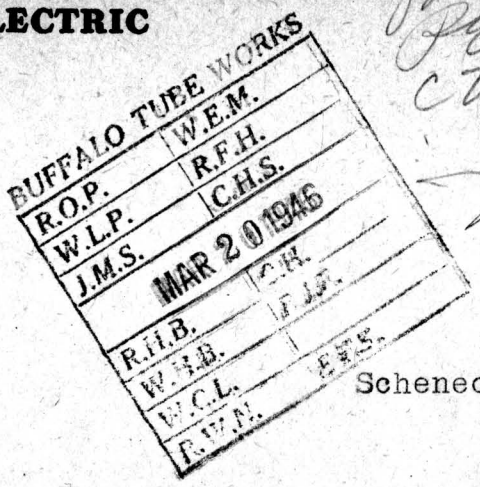
ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SUBJECT

LOCATION

REFERENCE



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FOR FILING

Schenectady - March 18, 1946

Mr. R. W. Newman
BUFFALO TUBE WORKS

We are enclosing a copy of Data Folder #77884 by Miss C. E. Kousnetz on breakdown potentials of gasses under various conditions..

The Data Folder on spectrographic analysis is in process and we will send you a copy as soon as completed.

HC Steiner/mm

ENGINEERING
TUBE DIVISION

HC Steiner:mm
Tel. 3710

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GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y., U. S. A.

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DATA FOLDER No. 77884

Title Variation in Breakdown Voltage With Pressure in the FG-238B and FG-259B and a More Complete Interpretation of the Standard "Hi-pot" Test

By

Electronic Tube Engineering Div.

Information prepared for Electronic Tube Engg. Div.

Tests made by C. Kousnetz

Information prepared by C. Kousnetz

Countersigned by K. C. DeWalt

Date Dec. 24. '45

Variation in Breakdown Voltage With Pressure in the FG-238B and FG-259B and a More Complete Interpretation of the Standard "Hi-pot" Test

Purpose:

These data were taken to investigate the possibility of using pressure vs. breakdown-voltage data for the qualitative and quantitative determination of gases present in vacuum tubes failing the standard "hi-pot" test.

Summary:

The determination of degree of vacuum present in a tube in terms of dielectric strength can be obtained by "hi-pot" testing of the tube if a pressure vs. breakdown voltage curve has been plotted for that tube type. This method will give the gas pressure as lying within a given range. The qualitative determination of gases present, however, proves difficult if not impossible, since the curves for all the common gases differ only slightly. (A possible exception would be the presence of CO_2 alone as it can be liquified at -78.5°C and the tube re-tested for gas).

Theory:

Assuming that the spark for breakdown is determined by secondary emission at the cathode, it can be shown mathematically that the following expression may be found for the sparking potential "V_s" of a uniform field:

$$V_s = \frac{Bpd}{\ln\left[\frac{Apd}{\ln(1/k)}\right]}$$

Since A, B and k are constants determined by the nature of the gas, the sparking potential is a function of the product of the pressure and the gap length alone.

This principle is applied in the "hi-potting" of vacuum tubes where a high voltage is impressed across the tube. If the tube will withstand a specified high voltage with no indication of breakdown in the inter-electrode gap, a sufficiently good vacuum exists and the tube passes the test.

However, thus far this principle has not been extended further

to the possible quantitative and qualitative determination of gases present in tubes failing the standard "hi-pot" test. In many cases it would prove most valuable in terms of design, production and exhaust to know the origin of the gas or gases present in the tube.

Procedure:

Using the circuit shown in figure (1), data were taken on three tubes having the same gap length "d", (i.e. 3/8" ± 1/16") the values of breakdown voltage vs. pressure being taken for N_2, CO_2, O_2 and air in that order. The gases were all dry and the purest obtainable. The air used was the moist air present in the room at the time of the experiment. Some mercury contamination was present throughout the experiment. Data were taken on an FG-238B (see K-5344704) without bakeout, an FG-238 which had been baked-out and an FG-259B (see K-5965388) from which most of the mercury had been removed. When the second set of data were taken on the FG-238B (ie. with bakeout) R was increased from 10,000 ohms to 100,000 ohms. The latter value was also used for the data taken on the 259.

Results:

Assuming a uniform field, the data in Figures 2 - 5 should correspond rather closely, as "d" is approximately the same for all three tubes.

Although at first glance some wide discrepancies appear to exist between the three tubes on which data were taken (see Figs. 2 - 5), most of these were attributable to the characteristics of the "hi-pot" set. Thus, below approximately 10 microns the data taken using R = 100,000 ohms were not reliable due to capacitance effects and in this range Figs. 2 and 3 give the closest values. Above this value, R = 10,000 ohms gave too little sensitivity to lowered voltage breakdown so in this range (ie. 10 microns and higher) the data taken in Fig. 3 using R = 10,000 ohms probably presents the truer picture. Allowing for these factors it is seen that in accordance with the theory the curves for the three tubes are approximately the same and follow the general form of Paschen's curve, showing the expected minimum in the 40 - 80 micron range.

The following conclusions can be drawn from these data:

(1) If the pressure is known to be less than 100 microns, pressures from 0 - 100 microns can be read in terms of dielectric strength to within approximately 20% of the true value.

(2) Pressures from 100 microns to 1 mm. of mercury can be read as lying within that range.

(3) If the pressure is known to exceed 100 microns of mercury pressures above 10 mm of mercury can be read to within approximately 20% of their true value.

(4) The qualitative determination from such data of the gas or gases present would be extremely difficult, if not impossible, as the curves for the different gases on which data were taken are so similar.

One general fact brought out by these data which is often overlooked is that the breakdown voltage <u>increases</u> with increasing gas pressure in the high pressure range, ie. above approximately 10 mm. Thus, the assumption which is generally made that an increase in breakdown voltage indicates a better vacuum, is not always true.

C. Kousnetz

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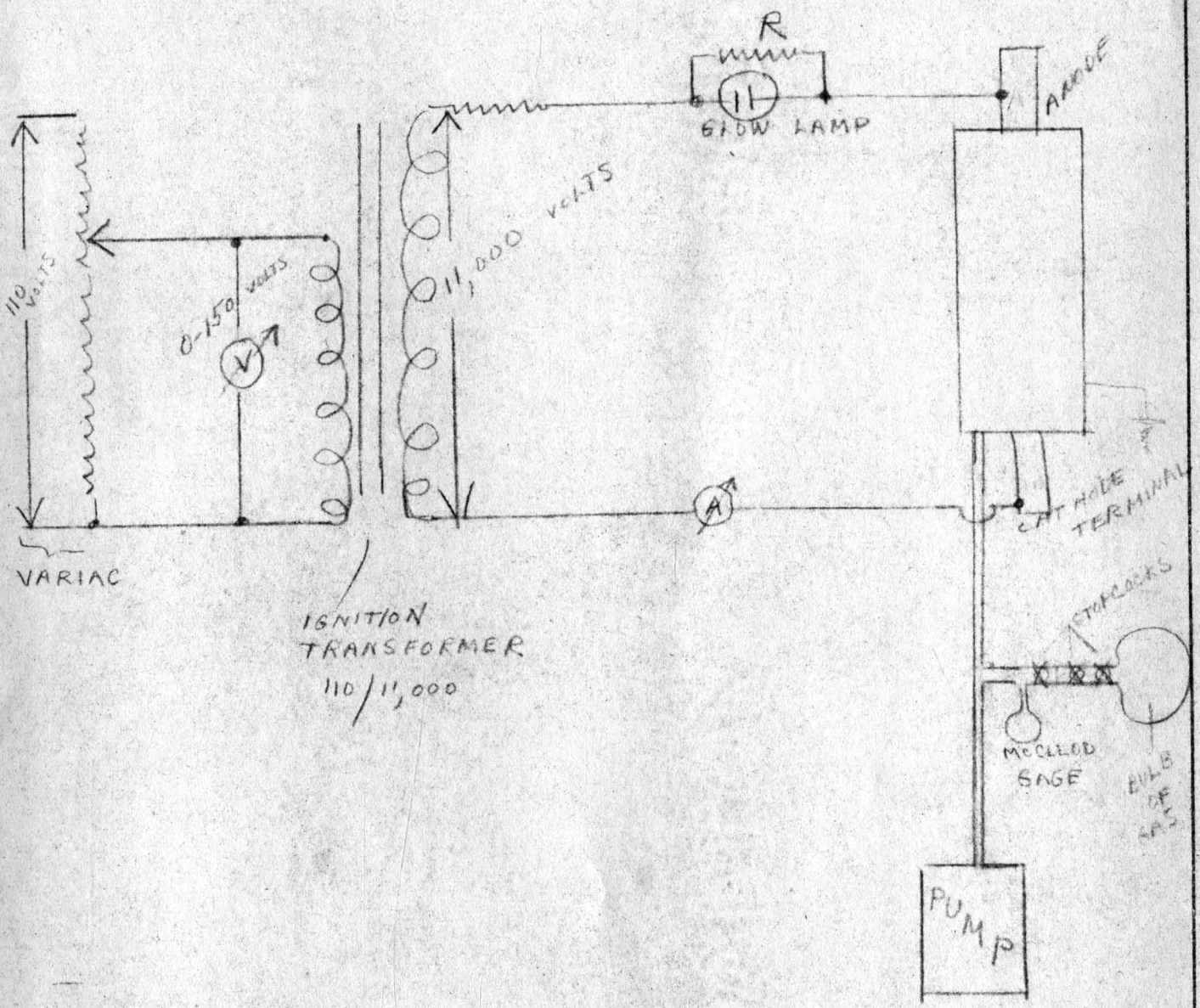

FIGURE ①

CIRCUIT DIAGRAM OF "Hi-POT" SET USED TO OBTAIN DATA INCLUDING SKETCH OF EXHAUST SET-UP.

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THIRD ANGLE PROJECTION

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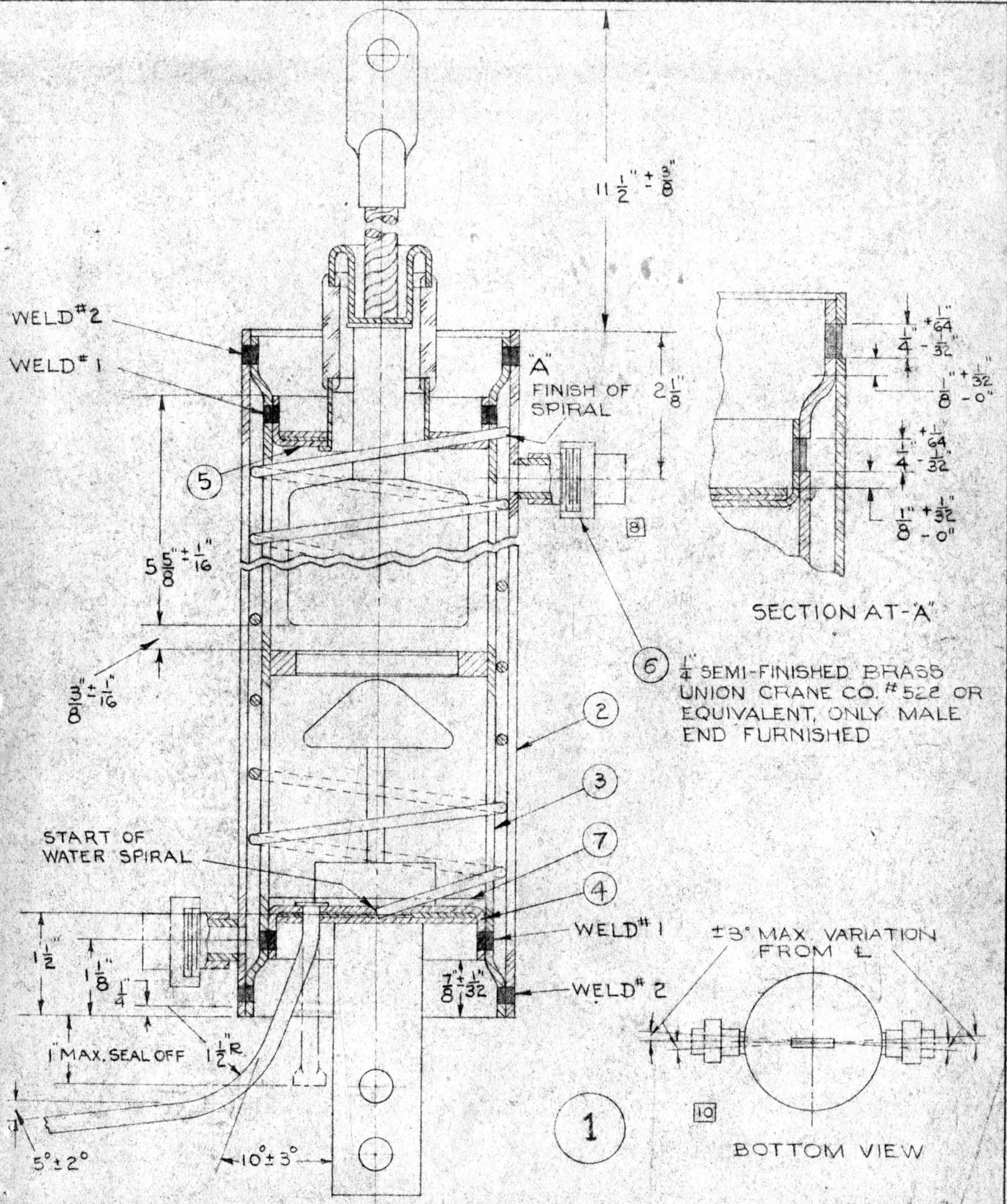

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10	MAY-3-45 GWJ B Kronick JK-5394	
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WELDING ASSEMBLY

FOR FG-259-B IGNITRON

ML-ISSUED

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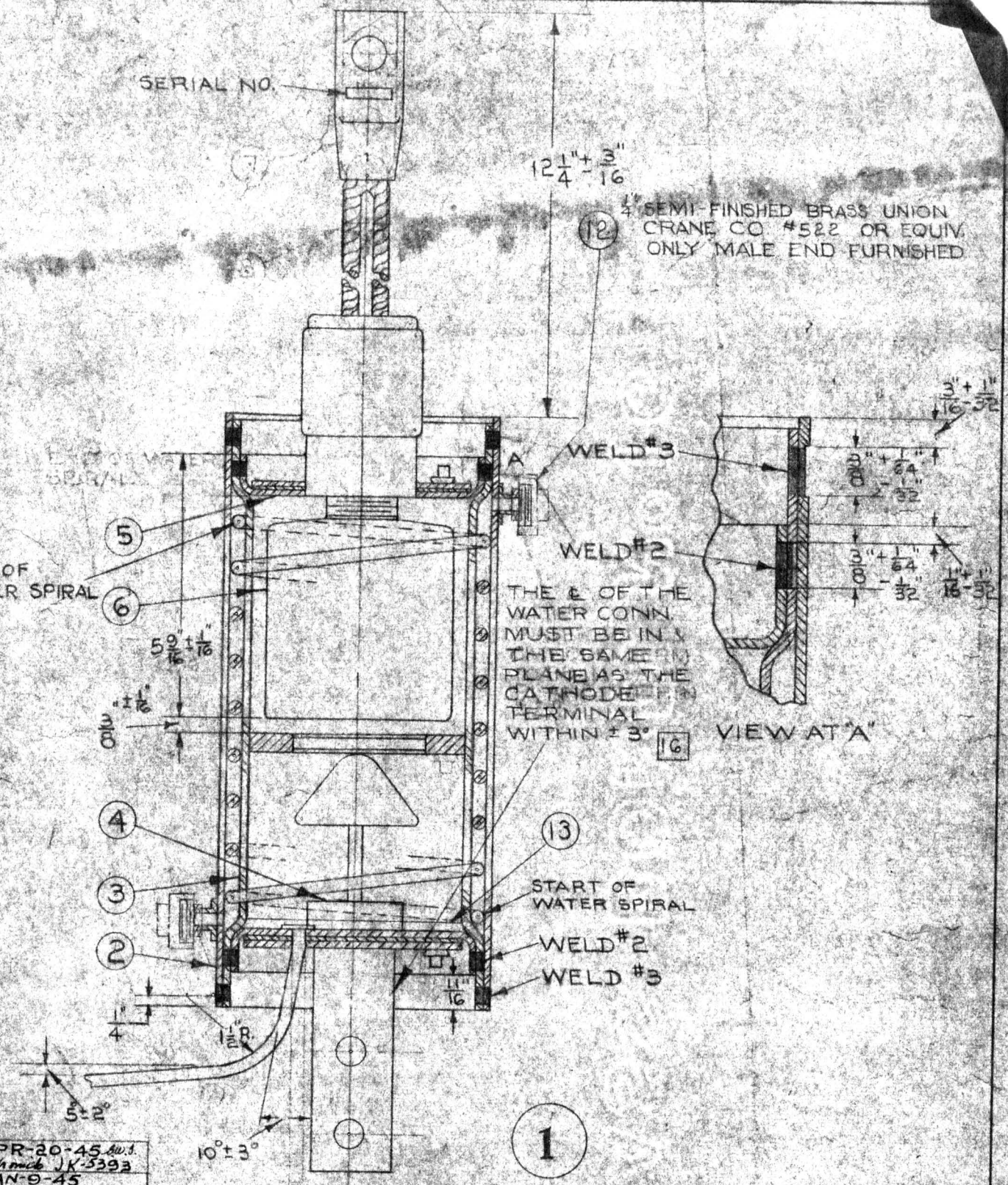

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16	APR-20-45 Rev. B. Kinnick JK-5393		
15	JAN-9-45 Q. Null JK-3949		
14	JUNE-1-43 H. Gruber JJ-6725		
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FG-238-B IGNITRON

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K-5344704

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37-11 PRINTS TO

PF-419-A (1-39)

FIG. 2

TUBE: FG 238 B
(NO BAKE)
CAROL KOLLNER
6-12-45

100,000

10,000

VOLTAGE BREAK DOWN

100

1 / 10 / 100 / 1000 / 10,000

PRESSURE IN MICRONS OF Hg

AIR → O_2 → CO_2

N_2

AIR

O_2

CO_2

N_2

2 min

$d = 3/8"$

$R = 10,000\Omega$

TUBE: F6 238 B
(BAKEOUT)
CAROL KOUSNETZ

FIG. 3

SEE FIGURE 2 FOR MORE ACCURATE VALUES IN THIS RANGE.

BREAKDOWN VOLTAGE

$\alpha = 3/8"$

$P = 100,000\ \Omega$

AIR = ●
O_2 = ×
CO_2 = ○
N_2 = △

FIG. 4 PRESSURE IN MICRONS OF Hg

TUBE: T6 238-B
BAKEOUT

CAROL KROUSE
12/6/45

KEUFFEL & ESSER CO. N. Y. NO. 358-1251
Logarithmic, 3 Cycles
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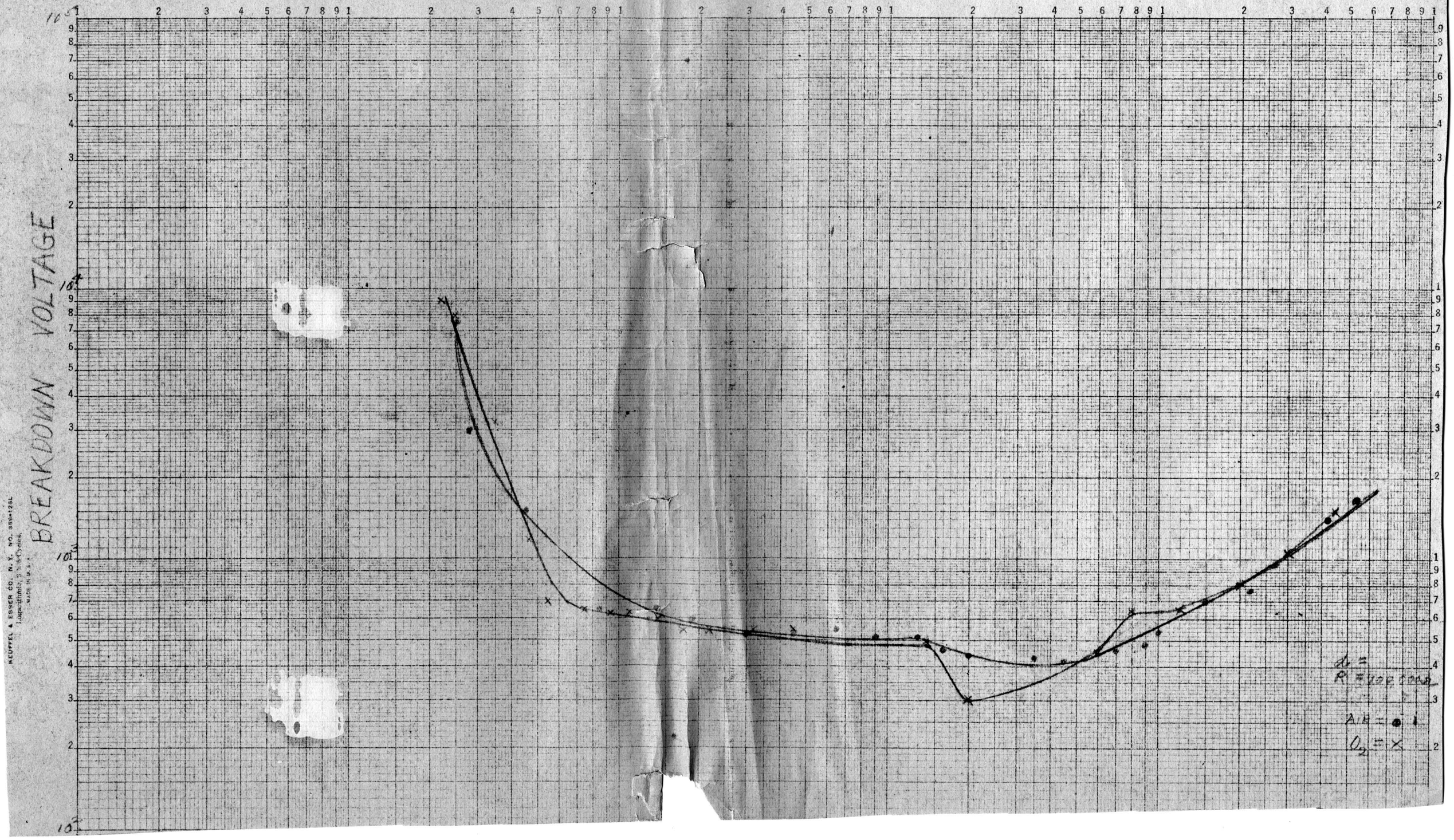
VOLTAGE
BREAKDOWN
d_1 =
R' = [illegible]
Air = ●
O_2 = ×
KEUFFEL & ESSER CO., N.Y. NO. 358-1251
Logarithmic, 3 x 5 Cycles
MADE IN U.S.A.