311.60
311.61

PES PHS
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DATA FOLDER No. 64587

Title Oscillographic Method of Measuring Positive Grid Characteristics

By

Vac. Tube Engg. Dept. Div.

Information prepared for

Tests made by

Information prepared by O. W. Livingston

Countersigned by

Date 9-6-39

DA-472000

Oscillographic Method of Measuring Positive Grid Characteristics

Vacuum Tube Engg. Dept. September 6, 1939.

Introduction

Considerable difficulty has been experienced in the past in obtaining positive grid characteristics of high-vacuum triodes since tube dissipation while taking these points is so high that the destruction of the tube is likely to take place if the power is left on sufficiently long to read a standard meter.

To obviate this difficulty, tests have been made in which the power is applied for only a short time and oscillograms taken on all the essential data. This method, however, requires considerable calculation from the oscillograms obtained and in many cases errors or peculiar results in the tests are not noticed until the calculations are made which may be sometime after the tests and the test setup may be no longer available. The method used in these tests, we believe, overcomes many of the difficulties involved in these former methods. It is essentially a point-to-point method in which each point on the desired characteristic is obtained separately and can be read directly and plotted as the test progresses. In this way any errors may be checked immediately when the work is completed. No further calculation is necessary since the curves are immediately available.

The Method of Test

Fig. 1 (K-6917413 - Sheet 1) shows the schematic diagram of the test setup. Fundamentally, the operation is as follows. The plate supply condenser C_1 and the grid supply condenser C_2 are charged to a predetermined voltage through their respective rectifier tubes and transformers VT_1, VT_2, T_3 and T_4. Then, when the switch S_1 is thrown to the discharge position an impulse generated in the grid transformers T_7 and T_8 "trip" the thyratrons VT_3 and VT_4 simultaneously applying potential to both the grid and anode. The wave shape of this voltage is similar to that shown in Fig. 2A, being essentially that of a condenser discharge. Since both the grid and anode potentials have this same shape, the instantaneous grid current and instantaneous plate current at the start of the phenomenon corresponds to the values normally obtained with the peak values of grid and plate voltage. The plate current in general always has the shape shown in Fig. A and the peak value of this is read readily by observing the drop across the series resistor R_{11} with a cathode-ray oscillograph and suitable amplifier and calibrating circuit. The

grid current under some conditions has the shape shown in Fig. 2A but under certain conditions may assume the shape shown in Fig. 2B, in which case the voltage appearing at the start of the phenomenon is measured. Under other conditions the grid current may go negative, in which case the negative peak is observed and recorded. It is important in this scheme that the decay of both the grid and the plate voltage be sufficiently slow that small errors in firing time of the two thyratrons VT_3 and VT_4 do not cause appreciable error. That is to say, it is important that the grid voltage is applied before the anode voltage has decayed appreciably, otherwise erroneous readings may be obtained.

Normally, the easiest method to operate this set is to make a calibration curve of the output voltage by the use of an oscillograph and amplifier on the potentiometers R_7-R_9 and R_8-R_{10} versus the voltage on the primary of the anode transformer which may be varied by a Variac or other similar device. After this calibration curve is available, it is then possible to set the grid voltage to some predetermined value, such as plus 300 volts, and vary the anode voltage over the operating range reading the drop across R_{11} and R_{12} to obtain the grid and plate currents respectively.

In some cases, it is further desirable to add additional "bleeding" resistance across the voltage potentiometers, particularly in the case of low or negative currents which sometimes occur in the grid circuit in order to insure reliable "firing" of the thyratrons. Under some conditions, if the lead lengths are not kept down oscillations may occur. These may be observed readily on the oscillograph if the conventional sweep is used. In most cases they may be corrected by placing a small condenser from the grid to the cathode on the anode to the cathode. In all cases these condensers should be small compared with the grid or anode supply condenser so that the peak voltage will not be lowered appreciably. In taking readings it is sometimes convenient to turn off the sweep circuit and simply read the peak, but wherever this is done the sweep should be used from time to time to determine whether or not oscillations are present and, as in the case of the grid current, whether or not the peak value is the correct point to read.

Fig. 3 (K-6917413 - Sheet 2) shows the arrangement of one of the peak supply which may be used for either the grid or the anode by use of appropriate supply transformers and condensers. Fig. 4 (K-6917413 - Sheet 3) shows the switching arrangement used in connection with these outfits. Fig. 5 (K-5344730) shows the oscillograph amplifier and calibration circuit. The data sheets and curves attached show the results of this method in a practical instance.

OWL:HT

O. W. Livingston

Sept. 6, 1939.

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CALIBRATION OF GRID SUPPLY

R_1/R_2	R	A-C	D-C	DC Volts
980/20	50/1	25	6.4-	320
"	"	30	7.5+	375
"	"	35	9.1	455
"	"	40	10.5	525
"	"	45	11.8	590
"	"	50	13.2	660
"	"	55	14.4	720
"	"	"	14.5	725
"	"	60	15.6	780
"	"	65	16.9+	845
"	"	70	18.3	915
"	"	75	19.7	985
"	"	80	21.1	1055
"	"	85	22.4	1120
"	"	25	6.4	320
950/50	20/1	"	15.8	316
"	"	20	12.7	254
900/100	10/1	"	25.6	256
"	"	15	18.6	186
"	"	10	11.7	117
"	"	13	16.0-	160
"	"	9	10.4	104
"	"	8	9.1	91
950/50	20/1	30	19.1	382

DF 64-51

CALIBRATION OF PLATE SUPPLY

R_1/R_2	R	AC	DC Reading	DC Value
9900/100	100/1	30	23.6	2360
9950/50	200/1	35	13.6	2720
9950/50	200/1	40	15.5	3100
"	"	45	17.2	3440
"	"	50	19.3	3860
"	"	55	21.0	4200
"	"	60	22.9	4580
"	"	65	24.9	4980
"	"	70	27.3	5460
"	"	75	29.2	5840
9980/20	500/1	75	11.6	5800
"	"	80	12.4	6200
"	"	80	12.6	6300
"	"	85	13.5	6750
"	"	90	14.2	7100
"	"	95	15.1	7550
"	"	100	15.9	7950
"	"	105	16.8	8400
"	"	110	17.8	8900
"	"	115	18.4	9200
9900/100	100/1	30	23.6	2360
"	"	25	19.8	1980
"	"	20	14.5	1450
"	"	15	11.3	1130
9800/200	50/1	10	15.0	750
"	"	7	10.2	510

#25217

WL-891 CHARACTERISTICS

+100 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	AC	DC	R	V	I
20	13.7	.685	10	750	100	5	.05
"	15.8	.79	13	1000	"	4.4	.044
"	24.8	1.24	19.6	1500	"	4.2	.042
10	17.0	1.7	26	2000	"	5.2	.052
"	20.6	2.06	32.5	2500	"	5.0	.05
"	24.8	2.48	39	3000	"	6.0	.06
5	15.0	3.00	45.5	3500	"	"	"
"	17.4	3.48	52	4000	"	"	"
"	19.2	3.84	58+	4500	"	5.6	.056
"	22.8	4.56	65-	5000	"	6.8	.068
"	24.9	4.98	71	5500	"	6.2	.062
3	16.8	5.60	77	6000	"	7.0	.07
"	19.1	6.37	83	6500	"	7.6	.076
"	20.7	6.90	88.7	7000	"	7.2	.072

+200 Volt Grid

20	25.0	1.25	10	750	100	12	.12
10	14.2	1.42	13	1000	"	10.2	.102
"	18.2	1.82	19.6	1500	"	7	.07
"	23.8	2.38	26	2000	"	5.5	.055
"	27.3	2.73	32.5	2500	"	5	.05
5	16.6	3.32	39	3000	"	4	.04
"	19.0	3.80	45.5	3500	"	3	.03
"	22.5	4.50	52	4000	"	"	"
"	24.6	4.92	58+	4500	"	"	"
"	27.6	5.52	65-	5000	"	3-4	"
"	29.4	5.88	71	5500	"	3	"
3	19.4	6.47	77	6000	"	"	"
"	21.5	7.17	83	6500	"	"	"

#25217

WL-891 CHARACTERISTICS

+300 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	AC	DC	R	V	I
10	19.4	1.95	10	750	50	11.5	.275
"	21.0	2.1	13	1000	"	8.6	.172
"	26.0	2.6	19.6	1500	"	5.8	.116
5	16.0	3.2	26	2000	"	3.5	.07
"	18.6	3.72	32.5	2500	"	1.0	.02
"	21.0	4.2	39	3000	"	-0.8	-.016
"	24.3	4.86	45.5	3500	"	-1.3	-.026
3	16.2	5.4	52	4000	"	-3.5	-.07
"	18.0	6.0	58	4500	"	-4.3	-.086
"	19.2	6.4	65	5000	"	-4.2	-.084
"	21.4	7.13	71	5500	"	"	"

+400 Volt Grid

10	25.6	2.56	10	750	50	+20.5	.41
5	14.4	2.88	13	1000	"	+15.9	.318
"	17.6	3.52	19.6	1500	"	+7.8	.156
"	20.0	4.0	26	2000	"	+4.8	.096
"	23.7	4.74	32.5	2500	100	+3.4	.034
"	26.5	5.30	39	3000	"	-3.5	-.035
"	29.5	5.90	45.5	3500	"	-9.5	-.095
3	19.5	6.5	52	4000	"	-14.8	-.148
"	21.2	7.07	58+	4500	"	-18.5	-.185
"	22.8	7.63	65	5000	50	10.6	-.218

#25217

WL-891 CHARACTERISTICS

+500 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	AC	DC	R	V	I
5	16.0	3.2	10	750	25	+16.5	.660
"	18.0	3.6	13	1000	"	12.5	.500
"	21.8	4.36	19.6	1500	"	6.5	.260
"	24.6	4.96	26	2000	100	12.5	.125
"	29.5	5.6	32.5	2500	"	4.0	.04
3	17.2	5.73	"	2500	"	"	"
"	19.6	6.53	39	3000	"	-3.0	-.03
"	21.4	7.13	45.5	3500	"	-10.0	-.10
"	23.2	7.73	52	4000	"	-17.6	-.176

+600 Volt Grid

5	19.2	3.84	10	750	25	24.4	.976
"	21.6	4.32	13	1000	"	19.5	.780
"	25.8	5.16	19.6	1500	"	11.5	.460
3	18.0	6.0	26	2000	"	4.0	.160
"	20.3	6.77	32.5	2500	"	1.1	.044
"	22.1	7.37	39	3000	100	-4.0	-.04
"	24.4	8.13	45.5	3500	"	-10.8	-.108
"	25.6	8.53	52	4000	"	-19.4	-.194

+700 Volt Grid

5	21.8	4.36	10	750	20	+27.2	1.36
"	25.0	5.0	13	1000	"	21.6	1.08
3	17.8	5.93	19.6	1500	"	13.4	.67
"	20.7	6.9	26	2000	"	7.0	.35
"	22.8	7.6	32.5	2500	100	8.0	.08
"	25.0	8.33	39	3000	"	-3.2	-.032
"	26.3	8.73	45.5	3500	"	-12.3	-.123

#25217

WL-891 CHARACTERISTICS

+800 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	AC	DC	R	V	I
3	14.4	4.8	10	750	10	18	1.8
"	16.8	5.6	13	1000	"	13.5	1.35
"	19.5	6.5	19.6	1500	"	8.9	.89
"	22.2	7.4	26	2000	"	4.9	.49
"	25.0	8.33	32.5	2500	"	1.4	.14
"	27.3	9.1	39	3000	25	-1.4	-.056

WL-892 CHARACTERISTICS

#25516

+100 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	A-C	D-C	R	V	I
25	9.0	.36	10.0	750	50	4.0	.08
"	11.3	.452	13.0	1000	"	"	"
"	11.0	.44	19.6	1500	"	3.9	.078
"	12.8	.552	26.0	2000	"	3.8-	.076
			32.5	2500			
"	16.0	.64	39.0	3000	"	3.5	.07
			45.5	3500			
"	19.0	.76	52.0	4000	"	3.4	.068
			58.0+	4500			
"	23.0	.92	65.0-	5000	"	"	"
			71.0	5500			
"	27.6	1.104	77.0	6000	"	3.2	.064
			83.0	6500			
10	12.5	1.25	88.7	7000	"	3.6	.072
			94.3	7500			
"	14.0	1.4	100.0	8000	"	"	"
			106.0	8500			
"	15.4	1.54	112.0	9000	"	3.5	.07

WL-892 CHARACTERISTICS

#25516

+200 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	A-C	D-C	R	V	I
25	23.6	.944	10.0	750	50	10.0	.20
10	10.3	1.03	13.0	1000	"	9.2	.184
"	11.2	1.12	19.6	1500	"	8.5	.17
"	12.1	1.21	26.0	2000	"	7.8	.156
"	13.9	1.39	39.0	3000	"	7.2	.144
"	16.0	1.6	52.0	4000	"	6.5	.13
"	18.0	1.8	65.0-	5000	"	5.8	.116
"	20.0	2.0	77.0	6000	"	5.2	.104
"	21.5	2.15	88.7	7000	"	4.7	.094
"	23.8	2.38	100.0	8000	"	4.5	.09
"	26.0	2.6	112.0	9000	"	4.1	.082

+300 Volt Grid

"	16.0	1.6	10.0	750	50	18.5	.370
"	16.8	1.68	13.0	1000	"	16.0	.32
"	18.2	1.82	19.6	1500	"	11.5	.23
"	20.0	2.0	26.0	2000	"	9.2	.184
5	11.8	2.36	39.0	3000	"	8.4	.168
"	12.9	2.58	52.0	4000	"	7.4	.148
"	13.8	2.76	65.0-	5000	"	6.5	.13
"	15.0	3.0	77.0	6000	"	5.8	.116
"	16.2	3.24	88.7	7000	"	4.2	.84
"	17.3	3.46	100.0	8000	"	3.0	.6
"	18.2	3.64	112.0	9000	"	1.4	.28

WL-892 CHARACTERISTICS

#25516

+400 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	A-C	D-C	R	V	I
10	21.5	2.15	10.0	750	25	14.2	.568
"	24.5	2.45	13.0	1000	"	12.5	.500
5	13.5	2.7	19.6	1500	"	8.4	.336
"	14.8	2.96	26.0	2000	"	5.5	.220
"	16.2	3.24	39.0	3000	"	3.0	.12
"	17.3	3.46	52.0	4000	"	2.2	.088
"	19.0	3.8	65.0-	5000	"	2.0	.08
"	20.0	4.0	77.0	6000	"	1.4	.056
"	21.3	4.26	88.7	7000	"	0.6	.024
"	22.5	4.5	100.0	8000	"	0.5	.020
"	23.7	4.74	112.0	9000	"	-0.6	-.024

+500 Volt Grid

5	14.5	2.9	10.0	750	25	21.5	.860
"	16.0	3.2	13.0	1000	"	19.0	.76
"	17.4	3.48	19.6	1500	"	13.3	.532
"	18.9	3.78	26.0	2000	"	8.3	.332
"	21.0	4.2	39.0	3000	"	2.8	.112
"	23.0	4.6	52.0	4000	"	0.6	.024
"	24.4	4.98	65.0-	5000	"	0.3	.012
3	15.1	5.03	77.0	6000	"	-0.4	-.016
"	16.2	5.4	88.7	7000	"	-0.8	-.032
"	17.0	5.67	100.0	8000	"	-1.6	-.064
"	17.8	5.93	112.0	9000	"	-3.0	-.12

DT-C4207

WL-892 CHARACTERISTICS

#25516

+600 Volt Grid

Anode Amperes			Ep		Grid Amperes		
R	V	I	A-C	D-C	R	V	I
5	18.0	3.6	10.0	750	20	25.0	1.25
"	19.6	3.92	13.0	1000	"	21.4	1.07
"	22.0	4.4	19.6	1500	"	14.5	.725
"	23.8	4.76	26.0	2000	"	10.6	.53
3	16.0	5.3	39.0	3000	"	3.0	.15
"	17.2	5.77	52.0	4000	"	-1.1	-.055
"	17.7	5.9	65.0-	5000	"	-1.8	-.09
"	19.0	6.33	77.0	6000	"	-2.3	-.115
"	19.8	6.6	88.7	7000	"	-2.8	-.14
"	20.8	6.93	100.0	8000	"	-3.3	-.165
"	21.6	7.2	112.0	9000	"	-3.5	-.175

+700 Volt Grid

5	20.2	4.04	10.0	750	10	17.0	1.7
"	22.6	4.52	13.0	1000	"	13.6	1.36
"	25.4	5.08	19.6	1500	"	10.0	1.0
3	16.7	5.57	26.0	2000	20	14.4	.72
"	19.0	6.33	39.0	3000	"	6.4	.32
"	20.6	6.87	52.0	4000	"	-1.0	-.05
"	22.2	7.4	65.0	5000	"	-3.8	-.19
"	23.0	7.67	77.0	6000	"	-4.1	-.205
			88.7	7000			
			100.0	8000			
			112.0	9000			

+800 Volt Grid

5	23.0	4.6	10.0	750	10	23.0	2.3
"	26.0	5.2	13.0	1000	"	17.8	1.78
3	17.7	5.9	19.6	1500	"	13.0	1.3
"	19.0	6.33	26.0	2000	"	10.0	1.0
"	21.6	7.2	39.0	3000	"	5.0	0.5
"	23.4	7.8	52.0	4000	"	0.8	0.08
			65.0	5000			
			77.0	6000			
			88.7	7000			

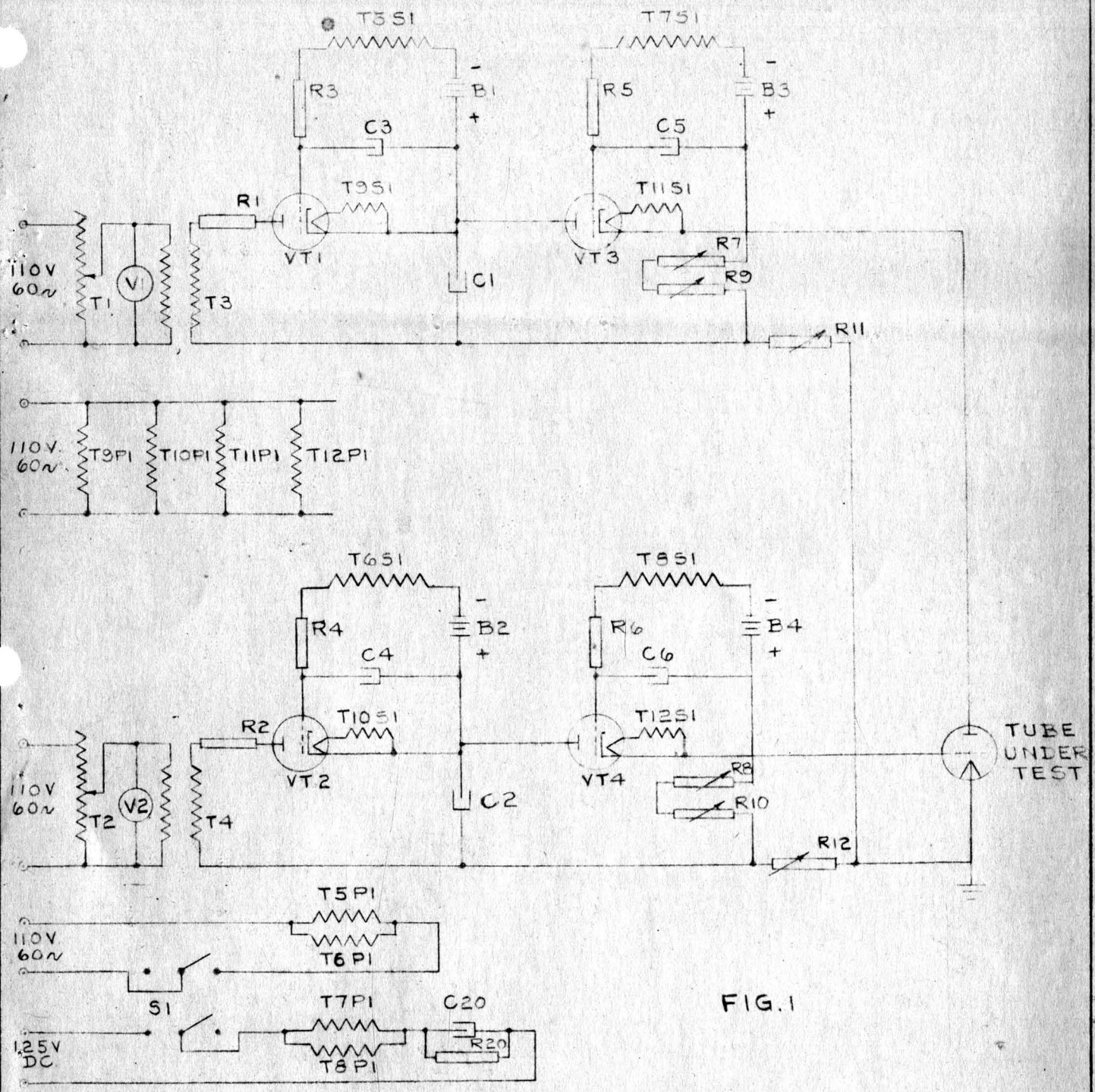


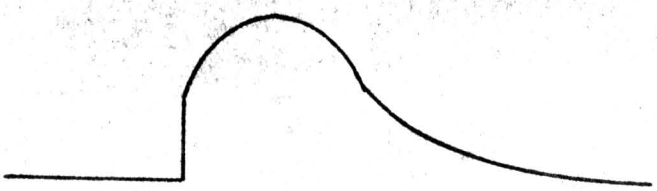
FIG. 1

SCHEMATIC DIAGRAM OF CONNECTIONS
for
POSITIVE GRID CHARACTERISTIC TEST SET

REVISIONS	MADE BY L.J. Eastman AUG 23 1939. INSPECTED BY Aug. 31, 1939. JH 8413	K-6917413	VT 8 PRINTS TO
	GENERAL ELECTRIC SCHENECTADY WORKS	SHEET NO. 1. CONT. ON SHEET 2	
FF-449-A (4-39) rev.	VT		

K-6917413

(a)



(b)

(c)

FIG. 2

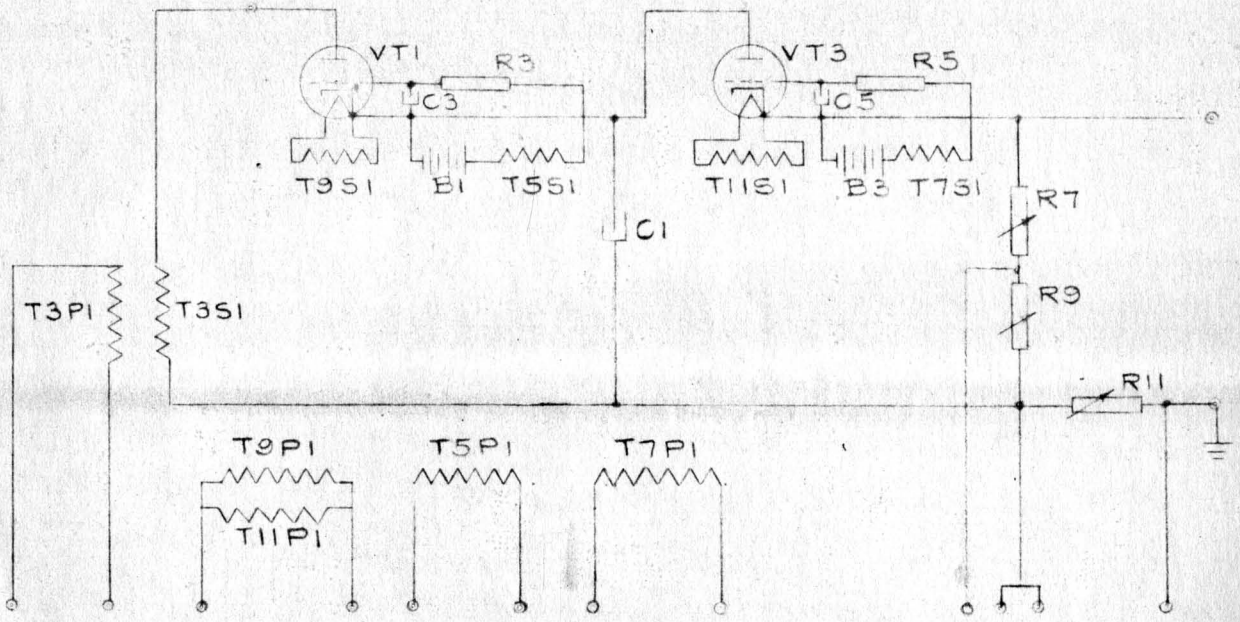


FIG. 3

K-6917413

SCHEMATIC DIAGRAM OF CONNECTIONS
for
POWER SUPPLY AND SWITCHING UNIT
for
POSITIVE GRID CHARACTERISTIC TEST

	MADE BY L. J. Erickson AUG 23 1939	INSPECTED BY Aug. 31, 1939	JH 8413	
REVISIONS	GENERAL ELECTRIC SCHENECTADY WORKS	K-6917413 SHEET NO. 2 CONT. ON SHEET 3		VT 8 PRINTS TO
FF-449-A (4-39) rev.	VT			

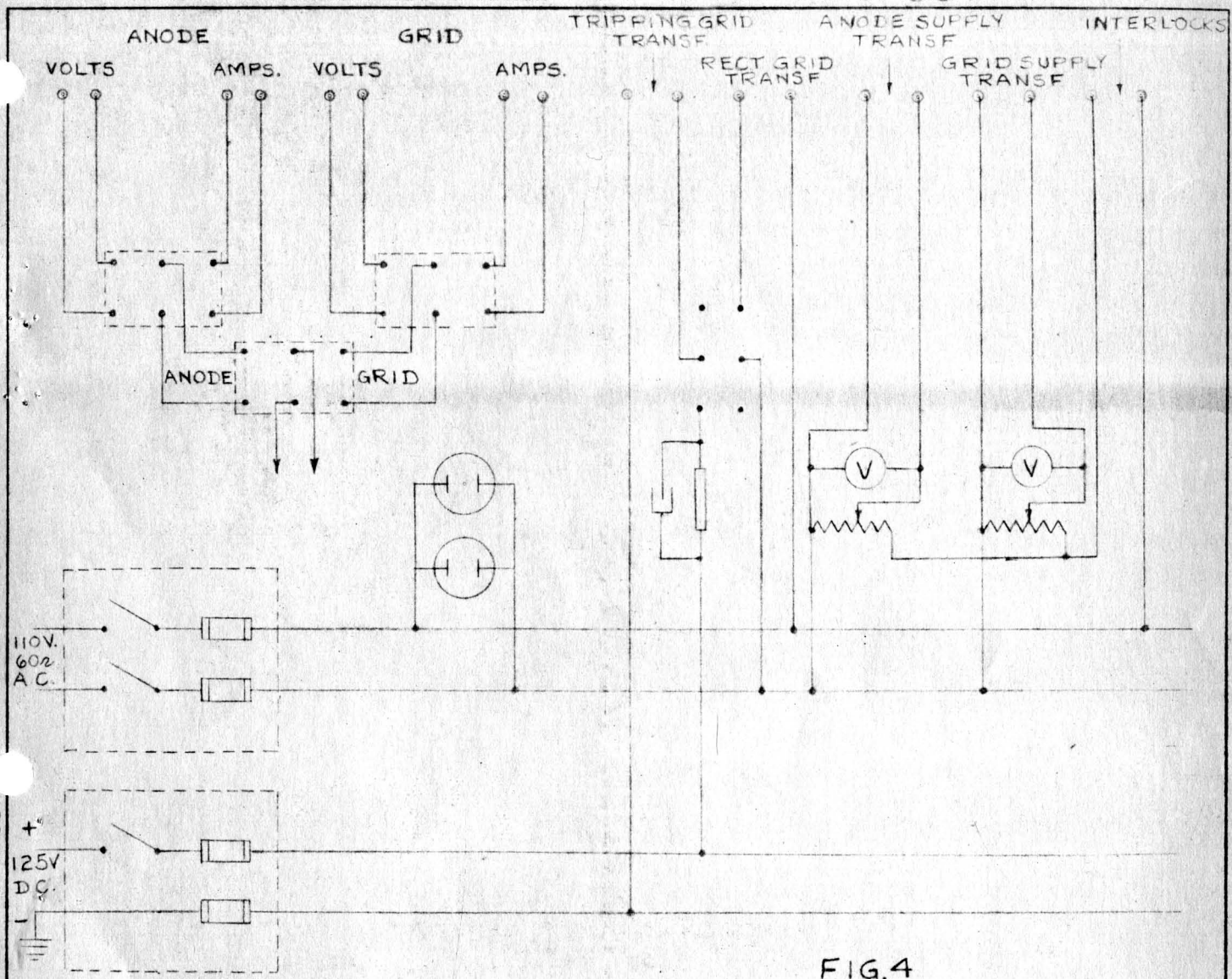


FIG. 4

K-6917413

SCHEMATIC DIAGRAM OF CONNECTIONS
CONTROL UNIT
for
POSITIVE GRID CHARACTERISTIC TEST

REVISIONS	MADE BY L. J. Erickson AUG. 24, 1939	INSPECTED BY Aug. 31, 1939. JH 8-4-13	VT8 PRINTS TO
	GENERAL ELECTRIC SCHENECTADY WORKS	K-6917413 SHEET NO. 3 CONT. ON SHEET 4	
FF-449-A (4-39) rev.	VT		

T1, T2	115 volt; 500 VA variac
T3	Anode supply trans. P.T. 110/220 to 6600
T4	Grid supply trans. P.T. 110/220 1100/2200
T5,T6,T7,T8	Grid trans. 110/110 insoltaed 15 kv - 100 VA
T9,T10,T11,T12	Filament trans. Y - 2052
C1	Anode supply condenser 16mfd - 9000 volts
C2	Grid supply condenser 45mfd - 1200 volts
C3,C4,C5,C6	Grid condensers 0.002mfd - 1000 volts
C20	7mfd - 300 volt
R1, R2	Charging resistors
R3,R4,R5,R6	Grid resistors
R7	100,000 ohm, decade box
R8	10,000 " " "
R9	1,000 " " "
R10	1,000 " " "
R11	100 " " "
R12	100 " " "
R20	5,000 " blue stick
V1	0-150 volts or less, as required
V2	0-150 " " " " "
VT1, VT2	FG-41 thyratrons
VT3, VT4	" "

K-6917413

NOMENCLATURE

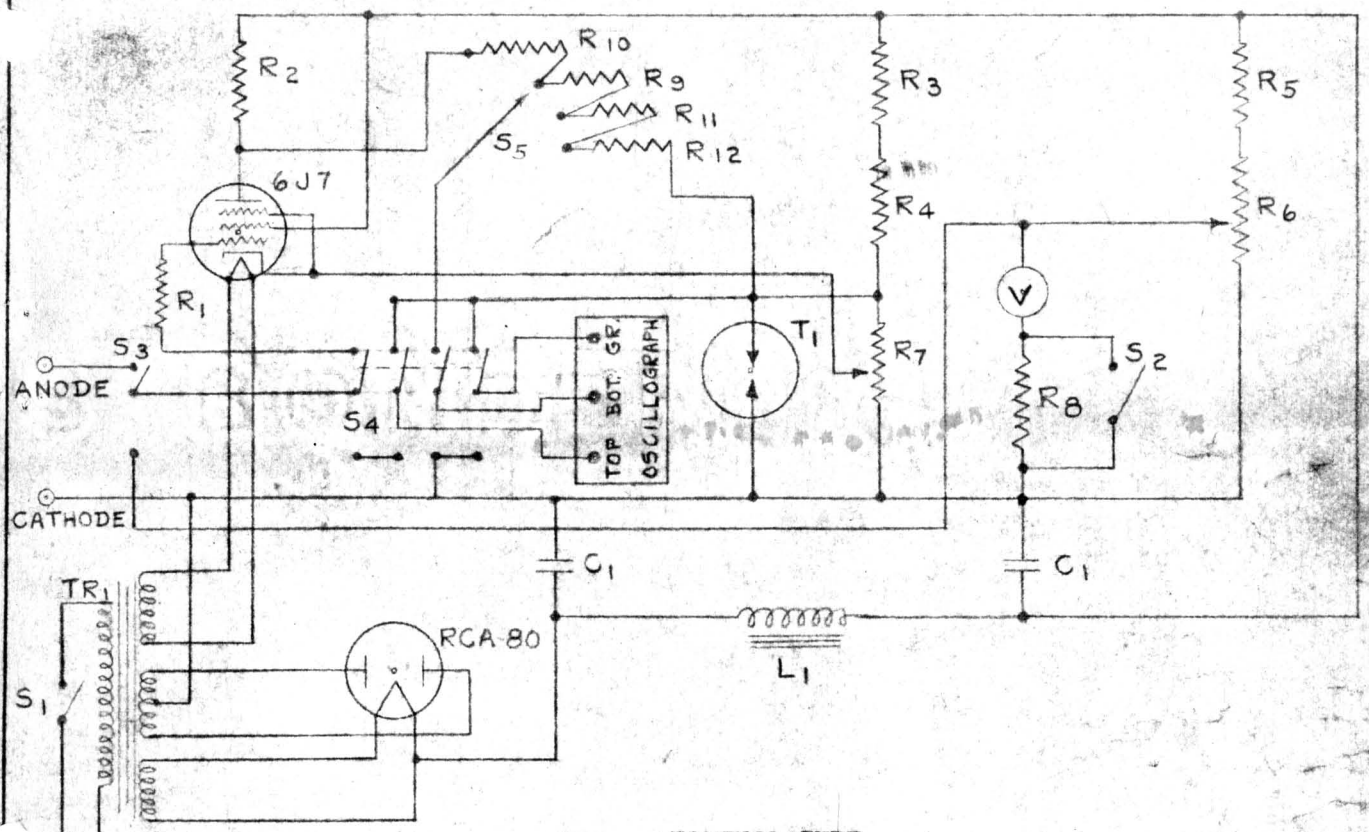
for

SCHEMATIC DIAGRAM OF CONNECTIONS

for POSITIVE GRID CHARACTERISTIC TEST

	MADE BY L.J. Eschenmann AUG-23-1939	INSPECTED BY Aug. 31, 1939	JH 8413
REVISIONS	GENERAL ELECTRIC SCHENECTADY WORKS	K-6917413 SHEET NO. 4 CONT. ON SHEET FINAL	VT 8 PRINTS TO
FF-449-A (4-39) rev.	VT		

THIRD ANGLE PROJECTION



NOMENCLATURE

R_1	-	10,000 ohm resistor	ohmite type 0385
R_2	-	50,000 " " "	" 0392
R_3	-	10,000 " " 1 watt	" WW-1
R_4	-	5,000 " " "	" WW-1
R_5	-	7,500 " " 25 watt	" B-100
R_6	-	2,500 " " Yaxley Potentiometer	
R_7	-	10,000 " " "	"
R_8	-	--- voltmeter multiplier 3:1 ratio	
R_9	-	50,000 ohm resistor	F-1
R_{10}	-	100,000 " "	F-1
R_{11}	-	25,000 " "	F-1
R_{12}	-	25,000 " "	F-1
V	-	25 volt meter DO-40	
T_1	-	Glow lamp CD-5003	
L_1	-	9XD234A1 reactor	
TR_1	-	Power supply transformer Kenyon 650V; 6.3V; 5 V	
C_1	-	7 mfd condenser 67x8	
S_3	-	Single pole double throw federal anti-capacity switch	
S_4	-	Four " " " " " "	
S_1 - S_2	-	Single " single " snap switch	
S_5	-	4 contact Yaxley switch	

VT 10

DIAGRAM OF CONNECTIONS

OSCILLOGRAPH AMPLIFIER-CALIBRATOR CIRCUIT

ROOM 426

1 Aug. 9. 37. Drawn 5513

VT ALSO FOR RATING AS SHOWN ON THE REVERSE SIDE OF THIS PRINT

GENERAL ELECTRIC WORKS SCHENECTADY

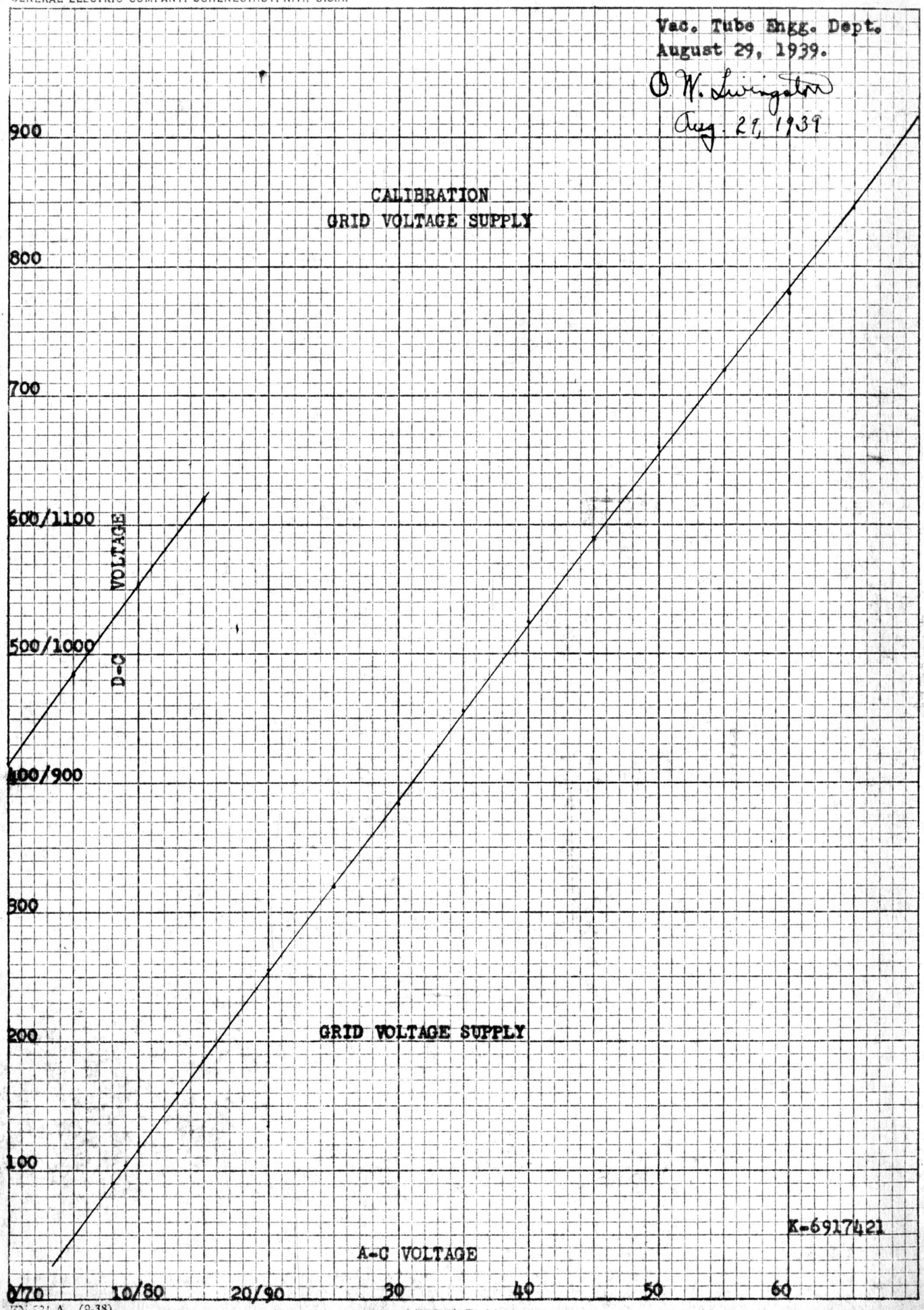
DRAWN BY L. J. Eckman MAR 19, 37

INSPECTED BY April 1-37

K-5344730

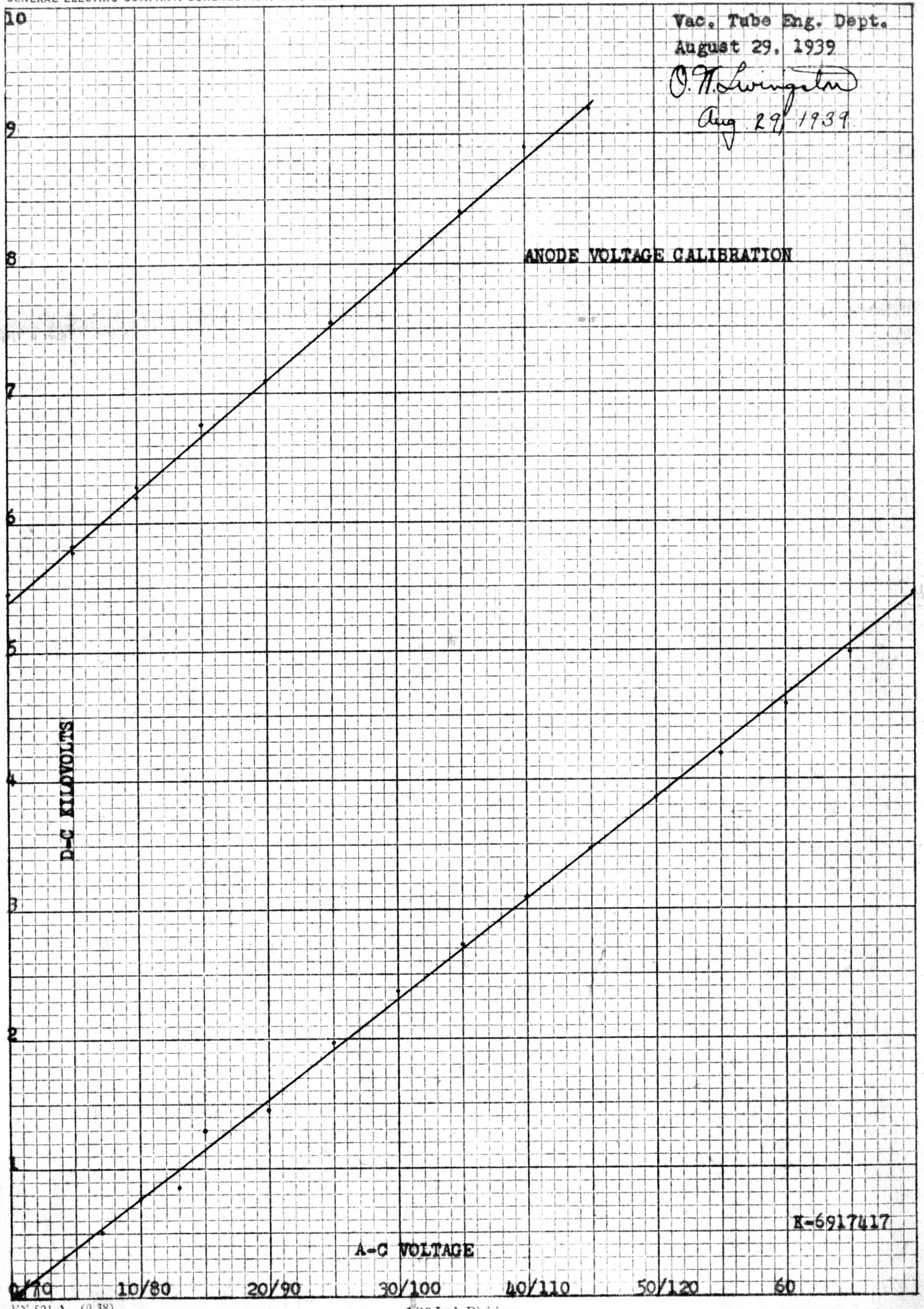
FE 449 A

Vac. Tube Engg. Dept.
August 29, 1939.
O W. Livingston
Aug. 29, 1939



E. L. Rogers
H-8447

1/10 Inch Divisions



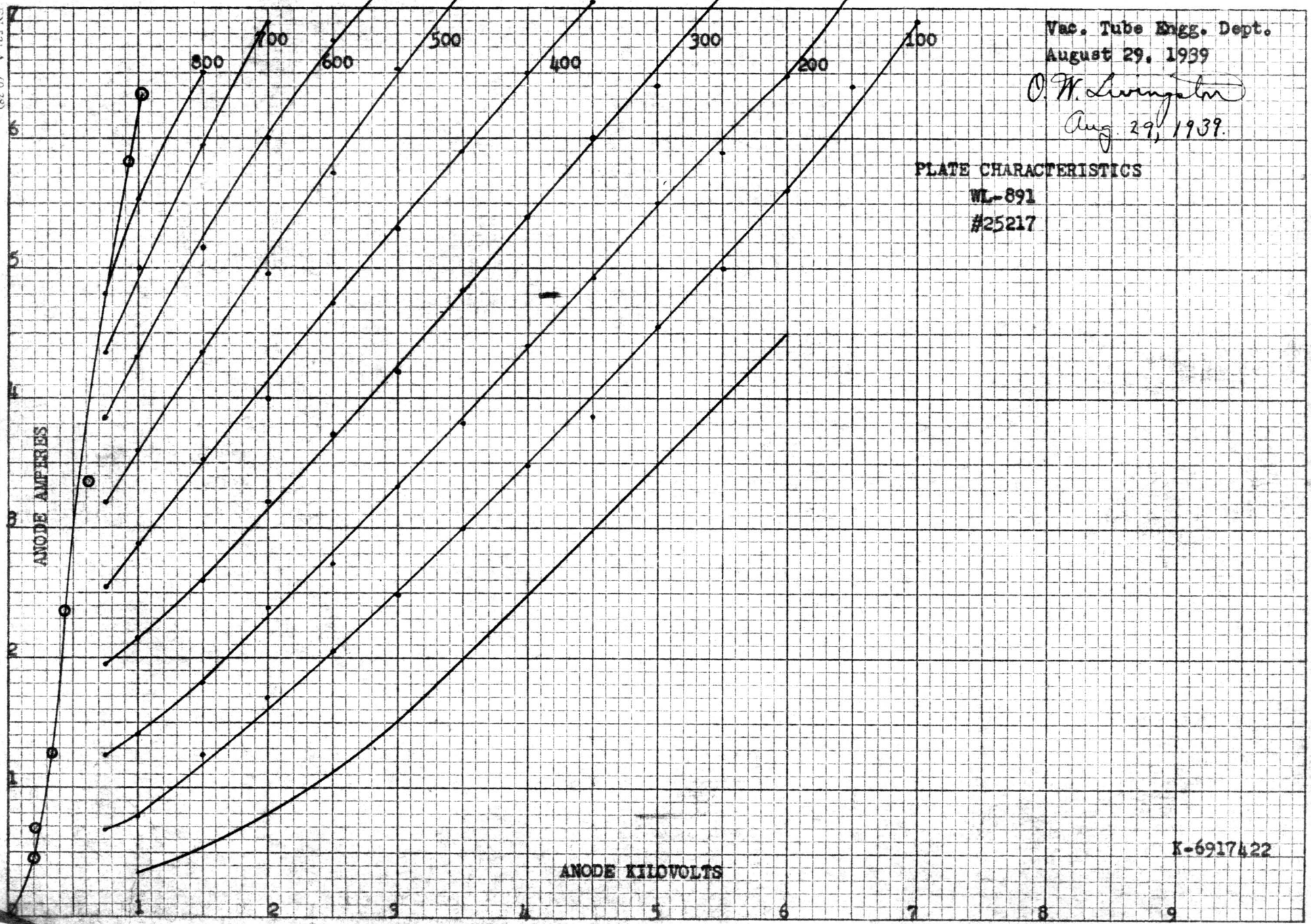
Aug. 29-39
E. H. Livingston
14-E-447

1/10 Inch Divisions

Aug-29-39
C.H. Rogers
M. 5249

FN-521-A (9-38)

1/10 Inch Divisions



Vac. Tube Engg. Dept.
August 29, 1939
O. W. Livingston
Aug. 29, 1939.

PLATE CHARACTERISTICS
WL-891
#25217

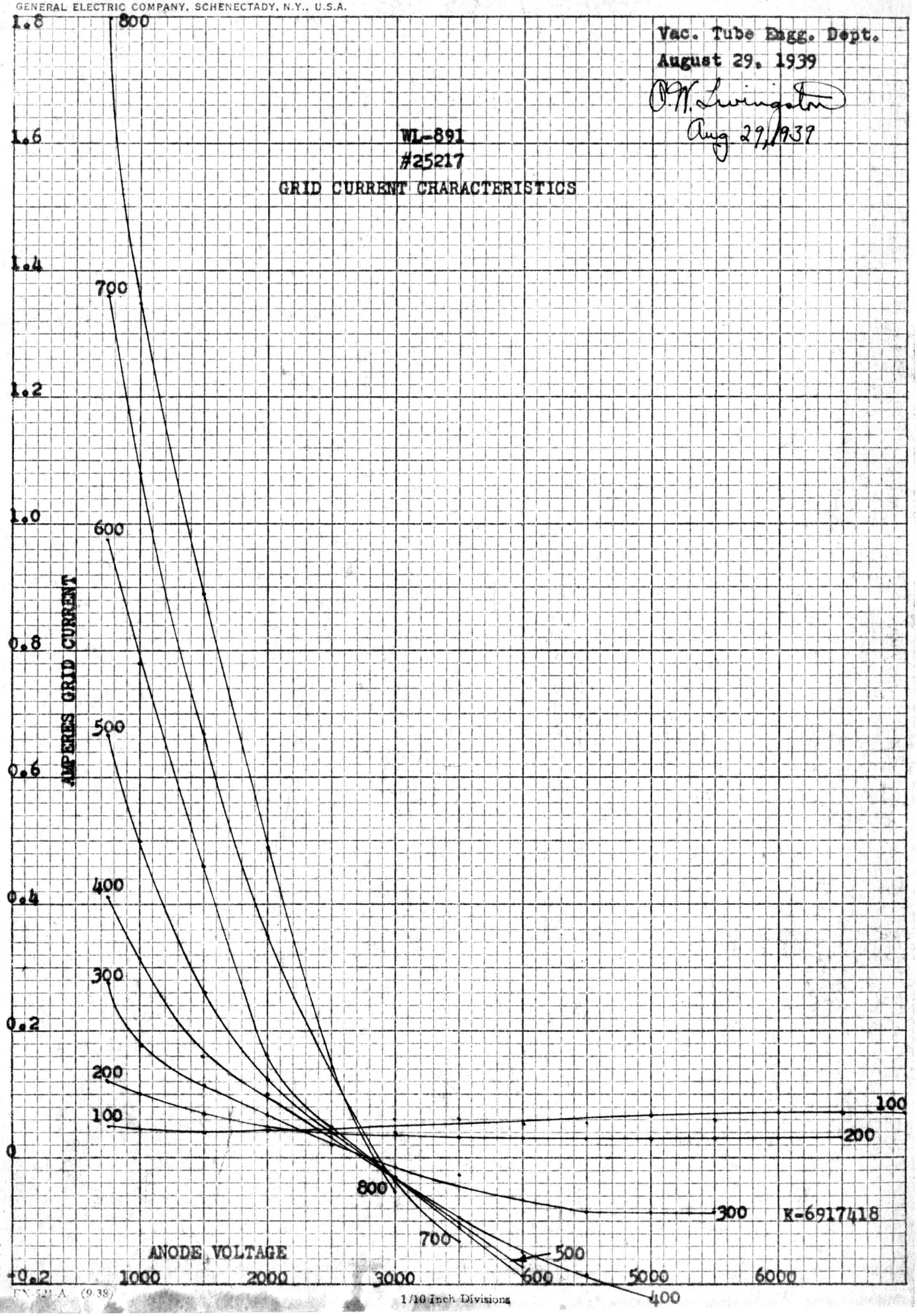
K-6917422

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

Vac. Tube Engg. Dept.
August 29, 1939
O. W. Livingston
Aug 29, 1939

WL-891
#25217

GRID CURRENT CHARACTERISTICS

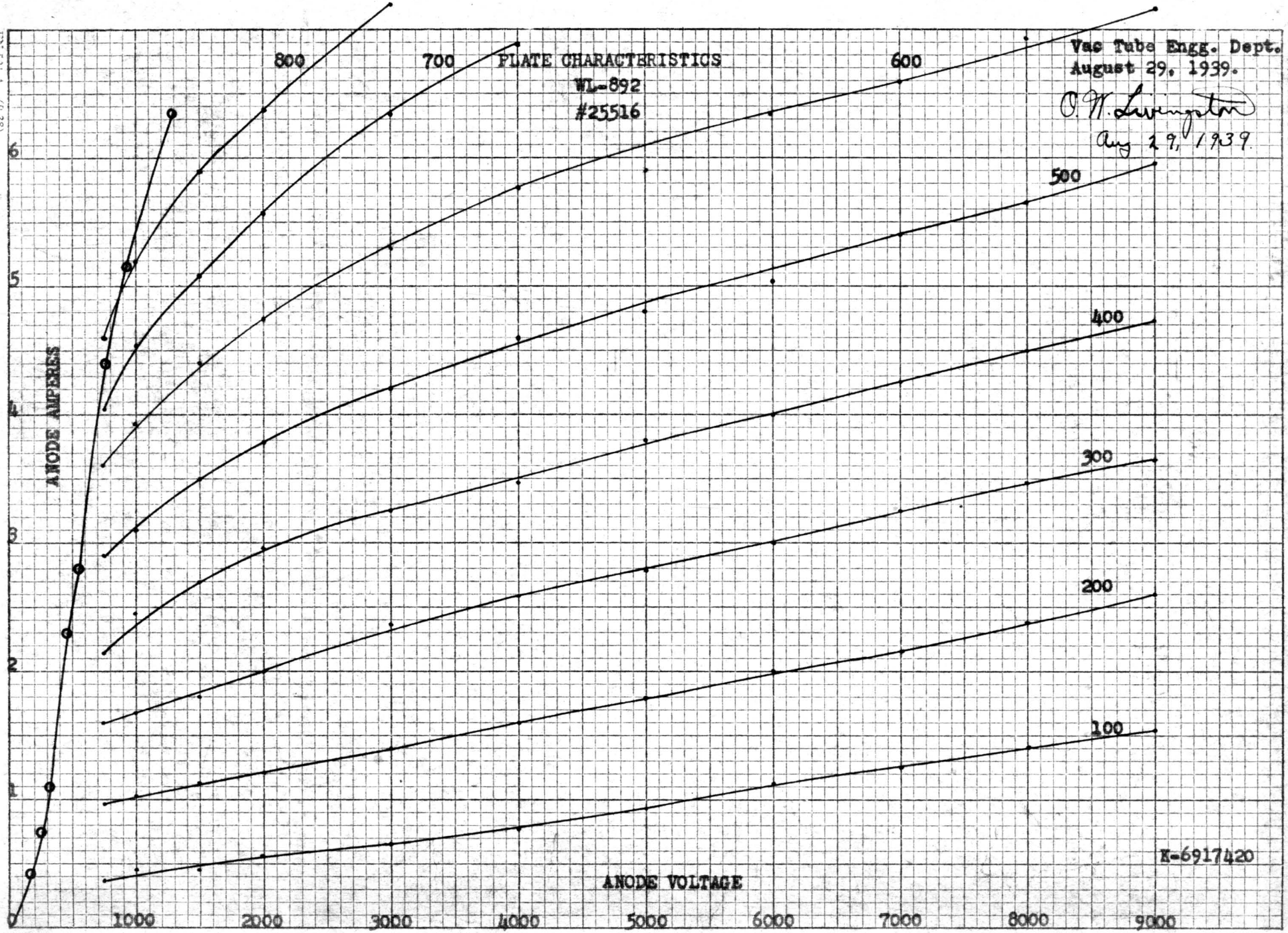


Aug 24-39
E. Rogers
JH-6447

FN 52-A (0-38)

1/10 Inch Divisions

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



Vac. Tube Engg. Dept.
August 29, 1939.
O.W. Livingston
Aug. 29, 1939.

WL-892
#25516

GRID CURRENT CHARACTERISTICS

AMPERES GRID CURRENT

2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4

800
700
600
500
400
300
200
100

1000 2000 3000 4000 5000 6000 7000 8000 9000

ANODE VOLTAGE

K-6917419