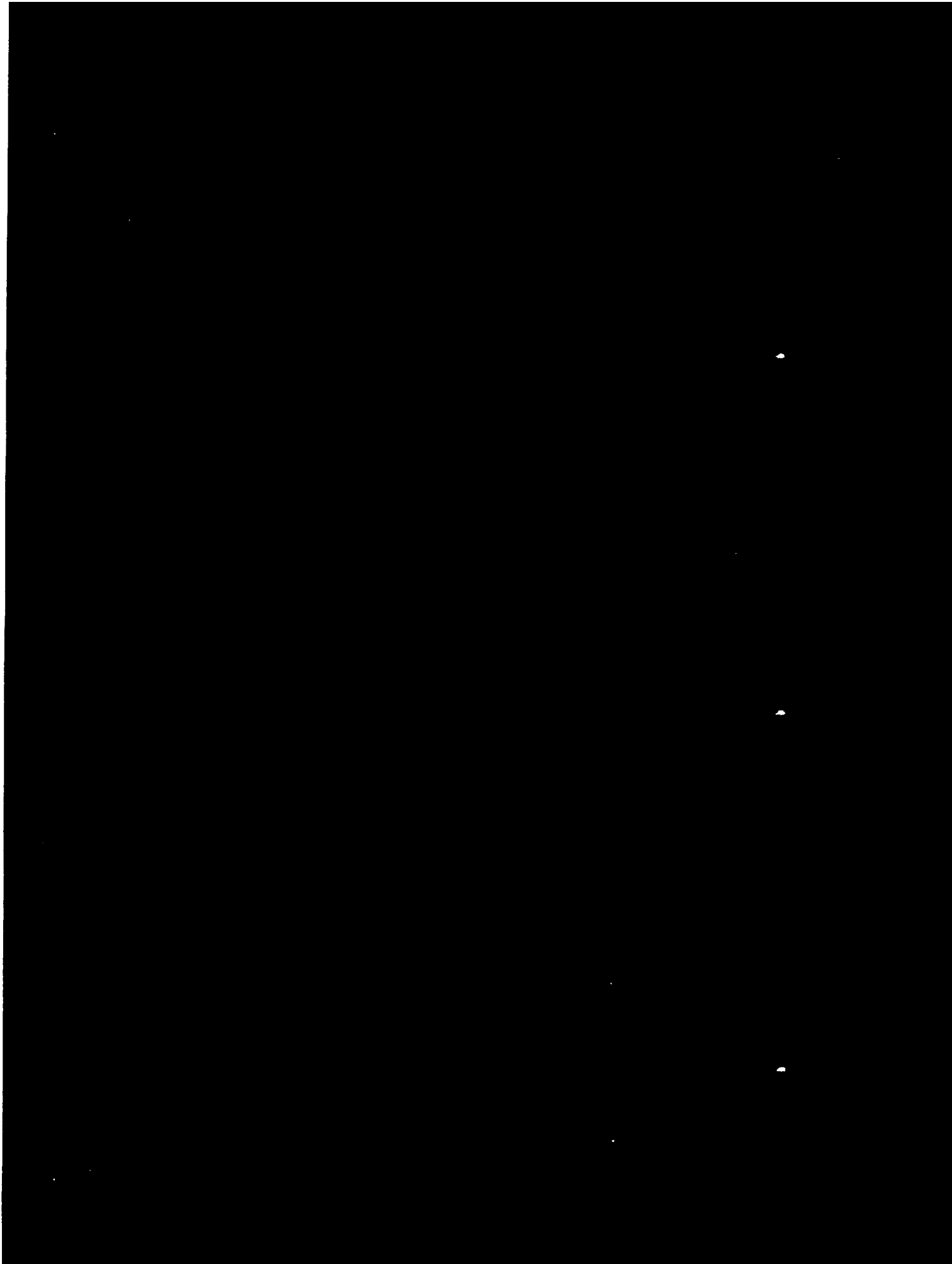


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PORTABLE FAST-NEUTRON FISSION-CHAMBER MONITOR



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Physical Instrumentation

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Abstract

An instrument that will detect fast neutrons by means of the fission of  $U^{238}$  is described. To attenuate the slow-neutron effect, the uranium is depleted of the 235 isotope to the ratio 5000/1. Battery-operated feedback amplifiers are used to obtain a pulse height sufficient to operate a discriminator and headphones. Circuit diagrams are given.

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**UNCLASSIFIED**PORTABLE FAST-NEUTRON FISSION-CHAMBER MONITORIntroduction

The relative biological effectiveness of fast neutrons emphasizes the need for portable instruments capable of detecting them. Unfortunately, however, the relatively low cross sections of suitable elements make difficult the attainment of sensitivity sufficient to be of value for health-survey purposes.

The electronic dilemma can be illustrated in the following manner. If one considers the usual parallel-plate ionization-chamber method of detecting fission pulses, a first thought would be to use more material in the chamber to compensate for the low cross section. However, the addition of material in the form of more plates will increase the capacitance. Thus, for a given voltage on the chamber, the pulse height will be reduced and more stringent requirements are placed upon stable amplification and low noise level. Thus the limit is reached when the capacitance of the chamber is such that the voltage pulse height is of the same magnitude as the noise level.

The present instrument is a compromise in this respect. As much material has been added as possible, consistent with the requirement that the pulses can be distinguished safely above the noise level.

Circuit

Figures 2 and 3 are photographs of the instrument. The chamber itself was designed by Dr. Simon Shlaer. The plans are given in Figures 4 and 5, and Figure 6. The aluminum chamber contains 25 aluminum plates, alternate ones insulated from each other. The active material was plated on the aluminum plates in the following manner. The aluminum plates were placed upon a table

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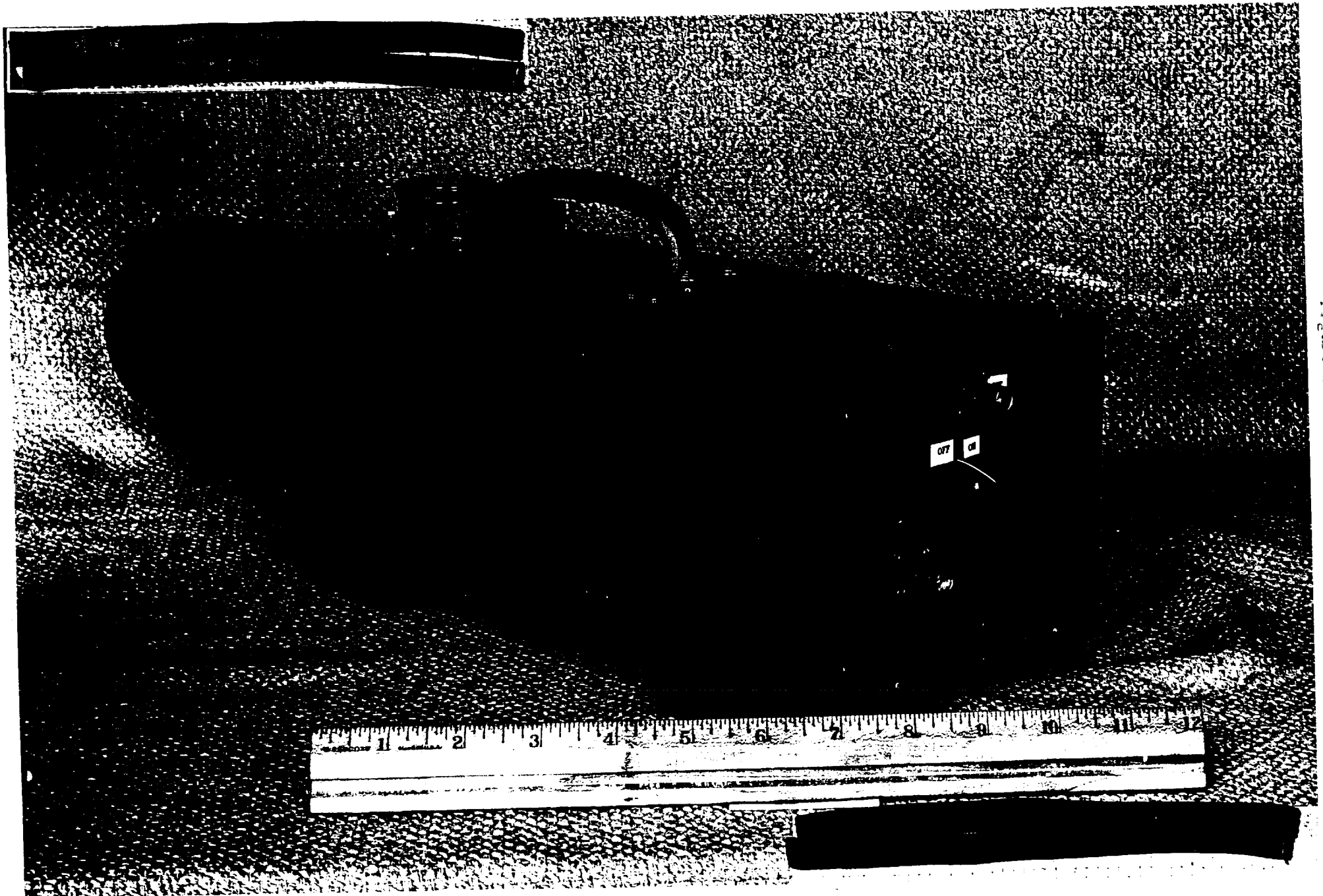


Figure 2

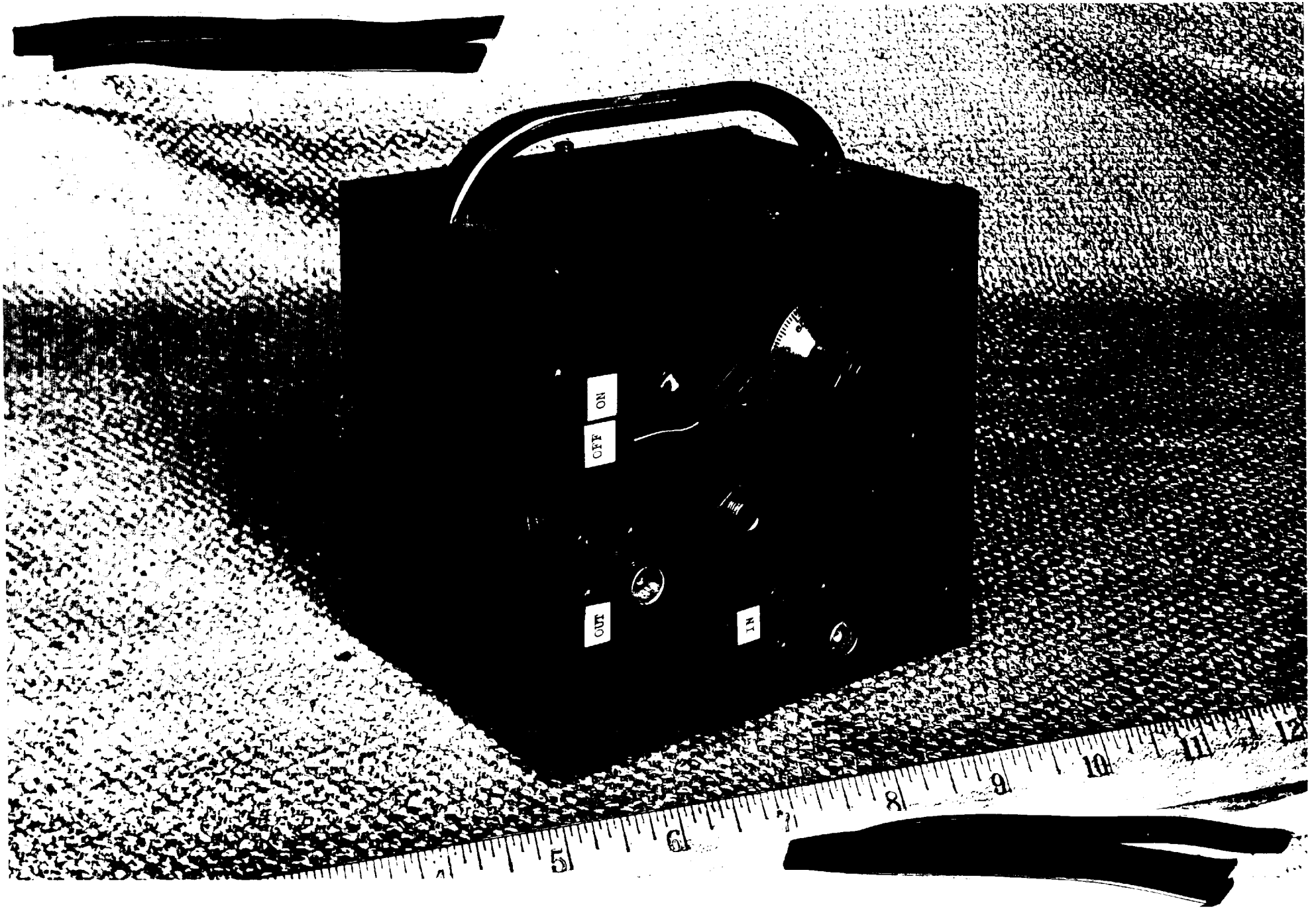
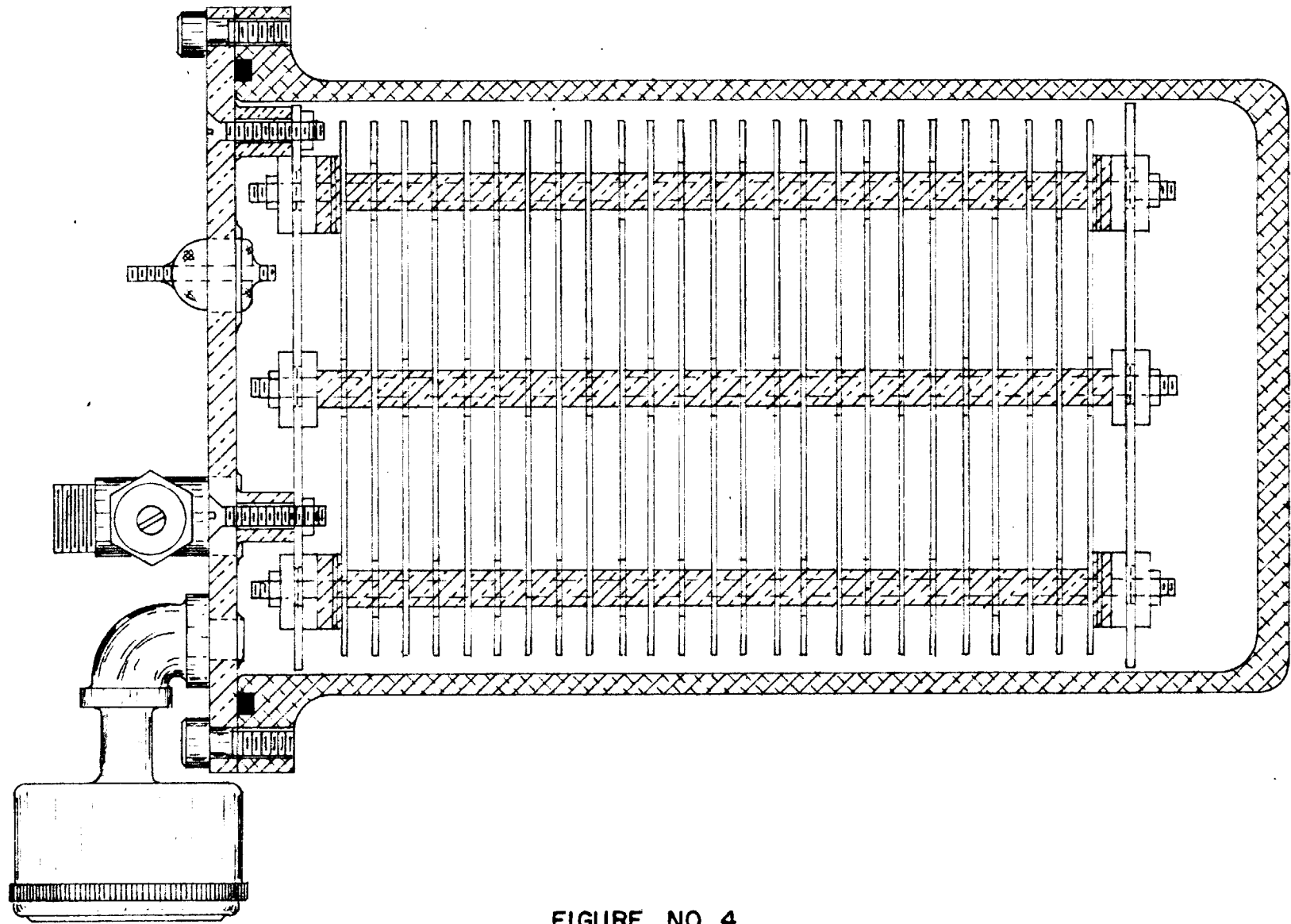


Figure 3



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FIGURE NO. 4



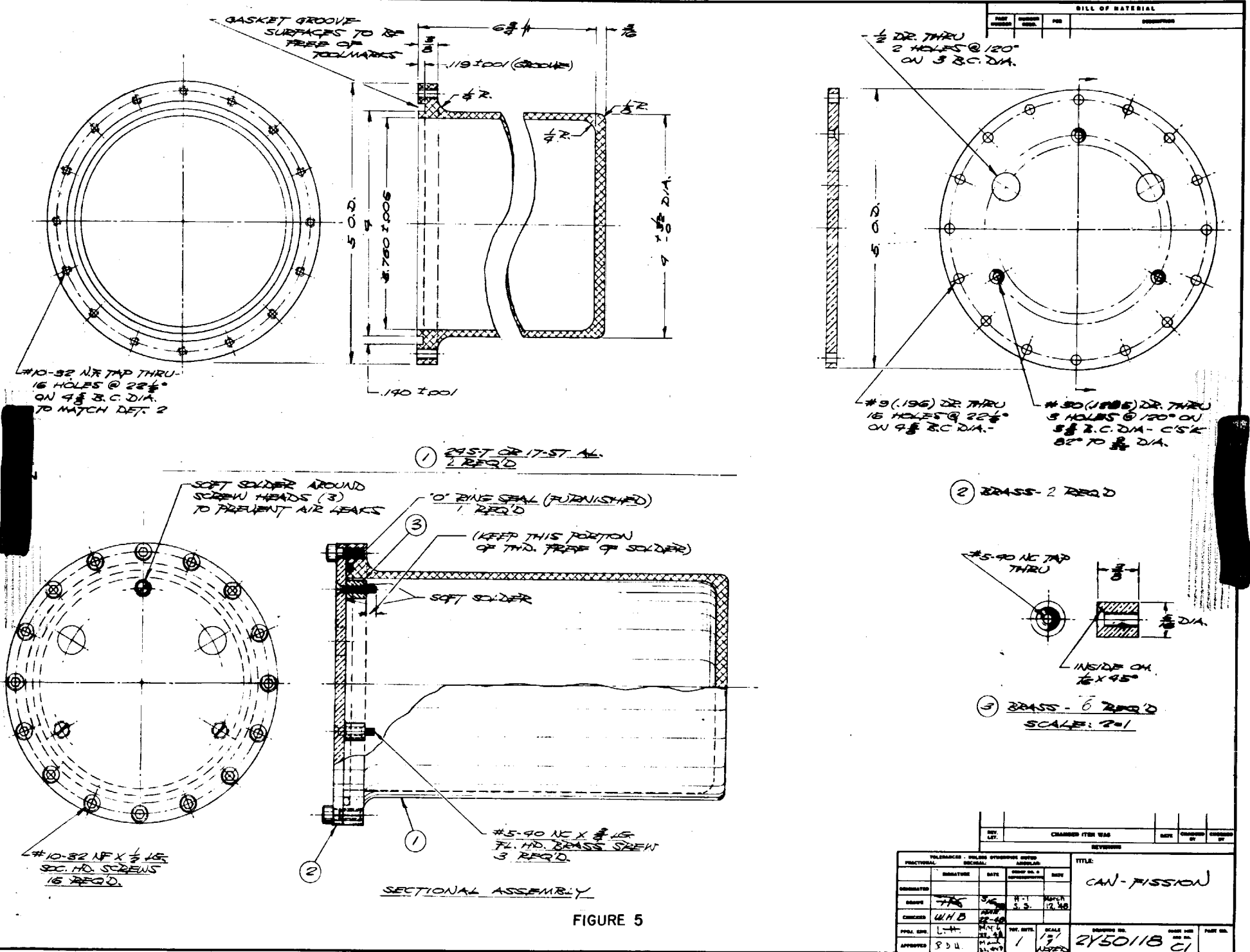
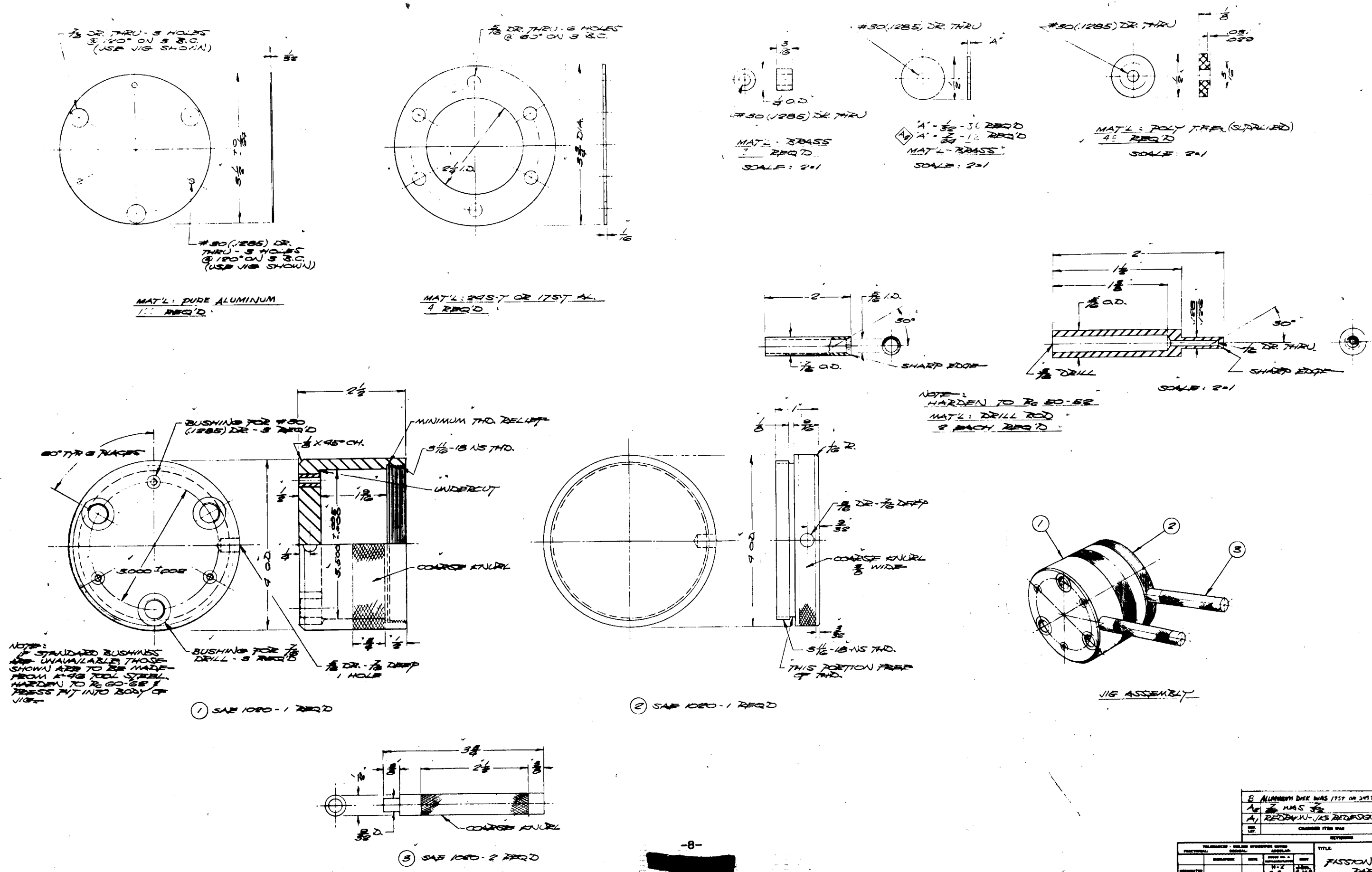


FIGURE 5



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PARTIAL		FASION COUNTER PARTS	
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revolving at a moderate speed and a solution of uranyl nitrate, alcohol and Zapon lacquer was painted upon them. (Revolving the plates ensured a more uniform deposition.) The plates were then removed to a hot plate and heated to 300°C. The material was thus converted to a mixture of  $UO_3$  and  $U_3O_8$ . By this means, a deposition of about 0.52 mg/cm<sup>2</sup> was obtained. The method seems to be limited to about 5 mg/cm<sup>2</sup>. Above this value, there is a considerable tendency for the uranium to flake off. Thin coats, however, will be retained very well, and no material can be shaken off. The total amount of material in the chamber was 0.96 g. To attenuate the slow-neutron effect, this material was depleted in the  $U^{235}$  isotope to the ratio  $U^{238}/U^{235} = 5000/1$ . After the chamber was assembled, it was filled to a pressure of 50 psi. This pressure was purely arbitrary; it was obtained by filling the chamber to 100 psi and observing the pulse height as a function of pressure. Since very little difference was observed between 50 and 100 psi, the pressure was lowered to 50 psi as an added safety factor. The capacitances of the chamber were measured and found to be as follows:

350		micromicrofarads between plates;
400	"	with one set of plates connected to the outer shell;
140	"	between one set of plates and the shell;
140	"	between the other set of plates and the shell.

To obtain stable amplification, two feedback loops are used. To obtain portability, subminiature tubes were selected. Figure 1 is a schematic of the circuit used. To reduce noise, the first tube in the first loop is triode-connected. Consequently, the feedback was arranged in such a way that the loop has a gain of 100. This allows a stability factor of about 15.

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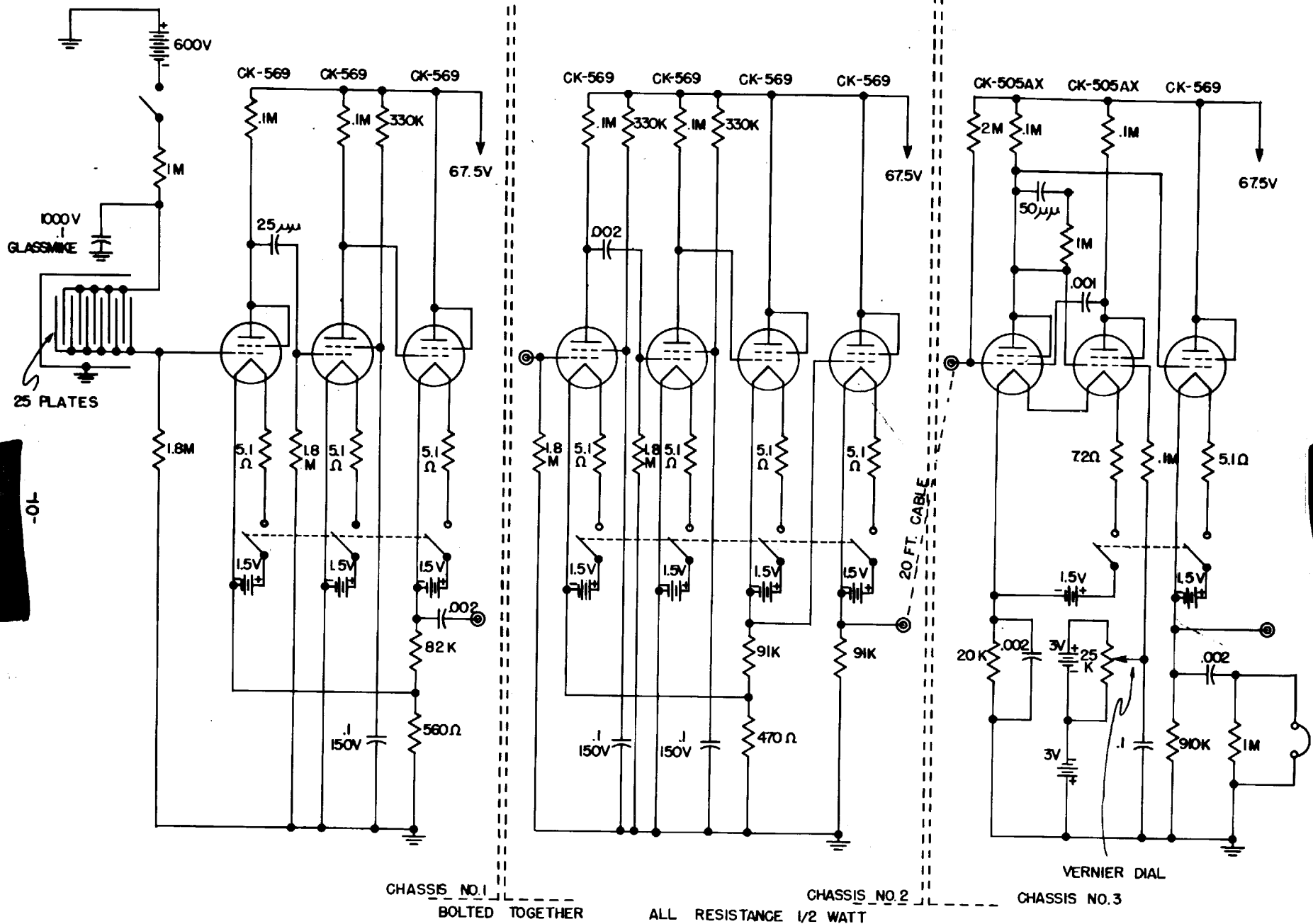


FIGURE 1

The second loop has a gain of 200. Bandwidths of both loops are about 450 kc if an 0.002-microfarad condenser is used in the first loop. Inasmuch as it was desired to drive a 20-foot length of cable, a cathode-follower output has been added to the output of the second loop. The discriminator is then in a separate box. This arrangement permits greater ease in testing the instrument with the Van de Graaff generator. In an earlier model, it was found necessary to shut down the generator for safety reasons every time the bias was changed. Consequently, it was difficult to obtain stable outputs from the generator for different energies.

A short time constant is incorporated in the first feedback loop to assist in the elimination of microphonics. However, it was still thought desirable to mount the instrument on two pieces of sponge rubber, as can be observed in the photograph.

The gain of the amplifier ( $2 \times 10^4$ ) is sufficient to produce signals of several volts. However, since the utmost in sensitivity was desired, it was decided that it would be necessary to adjust the discriminator bias so that noise could be counted. This was accomplished by adjusting the cathode resistor when the grid-control voltage was in its least-negative position.

#### Construction

The method of construction of the instrument can be observed from the photographs. The first amplifier and the 600-volt battery for the chamber were placed in a metal box. The chamber was so arranged that it protruded into the box. Thus, complete shielding was attained and the use of long input cables was eliminated. The second loop was placed in a second box bolted to the first. Electrical connection between the two boxes is by means of an external cable. In this manner, perfect shielding between

loops is accomplished. An added advantage of this method is the ease of servicing. For example, it is not necessary to disassemble the apparatus to change batteries in the second loop. The construction is such that the chassis and batteries are bolted to the end plates. Thus, the boxes slide off completely, exposing the electronic circuit in operating position. Tubes and resistors are mounted upon bakelite plates.

#### Performance

Stability of the circuit has been excellent. This is to be expected since, by means of feedback, changes due to battery fluctuations, etc., are minimized. The instrument has been tested with a Cockcroft-Walton, a Van de Graaff, and a Ra-Be source.

At 40 cm from the Cockcroft-Walton, the ratio of thermal/fast for 14-Mev neutrons was 0.0015. The instrument gave 50 cts/min for a flux of 330 14-Mev neutrons/cm<sup>2</sup>/sec. Background was 5 cts/min.

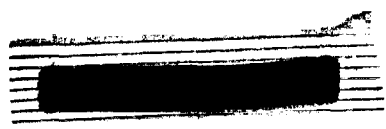
For one-Mev neutrons from the Van de Graaff, there was no appreciable rise in background for a flux of 350 neutrons/cm<sup>2</sup>/sec.

For Ra-Be neutrons, a flux of 350 neutrons/cm<sup>2</sup>/sec gave 10 cts/min.

Experiments for thermal neutrons are not complete, but it appears that the response will not be greater than for Ra-Be neutrons.

It is evident from the data that the instrument behaves as might be expected. It is unfortunate that the large thermal cross section of U<sup>235</sup> prevents a lack of response at energies below 1.5 Mev; by means of cadmium shielding however, it is possible to obtain some idea of the thermal-neutron component.

The instrument, complete, weighs 21 pounds.



Acknowledgment

I am indebted to Mrs. Jane Evans of the Foil Group for preparing the foils. Dr. Simon Shlaer designed the chamber, and Mr. Edwin Bemis was responsible for the testing of the instrument.





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