63-3-2

USAELRDL Technical Report 2342

THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES

Basil Markow

March 1963

UNITED STATES ARMY
ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, N.J.

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

March 1963

Technical Report 2342 has been prepared under the supervision of the Institute for Exploratory Research, and is published for the information and guidance of all concerned. Suggestions or criticisms relative to the form, contents, purpose, or use of this publication should be referred to the U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey, Attn: Director, Exploratory Research Division "S".

J. M. KIMBROUGH, JR.
Colonel, Signal Corps
Commanding

OFFICIAL:
HOWARD W. KILLAM
Major, SigC
Adjutant

DISTRIBUTION:
Special

THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES

Basil Markow

DA TASK 3A99-25-003-02-02

ABSTRACT

The need for a readily available gamma detector, capable of measuring the highly intense and rapidly changing fluxes of pulse sources, is filled with the use of a commercially available off-the-shelf item, the vac ion gauge, and an easily constructed cable connector.

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY

FORT MONMOUTH, NEW JERSEY

CONTENTS

FIGURES

THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES

INTRODUCTION

In recent years the investigation of nuclear radiation effects on various electronic components and materials has led to the use of more and more intense sources of nuclear radiation. Many of these sources are pulsed with very rapidly changing pulse profiles. In order to be able to relate the effect with intensities, it is necessary to have an accurate flux detector, one that will follow the flux changes too.

Since the standard sources for the calibration of radiation detectors are constant and many orders of magnitude less in intensity than the sources needed for experiments, the detector response must not saturate and must be able to follow rapid changes. Such a device was designed by Dr. S. Kronenberg[1] (SEMIRAD).

THEORY

The SEMIRAD detector is basically a vacuum diode. Secondary electrons emitted from the cathode (wall) are collected on the center electrode (anode). These secondary electrons are emitted from a surface whenever a high energy electron or ion either leaves or strikes the surface. A collection voltage of several hundred volts is sufficient to collect most of the secondary electrons.

A pure gamma flux will interact with the cathode to produce Compton electrons, photoelectrons, and electron positron pairs. No ions will be emitted from the wall.

A pure neutron flux can interact with the cathode walls in a nuclear reaction providing the wall material has a sufficient cross section for the energy of the incident neutrons. If the wall material is properly chosen the device will be neutron insensitive. Aluminum, titanium, and in fact most common metals fall into this class. However, titanium was found to be the best material with which to build a gamma SEMIRAD because of its good vacuum and mechanical properties.

Clearly, the only limitation on secondary electron emission from the cathode would be space charge limitations[2], and since the sensitivity of this detector is very low, about 10^{-16} amp/r/hr/cm^2, the current is proportional to gamma intensity up to 7×10^{14} r/hr with 100 volts on the anode of an instrument with a 30 cm^2 cathode.

As far as response to fluctuations in radiation intensity, it is limited only by the time of flight of electrons. This is about 10^{-9} seconds for the average detectors.

PROCEDURE

The two main problems with the experimental models fabricated until now have been: a) keeping the pressure in the detector below 10^{-6} mm Hg, and b) preventing secondary ionization chambers and cable leakage from swamping the actual signal.

In order to provide experimenters with a reliable interim instrument, various vacuum devices which contained electrodes were investigated. Although many were found suitable, the vac ion pumps[3,4] produced by Varian Associates in Palo Alto, California, were found to be the easiest to adapt. Two sizes were used: the .2 liter/sec pump and the 1 liter/sec pump. Figure 1 is a cross section of the .2 ℓ/s pump. No drawing of the 1 ℓ/s pump was made but it is known to possess an "egg crate" type of center electrode. The shape of this electrode does not affect the signal in any way. Figures 2 and 3 are photographs of the .2 ℓ/s and the 1 ℓ/s pump. Both of these pumps can be purchased already evacuated to about 10^{-6} mm Hg and the copper nipple sealed permanently. By applying a high voltage to the center electrode and using the permanent magnet, the pressure in the pump can be measured. When used as a SEMIRAD, a much lower voltage is applied and the magnet is not utilized.

With the vacuum problem out of the way, the only remaining problem was the design of a cable connector that would eliminate secondary ionization chambers. Figure 4 is a cross section of the assembled connector for a .2 ℓ/s pump, and Fig. 5 is a detailed drawing of the parts of the connector giving dimensions. Any small machine shop can easily fabricate the components. To mount the connector on the cable, the cable is stripped back and the connector assembled as in Fig. 4. The cable braid, however, is left unconnected. The connector is then inverted and locked in a bench vise. The cable is supported so it will not move. Potting mixture is poured in through the 1/2"-diameter hole around the cable insulation. After allowing the Hysol to harden overnight, the cable braid can be properly connected. The pump's ceramic insulator makes a vacuum tight seal to the "O" ring. This connector is satisfactory for microsecond changes in gamma intensity. However, for more rapid changes the cavity between the center pin and the "O" ring should be filled with silicone grease. A similar connector with larger dimensions can be made for the 1 ℓ/s pump.

Other connectors have also been devised. For example, pressure type BNC connectors (Amphenol 31-850) and General Radio Type 874's have been potted to both detector and cable. Although these proved satisfactory, they will not be considered in this report since more care is needed to prevent secondary ionization chambers than with the special connector above.

Figure 6 is a wiring diagram for using the vac ion pump as a SEMIRAD detector. The current measuring instrument can be a Keithley d.c. amplifier for low, constant intensity sources, or a properly terminated oscilloscope for high intensity rapidly changing fields. Calibration is usually performed by exposing the detector to X-rays of a known intensity and measuring the current with a Keithley. The wall of the pump in this schematic is shown positive, which would make the center electrode the emitter. Since the response is proportional to the area of the emitter, the detector could be made more sensitive by making the wall negative. In vac ion pumps, the area of the center electrode is nearly the same as the wall so the increase in sensitivity would be small. In other SEMIRADS, the center electrode is much smaller and the wall is almost always made negative.

RESULTS

Figures 7 and 8 are response curves for a .2 ℓ/s and a 1 ℓ/s pump exposed to 6 x 10^4 r/hr X-ray. The voltage was varied to show the plateau. This plateau remains the same even for very high intensities. It is recommended that individual instruments be calibrated before being used as detectors.

REFERENCES

1. Kronenberg, S. and H. M. Murphy, Jr., USASRDL Memo Rept, 10 Oct 1958.

2. Langmuir, I., Phys. Rev. 21 419 (1923).

3. Hall, L. D., Rev. Sci. Instr. 29 347 (1958).

4. Jepsen, R. L., A. B. Francis, and S. L. Rutherford, "Stabilized Air Pumping with Diode Type Getter-Ion Pumps," Varian Associates, Palo Alto, California.

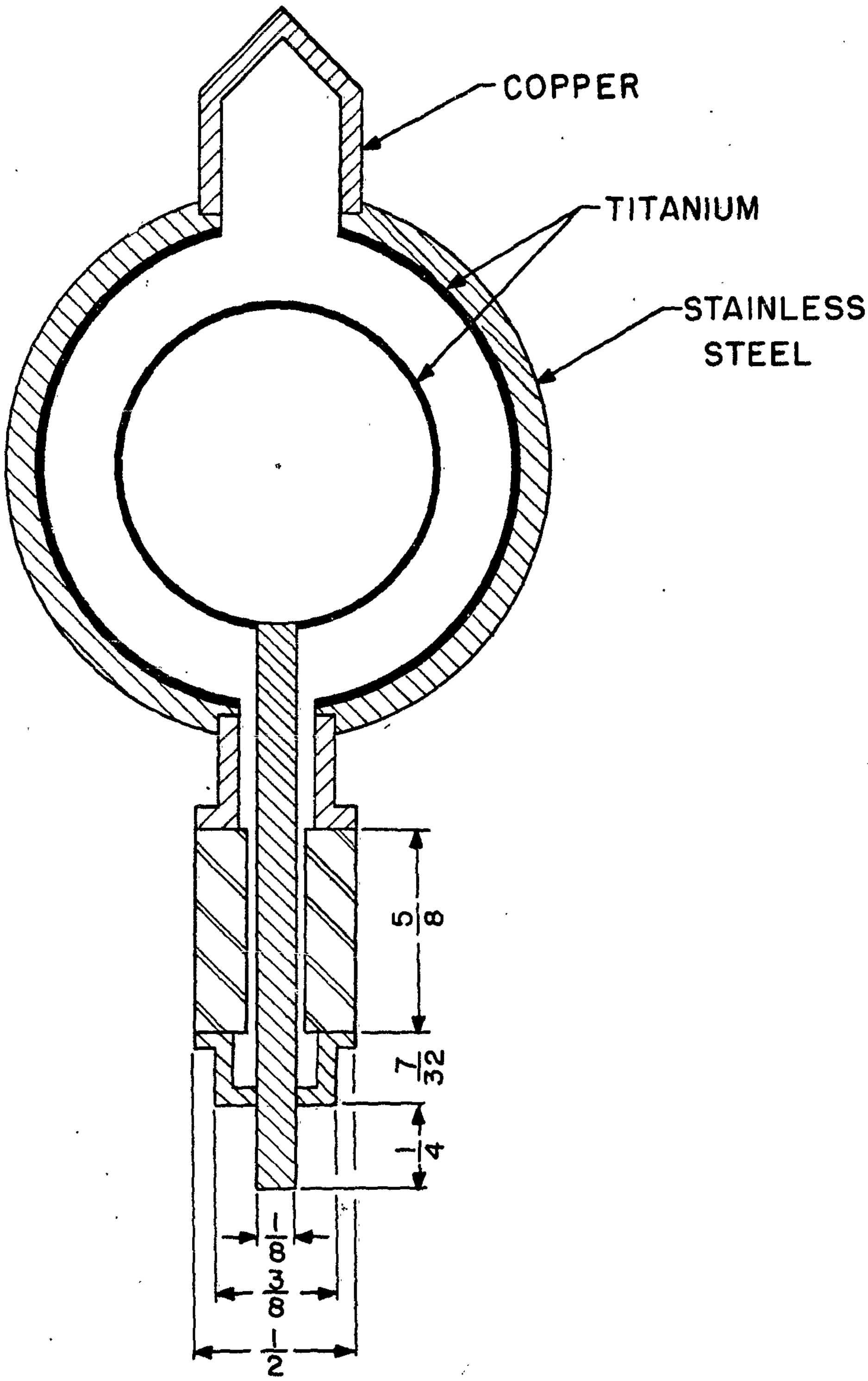

FIGURE 1. CROSS SECTION OF .2 ℓ/s VAC ION PUMP

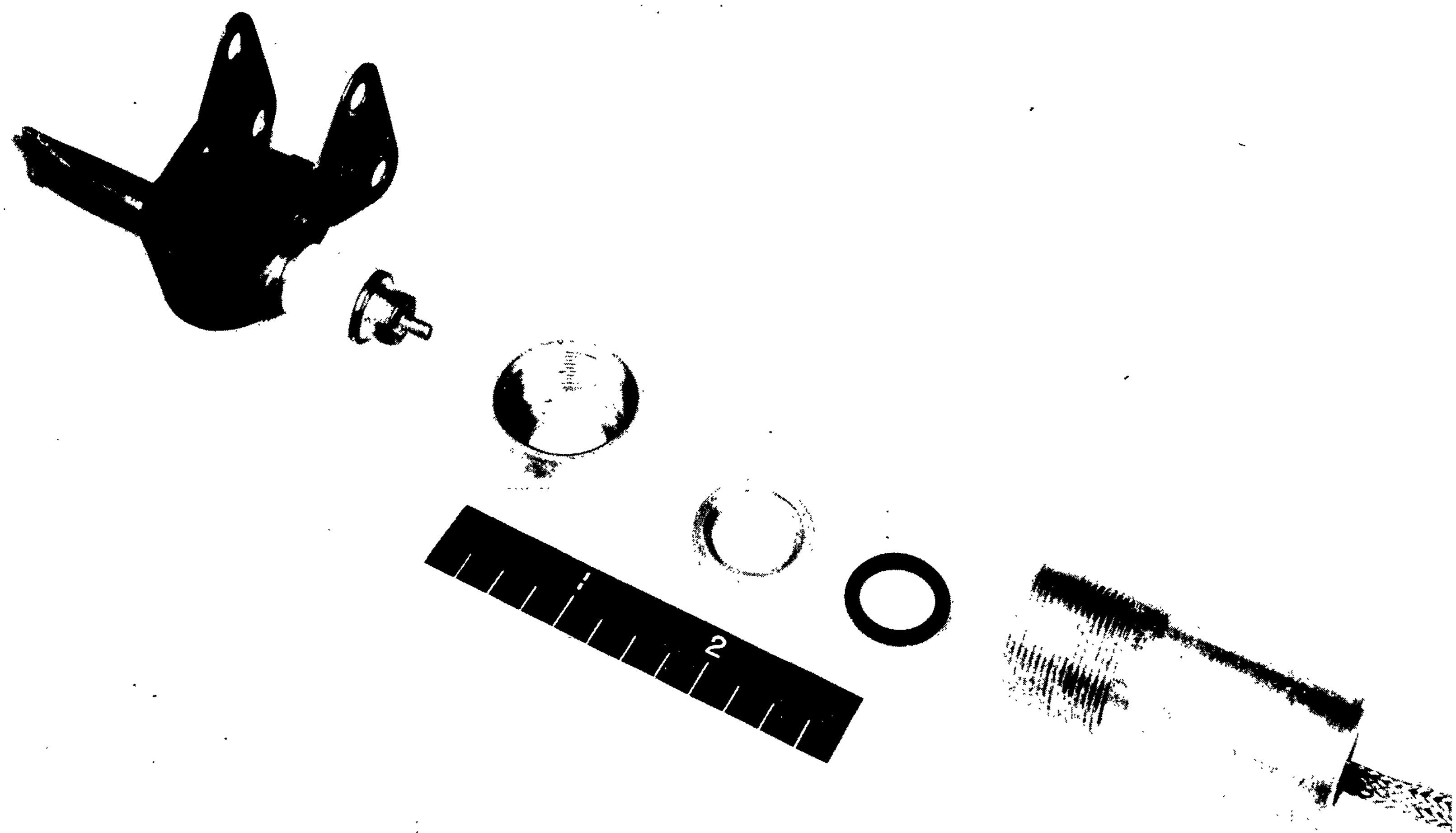

FIGURE 2. .2 ℓ/s VAC ION PUMP SEMIRAD

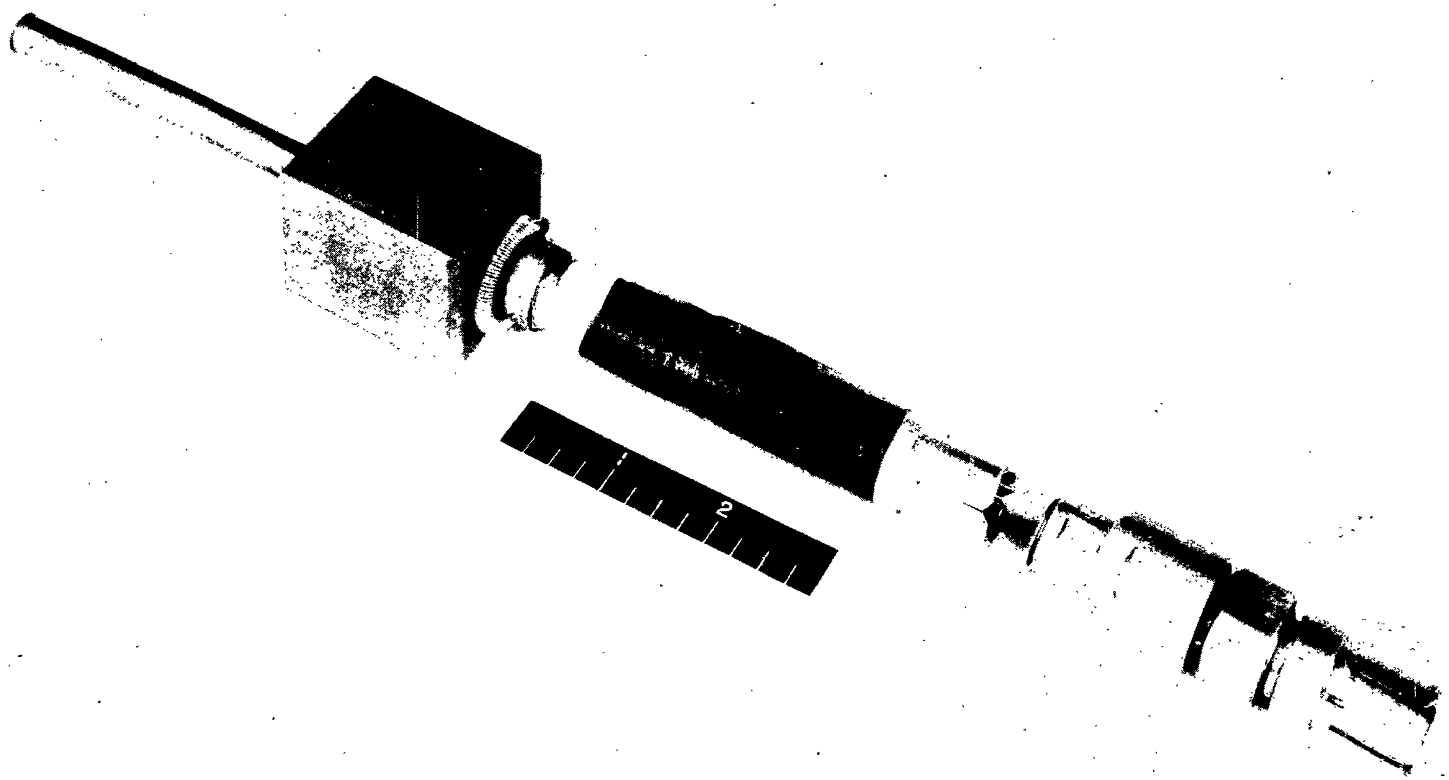

FIGURE 3. 1 ℓ/s VAC ION PUMP SEMIRAD

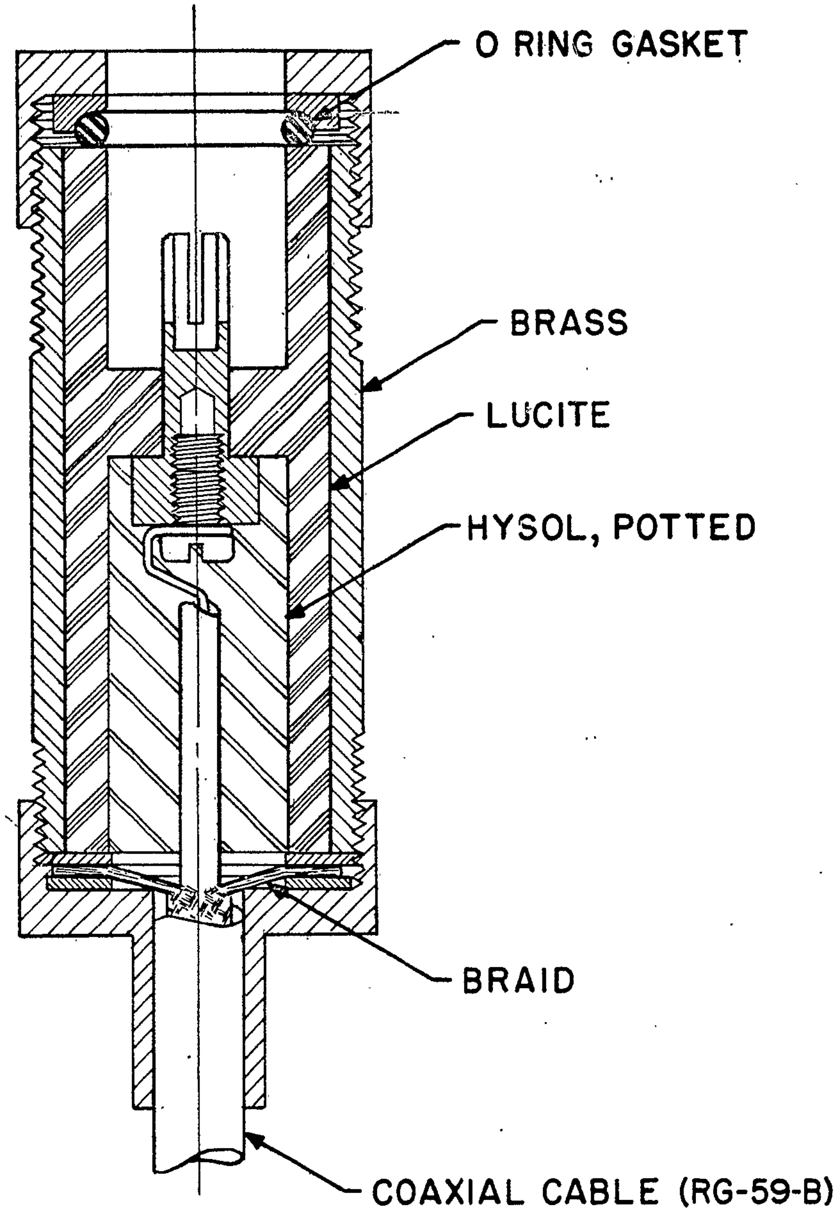

FIGURE 4. ASSEMBLY OF .2 ℓ/s VAC ION PUMP SEMIRAD CABLE CONNECTOR

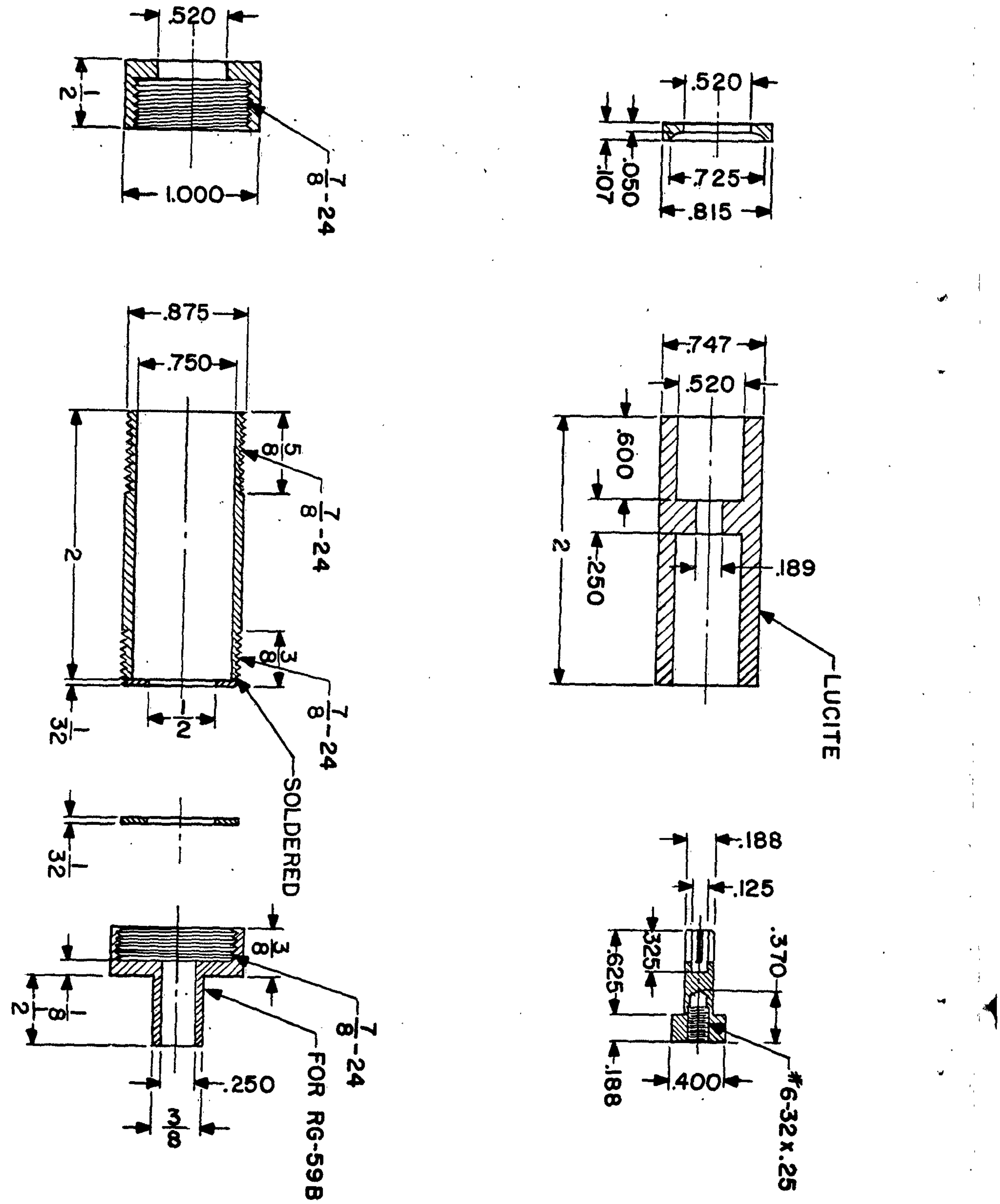

FIGURE 5. DETAILS OF .2 ℓ/s SEMIRAD CABLE CONNECTOR

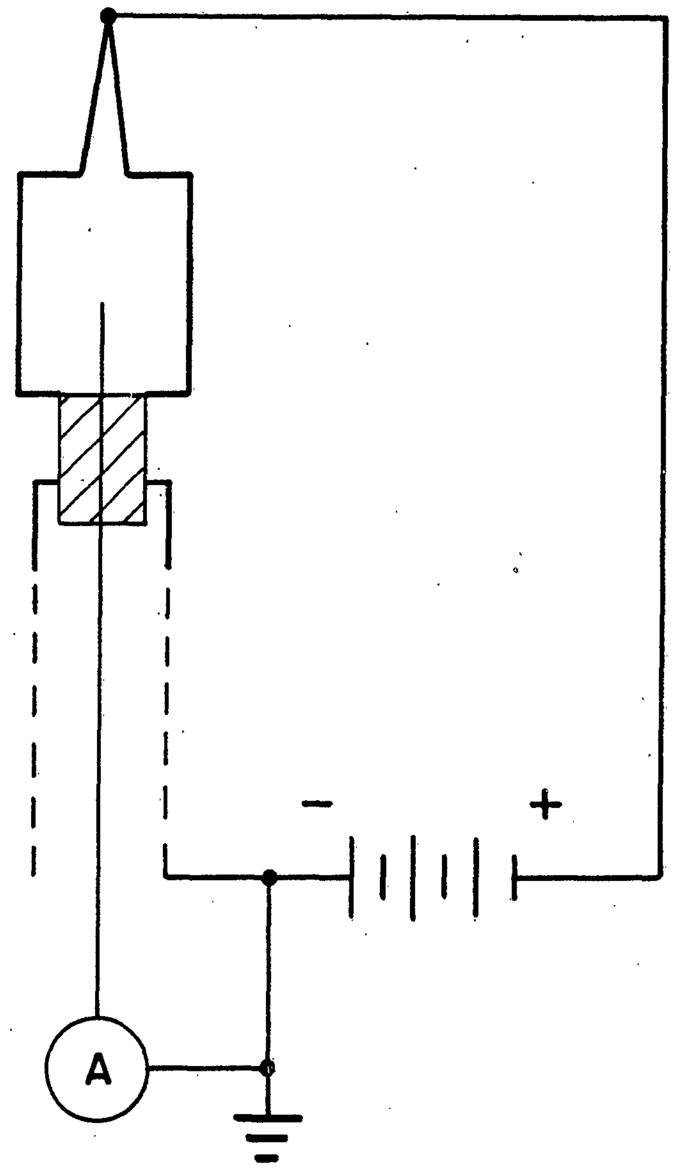

FIGURE 6. WIRING DIAGRAM FOR USING THE VAC ION PUMP AS A SEMIRAD DETECTOR

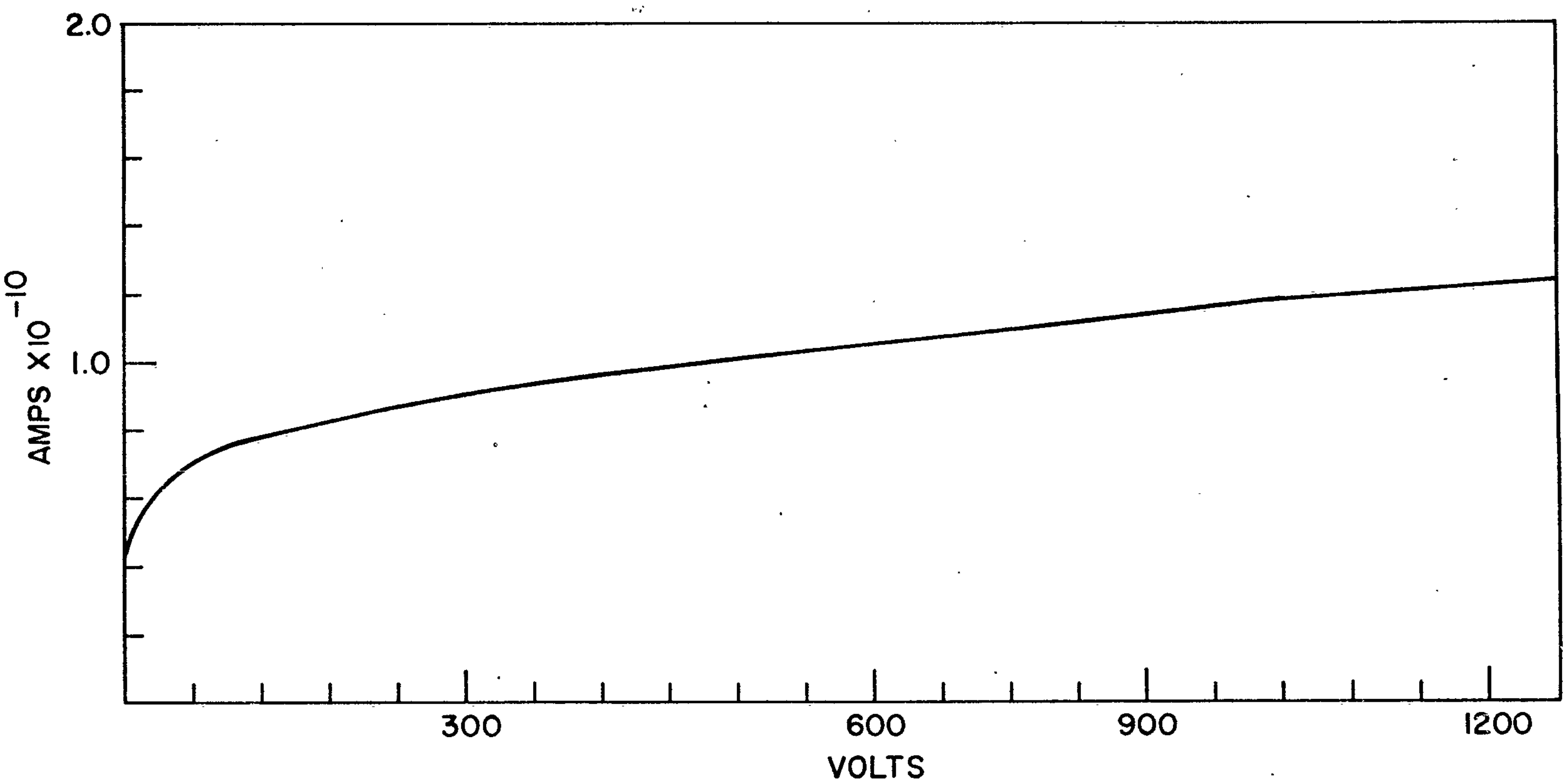

FIG. 7 RESPONSE OF 1 ℓ/s VAC ION PUMP TO 250 KV X-RAYS (6×10^4 R/HR)

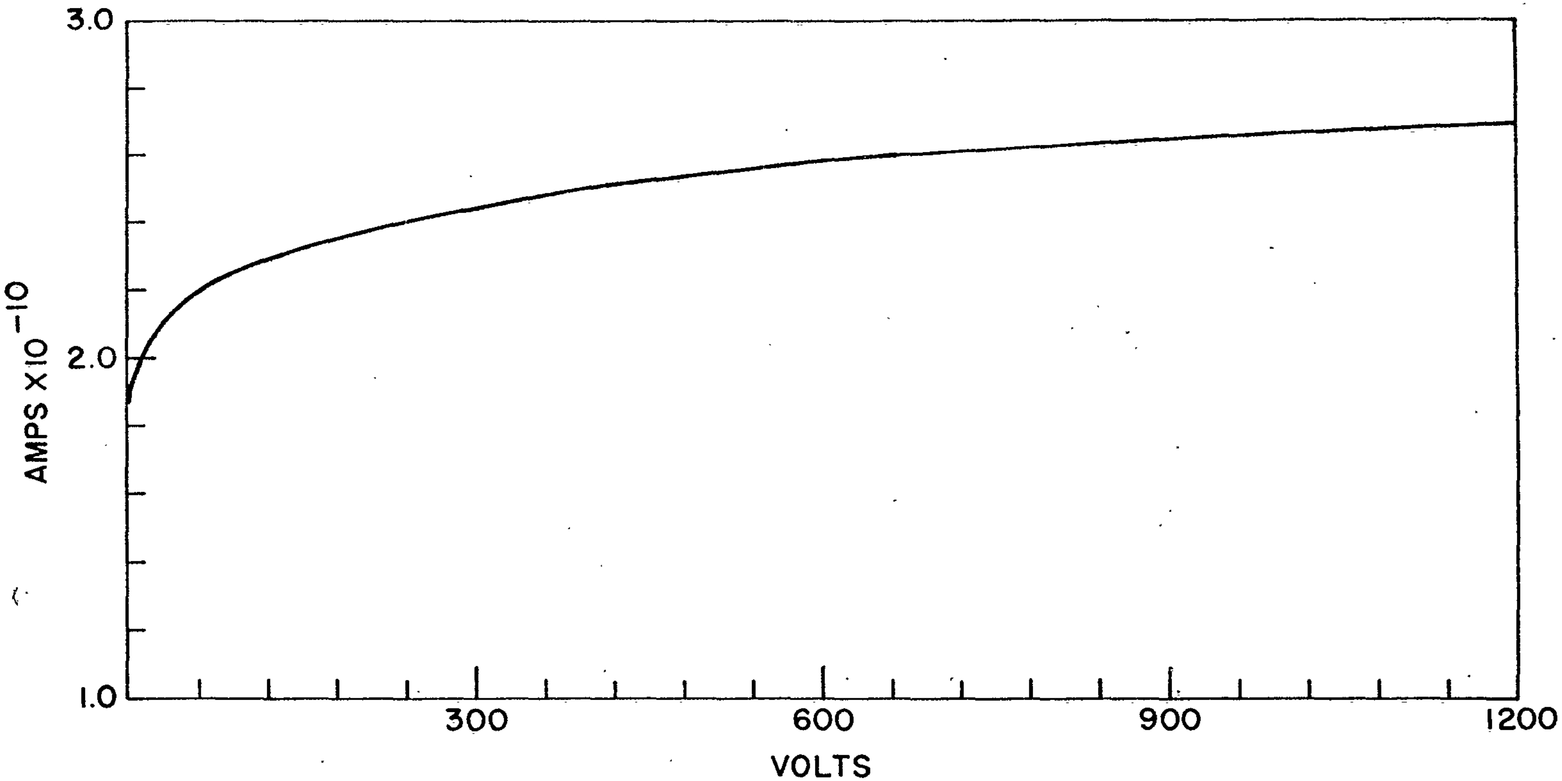

FIG. 8 RESPONSE OF .2 ℓ/s VAC ION PUMP TO 250KV X-RAYS (6×10^4 R/HR)

DISTRIBUTION

	COPIES
Office of the Assistant Secretary of Defense (Research and Engineering) ATTN: Technical Library Room 3E1065, The Pentagon Washington 25, D. C.	1
Commanding General U. S. Army Electronics Command ATTN: AMSEL-AD Fort Monmouth, New Jersey	3
Chief of Research and Development Department of the Army Washington 25, D. C.	2
Chief, United States Army Security Agency ATTN: ACofS, G4 (Technical Library) Arlington Hall Station Arlington 12, Virginia	1
Commanding Officer U. S. Army Electronics Research & Development Activity ATTN: Technical Library Fort Huachuca, Arizona	1
Commanding Officer U. S. Army Electronics Research & Development Activity ATTN: SELWS-AJ White Sands, New Mexico	1
Commanding Officer U. S. Army Electronics Research Unit P. O. Box 205 Mountain View, California	1
Commanding Officer U. S. Army Electronics Materiel Support Agency ATTN: SELMS-ADJ Fort Monmouth, New Jersey	1
Headquarters, United States Air Force ATTN: AFCIN Washington 25, D. C.	2
Rome Air Development Center ATTN: RAALD Griffiss Air Force Base, New York	1

DISTRIBUTION

	COPIES
Ground Electronics Engineering Installation Agency ATTN: ROZMEL Griffiss Air Force Base, New York	1
Aeronautical Systems Division ATTN: ASAPRL Wright-Patterson Air Force Base, Ohio	1
U. S. Air Force Security Service ATTN: ESD San Antonio, Texas	1
Strategic Air Command ATTN: DOCE Offutt Air Force Base Nebraska	1
Air Proving Ground Center ATTN: PGAPI Eglin Air Force Base, Florida	1
Air Force Cambridge Research Laboratories ATTN: CRXL-R Laurence G. Hanscom Field Bedford, Massachusetts	2
AFSC Scientific/Technical Liaison Office U. S. Naval Air Development Center Johnsville, Pa.	1
Chief of Naval Research ATTN: Code 427 Department of the Navy Washington 25, D. C.	1
Bureau of Ships Technical Library ATTN: Code 312 Main Navy Building, Room 1528 Washington 25, D. C.	1
Chief, Bureau of Ships ATTN: Code 454 Department of the Navy Washington 25, D. C.	1
Hq, Electronic Systems Division ATTN: ESAT Laurence G. Hanscom Field Bedford, Massachusetts	2

DISTRIBUTION

	COPIES
Chief, Bureau of Ships ATTN: Code 686B Department of the Navy Washington 25, D. C.	1
Director U. S. Naval Research Laboratory ATTN: Code 2027 Washington 25, D. C.	1
Commanding Officer & Director U. S. Navy Electronics Laboratory ATTN: Library San Diego 52, California	1
Commander U. S. Naval Ordnance Laboratory White Oak Silver Spring 19, Maryland	1
Director U. S. Army Engineer Research & Development Laboratories ATTN: Technical Documents Center Fort Belvoir, Virginia	1
Commanding Officer U. S. Army Chemical Warfare Laboratories ATTN: Technical Library, Building 330 Army Chemical Center, Maryland	1
Commander Armed Services Technical Information Agency ATTN: TISIA Arlington Hall Station Arlington 12, Virginia	20
USAELRDL Liaison Officer U. S. Army Tank-Automotive Center Detroit Arsenal Center Line, Michigan	1
Commanding Officer Harry Diamond Laboratories ATTN: Library, Bldg. 92, Room 211 Washington 25, D. C.	1
USAELRDL Liaison Officer Naval Research Laboratory ATTN: Code 1071 Washington 25, D. C.	1

DISTRIBUTION

	COPIES
USAELRDL Liaison Officer Massachusetts Institute of Technology Building 26, Room 131 77 Massachusetts Avenue Cambridge 39, Massachusetts	1
USAELRDL Liaison Office Aeronautical Systems Division ATTN: ASDL-9 Wright-Patterson Air Force Base Ohio	1
U. S. Army Research Liaison Office Lincoln Laboratory P. O. Box 73 Lexington, Massachusetts	1
USAELRDL Liaison Officer Rome Air Development Center ATTN: RAOL Griffiss Air Force Base New York	1
Chief Scientist U. S. Army Electronics Command Attn: AMSEL-SC Fort Monmouth, N. J.	1
USAEMSA Liaison Engineer USASCAJ A.P.O. 343 San Francisco,California	1
Technical Dir., SELRA/CS, Hq, USAELRDL	1
USAELRDA-White Sands Liaison Office, SELRA/LNW, USAELRDL	1
Corps of Engineers Liaison Officer, SELRA/LNE, USAELRDL	1
Marine Corps Liaison Officer, SELRA/LNR, USAELRDL	1
U. S. Army Combat Developments Command Liaison Office, SELRA/LNF USAELRDL	2
Commanding Officer, U. S. Army Security Agency Processing Center Fort Monmouth, N. J.	1
Chief, Technical Information Division, Hq, USAELRDL	6
USAELRDL Technical Documents Center, Hexagon	1

DISTRIBUTION

	COPIES
Commanding General U. S. Army Materiel Command ATTN: R&D Directorate Washington 25, D. C.	2
Director, Institute for Exploratory Research, USAELRDL	1
File Unit (XS) Evans Area	1
Technical Staff, IER	50
Commanding General, U. S. Army Satellite Communications Agency ATTN: Technical Documents Center, Fort Monmouth, N. J.	1
Air Force Systems Command Scientific/Technical Liaison Office SELRA/LNA, USAELRDL	1
Hq, Research and Technology Division ATTN: RTH Boiling AF Base Washington 25, D. C.	1
USAELRDL Liaison Office USA Combat Developments Command ATTN: CDCLN-EL Fort Belvoir, Virginia	1

Army-Ft Monmouth,NJ-1087-63

AD ______________ Div. ________________

Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES, by Basil Markow,
March 1963, 11p. incl. illus. 4 ref.
(USAELRDL Technical Report 2342) (DA Task 3A99-25-003-02-02) Unclassified Report

The need for a readily available gamma detector, capable of measuring the highly intense and rapidly changing fluxes of pulse sources, is filled with the use of a commercially available off-the-shelf item, the vac ion gauge, and an easily constructed cable connector.

UNCLASSIFIED

1. SEMIRAD
2. Vac ion gauge
3. Gamma measurement high intensity

I. Markow, Basil
II. Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
III. DA Task 3A99-25-003-02-02

UNCLASSIFIED

AD ______________ Div. ________________

Army Electronics esearch a Development Laboratory, Fort onmouth, . J.
THE MEASUREMENT HIGH INT ISITY GAMMA FLUXES WITH VAC ION GAU S, by Bas Markow,
March 1963, 11p. ncl. illu , 4 ref.
(USAELRI Technical Report 2342) (DA Task 3A99-25-003-02-C) Unclassified Report

The need for a r dily avai able gamma detector, capable of measu ng the hi ly intense and rapidly changing fl es of pul sources, is filled with the use of commercia y available off-the-shelf item, the c ion gau , and an easily constructed cable c nnector.

UNCLASSIFIED

1. SEMIRAD
2. Vac ion gauge
3. Gamma measurement high intensity

I. Markow, Basil
II. Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
III. DA Task 3A99-25-003-02-02

UNCLASSIFIED

AD ______________ Div. ________________

Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES, by Basil Markow,
March 1963, 11p. incl. illus. 4 ref.
(USAELRDL Technical Report 2342) (DA Task 3A99-25-003-02-02) Unclassified Report

The need for a readily available gamma detector, capable of measuring the highly intense and rapidly changing fluxes of pulse sources, is filled with the use of a commercially available off-the-shelf item, the vac ion gauge, and an easily constructed cable connector.

UNCLASSIFIED

1. SEMIRAD
2. Vac ion gauge
3. Gamma measurement high intensity

I. Markow, Basil
II. Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
III. DA Task 3A99-25-003-02-02

UNCLASSIFIED

AD ______________ Div. ________________

Army Electronics Research a d Development Laboratory, Fort Monmouth, . J.
THE MEASUREMENT F HIGH INT NSITY GAMMA FLUXES WITH VAC ION GAU ES, by Bas l Markow,
March 1963, 11p. incl. illu . 4 ref.
(USAELRI Technical Report 2342) (DA Task 3A99-25-003-02-C) Unclassified Report

The need for a r adily avai able gamma detector, capable of measu ing the hi ly intense and rapidly changing fl es of pul sources, is filled with the use of commercia ly available off-the-shelf item, the c ion gau , and an easily constructed cable c nnector.

UNCLASSIFIED

1. SEMIRAD
2. Vac ion gauge
3. Gamma measurement high intensity

I. Markow, Basil
II. Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.
III. DA Task 3A99-25-003-02-02

UNCLASSIFIED