T H E S I S

on

Design and Installation of a Switchboard for the Engineering Laboratory.

Submitted to the Faculty

of the

Oregon Agricultural College

For the

Degree of Bachelor of Science

by

Approved

Department of Electrical Engineering.

T H E S I S

Design and Installation of a Switchboard for the Engineering Laboratory.

The Engineering Laboratory next year will be located in two large rooms situated on the west half of the first floor of the Mechanical Hall. The dynamos, motors, and transformers used for testing purposes will be placed where the Machine Shop formerly was, while the instruments of precision used for the determinations of field resistance, insulation, etc., will be in the room, which was until recently occupied by the Printing Office.

The dynamo department will be equipped with a good collection of the following types of machines, direct and alternating current generators, direct current, synchronous and induction motors and rotary converters. In the design of this laboratory switchboard it is necessary to consider the future developments and requirments that must be met. here it will suffice to give the number of, and different types of machines with their rating, that will in all probability be installed by the close of the coming school year, and estimate from this the amount of switchboard space that will be required. The following are the different units that are expected to be placed in this department within at least two years from the present time.

2... 10 H.P., direct current, 220 volt motors.

1... 2 K.W., three phase, 110 volt rotary converter.

3... motors that are now used in the blacksmith shop.

1... 5 H.P., three phase, 110 volt induction motor.

1... 7½ H.P., two phase, 110 volt induction motor.

2... 5 K.W., 120 volt, direct current generators.

4... 3 K.W., 120 volt direct current generators.

1... 10 K.W., 10 volt, 1000 ampere, unipolar dynamo.

1... 12 K.W., three phase, 120 volt, rotating field alternator.

2... 4 K.W., three phase rotary converters.

4... 5 K.W., 120 volt machines.

1... Welding transformer, 10 volt, 1,000 ampere, or 5 volt, 2,000 ampere.

In the electric testing room there will be a number of different types of galvanometers, which will be used in experiments for the determination of resistances of dynamo circuits and armature insulation, and the obtaining of data for the ploting of magnetic curves, etc. This will necessitate the running of leads from such insturments to the switchboard. In this testing room will also be apparatus for making tests and experimenting along the line of electro-chemistry.

Having described the two laboratories with their equipments we are able to form some idea as to the number of circuits that should for convenience be bruoght to

one common center of distribution, where they will terminate on two panels, one for alternating and the other for direct current, A third will have mounted on it a set of Mercury Vapor Rectifying apparatus.

The power will be supplied to the board by a three phase, 110 volt, alternating system, and a direct current line of 110 volts pressure. The three phase power will have to be transformed into a single and two phase system in order to accomodate the different types of machin esin the dynamo department. There will be wires from the direct current line to the fields of all machines.

On raised platforms ten inches high, three feet wide and extending cross-wise with the room, the machines will be placed with enough distance between them to facilitate good testing work on each. Thus by elevating the dynamos and motors slightly above the floor, a system of wires may be placed under them extending from the differ ent machines to the switchboard.

The requirments of this engineering laboratory will constantly be increasing, and a type of board that can be altered and adde d to must be installed. To decide upon what material is best to be used for the panel is probably the first thing to be done after making a careful estimate, and considering all conditions that will arise; slate, marble, and asbestos-wood are each very satisfactory. A material to be well adapted for this purpose must offer a high resistance to electricity and

be a non absorbent of moisture, also be comparatively easy to work. The latter material mentioned above is coming to the front for switchboard use, and has several advantages over either slate or marble, as will be seen in the discussion of its properties and results obtained from tests, which will be treated in another paragraph.

Upon carefully comparing the different properties of the several substances just mentioned, decision in favor of the use of asbestos sheets was made. Plain ebony asbestos-wood presents a very neat appearance and will take a handsome oil or enamel finish. It can be turned at high speed, or sawed like wood, with ordinary wood working tools. This fact alone gives it a decided advantage over either slate or marble for laboratory use, as new insturments and circuits may easily be placed upon it after being erected, if the growth of the laboratory demands it. It is not affected by heat and will not crack or split when subjected to a great variation of temperature. When impregnated with insulation compound it has a resistance greater than that of the best marble.

It is of great importance that materials used for electrical insulation should not absorb an appreciable amount of moisture, because of the fact that its resistance would be materially reduced. A number of pieces of this asbestos-wood product were submerged in water for

different periods of time and tests were made with accurate insturments and results obtained therefrom show that after 216 hours of immersion, the samples were unaffected as regards their insulating properties.

The following are results of tests for insulation resistance made on samples of ebony asbestos-wood, which were placed between two electrodes each of an area of 9.6 square inches. Surface leakage was prevented by a guard ring. The resistances are expressed in megohms and are for the area just stated. The electric pressure used was 300 volts. All tests were made at atmospheric temperature, and all readings taken after one minute electrification. Each result quoted is computed from an average of three readings made on different parts of the sheet which were twelve inches square and of varying thicknesses.

Insulation resistance at atmospheric temperature.

Thickness.	When received.	After 24,	96,	216, hours of immersion.
1/4 inch.	4,000	2,800	4,400	2,300
1/2 "	175,000	150,000	204,000	188,000
9/16 "	45,000	43,000	60,000	35,000
5/8 "	38,000	34,000	43,000	22,000
3/4 "	20,500	27,000	32,000	26,000

Tests for puncture.

Voltage was started at zero and raised until specimen broke down.

Thickness	Puncture Voltage.
5/16 inch	20,000
	22,000
	23,000
	25,000
Average.....	22,000
5/16 inch	19,000
	22,000
	26,000
	19,000
	24,000
Average.....	22,000

The voltmeter was applied direct tO the specimen.

Switchboard Frame

Switchboards are usually supported by angle iron or gas pipe. The latter form of construction has been decided upon as best for the work undertaken. The frame is constructed for three panels of asbestos-wood, three feet wide, four feet high and one inch thick. The iron work consists of eight pieces of ordinary black, inch gas pipe; four of which are six feet long, and the rest three feet in length. To connect the parts together and fasten them to the floor and wall, elbows, waste-nuts, and floor plates are used. The panels are attached to the frame with one half inch by three inch bolts, having polished hexagonal heads.

Since in the laboratory we will often desire to change from the three to the two phase system by a means of transformers, it is well that the system that we propose to use be described. To make this transformation,

the method employed is that invented by Charles F.Scott, in which two transformers are to be used. One in which the ratio of the number of terms of the primary to that of the secondary winding is ten to one, with a tap at the middle point of the former coil; the other must have a ratio of 10 to .867. One terminal of the secondary of the latter is connected to the middle of the former, the remaining three free terminals are connected respectively to the three phase wires. A diagram showing this connection constitutes one of the plates.

From the panel connection can be made by means of the plugs and cables to and from the apparatus just described, after passing through the transformer will be supplied currents displaced in phase by ninety degrees. Thus from the alternating current panel we are able to make at one time tests of single, two,and three phase machines.

For laboratory work it is very necessary to devise some manner of connection at the switchboard to run two alternators in parallel, or to take off of any machine parallel circuits; for this a special form of jack and plug has been designed.

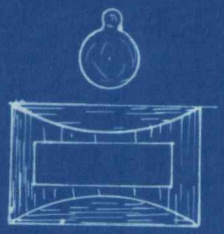
The jack is made of brass, which presents a very neat appearance on the switchboard, and comprises three principle parts. The tube, that is, the part in which the plug is inserted to make connections, is turned from

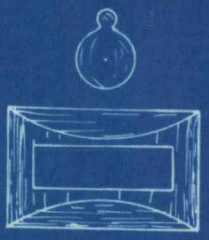
one inch brass rod, with a three eights inch hole through it to receive the plug. The hole in the tube has a special feature that is very important to insure good electrical contact between the tube and plug. The hole after being drilled must then be finished with a special rimmer, thus making it tapering to insure close connection when the plug is inserted. There are two tubes , each two inches long which form part of the jack. On the back of the board the tubes are connected in parallel by means of a brass plate one eight inch thick and having two holes in it through which their ends are inserted and held firmly to place by means of nuts. The brass plates are provided with a stud one inch high at right angles to its plane. A hole is drilled in this connector corresponding to the size of the leads, the end of the wire is then inserted in the hole and soldered making a perfect contact.

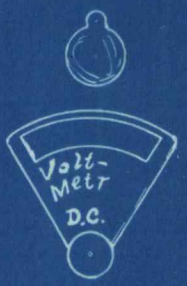
Connections are made with plugs and cable. The plugs are of three eights inch brass rod, one end of which is split so that it will be under compression when inserted in the tube, thus making a safe contact. The plug is five inches long, and three inches of it extend up into the wood handle to be connected to a flexible cable. There is a plug on each end of the cable. The cables are to be from eighteen to twenty-four inches in lenght and of an area of 35,000 circular mills A

cable of the above dimension cross sectional area will carry with safety from seventy-five to one hundred amperes; allowing from three hundred fifty to four hundred fifty circular mills per ampere. This flexible cable is made up of a great number of small copper wires laid together and is well insulated. The plug has hole drilled in one end large enough to accommodate the cable which is enserted in it and then soldered.

The handles are turned from well seasoned oak wood and given a coat of black enamel. The enamel preserves the wood and prevents it from absorbing moisture, also increasing its resistance to a very high degree.







1. 2.
3. 4.
2-Phase Circuit.

1. 2.
Sing.-Phase Circuit.

1. 2. 3. 4.
2-Phase Mains.

Sing.-Phase Mains.

1. 2. 3.
3-Phase Circuit.

1. 2. 3.
3-Phase Circuit.

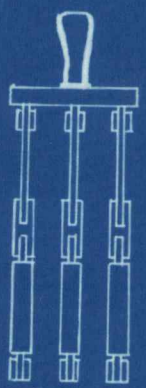
1. 2. 3.
To-Transformer.

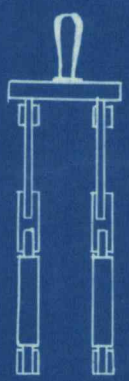
1. 2. 3.
3-Phase Mains.

Machine No. 3

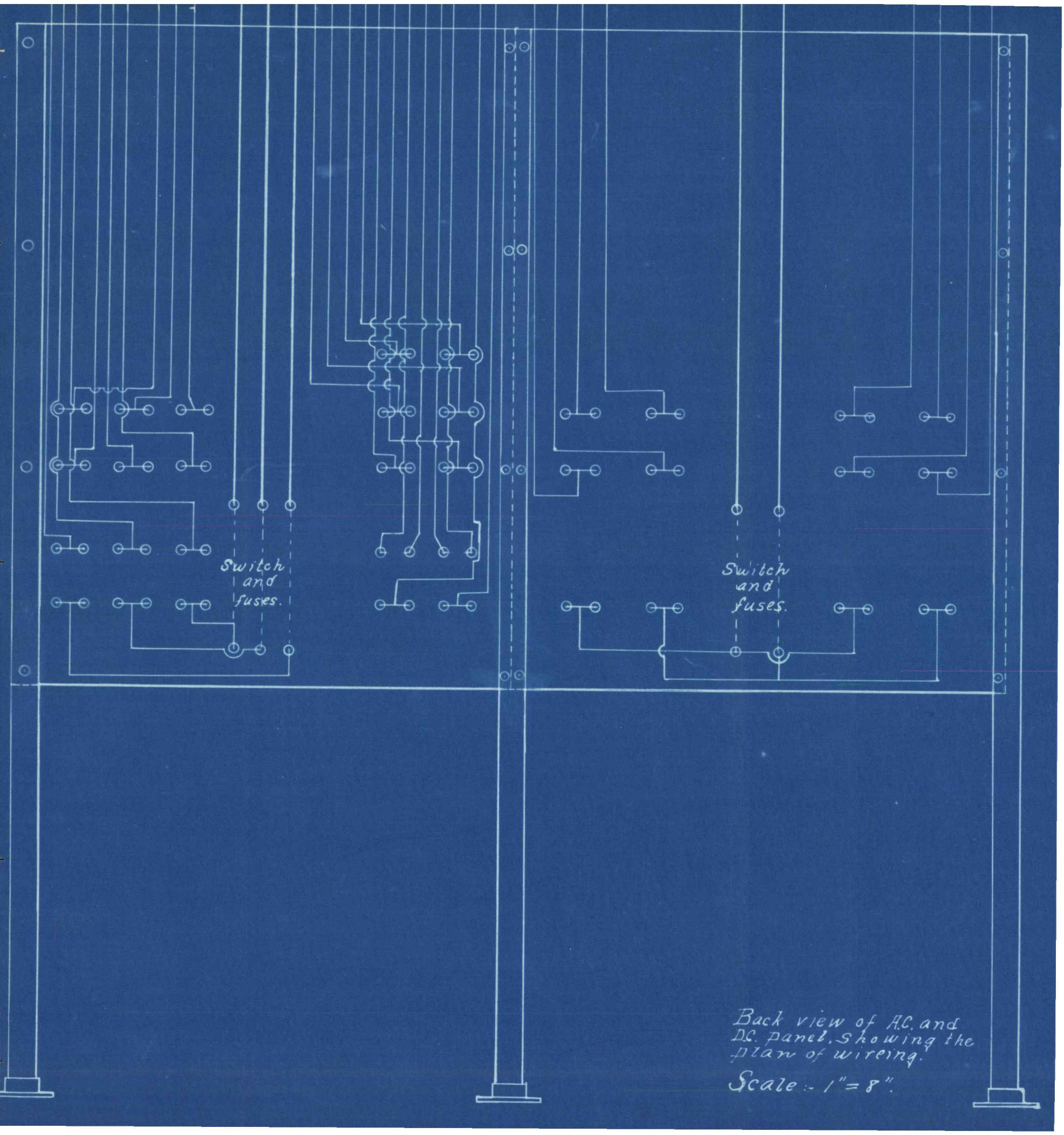
Machine No. 1

Main.
1



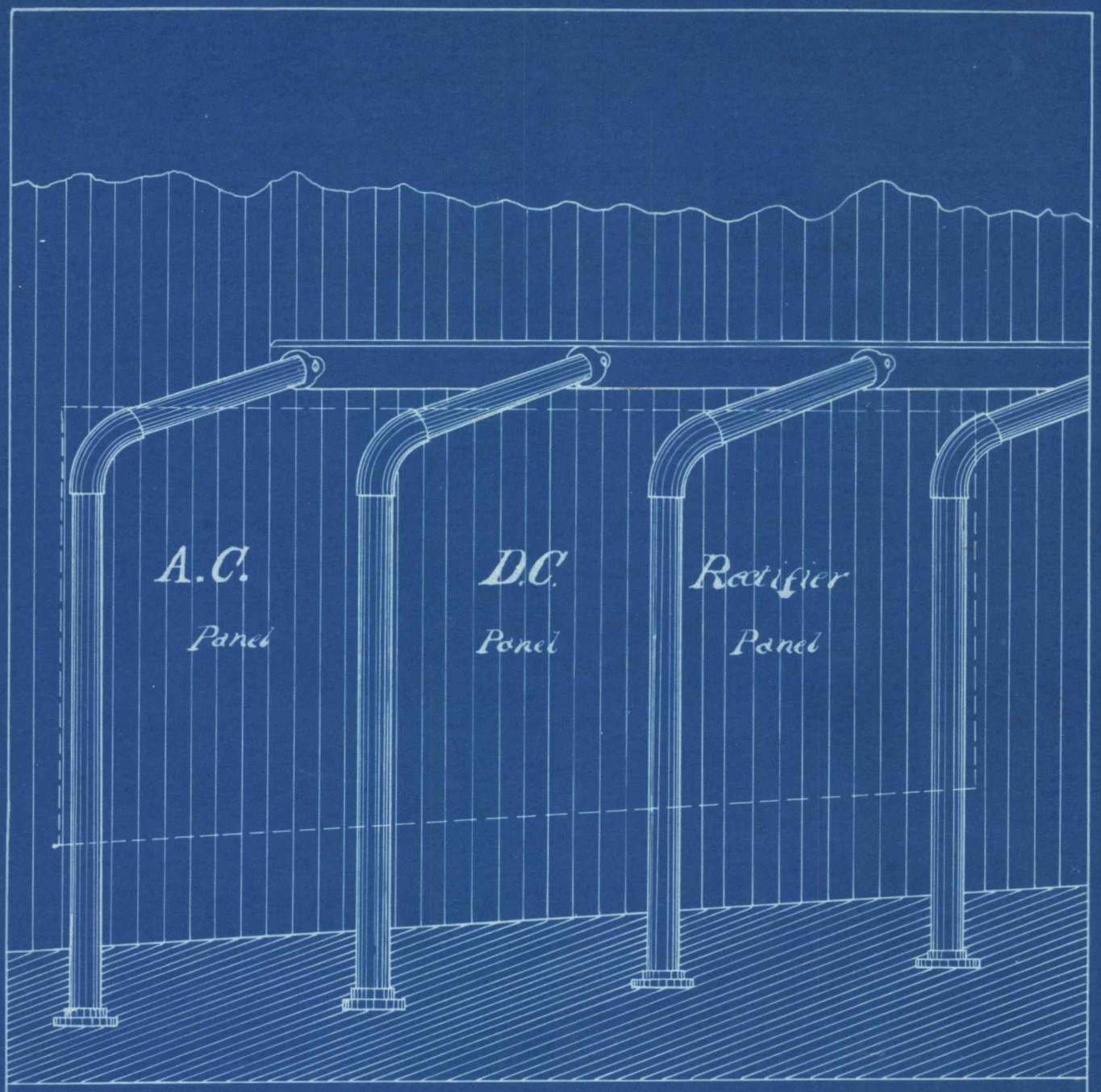


Front view. Scale, 1 to 8.



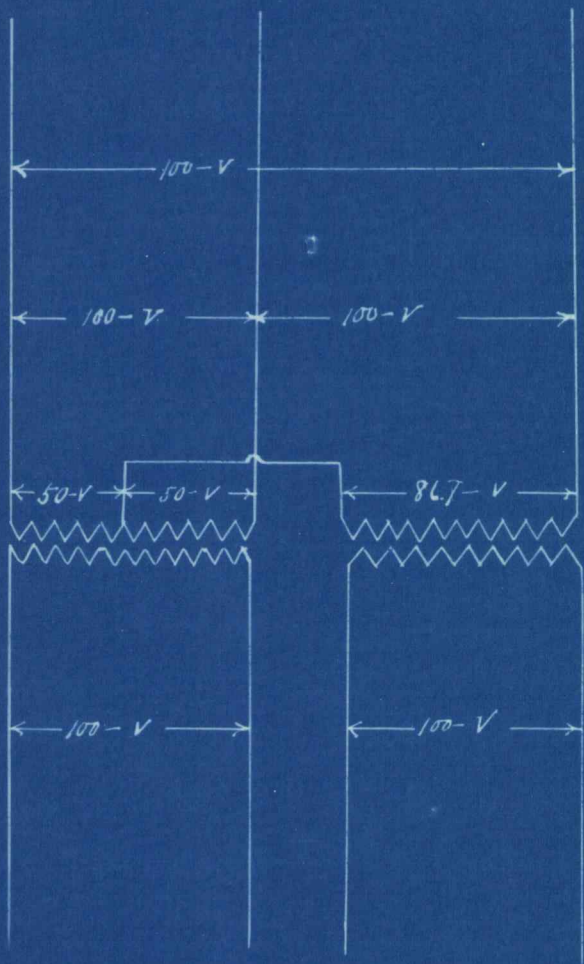
Back view of A.C. and D.C. panel, Showing the plan of wireing.

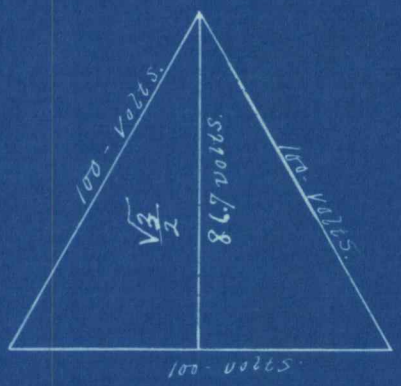
Scale :- 1" = 8".



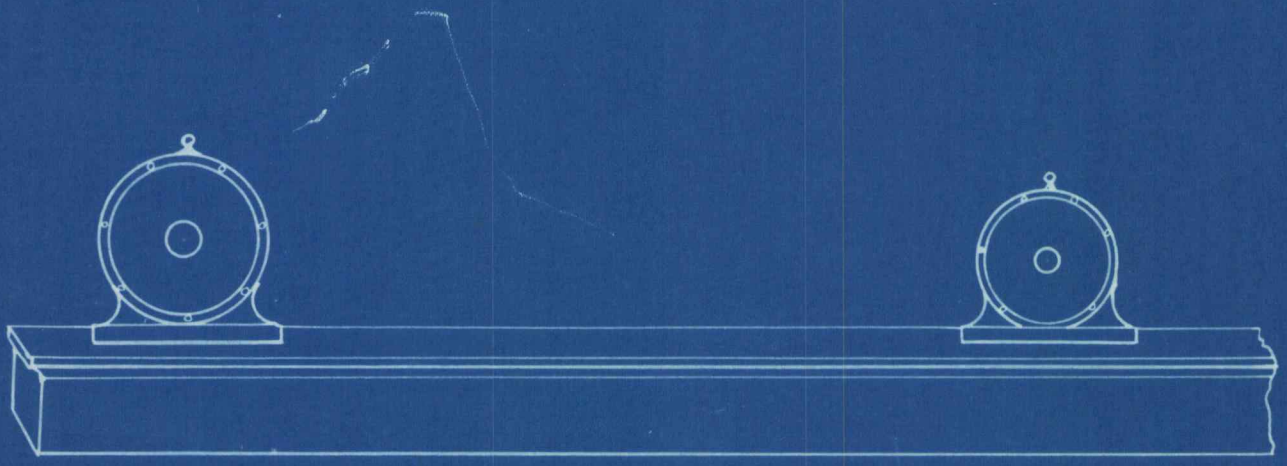
Frame for Laboratory Switch board

Perspective Drawing

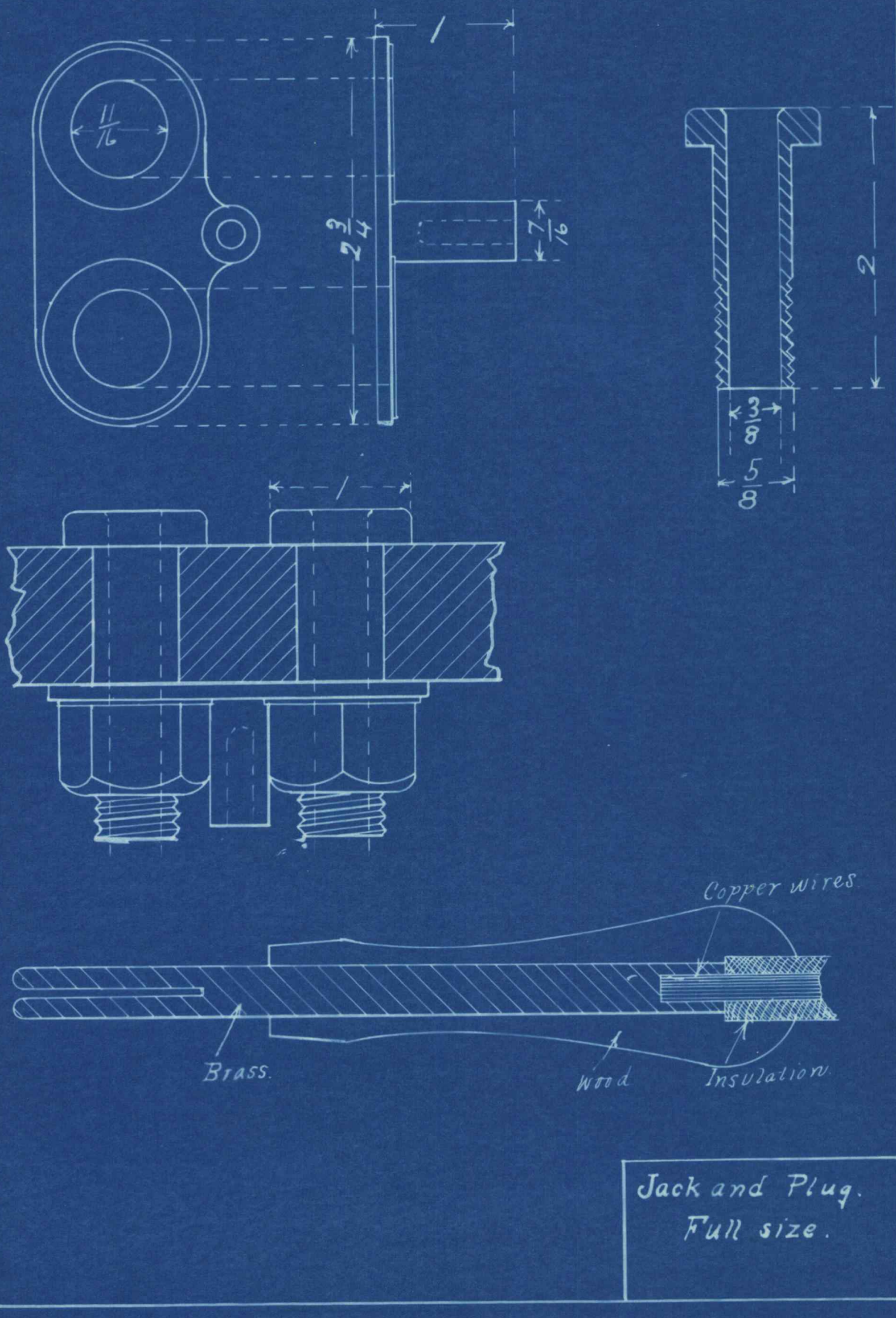




Scott Transformer Connection.



Showing machines
Placed on
raised Platform.



Jack and Plug.
Full size.