Secondary Unit Substation Transformers

LIQUID-FILLED

RECEIVING, HANDLING, AND STORING

RECEIVING

Secondary Unit Substation transformers are normally shipped completely assembled, liquid-filled and ready to install. Immediately upon receipt of the equipment, examine the packages and parts for any damage which may have occurred during shipment. If injury or rough handling is evident, file a damage claim with the transportation company and notify the nearest Apparatus Sales Office of the General Electric Company.

Tighten any parts which may have worked loose, such as nuts and leads and check the materials against the shipping list for possible shortages.

HANDLING

Lugs are provided for lifting the complete transformer, and where necessary, additional nuts and eyes are supplied for lifting the various parts. Lift the transformer by means of the main lifting lugs, using cables long enough to obtain cable pull angles not over 30 degrees from vertical. When lifting the transformer, the cover should be securely fastened in place to prevent buckling the tank walls.

Jacking space is provided in the base of the transformer. Do not attempt to move the unit by placing jacks under drain valves, cooling tubes or other attachments. Junction boxes, when provided, can be removed to facilitate moving the transformer.

STORING

Before placing a transformer in storage, make sure the insulating liquid is at its proper level, add *dry* nitrogen in the gas space until the pressure reaches 3 psi and then seal the unit. Before placing a transformer in service after a period of storage, relieve the internal gas pressure by venting to the atmosphere. See paragraph on "Venting".

Transformers stored for use as spares should be maintained in the same condition as those in service. Make periodic inspections of the liquid level, its dielectric strength, and when furnished, fans, alarms, and control circuits. Also check the pressure gage to make sure the transformer seal is being maintained and inspect junction boxes and other compartments for evidence of moisture condensation.

INSTALLATION

The only foundation necessary is a level floor strong enough to support the weight of the transformer. The transformer should be located at least six inches and preferably a foot or more away from walls and other obstructions which might prevent free circulation of air around the unit. Provisions have been made for moving valves and gages from the high-voltage to the low-voltage front and vice versa in the event that it becomes necessary to reverse the position of the transformer. Refer to the Outline drawing. Transformer finishes and components are designed for normal life in a non-corrosive atmosphere. Atmospheres which include corrosive agents may require additional protective measures.

If the transformer is to be opened outdoors on a damp or stormy day, take precautions to prevent entrance of moisture. CAUTION—Before removing a handhole cover, shipping plate, or other device, vent the transformer to atmospheric pressure.

Drilled flanges are provided on both the high- and low-voltage ends of the transformer for making connections to switchgear or terminal compartments. Terminal compartments, when provided, can be removed to facilitate installation of the transformer. To disassemble a compartment, remove the bolts around the edge of the front panel and

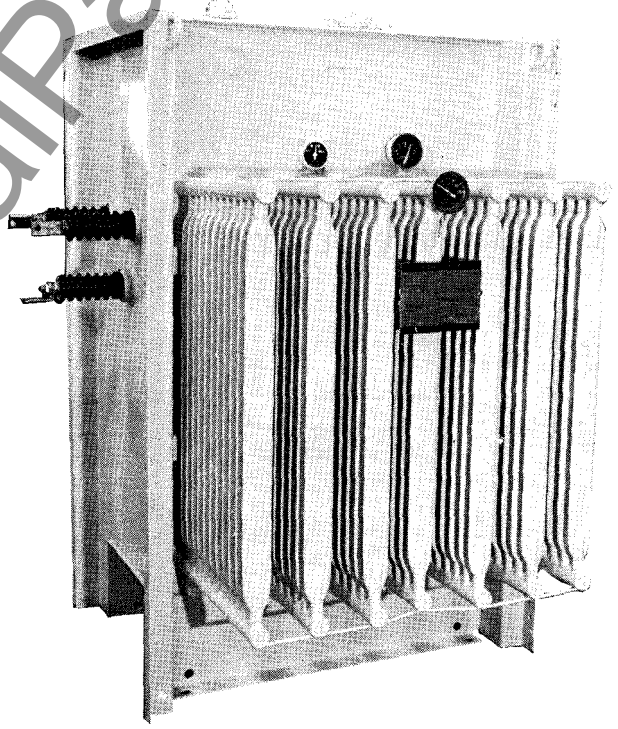


Fig. 1. Secondary unit substation transformer

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

GENERAL ELECTRIC

pull it away at the bottom until the top slides out from under the cover. The cover and side panels can then be removed as required. Protective covers on bushings should not be removed until the unit is ready for connection in order to prevent damage to the bushings.

Before placing the transformer in service, check the level and dielectric strength of the insulating liquid in all compartments as explained under "Sampling" and "Testing".

At higher altitudes, decreased air density reduces transformer cooling efficiency and lowers bushing arc-over voltages. Lower atmospheric pressures may require venting of the transformer before placing in service in order to equalize internal and external pressures. If the transformer is to be installed at an elevation above 3300 feet, consult the nearest Apparatus Sales Office of the General Electric Company relative to the transformer's suitability for operation at the higher altitude.

CONNECTIONS

The necessary hardware for making interconnections between a transformer and its co-ordinated switchgear is supplied with the switchgear. Bus bar joints should be properly aligned before bolting to prevent undue strain on the bushings. Connections to threaded bushing studs should be made as described under "Bushings" and as shown in Fig. 12. When making line connections, long sections of unsupported conductor should be avoided and leads should be flexible enough to allow for expansion and contraction. Make no connections except those authorized by the transformer nameplate.

Transformers having internal terminal boards are normally shipped connected for the highest rated voltage. When shipped otherwise, a tag fastened to the nameplate will indicate the connections that have been made. Before applying voltage to a transformer, see that all connections are tight and that the windings are connected for the desired voltage.

Ground the transformer permanently and effectively by means of the ground pad located at the bottom of the tank. Unit substation transformers can usually be connected to the common substation bus. A reliable, low-resistance ground is essential for adequate protection. A poor ground may be worse than none at all as it gives a sense of false security to those working around the equipment and may result in serious personal injury or damage to the transformer.

When a transformer is designed for use on a system having a solidly grounded neutral, be sure that the neutral lead is permanently and solidly grounded.

PIPE FITTINGS

When assembling pipe fittings, clean the threads thoroughly to remove all insulating liquid, grease, old compound and dirt. Apply G-E Compound No. A15A11A or Teflon tape to the threads and screw the mating parts tightly in place.

LEAK TESTS

Inspect the entire transformer for evidence of leaks and make the following pressure test. Introduce dry nitrogen through the pressure test valve (located on the tank wall opposite the pressure-vacuum gage) until the pressure in the transformer reaches 5 psi. Seal the tank at this pressure and make an examination for leaks over a period of 12 hours. Leaks above the liquid level can be located by applying a liquid soap solution to all gasketed joints, pipe fittings, etc.

VENTING

The transformer should be vented to the atmosphere before it is placed in service if it has been pressurized for leak tests or storage, or if the unit has been opened and resealed. Venting should take place with the liquid temperature at 25 C. If it is necessary to vent at other temperatures, re-vent as soon as the unit returns to 25 C. This operation is necessary to prevent excessive operating pressures or vacuums.

VAULT VENTILATION

If the transformer is to be installed in a vault, provide ventilation which is adequate to keep the room temperature from exceeding that of the incoming air by more than 5 C. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, provide about 20 square feet each of inlet and outlet openings for every 1000 kva of transformer capacity.

Arrange the air inlets and outlets so that they are permanently open. Do not use as ventilators, windows or doors which may be opened and closed by attendants, because of the danger of excessive heating in case they are inadvertently left closed during periods of heavy load or high temperature.

If forced ventilation is used, supply about 5000 cubic feet of air per minute for each 1000 kva of transformer capacity, and conduct the incoming air directly to the transformer so that it will flow up through and around the radiating members of the tank. If this cannot be done and the air is merely moved through the room, provide about 10,000 cubic feet per minute for each 1000 kva.

GASKETS

A number of different types of gaskets are used on secondary unit substation transformers, depending on the application. Gaskets used to maintain the transformer seal have been selected for their ability to resist deterioration by the insulating liquid and to avoid any contamination of the liquid. No substitution should be made for these original gasket materials without the approval of the General Electric Company. Replacement or spare gaskets can be purchased to size through the nearest Apparatus Sales Office of the General Electric Company. Identify the parts wanted as explained under "Renewal Parts".

All of the gaskets used to maintain the transformer seal can be reused many times unless damaged. Before installing a new gasket or replacing an old one, thoroughly clean the gasket surfaces. Although no stickers are required, the compound furnished with the gaskets may be used on all but the "O" rings to hold them in place during assembly. Compress the gasket approximately one-third, or to the stops when provided in either the mating parts or in the gasket itself. Gaskets are compressed to the stops when there is a noticeable increase in the torque required to tighten the bolts. A leak test is recommended following the opening and closing of any gasketed joint affecting the transformer seal.

WEATHERPROOF JOINTS

A length of sponge rubber gasket is furnished with each outdoor unit for the purpose of weatherproofing the joints

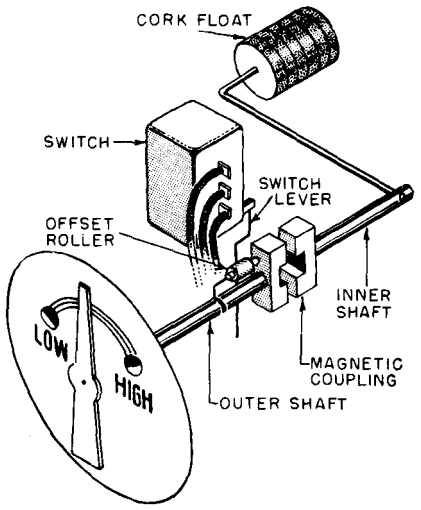


Fig. 2. Schematic view of magnetic liquid-level gage with alarm switch

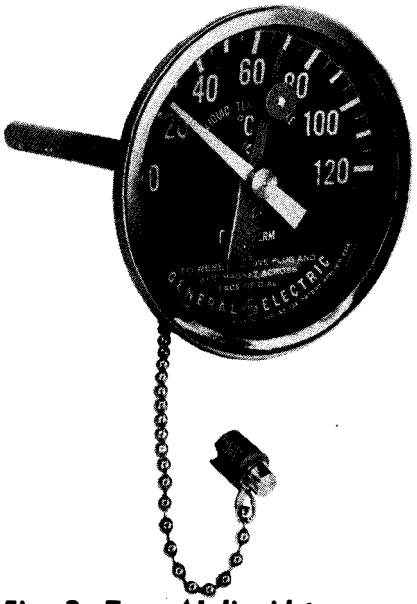


Fig. 3. Type AL liquid temperature indicator

between the transformer and its associated air-filled compartments. Install this gasket just outside the mounting studs or bolt holes and for the best weather-resistant joint allow the piece across the top to overlap the two side pieces.

To install a sponge rubber gasket, clean the surface on which it is to be mounted and apply a thin coat of the adhesive furnished to both the metal and the gasket. (*Do not* apply adhesive to the edges or outside surface of the gasket.) Allow the adhesive to dry until it is no longer tacky and then press the gasket against the metal with enough pressure to make a good contact.

When a retaining strip is provided the gasket should be assembled with its inner edge in contact with the strip. Tighten the gasket down to this stop or in the absence of a stop, compress it to approximately ½ size.

ACCESSORIES

LIQUID-LEVEL GAGE

A magnetic liquid level gage is used to indicate the level of the insulating liquid in the main transformer tank and in associated compartments. It consists of a float arm and magnet on one side of a liquid-tight partition and a second magnet and indicating pointer on the other side. See Fig. 2. The gage can be removed whenever the liquid is at or below the 25 C level.

Gages which have a snap-action switch can be wired to give an alarm when the liquid level approaches a point too low for safe operation of the transformer. A cam on the indicator shaft will operate the switch when the pointer drops to the "LOW" mark on the dial. As the liquid level rises the pointer indicates the change, but the switch will not clear the alarm circuit until the pointer has advanced from five to ten degrees above the "LOW" mark.

LIQUID TEMPERATURE INDICATOR

The liquid temperature indicator is used to indicate the top liquid temperature of the transformer and those having internal switches can be used to control fans and/or initiate an alarm. The standard type AL thermometer is shown in Fig. 3. When alarm contacts are required a Type ALR thermometer as shown in Fig. 4 will be furnished.

The thermometer is mounted with its temperature sensitive bulb in a well which extends into the transformer's top liquid and is secured with a union nut. The well is liquid-tight thus permitting removal of the thermometer without lowering the liquid level or breaking the transformer seal.

Dial calibration is in degrees centigrade with a yellow or white pointer to indicate top liquid temperature and a red pointer to show the maximum temperature which has been attained since last reset. To reset the maximum reading pointer, remove the magnet and wipe it across the face of the dial.

Type ALR indicators are equipped with two snap-action switches which are operated by cams on the indicating pointer shaft. Switch No. 1 is intended for fan control and Switch No. 2 can be used in an alarm or control circuit. Switch contacts are normally set to operate on rising temperatures as follows: Switch No. 1, 65C; Switch No. 2, 90C. With falling temperatures the switches operate between 5C and 10C below these settings. When Switch No. 1 is used for fan control, a separate "Hand-Auto" switch is included in the control circuit for manual operation.

To check operation of the thermometer or the temperature at which the switches operate, remove the unit and place the detector bulb in a container of liquid. Heat the liquid and using an accurate centigrade thermometer, compare readings and check switch operating temperatures. If the unit is not operating satisfactorily consult the nearest Apparatus Sales Office of the General Electric Company regarding repairs or replacement.

PRESSURE-VACUUM GAGE

The pressure-vacuum gage furnished with the transformer (Fig. 5) is of the compound type and is normally calibrated in psi. Gage readings should vary

Fig. 4. Type ALR liquid temperature indicator - relay

as the transformer temperature changes and should normally indicate a positive pressure. (The instrument should not be expected to read accurately near the zero point.) When the transformer is de-energized or is operating under light or no-load conditions in a low ambient temperature, the gage may indicate a vacuum within the tank. A lack of any change in reading with changes in temperature is an indication of a leak in the transformer seal and should be investigated.

PRESSURE-RELIEF DEVICE

A mechanical, self-resetting pressure relief device (Fig. 6) is normally supplied with transformers filled with Pyranol® insulating liquid and is used to protect the tank against excessive internal pressures such as those which may accompany an arc under the insulating liquid. It consists primarily of a mounting flange, cover, two trigger springs, and an "O"-ring gasket.

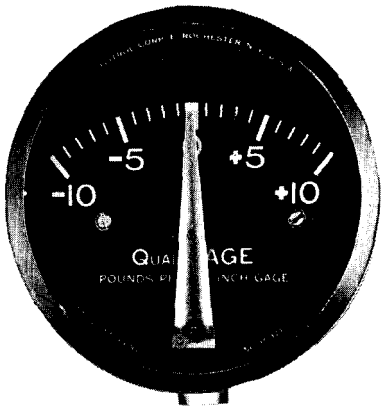


Fig. 5. Pressure-vacuum gage

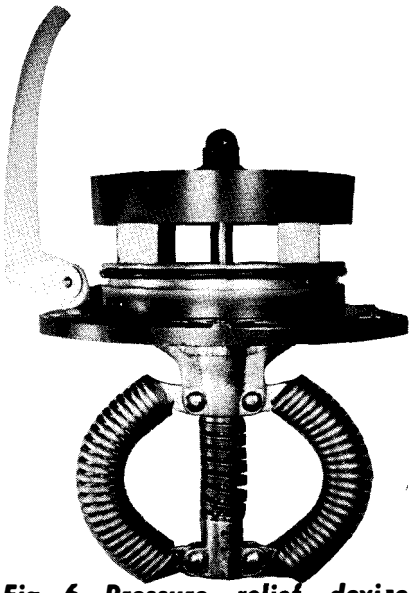


Fig. 6. Pressure relief device blocked open with alarm in vertical position

The relief cover is used as the means of sensing pressure and tripping the device. The gas pressure within the transformer is applied over the entire area of the relief cover which in turn exerts a force against two trigger springs. When the pressure increases to a critical value, the springs will bow out, permitting the cover to open and relieve the excessive gas pressure within the transformer tank. A bumper spring assembled on the center shaft cushions the opening shock and limits travel of the device. When the transformer pressure has returned to normal the device will return to its original position, automatically resetting itself and resealing the transformer.

The transformer seal is maintained by an "O" ring gasket between a vertical section of the mounting flange and the cover. The compression forces are at right angles to those acting on the cover to trigger the device and, therefore, have no effect on its calibration. To keep drag at a minimum, a wider-than-normal gasket groove is used which permits the "O" ring to roll rather than slide during the first part of the tripping action. By the time the "O" ring reaches the top of the groove the trigger springs have bowed beyond their critical point and sufficient force is then readily available for sliding the cover over the gasket.

The pressure relief device is provided with a mechanical alarm to give local indication of relief operation. The alarm consists of a plastic vane pivoted on a bracket and is normally removed for shipment. To install the alarm, remove a nut from one of the relief mounting studs, place the bracket over this stud with the vane resting on top of the relief cover, and replace the nut. The vane will then remain in a *horizontal* position until the pressure-relief device operates, at which time the cover will push the vane into a *vertical* position. After tripping, the vane must be reset in order to indicate subsequent operations.

Gas Absorbers and Vent Pipes

If a Pyranol-filled transformer is located in a poorly ventilated indoor area, provisions should be made to either absorb or carry off any discharged gases. Refer to the National Electric Code for regulations pertaining to the indoor installation of Pyranol-filled transformers.

Gas absorbers are designed for mounting directly on top of the pressure relief device using the same mounting studs. Instructions for installing and filling the absorber are furnished with that device. A special adapter flange and gasket (Items 2 and 3, Fig. 7) are available upon request for connecting vent pipes to the relief device. Order by drawing number 112A4035 G1 through the nearest Apparatus Sales Office of the General Electric Company.

The reducer (1) is to be made by the user and should have a maximum outside diameter of 10.20" in order to fit the 10.25" inside diameter of the adapter. The height to the first bend must be at least 6.50" to clear the relief device cover when it opens and the other dimensions can be made as required.

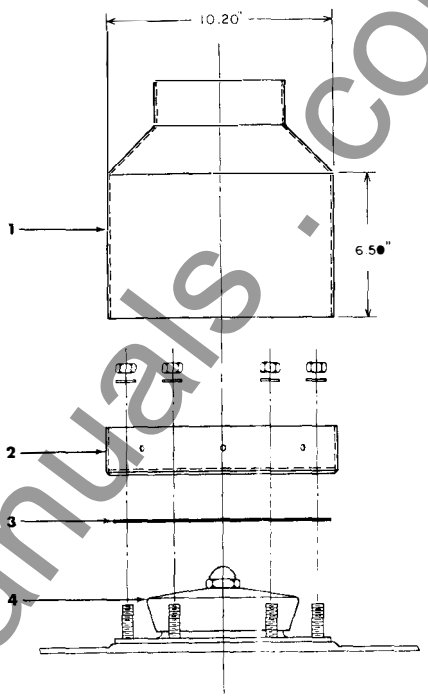
ELECTRICAL ALARMS

When electrical alarms are furnished with the various devices, the arrangement of contacts and color-coding of the leads will be as shown in Fig. 8 and on the transformer Connection Diagram. Switch No. 1 of the liquid temperature indicator is rated to carry 15 amps at 115 or 230 volts a-c. All other snap-action switches are rated as follows:

Circuit	Type of Load	Circuit Volts	Amperes
AC	Inductive and Non-Inductive	115	10
		230	5
DC	Inductive	125	0.05
		250	0.03
	Non-Inductive	125	0.25
		250	0.20
AC or DC	Inductive	125 And 250	Restrict starting inrush currents to values below
			Already Closed Contacts: 30 — Closing Contacts: 15

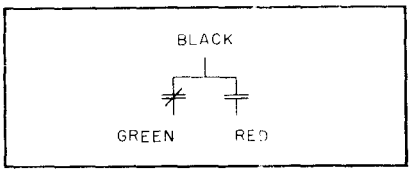
WEDGE-TYPE TAP CHANGER

The wedge-type tap changer, Fig. 9, provides a means of changing the voltage ratio of a de-energized transformer without breaking the transformer seal. It is shipped in place and is set on the position corresponding to the rated voltage shown on the transformer nameplate unless otherwise requested by the user.

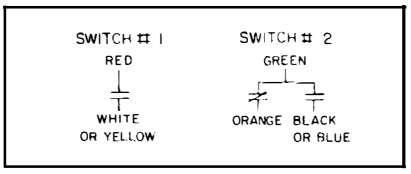


1. REDUCER
2. ADAPTER FLANGE
3. GASKET
4. PRESSURE-RELIEF DEVICE

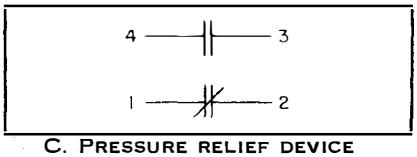
Fig. 7. Exploded view of vent pipe accessories



A. LIQUID LEVEL GAGE



B. LIQUID TEMPERATURE INDICATOR



C. PRESSURE RELIEF DEVICE

NOTE—COLOR CODING OF ONE LEAD MAY DIFFER. UNLESS OTHERWISE SPECIFIED BY USER, CONNECTIONS WILL BE MADE TO THE NORMALLY OPEN CONTACTS AND LEADS FROM THE NORMALLY CLOSED CONTACTS WILL BE TAPED UP.

Fig. 8. Switch and cable connections for alarm contacts (when furnished)

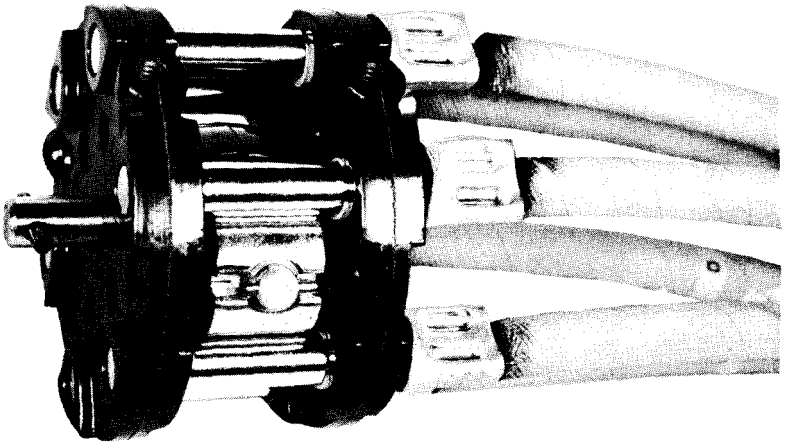


Fig. 9. Wedge-type tap changer

Tap leads from the transformer windings are connected to a circular group of nickel-plated copper rods which are held together between two insulating heads. A wedge in the middle can be moved by a crankshaft to wedge between any two adjacent rods. A spring between the wedge and crankshaft maintains a high-pressure line contact between current carrying components.

When the crankshaft is turned to move the wedge from one operating position to another, pressure is gradually reduced on the spring and the wedge is withdrawn from between rods. A "U"-shaped guide on the opposite side then pivots the wedge around to the next set of rods. As the crankshaft continues to turn, pressure is again applied to the spring and the wedge is forced into position with a wiping action, insuring positive contact.

The drive mechanism, Fig. 10, is located on the side or cover of the transformer and is connected through an insulator to the crankshaft of the tap changer. The cap covering the mechanism is gasketed to the mounting flange and an "O"-ring gasket is used between the mounting flange and drive shaft to maintain the transformer seal. One of the screws used to hold the cap in place has an oversize head with a hole in it for padlocking if desired. When requested, provisions can also be included for interlocking with the primary circuit breaker (or high-voltage disconnect switch) as explained under "Interlocks". Position indication is provided by an arrow on the mounting flange and a corresponding number on the cap.

Operation

CAUTION! The tap-changer must not be operated while the transformer is energized! Serious personal injury and/or damage to the transformer may result if this is attempted.

A table on the transformer nameplate gives the voltage and current rating for each tap position. TO CHANGE TAPS REMOVE THE TAP CHANGER CAP and use a wrench to turn the hex-head drive mechanism. The mechanism must be rotated through 5/6 of a turn to make a change of one tap. With the cap removed, the tap position can be observed through a slot in the indicator cams (See Fig. 10). Although the drive mechanism can be turned continuously in either direction placing the wedge in any one of six different positions, only five positions are numbered for use as shown on the transformer nameplate. The unnumbered position is unauthorized and should not be used.

After the desired change has been made, make sure that the cap gasket is in good condition and replace the cap. Note that the slots in the two indicator cams must coincide before the cap can be seated properly. This is to insure that the cap is not replaced until the tap changer is on position and also serves to align an appropriate position number on the cap with the arrow on the mounting flange.

Interlocks

Upon request, the operating mechanism can be mechanically interlocked with the circuit breaker or disconnect switch feeding the transformer. This can be done either by means of a special padlock inserted through the head of the oversize cap screw or by means of a captive key-operated plunger-type lock as shown in Fig. 11. The key for this lock is normally held in a similar lock on the primary circuit breaker and can be removed only by opening the breaker and locking it open. This de-energizes the transformer and permits the key to be removed and used to unlock the tap changer.

To place the transformer back in service after the desired tap change has been made, lock the tap changer in position, remove the key, and unlock and reclose the primary circuit breaker.

NOTE: A duplicate key is furnished with the transformer. This key is for emergency use only and should be removed from the operating area to insure the effectiveness of the interlock system.

Removing and Reassembling

If it becomes necessary to disconnect or remove a tap changer drive mechanism it should be placed on position 1 before removal in order to facilitate reassembly. To remove the drive mechanism, unbolt the flange and lift the device out as an assembly. Note that drive mechanisms are not interchangeable! When two or more are removed at the same time, care should be taken to reassemble them in the same location from which they were removed.

When replacing, see that the tap changer and the drive mechanism are both on position 1. The tap changer is on position 1 when the wedge bridges tap leads A and B and the index marks on the drive shaft and support structure are in line with one another. To reassemble, place the drive shaft through the opening in the mounting flange and slide the coupling over the tap changer shaft. The slotted end of the coupling should engage a pin in the tap changer

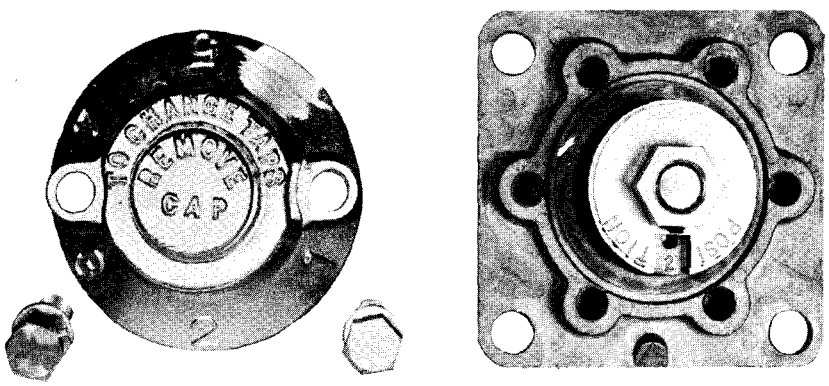


Fig. 10. Tap changer drive mechanism with cap removed

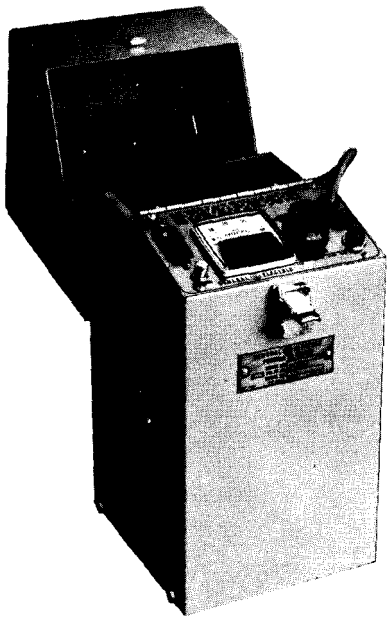


Fig. 13. Typical portable dielectric test set

If tests on the insulating liquid are satisfactory and no filter system is available, fill the transformer through a cover opening. Strain the liquid through two or more thicknesses of muslin or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. Use at least one set of cloths for each transformer.

SAMPLING INSULATING LIQUIDS

In the sampling and testing of insulating liquids, strict attention should be given to the cleaning and drying of sampling and testing receptacles. Samples should be taken when the insulating liquid is at least as warm as the surrounding air to avoid the possibility of moisture condensation. If the transformer or drum is outdoors, the sample should be taken on a clear day with precautions being taken to guard against contamination by windblown dust, etc. Observe the following procedure to obtain consistent results from samples taken either for field or factory tests.

Sampling From Transformers

1. Impurities which tend to affect the dielectric strength of 10C oil will generally be found at the bottom of the transformer, while those affecting Pyranol will be at the top. Therefore, on oil-filled transformers the sampling valve is located on the main drain valve and on Pyranol transformers it will be found on the side of the tank, about one inch below the 25C liquid level.

2. Three types of containers are recommended for sampling purposes — a one-quart, small-neck brown glass bottle; a clear glass bottle in a lightproof carton; or a one-quart tin can that has had the solder seams thoroughly cleaned to remove all traces of soldering flux. Do not use rubber stoppers or rings. If desired, glass sampling bottles may be obtained from the General Electric Company as explained under "Testing Service."

3. To clean the bottles, rinse with non-leaded, oil-free gasoline. Then wash with strong soapsuds, rinse thoroughly with distilled water, and dry in an oven at 105C to 110C for at least 8 hours. After drying, the bottles must be tightly sealed with glass stoppers or with clean corks protected by clean metal foil. Store them in a dry, dust-free cabinet or compartment.

4. Carefully clean the sampling valve or plug and allow enough insulating liquid to run out to remove any moisture or foreign matter which may have collected.

5. Rinse the bottle carefully, at least three times, with small portions of liquid drawn from the sampling valve. Allow the sampling bottle to drain thoroughly between rinses.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the liquid. Reseal the transformer and carefully seal the container to prevent exposure to the atmosphere.

7. When making repeated samplings, observe the transformer liquid level and add make-up as required.

Sampling From Drums

1. Drums should remain undisturbed for at least eight hours before being sampled. Take oil samples from the bottom and Pyranol samples from the top, using a chemically clean thief. Observe sampling precautions previously outlined.

2. Glass thieves should be cleaned, dried, and stored in the same manner as outlined for bottles.

TESTING INSULATING LIQUIDS

Dielectric Strength

A variety of high-voltage dielectric testing equipment may be purchased from the General Electric Company. A typical portable test set (Model No. 9T11Y8454) is shown in Fig. 13 and various console models are also available. Follow the technique specified by the American Society for Testing and Materials, Designation: D877. The following paragraphs give a general outline of the procedure.

1. Set the spacing of the 1.0 inch diameter electrodes at 0.100 inch.

2. Wipe the test cup and electrodes clean with dry, calendered tissue or clean, dry chamois and thoroughly rinse with non-leaded, oil-free, dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under standard conditions of voltage applications (3 kv per second rise). If the cup has a dielectric strength above 25 kv, it is considered suitable for testing purposes. Observe the usual precautions in handling gasoline.

4. Immediately after the final rinsing with gasoline, rinse the test cup with the sample under investigation, and proceed with the test at once.

5. *The temperature of the sample when tested should be the same as that of the room, which should be between* 20 *C and* 30 *C* (68*F and* 86 *F*). Tests made on samples above this temperature can be misleading. Under no circumstances should the test cup be colder than the sample being tested.

6. Agitate the sample gently before each filling to prevent variations in results due to a settling of contaminants. Pour the liquid into the receptacle slowly to avoid the formation of air bubbles and fill to overflowing. If air bubbles are present, gently rock the test cup a few times and wait at least 3 minutes before applying voltage.

7. Fill the cup at least five times, making one test per filling, and average the results.

Since the liquid is a major portion of the insulation system in the transformer, its dielectric strength should be maintained as high as possible. A low breakdown voltage is an indication that impurities such as moisture, conducting dust, lint, or carbonized particles have entered the liquid. Oil or Pyranol testing lower than 26 kv (30 kv when new) should either be filtered to bring it back to its original condition or be replaced, depending on the condition of the liquid and economic considerations.

Other Tests

Although a low dielectric strength indicates the presence of contaminants, a high value is not always a certain indication of their absence. A number of other tests can be performed on an insulating liquid to determine its condition and therefore no one test should be considered conclusive. ASTM Designation: D117 defines the standard tests and contains cross references to other ASTM Designations for detailed descriptions of each method.

Field Test for Moisture Content

The following field test can be used to detect the presence of excessive

amounts of moisture in the insulating liquid:

1. Obtain a sample of the insulating liquid when the transformer is at operating temperature. (Preferably above 40 C.)

2. Starting with the hot sample, rinse a clean, dry test tube with the liquid to be tested, fill half full and stir continuously with a centigrade thermometer while cooling to approximately 20 C. Cool as much as possible in the ambient air and complete the cooling by momentarily dipping the test tube in an ice bath, removing and stirring and then redipping, etc.

3. Observe the sample carefully and note the temperature at which initial cloudiness appears. Wipe the outside of the tube with a clean rag or paper towel to facilitate observation of the slight moisture cloud that may form. Compare to clean insulating liquid at ambient temperature in a similar tube if necessary. Examination for the presence of a cloud should preferably be made against a dark background and not directly into the sunlight.

4. If cloudiness appears at 20 C or above, high to excessive moisture content is indicated.

A. Inspect the unit for free water —on the bottom for oil, on the top for Pyranol.

B. If free water is not present, a sample should be forwarded to the Laboratory for a quantitative analysis and recommendations on treatment of the unit. See "Testing Service."

5. If cloudiness does not appear until the temperature is below 20 C, an acceptable moisture content range is indicated.

6. This field test for moisture should be regarded as a rough test only and if there is any reason to question the condition of the insulating liquid, a sample should be sent to the Laboratory for an accurate analysis.

FILTERING AND DRYING INSULATING LIQUIDS

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the liquid through a filter system. Any free water in the transformer should be removed before the filter operation is started. For details of the procedure to be followed refer to instructions GEH-754 for oil, or GEH-1031 for Pyranol. Copies of these publications can be obtained from the nearest Apparatus Sales Office of the General Electric Company.

A transformer contaminated with moisture will not only have moisture suspended in the insulating liquid, but also in the windings and insulation. The most efficient temperature for filtering moisture from the transformer is between 20 C and 40 C, but at this temperature the transfer of moisture from the windings and insulation to the insulating liquid is quite slow. In order to completely dry the transformer, the filtering operation should be followed by a short-circuit heat run.

DRYING A TRANSFORMER

Recommendations regarding the drying of any particular transformer can be obtained from the nearest Apparatus Sales Office of the General Electric Company. Requests for this information should include the serial number of the transformer and the voltages and kva available for drying, including any available step-up or step-down transformers, etc. A more detailed explanation of drying procedures can be found in instructions GEI-65070 for oil-filled transformers and GEI-65080 for Pyranol-filled units, copies of which can also be obtained through the Sales Office.

The first step in drying a transformer consists of removing any free water and the water in solution as previously explained under "Filtering and Drying Insulating Liquids." The moisture remaining in the windings and insulation can then be driven off by heating the transformer. *Exercise caution when heating the transformer to avoid damaging the insulation.* The maximum winding temperature as determined by resistance measurements should not be allowed to exceed 95 C. CAUTION—Any drying method which involves heating an oil-filled transformer when it is exposed to the atmosphere also creates a serious fire hazard. No smoking or open flames should be permitted near the transformer and suitable fire extinguishers, preferably the carbon dioxide type, should be on hand before beginning the dryout.

Heating the transformer can be accomplished by shorting one winding and applying a suitable voltage on the other. Full-load current can be obtained by applying the impedance volts of the transformer. *Be sure to load the entire winding.* If the transformer is at room temperature at the start of drying, 125 per cent load may be applied until the top liquid temperature reaches 65 C. At this point, the current should be reduced in accordance with the following table:

Max. Allowable Short-Circuit Amps in Percent of Full Load	Maximum Top-Oil Temperature in Degrees C
100	75
85	80
50	85

Since the windings are at a higher temperature than the insulating liquid, the insulation may be damaged if these values are exceeded. Filtration during the heat run will not greatly hasten the drying process, because at these temperatures the filter press loses its ability to remove any appreciable amount of moisture.

The air space in the transformer must be thoroughly ventilated to remove the water vapor given off. This can be done by removing manhole covers, the pressure-relief device, or the entire cover. If drying is done indoors, provide good ventilation to exhaust vapors from the room. If the cover is left in place, it should be thoroughly insulated to prevent condensation. The required temperatures can be more readily obtained by blanketing the transformer with heavy paper, cloth, building felt, etc.

Take liquid samples every four hours and make tests of the dielectric strength. Oil-filled transformers should be sampled from both the top and bottom. Pyranol-filled units require sampling at the top only. To determine the drying progress, plot curves of load current, top liquid temperature, and dielectric strength versus time. A decrease in dielectric strength indicates that moisture is passing from the windings and insulation into the insulating liquid. As the moisture is driven out of the liquid, the dielectric strength will increase, indicating that the drying process is progressing satisfactorily.

Continue the drying until four consecutive samples test at least 26 kv and preferably 30 kv or higher and until a satisfactory "cloud" test is obtained as outlined under "Moisture Content." When the drying operation has been completed, the liquid removed for sampling must be replaced. To avoid the possibility of entrapping air bubbles in the windings, it is recommended that the liquid be returned through the upper filter press connection.

MAINTENANCE

The condition of the external transformer surfaces should be examined at regular intervals. If it is found that weathering is taking place, the surface should be cleaned thoroughly and repainted with a good grade of durable paint recommended by the General Electric Company.

If it should become necessary to untank the core and coils, remove the weld bead around the cover as outlined under "Removing and Rewelding Covers" and then remove the tap changer drive mechanism as explained under "Wedge-Type Tap Changer." Lift off the cover and drain the insulating liquid. Disconnect the winding leads at the bushings

and remove the bushings using the "Removing and Replacing" procedure outlined under "Bushings." Remove the liquid level gage, top filter-press connection, thermometer well (on those where it protrudes into the tank), and any other parts which might get damaged or interfere with removal of the core and coils.

Take out the tanking wedges and remove the core and coil assembly. After reassembling the transformer, it may be necessary to conduct a drying run as explained in the preceding paragraphs. Questions concerning the necessity of drying a particular transformer should be referred to the nearest Apparatus Sales Office of the General Electric Company.

REMOVING AND REWELDING COVERS

Welded covers can be removed by chipping out the weld bead with diamond-point chisels and a pneumatic hammer or by the oxygen gouging method. The latter method is considerably faster and is recommended for all welds of 5/16" and over where adequate precautions can be taken for the fire hazard which exists with oxy-acetylene cutting operations.

When removing the weld bead, the cover should be clamped to the tank flange to hold it in place and prevent chips or welding slag from entering the transformer. Protect all openings against the entrance of foreign matter. Before oxygen gouging on oil- or Pyranol-filled transformers, thoroughly flush out the air space inside the tank with *dry* nitrogen or carbon dioxide gas and maintain a small flow of the gas during the gouging operation.

The entire weld may be removed in one pass, providing care is taken to avoid deep gouging of the edge of the cover or tank flange. The joint should be ground or chipped clean for rewelding before the cover is removed. Oxy-acetylene cutting torch equipment is necessary with gouging tips similar to Air Reduction Style No. 183. For best performance of the gouging operation, a cutting torch similar to Airco Series 3000 having a graduated control of the high-pressure oxygen flow is recommended. Tip sizes and gas pressures recommended for various fillet weld sizes are as follows:

Fillet Weld Size	Tip Size	Oxygen Pressure	Acetylene Pressure
5/16-in.	No. 8	60 psi	8 psi
3/8 and 7/16-in.	No. 10	70 psi	9 psi
1/2-in. and up	No. 12	75 psi	9 psi

REWELDING THE COVER

Before replacing the cover, remove all traces of dirt, grease, and oil from the areas to be welded. Cement a gasket to the tank flange or cover by applying a coat of water glass (sodium silicate) to both surfaces. The gasket should consist of a piece of 3/8-inch loose-twist glass or asbestos roving or a strip of 1/16 x 1½-inch dry asbestos folded to make it ¾-inch wide and should be located approximately ½-inch from the outer edge of the cover. To prevent spatter from entering the transformer during rewelding, compress this gasket by clamping the cover against its mounting flange and seal off all other external openings in the tank. Thoroughly flush out the air space with dry nitrogen and maintain a small flow of gas during the welding operation.

The arc-welding process, using 3/16" or ¼" diameter electrodes, is recommended for rewelding the cover. The fillet should be built up with a series of passes to a thickness comparable to that of the original weld. In order to make a pressure tight joint, slag and spatter should be completely removed before each succeeding pass and at each point where the arc is interrupted.

When the welding has been completed, remove all scale and pressure test the joint as explained under "Leak Test." After a satisfactory test, clean the weld and adjacent surfaces and apply one priming coat and two finish coats of paint.

RENEWAL PARTS

Orders for renewal or supply parts should be placed with the nearest Apparatus Sales Office of the General Electric Company. Specify the quantity required and give the catalog or drawing number along with the part numbers, whenever possible. If these numbers are not available, describe the parts in detail. When ordering a bushing, specify whether it is to be supplied separately or as an assembly with the adapter ring welded into place. Always include the serial number appearing on the transformer nameplate when requesting information or ordering parts for a particular transformer.

The only recommended spare part is the gasket for the handhole opening (or pressure relief device flange when provided.)

Materials that are unaffected by Pyranol have been used in constructing Pyranol transformers and no substitution should be made for these materials without the approval of the General Electric Company. Any renewal parts supplied will be manufactured from the same or similar materials as those used for new transformers. Successful operation of the renewal parts is contingent upon proper field assembly, the condition of the remaining parts and a thorough drying cycle if moisture has entered the transformer.

WHEN YOU NEED SERVICE

If you need to repair, recondition, or rebuild any electric apparatus, a G-E Service Shop near you is available day or night, seven days a week, for work in the shop or on your premises. Latest factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E equipment. For full information about these services, contact the nearest Apparatus Sales Office or General Electric Service Shop.

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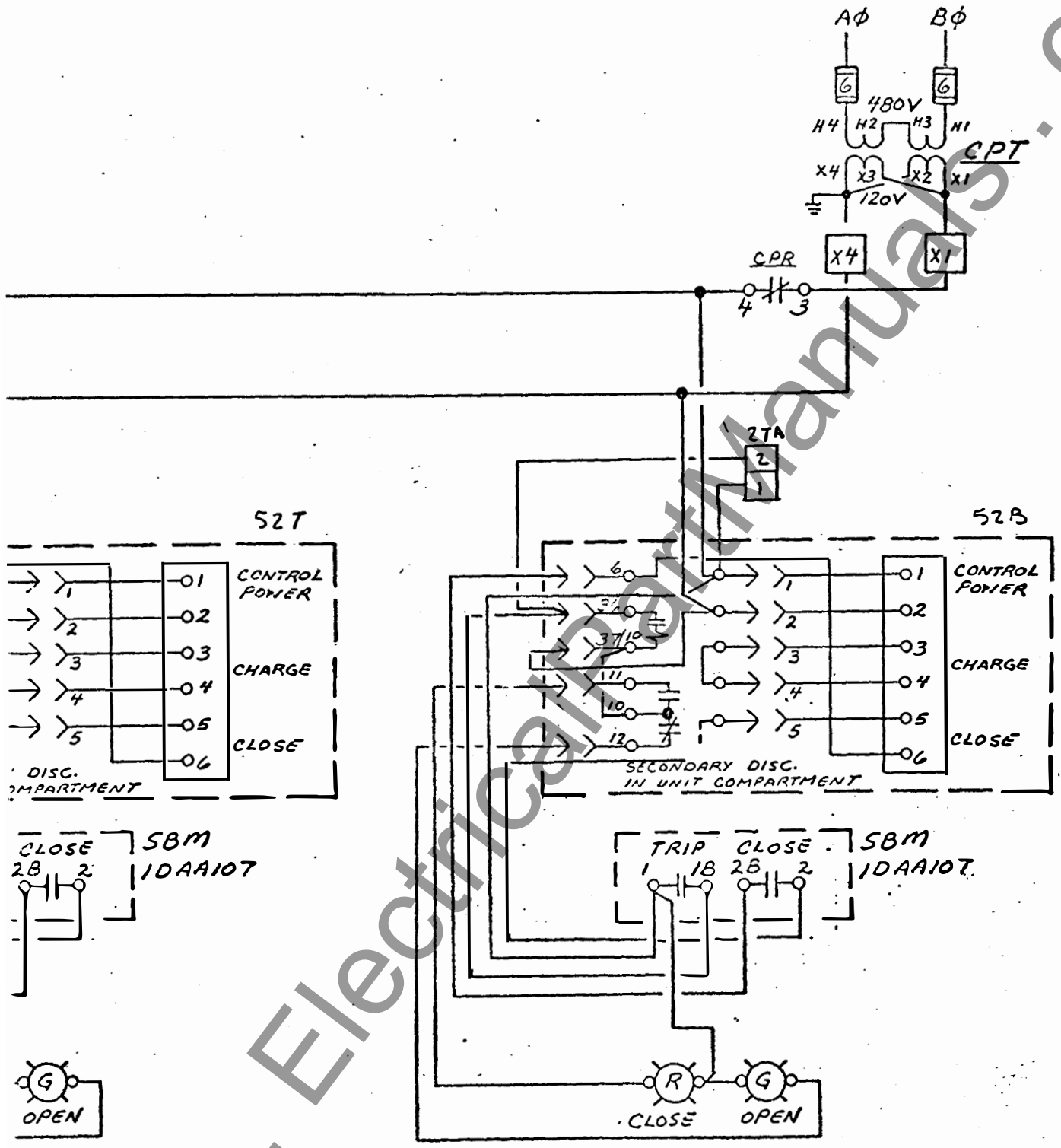

ANSFER RELAY

ROL WIRING

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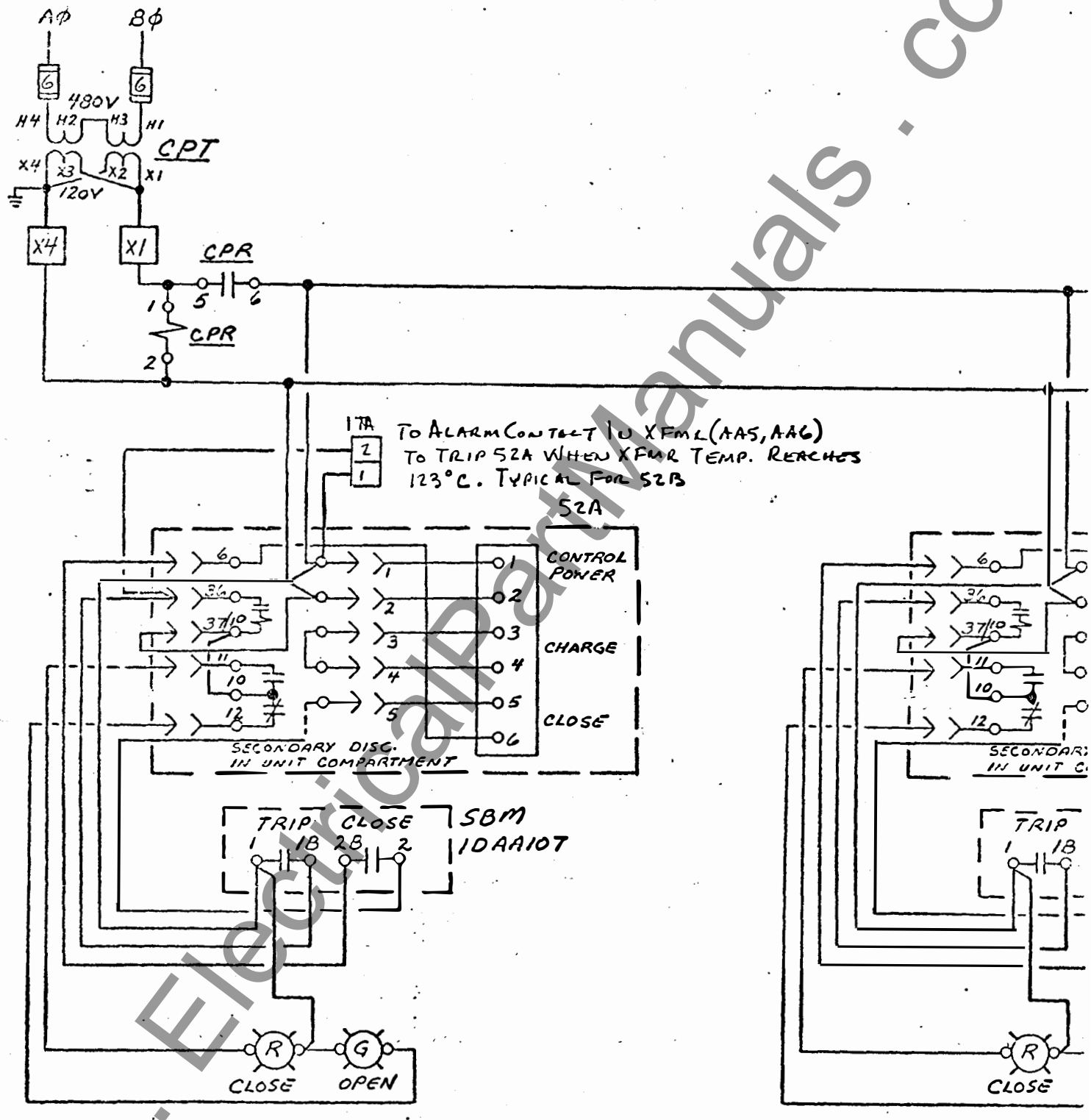

CPR- Control Power Tr

Circuit Breaker Cont.