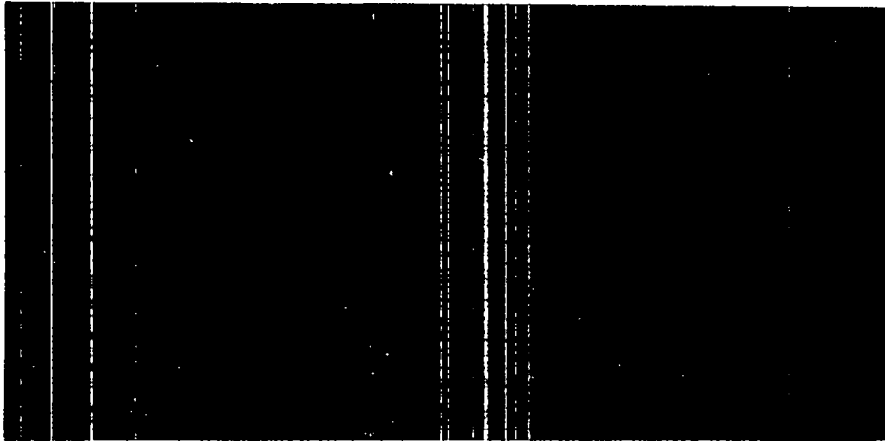


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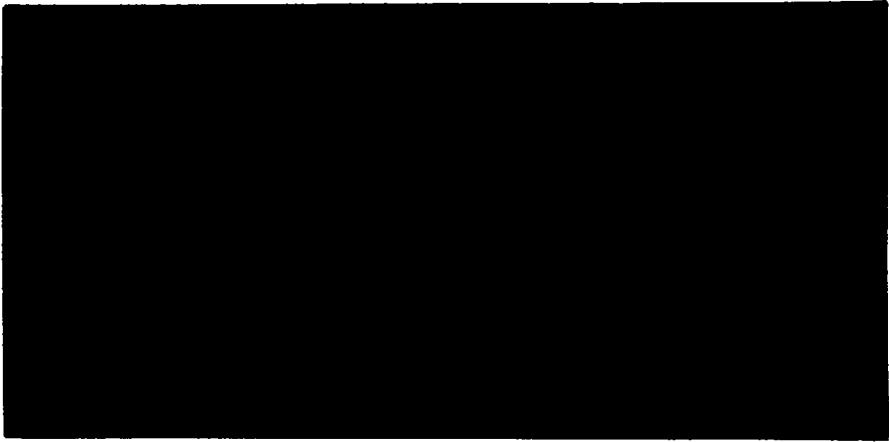
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Report written:
April 1955

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LA-1894

A PORTABLE APPARATUS
FOR THE DETERMINATION OF TRITIUM
IN BODY FLUIDS AND AQUEOUS SOLUTIONS

Work done by:

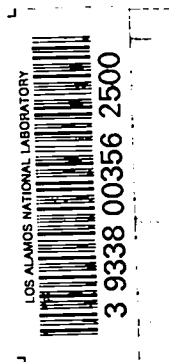
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This report supersedes LA-1678.

INSTRUMENTATION



ABSTRACT

A small apparatus of adequate sensitivity and more portable than that described in Report LA-1678 has been developed for the determination of tritium in body fluids and aqueous solutions. The entire system is adaptable to operation by untrained personnel.

The small glass vacuum manifold and ionization chamber are evacuated by means of water aspiration and filled to atmospheric pressure with a mixture of hydrogen-tritium gas. The hydrogen-tritium mixture is evolved by dropping a liquid (sputum, urine, blood, or water) onto metallic calcium and passing the gas through a drying column filled with indicating Drierite. The current produced by the beta activity within the ionization chamber is measured with either an Applied Physics Corporation Vibrating Reed Electrometer or a battery powered ionization chamber current meter designed by Los Alamos Scientific Laboratory. The method has a range of 10 to 10,000 μc of tritium per liter of liquid, depending upon the size of the ionization chamber and the measuring instrument.

1. Introduction

Many requirements for tritium health monitoring procedures have dictated the development of an apparatus more portable than that described in Report LA-1678. Although the authors are indebted to the basic work in that document, a system has now been developed which eliminates the need for liquid nitrogen, mercury manometers, and a vacuum pump.

A small glass vacuum manifold and ionization chamber are evacuated by means of water aspiration and filled to atmospheric pressure with a mixture of hydrogen-tritium gas. The hydrogen-tritium mixture is evolved by dropping a liquid (sputum, urine, blood, or water) onto metallic calcium and passing the gas through a drying column filled with indicating Drierite. The current produced by the beta activity within the ionization chamber is measured with either a vibrating reed electrometer or a battery powered ionization chamber current meter designed by the Los Alamos Scientific Laboratory. The method has a range of 10 to 10,000 μc of tritium per liter of liquid depending upon the size of the ionization chamber and the measuring instrument.

The Applied Physics Corporation ionization chamber, No. 3095, with a volume of 250 ml, is satisfactory for use with the vibrating reed electrometer. However, it is not of sufficient volume to provide the sensitivity necessary when using the Model 3 Ionization Chamber Current Meter, Figs. 1 and 2 (hereafter referred to as the ICCM), developed

by LASL Group P-1. Therefore, the authors developed the 1-liter E-R* chamber, Fig. 3, which is easily fabricated and designed to be operated with the vibrating reed as well as the ICCM.

The battery powered ICCM offers an instrument which will give a field measurement indicating tritium personnel exposures of 0.3 rep (250 μc of tritium per liter of body fluid) and above, with a 1-liter ionization chamber. The vibrating reed electrometer will indicate exposures from 0.03 rep (25 μc of tritium per liter of body fluid) with the same chamber.

2. Procedure

Reagents

Metallic Calcium - No. 10 mesh. The calcium is a specially purified product obtained from CMR-Division of LASL

Apiezon M Stopcock Grease

Dow Corning High Vacuum Grease

Dow Corning Antifoam A

Tritium Standard - A suitable series of standards in the range of physiologic importance

Indicating Drierite - CaSO_4 , No. 8 mesh

Apparatus

Glass Vacuum Manifold - Fig. 4

Glass Generators - Fig. 5

*Eutsler and Robbins

Water Aspirator and/or Vacuum Pump

Ionization Chamber - Fig. 3

Ionization Chamber Current Meter - Figs. 1 and 2

Vacuum Pressure Gauge - 15 lb x 30 in.

Portable Carrying Case - Fig. 6

Operational Procedure

The glass vacuum manifold, ionization chamber, and generator, shown in Fig. 7, are evacuated by means of water aspiration or a vacuum pump to a mercury pressure within 2 in. of vacuum at barometric pressure. Contrary to the statement on page 4 in Report LA-1678, the authors have found that water aspiration of the vacuum manifold and ionization chamber is satisfactory and reproducible at all levels.

For evacuation of the system, open stopcocks No. 1, No. 3, and No. 4, and close No. 2. Before evacuation of the system, add approximately 5 g of metallic calcium to the glass generator. Ring the lower part of the generator with antifoam. Grease the glass joint and the stopcock of the generator with suitable stopcock grease and assemble. Also grease the 18/9 male joint of the manifold and fit the generator to it. (The generator is held in place by means of foam rubber beneath it, thus providing a safety valve for any pressure excess.)

When sufficient vacuum has been achieved, close stopcock No. 4. Observe the vacuum pressure gauge to ensure there are no leaks in the system.

Add the liquid sample to the thistle tube of the generator. Slowly drop the liquid onto the metallic calcium through the generator stopcock. The hydrogen-tritium mixture evolved is dried in passing through the indicating Drierite. When the pressure of the system is slightly above atmospheric, close stopcock No. 1 and remove the generator from the system. Flood the generator with water and immerse it in an organic solvent (kerosene) to dissolve the grease. Open stopcock No. 2 momentarily to the atmosphere. Close the needle valve or stopcock on the ionization chamber. The chamber is now ready for counting.

3. Operating Instructions for Counting

Operating instructions are usually provided with the vibrating reed electrometer; however, they may also be found on pages 7-8 of Report LA-1678. Operating instructions for the battery powered ICCM are as follows.

1. To turn instrument on, hold down "discharge" button and switch from "off" to "warm" to "run."
2. After several minutes' warmup, depress "discharge," be sure "Slideback E" is on zero, and set zero on null meter with front panel zero control. The instrument is now ready for current reading.
3. Current readings may be taken directly across a resistive input element or by rate-of-charge method with a capacitance

input element. In either method the null meter is brought to zero with "Slideback E" dial. This dial reads 1 volt full scale or 1 mv per small division. Response of the null meter is slow when sliding back the voltage developed across a large resistive element. However, the null meter excursion is fairly linear, and corresponds to about 0.1 volt per microampere deflection, so one can make an intelligent approximation of proper slideback setting, wait, and then make a precise setting. Voltage reading is rapid when measured across a capacitive element. This rate-of-charge current measurement involves timing a certain voltage buildup across a capacitor and calculating the current from

$$I_{\text{ amp }} = C \text{ farads } \frac{\text{volts}}{\text{seconds}}$$

4. Place "input element" switch on 300 $\mu\mu\text{f}$ position when changing chambers. If possible, hold down "discharge" button when connecting or disconnecting chamber voltage. This will eliminate transients applied to the electrometer tube through chamber capacitance, and should help instrument stability.
5. Instrument leakage and grid currents add up to about 10^{-14} amp. This sets the upper limit of sensitivity for this technique of current measurement. Battery life should exceed 1500 hr of continuous operation.

CAUTION: To minimize transients from possible holdover charges, depress "discharge" button when changing input element ranges.

4. Calibration

Each ionization chamber should be calibrated in terms of the conditions for which the equipment is to be operated, i.e., water aspiration or vacuum pump for evacuation of the system.

Fill each ionization chamber to be used with inert hydrogen, generated from distilled water, as described in the procedure, page 5. Read the current on the ICCM or vibrating reed as given in the operating instructions, Step 3. The scale reading obtained is the background of the ionization chamber. Each chamber is then calibrated at appropriate levels of tritium concentration and plotted on linear square-section graph paper.

5. Summary

A small readily portable apparatus with a simple system of operation has been developed for the determination of tritium in body fluids and aqueous solutions. Using the ICCM, measurements of exposures of 0.3 rep and above are attainable, while measurements with the vibrating reed electrometer will indicate exposures 0.03 rep and above.

Although the system was designed to meet a need for tritium personnel monitoring, it is possible to count any gaseous beta emitter in the ionization chamber.

Under certain conditions the E-R chamber may find application as a grab sampler for air suspected of containing gaseous beta emitters.

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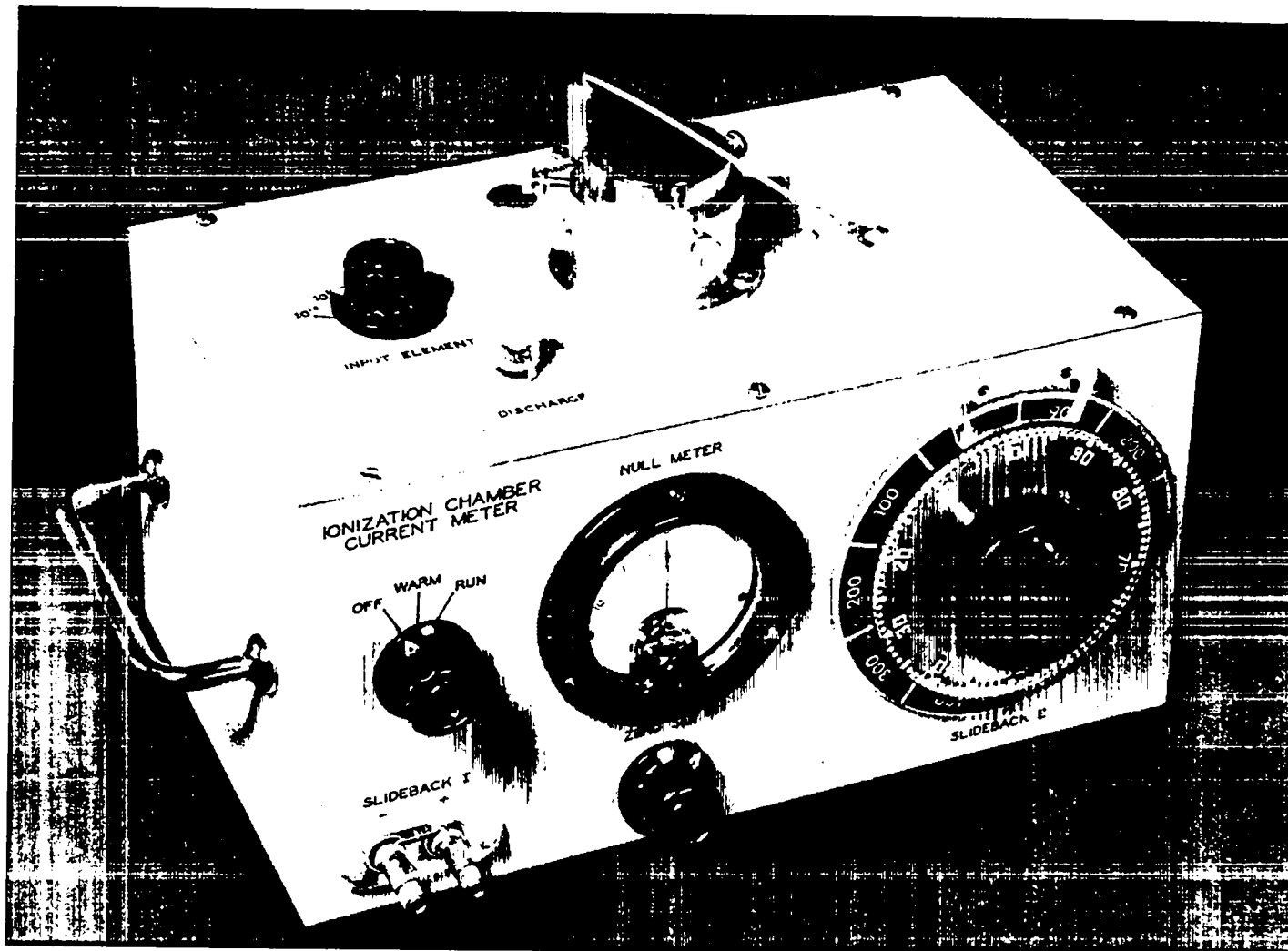


Fig. 1. Model 3 ionization chamber current meter.

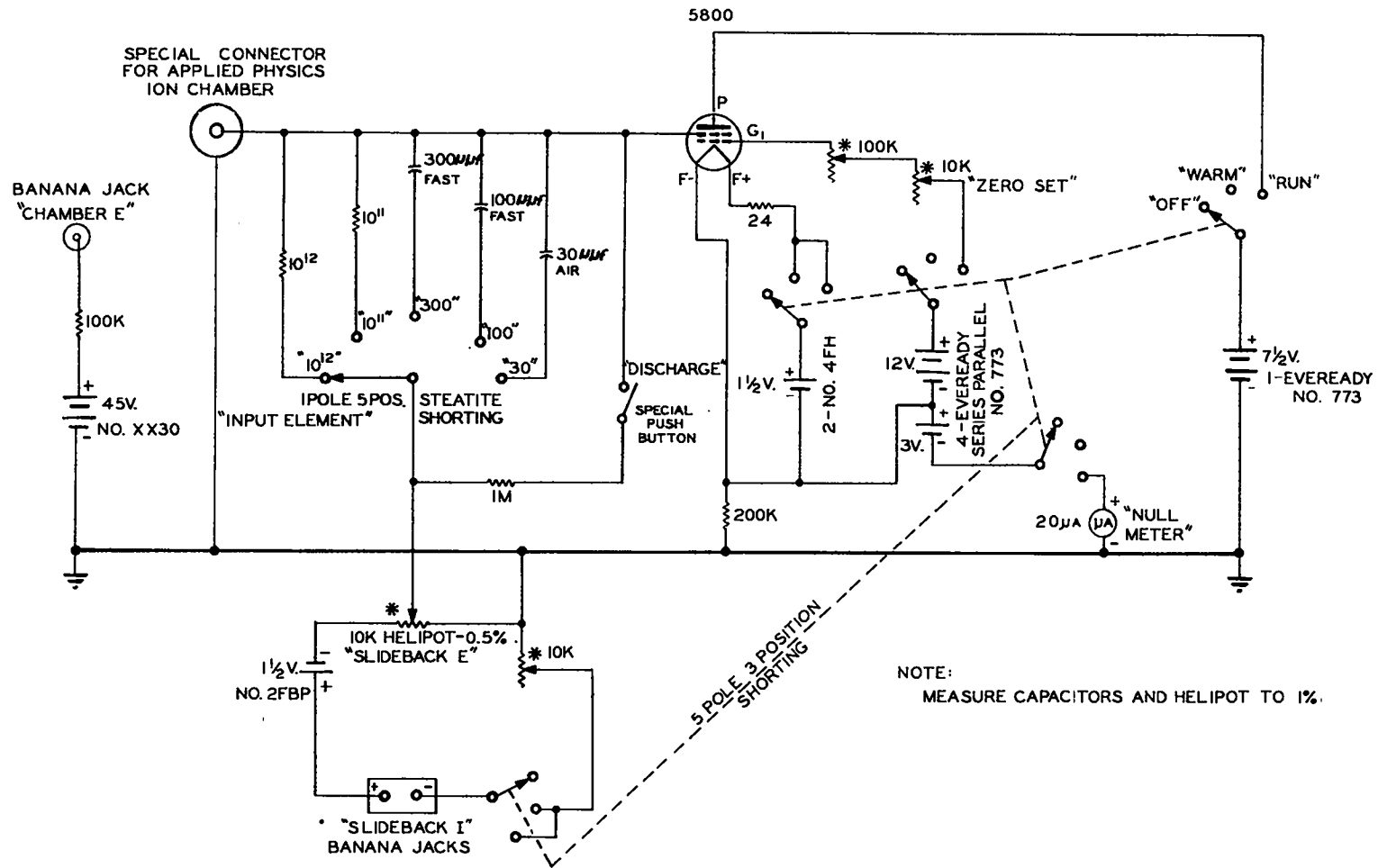


Fig. 2. Schematic drawing of model 3 ionization chamber current meter.

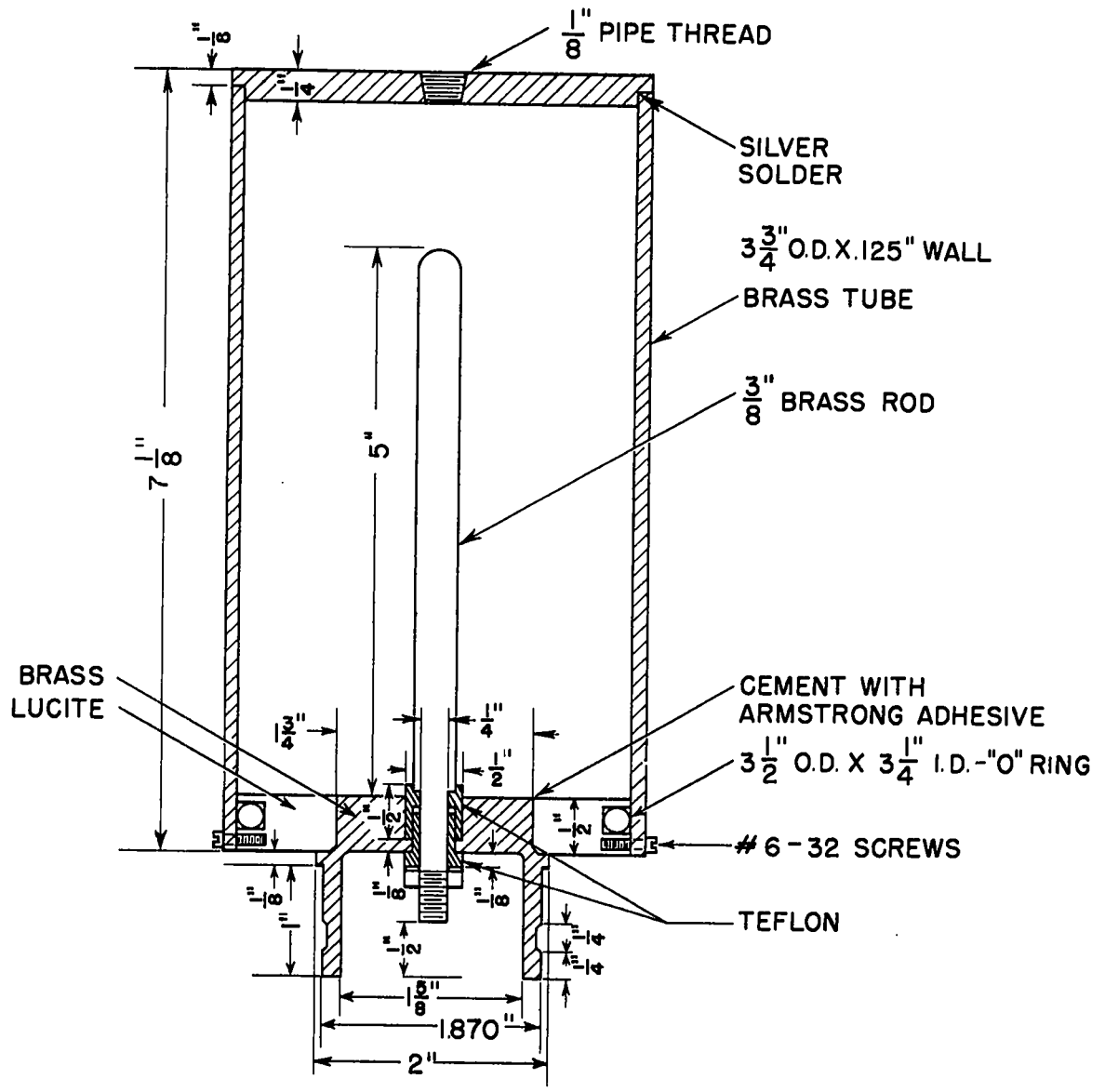


Fig 3. Cross section of E-R ionization chamber.

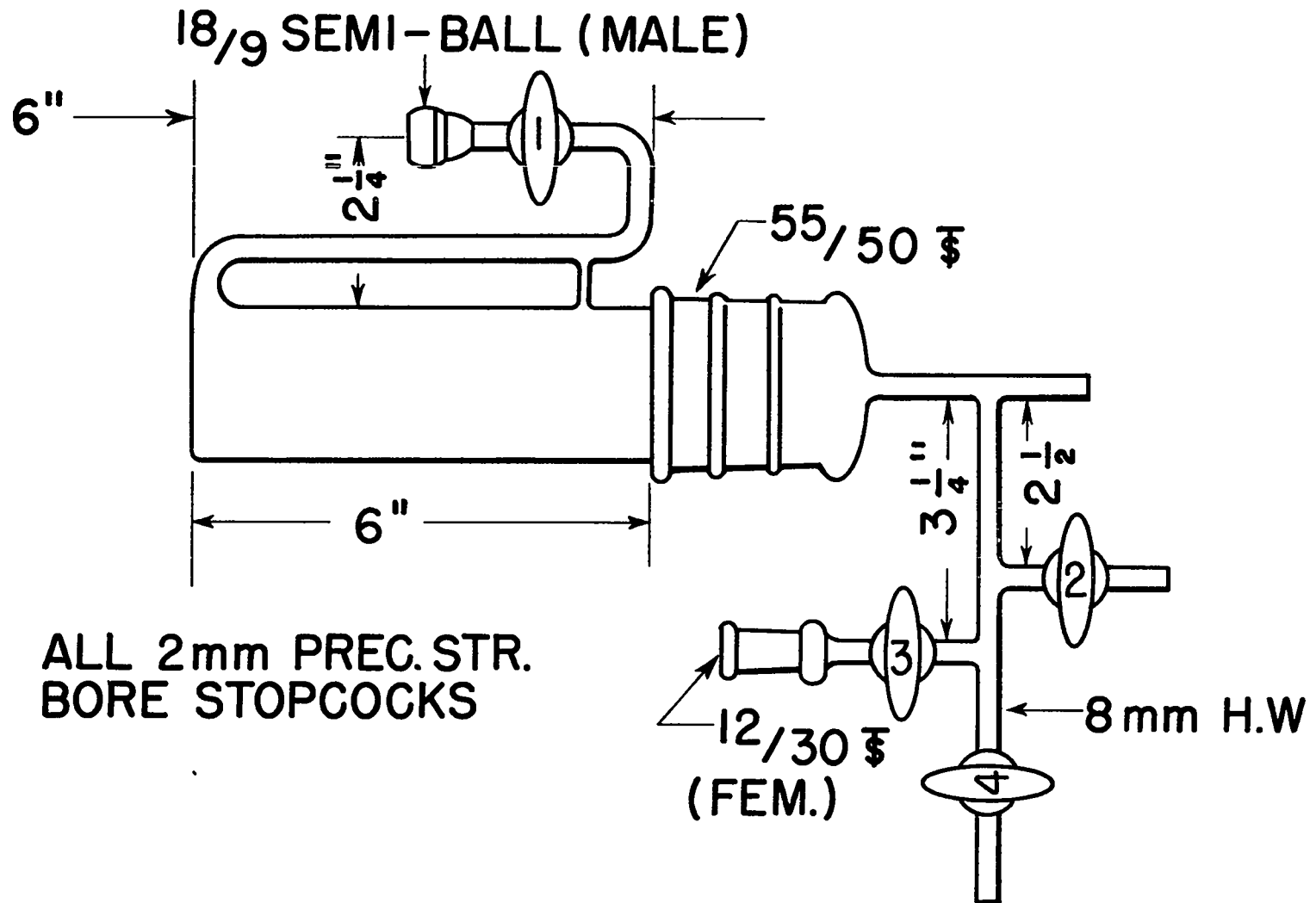


Fig. 4. Glass vacuum manifold.

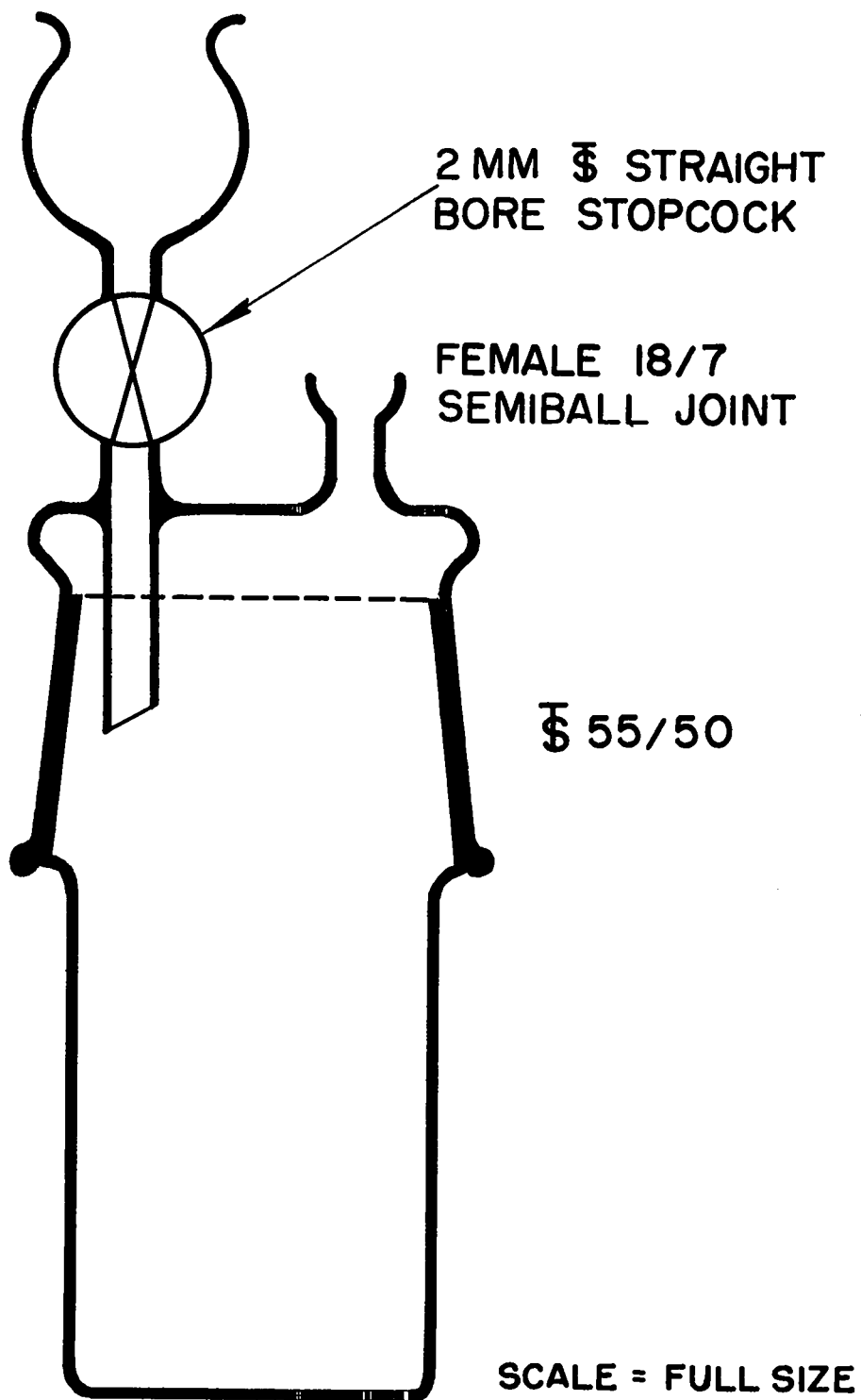


Fig. 5. Cross section of generator flask.

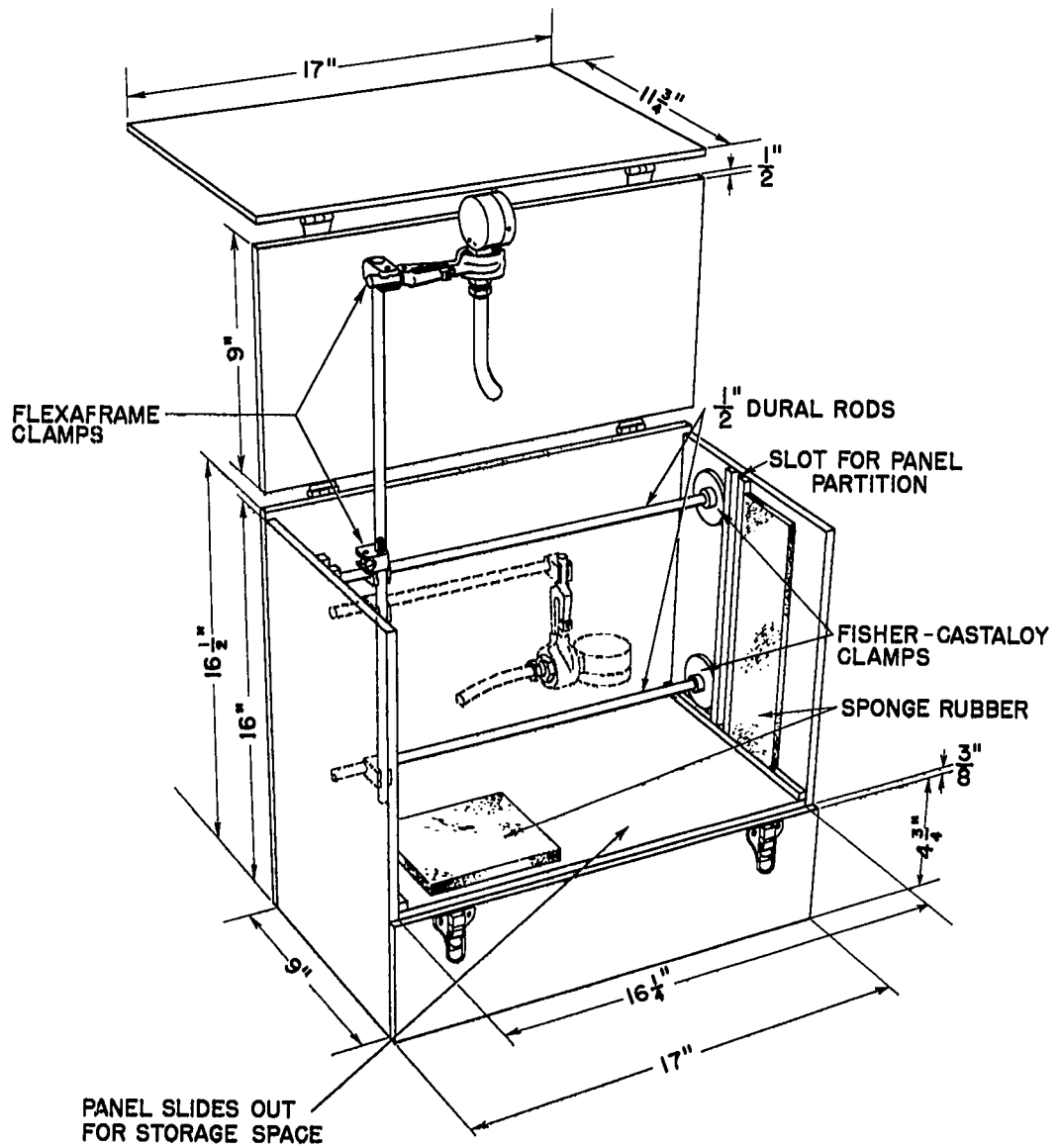


Fig. 6. Carrying case for glass vacuum manifold.

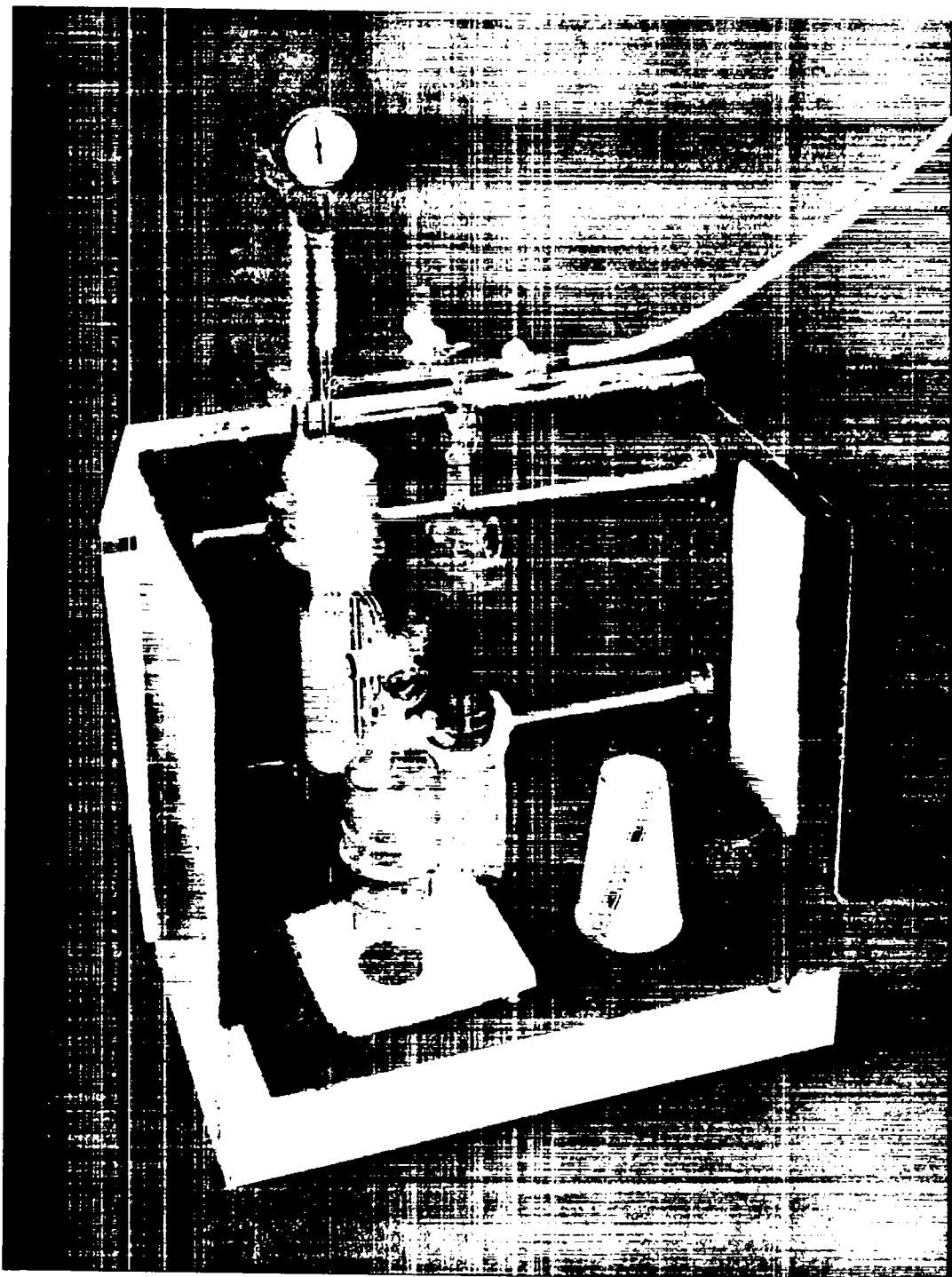


Fig. 7. Manifold and generator in assembled position in carrying case.

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