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LOS ALAMOS SCIENTIFIC LABORATORY

of

THE UNIVERSITY OF CALIFORNIA

February 15, 1951

LA-1270

CONTINUOUS TRITIUM MONITOR

by

James B. Deal, Jr.

INSTRUMENTATION

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INSTRUMENTATION

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CONTINUOUS TRITIUM MONITOR

The instrument developed to continuously detect and measure the amount of tritium in the atmosphere consists of a Model 30 Vibrating Reed Electrometer manufactured by the Applied Physics Corporation and a Model CI-I Ionization chamber designed for use with this electrometer.

The principle of operation is as follows: an electric fan continuously sucks room air first through a filter element, then through an ionization chamber and then blows the air back into the room. Except for the particles removed by the filter element the air sample inside the ionization chamber is identical to the air in the room.

The filter, ionization chamber and fan are all mounted together as a single unit about 18 inches long, 8 inches wide and weighing about 12.5 pounds (Photo 2). The unit is constructed, principally, of brass tubing silver soldered together. In addition there is a separate battery supply. These elements will now be described individually.

The filter element itself consists of two parts. First, there is a mechanical filter. This is a Chemical Warfare Service Aerosol Canister E4R3. It is a threaded unit that screws onto the chamber and may easily be replaced. All the air entering the ionization chamber must first pass through this unit where most of the particulate matter, but no gases are removed. Experiments with smoke and other particles show this to be an extremely efficient filter and adequate for the purpose. Second, there is an electrical filter. This is made up of two concentric cylinders between which all the air flows after passing through the mechanical filter and before entering the ionization chamber. The spacing between the cylinders is 0.5 inch and the voltage between them is about 1200 volts. It is the purpose of this electrical filter to remove any residual charged particles from the air before it passes into the ionization chamber. Without any filtering at all, the electrometer reading sometimes varies so wildly that it cannot be read.

A wire mesh screen separates the filter element from the ionization chamber element in order to prevent the high voltage field of the electrical filter from entering the ionization chamber proper.

The ionization chamber itself is of conventional cylindrical design, having a guard ring and a centered, polystyrene supported collecting rod. The volume is approximately one liter. The collecting voltage is 90 Volts, which is ample to collect all the ions formed within the chamber by any radioactive gases present as the air flows slowly through the chamber. The base of the chamber is designed to fit the Model 30 Vibrating Reed Electrometer and also acts as the support for the entire CI-1 unit. In addition there is a shielding collar around the collecting rod which extends upward from the guard ring about an inch. It is the purpose of this collar to shield the

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collecting rod from any electrostatic fields originating in the motor compartment, and also to prevent ionized particles caused by air turbulence at the bottom of the chamber from making their way to the collecting rod.

The fan is mounted on a spider support in a separate cylindrical compartment which is silver soldered to the main body of the chamber. The air is drawn in through a small hole that connects between the ionization chamber and the fan housing and is then blown back into the room. The motor (J80A-CC Eastern Air Devices, Inc.) is of the continuous duty, capacitor type. The propeller type fan blade is made by the same manufacturer especially to go with the motor and is cut down to fit the housing. No provision has been made for varying the air flow rate. It was not felt necessary because the ionization current collected is independent, within wide limits, of the air flow rate. The present air flow rate is determined solely by the characteristics of the fan operating at normal speed (3100 RPM) and by the resistance to the air flow offered by the entire air circuit through the unit. This rate is adequate to show any changes in room air conditions in approximately 30 seconds.

The battery supply, which is a separate unit, contains an Eveready W5 battery and two series connected Burgess 5308 (45 Volt) batteries. The W5 battery provides 1224 Volts for the electrical filter and the two 5308 batteries provide 90 Volts for operating the

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ionization chamber. A 5 megohm resistor is connected in series with the 1224 Volt source to protect personnel. However, any voltage supply providing approximately these voltages would work as well.

The Tritium Monitor is operated as follows: The Model CI-1 Ionization Chamber is mounted on the electrometer input connector and screwed securely in place. The batteries are connected so that the chamber wall is 90 Volts below ground (electrometer head) and the electrical filter element is 1224 Volts of either polority to the chamber wall. The fan is turned on. Then the electrometer is read in the usual way, giving the ionization current.

It has been found that the variation in the background current, due to cosmic rays, alpha particles from the chamber walls and natural radioactive gases in the air, etc., is the limiting factor in the sensitivity of this set-up. In other words it is the "signal-to-noise ratio" of the chamber itself, not the sensitivity of the electrometer, which limits the minuteness of the quantity of tritium that can be effectively measured. If the electrometer reading is recorded, this aids greatly in increasing the accuracy with which the current can be read since much of the spurious background can be discounted and only the integrated value of the current read. Using this method tritium concentrations on the order of tolerance (10^{-12} curies /cc) can be detected. Ten times tolerance can be read with ease.

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These last remarks can be amplified by citing the actual figures involved.

Because no known concentration of tritium in a room or other large enough enclosure was available, the chamber has been calibrated by calculation. A tolerance concentration of tritium with an average Beta energy of 6 Kev. in the one liter chamber will yield an ionization current of about 2.4×10^{-15} amperes. With the electrometer sensitivity set at 10^{-13} amperes full scale this reading will then be about 2.4% of full scale.

Now with the electrometer set at this same sensitivity of 10^{-13} amperes full scale, a continuous average background reading of about 3 or 4% of full scale is obtained on a recorder. On top of this there are variations of up to 3 or 4% of full scale of short duration. These short pulses or pips on the record may be ignored to the extent that a change in the average reading of 2.4% could be detected. The electrometer sensitivity can be increased 10 or 100 fold by merely turning a knob but this does not decrease the amount of tritium that can be detected against the background because its fluctuations will also be increased 10 or 100 times.

However, it goes without saying that any other radio-active gas or a nearby gamma source can also cause ionization current within the chamber. These currents cannot be distinguished from those caused by tritium.

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Tests were made on a chamber almost ten times the volume of the CI-1 and it was found to be more effective in measuring small amounts of radiation. This results from an improvement in the "signal-to-noise ratio" due to the fact that the ratio of the volume to the surface area is greatly increased. The desired ionization current varies directly with the chamber volume whereas part of the background current is a function of the chamber surface area. However, it was not felt that the greatly increased weight and bulk of the larger chamber was worth the improvement in performance.

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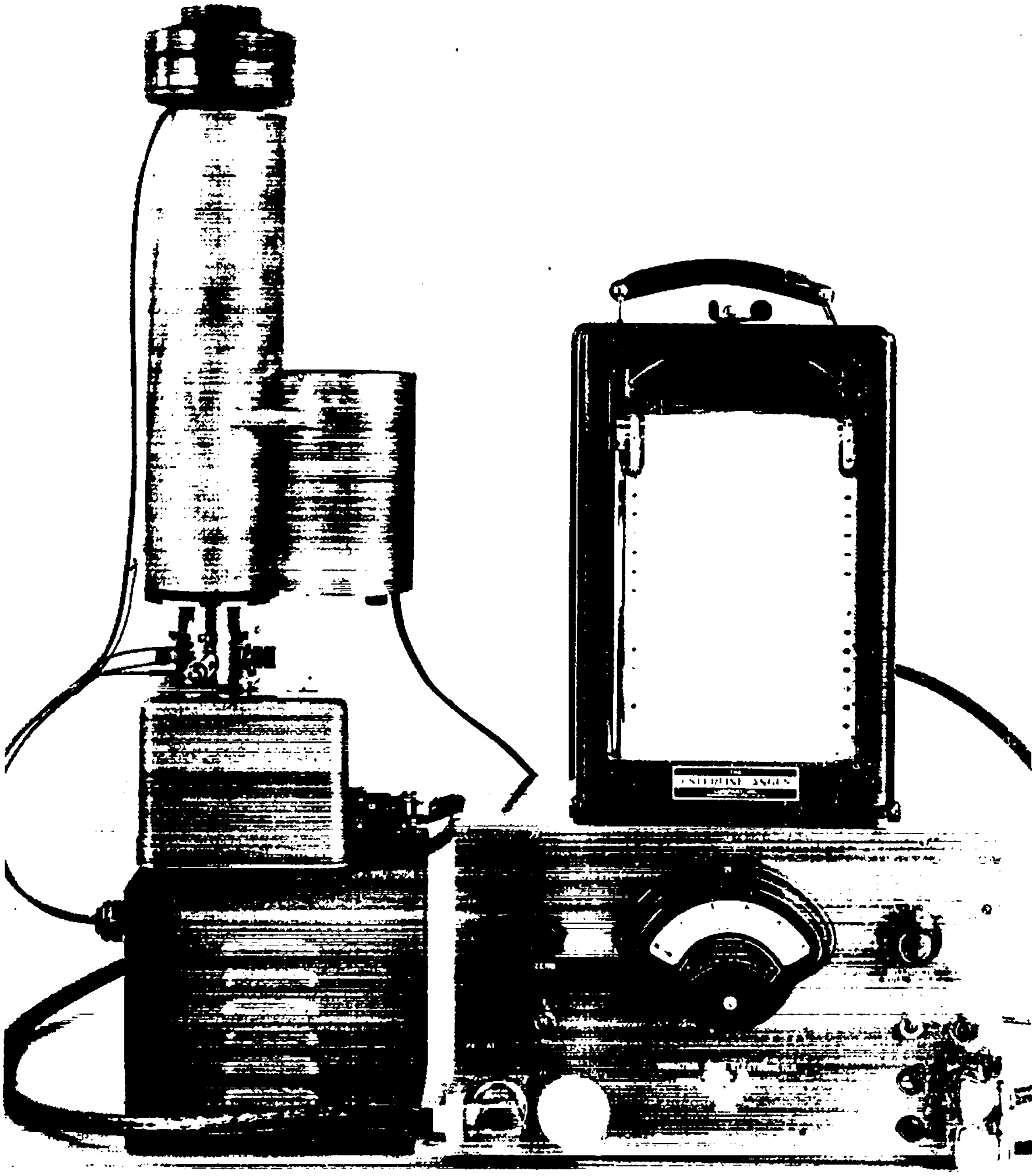

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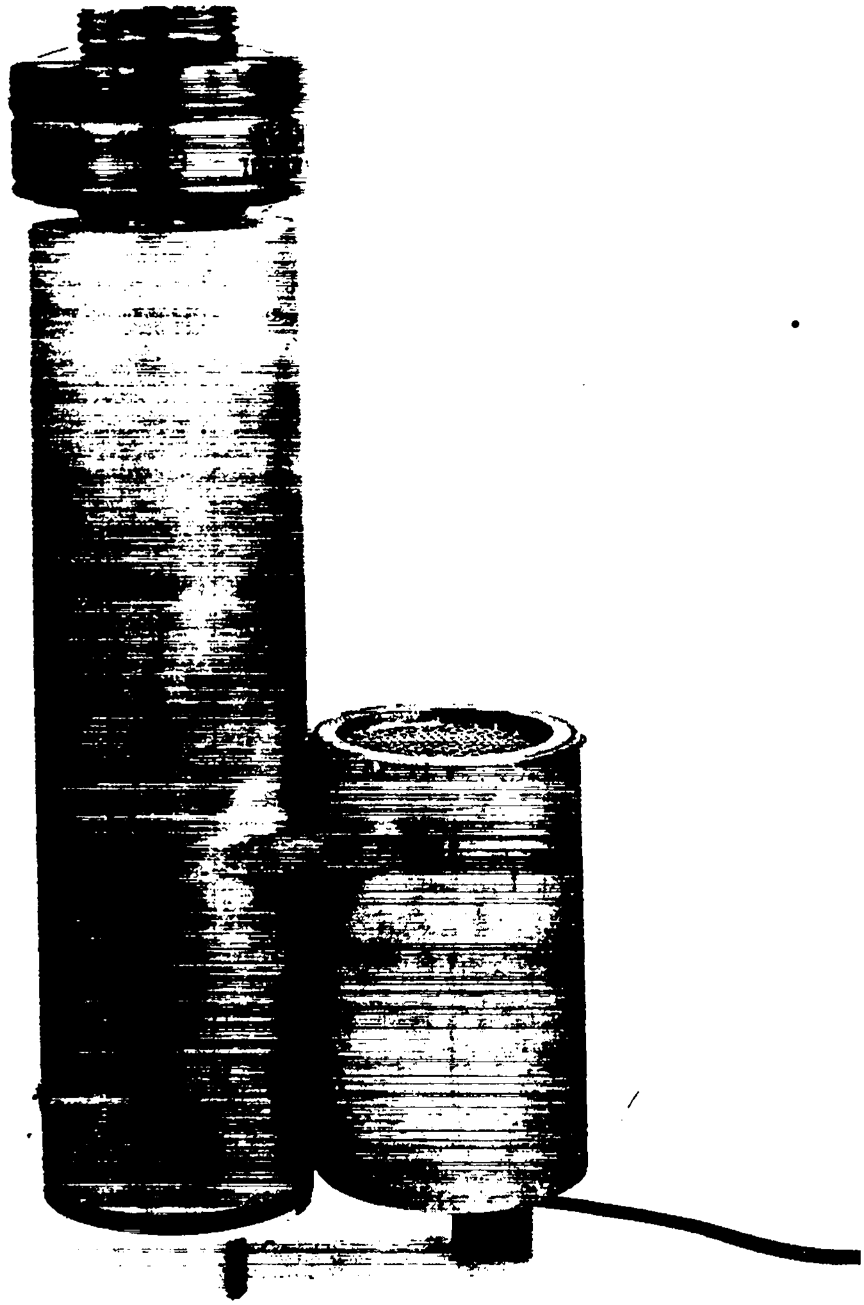

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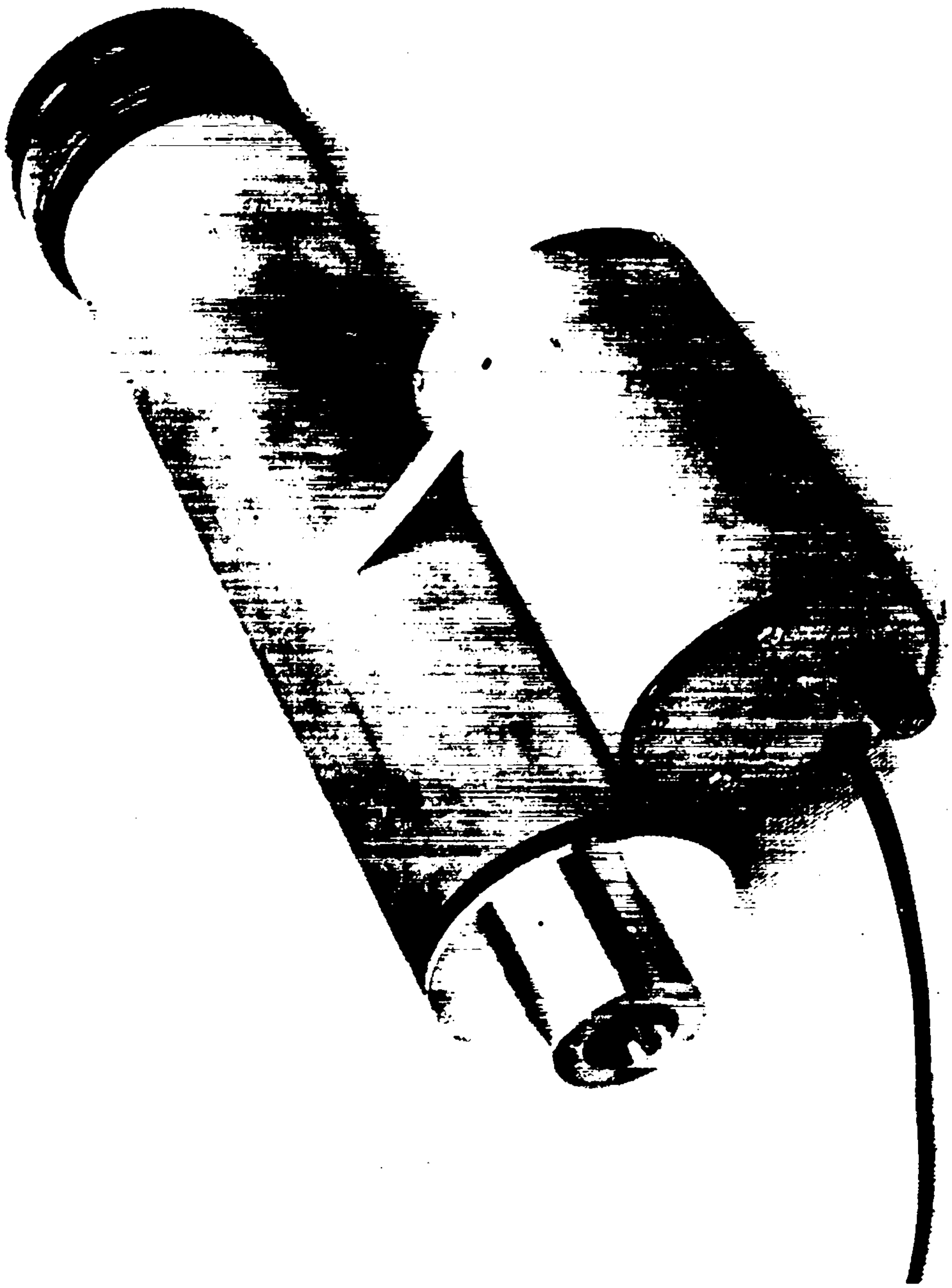

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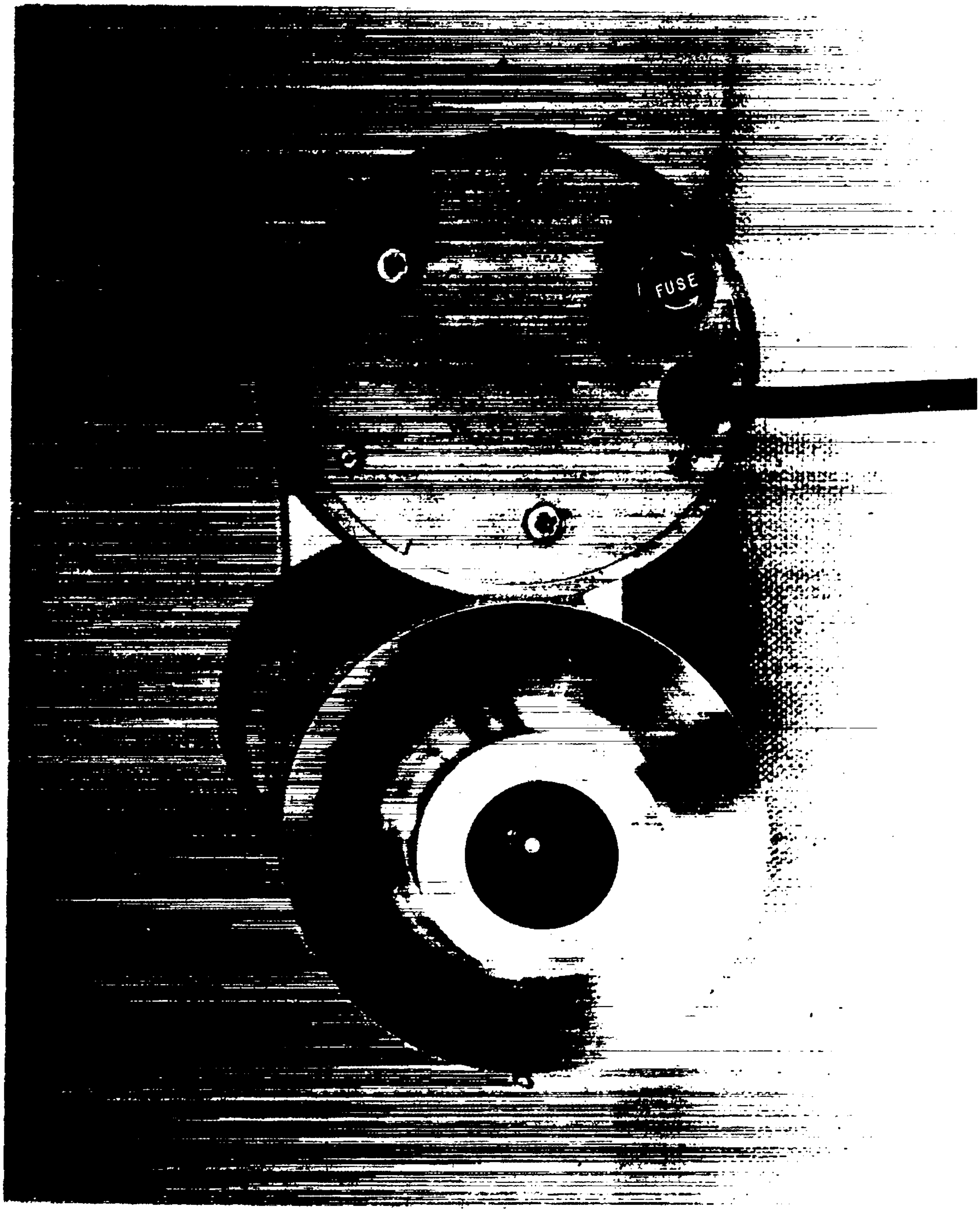

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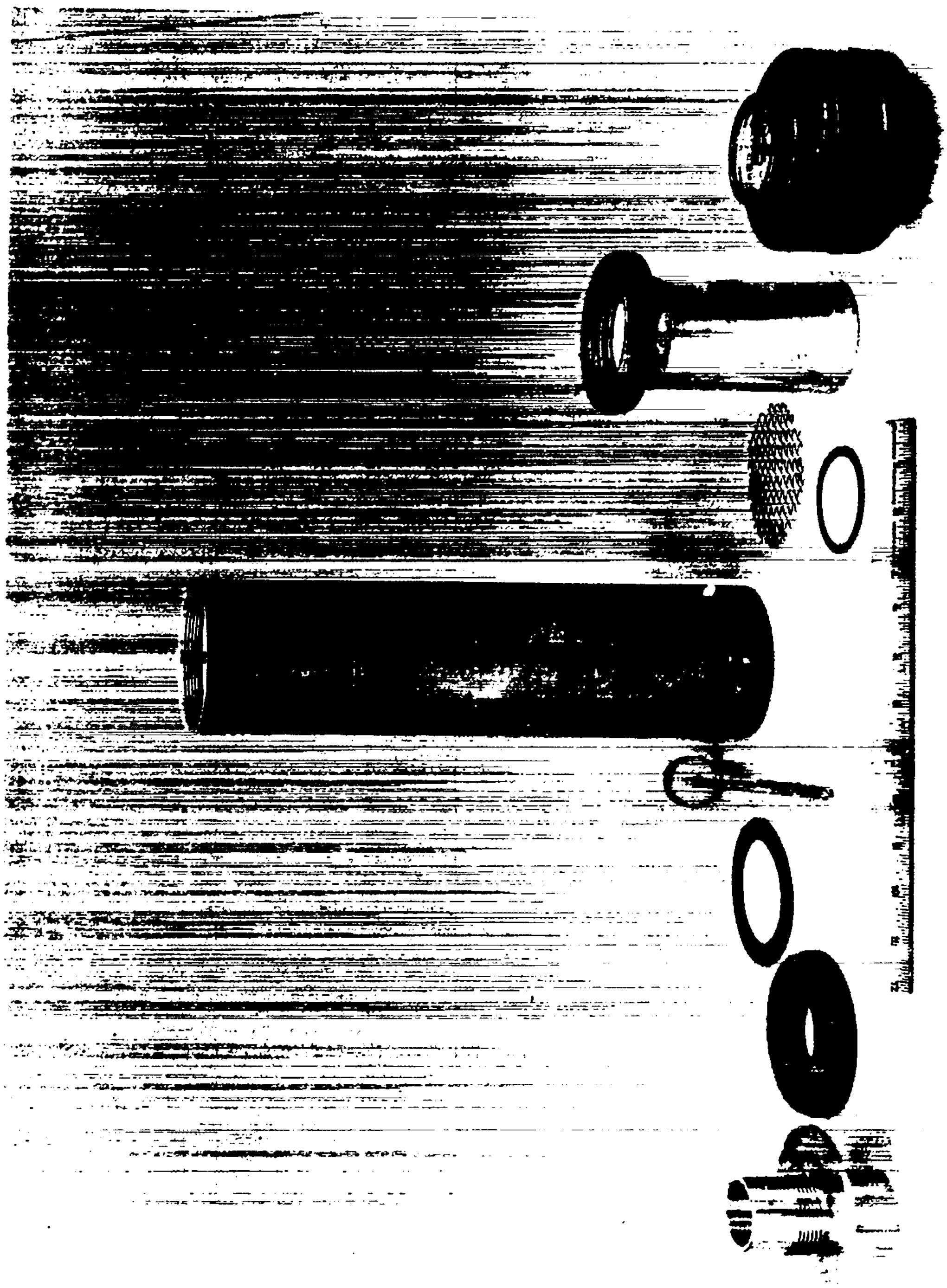

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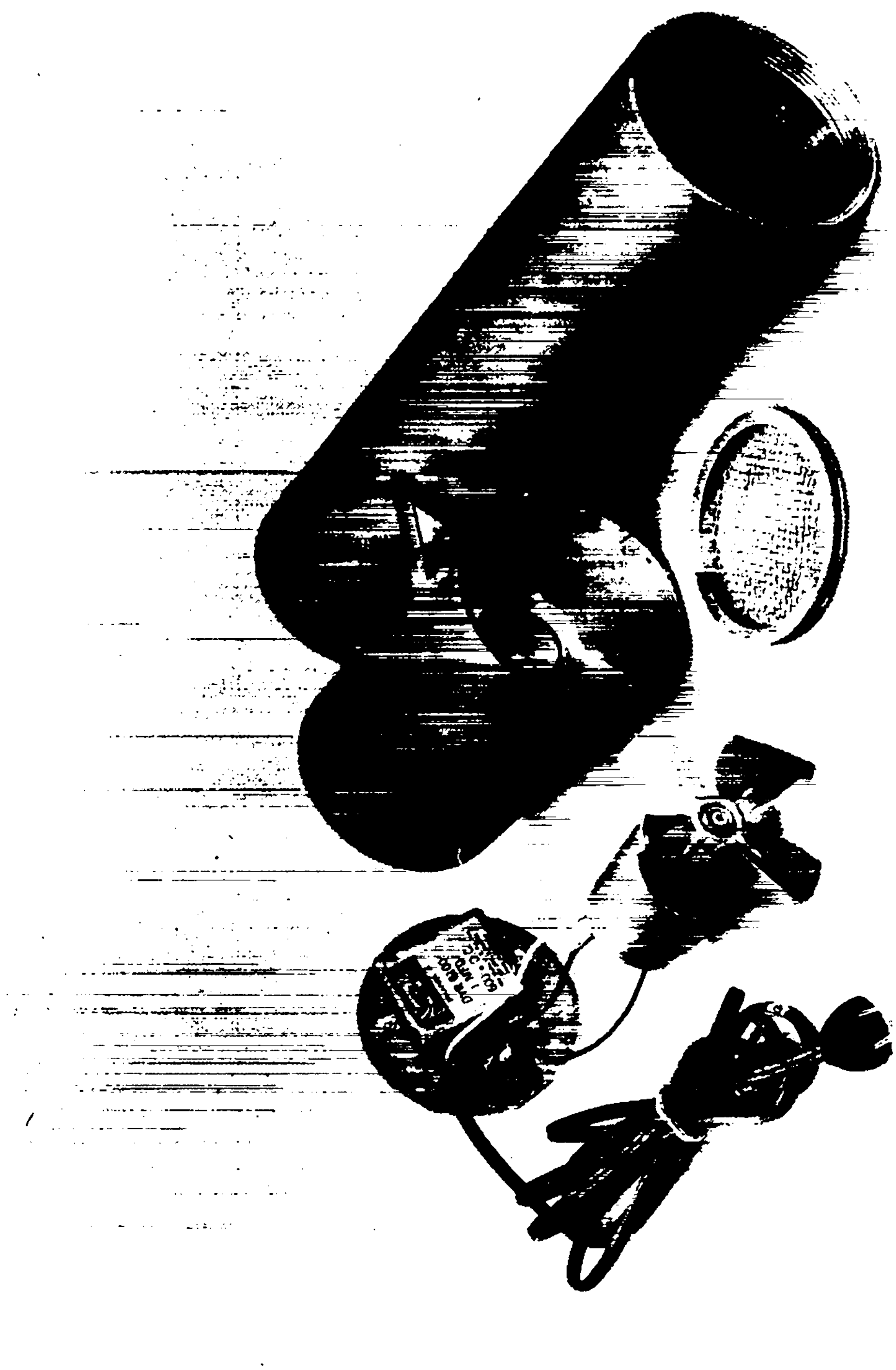

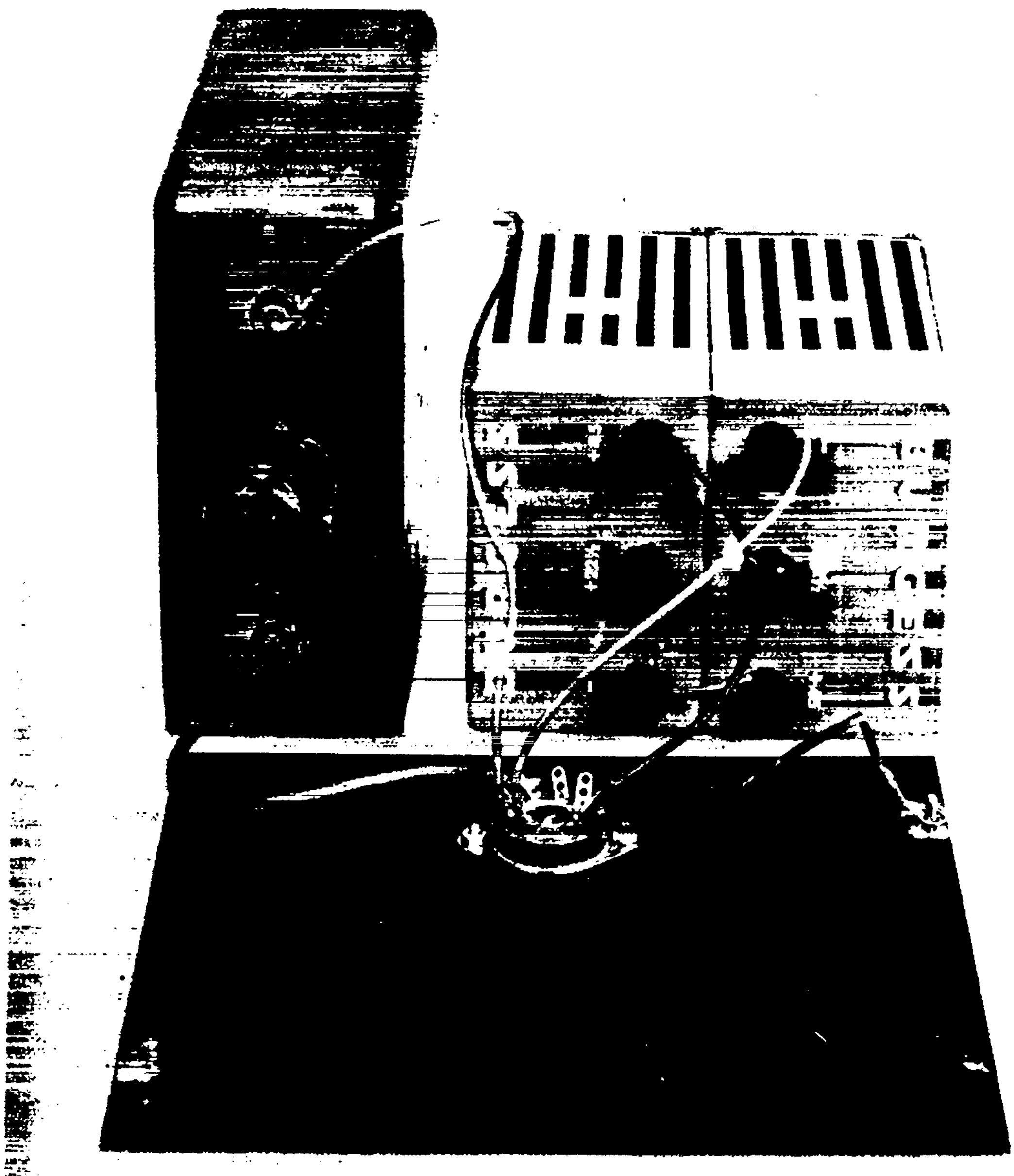

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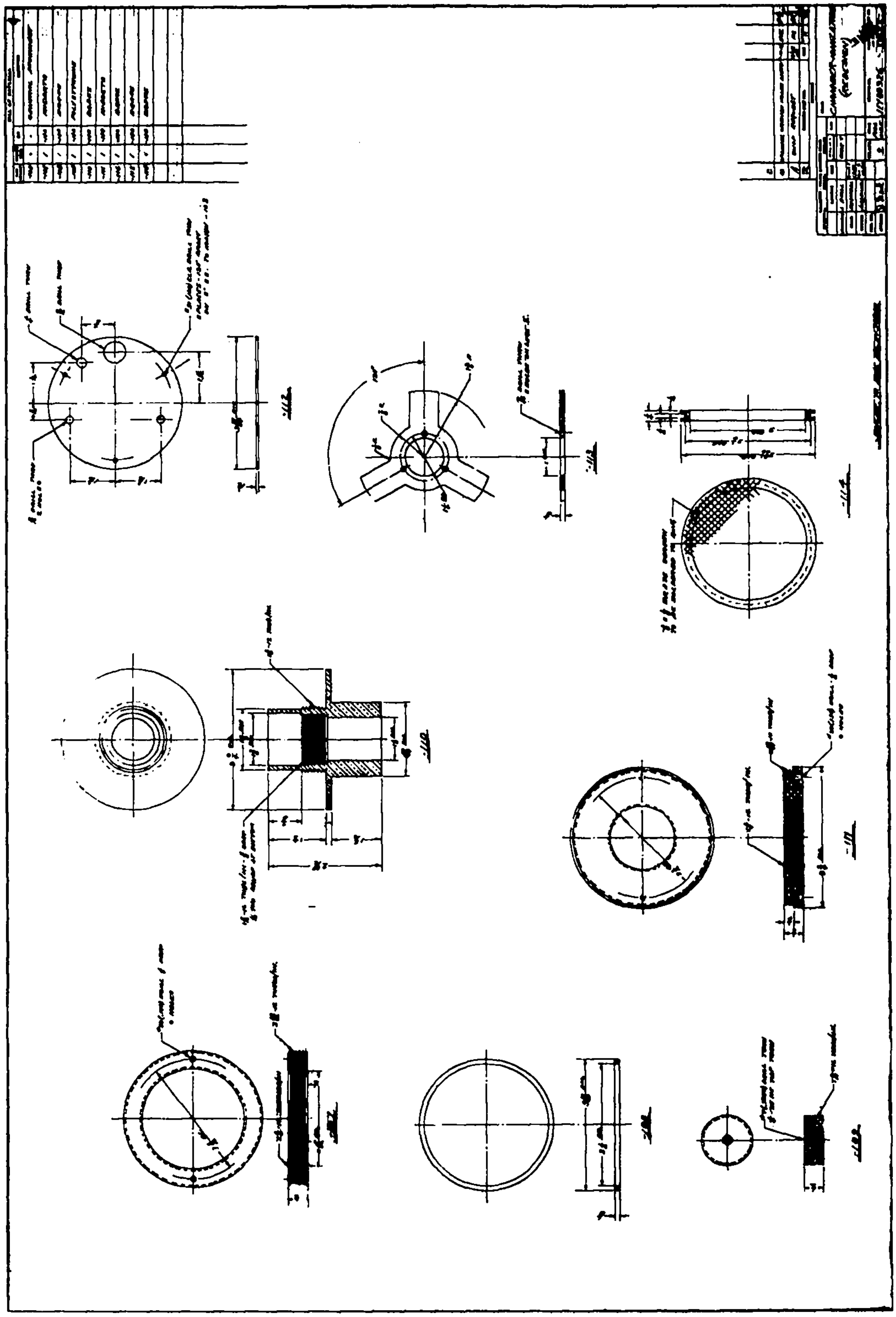

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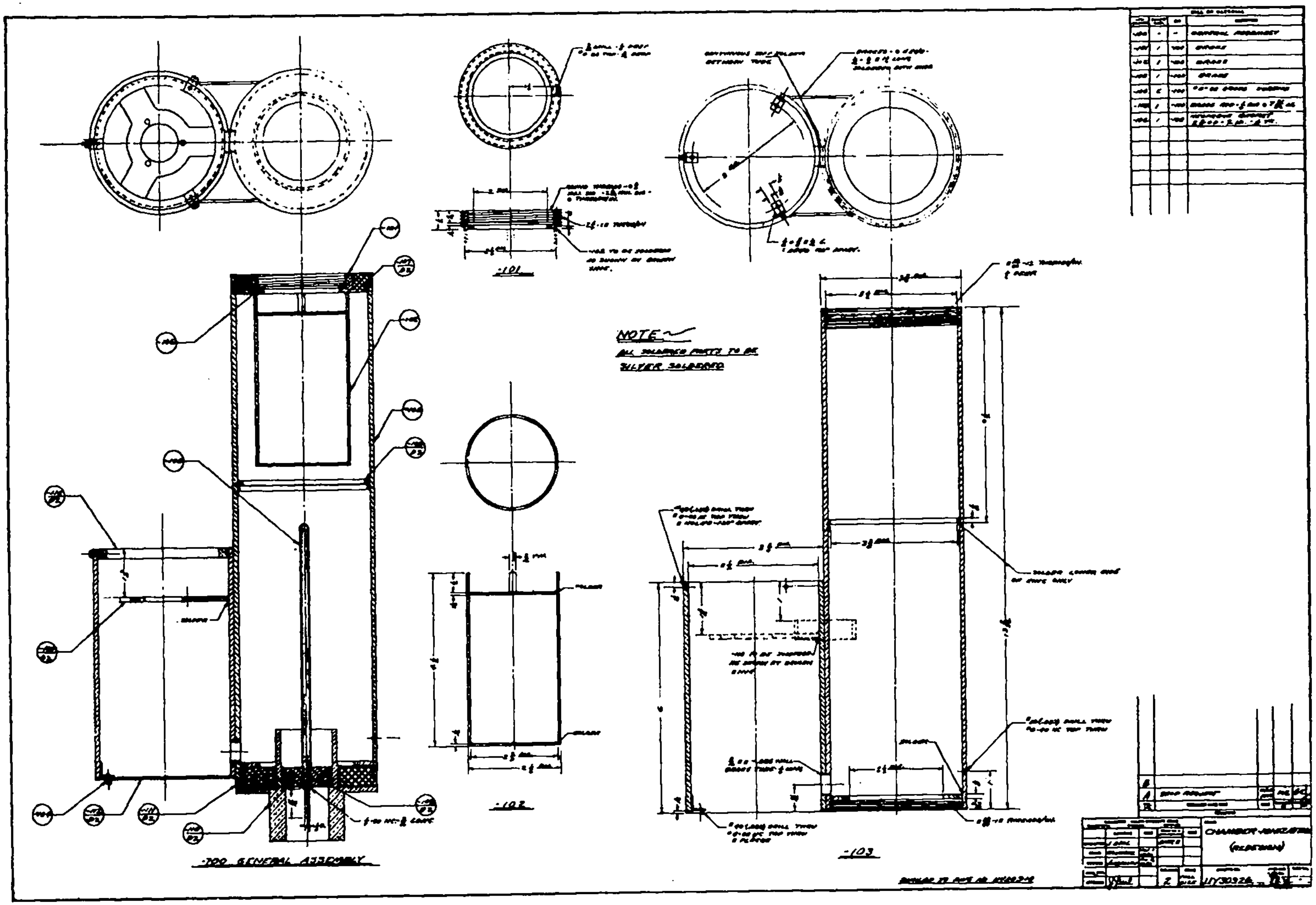

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