THE CALIBRATION OF ELECTRICAL INSTRUMENTS

by

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INTRODUCTION

Meters are probably the most important of all laboratory equipment. It is directly upon the meters that the investigator must depend for correct results in all his laboratory research and experiments. The percent of accuracy of the meters determines the percent of accuracy of experiments, assuming all other conditions to be equal. Since meters are of such importance to the laboratory investigator, it is of utmost importance that the meters are kept reading as accurately as possible. Since readjustment of meters is a costly and difficult task, it is often more convenient to make a calibration of the meters at intervals, recording the deviations of the meters from the actual reading.

There a number of causes for electrical instruments reading incorrectly. The three chief causes may be listed as follows: (1) Overlaoding, (2) Rough handling, (3) Incorrect usage.

I. Overloading

When an instrument is overloaded, one of the following things may happen to it.

1. It amy break down insulation of the coils in one or two places causing a short circuit and corresponding change in impedance which would tend to cause an incorrect reading.

2. The extra torque may cause a permanent deformation of the coil spring or pointer.

3. The added current may overheat the instrument, causing the coil spring to warp, or varnish from the case to run into the spring or bearings.

11. Rough Handling

Harm to the meter caused by rough handling is practically all mechanical. It may warp the instrument or break some of the moving parts, in which case, the meter will not read at all. Injuries caused by rough handling are readily detected.

III. Incorrect Usage

This applies particularly to experiments, where extreme accuracy is required and corrections must be made for losses. For example, if a wattmeter is designed for use on voltage of 150 to 300 volts, it is not good practice to operate it on 75 volts or lower and use the same correction factors as for 150 volts or above. Instruments should be selected so that the quantities to be read will fall near the center scale, because all alternating current meters have an extended scale in the center which make possible a more correct reading.

METHOD OF CALIBRATION

I. Voltmeter

In calibrating the voltmeter against a standard General Electric voltmeter, the 220 volt line was used from the supply through two induction generators (see connection diagram, Fig.I) which gave a variation in voltage of 0 to 600 volts, the range of all of the laboratory voltmeters. Readings were taken by setting the pointer of the meter to be tested exactly on the scale numbers and reading the standard meter scale to get the variation. The standard meter was calibrated with a Vernier scale which made it possible to read the meters in hendredths of a volt.

II. Ammeter

The ammeters were calibrated using a connection as shown by the diagram in Fig. 2. The current was brought in through two induction regulators connected in parallel so that the current would not exceed their coil capacities. The test and standard ammmeters were connected as shown in Fig. 2 and two variable rheostats supplied the load. Current variations were made possible by this setup of 0 to 50 amperes.

III. Wattmeters

The calibration of wattmeters requires in the circuit, in addition to the test and standard wattmeters, an ammeter and a voltmeter in order that the coils of the wattmeters will not be overloaded. Three variable resistances supplied the load (see Fig. 3), and a tapped variable resistance was placed in the circuit of the standard wattmeter voltage coil in order not to overload it. A variation of power was obtained by the circuit of Fig. 3 of 15 to 3000 watts. Care was taken that the voltage was always

within the range of the voltage coils. In making readings, the voltage was maintained constant within two volts. The current variations were made with the rheostats. Very small variations in current were made by varying, within small limits, the voltage.

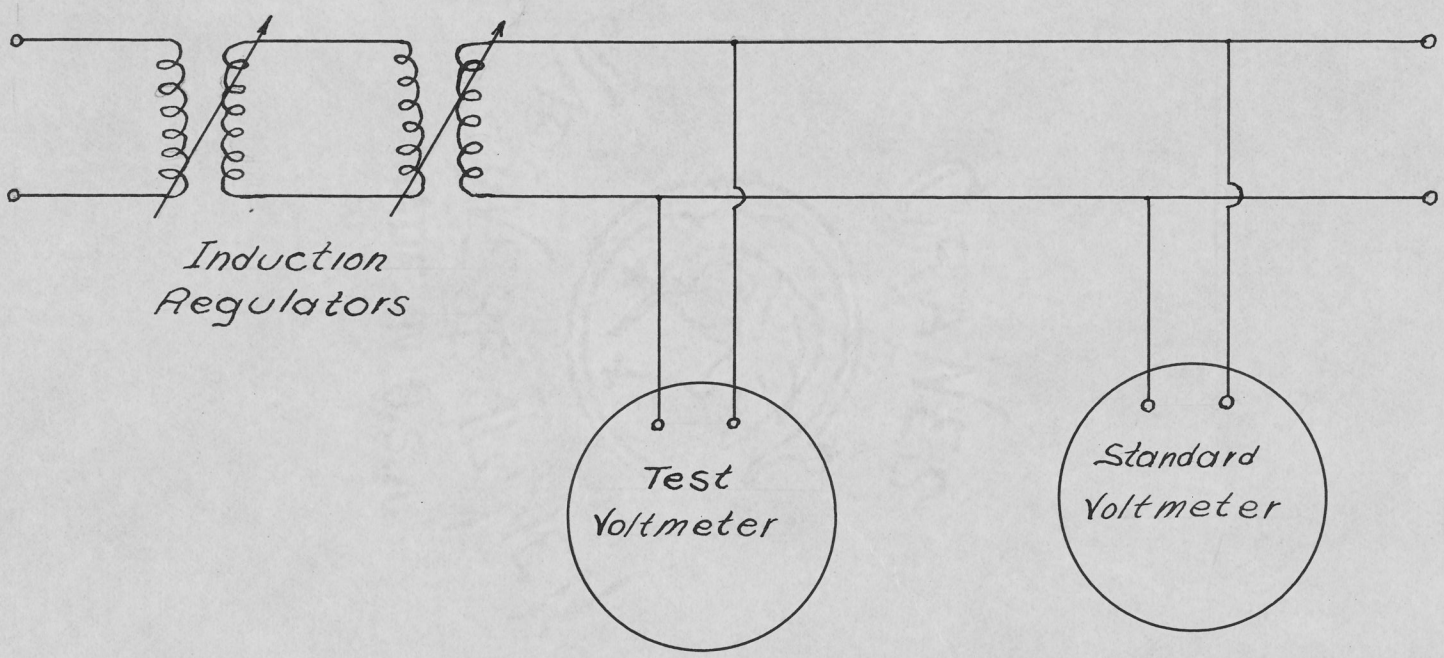


Fig 1
Circuit Diagram Of Calibration Test For
Voltmeters

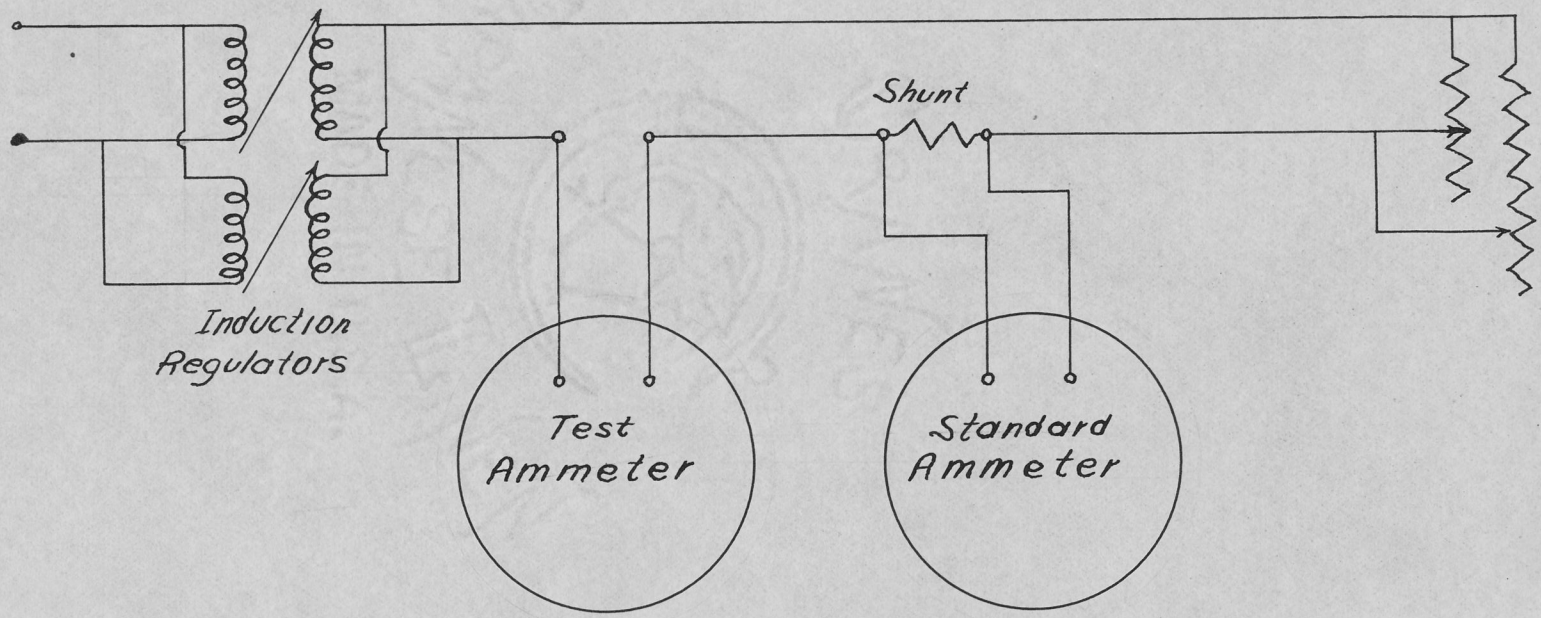


Fig 2
Circuit Diagram Of Calibration Test For Ammeters

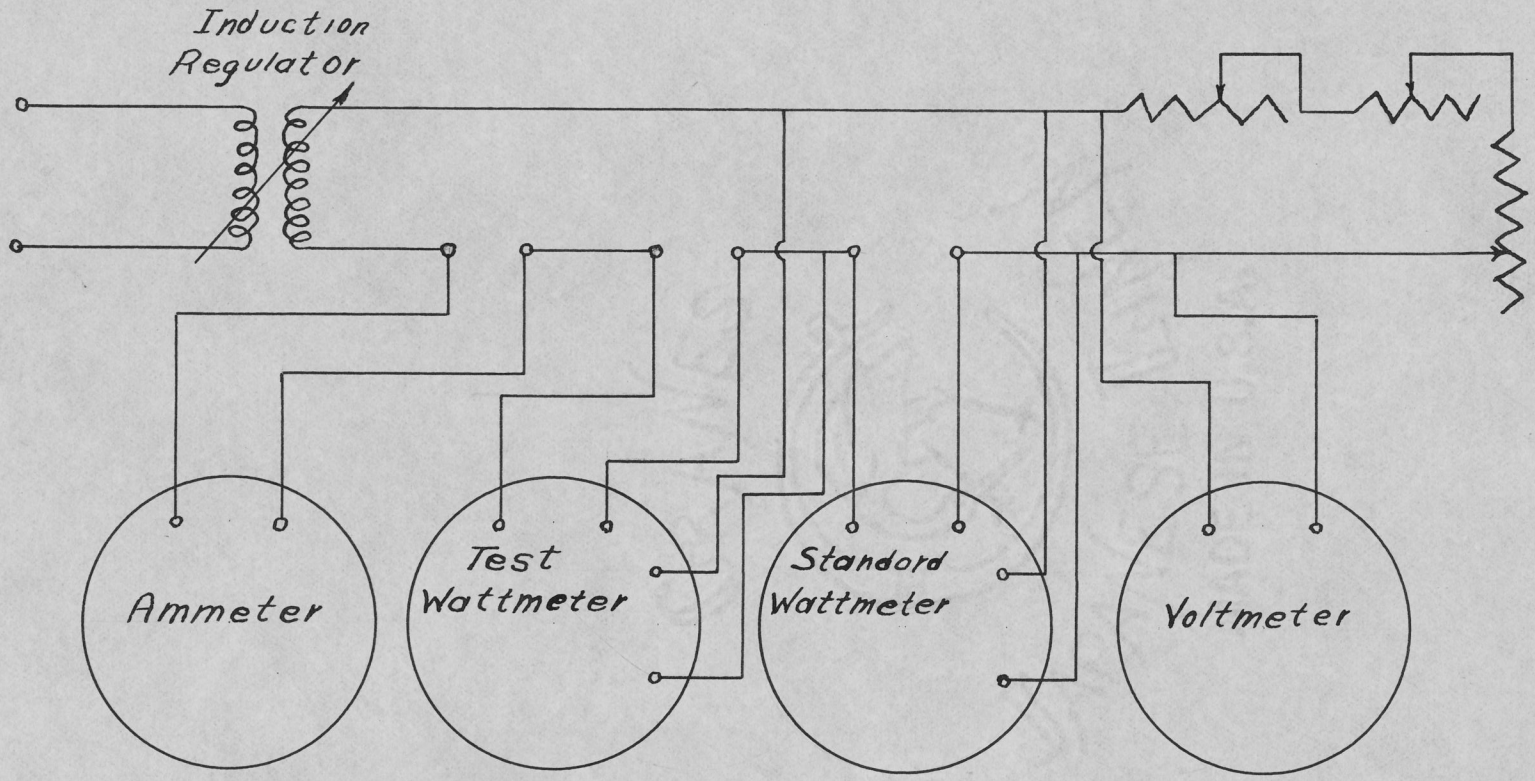


Fig 3
Circuit Diagram Of Calibration Test For Wattmeters

METER Voltmeter SCALE 150

TYPE 155 MAKE Weston

SERIAL NO. 37181 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
30	31.30
40	40.35
50	50.65
60	60.70
70	71.00
80	81.00
90	90.70
100	100.50
110	111.20
120	121.60
130	131.40
140	142.00
150	152.20

METER Voltmeter

TYPE Z155

SERIAL NO. 6202

SCALE 150

MAKE Weston

DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
30	30.00
40	40.25
50	50.15
60	60.00
70	69.90
80	79.70
90	89.70
100	99.60
110	109.70
120	119.60
130	129.20
140	139.00
150	148.60

METER Voltmeter SCALE 300

TYPE 155 MAKE Weston

SERIAL NO. 37207 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
60	62,00
80	80.20
100	100.00
120	119.70
140	139.50
160	160.40
180	179.20
200	201.00
220	221.20
240	241.40
260	261. 00
280	282.00
300	302.00

METER Volt meter SCALE 150-300

TYPE P-3 MAKE G-E

SERIAL NO. 510644 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
40	40.05
50	50.05
60	59.75
70	69.90
80	80.00
90	89.70
100	100.00
110	110.00
120	120.00
130	130.00
140	139.80
150	150.30
40	41.20
60	59.74
80	80.00
100	100.00
120	120.00
140	139.70
160	160.20
180	180.00
200	200.00
220	220.00
240	239.70
260	260.00
280	280.00
300	300.00

METER Voltmeter

TYPE 182963 "D"

SERIAL NO. 520476

SCALE 75

MAKE Westinghouse

DATE OF TEST 5/9/34

RECORD OF TEST

Test	Standard
20	21.50
25	25.10
30	30.90
35	35.80
40	40.70
45	45.50
50	50.50
55	55.50
60	60.60
65	65.50
70	70.20
75	75.50

METER Voltmeter SCALE 150

TYPE P-3 MAKE G-E

SERIAL NO. 981927 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
30	29.50
40	40.80
50	50.10
60	60.35
70	70.00
80	80.10
90	90.20
100	100.00
110	110.10
120	120.00
130	130.00
140	139.70
150	149.80

MAKE Voltmeter SCALE 75-150

TYPE P-3 MAKE G-E

SERIAL NO. 983302 DATE OF TEST 5/9/34

RECORD OF TEST

Test	Standard
20	20.30
25	25.00
30	29.70
35	35.00
40	40.00
45	45.05
50	50.10
55	55.35
60	60.60
65	66.00
70	71.20
75	76.60
30	29.80
40	39.69
50	49.50
60	59.30
70	69.60
80	79.60
90	90.00
100	100.00
110	110.60
120	121.10
130	131.60
140	142.50
150	153.20

METER Voltmeter SCALE 75-150

TYPE P-3 MAKE G-E

SERIAL NO. 985135 DATE OF TEST 5/9/34

RECORD OF TEST

Test	Standard
20	20.00
25	25.00
30	30.00
35	35.00
40	40.00
45	45.00
50	50.00
55	55.10
60	60.10
65	65.00
70	70.00
75	74.80
30	29.50
40	40.00
50	50.02
60	59.90
70	69.90
80	79.90
90	90.00
100	99.80
110	110.00
120	119.80
130	130.00
140	140.10
150	149.70

MAKE Voltmeter SCALE 75-150

TYPE P-3 MAKE G-E

SERIAL NO. 985206 DATE OF TEST 5/9/34

RECORD OF TEST

Test	Standard
10	9.750
20	20.000
30	30.100
35	35.050
40	40.050
45	45.100
50	50.000
55	55.000
60	60.000
65	65.100
70	70.000
75	75.000
20	19.44
30	30.10
40	40.10
50	50.00
60	60.00
70	70.10
80	80.20
90	90.00
100	100.00
110	110.00
120	120.00
130	130.20
140	140.00
150	150.00

METER Voltmeter SCALE 150-300

TYPE P-3 MAKE G-E

SERIAL NO. 987144 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
30	30.50
40	40.40
50	50.00
60	60.00
70	69.50
80	79.00
90	89.70
100	99.40
110	109.20
120	119.20
130	129.30
140	140.20
150	149.80
60	60.80
80	80.30
100	97.00
120	117.50
140	140.00
160	158.00
180	179.20
200	200.00
220	219.80
240	240.00
260	260.00
280	280.00
300	300.00

METER Voltmeter SCALE 150-300

TYPE P-3 MAKE G-E

SERIAL NO. 987473 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
60	61.80
80	81.40
100	101.30
120	120.60
140	140.00
160	160.00
180	180.00
200	200.00
220	220.00
240	240.00
260	260.20
280	280.40
300	300.00
120	122.00
160	162.00
200	202.20
240	241.00
280	280.20
320	320.00
360	358.80
400	399.60
440	440.00
480	480.00
520	520.80

METER Voltmeter SCALE 300-600

TYPE P-3 MAKE G-E

SERIAL NO. 987497 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
60	59.80
80	79.60
100	100.10
120	120.30
140	140.00
160	159.60
180	180.00
200	200.00
220	220.00
240	240.00
260	260.00
280	280.00
300	300.00
120	118.00
160	157.60
200	199.40
240	240.20
280	279.60
320	318.40
360	359.20
400	400.00
440	440.00
480	480.00
520	519.20

METER Voltmeter SCALE 75

TYPE P-3 MAKE G-E

SERIAL NO. 988720 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
20	20.10
25	25.20
30	30.20
35	35.10
40	40.05
45	45.00
50	50.00
55	55.20
60	60.40
65	65.10
70	70.00
75	74.80

METER Voltmeter SCALE 75

TYPE P-3 MAKE G-E

SERIAL NO. 992701 DATE OF TEST 5/9/34

Record OF TEST

Test	Standard
20	20.00
25	25.00
30	29.90
35	34.85
40	39.85
45	44.80
50	50.00
55	55.00
60	59.85
65	65.00
70	69.80
75	75.00

METER Ammeter SCALE 5

TYPE 155 MAKE Weston

SERIAL NO. 17396 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
1.0	0.960
1.5	1.450
2.0	1.960
2.5	2.495
3.0	2.980
3.5	3.485
4.0	3.984
4.5	4.500
5.0	5.000

METER Ammeter SCALE 5

TYPE 155 MAKE Weston

SERIAL NO. 37316 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
1.0	0.950
1.5	1.460
2.0	1.925
2.5	2.452
3.0	2.955
3.5	3.475
4.0	3.965
4.5	4.470
5.0	4.985

METER Ammeter SCALE 25

TYPE 155 MAKE Weston

SERIAL NO. 37394 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
6	6.250
8	7.850
10	10.000
12	11.825
14	13.950
16	15.825
18	17.980
20	19.975
22	22.100
25	25.150

METER Ammeter SCALE 5

TYPE 155 MAKE Weston

SERIAL NO. 39762 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
1.0	1.000
1.5	1.490
2.0	2.000
2.5	2.475
3.0	2.965
3.5	3.470
4.0	3.965
4.5	4.450
5.0	4.950

METER Ammeter SCALE 10

TYPE P-3 MAKE G-E

SERIAL NO. 989281 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
2	1.85
3	2.86
4	3.90
5	4.94
6	6.00
7	7.06
8	8.13
9	9.25
9.8	10.20

METER Ammeter SCALE 5

TYPE P-3 MAKE G-E

SERIAL NO. 989296 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
1.0	0.800
1.5	1.400
2.0	1.925
2.5	2.460
3.0	3.000
3.5	3.525
4.0	4.070
4.5	4.620
5.0	5.014

METER Ammeter SCALE 5

TYPE P-3 MAKE G-E

SERIAL NO. 988894 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
1.0	0.950
1.5	1.430
2.0	1.930
2.5	2.460
3.0	3.005
3.5	3.550
4.0	4.085
4.5	4.635
5.0	5.170

METER Ammeter SCALE 25

TYPE P-3 MAKE G-E

SERIAL NO. 989810 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
5	5.000
8	7.800
10	9.925
12	11.875
14	13.975
16	16.000
18	18.000
20	20.090
22	22.180
25	25.200

METER Ammeter SCALE 25

TYPE P-3 MAKE G-E

SERIAL NO. 989812 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
5	5.000
8	7.800
10	9.830
12	11.850
14	13.975
16	16.025
18	18.050
20	20.190
22	22.300
24	24.500

METER Ammeter SCALE 10

TYPE P-3 MAKE G-E

SERIAL NO. 989824 DATE OF TEST 5/10/34

RECORD OF TEST

Test	Standard
2	1.90
3	2.90
4	3.92
5	5.01
6	6.15
7	7.34
8	8.44
9	9.78

METER Wattmeter SCALE 300

TYPE P-3 MAKE G-E

SERIAL NO. 989698 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
60	59.5
80	79.0
100	99.8
120	119.0
140	138.5
160	158.0
180	178.5
200	197.5
220	217.5
240	237.5
260	257.0
280	276.0
300	295.0

METER Wattmeter SCALE 300

TYPE P-3 MAKE G-E

SERIAL NO. 989699 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
80	80.5
100	101.5
120	120.5
140	141.0
160	160.0
180	180.3
200	199.5
220	218.5
240	238.5
260	258.0
280	278.0
300	297.0

METER Wattmeter SCALE 300

TYPE P-3 MAKE G-E

SERIAL NO. 990446 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
80	80.0
100	100.0
120	120.0
140	140.0
160	160.0
180	178.8
200	199.0
220	218.0
240	238.5
260	258.0
280	277.5
300	297.0

METER WATTMETER SCALE 500

TYPE P-3 MAKE G-E

SERIAL NO. 991421 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
100	101.0
150	150.5
200	200.0
250	248.5
300	297.5
350	347.5
400	396.5
450	445.0
500	494.5

METER Wattmeter

TYPE P-3

SERIAL NO. 991692

SCALE 200

MAKE G-E

DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
60	60.0
80	80.0
100	100.1
120	119.8
140	138.5
160	159.7
180	178.6
200	198.7

METER Wattmeter SCALE 500

TYPE P-3 MAKE G-E

SERIAL NO. 992299 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
100	101.5
150	151.0
200	200.5
250	250.2
300	300.1
350	349.2
400	400.0
450	449.0
500	500.0

METER Wattmeter SCALE 200

TYPE P-3 MAKE G-e

SERIAL NO. 992300 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
60	60.0
80	80.0
100	100.1
120	120.0
140	139.6
160	160.0
180	178.5
200	199.0

METER Wattmeter SCALE 500

TYPE P-3 MAKE G-E

SERIAL NO. 992302 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
105	105.00
150	150.00
200	200.00
250	249.00
300	297.00
350	347.00
400	396.00
450	450.00
500	497.00

METER Wattmeter SCALE 500

TYPE P-3 MAKE G-E

SERIAL NO. 992395 DATE OF TEST 5/11/34

RECORD OF TEST

Test	Standard
100	100.0
150	151.0
200	200.5
250	250.5
300	300.0
350	348.5
400	399.0
450	448.0
500	497.0

METER Wattmeter SCALE 500

TYPE P-3 MAKE G-E

SERIAL NO. 992392 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
100	103.0
150	149.0
200	200.5
250	250.0
300	298.0
350	348.0
400	397.5
450	445.0
500	496.0

METER Wattmeter SCALE 600

TYPE P-3 MAKE G-E

SERIAL NO. 993168 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
100	100.0
120	120.0
140	140.0
160	158.6
180	180.0
200	200.0
220	219.0
240	240.0
260	259.5
300	299.0

(Test runs 1/2 for scale.)

METER Wattmeter SCALE 600

TYPE P-3 MAKE G-E

SERIAL NO. 993276 DATE OF TEST 5/16/34

RECORD OF TEST

Test	Standard
200	200.0
240	239.2
280	280.0
320	319.4
360	359.4
400	400.6
440	437.0
480	479.0
520	520.0
600	597.0

APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

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