NRC FORM 313
(1-84)
10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB
3150-0120
Expires 8-31-87

# APPLICATION FOR MATERIAL LICENSE

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

FEDERAL AGENCIES FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS, IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIAL SECTION B
631 PARK AVENUE
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
MATERIAL RADIATION PROTECTION SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
MATERIAL RADIATION PROTECTION SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR (Check appropriate item)

[XX] A. NEW LICENSE
[ ] B. AMENDMENT TO LICENSE NUMBER _____
[ ] C. RENEWAL OF LICENSE NUMBER _____

2. NAME AND MAILING ADDRESS OF APPLICANT (Include Zip Code)

Toshiba America, Inc.
9740 Irvine Blvd.
Irvine, CA 92718
(714) 583-3515

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

See 2., above

8806290150 871116
NMSS LIC30
04-23699-01E PDR

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

Joel S. Winnik, Hogan & Hartson

555 13th St., N.W.
Washington, D.C. 20004

TELEPHONE NUMBER: (202) 637-5857

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time: See Appendix, p. 7

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED: See Appendix, p. 7

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE: Not Applicable

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS: See Appendix, p. 6

9. FACILITIES AND EQUIPMENT: See Appendix, p. 5

10. RADIATION SAFETY PROGRAM: See Appendix, pp. 5 & 6

11. WASTE MANAGEMENT: See Appendix, p. 6

12. LICENSEE FEES (See 10 CFR 170 and Section 170.31)
FEE CATEGORY: 1. App.- New License
AMOUNT ENCLOSED: $290.00

13. CERTIFICATION (Must be completed by applicant) THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT NAMED IN ITEM 2 CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

| SIGNATURE—CERTIFYING OFFICER | TYPED/PRINTED NAME | TITLE | DATE |
|---|---|---|---|
| [signature] | Y. NISHIOKA | Director, Legal Services | 11/5/87 |

14. VOLUNTARY ECONOMIC DATA

a. ANNUAL RECEIPTS
[ ] < $250K
[ ] $250K - 500K
[ ] $500K - 750K
[ ] $750K - 1M
[ ] $1M - 3.5M
[ ] $3.5M - 7M
[ ] $7M - 10M
[ ] > $10M

b. NUMBER OF EMPLOYEES (Total for entire facility excluding outside contractors)

c. NUMBER OF BEDS

d. WOULD YOU BE WILLING TO FURNISH COST INFORMATION (dollar and/or staff hours) ON THE ECONOMIC IMPACT OF CURRENT NRC REGULATIONS OR ANY FUTURE PROPOSED NRC REGULATIONS THAT MAY AFFECT YOU? (NRC regulations permit it to protect confidential commercial or financial—proprietary—information furnished to the agency in confidence)
[ ] YES 8806290150 [ ] NO

FOR NRC USE ONLY

| TYPE OF FEE | FEE LOG | FEE CATEGORY | COMMENTS | APPROVED BY |
|---|---|---|---|---|
| App | Nov-1-HQs | 3I | 020354 | M. Nissin |
| AMOUNT RECEIVED | CHECK NUMBER | | | DATE |
| $290 | 001087 | | | 11/6/87 |

PRIVACY ACT STATEMENT ON THE REVERSE

TOSHIBA AMERICA, INC.
APPENDIX TO SPECIFIC LICENSE FOR
EXEMPT BYPRODUCT MATERIAL

I. Background of Application

A. Type of Application

Toshiba America, Inc. (Toshiba America) is hereby formally requesting a specific license to initially transfer for sale or distribution in the United States products containing exempt byproduct material. This application is made pursuant to 42 U.S.C. §§ 2111 (1982) and 10 C.F.R. §§ 30.3, 30.15, and 32.14 (1987). The subject of this license is an electron tube in the form of a glow lamp. The tube is within the class of products specifically exempted from certain licensing requirements by operation of 10 C.F.R. § 30.15(a)(8) because it contains less than 5 microcuries of nickel-63 (Ni-63) and radiation levels do not exceed 1 millirad per hour at a distance of 1 centimeter when measured through 7 milligrams per square centimeter of absorber. Toshiba America requests that this license encompass the electron tube itself, a "main frame" unit containing the tube, and a facsimile machine containing the tube and main frame assembly.

B. Products to be Licensed

1. Electron Tube

The electron tube is designed to function as a glow lamp in a facsimile machine. Each tube contains a maximum of 0.32 microcuries of Ni-63. The Ni-63 is plated onto electrodes comprised mainly of nonradioactive nickel-58. There are two electrodes, one at each end of the tube. Each electrode contains a maximum of 0.16 microcuries Ni-63. The outer envelope of the electron tube consists of leaded glass, 0.49-0.61 mm. thick, which is fused to close each end and form a cylinder approximately 271 mm. long and 6 mm. in diameter. The electron tube will not operate if the seal is imperfect or the glass envelope is cracked or otherwise compromised. A hard plastic mounting cap, which nearly completely covers each electrode, is attached to each end of the tube. A wiring harness completes the tube assembly.

2. The Main Frame

The tube is mounted in a subassembly called the main frame, which in turn is mounted as a unit into the facsimile machine. The main frame is a plastic and metal structure,

bearing the lamp, which functions as an assembly for storing the lamp and servicing the facsimile machine. The main frame is constructed so as to surround and protect the electron tube.

3. Facsimile Machine

The facsimile machine contains the main frame unit, including the electron tube. The facsimile encloses the tube within a hard plastic and metal shell comprised of the machine's outer casing and the main frame unit. This case further serves to protect the tube. When installed within the facsimile machine, the electron tube is visible only through two narrow slits designed to accommodate single sheets of paper.

C. Production and Shipping

The electron tube, main frame, and facsimile machine are imported by the applicant, Toshiba America. The facsimile machine and main frame are built in Japan by Toshiba Corporation, Toshiba America's parent company. The electron tube is built for Toshiba Corporation by Harison Electric Company, Ltd. (Harison), a subsidiary of Toshiba Corporation. The electrodes used in the tube are manufactured for Harison by Nemoto and Co. an unrelated company.

The electron tubes are initially distributed in the United States by Toshiba America. The company normally distributes the tubes as components of completed facsimile machines, but they may also be distributed as tubes alone or as main frames. Because tubes and main frames normally would be installed by service representatives, they are not expected to be distributed in those forms to users of the facsimile machines.

Toshiba America distributes the facsimile machines to dealers and distributors. The distributors include both Toshiba America locations and unrelated companies.

## II. Section 32.14 -- Requirements for Issuance of a Specific License for Distribution of Certain Items Containing Exempt Byproduct Material

### A. Section 32.14(a) -- General Requirements for Issuance of a Specific License (§30.33)

#### 1. Application for a Purpose Authorized by the Act.

The stated purpose of the Atomic Energy Act of 1954, as amended, (the Act) is to regulate the development of atomic energy so as to encourage its peaceful uses, 1/ including uses that will strengthen free competition in private enterprise, 2/ encourage the development of the atomic energy industry, 3/ and encourage maximum scientific and industrial progress. 4/ In

1/ 42 U.S.C. §§ 2011, 2013 (1982).
2/ 42 U.S.C. § 2011 (1982).
3/ 42 U.S.C. § 2012 (1982).
4/ 42 U.S.C. § 2013 (1982).

addition, section 2111 of the Act classifies "industrial use" as a useful application. Toshiba America's distribution of the electron tube makes effective industrial use of the byproduct material Ni-63 in a manner that facilitates modern electronic communications, constitutes a peaceful application of atomic energy, and strengthens free competition and private enterprise, thus encouraging both the further development of the atomic energy industry and maximum scientific and industrial progress within the meaning of the Act.

2. Adequate Equipment and Facilities

The applicant's electron tubes are tested individually by the manufacturer. They will not operate, and are rejected, if the glass envelope is not intact. The radiation emitted by the amount of Ni-63 on an electrode does not penetrate the intact glass tube.

The electron tubes are packed for shipping in cardboard and bubble wrap or other appropriate packaging designed to protect against breakage. Main frames and facsimile machines are similarly packed with appropriate protective material. As previously stated, the main frame and the facsimile increase the protection of the tube. A periodic random sample of electron tubes is subjected to vibration and shock tests designed to ensure the tubes will survive the conditions of shipping and handling. No tube has been known to break during such testing.

Toshiba America's warehouses have in-rack sprinkler systems, which are in full compliance with insurers' standards and offer exceptional protection against fire. The warehouses also incorporate modern security systems to prevent theft or tampering.

3. Training and Experience for Handling of Electron Tubes

Toshiba America has been in the electronics business for many years, and employees are experienced in the proper handling, shpping, and storage of electronic equipment requiring special care, such as electron tubes.

It should be noted that the Nuclear Regulatory Commission's (NRC) regulations recognize that electron tubes containing less than 5 microcuries of nickel-63 are iters of relatively small concern in terms of health and safety, since they are exempted from certain licensing requirements under 10 C.F.R. § 15(a)(8) (1987). Nevertheless, all Toshiba America personnel will be informed of the existence of byproduct material in the tubes and will receive instruction in proper handling of the tubes, including clean-up and disposal procedures in case of breakage. All waste disposal will meet or exceed NRC and applicable state regulations.

B. Section 32.14(b)(1) -- [Application Item 5] -- Radioactive Material

The radioactive material contained in the electron tube is nickel-63. The nickel-63 is a solid plated on an electrode composed of nickel-58 (non-radioactive). The maximum quantity per glow lamp is 0.32 microcuries.

C. Section 32.14(b)(2) -- [Application Item 6] -- Purpose for which Licensed Material will be Used

The licensed material will be contained in an electron tube which will function as glow lamp. The tube will be contained in a main frame that will in turn be contained in a facsimile machine. The tube, the main frame containing the tube and the facsimile machine containing the main frame may each be imported and distributed separately by Toshiba America.

D. Section 32.14(b)(2) -- Details of Construction

A drawing of the glow lamp is attached hereto as Attachment 1.

| | |
|---|---|
| Glass: | Lead glass |
| Dimensions: | As shown in drawing |
| Glass Thickness: | 0.49 - 0.61 mm |

Sealing is achieved by fusing the ends of the glass of each tube together utilizing heat followed by an annealing process.

A separate drawing of the main frame containing the glow lamp is attached as Attachment 2.

A separate drawing of the tube as contained in the facsimile unit is attached as Attachment 3.

E. Section 32.14(b)(3) -- Method of Containment or Binding

The nickel-63 is bound to the nickel-58 by means of electroplating.

For the details of the method of containment by means of the glass bulb, see Section D, above. In addition, hard plastic casing at each end of the electron tube protects each electrode in the extremely unlikely event of breakage of the bulb.

When contained in the facsimile machine or the main frame, the electron tubes are enclosed by the hard plastic and metal material of the finished facsimile product or the main frame. This enclosure would minimize or prevent any exposure to the environment in the extremely unlikely event of breakage of the bulb.

F. Section 32.14(b)(4) -- Procedures for and Results of Prototpe Testing

Harison subjects a random sample of glow lamps to a vibration test and a shock test in both the prototype and manufacturing stages. These tests are designed to replicate the most severe conditions likely to be encountered, i.e., shipping of the product. No break in the glow lamp has been experienced as a result of these tests, and consequently, there has been no release of the nuclear byproduct material to the environment.

Toshiba Corporation subjects each facsimile machine containing the glow lamp to a shock test in the prototype stage to ensure that the bulb will not break under the most severe conditions likely to be encountered.

G. Section 32.14(b)(5) -- Quality Control Procedures to be Followed in the Fabrication of Production Lots and Quality Control Standards

A schematic diagram showing all quality control procedures utilized by Harison in the fabrication of the electron tube is contained in Attachment 4. Harison subjects a random sample of the completed glow lamps to the shock and vibration tests described above. In addition, every lamp is test lighted by Harison. A lamp will not light if there is any break in the glass container.

With respect to the electrode itself, a random sample is undertaken by Nemoto and Co. of 10 in every 10,000 units to determine the amount of nickel-63 per electrode.

Toshiba Corporation test lights every electron tube as an individual electron tube, as contained in a main frame, and as contained in a facsimile unit before shipment to Toshiba America. Any electron tube not lighting, as in the case of a break in the glass container, would be rejected and returned to Harison. No such circumstance is known to have occurred.

Toshiba America will test light imported electron tubes as individual bulbs, as contained in a main frame and as contained in facsimile units, each such inspection to be conducted in accordance with §32.110(a). Any faulty electron tube will not be shipped and will be returned to Toshiba Corporation or disposed of, in every instance in accordance with applicable federal and/or state law.

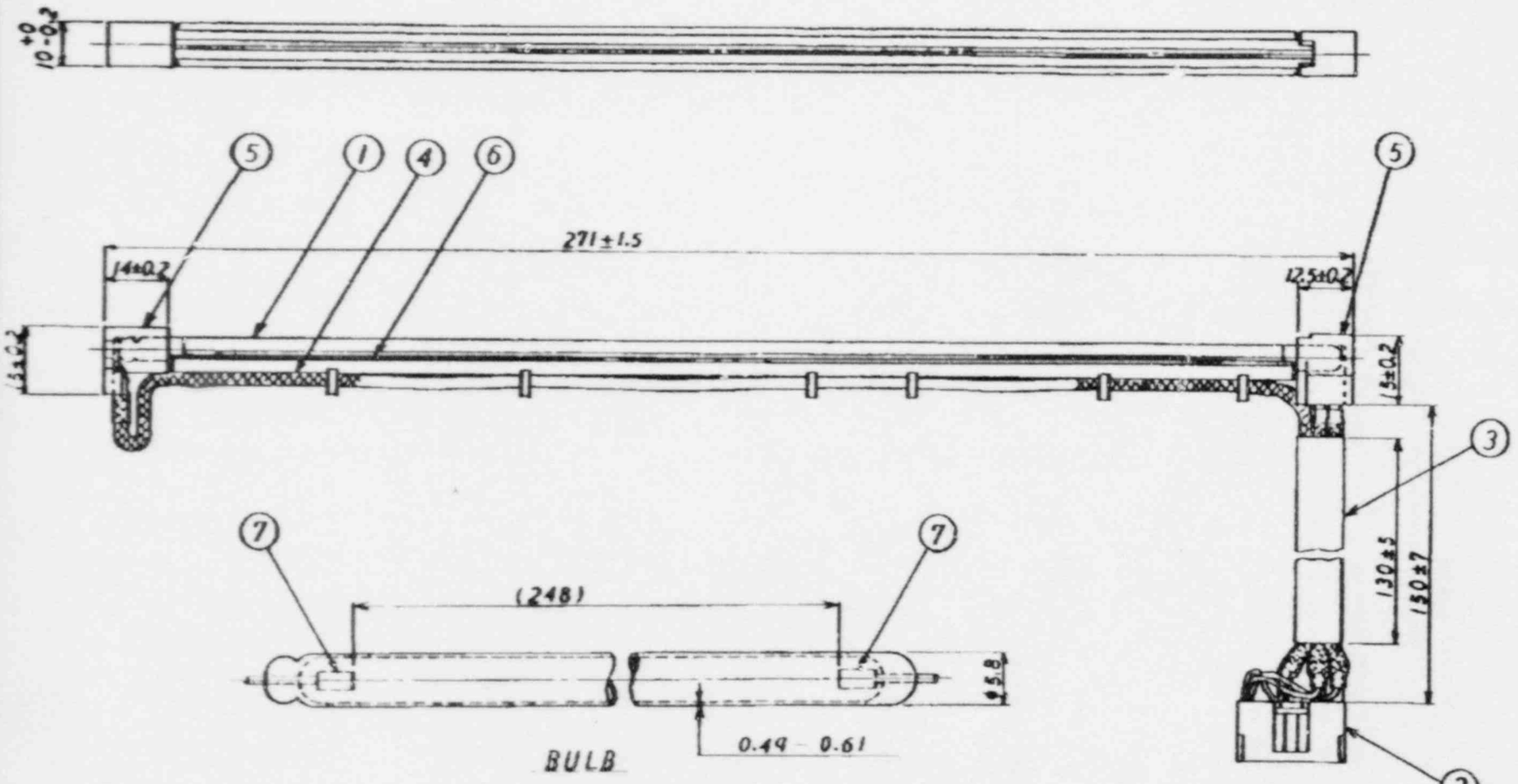
H. Section 32.14(b)(6) -- Labeling

Each electron tube individually and each electron tube within each facsimile unit or main frame will be labeled as follows:

Distributed by
Toshiba America, Inc.
Ni63

I. Section 32.14(b)(6) -- Radiation Level and Method of Measurement

The level of radiation from the electron tube both individually and as contained within each facsimile unit or within each main frame is zero. The level is measured with either of the following radiation measurement devices: Aloka, Model TDC-501 or Victoreen, Model 470A. A brochure for the Victoreen model is contained in Attachment 5.



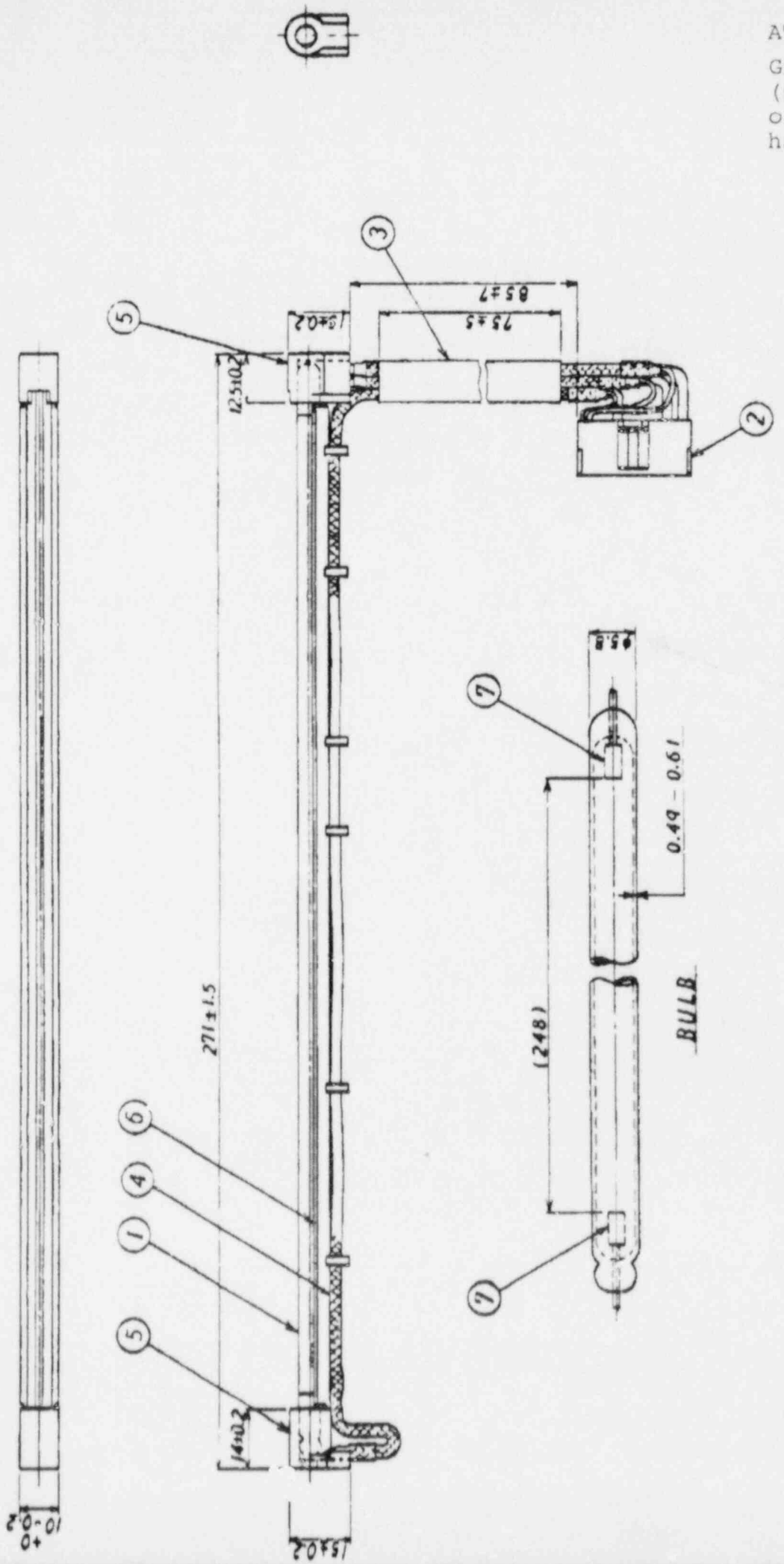

① BULB
② CONNECTOR
③ TUBE(Silicone)
④ WIRE
⑤ HOLDER
⑥ HOLDER
⑦ ELECTRODE(ø2×ℓ4)

ATTACHMENT 1
Glow Lamp
(two types of
wire harnesses)

H2

ATTACHMENT 1

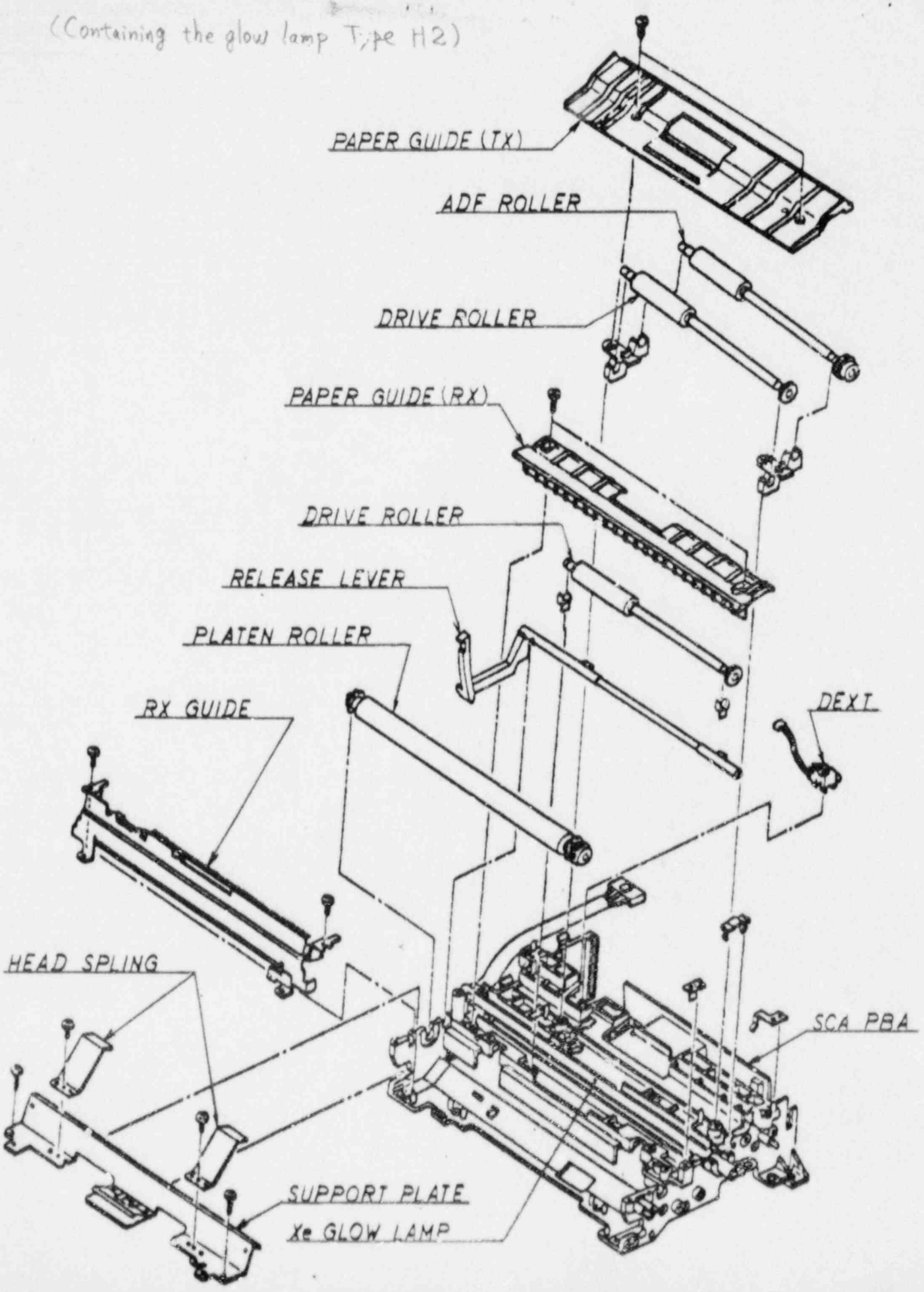
Glow Lamp
(two types
of wire
harnesses)




① BULB
② CONNECTOR
③ TUBE(Silicone)
④ WIRE
⑤ HOLDER
⑥ HOLDER
⑦ ELECTRODE(φ2×14)

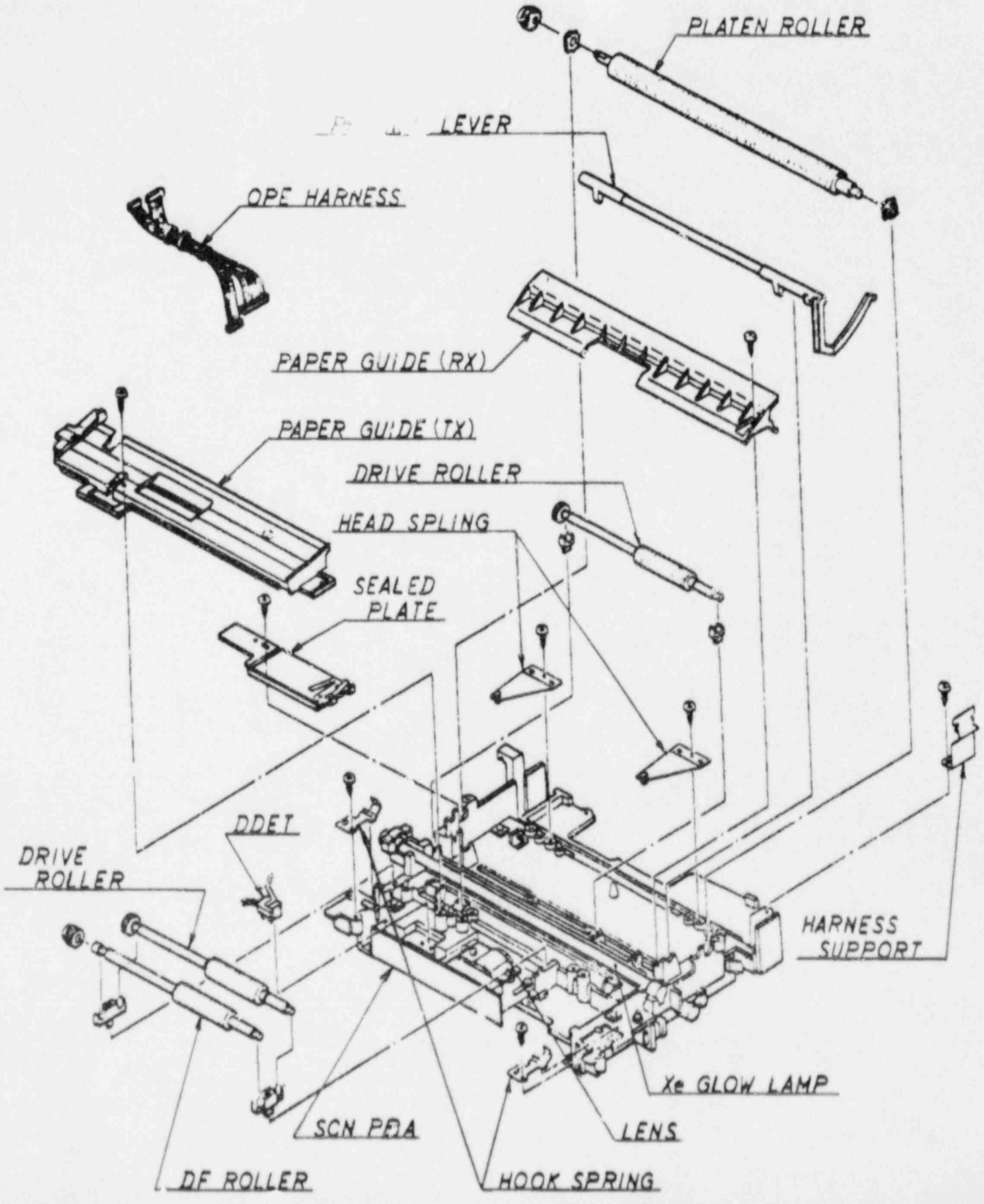
# MAIN FRAME UNIT

(Containing the glow lamp Type H2)



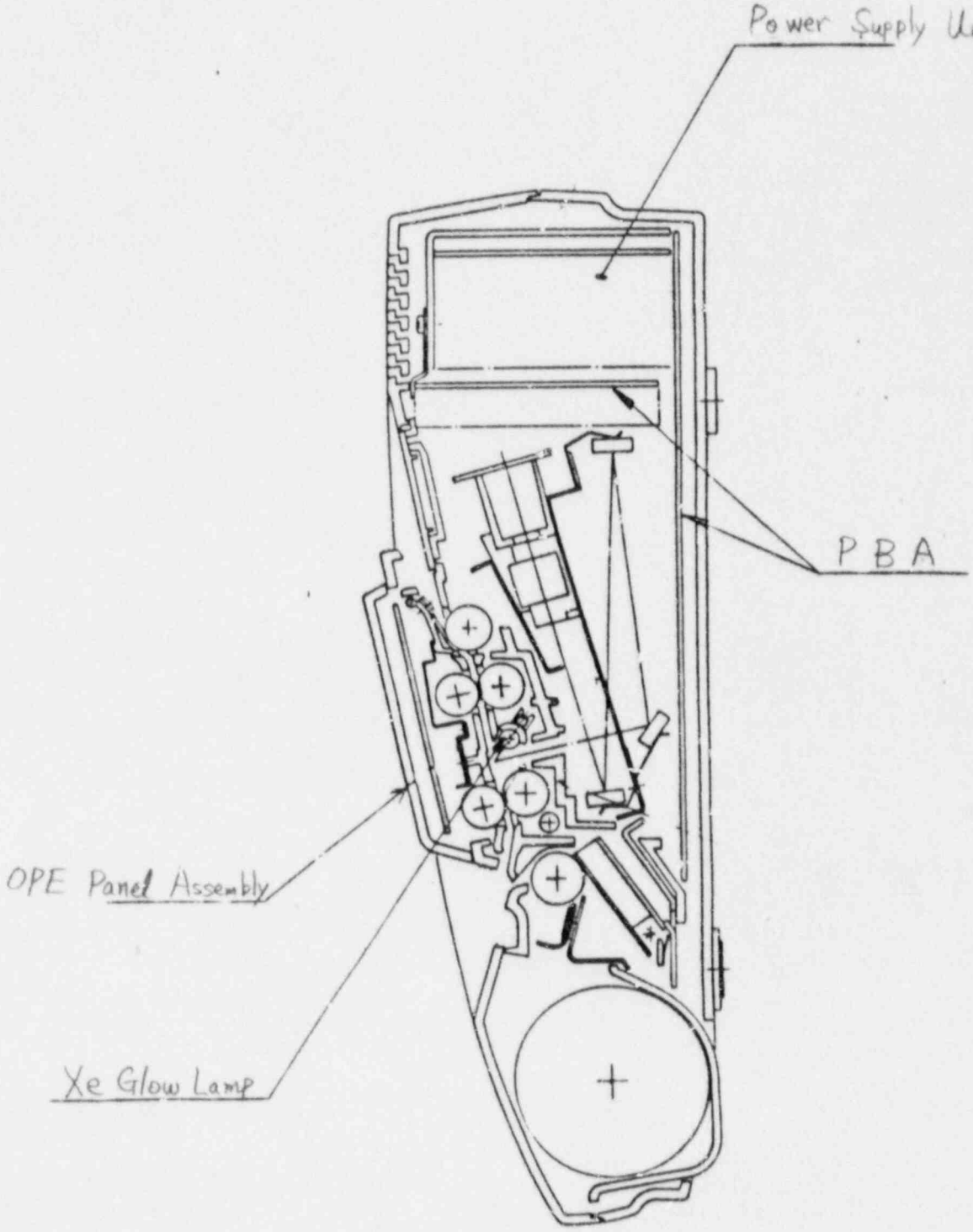
# MAIN FRAME UNIT

ow lamp Type H1)



ATTACHMENT 3

Facsimile machine
Type A containing
glow lamp



# CHAPTER 8 MECHANICAL DESCRIPTION

## 8.1 Configuration

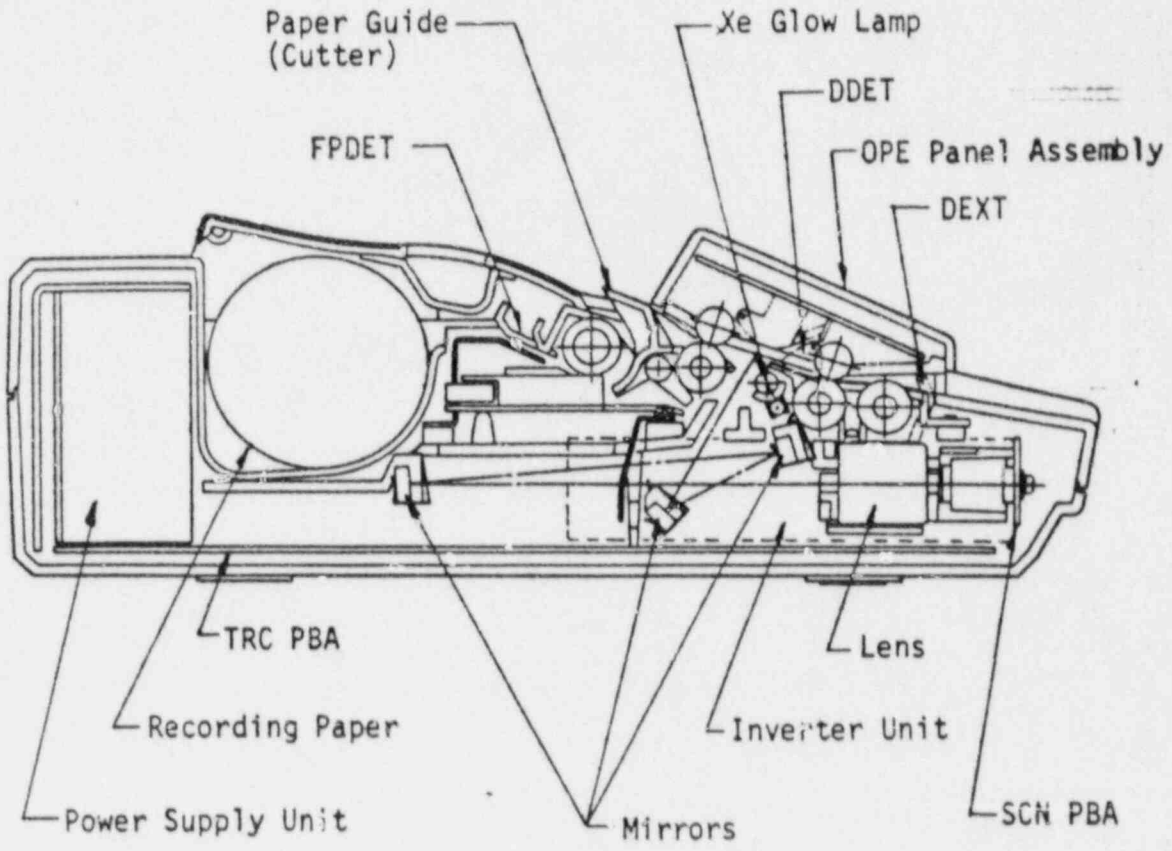



Fig. 8-1 Configuration Diagram

# TOSHIBA Xe Glow Lamp QUALITY CONTOROL PROCEDURES

| Flow Charal | Process | Control Item | Sampling | Testing Measure |
|---|---|---|---|---|
| | Glass Tube<br>Methanol | | | |
| | Tube Washing | | | |
| | Phospher | | | |
| | Phospher Coating | Drying Temp | At m/c start in morning | Thermometer |
| | Coating Inspection | Transmission | 2 pcs per 4 hour | Transmission device |
| | Baking | Oven Temp<br>Bulb Temp | At m/c start in morning | Thermometer<br>Temp Tape |
| | Electrode | | | |
| | Sealing | Appearance<br>Shape<br>Dimensions | 2 pcs per 4 hour<br>2 pcs per 4 hour<br>2 pcs per 4 hour | Visual<br>Visual<br>Scale |
| | Electrode | | | |
| | Glass Bead | | | |
| | Bead Mount Making | Appearance<br>Shape<br>Dimensions | 2 pcs per 4 hour<br>2 pcs per 4 hour<br>2 pcs per 4 hour | Visual<br>Visual<br>Scale |
| | Exhausting | Manifold Vacuum | At m/c start in morning | Vacuum Gauge |
| | Filling Gas | | | |
| | Gas Filling | Gas Pressure | At m/c start in morning | Pressure Gauge |
| | Aging | Voltage<br>Aging Time | At m/c start in morning | Voltmeter<br>Timer |
| | Aging Bulb Inspection | Lighting Status | All | Visual |
| | Electric Conductive Adhesive | | | |
| | Printing | Appearance<br>Dimensions | 2 pcs at m/c start in morning | Visual<br>Scale |
| | Inspection | Appearance<br>Starting Voltage | All<br>All | Visual<br>Testing Device |
| | Outo going Inspection & Test | Lamp Current<br>Lamp Voltage<br>Starting Voltage<br>Dimensions<br>Lighting Distribution | 5 pcs per lot<br>5 pcs per lot<br>5 pcs per lot<br>5 pcs per lot<br>5 pcs per lot | Characteristics<br>Testing Device<br><br>Scale<br>Lighting Distribution Testing Device |
| | | Life | 3 pcs per week | Life Tester |
| | Packing | | | |

# TOSHIBA Xe Glow Lamp QUARITY STANDARD

(Finished Lamp)

| Item | Specification | Sampling | Testing Measure |
|---|---|---|---|
| Lamp Current(mA) | 11.5~15.0 | n=3, c=0 per lot per day | Characteristic Testing Device |
| Lamp Voltage(V) | (310) | n=3, c=0 per lot per day | |
| Starting Voltage(V) | 22.5 max. | n=3, c=0 per lot per day | Test device with lighting circuit |
| Illuminance(lx) | 140 ±25% | n=3, c=0 per lot per day | Photometer |
| Vibration | 4 hours min. | n=3, c=0 per month | Vibration Tester |
| Shock | 30 G 3 times min. | n=3, c=0 per lot per day | Shock Tester |
| Life | 120000 times min. | n=3, c=0 per week | Life Tester |

**VICTOREEN NUCLEAR ASSOCIATES**

VICTOREEN

10101 Woodland Avenue
Cleveland, Ohio 44104
(216) 795-8200
TWX 810-421-8287

SG A Sheller-Globe Corporation Subsidiary

ATTACHMENT 5

# TABLE OF CONTENTS


| Paragraph | | Page |
|---|---|---|
| 1 | Purpose | 1 |
| 1.2 | Specifications | 1 |
| 2 | Installation | 5 |
| 2.1 | Unpacking | 5 |
| 2.2 | Power Requirements | 5 |
| 2.3 | Precautions | 8 |
| 3 | Operation | 8 |
| 3.1 | Function | 8 |
| 3.2 | Controls | 8 |
| 3.2.1 | Range Switch | 8 |
| 3.2.2 | Function Switch | 8 |
| 3.2.3 | Zero Set | 8 |
| 3.2.4 | Zero Adjust | 9 |
| 3.2.5 | Calibration Potentiometer and 22½ V Battery Test Switch | 9 |
| 3.3 | Operating Procedure (Turn-On Sequence) | 9 |
| 3.4 | Operational Tests | 10 |
| 4 | Theory of Operation | 10 |
| 4.1 | General Theory | 10 |
| 5 | Adjustments and Maintenance | 12 |
| 5.1 | Calibration | 12 |
| 5.1.1 | Energy Dependence | 12 |
| 5.1.2 | Temperature | 12 |
| 5.1.3 | Angular Dependence | 12 |
| 5.1.4 | Source Distance | 12 |
| 5.1.5 | Calibration Procedure | 17 |
| 5.2 | Troubleshooting | 17 |
| 5.2.1 | Test Procedure | 17 |


# ILLUSTRATIONS


| Figure | | Page |
|---|---|---|
| 1 | Collection Efficiency Graph | 4 |
| 2 | View of Instrument with VICTOREEN Logo Plate Removed Showing Battery Test Micro Switch, Calibration Control and Coarse Zero Potentiometer | 6 |
| 3 | Batteries, Cap and Contact Spring Replacement | 7 |
| 4 | Operational Amplifier; Current-Amplifier Configuration | 11 |
| 5 | Energy Response Correction Curve | 13 |
| 6 | Source Distance | 15 |
| 7 | 470A, Angular Dependence | 16 |
| 8 | Exploded View, 470A | 18 |
| 9 | Circuit Board Assembly | 20 |
| 10 | Schematic Circuit Diagram | 21 |

## LIST OF TABLES


| | | Page |
|---|---|---|
| Table I | Specifications for Model 470A . . . . . | 2 |
| Table II | Air Density Correction Table . . . . . | 14 |


## APPENDICES


| | | |
|---|---|---|
| Appendix I | List of Replaceable Parts . . . . . | 23-26 |

# GENERAL DESCRIPTION

1. Purpose - Model 470A is unparalleled in health physics surveys instrumentation. The latest solid-state IC technology has been utilized to miniaturize circuitry, reduce weight and increase reliability. Accuracy and convenience have also been carefully considered to assure the best possible indication of true radiation exposure. An extremely rugged high impact molded plastic case provides easy decontamination. The Model 470A is ideal in numerous applications including; background studies, general health physics surveys, radiochemical lab checks, surveying nuclear power plants, monitoring X-ray and radiotherapy facilities, fuel processing plants, research labs and in certain NDT applications.

1.2 Specifications - See specifications in Table I.

TABLE I: SPECIFICATIONS FOR MODEL 470A

| Feature | Specification |
|---|---|
| Range: | |
| Rate: | 0-3, 10, 30, 100, 300, 1000 mR/h and R/h |
| Integrate | 0-3, 10, 30, 100, 300, 1000 mR |
| Radiation Detected | Alpha, Beta, Gamma and X-ray |
| Detector | Unsealed, air ionization chamber |
| Material | Expanded plystyrene/275 cc vol |
| Wall Thickness | 17 mg/cm$^2$ |
| Cycolac Equilibrium Sleeve/Cap | 500 mg/cm$^2$ thick |
| Readout Meter | 3-1/8 inch (7.94 c,) scale, taut band movement (Spring-loaded trigger switch permits scale illumination for night use.) |
| Controls: | |
| External | Function switch (R/h, mR/h, mR Integrate) |
| | Range Switch (Off, Battery Check, 1000, 300, 100, 30, 10, 3) |
| | Zero set |
| | Zero Adjust |
| | Scale Illumination Switch |
| Internal | Calibration Adjustment |
| | High Voltage Check Switch |
| | Coarse Zero Adjust Potentiometer |
| Energy Response | ± 15% from 8.0 keV to 300 keV-bare |
| | ± 10% from 40 keV to 2 MeV-Covered |
| Response Time | 8 seconds on 3 mR/h range |
| | 3 seconds on 10 mR/h range |
| | 2 seconds on 30 mR/h range |
| | 1½ seconds on 100 mR/h and 300 mR/h range |
| Switching Transients | Less than 8 seconds on Function & Set Zero |

TABLE I: SPECIFICATIONS FOR MODEL 470A (Cont'd)

| Feature | Specification |
|---|---|
| Batteries | Two 1.5 volt D cells and four 22½ volt #505 Eveready |
| Battery Life | D cells 150 h<br>22½ volt shelf life |
| Zero Adjust | Can be properly adjusted in a radiation field |
| Warm-up Time | Less than one minute |
| Environmental Effects: | |
| Temperature Range | -20° to + 120° F (-29° + 49° C) |
| Humidity Range | 0 to 95%, non-condensing |
| Geotropism | Negligible |
| Response to Other Radiation: | |
| Minimum energy to penetrate chamber | Alpha; 8 MeV<br>Beta; 120 KeV |
| Zero Drift with Temperature | 6% per 10° C on 3 mR/h and 3 R/h range; 2% per 10° C on 10 mR/h and 10 R/h range; 0.6% per 10° C on 30 mR/h range and 30 R/h range. Can be completely eliminated by rezeroing |
| Collection Efficiency | See Figure 1 |
| Dimensions | 11 in. long (27.9 cm)<br>4-3/4 in. wide (12.1 cm)<br>9½ in. high (24.1 cm) |
| Weight | Less than 4 pounds |

## 2 Installation

8/29

2.1 Unpacking - When unpacking the 470A, check for any in-shipment damage.

2.2 Power Requirements - Two 1½ volt and four 22½ volt batteries are supplied with each instrument. Before installing the batteries be sure the Range Switch is in the OFF position. The D cells are installed in the handle by removing the two side retaining screws which permit removal of the cap. The batteries are inserted and the cap replaced. Be sure to observe battery polarity. When replacing the cap be sure the contact spring is properly oriented. See Figure 3.

To install the 22½ volt batteries, remove the five screws which hold the front of the instrument to the body and pull the front forward. The battery holder is mounted to the front instrument assembly. Install the 22½ volt batteries observing the proper polarity. (When mounting the front assembly to the body, dress the interconnecting cable in a manner which will not cause interference). Replace the five mounting screws. See Figure 3.

The 22½ volt batteries provide chamber collection voltage and do not experience significant current drain. Battery life is equal to shelf life which should be in excess of one year.

The BATT position on the Range Switch will check the condition of the D cells only, which must read in the green area of the meter. Since the 22½ volt batteries will last for shelf life, they require only infrequent checking. Checking may be accomplished by snapping out the VICTOREEN logo located below the meter and actuating a microswitch located on the left hand side of the opening. When the switch is actuated, the meter will read about 95% of full scale. Note the reading for future reference to establish battery condition. The batteries should be replaced when they have dropped about 5% below their initial reading. This check must be performed with the Range Switch in the OFF position. See Figure 2.

The purpose of the collecting voltage is to supply the electrostatic field which sweeps the ions created in the chamber to the walls and center electrode, where they constitute the current which is measured by the electronics. This should be accomplished with as little recombination of these ions as possible. The voltage necessary for a certain ion collecting efficiency varies as the square root of the

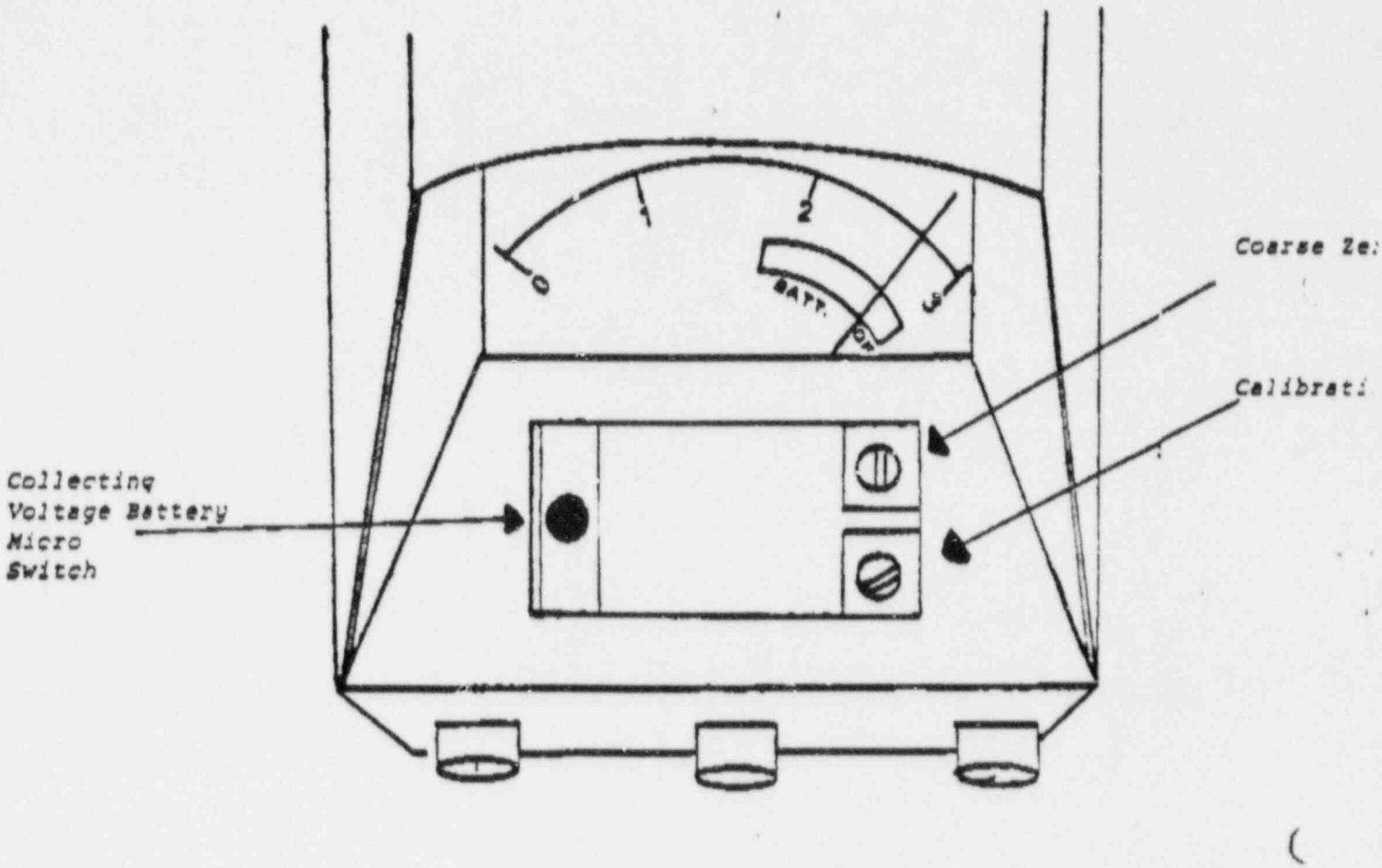



FIGURE 2. View of Instrument with VICTOREEN Logo Plate Removed Showing Battery Test Micro Switch, Calibration Control and Coarse Zero Potentiometer

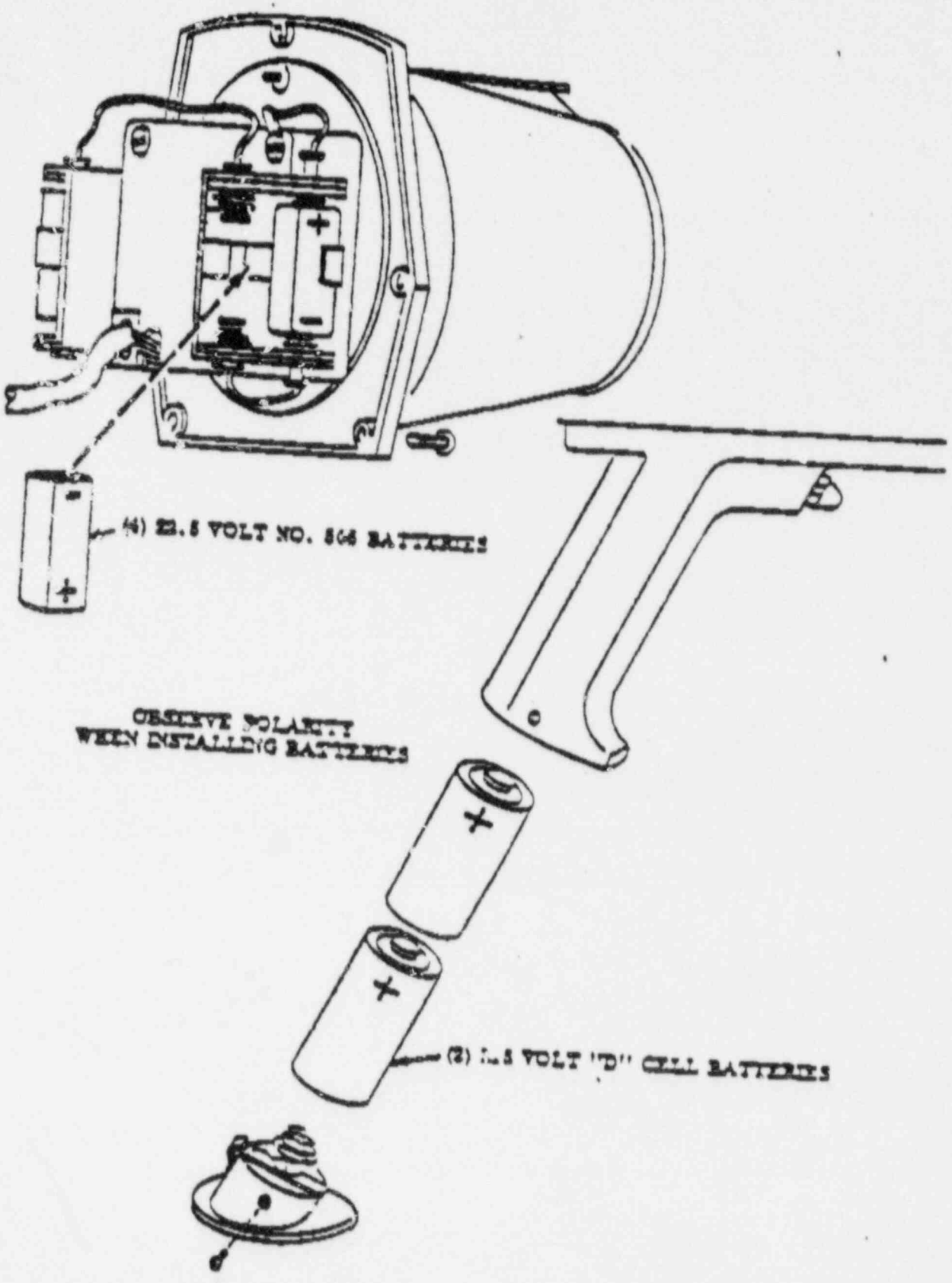



FIGURE 3. Batteries, Cap and Contact Spring Replacement

radiation intensity for a particular chamber geometry. Thus, since the chamber is 90% saturated at 1000 R/h at 90 volts, it requires only about 50 volts to produce 90% saturation at 300 R/h, full scale on the next range. Hence, the instrument is still quite useful, especially on the mR/h range, even if the collecting voltage has dropped to as much as half its original level. The reason for noting the reading of collecting voltage and replacing these batteries if the reading drops by about 5% is that such a decrease is a reasonable indication of the battery shelf life.

2.3 Precautions - If the ion chamber is broken or contaminated with radioactive material, the chamber must be replaced. See Section 5, paragraph 5.3 for this procedure.

## 3 Operation

3.1 Function - The 470A is an ionization chamber meter used to detect alpha, beta, gamma and X-ray radiation. It measures total exposure rate from 3 mR/h full scale for gamma and X-ray energies from 8.0 keV to 2 MeV.

3.2 Controls - The 470A has four front panel controls and a spring-loaded light switch for meter illumination, mounted on the instrument handle.

3.2.1 Range Switch - The Range Switch has eight positions. It can turn the instrument OFF, check the battery voltage, or set the sensitivity at 1000, 300, 100, 30, 10 or 3.

3.2.2 Function Switch - The Function Switch determines whether the 470A measures R/h, mR/h or integrates mR.

3.2.3 Zero Set - The Zero Set button is actuated whenever the instrument must be zeroed or operated in the Integrate Mode.

3.2.4 Zero Adjust - Since the instrument is susceptible to zero drift after initial turn on or when subjected to environmental extremes, zeroing is provided and may be accomplished in high radiation fields.

Depress the Zero Set button and adjust the Zero Adjust control on the instrument until the meter reads zero. Release the Zero Set button and the instrument is ready for operation. The zeroing procedure should be followed before performing integration.

3.2.5 Calibration Potentiometer and 22½ V Battery Test Switch - A calibration adjusting potentiometer, a coarse zero potentiometer, and a collecting voltage battery test switch are located under the VICTOREEN logo plate directly under the meter. (See Figure 2). This logo may be snapped out for access to these controls. The calibration potentiometer is factory adjusted and should be readjusted only with a calibrated radiation source.

In the event that the instrument cannot be zeroed with the external zero control as in 3.2.4 above, readjustment of the coarse zero control may be necessary. This is done by setting the external zero control to the middle of its range, turning the instrument to one of its operating ranges, depressing the Zero Set button and adjusting the coarse zero potentiometer till the indicating meter reads zero. The external zero control will then have ample range in each direction.

3.3 Operating Procedure (Turn-On Sequence) - Turn the Range Switch from OFF to BATT and make sure the meter is in the BATT. O.K. green region. Then turn the Range Switch to 1000. Push the Zero Set button and adjust zero as described in the previous paragraph. Turn the Function Switch to mR/h. As the ion chamber bias voltage rises to -90 volts, the instrument will read upscale. This lasts for less than one minute after the instrument is turned on.

After one minute, turn the range Switch to 3 mR/h. The instrument should now read background radiation. The 470A is now ready to make measurements.

After warm-up, the Mode and Range may be selected with the Function Switch.

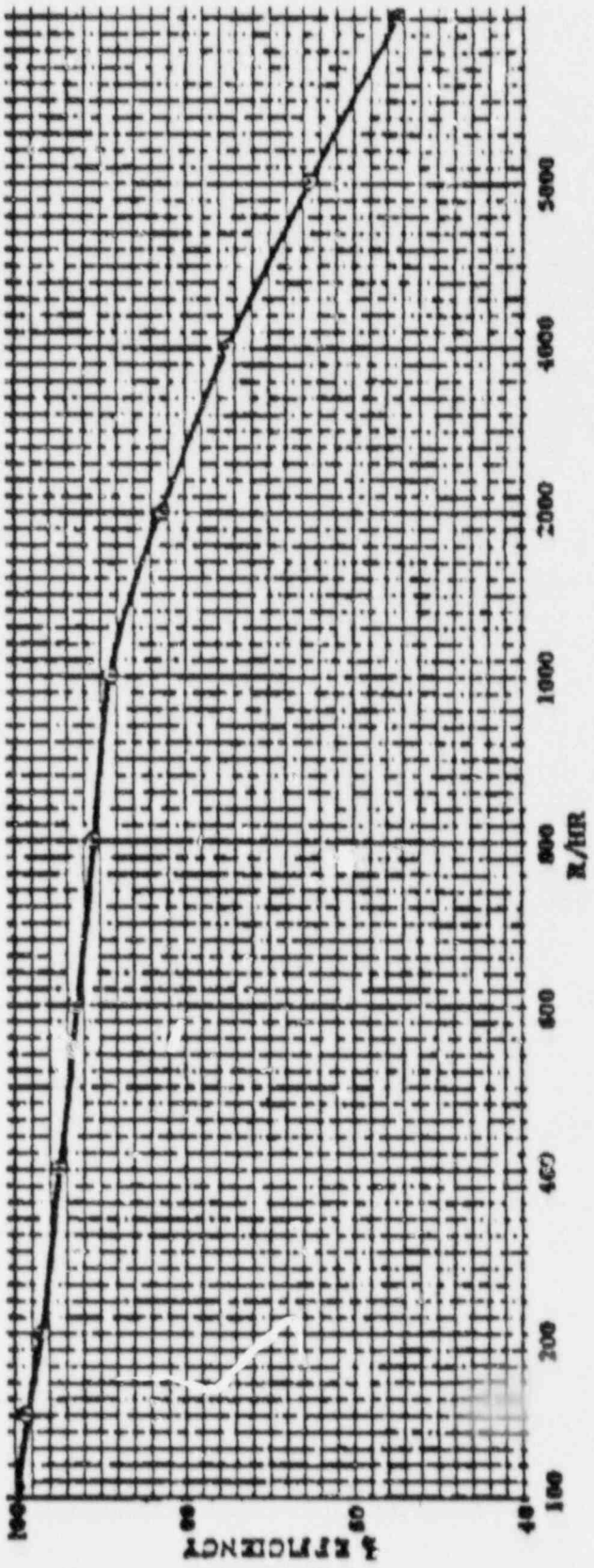



FIGURE 1: Collection Efficiency Graph

3.4 Operational Tests - First the 470A must pass the turn-on procedure. Then place a small radiation source nearby so the 470A reads about 1 mR/h. Turn the Range Switch to the 10 mR/h and to the 30 mR/h range, the meter reading should decrease on each range change to always indicate about 1 mR/h. If the 470A fails the turn-on or operational tests, turn to Section 5.2.

The Operational Check Source on the end cap of the chamber equilibrium sleeve can be used for the first of these tests. The Check Source consists of less than 0.01 microcuries of depleted uranium, and will produce a reading of between 0.6 and 1.5 mR/h when the source is placed on top of or in front of the bare chamber.

## 4 Theory of Operation

4.1 General Theory - When the ion chamber is exposed to radiation the internal air volume becomes ionized. A dc potential applied between the outer shell and center electrode separates the newly-formed ion pairs before they can recombine and collects them. The ions, upon reaching the electrodes, are restored to neutral gas atoms through the process of taking on (or giving up) electrons. This causes a direct current flow in the external circuit. The ion chamber can be considered a constant current generator whose output current is directly proportional to the rate of internal air ionization or exposure rate. These currents are extremely small however, and special electrometer circuitry is required to measure them.

An operational, current-amplifier configuration is employed in this instrument. See Figure 4. The large amount of negative feedback causes the output voltage to be a function of input current and feedback element value, rather than amplifier gain or other variables. A MOSFET electrometer is used for the operational amplifier. The feedback element is either a high megohm resistor or a capacitor.

Precision film resistors, elected by the Range Switch, determine the amount of dc voltage gain, and hence, the full scale sensitivity of the instrument. A variable resistor is employed to calibrate accurately the meter deflection to a known exposure rate radiation field.

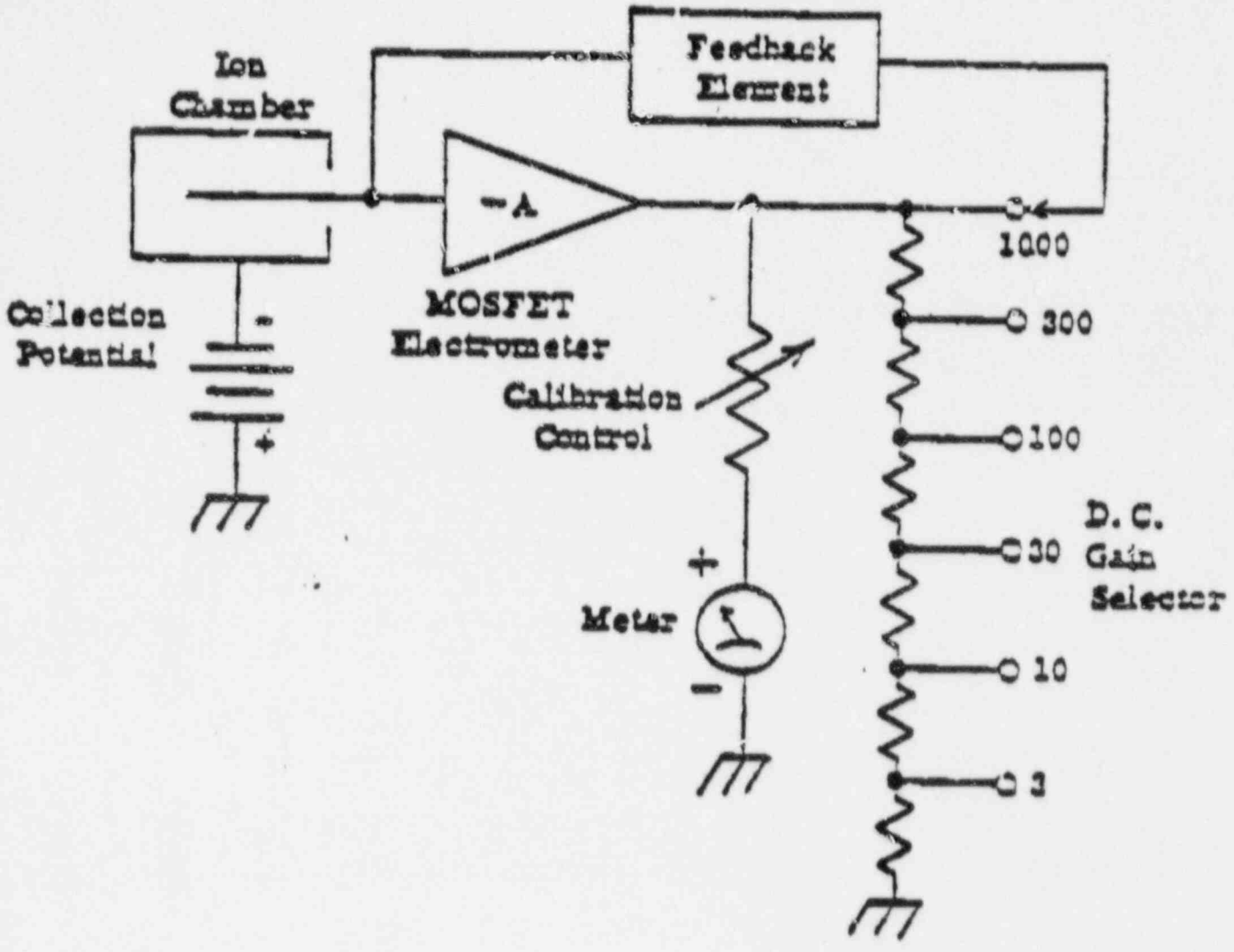



FIGURE 4. Operational Amplifier; Current-Amplifier Configuration

## 5 Adjustments and Maintenance

5.1 Calibration - The 470A is calibrated at the factory. When field recalibration is performed, four correction factors must be remembered.

5.1.1 Energy Dependence - Any ion chamber has a certain energy dependence. That is, holding the exposure rate constant, the chamber responds differently to different energy photons. The Model 470A has been calibrated at an effective energy of 662 keV from $^{137}$Cs. The response is fairly energy dependent in the low-energy region. For accurate usage at middle and high energy regions, the Energy Response Correction Curve must be used. See Figure 5.

5.1.2 Temperature and Pressure - Air, at standard temperature and pressure, is the ionized medium in the exposure rate definition. The density of the air determines directly the ionization rate with all other factors held constant. The density is, in turn, a function of barometric pressure and Kelvin temperature. Since the ion chamber is not sealed, a small correction must be made for temperatures and barometric pressures different from those during calibration. Standard temperature, 0° C, is rarely encountered in practice. The Model 470A is calibrated and corrented to 22° C and 760 mmHg. For different temperatures and pressures, correction factors will be found on the Air Density Correction Table II.

5.1.3 Angular Dependence - The shape, wall material, center electrode design, and position of the ionization chamber of the Model 470A results in an instrument response relatively independent of the direction of the incident radiation. Figure 7 gives the relative angular response of the Model 470A with the equilibrium cap on and off respectively, at 1.3 MeV ($^{60}$Co), and 120 keV and 40 keV effective.

5.1.4 Source Distance - If a point source or a collimated beam is used, the 470A chamber must be far enough from the source so the entire ion chamber is uniformly exposed. In practice this means any point source should be at least 1 meter from the ion chamber. The center of volume of the chamber is 5.7 cm from the end. See Figure 6.

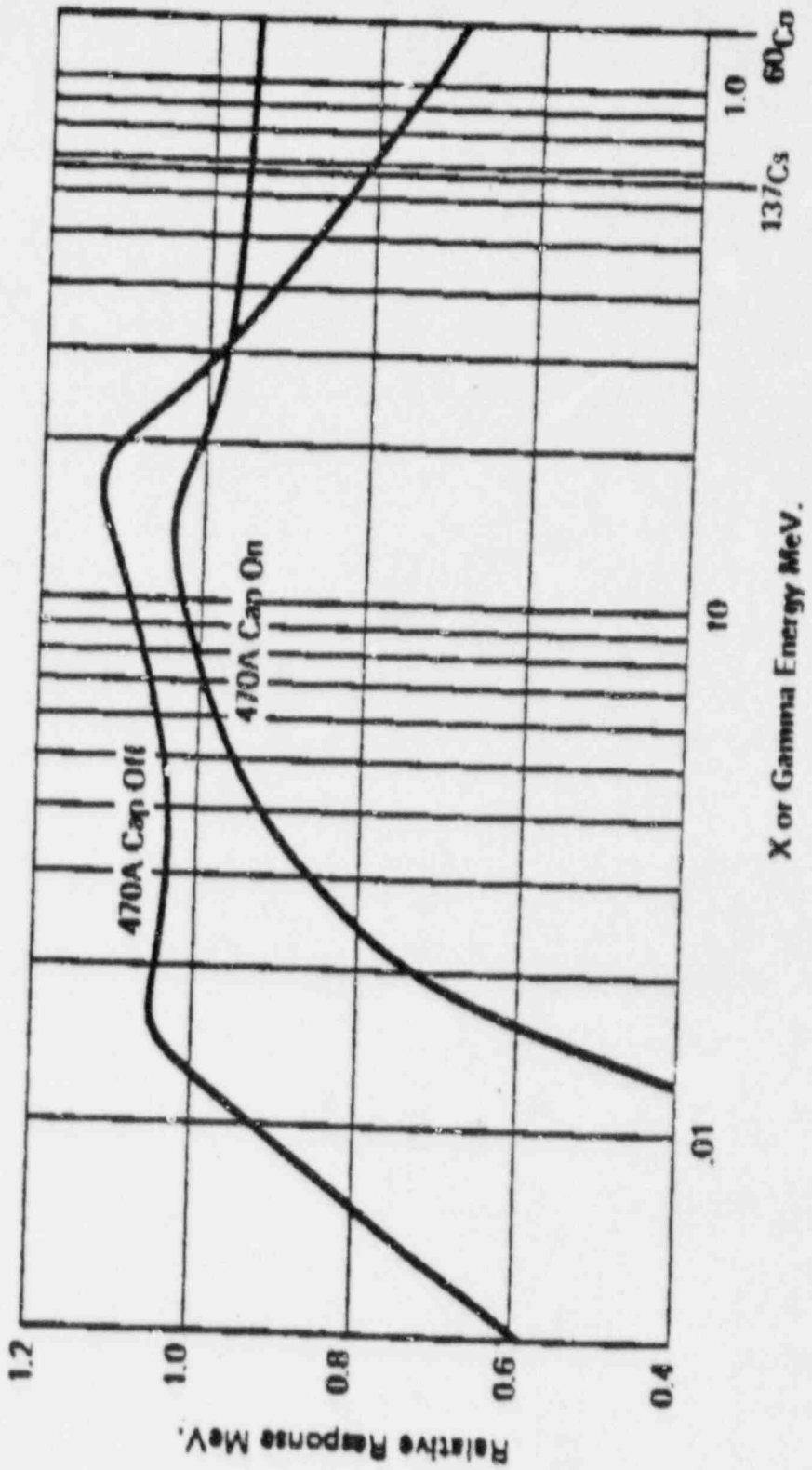



FIGURE 5. Energy Response Correction Curve

This instrument is calibrated in International Roentgens corrected to 0° Centigrade when used at 22° Centigrade and 760 mm. mercury (Hg) barometric pressure. For temperatures other than 22° Centigrade and pressures other than 760 mm. Hg., multiply the scale reading by the factor obtained from the following table.

| Inches | Mm. | 7.60.6 C. 16 | 64.6 18 | 68.0 20 | 71.6 22 | 75.2 24 | 78.8 26 | 82.3 28 | 86.0 30 | 89.6 32 | 93.2 34 | 96.8 36 | 100.4 38 | 104.0 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19.68 | 500 | 1.499 | 1.499 | 1.509 | 1.520 | 1.530 | 1.541 | 1.551 | 1.561 | 1.571 | 1.582 | 1.592 | 1.602 | 1.613 |
| 20.08 | 510 | 1.468 | 1.469 | 1.479 | 1.490 | 1.499 | 1.508 | 1.520 | 1.530 | 1.540 | 1.551 | 1.561 | 1.571 | 1.581 |
| 20.47 | 520 | 1.438 | 1.441 | 1.451 | 1.461 | 1.471 | 1.481 | 1.491 | 1.500 | 1.510 | 1.520 | 1.530 | 1.540 | 1.550 |
| 20.87 | 530 | 1.409 | 1.414 | 1.424 | 1.436 | 1.444 | 1.453 | 1.463 | 1.473 | 1.482 | 1.492 | 1.502 | 1.512 | 1.521 |
| 21.26 | 540 | 1.378 | 1.388 | 1.397 | 1.407 | 1.416 | 1.426 | 1.435 | 1.445 | 1.454 | 1.464 | 1.474 | 1.483 | 1.493 |
| 21.65 | 550 | 1.354 | 1.363 | 1.373 | 1.382 | 1.391 | 1.401 | 1.410 | 1.419 | 1.429 | 1.438 | 1.446 | 1.457 | 1.466 |
| 22.05 | 560 | 1.329 | 1.338 | 1.348 | 1.357 | 1.366 | 1.375 | 1.384 | 1.394 | 1.403 | 1.412 | 1.421 | 1.431 | 1.439 |
| 22.44 | 570 | 1.306 | 1.315 | 1.324 | 1.333 | 1.342 | 1.351 | 1.360 | 1.369 | 1.378 | 1.387 | 1.396 | 1.405 | 1.414 |
| 22.83 | 580 | 1.283 | 1.292 | 1.301 | 1.310 | 1.319 | 1.328 | 1.337 | 1.345 | 1.354 | 1.363 | 1.372 | 1.381 | 1.389 |
| 23.23 | 590 | 1.263 | 1.270 | 1.279 | 1.288 | 1.297 | 1.305 | 1.314 | 1.323 | 1.333 | 1.340 | 1.349 | 1.358 | 1.366 |
| 23.62 | 600 | 1.241 | 1.249 | 1.258 | 1.267 | 1.275 | 1.284 | 1.293 | 1.301 | 1.309 | 1.318 | 1.327 | 1.336 | 1.344 |
| 24.02 | 610 | 1.220 | 1.229 | 1.237 | 1.246 | 1.254 | 1.263 | 1.271 | 1.279 | 1.288 | 1.297 | 1.305 | 1.314 | 1.322 |
| 24.41 | 620 | 1.200 | 1.208 | 1.217 | 1.225 | 1.233 | 1.241 | 1.249 | 1.258 | 1.266 | 1.275 | 1.283 | 1.292 | 1.299 |
| 24.80 | 630 | 1.181 | 1.189 | 1.198 | 1.206 | 1.214 | 1.223 | 1.230 | 1.239 | 1.247 | 1.255 | 1.263 | 1.270 | 1.279 |
| 25.20 | 640 | 1.164 | 1.171 | 1.180 | 1.188 | 1.196 | 1.204 | 1.212 | 1.220 | 1.228 | 1.236 | 1.244 | 1.252 | 1.260 |
| 25.59 | 650 | 1.145 | 1.153 | 1.161 | 1.169 | 1.177 | 1.185 | 1.193 | 1.201 | 1.208 | 1.216 | 1.224 | 1.232 | 1.240 |
| 25.98 | 660 | 1.127 | 1.135 | 1.143 | 1.151 | 1.159 | 1.167 | 1.174 | 1.182 | 1.189 | 1.198 | 1.206 | 1.213 | 1.221 |
| 26.38 | 670 | 1.111 | 1.119 | 1.126 | 1.134 | 1.141 | 1.149 | 1.157 | 1.165 | 1.173 | 1.180 | 1.188 | 1.195 | 1.203 |
| 26.77 | 680 | 1.095 | 1.103 | 1.110 | 1.118 | 1.125 | 1.133 | 1.141 | 1.148 | 1.156 | 1.163 | 1.171 | 1.179 | 1.186 |
| 27.16 | 690 | 1.078 | 1.086 | 1.093 | 1.101 | 1.108 | 1.116 | 1.123 | 1.131 | 1.138 | 1.146 | 1.153 | 1.161 | 1.168 |
| 27.56 | 700 | 1.064 | 1.071 | 1.079 | 1.086 | 1.093 | 1.100 | 1.108 | 1.115 | 1.123 | 1.130 | 1.137 | 1.145 | 1.152 |
| 27.95 | 710 | 1.048 | 1.055 | 1.063 | 1.070 | 1.077 | 1.084 | 1.092 | 1.098 | 1.108 | 1.113 | 1.121 | 1.128 | 1.135 |
| 28.35 | 720 | 1.033 | 1.041 | 1.048 | 1.055 | 1.063 | 1.069 | 1.076 | 1.083 | 1.091 | 1.098 | 1.105 | 1.112 | 1.119 |
| 28.54 | 725 | 1.027 | 1.034 | 1.041 | 1.048 | 1.055 | 1.062 | 1.069 | 1.076 | 1.083 | 1.090 | 1.098 | 1.105 | 1.112 |
| 28.74 | 730 | 1.019 | 1.027 | 1.034 | 1.041 | 1.048 | 1.055 | 1.062 | 1.069 | 1.076 | 1.083 | 1.090 | 1.097 | 1.105 |
| 29.14 | 740 | 1.006 | 1.013 | 1.020 | 1.027 | 1.034 | 1.041 | 1.048 | 1.055 | 1.062 | 1.069 | 1.076 | 1.083 | 1.090 |
| 29.53 | 750 | .992 | .999 | 1.006 | 1.013 | 1.020 | 1.027 | 1.033 | 1.040 | 1.047 | 1.054 | 1.061 | 1.068 | 1.075 |
| 29.72 | 755 | .986 | .993 | 1.000 | 1.007 | 1.014 | 1.021 | 1.027 | 1.034 | 1.041 | 1.048 | 1.055 | 1.062 | 1.068 |
| 29.92 | 760 | .980 | .986 | .993 | 1.000 | 1.007 | 1.014 | 1.020 | 1.027 | 1.034 | 1.041 | 1.047 | 1.054 | 1.061 |
| 30.12 | 765 | .973 | .979 | .986 | .993 | .999 | 1.006 | 1.013 | 1.020 | 1.026 | 1.034 | 1.040 | 1.047 | 1.054 |
| 30.31 | 770 | .967 | .973 | .980 | .987 | .994 | 1.000 | 1.007 | 1.014 | 1.020 | 1.027 | 1.034 | 1.041 | 1.048 |
| 30.51 | 775 | .961 | .968 | .974 | .981 | .987 | .994 | 1.000 | 1.007 | 1.013 | 1.020 | 1.027 | 1.034 | 1.041 |
| 30.71 | 780 | .954 | .961 | .967 | .974 | .980 | .987 | .994 | 1.000 | 1.007 | 1.014 | 1.020 | 1.027 | 1.033 |
| 30.90 | 785 | .948 | .955 | .961 | .968 | .974 | .981 | .988 | .994 | 1.001 | 1.007 | 1.014 | 1.021 | 1.027 |
| 31.10 | 790 | .942 | .949 | .955 | .962 | .968 | .975 | .981 | .988 | .994 | 1.001 | 1.008 | 1.014 | 1.021 |

TABLE II: Air Density Correction Table

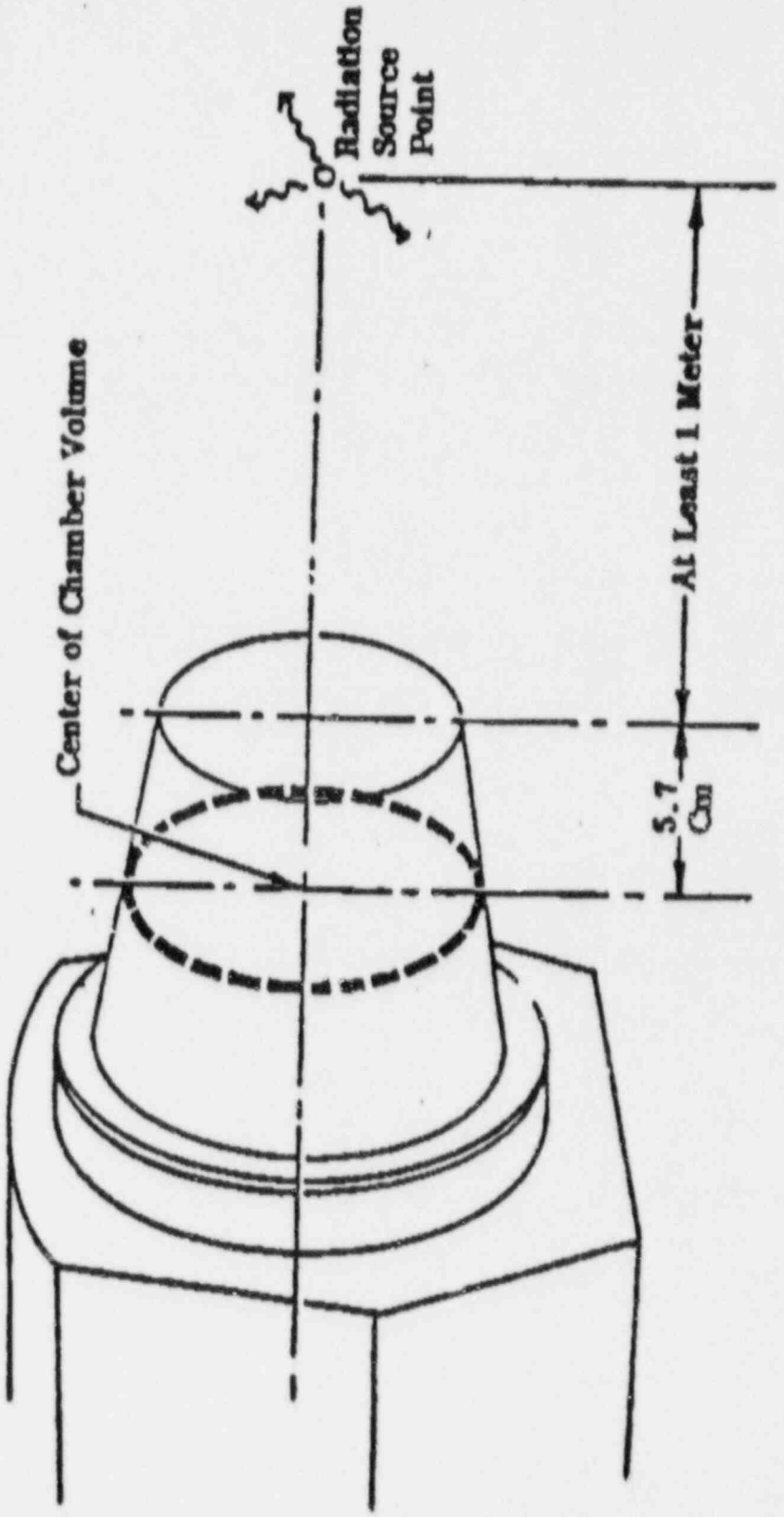



FIGURE 6. Source Distance

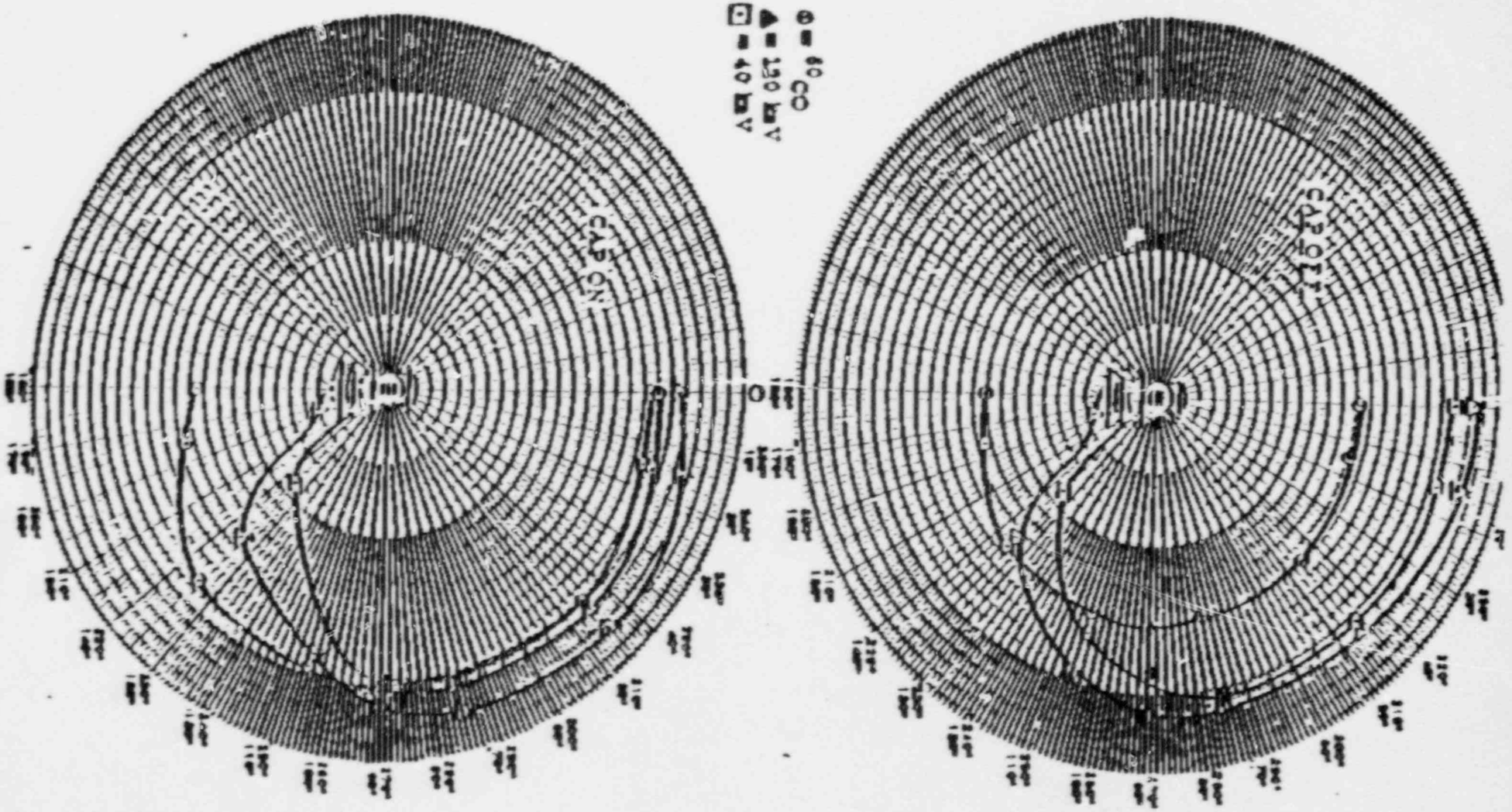



FIGURE 7. 470A, Angular Dependence

5.1.5 Calibration Procedure

1. Set the 470A to the 1 R/h range. Zero the 470A.

2. Pull out the VICTOREEN logo plate and look down through the opening at the circuit board. The calibration potentiometer, R7, is the lower one on the right side. See Figure 2.

3. Subject the ion chamber to a Low R/h field and adjust the pot for the correct reading. Use the equilibrium cap if the effective energy of the source is over 100 keV. Be sure to correct for temperature, pressure, and energy response.

5.2 Troubleshooting (See Exploded View, Figure 8)

5.2.1 Test Procedure - If the 470A does not pass its turn-on procedure and operational tests, then the following troubleshooting steps will check the batteries and main circuit board. If these parts test all right, but the 470A still does not work, contact the factory.

CAUTION

Do not attempt to repair the preamplifier. Tampering with it could void the VICTOREEN warranty.

To test the 470A follow these steps exactly:

1. Turn the Model 470A OFF and wait one minute.

2. Remove the two D cells from the handle.

3. Remove the 3 control knobs.

4. Remove the 5 screws from the preamplifier bulkhead and pull the preamplifier, bulkhead and ion chamber assembly from the rest of the instrument.

5. Slide out the meter and circuit board assembly and place the three portions of the instrument (case and handle, meter and circuit board, and preamplifier and ion chamber), still connected together, on a non-conducting surface.

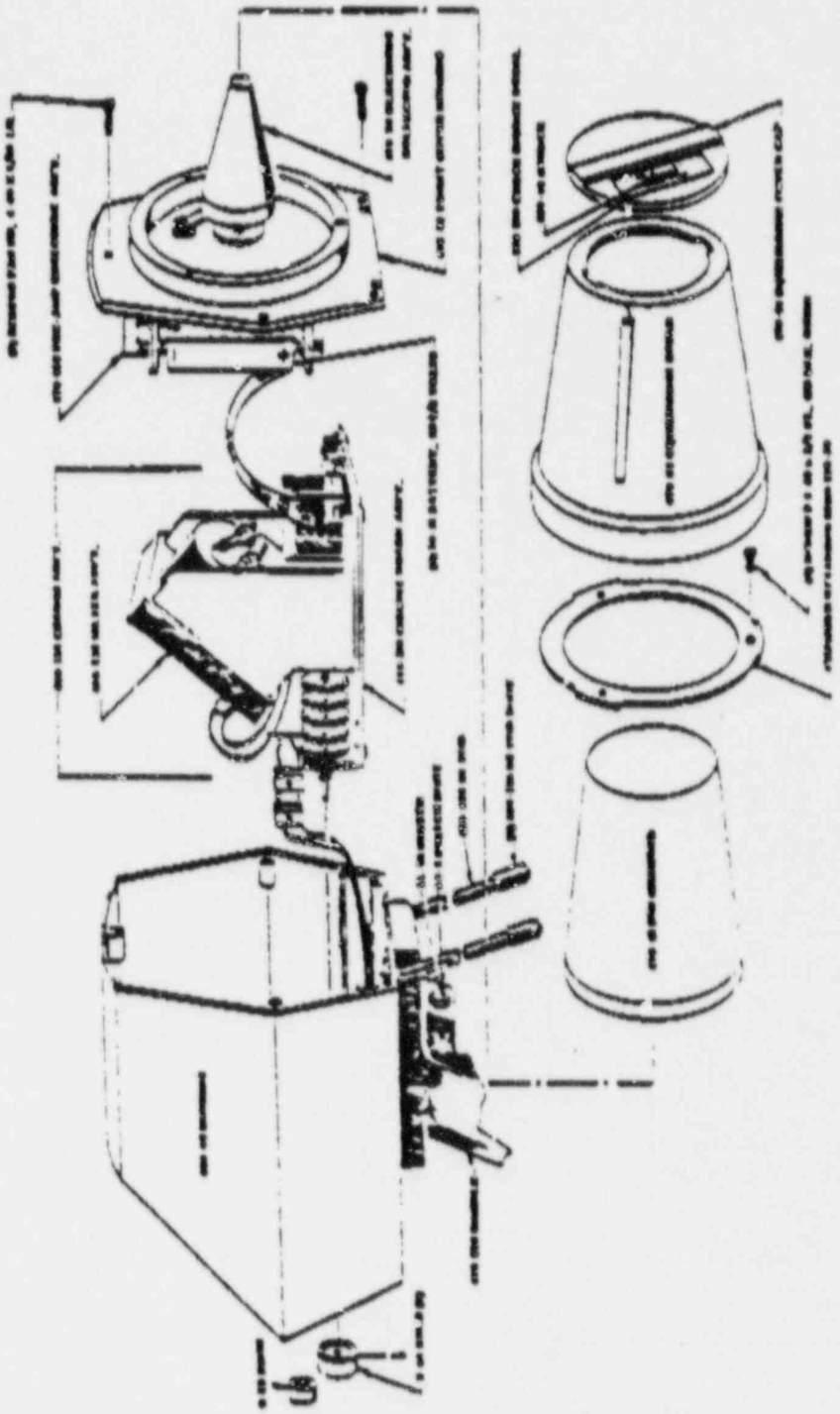


FIGURE 8: Exploded View, 470A

## CAUTION

Do not open or try to test the preamplifier: The circuitry is easily destroyed.

6. Replace the two D cells and control knobs to make the instrument operable.

7. Turn ON the Model 470A carefully. Some of the circuitry is at -90 volts. Wait 2 minutes. Place in the 0-3 R/h range.

8. Measure the three supply voltages; +8.2 ± 5%, -6.2 ± 5% and regulated battery voltage. The +8.2 volts and -6.2 volts are most conveniently measured between ground (the transformer T1 case) and the front and rear and terminals, respectively, of the Zero Adjust potentiometer R19. The regulated battery voltage is the voltage across C9 and should measure between 2.2 and 2.3 volts.

9. If these voltages are correct, check the voltages across R11 and R12. These should both be about 1.5 volts and equal. Refer to Figure 9, Circuit Board Assembly and Figure 10, Schematic Circuit Diagram, for further continuity and voltage checks. If the difficulty seems to lie in the preamplifier, return the instrument to a VICTOREEN Service Representative.

10. After testing, turn the 470A OFF and wait 2 minutes. Remove the two D cells from the handle, and reassemble the instrument in the reverse order of disassembly.

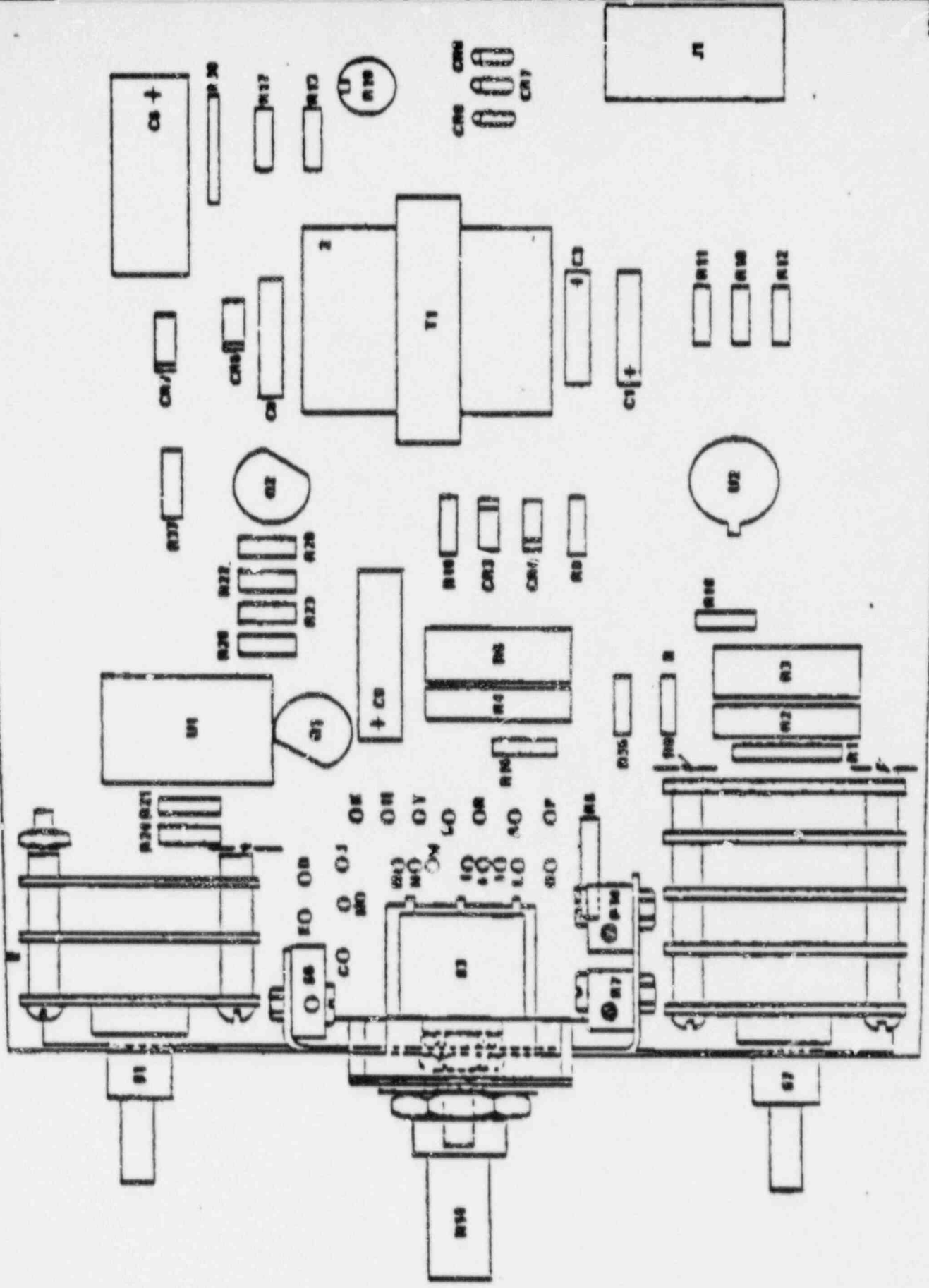


FIGURE 9 Circuit Board Assembly

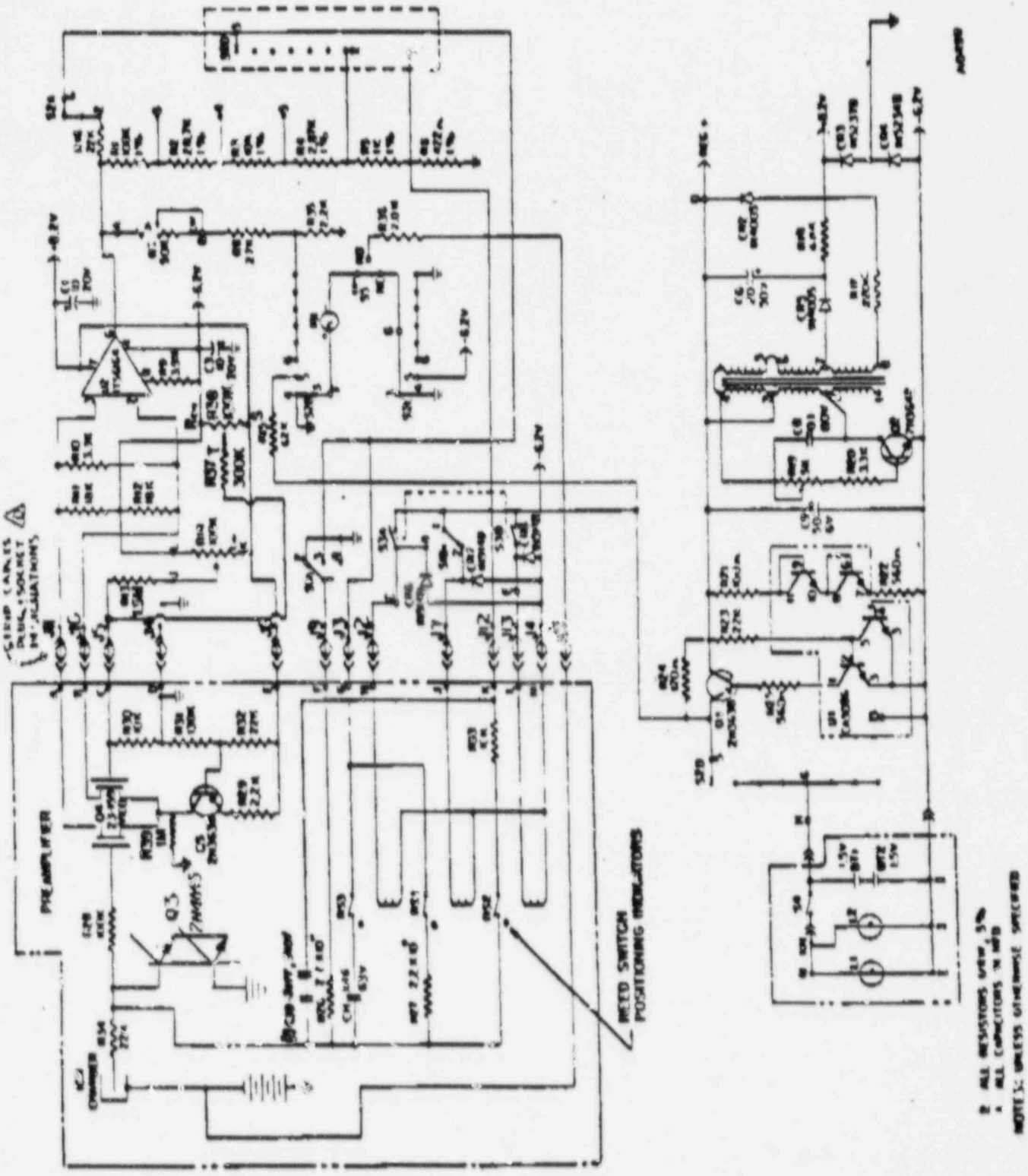



FIGURE 10. Schematic Circuit Diagram