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NAVY DEPARTMENT

Report On

Geiger Counter Detector of Radioactive Ink

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ANACOSTIA STATION
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Office of Censorship

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PLATES

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1. Reference: (a) Ltr. from Chief Postal Censor, Lt. Col. N.V. Carlson, The Office of Censorship, to the Director, Naval Research Laboratory.

2. In reference (a) the Office of Censorship requested this Laboratory to develop a rapid means of inspecting mail for radioactive ink messages. It was suspected that the radioactive ink employed by enemy agents would be prepared from radio-sodium. By proper treatment, this ink could be rendered safe from detection by the usual chemical tests. The message could be revealed by placing the letter sheet in contact with photographic film and exposing for a few hours, which was too lengthly a time for Censorship inspection. In the following paragraphs is described a Geiger counter device which appeared to be sufficiently sensitive and rapid for the purpose.

3. Na^{22} may be prepared by bombarding fluorine in the form of NaF and LiF with alpha particles from radon. The reaction is described by

$${}_9F^{19} + {}_2He^4 = {}_{11}Na^{22} + {}_0n^1.$$

4. Stronger preparations can be produced by the bombardment of magnesium with high speed deuterons, according to the reaction

$${}_{12}Mg^{24} + {}_1H^2 = {}_{11}Na^{22} + {}_2He^4.$$

5. The active sodium disintegrates to form neon gas and positrons,

$${}_{11}Na^{22} = {}_{10}Ne^{22} + e^+.$$

6. The positrons have the energy distribution shown in Plate 1, with a maximum energy near 0.6 MEV. Accompanying the positrons are an equal number of gamma ray quanta of energy 1.3 MEV. Both the positron and gamma ray radiations may be detected with Geiger counters.

7. The Geiger counter is a sensitive detector of ionizing particles and quanta since it responds to single charged particles. It falls short of being a perfect detector because of its background count, which ordinarily is about two per minute per square centimeter of cathode area. This background tends to mask the effect of the disintegration radiation. In general, it is difficult to detect quickly radiation which produces fewer counts than the background. Using a gamma ray counter, it was found that the counts from a letter written with radio-sodium amounted to little more then the background count - making it necessary to count for about one half minute to assure detection. Detection with a positron counter, was much more effective. The explanation lay in the relative efficiencies of the two counting processes. Gamma rays do not ionize the gaseous volume of the counter directly but eject Compton electrons from the cathode wall. On the average, only one out of every hundred quanta striking the cathode

succeed in ejecting electrons into the active volume of a counter. Positrons, however, ionize the gaseous volume of a counter readily, producing from 50 to 1000 ion pairs per centimeter of path at atmospheric pressure. Since only one ion pair is needed to trigger a count it is obvious that positrons may be counted with 100 percent efficiency.

8. The major problem in positron counting is to get the positrons into the active volume of the counter. Plate 2 shows the number of positrons from radio-sodium which penetrate various thicknesses of aluminum foil. At the maximum energy of 0.6 MEV, 0.5 mm of aluminum is required to stop all the positrons. Eight hundredths of a millimeter stops half the positron emission and four hundredths transmits three fourths of the positrons. A positron counter should therefore be constructed with as thin a window as possible. Since the counter must be evacuated, the window foil must be strong enough to support atmospheric pressure. Aluminum foil one-thousandth of an inch thick, supported atmospheric pressure over an area one-half inch in diameter. To provide a window of larger area, the foil was supported on a perforated disk of heavier metal, as shown in Plate 3, where the complete window is three inches in diameter and the individual apertures are 3/8 inch across. One quarter of the cathode was cut away facing the window so that the positrons penetrating the window entered the active volume directly (Plate 4). With this counter, the positron count from a letter was about ten times the background count and therefore immediately detectable.

9. A slight improvement was achieved by the use of duraluminum foil, which supported atmospheric pressure over two square inches, (Plate 5).

10. A sheet of common writing paper is of the order of three thousandths of an inch thick, and stops as many positrons as one thousandth of an inch of aluminum. The inspection is therefore limited to one letter at a time if the letter is not to be removed from its envelope. About ten letters per minute may be inspected.

11. The counters illustrated were filled with argon and alcohol and could be used with any of the conventional counting or integrating circuits. The complete system built for the Office of Censorship is shown in Plate 6. It employed the simple integrating circuit of Plate 7. A radioactive letter passed across the window of the counter would deflect the meter full scale.

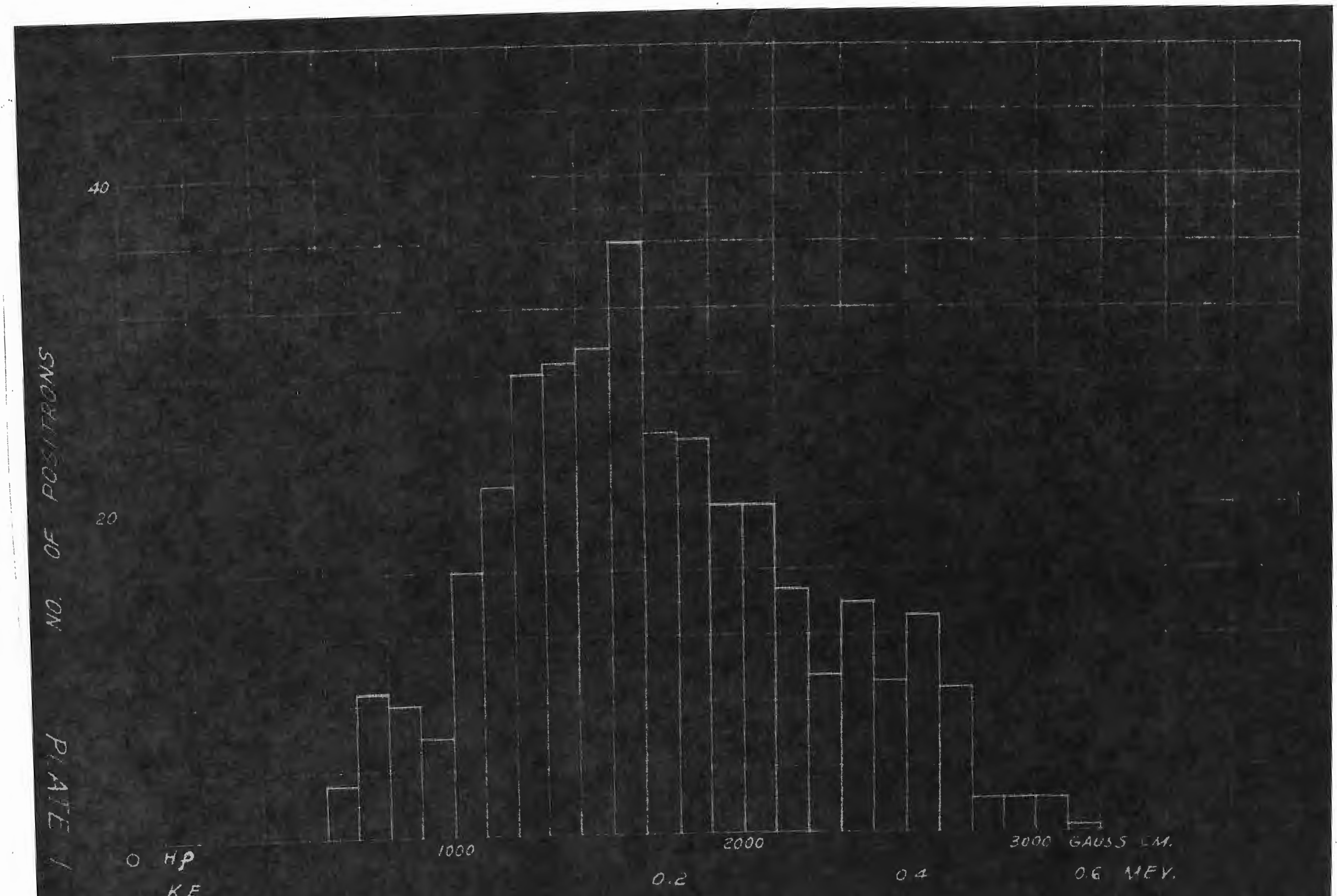

PLATE I

MOMENTUM DISTRIBUTION OF POSITRONS FROM Na^{22}

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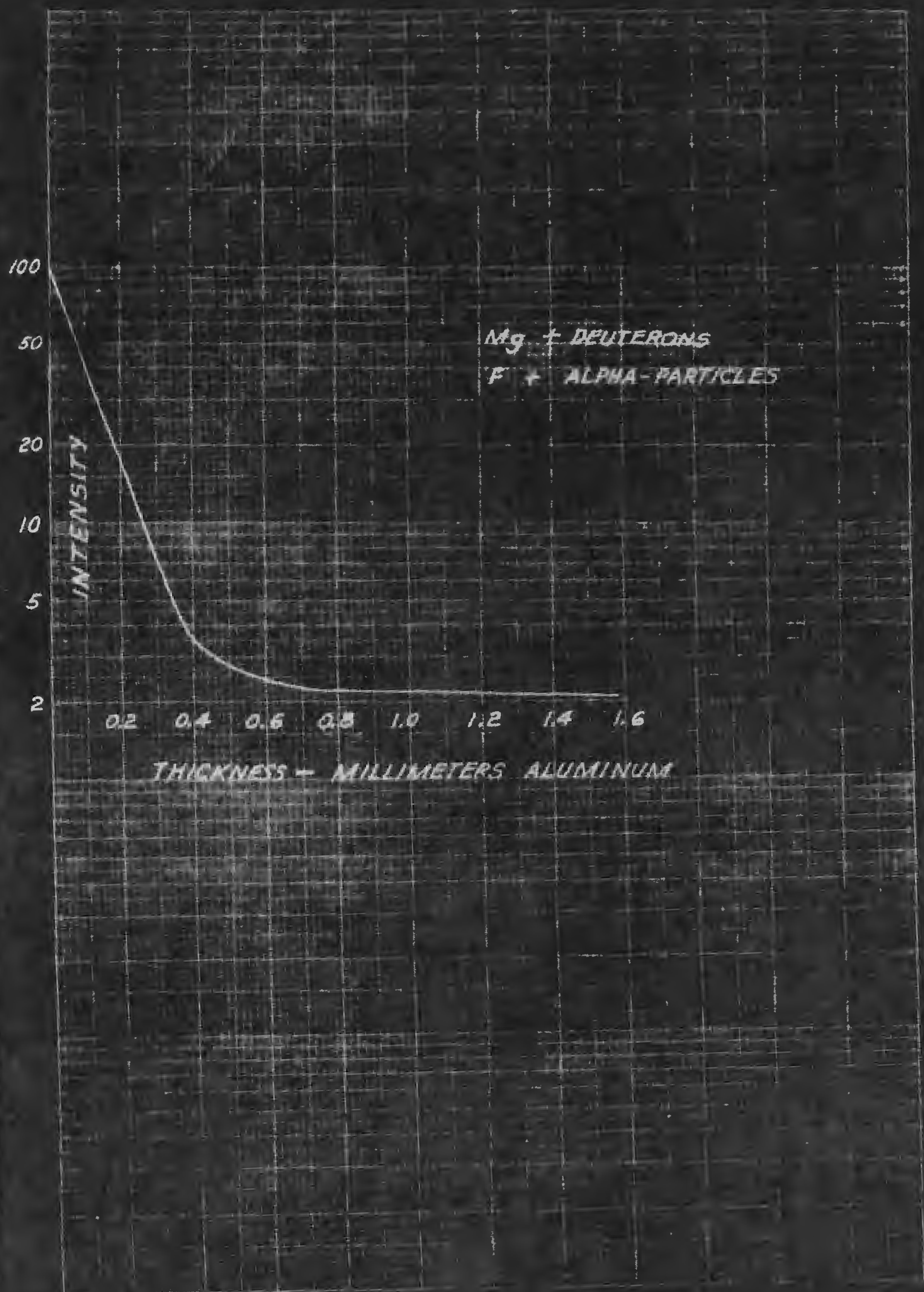

PLATE 2

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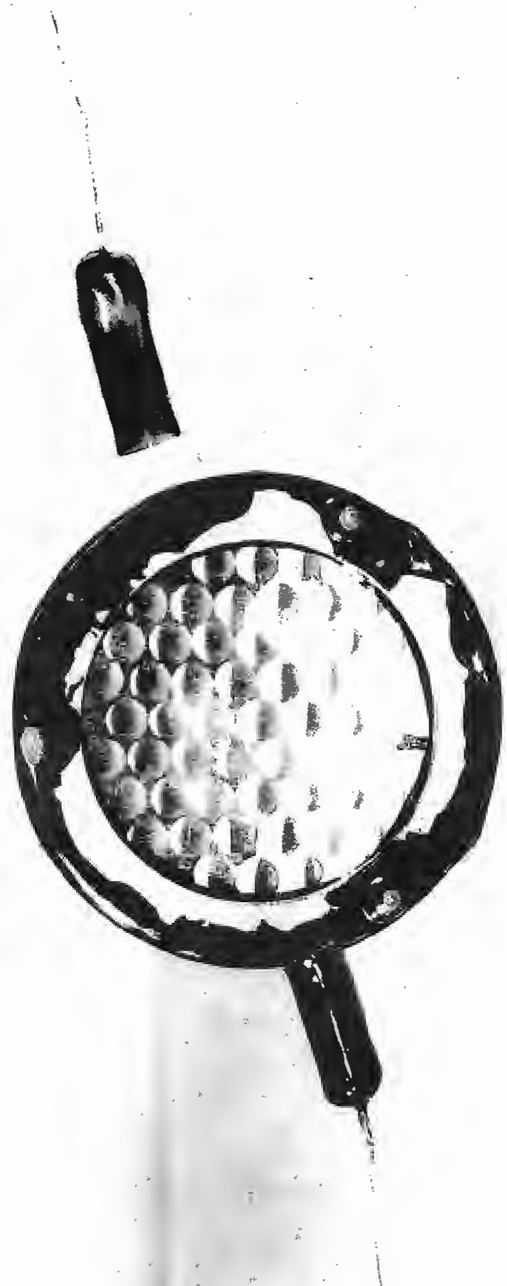

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PLATE 3

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PLATE 4

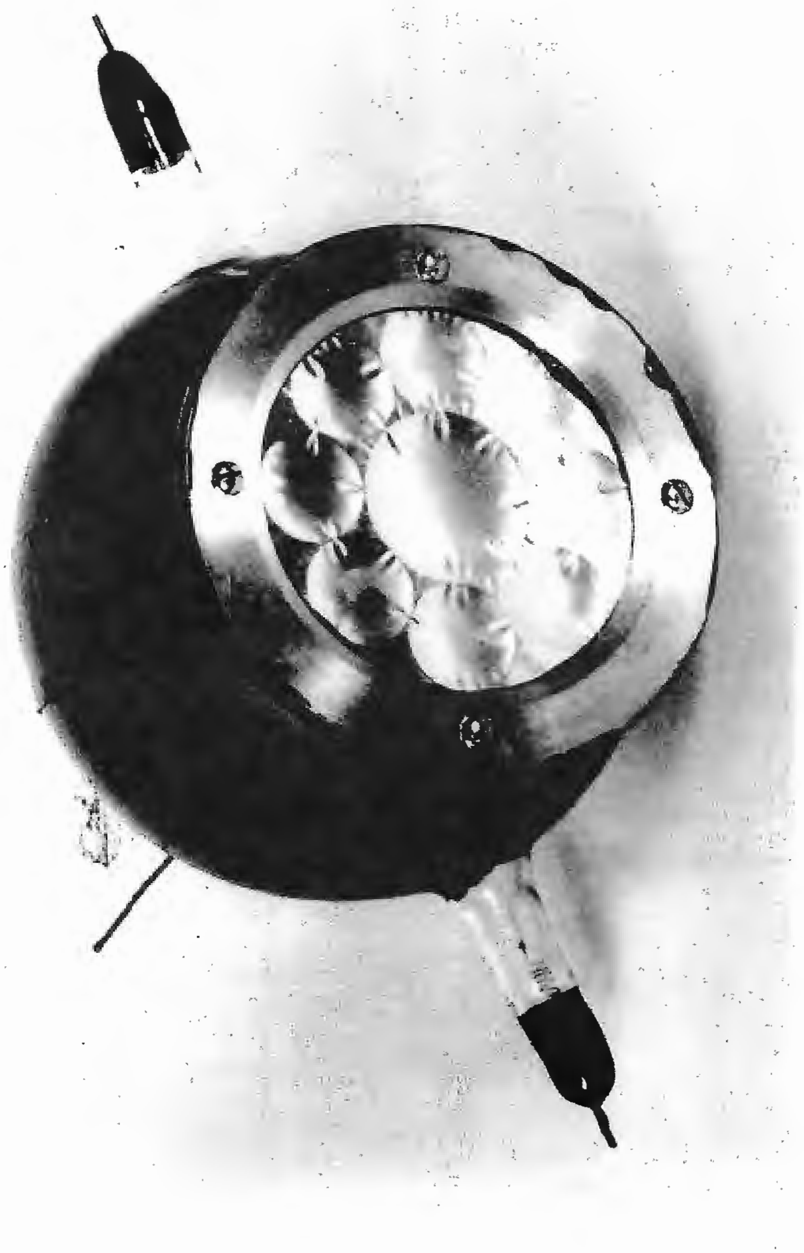

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PLATE 5

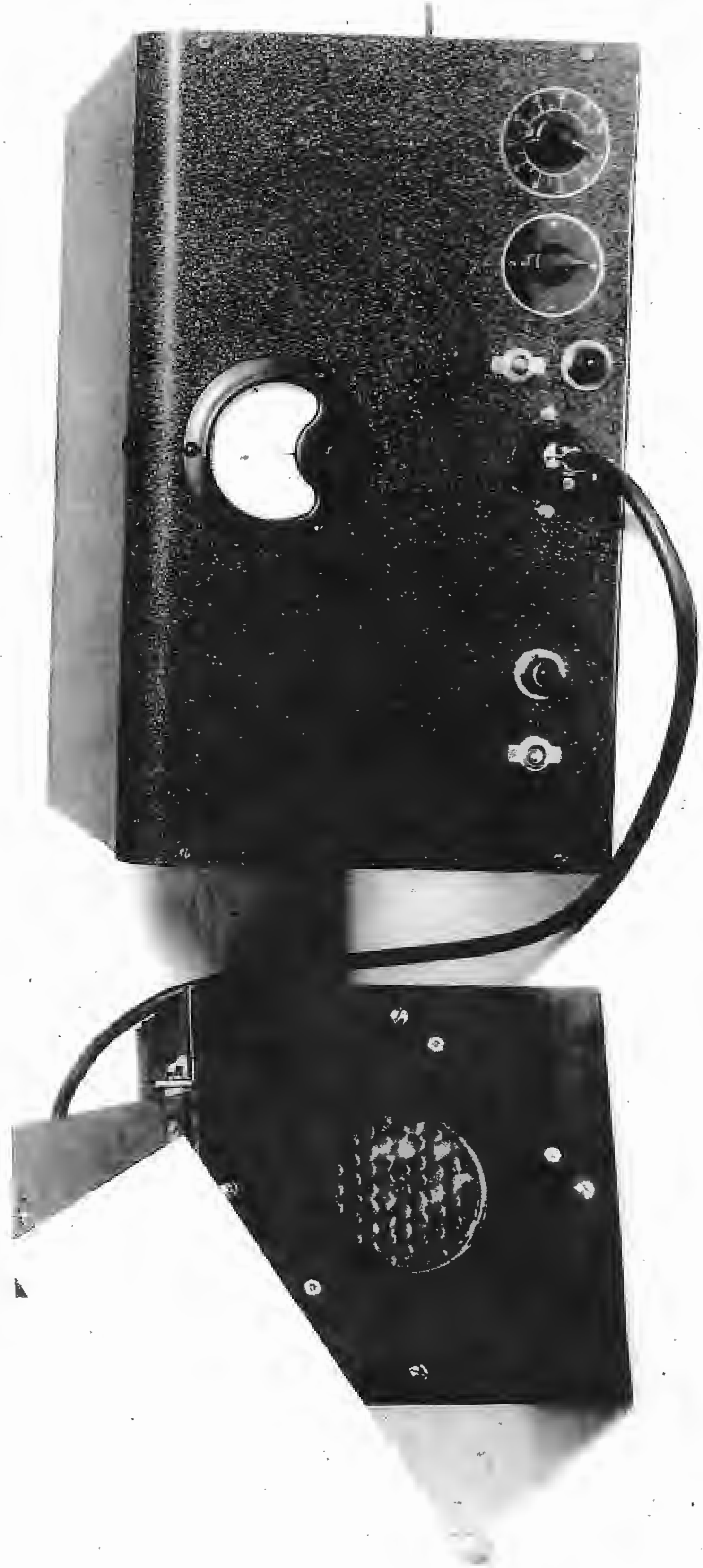

PLATE 6

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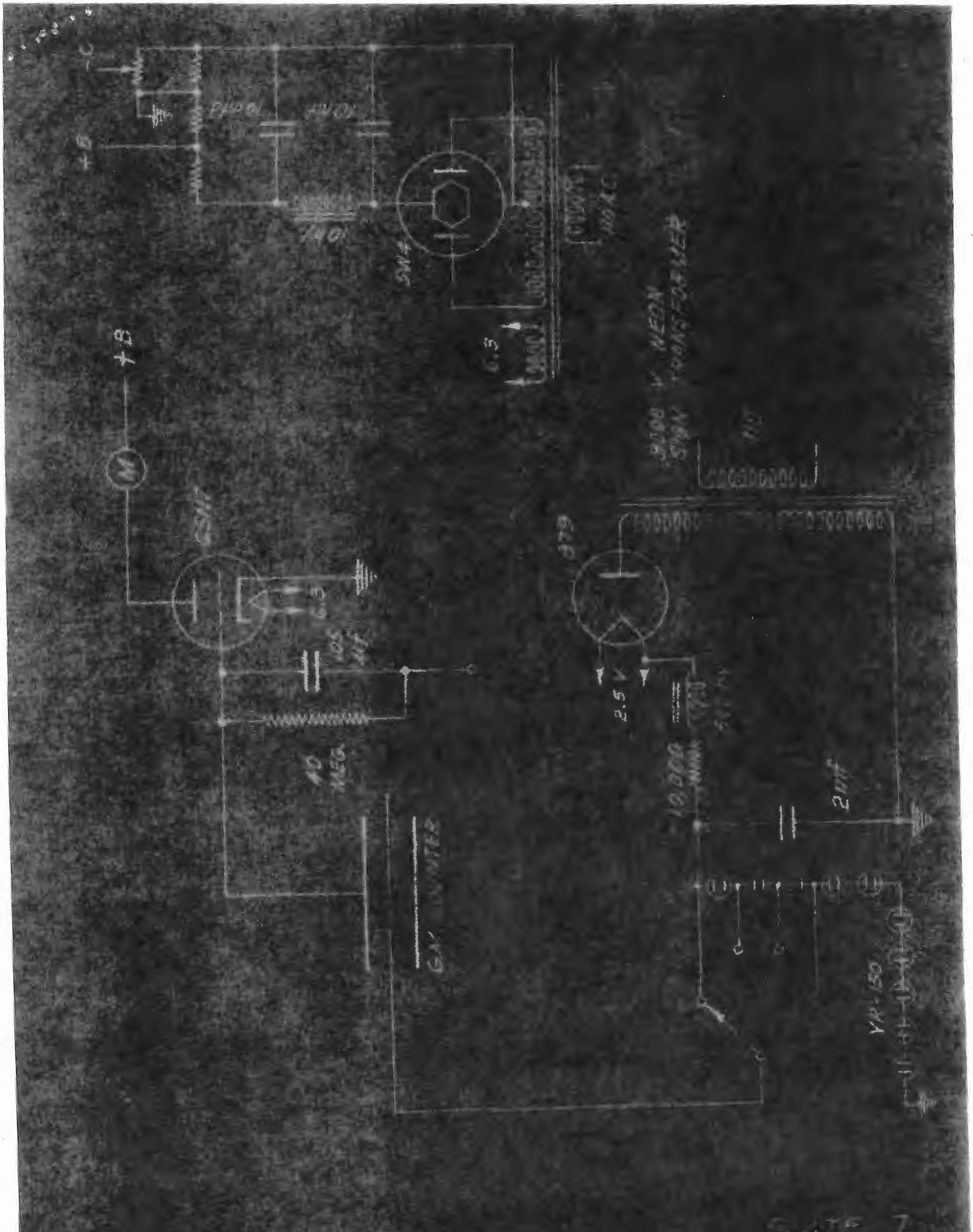

PLATE 7

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