



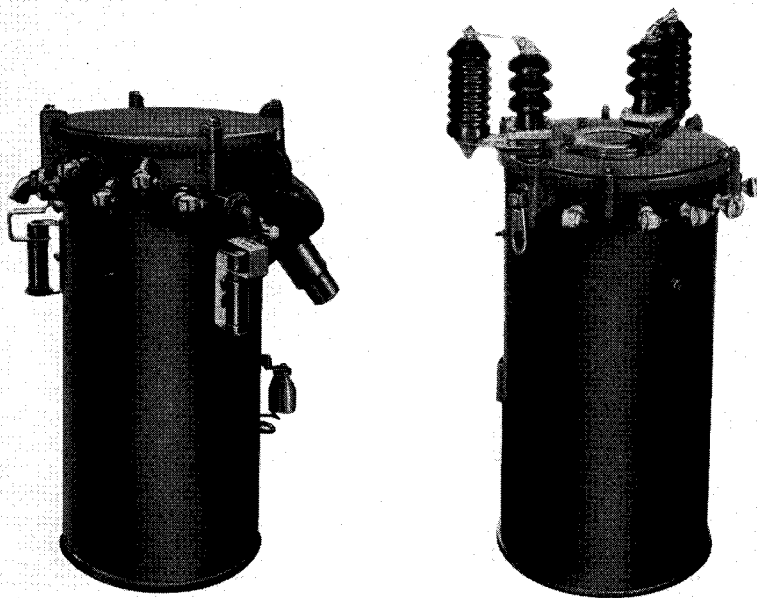
INSTRUCTION BOOK

Oil-Immersed
DISTRIBUTION
TRANSFORMERS
For Secondary Banking

Westinghouse Electric Corporation

L. E. 46-150-1

“CSPB” and “CPB” Oil-Immersed DISTRIBUTION TRANSFORMERS For Secondary Banking



This instruction book has been prepared to assist the purchaser in properly installing, operating and maintaining the CSPB and CPB distribution transformers supplied by Westinghouse. The methods and recommendations presented are based on the best practical judgment of Westinghouse engineers, from their experience in design and installation of this apparatus and the reports of experience from purchasers of similar or related apparatus.

This book applies to all standard and most special CSPB and CPB transformers. However, it must be recognized that a publication of this type cannot cover exact construction details of all possible voltage and kva ratings and all other modifications which may be furnished on special orders. The information contained herein together with the data appearing on the nameplate attached to the transformer, and on the connection diagram if specified on the nameplate, should permit satisfactory operation of the transformer.

DESCRIPTION

APPLICATION

"CSPB" and "CPB" oil-immersed distribution transformers are normally used for stepping public utility "distribution voltages" (ranging from 2400 to 15,000 volts) down to household utilization voltages (usually 240/120 volts). Furthermore they are intended specifically for service where several such transformers are to be banked (primaries connected to the same feeder and secondaries to same secondary main).

COMPONENT PARTS

"CSPB" and "CPB" distribution transformers consist essentially of: (1) a closed-loop magnetic core upon which is wound two or more separate copper coils; (2) a tank for containing the insulating and cooling oil in which the core-coil assembly is immersed; (3) the necessary bushings for bringing incoming and outgoing leads through the tank or cover; (4) two low-voltage circuit breakers used to feed two separate outgoing circuits; (5) high-

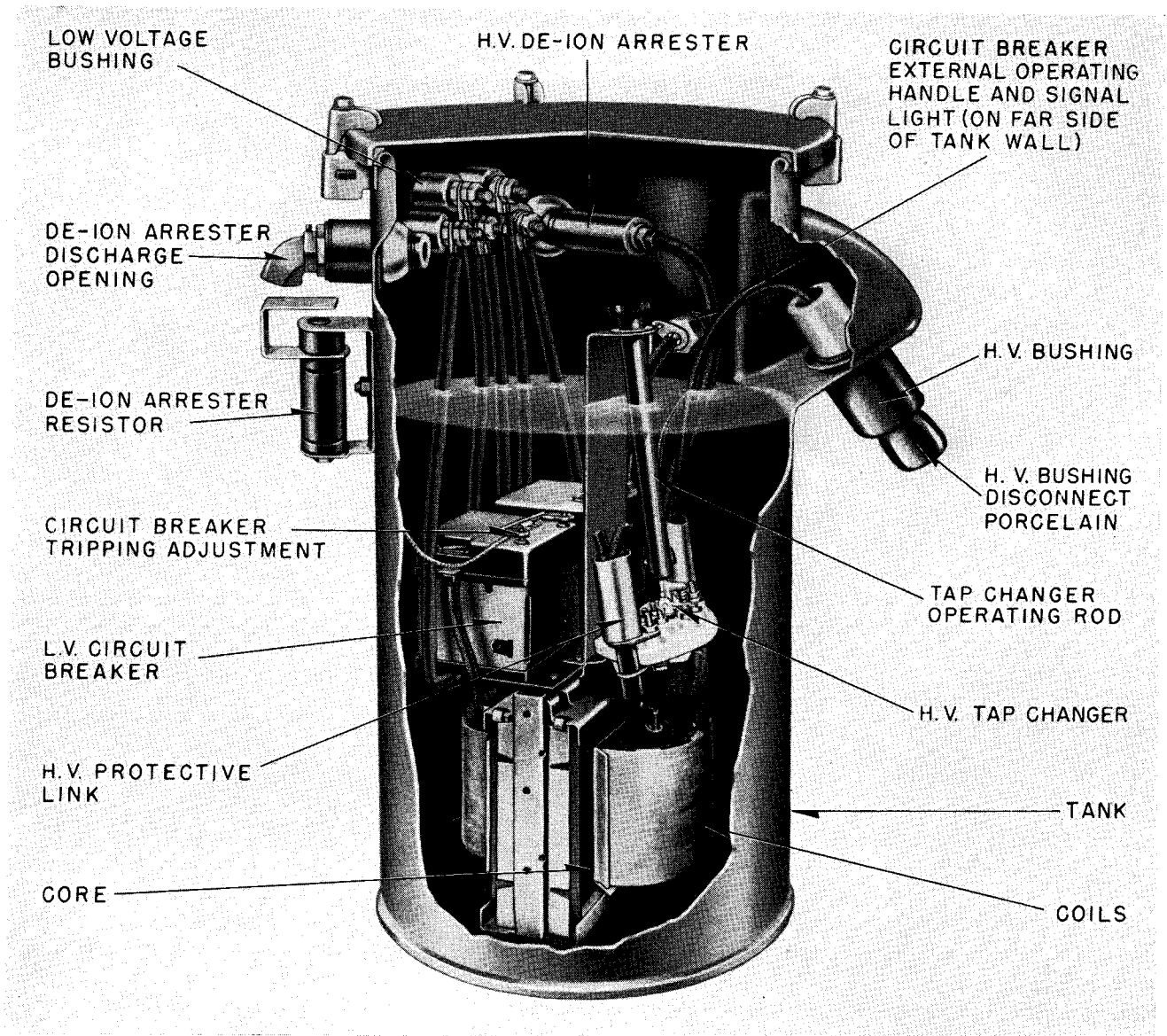


FIG. 1. Cutaway View of Typical Single-Phase Pocket Bushing "CSPB" Transformer.

DESCRIPTION

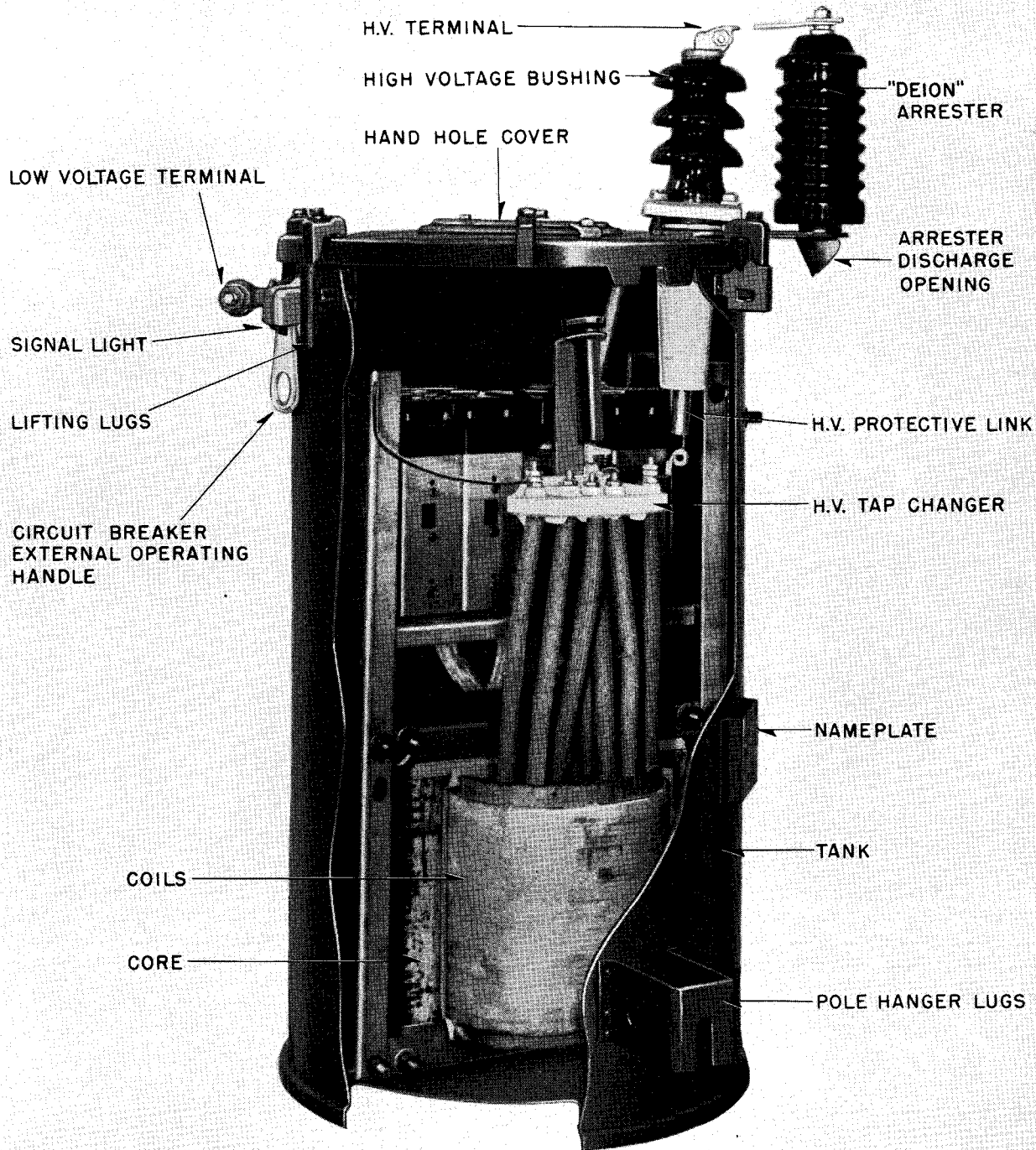


FIG. 2. Cutaway View of Typical Cover Bushing "CSPB" Transformer.

voltage protective links used to disconnect the transformer from the primary feeder in case of a winding failure; and (6) on "CSPB" transformer only, integrally mounted "De-ion" lightning arresters for lightning protection.

Since single-phase "CSPB" transformers are

designed for supplying three-wire secondary mains, as most commonly used for secondary distribution, it is necessary to have five low-voltage bushings. Three-phase "CSPB's" for 4-wire Y-connected secondary circuits have seven low-voltage bushings and three-phase "CSPB's" for delta low-voltage

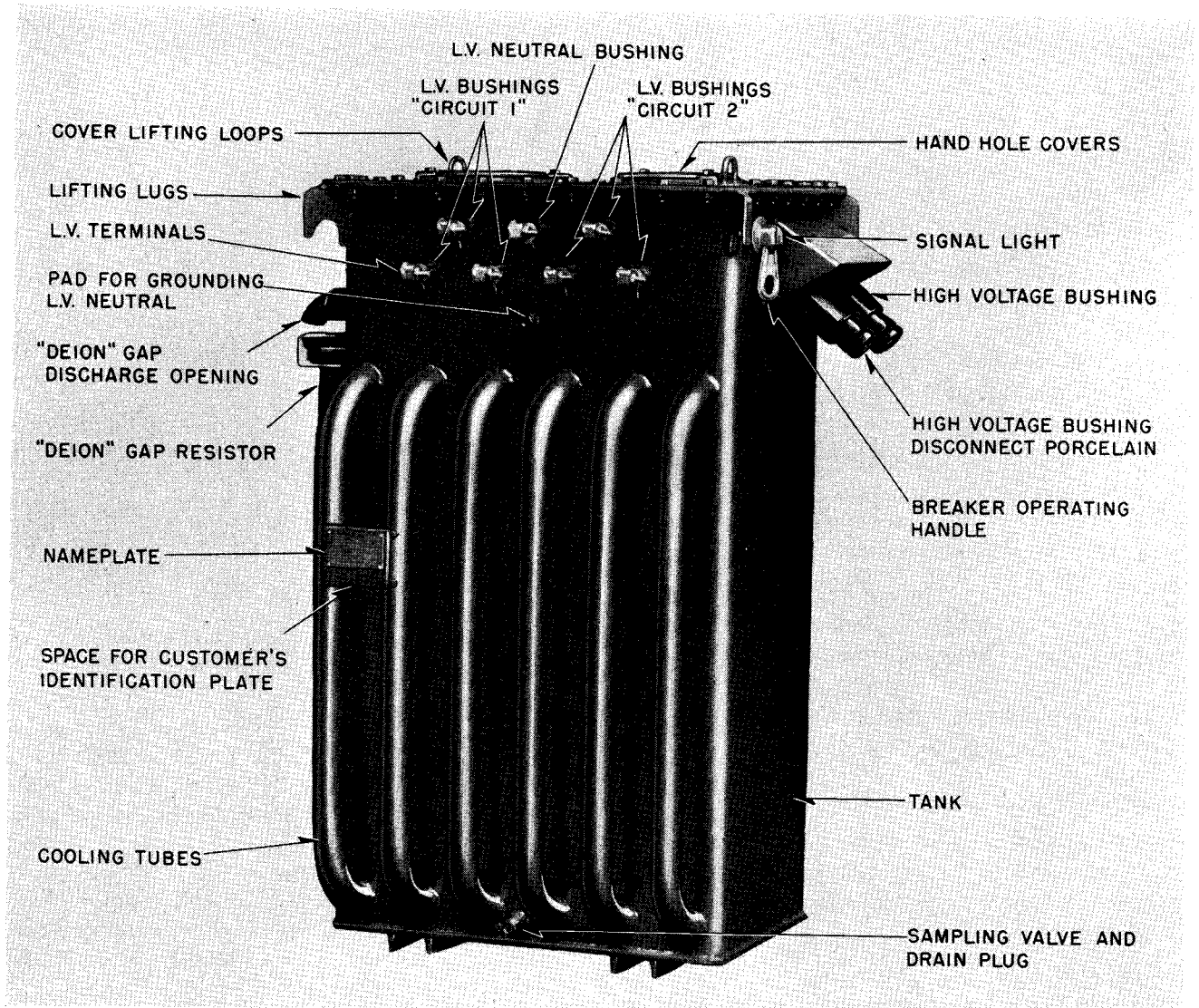


FIG. 3. Typical Three-Phase "CSPB" Transformer.

circuits have six. On special orders, transformers may be furnished with variations and/or additions to the above parts.

Typical single-phase "CSPB" transformers are shown in Fig. 1 and 2, and a typical three-phase "CSPB" transformer in Fig. 3. "CPB" transformers are similar except that "De-ion" lightning arresters are omitted. "CPB" transformers should be applied only in those localities or installations where lightning protection is considered unnecessary.

OPERATING LIMITS

Unless specifically ordered otherwise, this apparatus has been built in conformance with current A.S.A., A.I.E.E., N.E.M.A., and E.E.I.-N.E.M.A. standards.

Care should be used that the following major operating limits are not exceeded, or if exceeded, that sufficient compensation is provided elsewhere:

1. Frequency should not be appreciably lower than or greatly in excess of rating.
2. Voltage should not exceed rating by more than 5 percent while delivering continuous output or by more than 10 percent at no load.
3. Elevation at installation should not exceed 3300 feet (1000 meters) above sea level (unless transformer was designed for this service).
4. Ambient temperature should not exceed 40 degrees C (unless transformer is specially designed).

PART TWO

INSTALLATION

RECEIVING, HANDLING AND STORING

Distribution transformers are normally shipped completely assembled (except pole hangers which are shipped separately when ordered). All shipments should be inspected immediately upon receipt and the transportation company notified of any damage.

Distribution transformers may be lifted by means of the lifting lugs welded to the tanks. When handling the units before removal from the crate, it is often convenient to use these same lugs.

Since distribution transformers are built for outdoor service, no unusual precautions for storing need be taken. However, care must be exercised to prevent their being submerged in water. They should preferably be stored in locations where the relative humidity is not extremely high.

PREPARATION FOR INSTALLATION

If an inspection indicates that a transformer has absorbed moisture for any reason, remove the oil and dry the unit. However, this will seldom be necessary.

These transformers are normally filled with "Wemco C" oil at the factory, then given a vacuum oil treatment in their own tanks, after which the oil is not disturbed. It is only by such a treatment that a high initial dielectric strength, comparable to that attained after long periods in service, can be obtained. Units are therefore normally ready for service (except possibly for taps—see below) when received. If, however, instructions have been given to ship the units dry, they should be filled with "Wemco C" oil to the cold oil level mark on the inside of the tank, or until the oil gauge indicates the proper quantity. This filling should be done as long before placing in service as possible and the unit should preferably be given a vacuum treatment.

Transformers must never be operated with the oil level below the cold oil level mark. New transformers shipped with oil should be inspected for evidence of oil leakage during shipment, and if transformers are shipped dry and filled with oil before installation, they should be inspected a short time after filling and any oil absorbed by the insula-

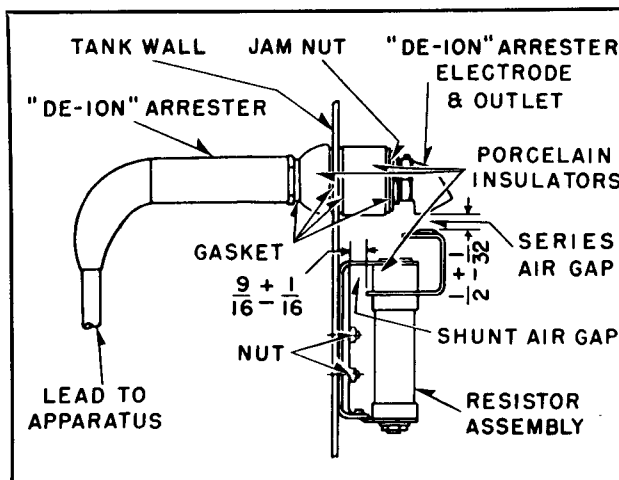


FIG. 4. "De-ion" Arrester Resistor Assembly and Gap Adjustment.

tion replaced. Only "Wemco C" oil should be used. When the transformer oil is being replenished, care must be taken that no moisture gets inside the tank.

For the proper operation of "De-ion" arresters, the air gaps should have spacings as shown in Figs. 4 or 10. These settings are made at the factory and require no adjustment unless they have been tampered with or damaged in handling or shipping.

Operator's data on the transformer may be attached using the space on the nameplate pad below the nameplate. The holes in the pad may be tapped for #6-32 machine screws, or #4 self-tapping screws may be used. Screws shall be $\frac{5}{16} \pm \frac{1}{16}$ inch long.

It is standard practice to ship transformers, unless ordered otherwise, with both high-voltage and low-voltage windings connected for their maximum nominal voltage. Transformers having taps above nominal voltage are shipped connected for the nominal voltage.

Three-phase transformers designed for both delta and wye operation are normally shipped connected for the wye voltage.

Depending on individual circumstances, it may be desirable to change these connections or taps

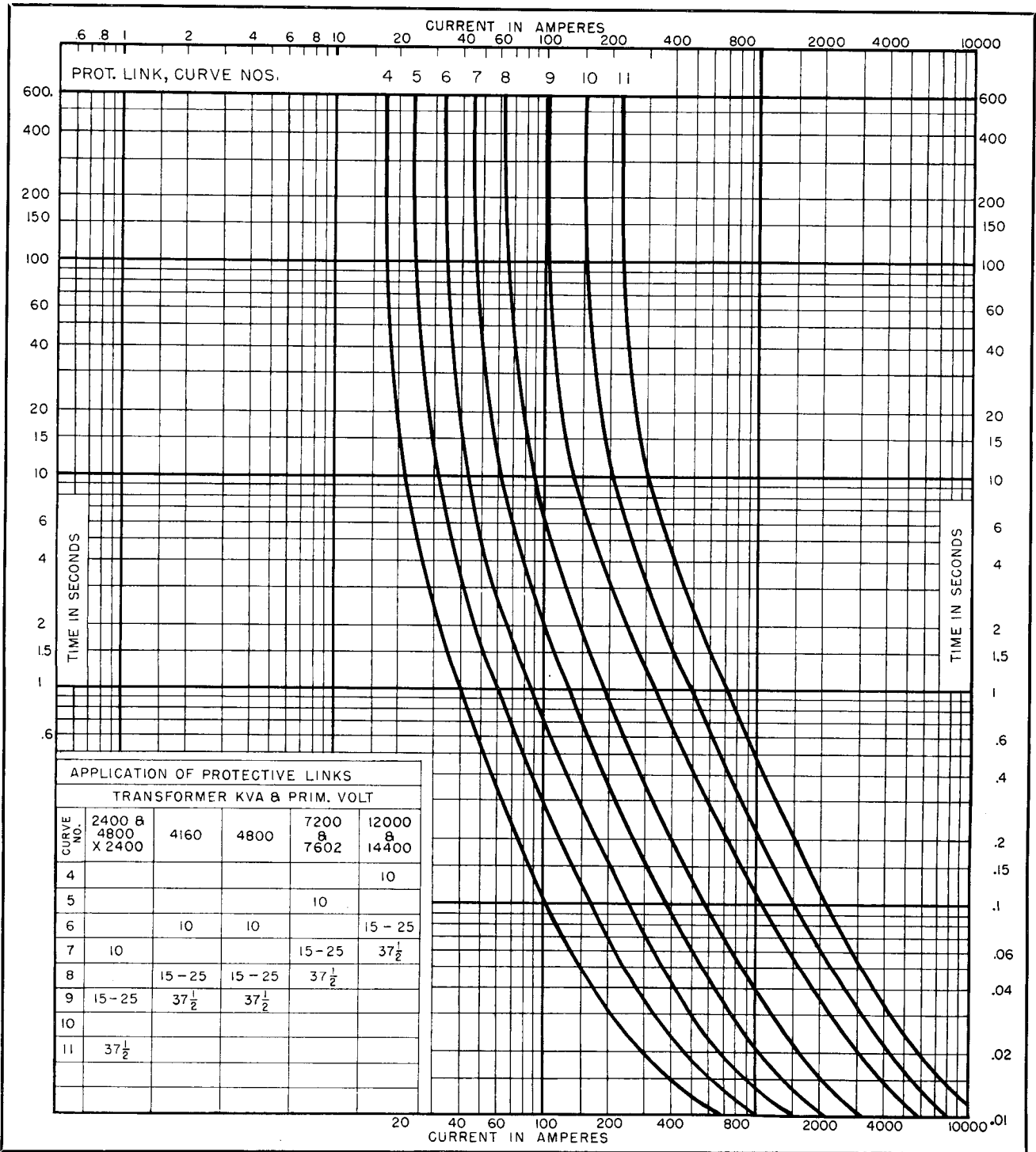


FIG. 5. Protective Link Current-Time Curves for Single-Phase "CSPB" and "CPB" Transformers.

before mounting the transformer on the pole. For three-phase installations, it is important that the connections (and taps) be alike on all three phases.

Care must be used in replacing the cover or hand-hole cover. If the gasket is not properly in place or the cover not securely bolted, moisture in the form of rain or snow may be driven or sucked into the tank.

BANK DESIGN

It is recommended that at least initially all transformers in a bank have the same kva rating. At most, adjacent transformers in a bank should not differ by more than one size. Otherwise there is danger that adjacent smaller transformers may not be able to carry the load if the larger one is out of service.

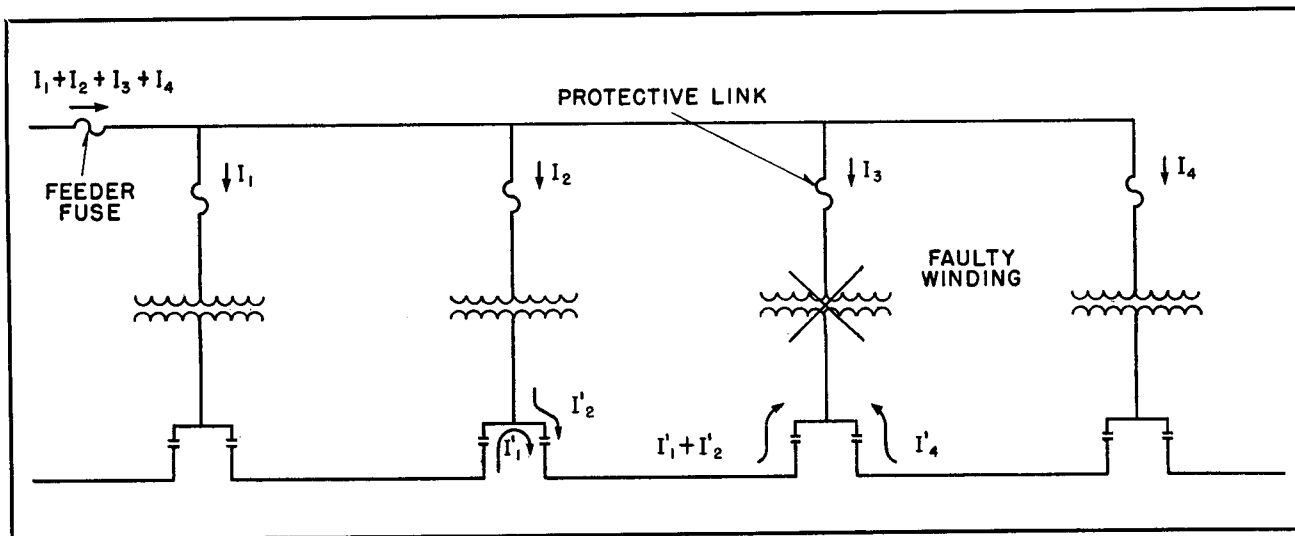


FIG. 6. Fault Currents in a "CSPB" Bank.

For greater reliability a bank should preferably have 4 or more units but too many units may produce too large an unbalance between primary phases.

The complete design of a bank is beyond the scope of this book but further information is contained in Westinghouse Distribution Transformer Technical Data 46-407.

PROTECTIVE LINK COORDINATION

These transformers are provided with internally-mounted protective links which are intended to fuse in case a fault should develop within the winding of the transformer. The current-time characteristics of these links are shown in Fig. 5. It is important, in order to limit the outage to the single transformer, that any fuses, circuit reclosers, or circuit breakers at branch lines or substations through which the transformer is fed, be coordinated with the protective links so that the link will fuse in a shorter time. A more detailed discussion of the general subject of the coordination of over-current devices is given in Westinghouse Distribution Transformer Technical Data 46-403.

As with any method of secondary banking, when an internal transformer fault develops, a somewhat greater current will flow through the feeder fuse or recloser than flows through the protective device on the high-voltage side of the transformer. This is true because current is also fed into the fault from the low-voltage side of other transformers in the bank, as indicated in Fig. 6. This coordination problem when using "CSPB" transformers is essentially the same as when using a conventional bank.

MOUNTING

Single-phase transformers rated 37½ kva and less, and three-phase transformers rated 75 kva and less, and rated 15,000 volts and less, may be mounted on poles.

When pole mounting is used, there are three generally accepted methods. The simplest and most economical, where no auxiliary equipment on the pole is necessary, is to bolt the transformer directly to the pole as shown in "A", Fig. 7. No cross-arms on the pole are used unless needed for other purposes. Square-headed through bolts (5/8-inch or 3/4-inch diameter depending on the size of the transformer) are located at the proper point on the pole (for standard transformers on 12-inch, 24-inch or 36-inch centers, depending on the size of the transformer), with the heads of the bolts toward the transformer. It is recommended that a flat washer be used between the hanger lug and the pole, and a square washer and nut used on the opposite side of the pole. The nut should be left sufficiently loose so there is a space large enough for the transformer hanger lug between the flat washer and the bolt head. The transformer should then be lifted and the mounting slots in the hanger lugs hooked over the bolt heads. The slots are spaced slightly less than the above 12, 24, or 36 inches to facilitate entering bolts into the slots and to allow for a tolerance in boring the bolt holes through the pole. After the nuts on the through bolts are tightened, the bolt head on the upper lug will engage "jump proof lips" on the lug (on standard transformers), which will prevent the transformer from jumping off the pole if it is hit by an automobile or receives a similar impact. Transformers rated 37½ kva and smaller, single-

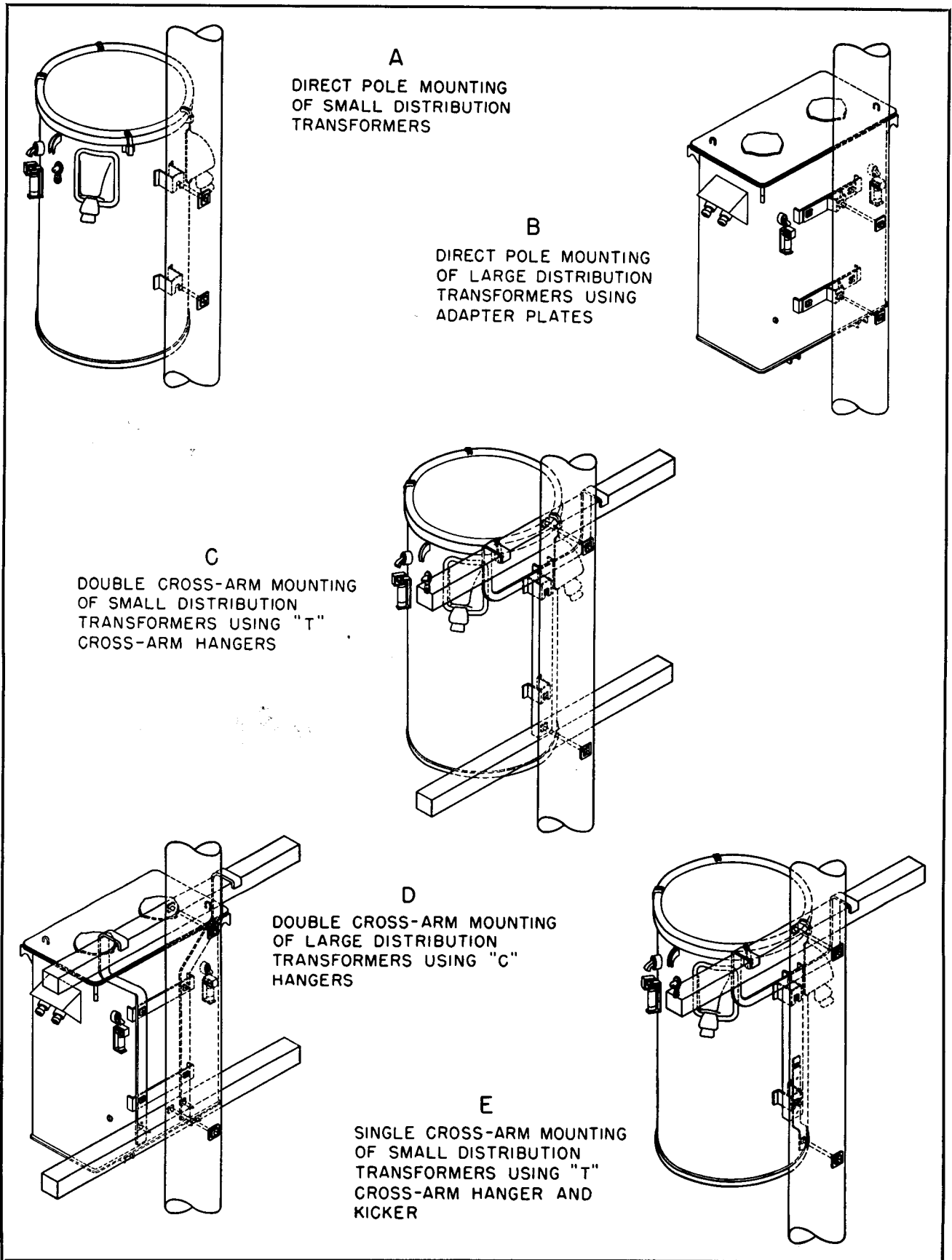


FIG. 7. Various Pole Mountings for Distribution Transformers.

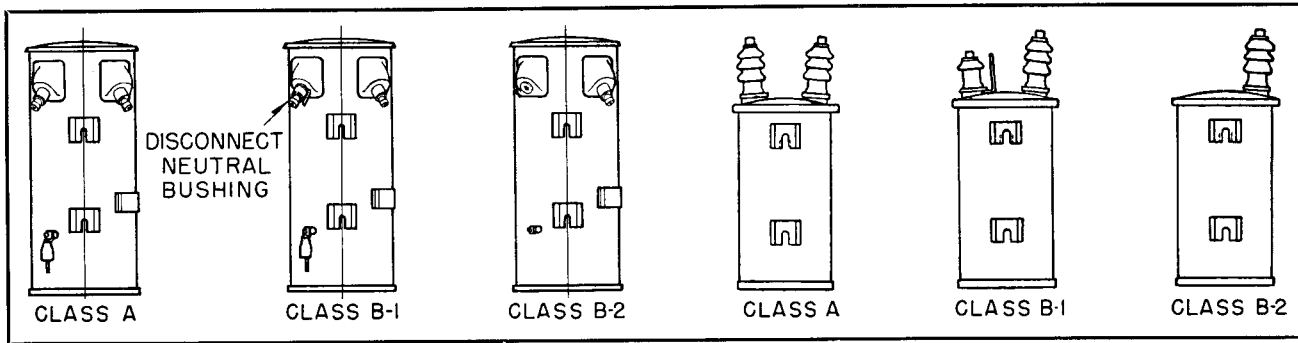


FIG. 8. Transformer Class Designations.

phase, or 45 kva and smaller, three-phase, have lugs capable of the above type bolting. Adapters are available for three-phase, 75-kva ratings, 15,000 volts and less. These adapters should be installed as shown in "B", Fig. 7.

Where two crossarms are used for mounting the transformer on a pole "T-crossarm hangers" as shown in "C" Fig. 7 for the smaller units, and "Type C hangers" as shown in "D" Fig. 7 for the larger units are available. The hangers may be fastened to the transformers before raising from the ground. The transformer may then be lifted by means of its lifting lugs until the hooks on the hanger can be made to hook over the upper crossarm. The lower portion of the hanger will then rest against the lower crossarm and hold the transformer in a vertical position. If desired, lag screws may be inserted through holes in the bottom of the hanger into the lower crossarm to prevent the transformer jumping off the pole in case of an impact.

Where "T-crossarm hangers" are used, the lower crossarm may be omitted, if desired. The "T-crossarm hanger", together with a "kicker" (available from Westinghouse Elec. Corp.), is then employed as shown in "E", Fig. 7. The kicker rests directly against the pole and keeps the transformer in a vertical position. A lag screw or through bolt is desirable through the bottom hole of the kicker.

Regardless of the type of mounting used, transformers should always be mounted vertically so that the terminal blocks, circuit breakers and protective links are adequately immersed in oil.

HIGH VOLTAGE CONNECTIONS

When installing a transformer, the amount of protective apparatus required depends upon the type of transformer. The "CSPB" transformer is completely self-protected and requires neither lightning arresters nor fuse cutouts. The "CPB" transformer is the same as the "CSPB" transformer except the "De-ion" arresters are omitted. Hot line clamps may be advantageously used for con-

necting the transformer to the high-voltage lines.

If the transformer has multiple high-voltage rating or has taps, refer to the diagram nameplate or the connection diagram specified on the nameplate, and connect the transformer or adjust the tap changer for the desired voltage.

Since the transformers are paralleled on both primary and secondary sides it is important that only terminals having the same designation be connected together (both H.V. and L.V. sides) see Fig. 9. Wherever possible it is desirable that the high-voltage feeder form a loop for greater reliability. Units to be banked together must all be supplied from the same feeder. Single-phase units must all be supplied from the same phase.

Pocket Bushing Transformers. The H. V. bushings normally supplied on transformers rated 2400 volts or more are of the disconnect type. The incoming line lead, which must be in the size range of No. 2 to No. 8 solid wire, is connected to this bushing as follows:

First grasp the outer porcelain (See Fig.1) and unscrew it counter-clockwise until the line lead can be inserted but not beyond the point where resistance to further turning is encountered. This resistance to further turning is a signal that it has been loosened sufficiently and that further forceful movement will cause it to be removed completely, in which case there is some possibility of its being dropped to the ground. After the line lead has been inserted into the hole in the outer porcelain and between the jaws of the bushing, the outer porcelain is then rotated in a clockwise direction until the lead is tightly gripped. The lead can quickly be disconnected by again rotating the outer porcelain in a counter-clockwise direction.

1. Single-phase transformers with two fully insulated high-voltage bushings (Class A for use on delta systems—see "Note" below) or three-phase transformers. Connect the H. V. terminals to the H. V. lines.

Note: These transformers, if rated winding voltage is 8660 volts or less, may also be used on three-phase, four-wire grounded neutral circuits, although the transformer cost may be less for Class B-1 or Class B-2 transformers. See Fig. 8 for transformer class designations.

2. Single-phase transformers with one fully insulated high-voltage bushing and one neutral high-voltage bushing (Class B-1 for use on three-phase, four-wire system with grounded neutral). Connect the fully insulated bushing to the phase line and the neutral bushing to the neutral line which may be grounded at each pole or at the substation only. A pad is provided on the rear of the tank so that a bolt may be inserted for convenient grounding of the H. V. neutral to the tank if desired. To use this pad, pry out the thread protector with a sharp tool.

On "CSPB" transformers of this type, only one "De-ion" arrester for lightning protection is provided. This arrester, when shipped, is connected to the fully insulated bushing lead as shown on the nameplate. It may be desirable, for convenience of mounting and connecting to the supply lines, to interchange the line and neutral outlets of the transformer. To do so, the external "De-ion" arrester may be physically moved to the other side of the tank and reconnected to the other H. V. terminal. The clamp type H. V. bushing gap must also be unclamped from its normal bushing and moved to the bushing not protected by the "De-ion" arrester.

3. Transformers with one fully insulated H. V. bushing, the other end of the H. V. winding being grounded internally to the tank (Class B-2 for use on three-phase, four-wire systems with grounded neutral).

In these transformers, the L. V. neutral is usually also grounded to the tank externally. On "CSPB" transformers, the "De-ion" arrester is connected to the terminal of the fully insulated bushing. Connect this bushing directly to the phase line. The tank should be connected to the neutral line and should also be solidly grounded at the same pole.

Cover Bushing Transformers.

1. Single-phase transformers with two fully insulated high-voltage bushings (Class A for use on delta systems—see "Note" top of this column) or three-phase transformers. Connect the H. V. terminals to the H. V. lines.

2. Single-phase transformers with one fully insulated high-voltage bushing and one neutral high-voltage bushing (Class B-1 for use on three-phase, four-wire system with grounded neutral). Connect the fully insulated bushing to the phase line and the neutral bushing to the neutral which may be grounded at each pole or at the substation only. A pad is provided on the rear of the tank so that a bolt may be inserted for convenient grounding of the H. V. neutral to the tank if desired. To use this pad, pry out the thread protector with a sharp tool.

On "CSPB" transformers of this type, only one "De-ion" arrester for lightning protection is provided. This arrester is connected externally to the fully insulated bushing. It may be desirable, for convenience of mounting, to interchange the line and neutral outlets of the transformer. It is then necessary to interchange the line and neutral bushings and to move the "De-ion" arrester to the other bushing. These changes may easily be made by removing nuts on the bushing mounting studs. See Fig. 10.

3. Single-Phase transformers with one fully insulated high-voltage bushing, the other end of the high-voltage winding being grounded internally to the tank (Class B-2).

In these transformers, the L. V. neutral is usually also grounded to the tank externally. On "CSPB" transformers, the "De-ion" arrester is connected to the fully insulated high-voltage bushing and this in turn should be connected to the phase line. The tank should be connected to the neutral wire and should also be solidly grounded at the same pole.

Note: The internal electrical connections to cover mounted bushings must be disconnected before the cover is removed. These connections are accessible through the handhole provided in the cover.

LOW VOLTAGE CONNECTIONS

Refer to the diagram nameplate or the connection diagram specified on the nameplate and connect low-voltage terminals to service lines as indicated.

Referring to Fig. 9, the neutral of the three-wire secondary circuit should be continuous throughout the bank, and the low-voltage neutral of each transformer in the bank must be solidly tapped onto it. Each of the two "hot" low-voltage mains, however, must be sectionalized at each transformer by a strain insulator or secondary rack, as otherwise the special means taken within the trans-

INSTALLATION

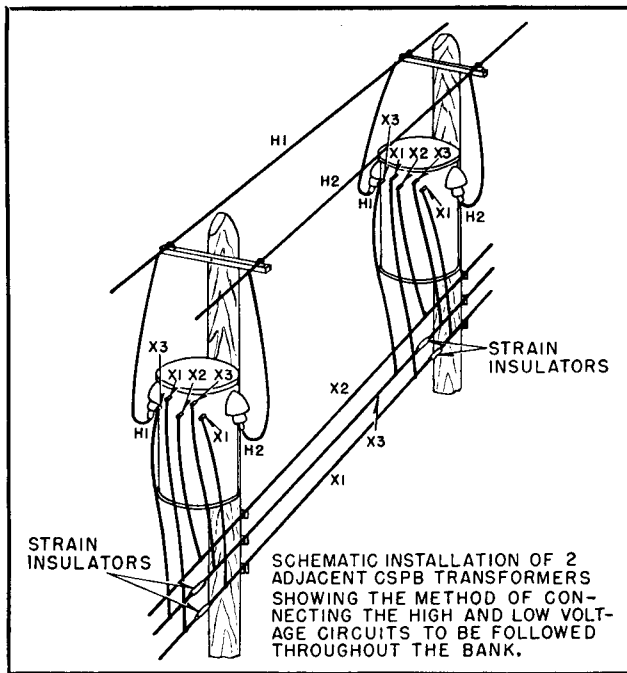


FIG. 9. Above Installation Wiring Applies Equally to "CSPB" and "CPB" Transformers.

former for sectionalizing the external circuit would be nullified.

The neutral lead of the transformer is designated by X₂ on the diagram nameplate, and the two line leads are designated by X₁ and X₃. One of the

hot mains may be thought of as the X₁ main throughout the entire secondary bank, and the X₁ leads of all the transformers must be connected to this main. Likewise, the remaining hot main may be designated as X₃ throughout the bank and all the X₃ leads of all the transformers must be connected to it.

If the transformer has been specially designed for two-wire service, one of the leads is usually grounded. See National Electric Code for specific instructions.

On single phase Class B-2 transformers (one high-voltage bushing with H-2 terminal grounded to tank), the low-voltage neutral bushing is usually connected by means of a jumper to the tank.

Caution: In any system of banking, it should be realized by linemen that even though the individual transformer has been disconnected from the high-voltage feeders, the high-voltage and outlet terminals will still be "hot" as long as the low-voltage circuit is "alive" and the low-voltage terminals of the transformer are connected to the low-voltage mains. Therefore, any transformer in a secondary banked circuit must be disconnected from both the high-voltage feeders and low-voltage mains before it can be assumed to be "cold".

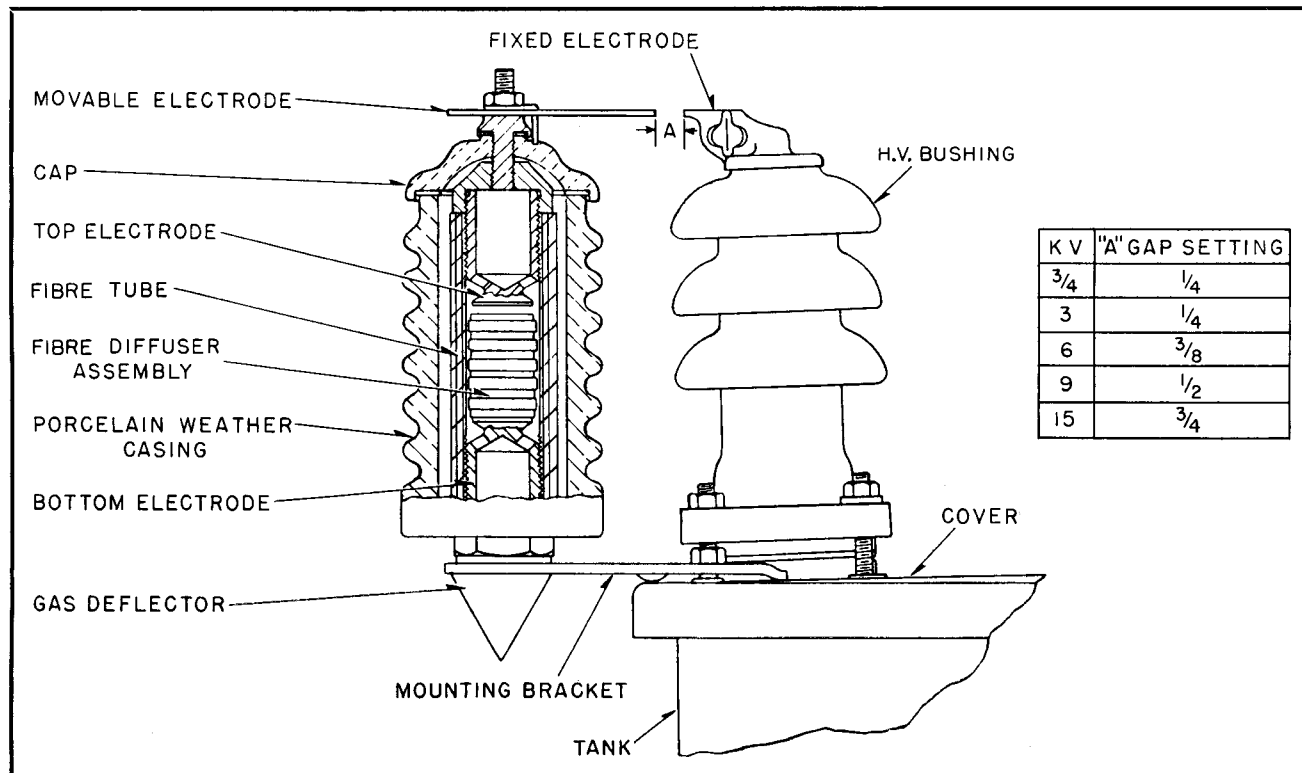


FIG. 10. Externally Mounted "De-ion" Lightning Arrester and Gap Adjustment.

TANK GROUNDING CONNECTIONS

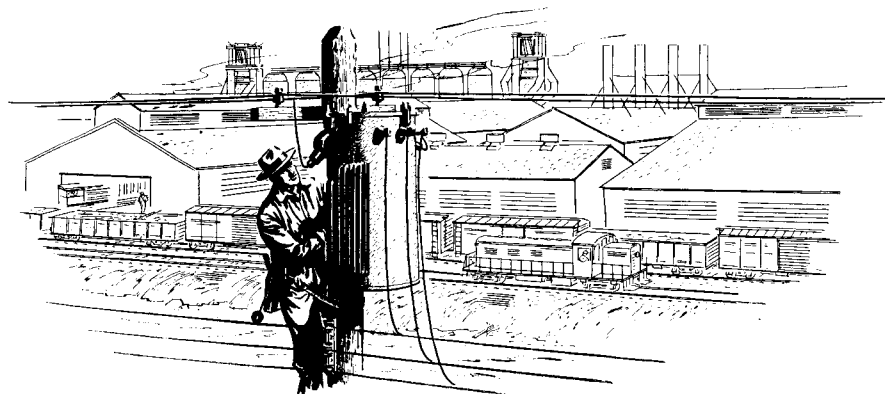
Many public utilities follow a practice of grounding distribution transformer tanks while many others follow the exactly opposite practice of operating with ungrounded tanks. Whatever the practice, it is followed for the purpose of safety for the linemen. In the one case, the linemen have become accustomed to grounded tanks and consider them "safe" because they are grounded. In the other case, the linemen have become accustomed to ungrounded tanks, and they too are considered "safe" because they are ungrounded. Westinghouse transformers (except those with one primary lead solidly connected to the tank) may be operated either way. In the "three-point" method of lightning protection, as used on all "CSPB" transformers, the "De-ion" arresters discharge lightning surges to the tank. When tanks are to be operated ungrounded, it is therefore necessary to use a tank discharge gap for dissipating the lightning surge to ground. This gap permits the tank to be normally insulated from ground but sparks over to form a discharge path to ground in the event of a lightning surge. Unless otherwise ordered, such tank discharge gaps are furnished with all "CSPB" transformers having two high-voltage bushings (including those having one neutral H. V. bushing). They may or may not be located in the exact physical location indicated by the transformer schematic diagram. In case the tanks are to be grounded, the tank discharge gap

may be removed. The above may be summarized as follows:

1. Ungrounded Tanks—"CPB" Transformer. As in conventional transformers, no discharge gap is provided on "CPB" transformers. Many utilities, however, do interconnect tank through gaps with the lightning arrester and/or secondary neutral ground for the purpose of obtaining improved lightning protection under condition of high surge current and/or high ground resistance. (See National Electric Code.)

2. Ungrounded Tanks—"CSPB" Transformer. Connect the lead from the tank discharge gap to a water pipe or other approved ground (See National Electric Code). When the neutral or any other L. V. lead is grounded to a water pipe or other approved ground (See National Electric Code), the tank discharge gap lead may be connected to this grounded L. V. lead. If it is not convenient to obtain a low resistance ground or if for any reason it may be undesirable to make this connection, such as in the case of delta-connected secondaries, the tank discharge gap should be grounded at the pole.

3. Grounded Tanks. Remove the tank discharge gap, if present. Connect from the grounding lug on the tank wall to the grounded low-voltage lead and/or directly to ground at the pole depending upon conditions described in the above paragraph.



PRINCIPLES OF OPERATION

TRANSFORMER PROPER

Very briefly and simply stated, the principles of operation of the core and coil assembly of the transformer are as follows:

The alternating voltage applied to the primary winding causes an alternating current to flow through the primary winding, which in turn generates an alternating magnetic flux in the iron core upon which the primary coil is wound. The magnetic flux links the turns of both the primary and secondary windings and hence it induces a voltage in the secondary winding and also induces a back voltage in the primary winding which is very nearly equal to the applied voltage. The difference between the back voltage and the applied voltage is a voltage just sufficient to force the magnetizing current through the impedance of the primary winding. The primary back voltage and secondary voltage have the same ratio as the ratio of turns in the primary and secondary windings since the same magnetic flux links both windings. Since the primary applied voltage is practically the same as the back voltage, the applied primary voltage and secondary induced voltage, practically speaking, have the same ratio as the ratio of turns.

When a load is applied to the secondary winding, the load current flows through the secondary winding and this current tends to destroy the magnetic flux. It actually does change the magnetic flux a slight amount, so that the back voltage differs from the applied voltage by a larger amount and a greater primary current flows. A balance is obtained when the product of primary turns and primary amperes is approximately equal to the product of secondary turns and secondary amperes. By this relation, the ratio of primary and secondary currents is the inverse of the primary and secondary turn ratio. A more detailed and exact discussion of a transformer can be found in any good textbook on transformer theory.

From the above description, it is obvious that the core and coil assembly has no moving parts and thus it is a very simple mechanism. However, the oil in the transformer does move. The heat from the losses in the coil expands the oil in the coil ducts slightly, causing it to be lighter than the cooler oil outside the coil. The oil, therefore, rises up through

the coil ducts, being replaced by heavier cool oil at the bottom of the coils. The hot oil is cooled by the tank wall, which in turn is cooled by the flow of air over its outside surface. The oil in the transformer thus serves to facilitate the transfer of heat from the coils to the atmosphere and to keep the coil temperature for a given load at a low value. In addition to this important duty, the oil serves as insulation and greatly increases the voltage (particularly the transient lightning voltage), which a given coil can withstand compared to the same coil in the air.

LIGHTNING PROTECTION

There are three "major" insulations in a transformer which must be protected against lightning voltages: (1) The insulation between the high-voltage winding and the core or tank; (2) the insulation between the low-voltage winding and the core or tank; and (3) the insulation between the high-voltage winding and the low-voltage winding. In addition, there are several kinds of "minor" insulation which must be protected: Layer-to-layer insulation and turn-to-turn insulation in the H. V. winding; layer-to-layer insulation and turn-to-turn insulation in the low-voltage winding; and lead insulation. All of these "minor" insulations can be made by design such that they will be protected if all of the "major" insulations are protected; but each major insulation must have separate consideration in any complete protection scheme.

Westinghouse "CSPB" transformers furnish protection to insulation (1) by "De-ion" arresters which limit the voltage between the high-voltage winding and the tank; to insulation (2) by secondary bushing gaps which limit the voltage between the secondary winding and tank; and to insulation (3) by the combination of the "De-ion" arrester on the high-voltage side and the bushing gaps on the secondary side, which limit the voltage between the primary and secondary windings to not more than the greater of the protective levels of the primary and secondary devices. It should be noted that bringing the tank into this circuit is an important part of the protection which is known as "three-point surge protection" since all three insulations are protected. For the sequence of events in the operation of this "three-point surge protection" scheme, see Fig. 11.

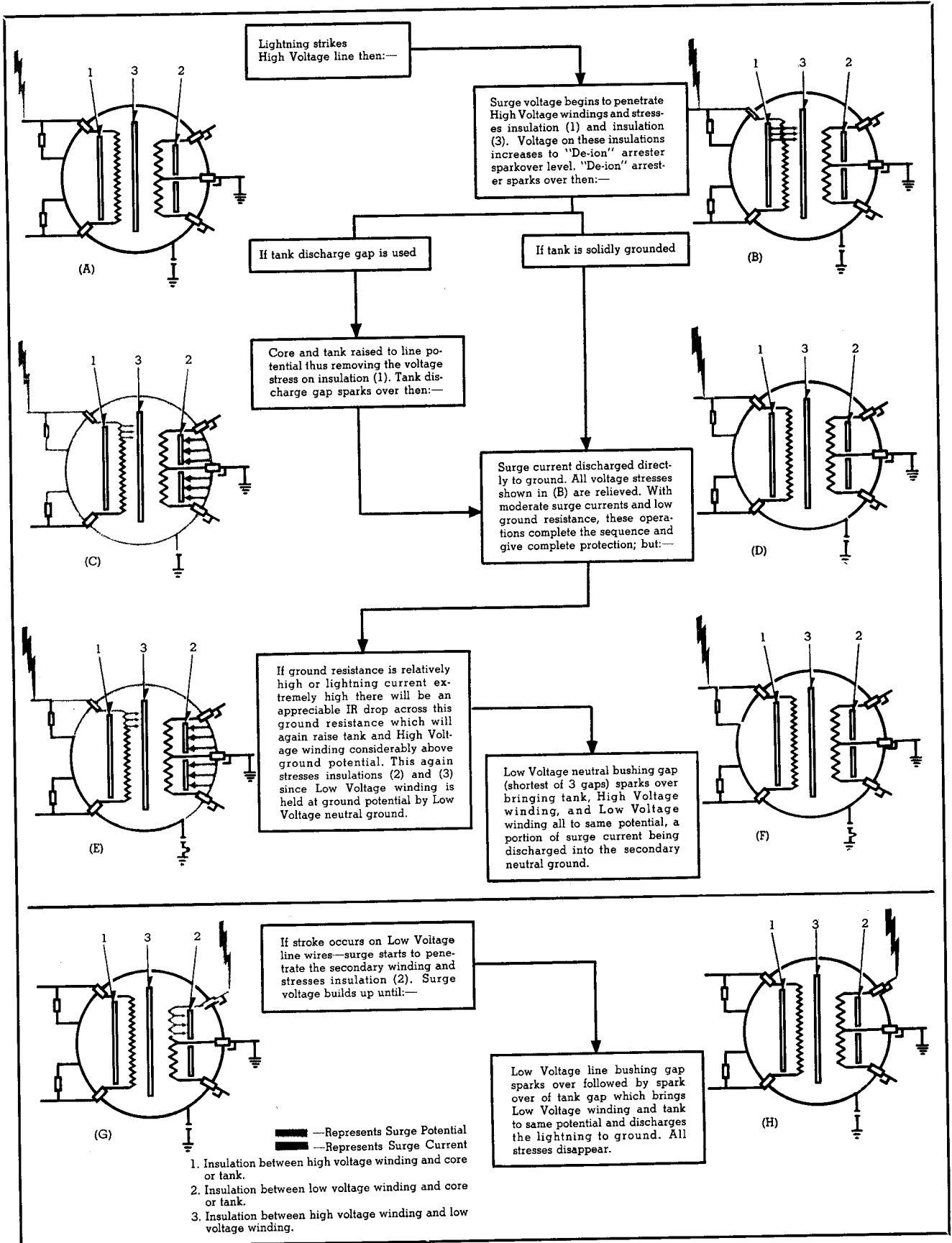


FIG. 11. Mechanism of "Three-Point Surge Protection".
(For Simplicity, the Secondary Circuit Breakers and the Two Secondary Circuits Are Not Shown.)

PRINCIPLES OF OPERATION

The operation of the secondary bushing gaps is very simple. The voltage developed by the lightning surge is applied in parallel to the spark gap and to the low-voltage winding. When this voltage reaches a critical value, the gap sparks over and limits further rise of the voltage applied to the winding. The voltage across the gap and the winding is decreased to the arc voltage of the gap which is only a small fraction of the dielectric strength of the insulation. The gaps are self-clearing at low voltages and the arc will go out at least by the end of the first half cycle of power frequency following the surge.

The operation of the "De-ion" arresters for the protection of the high-voltage winding is the same as the secondary bushing gaps except that the voltage is too high to be self-clearing if applied to a plain gap and additional features must therefore be designed into the arrester to interrupt the flow of power current.

The "De-ion" arrester (see cutaway view Fig. 10) consists essentially of two electrodes encased in an insulating tube and separated by several slotted fibre plates. This assembly may be mounted inside the tank, as shown in Fig. 1. When a sparkover occurs from one electrode past the slotted fibre plates to the other electrode, if it occurs at a time in the cycle when the voltage on the line is of sufficient magnitude, and should the line characteristics be favorable to the flow of such a current, power current may follow the surge discharged.

The "De-ion" arrester used on cover bushing transformers shown in Figs. 2 and 10 is designed such that the power current is limited without the use of a series resistor.

The power current through internally mounted "De-ion" arresters is limited by means of a series resistor (See Figs. 1 and 4) to about 350 amperes, regardless of the short-circuit current of the system. This prevents system disturbance such as the blowing of sectionalizing fuses and lengthens the life of the "De-ion" arrester. The heat from the discharge passing through the narrow passages causes gas to be given off from the fibre walls. This gas mixes into the ionized arc path in such a way that at the first current zero of power current, the discharge is de-ionized by the fresh un-ionized gas and the current is not built up in the opposite direction. The gas so produced is vented to the atmosphere through a hole in the ground electrode. There is no minimum current which the "De-ion" arrester will inter-

rupt since the passages through the fibre assembly are sufficiently small that even the smallest currents are in contact with the fibre.

The series resistor is provided with a shunt gap which sparks over when extremely large surge currents are encountered. The IR voltage drop across the resistor is thus limited to about 30 kv. This 30 kv does not add to the sparkover voltage of the gap proper because the sparkover voltage is maintained only until sparkover takes place. Since there is no current flow up to that time, there can be no IR voltage drop across the resistor until after the sparkover voltage has decayed. Similarly, the 30 kv can be obtained only with a heavy flow of surge current; the voltage across the de-ionizing portion of the arrester is at that time only the arc voltage of a few kv. The arrester sparkover voltage is thus the highest voltage which may ever be applied to the winding and this normally lasts only a small fraction of a microsecond—so short a time that the insulation has a temporary added strength for this length of time.

A more detailed discussion on the lightning protection of "CSPB" transformers is contained in Westinghouse Distribution Transformer Technical Data Booklet No.1.

BURNOUT PROTECTION

Thermal protection for "CSPB" and "CPB" transformers is afforded by circuit breakers connected in series with the low-voltage winding. There are five major reasons for using these breakers.

1. To eliminate the fuse cutout, thereby eliminating fuse outages which are the largest single source of trouble with "S" or "SP" transformer installations.
2. To provide definite thermal protection without the sacrifice of short-time overload capacity—an impossibility with any device such as an external fuse which is not affected by both the temperature of the transformer oil and the load current.
3. To provide an economical automatic load check through the medium of the signal light which in turn is actuated by the circuit breaker.
4. To sectionalize the bank of transformers in case of a fault on the secondary main.
5. To disconnect the transformer from the secondary main in case of a faulty winding.

The first of the above reasons is easily understood; the second is perhaps not so obvious. Fig. 12

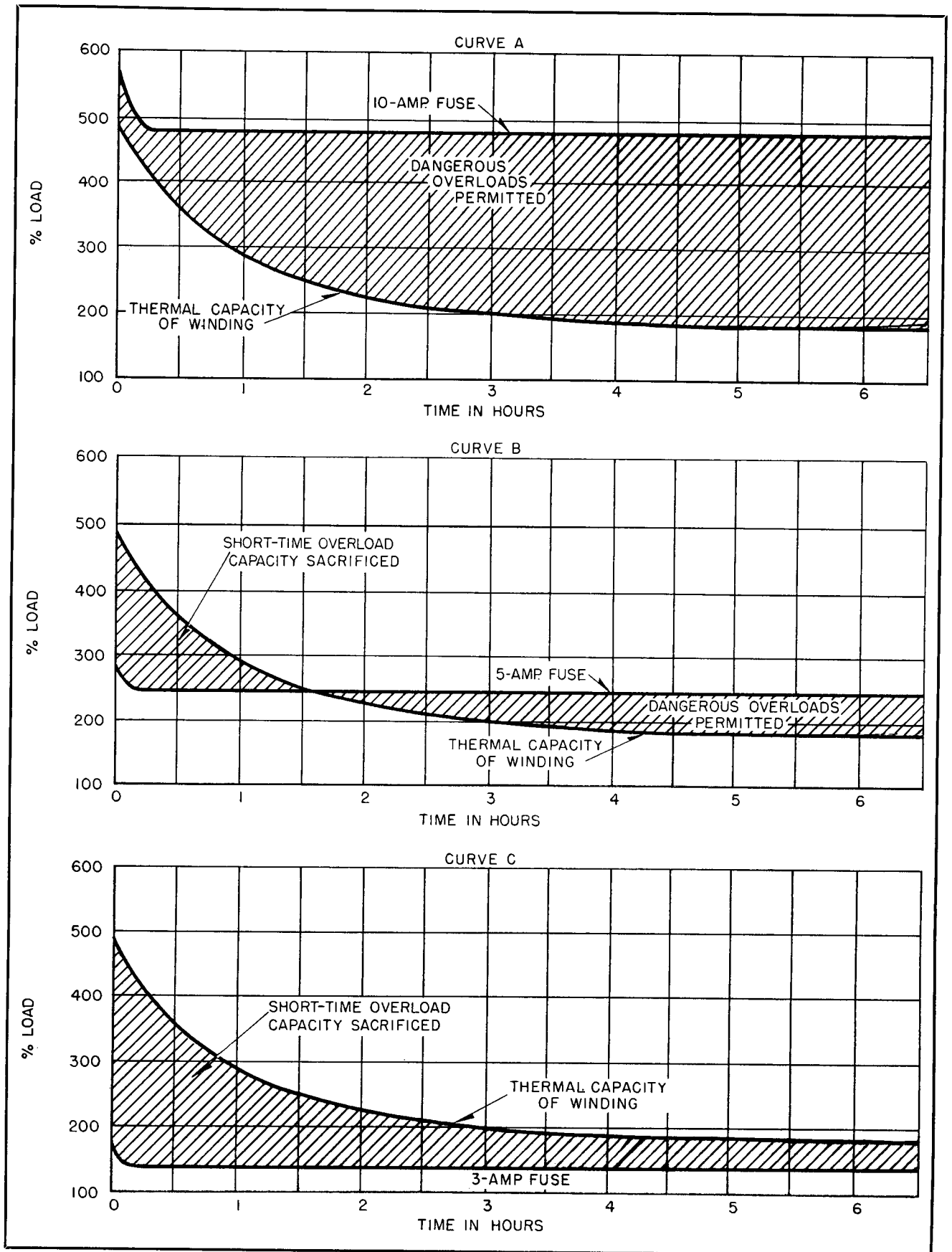


FIG. 12. Curves Showing that Thermal Protection of Distribution Transformers by Fuses is Unsatisfactory.

PRINCIPLES OF OPERATION

shows three curves for a 10-kva, 2400-volt, Type "S" transformer protected with 10-, 5-, and 3-ampere fuses respectively. The overload capacity of the transformer depends upon the duration of the load and does not reach equilibrium for over six hours. At times less than six hours, there is considerable short-time overload capacity available which is very useful in carrying temporary load peaks, motor starting loads, etc. However, since all fuses commonly used have current-time characteristics which are essentially flat after a very few minutes, their characteristics when plotted in Fig. 12 are straight horizontal lines with an upturn near the zero axis. In order to take advantage of essentially all the short-time overload capacity of this transformer, it would be necessary to use a 10-ampere fuse as shown in curve "A", Fig. 12. However, this will permit dangerous overloads to be carried unless they are very large—probably approaching short circuits. On the other hand, if a 3-ampere fuse is used to obtain complete protection as shown in curve "C", Fig. 12, then nothing greater than a 145 percent load can be carried for more than a few seconds. A large block of short-time overload capacity is sacrificed. If a compromise is made with a 5-ampere fuse as shown in curve "B", Fig. 12, then some dangerous overloads are permitted and some short-time overload capacity is lost—still an undesirable condition.

With the "CSPB" or "CPB" transformers, however, the circuit breaker is tripped when a piece of bimetal in the circuit breaker reaches a predetermined temperature. The bimetal is immersed in the transformer oil the same as are the copper windings, and the transformer load current is passed through the bimetal so that it is heated above the oil temperature by load current the same as are the windings. The conditions of temperature in the coil are therefore duplicated in the bimetal. By the time the windings have reached the upper limit of this safe temperature, the bimetal has reached the trip temperature; the breaker is thus tripped; the transformer has been protected; and furthermore, this is true regardless of the shape of the load-time curve or of the previous loading of the transformer.

With a device of this kind, its load-time characteristic is practically identical with the thermal capacity curve (Fig. 12). Hence, no dangerous loads are permitted and no short-time overloads are sacrificed. A more detailed discussion of the thermal problem is given in Westinghouse Distribution Transformer Technical Data 46-402.

The adjustment of the breaker bimetal as made at the factory (adjustment nuts in center of adjustment range) is such as to light the warning signal light at a coil temperature approximating that recognized by the A.I.E.E. as a limit for Class A insulation for both continuous and short-time overloads, and to open the circuit at a higher temperature just under the winding burnout point.

To provide the above thermal protection, two types of circuit breakers are used, both of which are trip-free of their operating handles. The "TR" breaker is applied on 10 and 15-kva single-phase ratings. The "BR" circuit breaker is similar to the "TR" but has a higher current rating and is applied on 25 and 37½-kva single-phase ratings and on all 3-phase ratings.

"TR" BREAKER

Type "TR" circuit breakers are shown mounted in the transformer in Fig. 1, and a cutaway view of the breaker is shown in Fig. 13. The handle arm is connected through a linkage to an operating handle on the outside of the tank so that the breaker may be manually opened, closed, or reset. The signal circuit leads are connected in series with an auxiliary winding on the transformer core and in series with the signal light which is mounted in the operating handle. Fig. 14, contains schematic sketches somewhat simplified to better show the principles of operation.

The electrical circuit is carried (sketch "A", Fig. 14) from the coil to the breaker contacts, then through the bimetal to the L. V. bushing. As the bimetal temperature increases due to the temperature of the oil and/or the load current, it deflects upward as shown. At overloads sufficiently great to cause the transformer coil to reach its maximum safe operating temperature, the shorter latch is released. This latch then rotates clockwise (sketch "B", Fig. 14) under the force of the latch spring so that the signal trip lever is moved up and the small contacts of the signal circuit are closed. This energizes the lamp which stays lit until the short latch is reset manually, regardless of subsequent changes of load on the transformer or the position of the bimetal. Resetting of the light latch is accomplished by moving the external handle to or beyond the "Reset Light" position (Fig. 24) and then reclosing. If the handle is not moved appreciably beyond the "Reset Light" position, the short latch can be reset without opening the main breaker contacts.

If the bimetal temperature is increased still further by the load, the bimetal deflects still further up-

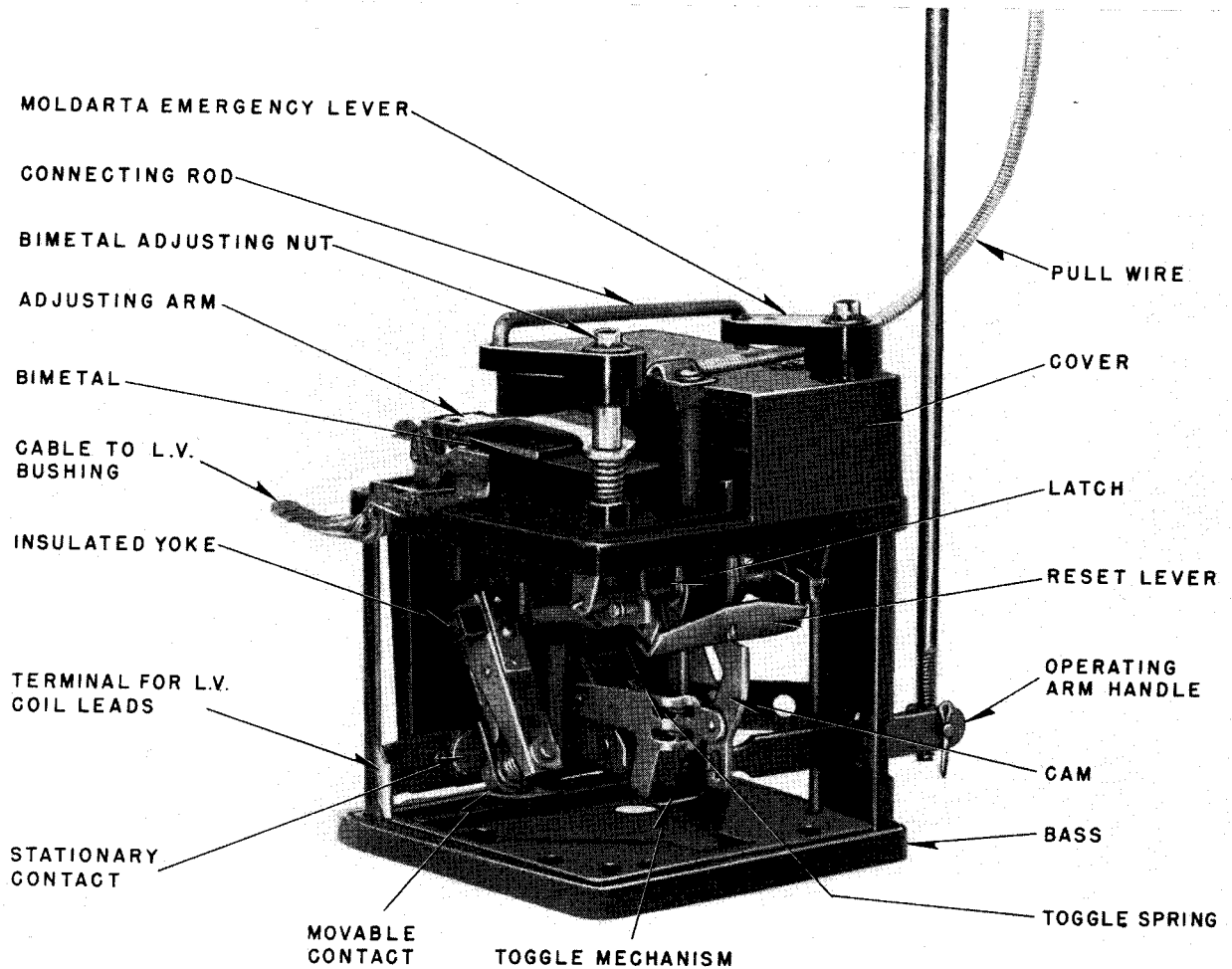


FIG. 13. Cutaway View of Type "TR" Circuit Breaker.

ward until the longer latch is released. This occurs at a coil temperature just below the burnout temperature. When the longer latch trips (sketch "C", Fig. 14), it rotates in a clockwise direction to raise the breaker trip lever upward, which releases the tip of the cradle. The cradle then rotates clockwise under the pull of the toggle springs until its nose strikes the toggle at its center, and the toggle "breaks" with a snap action, thus opening the contacts. Since both movable contacts are mounted on a common insulated yoke (Fig. 13), both poles are opened simultaneously. Resetting is accomplished by first moving the external handle to the "Reset" position (Fig. 20) which resets the cradle and all the latches, and then reclosing. As the external handle is moved to the "Close" position, the ends of the breaker toggle springs are moved so that the line of action of the spring force crosses the pivot center and the toggle is straightened and the contacts closed with a snap action. Manual opening and

closing are accomplished by operation of the external handle which causes the end of the toggle spring "X" (shown in sketch "A", Fig. 14) to move over center. This breaks or straightens the toggle to open or close the contacts without tripping the bimetal latches or the cradle.

A further description of the "TR" breaker is given in Westinghouse Distribution Transformer Technical Data 46-404.

"BR" BREAKER

A cutaway view of a two-pole "BR" breaker is shown in Fig. 15. The general principles of operation are the same as the "TR" breaker although the breaker is larger in order to handle the larger currents and mechanically somewhat different. Like the "TR" breaker, the "BR" breaker has the signal light feature

The electrical circuit is carried (sketch "A", Fig.

PRINCIPLES OF OPERATION

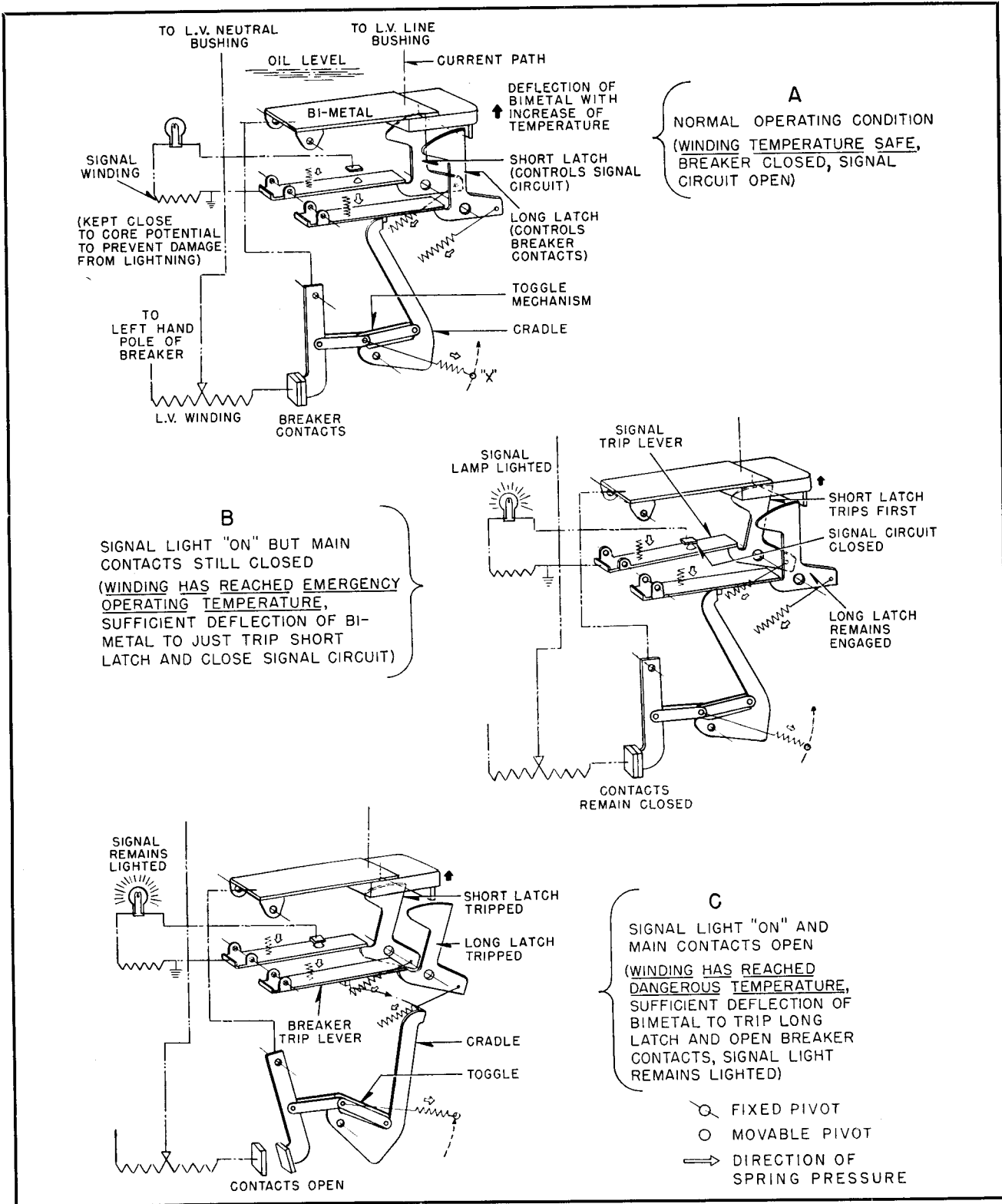


FIG. 14. Schematic Operation Sketches of "TR" Circuit Breaker.

16) from the coil to the arcing contacts and to the main contacts and then through the bimetal at the top of the breaker to the L. V. bushing. As the bimetal temperature increases, the bimetal deflects upward as shown. At the maximum safe coil tem-

perature, the shorter latch is released and rotates clockwise under the force of the latch spring to close the signal light contacts. The lamp remains energized until the short latch is reset manually by the external handle.

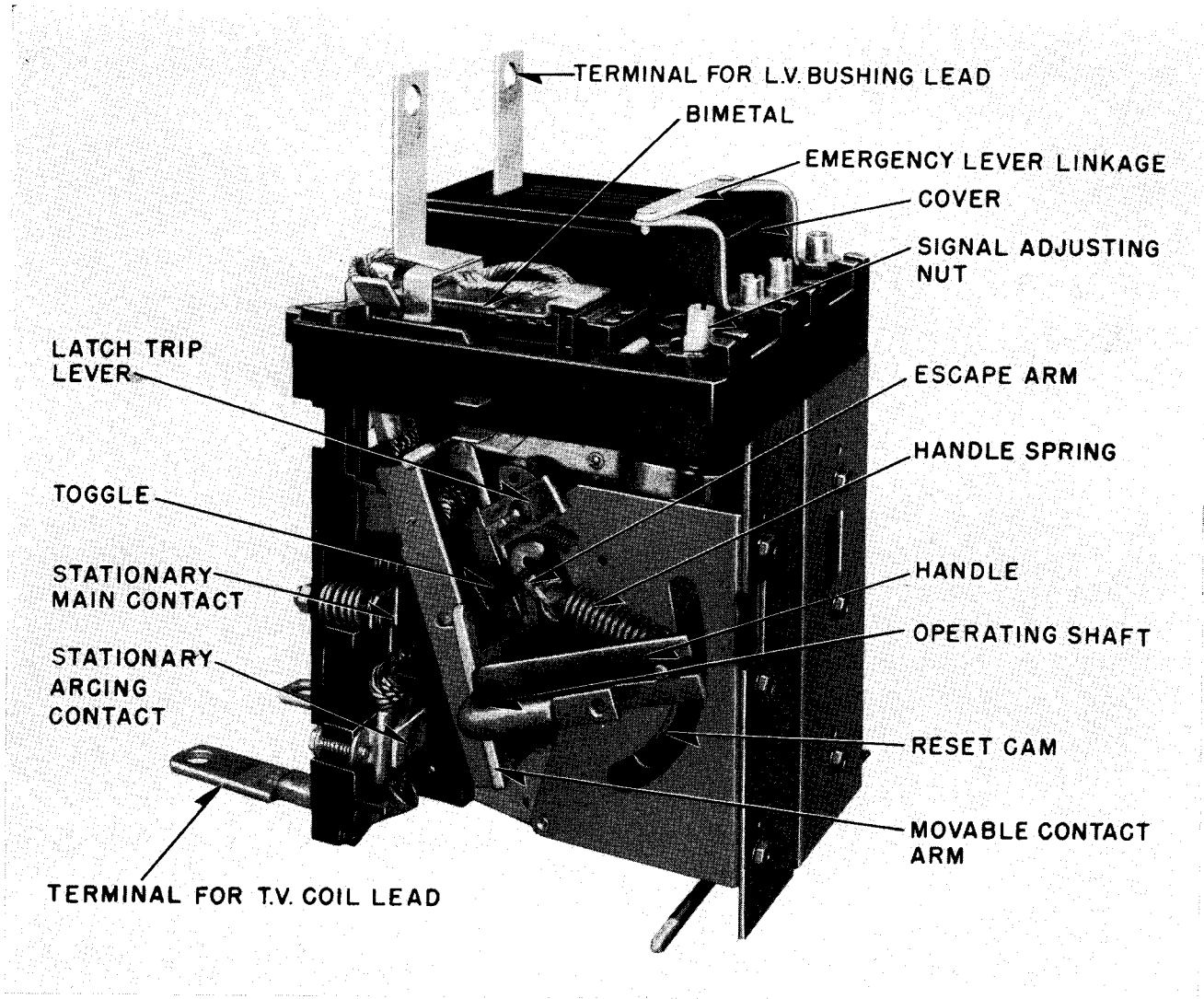


FIG. 15. Cutaway View of "BR" Circuit Breaker.

If the bimetal temperature is further increased, the bimetal deflects further upward and the long latch is released. This also rotates clockwise under the influence of its latch spring until its tail strikes the latch trip lever. The latch trip lever is thus rotated counter-clockwise, the cradle is released, and it then rotates clockwise under force of the cradle spring. Up to now, the movable pivot attaching the toggle links to the cradle has been exactly in line with the fixed escape arm pivot; but under rotation of the cradle, the toggle link pivot moves. This allows the pin extending through the joint between the toggle links to move to the right in the slot in the escape arm. The movable main contact is also beginning to back away from the stationary main contact while the arcing contacts are held together by the arcing contact spring.

By the time the toggle link pin has reached the end of the escape arm slot, the main contacts are

open and the nose on the lower end of the cradle strikes the right toggle link causing the toggle link pin to escape from the escape arm. Sketch "B", Fig. 16 shows the momentary position just after the pin escapes. The toggle is thus broken to open the arcing contacts and to open the main contacts wider. Since the latch trip lever is mechanically coupled to the latch trip levers in adjacent poles, the cradles are similarly released in all poles and contacts in all poles open simultaneously.

Resetting is accomplished by moving the external handle to the "Reset" position. This moves the handle (sketch "C", Fig. 16) counter-clockwise until the escape arm spring crosses the pivot point. The escape arm then rotates clockwise until the toggle link pin again starts to engage the escape arm slot. The latter portion of the movement of the external handle to "Reset" causes the main latch and the cradle to be reset. Resetting of the cradle again

PRINCIPLES OF OPERATION

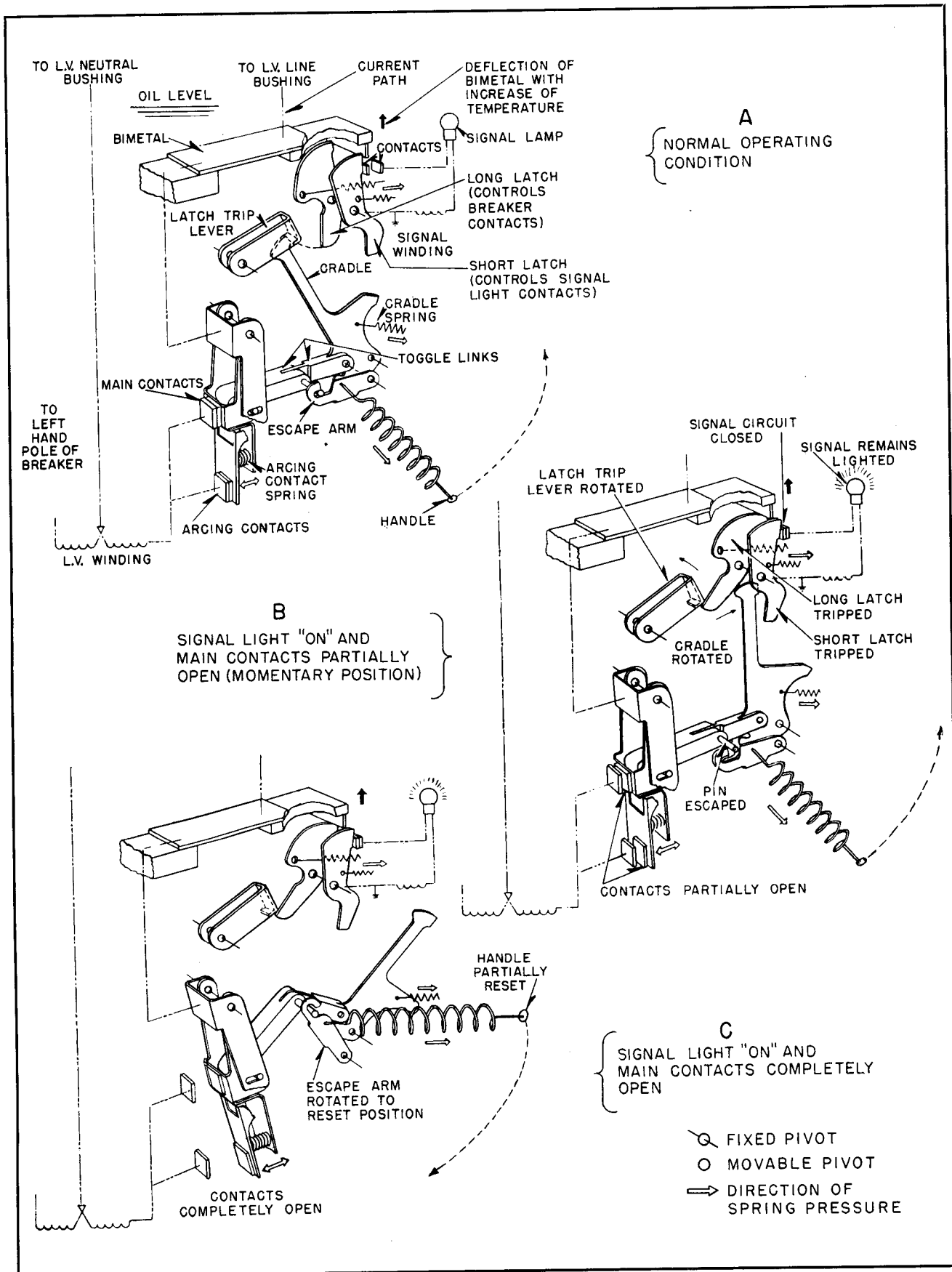


FIG. 16. Schematic Operational Sketches of "BR" Circuit Breakers.

brings the pivot joining the toggle link to the cradle in line with the escape arm pivot which forces the toggle link pin into the slot of the escape arm. Movement of the handle to the "Close" position then returns the escape arm to its original position shown in sketch "A", Fig. 16, and in so doing it pulls the toggle links back with it thus reclosing the contacts.

Manual operation when the latches have not been tripped is accomplished by operation of the external handle which has the effect of carrying the handle spring back and forth across the escape arm pivot. This causes the escape arm to snap from the position shown in sketch "A", Fig. 16 to that shown in sketch "C", Fig. 16 and vice versa. Since the cradle is not tripped, the pivot joining the toggle links to the cradle is continuously in line with the escape arm pivot, the toggle link pin is held continuously in the slot of the escape arm, and the above movement of the escape arm carries the toggle links with it thus opening and closing the contacts.

The "BR" breaker is equipped with what is in reality a double-bimetal. The upper bimetal is separated from the regular bimetal by a thin sheet of insulation, and it does not carry load current. Its only influence is to slow the action of the load-carrying bimetal at times of heavy load, since that bimetal stores within itself some of the heat produced by heavy loads, whereas the upper bimetal is influenced only by the ambient temperature of the oil.

(On ordinary loads, the two bimetals work together, since there is then no exceptional heat storage in the lower load carrying bimetal.)

The "BR" bimetal unit is thus able to handle a greater amount of power for motor starting, or for the burning clear of secondary faults, with more accurate control of these heavy loads.

A further description of the "BR" breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 6.

BANKING CIRCUIT

Fig. 17 is a wiring diagram of a single-phase "CSPB" transformer. The incoming high-voltage lead passes through the protective link to the high-voltage winding. Power is fed from the low-voltage winding to a junction point in the internal transformer connections, where it divides and passes through the two breakers to the two external circuits, in accordance with the loading on these circuits.

The two breakers used in any particular "CSPB" transformer are identical in all respects.

Fig. 18 shows four "CSPB" transformers connected to form a loop type bank. The secondaries are sectionalized by means of breakers in the transformers.

Fig. 18-A is a wiring diagram of a three-phase "CSPB" transformer, which operates generally in the same manner as the single-phase "CSPB" transformer.

Referring to Fig. 18, if a fault occurs such as at point "X", this fault will receive fault current from transformer "A" through bimetal 2 and from transformer "D" through bimetals 1 and 2 in series. Therefore, the current in bimetal 2 is always greater than in bimetal 1 so that bimetal 2 opens contacts 2 first. From the other direction, fault "X" receives fault current from transformer "B" through bimetal 3 and from transformer "C" through bimetal 4 and 3 in series. Therefore, the current in bimetal 3 is always greater than in bimetal 4 so that on this side of the fault, bimetal 3 opens contacts 3 first.

Therefore, the fault has been completely isolated. Only those services in the faulted section have been disconnected from the loop and all transformers remain connected to supply power to the remainder of the bank. Signal indication on the sides of transformers A and B adjacent to the fault will show that these two breakers have tripped.

Now, consider what happens to the bank of "CSPB" transformers in case of an overload condition.

Suppose, for example, that transformer "A" becomes overloaded. Rarely, in actual service, would it be expected that the loads on both of

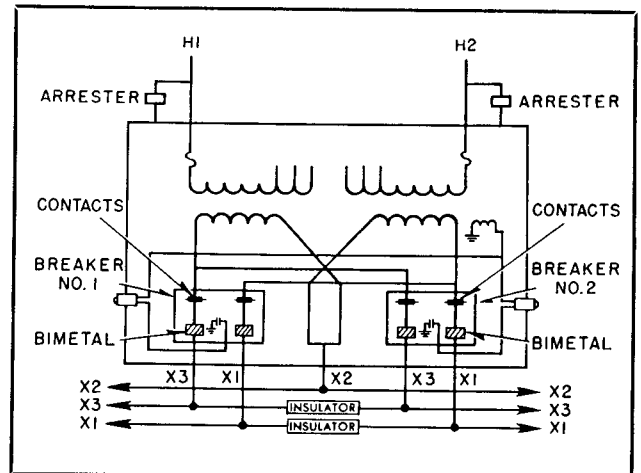


FIG. 17. Schematic Wiring Diagram of a "CSPB" Transformer.

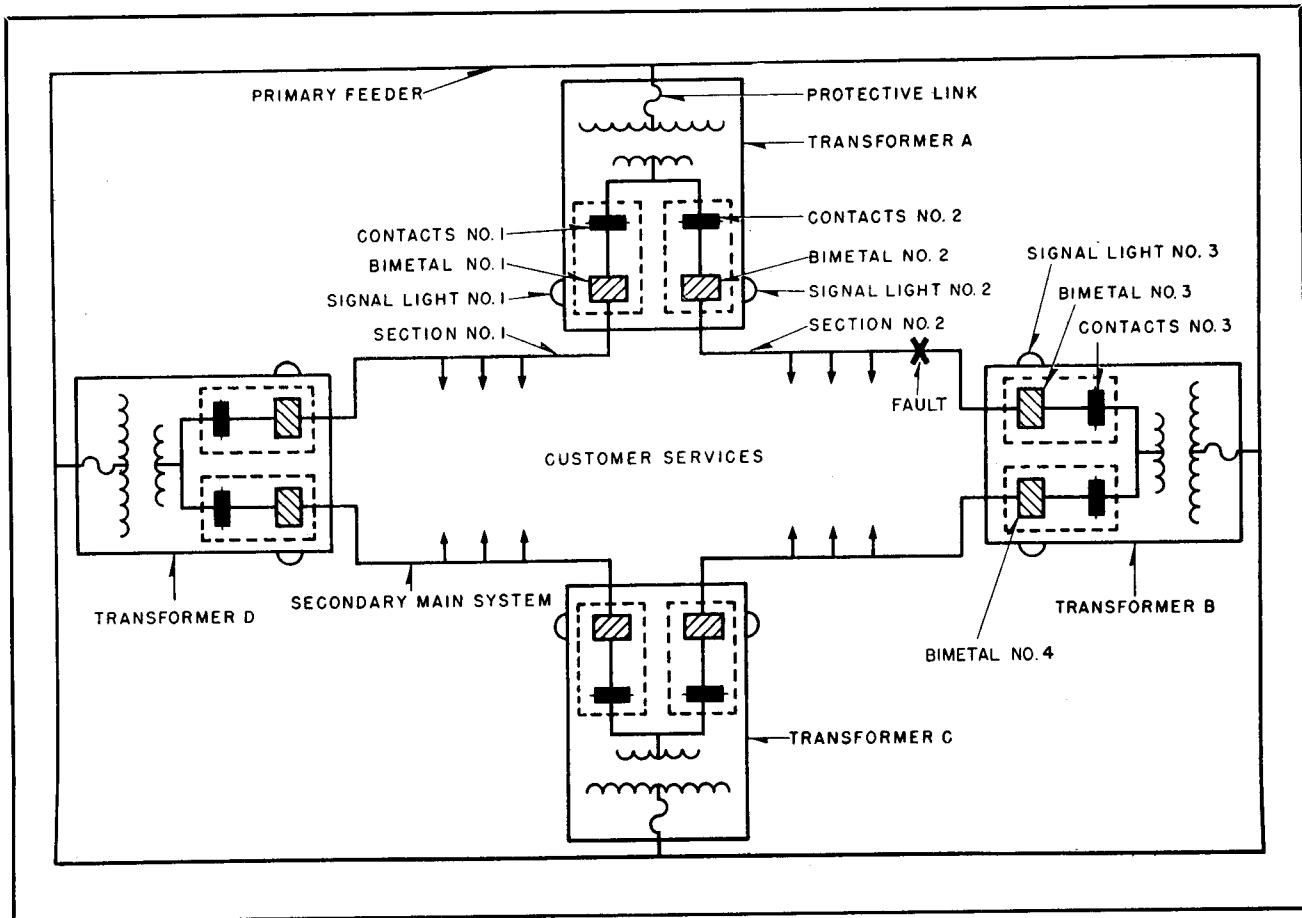


FIG. 18. Single Line Diagram Showing Four "CSPB" Transformers in a Loop Bank.

the circuits were exactly equal, so that, for the purpose of example, it may be assumed that circuit No. 2 in this case is somewhat more heavily loaded than circuit No. 1. When the daily peak load first causes the maximum safe copper temperature of this transformer to be reached, bimetal No. 2 will trip the short latch of its breaker and thereby give an advance warning by lighting the signal lamp associated with this breaker. The light remains lighted and gives the power company an opportunity to check load conditions, and, if necessary, replace the transformer with a larger unit or re-arrange the bank in ample time to avoid a forced outage. However, if the warning is not heeded, and the daily peak loads eventually increase to the danger point, then bimetal No. 2 will trip its longer latch and open contacts No. 2. This will disconnect any portion of the overload which is coming from circuit No. 2. It is probable that this will reduce the overload to a sufficient extent that no further tripping will be required. The load on the winding of transformer "A" has thus been reduced and this load has been transferred to transformer "B". Should this trans-

fer of load increase the load on the winding of transformer "B" to the point where it could not be carried thermally, then bimetal No. 3 would operate to open contacts No. 3, thus dropping the heavily loaded section but leaving all of the transformers in service to carry the remaining load.

Thus, the transformer winding is protected completely, and only that portion of the load necessary to give relief to the transformer is disconnected.

Fig. 18-A shows the application of the above principles in the case of three-phase "CSPB" transformers.

PROTECTIVE LINKS

In spite of any factory tests that can be devised, it will sometimes (though rarely) happen that some particular transformer will develop a faulty winding. At such a time, it is important that the winding be disconnected from the system for the purpose of preventing a "lock-out" of the distribution feeder. In "CSPB" or "CPB" transformers, the protective link connected in series with the high-voltage winding disconnects the faulty transformer from the

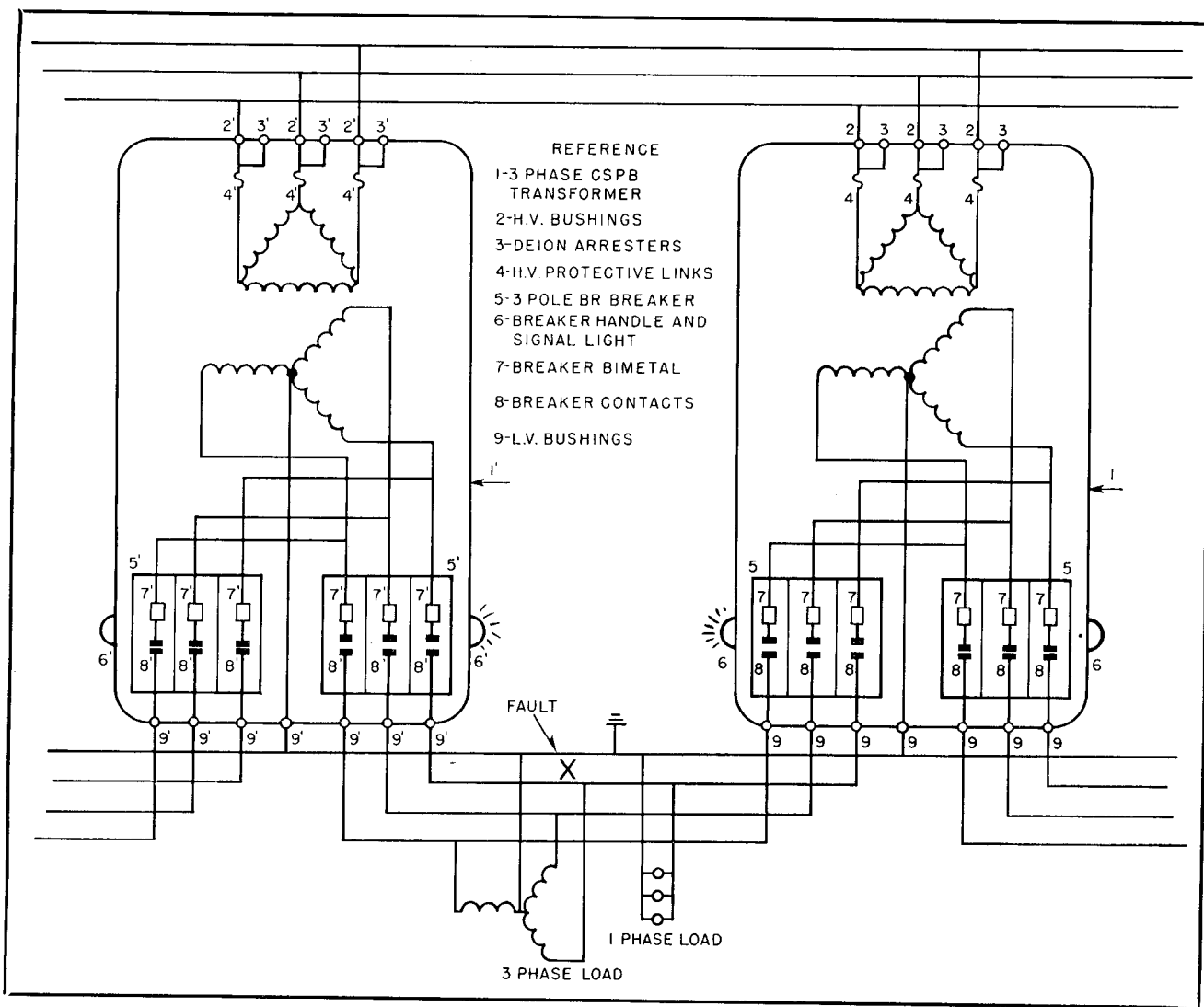


FIG. 18-A. Wiring Diagram of 3-Phase "CSPB" Transformers.

high-voltage feeders and the low-voltage breakers disconnect it from the low-voltage mains which in the case of a secondary banked system are available for supplying fault current to the transformer. The protective link must, of course, have a current-time characteristic such that it will not fuse in a time less than that required to trip the secondary circuit breaker (in case of a secondary overload or short circuit); but it should fuse in as short a time as required to make coordination with branch fuses, circuit reclosers, and circuit breakers easier.

The protective link is normally fused only in case of a faulty winding. It is therefore desirable to mount the protective link inside the tank where it is protected from the weather and where the "De-ion" arrester can be connected ahead of the link, thus by-passing lightning currents which would cause it to fuse. It is mounted in the H. V. bushing (Fig. 2)

or on the terminal block (Fig 1.)

The link is made from a high melting temperature alloy wire which, in turn, is surrounded by an insulating sleeve which serves as a heat blanket. This, in turn, is mounted in a fibre tube which is sealed at the upper end. When an excessive current flows through the protective link, the fusible element is heated and gas is formed from the oil. This gas serves to control the fusing characteristic. When the melting temperature is finally reached, the wire fuses and an arc is formed. The current is usually limited by at least a partial impedance of the faulty transformer winding, but if the current is great enough, sufficient gas pressure is developed to drive the lower electrode violently from the protective link tube. This rapid movement of the electrode through the oil quickly quenches the arc. In cases of smaller currents, they are quenched within the tube without expelling the lower electrode.

PART FOUR

OPERATING INSTRUCTIONS

Since there are no moving parts in the transformer proper, very little operating attention is required. However, occasionally attention to some of the accessories such as tap changers, circuit breakers, etc., may be required.

TAPS

Caution: Connections should not be changed by either tap changers or terminal board while the transformer is excited because of personal danger and because tap changers are not designed for operation while carrying current. On three-phase installations, the voltage ratings of connections used should be the same for all three phases.

When secondary voltage is too low, it may be raised by moving the tap changer on the primary side to a position having a lower rated voltage. To guide the operator in the selection of the desired voltage ratios, an indicator plate (with numerals corresponding to the position number on the diagram nameplate) is located just below the handle. Both the handle and the indicator plate are above the oil level. The positive snap action of the tap changer into position also guides the operator and insures a positive contact. Where a terminal board is furnished in lieu of a tap changer, similar results can be obtained by reconnecting in accordance with the nameplate or with the connection diagram specified on the nameplate.

CIRCUIT BREAKER MANUAL OPERATION

The circuit breakers may be opened by movement of the external handle to the "Open" position. Reclosing is accomplished by movement of the external handle to the "Close" position.

SIGNAL LIGHTS

The signal light furnishes a valuable service in providing the means for an automatic overload survey. Because of this, many utilities install smaller transformers than "normal", planning that this can safely be done since the "CSPB" will warn of any growing overloads. For information on planning a secondary bank using "CSPB" and "CPB" transformers, refer to Technical Data 46-407.

Signal Light Indication. A signal light is provided for each of the two breakers in "CSPB" or "CPB" transformer. The right hand signal light (when facing the low voltage of the transformer) is operated by the right hand breaker, and the left hand signal light is operated by the left hand breaker.

The signal light becomes illuminated when a secondary fault occurs. In a "CSPB" bank, the breaker which is connected to the faulted section will trip in the two transformers adjacent to the faulted section. The signal lights will remain lighted to indicate the open breakers until reset by the external handle. When word has been received of a section outage, the lineman should first remove the fault from this section and service may then be restored by simply closing the two open breakers.

One of the most valuable functions of the signal light is that it becomes illuminated when the load on the transformer has reached a maximum safe value. It, therefore, acts as a signal for an impending operation of the breaker. As soon as an illuminated signal is reported by a customer or observed by a lineman, an investigation should be made. The signal light may be reset by the external handle. If the lamp does not relight when the light circuit has been reset, it is an indication that a satisfactory thermal condition exists at that time in the transformer. However, if the signal light again comes on at a later date, it probably indicates that the load growth has reached the point where additional transformer capacity should be supplied. By reviewing the load conditions by suitable measurements and by taking the proper steps promptly, an outage at some later date will be avoided.

It is not recommended that transformers be operated for any extended period at loads which cause the signal light to become lighted. The band of loadings permitted between the initial lighting of the signal light and the opening of the breaker is provided to permit temporary operation at these overloads in order to prevent service outages.

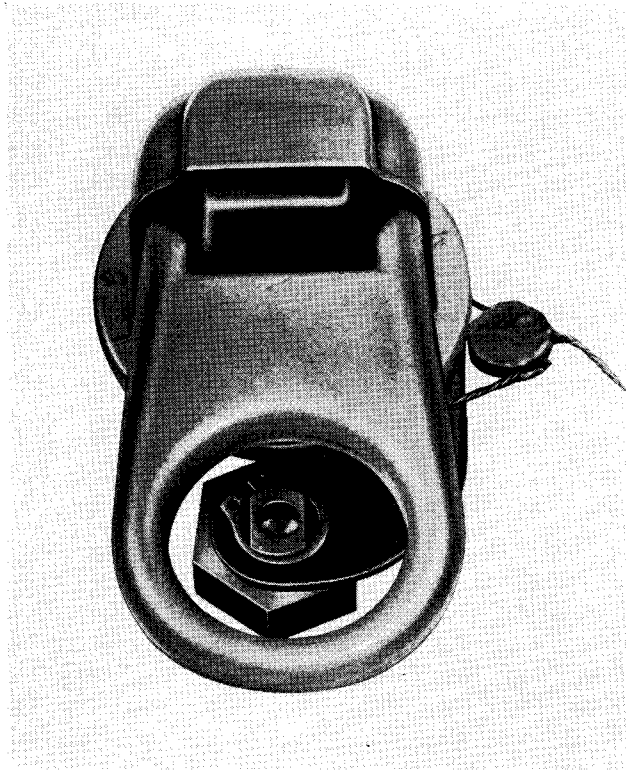


FIG. 19. Emergency Control Handle in Normal Position.

CIRCUIT BREAKER TRIPPING

In some cases, if the signal light warning is not heeded, or if an overload is extreme, the circuit breaker may trip open to prevent the winding from burning out. Since this will disconnect a portion of the load, the transformer will usually have cooled sufficiently by the time the trouble man arrives that the breaker can be reclosed to restore service at least temporarily. If the oil temperature is still high, however, the signal light may continue to burn after the breaker has been reset. If the load is still excessive, the circuit breaker may again trip open to protect the winding against burnout.

Important: Both breakers must be closed to supply power to both secondary circuits.

EMERGENCY CONTROL

Adjustment of the trip setting of the circuit breaker in the field, to increase the transformer capacity in emergencies, has always been possible within narrow limits by means of the adjusting nuts which project from the top of the breaker. Making this change in the field has not usually been convenient and, therefore, it was not always practical to make this adjustment.

A new mechanism is now provided to change the setting of these nuts from the outside of the tank.

Type "TR" Breaker. The external appearance of the new assembly is shown in the photograph, Fig. 19. The new "emergency control handle" is mounted so as to be partially concealed by the larger breaker operating handle. Internal mechanical connection is made to the circuit breaker as shown in Fig. 21. The two insulating arms on the two adjusting nuts are coupled together by a small steel rod which in turn is attached to one end of a pull wire control. The other end of this wire terminates near the external operating handle where it is held by an arm which is attached to the shaft extending out through the tank wall.

As long as the emergency control handle is allowed to remain in the normal position, that is, with the handle up, the breaker is in the lowest setting, which corresponds to the adjustment which has been standard on Westinghouse "CSP" transformers. As shown in Fig. 21, pulling the handle down turns the screws to the right, which in turn moves the adjusting arm down (see Fig. 14) and provides a greater engagement of the bimetal with the two latches. This increase of engagement requires a greater than normal bimetal temperature rise before the latches trip, and thus an extra capacity is provided to take care of emergency overload conditions.

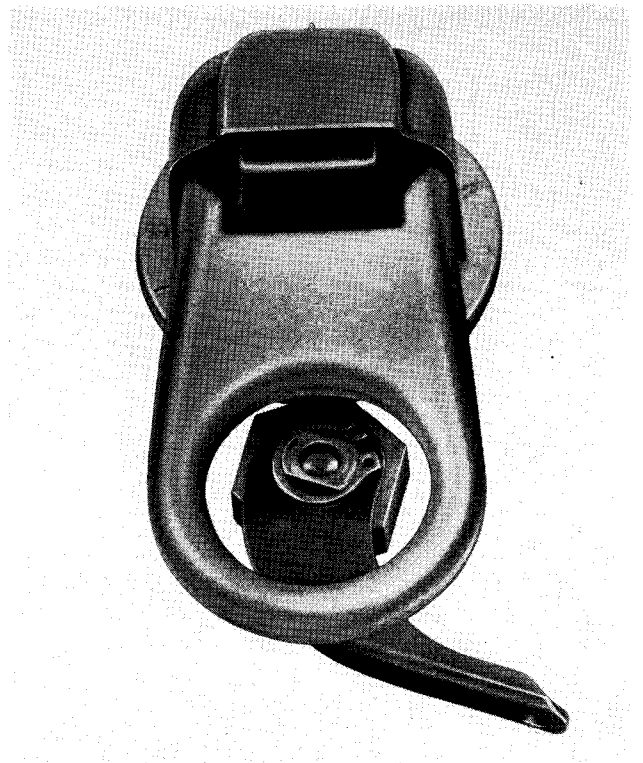


Fig. 20. Emergency Control Handle in Emergency Position.

OPERATING INSTRUCTIONS

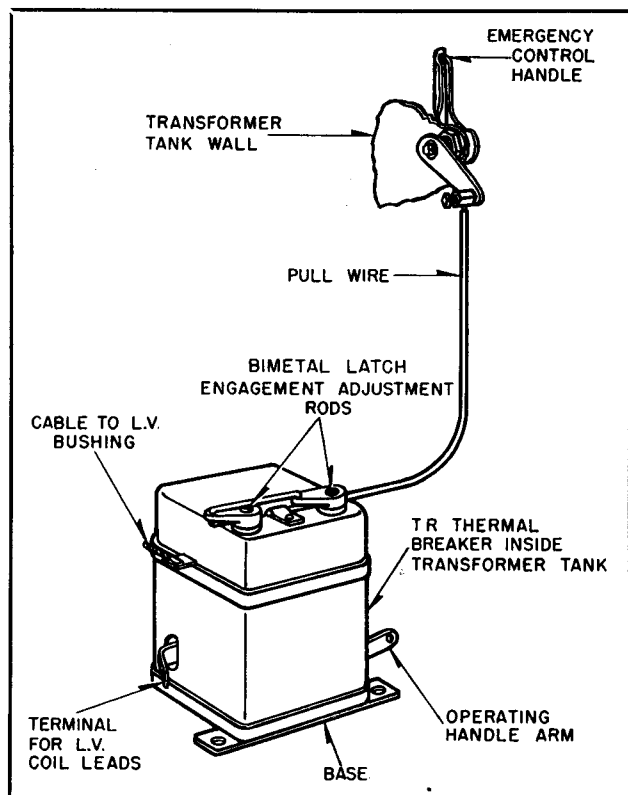


FIG. 21. One Unit of "TR" Breaker with Emergency Control Linkage.

The effect on the performance of the transformer may be more easily understood by referring to Fig. 23. Curve A shows the normal performance of the breaker; Curve B shows the performance with maximum increase of the emergency control setting.

This method of providing for overload emergency still permits manual operation of the breaker and also retains the protective features of the "CSP" designs against short circuit conditions.

It must be realized that this extra load capacity is provided at the expense of insulation life and, therefore, it is important that the control be used only when necessary and that it be left on only as long as conditions require.

Type BR Breaker. This feature has been added to the "BR" breaker in much the same way that it was on the "TR" breaker.

The emergency control mechanism is shown by Fig. 22. A bent steel arm is fitted on the bimetal adjusting nut for the breaker latch of each pole, and the arms linked together by a suitable connecting rod. This, in turn, is attached to a pull-wire which goes to a control arm on the inside of the tank wall. A shaft in a sealed bearing connects the control arm to an operating handle on the outside of the tank. Rotation of the handle

increases the trip temperature of the breaker, facilitating reclosure and increasing the over-load required to trip the breaker in a given time.

Operating Instructions. The transformer should always be installed with the control in the normal position in which it is set and sealed at the factory. Under ordinary circumstances it should always be allowed to remain in this position.

In case the breaker has tripped because of excessive overload, an attempt should first be made to reset the breaker in the usual manner without moving the emergency control handle. Usually this will be possible, and no other action will be necessary. If the tripping is the result of a growth in load, then the transformer should be replaced with a larger unit.

However, if this replacement cannot be made immediately, and if the breaker cannot be reclosed, or if it trips out very quickly after it has been reclosed, then it may be necessary to use the emergency control device. The seal must then be broken and the handle rotated clockwise. The breaker operating handle can then be moved to the reset position and the breaker reclosed in the usual manner.

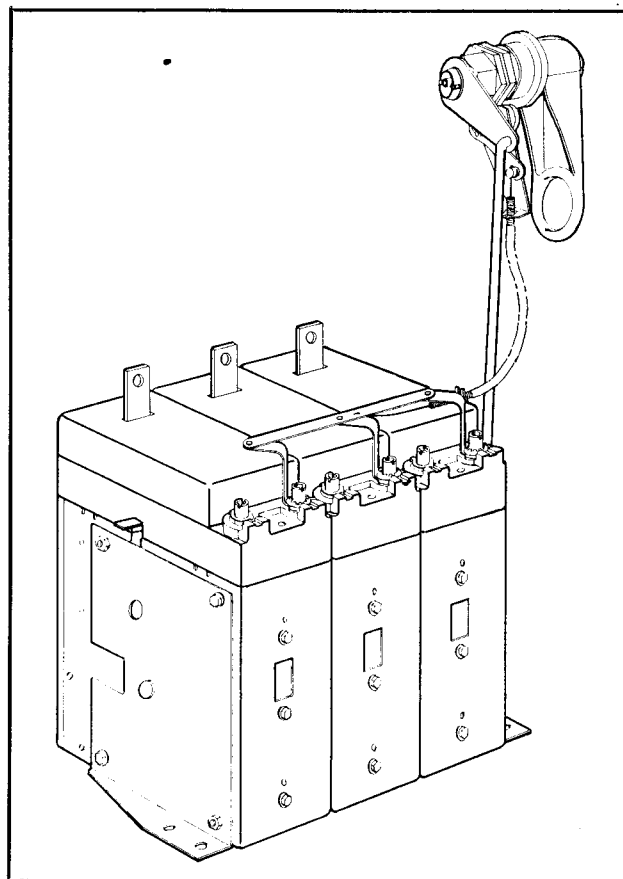


FIG. 22. One Unit of Three-Pole "BR" Breaker with Manual Operating Mechanism and Emergency Control.

CIRCUIT BREAKER OPERATING LINKAGE ADJUSTMENT

The external operating mechanism is properly adjusted at the factory. No further check of this adjustment should be required in the field, except to see that the breaker opens and closes properly by movement of the handle.

However, in case it is desired to repeat the factory adjustment, the procedure is as follows:

With the transformer cover off and the upper end of the vertical rod removed from the arm, set the external handle in the closed position against its stop. Also, by means of the vertical rod, set the breaker in the closed position against its stop. Turn the upper end of the vertical rod to screw it into or out of its socket until the upper end just fits in the hole in the operating arm.

If construction is as shown in Fig. 24, turn the upper end of the vertical rod to the right (which shortens the rod) two full turns. Move the handle away from its stop slightly so that the end of the rod may again be inserted in the hole of the operating arm. The cotter pin should then be replaced.

If construction is as shown in Fig. 25, turn the upper end of the vertical rod to the left (which lengthens the rod) one full turn. Move the handle away from its stop slightly so that the end of the rod may again be inserted in the hole of the operating arm. The cotter pin should then be replaced.

By the above means, a slight clearance is obtained between the handle stop and quadrant stop on closing, and at the same time adequate clearance is obtained to the opposite stops to permit proper resetting.

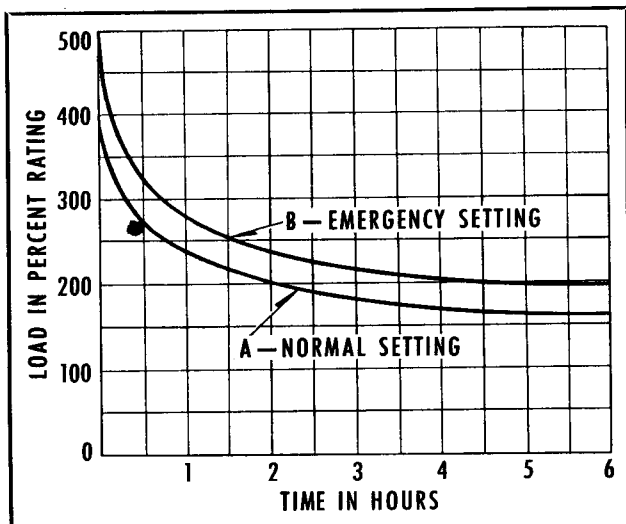


FIG. 23. Typical Breaker Trip Curves Showing Effect of Emergency Control.

Note: For some overloads, it may be necessary to operate the emergency control of the breaker on the second "CSPB" feeding the same section of the line.

In general, the transformer should be allowed to carry this peak load only until the transformer can be replaced, preferably not more than a day. It is recommended that a new seal (any meter seal may be used) be applied to the handle after it has been reset.

Caution: Since as mentioned above, the use of the emergency control may result in a reduction of transformer life, it should be used only when and as long as absolutely necessary.

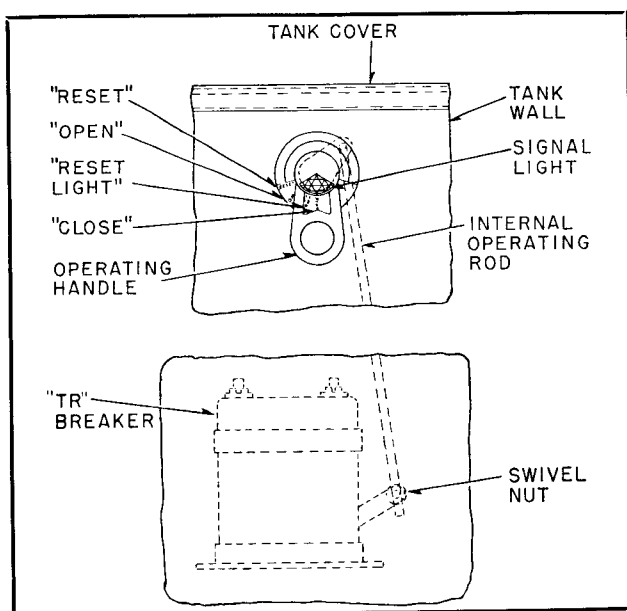


FIG. 24. "TR" Breaker Operating Handle, Linkage, and Signal Light.

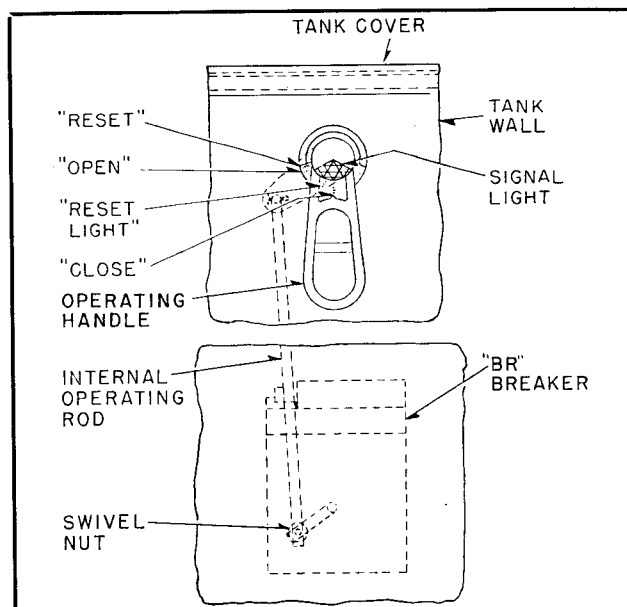


FIG. 25. "BR" Breaker Operation Handle Linkage, and Signal Light.

PART FIVE

SERVICE INSPECTION AND MAINTENANCE

Because of the comparatively small investment involved at each location and because of the generally high level of reliability, very little inspection or maintenance is economically justified for the great majority of distribution transformers. A visual inspection of the external parts of the transformer is desirable at perhaps two-year intervals. At such times, the general condition of the following should be noted:

1. High-voltage bushings and leads.
2. Low-voltage bushings.
3. External "De-ion" arresters and porcelains.
4. "De-ion" arrester resistors.
5. Finish on tank.

Where parts have become broken or where the tank shows evidence of excessive rusting, the transformer should be returned to a service shop for repair.

When transformers are returned to a service shop for any reason, it is common practice to make a thorough inspection of all parts, and make any additional repairs which may be indicated, including the repainting of at least the exterior surfaces of the tank. Gasketing of the transformer, particularly that of the cover or handhole cover, should be checked at this time. If there is any evidence of moisture having entered the unit, the oil should be drained, the core and coil assembly thoroughly

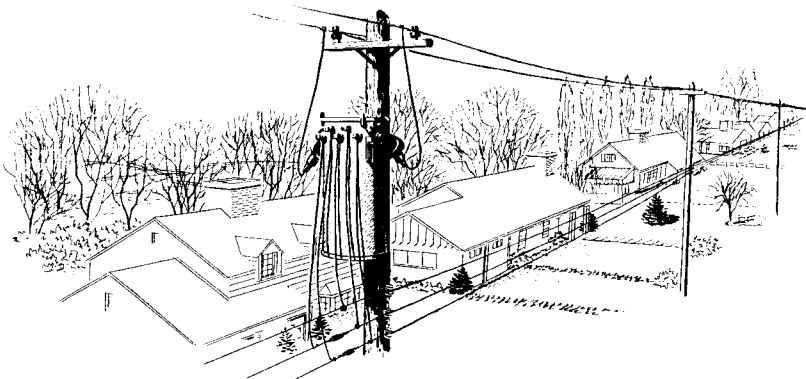
dried, and the unit then refilled with new Wemco C oil. It is preferable to vacuum treat the unit after refilling to insure maximum electrical strength. Whether or not the oil is replaced, the level should be brought to the proper height, as indicated by the oil gauge (if any) or by the oil level mark on the inside of the tank.

If the transformer is tested either before or after the repair operations, the test voltage used should not exceed 65 percent of the factory test values. See N.E.M.A. Transformer Standard 48-132.

RENEWAL PARTS

Maintenance and repair work on distribution transformers is usually done in a shop after a replacement unit has been installed to continue service. It is, therefore, not usually necessary that spare parts be carried to meet "emergency" conditions, but only from a repair shop "convenience" standpoint. Stocking practice varies widely with different operators. It sometimes depends on how many units are in service with like parts. Most operators limit their renewal parts stock to bushings, terminal boards, tap changers and in some cases "De-ion" arresters. Some operators carry practically no renewal parts but order them only when required for a specific case.

Renewal parts for Westinghouse transformers are listed and described in Transformer Renewal Parts Data 150 which is available upon request.



WESTINGHOUSE ELECTRIC CORPORATION

HEADQUARTERS: 306 4th AVE., P. O. BOX 1017, PITTSBURGH 30, PA.
SALES OFFICES

AKRON 8, OHIO, 106 South Main St.
ALBANY 4, N. Y., 454 No. Pearl St.
ALBUQUERQUE, N. M., 1115 1/2 E. Central Ave.
ALLENTOWN, PA., 739 Hamilton St.
AMARILLO, TEXAS, 301 Amarillo Bldg.
APPLETON, WIS., 321 W. College Ave., P.O. Box 206
ATLANTA 2, GA., 1299 Northside Drive, N.W.
AUGUSTA, MAINE, 9 Bowman St.
BAKERSFIELD, CALIF., 2224 San Emidio St.
BALTIMORE 2, MD., 501 St. Paul Pl.
BEAUMONT, TEXAS, 515 American National Bank Bldg.
BINGHAMTON 62, N. Y., 704 Marine Midland Bldg.
BIRMINGHAM 3, ALA., 1407 Corn St.
BLUEFIELD, W. VA., 704 Bland St., P.O. Box 848
BOSTON 10, MASS., 10 High St.
BRIDGEPORT 8, CONN., 540 Grant St.
BUFFALO 3, N. Y., 814 Ellicott Square Bldg.
BUTTE, MONTANA, 1 East Broadway
CANTON 2, OHIO, 120 W. Tuscarawas St.
CEDAR RAPIDS, IOWA, 512 Dows Bldg., P.O. Box 1828
CHARLESTON, S. C., 89 G. Smith St.
CHARLESTON 1, W. VA., 179 Summer St., P.O. Box 911
CHARLOTTE 1, N. C., 210 East Sixth St.
CHATTANOOGA 2, TENN., Volunteer State Life Bldg.
CHICAGO 6, ILL., 20 N. Wacker Drive
(After March 1, 1951, Mdse. Mart Plaza, Chicago 54, Ill.)
CINCINNATI 2, OHIO, 207 West Third St.
CLEVELAND 13, OHIO, 1370 Ontario St.
COLUMBUS 15, OHIO, 262 N. 4th St.
CORPUS CHRISTI, TEXAS, 416 N. Chaparral St.
DALLAS 1, TEXAS, 209 Browder St.
DAVENPORT, IOWA, 2212 E. 12th St., P.O. Box 29
DAYTON 2, OHIO, 32 North Main St.
DENVER 2, COLORADO, 910 Fifteenth St.
DES MOINES 8, IOWA, 1400 Walnut St.
DETROIT 31, MICH., 5757 Trumbull Ave., P.O. Box 828
DULUTH 2, MINN., 10 East Superior St.
EL PASO, TEXAS, 718 Mills Bldg.
EMERYVILLE 8, CALIF., 5815 Peladeau St.
ERIE, PA., 1003 State St.
EVANSVILLE 8, IND., 106 Vine St.
FAIRMONT, W. VA., 10th and Beltline Sts.
FERGUS FALLS, MINN., 101 1/2 W. Lincoln St.
FORT WAYNE 2, IND., 610 S. Harrison St.
FT. WORTH 2, TEXAS, 408 West Seventh St.
FRESNO 1, CALIF., 2608 California Ave.
GARY, IND., 846 Broadway
GRAND RAPIDS 2, MICH., 148 Monroe Ave., N.W.
GREENSBORO, N. C., 1008 Pamlico Drive
GREENVILLE, S. C., 160 W. Tallulah Drive
HAMMOND, IND., 238 Locust St.
HARTFORD 3, CONN., 119 Ann St.
HOUSTON 2, TEXAS, 1314 Texas Ave.
HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150
INDIANAPOLIS 9, IND., 137 S. Pennsylvania St.
JACKSON, MICH., 180 West Michigan Ave.
JACKSON, MISS., Fondren Station, P.O. Box 4296
JACKSONVILLE 3, FLA., 37 South Hogan St.
JAMESTOWN, N. Y., 300 Wellman Bldg., 101 West 3rd St.
JOHNSTOWN, PA., 107 Station St.
KANSAS CITY 6, MO., 101 W. Eleventh St.
KNOXVILLE 8, TENN., 605 Burwell Bldg.
LITTLE ROCK, ARKANSAS, 707 Boyle Bldg.
LOS ANGELES 17, CALIF., 600 St. Paul Ave.

LOUISVILLE 2, KY., 332 West Broadway
MADISON 3, WIS., 1022 E. Washington Ave.
MEDFORD, ORE., 38 N. Bartlett St., P.O. Box 1308
MEMPHIS 3, TENN., 825 Exchange Bldg.
MIAMI 4, FLA., 11 N. E. Sixth St.
MIDDLESBORO, KY., 2019 Cumberland Ave.
MILWAUKEE 2, WIS., 538 N. Broadway
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N.E.
MOBILE, ALA., 171 Emogene Pl.
NASHVILLE 3, TENN., 6th Ave. at Shirley St.
NEWARK 2, N. J., 1180 Raymond Blvd.
NEW HAVEN 10, CONN., 42 Church St.
NEW ORLEANS 13, LA., 238 South Saratoga St.
NEW YORK 5, N. Y., 40 Wall St.
NIAGARA FALLS, N. Y., 253 Second St.
NORFOLK 10, VA., 915 W. 21st St.
OKLAHOMA CITY 2, OKLA., 120 N. Robinson St.
OMAHA 2, NEB., 117 North Thirtieth St.
PEORIA 2, ILL., 418 S. Washington St.
PHILADELPHIA 4, PA., 3001 Walnut St.
PHOENIX, ARIZONA, 11 West Jefferson St.
PITTSBURGH 30, PA., 306 4th Ave., Box 1017
PORTLAND 4, OREGON, 309 S. W. Sixth Ave.
PROVIDENCE 3, R. I., 16 Elbow St.
RALEIGH, N. C., 803 North Person St.
READING, PA., 4th and Elm Sts.
RICHMOND 19, VA., 1110 East Main St.
ROANOKE 4, VA., Kirk Ave. and First St., P.O. Box 599
ROCHESTER 7, N. Y., 1048 University Ave.
ROCKFORD, ILL., 323 South Main St.
RUTLAND, VT., 98 Merchants Row
SACRAMENTO 14, CALIF., 1720 14th St.
SAGINAW, MICH., 124 S. Jefferson Ave.
ST. LOUIS 1, MO., 411 North Seventh St.
SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
SAN ANTONIO 5, TEXAS, 115 W. Travis St.
SAN DIEGO 1, CALIF., 861 Sixth Ave.
SAN FRANCISCO 8, CALIF., 410 Bush St.
SEATTLE 4, WASH., 3451 East Marginal Way
SHREVEPORT, LA., 222 Spring St.
SIOUX CITY 4, IOWA, 1005 Dace St.
SOUTH BEND 4, IND., 216 East Wayne St.
SPOKANE 8, WASH., 1023 W. Riverside Ave.
SPRINGFIELD, ILL., 517 Illinois Bldg., P.O. Box 37
SPRINGFIELD 3, MASS., 26 Vernon St.
SYRACUSE 4, N. Y., 700 W. Genesee St.
TACOMA 2, WASH., 1930 Pacific Ave.
TAMPA 1, FLA., 609 Wallace S. Bldg., 608 Tampa St.
TOLEDO 4, OHIO, 245 Summit St.
TRENTON 10, N. J., 1100 S. Broad St.
TULSA 3, OKLA., 619 S. Main St.
UTICA 1, N. Y., 113 N. Genesee St.
WALLA WALLA, WASH., 17 N. 2nd Ave., P.O. Box 182
WASHINGTON 8, D. C., 1625 K St., N.W.
WATERLOO, IOWA, 300 West 3rd St.
WATERTOWN, N. Y., 245 State St.
WHEELING, W. VA., 12th and Main Sts., P.O. Box 329
WICHITA 2, KANSAS, 301 South Market St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
WILLIAMSPORT 1, PA., 348 W. Fourth St.
WORCESTER 8, MASS., 507 Main St.
YORK, PA., 11 W. Market St.
YOUNGSTOWN 3, OHIO, 25 E. Boardman St.

MANUFACTURING AND REPAIR DEPARTMENT OFFICES

ATLANTA 2, GA., 1299 Northside Drive, N.W.
AUGUSTA, MAINE, 9 Bowman St.
BALTIMORE 24, MD., 4015 Foster Ave.
BATON ROUGE, LA., 585 Choctaw Drive
BOSTON 27, MASS., 235 Old Colony Ave., So. Boston
BRIDGEPORT 8, CONN., 540 Grant St.
BUFFALO 10, N. Y., 1132 Seneca St.
CHARLOTTE 1, N. C., 210 East Sixth St.
CHICAGO 32, ILL., 3900 W. 41st St.
CINCINNATI 29, OHIO, 1050 Laidlaw Ave., Bond Hill
CLEVELAND 2, OHIO, 5901 Breakwater Ave., Station A
DENVER 9, COLORADO, 200 Rio Grande Blvd.
DETROIT 31, MICH., 5757 Trumbull Ave., P.O. Box 828
EMERYVILLE 8, CALIF., 5815 Peladeau St.
FAIRMONT, W. VA., 10th and Beltline Sts.
FORT WORTH 7, TEXAS, 100 Rupert St.
HILLSIDE, N. J., 1441 Chestnut Ave.
HOUSTON 20, TEXAS, 5730 Clinton Dr.
HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150

INDIANAPOLIS 2, IND., 551 West Merrill St.
JOHNSTOWN, PA., 107 Station St.
LOS ANGELES, CALIF., 3383 E. Gage Ave., Huntington Park
MILWAUKEE 3, WIS., 424 North Fourth St.
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N.E.
NEWARK, N. J., (See Hillside, N. J.)
PHILADELPHIA 34, PA., Erie Ave. & "D" St.
PHILADELPHIA 4, PA., 3001 Walnut St.
PITTSBURGH 8, PA., 543 N. Lang Ave.
PORTLAND 12, ORE., 626 North Tillamook St.
PROVIDENCE 3, R. I., 16 Elbow St.
ST. LOUIS 10, MO., 1601 S. Vandeventer St.
SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
SEATTLE 4, WASH., 3451 East Marginal Way
SPRINGFIELD 1, MASS., 395 Liberty St.
SUNNYVALE, CALIF., P.O. Box 37
SYRACUSE 4, N. Y., 700 W. Genesee St.
UTICA 1, N. Y., 113 N. Genesee St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.

DISTRICT ENGINEERING AND SERVICE DEPARTMENT OFFICES

ATLANTA 2, GA., 1299 Northside Drive, N.W.
BALTIMORE 2, MD., 501 St. Paul Pl.
BEAUMONT, TEXAS, 515 American National Bank Bldg.
BLUEFIELD, W. VA., 704 Bland St., P.O. Box 848
BOSTON 10, MASS., 10 High St.
BRIDGEPORT 8, CONN., 540 Grant St.
BUFFALO 3, N. Y., 814 Ellicott Square Bldg.
BUTTE 1, MONTANA, 1 East Broadway
CHARLOTTE 1, N. C., 210 East Sixth St.
CHICAGO 6, ILL., 20 N. Wacker Drive
(After March 1, 1951, Mdse. Mart Plaza, Chicago 54, Ill.)
CINCINNATI 2, OHIO, 207 West Third St.
CLEVELAND 13, OHIO, 1370 Ontario St.
DALLAS 1, TEXAS, 209 Browder St.
DENVER 2, COLORADO, 910 Fifteenth St.
DES MOINES 8, IOWA, 1400 Walnut St.
DETROIT 31, MICH., 5757 Trumbull Ave., P.O. Box 828
DULUTH 2, MINN., 10 East Superior St.
EL PASO, TEXAS, 1211 Mills Bldg.
GRAND RAPIDS 2, MICH., 148 Monroe Ave., N.W.
HOUSTON 2, TEXAS, 1314 Texas Ave.
HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150
INDIANAPOLIS 9, IND., 137 S. Pennsylvania St.
JACKSON, MICH., 180 W. Michigan Ave.
KANSAS CITY 6, MO., 101 W. Eleventh St.
LOS ANGELES 14, CALIF., 600 St. Paul Ave.
LOUISVILLE 2, KY., 332 West Broadway

MEMPHIS 3, TENN., 825 Exchange Bldg.
MILWAUKEE 2, WIS., 538 N. Broadway
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N.E.
NEW ORLEANS 13, LA., 238 South Saratoga St.
NEW YORK 5, N. Y., 40 Wall St.
NORFOLK 10, VA., 915 W. 21st St.
PHILADELPHIA 4, PA., 3001 Walnut St.
PHOENIX, ARIZ., 11 West Jefferson St.
PITTSBURGH 30, PA., 306 4th Ave., Box 1017
PORTLAND 4, OREGON, 309 S. W. Sixth Ave.
PROVIDENCE 3, R. I., 16 Elbow St.
RICHMOND 19, VA., 1110 East Main St.
ROANOKE 4, VA., Kirk Ave. and First St., P.O. Box 599
ST. LOUIS 1, MO., 411 North Seventh St.
SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
SAN DIEGO 1, CALIF., 861 Sixth Ave.
SAN FRANCISCO 8, CALIF., 410 Bush St.
SEATTLE 4, WASH., 3451 East Marginal Way
SPOKANE 8, WASH., 1023 W. Riverside Ave.
SPRINGFIELD 3, MASS., 26 Vernon St.
SYRACUSE 4, N. Y., 700 W. Genesee St.
TOLEDO 4, OHIO, 245 Summit St.
UTICA 1, N. Y., 113 N. Genesee St.
WASHINGTON 8, D. C., 1625 K Street, N.W.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
YOUNGSTOWN 3, OHIO, 25 E. Boardman St.

