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NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report on

Electrical Characteristics and Performance of Rectifier Unit Type CAY-20018 of the Model TBK Radio Transmitter.

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Washington, D.C.

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Authorization: Bu.Eng.let. NOs-36091(4-25-W8) of 21 July 1934.

Date of Test: 31 October and 1 November 1934.

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Distribution:
Bu.Engr. (5)

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APPENDICES

AUTHORIZATION FOR TEST

1. The subject tests were authorized by reference (a), and references (b) to (e) inclusive, are also pertinent.

Reference: (a) Eng.let. NOs-36091(4-25-W8) of 21 July 1934.
(b) Eng.let. S-900-7409(4-25-W8) of 30 April 1934.
(c) NRL let. S67/38 of 31 May 1934.
(d) Navy Schedule 900-7409, radio transmitting equipment.
(e) Westinghouse Elec.& Mfg.Co. let. W.G. 16600 of 6 July 1934 to BuEngr.

OBJECT OF TEST

2. The object of this investigation was to study the electrical performance of the Rectigon Control Circuit of the Model TBK Radio Transmitter Rectifier Unit Type CAY-20018, and to determine its suitability for use in Naval radio equipment.

ABSTRACT OF TEST

3. The performance of the type CAY-20018 rectifier unit of the Model TBK radio transmitter was observed under three different circuit conditions as shown in Figures 1, 2 and 3 respectively. Under normal operation, as shown in Figure 2, data was obtained and calculations made on tube and transformer characteristics, the separation of the rectifier circuit losses into their component parts, overall efficiency of operation, and percent output voltage ripple.

Conclusions

(a) The Rectigon tubes used in the Model TBK radio transmitter rectifier unit are being operated within their rating of peak current and peak inverse voltage.

(b) The Rectigon tubes are electrically and mechanically satisfactory for use in the subject Naval equipment with an ample factor of safety. However, the life expectation is not apt to be greatly in excess of 1000 hours which means tube replacement approximately every six weeks, if continuous operation exists.

(c) The Rectigon tubes represent a makeshift application of a tube design already existing, and therefore do not represent the most efficient type of tube for this circuit, from the standpoint of filament energy consumption, voltage and current ratings, life expectation, and overall efficiency for continuous operation at light load and full load.

(d) The space requirements of the Rectigon circuit and its weight are considered excessive for the amount of power output.

Recommendations

(a) The rectifier tubes used in the control supply circuit of the TBK radio transmitter which furnishes 110 volts direct should be replaced with a tube design which better fulfills the circuit output requirements and which has a life expectancy of 3000 to 6000 hours. This would lower the initial cost and maintenance, decrease weight and space requirements, and increase the overall efficiency of the rectifier circuit.

(b) Each rectifier type transmitter should have a self-contained rectifier circuit for supplying 110 volts for control and key circuits.

DESCRIPTION OF APPARATUS UNDER TEST

4. The apparatus whose electrical performance was studied was the control rectifier circuit of the Model TBK Radio Transmitter Rectifier Unit Type CAY-20018 manufactured by the Westinghouse Electric and Manufacturing Co., and consists of a single phase full wave rectifier circuit with two type S-289416D Rectigon tubes. The output obtained from this circuit is 110 volts average at 1.0 amperes average and was incorporated in the TBK Transmitter equipment to provide the necessary energy for the 110 volt D.C. control and keying circuits.

5. The control circuits so supplied are inductive and therefore the rectifier apparatus and circuit was studied under this condition. In addition, the electrical performance of this rectifier circuit was studied under the conditions of non-inductive output load, both with a condenser input filter of 200 microfarads, and also an inductive input type of filter. A diagram of connections for the Rectigon Control Supply Circuit is shown in Plate 11 of Figures 1, 2 and 3. Under actual operating conditions the circuit used is that shown in Figure 2, where the load applied to the rectifier circuit is inductive. This corresponds to the relay load which exists in the TBK radio transmitter. Figure 1 shows the same circuit with the exception that the output load on the rectifier circuit is non-inductive. Figure 3 shows the circuit condition where the condenser input filter has been substituted by a choke input filter. This is the condition under which the rectifier circuit was studied when the material for ref.(c) was obtained. Figure 1 and Figure 3 were circuits studied as a matter of comparison with the circuit shown in Figure 2.

METHOD OF TEST

6. The method of test is indicated in Plate 11 of Figures 1, 2 and 3. All instantaneous electrical quantities were obtained by means of an oscillograph with the proper calibration applied. The instruments for measuring the average or effective electrical quantities involved either for calibration or otherwise, were obtained through the use of instruments of either the D'Arsonval type or the electrodynamometer type.

DATA RECORDED DURING TESTS

7. The data recorded during tests are shown in Table 1 and Plates 1 to 11, inclusive, and were taken with the object of obtaining information on the following rectifier characteristics:

(a) Operation with condenser input filter, non-inductive load.
(b) Operation with condenser input filter, inductive load.
(c) Operation with choke input filter, non-inductive load.

(d) Rectifier output voltage regulation under various conditions.
(e) Impedance of transformer windings.
(f) Rectifier tube characteristics.
(g) Losses in circuit elements.
(h) Percent ripple.

PROBABLE ERROR IN RESULTS

8. The accuracy with which oscillograph records can be read and measured is 5%. The calibration of these records is accurate to about 5%. Meter measurements, using precision instruments, were made within 1/2 of 1%. The accuracy with which calculations were made is indicated under "Results of Test".

RESULTS OF TEST

9. Operation with condenser input filter, non-inductive load (Figure 1 of Plate 11).

(a) In Table 1 there is given data taken on the Model TBK type 20018 Rectigon control circuit under circuit conditions as shown in Figure 1 of Plate 11. Oscillographic traces showing wave forms, instantaneous values and phase relationship of the electrical quantities involved are portrayed in corresponding film records 1A, 1C, 2A, 2B, 2C, 3A, 3B and 3C of Plates 1, 2, 3 and 4.

(b) Film record 1A, traces 1 and 2, give the wave form and instantaneous values of primary input volts and amperes to the rectifier transformer. Attention is invited to the peak value of 3.46 primary amperes, whereas the R.M.S. value shown in Table 1 is 1.30 amperes. The high peak value of current found in the primary current wave form of the transformer for both positive and negative half cycles is due to the effect of the large charging current which enters the 200 mfd filter condenser during the conduction period for every half cycle. This conduction period is approximately 45 electrical degrees.

(c) Film record 1C, traces 5 and 6, show the wave form and instantaneous values of anode currents for both Rectigon rectifier tubes. These tubes, Argon gas filled, type S-289416D were operated at peak values of 7.52 amperes for the rear Rectigon No. J-3 and 7.14 amperes for front Rectigon No. B-4, these values being well within the manufacturer's peak anode current rating. The angle of conduction of plate current through each rectifier tube was measured as approximately 45°.

(d) Film record 2A, traces 7 and 8, show the wave form and instantaneous values of anode-cathode voltages for both Rectigon rectifier tubes. Both tubes show a peak inverse voltage of about 260 volts. This is also within the manufacturer's rating of 375 volts.

(e) Film record 2B shows the wave form and instantaneous values of anode-cathode voltage on trace 9 for the front Rectigon No. B-4 and anode amperes on trace 10 for this same tube. The phase relationship is evident upon comparison of these two traces.

(f) Film record 2C, trace 11, shows the wave form and instantaneous value of load output and condenser volts which consists of an alternating component of voltage superimposed on the direct voltage. The average voltage shown is 110.7 volts, with a peak value which is successively 129.6 and 132 volts (due to tube dissimilarity) and a valley-bottom value of 91.9 volts. The point at which the valley-bottom value of condenser voltage occurs is at the instant when a Rectigon tube begins to conduct and charge the 200 microfarad condenser, thereby raising its voltage. The peak condenser current inflow occurs at this instant. The condenser current then subsides, becoming zero as the counter-electromotive force of the condenser becomes equal to the transformer induced voltage. This event occurs each time that the condenser voltage reaches its peak value. Alternate tubes supply adjacent pulses of current and voltage to the condenser and output circuit. Immediately upon cessation of the tube and transformer to further charge the condenser, the current in the condenser reverses and supplies the load with a gradually diminishing condenser voltage and current until the opposite tube permits the re-charge of the condenser again. At this moment, the above cycle is again repeated.

(g) During the interval that the condenser voltage is rising the power transformer supply is charging the condenser and furnishing load current to the output in addition. During the interval that the condenser voltage is decreasing, the power transformer supply is not furnishing any energy either to the condenser or the load. During this interval the condenser supplies the load with energy. The above cycle of condenser-charge-discharge occurs at twice the frequency of the transformer input supply frequency.

(h) Trace 12 shows the wave form and instantaneous value of condenser amperes, with peak values of 7.22 amperes for the rear Rectigon tube No. J-3 and 6.94 amperes for the front Rectigon tube No. B-4. The values of peak current from each of the tubes differ on account of slightly dissimilar tube characteristics. As set forth in paragraph 3 of reference (c), the arc drop voltage on tube No. B-4 is 7.0 volts whereas the value found on tube No. J-3 was 5.0 volts. Tube No. B-4 with the 7.0 volt arc drop therefore has a higher internal resistance than tube No. J-3, and hence limited the peak plate current to a smaller value during the conducting portion of its half cycle than did tube No. J-3 on the conducting portion of its opposite half cycle.

(i) Film record 3A, traces 13 and 14, shows the wave form, instantaneous values, and phase relationship of full secondary transformer volts, and the condenser amperes to the 200 microfarad filter and storage condenser. It can be clearly seen that the transformer has considerable internal impedance, which is indicated by the "sag" in the transformer secondary voltage as each of the Rectigon tubes begin to conduct and charge the 200 microfarad filter condenser.

(j) Film record 3B, traces 15 and 16, show the wave form, instantaneous values, and phase relationship of full secondary transformer volts and the anode amperes of the front Rectigon No. B-4. The anode current is made up of two components, that which flows into the condenser and that part which supplies the load output circuit.

(k) Film record 3C, traces 3 and 4, give the wave form, instantaneous values, and phase relationship of the load output voltage and current. Since the load output is non-inductive, both wave forms are identical.

10. Operation with condenser input filter, inductive load (Figure 2 of Plate 11).

(a) In Table 1 is given data on the Model TBK type 20018 Rectigon control circuit supply rectifier taken under circuit conditions as shown in Figure 2. Oscillograph traces showing wave forms, instantaneous values, and phase relationship of the electrical quantities involved are portrayed in corresponding film records 4A, 4B, 4C, 5A, 5B, 5C, 6A and 6B of Plates 5, 6, 7 and 8. These records bear some close resemblance to those shown in Plates 1, 2, 3 and 4 since the circuit output contained the only electrical element which was varied.

(b) Film record 4A, traces 17 and 18 show the primary input volts and amperes to the rectifier transformer.

(c) Film record 4B, traces 19 and 20 show the output load volts and amperes. The load output amperes has had the alternating component partly removed by the choking action of the load inductance.

(d) Film record 4C, traces 21 and 22 show the anode amperes for each of the Rectigon rectifier tubes. Again note that front tube No. B-4, the tube with higher internal resistance, shows the lowest peak current.

(e) Film record 5A, traces 23 and 24, show anode-cathode volts on both rectifier tubes. Together, film records 4C and 5A show that the Rectigon tubes are being operated well within their peak inverse voltage rating of 375 volts and their peak anode current of 18.8 amperes. With the circuit, Figure 2, as used, which simulates normal operation, the peak anode currents are 7.55 amperes for Rectigon No. J-3 and 7.24 amperes for Rectigon No. B-4.

(f) Film 5B, traces 25 and 26 show the phase relationship between the anode-cathode volts and the anode amperes of front Rectigon No. B-4.

(g) Film 5C, traces 27 and 28 again illustrate the phase relationship between the output load or condenser volts as compared with the condenser current.

(h) Film record 6A, traces 29 and 30 show the phase relationship, wave form, and instantaneous values of full secondary transformer volts and condenser amperes.

(i) Film record 6B, traces 31 and 32 give a comparison between full secondary volts of the rectifier transformer versus anode amperes on front Rectigon tube No. B-4.

11. Operation with choke input filter, non-inductive load (Figure 3 of Plate 11).

(a) In Table 1 is given data on the Model TBK type 20018 Rectigon control supply circuit taken under circuit conditions as shown in Figure 3. This circuit is similar to that used when reference (c) report data was obtained with the exception that the plate transformer used to obtain reference (c) data had sufficient secondary voltage available to exceed the manufacturer's peak inverse voltage rating when such operation was desired. In the present report, subsequent oscillographic film records 6C, 7A, 7B and 7C of Plates 9 and 10, were taken with the rectifier circuit supplied by the manufacturer. This transformer did not, however, give as much peak inverse voltage as the secondary of the transformer used when the experimental data was obtained for reference (c). The peak inverse voltage which would have existed for an average output voltage of 110 volts and an average output current of 1.0 ampere is calculated as 475 volts where the manufacturer's peak inverse voltage rating is 375 volts. This explains the arc back conditions encountered in the tests reported in reference (c) when using a choke input type of filter where, in order to obtain the average output conditions of 110 volts at one ampere, the peak inverse voltage rating of the Rectigon rectifier tubes was exceeded, hence the accompanying arc backs encountered.

(b) Film record 6C, trace 33 shows the full secondary transformer voltage. Beneath this trace is that of trace 34 showing the anode amperes of front Rectigon No. B-4. The angle of conduction (current flow) through the tube is seen to be 180 electrical degrees.

(c) The wave form for the anode amperes of rear Rectigon No. J-3 is not shown, but is similar to that shown in trace 34 except that it is displaced by 180°. If the anode currents of both Rectigons are placed together side by side there results a wave form similar to that shown in Film No. 7B, trace 38.

(d) In trace 34 the peak anode current is correspondingly lower than in the case of the condenser input filter where the conduction angle was approximately 45 electrical degrees.

(e) Film No. 7A, traces 35 and 36 show the impressed voltage across the rectifier transformer primary circuit and primary input amperes. Note should be made of the absence of extremely high peaks and to the similarity of the rectified anode current wave shape with the primary input current wave form.

(f) Film 7B, traces 37 and 38 give the wave form, instantaneous values, and phase relationship of the average load output volts and amperes. The principal frequency is double the supply frequency, i.e., 120 cycles per second.

(g) Film 7C, traces 39 and 40 give the full secondary transformer volts and average load output amperes for comparison.

12. Rectifier Regulation under various conditions.

(a) With the rectifier circuit operated as shown in Figure 2 with the transformer primary input voltage held substantially constant, and with load output current average the independent variable, and load output voltage average as the dependent variable, the following observations were made and recorded:

Transformer Primary Input volts	Rectigon Fila.volts	Output Load Volts Aver.	Output Load Amperes Aver.
225.5	2.20	118	0.2
225.5	"	114	0.4
225	"	113.5	0.6
225.5	"	111.5	0.8
225.5	2.18	109	1.0
225	"	106.5	1.2
225	"	104.5	1.3
225	"	103	1.4
225	"	102	1.5
225	"	100	1.6
225	"	98.5	1.7
225	"	97.5	1.8
225	"	95.5	1.9
225	"	94.5	2.0
225	"	93.0	2.1
225	"	92.0	2.2
224	"	90.5	2.3
224.5	"	89.0	2.4
223	"	88.0	2.5

(b) With the rectifier circuit operated as shown in Figure 2, with the load output current average as the independent variable, the transformer secondary, volts R.M.S. and the load output volts average as the dependent variables, the following observations were made and recorded:

Transformer Volts - All of Secondary	Peak Inverse Volts on Rectigons	Fila. Volts on Rectigons	Load Output volts Average	Load Output amperes Average
199.5	282	2.28	116.2	1.0
207	293	2.30	122	1.0
212.2	300	2.44	126.5	1.0
219	310	2.50	131.8	1.0
227	321	2.60	138	1.0
*235	333	2.69	144	1.0
230.5	326	2.66	137.8	1.5
229	324	2.66	131	2.0

Manufacturer's Rated Peak Inverse Volts on Rectigon = 375.

* Voltage of Primary and Secondary not increased further due to the fact that the Rectigon filament supply is from this transformer. The Rectigon filament is rated at 2.2 volts. Under the above condition the Rectigon tubes and associated circuit functioned in a satisfactory manner despite the fact that the peak inverse voltage on the tubes had been increased by 23.8%. If the manufacturer's rated value is taken the margin of safe operation on peak inverse voltage is 39.4%.

13. The equivalent resistance and reactance of the transformer, referred to the secondary, was measured under the condition of using only half of the secondary winding and are given below:

Equivalent Resistance to Secondary = 2.5 ohms.

Equivalent Reactance to Secondary = 1.9 ohms.

Equivalent Impedance to Secondary = 3.1 ohms.

14. Rectigon rectifiers type S-289416-D were used in the subject rectifier. The starting and arc-drop voltages, taken from reference (c), are as follows:

Numerical Designation	Starting Voltage	Arc-Drop Voltage
B-4	11.4	7.0
J-3	12.7	5.0

15. Analysis of losses in the various circuit elements of the rectifier as shown in Figure 2, using a 200 microfarad smoothing capacitor, and an inductive output load, are as follows:

Losses	Watts	Within accuracy of
Transformer, Iron, estimated.................	12	± 20%
Transformer Copper, calculated..............	25	± 5%
Rectigon Tube filaments, 2 tubes............	85	± 1/2 of 1%
Rectigon Tube Arc Drop......................	12	± 5%
Filter Inductive Reactance, estimated........	1	---
Filter capacitor, negligible.................	--	---
Output load Expenditure, A.C.................	11	± 20%
Output load Expenditure, D.C.................	111	± 1/2 of 1%
Oscillograph current elements in circuit.....	2	---
TOTAL...............	259 watts	
Measured Rectifier Transformer Input.........	259 watts	± 1/2 of 1%

Overall Efficiency = $\frac{111}{259}$ = 42.8% ± 1/2 of 1%

In computing the transformer losses, the A.C. watts expenditure in the output load circuit, and the loss through the tube arc drop, the calculations were based on the existing wave forms encountered in the circuit.

16. Per cent ripple can be expressed in a number of ways. If the definition of per cent ripple is taken as the ratio of peak to valley bottom of the alternating voltage to the average voltage expressed in per cent, then the value obtained from Figure 2 circuit operation is found to be as follows, when actual values are taken from Film No. 4B, trace 19.

Peak of Alternating Voltage	133.6
Valley bottom alternating voltage	89.2
Difference............	44.4
Average Output Voltage	110.9

Ripple = $\frac{44.4}{110.9}$ = 40%

However, if the definition of percent ripple is taken as the ratio of the effective value of the ripple voltage to the average value of total voltage, expressed in per cent, then the value obtained from Figure 2 circuit operation is found to be as follows, when actual values are taken from Film No. 4B, trace 19.

R.M.S. Value of Ripple Voltage	16.2 (calculated from wave form)
Average value of total voltage	110.9

$$\text{Ripple} = \frac{16.2}{110.9} = 14.6\%$$

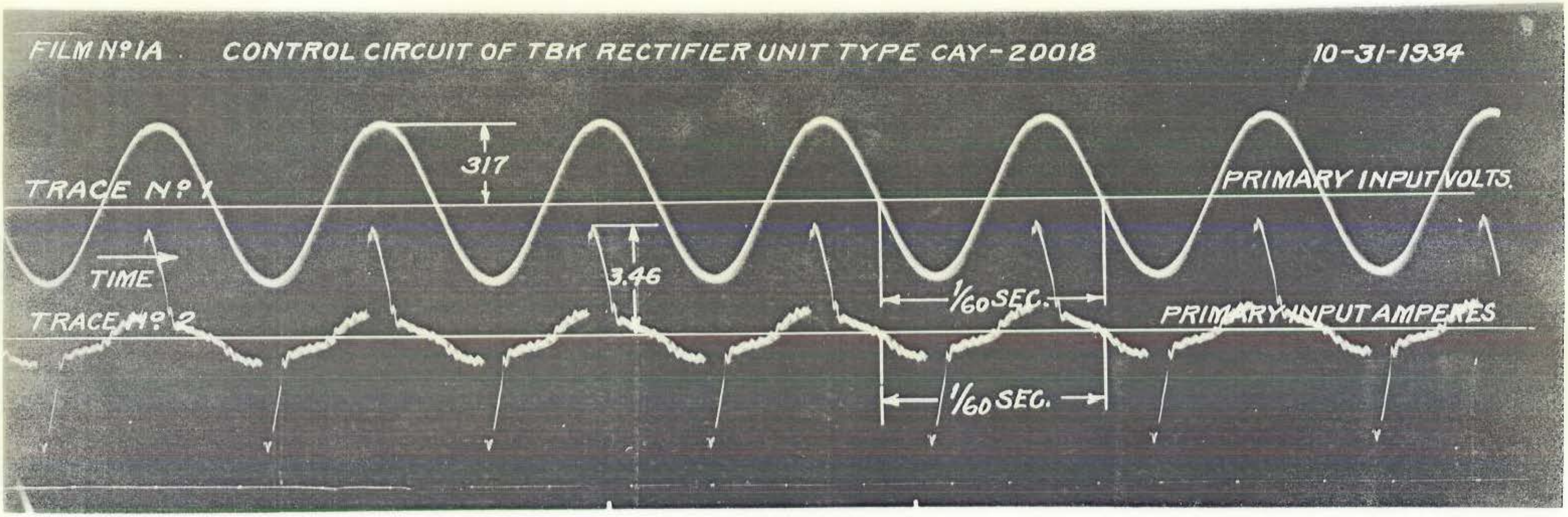
CONCLUSIONS

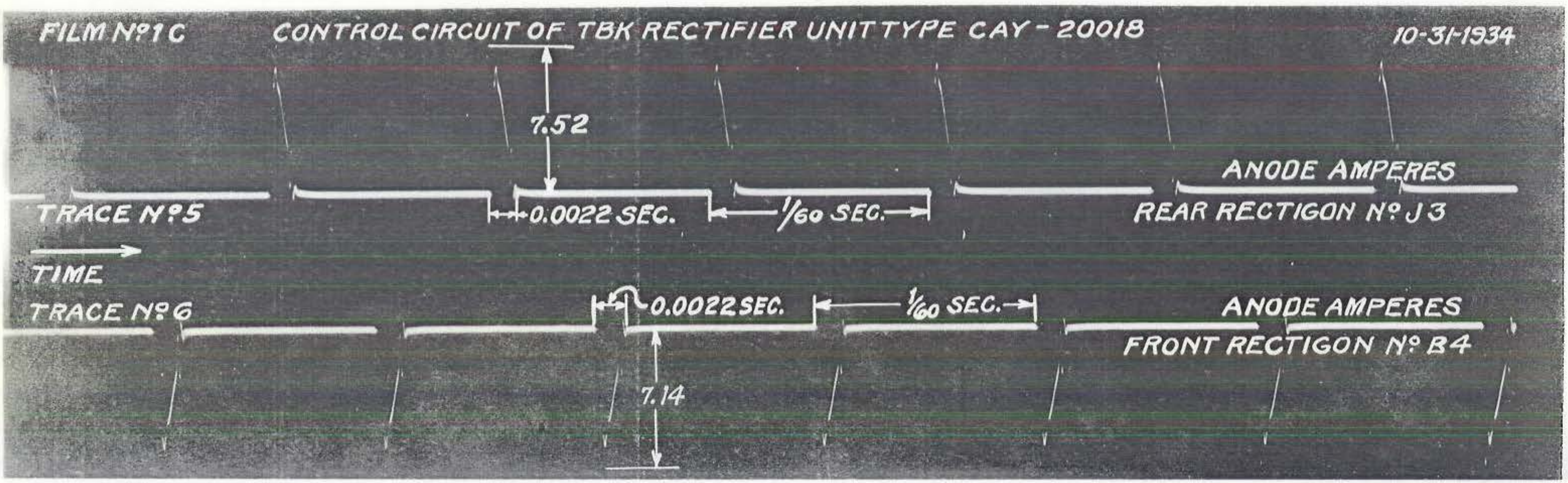
17. The Rectigon tubes used in the Model TBK radio transmitter rectifier unit are being operated within their rating of peak current and peak inverse voltage.

18. The Rectigon tubes are electrically and mechanically satisfactory for use in the subject Naval equipment with an ample factor of safety. However, the life expectation is not apt to be greatly in excess of 1000 hours which means tube replacement approximately every six weeks, if continuous operation exists.

19. The Rectigon tubes represent a makeshift application of a tube design already existing, and therefore do not represent the most efficient type of tube for this circuit, from the standpoint of filament energy consumption, voltage and current ratings, life expectation, and overall efficiency for continuous operation at light load and full load.

20. The space requirements of the Rectigon circuit and its weight are considered excessive for the amount of power output.


FILM Nº 1A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
10-31-1934
TRACE Nº 1
317
PRIMARY INPUT VOLTS.
TIME
3.46
1/60 SEC.
TRACE Nº 2
PRIMARY INPUT AMPERES
1/60 SEC.


FILM Nº 1C
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
10-31-1934
7.52
ANODE AMPERES
TRACE Nº 5
0.0022 SEC.
1/60 SEC.
REAR RECTIGON Nº J3
TIME
TRACE Nº 6
0.0022 SEC.
1/60 SEC.
ANODE AMPERES
FRONT RECTIGON Nº B4
7.14

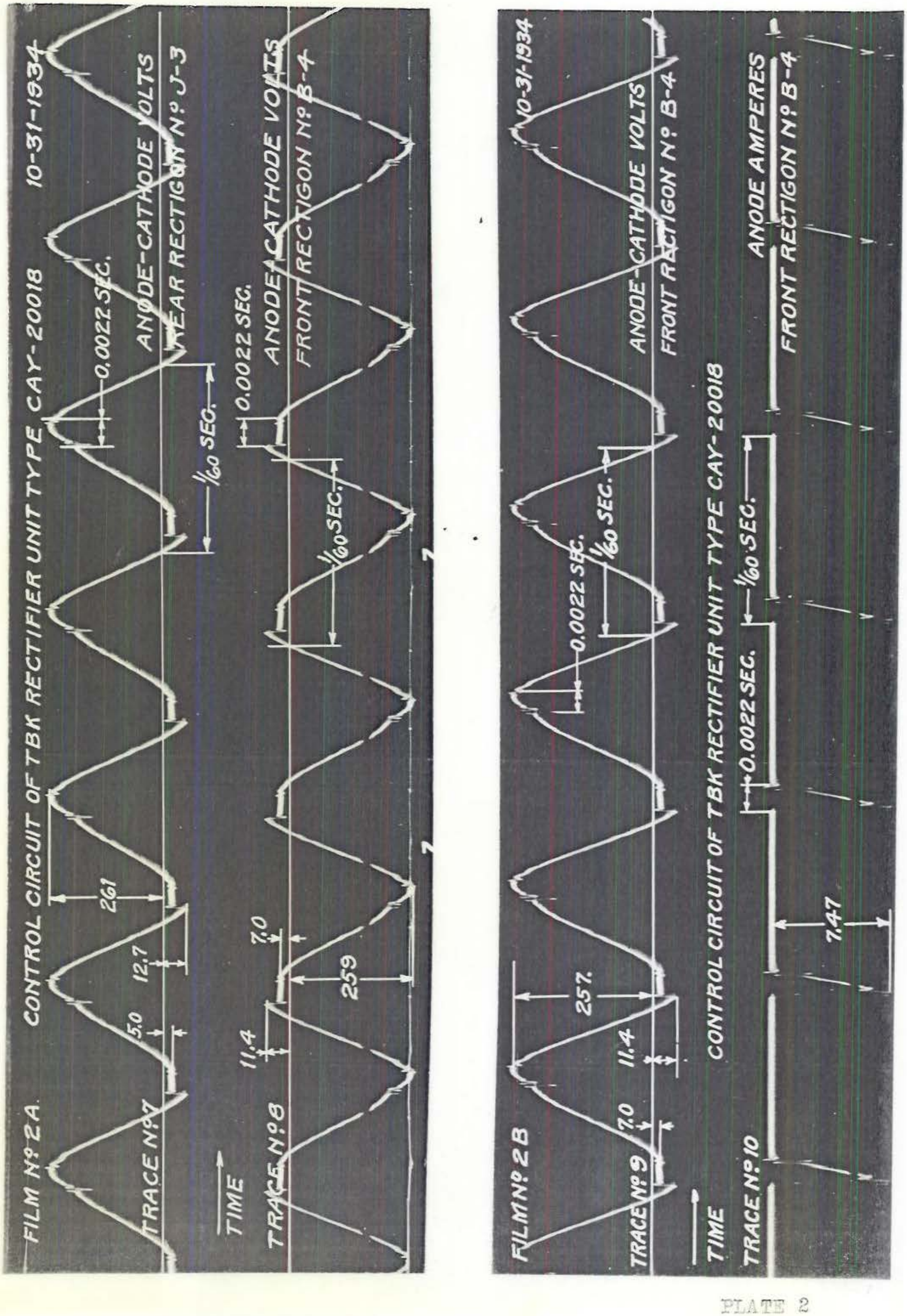

FILM Nº 2A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
10-31-1934
TRACE Nº 7
ANODE-CATHODE VOLTS
REAR RECTIGON Nº J-3
5.0
12.7
261
0.0022 SEC.
1/60 SEC.
TIME
TRACE Nº 8
ANODE-CATHODE VOLTS
FRONT RECTIGON Nº B-4
11.4
7.0
259
0.0022 SEC.
1/60 SEC.
FILM Nº 2B
10-31-1934
TRACE Nº 9
ANODE-CATHODE VOLTS
FRONT RECTIGON Nº B-4
7.0
11.4
257.
0.0022 SEC.
1/60 SEC.
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
TIME
TRACE Nº 10
ANODE AMPERES
FRONT RECTIGON Nº B-4
0.0022 SEC.
1/60 SEC.
7.47

PLATE 2

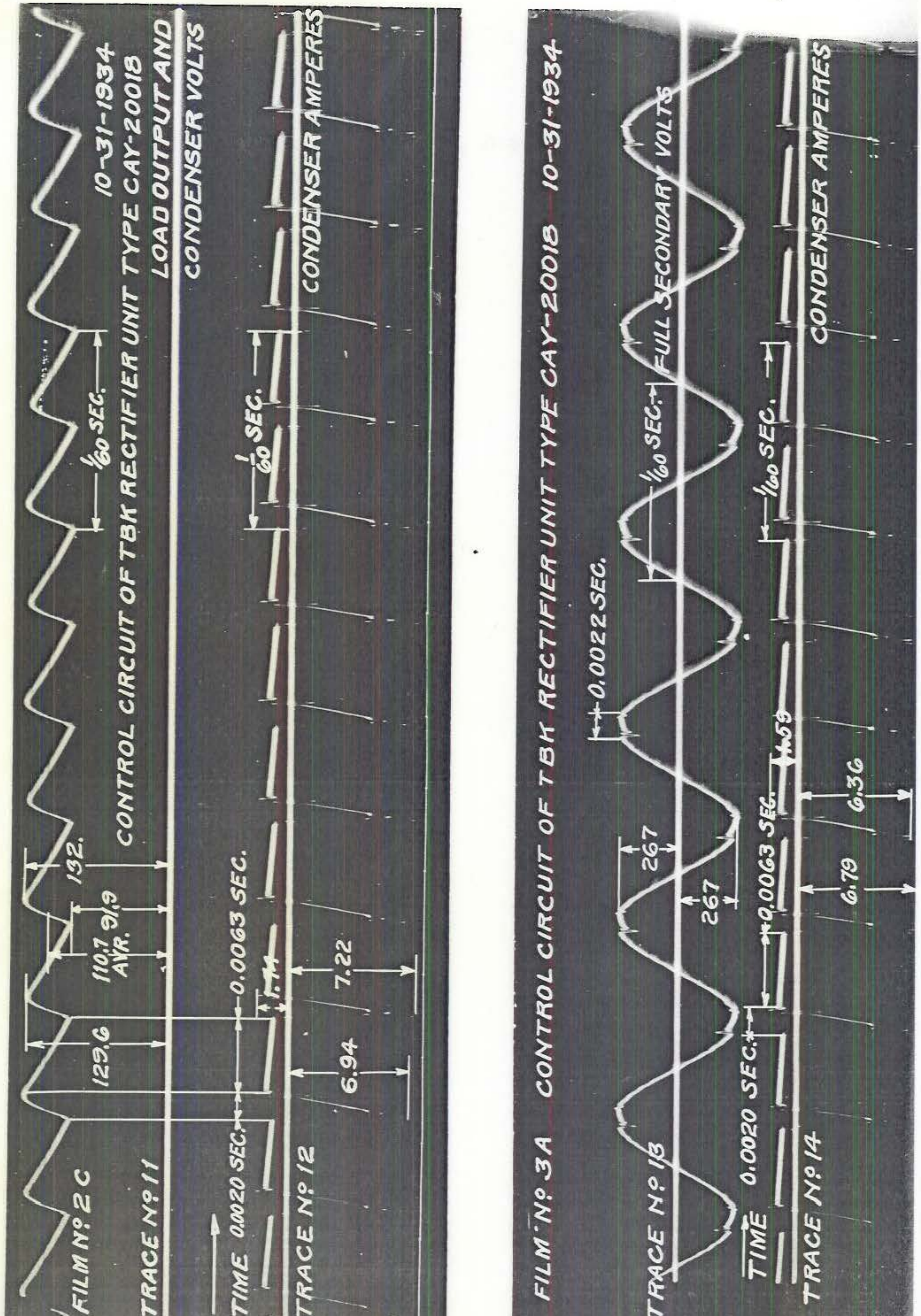
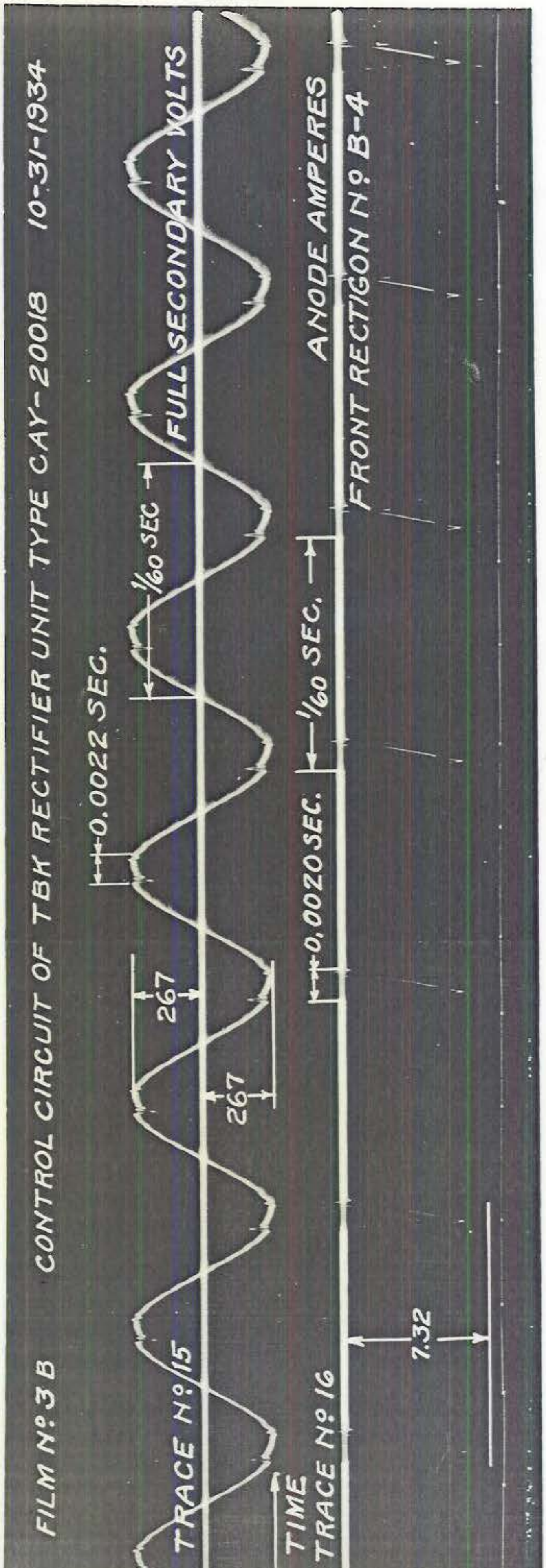

FILM No. 2 C
10-31-1934
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
TRACE No. 11
LOAD OUTPUT AND CONDENSER VOLTS
129.6
110.7
AVR.
91.9
132.
1/60 SEC.
TIME
0.0020 SEC.
0.0063 SEC.
1/60 SEC.
TRACE No. 12
CONDENSER AMPERES
6.94
7.22
FILM No. 3A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
10-31-1934
TRACE No. 13
FULL SECONDARY VOLTS
267
267
0.0022 SEC.
1/60 SEC.
TIME
0.0020 SEC.
0.0063 SEC.
1.59
1/60 SEC.
TRACE No. 14
CONDENSER AMPERES
6.79
6.36

Plate 5


FILM No 3 B
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-2001B
10-31-1934
TRACE No 15
FULL SECONDARY VOLTS
TIME
TRACE No 16
ANODE AMPERES
FRONT RECTIGON No B-4
267
267
0.0022 SEC.
1/60 SEC
0.0020 SEC.
1/60 SEC.
7.32

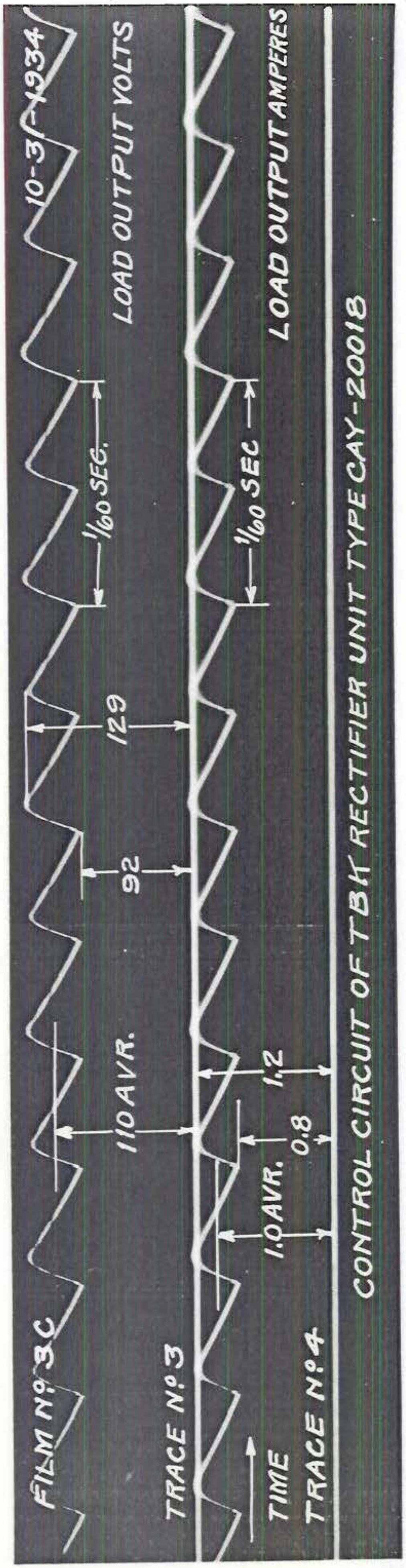
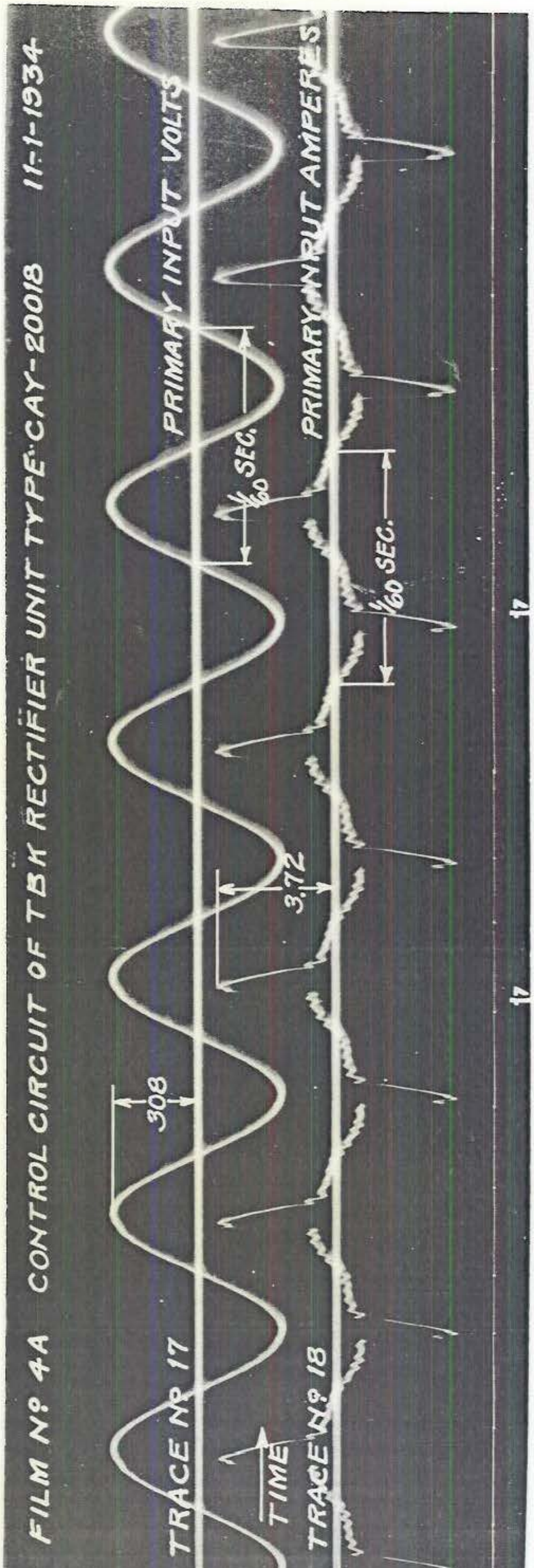

FILM No 3C
10-31-1934
TRACE No 3
LOAD OUTPUT VOLTS
TIME
TRACE No 4
LOAD OUTPUT AMPERES
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-2001B
110 AVR.
92
129
1/60 SEC.
1.0 AVR.
0.8
1.2
1/60 SEC

Plate 4


FILM No 4A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
11-1-1934
TRACE No 17
PRIMARY INPUT VOLTS
308
3.72
1/60 SEC.
TIME
TRACE No 18
PRIMARY INPUT AMPERES
1/60 SEC.

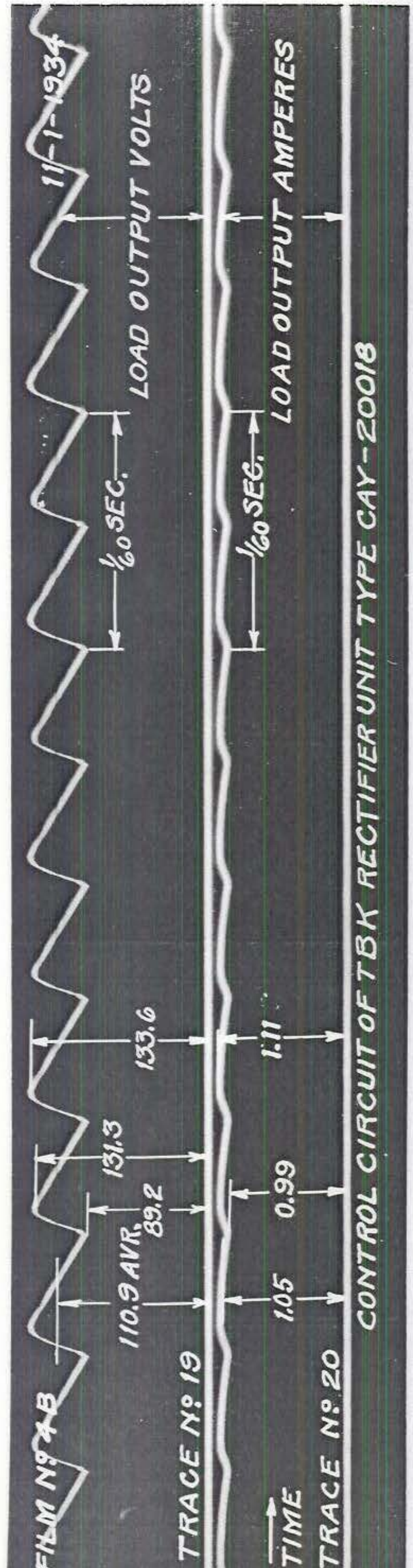
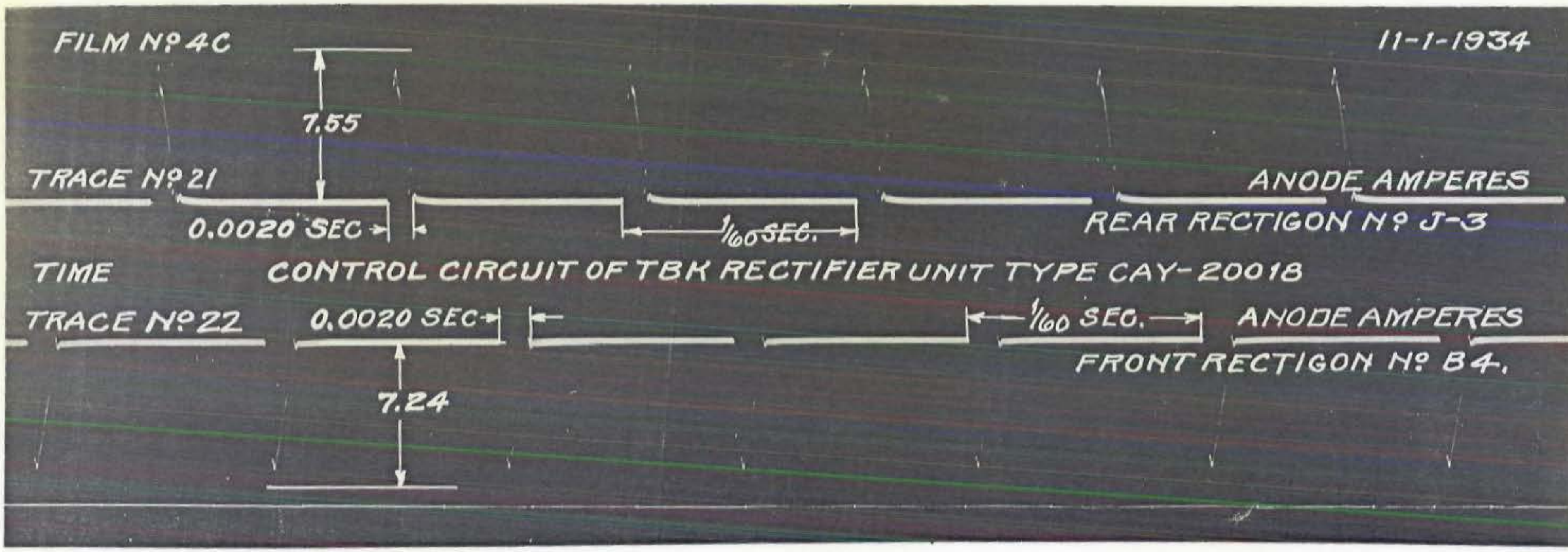
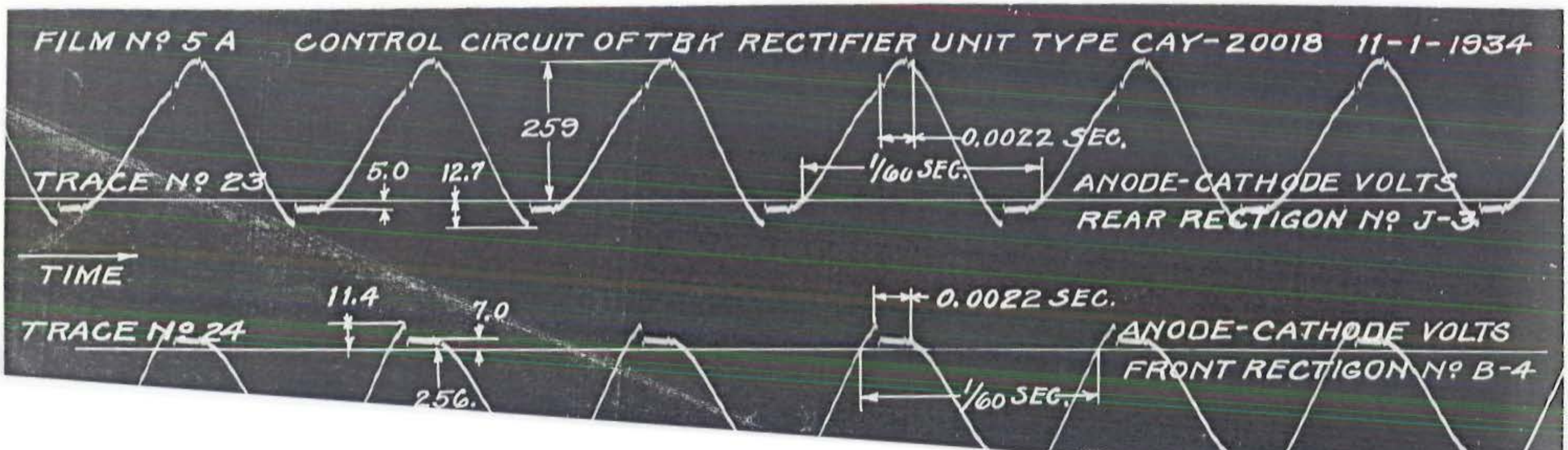
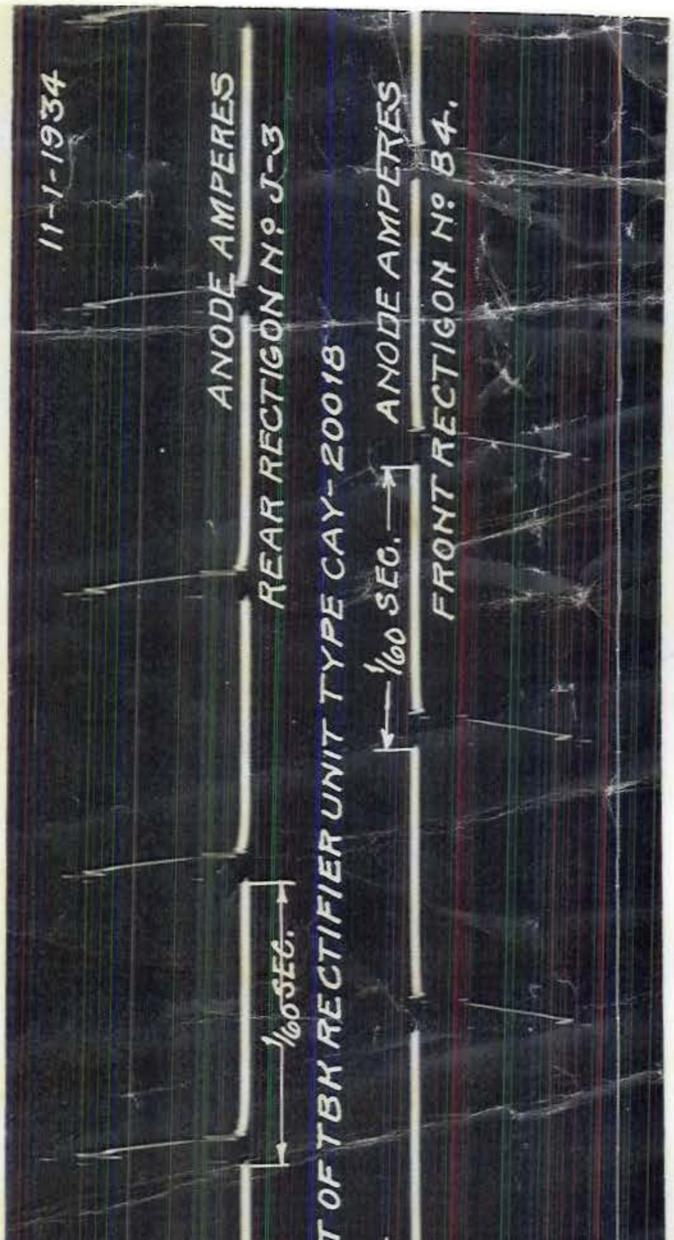

FILM No 4B
11-1-1934
LOAD OUTPUT VOLTS
110.9 AVR.
89.2
131.3
133.6
1/60 SEC.
TRACE No 19
1.05
0.99
1.11
1/60 SEC.
LOAD OUTPUT AMPERES
TIME
TRACE No. 20
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018

Plate 5


FILM Nº 4C
11-1-1934
7.55
TRACE Nº 21
ANODE AMPERES
0.0020 SEC
1/60 SEC.
REAR RECTIGON Nº J-3
TIME
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
TRACE Nº 22
0.0020 SEC
1/60 SEC.
ANODE AMPERES
FRONT RECTIGON Nº B4.
7.24


FILM Nº 5 A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
11-1-1934
259
0.0022 SEC.
TRACE Nº 23
5.0
12.7
1/60 SEC.
ANODE-CATHODE VOLTS
REAR RECTIGON Nº J-3
TIME
11.4
7.0
0.0022 SEC.
TRACE Nº 24
ANODE-CATHODE VOLTS
FRONT RECTIGON Nº B-4
2.56.
1/60 SEC.

PLATE


FILM Nº 4C
11-1-1934
TRACE Nº 21
ANODE AMPERES
REAR RECTIGON Nº J-3
7.55
0.0020 SEC
1/60 SEC.
TIME
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
TRACE Nº 22
0.0020 SEC
1/60 SEC.
ANODE AMPERES
FRONT RECTIGON Nº B4.
7.24


FILM Nº 5 A
CONTROL CIRCUIT OF TBK RECTIFIER UNIT TYPE CAY-20018
11-1-1934
TRACE Nº 23
5.0
12.7
259
0.0022 SEC.
1/60 SEC.
ANODE-CATHODE VOLTS
REAR RECTIGON Nº J-3
TIME
TRACE Nº 24
11.4
7.0
256.
0.0022 SEC.
1/60 SEC.
ANODE-CATHODE VOLTS
FRONT RECTIGON Nº B-4

1122 PLATE 6