AIR SWITCH FOR CSP POWER TRANSFORMERS
INSTRUCTIONS

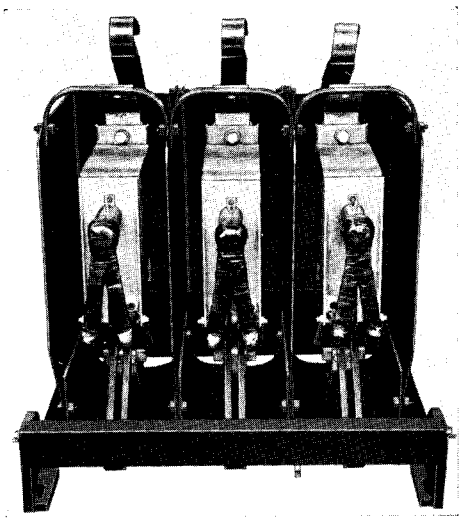

FIG. 1—COMPLETE TYPE U DE-ION AIR SWITCH FOR CSP POWER TRANSFORMER

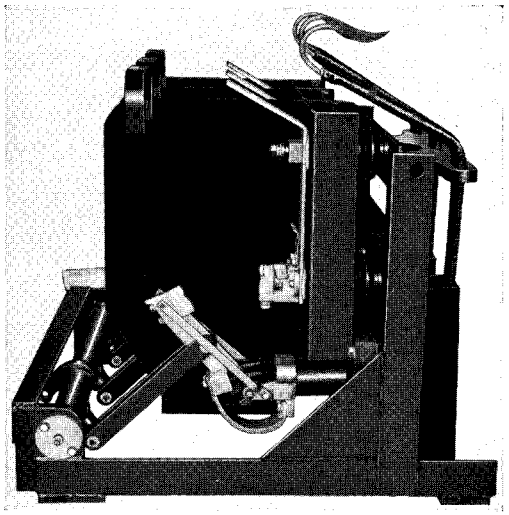

FIG. 2—AIR SWITCH WITH DE-ION CHAMBER AND SIDE INSULATING BARRIER REMOVED.

GENERAL

The air switch which is used on "CSP" Power Transformers is essentially the same as standard Westinghouse type U, De-ion air circuit breaker but is modified to adapt it to use as an integral part of the "CSP" Power Transformers. It is so designed and mounted that all normal maintenance can be made without removing the air switch from the tank. Since no oil is used, oil maintenance is eliminated.

CAUTION: If the transformer is allowed to stand de-energized, place a heater in the air switch compartment to prevent condensation of moisture in the air switch arc boxes.

PRINCIPLE OF OPERATION

The theory of operation of the De-ion air breaker is unlike that of any previous conventional breaker. Oil circuit breaker arc extinction is based upon the theory of the extinction of the long A-C. arc. The De-ion air circuit breaker theory concerns the short A-C. arc.

In this circuit breaker an arc is drawn in air and forced into a de-ionizing chamber where it is broken up into a multiplicity of short arcs which are moved over metal plates at a velocity sufficient to prevent burning. This movement of the arcs is maintained over an annular path until the current wave reaches zero, after which the arcs between the metal plates are de-ionized simultaneously, quickly changing from a good conductor to a good insulator. Thus, the arc is prevented from re-establishing and the circuit is thereby interrupted. See Fig. 3.

Investigation of the fundamental principles governing the conduction of electrical energy in a gas such as air, indicates that a thin layer of air immediately adjacent to the cathode (copper plate in de-ionizing chamber) regains its insulating qualities almost instantly, while the remainder of the arc path builds up at a much slower rate. As the current wave in an alternating-current arc approaches zero, and for a short time immediately following zero, the factors producing new ions in the arc path have practically ceased their activity. Initially the density of positive ions and electrons may be considered as substantially equal throughout, but the application of an electric field, due to the recovery voltage, disturbs this equality and the field becomes distorted. At the cathode (copper plate in stack) electrons are repelled and positive ions are attracted. A positive space charge, therefore, develops in front of each copper plate which increases the dielectric strength there. Thus a thin layer of air immediately adjacent to each of the plates, the cathode layer, becomes de-ionized in an exceedingly short space of time.

Theory and experiment indicate that the first 250 volts, peak value, or about 175 volts R.M.S. value, are borns almost entirely by each cathode layer and that the ability to withstand thie voltage is attained in a fraction of a microsecond. In order to provide a factor of safety in breaker design, sufficient gaps are used to give a working stress of about 110 volts per gap.

In the De-ion circuit breaker a single long arc drawn between the contacts is broken up into a large number of short arcs in series, each short arc no longer than the width of the thin air space between the plates. Since each short arc can withstand 110 volts almost instantaneously after zero current, 100 short arcs for instance, can withstand 110 x 100 or 11,000 volts and interrupt such a circuit. This is the principle upon which the De-ion circuit breaker operates.

Due to the fact that the metal plates of the de-ionizing chamber are insulated from each other, the restored voltage will not be distributed equally among the arc spaces and some would be overstressed in voltage and others would be understressed. For this reason, on the higher voltage breakers, static shields are applied to give a substantially uniform distribution of voltage over the spaces between the plates.

From the time the arc leaves the arcing contacts, it must be handled as a cold cathode arc; in other words, it must be kept moving fast enough to prevent metal at the arc terminals from

Air Switch for CSP Power Transformers—Continued

INSTRUCTIONS—Continued

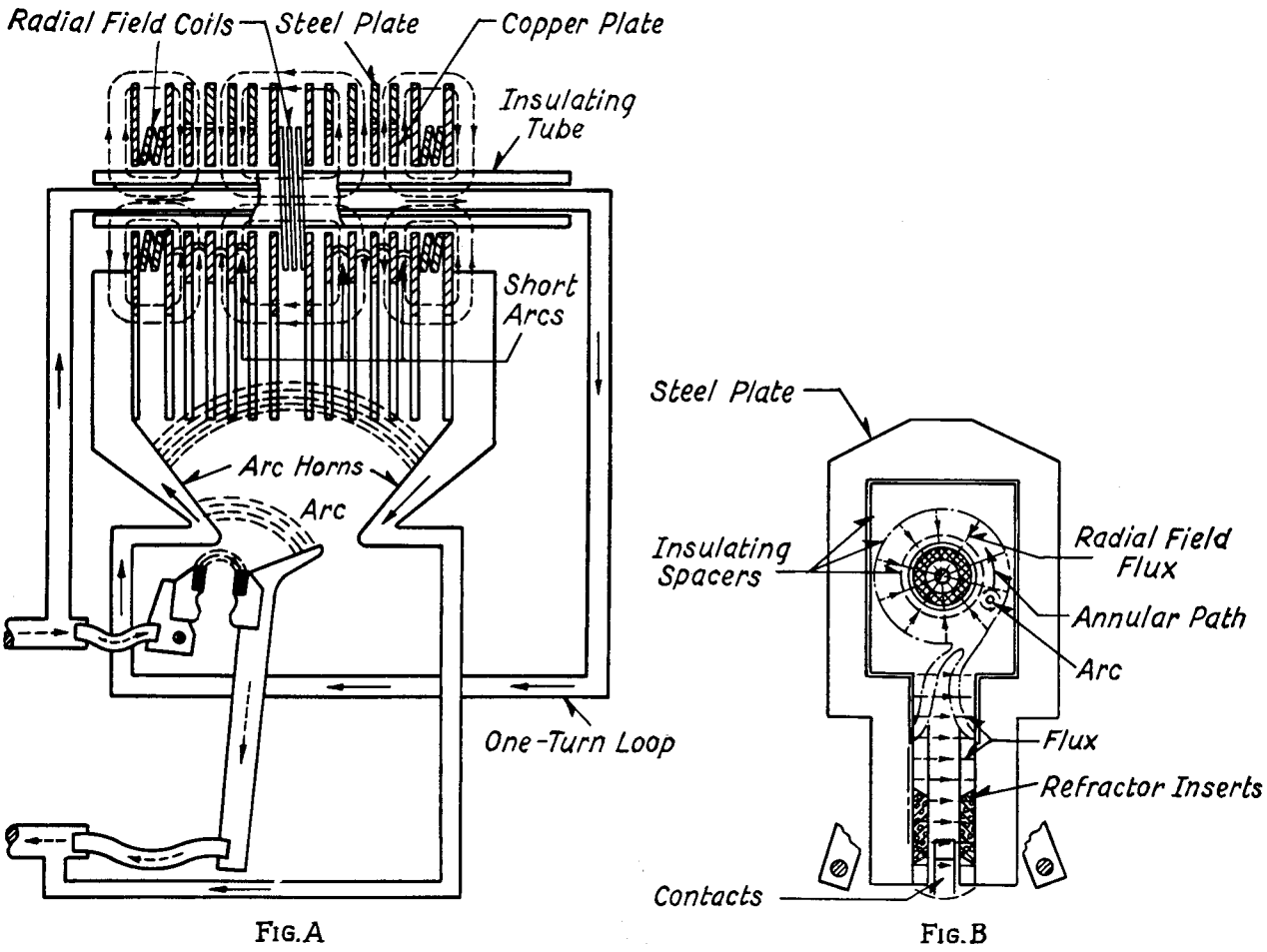

FIG. 3—TYPICAL ARRANGEMENT OF COMPONENT PARTS SHOWING METHOD OF DRAWING AND EXTINGUISHING THE ARC IN THE TYPE "U" DE-ION AIR CIRCUIT BREAKER

burning. Tests indicate the arcs travel over the de-ionizing plates at several times the velocity of sound. A specially designed blow-in magnet produces this rapid movement of the arc from the point at which it is drawn on the contacts to the transfer to the de-ionizing plates where it is cut into a series of short arcs. These arcs travel at a very high velocity and the action which is finally to dispose of them cannot take place until the current zero is reached. Radial coils, in series with the arc, arranged between the plates at intervals throughout the stack produce a circular motion of the arcs at high velocity during whatever period may remain of the particular half cycle in which they were transferred to the plates.

Although a description of this process of operation may seem lengthy, the time required for the De-ion air breaker to interrupt the circuit is very short. For current above a few hundred amperes, the arc is drawn at the arc tips, moved into the stack of plates and interrupted within one cycle of arcing or less.

THEORY OF OPERATION

The de-ionizing chamber is built up of copper plates insulated from each other to form a series of gaps, as shown in Fig. A. Each copper plate is partially surrounded by a steel plate of the same thickness, Fig. B.

As the contacts separate, the arc is drawn as shown in Fig. A, and the circuit is completed as indicated by the broken arrows. It rises due to the magnetic field of the arc current, impinges on the arc horn immediately above, and currents begins to flow through the one-turn loop. The individual steel plates act as a magnetic yoke which, when energized by the one-turn loop, supply additional magnetic field for moving the arc into the plate structure.

When the arc impinges on the copper plates, the radial field coils are introduced into the circuit. These coils supply the field for spinning the arc around the annular path, in the same manner that the armature conductor of a series motor is driven in a circular path by the field of the motor. The arc, as shown, is now broken up into a number of short arcs. The spinning action continues until a zero point occurs in the current. At that instant the circuit is interrupted.

Air Switch for CSP Power Transformers—Continued

INSTRUCTIONS—Continued

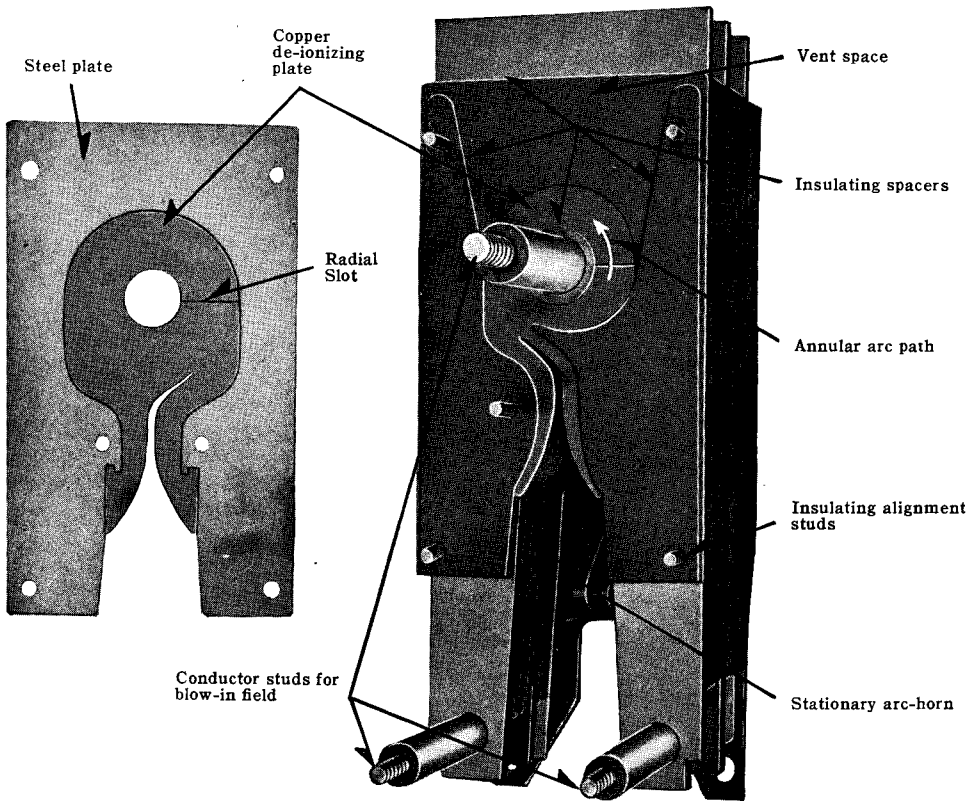

FIG. 4—PARTIALLY ASSEMBLED DE-IONIZING CHAMBER OF TYPE 25-U-25 DE-ION AIR CIRCUIT BREAKER

NOTE—The copper and steel plates are arranged in pairs in the same plane. These pairs of plates are spaced apart by the insulating spacers which are so shaped as to define the annular path in which the short arcs rotate and also to form individual vents for each short arc. The radial slots in the copper plates reduce eddy currents in these plates which in turn prevents weakening of the magnetic fields for rotating the short arcs in the annular paths.

Of course this action takes place much more quickly than it can be described. Complete interruption of the arc—drawing, moving it into the gaps, and spinning it—usually requires only one-half to one cycle on a 60 cycle wave. The arc may be spun at the rate of 20 revolutions per half cycle.

Details of the plates are shown in Fig. B. Refractory inserts insulate against the heat caused by the arc as the contacts open. The flux, indicated by dotted arrows, forces the arc into the annular path where it is spun around under the influence of the radial flux field. The bars, part of which are shown on each side at the bottom, are connected to the conductor in the center of the annular path and are shown more clearly in the picture of the entire circuit breaker.

CONSTRUCTION

A **three-pole breaker** consists of three de-ionizing chambers or stacks and a solenoid operating mechanism.

The **de-ionizing chambers** are mounted at the extreme top of the structure and are so arranged that an arc drawn on the arcing contacts is driven directly into it by a magnetic blow-in field.

The de-ionizing chamber consists essentially of a stack of thin copper plates spaced a short distance apart by thin insulating spacers so that one surface of each plate forms the cathode of a short arc, the general arrangement being as shown in Fig. 4 which is a view of a chamber partially dismantled. It is this part of the circuit breaker which actually interrupts the arc.

The arc is drawn at the two contacts shown below the arc horns which extend downward from the two ends of the plate stack. It is blown, by means of a powerful magnetic field, upward along the horns and against the plates. Each plate is similarly shaped with a tapered slot at the lower end. As the arc enters the tapered end slots, it diminishes in size which causes it to require a higher voltage and as a result, when the arc reaches the ends of the slots, it attaches itself quite readily to the plates, forming a short arc between each pair of plates. The arcs are then caused by magnetic fields to move very rapidly over the surface of the plates, around the circular pathway, until a zero point occurs in the current wave, at such a high velocity that no metal is burned.

Air Switch for CSP Power Transformers—Continued

INSTRUCTIONS—Continued

With this annular path for the arc a very important advantage is obtained. The de-ionizing structure becomes an almost completely closed structure. The arc, when driven in, cannot get out again, and stays in until its extinction at the end of a half-cycle.

The De-ionizing chamber may be raised for the purpose of inspecting the contacts and other parts which are inaccessible when the stack is in the normal operating position. A special lifting device may be furnished for the purpose of raising the stack and holding it up for inspection purposes.

The air switch is mounted on a frame which sets in the compartment of the tank and is fastened in place by four bolts.

MAINTENANCE

Regular periodic inspections of the air switch should be made to see that it is kept in first class condition. The frequency of the inspections and the amount of maintenance of the contacts will depend upon the severity of the service which the air switch is called upon to give.

To inspect the contacts and De-ion chamber, the chamber should be removed. This is accomplished by removing the two bolts at the lower front corners which fasten the chute to the supports and removing the large bolt at the center of the top. The arc chute can then be lifted vertically far enough to disengage the spring contact clips, in the back and pulled forward, using the chute lifter as illustrated in Figure 5.

The arc chamber may be inspected roughly by viewing from below with a flashlight or other suitable light. If there are indications of severe burning or excessive deposits of carbon, the arc box may be cleaned with a file or sandpaper.

For a more thorough inspection, each gap between pairs of copper and steel plates may be "lighted" or "rung" out with a light or bell ringer at not more than 250 volts per gap. Each gap should be open, but in case of extremely severe duty, some may become short-circuited by particles being blown from the arc box or contacts. Loose particles may be removed by blowing out the chamber thoroughly with dry compressed air. If this does not remove the particles, pass 100 to 200 amperes at not more than 125 volts A-C. through the shorted gaps. This may be applied by thin copper straps inserted between the copper plates on each side of the shorted gaps. This should burn the gaps clean instantly but any short-circuits not removed by this treatment can be left until such time as the stack is disassembled. In an emergency a chamber may be used with as many as 15 per cent of the gaps short-circuited but it is recommended that any chambers having shorted gaps which do not clean up with the above treatment be disassembled and any damaged parts be replaced.

The contacts should be inspected. See that the bolts holding the contacts in place are tight. Under normal conditions the contacts should be good for a large number of operations at rated rupturing capacity of the breaker. A moderate amount of burning on the main contact surfaces will not impair their current carrying ability on account of the high contact pressure used. However, if the contacts show signs of excessive burning, they should be checked as follows:—With the hand closing lever, move the contacts toward the closed position until they just touch. In this position the clearance between the lower or main contact surfaces should be approximately $\frac{1}{8}$". In the latched or completely closed position of the breaker the clearance between the arc tips should be approximately $\frac{1}{16}$" or less but not touching.

Inspect the switch structure in general and see that all bolts, nuts, set screws, etc. are tight and that all spring cotter pins, etc. are in place. Note evidence of excessive wear or other improper operation of the various parts. In operating the breaker by hand there should be no binding or excessive friction.

Note:—When the transformer on which the air switch is mounted is energized, the heat from the transformer will prevent moisture condensation on the switch insulation. But if the transformer is de-energized, this heat will not be available and a heater must be supplied. This heater should be at least 1000 watts, and at least 1500 watts if the ambient temperature is subject to rapid temperature changes.

At the time the air switch is inspected, a small amount of oil should be put on the bearings of the metal pull rods.

RENEWAL PARTS

In case renewal parts are required, order from the nearest Westinghouse Electric and Manufacturing Company Office, or direct from the Sharon, Pa. Works, giving description of parts required and serial and shop order number as stamped on the nameplate on the transformer.

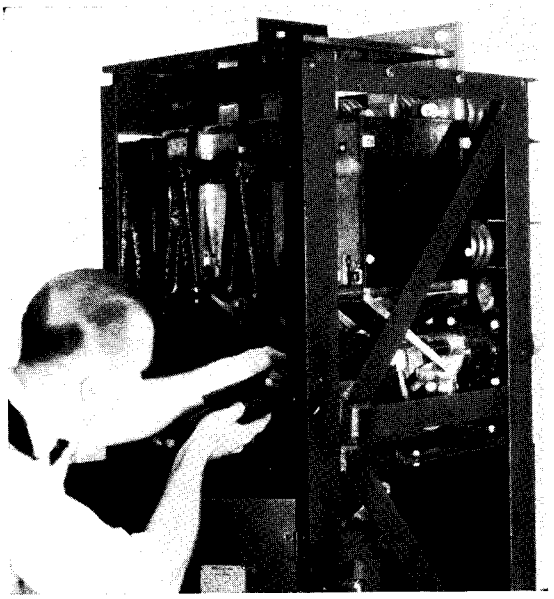

FIG. 5—METHOD OF LIFTING DE-IONIZING CHAMBER

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