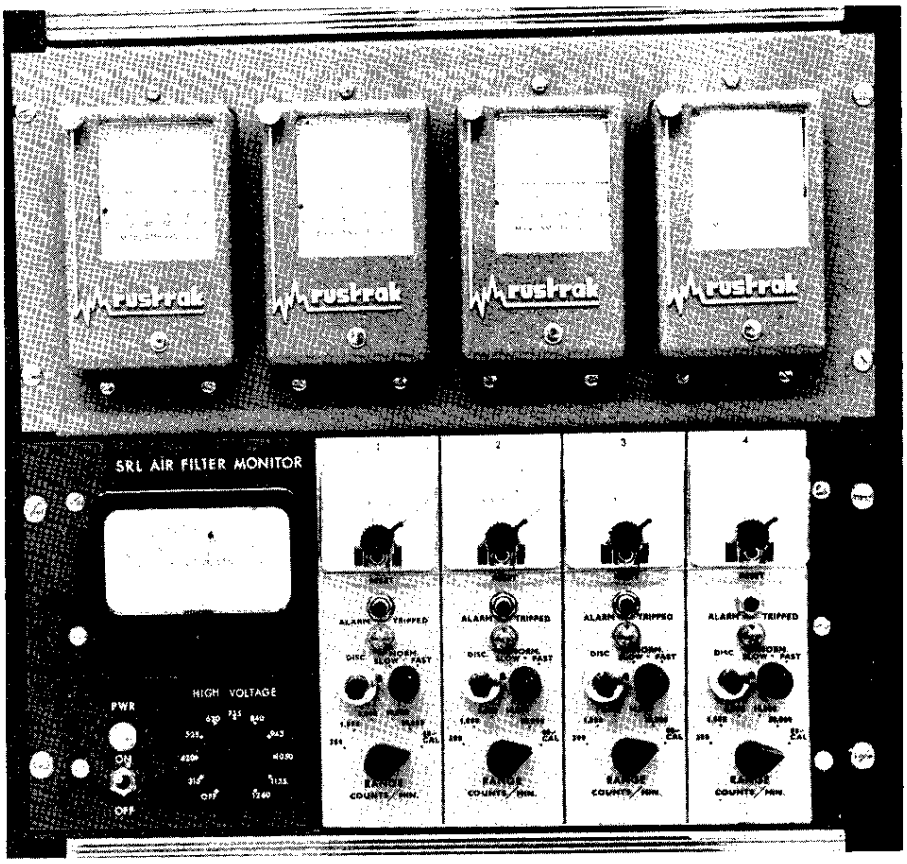


FIG. 1 FRONT VIEW OF AIR MONITOR CHASSIS AND RACK MOUNTED STRIP CHART RECORDERS

DESIGN

Detector

A four-channel air monitor accepts signals from four remotely located scintillation detectors. A detector is mounted on a standard laboratory air sampler so that the scintillator faces the upstream side of the filter (Figure 2). Approximately six cubic feet of air per minute pass through the filter, depositing airborne particulate matter in front of the radiation detector.

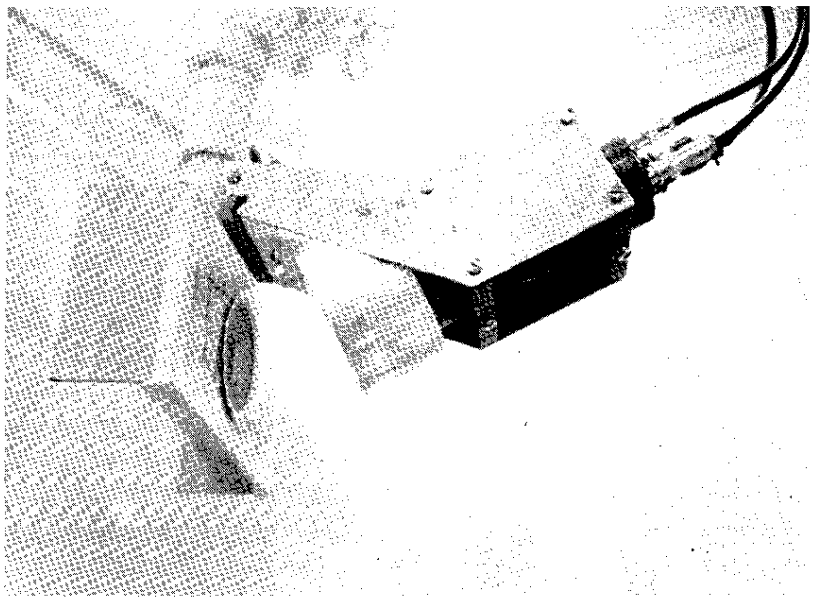


FIG. 2 DETECTION UNIT MOUNTED ON ROOM AIR SAMPLER

The four detectors are photomultiplier tubes, light-coupled to scintillating materials that are sensitive to the type of radiation expected, and each is matched to a coaxial cable with a transistorized preamplifier.[1] Four detectors can be coupled through coaxial cables to four input jacks on the back of the air monitor (Figure 3). Each input feeds a count rate circuit.

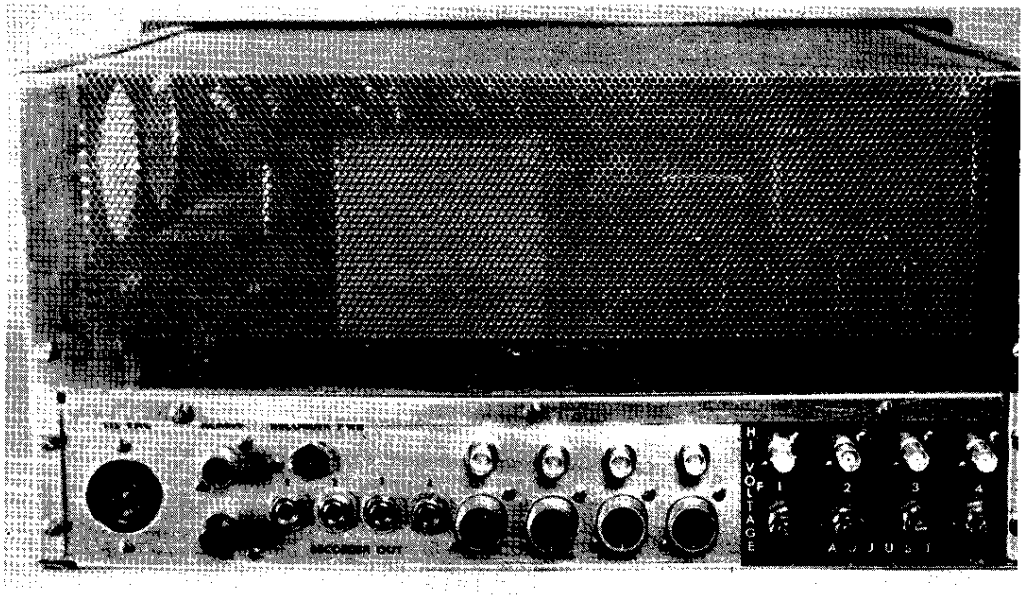


FIG. 3 REAR VIEW OF AIR MONITOR CHASSIS

Count Rate Circuit

A count rate circuit is made up of five interconnected plug-in circuit boards:[2] an amplifier, a discriminator, a count rate meter, count rate meter range, and count rate meter time constant (Figures 4-6). The amplifier has a voltage gain of 100 and a frequency response suitable for fast-rising pulses. The discriminator is an integral type, with base-line voltage adjusted by a ten-turn potentiometer mounted on the front panel of the air monitor. Amplified pulses having voltage amplitudes greater than the base-line setting produce output pulses from the discriminator that drive the count rate meter (CRM).

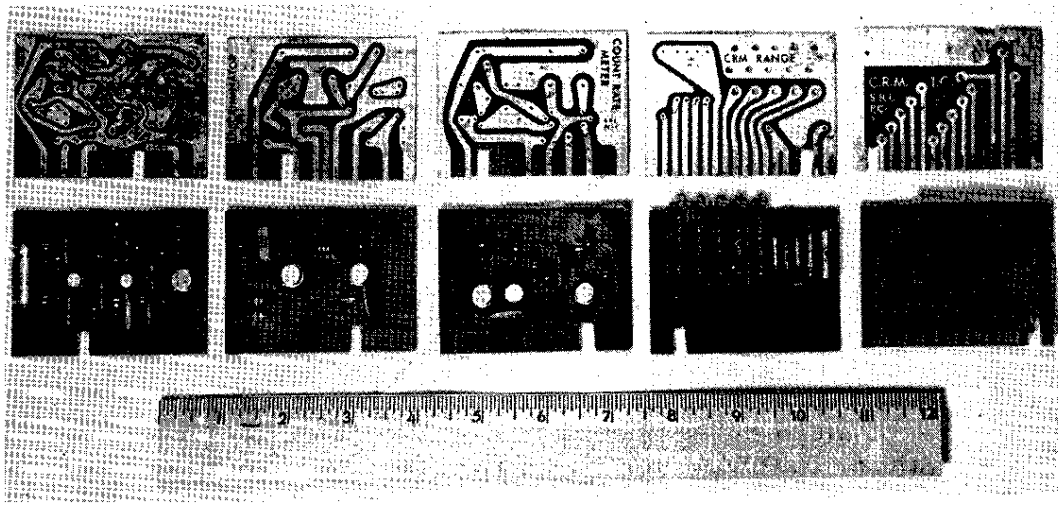


FIG. 4 CIRCUIT BOARDS FOR 5-RANGE COUNT RATE METER

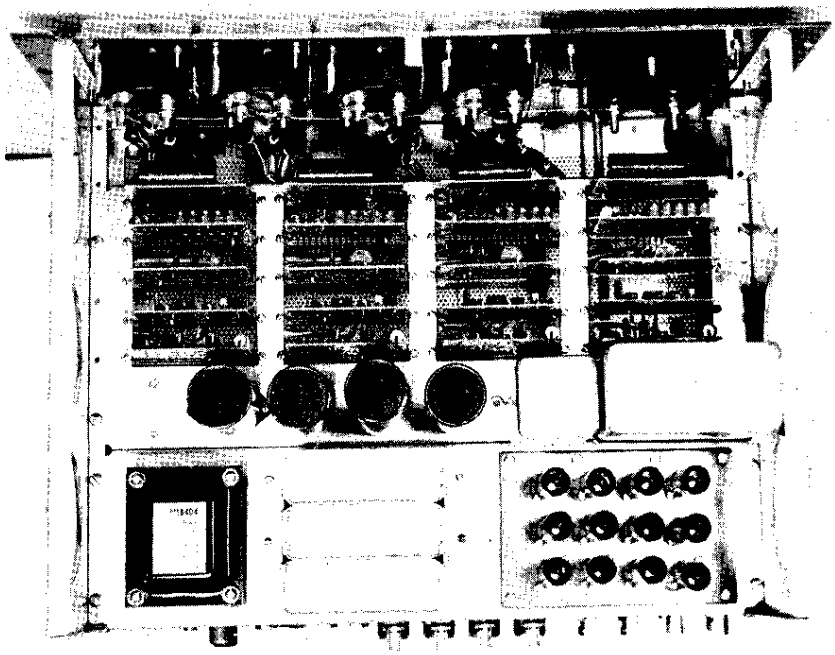


FIG. 5 TOP VIEW OF AIR MONITOR CHASSIS SHOWING PLUG-IN CIRCUIT BOARDS

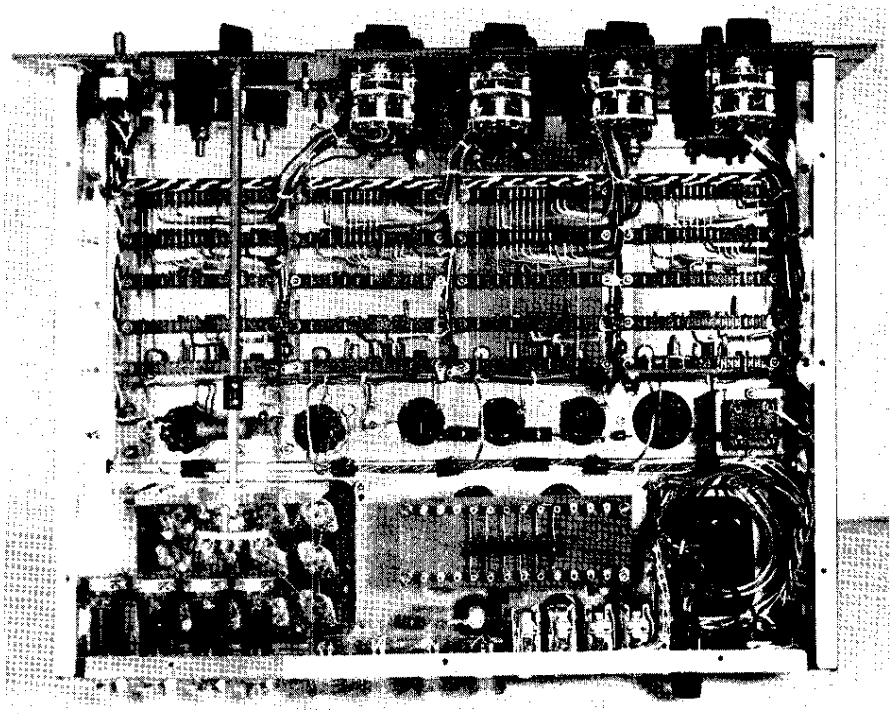


FIG. 6 BOTTOM VIEW OF AIR MONITOR CHASSIS SHOWING CIRCUIT BOARD INTERCONNECTIONS

The CRM accepts pulses of various sizes and shapes and converts them to pulses of constant width and amplitude for presentation to a 0-100 μamp dc readout meter on the front panel of the air monitor. An integrating capacitor shunts the meter and its calibration resistors so that the meter reads the average dc level. The readout meters are contact-making types with locking coils. If any of the four meter contacts are closed, an alarm relay is activated, and the locking coil current maintains the meter contact until a reset pushbutton is operated. Each channel has a neon lamp that is lighted while the meter contact is made, providing a quick visual indication of an alarm condition until the condition has been cleared and the meter reset. Alarm relay contacts are brought out through a rear panel connector for remote annunciator operation.

A miniature strip chart recorder (also 0-100 μamp dc) is connected in series with the meter in each channel to provide a permanent record. Each recorder is connected through a closed-circuit jack at the rear of the monitor so that a dummy resistance is substituted when the recorder is not connected. Power to all four recorders comes from a single rear panel connector.

The appropriate pulse width and calibration resistance for each of five ranges (300, 1,000, 3,000, 10,000, and 30,000 c/m) can be selected with a range switch that is mounted on the front panel. The switch also provides a position for a calibration check against the 60 hertz line frequency.

Three integration time constants (fast, normal, and slow) for each range can be selected with a switch. In the "fast" position, only the series resistances of the meter and recorder are shunted by the calibration potentiometer and the integrating capacitor for fastest meter response. In the "normal" position, a resistance (different value for each range) is added in series with a meter-recorder-calibration potentiometer combination to provide a long enough time constant for smooth meter response. In the "slow" position an additional 5,000 ohms produces a very long time constant to further smooth meter response on all ranges. (A mathematical derivation showing how the time constant can be changed without affecting calibration is given in Reference 2.)

Regulated high voltage is supplied to four series potentiometers, each of which is connected to a rear panel jack. Voltage to each probe may be adjusted from the value shown on the front panel meter to approximately 25% less. A front panel switch selects high voltage in steps of 105 volts from 315 through 1260 volts. The ac power (6.3 volts) is provided to the preamplifiers through four rear panel connectors. A complete schematic diagram of the monitor is shown in Figure 7.

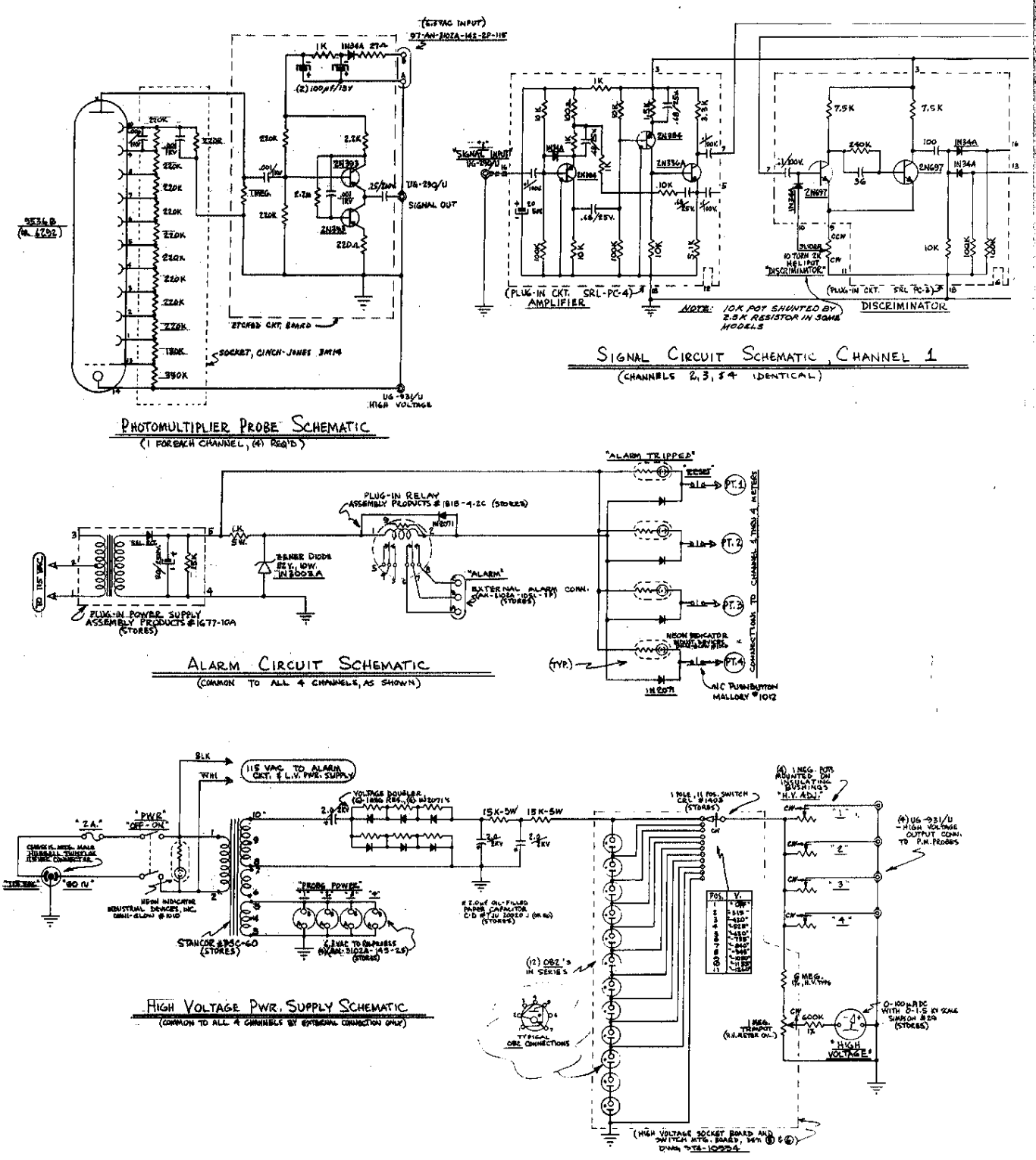
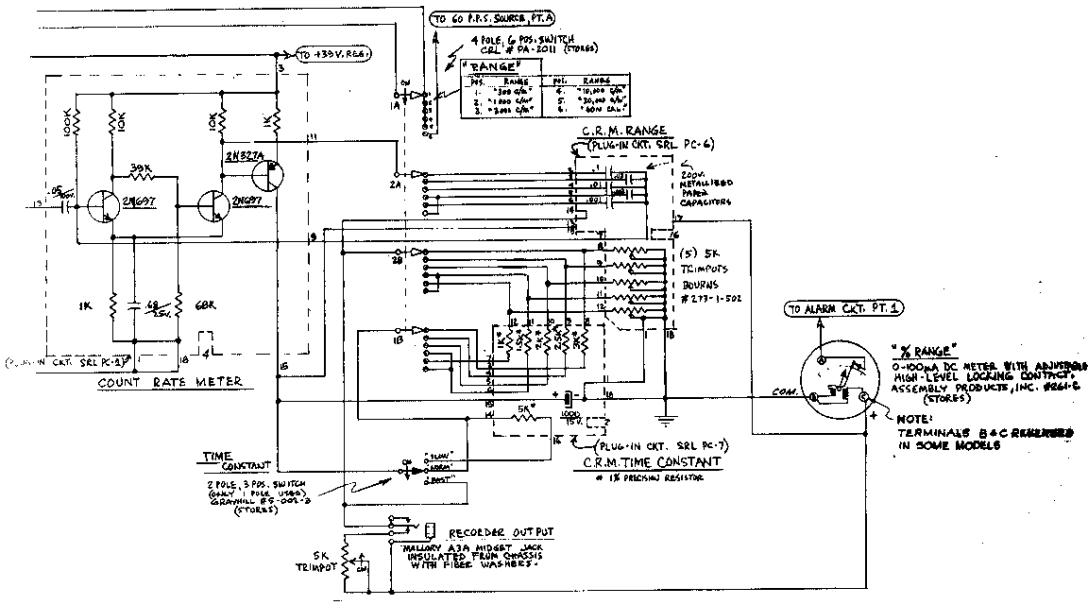
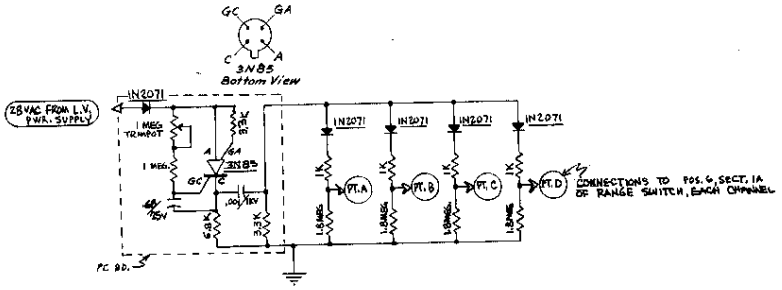


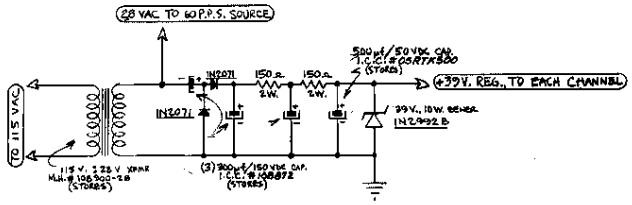
FIG. 7 DIAGRAM OF FOUR-CHANNEL AIR MONITOR





60 P.P.S. SOURCE SCHEMATIC

(COMMON TO ALL 4 CHANNELS, AS SHOWN)



Low Voltage Power Supply

(COMMON TO ALL 4 CHANNELS, AS SHOWN)

NOTE:
TRIAD F-40X TRANSFORMER USED IN SOME MODELS, 26.8 VCT, WITH C.T. WIRE CUT OFF. 150Ω 2 WATT RESISTORS CHANGED TO 100Ω 2 WATT IN THESE MODELS.

NOTES:

1. ALL RESISTORS ½ WATT UNLESS NOTED.
2. ALL ELECTROLYTIC CAPACITORS SHOWN POLARIZED, VALUE IN MFD.
3. ALL PAPER & CERAMIC CAPACITORS VOLTAGE RATED, VALUE IN MFD.
4. ALL OTHER CAPACITORS MICA, WHOLE NUMBER VALUES IN MMF.
5. ALL PLUG-IN UNITS SHOWN WITH SOCKET PIN NUMBERS.
6. CLOCKWISE ROTATION OF ALL CONTROLS SHOWN BY ARROW.
7. ALL PANEL MARKINGS ASSOCIATED WITH CONTROLS SHOWN BY "—".
8. UNLESS CONNECTION SHOWN BY STAPLE TERMINATION OF LINE.

(FIG. 7 CONTINUED)

EVALUATION

The air monitor was evaluated as a beta monitor and as an alpha monitor. In both evaluations the flow through the filter was 6 ft^3/min (of air), and the filters were 3-inch diameter, with a 2.5-inch-diameter active area.

Beta Monitoring

For beta monitoring, a 2-inch-diameter phototube (E.M.I. 9536B) was light-coupled to a NE-102 plastic scintillator which was 0.010 inch thick and covered with 0.0025-inch-thick aluminized "Mylar"*.

Beta sources were made by uniformly depositing ^{90}Sr-^{90}Y on 2.5-inch-diameter Gelman E filters. Tests conducted with various source strengths showed that the monitor readily detected concentrations of 0.5×10^{-9} µCi/cc of mixed fission products in air, or one-half the maximum permissible concentration of 1×10^{-9} µCi/cc. The contribution from radon-thoron was negligible, and a 25 mR/hr gamma field only added 5% of scale. Tests were conducted using the 0 to 30,000 c/m range.

Alpha Monitoring

For alpha monitoring, a 3-inch-diameter phototube (Du Mont 6363) was used to assure detection from the extreme edges of the filter. The tube's window was covered with a decal that provides

*Du Pont trademark for its polyester film.

light coupling and approximately 15 mg/cm^2 zinc sulfide scintillator (Alph-A-Cal"*). Aluminized "Mylar" was again used to lightproof the detector.

Alpha sources were of ^{239}Pu because the maximum permissible concentration of this isotope in air (2 x 10^{-12} μCi/cc) is lower than that for other alpha emitters handled at Savannah River Laboratory. The sources were plated in 2.5-inch-diameter circles on 3-inch-diameter stainless steel discs, with activities ≥3 x 10^3 dis/min. The 10,000 c/m range was used for these tests because radon-thoron activity varied from 600 to 2300 dis/min (2 to 10% of scale) and a 30 mR/hr gamma field increased the reading about 5% of scale on this range. The lowest source activity available was equivalent to 20 x 10^{-12} μCi/cc. The monitor readily detected this activity in the presence of maximum background, yielding an increased reading of about 12% of scale.

Service Record

Fourteen air monitors have been fabricated and placed in service at Savannah River Laboratory, one for beta and the others for alpha monitoring. All have performed satisfactorily,[3] and on several occasions radioactive releases have been detected in ample time to prevent contamination of personnel.

*Tradename of material by Greydon Co., Williston, S. C.

REFERENCES

1. W. J. Woodward. *A Transistorized Photomultiplier Probe with a Stacked Emitter Follower.* USAEC Report DP-786, E. I. du Pont de Nemours and Co., Savannah River Laboratory, Aiken, S. C. (1962).

2. W. J. Woodward. *Solid State Plug-In Circuits as Instrument Building Blocks.* USAEC Report DP-1079, E. I. du Pont de Nemours and Co., Savannah River Laboratory, Aiken, S. C. (1967).

3. R. A. Moyer. "Savannah River Experience with Transplutonium Elements." *Health Phy.* **15**, 133 (1968).