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APPLICATION NOTES

APPLICATION NOTE No. 39

May 11, 1934

APPLICATION NOTE ON THE DESIGN OF A VOLTAGE SUPPLY FOR THE 905 AND 906 CATHODE-RAY TUBES

The cathode-ray oscillograph is becoming increasingly popular as new applications in the laboratory and in the radio industry are found for it. This popularity is chiefly due to the simplicity of construction, convenience of operation, portability and low cost of modern oscillographic equipment employing cathode-ray tubes.

Our experience with various oscillographic applications has shown that the equipment required for all usual purposes can be constructed at low cost, can be made portable enough to be carried about by hand and is simpler to construct than the power supply for an a-c operated radio receiver.

In this Application Note we will show circuits and design information for voltage supplies for the 905* and 906 (3-inch and 5-inch cathode-ray tubes) and will give illustrations of a small portable oscillograph which has been found very convenient for laboratory use and admirably suited to many industrial applications. This oscillograph, shown in Figures 5 and 6, is constructed in a case whose outside dimensions are 17 inches in length, 8 inches in height and 6 inches in width.

VOLTAGE SUPPLY

The d-c voltages required are 1000 volts maximum for the 906 and 2000 volts maximum for the 905. The transformer specified is designed to supply 1000 volts in a half-wave rectifier circuit and is

*The same voltage supply can also be used to provide 2000-volt operation of the 903 and 904 cathode-ray tubes.

also used for the 2000-volt supply by employing two half-wave rectifier tubes in a voltage-doubling circuit. The design specifications for this high-voltage transformer are included in this Note under our identification number S-122. Specifications are also given for the filament and timing-voltage transformer, identified as S-124. It will be noted that both of these transformers have been designed to have small physical dimensions.

If it is inconvenient to obtain a transformer such as the S-122, any transformer capable of supplying to the rectifier a peak voltage of 1000 volts at 5 milliamperes may be used. The desired rectified d-c potential is assumed to be equal to the peak voltage provided the charging of the condenser C_1 (Figures 1 and 2) takes place during a small part of the a-c cycle and provided the direct current taken from the condenser is so small that the condenser voltage is practically contant throughout the cycle. This assumption is justified when a low value of ripple is a design requirement.

The value of condenser C_1 depends upon the amount of ripple that can be tolerated and the permissible ripple in turn depends upon the application of the cathode-ray tube. When too much ripple is present, it varies the potential on the control grid of the cathode-ray tube and produces flicker, or an intermittent trace, and also some defocussing of the beam. Also, if the ripple is too great, hum may become troublesome in the anode circuit and manifest itself in distortion of the image. In general, the ripple voltage for good filtering should not exceed one per cent.

The curves of Figure 3 show per cent ripple voltage vs. effective load in megohms for the various values of filter capacity C_1. To illustrate the use of these curves, let us take an example. In Figure 1, the parallel resistance of the voltage divider and the voltmeter is 1.4 megohms. From Figure 3, the corresponding capacity for one per cent ripple voltage is read as approximately 0.3 microfarad. The voltage supplies of Figures 1 and 2 employ a capacity C_1 of 2 microfarads and have a ripple of only 0.2 per cent.

Figure 4 shows the voltage regulation for the 1000-volt and 2000-volt supplies. These curves indicate that the desired maximum voltages of 1050 volts for the half-wave circuit and 2050 volts for the voltage-doubler circuit are obtained when the load current is adjusted to 0.5 milliampere and 1.5 milliamperes, respectively. In each case, these voltages include an allowance of 50 volts to provide for control-grid bias of the 905 or 906 tube. This bias is taken from the potentiometers R_4 and R_9 (Figures 1 and 2).

The anode current of either the 905 or the 906 is very small and normally does not exceed 200 microamperes. Care should be taken that the combined bleeder and anode current is not so high as to reduce the anode voltage below the desired value. The resistance values shown for the voltage dividers of Figures 1 and 2 were selected to provide as large a bleeder current as is consistent with voltage requirements in order that the anode current might be a minimum percentage of the total divider current. This was done to insure optimum voltage regulation from the divider when adjustment either of anode No.1 voltage or of the control-grid voltage is made. The regulation curves and divider values are based on an input supply of 115 volts to the primary of transformers S-122 and S-124.

If a voltage divider of lower resistance is used so that the anode current becomes a sufficiently small percentage of the bleeder current, defocussing due to adjustment of the control-grid voltage will be minimized and readjustment of the anode voltage made unnecessary.

In case a high-voltage transformer other than the S-122 is used, and its regulation permits operation with higher bleeder currents than those discussed above, the voltage divider should be designed to supply to anode No.2 a voltage approximately one-fifth of that (the maximum) applied to anode No.1; and to supply a negative bias of from 45 to 50 volts to the control grid.

There are two 115-volt secondaries on the filament and timing-voltage transformer. One of these is used to supply the control grid with a voltage of the same frequency as that of the spreader voltage, in this instance, 60 cycles, but 90° out of phase. This procedure causes a brightening of the front wave and a darkening or elimination of the back wave of the screen trace and thus simplifies the pattern for purposes of frequency determination or wave study. The other 115-volt winding provides the 60-cycle timing voltage for one pair of deflection plates. These plates are connected to terminals on the case of the instrument in order that a voltage for any other timing-axis frequency may be conveniently utilized. The 905 may require at times a timing voltage of 220 volts.

It is important that precautions be taken to prevent the user from coming in contact with any high voltage. These precautions should include grounding the case of the instrument during operation, discharging the condenser before the case is opened and completely enclosing all parts carrying the high voltage. An interlock switch should be used to break the power-supply circuit when the case is opened.

As previously stated, this compact cathode-ray oscillograph has been found very useful in our laboratory. It has provided a ready means of making frequency determinations, examining wave forms, checking percentage modulation and observing voltages of high or low frequency. It can also be used as an indicator for high-frequency bridge measurements and for curve-drawing applications.

TRANSFORMER S-122* SPECIFICATIONS

High-Voltage Transformer

Core

Material - Dynamo Steel, Allegheny Steel Company or equivalent

Punching	EI-12
Window	1.5" x 0.5"
Tongue	1"
Stack	1"
Stacking factor	0.88
Joint	Lap
Net section	5.7 cm^2
Mean length magnetic circuit	17.78 cm
Weight	1.47 lbs

Primary

Turns	800	#30 enameled wire
Location	Next to core	
Turns per layer	100	
Layers	8	
Insulation between layers	0.003"	
Insulation under winding	0.063"	
Clearance under winding	0.015"	
Depth of winding	0.110"	
Mean length of turn	5"	
Total length	334 ft	
Resistance at 25°C	36 ohms	

Secondary

Turns	5500	#40 enameled wire
Location	Over primary	
Turns per layer	280	
Layers	20	
Insulation between layers	0.003"	
Insulation under winding	0.030"	varnished cambric 0.010"
Insulation over winding	0.025"	
Clearance over winding	0.050"	
Depth of winding	0.130"	
Mean length of turn	6.2"	
Total length	2840 ft	
Resistance	3200 ohms	

*Our design identification number.

TRANSFORMER S-124* SPECIFICATIONS

Filament and Timing-Voltage Transformer

Core

Material - Dynamo Steel, Allegheny Steel Company or equivalent

Punching	EI-12
Window	1.5" x 0.5"
Tongue	1"
Stack	1.5"
Stacking factor	0.88"
Joint	Lap
Net section	8.52 cm^2
Mean length magnetic circuit	17.78 cm
Weight	2.2 lbs

Primary (115 volt)

Turns	412	#27 enameled wire
Winding order	1st	
Turns per layer	72	
Layers	6	
Insulation between layers	0.003"	
Insulation under winding	0.045"	
Clearance under winding	0.015"	
Depth of winding	0.110"	
Mean length of turn	6"	
Total length	206 ft	
Resistance at 25°C	11 ohms	

Secondaries

Secondaries	1	2	3	4	5
Windings**	110v/.027a	110v/.027a	7.6v/1.25a	7.6v/1.25a	2.58v/2a
Insulation #	2000v V.C.	2000v V.C.	2000v V.C.	2000v V.C.	2000v V.C.
Wire	38 enam.	38 enam.	22 enam.	22 enam.	20 enam.
Turns	405	405	28	28	9.5
Winding order	2nd	3rd	4th	5th	6th
Turns per layer	230	230	-	-	-
Layers	2	2	1	1	1
Insul. between layers	0.0015"	0.0015"	-	-	-
Insul. under winding	0.25"	0.25"	0.25"	0.25"	0.25"
Insul. over winding	-	-	-	-	0.25"
Clearance over winding	-	-	-	-	0.50"
Depth of winding	0.011"	0.011"	0.0273"	0.0273"	0.0343"
Mean length of turn	6"	-------------------7" Average-----------------			
Total length (ft)	236	236	16.5	16.5	5.55
Resist. at 25°C (ohms)	158	158	0.277	0.277	0.058

*Our design identification number.
**Voltages are for indicated full load current.
#V.C. means Varnished Cambric.

TYPICAL CIRCUITS FOR PORTABLE CATHODE-RAY OSCILLOGRAPH

HALF-WAVE CIRCUIT TO SUPPLY 1000 VOLTS FOR OPERATION OF TYPE 906

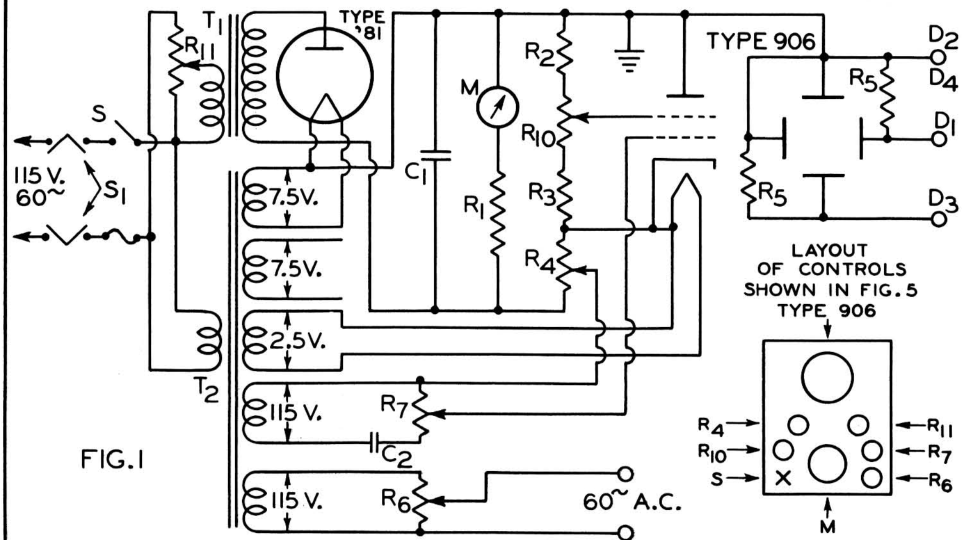

FIG. 1

VOLTAGE-DOUBLER CIRCUIT TO SUPPLY 2000 V. FOR OPERATION OF TYPE 905

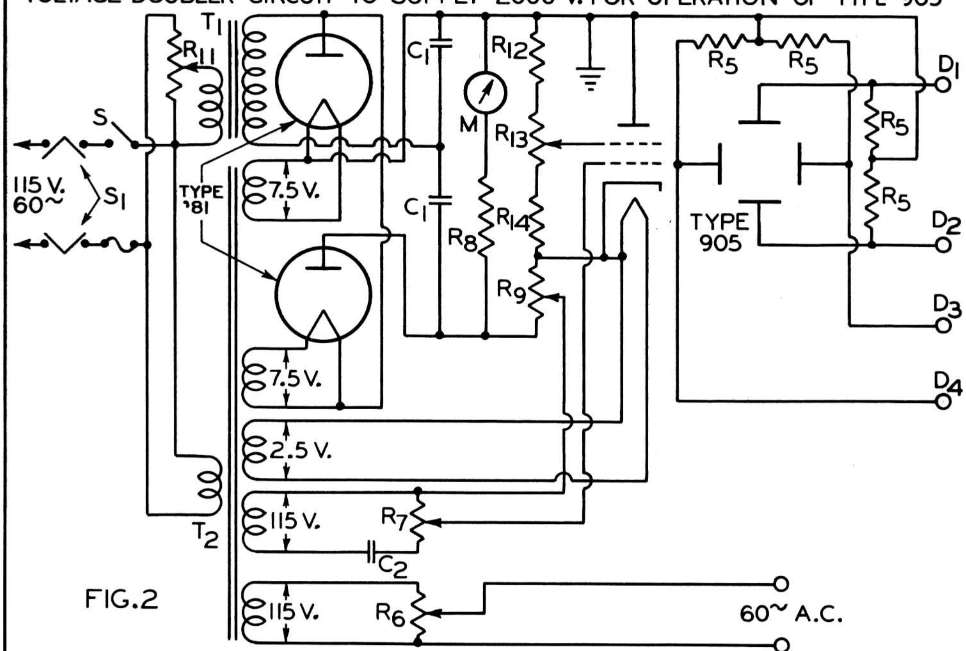

FIG. 2

VALUES OF COMPONENT PARTS

C_1 = 2 μf (1000 V.)
C_2 = 0.015 μf (200 V.)
R_1 = 5 MEGOHMS
R_2 = 1.0 MEGOHM
R_3 = 0.4 MEGOHM
R_4 = 0.1 MEGOHM
R_5 = 1 TO 10 MEGOHMS
R_6 = 50000 OHMS
R_7 = 50000 OHMS
R_8 = 10 MEGOHMS
R_9 = 30000 OHMS
R_{10} = 0.5 MEGOHM
R_{11} = 1000 OHMS
R_{12} = 0.75 MEGOHM
R_{13} = 0.4 MEGOHM
R_{14} = 0.25 MEGOHM
M = MICROAMMETER (0-200 μ AMP)
S = SWITCH
S_1 = INTERLOCK SAFETY SWITCH
T_1 = TRANSFORMER - OUR DESIGN IDENTIFICATION № S-122
T_2 = TRANSFORMER - OUR DESIGN IDENTIFICATION № S-124

MAY 1, 1934

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FILTER DESIGN CONSIDERATIONS
FOR POWER SUPPLY OF CATHODE-RAY TUBES

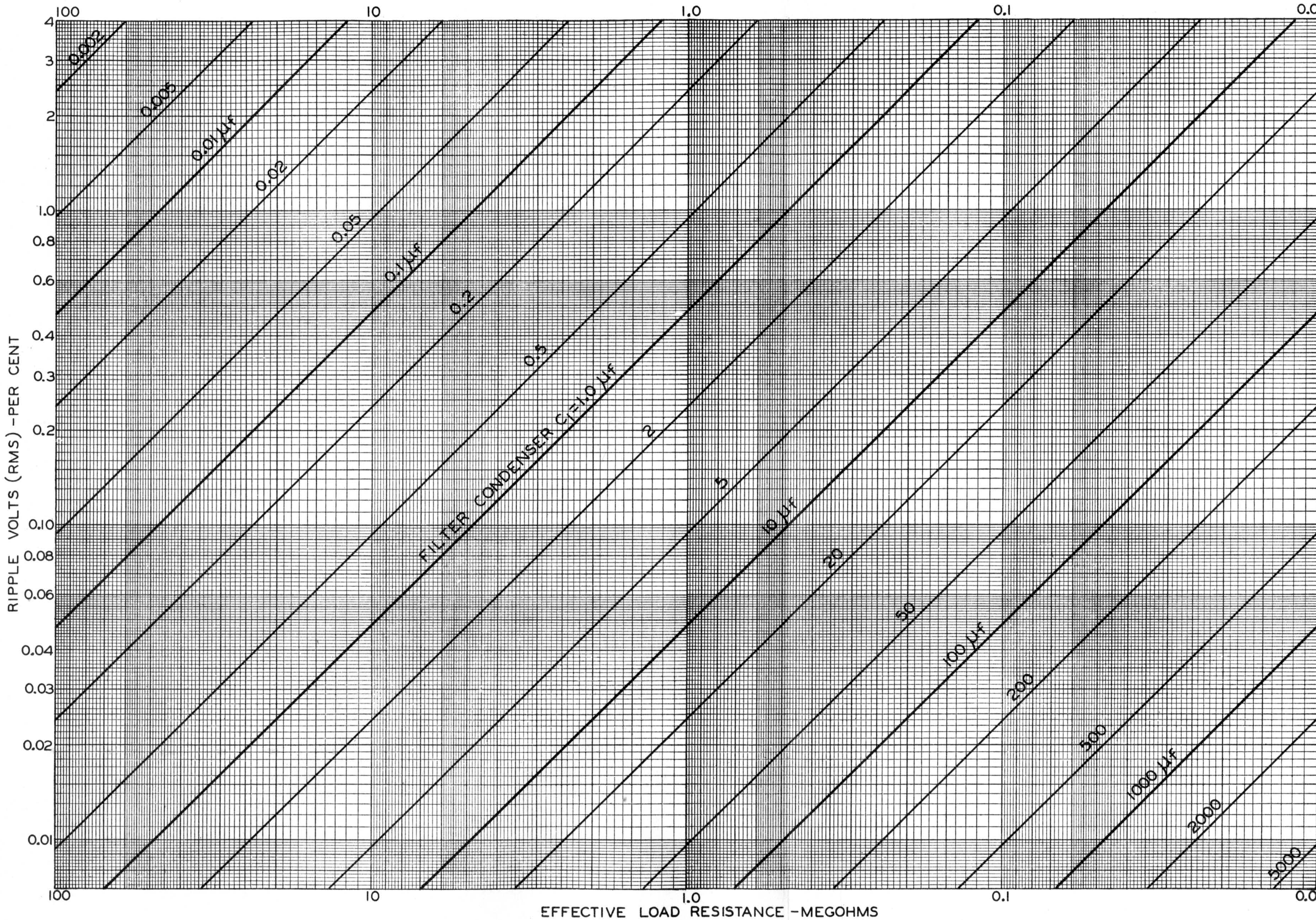

FIG. 3

APRIL 27, 1934

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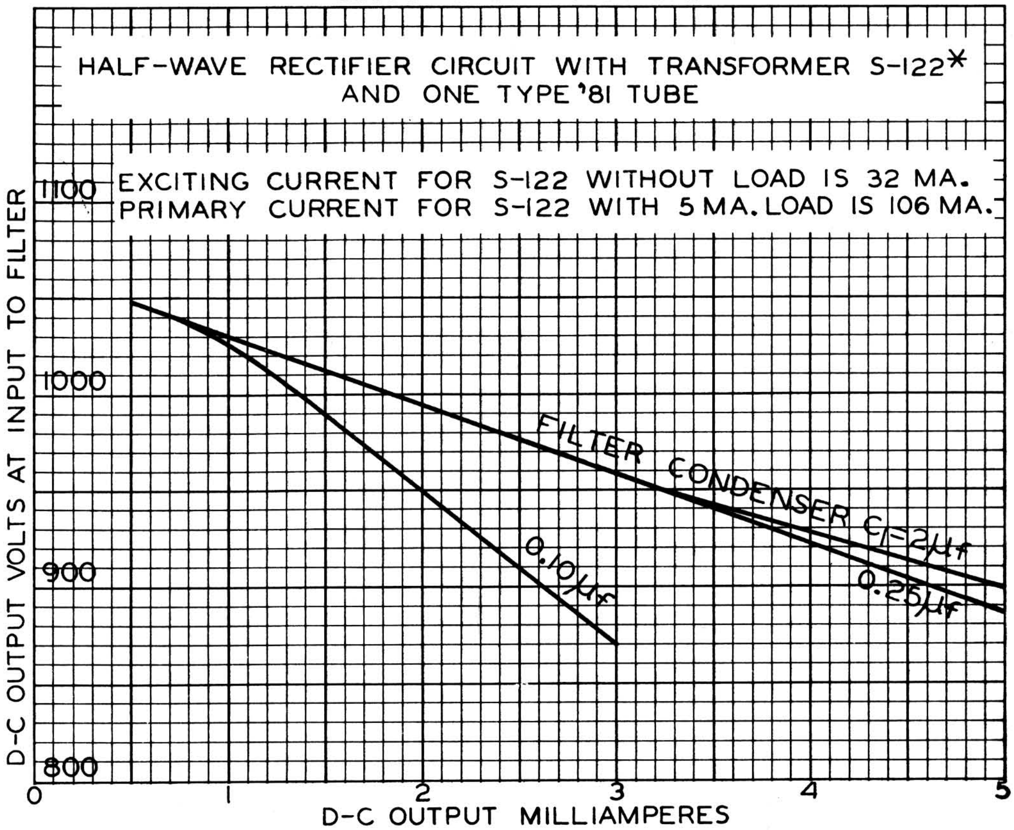
92S-5507

REGULATION CHARACTERISTICS
CIRCUITS OF FIGS. 1 & 2



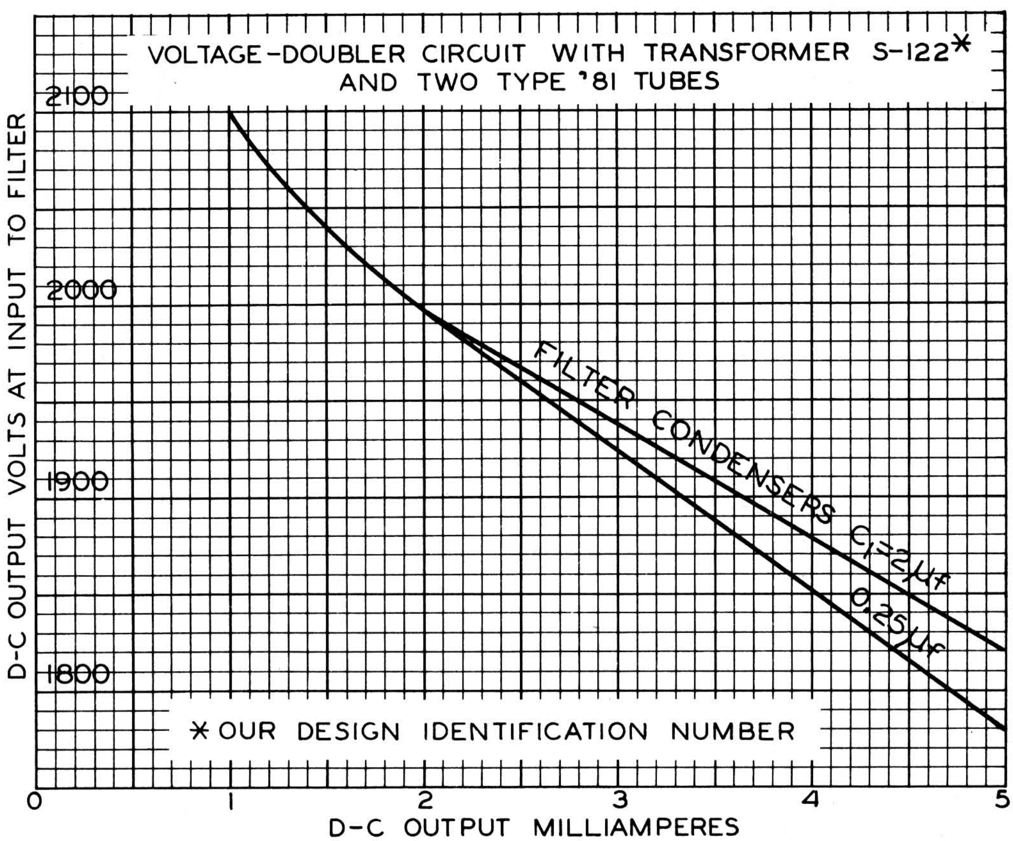


FIG. 4

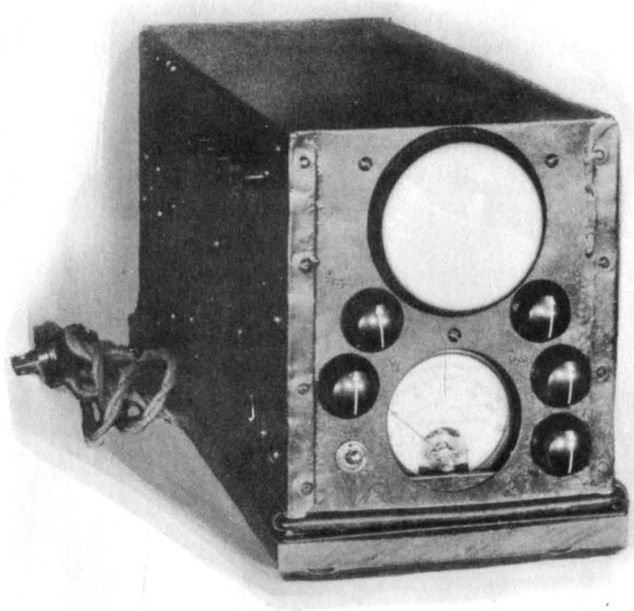


FIG.5 - THE PORTABLE CATHODE-RAY OSCILLOGRAPH WITH THE 906 CATHODE-RAY TUBE

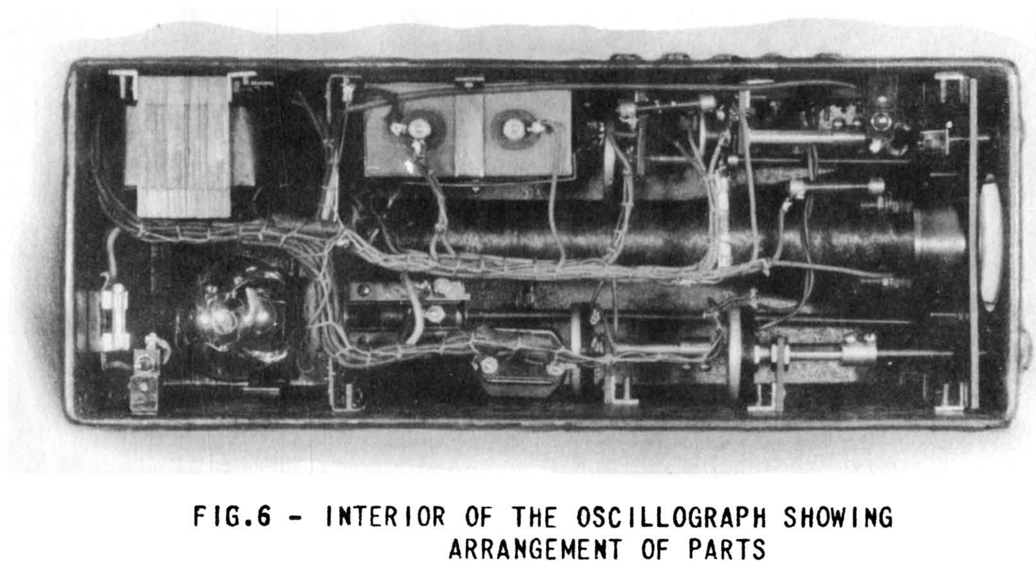


FIG.6 - INTERIOR OF THE OSCILLOGRAPH SHOWING ARRANGEMENT OF PARTS