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

DATA FOLDER No. 45719

Title PROPOSED OUTPUT TEST FOR JAN 4B26 RECTIFIER TUBE,
CATALOG #189049 TUNGAR BULB

By

.....Div.

Information prepared for .....

Tests made by .....

Information prepared by J. S. NEISON

Countersigned by .....

Date 9/25/43

GENERAL ELECTRIC COMPANY

RECTIFIER TUBE DIVISION, WEST LYNN WORKS, GENERAL ELECTRIC COMPANY

Proposed Output Test for JAN 4B26 Rectifier Tube,

Catalog # 189049 Tungar Bulb

Report Prepared by: J. S. Nelson
Date: September 25, 1943

References:

(1) Rectifier Tube Department File #290-51, "R.M.A. Data Bureau Correspondence on Cat. # 16X897 and 189049 Tungars", 1942-1943.

(2) "Notes on Procedure Used in Testing 6 Amp. Rectigons" - W.W. Watrous per C. Beckman, Electronics Engrg. Dept., Westinghouse Lamp Works, June 28, 1943.

(3) Westinghouse prints BM-9701, 9702, 9703, air-core reactor (6-25-43).

(4) "Minutes of meeting of a Special Sub-Committee of the R.M.A. Sub-Committee on Gas Filled Rectifiers, Controlled and Uncontrolled", June 22, 1943, R.C.A. Mfg. Co., Harrison, N.J.

(5) Construction Specification No. 280037, "Tungar Bulb Testing Rectifier".

(6) Standing Instruction WL-3393, Output Test.

(7) Works Laboratory Test #1050, Transformer Division.

(8) "Operation of a Thyratron as a Rectifier", L. A. Ware, Proceedings of the I.R.E., Nov., 1942.

Purpose:

To establish the correlation of the JAN-1-4B26 air-core reactor output test with the test as per Standing Instruction WL-3393 (iron-core saturable reactor) and with pick-up and arc-drop measurements.

To establish for the JAN4B26 rectifier tube (Cat. #189049 Tungar Bulb) an output rating on the JAN-1-4B26 air-core reactor test for recommendation to the Radio Manufacturer's Association Sub-Committee.

Apparatus Tested:

Output tests: 120 Catalog #189049 Tungar Bulbs, including bench exhaust, automatic exhaust, and 25 especially selected "low readers".

Life tests: 64 Catalog 189049 Tungar Bulbs.

Summary:

The 3.5 ampere limit of WL-3393 was found to correspond with an output of 1.8 amperes on the JAN-1-4B26 air-core reactor test. Curves were made showing the relation of the two tests over the entire range of tube quality (Curve 1). The air-core test is more severe for any limit because a lower pick-up voltage is required to pass.

On the average, a tube with an output of 1.8 will have a d.c. pick-up of 14 volts and a d.c. arc drop of 10.3 volts (see Curve II for relationship of output, pick-up and arc drop over the entire range).

Limits selected for recommendation are as follows:

Minimum output 2.4 amperes (corresponding to 4.0 on the iron-core reactor test), maximum (for design purposes) 4.3 amperes, this output to be attained in 2 seconds or less, and these same limits to apply after life test of 100 hours intermittent duty.

A limit of 4.0 is a virtual guarantee that tubes of our manufacture accepted will have operating characteristics within our published limits after 1200 hours of life in the customer's service, provided they are not abused.

Procedure:

Correspondence of output tests:

The output readings for the air-core test were taken with the circuit of reference (2). The reactor is specified by references (3) and (4) and has an impedance,

$$Z = 1.827 \angle 82^\circ \text{ ohms (Reference 7)}$$

The reactor used consists of 186 turns of 0.070" X 0.155" cotton-covered copper wire. Regulation of the plate supply is 1.3%.

A.C. pick-up and arc drop measurements were made using an oscilloscope on the same circuit by the method described in reference (2).

D.C. pick-up and arc drop measurements were made substantially as in reference (2). The load resistance in the pick-up circuit was only 60 ohms instead of the 1000 in the references making it necessary for the operator to note the highest point reached by the voltmeter just prior to conduction but eliminating the "double breakdown" effect mentioned. The load return was made to one side of the non-center-tapped filament transformer.

Measurements of pick-up time are described in the discussion of the data.

Life tests:

An analysis of the life tests studied is presented in the results of this report.

Unfortunately, none of the tests was made with as high a closed-circuit voltage as that called for in JAN-1-4B26. It is not believed that this will invalidate the evidence of these tests because a breakdown of the data with respect to applied voltage indicates little effect on life, in the region of voltages considered.

Tubes are placed on life test with approximately rated filament voltage, resistance loads, and no time delay between application of filament and plate voltages. Schedules of operation are as follows:

Continuous-duty tubes:

on 122 hours per week
on 23 hours daily
off 39 operating hours, week-ends
off 1/2 hour morning and night

Intermittent-duty tubes:

on 15 minutes, off 15 minutes
on 65 hours weekly
on 12 hours daily
off 19 operating hours on week ends

Results:

Accuracy of data:

All indicating instruments were carefully calibrated laboratory portables, General Electric Types P3, DP2, and DP2X.

The accuracy of oscilloscope readings was about 5%. Calculations of output based on oscilloscope readings of dynamic pick-up and arc

drop show a close agreement with the measured value. Such a calculation for a typical tube tested is appended to this report.

Discussion of data:

It may be concluded that the air-core test shows a good correlation with other methods of measuring rectifier tube performance and when it is carefully performed the test is quite repeatable. A better correspondence with the iron-core test could be had by increasing both the applied voltage and the impedance of the air-core test to pass tubes of slightly higher starting characteristics without relaxing the arc drop requirements. It is not recommended that this be done, inasmuch as pick-up is invariably the first characteristic to exceed the limits during life test.

The data upon which the curves at the end of this report are based derive from the correspondingly numbered tables.

The relation between output test sets, Curve I, has the aspect of a double-probability curve because the lower voltage used on the air-core test caused some tubes to fail to pick up.

Curve II presents d.c. arc drop at rated current (resistance load) and d.c. pick-up as a function of output. A tube having the output shown on the abscissa will, on the average, have the pick-up and arc drop plotted as ordinates. Any given tube may achieve the same output with a higher pick-up and lower arc drop, or with a lower pick-up and higher arc drop.

In Curve III we have output scores against which are plotted simultaneous readings of a.c. dynamic pick-up and a.c. peak arc drop. Also plotted are initial a.c. pick-up for tubes of different output and, for half the tubes, d.c. arc-drop with load current adjusted to equal output score. D.C. plate voltage was 120. The inherent difference between peak arc drop (oscilloscope) and average arc drop (d.c.) is greater for tubes of low output.

Table IV lists starting time in seconds on the air core test and time to reach 3 amperes output. The switch used to initiate the test also served to start a synchronous timer (Standard Electric Co., Springfield, Mass.). When the tube fired, as evidenced by the break-down of the trace on an oscilloscope screen, a thumb switch was pressed to stop the clock. Figures in the table include reaction time, estimated at 0.1 to 0.15 seconds average. Time to reach 3.0 amperes was measured the same way with the exception that the operator stopped the clock when the pointer of an ammeter passed out from under a masked portion of the scale. Figures in this case include a partially compensated reaction time and the response lag of the ammeter.

Table V is a comparison of output readings made at two seconds and at three seconds for the iron-core test and the air-core test.

Data was taken by watching a sweep-second hand and individual readings are subject to fairly large human error in respect to time.

For the iron-core test, the average two second reading equals the average three second reading. The average two second reading on the air-core test is 99% of the corresponding three second output.

Table VI, characteristics on Life Test, lists life tests over a period of eight years. Included are overloaded and underloaded tubes, intermittent and continuous duty, so that figures for average life are not very significant. This listing served as the basis for Tables VII and VIII.

Table VII, Standard Catalog #189049 Life Test, is a breakdown of figures from Table VI with respect to type of duty. In 1200 hours operating time the average pick-up for intermittent-duty tubes increased 17% of the initial value whereas for continuous tubes the increase was only 10%. Arc drop increases were 13.6% and 0 respectively.

Table VIII is further classified into groups tested at different voltages. Among the samples tested low-voltage tubes fared better on intermittent duty and higher-voltage tubes fared better on continuous duty.

Table IX shows change in output after 100 hours on test.

For intermittent-duty tubes an average decrease in output of 5.88% is shown. This rate of decrease cannot be extrapolated linearly or used to set rejection limits because several of the tubes tested displayed a very high initial output which was found to fall off rapidly during the first few hours of life and slowly thereafter. Further, the three tubes with the lowest initial output showed an average <u>increase</u> in output of 12% after 100 hours.

Experience has shown that decrease in output during the first 100 hours can be expected, and should be tolerated, only for tubes of quite high initial output. The cycle of failure is comparatively rapid once it begins and decrease in output is definitely not a linear function of hours of duty.

For these reasons it is suggested that the test limit after 100 hours be made the same as the initial test limit.

Upper Limits:

As an upper limit is required for set-design purposes we recommend an output of 4.3 amperes which roughly corresponds to our published minimum d.c. characteristics.

TABLE I

Data for Curve I, Relation Between Test Sets

Filament Voltage, 2.20

Readings Taken at 3 Seconds

Tube No.	Output on Iron-Core Test		Output on Air-Core Test	
	Initial	After D.C. Test	Initial	After D.C. Test
1	3.2	3.18	1.5	1.25
2	3.2	3.70	0.4	1.89
3	4.6	4.8	3.1	3.32
4	4.4	4.75	3.1	3.20
5	4.2	4.5	2.85	2.98
6	3.6	3.87	2.0	2.20
7	3.2	3.63	0.7	1.80
8	2.3	3.10	0.45	1.90
9	1.7	3.4	0.0	0.0
10	3.4	3.44	0.0	0.0
11	2.3	2.7	0.3	1.90
12	3.7	4.5	0.0	0.0
13	2.0	3.8	0.3	2.0
14	3.3	4.35	0.0	0.0
15	3.3	3.7	0.0	0.0
16	2.1	3.9	0.35	2.27
17	2.7	2.9	0.0	0.0
18	2.3	2.8	0.0	0.0
19	3.4	3.9	0.0	0.0
20	2.7	4.25	0.7	2.38
21	2.4	3.8	0.3	2.27
22	2.2	4.0	0.5	2.30
23	2.2	3.85	0.4	2.17
24	2.4	2.5	0.26	1.50
25	2.3	4.33	0.4	2.40

Tubes 1 - 25 inclusive were rejected by the factory for low output. Note that readings on both tests are improved after the D.C. test at 6 amperes.

26	4.6	4.8	3.05	3.20
27	5.0	5.2	3.7	3.58
28 leaker				
29	5.2	5.6	4.05	3.99
30	5.1	5.4	3.80	3.78
31	5.2	5.38	4.00	4.00
32	5.0	5.43	3.80	3.78
33	5.1	5.4	3.70	3.63

TABLE I (Continued)

Tube No.	Output on Iron-Core Test		Output on Air-Core Test	
	Initial	After D.C. Test	Initial	After D.C. Test
34	4.7	5.2	3.74	3.70
35	5.2	5.3	3.89	3.90
36 leaker				
37	4.6	4.75	3.24	3.18
38	4.8	4.9	3.34	3.41
39	4.8	4.85	3.30	3.30
40	4.8	5.1	3.54	3.54
41	4.3	4.5	3.19	3.13
42	0.05	0.1	0.0	0.0
43	4.7	4.7	3.40	3.19
44	5.1	5.4	3.70	3.68
45	5.0	5.2	3.63	3.61
46	4.9	5.0	3.53	3.53
47	3.6	3.6	2.15	2.04
48	4.7	5.0	3.39	0.0
49	3.1	2.8	0.0	0.0
50	4.7	4.75	3.10	3.13
51	5.4	5.6	4.00	3.99
52	5.1	5.33	3.80	3.70
53	5.4	5.6	3.98	4.06
54	5.3	5.45	4.05	3.91

TABLE II

Data for Curve II

Filament Voltage, 2.20

Tube #	Output on Air-Core (Initial)	D.C. Voltmeter P. U. (Cold Readings)	A.D. at 6 amp. load
1	1.5	14.7	10.5
2	0.4	14.6	9.9
3	3.1	13.1	8.2
4	3.1	11.9	8.9
5	2.85	13.6	8.4
6	2.0	13.7	10.5
7	0.7	14.2	9.7
8	0.45	14.3	12.1
9	0.0	15.4	11.5
10	0.0	18.6	11.2
11	0.3	14.2	12.8
12	0.0	15.2	9.3
13	0.3	16.4	11.8
14	0.0	14.7	9.8
15	0.0	15.5	9.7
16	0.35	15.0	11.6
17	0.0	15.6	11.1
18	0.0	17.6	10.5
19	0.0	16.1	10.0
20	0.7	15.0	11.0
21	0.3	15.1	12.3
22	0.5	14.8	11.9
23	0.4	14.7	11.8
24	0.26	14.4	12.4
25	0.4	14.6	10.0
26	3.05	12.4	8.5
27	3.7	12.1	7.7
28	Leaker		
29	4.05	10.8	6.7
30	3.80	12.4	7.2
31	4.00	10.7	6.5
32	3.80	12.5	7.0
33	3.70	12.8	6.8
34	3.74	11.8	7.5
35	3.89	12.3	7.4
36	Leaker		
37	3.24	12.8	8.6
38	3.34	13.0	7.6
39	3.30	13.0	8.4

TABLE II (Continued)

Tube #	Output on Air-Core (Initial)	D.C. Voltmeter P. U. (Cold Readings)	D.C. Voltmeter A.D. at 6 amp. load (Cold Readings)
40	3.54	12.4	8.2
41	3.19	13.0	8.9
42	0.0		
43	3.40	13.2	8.7
44	3.70	12.4	7.9
45	3.63	12.6	7.5
46	3.53	12.6	7.8
47	2.15	13.8	9.8
48	3.39	13.6	8.3
49	0.0	16.2	11.0
50	3.10	13.6	9.2
51	4.00	12.0	7.2
52	3.80	12.0	7.8
53	3.98	10.6	7.2
54	4.05	11.4	6.7

TABLE III

Data for Curve III

Filament Voltage, 2.20

Tube #	Initial P. U. $\sqrt{2}$ Erms	Dynamic P. U. (Oscilloscope)	Peak Arc Drop (Oscilloscope)	Output Air-Core
1	22.4	15.6	11.4	2.3
2	19.7	14.8	12.6	2.24
3	18.5	13.8	8.2	3.20
4	17.5	12.4	7.8	3.41
5	20.2	13.9	9.4	2.80
6	21.8	12.4	9.2	2.70
7	19.1	15.0	13.4	2.30
8	20.1	18.4	2.1	0.45
9	23.6	18.0	16.0	1.30
10	25.2	18.4	15.0	1.45
11	19.6	17.8	19.0	0.20
12	24.5	14.4	8.0	3.00
13	22.1	15.2	12.6	2.09
14	24.7	14.4	8.8	2.88
15	26.9	17.2	9.6	2.43
16	21.3	16.8	15.4	1.95
17	23.6	20.0	16.0	1.15
18	28.2	21.0	16.0	0.95
19	28.0	16.8	10.6	2.56
20	20.3	14.4	14.4	1.48
21	21.8	17.6	20.0	0.69
22	19.1	16.0	19.8	0.80
23	20.9	15.2	17.2	1.30
24	18.5	17.4	21.6	0.35
25	20.9	14.8	8.8	2.71

TABLE III (Continued)

Tube #	I.P.U.	D.P.U.	P.A.D.	Output	D.C. Arc Drop at Current in Adjacent Column
26	20.5	13.9	8.1	3.15	8.2
27	18.8	13.1	7.1	3.55	7.8
28	-	-		-	-
29	16.3	12.3	5.3	4.0	5.8
30	19.4	13.3	5.5	3.75	6.1
31	16.8	12.9	5.5	3.90	6.0
32	23.8	14.3	5.5	3.78	6.4
33	21.2	13.5	5.9	3.62	6.0
34	18.7	13.3	5.5	3.75	6.4
35	21.4	13.1	5.7	3.80	6.9
36	-	-	-	-	-
37	21.5	13.4	7.0	3.20	7.9
38	20.7	14.8	5.8	3.60	6.2
39	20.9	13.4	6.8	3.61	8.5
40	17.7	12.6	6.8	3.75	7.7
41	19.2	13.2	9.6	2.93	8.4
42	38	-	-	-	-
43	20.0	14.0	8.0	3.46	8.8
44	18.0	14.2	6.6	3.80	6.7
45	18.3	15.4	5.8	3.65	6.6
46	20.2	14.0	6.6	3.67	6.7
47	20.8	15.2	11.2	2.51	10.2
48	21.1	15.0	7.0	3.39	6.4
49	22.0	15.2	13.8	2.08	12.0
50	19.7	14.6	8.4	3.00	7.4
51	19.0	13.2	5.8	3.90	6.2
52	18.8	13.4	5.4	3.88	6.0
53	17.1	12.2	5.4	4.18	6.0
54	14.9	13.8	6.0	3.95	5.7

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TABLE IV

Starting Time

$E_f = 2.2$ $E_p = 15.55$ $Z_L = 1.83 \angle 82^\circ$

Tube No.	Seconds to Pick Up (Oscilloscope Used As Indicator)			Time to Reach 3.0 Amp. Scale Masked to 2.5 Amp.		
	Trial One	Trial Two	Avg.	Trial One	Trial Two	Avg.
26	1.04	1.15	1.09	1.74		1.74
27	.80	.80	.80	1.41	1.41	1.41
29	.82	.87	.85	1.36	1.32	1.34
30	.98	.95	.97	1.47	1.48	1.48
31	.79	.81	.80	1.31	1.33	1.32
32	1.34	1.40	1.37	1.79	1.96	1.83
33	1.20	1.25	1.23	1.70	1.68	1.69
34	1.05	1.12	1.09	1.61	1.62	1.62
35	1.04	1.06	1.05	1.59	1.31	1.45
37	1.13	1.16	1.15	1.84	1.75	1.80
38	1.56	1.37	1.47	1.95	1.98	1.96
39	1.36	1.29	1.33	1.88	1.62	1.75
40	1.11	1.10	1.11	1.63	1.68	1.66
41	1.18	1.25	1.22	-	-	
42	15	-	-	-	-	
43	1.22	1.22	1.22	1.91	1.84	1.88
44	1.04	1.04	1.04	1.55	1.54	1.54
45	1.03	1.12	1.08	1.55	1.56	1.56
46	1.05	1.19	1.12	1.61	1.62	1.62
47	1.29	1.39	1.34	-	-	
48	1.46	1.55	1.51	2.02	2.06	2.04
49	1.73	2.15	1.94	-	- -	
50	1.06	1.23	1.15	29.85	12.01	-
51	.88	.89	.89	1.44	1.47	1.46
52	1.10	1.06	1.08	1.61	1.59	1.60
54	.81	.75	.78	1.32	1.34	1.33
		Avg.	1.15 seconds		Avg.	1.62 seconds

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TABLE V

Comparison of 2-Second and 3-Second Output Readings

	Iron-Core Test Output			Air-Core Test	
	3-Sec. (From Curve 1)	2-Sec.		2-Sec.	3-Sec.
26	4.8	4.85		3.32	3.35
27	5.2	5.20		3.65	3.73
28					
29	5.6	5.40		4.12	4.18
30	5.4	5.30		3.92	3.97
31	5.38	5.35		4.00	3.99
32	5.43	5.15		3.90	3.92
33	5.4	5.30		3.80	3.80
34	5.2	5.20		3.80	3.80
35	5.3	5.23		3.98	3.99
36					
37	4.75	4.98		3.40	3.30
38	4.9	4.95		3.40	3.46
39	4.85	4.80		3.37	3.26
40	5.1	5.10		3.72	3.72
41	4.5	4.57		3.05	2.60
42	0.1	0.05		0.00	0.00
43	4.7	4.90		3.24	3.18
44	5.4	5.35		3.80	3.92
45	5.2	5.30		3.73	3.79
46	5.0	5.00		3.60	3.70
47	3.6	3.70		2.00	2.10
48	5.0	5.00		3.35	3.64
49	2.8	2.85		0.00	0.00
50	4.75	4.85		2.78	3.10
51	5.6	5.60		3.98	4.00
52	5.33	5.40		3.90	3.98
54	5.6	5.58		4.00	4.10
Avg.	4.80	4.80	Avg. of 24	3.57	3.61

TABLE VI

Characteristics on Life Test - Catalog #189049 Tungar Bulb - JAN-1-4B26

Date Started	Intermittent or Continuous	Plate Volts	Load Amps.	Hot Characteristics - Initial D.C. Arc Drop	Initial D.C. Pick-Up (Voltmeter)	After 1200 Hours A.D.	After 1200 Hours P.U.	Failure Due to High P.U. # Hours	Failure to Rectify or Removed From Test Hrs.	Comments
9-29-35	I	60	6	6.6	10.8	6.8	11.8		3478	Date of Last Test
"	C	60	6	6.8	10.8	6.2	10.1		6956	" " " "
"	C	120	6	6.9	11.2	6.1	11.1		6956	" " " "
10-21-35	I	60	6	6.4	10.6	7.0	11.4		3278	" " " "
"	I	120	6	6.8	11.2	6.1	10.8		3278	" " " "
3-16-36	I	120	6	6.5	10.3	7.8	11.2		1764	" " " "
"	I	120	6	6.5	10.9	8.4	12.4		1764	" " " "
"	C	60	6	6.2	10.1	6.8	10.0		1764	" " " "
"	I	120	6	6.4	10.2	7.0	11.6		1764	" " " "
2-7-38	C	60	0.25	7.3	10.6	7.0	11.9		-	
"	C	60	0.25	7.6	11.0	7.4	11.5			
"	C	60	0.25	9.1	13.3	10.3	14.8	1920	1920	High pick-up
"	C	60	0.25	6.9	11.4	8.8	12.6	2616	2616	" "
"	C	60	0.25	7.0	11.1	9.1	13.0			
"	C	60	0.25	7.5	11.0	7.1	11.8			
"	C	60	6	7.0	11.0	8.5	13.7	2616	2616	High pick-up
"	C	60	6	7.0	11.0	8.3	12.4			
"	C	60	6	6.7	11.0	8.0	12.3			
1-23-40	C	120	5.6	7.3	11.0	7.0	13.0	1704	1704	Removed O.K.
"	C	120	6.4	7.3	11.0	6.6	11.7	2500	5064	Broken
"	I	120	9	7.0	10.5	6.5	10.6	1872	1872	Leak
"	I	60	5.7	7.0	10.5	8.3	12.5	2300	3432	Filament etched; high P.U. & A.D.
2-26-40	C	120	6	6.5	11.0	6.8	11.8	1990	1990	Leak
"	I	60	6	7.6	10.6	7.9	10.5	3400	3400	Fil. etched & open
12-2-40	*C	120	9	7.8	11.0	7.0	11.0	5600	11493	Removed

\# Usual failure due to high cold pick-up.
* Tubes started 12-2-40 had special butt-welded anode leads.

TABLE VI (Continued)

Date Started	Intermittent or Continuous	Plate Volts	Load Amps.	Hot Characteristics: Initial D.C. Arc Drop	Initial D.C. Pick-Up (Voltmeter)	After 1200 Hours A.D.	After 1200 Hours P.U.	Failure Due to High P.U. # Hours	Failure to Rectify or Removed From Test Hrs.	Comments
12-2-40	*I	120	6	8.2	12.0	8.5	14.5	1500	3786	Filament open
"	*I	120	6	8.0	11.7	10.3	18.6	500	3462	" "
"	*I	120	6	7.7	11.3	9.9	15.5	612	2720	" "
"	*I	120	9	7.7	10.4	9.0	17.0	612	2892	Cracked Cathode Stem
1-8-41	I	120	6	6.6	10.7	7.0	13.9	2616	2616	Cracked Stems
"	C	120	6	6.8	12.0	6.5	13.6	4536	9362	Open filament
5-1-41	I	120	6	6.0	11.5	7.8	17.0	500	1812	Loose base
"	I	60	6	5.8	11.4	7.5	13.0	1644	4206	Open filament
"	I	120	9	6.2	11.1	8.9	13.5	1500	2412	" "
"	I	60	9	7.3	12.0	8.8	14.0	1284	2528	" "
"	I	78	6	6.5	11.7	8.5	14.5	1200	3466	" "
"	I	78	9	6.3	11.6	8.7	13.0	3099	3099	" "
"	I	83	6	6.7	11.9	8.0	13.3	1500	3082	Cracked Cathode Stem
"	I	83	5.8	7.5	11.9	8.2	14.3	1000	2420	" " "
9-24-41	I	82	9	6.7	11.7	8.5	15.0	1988	1988	Open filament
1-20-42	I	65	6.0	11.0	7.0	9.5	12.0	2900	4529	" "
8-12-42	C	63	6.0	7.5	11.0	5.8	12.5	3711	3711	Loose base
5-20-42	I	117	5.8	7.1	11.1	8.0	12.3	2220	2220	Cracked Cathode Stem
3-11-42	I	118	6	6.6	11.6	7.1	11.7	1800	2903	" " "
3-19-42	I	120	6	6.4	10.8	10.3	14.6	1600	3132	Filament etched & open
2-13-42	I	64	6	6.8	11.3	7.5	14.4	1600	4207	" " "
1-12-42	+C	123	5.7	6.6	11.7	7.6	12.0		3400	Todate
1-12-42	+C	119	6.0	6.4	11.0	6.8	13.1		3400	"
1-12-42	+C	124	6.4	7.5	11.8	7.8	13.8	1900	3400	"
	Average of 32							2040 hrs.	[illegible] hrs	
	Average of 31								3090 hrs.	
	Average of 49			7.07	11.09	7.82	12.92			
	Avg. increment					0.75	1.83			
	Avg. % increment					10.6	16.5			

+ Brass-dipped steel bases (currently on test)
# Usual failure due to high cold pick-up.
* Tubes started 12-2-40 had special butt-welded anode leads.

Standard Catalog 189049, Life Test

Breakdown with Respect to Type of Duty

Intermittent Duty					Continuous Duty				
Initial		1200 Hrs.		Hrs. to	Initial		1200 Hrs.		Hrs. to
A.D.	P.U.	A.D.	P.U.	>16 P.U.	A.D.	P.U.	A.D.	P.U.	High P.U.
6.6	10.8	6.8	11.8		6.8	10.8	6.2	10.1	
6.4	10.6	7.0	11.4		6.9	11.2	6.1	11.1	
6.8	11.2	6.1	10.8		7.0	11.0	8.5	13.7	2616
6.5	10.3	7.8	11.2		7.0	11.0	8.3	12.4	
6.5	10.9	8.4	12.4		6.7	11.0	8.0	12.3	
6.2	10.1	6.8	10.0		7.3	11.0	7.0	13.0	1704
6.4	10.2	7.0	11.6		7.3	11.0	6.6	11.7	2500
7.0	10.5	8.3	12.5	2300	6.5	11.0	6.8	11.8	1990
7.6	10.6	7.9	10.5	3400	6.8	12.0	6.5	13.6	4536
6.6	10.7	7.0	13.9	2616	7.5	11.0	5.8	12.5	3711
6.0	11.5	7.8	17.0	500					
5.8	11.4	7.5	13.0	1644	Avg. 6.98	11.1	6.98	12.2	2840
6.5	11.7	8.5	14.5	3466	Increment		0	1.1	
6.7	11.9	8.0	13.3	1500	% Increment		0	10%	
7.5	11.9	8.2	14.3	1000					
11.0	7.0	9.5	12.0	2900					
7.1	11.1	8.0	12.3	2220					
6.4	10.8	10.3	14.6	1600					
6.8	11.3	7.5	14.4	1600					
6.6	11.6	7.1	11.7	1800					
Avg. 6.85	10.81	7.78	12.65	2039					
Increment		0.93	1.84						
% Increment		13.6	17%						

Load current = approximately 6 amperes

TABLE VIII

Standard Catalog 189049, Life Test
6 Ampere Load

Breakdown with Respect to Nominal Open Circuit Voltage and Type of Duty

Intermittent Duty

15 Min. on - 15 Min. off

60 Volts a.c. r.m.s.				120 Volts a.c. r.m.s.			
Initial		After 1200 hrs.		Initial		After 1200 hrs.	
A.D.	P.U.	A.D.	P.U.	A.D.	P.U.	A.D.	P.U.
6.6	10.8	6.8	11.8	6.8	11.2	6.1	10.8
6.4	10.6	7.0	11.4	6.5	10.3	7.8	11.2
7.0	10.5	8.3	12.5	6.5	10.9	8.4	12.4
5.8	11.4	7.3	13.0	6.4	10.2	7.0	11.6
7.0	11.0	9.5	12.0	6.6	10.7	7.0	13.9
6.8	11.3	7.5	14.4	6.0	11.5	7.8	17.0
				6.5	11.7	8.5	14.5
Avg.				6.7	11.9	8.0	13.3
6.6	10.9	7.8	12.5	7.5	11.9	8.2	14.3
Increment		18.2%	14%	7.1	11.1	8.0	12.3
				6.6	11.6	7.1	11.7
				6.4	10.8	10.3	14.6
				Avg. 6.6	11.1	7.85	13.1
				Increment		19.0%	18%

Continuous Duty

Off 1/2 hr. morning and night; Off Saturday night to Monday morning

6.8	10.8	6.2	10.1	6.9	11.2	6.1	11.1
7.0	11.0	8.5	13.7	7.3	11.0	7.0	13.0
7.0	11.0	8.3	12.4	7.3	11.0	6.6	11.7
6.7	11.0	8.0	12.3	6.5	11.0	6.8	11.8
7.5	11.0	5.8	12.5	6.8	12.0	6.5	13.6
				6.6	11.7	7.6	12.0
Avg.				6.4	11.0	6.8	13.1
7.0	10.9	7.35	12.2	7.5	11.8	7.8	13.8
Avg. Increment		5%	11.9%				
				Avg. 6.91	11.35	6.90	12.5
				Avg. Increment		-.14%	10.1%

TABLE IX

Change of Output after 100 Hours

Catalog 189049 Tungar Bulb with Steel Base

Iron-Core Output Test

	Output at Start of Test		Output after 100 Hours	
	Intermittent	Continuous	Intermittent	Continuous
	5.7	5.2	5.2	4.9
	4.9	5.3	4.1	5.2
	5.6	5.2	4.4	4.7
	5.4	5.2	5.1	5.2
	4.9		4.9	
	5.2		5.2	
	4.8		3.6	
	4.4		4.9	
	4.4		5.2	
	4.5		4.8	
	4.6		3.8	
Average	4.94	5.23	4.65	5.0
			5.88% less*	44% less

During first 100 hours decrease in output for continuous-duty tubes was 79.4% of the decrease for intermittent-duty tubes.

*Note increase in output for tubes of comparatively low (but O.K.) initial output.

4108320

I.

COMPARISON OF OUTPUT TESTS

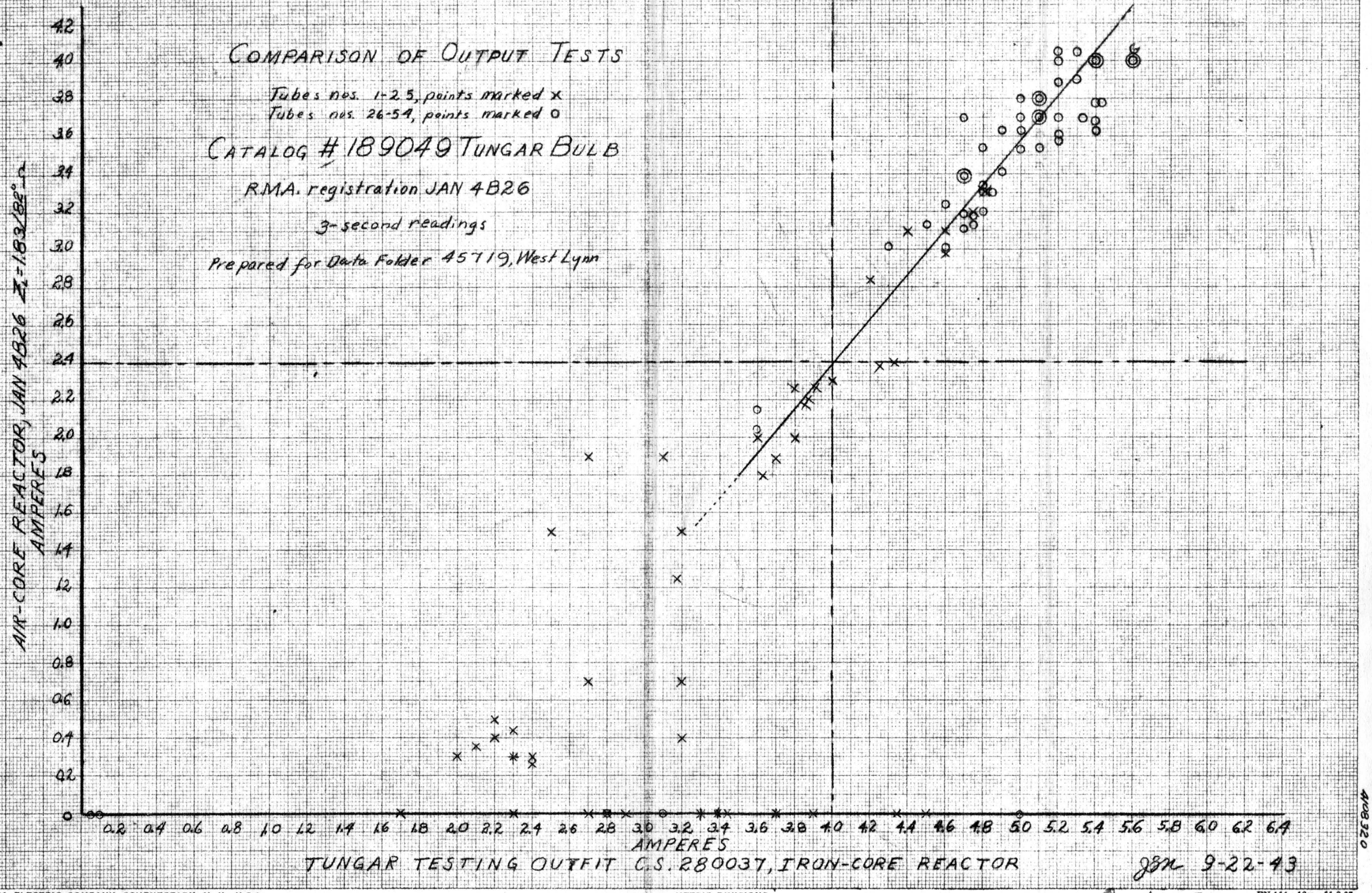
Tubes nos. 1-25, points marked ×
Tubes nos. 26-54, points marked ○

CATALOG # 189049 TUNGAR BULB

R.M.A. registration JAN 4826

3-second readings

Prepared for Data Folder 45719, West Lynn



TUNGAR TESTING OUTFIT C.S. 280037, IRON-CORE REACTOR

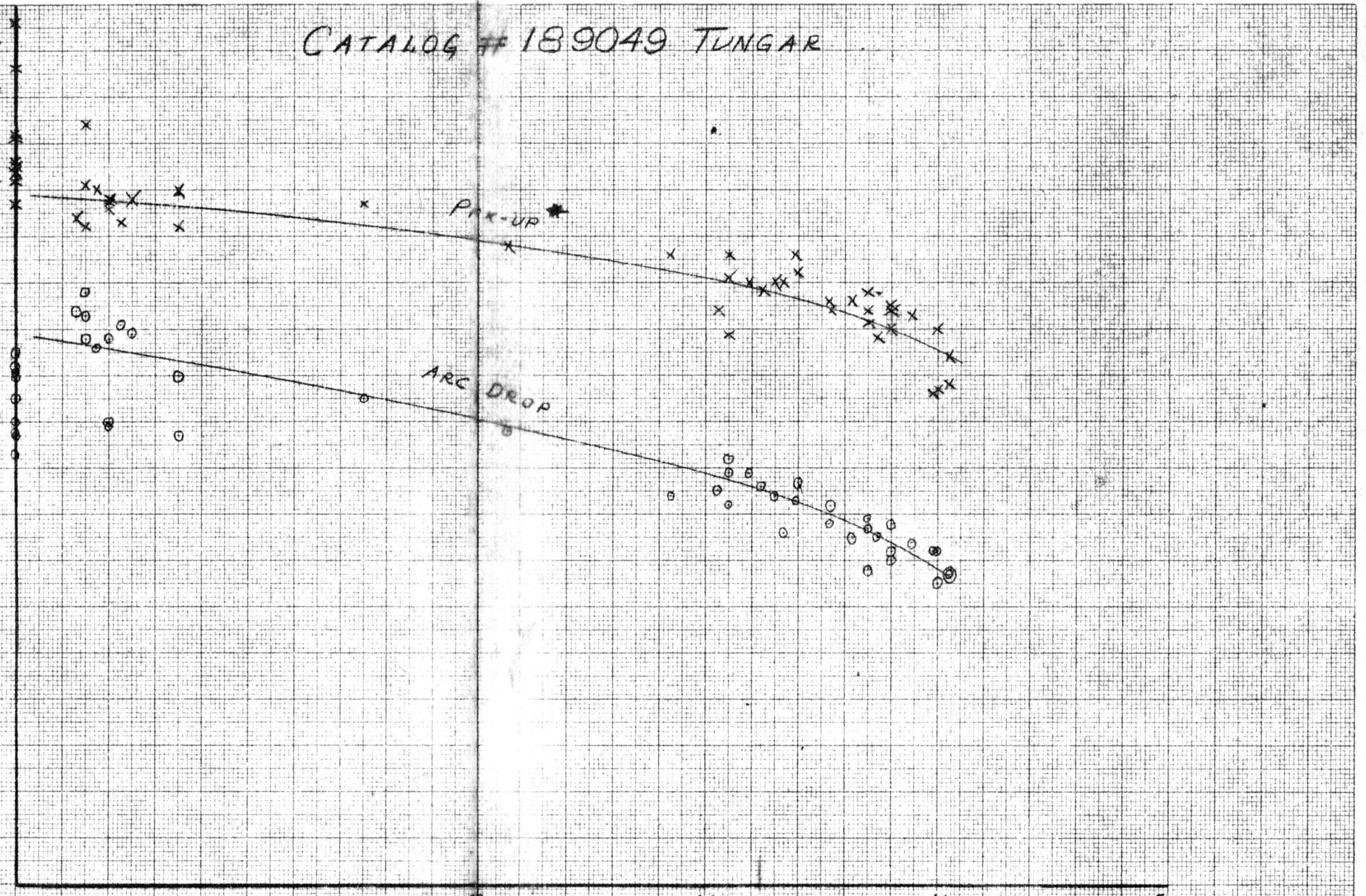
JBn 9-22-43

4108320

C-4108320

II. For data folder 45719

CATALOG # 189049 TUNGAR



* For true pick-up, add IE_f = 3.11 volts

AMPERES OUTPUT JAN 4B26 TEST

Z_L = 1.83 /82° (Air core); Applied voltage 15.55 a.c., r.m.s.; Reg. 1.29%

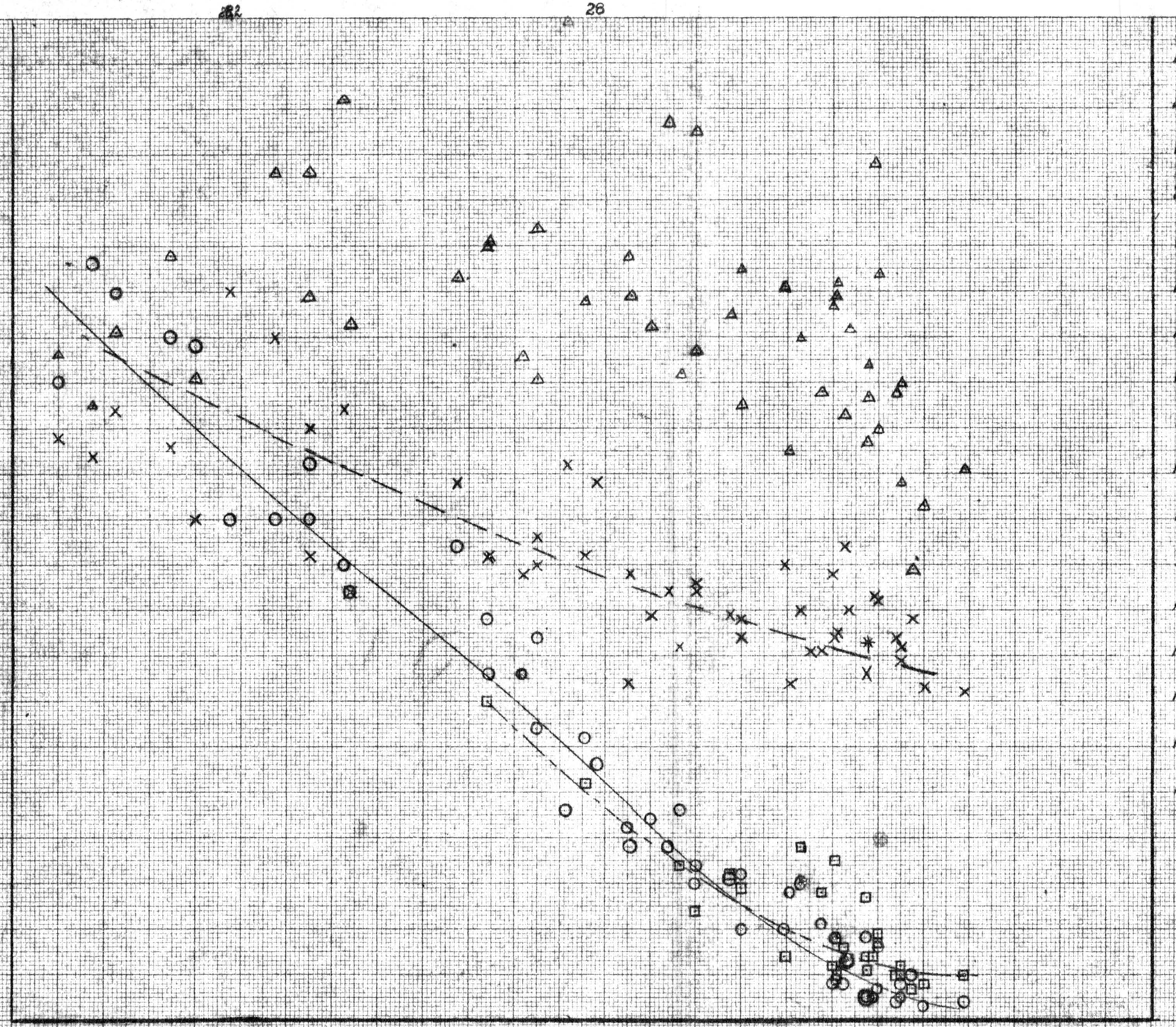
3 second readings E_f = 2.2 a.c., r.m.s.

August 13, 1943

C-4108321

4108321

III
For Data Folder 4519
Data from Table III.



26 Catalog 189049,
25 R.M.A. registration
24 JAN 4B26.
23 Various characteristics
22 versus output on
21 air-core reactor test.
20 △ Initial A.C. pick-up, 12 E rms
19 ✱—✱ Dynamic Pick-up
18 ◎ (oscilloscope)
17 ○—○ A.C. peak arc drop
16 (oscilloscope)
15 □-□ D.C. arc drop with
14 resistance load adjusted
13 for load current equal to
12 output under JAN 4B26
11 test conditions.
10
9
8
7
6
5

J. Nelson
August 16, 1943

C-4108322