METER TESTING TABLE

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METER TESTING TABLE

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PREFACE

In January of 1951, the writer was requested by Professor Naeter, head of the School of Electrical Engineering of the Oklahoma Institute of Technology to work with Doctor Attie L. Betts on his thesis.

The Meter Testing Table was suggested by Professor Naeter, after having read an article that appeared in the December 31, 1951, issue of the Electrical World magazine, as a possible solution to reduce the amount of time and energy lost in setting up equipment to calibrate laboratory meters against standard meters.

The writer wishes to express his appreciation to the staff of the School of Electrical Engineering of the Oklahoma Institute of Technology for its cooperation and helpful advice and especially to Doctor Attie L. Betts, under whose supervision the construction and testing were carried out.

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CHAPTER I

INTRODUCTION

The Meter Testing Table design was based on an article[1] that appeared in the December 31, 1951, issue of Electrical World magazine, which described a portable tester manufactured by the Arthur E. Booth Company. With this idea in mind the Meter Testing Table was designed and constructed to fit the present needs of the college. Allowances were made, however, for the installation of equipment to meet future requirements.

Based on meters that are used as standards at the college, the following ranges of voltage and ampere were selected: 0-750 volts A.C., 0-750 volts D.C., 0-100 amperes D.C., and 0-100 amperes A.C. These were arbitrary figures which would cover enough of the range of the standard meter to be able to calibrate. However the ranges were exceeded in most cases because the equipment used was procured from war surplus material available at the college after World War II. The only exception was the 0-100 ampere direct current because it was limited in its output by the rating of the selenium rectifier which was purchased from the International Rectifier Corporation.

Formerly direct current and voltage were obtained from a motor-generator set. In order to register individual values a repetituous

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[1] W. A. Erskine, "Power Supply Doubles Test Efficiency," Electrical World, December 31, 1951, p. 74.

procedure that involved time and excessive expenditure of power had to be followed. Now by the construction of the Meter Testing Table all controls for the variation of the source of voltage and current of the alternating current and direct current circuits facilitate the checking of laboratory meters against standards.

CHAPTER II

CONSTRUCTION, DESIGN, AND DESCRIPTION

The material used in the Meter Testing Table construction was oak to match other equipment in the School of Electrical Engineering. The dimensions of the table top accommodate a standard meter and four laboratory meters. This and the height were the only factors taken into consideration in determining its size. For further details as to the dimensions of the table see Table Construction drawing 1 (page 4) and 2 (page 5).

The table was designed to test only one type of meter at a time, either alternating or direct voltages (or alternating or direct current), thus reducing the amount of equipment necessary. Only two transformers are required, one for the voltage ranges and one for the current ranges.

In tracing the circuit (drawing 3, page 6) 110 volt potential is applied through two 10 ampere fuses (11) to the power switch which is a 110 volt, 25 ampere switch (14). The voltage is then applied to the coarse control autotransformer (8). The fine control autotransformer (10) is connected across the output of the coarse control autotransformer (8). The 115 volt secondary of the transformer (9) has the output of the fine control autotransformer (10) applied to it, with the 5 volt primary connected in series with the output of the coarse control autotransformer. This transformer is connected so that by varying the fine control autotransformer it adds to the output of the coarse control autotransformer

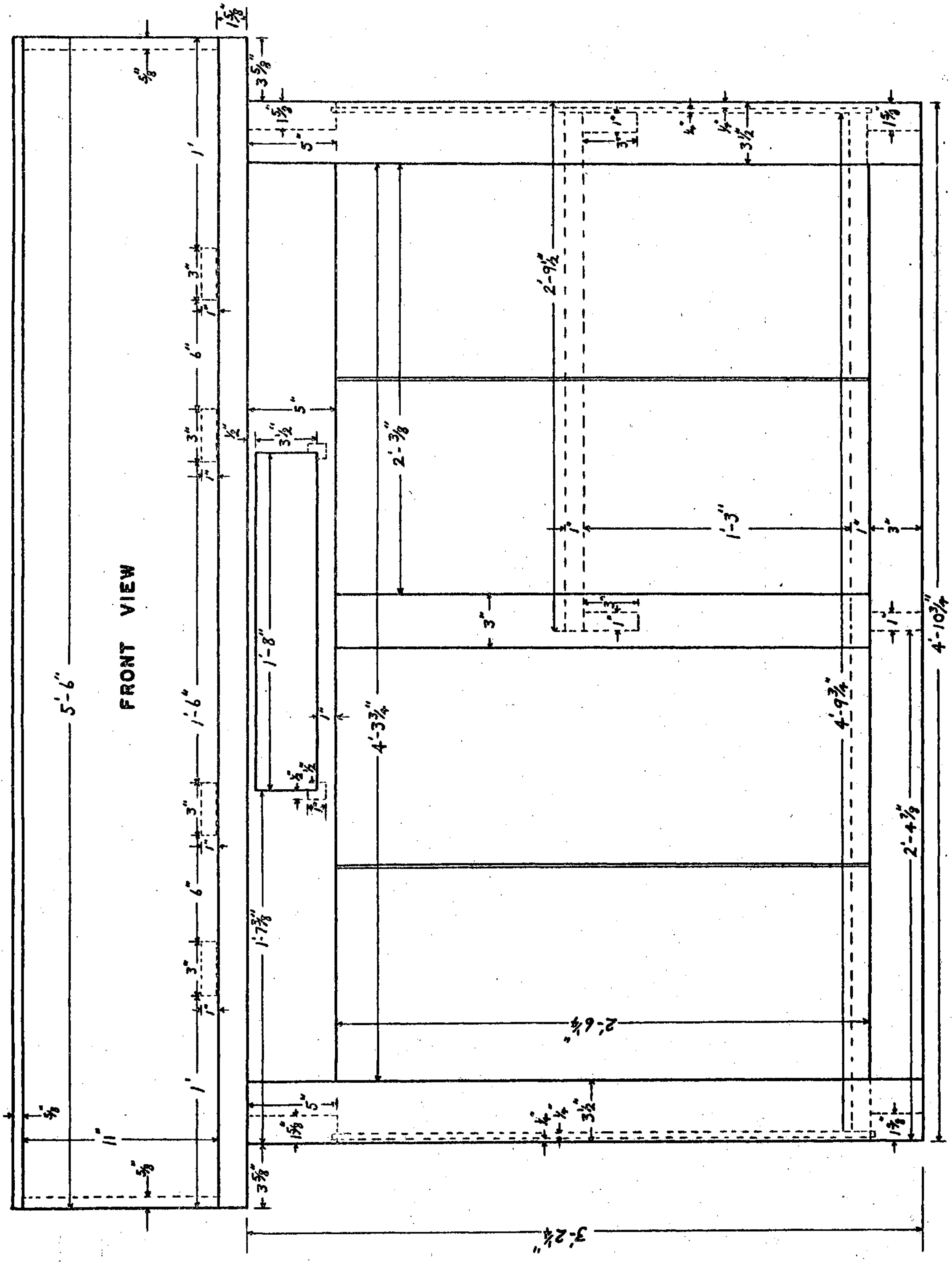


Figure 1. Table Drawing 1

Note: Material used--oak, doors and side panels oak plywood, table finish natural oak. Table to be mounted on (4) four rollers temporarily. Boards "A & B" to be screwed on so they can be removed for installation of equipment.

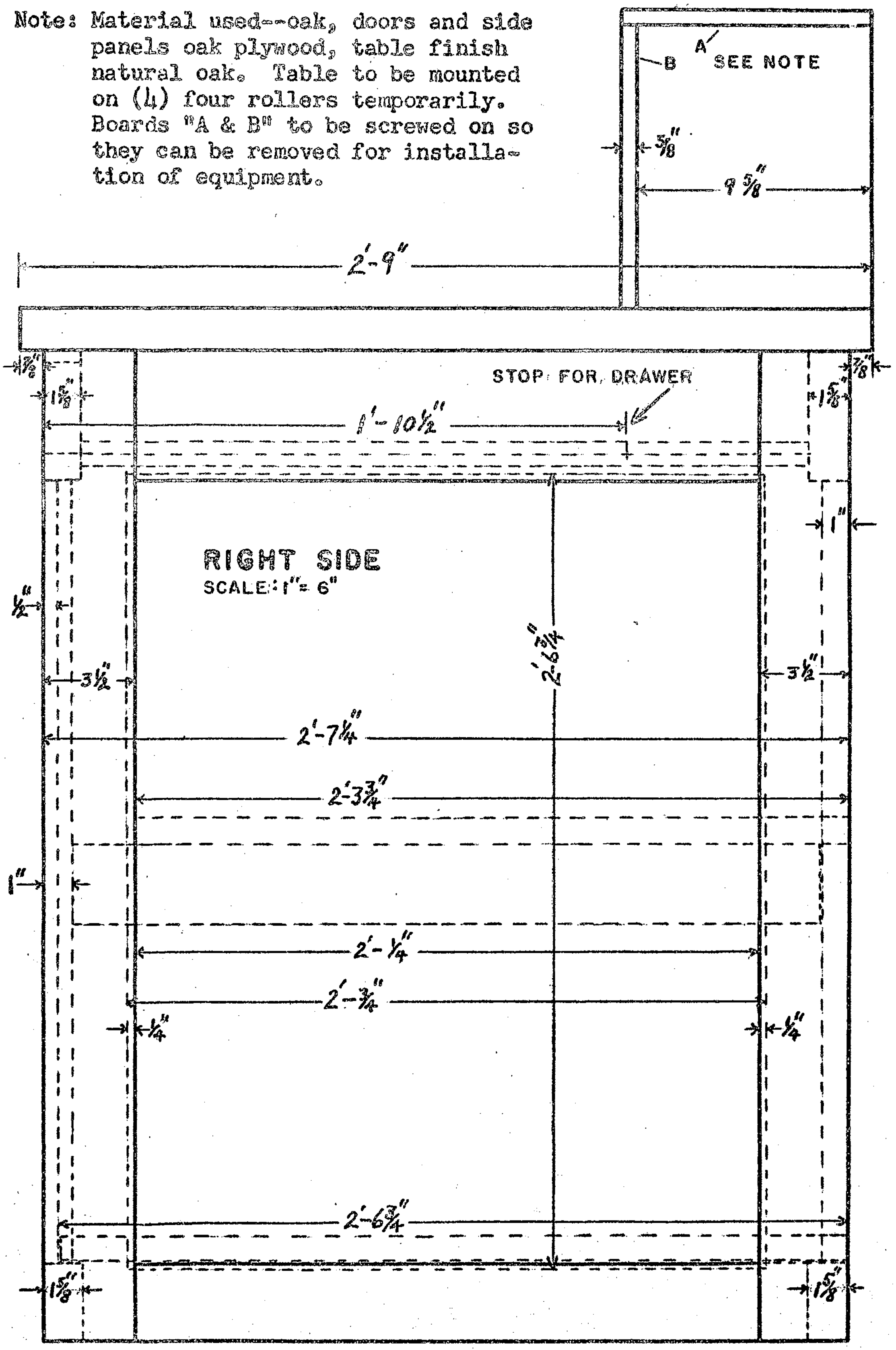


Figure 2. Table Drawing 2

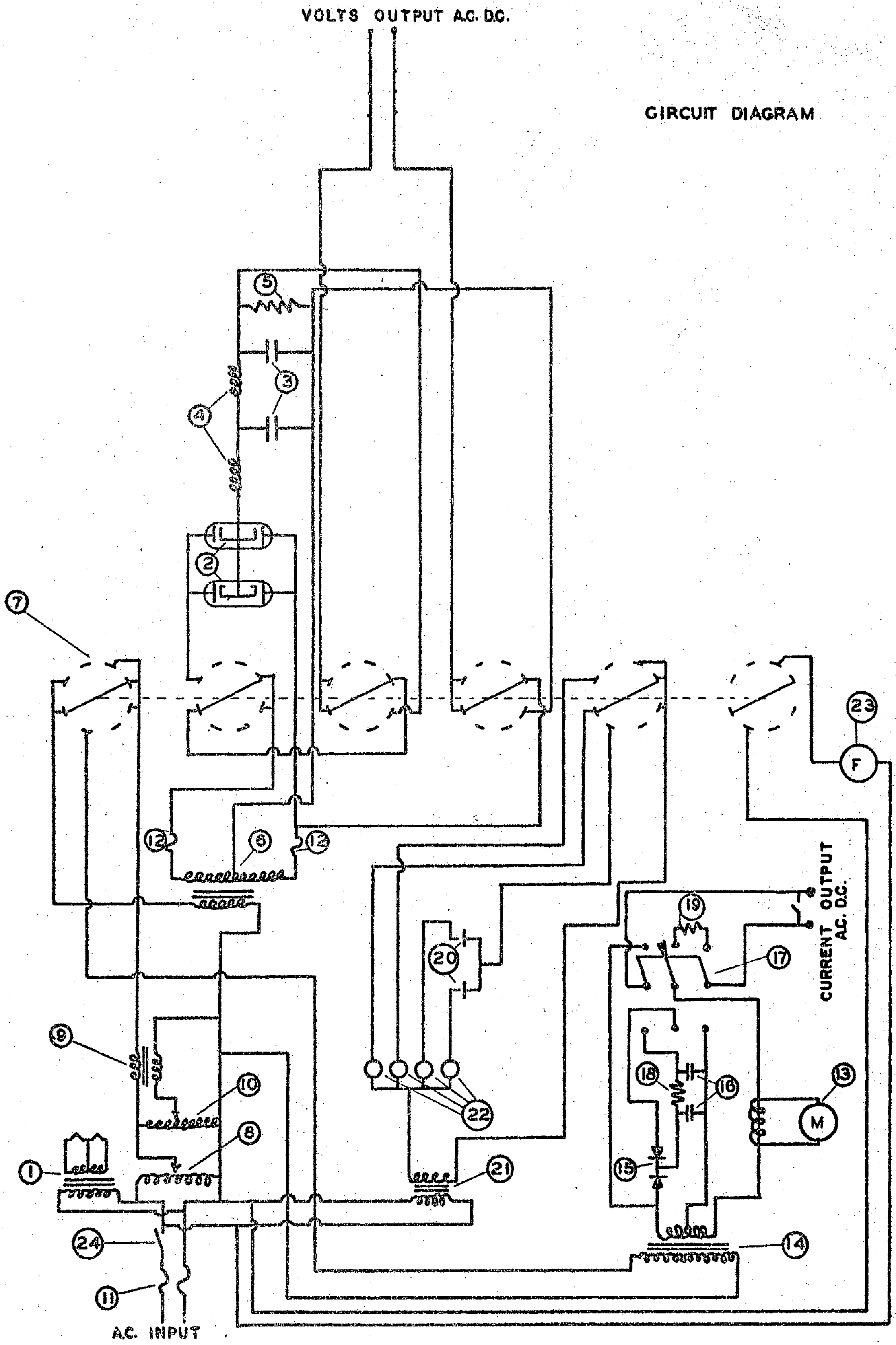


Figure 3. Circuit Diagram of Meter Testing Table

TABLE I

PARTS LIST OF EQUIPMENT USED IN CONSTRUCTION OF METER TESTING TABLE

Number	Number Required	Description
1.	1	Filament transformer, 110 to 5-0-5 volts, 4 amperes (Standard Transformer Corporation)
2.	2	Rectifier tubes, 5R4
3.	2	Capacitors, 1,000 volts, 10 M.F.
4.	2	Inductance reactors, 1.72 Henrys, .400 amperes 10,000 volt insulation, Kenyon Transformer Co.
5.	2	Resistor, bleeders, 11,500 ohms
6.	1	Transformer, primary 115 volts, secondary 2,500 volts, center tap, .300 amperes D. C., 550 volt amperes, Thordarson Electric Manufacturing Company, type T-19P59
7.	1	Switch rotary gang operated--six switches single pole double throw
8.	1	Voltage regulator-variac, maximum amperes 22.5, fix winding 115 volts, commutation range 0-130 volts maximum KVA 2.93, Transtat Manufacturing Company, catalogue number TH 22 1/2 A
9.	1	Transformer, 115-5 volts, 5 amperes, Thordarson Manufacturing Company
10.	1	Variac, 5 amperes, 0-115 volts
11.	2	Fuses, 10 amperes
12.	2	Fuses, .5 amperes
13.	1	Ammeter meter 0-200 amperes
14.	1	Transformer, 200 amperes, 115-5.5-0-5.5 volts
15.	1	Selenium rectifier, full wave, 100 amperes, air cooled
16.	4	Capacitor, 2000 M.F., 25 volts
17.	1	Switch, 3 pple double throw
18.	2	Resistor, 3/32" x 8 1/2" stainless steel welding rod, .043 ohms

(TABLE I continued)

Number	Number Required	Description
19.	4	Resistor, 3/32" x 8 1/2" stainless steel welding rod, .043 ohms
20.	2	Switch, push button
21.	1	Transformer, 110-6.3 volts
22.	4	Lights, pilot, 6.3 volts
23.	1	Fan, 6" centrifugal fan
24.	1	Switch, 110 volt, 25 amperes, single pole, single throw

by five per cent, thus giving a vernier adjustment of voltage in the circuit. The output of the above circuit is common to all circuits in the table. From here the potential is applied to a rotary switch (7) where the individual circuits are selected.

When testing an alternating current from 0-750 volts, the output is then applied to the high voltage transformer (6) which in turn is connected to another rotary switch (7) of the gang operated rotary switch and then applied to the test plugs on the front panel.

The same high voltage transformer is employed in the direct current high voltage circuit. Instead of being connected to the test plugs through the rotary switches, it is connected to two 5R4 rectifier tubes (2) which are connected in parallel. The output of the tubes is applied to a two section choke input filter, the output of which is returned to the rotary switches and from there is reconnected to the test plugs on the panel, thereby utilizing both the high voltage transformer and the same test plugs for both circuits. The filament voltage for the 5R4 tubes is obtained from a separate transformer (1) that is connected to the 110 volt line behind the power switch, thus eliminating the possibility of high voltages being applied to the plates of the tubes when no filament voltage is present.

In selecting the high alternating current range the rotary switch is turned so that the output of the control circuits is connected to the high current transformer (14). The output of the transformer is then applied to a three pole double throw switch (17). From the switch it is fed to a resistance load (19) which gives a fine control by limiting the current. This output is applied to the test connection on the control panel.

In endeavoring to locate a resistance load that would carry the high current and have the approximate value of resistance, a 3/32" x 8 1/2" stainless steel welding rod was measured with a wheatstone bridge and found to have a resistance of .043 ohms. One rod was not sufficient to dissipate the heat which was generated, thus four rods were connected in series parallel and the ends were silver soldered in copper connectors to accomplish this task. Additional considerations were that these rods would not rust, had exceptional durability, and would not deteriorate generally.

To change from alternating current to direct current the three pole double throw switch is used. The output of the high current transformer (14) is switched from the control panel to a full wave selenium rectifier (15). The output of this rectifier is in turn connected to a two section capacitor (16) resistor (18) filter circuit, and then to the test connectors on the control panel. Here again the 3/32" x 8 1/2" stainless steel welding rods were used, but only two rods connected in parallel.

A set of pilot lights (22) were installed to indicate which circuit is in operation. Its voltage is obtained from a separate 110/6.3 volt transformer (21) connected across the 110 volt input behind the power switch. A rotary switch (7), one of the gang operated rotary switches, is used to indicate when the 0-100 ampere alternating current or direct current is on, but since the rotary switches are in the same position for 0-100 ampere alternating current and direct current, two push button switches (20) were installed on the three pole double throw switch to indicate whether the 0-100 ampere alternating current or the direct current circuit is in operation.

In order to reduse the size of the selenium rectifier (15) used in the 0-100 ampere direct current circuit a forced air-cooled rectifier was used. To cool this recitifer a six inch centrifugal fan (23) was installed which also cooled both the load resistor and the resistor in the capacitor resistor filter circuit in the high current circuits. The fan is turned on automatically by one of the rotary switches when the selector switch is turned on to the position AC-DC current.

In the high current circuit number 1/0 rubber covered wire was used in connecting all the equipment.

In connecting all other equipment number 14 rubber covered switchboard wire was used except in the pilot light circuit, where plastic covered number 18 was employed.

A 150 ampere connector was used on the ends of the number 1/0 rubber covered copper wire when they were terminated at the equipment or test poles. No special connectors were used in attaching the number 14 rubber covered switchboard wire; it was either soldered directly or fastened to the binding post.

Thus the basic wiring essential for testing was completed.

In looking at the drawing (page 12) and photograph (page 13) of the control panel, one sees that the switch for the source of all the electricity is located at the extreme left. Next to this power switch are four pilot lights which indicate the circuit in operation. Continuing across the panel from left to right there are at intervals 8 female test jacks for the alternating current and direct current high voltage. Beside this is the selector switch which is used to choose the voltage or current desired. The coarse control autotransformer is to the right of the selector switch and in the center of the control panel. This varies the

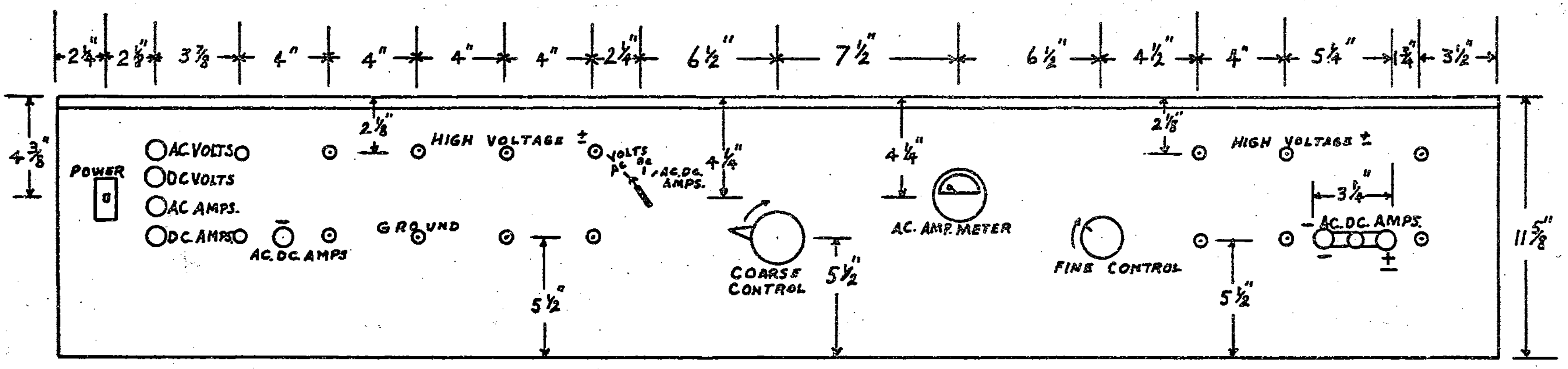


Figure 4. FRONT VIEW OF CONTROL PANEL

Plate I. Photograph of Control Panel

voltage from 0-120 volts. Next to this is the alternating current ammeter which will give the approximate amperes that the high current transformer is delivering to the 0-100 ampere, alternating current and direct current circuit. To the right of the alternating current ammeter is the fine control autotransformer used in varying the output voltage of the control circuit by 5 per cent. At the extreme right are the output terminals of the 0-100 ampere, alternating current, and direct current circuit. Between the two output terminals is a shorting bar, taken from a wheatstone bridge, to short out the alternating current or direct current so that the test meters can be disconnected without interrupting the setting of the controls or breaking a circuit when high current is flowing. This also eliminates the changing of the setting and allows meters to be inserted in the circuit to be tested at the same current setting. Located at the left end of the control panel and connected in parallel with the negative pole is another negative pole which is employed to eliminate long test leads of large copper wire.

The equipment located behind the control panel (see drawing page 15 and photograph page 16) from left to right includes two 10 amperes fuses mounted on the vertical end of the table and connected to the 110 volt input. On the top of the table behind the control panel is a chassis upon which is mounted two 5R4 tubes, one 110/5 volt filament transformer for the 5R4 tubes, two 1,000 volt 10 microfarad capacitors, and two bleeder resistors. Next to the chassis are two choke coils which with the equipment mounted on the chassis comprise the high voltage direct current rectifier circuit. Beside this is the high voltage 110/1250 volt transformer which is employed in the alternating current and direct current high voltage circuits. There are two 5 amperes cartridge fuses

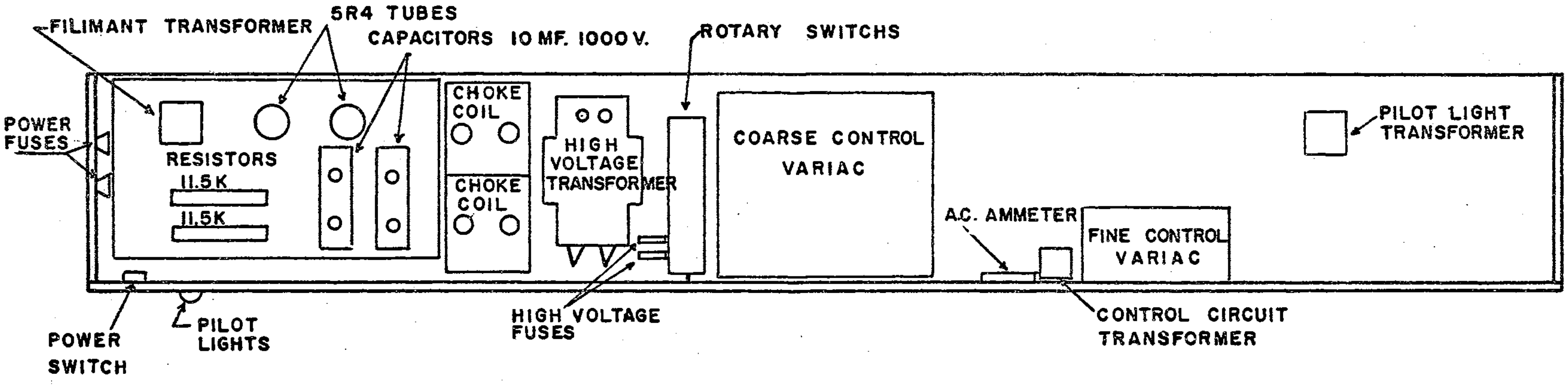
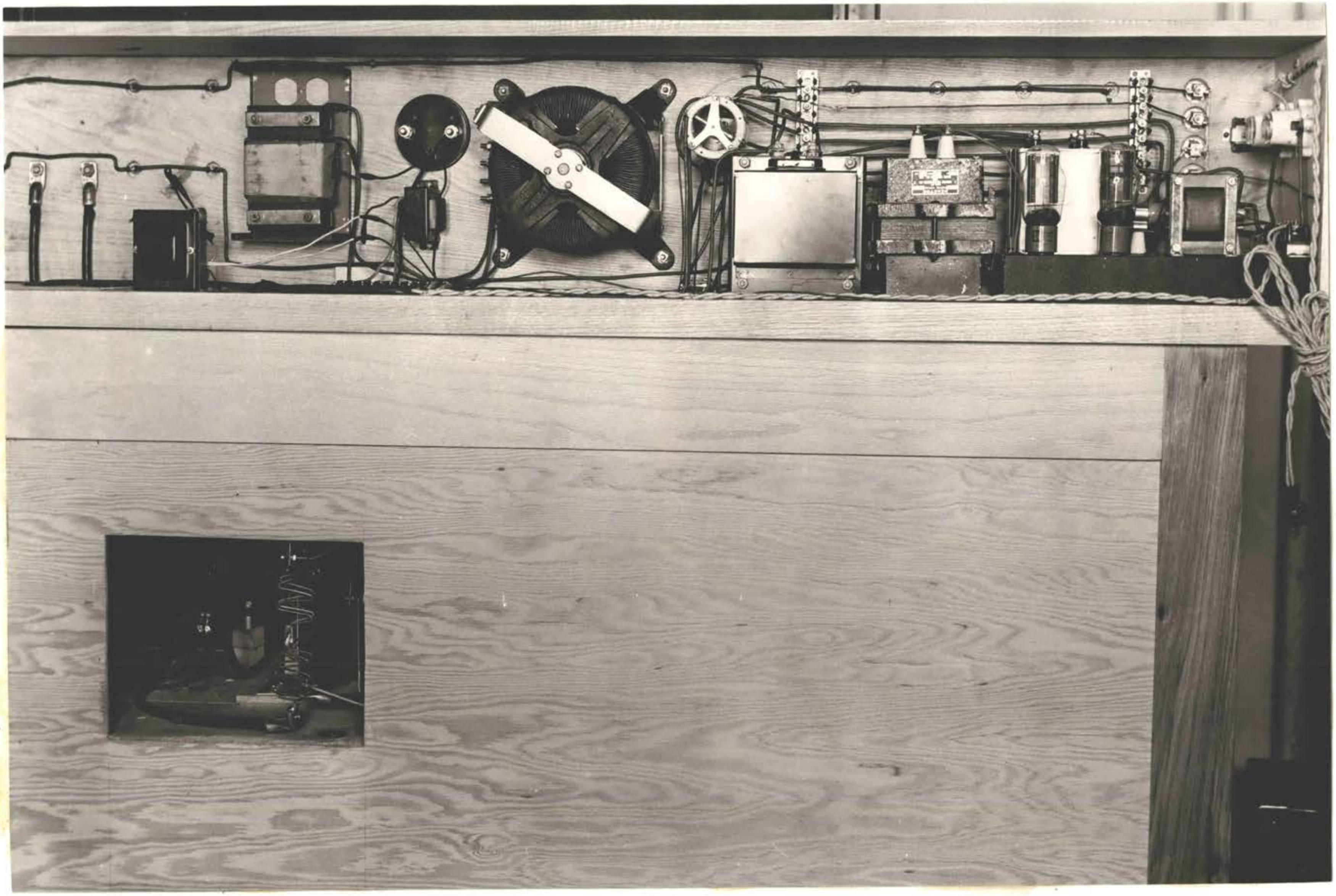


Figure 5. LOCATION OF EQUIPMENT BEHIND CONTROL PANEL

Plate II. Photograph of Equipment behind Control Panel



next to the high voltage transformer and in the high voltage leads to protect the high voltage transformer. Directly above the fuses are the gang operated rotary switches. Each switch is a four position double break contact. The gang switch was taken from two SCR-193 Army transmitters. The original only had three switches, so that two were connected on the same shaft to make up the six switches necessary. To the right is the coarse control autotransformer which is mounted on the back of the control panel. The autotransformer was procured from the SCR-270 Army radar transmitter. Beside this is the 110/5 volt transformer, which is connected in the control circuit to give a 5 per cent variation in the output of the control circuit. Next is the 5 ampere fine control autotransformer which is also mounted on the back of the control panel. The final piece of equipment located behind the control panel is the 110/6.3 volt transformer which furnished the power for the pilot lights.

Upon opening the right front door one finds one 3 pole double throw knife switch (see drawing page 18 and photograph page 19). This switch was converted from a 2 pole double throw to a 3 pole double throw by adding another knife switch. It is used to change the 0-100 ampere circuit from alternating current to direct current or vice versa. At each end of the 3 pole double throw switch is a switch which is depressed with the 3 pole switch is operated. These push button switches are for the pilot lights to indicate if the alternating current and direct current circuit is in operation. Directly behind this is the six inch centrifugal fan which cools the selenium rectifier. Also in line with the rectifier and cooled by the fan is the resistor for the capacitor resistor filter circuit and the load resistor, which were made of the 3/32" x 8 1/2" stainless steel welding rods. Also situated on the first shelf are

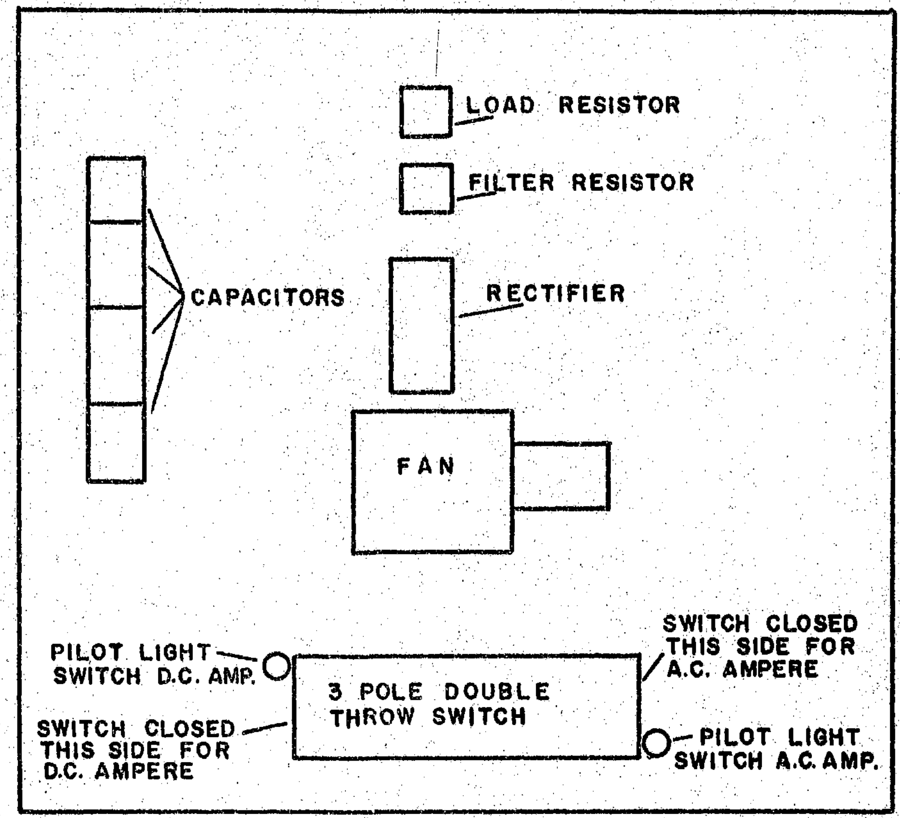


Figure 7. LOCATION OF EQUIPMENT ON FIRST SHELF

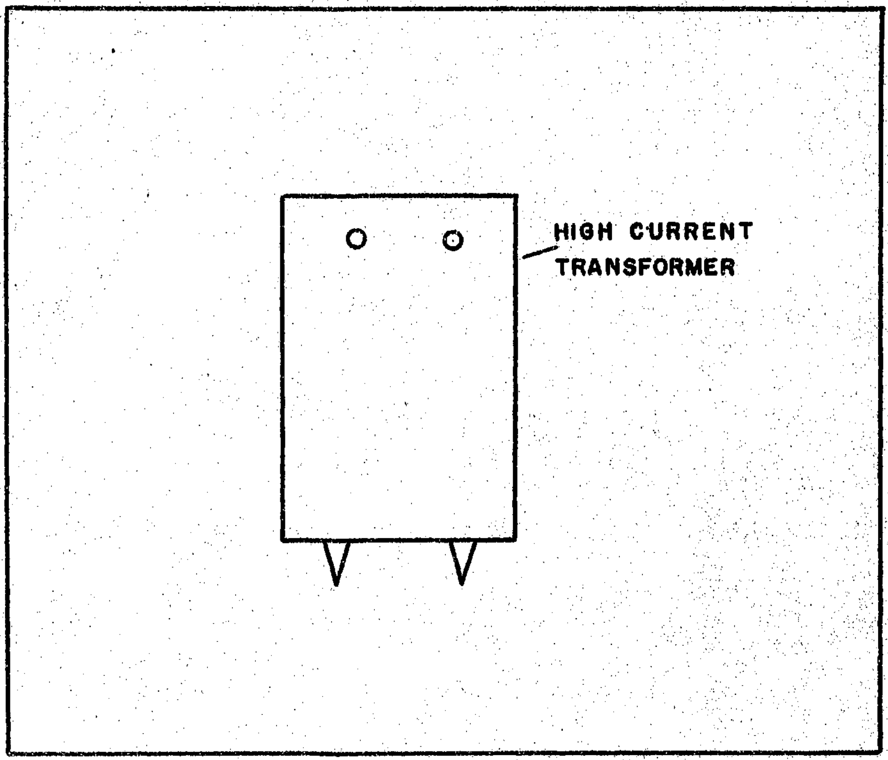


Figure 8. LOCATION OF EQUIPMENT ON BOTTOM SHELF

Plate III. Photograph of Equipment on First and Bottom Shelves

the four 2000 microfarad 25 volt capacitors of the capacitor resistor filter of the 0-100 ampere direct current circuits. The only equipment placed on the bottom shelf is the air-cooled high current transformer which was taken from the transmitter of the SCR-270 where it provided the filament voltage for the transmitter tubes. It should be noted that all the equipment located below the top of the table occupies only the right half which leaves the left half of the table for future installation of other equipment.

CHAPTER III

TESTING

The first test which was performed on the Meter Testing Table was on the 0-100 ampere direct current circuit. The equipment used to check this circuit was an oscilloscope and a Hewlett Packard meter, model 400C. The oscilloscope and the Hewlett Packard meter were connected across a 150 ampere 50 millivolt shunt. For different values of current the wave form was observed on the oscilloscope and the rms alternating current volts were recorded and plotted on a graph on page 22. From the wave form it was observed that the direct current was not a pure direct current, which showed that the capacitor resistor filter circuit was not filtering the direct current. The resistance of the filter current was increased in size to improve the filtering of the direct current circuit. The results of this were negligible. The increasing of the resistance only resulted in decreasing the output of the 0-100 ampere circuits.

Another test was performed using different types of meter movements. and a pure direct current. The two meters used were a Weston Electrical instrument--5 ampere alternating current ammeter--and a Weston Electrical instrument--direct current ammeter, model 45. The Weston alternating current ammeter has an electromagnet moving coil type and the Weston direct current model 45 has a permanent magnet moving coil type movement. The pure direct current was supplied by a 6 volt storage battery which

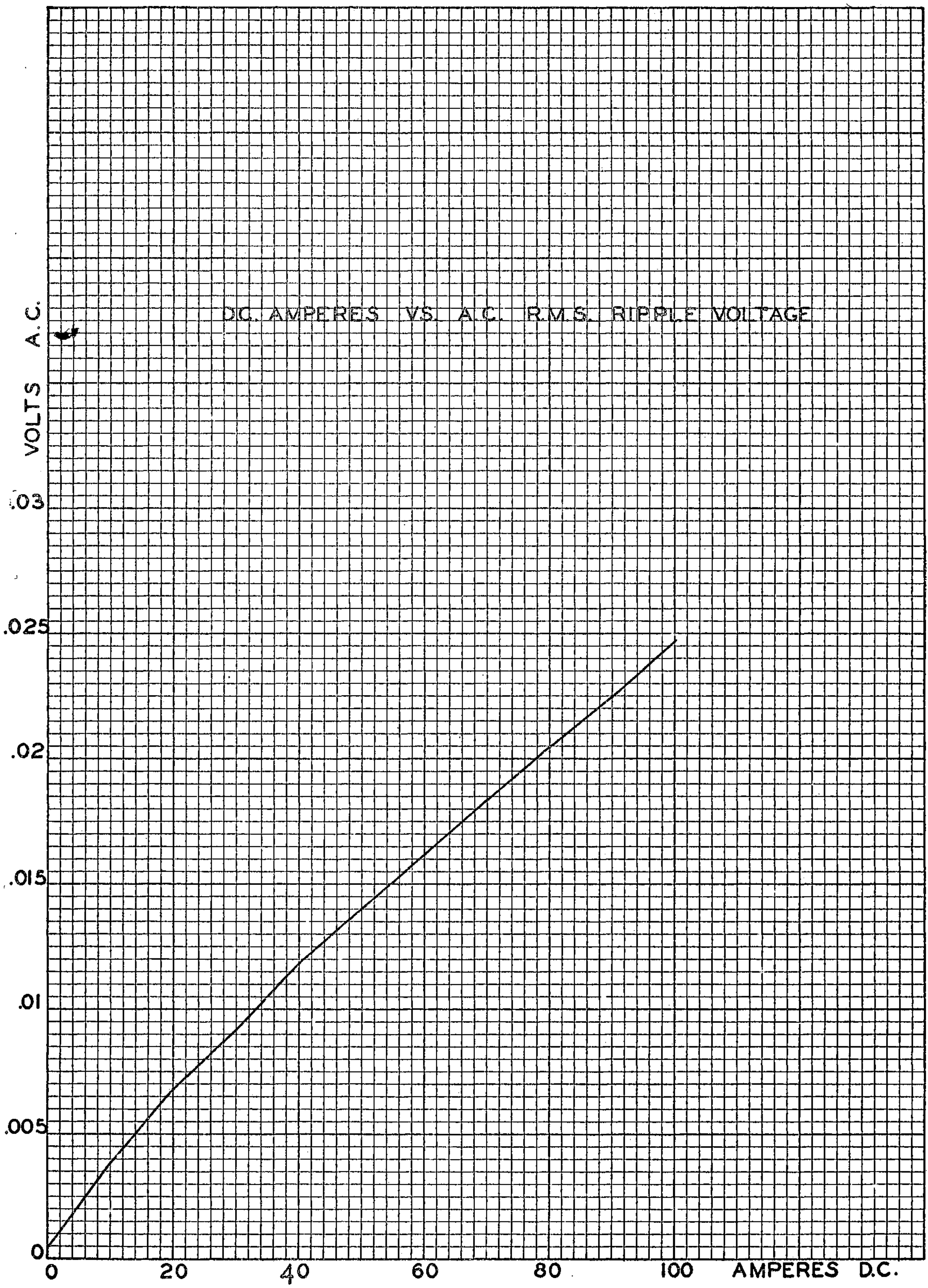


Figure 8. Graph of Meter Testing Table Direct Current Amperes Versus Alternating Current RMS Ripple Voltage

was connected to a variable resistor in series with the two meters. A 5 ampere 50 millivolt shunt was used with the Weston model 45 ammeter. The results, which are shown on the graph on page 24, show that there was a very small difference in the reading of the meters for a certain value of current.

The same two meters were used, but the direct current was supplied by the Meter Testing Table. In this test the difference in the reading of meters was much greater, which showed again that the direct current from the Meter Testing Table is not a pure direct current. From the graphs on page 24 it can be seen that when there is a ripple voltage on the direct current, the Weston Electrical Instrument--5 ampere alternating current meter--would measure both of these currents, which resulted in a higher reading of current than the Weston Electrical Instrument--direct current ammeter, model 45.

The next test performed unsed a General Electric alternating current ammeter type P-3 and the Weston direct current ammeter, model 45. The General Electric alternating current ammeter has a magnetic-vane type movement. The same procedure was followed as the above test; that is, the pure direct current was supplied by a 6 volt storage battery which was connected to a variable resistor in series with the two meters. Then the direct current source of the Meter Testing Table was used with the same two meters. The result of both tests can be compared from the graphs on page 25 and here again the presence of the alternating current ripple on the direct current caused the difference in the readings of the two meters.

From the proceeding tests it is apparent that to use the direct current supply of the Meter Testing Table, meters with a different type

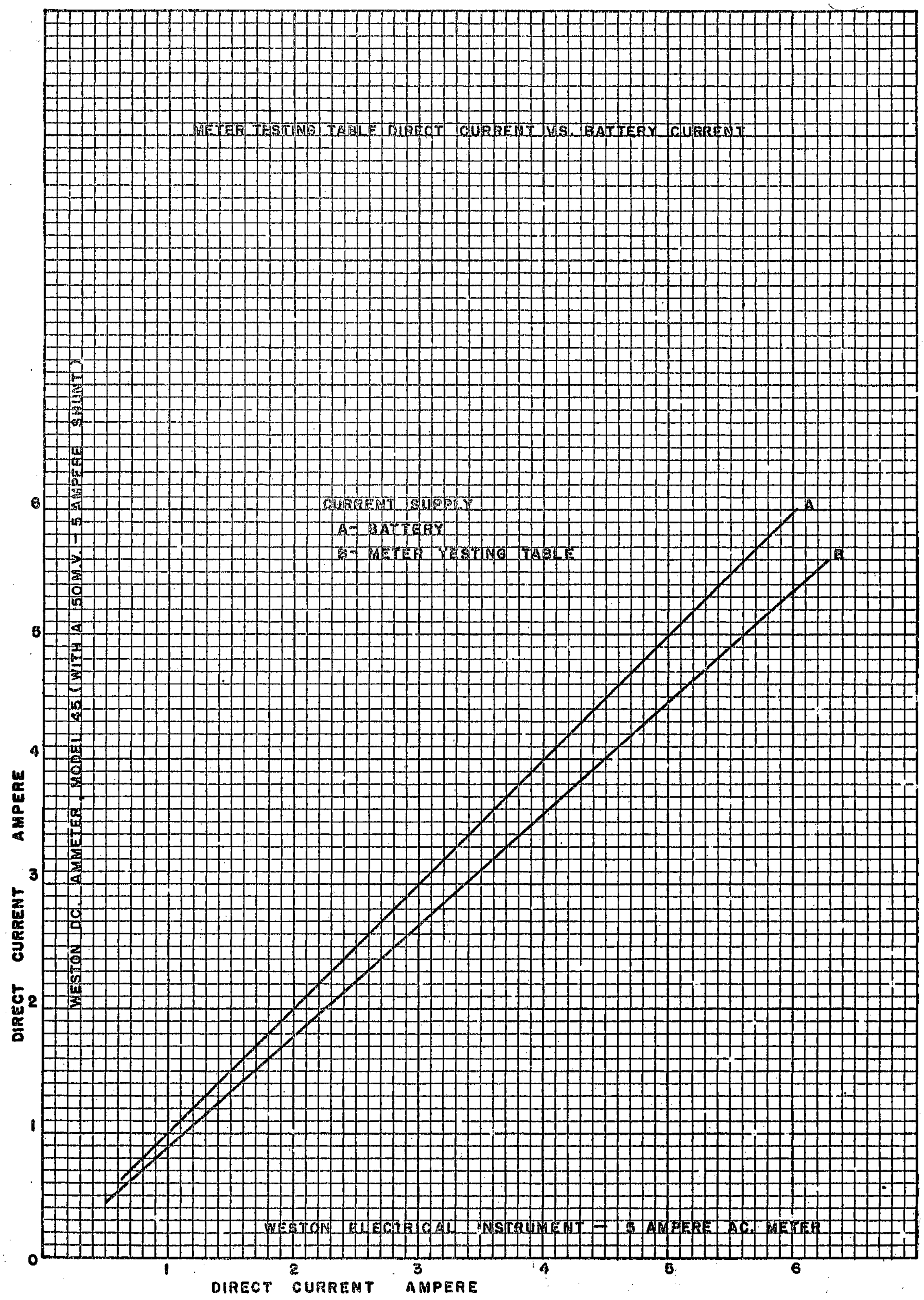


Figure 9. Graph of Meter Testing Table Direct Current Versus Battery Current Using Weston D.C. Ammeter and Weston 5 ampere A.C. Meter.

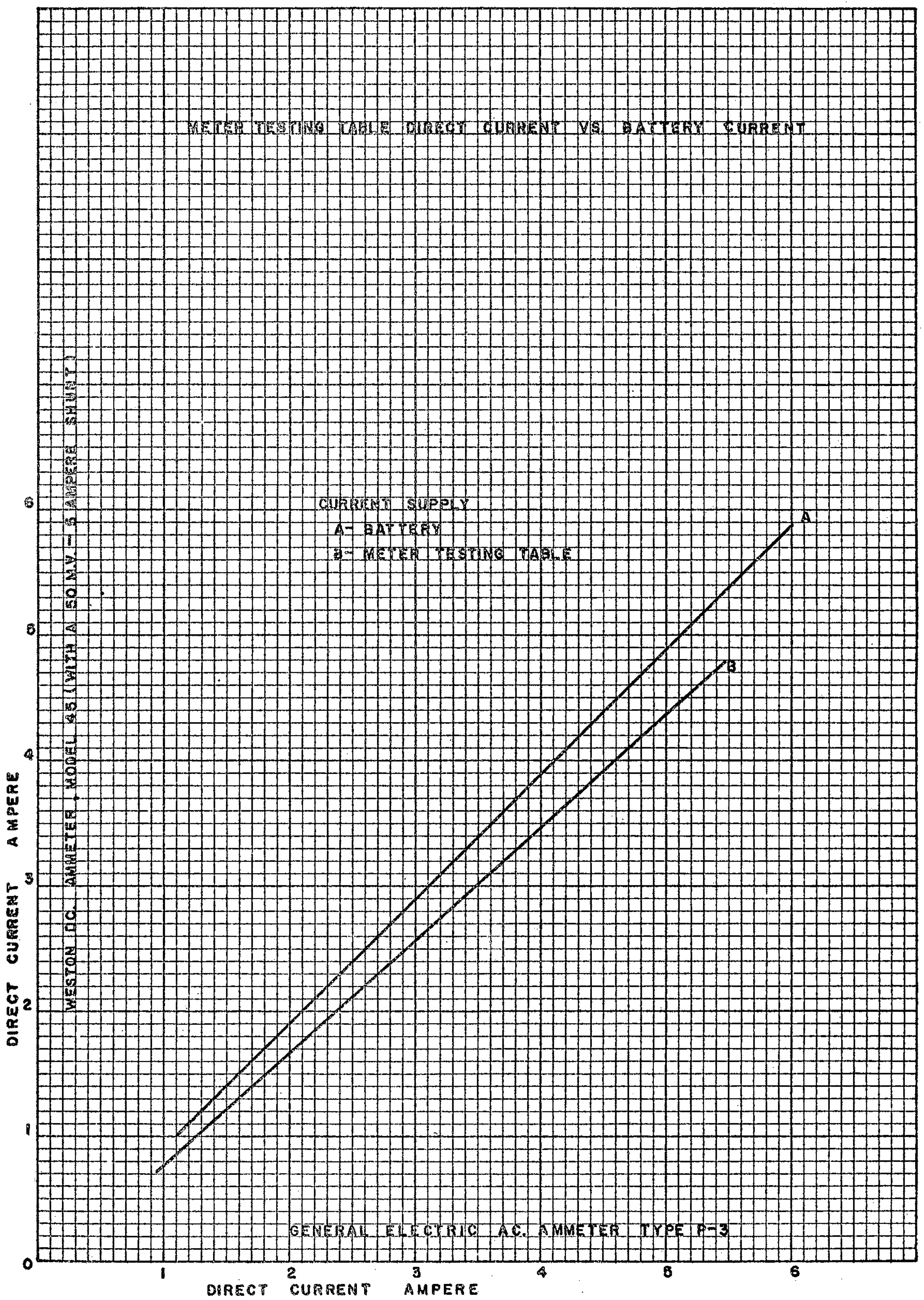


Figure 10. Graph of Meter Testing Table Direct Current Versus Battery Current Using General Electric A.C. Ammeter and Weston D.C. Ammeter.

of movement than the standard should not be used. Caution should be taken in calibrating direct current meters against the standard to make sure that they have the same type of movement.

The next test was performed on the direct current voltage circuit of the Meter Testing Table and two meters with different types of movements were used, a General Electric type P-3 with a electrodynamic movement and a Weston Electrical instrument with a permanent magnet moving coil type movement. The difference in the readings on the voltmeters for different values of volts was too small to read, which indicated that the small alternating current ripple voltage on the direct current voltage was not enough to affect the readings on two different types of meter movements. A Hewlett Packard model 400 C meter was used to check the amount of rms alternating current ripple voltage on the direct current voltage. The results of this test were plotted on a graph on page 27.

The only test performed on the alternating current and voltage circuits was made with an oscilloscope. These appeared, from a visual observation of the wave forms, to be not distorted but approaching a sine wave. The output wave from was also compared to the input wave form on both circuits and if there was any distortion it was not caused by the Meter Testing Table but was present in the input.

To determine the amount of power needed by each circuit of the Meter Testing Table a watt meter was connected in the input circuit. The alternating voltage circuit consumed more power than the direct voltage circuit due to the 5R4 rectifier tube filaments being on any time the table's input power switch is turned on. The maximum power consumed by each circuit was 73 watts for the direct voltage circuit and

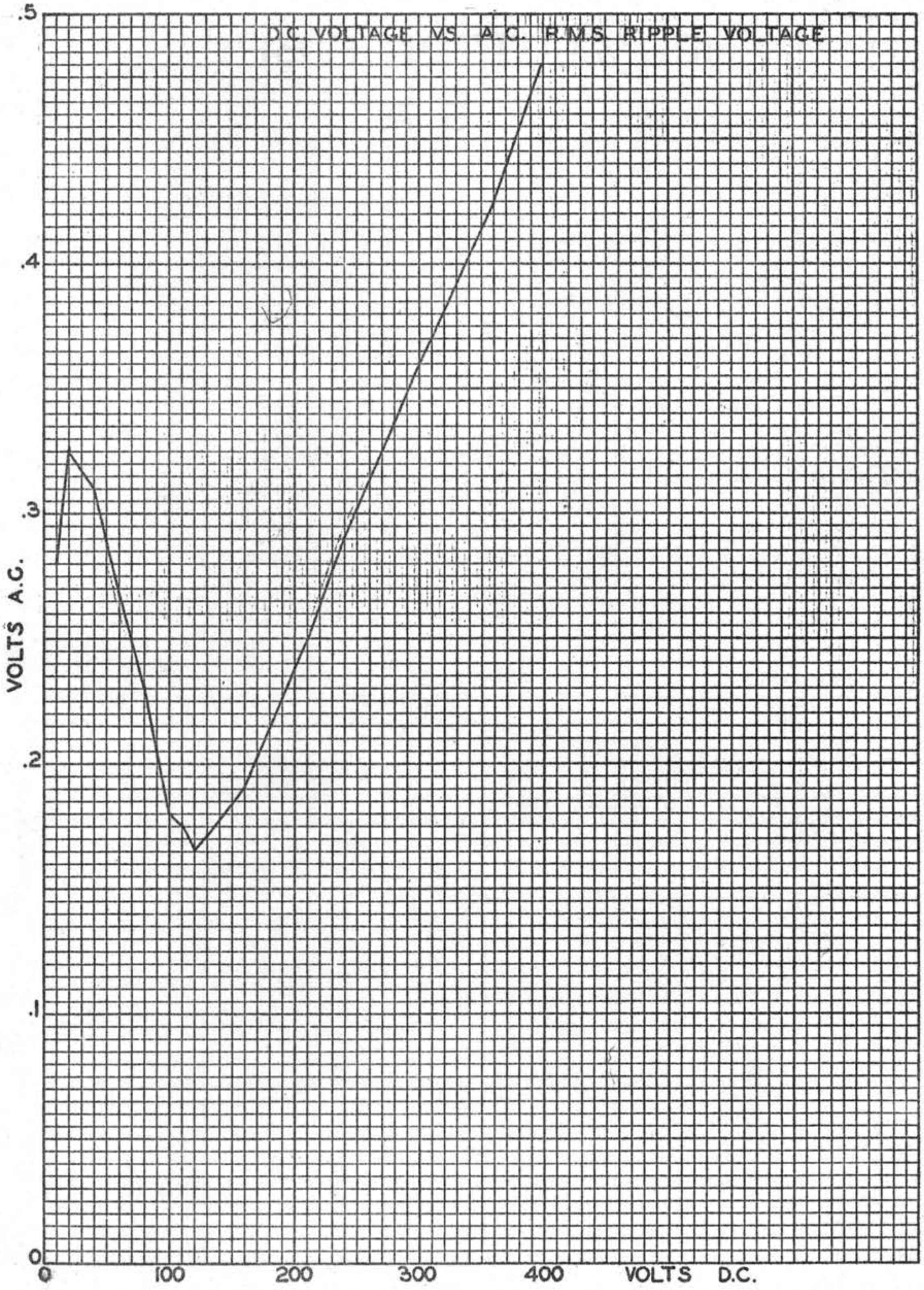


Figure 11. Graph of Meter Testing Table Direct Current Voltage Versus Alternating Current RMS Ripple Voltage Output.

90 watts for the alternating voltage circuit. Other values of power consumed at different voltages are plotted as a graph on page 29. In reference to the graph, the amount of power, 42 watts, for zero output voltage is required by the filaments of the 5R4 rectifier tubes, the coarse control variac, the pilot light, and the pilot light transformer.

The power required for the 0-100 ampere alternating and direct current circuits is much larger than than of the voltage circuits for zero output. The main reason for this is that the additional power for the six inch centrifugal fan is added to the amount of power required to energize the table for zero output of the voltage circuits. This has to be true because both circuits, the voltage and current circuits, use the same equipment except for the six inch centrifugal fan.

The maximum power required for the Meter Testing Table was 890 watts and this was consumed by the 0-100 ampere alternating current circuits. Other values of power requirements for the 0-100 ampere alternating or direct current circuits are plotted as a graph on page 30.

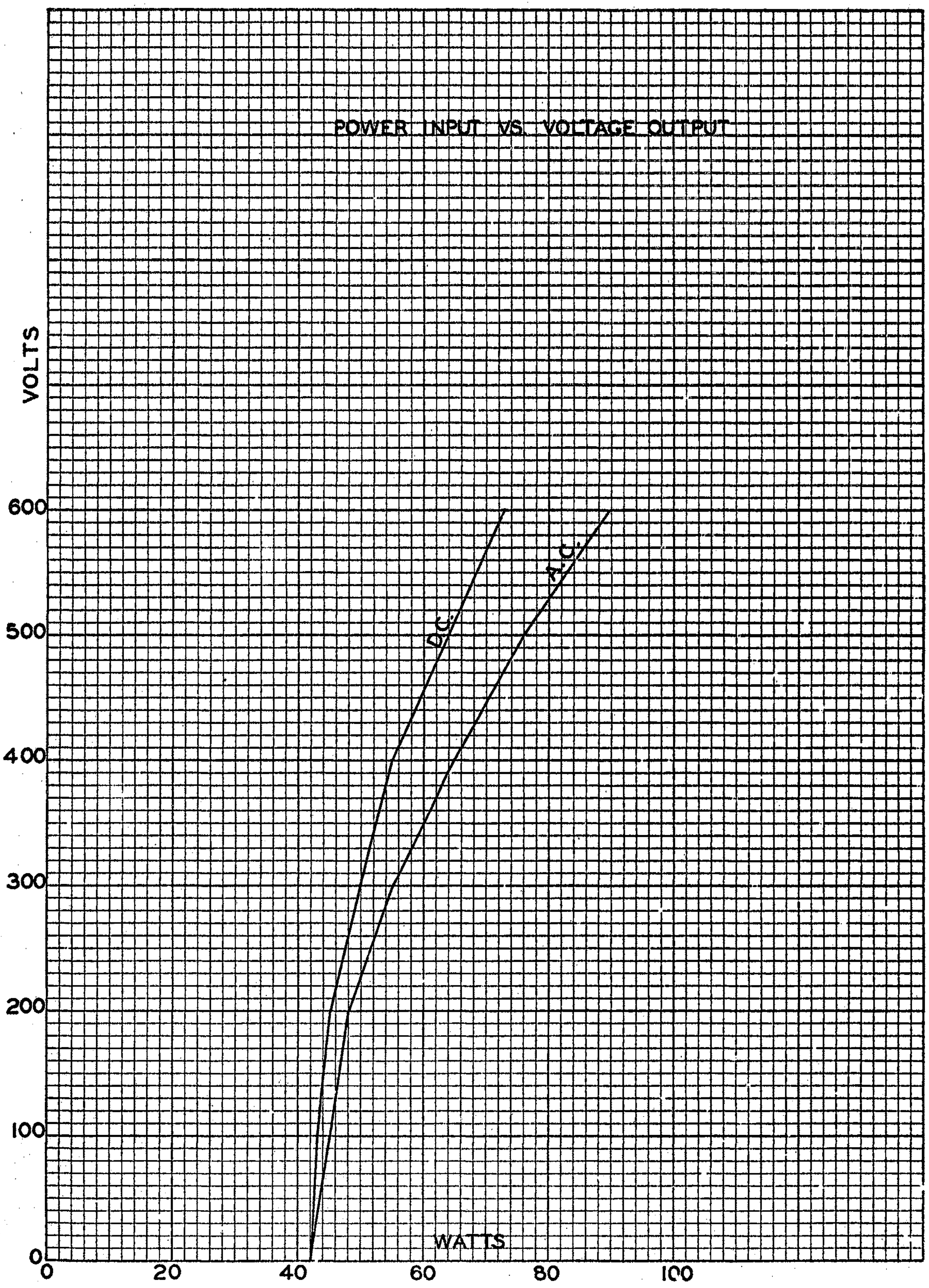


Figure 12. Graph of Meter Testing Table Power Input Versus Alternating Current and Direct Current Voltage Output.

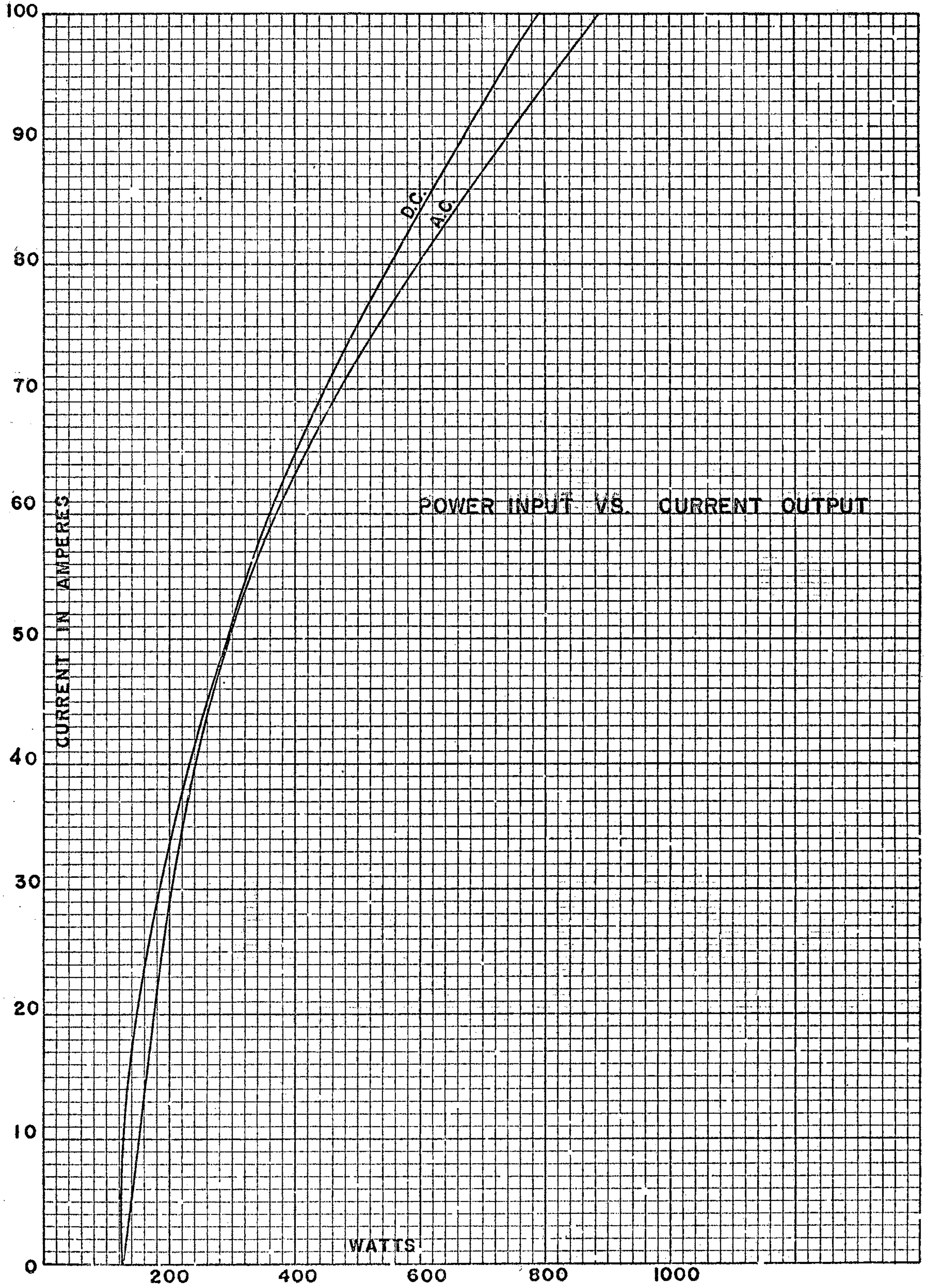


Figure 13. Graph of Meter Testing Table Power Input Versus Alternating Current and Direct Current Output.

CHAPTER IV

CONCLUSION AND SUGGESTED IMPROVEMENT

From the results of the tests that were performed, the only circuit that did not come up to expectation was the 0-100 ampere direct current circuit. The capacitor resistor filter did not filter the rectified alternating current, and when the value of resistor in the filter circuit was increased, the output of the circuit decreased below 100 amperes. If the capacitors, which were unobtainable, had been increased it would have taken more room than that available under the table. The only suggestion to improve this circuit would be to design an induction coil which has an iron core that would not be saturated when 100 amperes of current flow through it. This induction coil along with appropriate capacitors could replace the present capacitor resistor filter circuit in the 0-100 ampere direct current circuit. If this were accomplished, the Meter Testing Table would meet all the requirements for checking standard meters with laboratory meters.

While performing the tests on the Meter Testing Table it was noted that the supply voltage varied from time to time and required a constant recheck when reading meters. To eliminate this condition it is suggested that a voltage regulator be used to insure a constant input voltage. This would eliminate all errors in readings of the meters due to the variation of input voltage. The voltage regulator could be mounted in the bottom left side of the table and made a part thereof.

The gang operated switch, which was originally two switches and whose shaft is porcelain, was joined together with plastic. Since the shaft was only designed for three switches by increasing its length it was weakened. Also the shaft could not be made rigid with the plastic so that the connection on the end of the shaft, over a period of time, would gradually chip off. The shaft could be replaced with a new one made of one piece, thereby eliminating this future trouble.

There are other improvements that could be made in the Meter Testing Table which would not improve the output but would improve the operating, such as installing relays. One relay could be installed in the high voltage direct current circuit to eliminate the possibility of high voltage being applied to the plates of the 5R4 rectifier tubes when the table is first turned on. These improvements were not incorporated in the table because it was desired to keep the circuits as simple as possible and use parts that were available at the college.

The Meter Testing Table meets all the numerous requirements in a standard laboratory for checking alternating current and direct current laboratory meters against standards.

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