TYPE SL CORE FORM TRANSFORMERS

INSTRUCTIONS

WINDINGS

The windings of Westinghouse Type "SL" Transformers are made with special electrolytic oxygen-free copper conductor. This copper conductor is manufactured without melting by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special copper conductor prevents insulation failures resulting from surface imperfections in the conductor.

The insulation applied to each conductor consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought out from the center of the coil stack. With this arrangement the tapped portion of the winding is not exposed to line surges, and the electrical centers are more nearly balanced on all connections.

All coils are circular in form and, in general, may be classified as follows:

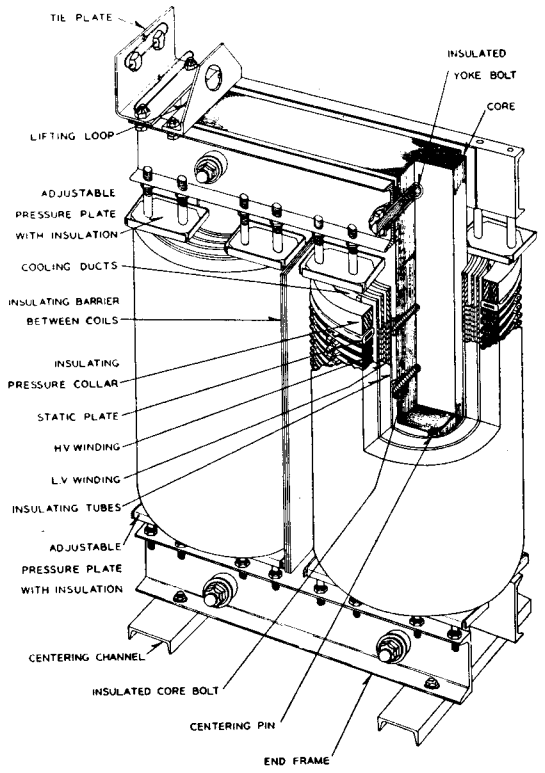

FIG. 1—SECTIONAL VIEW OF A SINGLE PHASE CORE FORM TRANSFORMER

CYLINDRICAL COIL

The cylindrical coil for voltages 8.7 kv. and less consists of one or more layers of insulated conductors wound on a Micarta cylinder. Each conductor consists of a number of copper ribbons of suitable cross-section in parallel which are properly transposed to minimize eddy losses. Micarta collars of suitable form are placed at the ends of the layers and anchored in place to give the necessary electrical and mechanical strength. The copper conductors on the edges of adjacent turns are taped with extra insulation giving additional turn-to-turn insulation strength. Ducts are supplied for the cooling medium so that coil temperature gradients are kept uniformly low.

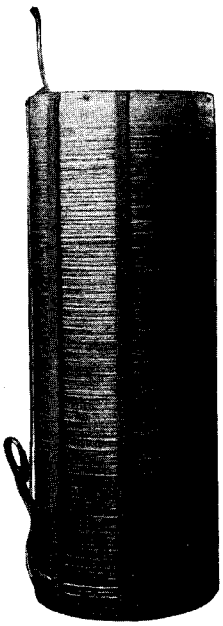

FIG. 2—CYLINDRICAL COIL WINDING

CONTINUOUS-WOUND PANCAKE COIL

The continuous-wound pancake coil for voltages above 8.7 kv. consists of a number of circular disc coil sections, of rectangular strap conductor with one turn per layer, wound by a continuous process with no joints at section connections. The conductor may consist of one or more copper ribbons of suitable cross-section and where multi-conductors are used in parallel, they are properly transposed throughout the coil to minimize eddy losses. The circular disc

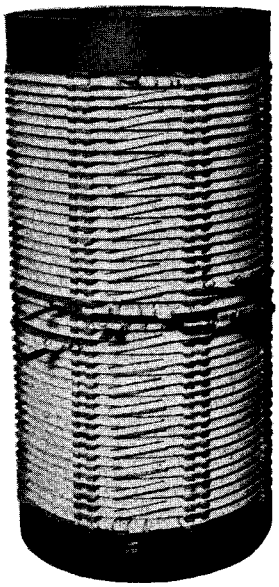

FIG. 3—CONTINUOUS WOUND PANCAKE COIL WINDING

TYPE SL CORE TRANSFORMERS—Continued

INSTRUCTIONS—Continued

sections are wound on vertical insulating spacers placed over a heavy insulating cylinder and are spaced from each other by radial insulating spacers. These spacers are held in place by being dovetailed together. A heavy insulating collar is placed at the ends of the coil for electrical and mechanical strength. The thickness of the coil section is the width of the conductor and each conductor is exposed to the cooling medium. The edges of the conductor do not touch; only the flat sides are in contact, thus eliminating the danger of mechanical forces cutting the insulation. This type of winding gives the highest capacity per unit of space and permits free circulation of the cooling medium. Hot spots are eliminated and high thermal efficiency results.

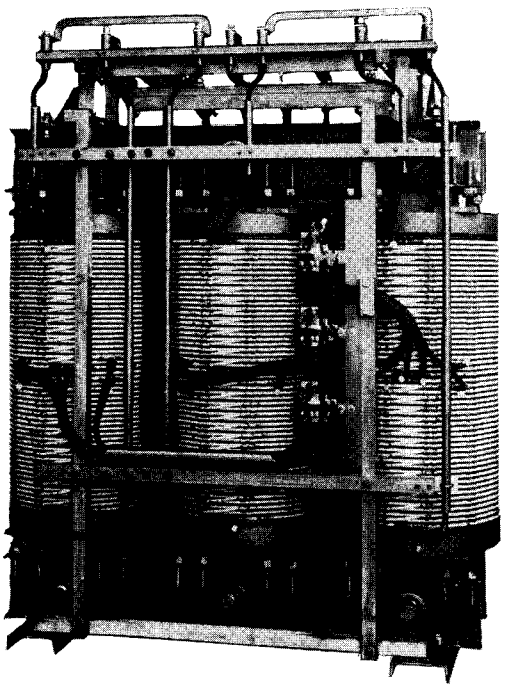

FIG. 5—CORE AND COILS OF A 6000 KV-A., 34.5 KV. 60 CYCLE CORE FORM TRANSFORMER

DOUBLE-SECTION PANCAKE COIL

The double-section pancake coil, in general, is used for voltages above 8.7 kv. and current ratings in excess of two hundred and fifty amperes and for very large coils. It consists of two circular disc sections of rectangular strap conductor with one turn per layer. The conductor may consist of one or more copper ribbons of suitable cross-section. When copper ribbons are used in parallel, they are properly transposed between the sections to keep eddy losses to a minimum. The circular disc sections are spaced from each other by insulating washers or radial spacers. The thickness of the coil section is the width of the conductor and each conductor is exposed to the cooling medium. The edges of the conductor do not touch; only the flat sides are in contact, thus eliminating the danger of mechanical forces cutting the insulation.

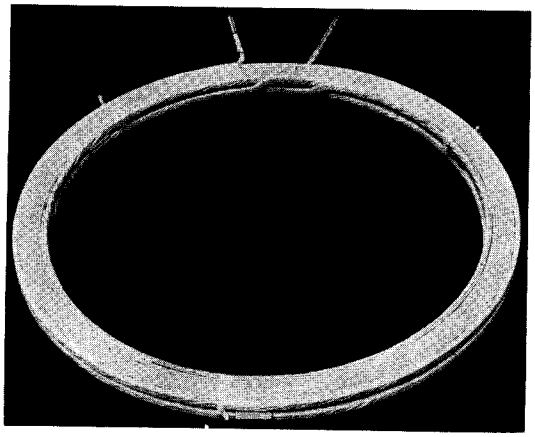

FIG. 4—DOUBLE SECTION PANCAKE COIL SHOWING TRANSPOSITION

ROUND-WIRE PANCAKE COIL

The round-wire pancake coil is used for high voltages and current ratings of less than ten amperes where it is necessary to obtain a large number of turns in a minimum space. It is circular in form and consists of a number of layers with several turns of round paper-covered, enameled wire per layer. This coil is wound on an insulating foundation ring with a length equal to the thickness of the coil. The layers of conductor are spaced from each other by insulating sleeves of crimped paper. The sleeve insulation consists of a strip of paper around the end turn forming a double thickness of paper insulation between the layers of conductor. The crimped paper insulation has an extension at each end of the layer. Where it extends beyond the conductor it is crimped forming a small collar.

Reenforcing segments are placed in the coil near the outer edge during the winding and are spaced so that they are directly under the radial spacers. The width of the segments is the same as the length of the insulating foundation ring. This construction gives maximum mechanical strength due to the fact that the pressure on the coil stack is transmitted from coil to coil through the foundation ring and the segments, thereby eliminating pressure on the wires of the coil.

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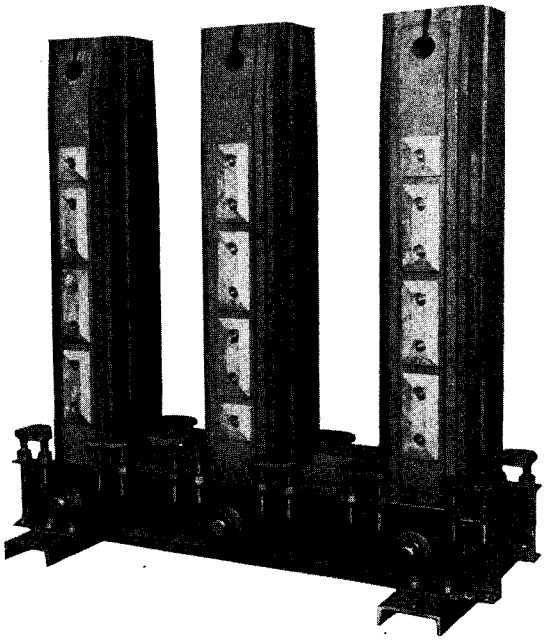

FIG. 6—PARTIAL CORE ASSEMBLY FOR A THREE PHASE CORE FORM TRANSFORMER

HELITRAN COIL

The Helitran coil is spirally wound and, in general, is used for medium voltage and high current. The conductor consists of several insulated copper ribbons in parallel properly transposed throughout the winding to reduce the eddy losses to a minimum. This coil is wound over vertical insulating spacers on a heavy insulating tube with the layers spaced from each other by radial insulating spacers. The radial and vertical insulating spacers are dovetailed together giving electrical and mechanical separation and providing ventilating ducts for the circulation of the cooling medium. The ends of the winding are rigidly held in place by properly anchoring the leads and by the use of heavy insulating collars at the ends of the coil. This type of coil construction gives high insulation strength and uniformly low temperature gradients.

ASSEMBLY OF WINDINGS

Coils of the cylindrical type require no further individual assembly after winding.

Continuous wound pancake coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

Double section pancake coils are assembled in stacks on their insulating cylinder. They are separated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The joints between coils are made by brazing, no solder being used. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Round wire pancake coils are assembled in stacks on their insulating cylinder. They are separated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Helitran coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

The high and low voltage windings are assembled concentrically on the core with the low voltage winding nearest the core leg. The low voltage winding is centered on the core leg by four maple rods driven tightly in four corners of the cruciform leg between the core and the low voltage insulating cylinder. The high voltage winding is separated from the low voltage winding by one or more insulating cylinders and vertical spacing strips. For the higher voltages the cylinders have interleaved with them at the ends—insulating angle rings.

At the ends of the stacks of coils are placed heavy insulating collars interleaved where necessary with angles and washers. These give the required insulation strength and a mechanical structure between the coils and pressure plates which is more than adequate to withstand the mechanical forces set up under short circuit.

All leads, except the very short ones, are run in insulating tubes and are rigidly supported at frequent intervals. They present a neat appearance and are free from vibration or distortion under short circuits.

INSULATION

The major insulation of Type SL transformers consists of insulating cylinders and oil ducts so proportioned as to give the necessary dielectric strength and, at the same time, allow the cooling oil to flow naturally across at least one side of all turns. All units are designed to withstand the standard A.I.E.E. impulse and low frequency tests. Impulse strength is obtained by predetermining the stress at each point of the winding and providing at each point the necessary insulation. This is done by placing at the ends of the stacks of coils an insulated static plate and using uniform insulation throughout, based on the maximum stress at any point. Shields or constructions which offer insulation hazards to other coils and to ground, as well as interfere with oil circulation, are not used.

TREATMENT

Individual coils before assembly are not treated in varnish, gums or similar compounds. This assures freedom from surface coating which might prevent proper oil impregnation.

After assembly the core and coils are preheated, and then thoroughly dried under vacuum in a heated oven. While still hot and under vacuum they are impregnated with transformer oil. Small units whose tanks naturally will withstand a vacuum, and all units above 46

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kv., are filled with oil under vacuum in their own tanks after complete assembly.

CORES

The magnetic circuit for the Type SL transformer is rectangular in shape with a rectangular opening, or openings, and is built from I-plates with interleaved corner joints. The laminations of the legs are stepped in width to approximate a circular section to fit the round coils. The core plates are sheared from perfectly flat sheets of the highest grade of non-aging silicon steel and are annealed after shearing to eliminate the possibility of localized heating and high loss caused by shearing strains. Each lamination is given a coating of a heat resistant insulating compound before stacking. The laminations are bolted together into a rigid mechanical structure by means of insulated core bolts. For the larger cores, clamping plates are used with the bolts to give uniform pressure over the surface of the laminations.

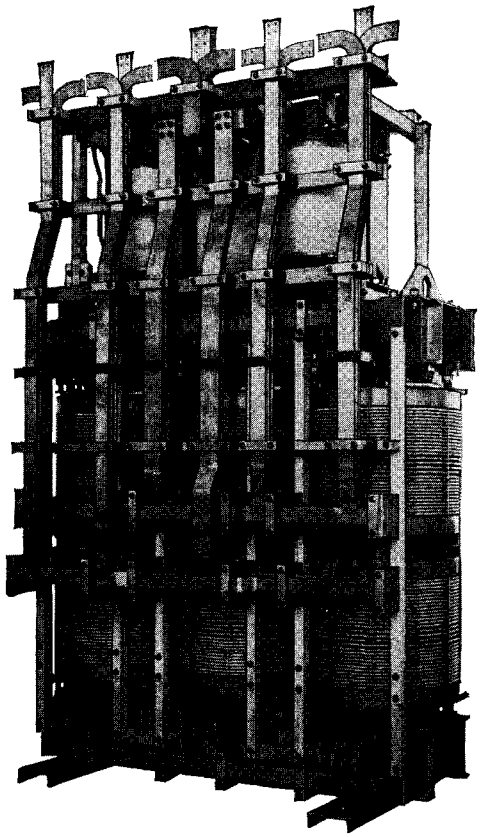

FIG. 7—CORE AND COILS FOR 12 PHASE, 6000 KW. 600 VOLT RECTIFIER TRANSFORMER WITH INTERPHASE TRANSFORMERS MOUNTED ON UPPER END FRAME

COIL BRACING

The magnetic core itself absorbs the stresses which result when the transformer is short circuited. On each side of the top and bottom members of the core is bolted a steel channel, or end frame, by means of heavy insulated bolts passing through the yoke at the center of each leg. The coils are clamped between these channels by means of adjustable steel pressure plates which have jack screws extending through the flanges of the channels.

Between the pressure plates and the coils there is placed a heavy insulating ring, which distributes the pressure uniformly over the circumference of the coils. Both the high voltage and the low voltage coil stacks are pressed while hot to a predetermined height, which is the same for both. They are then assembled on the core and both stacks are clamped by the same pressure plates. This system has two important results: First; clamping each stack under pressure while hot, permits building with an accurately determined column length. Second; the use of a common pressure system for both stacks assures assembly with the electrical centerlines in the same horizontal plane and prevents any subsequent shifting. Since the stress developed on short circuit depends on a vertical displacement of the electrical centerlines, the method used on these transformers to build and brace the coils is ideally suited to minimize such stresses.

HANDLING AND BRACING

The core and coil structure is lifted as a unit by means of lifting lugs bolted to the top end frames and located as near as practical over the center of the outer legs. Since the end frames are bolted to the core through the center of the legs, the lift is made in line with the center of support of the structure and there is no tendency for the end frames to deflect and release the clamping forces on the coils. The transformer is centered in its tank by lugs welded to the tank bottom which bear against channel feet bolted to the bottom end frames. At the top of the core, tie plates are bolted to the end frames and to pads welded to the tank wall. The bolts and nuts used with the tie plates are of heat treated steel and are drilled and wired to provide a positive lock.

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