Load/Vac® Tap Changer

TYPE LRT-200-2

CAUTION

THE EQUIPMENT COVERED BY THESE INSTRUCTIONS SHOULD BE INSTALLED, OPERATED, AND SERVICED ONLY BY COMPETENT TECHNICIANS FAMILIAR WITH GOOD SAFETY PRACTICES. THESE INSTRUCTIONS ARE WRITTEN FOR SUCH PERSONNEL AND ARE NOT INTENDED AS A SUBSTITUTE FOR ADEQUATE TRAINING AND EXPERIENCE IN SAFE PROCEDURES FOR THIS TYPE OF EQUIPMENT.

CONTENTS

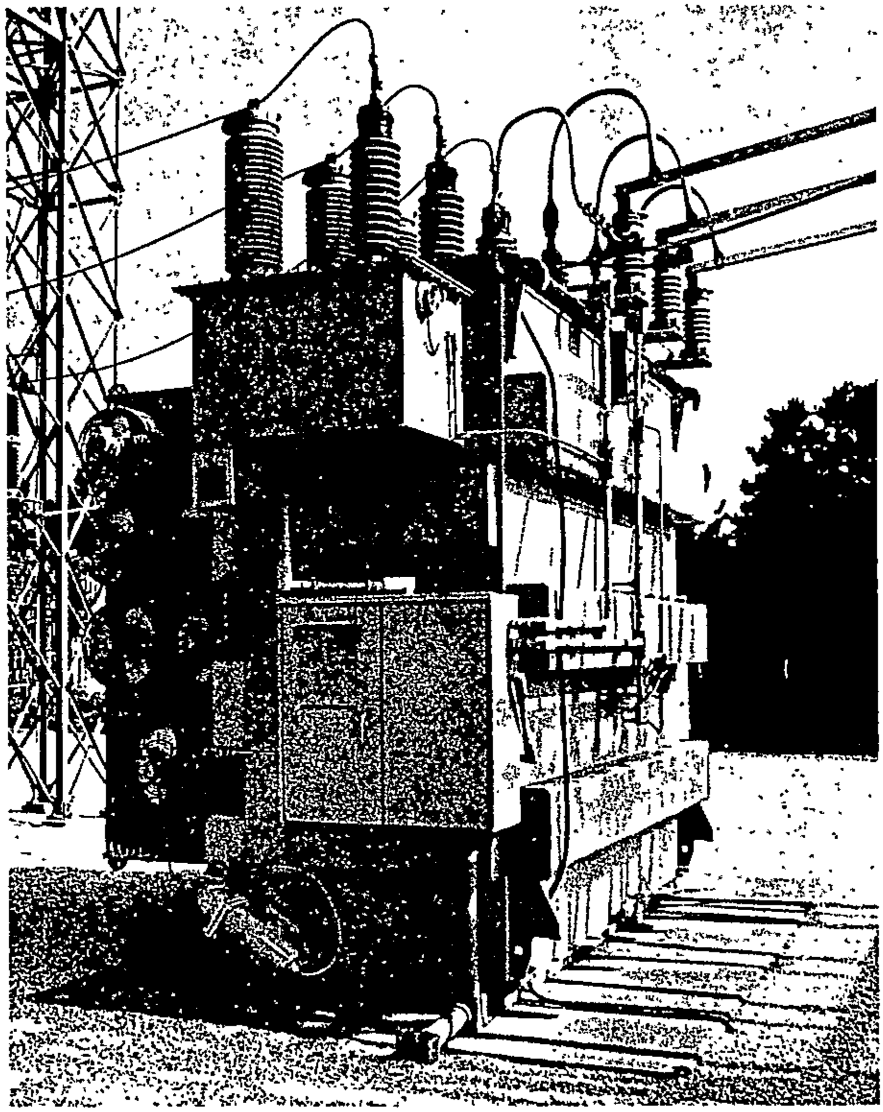


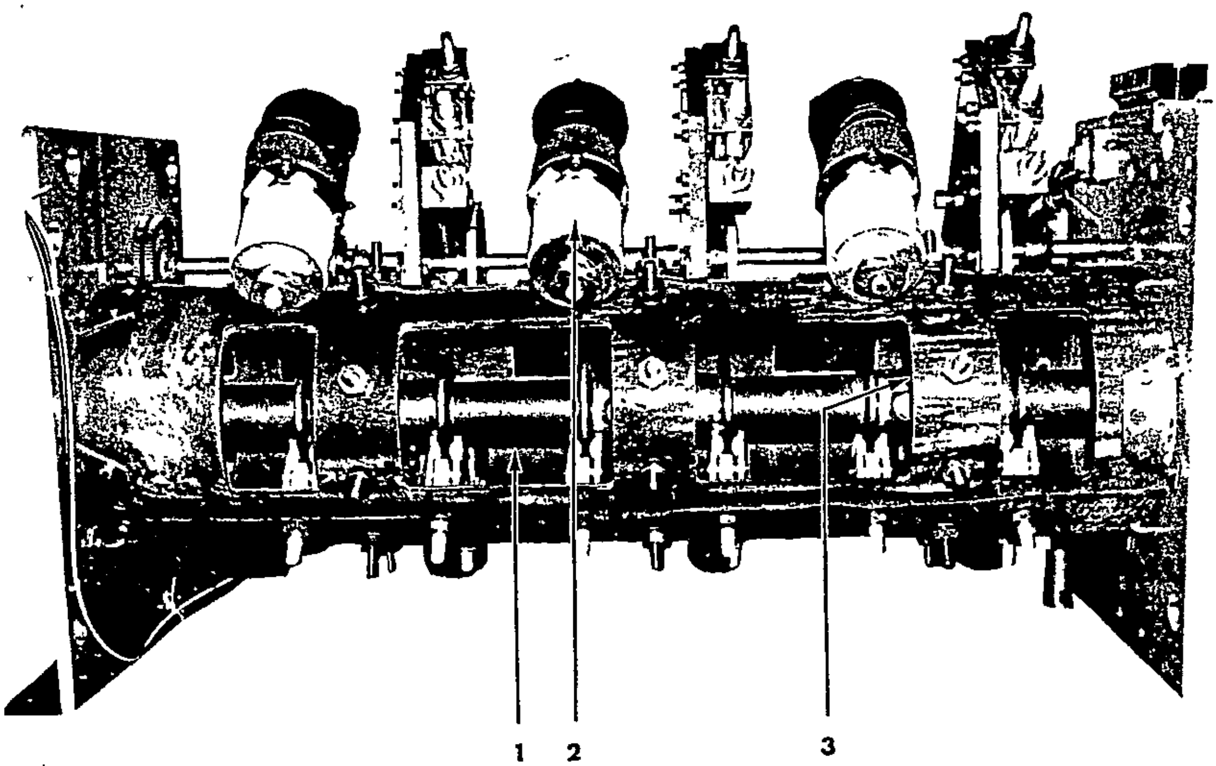
Fig. 1. Load-tap-changing equipment, type LRT-200

INTRODUCTION

The Type LRT-200 load-tap-changing mechanism utilizes vacuum interrupters to break the current when changing tap positions. Since all arcing takes place within a vacuum chamber, oil contamination is eliminated and the arcing contact life is prolonged.

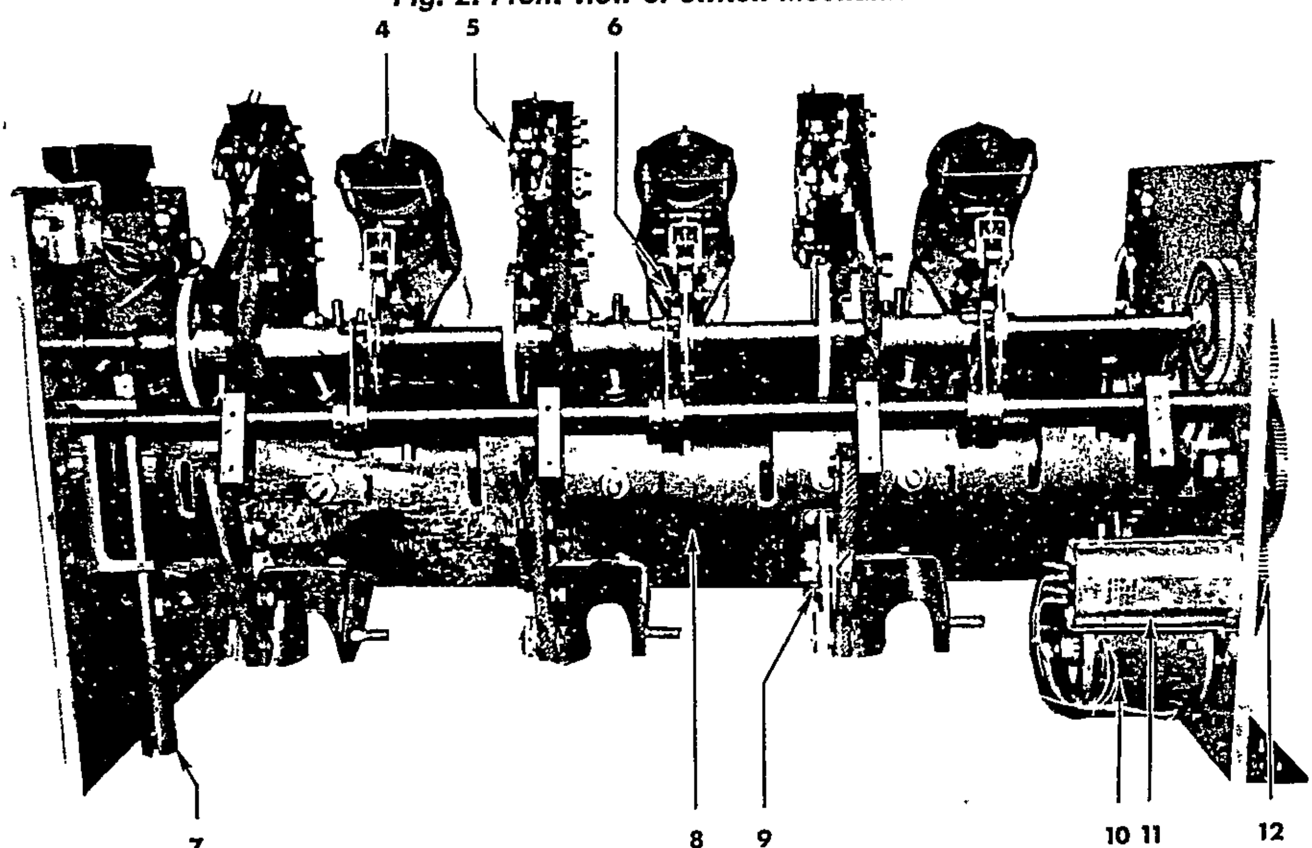
Control of the motor drive equipment may be either manual or automatic/manual, depending on the requirements of the installation, and can be located at the transformer and/or on a remote panel. When equipped with automatic controls a relatively constant voltage can be maintained automatically at some predetermined load center as the transformer input voltage fluctuates and as load conditions vary.

In the following text, numbers in parentheses refer to items in the various figures and symbols in italics refer to



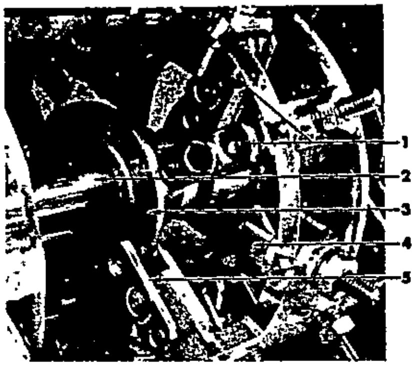
1. CONCENTRIC DRIVE SHAFTS
2. VACUUM INTERRUPTER
3. TAP-SELECTOR SWITCH

Fig. 2. Front view of switch mechanism



4. WEAR INDICATOR
5. BY-PASS SWITCH
6. CONTROL CAM
7. CONTROL SHAFT
8. INSULATING CYLINDER
9. REVERSING SWITCH
10. MOTOR
11. MOTOR CAPACITOR
12. REDUCTION GEARS

Fig. 3. Rear view of swtich mechanism



1. MOVABLE CONTACTS
2. CONCENTRIC DRIVE SHAFTS
3. MOVABLE CONTACT SLIP RING
4. STATIONARY CONTACT
5. COLLECTOR FINGER

Fig. 4. Tap selector switch

components shown in Fig. 14 and on the LTC Control Diagram. For complete details of any particular installation the user is referred to the Control Diagram furnished with the transformer. This should be used in conjunction with the motor drive diagram shown in Fig. 14.

DESCRIPTION

The LTC equipment is assembled in three separate compartments mounted on the end of the transformer tank as shown in Fig. 1. The upper compartment is oil filled and contains the tap selectors, reversing switches, by-pass switches, vacuum interrupters, motor, gears, a portion of the protective circuit, etc. This compartment is sealed to protect the mechanism and its insulating oil from exposure to the atmosphere.

Directly below the oil compartment and attached to it is a small air-filled auxiliary control compartment with a viewing window for observation of the position indicator and containing the limit and cam-operated control switches. The hand-crank drive shaft is also located in this compartment and space has been provided for selsyns and/or other types of remote position indicating devices, as required.

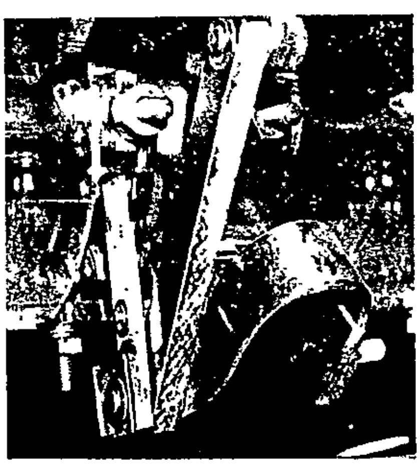


Fig. 6. Reversing switch

The lower air-filled compartment is mounted at a convenient height above ground level and contains the balance of the automatic LTC control equipment. Provisions are included for various optional control features such as paralleling CT's, lockout relays, voltage reduction controls, etc., plus certain transformer auxiliaries such as a fault pressure relay seal-in circuit, cooling equipment controls, current transformer terminal boards, etc.

TAP SELECTOR

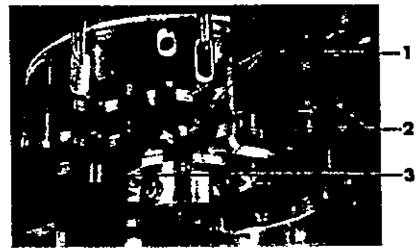
The tap selector (Figs. 2 and 3) consists of three dial-type switches mounted inside a common insulating cylinder (8). Each switch (Fig. 4) has two movable contacts (1) and nine stationary contacts (4). The stationary contacts are arranged in a circle inside the cylinder and are connected to taps in the transformer windings. Each contact has two shelves, one for each of the two movable contacts.

The movable contacts are mounted on two concentric drive shafts (2) and are insulated from one another. Connections are made to these contacts through collector fingers (5) sliding on slip rings (3). One pair of movable contacts in each phase is attached to the outer shaft and the other pair is attached to the inner shaft through slots in the outer shaft. These slots are designed to allow sufficient travel for the inner and outer shafts to rotate the movable contacts independently of one another, making contact with either the same or adjacent stationary contacts as required.

A Geneva gear is mounted at the end of each drive shaft and these two gears (1, Fig. 5) are actuated by pins (2, Fig. 5), on a double Geneva gear driver. The arrangement is such that the two shafts and their contacts are locked in position except during tap changes at which time they are rotated in an alternating sequence by the double driver. With the two arms on the same stationary contact, a one-half revolution of the Geneva gear driver causes one arm to move to the next adjacent contact, and on completion of the revolution the second arm is moved to this same contact.

Reversing Switch

Each of the three dial-type tap-selector switches is provided with a separate



1. GENEVA GEARS
2. GENEVA GEAR DRIVER PINS
3. POSITIVE STOP LUG

Fig. 5. Geneva gear assembly

single-pole, double-throw switch. This switch is used to reverse the polarity of the tapped portion of the transformer winding and thus doubles the number of available tap positions. Mounted near the bottom of the tap-selector cylinder (Fig. 6), its stationary contacts are located inside the cylinder and the remainder of the assembly is bolted on the outside.

The switch is actuated by a boss on one of the Geneva gears acting through a Geneva sector, lever arms, and connecting rods. It remains locked in one position during all operations of the tap selector until the ninth tap is reached. At this point it flips over and is then locked in the opposite position while the tap selector continues on its second revolution.

1. STATIONARY CONTACTS
2. COMMON CONTACT
3. MOVING CONTACT BLADE

Fig. 7. By-pass switch

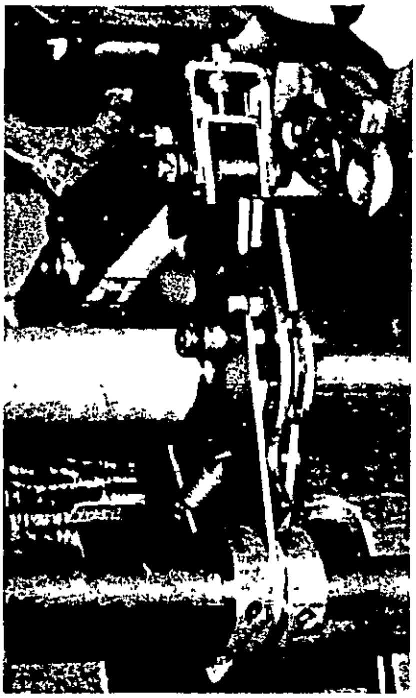


Fig. 8. Dual-slope control cam

Positive Stop

In addition to electrical limit switches, the mechanism is provided with a mechanical stop. The stop consists of a lug (3, Fig. 5) on each of the two Geneva gears which comes in contact with the reversing switch actuator when the mechanism reaches its maximum position in either direction. Engagement is made just slightly beyond the point at which the electrical limit switches should stop the mechanism, thus mechanically blocking any further movement beyond the final end positions.

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BY-PASS SWITCH

A by-pass switch is used in each phase to shunt current flow around the vacuum interrupter except when taps are being changed.

The switch (Fig. 7) consists of a common contact (2) and two stationary contacts (1) which are normally bridged by a cam controlled moving contact blade (3). The control cam is on the same shaft as the vacuum interrupter cam. At the beginning of a tap change the connection at one of the stationary contacts is broken causing the current in that half of the circuit to be diverted through the vacuum interrupter. It remains broken while the interrupter and tap selector function to change taps. Near the end of the cycle the connection is remade to complete the change.

Movements of the tap selectors, by-pass switches, reversing switches, and vacuum interrupters are coordinated in a fixed sequence, causing all contact arcing to take place within the interrupters. For a detailed description of this series of operations, refer to the section entitled "Tap Changing Sequence."

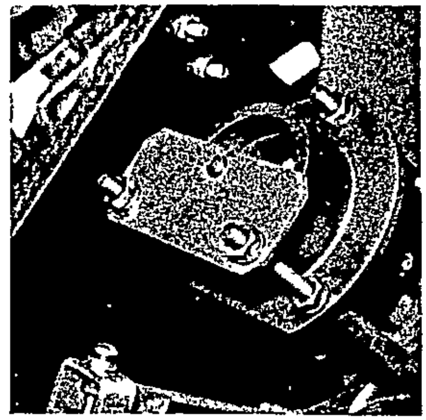
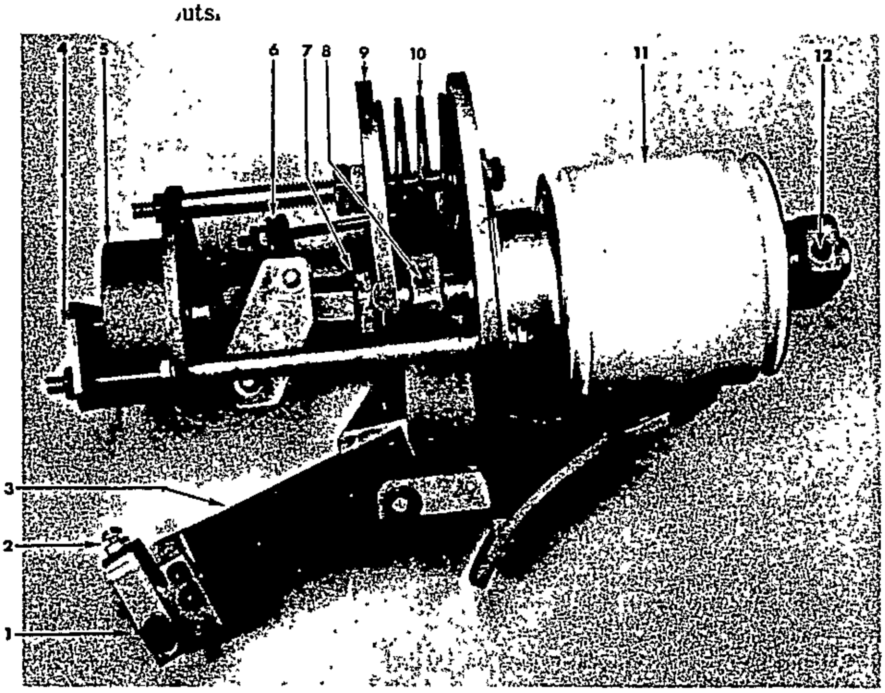


Fig. 10. Wear Indicator



1. CAM ROLLER
2. ADJUSTMENT SCREW
3. ACTUATOR ARM (LOWER END)
4. WEAR INDICATOR
5. DASHPOT
6. LATCH
7. DRIVE NUT
8. MOVABLE CONTACT TERMINAL
9. ACTUATOR ARM (UPPER END)
10. ACTUATOR SPRING
11. VACUUM INTERRUPTER
12. STATIONARY CONTACT TERMINAL

Fig. 9. Vacuum interrupter assembly

VACUUM INTERRUPTER ASSEMBLY

A special dual-slope cam assembly (Fig. 8) controls the movement of the vacuum interrupter mechanism, providing a steep slope for opening and a moderate slope for closing. The two different cam slopes are obtained in both directions of rotation by means of an auxiliary cam, roller, and spring assembly which controls the position of the steep slope portion of the cam.

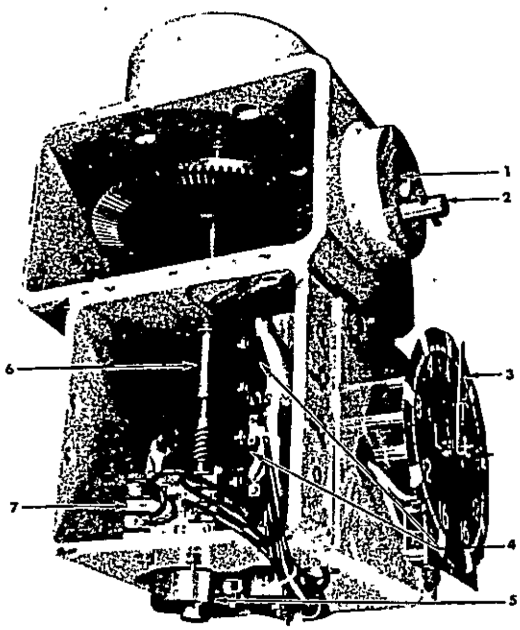
At the appropriate time during each tap change, the control cam allows the two-piece actuator arm (3 and 9, Fig. 9) to drop abruptly. Spring (10) accelerates this movement of the arm through a short distance of free travel, increasing its momentum prior to striking drive nut (7). This impact followed by a continuing movement in the same direction produces a very rapid opening of the interrupter contacts.

As the moving contact of the interrupter reaches its maximum open position, latch (6) engages an extension of the operating rod (10, Fig. 11) to hold the contacts open temporarily. Inside the vacuum interrupter a metallic vapor arc is produced by the separation of its two contacts. This arc is extinguished during the first current zero owing to the high-speed opening of the contacts and the vapors then disperse and condense on shield (7), thus retaining the high dielectric strength of the vacuum.

When the tap selector has completed its sequence, the moderate slope of the control cam begins to raise the actuator arm and recompress the actuator spring. As the force which opened the contacts is removed, the pressure differential caused by the vacuum within the interrupter acts on the operating rod through bellows (1) to exert a closing force against the latch. Just before the control arm reaches the top of the cam it trips the latch, releasing the operating rod and initiating a high-speed reclosing of the interrupter contacts, the rate of which is controlled by a dashpot (5, Fig. 9).

Wear Indicator

During each tap change a minute quantity of contact metal is vaporized, resulting in eventual erosion of the contact tips. Since the contacts are not visible, an external wear indicator has been provided above the dashpot on each vacuum interrupter assembly as shown in Fig. 10. An extension of the operating rod protrudes through a hole in the indicator plate and the amount of this protrusion is gradually reduced over the life of the interrupter. Thus when the top of the rod becomes flush with the indicator plate (with the interrupter closed) the contacts are worn out and the interrupter must be replaced.



1. ON-POSITION OBSERVATION PORT
2. HANDCRANK COUPLING
3. POSITION INDICATOR
4. LIMIT SWITCHES
5. CAMS
6. CONTROL SHAFT
7. SEQUENCING SWITCHES

Fig. 12. Auxiliary controls with housing removed

AUXILIARY CONTROLS

The control shaft (7, Fig. 3) extends down through a self-adjusting seal at the bottom of the oil compartment and into the auxiliary control compartment. This compartment is shown in Fig. 12 with its sheet metal housing removed.

Control Switches and Dynamic Braking

The sequence of operations required to make a tap change is controlled by cams (5) mounted on control shaft (6). Rotation of the shaft causes the cams to operate contacts of the three sequencing switches *33S* (7). These contacts in turn control the operation of a number of relays and timers to insure completion of the tap changing cycle.

The switching sequence also serves to stop the mechanism exactly on position at the end of each tap change through the use of a dynamic braking circuit. This method of stopping involves the application of a momentary d-c current across the motor windings at the proper time as explained more fully under "Operation, Motor Drive."

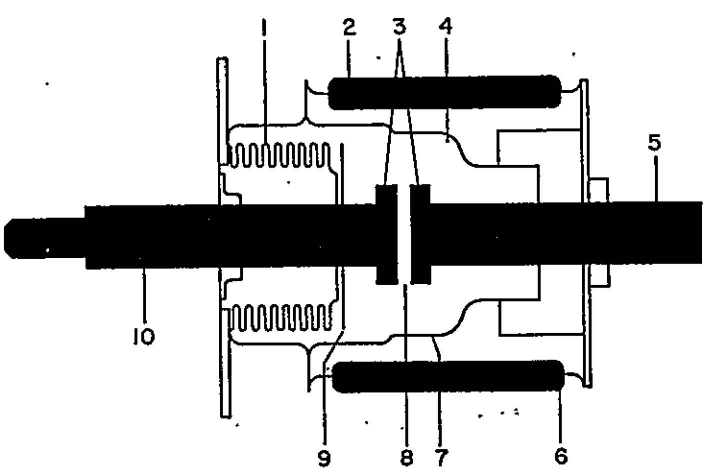
Position Indication

The position indicator (3) is driven by a worm gear on the control shaft. The gear ratio is such as to cause the indicating pointer to move through 320 degrees for the full range of tap changes. Numbers on the dial correspond to tap positions shown on the transformer nameplate and drag fingers show the extremes in operating positions since last reset. The fingers are held in position by a spring and ratchet assembly and can be reset by means of a solenoid which is energized through a switch on the control panel in the lower control compartment or by manually lifting the solenoid plunger directly behind the base of the indicator dial.

An observation port (1) just above the position indicator provides a visual means of determining whether or not the tap selector and interrupter assembly has stopped on position. A paint mark on the large gear visible through the hole should be aligned with the nearby pointer at the conclusion of each tap change if the mechanism is functioning properly.

Limit Switches

Snap-action limit switches (4) are mounted behind the position indicator dial and their contacts are wired into the



1. FLEXIBLE METALLIC BELLOWS ASSEMBLY
2. INSULATING VACUUM ENVELOPE
3. ARCING CONTACTS
4. VACUUM CHAMBER
5. STATIONARY ELECTRICAL TERMINAL
6. METAL-TO-INSULATION VACUUM SEAL
7. METAL VAPOR CONDENSING SHIELD
8. ELECTRIC ARCING REGION
9. BELLOWS SHIELD
10. OPERATING ROD (MOVABLE TERMINAL)

Fig. 11. Cutaway view of POWER/VAC® vacuum interrupter

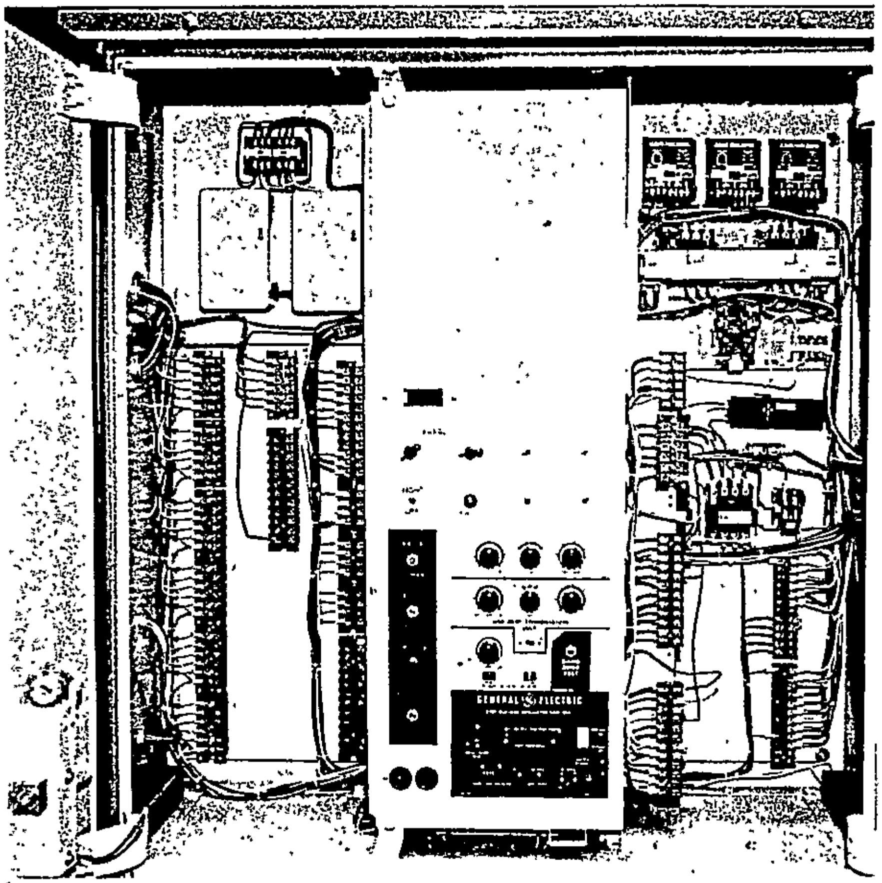


Fig. 13. Control compartment

motor relay circuit. A trip lever on the position indicator shaft opens switch (*LS/L*) at the maximum lower position, or switch (*LS/R*) at the maximum raise position, to prevent electrical operation of the mechanism beyond either of the end positions.

CONTROL COMPARTMENT

Items mounted in this compartment, Fig. 13, include an operating panel with control power circuit breaker *8M*, position indicator drag finger reset switch *S7*, operation counter *K3*, raise/lower switch *CST*, auto/manual switch *43T*, remote/local switch *43TRL*. (when required); the vacuum interrupter protective system; and the automatic static control equipment (as described in separate instructions). When required, certain other auxiliary transformer devices may also be located in this compartment.

Operation Counter

An operation counter *K3* is mounted near the bottom of the automatic control panel and is electrically operated through contacts *2-3* of sequencing switch *33S*. Periodic recordings of the counter readings are recommended as a means of determining when to make an inspection of the vacuum interrupter wear indicators. See "Maintenance."

Protective System

A protective system has been provided to guard against the possibility of developing an arc across the tap selector in the event that an interrupter should fail to open properly during a tap change. The system utilizes a current transformer in series with each vacuum interrupter (see Fig. 15) and the outputs of these three transformers *CT1P*, *CT2P* and *CT3P* are paralleled as shown in Fig. 14. Switch *S3P* on the mechanism shorts these secondaries while the vacuum interrupters are closed. This switch is vane operated in a sequence which causes it to open just after the vacuum interrupters have opened and to close just before they reclose. Therefore, an output will be obtained from the current transformer circuit only if an interrupter fails to function properly; i.e., only if it continues to carry current at a time when no current should be flowing.

The current transformer output is applied to the gate circuit of silicon controlled rectifier *SCR1P* through a voltage limiting network consisting of rectifier *CR4P*, and transformer *T2P*. Whenever a signal appears, *SCR1P* is triggered into conduction and will then *continue* to conduct until manually reset by means of switch *S1P*. Conduction through *SCR1P* energizes red fault light *L1P*, initiates a control sequence which stops the motor and returns the mechanism to its last operating position and also opens the control circuits to prevent initiation of any further tap changes. These operations are explained more fully under "Operation, Protective System." Relay *68* is a mechanically latching relay so that the fault indications will not be lost if control power is temporarily lost.

Test switch *S2P* is provided for checking the protective system at installation and occasionally throughout the life of the transformer. Closing this switch introduces a current into the system through resistor *R4P* which is equivalent to that produced by a CT when an interrupter fails to open. The routine for testing is outlined under "Installation."

INSTALLATION

The load-tap-changing equipment is shipped in place and is to be prepared for service by observing the following installation guide. Do not operate the equipment while a vacuum is applied to either the LTC housing or the main transformer tank.

CAUTION — Note that insulating materials in the oil compartment can absorb moisture during prolonged exposure to the atmosphere. Periods exceeding 60 hours should, therefore, be avoided since a drying cycle may then be required.

INSPECTION

Before placing the transformer in service, drain the oil from the tap-selector compartment and make the following inspection:

1. Check for loose or damaged parts.

2. Check electrical connections for tightness and for clearance between bare parts of connectors and metallic parts of the mechanism. If connections appear to be loose, they should be tightened to a torque of 16 to 18 footpounds.

3. Operate the tap selector with the handcrank and check for binding. See "HANDCRANK OPERATION." Check that the auxiliary cams of the dual-slope cams, Fig. 8, hold the outer cams back in each direction so the interrupters receive an impact for opening.

4. With the mechanism on an operating position, refer to Fig. 9, measure the gap between drive nut (7) and upper ac-

tuator arm (9) on each interrupter. Note that the gap to be measured is between the nut and the top of the .125" (3.18mm) bump on the actuator arm. This gap should be .125 ± .010 inch (3.18mm ± .25mm). If it is not within limits, follow the adjustment procedure outlined under "INTERRUPTER REPLACEMENT."

5. Operate through all positions electrically by means of raise/lower switch CST checking the following:

a. See that braking relay *84X*, the upper left relay in the group of six control relays located behind the center control panel, Fig. 13, functions to provide about one second of braking current to the motor at the end of the tap change sequence. Time delay is not critical within the range of 0.5 to 2.0 seconds and is adjustable by means of a knob on the bottom of the relay.

b. Make sure the mechanism stops on position by checking to see that the paint mark on the gear above the position indicator is aligned with its pointer, and that the position marks on the upper drive gears inside the end plate on the mechanism are aligned with one another. If there is not agreement between sets of marks, the marks on the mechanism gears should take precedence in making adjustments. If the mechanism does not stop on position, the control cams (item 5, Fig. 12) should be adjusted as required to make it do so.

c. See that the auxiliary cam followers on the dual-slope control cams (Fig. 8) go into the indent on the auxiliary cams on each phase when operated in both directions.

d. See that the position indicator and operation counter function properly.

e. Make sure the limit switches do not stop the mechanism before the final position is reached and that they do not permit initiation of a tap change after it is reached. If necessary, adjust the position of the switches to obtain this performance.

TESTING PROTECTIVE SYSTEM

Make a check of the vacuum interrupter protective system by holding switch *S2P* in the TEST position and attempting to change taps in the raise direction by means of control switch *CST*. If the protective system is working property, this will create the effect of an interrupter failure as soon as switch *S3P* opens. The mechanism should run in the raise direction only far enough to open the vacuum interrupters and switch *S3P*. It should stop before the tap selector opens, reverse itself and run back to the normal operation position.

At this position the red FAULT light should also come on, indicating that an interrupter failure has occurred and that the controls have been locked out. Check the integrity of this lockout by attempting to operate the mechanism again in both directions using *CST*. No further movement of any kind should take place.

After making the preceding test in the raise direction, press reset switch *S1P* and repeat the same test in the lower direction.

CHECK FOR INTERRUPTER LEAKS

The interrupters are designed to maintain their vacuum integrity throughout their operating life. However, before placing the transformer in service each interrupter should be checked for leaks.

Major leaks as a result of shipping damage, or smaller leaks over an extended period such as during storage, can cause a total loss of vacuum and can be detected as follows.

1. Operate the mechanism manually while carefully observing movement of the wear indicator and all components of the actuator assembly.

2. The wear indicator should travel a distance of approximately 0.1-inch between the open and closed positions. If it does not, and the actuator assembly is working properly, indications are that the interrupter has lost its vacuum and must be replaced.

3. Complete loss of vacuum can be confirmed by making a continuity test as follows. Turn the handcrank until the interrupters open. Connect the leads from a low-voltage continuity tester (suitable for touching without injury) across the contacts of the interrupter and operate the closing mechanism by hand, i.e., close the interrupter by manually compressing the actuator spring. If the interrupter has lost the major portion of its vacuum, its contacts will not close and, of course, it must be replaced.

If preferred, continuity can be checked with the mechanism on an operating position and the interrupters closed by the actuator assemblies. In this case it will be necessary to disconnect the leads from the moving contacts as outlined in the following paragraphs on "Hi-Pot Test."

Minor leaks can substantially reduce the ability of an interrupter to break an electrical arc without affecting its mechanical operation. Since the preceding inspection will not detect problems of this nature, a hi-pot test is also to be made on each interrupter.

HI-POT TEST

Before refilling the compartment, perform a hi-pot test on each vacuum interrupter to make sure it has not lost vacuum during shipment, storage or installation of the transformer. This same test should also be made any time thereafter that faulty operation is suspected such as when the FAULT light comes on. See "Operation."

1. Open control power circuit breaker *8M*.

2. Use the handcrank to run the mechanism until the vacuum interrupters open (until the control cams allow all of the actuator arms to drop).

3. Disconnect the cable lead from the movable contact (top end) at the point where it is bolted to the by-pass switch connector.

4. Separate the cable from the connector by at least two inches and connect the "hot" test lead to this cable.

5. Connect the "ground" test lead to the stationary contact, either at the bottom end of the interrupter or at the point where its cable lead is attached to the by-pass switch connector. Note that, if hi-pot equipment with a grounded center tap is used, both ends of the interrupter must be disconnected from the mechanism before testing.

6. Apply a 10kV a-c (or 14kV d-c) hi-pot test voltage across the interrupter contacts for a period of one minute. Any breakdown indicates loss of a suitable vacuum and requires replacement of the interrupter.

Since external leakage current may result from surface contamination of the interrupter shell, some discretion is required in judging the integrity of the vacuum by this method. Currents up to 250 micro-amperes probably do not indicate a loss of vacuum. Above that level, further checking is warranted. First observe the applied voltage at which current starts to increase and the approximate change in current for a 10% change in voltage. If current change is several times voltage change, it is probably due to breakdown of the interal gap between contacts. This can be verified by placing a 0.02 to 0.03 spacer between the actuator arm and the drive nut in order to increase the contact gap and repeating the hi-pot. If there is internal breakdown, this should increase the potential at which current starts to flow. No change in current-voltage characteristics will indicate that the current is due to surface contamination. If surface contamination is indicated, it should be reduced by wiping the insulating shell with a clean, dry, lint-free cloth. If internal current is indicated and a 0.03 increase in gap does not decrease the leakage current to below 50 microamperes, the interrupter should be replaced.

7. Disconnect test leads and reconnect the cables. To avoid strain on the interrupter bellows, dress the cable from the movable contact in such a way that the hole in its crimp connector remains aligned with the hole in the connector of its own accord before replacing the bolt.

8. Use the handcrank to continue running the mechanism to the next tap position and check to see that all interrupters reclose properly.

OIL FILLING

Check dielectric strength of the oil and fill the compartment to the 25C level as indicated on the liquid level gage. The manhole should be left open during filling to serve as a vent. The compartment is designed to be sealed for normal operation. After oil filling and sealing, it should be pressurized to 2 psi (13.8 kPa) with *dry* nitrogen gas through the pressure test valve. Thereafter, the pressure-vacuum bleeder will serve to maintain the operating pressure within safe limits.

If there is any reason to suspect that moisture has entered the compartment, it should be removed before filling. Remove any free water first by wiping with dry rags. Any remaining surface moisture can then be removed by drawing a vacuum of 2 millimeters (266.6 kPa) absolute pressure and holding for a minimum of 4 hours. If it is necessary to draw a vacuum, remove the pressure-vacuum bleeder and pressure-vacuum gage and replace them with pipe plugs.

CONNECTIONS

Refer to the transformer Connection Diagram for accessory wiring in the control compartment and to the LTC Control Diagram for wiring and elementary diagrams of the load-tap-changer control circuits. A removable drillplate is provided in the bottom of the compartment for making conduit connections.

When provided with automatic controls, note that the 120 volt potential supply must be taken from the circuit to be regulated. For proper, line-drop compensation, the potential supply and the current supply must be in phase on the basis of unity power-factor load current. When a reclosing relay is provided for the main circuit breaker feeding the transformer, refer to the notations on the Control Diagram for special connections to prevent initiation of a tap change under fault conditions.

OPERATION

HANDCRANK

WARNING - **The protective system is inoperative when the taps are being changed by hand! Therefore do not attempt to change taps with the handcrank while the transformer is energized as serious damage to the transformer and/or personal injury may result!**

The load-tap-changing mechanism can be operated manually for inspection and maintenance purposes by means of a handcrank. A handcrank coupling is provided above the position indicator (2, Fig. 12) and the crank itself is stored inside the air compartment on the left-hand door. To operate the mechanism by hand, de-energize the control circuits by opening control power circuit breaker *8M* and use the handcrank to turn the coupling. Approximately 3 turns are required to make a change of one tap. There will be a noticeable increase in the torque required to turn the crank at one point during each tap change owing to the force required to recompress the actuator springs.

The position indicator will show the tap position and also the direction in which taps are being changed. Watch the indicator and the on-position paint marks on the beveled-gear drive assembly to make sure the mechanism is stopped at an operating position. The mechanical stop becomes effective on the end positions to prevent further hand operation beyond limiting positions if such operation is attempted.

Note that removing the handcrank from its mounting bracket opens interlock switch *84I* to de-energize the motor drive circuit. After changing taps manually, the handcrank must be replaced on its bracket before the motor can be operated again. After replacing the crank, reclose breaker *8M* to place the mechanism back under motor control.

MOTOR DRIVE

Manual operation of the motor drive can be obtained by placing switch *43T* on MANUAL and momentarily placing *CST* in either the RAISE or LOWER position. (Hold in contact long enough for the seal-in circuit to establish itself.) Automatic control is obtained by placing *43T* on AUTO. Once a tap change has been initiated, control of the mechanism is taken over by the control cams and their related switches, *33S*. The operating sequence of these switches is illustrated in the typical motor-drive control diagram of Fig. 14.

Assuming that a change of taps has been called for in the raise direction, the motor drive equipment will function as follows (temporarily disregarding the function of protective relays *68*, *68X/R* and *68X/L*):

1. Motor raise relay *84R* is energized through normally closed contacts *7-8* of relay *84L* and limit switch *LS/R*.

2. Once relay *84R* has been energized, the following occurs:

a. Contacts *9-10* close to seal-in relay *84R* through contacts *22-23* of switch *33S* (which are closed by the middle cam as soon as the motor begins to run).

b. Contacts *3-4* close to energize motor *84*.

c. Contacts *7-8* open to lock out the corresponding lower circuit.

d. Contacts *5-6* open to prevent dynamic braking power from being applied to the motor while it is being energized through relay *84R*.

3. As the mechanism moves off position, contacts *1-2* (bottom cam) of *33S* open to de-energize auxiliary relay *84X*.

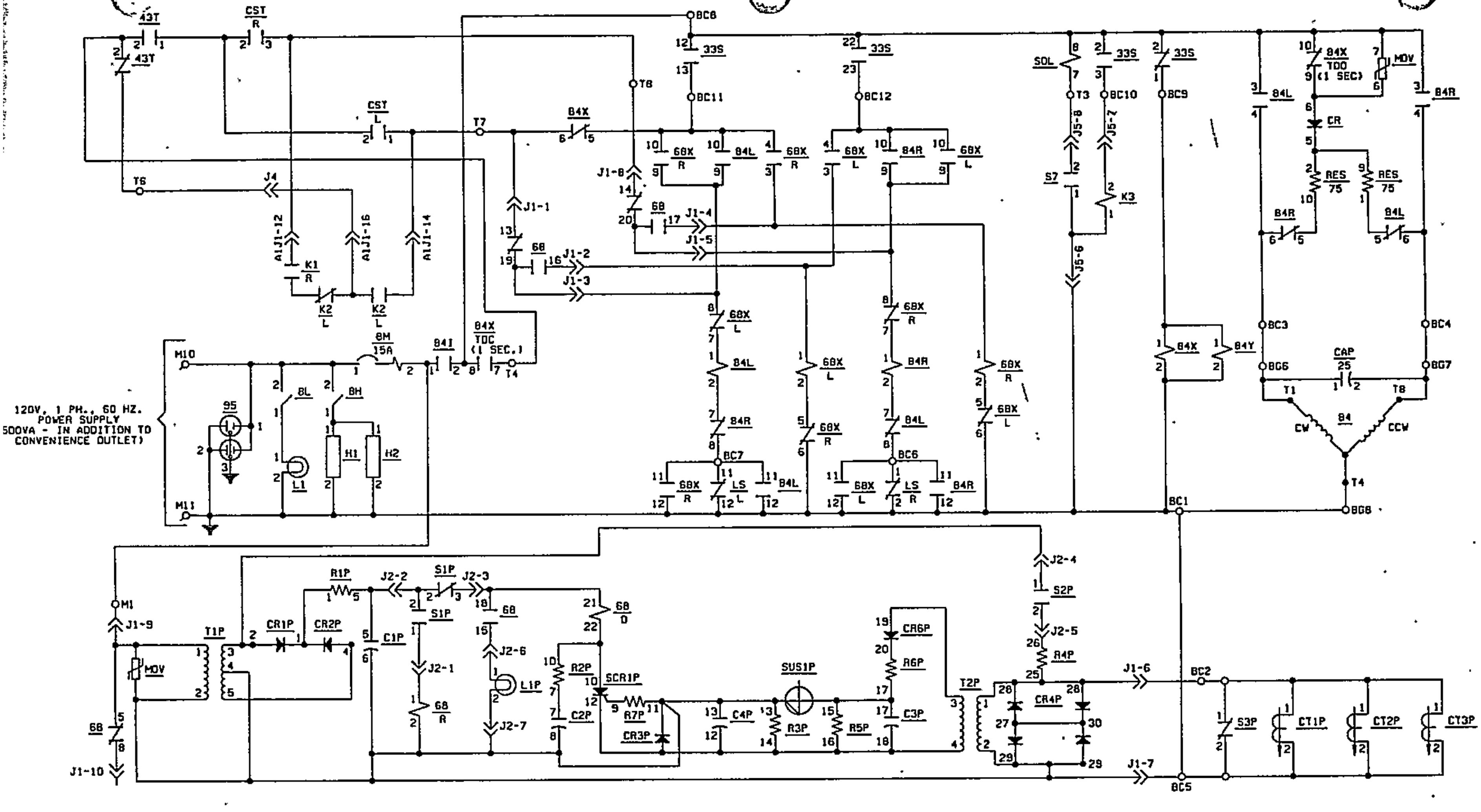
a. Its contacts *7-8* then open to disconnect the automatic controls and reclose with a time delay following completion of the tap change. This delay allows time for the automatic controls to determine whether or not the voltage requirements have been satisfied before initiating any additional changes.

b. Contacts *9-10* close to prepare for the dynamic braking operation to follow.

c. Contacts *5-6* close to by-pass the seal-in contacts for motor lower relay *84L*. (No time delay, either opening or closing.) This action serves to protect the mechanism from remaining off position (see "Off-Position Operation") in the event of temporary loss of control power.

If the power supply should fail, relay *84R* would drop out, losing its seal-in and preventing any further movement in the raise direction. However, at the same time it would also reclose its contacts *7-8*, thereby completing the lower circuit and allowing the mechanism to return to the next lower operating position upon return of power. At that point the control would revert to normal and the mechanism would then be free to move again as required.

4. Contacts *1-2* of *33S* also de-energize auxiliary relay *84Y*. Contacts *3-4* and *5-6* of this relay can be connected by the user



LEGEND

A1J1	16 POINT CONNECTOR ON CONTROL CIRCUIT COMPONENT BOARD
C1P-C4P	CAPACITORS
CAP	CAPACITOR
CCW	COUNTERCLOCKWISE
CR	DC BRAKING RECTIFIER
CR1P-CR6P	RECTIFIERS
CST	CONTROL SWITCH AT TRANSFORMER (RAISE-NORMAL-LOWER)
CT1P-CT3P	CURRENT TRANSFORMERS
CW	CLOCKWISE
H	HEATER (240V-250W; EFFECTIVE WATTS AT 120V=62)
J1	12 POINT CONNECTOR
J2, J5	9 POINT CONNECTORS
J4	SINGLE POINT CONNECTOR
K3	OPERATION COUNTER
L	LOWER
L1	COMPARTMENT LIGHT
L1P	INDICATOR LIGHT
LS	LIMIT SWITCH
MOV	METAL OXIDE VARISTOR
PI	POSITION INDICATOR
R	RAISE
R1P-R7P	RESISTORS
RES	RESISTOR
S1P	RESET SWITCH
S2P	TEST SWITCH
S3P	CURRENT TRANSFORMER SHORTING SWITCH
S7	DRAG HAND RESET SWITCH
SCR1P	SILICON CONTROLLED RECTIFIER
SOL	DRAG HAND RESET SOLENOID
SUS1P	SILICON UNILATERAL SWITCH
T1P, T2P	TRANSFORMERS
TDC	TIME DELAY CLOSING
TDO	TIME DELAY OPENING
8H	HEATER SWITCH
8L	COMPARTMENT LIGHT SWITCH
8M	MOTOR DISCONNECT DEVICE
33S	SEQUENCING SWITCH FOR 84, MECHANICALLY OPERATED
43T	TRANSFER SWITCH AT TRANSFORMER (MANUAL-AUTO)
68	LATCHING RELAY O=OPERATING R=RESET
68X	AUXILIARY RELAY FOR 68
84	OPERATING MOTOR
84I	MOTOR DRIVE INTERLOCK SWITCH
84L, 84R	MOTOR REVERSING RELAYS
84X	AUXILIARY RELAY FOR MOTOR CONTROL
84Y	AUXILIARY RELAY FOR MECHANISM POSITION INDICATION
95	CONVENIENCE OUTLET (15 AMP-120 VOLT)

Fig. 14. Typical motor drive control diagram

to provide remote on- and off-position indication as shown on the Control Diagram.

5. Contacts *2-3* of *33S* close and open during each tap change to provide a pulse for operation counter *K3*.

6. When the mechanism approaches the next operating position, *33S* contacts *1-2* reclose to energize relay *84X* and:

a. Initiate the time delay for the automatic controls.

b. Initiate the time delay for the dynamic braking circuit.

c. Defeat the off-position emergency run-back circuit.

7. At the same time, *33S* contacts *22-23* reopen to drop out relay *84R*, thus removing a-c power from the motor. Contacts *9-10* of *84X* maintain a circuit through rectifier *CR* and resistors *RES* to pass d-c (half-wave rectified a-c) through both motor windings, effecting dynamic braking. After approximately one second, contacts *9-10* open to remove the d-c power from the motor.

8. The sequence of operations for changing taps in the lower direction is essentially the same as those outlined for raising except that the change is initiated through relay *84L*.

PROTECTIVE SYSTEM

If, for any reason, a vacuum interrupter fails to open properly at the beginning of a tap change, relay *68* will be picked up and sealed in as previously outlined under "Description." Assuming a change has started in the raise direction, relay *68* then causes the following actions to take place:

1. Contacts *13-19* and *14-20* will open to disconnect the manual and automatic controls, preventing any further changes from being initiated in either direction.

2. Contacts *17-20* close to energize auxiliary relay *68X/R* through the *84R* seal-in circuit consisting of *33S* contacts *22-23* and *84R* contacts *9-10* plus contacts *5-6* of auxiliary relay *68X/L*.

3. When *68X/R* picks up, the following simultaneous actions occur:

a. Contacts *7-8* open to de-energize relay *84R* which in turn stops the motor from running any further in the raise direction.

b. Contacts *3-4* close to seal in *68X/R* through lower contacts *12-13* of sequence switch *33S* (top cam).

c. Contacts *9-10* close to apply power to lower relay *84L*, causing the motor to run in the opposite direction and returning the mechanism to its starting position.

d. Contacts *11-12* close to by-pass the lower limit switch contacts *11-12* of *LS/L*. This insures completion of the circuit to energize relay *84L* in the event that the mechanism happens to have started raising from the maximum lower position at which time the lower limit switch contacts may be open.

e. Contacts *5-6* open to provide an interlock with relay *68X/L*, preventing it from being energized at the same time as *68X/R* (through contacts *16-19* of *68* which will be closed at that time).

4. When the mechanism has returned to its starting position, contacts *12-13* of *33S* open to de-energize both *84L* and *68X/R* and the system then returns to normal except for relay *68* which remains sealed in through *SCR1P*.

5. Contacts *13-19* and *14-20* of *68* will remain open and continue to prevent any attempt to change taps by either the manual or automatic controls until such time as reset switch *S1P* is closed.

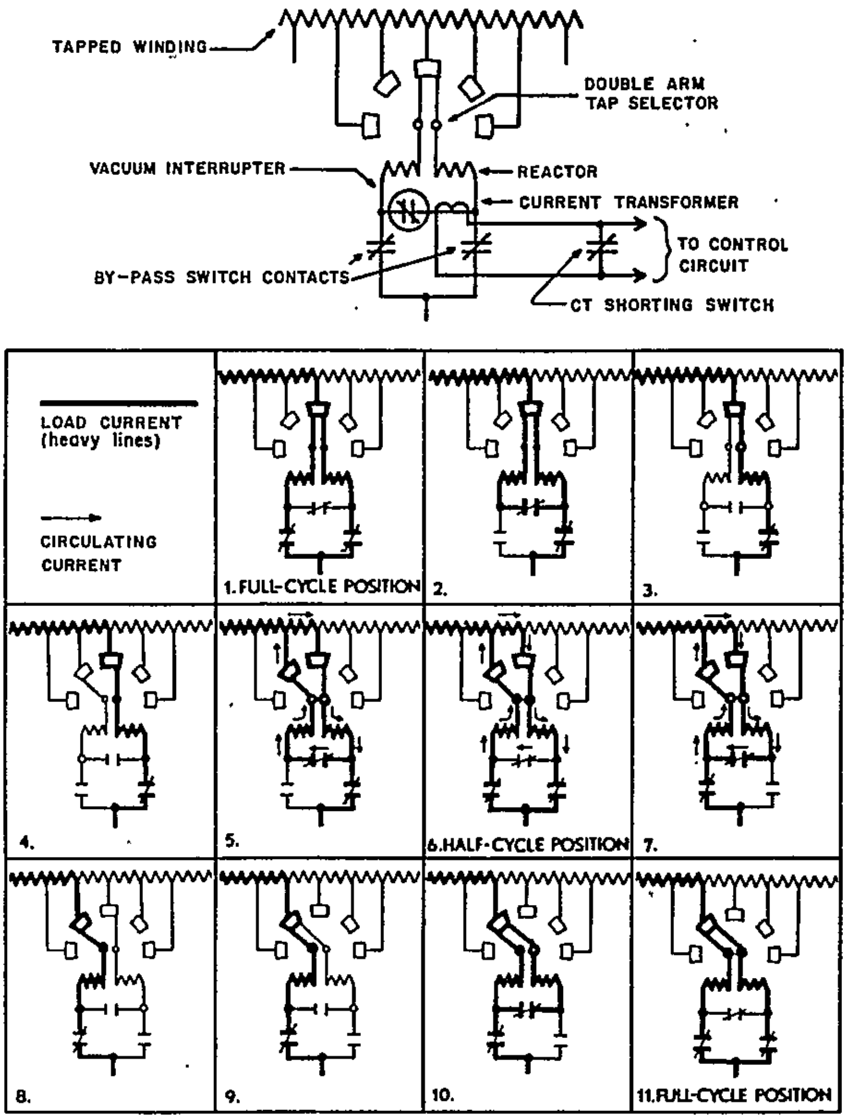


Fig. 15. Tap changing sequence

FAULT ALARM

When the FAULT light *L1P* comes on this is an indication that a loss of vacuum has occurred in an interrupter and that the protective system has operated to return the motor drive to its starting position and block any further attempts to change taps. The transformer can operate satisfactorily in this condition indefinitely but it will no longer have the ability to change taps.

WARNING — Do not attempt to change taps by means of the handcrank under these conditions as the protective system will not prevent such changes and serious damage to the transformer and/or personal injury may result!

If the fault light comes on, leave the controls locked out and take the transformer out of service for inspection as soon as convenient. Make a visual examination of the mechanism in accordance with the procedures outlined under "Installation." In particular, look for such things as loose, worn, or broken parts; binding; misalignment; etc. Also check for proper movement of the wear indicators and actuator assemblies while changing taps manually. If no problems are found during this examination, the lockout was most likely caused by a slight loss of vacuum in one of the interrupters, resulting in its failure to extinguish the arc properly. Hi-pot testing should then be performed to locate the defective component.

TAP CHANGING SEQUENCE

The sequence of operations and the methods of connecting the tap selectors, by-pass switches and vacuum interrupters are described in the following paragraphs and the corresponding steps are illustrated in Fig. 15. The information is of a typical nature only and for details of the actual connections, tap voltages, sequence of operations, etc., used in a particular application, refer to the transformer nameplate.

1. Assume a starting position with both of the tap selector's movable contacts on the same stationary contact. In this configuration load current is evenly divided between both sets of contacts and the two by-pass switches. This is referred to as the "full-cycle" position.

2. As a change of taps begins, one by-pass switch opens, diverting its half of the load through the vacuum interrupter.

3. The interrupter then opens, breaking one-half of the load current and causing the entire load to be carried through the remaining half of the circuit.

4. The open-circuited contact of the tap selector is then free to move to the next tap position without interrupting current.

5. The vacuum interrupter recloses to redivide the load.

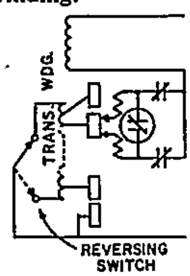
6. The change of taps is completed when the open by-pass switch is reclosed, requiring approximately 2.2 seconds for the entire sequence of operations. In this configuration, a section of the transformer winding is bridged by the tap selectors and, therefore, a reactor has been placed in the circuit to limit the flow of circulating current. By designing the winding and reactor to carry the circulating current, this bridging (or "half-cycle") position can be used as an intermediate operating position and, in effect, doubles the number of taps or steps.

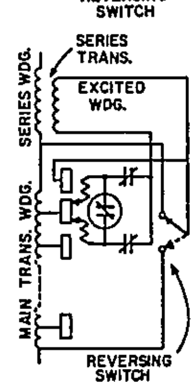
7. If the next change of taps is in the same direction, or in the event the bridging position is not used as an operating position, the opposite by-pass switch will open.

8. The interrupter opens again and a sequence of operations continues in the same manner as before until both movable contacts of the tap selector again come to rest on the same stationary contact returning the mechanism to the "full-cycle" position as shown in Step 11. When the half-cycle position is omitted as an operating position, approximately 4.4 seconds are required to move from one full-cycle position to the next.

In addition to doubling the number of steps by means of the half-cycle position, a two-position reversing switch is also included to double the number of steps again. The switch is used to reverse the polarity of the voltage taken from the tapped section, permitting the tapped section to be used twice — one time adding to and the other time subtracting from the voltage of the main winding.

The addition of a series transformer permits the use of the tap selector switch in circuits where the voltage stresses or current to be interrupted would otherwise exceed the capability of the switch. Its series winding is placed in series with the load and voltage from the tapped section is impressed upon its excited winding. A reversing switch changes the polarity of the voltage applied to the excited winding, making it possible to add to or subtract from the voltage in the main transformer winding, thus regulating the output. With the tap changer on the middle or neutral position, zero voltage is impressed on the excited winding and the output voltage is neither raised nor lowered.





OFF-POSITION OPERATION

In the event of an emergency situation such as failure of the power supply, controls, motor, etc., it is possible for the mechanism to stop with one of its by-pass switches open as in Step 2 (Fig. 15) or with a by-pass switch and an interrupter open as in Step 3. Although operation in the Step 2 condition is undesirable, it should not cause any damage to the transformer. However, in the Step 3 condition all of the load current must pass through half of the reactor circuit.

CAUTION — The transformer is designed to permit off-position operation under full load. However, if off-position operation occurs, steps should be taken as soon as possible either to return the mechanism to a normal operating condition or to reduce the load current to one-half of the maximum nameplate rating in order to avoid possible internal damage to the transformer.

Contacts on auxiliary relay *84Y* can be wired into the user's alarm system to warn of an off-position condition as explained under "Operation, Motor Drive" and as shown on the LTC Control Diagram.

MAINTENANCE

GENERAL

The following items should be inspected at yearly intervals or as dictated by the user's maintenance experience.

1. Check the condition and dielectric strength of the oil in the tap-selector compartment and replace if necessary. Maintain the minimum oil level as indicated by the liquid level gage.

2. Examine the self-adjusting oil seal at the point where the control shaft (6, Fig. 12) enters the bottom of the oil compartment.

3. Check operation of the protective system outlined under "Testing Protective System." If the FAULT light is on, review the paragraphs under "Fault Alarm."

4. Check to see that the gear-teeth paint marks are properly aligned when viewed through the on-position observation port (1, Fig. 12). If the drive does not stop exactly on position, the control cams and their respective switches should be examined to see that they are secure. The timing of the dynamic braking can be adjusted by slightly shifting the appropriate cam or cams. Refer to "Operation, Motor Drive" and to the Control Diagram.

5. Keep the mechanism gears and control cams lightly greased.

CONTROL CIRCUITS

WARNING — If it becomes necessary to work on any of the circuits associated with the line-drop-compensator current transformer, **be sure to short circuit its secondary before removing the burden. The secondary circuit of an energized current**

transformer should never be opened, as dangerously high voltages may develop! These voltages can not only break down insulation and destroy the current transformer but present a serious hazard to personnel.

Relay Maintenance

Relay contact surfaces should be kept clean but require no further attention until the silver is almost gone. Filing or otherwise dressing the contacts results only in loss of silver and reduces normal contact life.

VACUUM INTERRUPTER

The arcing contacts within the interrupter will gradually wear out over a period of time as a result of interrupting current during each tap change. It is recommended, therefore, that the wear indicators (Fig. 10) and the entire switch mechanism be inspected after the first two years of service or 25,000 operations, whichever occurs first. The frequency of inspection thereafter should be based on the observed rate of wear and any other pertinent factors such as subsequent changes in load conditions, the importance of continuity of service, previous experience, etc., but at no greater than 10-year intervals.

When the interrupters are new and in the closed position, the wear indicator pins protrude 0.040-inches (1.02mm) above the surrounding surface of the indicators. When this protrusion has been reduced to zero, the interrupters are no longer suitable for service and must be replaced. As an aid in determining the percentage of remaining life, the amount of protrusion can be roughly measured with a special "go or no-go" gage provided with each transformer for this purpose.

The gage consists of a square brass bar with one end machined off to a different depth on each of the four sides. These four steps are graduated to represent the amount of pin protrusion corresponding to 100%, 75%, 50% and 25% of remaining contact life. To use the gage, place the machined end of it squarely against the surface of the wear indicator adjacent to the pin and attempt to slide the various graduations over the pin. The remaining life will be in the range of percentages between the step that will just go over the pin and the next smaller step that will not.

Interrupter Replacement

New interrupters will be furnished as an assembly, complete with actuator, springs, latch, dashpot, wear indicators, etc., as shown in Fig. 9. Assemblies can be ordered by Catalog No. 229A2079G2 through the nearest Sales Office of the General Electric Company. One assembly is required for each phase, or a total of three for the entire mechanism. All of the necessary adjusting and tightening has been done at the factory and no further changes should be made in any of these settings since improper techniques can damage the interrupter and/or prevent the assembly from functioning properly.

To replace a vacuum interrupter assembly, first remove the old assembly by disconnecting the two cable leads and removing the three mounting bolts. When installing the new assembly, hold it away from the operating cam and securely tighten all three mounting bolts. After installation, a gap of 0.125 ± .010 inches (3.18mm ± .25mm) is to be established between the drive nut (7) and upper actuator arm (9). This is to be measured with the mounting bolts tight and the cam roller (1) on top of its cam, i.e., with the interrupter in the closed position. If adjustment is required, loosen the locking nut just under the head of the cam adjustment screw in the appropriate direction to correct the gap. Repeat if necessary to obtain the required gap.

Before replacing the cable leads a hi-pot test should be conducted as outlined under "Installation." Be sure to observe the comments on positioning of the movable contact lead before reconnecting.

CLEANING

Each time the switch compartment is opened for inspection or maintenance, the oil should be drained and all surfaces of the mechanism and its tank should be thoroughly cleaned. Clean by washing with clean, dry transformer oil applied with dry, lint-free cloths; then flush out the interior of the compartment and refill with filtered or new oil.

LIMIT SWITCHES

Operation of the limit switches at the maximum raise and lower positions should occur slightly before operation of the cam-operated control switches. Operation into the limit position is maintained by a control relay contact in parallel with the limit switch. When the mechanism reaches either of its maximum positions, the respective limit switch should be open to prevent any further movement in the same direction. To adjust one of the snap-action limit switches, loosen the mounting screw at the roller end and move the switch so as to advance or retard engagement of the roller with the actuating lever on the position indicator shaft.

COUPLING DISASSEMBLY

If it becomes necessary to disconnect the position indicator or control shaft or to remove the LTC mechanism from the oil compartment, care must be taken to see that the parts are reassembled correctly. It is recommended, therefore, that the mechanism be set on the middle tap position (normally the neutral position — see transformer nameplate) before disassembly and again before reassembly. If in doubt about the position of the tap selector switch, its middle position can be established by placing both of the movable contacts on the stationary contact labeled "M" on the cylinder wall.

CHECK AFTER REASSEMBLY

After any reassembly of the load-tap changing equipment, the appropriate test routines outlined under "Installation" should be repeated.

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GENERAL ELECTRIC COMPANY
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