INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

Oil-Immersed

DISTRIBUTION TRANSFORMERS

TYPES

CSP — Completely Self-Protected

CP — Current Protected

S — Conventional

SB — Shovel (Special Braced)

3 to 167 Kva

15,000 Volts or Less

Single- and Three-Phase

WESTINGHOUSE ELECTRIC CORPORATION

SHARON, PA. • TRANSFORMER DIVISION • SUNNYVALE, CALIF.

SUPERSEDES I.B. 46-100-1 AND SUPPLEMENT "A"

MAY, 1954

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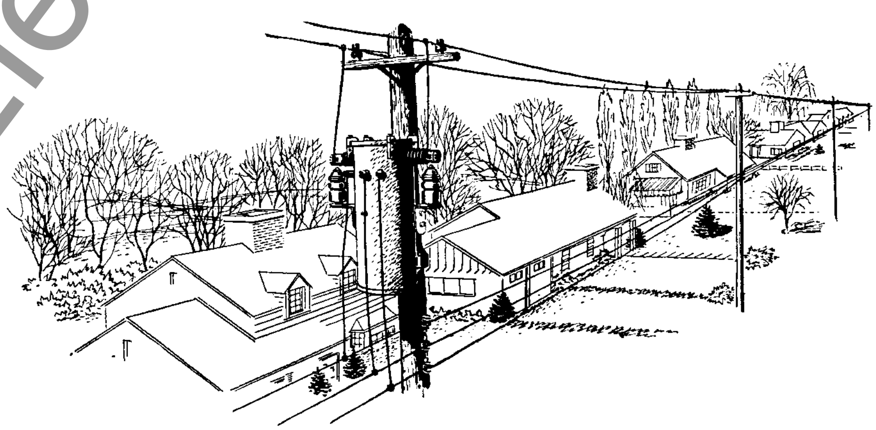
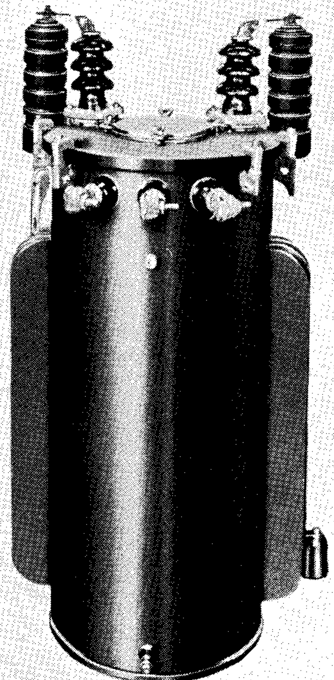
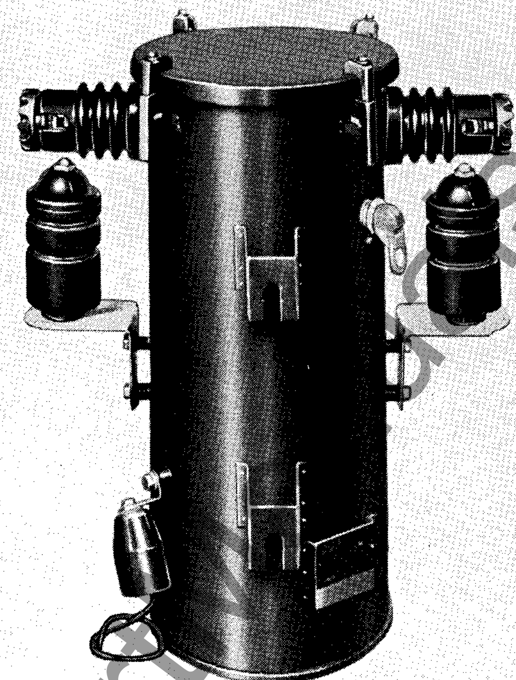


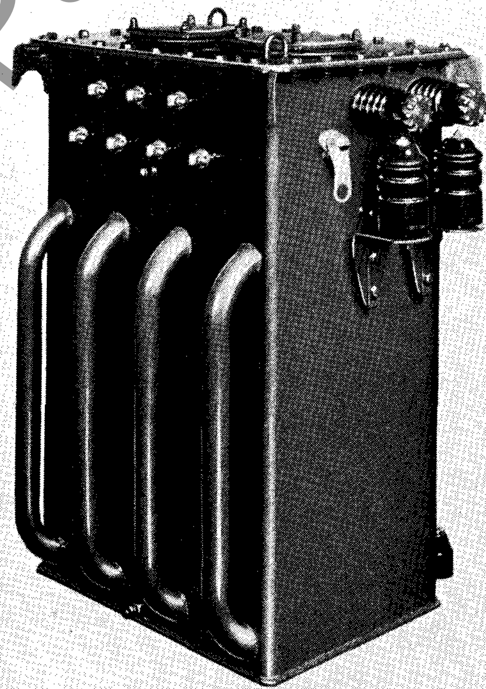


"CSP" Transformer with two Cover-Mounted Bushings



"CSP" Transformer with two Wall Bushings

"S" Conventional Transformer (167 Kva)



3 Phase "CSPB" Transformer with Wall Bushings

Oil-Immersed DISTRIBUTION TRANSFORMERS

This instruction book has been prepared to assist the purchaser in properly installing, operating and maintaining the oil-immersed 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 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

Oil-immersed distribution transformers are normally used for stepping public utility "distribution voltages" (ranging from 2400 to 15,000 volts) down to lower utilization voltages. By far the greatest quantity are used for stepping down to a household voltage of 120/240 volts although a few are used for stepping down to industrial voltages of 240/480,600, or 2400 volts. These same transformers are sometimes used for small substations and for miscellaneous applications. As with any transformer, they can also serve as step-up units.

COMPONENT PARTS

Oil-immersed 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.

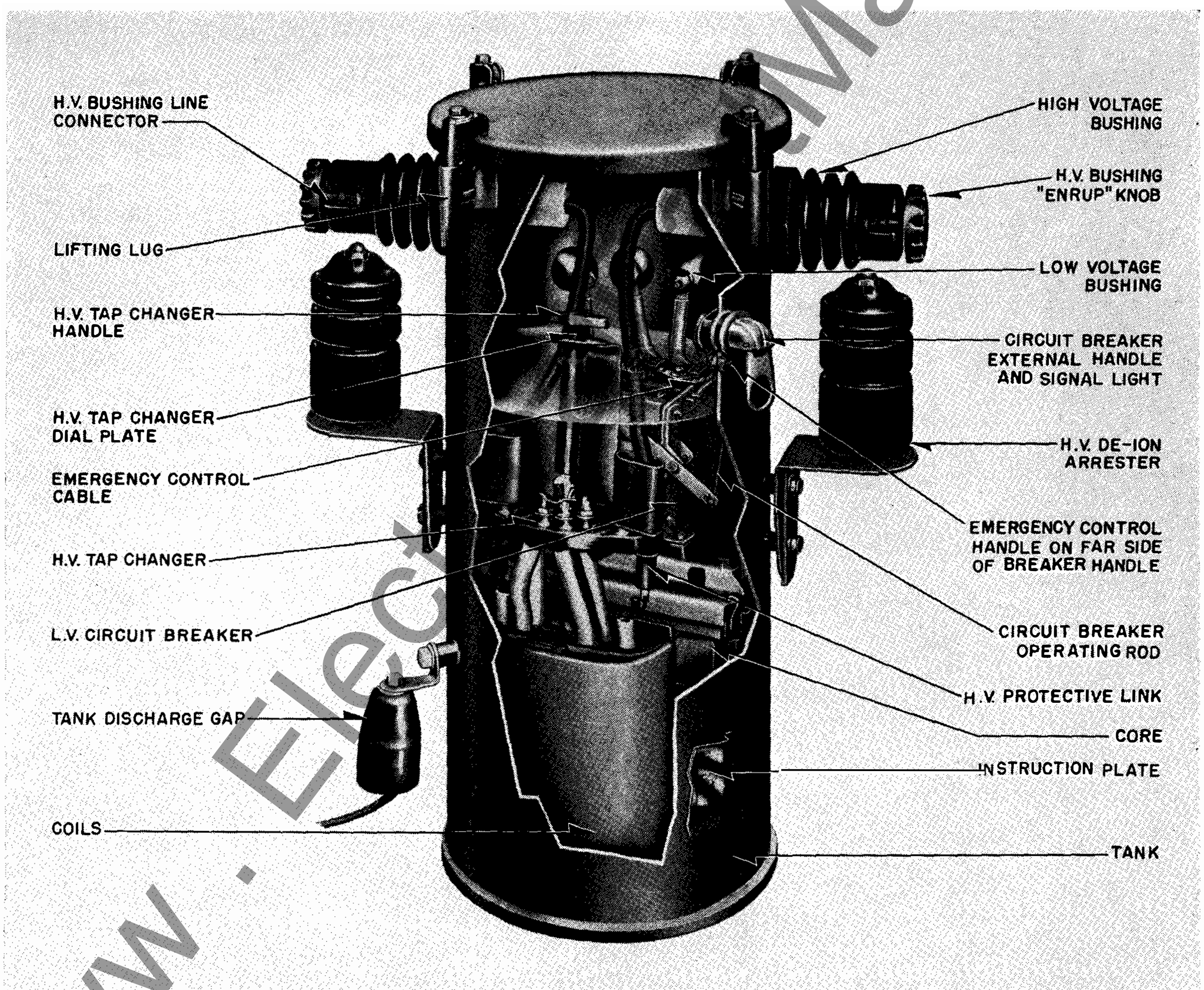


FIG. 1. Cutaway View of Typical Wall Bushing "CSP" Transformer.

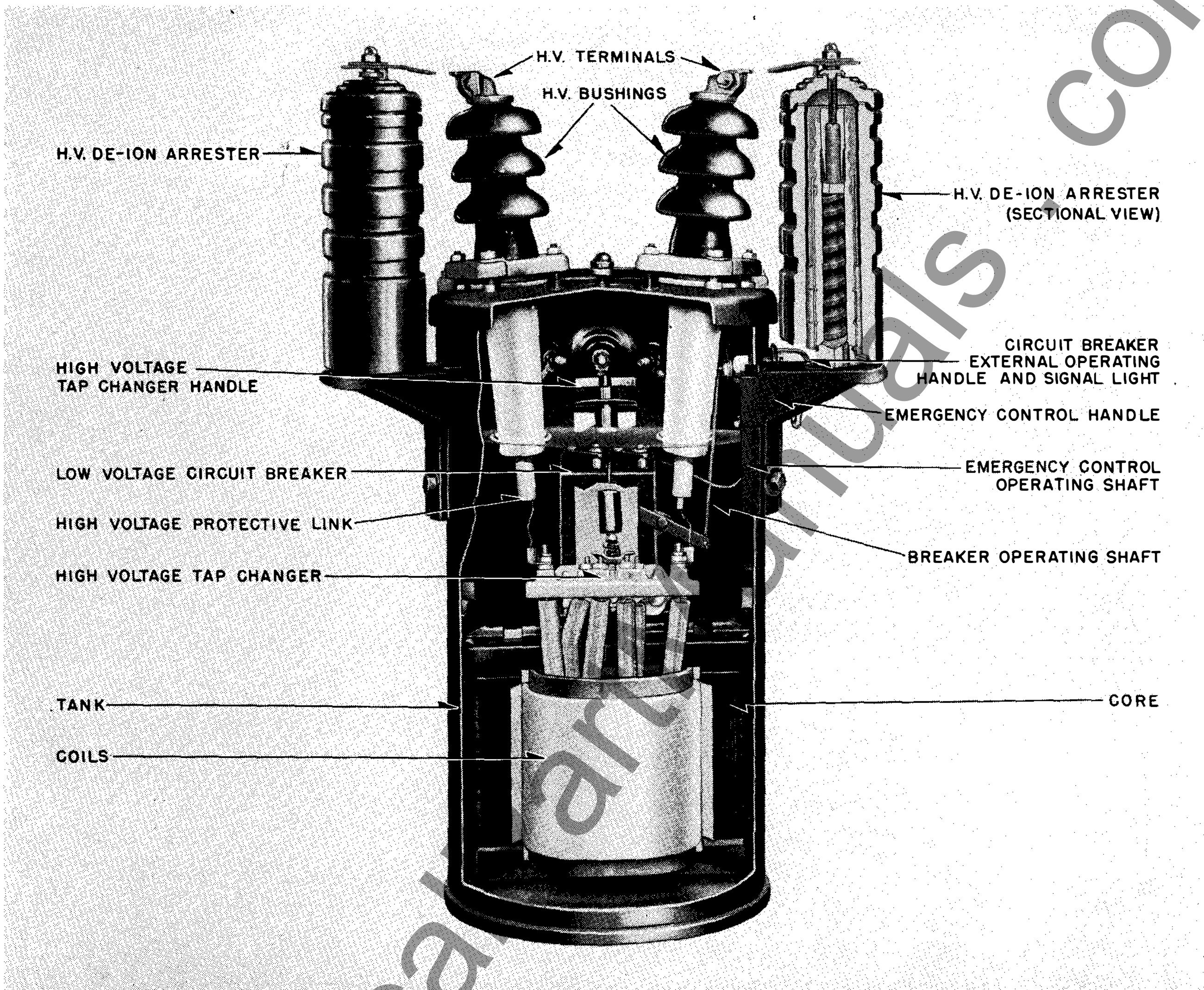


FIG. 2. Cutaway View of Typical Cover Bushing "CSP" Transformer.

Completely self-protected "CSP" transformers have integrally-mounted "De-ion" lightning arresters, and in addition have internally-mounted circuit breakers connected in series with the low-voltage winding, and protective links connected in series with the high-voltage winding. On special orders, transformers may be furnished with variations and/or additions to the above parts.

Typical "CSP" transformers are shown in Figs. 1 and 2. ("S" transformers are similar except that the circuit breaker, its operating mechanism, protective links, discharge gaps and "De-ion" lightning arresters are omitted). A typical "CSP" three-phase transformer is shown in Fig. 3.

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 and the average temperature for any 24 hour period should not exceed 30 degrees C (unless transformer is specially designed).

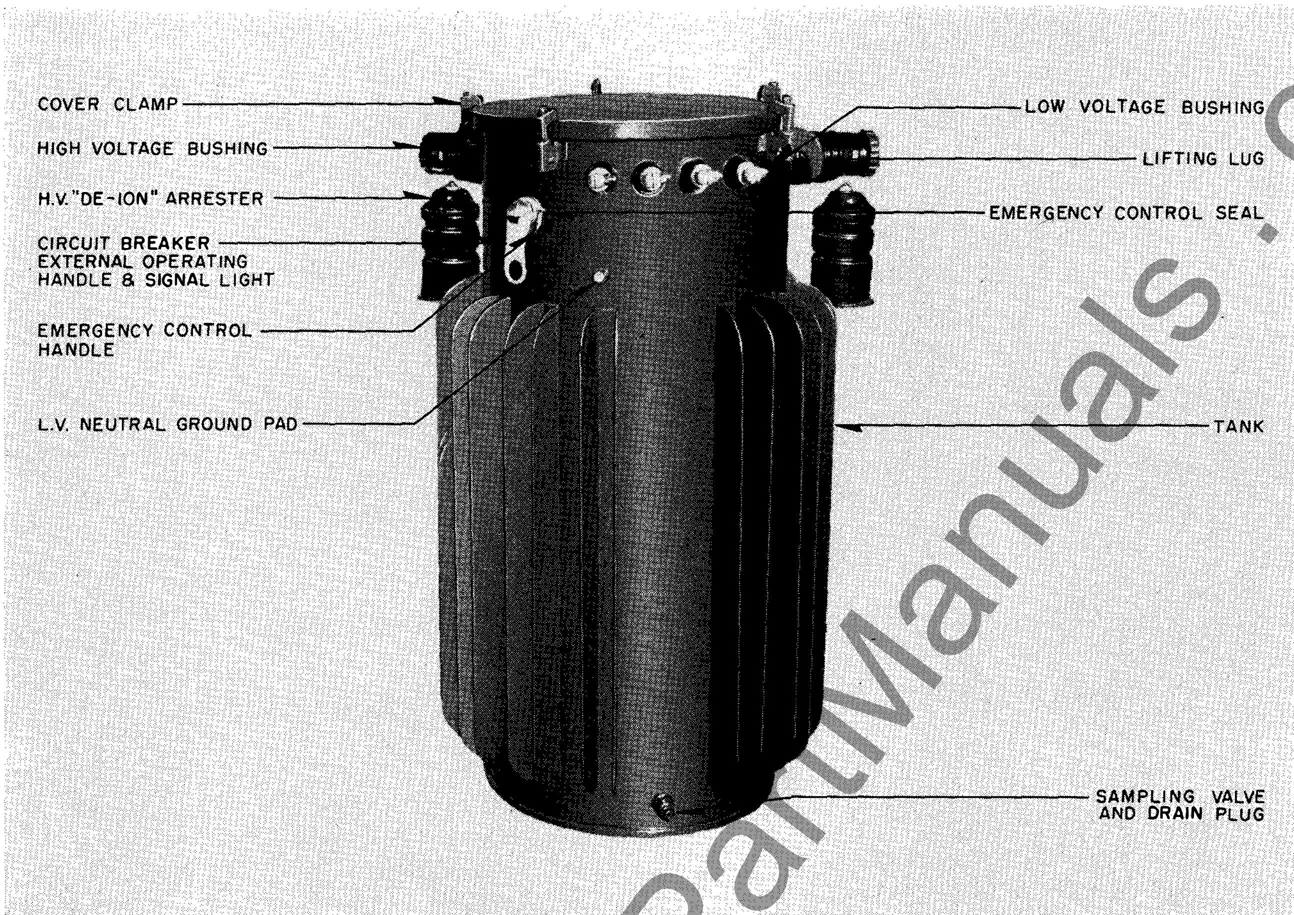


FIG. 3. Typical Three-Phase "CSP" Transformer.

5. Continuous kva load should not exceed rating (except for "CSP" transformers, in which case the circuit breaker will automatically allow loading up to the full thermal capacity of the transformer, according to existing ambient temperature).

6. Continuous kva load on reduced capacity taps should not exceed reduced capacity rating (except "CSP" transformers). Taps at voltages less than 90 percent of maximum voltage are usually rated at reduced kva.

7. For transformers which do not have built-in lightning protection, suitable external protection should be provided since bushing flashover is not considered as adequate protection against all forms of natural lightning.

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. (Never lift the transformer by the bushings).

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 (except "subway" transformers). 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 CI" 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 CI" 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 insulation replaced. Only "Wemco CI" oil should be used. When the transformer oil is being replenished, care must be taken that no moisture gets inside the tank.

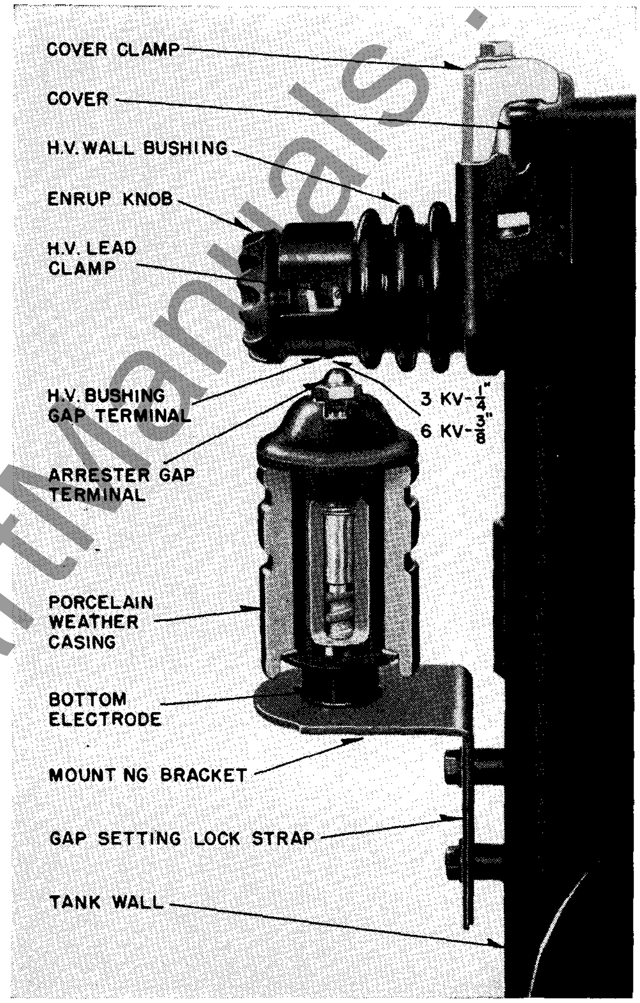
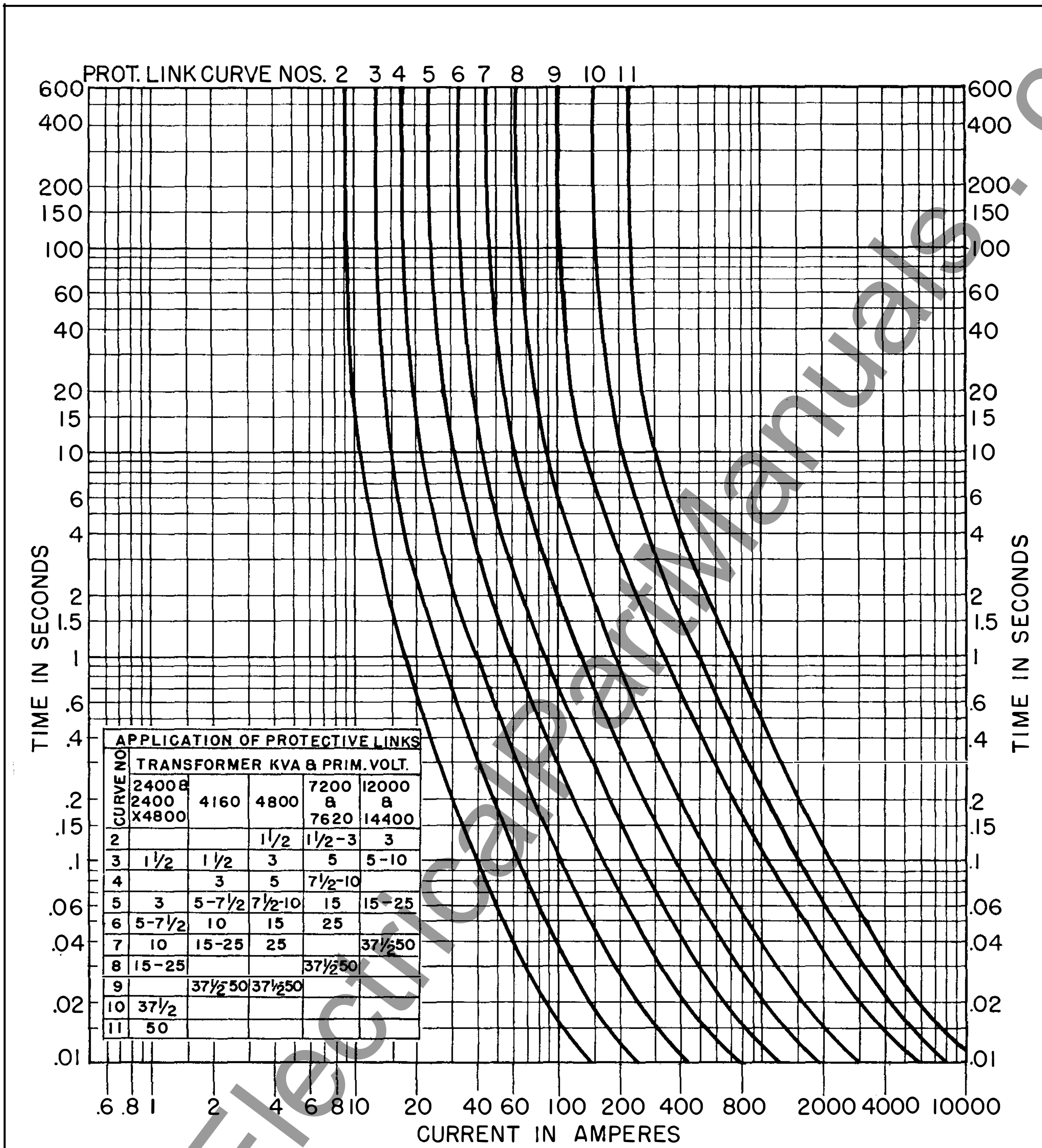


FIG. 4. Wall Mounted "De-ion" Arrester Assembly and Gap Adjustment.

For the proper operation of "De-ion" arresters, the air gaps should have spacings as shown in Figs. 4 or 9. 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



APPLICATION OF PROTECTIVE LINKS

CURVE NO.	TRANSFORMER KVA & PRIM. VOLT.				
	2400 & 2400 X4800	4160	4800	7200 & 7620	12000 & 14400
2			1½	1½-3	3
3	1½	1½	3	5	5-10
4		3	5	7½-10	
5	3	5-7½	7½-10	15	15-25
6	5-7½	10	15	25	
7	10	15-25	25		37½-50
8	15-25			37½-50	
9		37½-50	37½-50		
10	37½				
11	50				

FIG. 5. Protective Link Current Time Curves.

tapped for #6-32 machine screws, or #4 self-tapping screws may be used. Screws shall be 5/16 ± 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.

Transformers designed both for series-multiple and three-wire operation are normally shipped connected in series with the mid-point out for three-wire operation. Those designed for series-multiple only are shipped connected in series.

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 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.

PARALLEL OPERATION

When transformers are banked in multiple and distributed along the line on different poles, the line drop will usually compensate for difference in impedance. Transformers on the same pole are not usually operated in multiple except as an emergency condition because the losses of the units will usually exceed the losses of a larger unit having a rating equal to their total. If transformers are so operated, the transformer having the lowest impedance will take more than its share of the load. Transformers are usually considered satisfactory for paralleling if their impedances are within 7.5 percent of the larger value for two-winding transformers or 10 percent for auto-transformers, providing, of course, that their ratios are the same. However, it is advisable, where it is probable that the load may not be properly distributed, to take current readings to determine the exact distribution.

PROTECTIVE LINK COORDINATION ("CSP" TRANSFORMERS ONLY)

"CSP" 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 coordination of over-current devices is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-403.

FUSING PRACTICES ("S" TRANSFORMERS ONLY)

Transformers without internal breakers must be protected by external fuses which should be selected for short-circuit protection—not for overload protection. It will be found that fuse outages will be greatly reduced if a minimum rating of 10 amperes is used. This is particularly true where the fuse is connected ahead of the lightning arrester or "De-ion" arrester so that lightning currents must pass through the fuse to reach the arrester.

MOUNTING

Single-phase transformers rated 100 kva and less, and three-phase transformers rated 112½ kva and less, and rated 15,000 volts and less, may be mounted on poles. Three-phase 150-kva transformers may be pole mounted if an auxiliary support is provided to carry the weight of the unit. Larger ratings are normally designed for platform mounting only.

When pole mounting is used, there are three generally accepted methods. The simplest and most economical, particularly for "CSP" transformers where no auxiliary equipment on the pole is necessary, is to bolt the transformer directly to the pole as shown in "A", Fig. 6. No cross-arms on the pole are used unless needed for other purposes. Square-headed through bolts (⅝-inch or ¾-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 50 kva and smaller, single phase, or 45 kva and smaller, three phase, have lugs capable of the above type bolting. Adapters are available for single-phase, 75- and 100-kva ratings or for three-phase, 75-, 112½-, and 150-kva ratings, 15,000 volts and less. These adapters should be installed as shown in "B", Fig. 6.

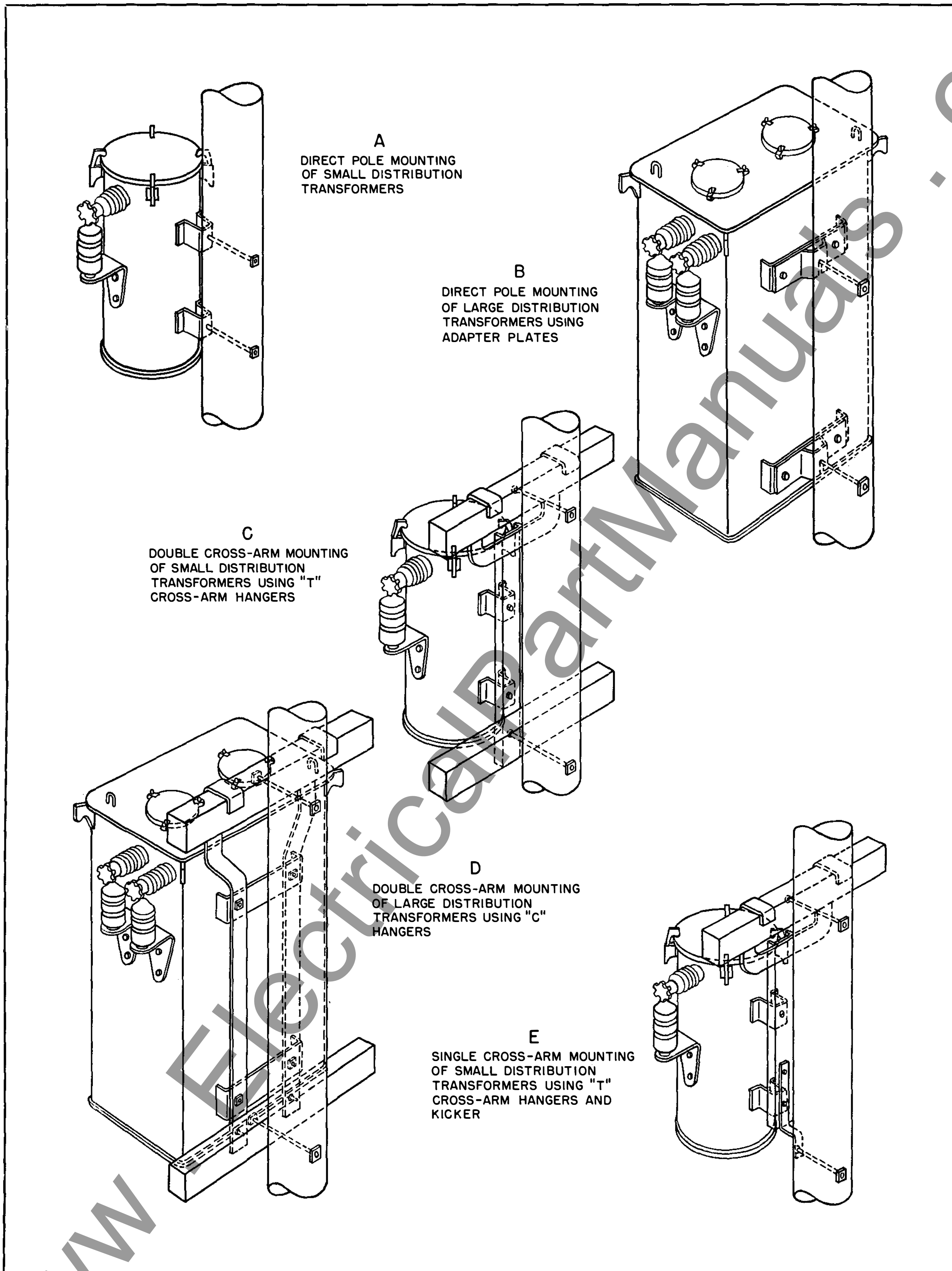


FIG. 6. Pole Mountings for Distribution Transformers.

Where two crossarms are used for mounting the transformer on a pole (nearly all three-phase installations of single-phase transformers and some other installations), "T-crossarm hangers" as shown in "C" Fig. 6 for the smaller units, and "Type C hangers" as shown in "D" Fig. 6 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 the manufacturer), is then employed as shown in "E", Fig. 6. 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.

BUSHING ARRANGEMENT

High-voltage, single-phase and three-phase transformers having a high-voltage rating of 5 KV and less have wall mounted high-voltage bushings. Single-phase and three-phase transformers having a high-voltage rating from 7.2 to 15.0 KV inclusive have cover mounted bushings.

HIGH VOLTAGE CONNECTIONS

When installing a transformer, the amount of protective apparatus required depends upon the type of transformer. The "CSP" transformer is completely self-protected and requires neither lightning arresters nor fuse cutouts. The "conventional" transformer should be provided with both lightning arresters (preferably connected for "three-point surge protection") and fuse cutouts. Hot line clamps may be advantageously used (particularly with the "CSP" transformer) for connecting 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.

Fig. 7 shows the proper internal and external connections to obtain the phase relations shown by the vector diagrams when connecting three standard single-phase transformers in a three-phase bank.

Westinghouse Instruction Book 46-100-3, available upon request, shows additional external circuit connection diagrams for the more common single-, two-, three-, and six-phase connections.

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 "CSP" 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 "De-ion" arrester may be physically interchanged with the coordinating strap.

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 "CSP" transformers, the "De-ion" arrester is mounted adjacent to the fully insulated bushing. Connect

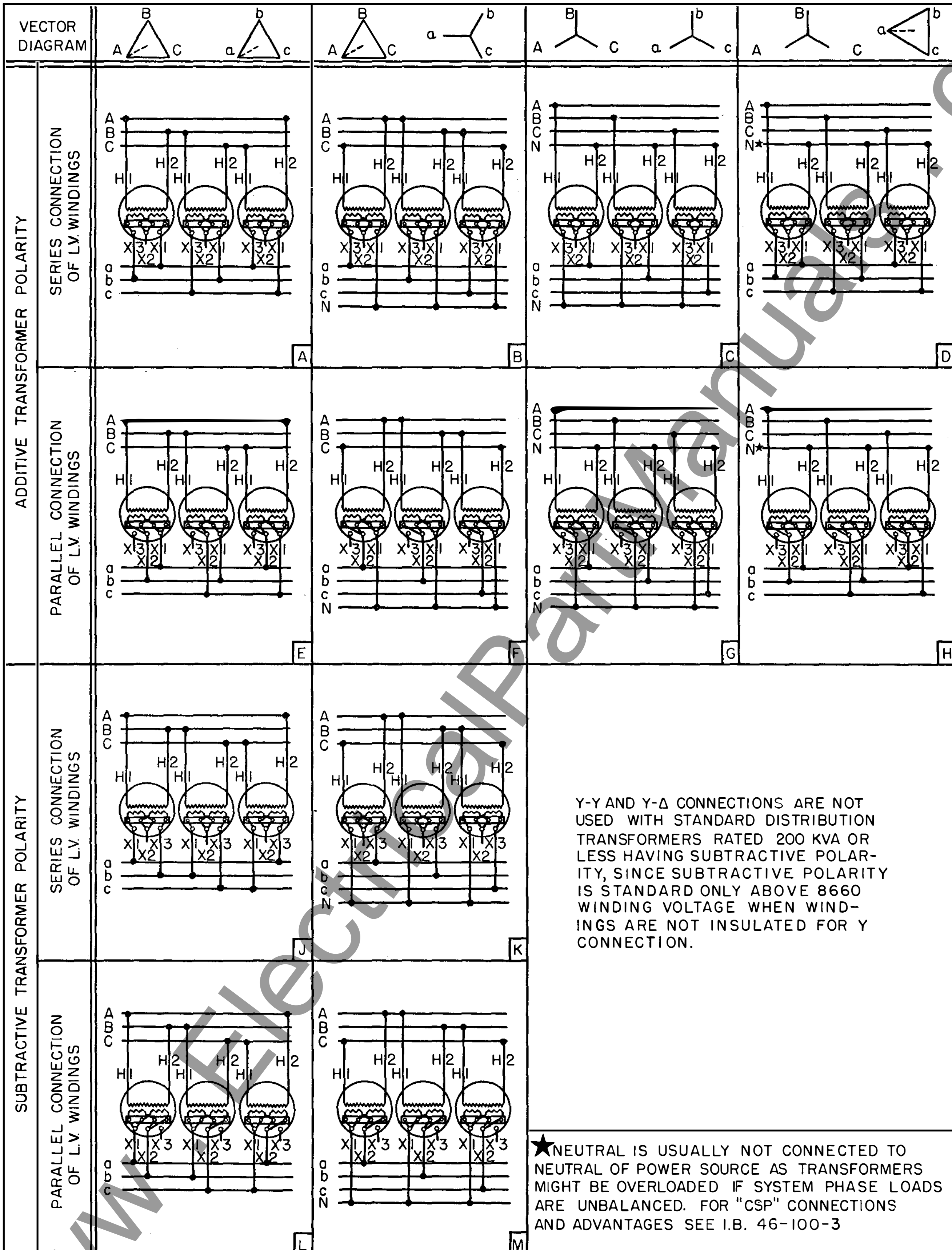


FIG. 7. Three-Phase Connection of Standard Single-Phase Transformers.

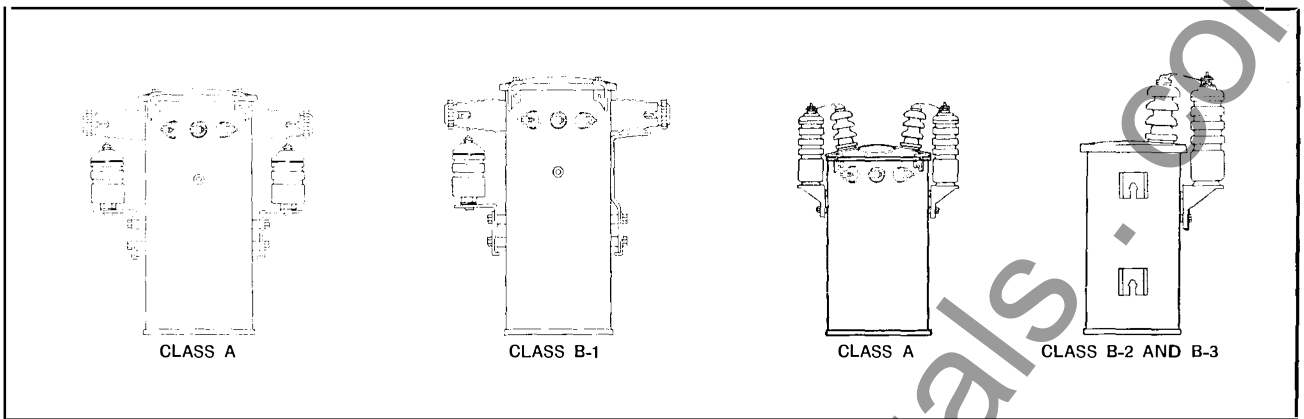


FIG. 8. **Transformer Class Designations.**

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.

LOW VOLTAGE CONNECTIONS

Refer to the diagram nameplate or the connection diagram specified on the nameplate and connect low-voltage terminals to service lines to secure the desired voltage. If a parallel connection of two sections of a low-voltage winding is made outside the transformer tank, the connection should be as short and as close to the low-voltage bushings as possible to insure equal division of current between the winding sections.

Where single-phase, three-wire service is supplied from a single-phase transformer, the neutral is usually grounded. When two-wire service is supplied, one of the leads is usually grounded if conditions permit. See National Electric Code for specific instructions. If leads are re-connected at the L. V. bushings to secure two-wire service, care should be used to maintain at least one inch clearance between live parts and between live parts and ground.

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. When installing such transformers in a three-phase bank, ***it is necessary to remove this connection on at least two transformers*** to prevent a short circuit when the three tanks are connected together.

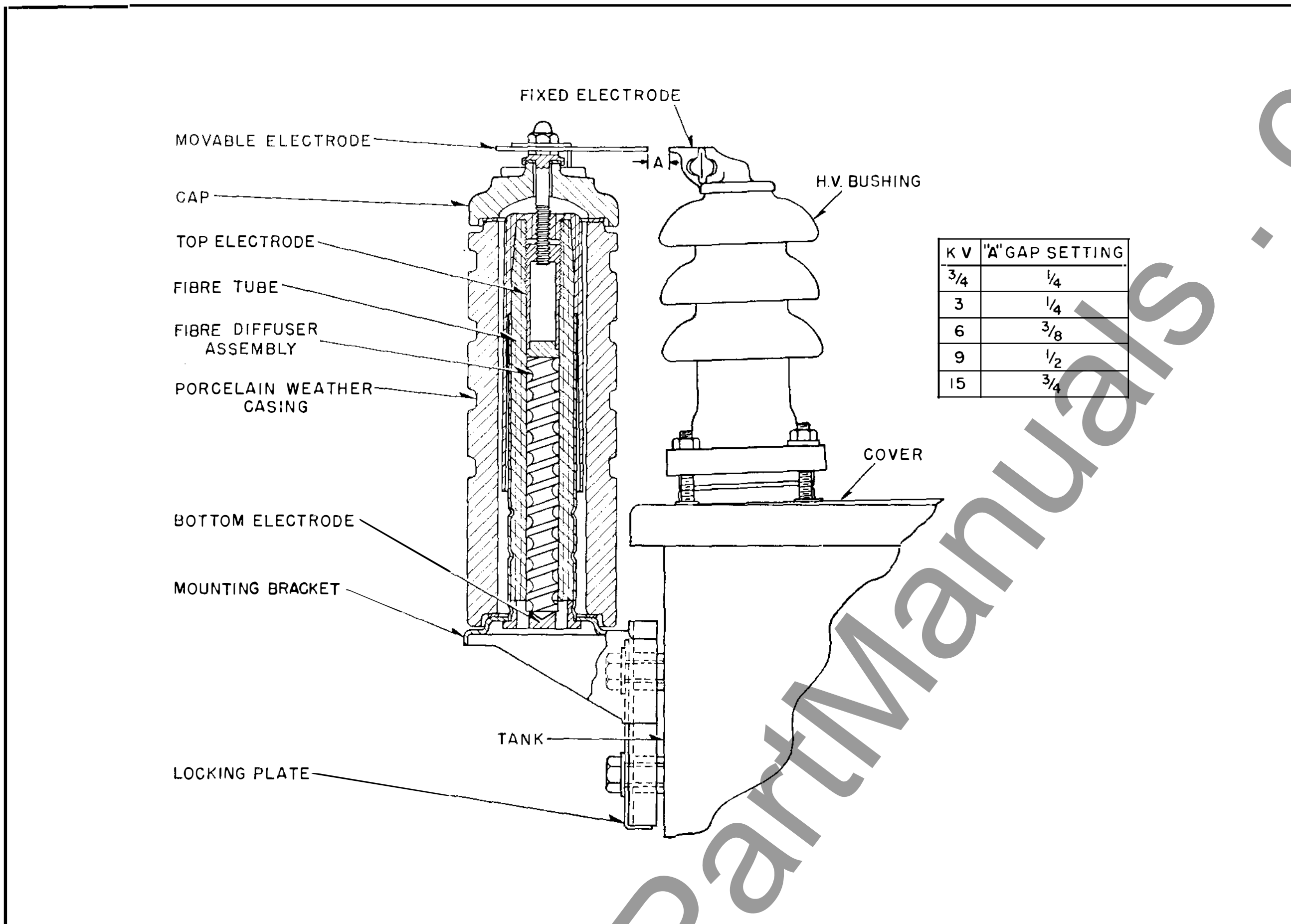
If standard single-phase "CSP" transformers are to be used to supply a combined three-phase load and a single-phase, ***three-wire*** load, it is important, except when the secondaries are connected in wye, that only two transformers connected in open delta be used, or that a balance coil be used. The reason for this is shown by Fig. 10. Should an overload cause circuit breaker a-a' in transformer A to trip, then line wires (1) and (3) would still be fed by transformers B and C. The neutral (2) would float in potential and voltages (1)-(2) and (2)-(3) would be determined only by load impedances. Transformer C, shown dotted, should therefore be omitted and transformers A and B used in open delta.

On combined three-phase loads and single-phase, ***two-wire*** loads, three single-phase "CSP" transformers may be used in a bank. However, they should not be used on three-phase, wye-delta banks without the neutral of the wye connected because the opening of a circuit breaker in a transformer in one phase will cause badly unbalanced voltages to appear across the three secondary leads.

Unless the ***system load*** on the three phases are balanced, a primary neutral connection on a wye-delta bank will produce a circulating current in the delta secondary to try to balance the load on the three-phases of the system. This unbalance may create a current large enough to open the secondary breakers in "CSP" transformers.

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



KV	"A" GAP SETTING
3/4	1/4
3	1/4
6	3/8
9	1/2
15	3/4

FIG. 9. Externally Mounted "De-ion" Lightning Arresters and Gap Adjustment.

connected to the tank) may be operated either way. In the "three-point" method of lightning protection, as used on all "CSP" 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

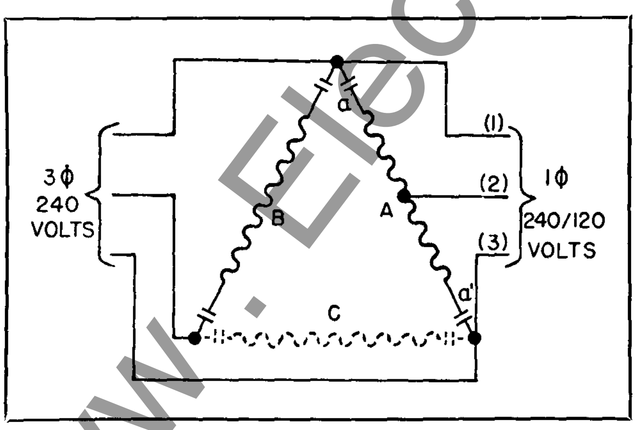


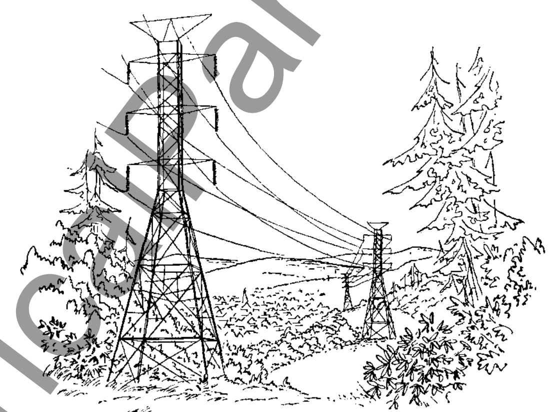
FIG. 10. Combined Single-Phase, 3-Wire Load and Three-Phase Load on "CSP" Transformer (Use Open Delta Connection Omitting Dotted Transformer).

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 specified, such tank discharge gaps are furnished with all "CSP" 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—"S" (Conventional) Transformer.*** No tank ground is required. 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—"CSP" Transformers.*** 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 asembly 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 more 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 air.

LIGHTNING PROTECTION ("CSP" TRANSFORMERS)

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 also 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 "CSP" 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 (or by "De-ion" arresters if the rated secondary voltage is sufficiently high) 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 whatever device is used 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

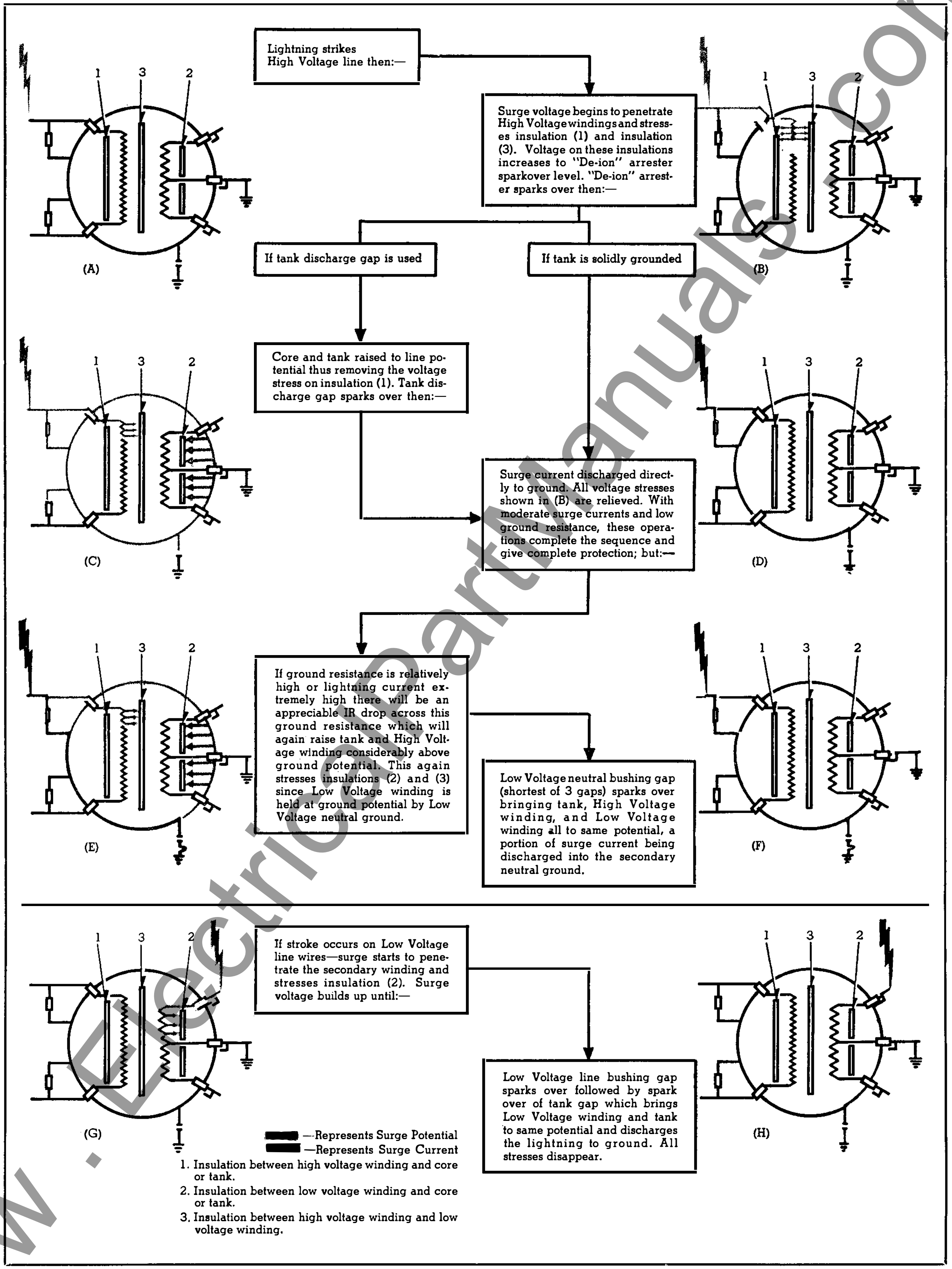


FIG. 11. Mechanism of "Three-Point Surge Protection".

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.

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. 9) consists essentially of two electrodes encased in an insulating tube and separated by a spiral filler. When a sparkover occurs from one electrode to the other 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 discharge. 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 interrupt since the passages through the fibre assembly are sufficiently small that even the smallest currents are in contact with the fibre.

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

BURNOUT PROTECTION ("CSP" AND "CP" TRANSFORMERS)

Thermal protection for "CSP" and "CP" transformers is afforded by a circuit breaker connected in series with the low-voltage winding. There are three major reasons for using this breaker:

1. To eliminate the fuse cutout, thereby eliminating fuse outages which are the largest single source of trouble with conventional transformer installation.

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.

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

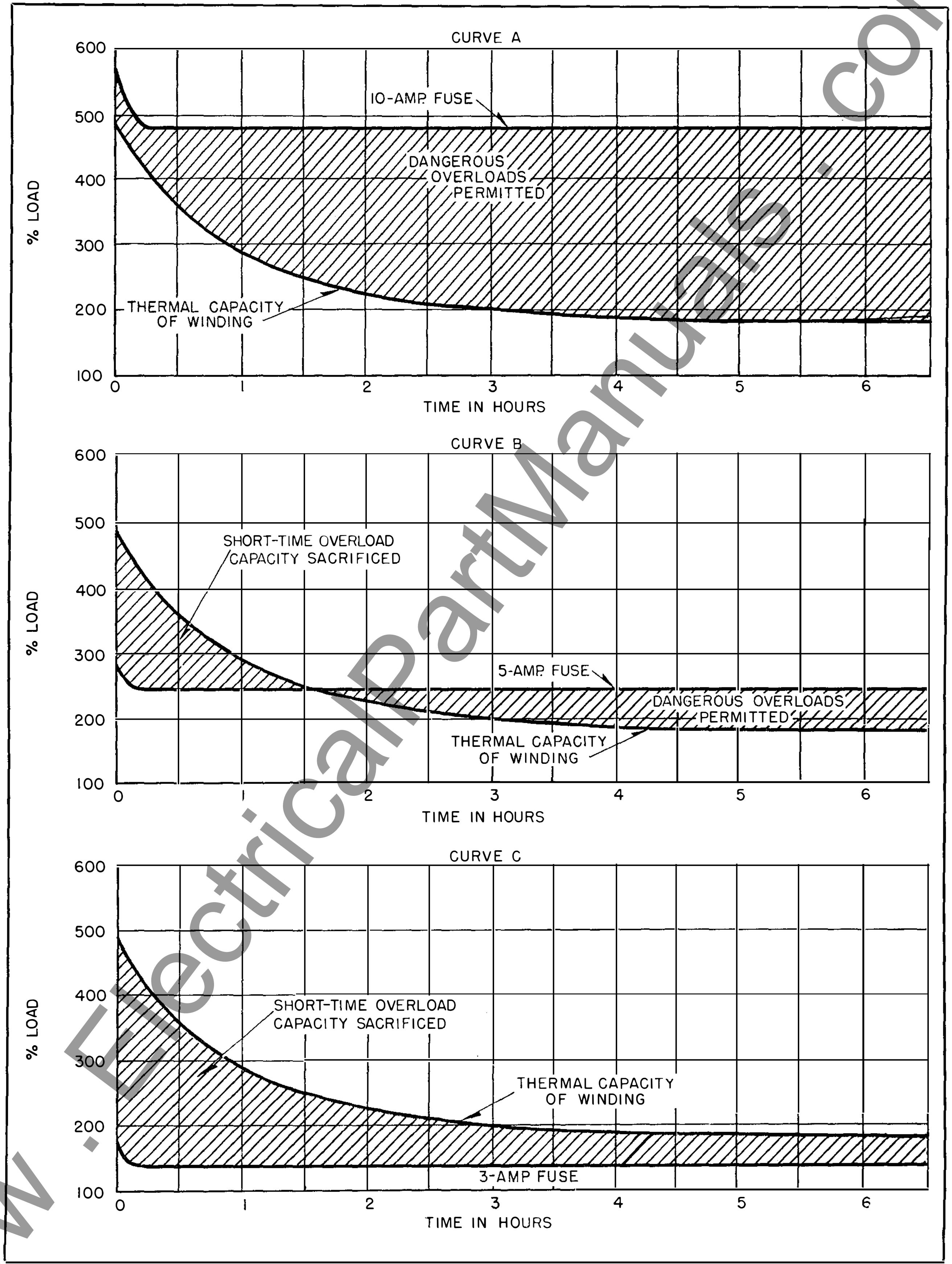


FIG. 12. Curves Showing that Thermal Protection of Distribution Transformers by Fuses is Unsatisfactory.

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 Booklet No. 46-402.

The adjustment of the breaker bimetal as made at the factory 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, three types of circuit breakers are used, all of which are trip free of their operating handles. The "LR" breaker has an advance signal and is available in ratings through 25 kva at 240 volts on L. V. or through 50 kva at 480 volts on L. V. The "BR" circuit breaker is similar to the "LR" but has a higher current rating and is applied on 37½ to 100 kva at 240 volts on L. V., or 75 and 100 kva at 480 volts on L. V. The above breakers are made in three-pole units for three-phase transformers.

The "FR" circuit breaker has no signal light nor emergency control provisions and is of lighter construction throughout. It is used on the smaller kva ratings where the extra cost of the signal light and emergency control is not considered justified.

In the larger ratings, two breakers may be used in order to provide sufficient capacity. These breakers are connected as shown in Fig. 13. The impedance of the transformer windings will cause the load to be divided equally between the two parallel secondary windings and contacts. When one of the bimetals finally opens one of the contacts (for example in X1), the current in the other bimetal is doubled and it then trips out immediately thus completely opening the X1 lead. However, when the first contact in X1 opened, one of the contacts in the X3 lead also opened because it is mechanically coupled to the X1 contact in the breaker; and when the second contact in X1 opened, the second contact

* Trade-Mark

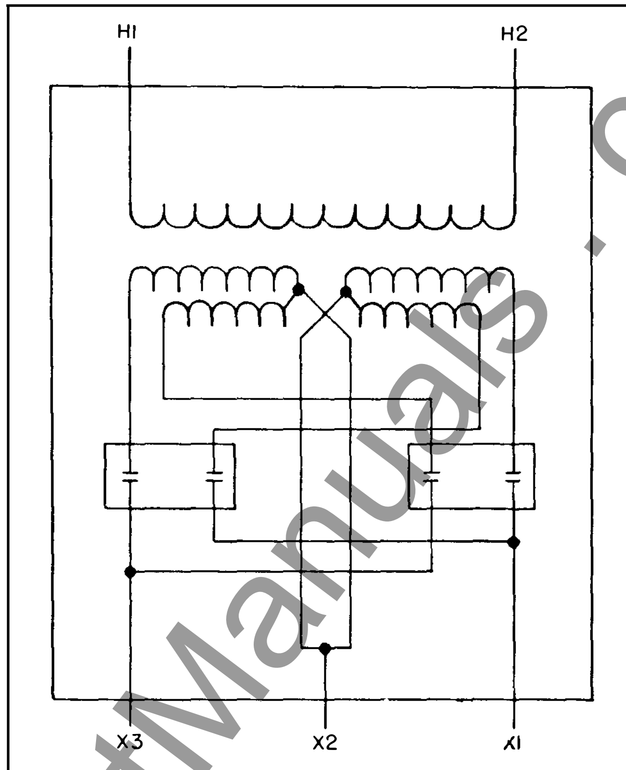


FIG. 13. Connection to Utilize Two Circuit Breakers for Larger "CSP" Transformers.

in X3 also opened. Hence, an overload on either half of the secondary will cause both breaker contacts in both halves to open.

"LR" BREAKER

A cutaway view of the "LR" breaker is shown in Fig. 14. 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. 15 contains schematic sketches somewhat simplified to better show the principles of operation.

When a transformer breaker trips out, there are a few rare occasions when a combination of circumstances make if difficult to reclose the main breaker contacts, especially if the oil has been heated by a long continued overload. If it is essential to restore service immediately, then this can be accomplished by using the emergency control device.

The emergency control handle is shown in Figs. 20 and 21. A Moldarta* lever is fitted on the bimetal adjusting nut of each pole section, and these Moldarta levers are linked together by a suitable connecting rod. This, in turn, is attached to a pull-wire which is affixed to a control arm on the inside of the tank wall. A shaft, working through a sealed bearing, connects this control arm to the emergency control operating handle on the outside of the tank. Pulling the emergency control handle downward causes the pull wire to rotate the Moldarta levers clockwise, thus increasing the bimetal latch engagement. This action increases the trip temperature setting of the breaker bimetal element, thus facilitating reclosure of the breaker contacts. With this emergency setting, a greater overload is required to trip the breaker in a given time. However, the breaker still protects the transformer from short circuits.

The external emergency control handle is set at the factory for normal operating conditions, and is held securely by a meter-seal to prevent unauthorized tampering. If an emergency makes it necessary to operate the emergency control mechanism, it is recommended that the overloaded transformer be replaced as soon as possible with a larger transformer. The emergency control handle on the originally overloaded transformer should be restored to its normal position and resealed before the unit is again put into active service elsewhere. ***Operation in the emergency position over a long period of time is not recommended, since it may reduce the life of the transformer insulation.***

A further description of the "LR" breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-408.

The electrical circuit is carried (sketch "A", Fig. 15) from the coil to the breaker contacts, then through the bimetal to the L. V. bushing. As the bimetal temperature increases due to the temper-

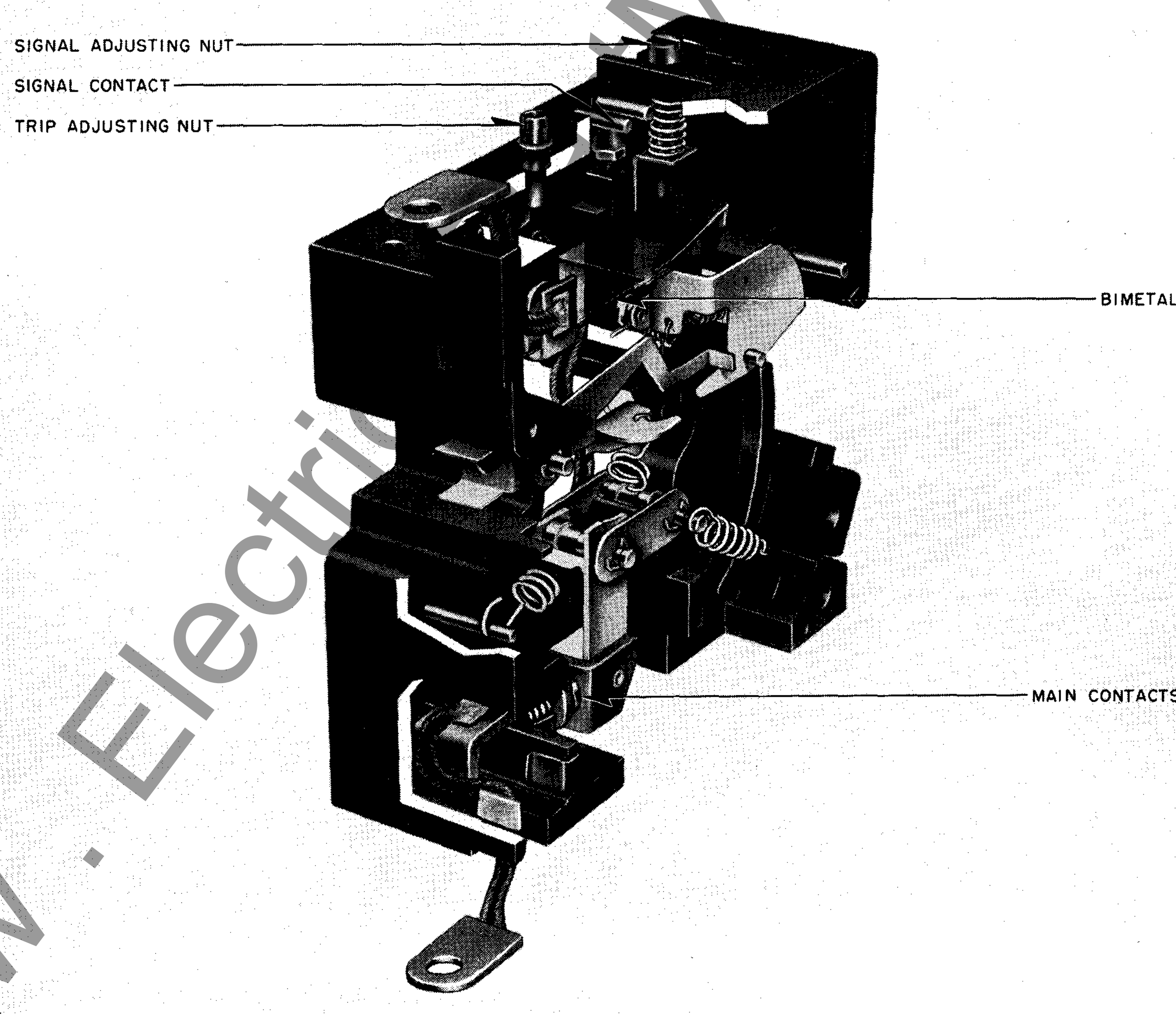


FIG. 14. Cutaway View of "LR" Circuit Breaker.

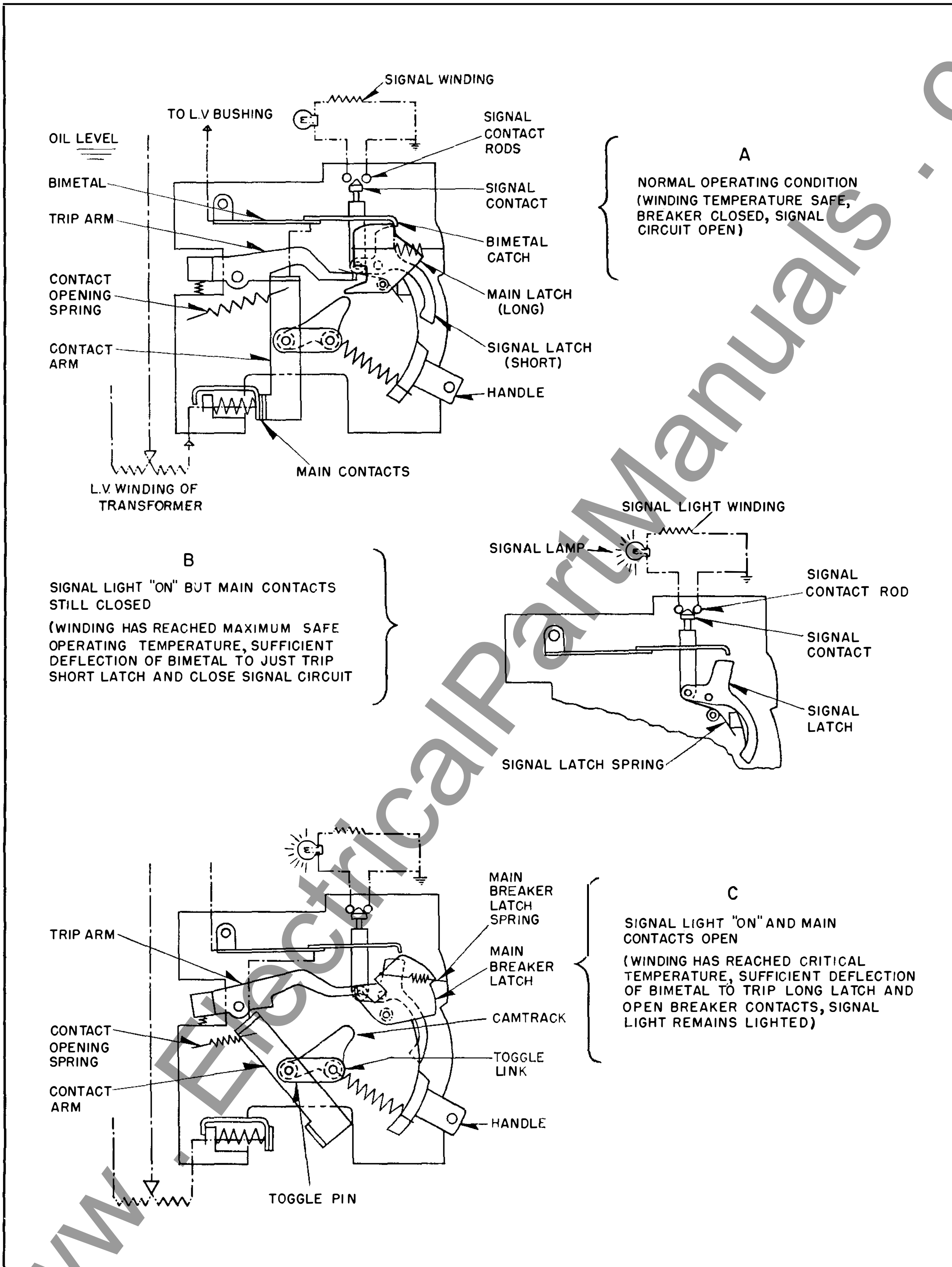


FIG. 15. Schematic Operational Sketches of "LR" Circuit Breaker.

ature of the oil and/or the load current, it deflects upward. At overloads sufficiently great to cause the transformer coil to reach its maximum safe operating temperature, the signal latch is released. This latch then rotates clockwise (sketch "B", Fig. 15) under the force of the latch spring so that the signal contact closes the circuit between the signal contact rods of the signal light circuit. 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. 26) and then reclosing. If the handle is not moved appreciably beyond the "Reset Light" position, the signal 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 upward until the main latch is released. This occurs at a coil temperature just below the burnout temperature.

When the main latch trips (sketch "C", Fig. 15) it rotates in a clockwise direction to impart counterclockwise rotation to the trip arm which releases the tip of the contact arm. The contact arm then rotates counterclockwise, under the pull of its opening spring, to open the main breaker contacts with a snap action; since both trip arms are connected together through an interlock, both poles open simultaneously. Resetting is accomplished by first moving the external handle (Fig. 26) to the "reset" position (which resets the latches and reengages the contact and trip arms) then reclosing. As the external handle is moved to the "close"

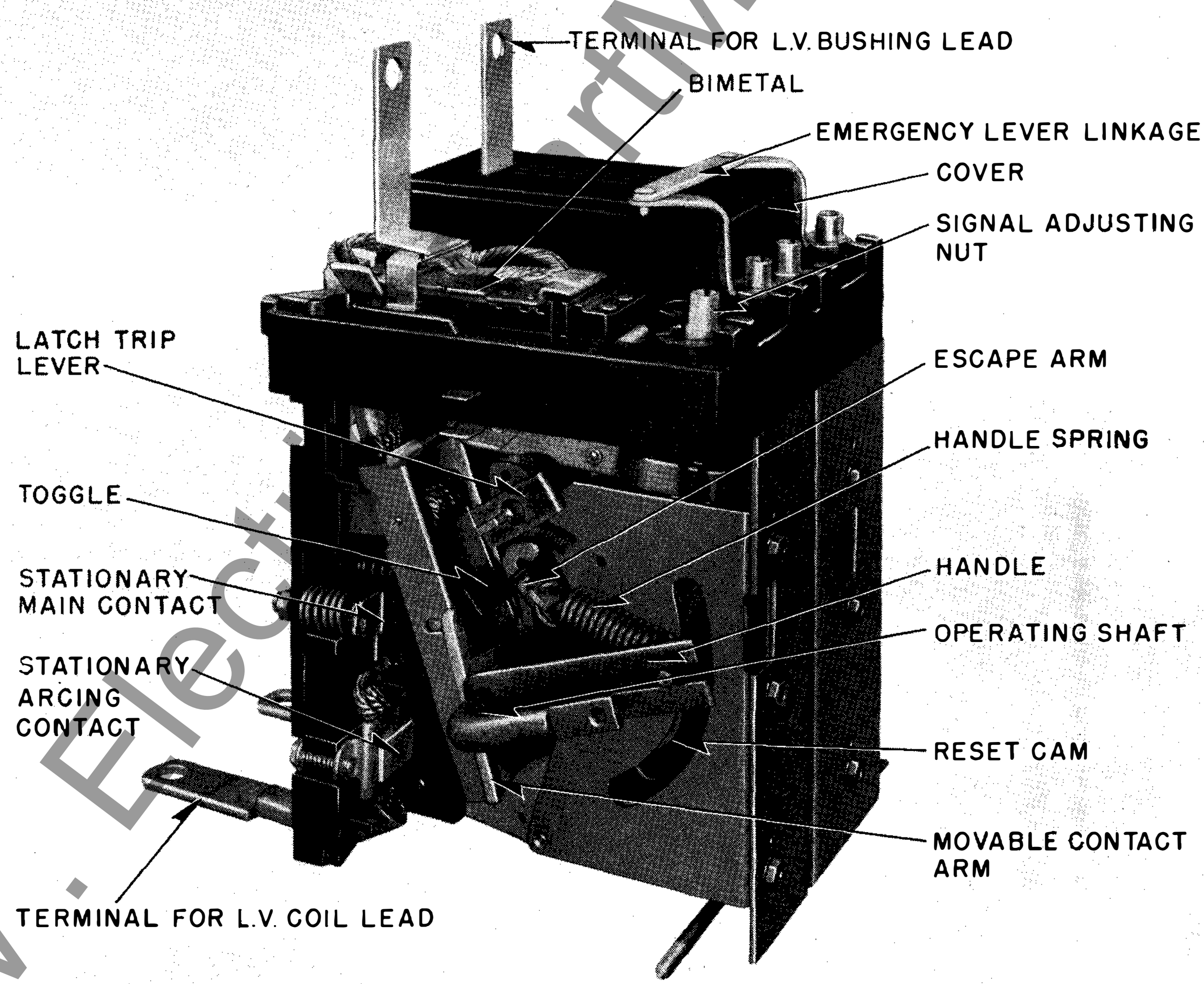


FIG. 16. Cutaway View of "BR" Circuit Breaker.

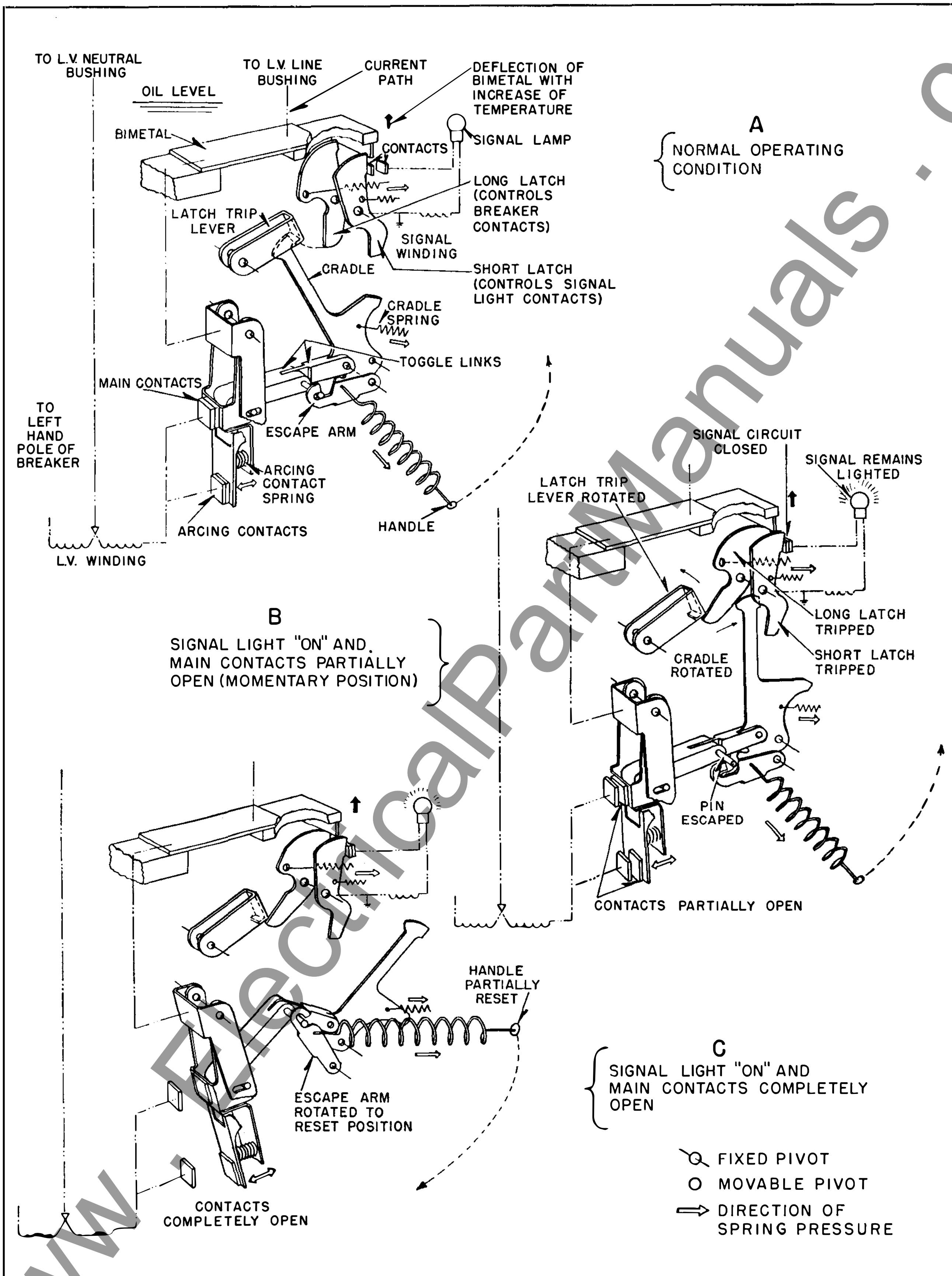


FIG. 17. Schematic Operational Sketches of "BR" Circuit Breaker.

position, the toggle pin (which has moved up and to the right along the "cam-track") returns to its original position and through the toggle link recloses the breaker main contacts. The contacts open and close with snap action because of the shape of the surface on which the toggle pin rides. This "cam-track" is designed to restrain the motion of the toggle until the springs have enough stored energy to carry the contacts to the desired position.

Manual opening and closing are accomplished by operation of the external handle which actuates the toggle pin at the center portion of the toggle and with it, the contact arm. In this type of operation, the center pin of the contact arm is moved and the upper end remains substantially stationary.

"BR" BREAKER

A cutaway view of a two-pole "BR" breaker is shown in Fig. 16. This breaker is used in the larger single-phase transformers; a similar three-pole assembly is used in the larger three-phase "CSP" transformers. The general principles of operation are the same as the "LR" breaker, although the breaker is larger in order to handle the heavier currents and is mechanically somewhat different. Like the "LR" breaker, the "BR" breaker has the signal light and Emergency Control features.

The electrical circuit is carried (sketch "A", Fig. 17) 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 temperature, 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.

If the bimetal temperature is further increased, the bimetal deflects further upward and the long latch is released. This latch 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 counterclockwise, the cradle is released, and it then rotates clockwise under force of the cradle spring. So far, 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 two 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. 17 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. 17) counterclockwise 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 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. 17, 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. 17 to that shown in sketch "C", Fig. 17 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.

A further description of the "BR" breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-406.

"FR" BREAKER

An "FR" breaker is shown in a cutaway view in Fig. 18. This type breaker is used in the smaller transformers, where a lower cost breaker is desired and where the signal light and emergency control

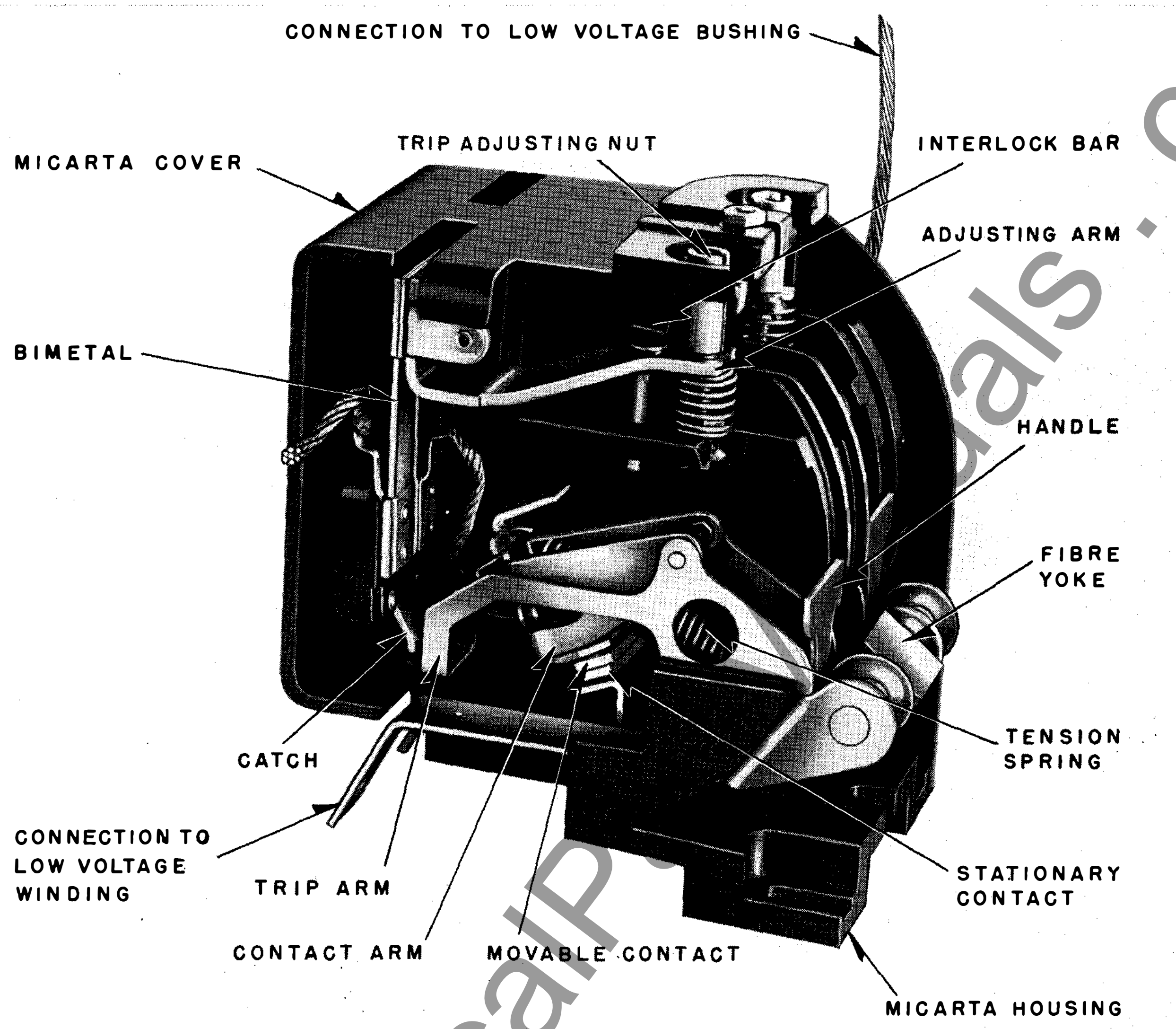


FIG. 18. Cutaway View of "FR" Circuit Breaker.

features are not considered economically justified. The general principles of operation are the same as those for the "LR" breaker, but the various parts are somewhat different.

Fig. 19 contains schematic sketches somewhat simplified to better show the operation. The electrical circuit is carried 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 to the left as shown. At overloads sufficiently great to cause the transformer coil to approach the burnout temperature, the catch slips off the end of the trip arm which is then rotated clockwise by the main breaker spring. After a slight rotation, it engages the projecting finger on the contact arm. The trip arm and contact arm then rotate together and the contacts are opened (sketch "B", Fig. 19) thus interrupting the circuit. The contact arm finally comes to rest, pressing against the interlock pin (sketch "C", Fig. 19). This pin, in turn, presses upward on the interlock bar which is pivoted at its center. The opposite end of the bar, therefore, presses downward on the adjusting arm of the other pole. This pressure overcomes the adjusting arm spring pressure and the whole adjusting-arm-bimetal-assembly rotates clockwise to release the trip arm of this pole also. Hence, the second pole is opened immediately by the opening of the first pole. Resetting is accomplished with this breaker as with the "LR" breaker by moving the external handle to the "Reset" position (see Fig. 27). This movement engages the reset tail "X" of the trip arm, thereby rotating it until the trip arm again engages the bimetal catch. The breaker may then be closed by moving the external handle to the "Close" posi-

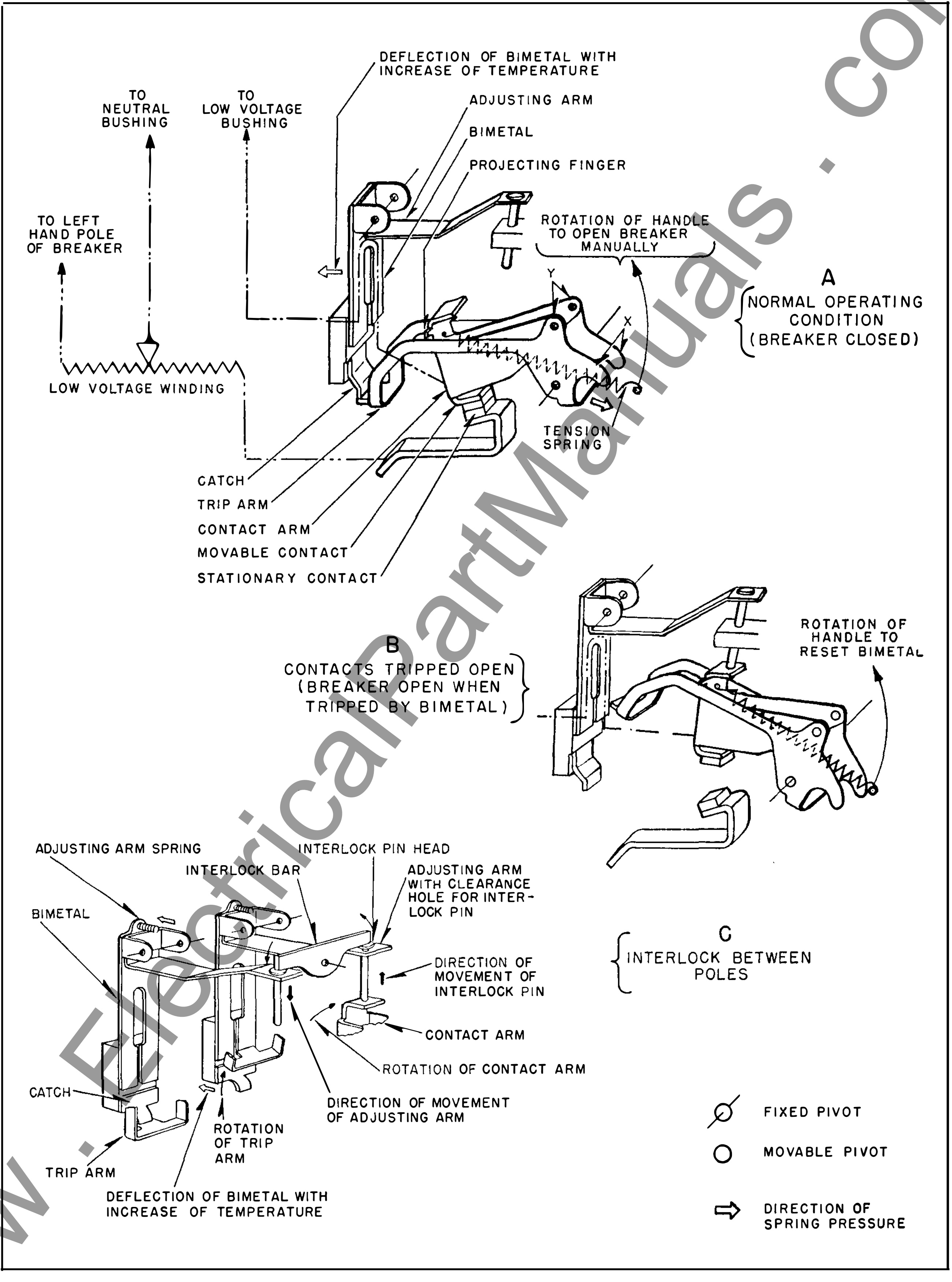


FIG. 19. Schematic Operational Sketches of "FR" Circuit Breaker.

tion, which throws the main spring over center, closing the contacts with a snap action. Manual opening and closing is accomplished by operation of the external handle which has the effect of carrying the spring back and forth across the pivot center "Y" of the contact arm (sketch "A", Fig. 19), thus causing it to snap quickly from its closed to its open position and vice versa without tripping the bimetal.

A further description of the "FR" circuit breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-405.

SERVICE CONTROL DEVICE

This device permits operation of the internal secondary breaker of type "CSP" and type "CP" transformers from ground level. Fig. 28 (Part Four) shows the service control device mounted on an installed transformer. Also see discussion of service control device beginning on page 34.

PROTECTIVE LINKS

In spite of all the factory precautions to prevent and detect faulty windings, a transformer will occasionally (though rarely) fail in service. At such a time, it is important that the winding be disconnected from the system for the purpose of preventing a "lockout" of the distribution feeder. In "CSP" or "CP" transformers, the protective link connected in series with the high voltage winding serves this purpose. 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 possible 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 below the oil level where it is protected from the weather. The "De-ion" arrester is connected ahead of the link, to by-pass lightning currents which might cause the protective link to operate. The protective link is mounted in the H. V. bushing (Fig. 2) or on the terminal block (Fig. 1).

The link consists of a high melting temperature alloy wire which is surrounded by an insulating sleeve which serves as a heat blanket. The wire and sleeve are 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, thus causing gas to be evolved from the fibre tube. 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.

OPERATION AND MAINTENANCE

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 energized 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. The operating handle is above the oil level, and an indicator plate (with numerals corresponding to the position numbers on the diagram nameplate) is located just below the handle.

The positive snap action of the tap changer into position also guides the operator and insures a positive contact and a stop is provided to identify the highest and the lowest tap positions. 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

On "CSP" or "CP" transformers, the circuit breaker 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

On "CSP" or "CP" transformers (except small kva transformers with "FR" breakers), the signal light furnishes a valuable service in providing the means for an automatic overload survey. Many

FIG. 20. Emergency Control Handle in Normal Position.

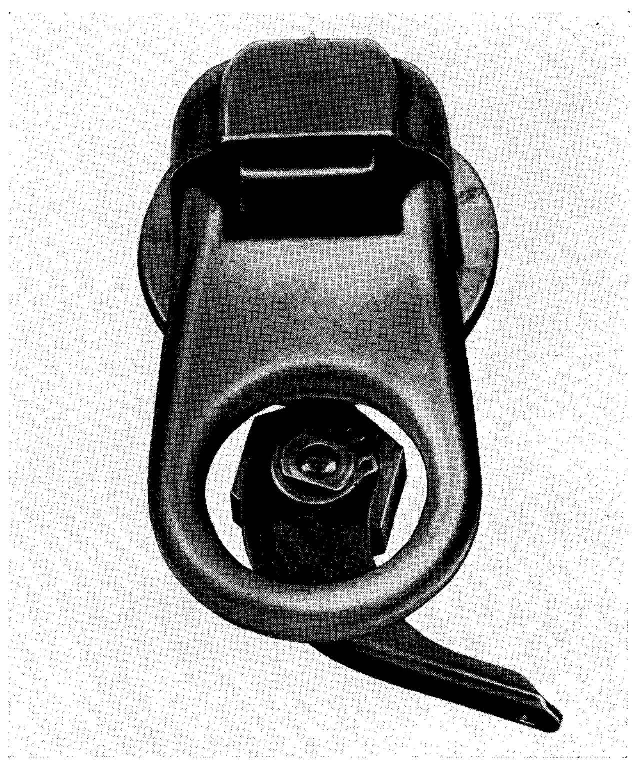


FIG. 21. Emergency Control Handle in Emergency Position.

utilities install one size smaller "CSP" transformer than "normal", planning that this can safely be done since the "CSP" will warn of any growing overloads. If the load reaches a magnitude such that dangerous winding temperatures are being approached, the circuit breaker will light the external signal light (without tripping the breaker unless the load continues long enough to raise the temperature still further toward the burnout point). Whenever a signal light is observed, it is common practice to reset the signal light at least once to determine whether its operation was caused by some isolated condition or whether it was caused by a repetitive condition. The signal light may be reset without disconnecting the secondary load by movement of the external handle only as far as the "Reset Light" position and then by movement back to the "Close" position. If the light is immediately re-lighted, the overload is either still continuing or has occurred so recently that the transformer has not yet cooled down. If the light is re-lighted within 24 hours or within a few days, this is probably an indication of a recurrent overload. The operator must then judge whether the overload is of such a nature that a larger transformer should be installed or whether there is some temporary condition which the existing transformer can handle. 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 operation of the signal light and the opening of the breaker allows temporary overloading without service outage.

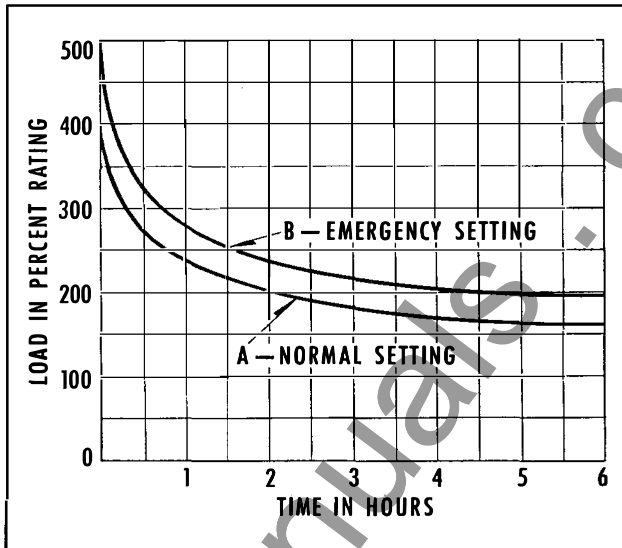


FIG. 23. Typical Breaker Trip Curves Showing Effects of Emergency Control.

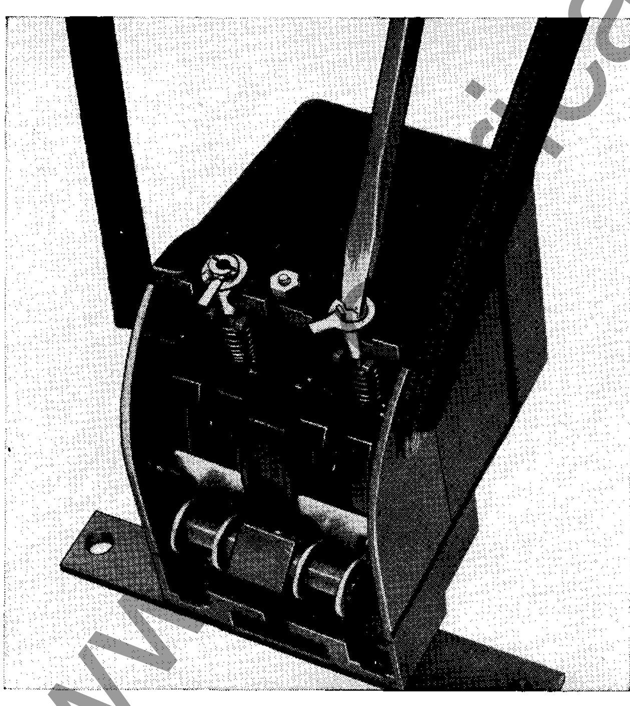


FIG. 22. "FR" Breaker Tripping Adjustment.

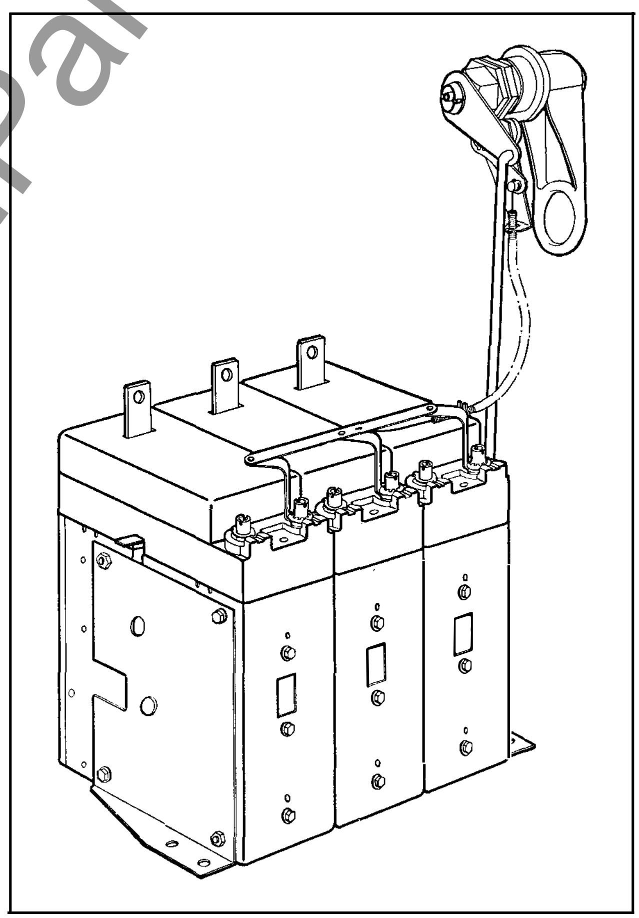


FIG. 24. "BR" Breaker with Manual Operating Mechanism and Emergency Control.

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 the load entirely, 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: On transformers which have two circuit breakers, both breakers must be closed to secure full transformer capacity.

CIRCUIT BREAKER TRIPPING ADJUSTMENT

Circuit breakers supplied in "CSP" or "CP" transformers are provided with an adjustment for increasing, above normal, the current required to trip the breakers. Occasionally, it may be desirable to continue to carry a certain load in an emergency even at the risk of burning out the transformer. In such a case, this can be done by rotating the adjusting nuts on the top of the breaker clockwise. This can be done on the "FR" breaker by means of a screwdriver inserted into the slots of the adjusting nut (see Fig. 22). The nut can be turned only about 30 degrees when the finger on the adjusting nut will strike its stop. The adjusting nuts should not be forced after the fingers reach the stops. All nuts should always be set with the fingers in the same relative position.

The same adjustment can be made on the "LR" and "BR" Breakers with an externally operated emergency control handle. The external appearance of the assembly is shown in Figs. 20 and 21. The handle is mounted so as to be partially concealed by the breaker operating handle. Internal mechanical connection is made to the circuit breaker as shown in Figs. 24 and 25. In the "LR" Breaker (Fig. 25) two insulating arms are attached to the bimetal adjusting nuts and 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. The "BR" mechanism (Fig. 24) works in much the same way except a bent steel arm is fitted on the bimetal adjusting nuts instead of the insulating arm used on the "LR".

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. Pulling the handle down as shown in Fig. 21, turns the screws to the right, which in turn moves the adjusting arm down (see Fig. 25) 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.

In general, the transformer should be allowed to carry the peak load only until the transformer can be replaced properly (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. See Fig. 23 for load time curve with emergency control setting.

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.

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. 27, then turn to the left (which lengthens 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 right (which

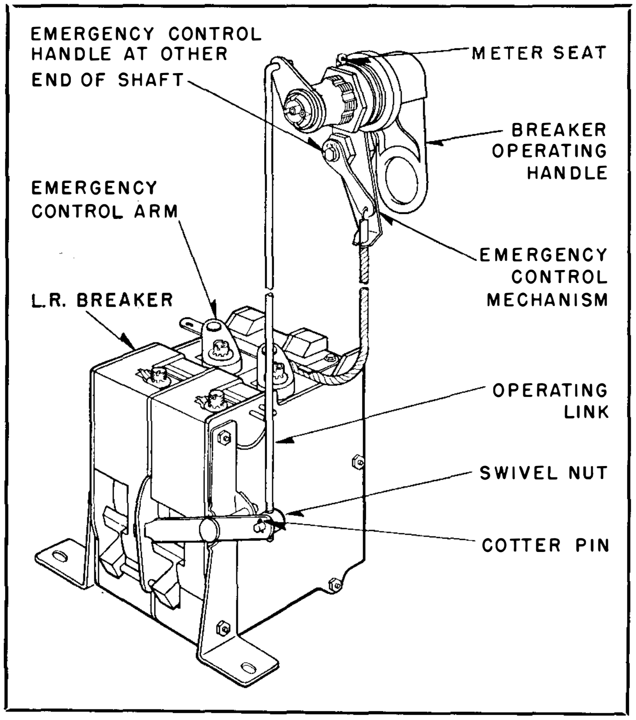


FIG. 25. "LR" Breaker Operating Handle, Linkage, and Signal Light.

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. 26, turn the upper end of the vertical rod to the left (which

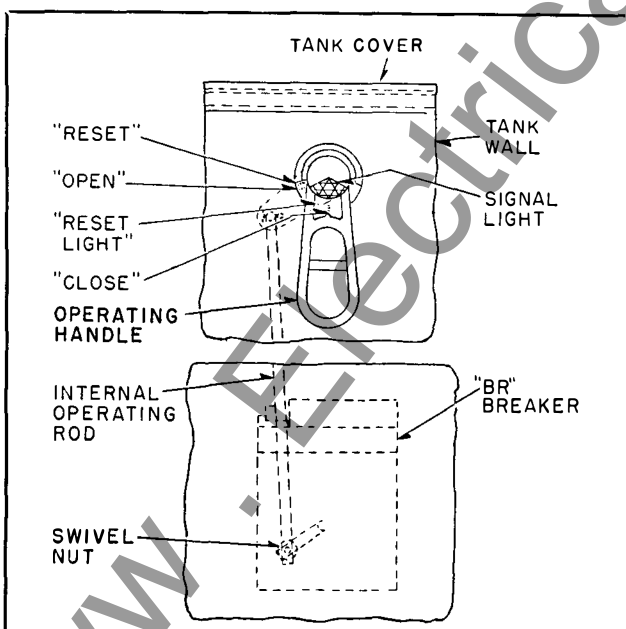


FIG. 26. "BR" Breaker Operating Handle, Linkage, and Signal Light.

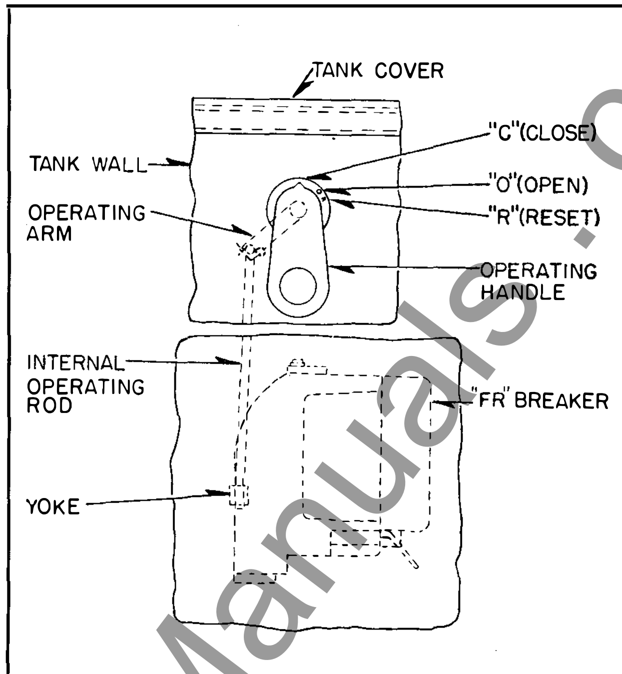


FIG. 27. "FR" Breaker Operating Handle and Linkage.

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.

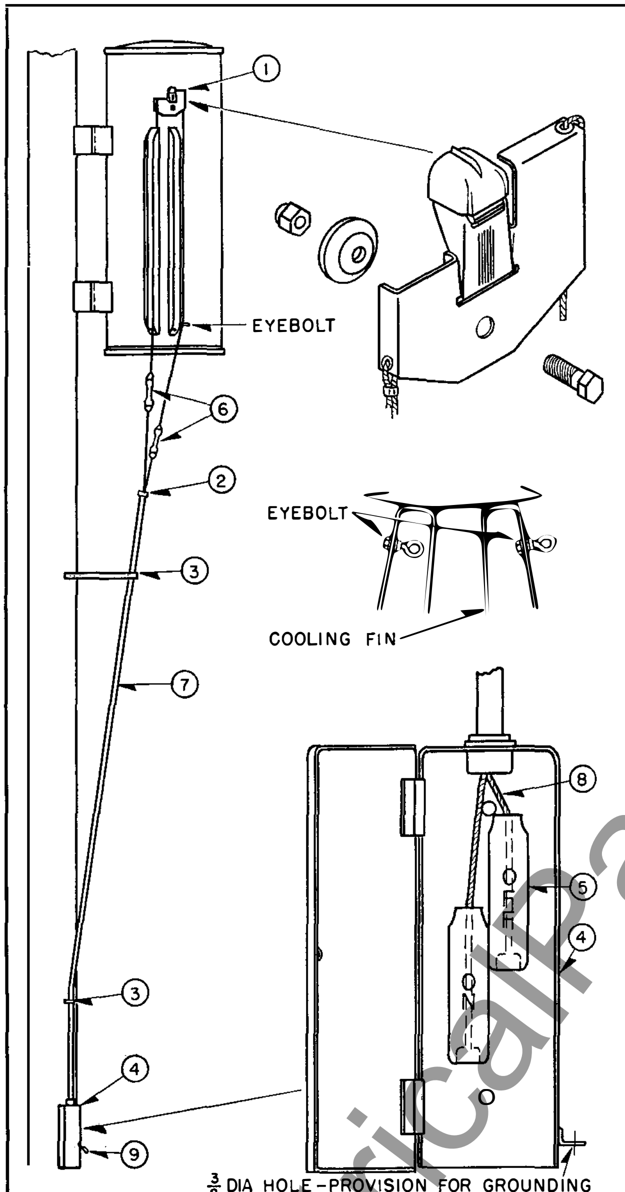
SERVICE CONTROL DEVICE

Fig. 28 shows the service control device with all of its component parts. The following is a description of the method of operation.

If the breaker trips while in service, open the control box, pull down handle marked "off" until breaker operating handle on tank has moved its full upward position (approximately 90°). Then pull down handle marked "on" until breaker operating handle has returned to its original position (vertical).

To disconnect breaker while it is in operation, open control box, pull down handle marked "off" until breaker operating handle on tank has moved to its full upward position (approximately 90°).

To close breaker after the above operation, open control box, pull down handle marked "on" until breaker operating handle has returned to vertical position.



PARTS SUPPLIED BY WESTINGHOUSE

1. Adapter Assembly (includes adapter for signal light with locking pieces cable down to insulators, and eyebolt assembly on each side).
2. Bushing for end of conduit.
3. Conduit Clamps.
4. Control Box.
5. Operating Handles.
6. Insulators.

SUPPLIED BY CUSTOMER

7. Conduit.
8. Cable (between insulators and operating handles).
9. Padlock for locking control box.

FIG. 28. Method of Mounting Control Device When Above Fins. Also Parts List.

The following precautionary steps should be followed in use of control device:

1. Control box should be locked except when an authorized person is operating the control device.

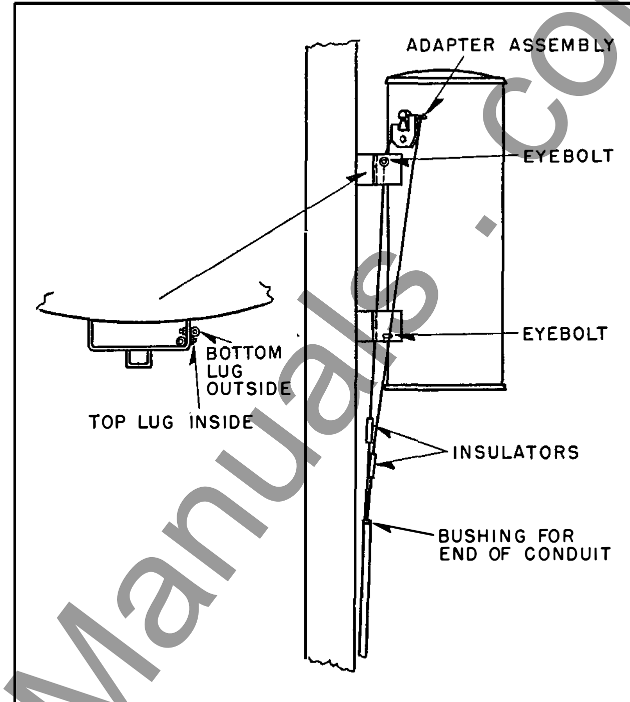


FIG. 29. Method of Mounting Control Device When Above Hanger Lugs.

2. Use a steady pull to operate device. Do not jerk on handle.

3. Be sure that control box is properly grounded.

METHOD OF MOUNTING CONTROL DEVICE

1. When fins are located below breaker handle, Fig. 28, drill 5/16 inch diameter holes in fins near the bottom as indicated. If there are hanger lugs below the breaker handle, Fig. 29, holes should be drilled in hanger lugs, as shown.

2. Slip adapter assembly over breaker operating handle, insert adapter bushing, and bolt into position. Set breaker handle in "On" position (approximately vertical). Assemble eyebolts to fins and paint.

3. Clamp insulators to ends of wire cables. (Note that insulator closest to tank must be at least 6 inches from bottom and that insulators must be staggered with no overlap, as shown).

4. Attach conduit to control box. Locate control box on pole in such position as to leave 6 inch minimum between lowest insulator and top of conduit. Install bushing in top end of conduit (2). Bend conduit so that cable from insulators will be in line with the conduit at points of entry. Clamp conduit to pole where indicated and secure box to pole with 1/4 inch wood screws.

5. Clamp $1/8$ inch galvanized wire cable loosely to lower end of insulators, thread through conduit into control box and gauge position of plastic handles.

6. Make permanent connection at bottoms of handles, then, hold handles in desired position, and make final connections at insulators. Make sure that the "Off" handle is connected to the upper right hand lug on fixture and the "On" handle to the lower left hand lug. Make sure that cables are not twisted together in conduit. If desired the permanent connection to the insulators may be made before attaching handles.

7. Ground control box, by means of lug provided, to transformer ground or other suitable point.

8. Set breaker in desired position and close box. Box may be locked if desired.

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.

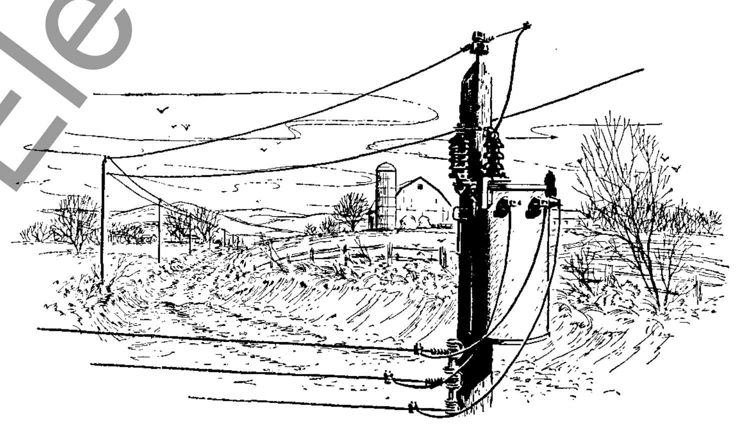
Where parts have become broken or where the tank shows evidence of excessive rusting, the transformer should be returned to a service shop for repair.

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 (for "CSP" transformers) "De-ion" arresters. Some operators carry practically no renewal parts but order them only when required for a specific case.

Renewal parts data for Westinghouse transformers is available upon request.



INSTRUCTION BOOK

Oil-Immersed
DISTRIBUTION TRANSFORMERS

Westinghouse Electric Corporation

I. B. 46-100-1A

SPECIAL INQUIRIES

When communicating with Westinghouse regarding the product covered by this Instruction Book, include the serial number, style number ***and sub letter,*** type, and rating as given on the apparatus nameplate.* Also, to facilitate replies when particular information is required, be sure to state fully and clearly the problem and attendant conditions.

Address all communications to the nearest Westinghouse representative as listed in the back of this book.

*For a permanent record, it is suggested that all nameplate data be duplicated and retained in a convenient location.

Note: This Instruction Book includes design changes not covered by Instruction Cards 116, 2339, 2447, 2448, 2462, 2652, and Instruction Books 5379, 5922, 5922-1, and 46-100-1.

It is suggested that operators keep the older instructions on file for older transformers in service.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

Oil-Immersed

DISTRIBUTION TRANSFORMERS

TYPES

CSP—Completely Self-Protected

CP—Current Protected

S—Conventional

SB—Shovel (Special Braced)

3 to 167 Kva

15,000 Volts or Less

Single- and Three-Phase

WESTINGHOUSE ELECTRIC CORPORATION
SHARON, PA. • TRANSFORMER DIVISION • SUNNYVALE, CALIF.

SUPERSEDES I.B. 46-100-1 AND SUPPLEMENT "A"

MAY, 1954

Printed in U.S.A.

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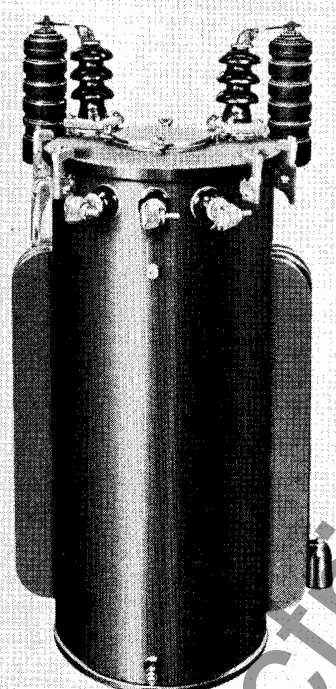
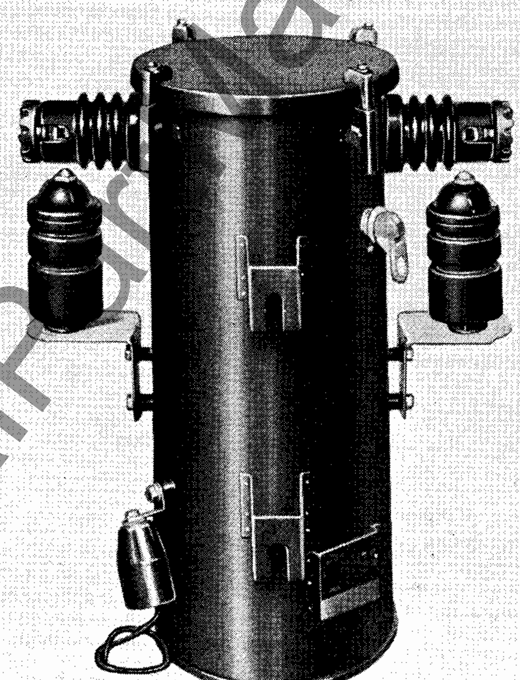
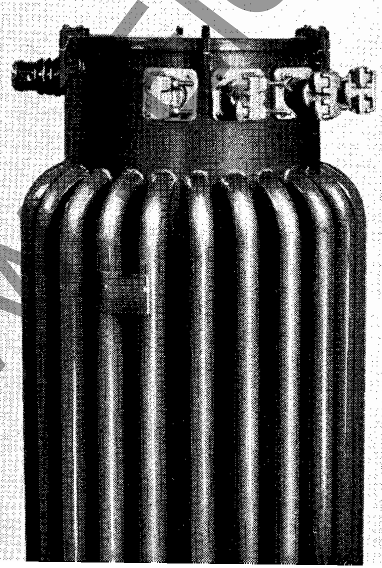
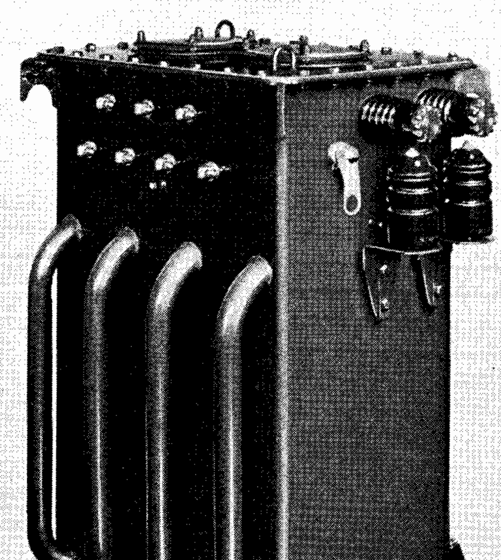


"CSP" Transformer with two Cover-Mounted Bushings



"CSP" Transformer with two Wall Bushings





Oil-Immersed
DISTRIBUTION TRANSFORMERS

This instruction book has been prepared to assist the purchaser in properly installing, operating and maintaining the oil-immersed 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 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

Oil-immersed distribution transformers are normally used for stepping public utility "distribution voltages" (ranging from 2400 to 15,000 volts) down to lower utilization voltages. By far the greatest quantity are used for stepping down to a household voltage of 120/240 volts although a few are used for stepping down to industrial voltages of 240/480, 600, or 2400 volts. These same transformers are sometimes used for small substations and for miscellaneous applications. As with any transformer, they can also serve as step-up units.

COMPONENT PARTS

Oil-immersed 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.

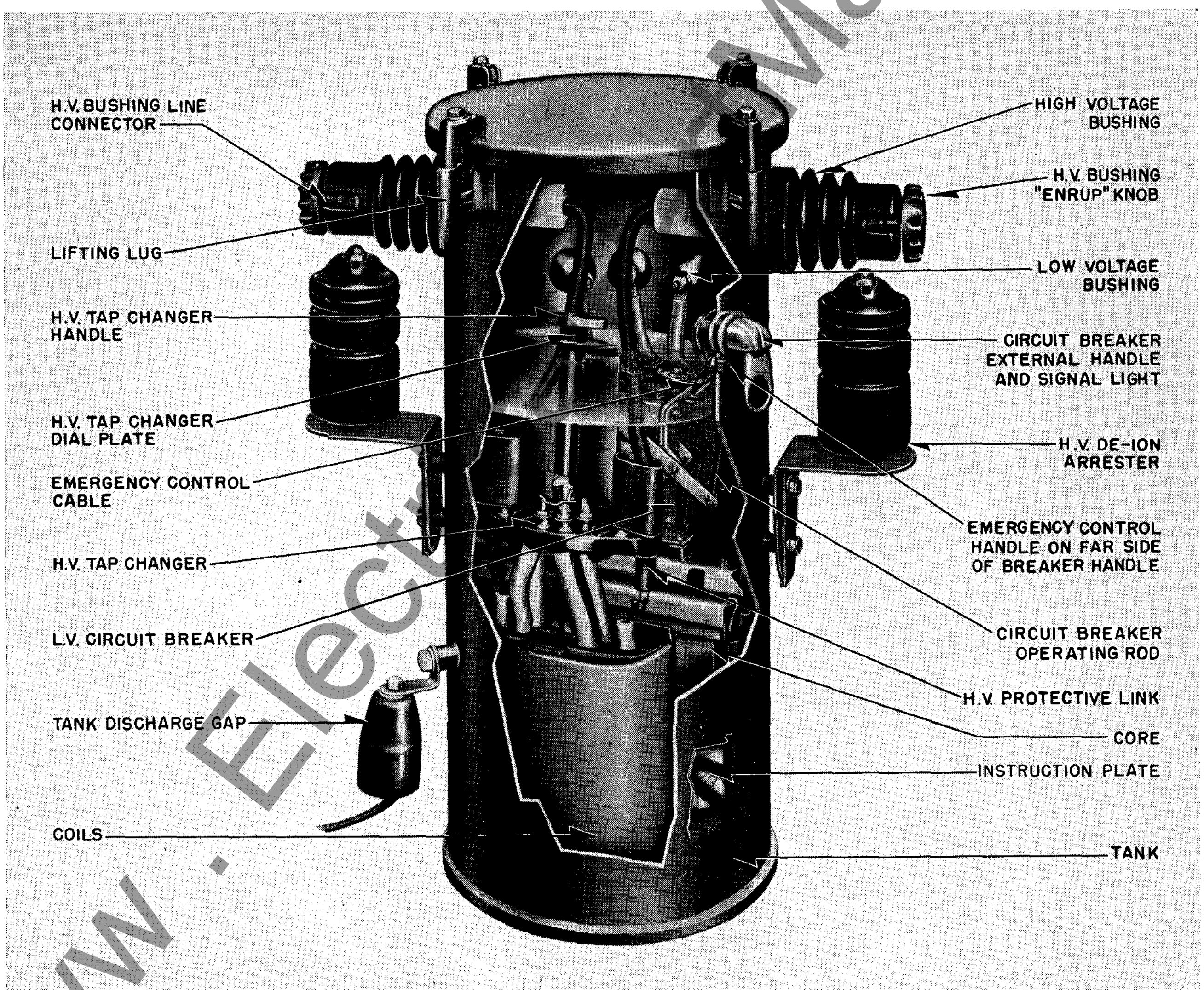


FIG. 1. Cutaway View of Typical Wall Bushing "CSP" Transformer.

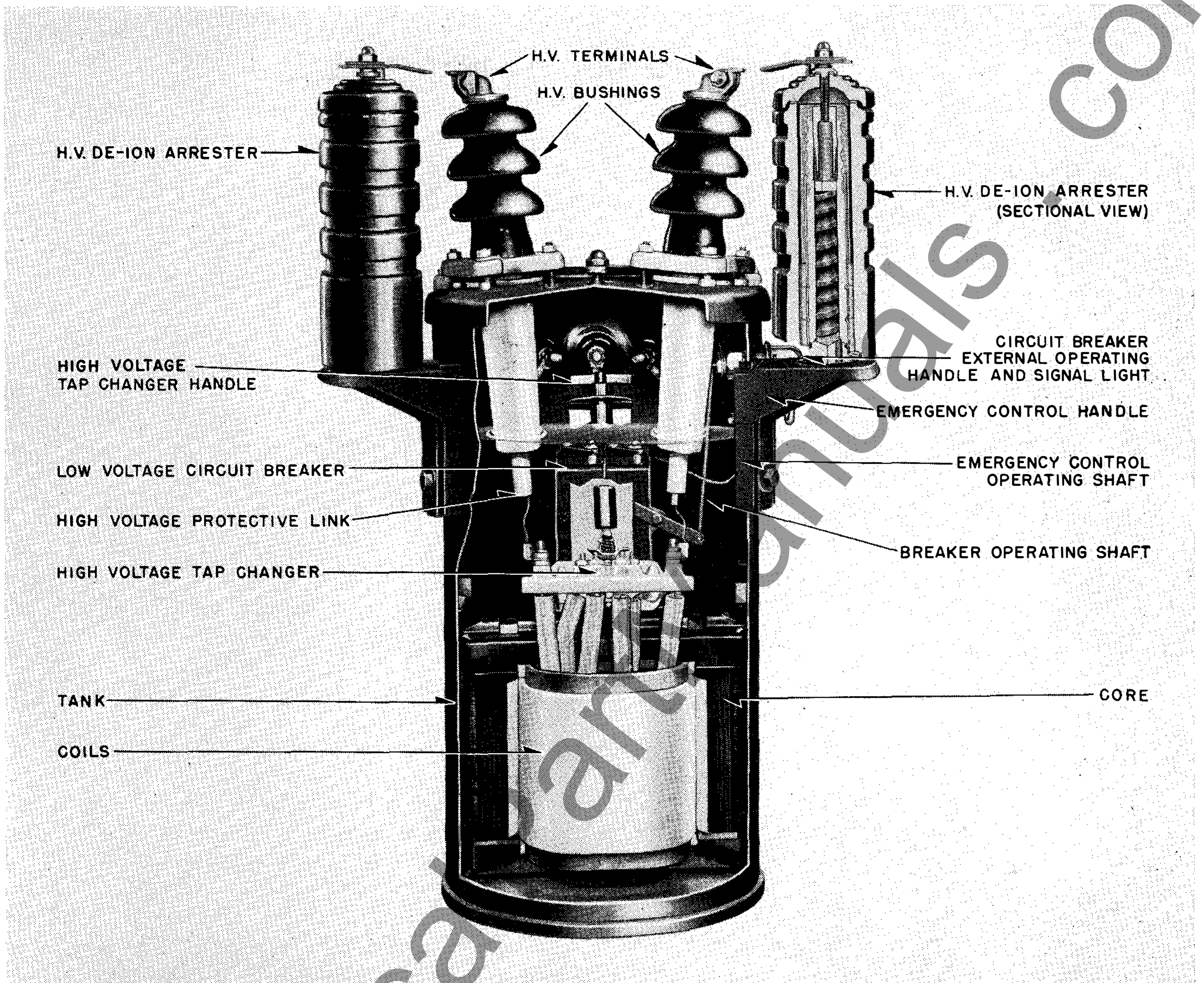


FIG. 2. Cutaway View of Typical Cover Bushing "CSP" Transformer.

Completely self-protected "CSP" transformers have integrally-mounted "De-ion" lightning arresters, and in addition have internally-mounted circuit breakers connected in series with the low-voltage winding, and protective links connected in series with the high-voltage winding. On special orders, transformers may be furnished with variations and/or additions to the above parts.

Typical "CSP" transformers are shown in Figs. 1 and 2. ("S" transformers are similar except that the circuit breaker, its operating mechanism, protective links, discharge gaps and "De-ion" lightning arresters are omitted). A typical "CSP" three-phase transformer is shown in Fig. 3.

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 and the average temperature for any 24 hour period should not exceed 30 degrees C (unless transformer is specially designed).

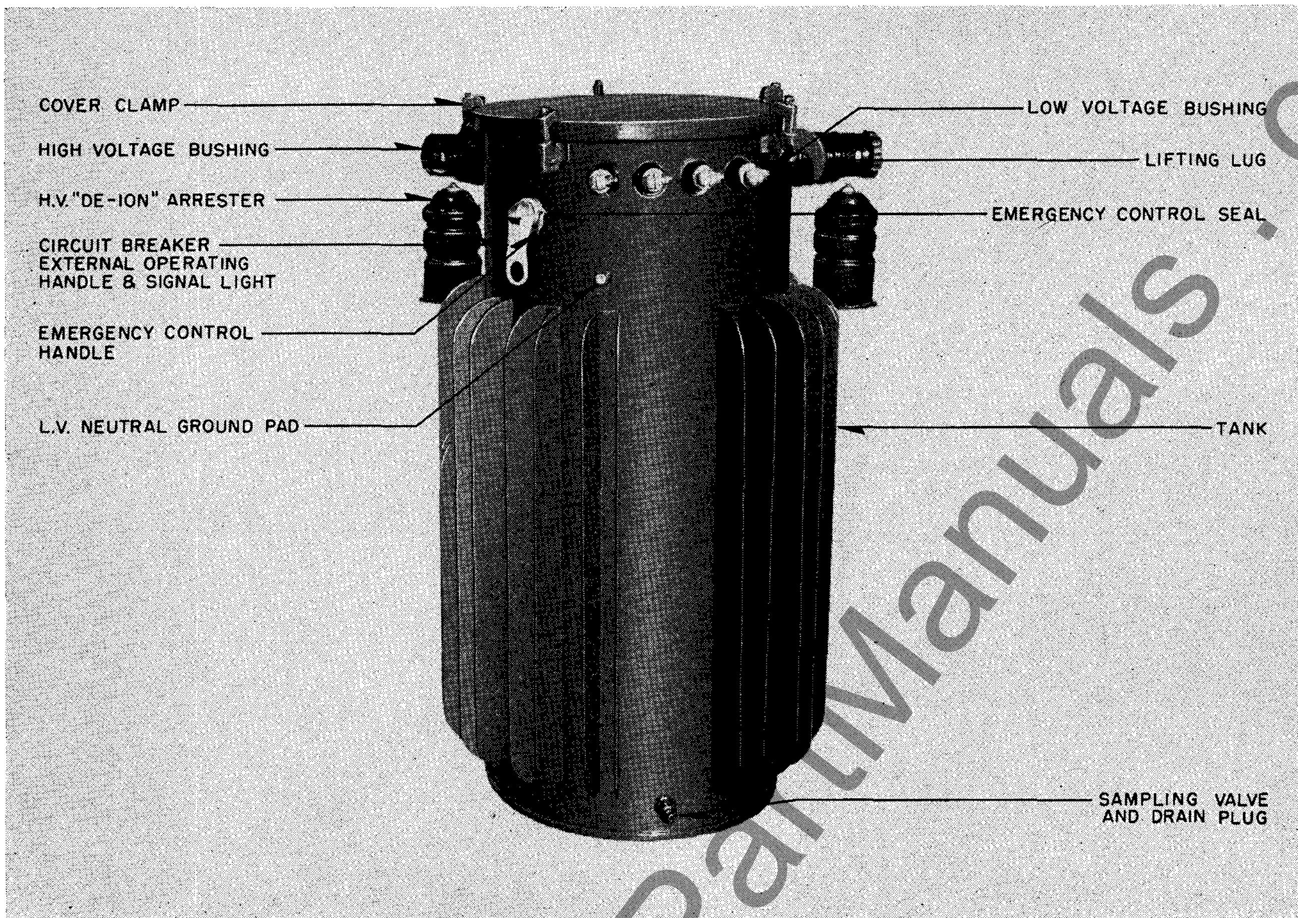


FIG. 3. Typical Three-Phase "CSP" Transformer.

5. Continuous kva load should not exceed rating (except for "CSP" transformers, in which case the circuit breaker will automatically allow loading up to the full thermal capacity of the transformer, according to existing ambient temperature).

6. Continuous kva load on reduced capacity taps should not exceed reduced capacity rating (except "CSP" transformers). Taps at voltages less than 90 percent of maximum voltage are usually rated at reduced kva.

7. For transformers which do not have built-in lightning protection, suitable external protection should be provided since bushing flashover is not considered as adequate protection against all forms of natural lightning.

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. (Never lift the transformer by the bushings).

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 (except "subway" transformers). 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 CI" 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 CI" 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 insulation replaced. Only "Wemco CI" oil should be used. When the transformer oil is being replenished, care must be taken that no moisture gets inside the tank.

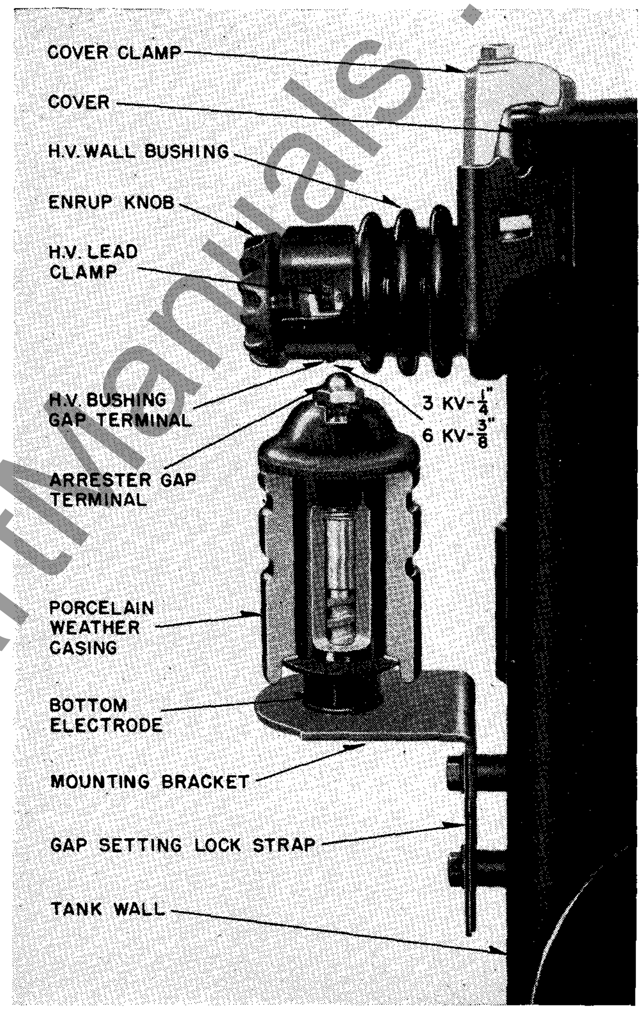
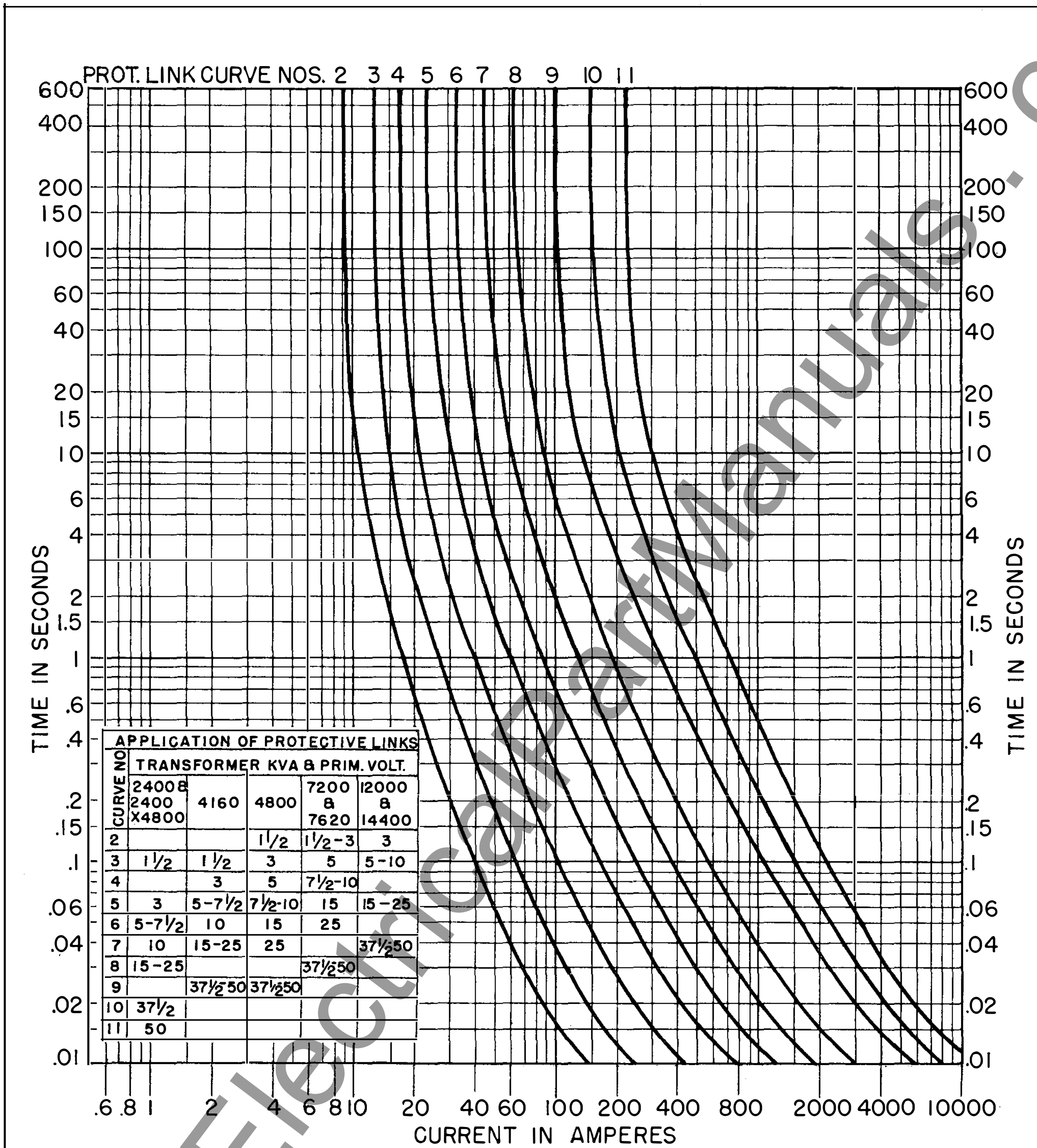


FIG. 4. Wall Mounted "De-ion" Arrester Assembly and Gap Adjustment.

For the proper operation of "De-ion" arresters, the air gaps should have spacings as shown in Figs. 4 or 9. 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



APPLICATION OF PROTECTIVE LINKS

CURVE NO	TRANSFORMER KVA & PRIM. VOLT.				
	2400 & 2400 X4800	4160	4800	7200 & 7620	12000 & 14400
2			1½	1½-3	3
3	1½	1½	3	5	5-10
4		3	5	7½-10	
5	3	5-7½	7½-10	15	15-25
6	5-7½	10	15	25	
7	10	15-25	25		37½-50
8	15-25			37½-50	
9		37½-50	37½-50		
10	37½				
11	50				

FIG. 5. Protective Link Current Time Curves.

tapped for #6-32 machine screws, or #4 self-tapping screws may be used. Screws shall be 5/16 ± 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.

Transformers designed both for series-multiple and three-wire operation are normally shipped connected in series with the mid-point out for three-wire operation. Those designed for series-multiple only are shipped connected in series.

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 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 handhole 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.

PARALLEL OPERATION

When transformers are banked in multiple and distributed along the line on different poles, the line drop will usually compensate for difference in impedance. Transformers on the same pole are not usually operated in multiple except as an emergency condition because the losses of the units will usually exceed the losses of a larger unit having a rating equal to their total. If transformers are so operated, the transformer having the lowest impedance will take more than its share of the load. Transformers are usually considered satisfactory for paralleling if their impedances are within 7.5 percent of the larger value for two-winding transformers or 10 percent for auto-transformers, providing, of course, that their ratios are the same. However, it is advisable, where it is probable that the load may not be properly distributed, to take current readings to determine the exact distribution.

PROTECTIVE LINK COORDINATION ("CSP" TRANSFORMERS ONLY)

"CSP" 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 coordination of over-current devices is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-403.

FUSING PRACTICES ("S" TRANSFORMERS ONLY)

Transformers without internal breakers must be protected by external fuses which should be selected for short-circuit protection—not for overload protection. It will be found that fuse outages will be greatly reduced if a minimum rating of 10 amperes is used. This is particularly true where the fuse is connected ahead of the lightning arrester or "De-ion" arrester so that lightning currents must pass through the fuse to reach the arrester.

MOUNTING

Single-phase transformers rated 100 kva and less, and three-phase transformers rated 112½ kva and less, and rated 15,000 volts and less, may be mounted on poles. Three-phase 150-kva transformers may be pole mounted if an auxiliary support is provided to carry the weight of the unit. Larger ratings are normally designed for platform mounting only.

When pole mounting is used, there are three generally accepted methods. The simplest and most economical, particularly for "CSP" transformers where no auxiliary equipment on the pole is necessary, is to bolt the transformer directly to the pole as shown in "A", Fig. 6. No cross-arms on the pole are used unless needed for other purposes. Square-headed through bolts (⅝-inch or ¾-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 50 kva and smaller, single phase, or 45 kva and smaller, three phase, have lugs capable of the above type bolting. Adapters are available for single-phase, 75- and 100-kva ratings or for three-phase, 75-, 112½-, and 150-kva ratings, 15,000 volts and less. These adapters should be installed as shown in "B", Fig. 6.

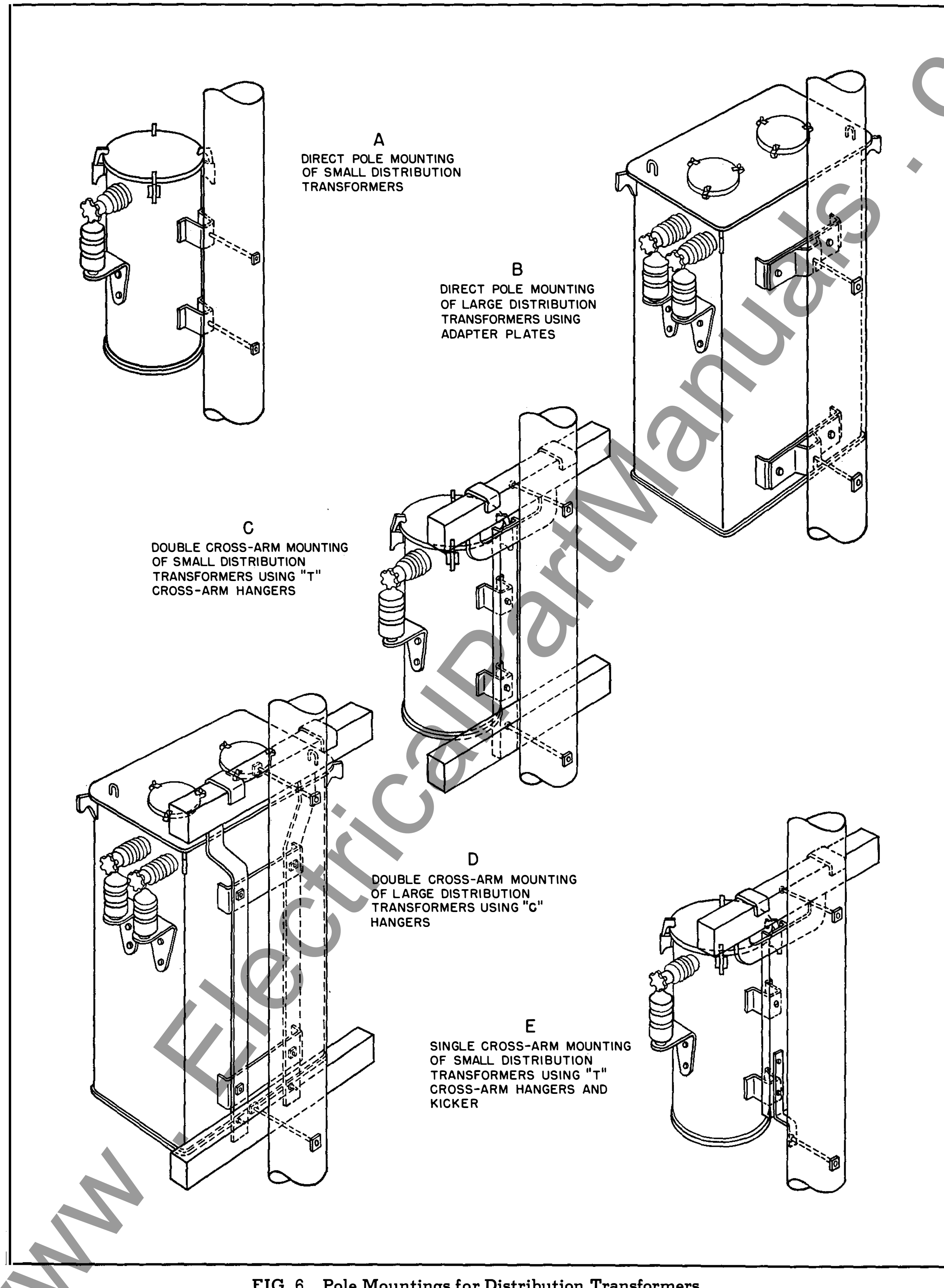


FIG. 6. Pole Mountings for Distribution Transformers.

Where two crossarms are used for mounting the transformer on a pole (nearly all three-phase installations of single-phase transformers and some other installations), "T-crossarm hangers" as shown in "C" Fig. 6 for the smaller units, and "Type C hangers" as shown in "D" Fig. 6 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 the manufacturer), is then employed as shown in "E", Fig. 6. 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.

BUSHING ARRANGEMENT

High-voltage, single-phase and three-phase transformers having a high-voltage rating of 5 KV and less have wall mounted high-voltage bushings. Single-phase and three-phase transformers having a high-voltage rating from 7.2 to 15.0 KV inclusive have cover mounted bushings.

HIGH VOLTAGE CONNECTIONS

When installing a transformer, the amount of protective apparatus required depends upon the type of transformer. The "CSP" transformer is completely self-protected and requires neither lightning arresters nor fuse cutouts. The "conventional" transformer should be provided with both lightning arresters (preferably connected for "three-point surge protection") and fuse cutouts. Hot line clamps may be advantageously used (particularly with the "CSP" transformer) for connecting 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.

Fig. 7 shows the proper internal and external connections to obtain the phase relations shown by the vector diagrams when connecting three standard single-phase transformers in a three-phase bank.

Westinghouse Instruction Book 46-100-3, available upon request, shows additional external circuit connection diagrams for the more common single-, two-, three-, and six-phase connections.

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 "CSP" 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 "De-ion" arrester may be physically interchanged with the coordinating strap.

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 "CSP" transformers, the "De-ion" arrester is mounted adjacent to the fully insulated bushing. Connect

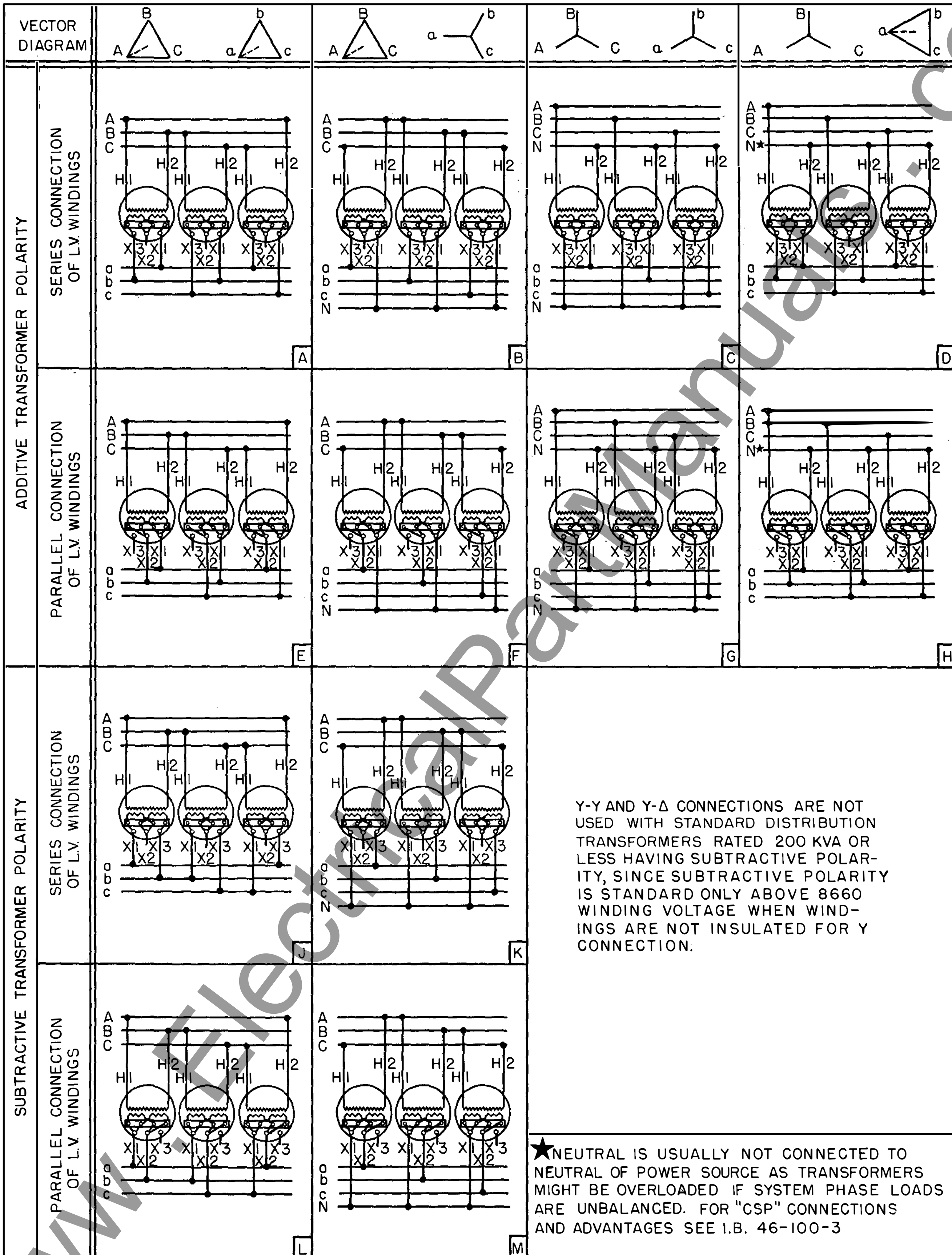


FIG. 7. Three-Phase Connection of Standard Single-Phase Transformers.

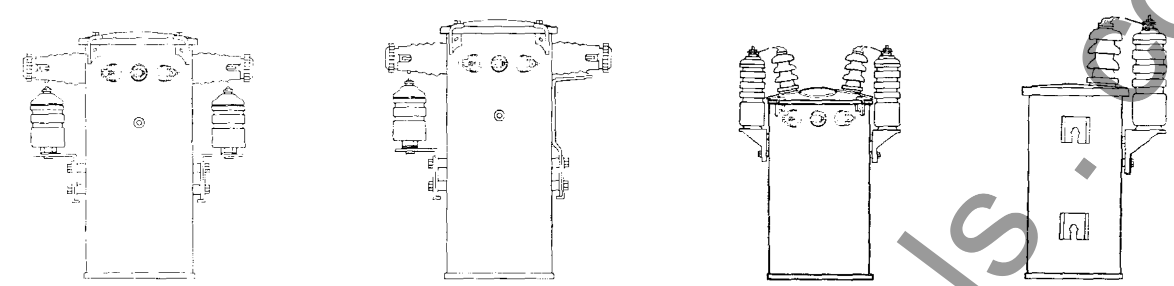


FIG. 8. Transformer Class Designations.

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.

LOW VOLTAGE CONNECTIONS

Refer to the diagram nameplate or the connection diagram specified on the nameplate and connect low-voltage terminals to service lines to secure the desired voltage. If a parallel connection of two sections of a low-voltage winding is made outside the transformer tank, the connection should be as short and as close to the low-voltage bushings as possible to insure equal division of current between the winding sections.

Where single-phase, three-wire service is supplied from a single-phase transformer, the neutral is usually grounded. When two-wire service is supplied, one of the leads is usually grounded if conditions permit. See National Electric Code for specific instructions. If leads are re-connected at the L. V. bushings to secure two-wire service, care should be used to maintain at least one inch clearance between live parts and between live parts and ground.

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. When installing such transformers in a three-phase bank, ***it is necessary to remove this connection on at least two transformers*** to prevent a short circuit when the three tanks are connected together.

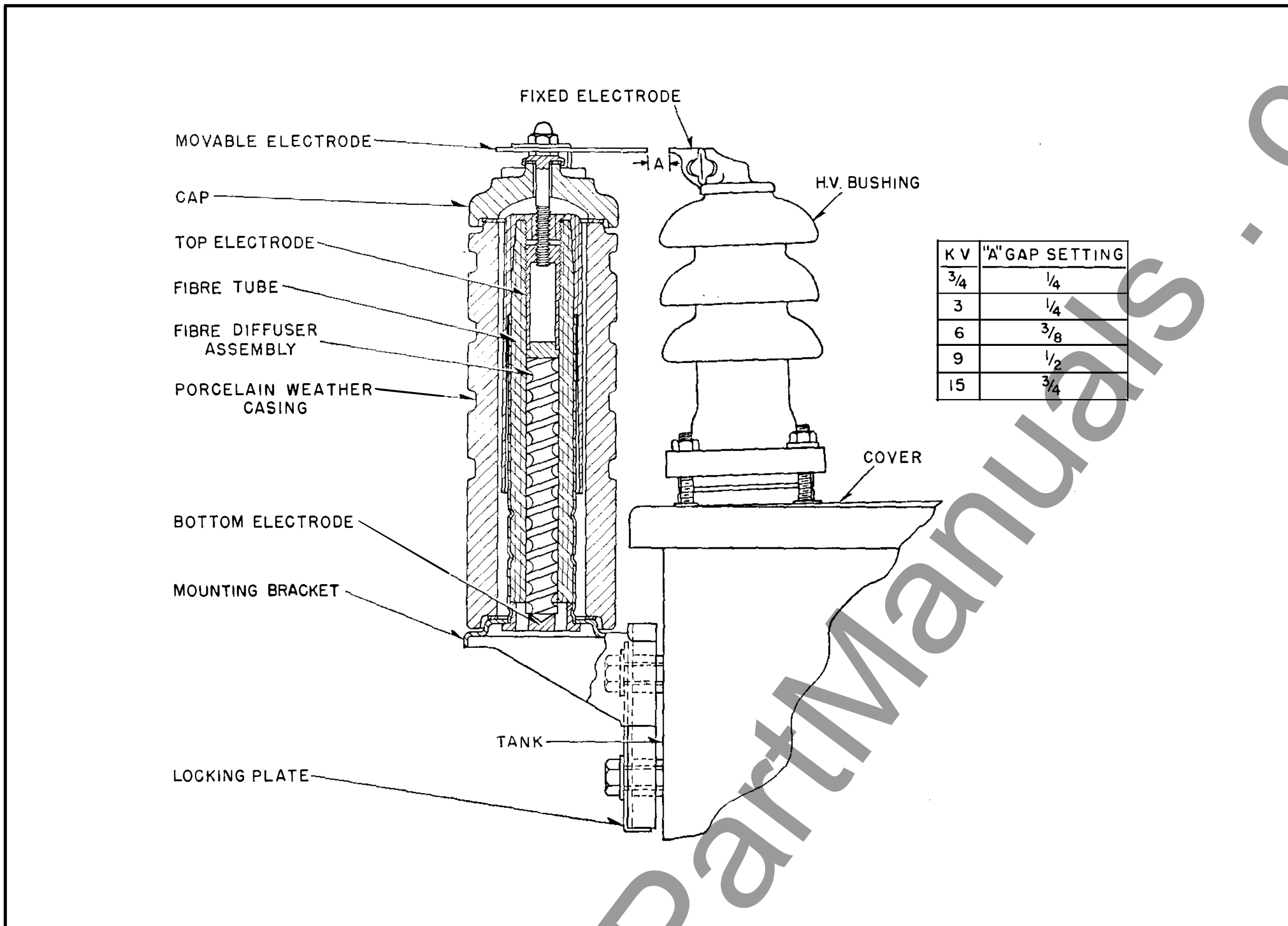
If standard single-phase "CSP" transformers are to be used to supply a combined three-phase load and a single-phase, ***three-wire*** load, it is important, except when the secondaries are connected in wye, that only two transformers connected in open delta be used, or that a balance coil be used. The reason for this is shown by Fig. 10. Should an overload cause circuit breaker a-a' in transformer A to trip, then line wires (1) and (3) would still be fed by transformers B and C. The neutral (2) would float in potential and voltages (1)-(2) and (2)-(3) would be determined only by load impedances. Transformer C, shown dotted, should therefore be omitted and transformers A and B used in open delta.

On combined three-phase loads and single-phase, ***two-wire*** loads, three single-phase "CSP" transformers may be used in a bank. However, they should not be used on three-phase, wye-delta banks without the neutral of the wye connected because the opening of a circuit breaker in a transformer in one phase will cause badly unbalanced voltages to appear across the three secondary leads.

Unless the ***system load*** on the three phases are balanced, a primary neutral connection on a wye-delta bank will produce a circulating current in the delta secondary to try to balance the load on the three-phases of the system. This unbalance may create a current large enough to open the secondary breakers in "CSP" transformers.

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



KV	"A" GAP SETTING
3/4	1/4
3	1/4
6	3/8
9	1/2
15	3/4

FIG. 9. Externally Mounted "De-ion" Lightning Arresters and Gap Adjustment.

connected to the tank) may be operated either way. In the "three-point" method of lightning protection, as used on all "CSP" 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

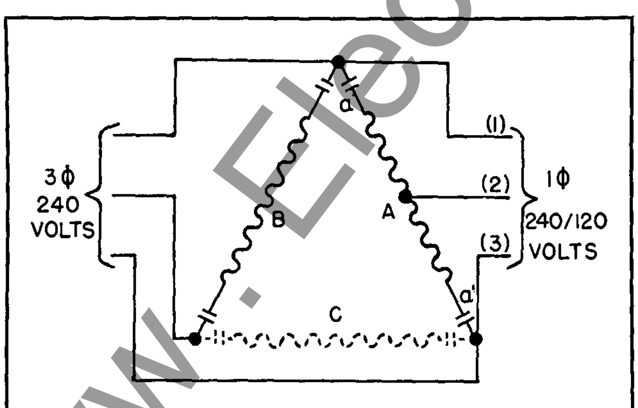


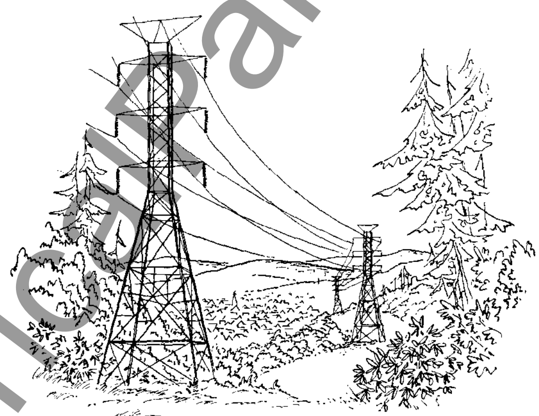
FIG. 10. Combined Single-Phase, 3-Wire Load and Three-Phase Load on "CSP" Transformer (Use Open Delta Connection Omitting Dotted Transformer).

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 specified, such tank discharge gaps are furnished with all "CSP" 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—"S" (Conventional) Transformer.*** No tank ground is required. 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—"CSP" Transformers.*** 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 asembly 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 more 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 air.

LIGHTNING PROTECTION ("CSP" TRANSFORMERS)

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 also 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 "CSP" 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 (or by "De-ion" arresters if the rated secondary voltage is sufficiently high) 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 whatever device is used 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

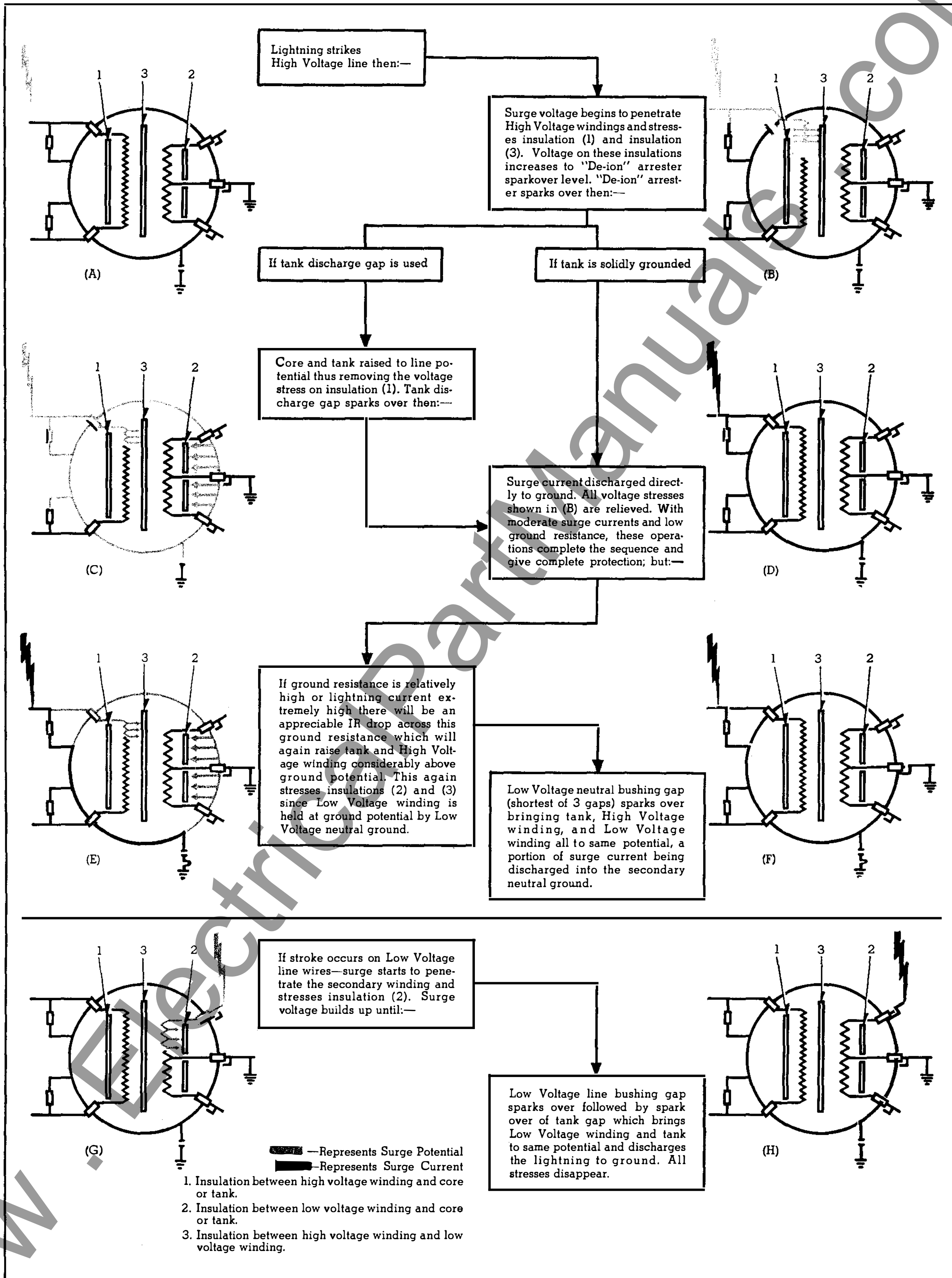


FIG. 11. Mechanism of "Three-Point Surge Protection".

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.

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. 9) consists essentially of two electrodes encased in an insulating tube and separated by a spiral filler. When a sparkover occurs from one electrode to the other 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 discharge. 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 interrupt since the passages through the fibre assembly are sufficiently small that even the smallest currents are in contact with the fibre.

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

BURNOUT PROTECTION ("CSP" AND "CP" TRANSFORMERS)

Thermal protection for "CSP" and "CP" transformers is afforded by a circuit breaker connected in series with the low-voltage winding. There are three major reasons for using this breaker:

1. To eliminate the fuse cutout, thereby eliminating fuse outages which are the largest single source of trouble with conventional transformer installation.

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.

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

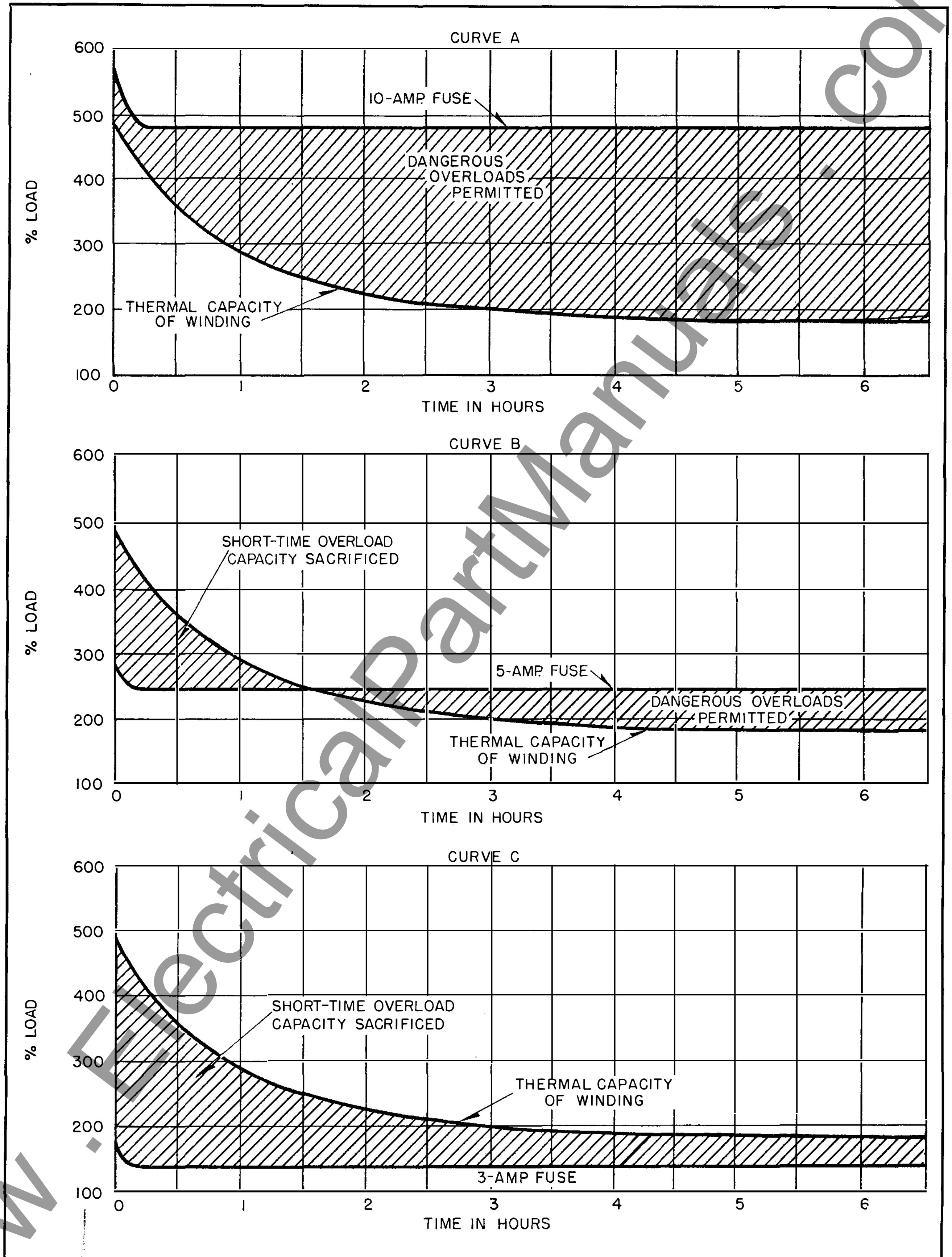


FIG. 12. Curves Showing that Thermal Protection of Distribution Transformers by Fuses is Unsatisfactory.

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 Booklet No. 46-402.

The adjustment of the breaker bimetal as made at the factory 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, three types of circuit breakers are used, all of which are trip free of their operating handles. The "LR" breaker has an advance signal and is available in ratings through 25 kva at 240 volts on L. V. or through 50 kva at 480 volts on L. V. The "BR" circuit breaker is similar to the "LR" but has a higher current rating and is applied on 37½ to 100 kva at 240 volts on L. V., or 75 and 100 kva at 480 volts on L. V. The above breakers are made in three-pole units for three-phase transformers.

The "FR" circuit breaker has no signal light nor emergency control provisions and is of lighter construction throughout. It is used on the smaller kva ratings where the extra cost of the signal light and emergency control is not considered justified.

In the larger ratings, two breakers may be used in order to provide sufficient capacity. These breakers are connected as shown in Fig. 13. The impedance of the transformer windings will cause the load to be divided equally between the two parallel secondary windings and contacts. When one of the bimetals finally opens one of the contacts (for example in X1), the current in the other bimetal is doubled and it then trips out immediately thus completely opening the X1 lead. However, when the first contact in X1 opened, one of the contacts in the X3 lead also opened because it is mechanically coupled to the X1 contact in the breaker; and when the second contact in X1 opened, the second contact

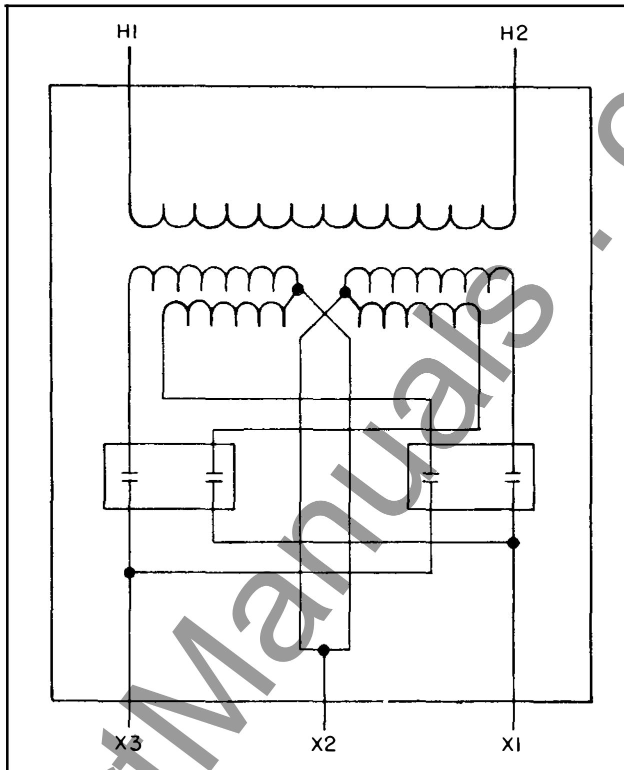


FIG. 13. Connection to Utilize Two Circuit Breakers for Larger "CSP" Transformers.

in X3 also opened. Hence, an overload on either half of the secondary will cause both breaker contacts in both halves to open.

"LR" BREAKER

A cutaway view of the "LR" breaker is shown in Fig. 14. 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. 15 contains schematic sketches somewhat simplified to better show the principles of operation.

When a transformer breaker trips out, there are a few rare occasions when a combination of circumstances make if difficult to reclose the main breaker contacts, especially if the oil has been heated by a long continued overload. If it is essential to restore service immediately, then this can be accomplished by using the emergency control device.

The emergency control handle is shown in Figs. 20 and 21. A Moldarta* lever is fitted on the bimetal adjusting nut of each pole section, and these Moldarta levers are linked together by a suitable

* Trade-Mark

connecting rod. This, in turn, is attached to a pull-wire which is affixed to a control arm on the inside of the tank wall. A shaft, working through a sealed bearing, connects this control arm to the emergency control operating handle on the outside of the tank. Pulling the emergency control handle downward causes the pull wire to rotate the Moldarta levers clockwise, thus increasing the bimetal latch engagement. This action increases the trip temperature setting of the breaker bimetal element, thus facilitating reclosure of the breaker contacts. With this emergency setting, a greater overload is required to trip the breaker in a given time. However, the breaker still protects the transformer from short circuits.

The external emergency control handle is set at the factory for normal operating conditions, and is held securely by a meter-seal to prevent unauthorized tampering. If an emergency makes it necessary to operate the emergency control mechanism, it is recommended that the overloaded transformer be replaced as soon as possible with a larger transformer. The emergency control handle on the originally overloaded transformer should be restored to its normal position and resealed before the unit is again put into active service elsewhere. ***Operation in the emergency position over a long period of time is not recommended, since it may reduce the life of the transformer insulation.***

A further description of the "LR" breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-408.

The electrical circuit is carried (sketch "A", Fig. 15) from the coil to the breaker contacts, then through the bimetal to the L. V. bushing. As the bimetal temperature increases due to the temper-

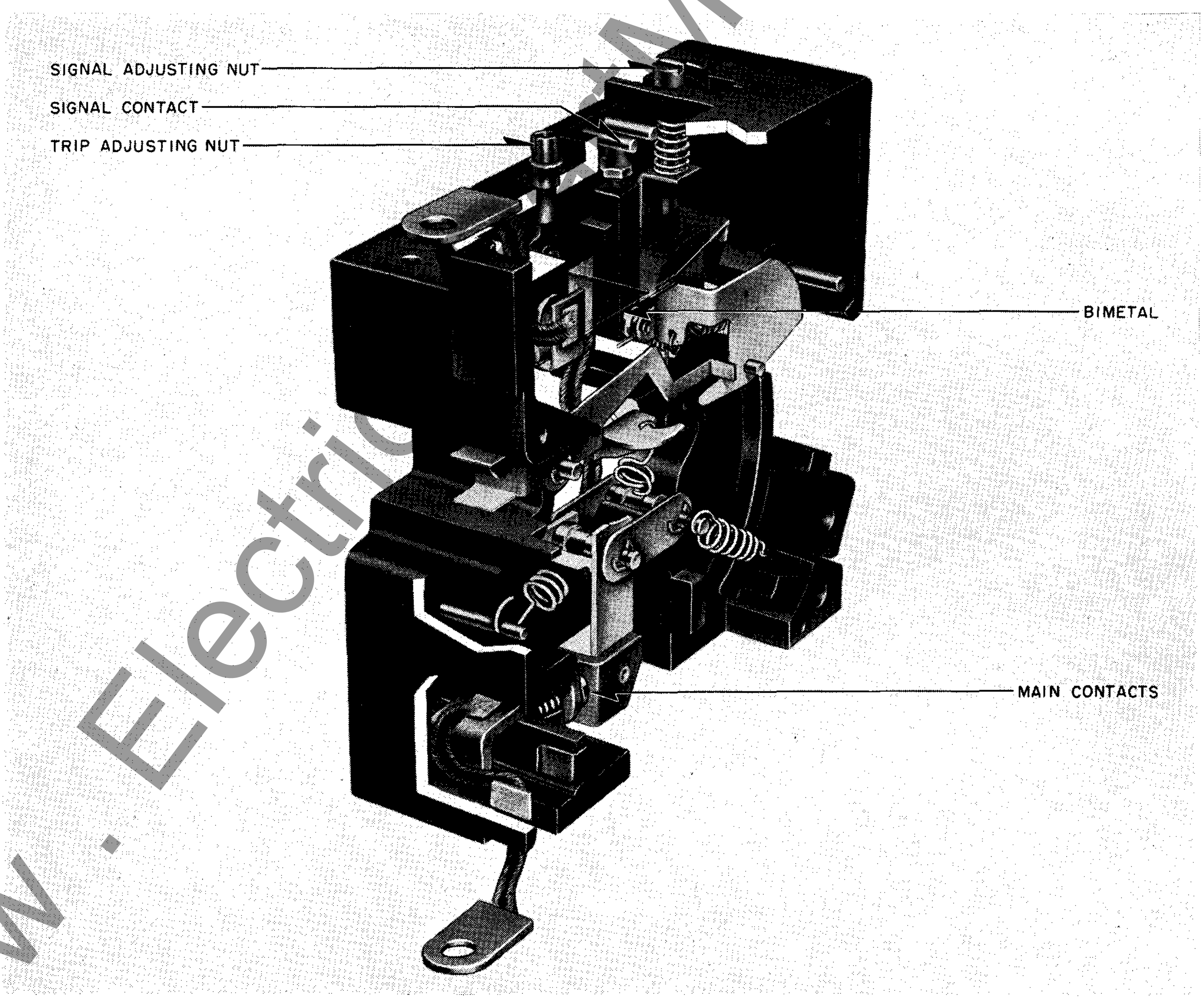


FIG. 14. Cutaway View of "LR" Circuit Breaker.

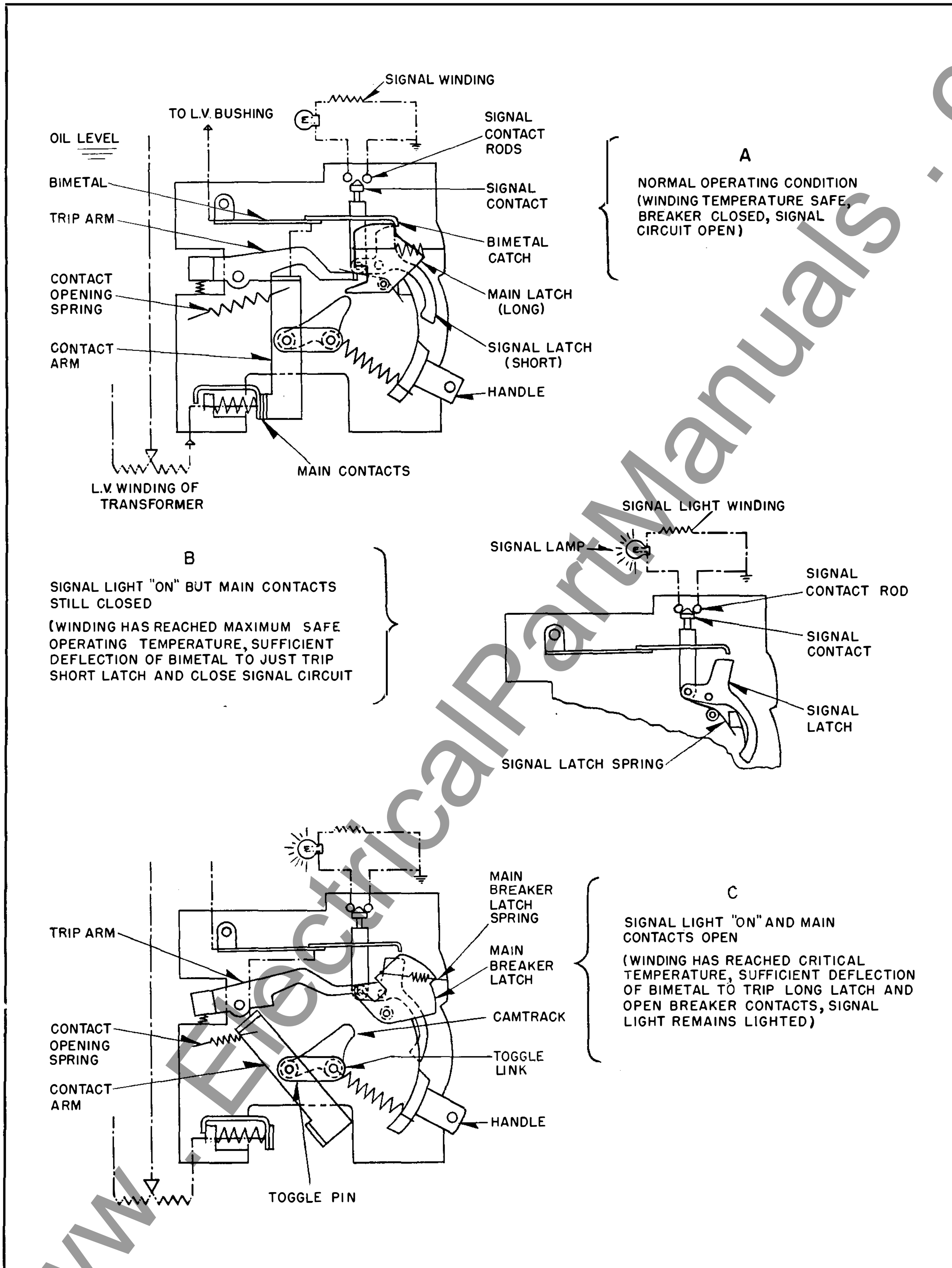


FIG. 15. Schematic Operational Sketches of "LR" Circuit Breaker.

ature of the oil and/or the load current, it deflects upward. At overloads sufficiently great to cause the transformer coil to reach its maximum safe operating temperature, the signal latch is released. This latch then rotates clockwise (sketch "B", Fig. 15) under the force of the latch spring so that the signal contact closes the circuit between the signal contact rods of the signal light circuit. 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. 26) and then reclosing. If the handle is not moved appreciably beyond the "Reset Light" position, the signal 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 upward until the main latch is released. This occurs at a coil temperature just below the burnout temperature.

When the main latch trips (sketch "C", Fig. 15) it rotates in a clockwise direction to impart counterclockwise rotation to the trip arm which releases the tip of the contact arm. The contact arm then rotates counterclockwise, under the pull of its opening spring, to open the main breaker contacts with a snap action; since both trip arms are connected together through an interlock, both poles open simultaneously. Resetting is accomplished by first moving the external handle (Fig. 26) to the "reset" position (which resets the latches and reengages the contact and trip arms) then reclosing. As the external handle is moved to the "close"

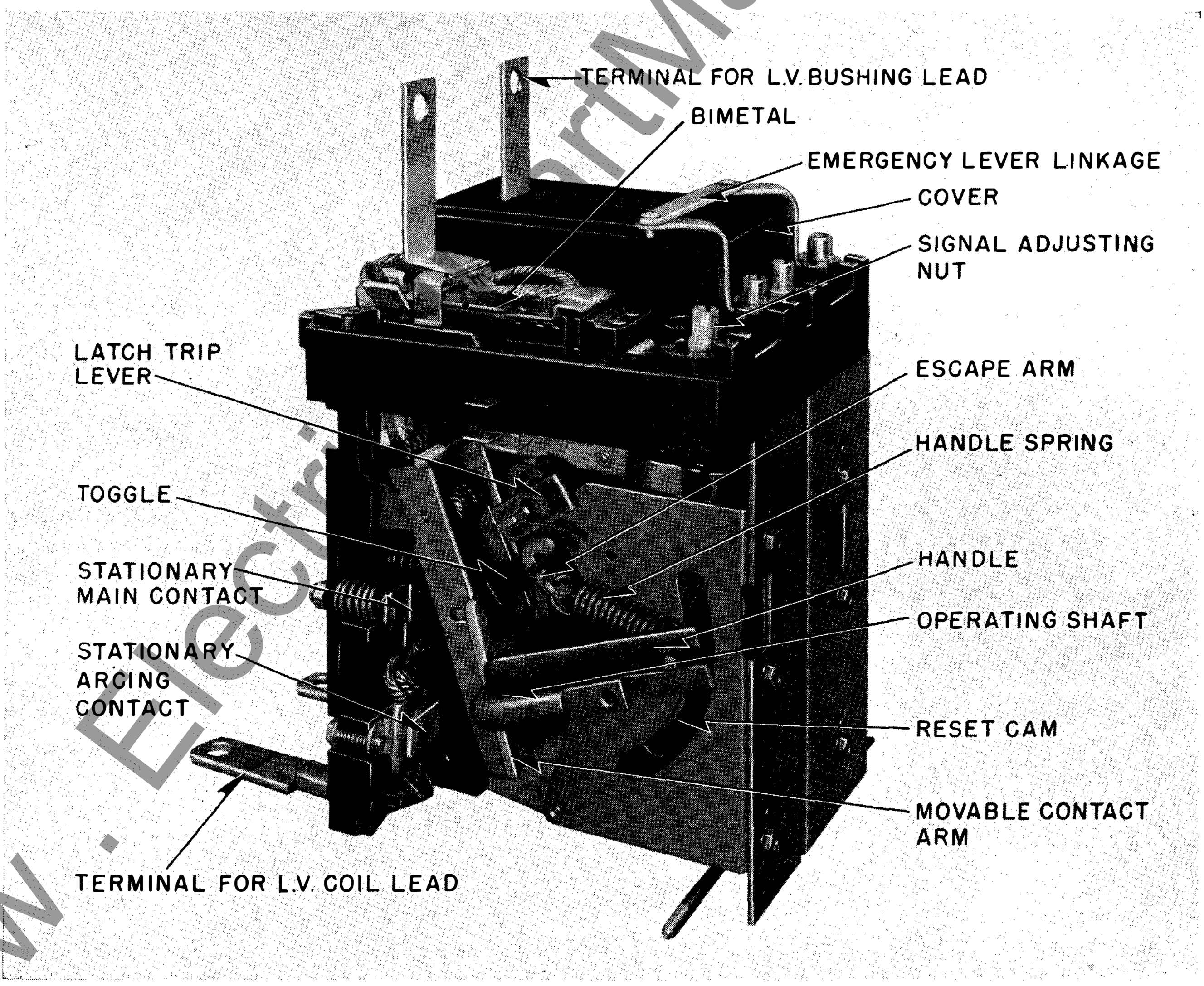


FIG. 16. Cutaway View of "BR" Circuit Breaker.

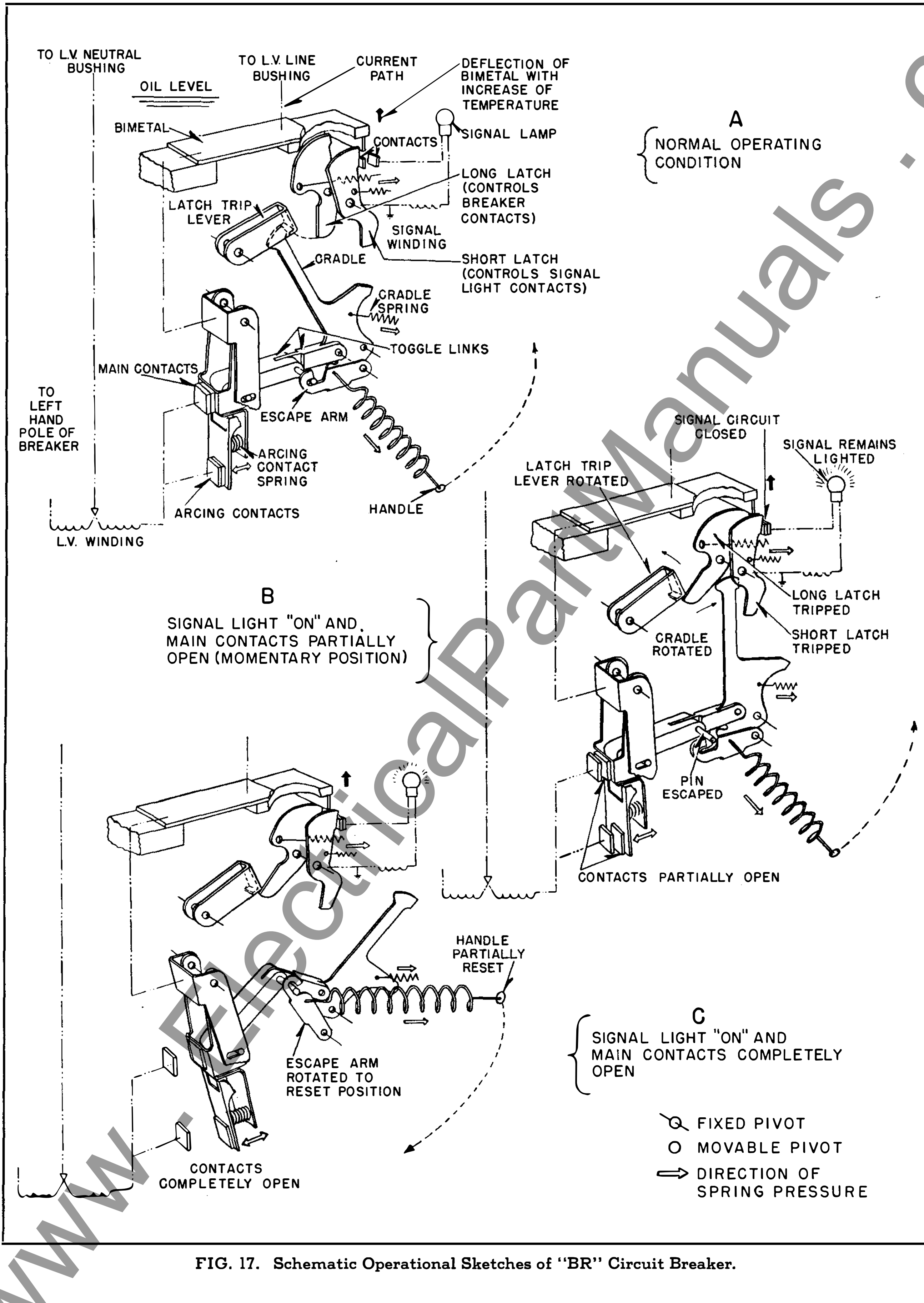


FIG. 17. Schematic Operational Sketches of "BR" Circuit Breaker.

position, the toggle pin (which has moved up and to the right along the "cam-track") returns to its original position and through the toggle link recloses the breaker main contacts. The contacts open and close with snap action because of the shape of the surface on which the toggle pin rides. This "cam-track" is designed to restrain the motion of the toggle until the springs have enough stored energy to carry the contacts to the desired position.

Manual opening and closing are accomplished by operation of the external handle which actuates the toggle pin at the center portion of the toggle and with it, the contact arm. In this type of operation, the center pin of the contact arm is moved and the upper end remains substantially stationary.

"BR" BREAKER

A cutaway view of a two-pole "BR" breaker is shown in Fig. 16. This breaker is used in the larger single-phase transformers; a similar three-pole assembly is used in the larger three-phase "CSP" transformers. The general principles of operation are the same as the "LR" breaker, although the breaker is larger in order to handle the heavier currents and is mechanically somewhat different. Like the "LR" breaker, the "BR" breaker has the signal light and Emergency Control features.

The electrical circuit is carried (sketch "A", Fig. 17) 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 temperature, 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.

If the bimetal temperature is further increased, the bimetal deflects further upward and the long latch is released. This latch 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 counterclockwise, the cradle is released, and it then rotates clockwise under force of the cradle spring. So far, 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 two 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. 17 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. 17) counterclockwise 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 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. 17, 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. 17 to that shown in sketch "C", Fig. 17 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.

A further description of the "BR" breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-406.

"FR" BREAKER

An "FR" breaker is shown in a cutaway view in Fig. 18. This type breaker is used in the smaller transformers, where a lower cost breaker is desired and where the signal light and emergency control

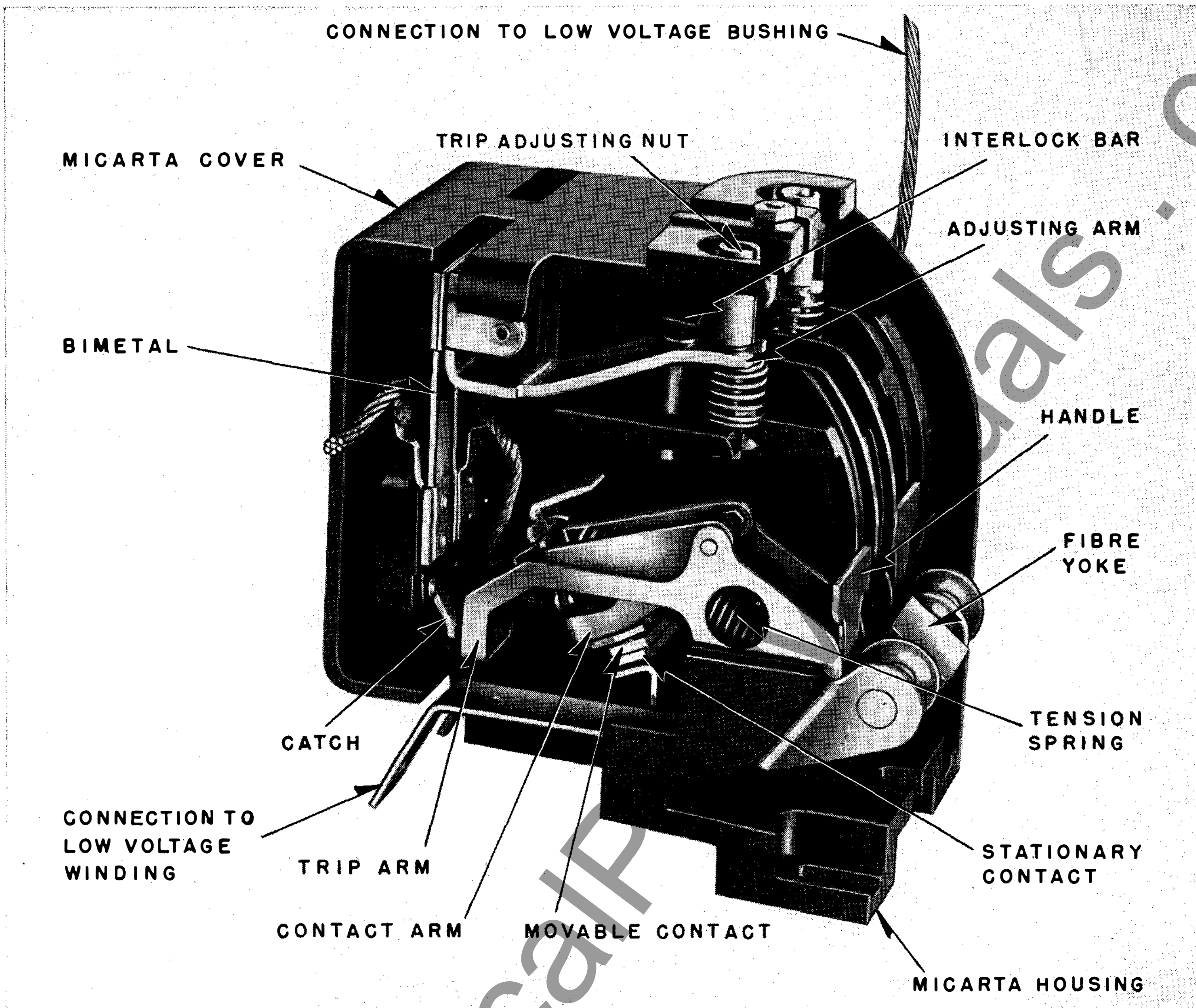


FIG. 18. Cutaway View of "FR" Circuit Breaker.

features are not considered economically justified. The general principles of operation are the same as those for the "LR" breaker, but the various parts are somewhat different.

Fig. 19 contains schematic sketches somewhat simplified to better show the operation. The electrical circuit is carried 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 to the left as shown. At overloads sufficiently great to cause the transformer coil to approach the burnout temperature, the catch slips off the end of the trip arm which is then rotated clockwise by the main breaker spring. After a slight rotation, it engages the projecting finger on the contact arm. The trip arm and contact arm then rotate together and the contacts are opened (sketch "B", Fig. 19) thus interrupting the circuit. The contact arm finally comes to rest, pressing against the interlock pin (sketch "C", Fig. 19). This pin, in turn, presses upward on the interlock bar which is pivoted at its center. The opposite end of the bar, therefore, presses downward on the adjusting arm of the other pole. This pressure overcomes the adjusting arm spring pressure and the whole adjusting-arm-bimetal-assembly rotates clockwise to release the trip arm of this pole also. Hence, the second pole is opened immediately by the opening of the first pole. Resetting is accomplished with this breaker as with the "LR" breaker by moving the external handle to the "Reset" position (see Fig. 27). This movement engages the reset tail "X" of the trip arm, thereby rotating it until the trip arm again engages the bimetal catch. The breaker may then be closed by moving the external handle to the "Close" posi-

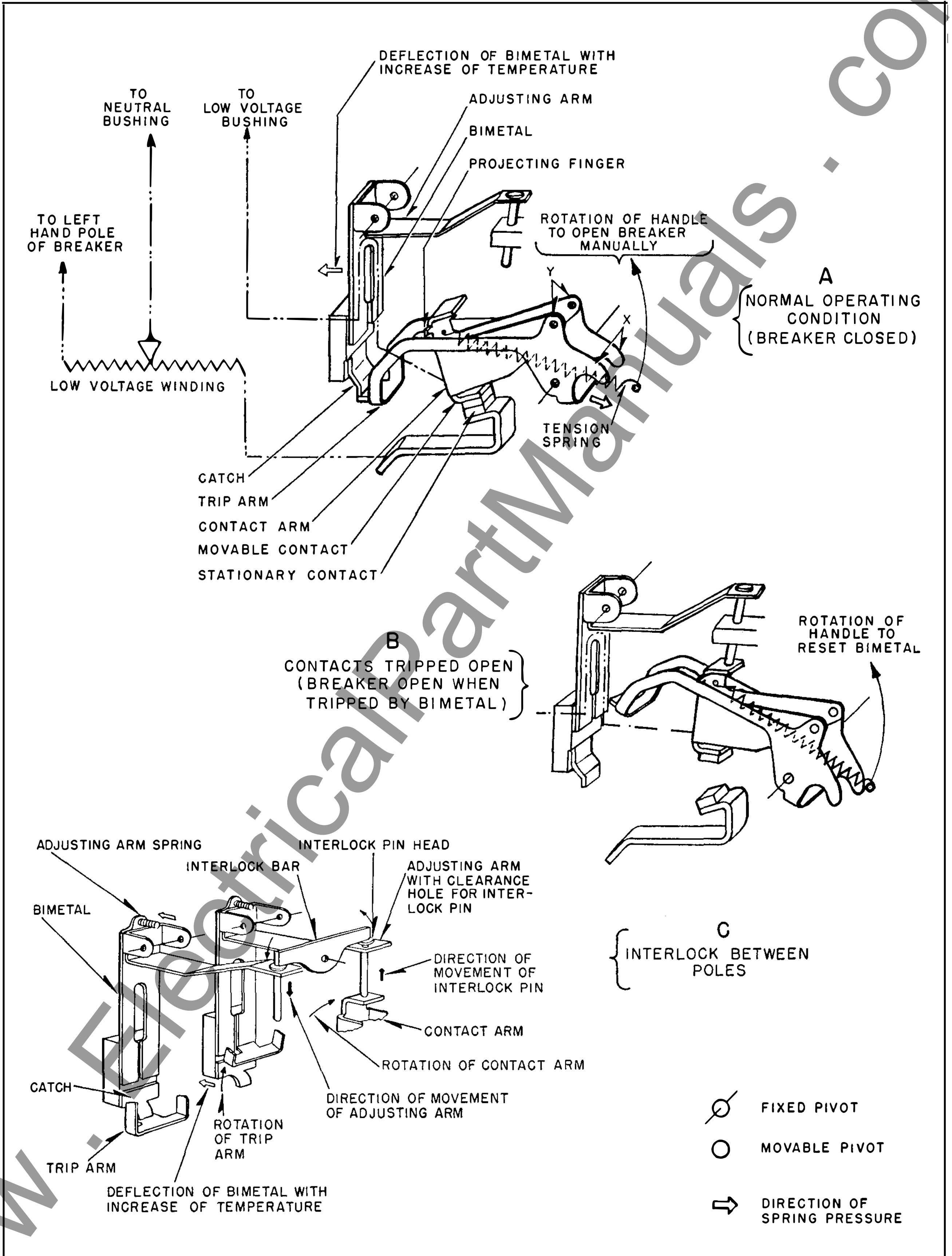


FIG. 19. Schematic Operational Sketches of "FR" Circuit Breaker.

tion, which throws the main spring over center, closing the contacts with a snap action. Manual opening and closing is accomplished by operation of the external handle which has the effect of carrying the spring back and forth across the pivot center "Y" of the contact arm (sketch "A", Fig. 19), thus causing it to snap quickly from its closed to its open position and vice versa without tripping the bimetal.

A further description of the "FR" circuit breaker is given in Westinghouse Distribution Transformer Technical Data Booklet No. 46-405.

SERVICE CONTROL DEVICE

This device permits operation of the internal secondary breaker of type "CSP" and type "CP" transformers from ground level. Fig. 28 (Part Four) shows the service control device mounted on an installed transformer. Also see discussion of service control device beginning on page 34.

PROTECTIVE LINKS

In spite of all the factory precautions to prevent and detect faulty windings, a transformer will occasionally (though rarely) fail in service. At such a time, it is important that the winding be disconnected from the system for the purpose of preventing a "lockout" of the distribution feeder. In "CSP" or "CP" transformers, the protective link connected in series with the high voltage winding serves this purpose. 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 possible 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 below the oil level where it is protected from the weather. The "De-ion" arrester is connected ahead of the link, to by-pass lightning currents which might cause the protective link to operate. The protective link is mounted in the H. V. bushing (Fig. 2) or on the terminal block (Fig. 1).

The link consists of a high melting temperature alloy wire which is surrounded by an insulating sleeve which serves as a heat blanket. The wire and sleeve are 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, thus causing gas to be evolved from the fibre tube. 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.

OPERATION AND MAINTENANCE

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 energized 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. The operating handle is above the oil level, and an indicator plate (with numerals corresponding to the position numbers on the diagram nameplate) is located just below the handle.

The positive snap action of the tap changer into position also guides the operator and insures a positive contact and a stop is provided to identify the highest and the lowest tap positions. 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

On "CSP" or "CP" transformers, the circuit breaker 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

On "CSP" or "CP" transformers (except small kva transformers with "FR" breakers), the signal light furnishes a valuable service in providing the means for an automatic overload survey. Many

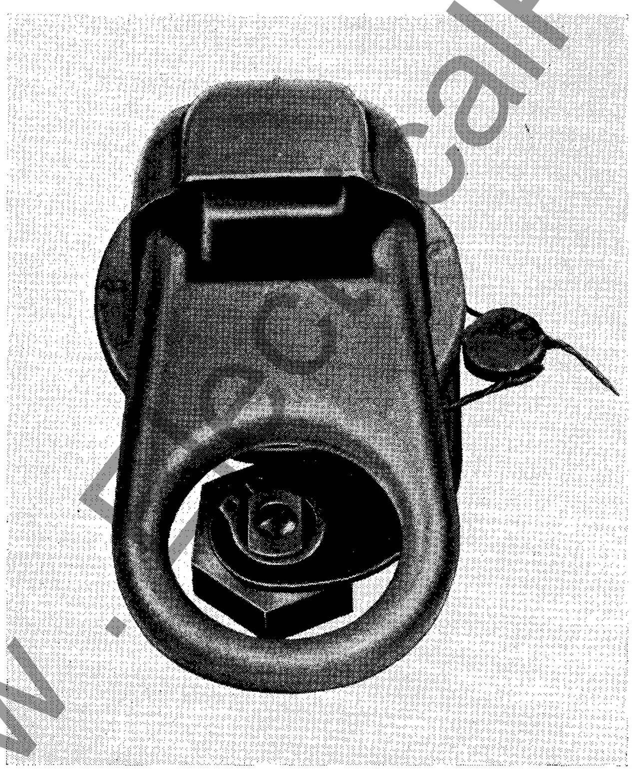


FIG. 20. Emergency Control Handle in Normal Position.

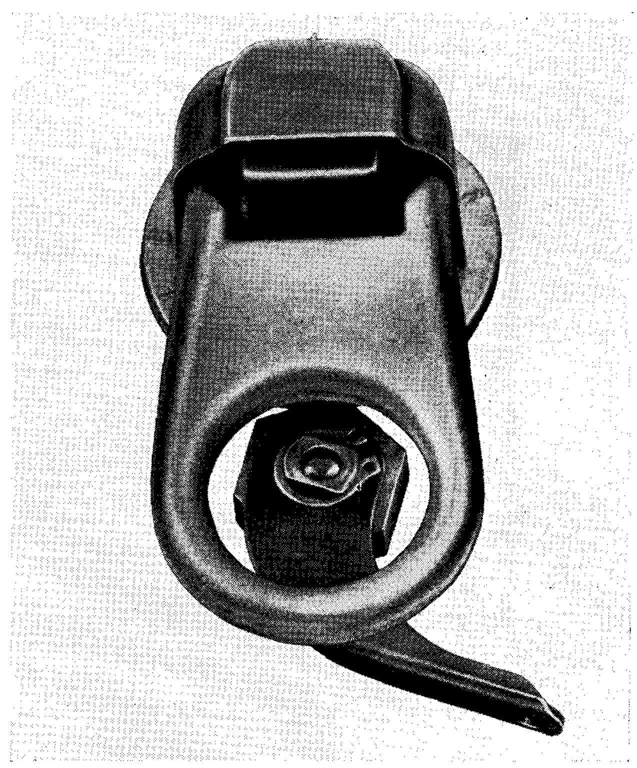


FIG. 21. Emergency Control Handle in Emergency Position.

utilities install one size smaller "CSP" transformer than "normal", planning that this can safely be done since the "CSP" will warn of any growing overloads. If the load reaches a magnitude such that dangerous winding temperatures are being approached, the circuit breaker will light the external signal light (without tripping the breaker unless the load continues long enough to raise the temperature still further toward the burnout point). Whenever a signal light is observed, it is common practice to reset the signal light at least once to determine whether its operation was caused by some isolated condition or whether it was caused by a repetitive condition. The signal light may be reset without disconnecting the secondary load by movement of the external handle only as far as the "Reset Light" position and then by movement back to the "Close" position. If the light is immediately re-lighted, the overload is either still continuing or has occurred so recently that the transformer has not yet cooled down. If the light is re-lighted within 24 hours or within a few days, this is probably an indication of a recurrent overload. The operator must then judge whether the overload is of such a nature that a larger transformer should be installed or whether there is some temporary condition which the existing transformer can handle. 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 operation of the signal light and the opening of the breaker allows temporary overloading without service outage.

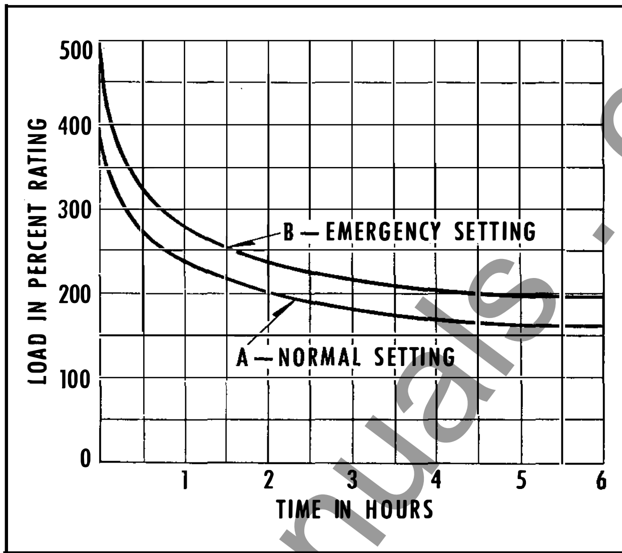


FIG. 23. Typical Breaker Trip Curves Showing Effects of Emergency Control.

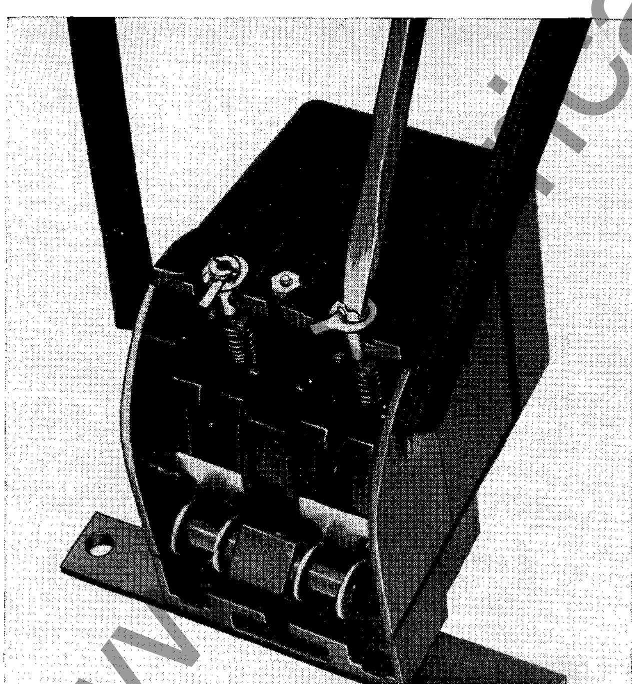


FIG. 22. "FR" Breaker Tripping Adjustment.

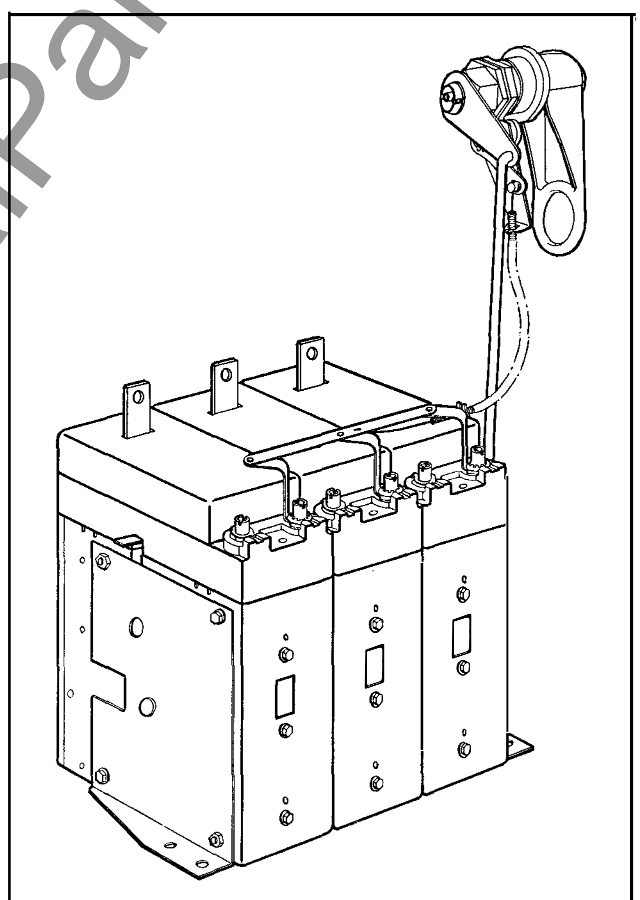


FIG. 24. "BR" Breaker with Manual Operating Mechanism and Emergency Control.

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 the load entirely, 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: On transformers which have two circuit breakers, both breakers must be closed to secure full transformer capacity.

CIRCUIT BREAKER TRIPPING ADJUSTMENT

Circuit breakers supplied in "CSP" or "CP" transformers are provided with an adjustment for increasing, above normal, the current required to trip the breakers. Occasionally, it may be desirable to continue to carry a certain load in an emergency even at the risk of burning out the transformer. In such a case, this can be done by rotating the adjusting nuts on the top of the breaker clockwise. This can be done on the "FR" breaker by means of a screwdriver inserted into the slots of the adjusting nut (see Fig. 22). The nut can be turned only about 30 degrees when the finger on the adjusting nut will strike its stop. The adjusting nuts should not be forced after the fingers reach the stops. All nuts should always be set with the fingers in the same relative position.

The same adjustment can be made on the "LR" and "BR" Breakers with an externally operated emergency control handle. The external appearance of the assembly is shown in Figs. 20 and 21. The handle is mounted so as to be partially concealed by the breaker operating handle. Internal mechanical connection is made to the circuit breaker as shown in Figs. 24 and 25. In the "LR" Breaker (Fig. 25) two insulating arms are attached to the bimetal adjusting nuts and 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. The "BR" mechanism (Fig. 24) works in much the same way except a bent steel arm is fitted on the bimetal adjusting nuts instead of the insulating arm used on the "LR".

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. Pulling the handle down as shown in Fig. 21, turns the screws to the right, which in turn moves the adjusting arm down (see Fig. 25) 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.

In general, the transformer should be allowed to carry the peak load only until the transformer can be replaced properly (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. See Fig. 23 for load time curve with emergency control setting.

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.

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. 27, then turn to the left (which lengthens 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 right (which

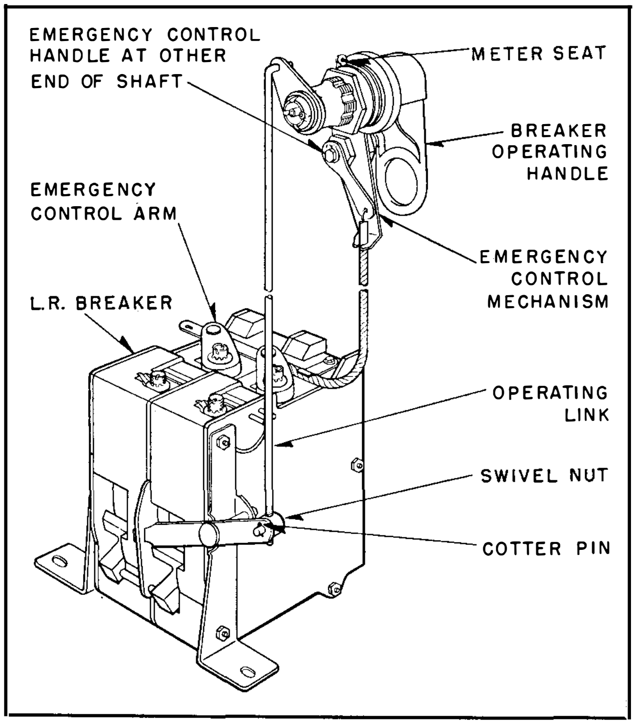


FIG. 25. "LR" Breaker Operating Handle, Linkage, and Signal Light.

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. 26, turn the upper end of the vertical rod to the left (which

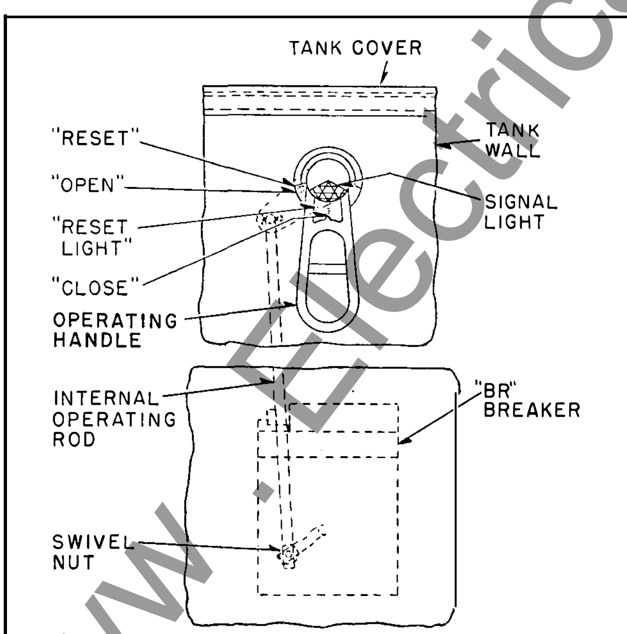


FIG. 26. "BR" Breaker Operating Handle, Linkage, and Signal Light.

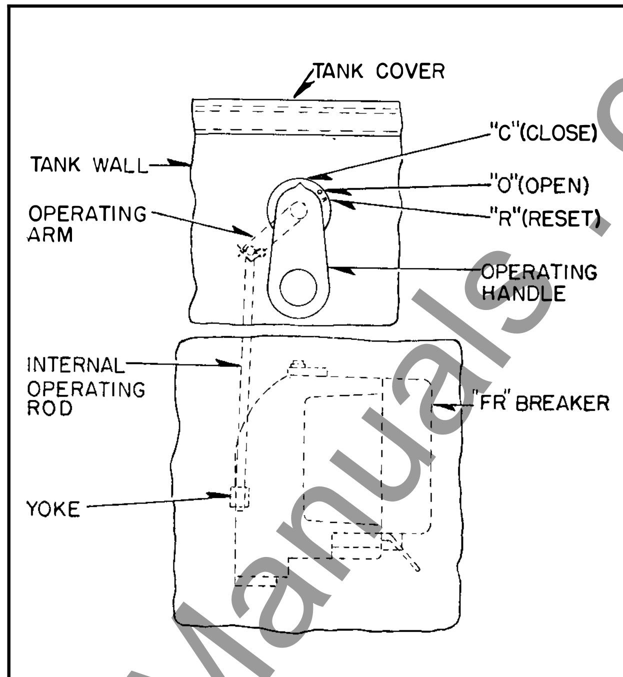


FIG. 27. "FR" Breaker Operating Handle and Linkage.

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.

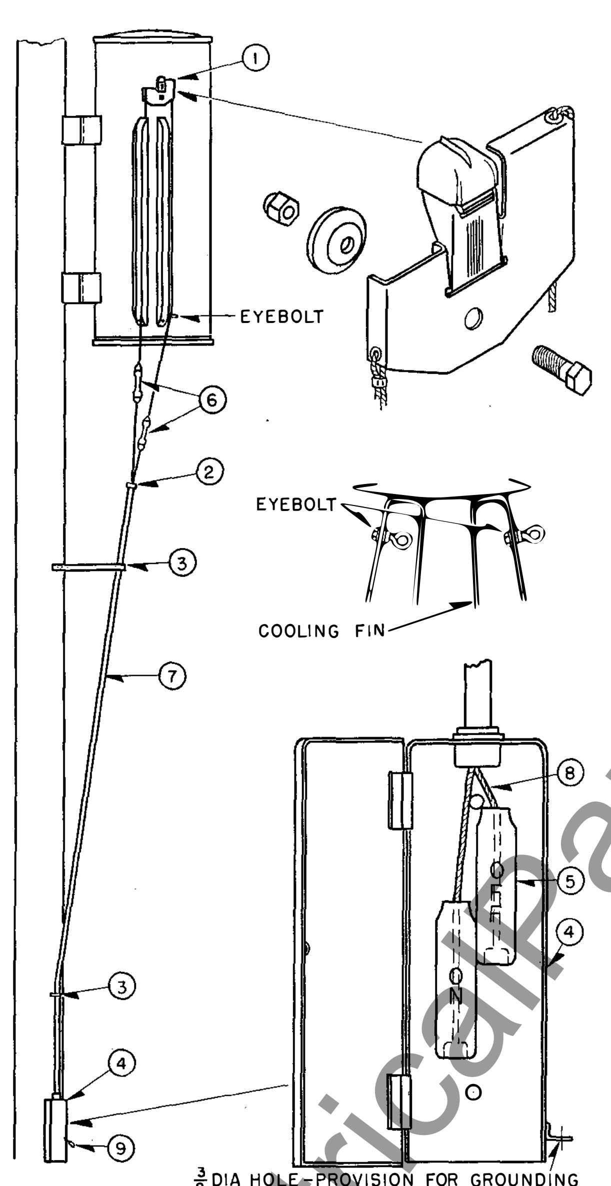
SERVICE CONTROL DEVICE

Fig. 28 shows the service control device with all of its component parts. The following is a description of the method of operation.

If the breaker trips while in service, open the control box, pull down handle marked "off" until breaker operating handle on tank has moved its full upward position (approximately 90°). Then pull down handle marked "on" until breaker operating handle has returned to its original position (vertical).

To disconnect breaker while it is in operation, open control box, pull down handle marked "off" until breaker operating handle on tank has moved to its full upward position (approximately 90°).

To close breaker after the above operation, open control box, pull down handle marked "on" until breaker operating handle has returned to vertical position.



PARTS SUPPLIED BY WESTINGHOUSE

1. Adapter Assembly (includes adapter for signal light with locking pieces, cable down to insulators, and eyebolt assembly on each side).
2. Bushing for end of conduit.
3. Conduit Clamps.
4. Control Box.
5. Operating Handles.
6. Insulators.

SUPPLIED BY CUSTOMER

7. Conduit.
8. Cable (between insulators and operating handles).
9. Padlock for locking control box.

FIG. 28. Method of Mounting Control Device When Above Fins. Also Parts List.

The following precautionary steps should be followed in use of control device:

1. Control box should be locked except when an authorized person is operating the control device.

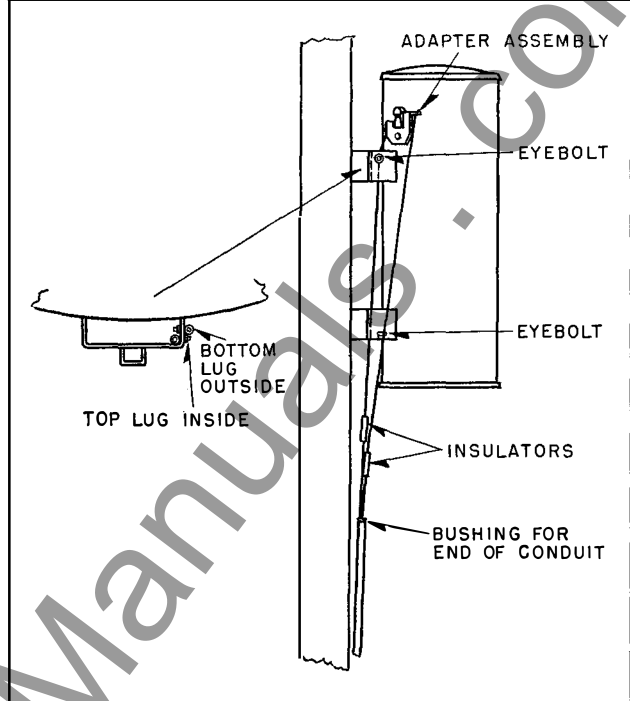


FIG. 29. Method of Mounting Control Device When Above Hanger Lugs.

2. Use a steady pull to operate device. Do not jerk on handle.

3. Be sure that control box is properly grounded.

METHOD OF MOUNTING CONTROL DEVICE

1. When fins are located below breaker handle, Fig. 28, drill 5/16 inch diameter holes in fins near the bottom as indicated. If there are hanger lugs below the breaker handle, Fig. 29, holes should be drilled in hanger lugs, as shown.

2. Slip adapter assembly over breaker operating handle, insert adapter bushing, and bolt into position. Set breaker handle in "On" position (approximately vertical). Assemble eyebolts to fins and paint.

3. Clamp insulators to ends of wire cables. (Note that insulator closest to tank must be at least 6 inches from bottom and that insulators must be staggered with no overlap, as shown).

4. Attach conduit to control box. Locate control box on pole in such position as to leave 6 inch minimum between lowest insulator and top of conduit. Install bushing in top end of conduit (2). Bend conduit so that cable from insulators will be in line with the conduit at points of entry. Clamp conduit to pole where indicated and secure box to pole with 1/4 inch wood screws.

5. Clamp $1/8$ inch galvanized wire cable loosely to lower end of insulators, thread through conduit into control box and gauge position of plastic handles.

6. Make permanent connection at bottoms of handles, then, hold handles in desired position, and make final connections at insulators. Make sure that the "Off" handle is connected to the upper right hand lug on fixture and the "On" handle to the lower left hand lug. Make sure that cables are not twisted together in conduit. If desired the permanent connection to the insulators may be made before attaching handles.

7. Ground control box, by means of lug provided, to transformer ground or other suitable point.

8. Set breaker in desired position and close box. Box may be locked if desired.

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.

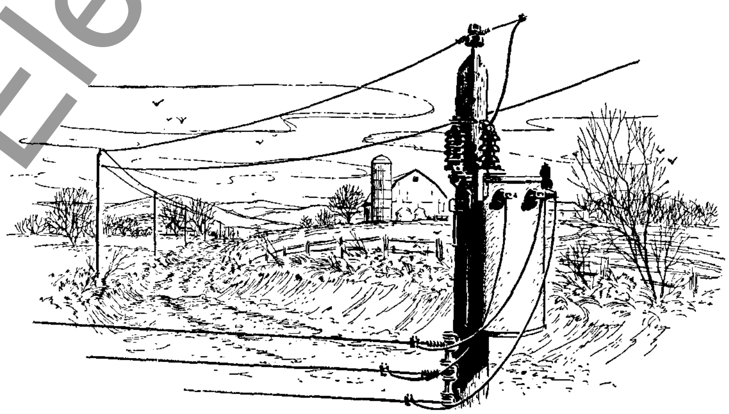
Where parts have become broken or where the tank shows evidence of excessive rusting, the transformer should be returned to a service shop for repair.

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 (for "CSP" transformers) "De-ion" arresters. Some operators carry practically no renewal parts but order them only when required for a specific case.

Renewal parts data for Westinghouse transformers is available upon request.



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LOS ANGELES, CALIF., 3383 E. Gage Ave., P.O. Box 629, Huntington Park
MILWAUKEE 9, WIS., 1500 W. Cornell St.
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N. E.
PHILADELPHIA 4, PA., 3001 Walnut St.
PHILADELPHIA 34, PA., Erie Ave. & "D" 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 Ave.
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. (Sunnyvale Plant), P.O. Box 37
SYRACUSE 4, N. Y., 700 West Genesee St.
UTICA 1, N. Y., 113 N. Genesee St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.

DISTRICT ENGINEERING AND SERVICE DEPT. OFFICES

AKRON 8, OHIO, 106 S. Main St.
ATLANTA 2, GA., 1299 Northside Drive, N. W., P.O. Box 4808
BALTIMORE 2, MD., 501 St. Paul Pl.
BEAUMONT, TEXAS, 515 American National Bank Bldg.
BIRMINGHAM 3, ALA., 1407 Comer Bldg.
BOSTON 10, MASS., 10 High St.
BUFFALO 3, N. Y., Ellicott Square Bldg.
BUTTE, MONT., 1 East Broadway
CHARLOTTE 1, N. C., 210 East Sixth St.
CHICAGO, ILL., Merchandise Mart Plaza
CINCINNATI 2, OHIO, 207 West Third St.
CLEVELAND 13, OHIO, 1370 Ontario St.
COLUMBUS 15, OHIO, 262 N. 4th St.
DALLAS 1, TEXAS, 1232 Fidelity Union Life Bldg.
DAVENPORT, IOWA, 2212 E. 12th St.
DENVER, COLO., 910 Fifteenth St.
DES MOINES 8, IOWA, 1408 Wlanut St.
DETROIT 32, MICH., 5757 Trumbull Ave., P.O. Box 502
DULUTH 2, MINN., 408 Bradley Bldg., 10 East Superior St.
EL PASO, TEXAS, 718 Mills Bldg.
FRESNO 1, CALIF., 2608 California Ave.
GRAND RAPIDS 2, MICH., 148 Monroe Ave., N. W.
HARTFORD 3, CONN., 119 Ann St.
HOUSTON 2, TEXAS, 507 Dallas Ave.
HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150
...NAPOLIS 9, IND., 137 S. Pennsylvania St.
... 120 W. Michigan Ave.
... Eleventh St.
LOS ANGELES 17, CALIF., 600 St. Paul Ave.
LOUISVILLE 2, KY., 332 West Broadway
MEMPHIS 3, TENN., 825 Exchange Bldg., 130 Madison Ave.
MILWAUKEE 2, WIS., 538 N. Broadway
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N. E.
NEWARK 2, N. J., 1180 Raymond Blvd.
NEW ORLEANS 12, LA., 1226 Whitney Bldg., 288 St. Charles St.
NEW YORK 5, N. Y., 40 Wall St.
NORFOLK 10, VA., 915 W. 21st St.
OMAHA 2, NEBR., 117 N. 13th St.
PHILADELPHIA 4, PA., 3001 Walnut St.
PHOENIX, ARIZ., 1102 N. 21st Ave., P.O. Box 6144
PITTSBURGH 30, PA., 306 4th Ave., P.O. Box 1017
PORTLAND 4, ORE., 309 S.W. 6th Ave.
RICHMOND 19, VA., 1110 East Main St.
ROANOKE 4, VA., 303 1st St. S.W.
ST. LOUIS, MO., 411 North Seventh St.
SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
SAN DIEGO 1, CALIF., 525 "E" St.
SAN FRANCISCO 8, CALIF., 410 Bush St.
SEATTLE 4, WASH., 3451 East Marginal Way
SPOKANE 1, WASH., N. 1023 Monroe St.
SYRACUSE 4, N. Y., 700 W. Genesee St.
TOLEDO 4, OHIO, 245 Summit St.
UTICA 2, N. Y., 255-257 Genesee St.
WASHINGTON 6, D. C., 1625 "K" Street, N.W.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
YOUNGSTOWN 3, OHIO, 25 E. Boardman St.

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