REBUILDING A 10 K. W. (110-100,000 VOLT) TESTING TRANSFORMER

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UNDER

DR. CHARLES A. PERKINS

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REBUILDING A 110-100,000 VOLT TRANSFORMER.

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DESIGNERS

This transformer was designed and built by Mr. W. C. Burnley, and C. A. Weigel, in 1908.

The conditions of design were as follows:

Primary E. M. F. 110 Volts.

Secondary E. M. F. 100,000 Volts.

Capacity 10 K. W.

The transformer was of the core type. The core was made of iron, having a thickness of 0.022 inches, (with a value of B = 7000 lines of flux for each square centimeter cross section of the core.) The length of the yoke was 21 inches, and that of the core 16 inches; with a diameter of 7 inches.

The size of the wire on the primary was No. 7 B. & S. guage, with thirty two turns in parallel. The size of the wire on the secondary was No. 30 B. & S. double cotton, covered with 29,000 turns in series. These 29,000 turns were made up in seventy coils, with 415 turns in each coil; the coils being separated by two layers of 1/16" veneering glued together with the grain crossed. The size of the coils was 9½" inside, and

10¾" outside diameter. The wire was wound in a bath of hot paraffine to hold the coils in place until they were put on the boards so that the turns would not come apart.

THE FAULTS WITH THE DESIGN AND CONSTRUCTION OF THE TRANSFORMER:

Trouble first appeared in the primary taking an excessive current and throwing the circuit breaker. This at first led to belief that the core was too small, and that the core was taking an excessive magnetizing current.

Later, when the circuit was closed by throwing the switch, the oil would bubble and the secondary would flash over to the primary; thus making a dead short.

When the yoke and secondary were removed it was found that the paraffine had disintegrated under the influence of the transformer oil, allowing the secondary coils to come apart, and be drawn over to the primary windings by the magnetic or electrostatic attraction between the two coils. This would cause a short circuit, and burn the secondary turns wherever they touched the primary. The turns in the secondary would get crossed, causing a big drop between adjacent turns, causing the cotton insulation to be punctured.

REBUILDING:

The problem to be met in rebuilding the Transformer.

The problem was then to find some substance that would

not disintegrate in transformer oil; but would impregnate the coils and insulate each turn from the turns that touch it, giving the coils a stiff body, holding each turn firmly in its place, to fasten the coils so that no coil or group of coils could shift in its position and come in contact with the secondary.

SELECTION OF INSULATING SUBSTANCE.

In the selection of insulating substances several requirements had to be met before the substance would be suitable for the purpose.

First, it must be a good insulator.

Second, it must have sufficient mechanical strength to hold the turns in place.

Third, it must be applied to that the coils won't be damaged.

Fourth, it must be absolutely insoluble in oil.

In the selection of this insulating substance several things were considered; but were found to be either too dense to impregnate the coils, or soluble in oil. Some of these were beeswax, asphalt, and sealing wax materials.

BAKELITE:

The final product decided upon was Bakelite.

Bakelite is a phenol- formaldehyde condensation product of high dilectric properties, and does not melt or soften by

heat, insoluble in oil, and other solvents, highly resistive to atmospheric agents, and almost all other chemicals. It has great mechanical strength, and is slightly flexible, about as much so as hard rubber. This product has been adopted by the leading electrical concerns of the world for impregnation and for moulded insulation.

This is a patented product and is manufactured by the General Bakelite Company, 100 William Street, New York.

TREATMENT OF SECONDARY COILS:

The coils were first taken from around the core and inspected. Those that were damaged beyond repair were discarded. In replacing the damaged coils new ones were wound on the form used by the original builders of the transformer.

The wire was baked in an electric oven, until all moisture had been driven off, then through a bath of Bakelite on the winding form. A spring was fastened rigidly to the tool holder on the lathe pressed in the groove, and pressed the wires in their places as they came on the form.

Removing the coils from the winding frame was the greatest trouble connected with rewinding the damaged coils. It was found that if the winding form was cleaned by wiping with waste soaked in alcohol, until all the Bakelite was removed, then covered with a thin layer of cylinder oil, the wires would not stick to the plates.

TREATMENT OF COILS:

Those that were not damaged were first wrapped while on the board supports, with cotton thread, care being taken to see that every turn was in its place, so that no turns were crossed. The coils were placed on 12" x 12" wire netting, covered with several layers of paper. They were then placed in an electric oven where a constant temperature of 75 degrees C was held for twelve hours. This temperature melted the paraffine, which was absorbed by the paper. At the end of twelve hours the coils were removed and washed in gasoline to remove all grease and foreign matter. The coils were then allowed to dry for twelve hours, so that all the gasoline would evaporate. (On one occasion the coils were not allowed to dry before being put in the oven, the results were that the gasoline caught fire, destroying ten coils.) Then they were replaced in the oven and baked for twelve hours to remove all moisture and traces of gasoline. After the coils were free from moisture and gasoline, they were dipped in Bakelite, and allowed to remain ten minutes, then removed to drain. They were then turned off the dipping frame on a wire net, covered with a layer of butter paper, to keep them from sticking. The coils were again placed in the oven and baked for twenty four hours; six at sixty degrees C; six at seventy

five degrees C; and twelve at one hundred and twenty degrees C. After the coils had been baked, they were put on the board separators, and fastened by wooden blocks glued around the edges of the coils; then by wrapping tightly with harness thread.

REPAIRING THE PRIMARY:

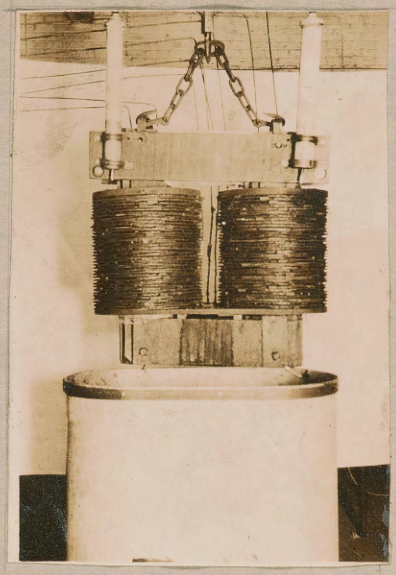
The primary windings were loose and out of place. These windings were rewound and fastened securely at both ends by tying with cords. They were then covered with two layers of light canvas, sewed so that it could not come loose.

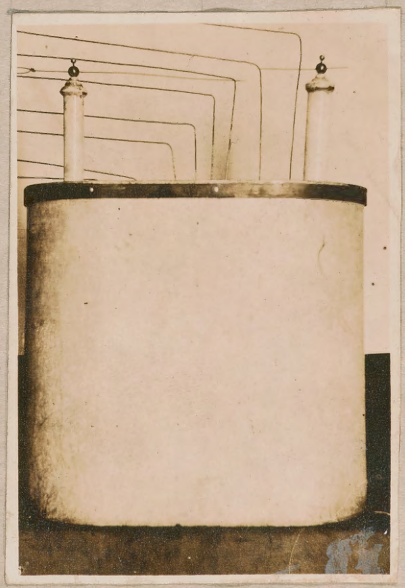
HOLDING SECONDARY IN POSITION:

The secondary coils rest on a board 13" x 27", with two holes 8½" so that it will fit down on the core. In each of these holes six uprights ½" x ⅜" x 14" were placed, the secondary being placed around these uprights, on top of the secondary coils a wooden ring 8½" inside, and 12" outside diameter was fastened to the uprights by wooden pegs. This held the secondary in place, so that it could not slip around in handling.

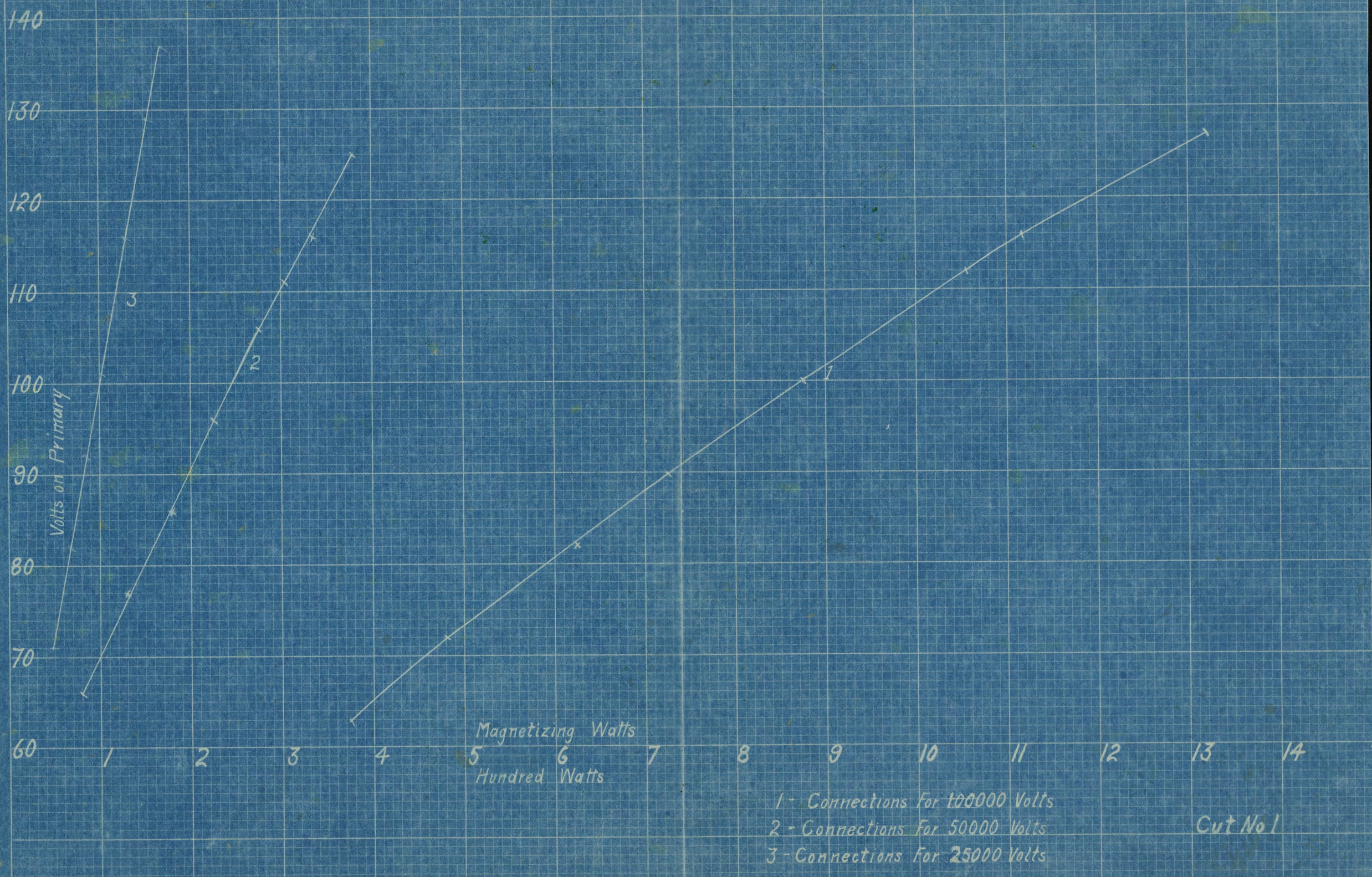
COST OF REPAIRING TRANSFORMER:

Cost of Secondary wire	$ 6.50
Cost of Bakelite	$11.00
Cost of Electricity for oven	$ 2.00
Cost of Canvas for primary	$ .75
Cost of wire netting	$ .75
TOTAL	$21.00





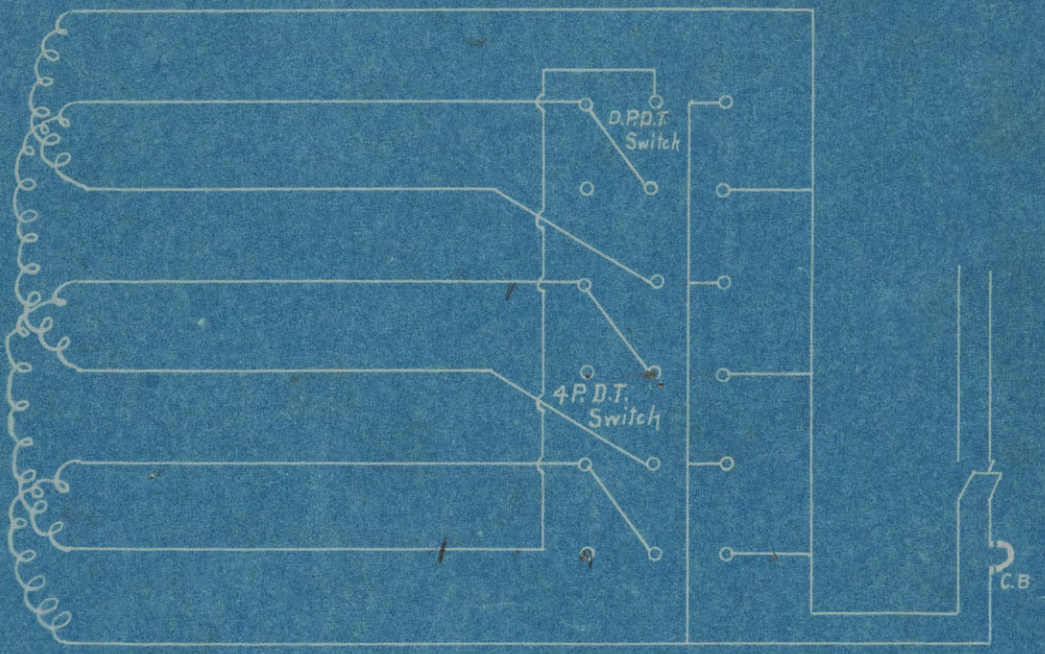
Curves Between Primary Volts and Magnetizing Watts



1 - Connections For 100000 Volts
2 - Connections For 50000 Volts
3 - Connections For 25000 Volts

Cut No 1

Diagram of Transformer Connections



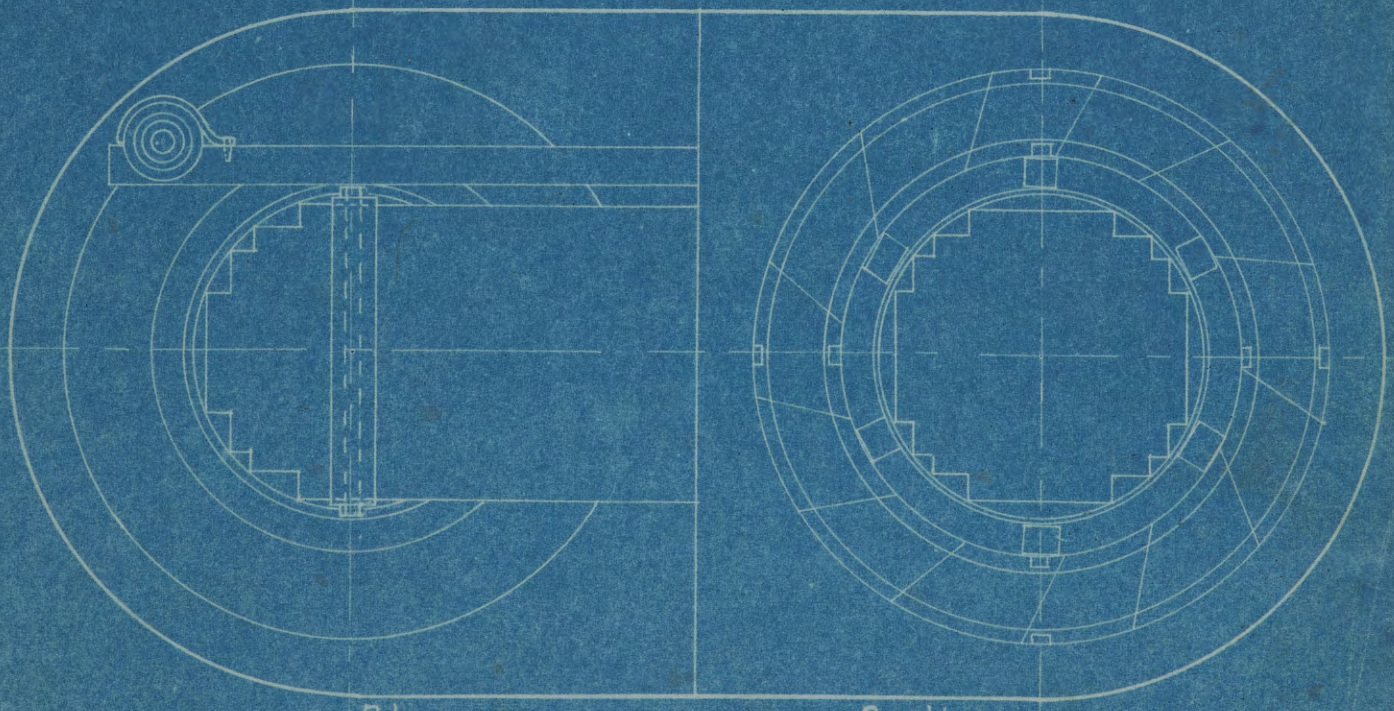
For 100000 volts throw both switches to right
For 50000 volts throw top switch to right and bottom switch to left
For 25000 volts throw both switches to left.

Cut No 2

Table of Magnetizing Current and Watts for Different Voltages

Connections For 100000 Volts			Connections For 50000 Volts			Connections For 25000 Volts		
Amp	Volts	Watts	Amp	Volts	Watts	Amp	Volts	Watts
11.4	63	375	4.4	66	80	1.75	71	48
12.4	72	480	4.75	77	130	1.90	82	67
13.6	82	625	5.0	86	180	2.0	92	85
14.6	90	725	5.3	96	225	2.05	101	102
15.8	100	875	5.5	106	275	2.10	111	120
17.6	112	1055	5.65	111	305	2.13	116	127
18.2	116	1115	5.8	116	335	2.21	129	152
20.6	127	1320	6.0	125	380	2.30	139	170

Top View of Transformer



Plan Section

Cut No 3