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Project 2511 Transistor Video Amplifier

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I Gain Requirements

A crystal-video amplifier must have sufficient gain to bring pulses up from the noise level of a biased crystal detector to an amplitude suitable for reducing the forward resistance of a pulse stretching diode to a value that will produce the necessary pulse stretching ratio. Experiments on a 1N26 and a 1N23B crystal diode biased for maximum sensitivity indicated a noise voltage of 25 microvolts rms on the input of the amplifier.

To determine how much gain the amplifier must have the pulse widths that are to be amplified must be known. Information from several sources indicate that the longest pulse would be approximately 50 microsecond. The band pass of the amplifier will determine the shortest pulse that can be amplified. As a first order of magnitude we will assume that the shortest pulse that can be passed is 0.5 microsecond. Using these two figures and assuming that an audio amplifier can be designed to pass the 50 microsecond pulse, the pulse stretcher must have a stretching ratio of $\frac{50}{.5}$ or 100. The stretching ratio of the pulse stretcher is determined by the reverse to forward resistance of the pulse stretching diode. This forward and reverse resistance ratio varies with types of diodes and with the magnitude of the voltage impressed on the diode. The best diode for this application is a diode with a high resistance ratio at low voltage levels and a low forward resistance. Several diodes were investigated and the 1N56 type seemed to exhibit the best properties of those available. The 1N56 has a reverse to forward resistance ratio of 250 at a voltage of 0.25 volts (see figure 1). On the basis of the forgoing figures and assuming a signal to noise ratio of 1 to 1 the amplifier will require a voltage gain of $20 \log \frac{.25}{25 \times 10^{-6}} = 80$ db.

The forward resistance of the 1N56 is approximately 600 ohms at a voltage of 0.25 volts (see figure 2). These figures represent a power level of $\frac{(.25)^2}{600} = 1 \times 10^{-4}$ watt. Taking an input level of 25×10^{-6} volt and a transistor input resistance of 10000 ohm, the input noise power is $\frac{625 \times 10^{-12}}{10^4} = 625 \times 10^{-16}$ watt. The power gain required to raise this to 1.0×10^{-4} watt is $10 \log \frac{1.0 \times 10^{-4}}{625 \times 10^{-16}}$ or

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To obtain a voltage gain of 80 db and a power gain of 90 db it will be necessary to use 4 SB100 grounded emitter iterated resistance coupled amplifiers with 20 db gain in each stage and 1 SB100 grounded collecter stage with a power gain of 10 db. This is a total of 5 transistors in the video amplifier.

The grounded collector stage will serve to isolate the pulse stretcher capacity from the preceding stages, increasing the bandwidth, and provide a low impedance source for the pulse stretcher. A low impedance source is necessary in order to provide the required power into the low forward resistance of the diode.

The back resistance of the 1N56 diode is approximately 0.15 megohm at a voltage level of .25 volts (see figure 2). This is the back resistance at a stretching ratio of 250. The maximum stretching ratio required is 100, therefore the total parallel resistance of the pulse stretcher (back resistance of diode and input resistance of the following audio amplifier) need be no greater than 60000 ohms. The input resistance to the audio amplifier should be approximately 0.1 megohm to obtain this total parallel resistance of 60000 ohms.

The audio amplifier gain requirement is determined by the power needed by the Telex headset (5 milliwatts), and the power available at the audio input stage. The power available to the audio input stage is 20 db less than the power input to the pulse stretcher. This is true when receiving 0.5 microsecond pulses and stretching them to 50 microseconds or a stretching ratio of 100.

Power input to pulse stretcher	----	1.0×10^{-4} watt.
Less 20 db	----	1.0×10^{-6} watt.

There will be 1.0×10^{-6} watt applied across the 0.1 megohm resistor in series with the input resistance of the transistor (approximately 2000 ohms).

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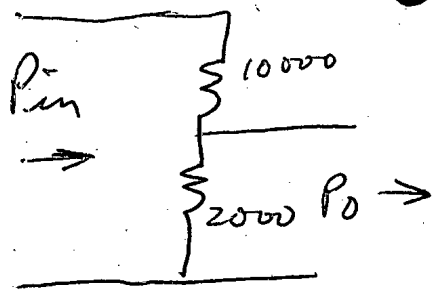

$$P_{out} = \frac{2000}{100000} \times 1.0\times10^{-6} = 3\times10^{-8} \text{ watt.}$$

$$\text{Power gain required} = 10\log \frac{5\times10^{-3}}{3\times10^{-8}} = \underline{50 \text{ db.}}$$

Audio amplifier voltage gain :

$$5\times10^{-3} \times 2000 = E_{out}^2 \quad \text{(voltage across headset)}$$

$$E_{out} = 3.15 \text{ volt}$$

$$E_{in} = .25 \times \frac{2000}{100000} = .005 \text{ volt}$$ (voltage at input to audio amplifier)

$$\text{Voltage gain} = 20 \log \frac{3.15}{.25\times10^{-3}} \cong \underline{60 \text{ db}}$$

This gain may be obtained by using 2 2n47 Philco audio amplifier stages with approximately 25 db per stage.

II Band Width Requirements

1. Lower Frequency Limit

If we assume 10% droop, the frequency $= \frac{\%}{T} = \frac{.1}{50\times10^{-6}} = 2000$ cps.

where T = 50 microseconds

It may be possible to allow more than 10% droop. This can be determined experimentally for a 50 microsecond pulse.

2. Upper Frequency Limit

one type experimental 4 stage 80 db gain SB100 video amplifier had an upper frequency limit of approximately 220 kcs. Figure 3 shows the manner in which the upper frequency limit of a video amplifier attenuates a given pulse. Curve number 2 is probably the most accurate representation of this phenomenon, since it was determined experimentally. This curve shows that an amplifier having an upper frequency response of 220 kcs will pass a 1 microsecond pulse with 3 db attenuation. If it is assumed that an

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amplifier must pass 0.5 microsecond pulses with only 3 db attenuation then the ~~upsp~~amplifier must have an upper frequency limit of 500 kcs. The band pass requirement for any length pulse may be determined from the curves on Figure 3.

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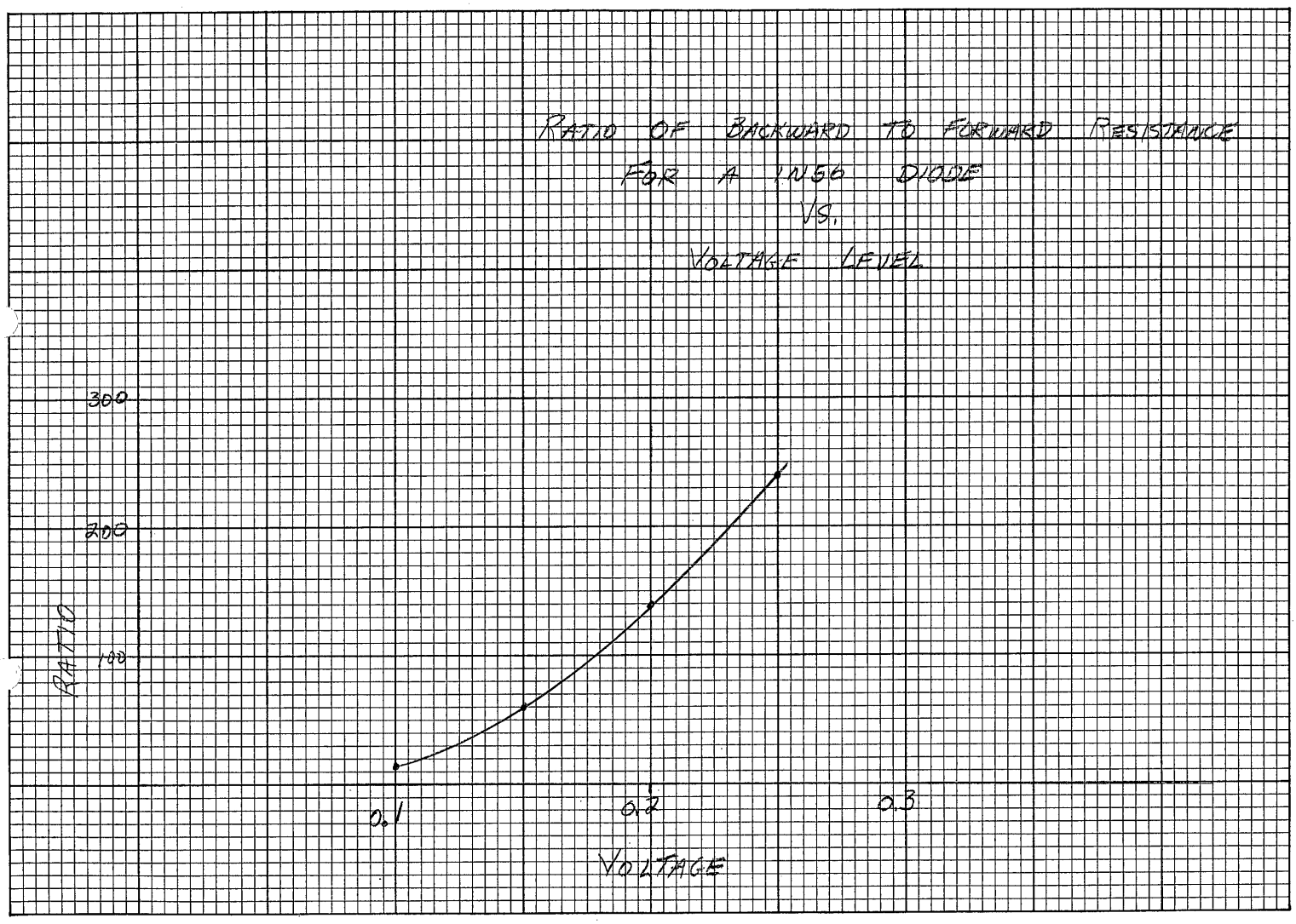

FIG. 1

K+E 10 X 10 TO THE INCH 359-5 KEUFFEL & ESSER CO. MADE IN U.S.A.

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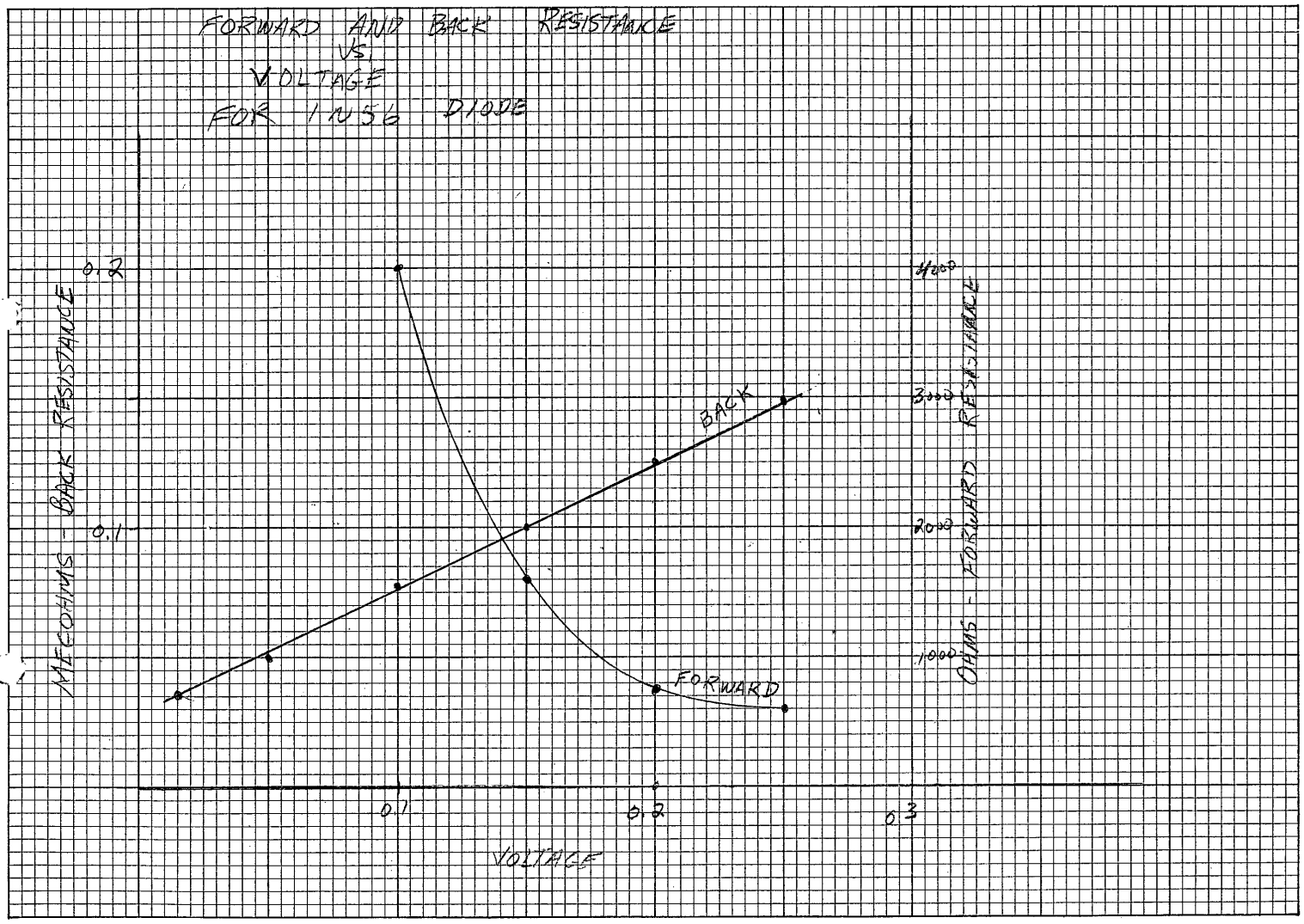

FIG 2.

K+E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO. MADE IN U.S.A.

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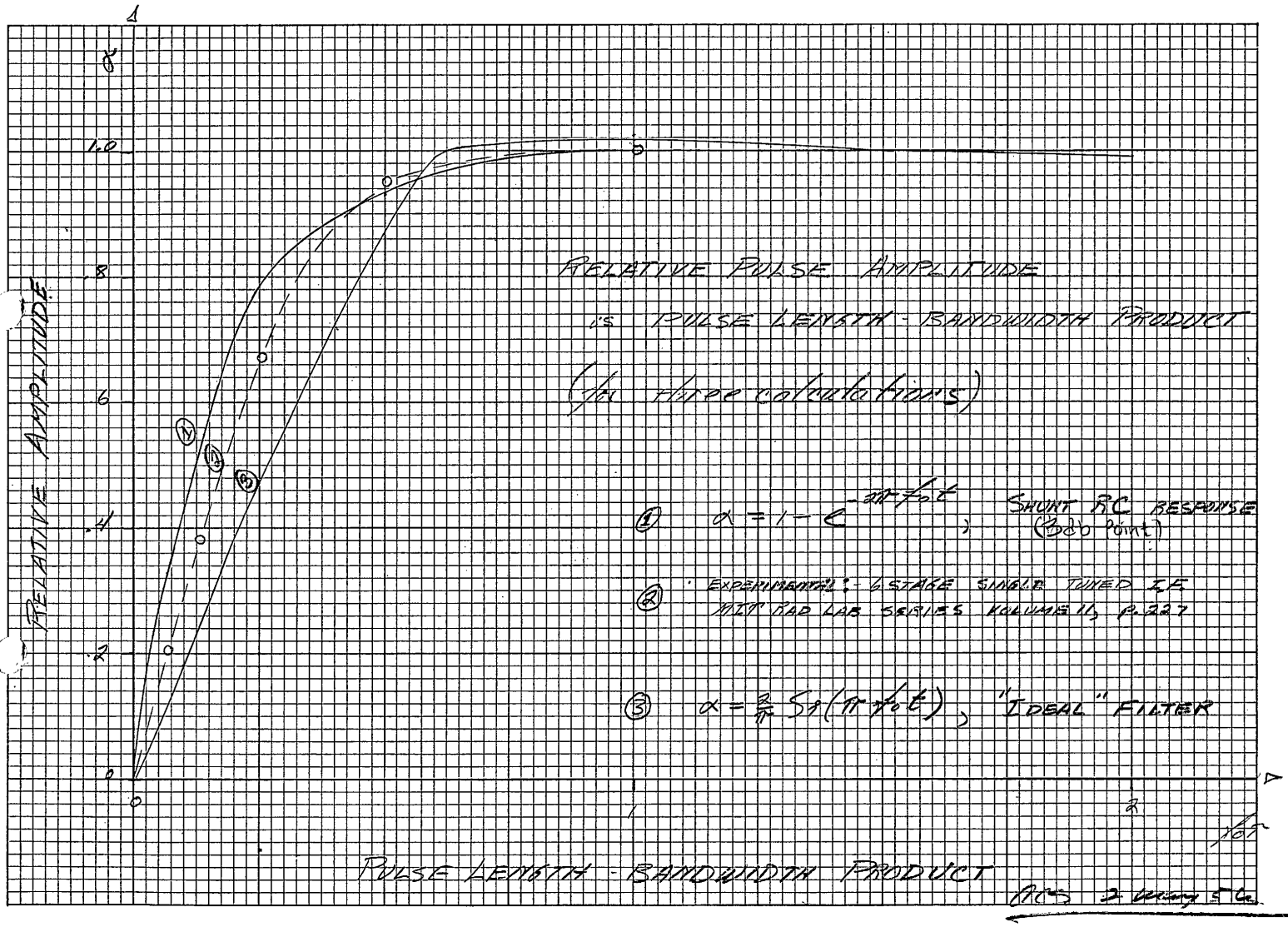

Fig 3

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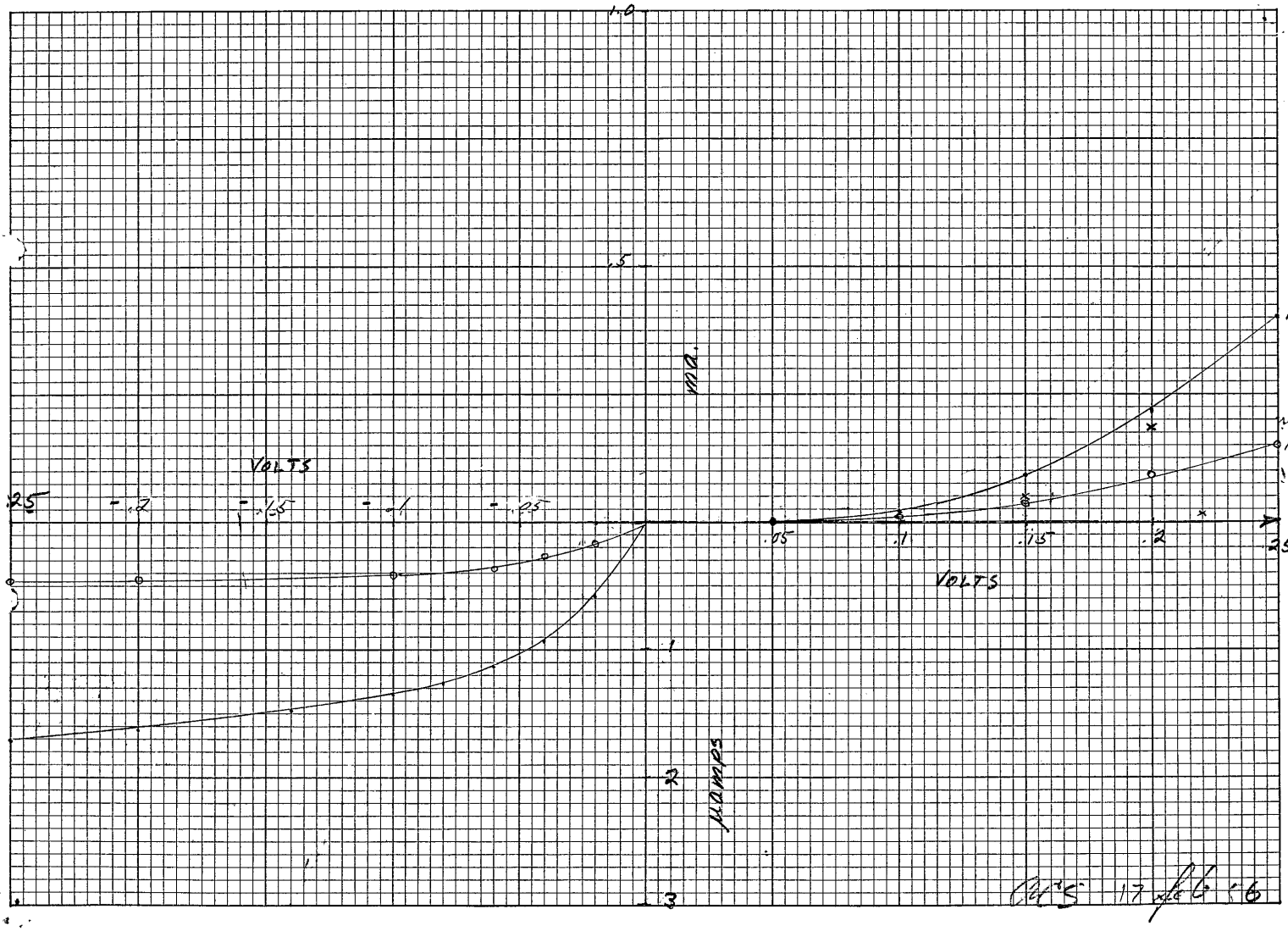

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