DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

Three-Phase
Automatic, Step-Type
VOLTAGE REGULATOR
Type URS

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

NEW INFORMATION
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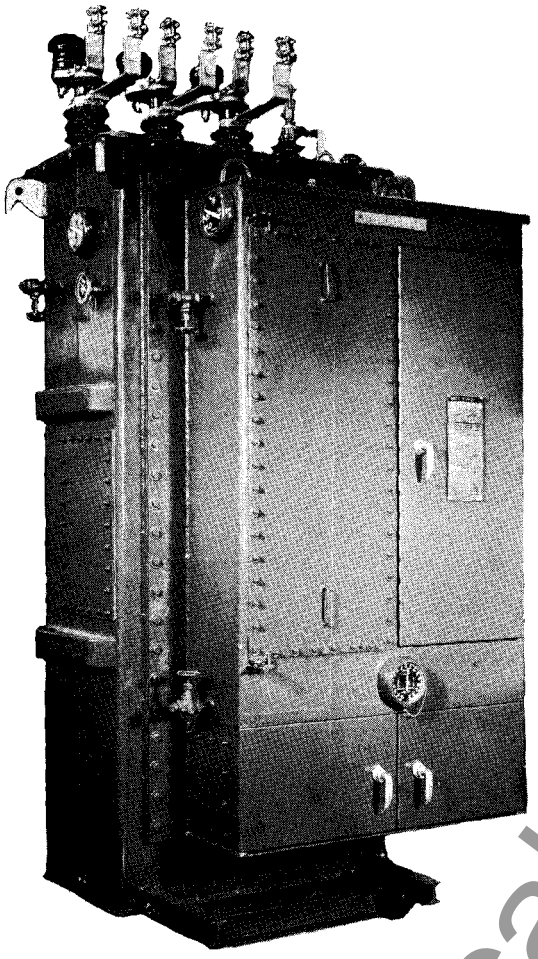


Type URS Regulator with Vertical Arrangement of Phases in the Tap Changer.

The purpose of this Instruction Book is to familiarize the user with the construction of the Type URS three-phase automatic step-type voltage regulator, and to provide a guide for its installation, operation, and maintenance.

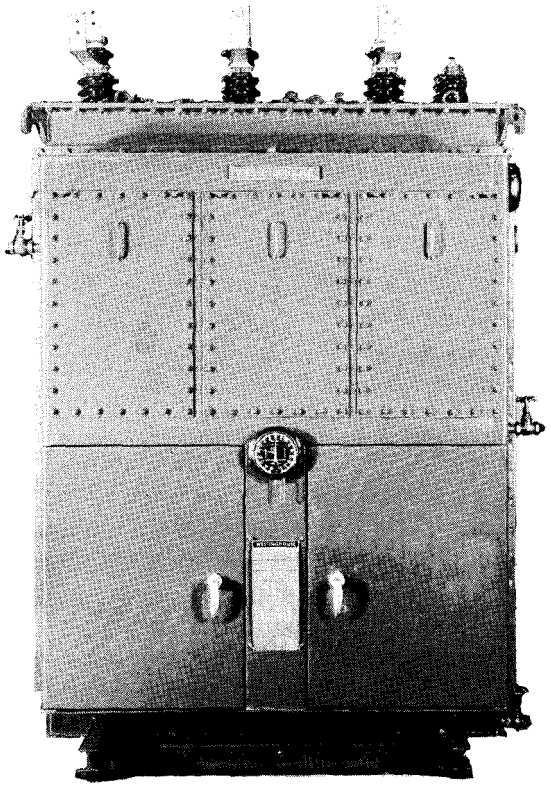
This regulator is used primarily to maintain a constant normal voltage on transmission lines and distribution feeders. Regulation is accomplished by the use of a Type URS Load Tap Changer which operates over a tapped regulating auto-tranformer, selecting the proper voltage tap and polarity relation to obtain the desired range of regulation.

The Type URS regulator is of the latest design. Proven principles of past designs have been incorporated and improvements made to accomplish Load Tap Changing with a minimum of attention and maintenance in service.

Surge Protection. Standard Type URS Step-Voltage Regulators are designed to meet the basic impulse level corresponding to the regulator voltage class in accordance with the NEMA and ASA standards. The basic impulse level is obtained by adequate insulation of the core and coils and the use of lightning arresters where induced surges might exceed the basic impulse level. If by-pass arresters are supplied with the regulator, they are needed for proper protection of the concentric lead bushings and should not be removed.

Thus the insulation of the URS Regulators is guaranteed to withstand the surge voltages specified by NEMA and ASA standards. Therefore, it is necessary that the magnitude of surge voltages on S and L terminals be limited to the values specified for the particular voltage class and basic impulse level of the regulator.

Protective apparatus properly installed at the line terminals will provide this lightning protection. In the event detailed information is desired, please consult the nearest Westinghouse District Office.



Type URS Regulator with Horizontal Arrangement of Phases in the Tap Changer.

DESCRIPTION

The Type URS Voltage Regulator consists of a regulating auto-transformer, a preventive auto-transformer, a Type URS tap changer, and voltage, current and power supplies for the necessary control components and tap changer mechanism. On units which exceed the maximum current or voltage rating of the tap changer, a series transformer is included to bring these factors within the prescribed tap changer limits.

The parts are designed and assembled into an integral unit of weatherproof construction for outdoor service. Completely assembled, it is only necessary to connect the unit into the line for placing into service. The only additional auxiliary equipment required, other than that built into the unit is Line Arresters and a by-pass switch. The line arresters are to be used for protection of the equipment from a line surge. The by-pass switch is used for removal of the regulator from the line for maintenance.

A completely assembled Type URS Regulator is shown in the frontispiece. (Also see Fig. 1.) It comprises two main distinct compartments; the main tank which contains all of the transformer core and coil assemblies, and the tap changer compartment containing the tap changer and its operating mechanism, as well as the automatic and manual control equipment. The tap changer compartment is bolted to the main tank using a gasketed flange at the rear of the compartment and separated from the main tank by an oil and vapor tight insulating Micarta® barrier. The control equipment is mounted on a hinged steel panel in a control compartment incorporated into the tap changer compartment and completely isolated from the contact compartment.

Both the transformer tank and the tap changer compartment are fabricated from heavy steel plate with all seams welded. Lifting lugs are provided for handling the regulator with a crane. A structural steel base supports the regulator and is arranged for rolling in two directions. Jack lugs are provided for convenience in installing or moving the regulator.

Inspection plates or manholes for both compartments have been provided to facilitate maintenance and ease of inspection. All covers and inspection plates are gasketed and made oil tight.

Filter press connections, drain valves with sampler devices, and magnetic type oil gauges are provided for each compartment. A dial type thermometer is mounted on the transformer tank.

Vertical bulk type concentric lead bushings containing both load and source conductors are provided for connection to the line where the regulator is rated for 15 kv or less. Above 15 kv, condenser bushings are used.

Standard finish, consisting of two primer coats followed by a final coat of grey paint, is used for protection of all external surfaces of the regulators.

TRANSFORMER CORE AND COILS

The regulating, preventive auto, and auxiliary transformers are all of the core form construction. The winding conductors are special electrolytic oxygen-free copper. All units are designed to withstand ASA impulse and low frequency dielectric tests.

The main core and coil assembly is designed and constructed in the same manner as small power or distribution transformers, and therefore does not require detailed description. (Type SL core form transformers are described in I.L. 47-610-1.)

TAP CHANGER

Figure 2 shows a cutaway view of the tap changer.

The tap changer compartment contains the motor operated driving mechanism, reversing switches and the selector switches. The selector switches, the function of which is the selection of voltage magnitude, are connected to the regulating transformer taps. The reversing switches have the function of changing the method of connection of the series winding to enable the series voltage to aid or oppose the exciting or source voltage so that the load voltage will either be less or more than the source of applied voltage.

The selector switches of the Type URS tap changer consist of the stationary contacts, two moving contacts, and two sliding contact connections of the moving contacts.

Each stationary contact consists of a copper alloy foot mounted on the main isolating and insulating Micarta barrier between the transformer and the tap changer housing. Each foot

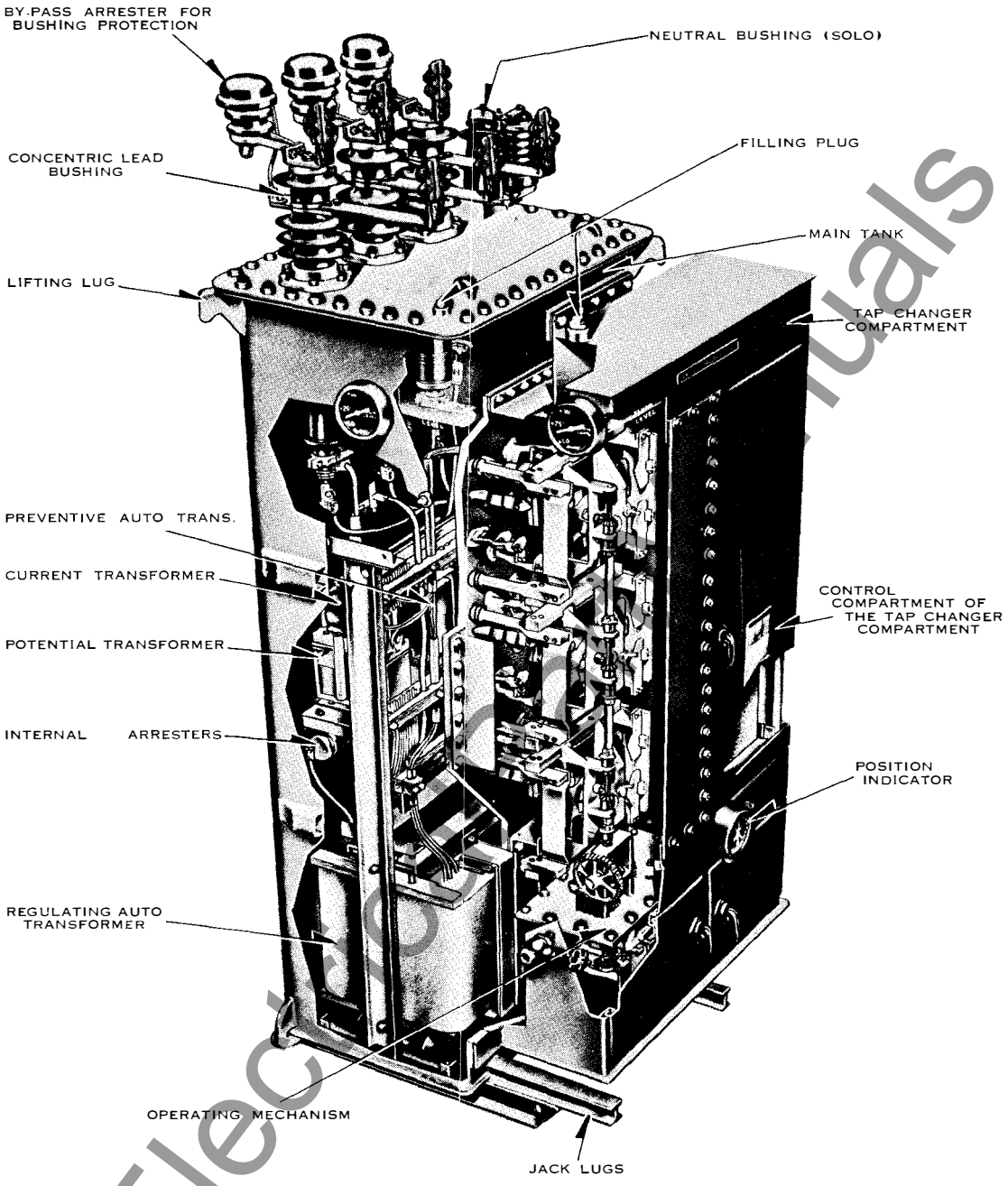


FIG. 1. Cutaway View of Type URS Voltage Regulator.

is held in place by two bolts through the barrier, and is connected to its transformer tap by means of a separate copper stud through the barrier. Each foot supports two contact blades having special arc resisting alloy inserts at the edges, the two blades being in different planes to match with their respective moving contacts.

The rear moving contact consists of a set of fingers with special arc resisting alloy shoes. These are mounted on a Micarta insulating arm which is rotated by the central shaft in each phase.

The sliding contact connection to the rear moving contact consists of a set of fingers with copper shoes, connected to the rear moving selector fingers. These are mounted on a Micarta

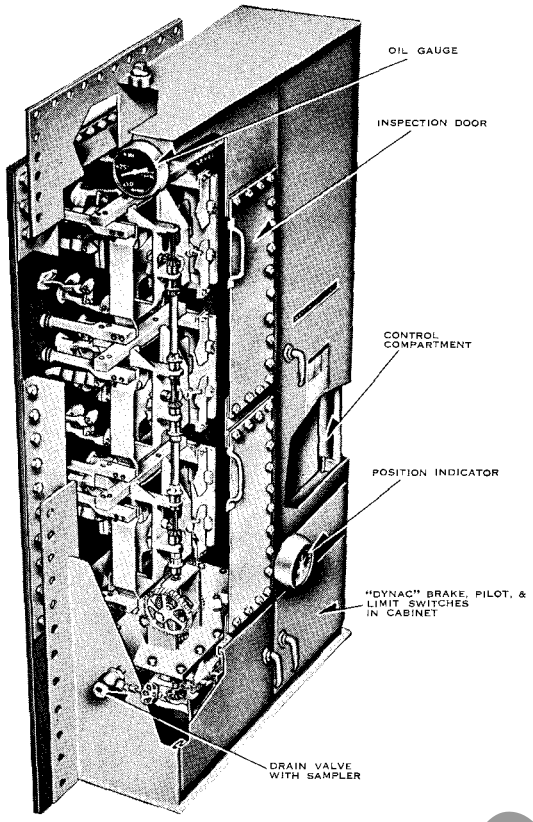


FIG. 2. Cutaway View of Type URS Tap Changer with Vertical Phase Arrangement.

arm, which carries the rear moving contact, and arranged to slide on a central collector disc. This copper disc is mounted on the main insulating Micarta barrier plate in a manner similar to that of the stationary selector contact feet.

The front moving contact consists of a set of fingers identical to the rear moving contact fingers. These are mounted on an arm which is rotated by a shaft concentric about the central shaft.

The sliding contact connection to the front moving contact consists of a set of fingers with copper shoes mounted from two of the corner posts which support the shaft assembly in each phase. The mechanical parts and main frame in each phase are at the potential of the front moving contact. The mounting is of copper and the posts are cast from a high conductivity alloy. The connection to the transformer is made through the main insulating Micarta barrier plate in the same manner as the stationary selector contacts. These fingers slide on a copper alloy collector disc connected to the front moving selector contact.

REVERSING SWITCH

The reversing switch moving contacts consist of two sets of fingers with copper shoes, connected together and mounted on an insulating Micarta arm. This arm is pivoted on a stub shaft, and its motion is related by gearing to the motion of the rear moving selector contact. The rear moving reversing switch contact slides on a continuous copper blade connected to stationary selector contact R. The front moving reversing switch contact moves between two copper alloy blades. Each of these blades is mounted on one of the conducting supporting posts for the phase assembly and the posts make connection to the transformer through the main insulating Micarta barrier plate as previously described.

Figs. 2, 2A and 2B show the URS tap changers and operating mechanism with parts cut away to illustrate the construction and operation of those portions normally hidden from view.

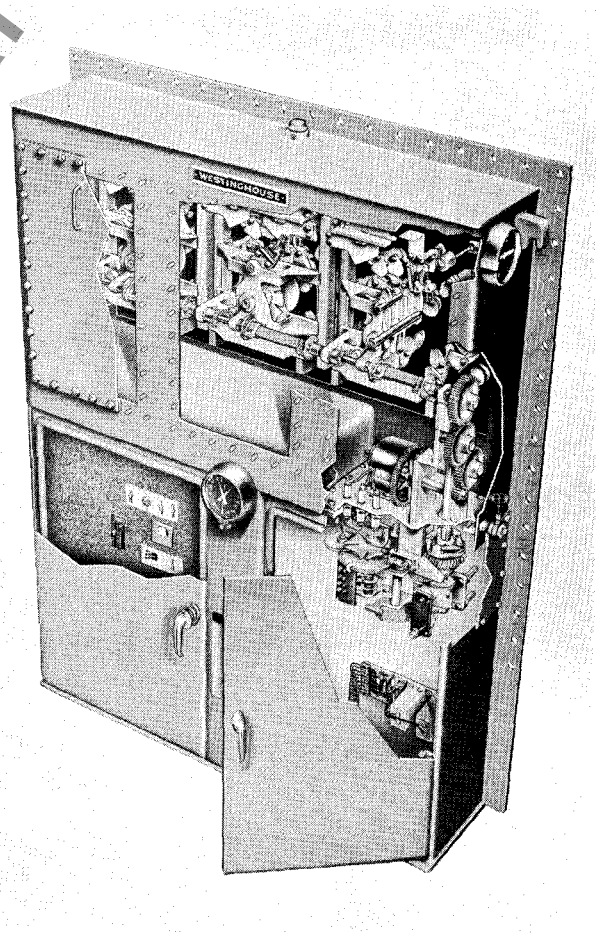


FIG. 2A. Cutaway View of Type URS Tap Changer with Horizontal Phase Arrangement.

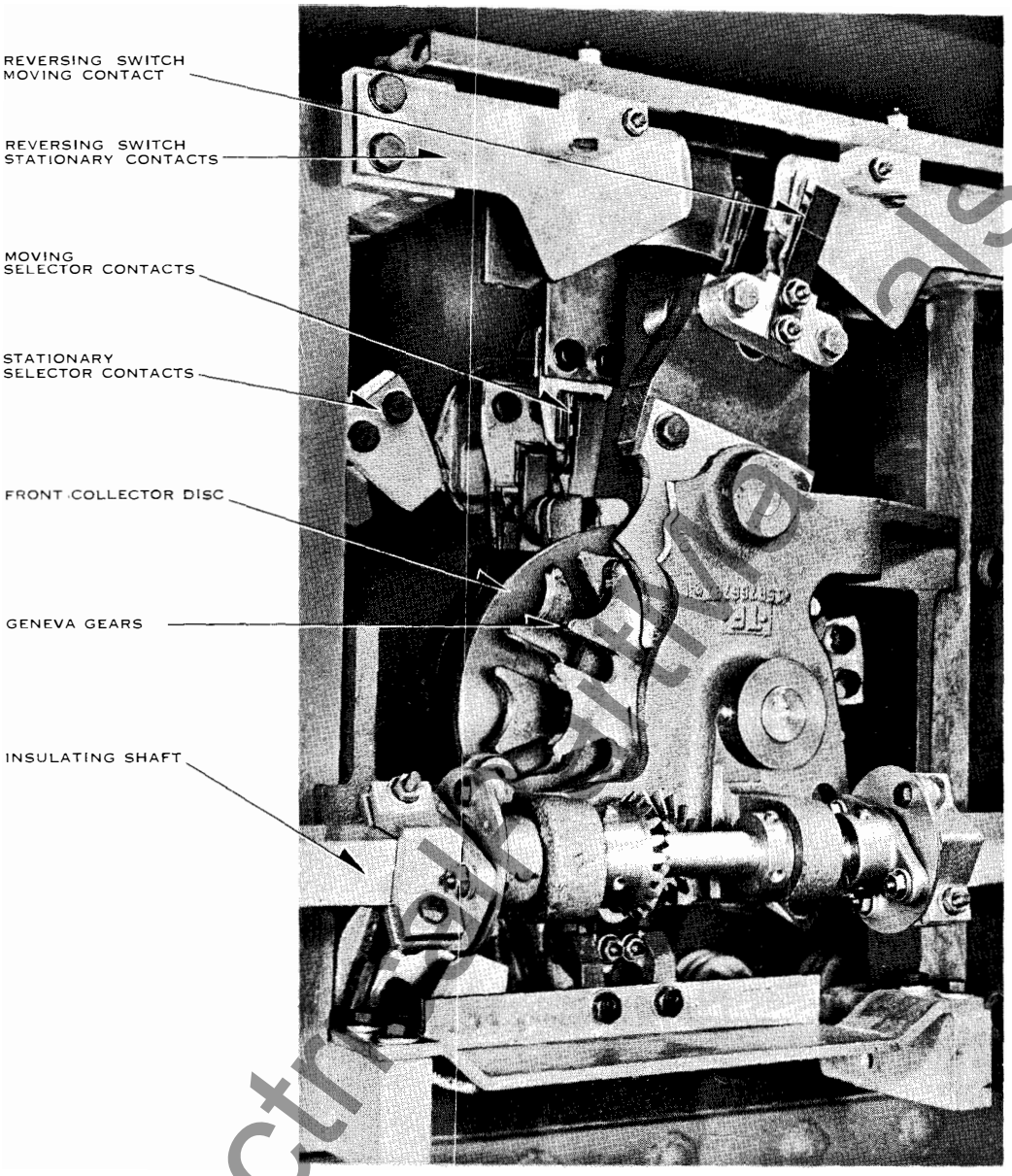


FIG. 2B. Sectional View of Type URS Selector Switch Assembly.

OPERATING MECHANISM

The operating mechanism consists of the motor, gears, and shafts for operating the tap changer. The motor and the gearing between the motor and tap changer are contained in the oil-filled tap-changing housing. A shaft is extended through the bottom of the main housing into an air compartment which houses the RC "DynAC* Brake", switches, and auxiliary gears for their operation.

The driving motor is a 230-volt, a-c single-phase, reversible, capacitor-start, capacitor-run motor especially designed for operation under oil. Its capacitor is mounted in the air compartment. For positive stopping, the RC "DynAC Brake" is used.

Through one Micarta to steel and one steel to steel spur gear reduction and one steel to steel bevel-gear assembly, the motor is coupled to the main vertical drive shaft. Between phases and between phase and drive, Micarta insulating shafts are used. To minimize alignment difficulties a flexible coupling connects the insulating shafts to the steel shafts. At each end of

*Westinghouse Trade-Mark

the Micarta shaft is a disc of special alloy arranged to act by flexure in the manner of a universal joint. The discs are attached to the square Micarta shaft with clamp type fittings, and to the steel shafts by a pinned collar.

Each phase assembly is driven from its vertical shaft through a steel bevel-gear takeoff. In the principal cast steel frame is mounted a pinion shaft carrying two geneva pinions. The front pinion engages a bronze geneva gear mounted on the central shaft to operate the rear moving selector contact arm. The rear pinion engages a bronze geneva gear mounted on the outer concentric shaft to operate the front moving selector contact. The action of these geneva gears imparts a very rapid motion to the moving contacts at the time of switching, thus obtaining the contact parting speed requisite to efficient switching with smooth acceleration and deceleration to assure long mechanical life.

On the front geneva gear is mounted an additional geneva pinion which engages a bronze geneva gear to operate the reversing switch moving contact on its separate stub shaft in the main phase assembly frame.

CAM SWITCH ASSEMBLY

The air compartment contains the cam switches, mechanical stop, RC "DynAC Brake" and hand cranking arrangements. Electrical connections from the motor are brought into this compartment through spark plug type porcelain bushings.

A vertical operating shaft extends downward from the oil compartment through a spring loaded synthetic rubber oil-seal into the air compartment. To it is coupled, by a worm pivotable from an out-of-mesh position, a short shaft with socket for insertion of a crank for hand operation of the tap changer. A socket and clip are provided on the inside of the air compartment for the crank when not in use. An interlocking switch is provided which removes all power from the motor when the worm is moved from its out-of-mesh position.

Through steel spur gears, auxiliary shafts are driven at the different speeds required for the auxiliary functions. One travels 180 degrees per position. On it are cams actuating switches to insure completion of each operation and stopping of the tap changer only on operating positions. A cam on this shaft operates a mechanical operation counter to record the number of tap changer operations.

A shaft is included which travels ten degrees per position. This shaft is connected to the dial type position indicator having resettable maximum-minimum hands. The indicator is located on the face of the tap changer. This shaft may also be used to drive a "Synchrotie®" transmitter for remote position indication, or for other special switching or indicating systems.

The shaft bearing the limit switch cams and mechanical stop trip is geneva driven to achieve maximum movement at the limiting positions to obtain fast, positive action of the limit switches.

Other cams, switches, etc., are provided to suit such optional auxiliary functions as may be included in the particular control circuit design.

The disc-shaped Micarta cams which operate the auxiliary switches are permanently and accurately aligned on their shafts by the close fit between their hexagonal center hole and the hexagonal shaft. For replacement or modification, any individual complete shaft assembly may conveniently be removed as a whole, including the factory match-marked gears. For replacement or modification purposes, accurate interchangeable parts may be obtained through the nearest Westinghouse Office.

All interlocking switches are of a self-aligning, bridging contact type with heavy silver con-

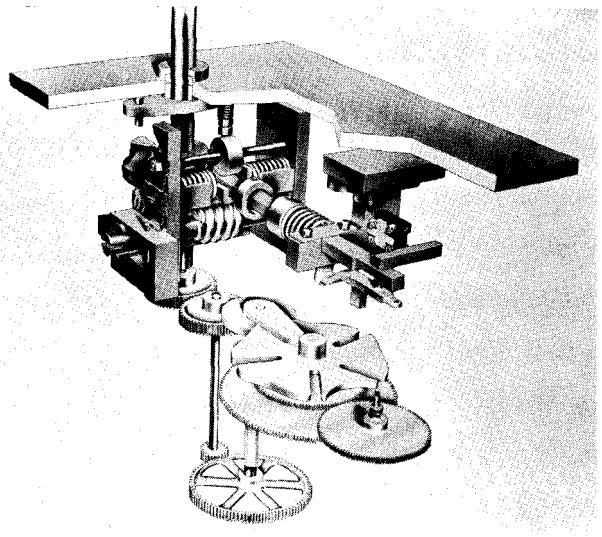


FIG. 3. Tap Changer Mechanical Stop for the Vertical Phase Arrangement.

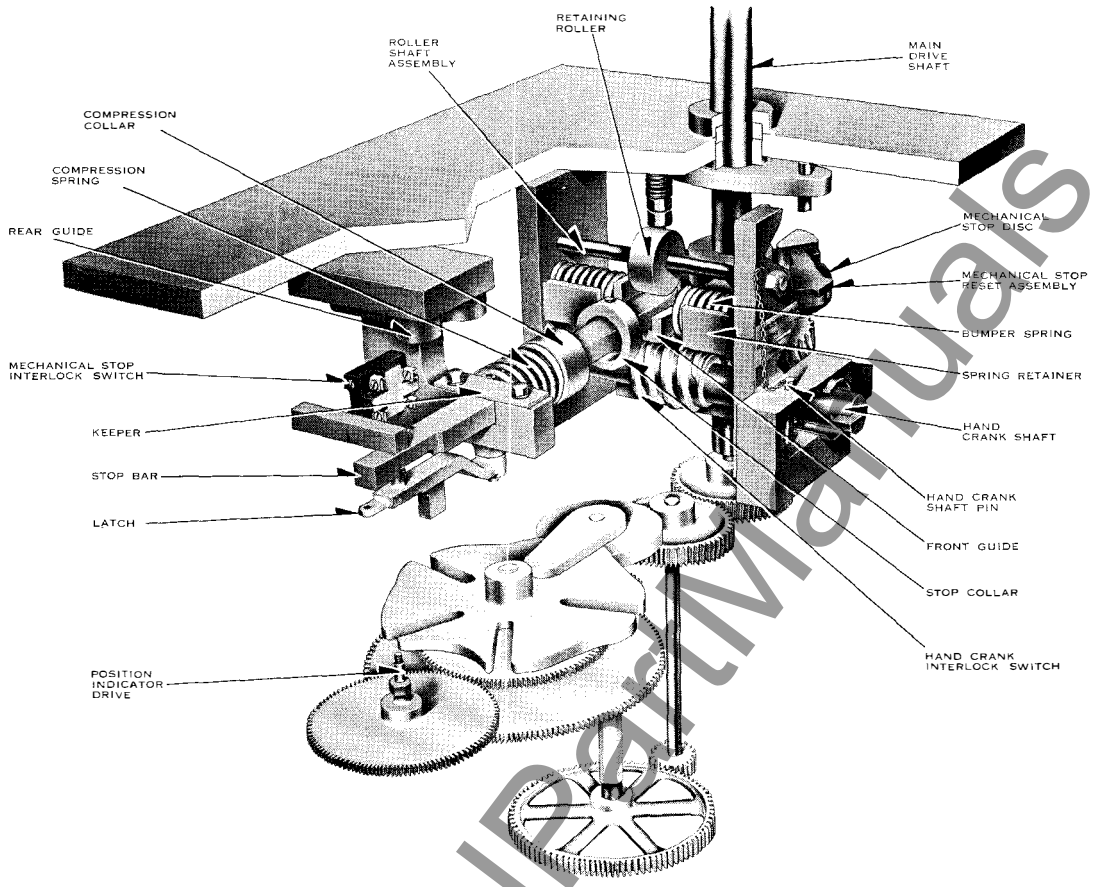


FIG. 3A. Tap Changer Mechanical Stop for the Horizontal Phase Arrangement.

tact buttons. A wiping contact action assures reliable operation.

MECHANICAL STOP

The cam-operated switches insure that the URS tap changer will not run beyond the limits of its operating range; however, as an additional safeguard, a mechanical stop is provided so that even though jumpers had been put across the contacts of the limit switches, the tap changer would be positively stopped before the moving contact fingers could leave the stationary selector switch contacts. The stop mechanism is illustrated in Figs. 3 and 3A.

The mechanical stop trip mentioned above releases a spring actuated mechanism to stop the tap changer should it be moved appreciably beyond its end position in either direction. This mechanism throws a steel plunger into a slot in a bronze disc mounted on the main operating shaft, providing a definite mechanical stop to prevent further motion. The motion of the plunger also opens the MS switch removing all power from the motor circuit. This mechanical stop is reset by use of the hand crank. First, operate the tap changer solidly against the stop, then return the tap changer to an operating position.

The mechanical stop disc, having large bosses on its top surface, is mounted on the main driveshaft in the operating mechanism compartment. The mechanical stop trip is geared to the main driveshaft and has a separate adjusting screw for each of the two limit positions and set screws to lock the setting of the adjusting screws. The bosses on the mechanical stop disc are so spaced that when the stop bar enters the wide space the tap changer is stopped with both selector switch contacts still made. If the adjustment of the stop were incorrect so that the stop bar would fail to enter the wide space, it would enter the following narrow space stopping the tap changer before completion of the next tap change.

The stop bar is a rectangular bar of steel which is spring loaded and is held in its normal position by a tripping latch. The tripping latch is counter-balanced by a spring so that the normal position of the latch roller is at the centerline of the stop bar. The latch roller resets into a slot in the stop bar. The slot in this bar has circular ends so that the roller is forced to the lateral center of the slot even without the spring counter-balance. When the mechanism stop adjusting screw strikes the tripping latch, the latch roller is forced out of the slot in the stop bar permitting the compression spring on the stop bar to push the bar into the wide space between the disc bosses, positively preventing the tap changer from making any further movement. The stop bar is supported in a front and rear guide. A keeper holds the bar in the rear guide while a retaining roller keeps the bar in the channel provided in the front guide. The retaining roller is free to move along its axis at right angles to the length of the stop bar, being held in place by the channel in which the stop bar slides. The front guide channel is held in a balanced position between two heavy springs which serve to absorb the energy of the system when the stop disc strikes the stop bar. A collar near the front end of the stop bar limits the forward thrust into the stop disc when the stop bar is tripped.

When the mechanical stop is tripped, an arm on the stop bar opens the mechanical stop switch MS, de-energizing the motor as an added safety feature.

Moving the hand crank shaft into the operating position also de-energizes the motor circuit so that electrical operation is prevented while the hand crank is being used.

From the above it can be seen that the mechanical stop bar must be reset, and the hand crank shaft pinned in the disengaged position for the motor to be operated electrically.

When major maintenance operations are performed on the control mechanism, the setting of the mechanical stop must be rechecked and, if necessary, adjusted to agree with the tap changer.

Adjustment. The mechanical stop may be adjusted for earlier or later operation as outlined by the following procedure. However, it should always be in conformity with the tap changer and the mechanical stop disc. If any parts of the tap changer are disassembled, and reassembled, alignment should be checked carefully in accordance with the match marks as described later. In the interest of safety, the unit should be de-energized before any major work or adjustments are undertaken on the mechanical stop linkage.

1. De-energize the control circuit and turn the tap changer beyond its limit positions by hand. With the location of the 120 switch cam roller on the center of the lobe of the 120 cam as a reference, check the angular movement of the 120 cam shaft as the mechanical stop is tripped. The set screw locking the adjusting screw should then be released and the adjusting screw should be turned in or out to make the stop trip correspondingly later or earlier as required. The mechanical stop should trip with the 120 cam shaft at 30° from its reference position. This is approximately $\frac{5}{8}$ of a hand crank turn.

2. After adjusting the tripping position for hand operation, by-pass the LL, LR, CLL and CLR switches. Set the tap changer for manual operation and energize the control circuit. Now start at least one position from the limit positions and hold the raise-lower switch closed to run the tap changer through the limit positions to trip the mechanical stop. Readjust the trip as necessary to insure that the mechanical stop bar, when tripped, enters the wide space between the bosses on the stop disc so that the tap changer contacts are still made. (Lock the adjustment by means of the set screws and recheck.) When the stop enters the narrow space between the bosses on the stop dics, one contact is already open, stopping the tap changer with one leg of the preventive auto transformer disconnected.

CAUTION: The narrow space is provided only to insure that if the adjustment is incorrect the mechanism will be stopped before the tap change is completed. If the tap change were to be completed, the regulating winding would be connected across the preventive auto impressing excessive voltage on the preventive auto.

Resetting. The mechanical stop is an additional safety feature set to trip only when some trouble develops in the mechanism or in the control circuit. Each time the mechanical stop trips, the unit should be very carefully inspected and the trouble corrected before the unit is placed in service again.

The mechanical stop must be reset manually.

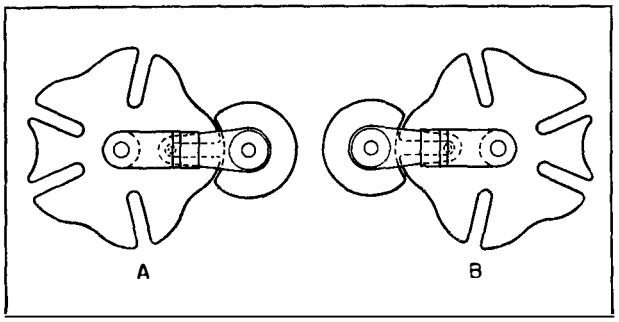


FIG. 4. Geneva Gearing for Type URS Cam Switch Unit (Position Shown is for Position O)

A—For Horizontal Phase Arrangement Tap Changer.
B—For Vertical Phase Arrangement Tap Changer.

Under normal conditions, it is merely necessary to use the hand crank and operate the tap changer solidly against the mechanical stop, then reverse rotation of the crank and return the tap changer to a position where the 120 cam switch is open. Operating the tap changer solidly against the stop cocks and latches a brass cam which, when the tap changer is returned to an operating position, resets the stop plunger. This reset cam is in turn unlatched by two trip blocks bolted to the mechanism in order that the cams may return to a withdrawn position.

The following suggestions will serve as a guide for resetting the mechanical stop if the stop bar enters the narrow slot previously described so as to prevent normal automatic reset.

1. De-energize the unit.
2. Hold the stop bar to the left with its loading spring fully compressed.
3. Permit the latch to reset by hand cranking the tap changer to position 14.
4. Readjust the mechanical stop trip.
5. Energize the control circuit of the tap changer and check its operation.
6. Eliminate any possible troubles and place unit in service.

MATCH MARKS

The following simultaneous conditions constitute proper adjustment of the tap changer as indexed at the factory.

1. The tap changer is set on the neutral position O.
2. The selector contacts are exactly on position on stationary contact R.
3. A straight edge placed across the wide space between bosses on the top disc is parallel to the side wall of the tap changer compartment.
4. The match marks (small arrows) on the front of the stop disc are in a vertical line with similar match marks to the side of the hand crank shaft on its front bearing support.
5. The cam assembly is lined up with the 120 cam switch roller on the center of the 120 cam lobe which has the arrow on its bottom surface.
6. The position indicator is in agreement with the location of the tap changer contacts (on the mid range position or O).
7. The match marks on the gears between cam shafts of the control switch assembly are in line.
8. The large end of all taper pins is toward the front of the tap changer with the smaller end to the back.
9. The Geneva Gearing used for the limit switch shaft is as shown in Fig. 4.

Note: It is recommended that whenever any component parts of the tap changer are disassembled or assembled ALL parts be put on position O, where ALL match marks are in line.

HOUSING

The Type URS tap changer is enclosed in a housing fabricated from steel plate with a gasketed flange in the rear for connection to the opening in the transformer tank, and with gasketed cover plates in the front for ready access to all parts for inspection or maintenance. This housing is sealed, except for a small vent to allow release of the gases evolved due to arc interruption. The unidirectional breather, attached to this vent, prevents any in-breathing of outside air into the tap changer compartment, but permits gases to vent outward at a minimum pressure of one pound per square inch. An oil drain valve is provided, as well as an upper filter press connection. Also, the drain valve is equipped with a sampling connection.

INSTALLATION

RECEIVING AND HANDLING

Immediately upon receiving the regulator, an inspection should be made of all parts to make sure that no damage has resulted during shipment. If damage or injury is evident, file a claim with the transportation company at once,

and promptly notify the nearest Westinghouse Sales Office. If the unit is to be stored for a time before installing, a dry place should be selected. If indoor storage is not practical, an energized heater (250 watts for normal conditions) should be placed in the bottom of the air compartment to protect the control equipment from moisture condensation.

Care must be taken in handling and installing the regulator. Where possible, the regulator should be handled with a crane. Lifting lugs have been provided on the tank for this purpose. Where a crane is not available, or is impractical to use, the unit may be skidded or moved into place on rollers. Jack lugs have been provided for convenience in lifting the unit. A jack should not be used on any other part of the regulator.

When handling or working on the regulator, care must be taken not to crack or damage the surfaces of the porcelain bushings.

INSTALLING

The standard Type URS Regulator is shipped as a complete unit and is entirely self-contained. Both transformer and tap changer compartments are usually shipped filled with WEMCO "C" Oil to the required level. The following procedure is recommended to insure that the regulator will function properly and require little maintenance after being placed in service.

1. Remove any blocking from any relays that may be on the control panel. These relays are thoroughly inspected at the factory, but if another inspection is desired, refer to the Instruction Leaflets included in this Instruction Book.

2. Crank the tap changer over its entire range by hand, to make sure that the mechanism is not binding at any point. A hand crank is provided for this purpose.

3. Operate the tap changer over its entire range electrically by means of an external source of voltage. Open the potential and auxiliary sources at their AB control breakers and connect the external 110/220-volt, single-phase source to the control side of the breaker marked "Tap Changer Control". Refer to the wiring diagram furnished with the unit for the lead markings.

CAUTION: The Control Breakers must be in the open position, otherwise the external source voltage may feed back into the main transformer, causing a high voltage to develop across the line bushings and overload the potential and auxiliary transformers. Refer to the wiring diagram furnished with each unit.

4. Turn the "automatic-manual" switch to the "manual" position and operate the tap changer over its entire range by means of the "raise-lower" switch.

5. The voltage regulating control should balance at the normal secondary voltage of the potential transformer. Refer to the regulator instruction plate for this voltage value. The voltage should be applied to the voltage test terminals.

6. Set the line drop compensator dials for proper resistance and reactance compensation of the line between the regulator and the load center. Refer to I.L. 47-431-6 for detailed information on the compensator adjustment.

7. Return the regulator to the neutral position, normally position O of the tap changer.

8. Remove the test voltages.

The Type URS Regulator may be used on a transmission system having either an isolated neutral or a solidly grounded neutral. The regulator neutral grounding strap must be removed when regulator is used on an isolated neutral system.

Note: The regulator should never be operated or energized unless the main tank is always solidly grounded.

The oil level in both the transformer tank and the tap changer tank should be checked to make sure that it is filled to the 25 degree level as indicated by the oil gauges. The oil used with Westinghouse Regulators should be WEMCO "C" oil, which is supplied with them, or an oil specifically approved by Westinghouse.

IMPORTANT: All oil should be carefully inspected and tested before using, regardless of the length of time the unit has been idle or in storage. The oil in each compartment should be tested prior to energization of the unit. For methods of testing and handling oils, see I.B. 44-820-1.

Connect the regulator to the line making sure to connect the "S" leads to the source and the "L" leads to the load, regardless of whether the regulator is to be connected to the sending or receiving end of the line. Care should be taken to see that all connections are properly made, as a wrong connection may cause serious damage.

If possible, the voltage should be brought up slowly so that any trouble may be found before damage can result. Close the AB control breakers and operate the tap changer over its entire range and back to the neutral position by means of the "raise-lower" switch. Turn the "automatic-manual" switch to the "automatic" position if this is desired.

In the source and load lead structure, we recommend that a disconnect by-pass switch be installed. This switch is used to disconnect and by-pass the regulator during the periods of maintenance. The Westinghouse Regulator By-Pass Switches are described in Catalog Section No. 36-145, not included in this Instruction Book.

In addition to the Regulator By-Pass Switches, we also recommend that line lightning arresters be applied to both the Source and Load leads. These lightning arresters should be determined from the normal system voltage and are used for protection of the lines as well as the regulator. No additional lightning protection other than these line arresters are required as lightning arresters are supplied with the regulator to protect those points where an induced surge might exceed the basic impulse level.

* * * * *

OPERATION

PRINCIPLE OF REGULATOR OPERATION

A typical schematic diagram of connections of a Type URS Regulator is shown in Fig. 5. The sequence of operation of the Type URS Load Tap Changer is shown in Fig. 6. A series transformer (not shown) is used in the larger current or voltage classes. The schematic diagram of connections of one phase shown in Fig. 6 shows more clearly the principle of operation.

The tapped section of the transformer winding is shown between 3 and 12, with taps 4 to 11 inclusive connected to the stationary contacts of the selector switches of corresponding numbers. Taps 3 and 12 are connected to the reversing switch stationary contacts, and tap 2 to the stationary selector contact R, and reversing switch moving contact R. Terminals P1 and P3 of the preventive auto transformer are connected to the two moving contact fingers of the selector switches.

Fig. 6 shows the tap changer in its neutral position, with both moving contacts on stationary contact R, the preventive auto short circuited, the reversing switch connecting R to A, and

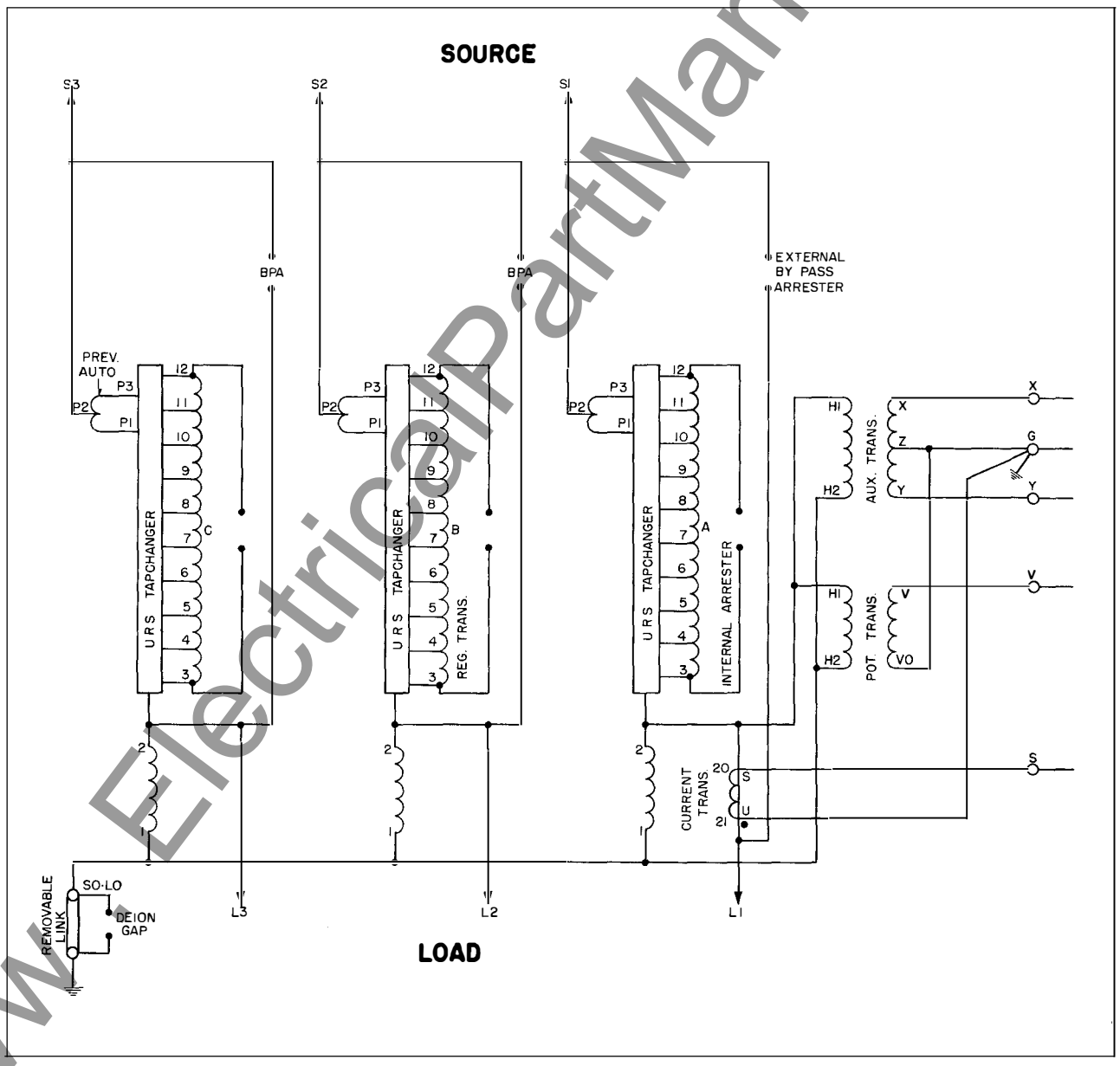
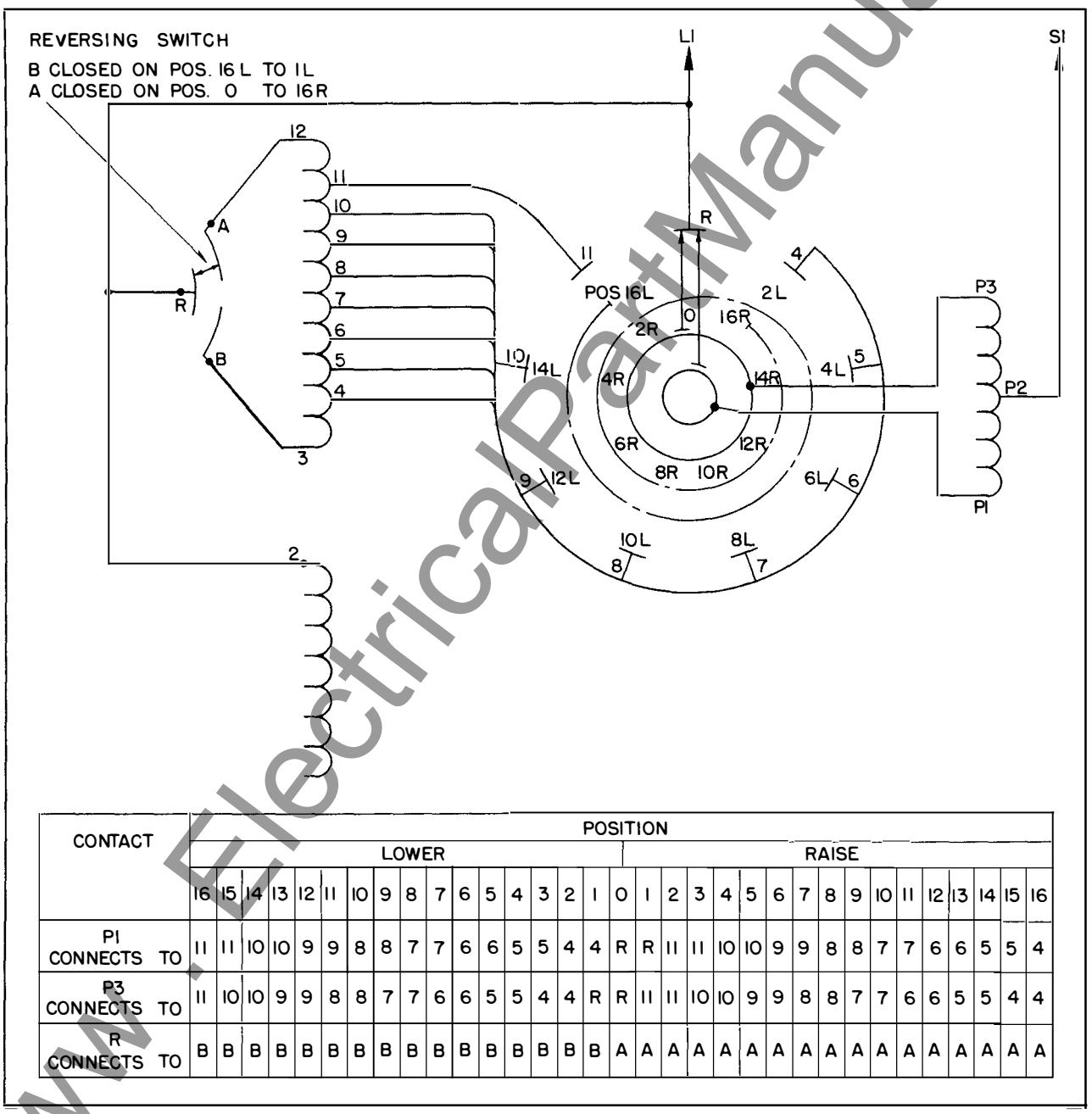


FIG. 5. Three Phase Type URS Voltage Regulator Connection Diagram.

none of the tapped section of transformer winding connected into the circuit. This is position O.

In changing from position O to position 1R, a bridging position midway between position O and position 2R, the moving contact connected to P3 leaves stationary contact R and moves to stationary contact 11. This connects the preventive auto transformer across taps 12 and 11, and causes the number of effective turns in the winding between S1 and 1 to be decreased by half the number of turns of the tapped section 11-12. By thus increasing the volts per turn in the fixed winding between 1 and 2, the voltage appearing between L1, L2 and L3 is increased.

Continuing the operation from position 1R to position 2R, the moving contact connected to P1 leaves stationary contact R and moves to stationary contact 11. This short circuits the preventive auto transformer and the number of effective turns in the winding between S1 and 1 is again decreased by half the number of turns in the tapped section 11-12.



CONTACT	POSITION																															
	LOWER																	RAISE															
	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P1 CONNECTS TO	11	11	10	10	9	9	8	8	7	7	6	6	5	5	4	4	R	R	11	11	10	10	9	9	8	8	7	7	6	6	5	5	4
P3 CONNECTS TO	11	10	10	9	9	8	8	7	7	6	6	5	5	4	4	R	R	11	11	10	10	9	9	8	8	7	7	6	6	5	5	4	4
R CONNECTS TO	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

FIG. 6. Typical Schematic Connection Diagram of One Phase of Regulator and Sequence Chart of Tap Changer Positions.

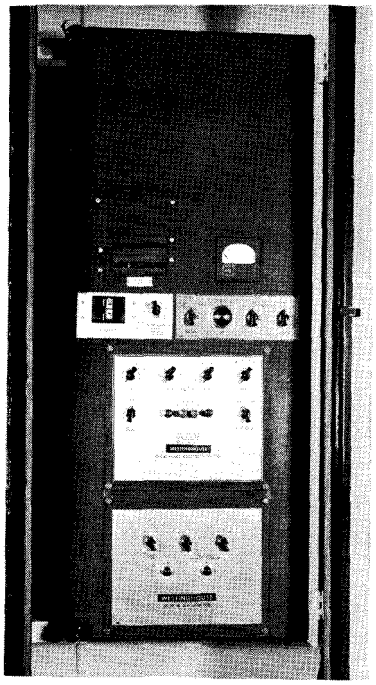


FIG. 7. Typical Control Panel for Vertical Phase Arrangement Tap Changer.

By continuing the same sequence of operations of the selector switches, the connection is moved successively from tap 11 to tap 10 . . . to tap 4 which represents the minimum turns position, which is also the maximum voltage position between L1, L2 and L3.

In changing from position O to position 1L, the reversing switch acts to reverse the connections to the tapped winding and contact P1 moves to stationary contact 4. The sequence is as follows: R-A opens, P1-R opens, R-B closes, P1-4 closes. This connects the preventive auto transformer across taps 3 and 4, and causes the number of effective turns in the winding to be increased by half the number of turns in the tapped section 3-4. By thus decreasing the volts per turn in the fixed winding between 1 and 2, the voltage between L1, L2 and L3 is decreased.

Continuing the operation from position 1L to position 2L, the moving contact connected to P3 leaves stationary contact R and moves to stationary contact 4. This short circuits the preventive auto transformer, and the number of effective turns in the winding is again increased by half the number of turns in the tapped section 3-4.

By continuing the same sequence of operations of the selector switches, the connection is moved successively from tap 4 to tap 5 . . . to tap 11, which represents the maximum turns between S1 and 1, or minimum voltage between L1, L2 and L3.

PRINCIPLE OF CONTROL OPERATION

A typical control panel for the Type URS regulator is shown in Figs. 7 and 7A. The control circuit is shown schematically in Fig. 8.

The panel is of steel and is in a steel compartment mounted on the side or bottom of the tap changer. A hinged mounting is used so that both front and rear of the panel is readily accessible for inspection and maintenance. The control elements and equipment are all constructed for flush mounting. This removable unit assembly construction allows the control elements to be easily disassembled for inspection, testing, adjusting and remounting. Potential test terminals and current test terminals are available with each unit for use in testing these controls.

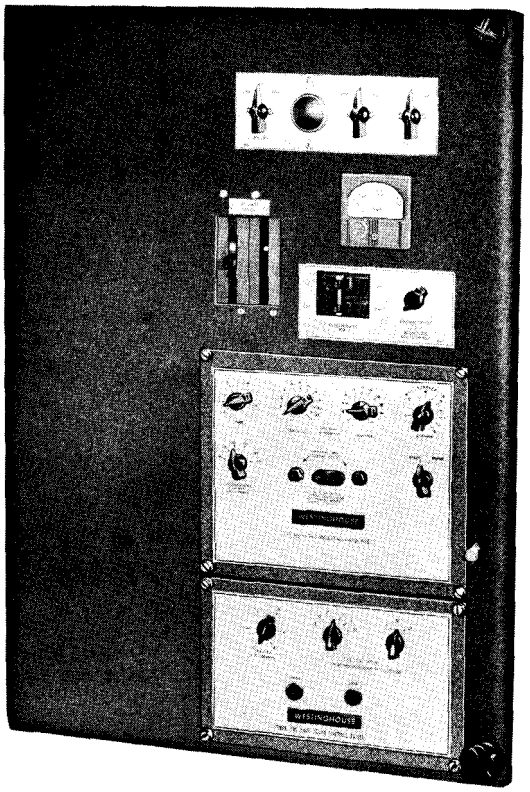


FIG. 7A. Typical Control Panel for Horizontal Phase Arrangement Tap Changer.

FUNCTIONS

In general, the control system to be completely adequate must perform five distinct functions:

1. Initiate the operation of the tap changer motor to cause a tap change.

2. Provide means for insuring that once a tap change is initiated it will be carried through to completion.

3. Protect the source of auxiliary power and the potential transformer in case of short circuit.

4. Prevent the tap changer mechanism from running past the limit positions.

5. Indicate the tap changer position, number of operations, etc.

In the description of control circuit operation which follows, the equipment which performs the above functions is described and its operation is outlined.

The schematic control circuit for automatic or manual control of a Type URS Tap Changer is shown in Fig. 8. An automatic-manual switch, "AM", enables the selection of automatic or manual operation by the closing of the "AMA" or "AMM" contacts respective. The MS Voltage Regulating Control is responsive to voltage changes in the regulated line and initiates tap changer operations automatically. The MS control inherently prevents automatic operation to maximum boost if AB1 is inadvertently opened, or purposely opened for testing.

Type TM time delay control is provided to over-ride minor voltage fluctuations and avoid many needless tap changer operations. The delay operated contacts TR and TL operate the motor control relays. A manual control switch, "MC", mounted on the control panel, is provided to enable operation of the tap changer by the closing of "MCR" for raising or "MCL" for lowering the tap changer position.

An interlock switch MS is mounted to de-energize the motor in the event of a mechanical stop operation. In addition, another interlock switch SS is mounted to de-energize both the motor and the control circuit when using the hand crank and manually operating the tap changer. Thus, the unit cannot be operated electrically if either the mechanical stop has tripped or the hand crank is engaged.

Type AB control breakers are provided to disconnect the control circuits from the supply transformers, and to protect the supply transformers from control short circuits. Terminals 1, 2, 3, and 4 receive their potential from the auxiliary and potential transformers, and terminals 2 and 5 receive current from the current transformer.

BC is the RC "DynAC Brake" relay. The RC "DynAC Brake" is a rectifier, capacitor, and relay combination, operated by a cam in the control assembly. Complete descripton is given in I.L. 46-713-8.

The following switches are cam operated and are contained in the air compartment of the tap changer.

120 is an auxiliary switch which is closed when the tap changer is off position. It acts to seal in the motor contactor to ensure completion of a tap change once the tap changing sequence is initiated.

CLR and LR are limit switches, open on position 16R and beyond, and closed on positions 16L through 15R.

CLL and LL are limit switches, open on position 16L and beyond, and closed on positions 15L through 16R.

XL and XR are the brake resistors in series with SL3 and SR3 respectively.

SR and SL are the coils of two type N motor control relays mounted in the air compartment of the tap changer. The coils act to open and close contacts of the same designation (i.e., SRI, SL2, etc.)

RL is a red lamp on the control panel which indicates when the tap changer is off position.

NEL and NER are two indicating lights which are used to give visual indication of when the voltage regulating control operates to detect an unbalance in voltage. The lights indicate that a tap change is required after the set time delay has elapsed.

V is the voltmeter used to measure the voltage being applied to the MS Voltage Regulating Control.

VA is a variable voltage adjustment used to adjust the input voltage to the MS Voltage Regulating Control while balance voltage settings are being made. The VA switch must be returned to the "OFF" position after settings are made.

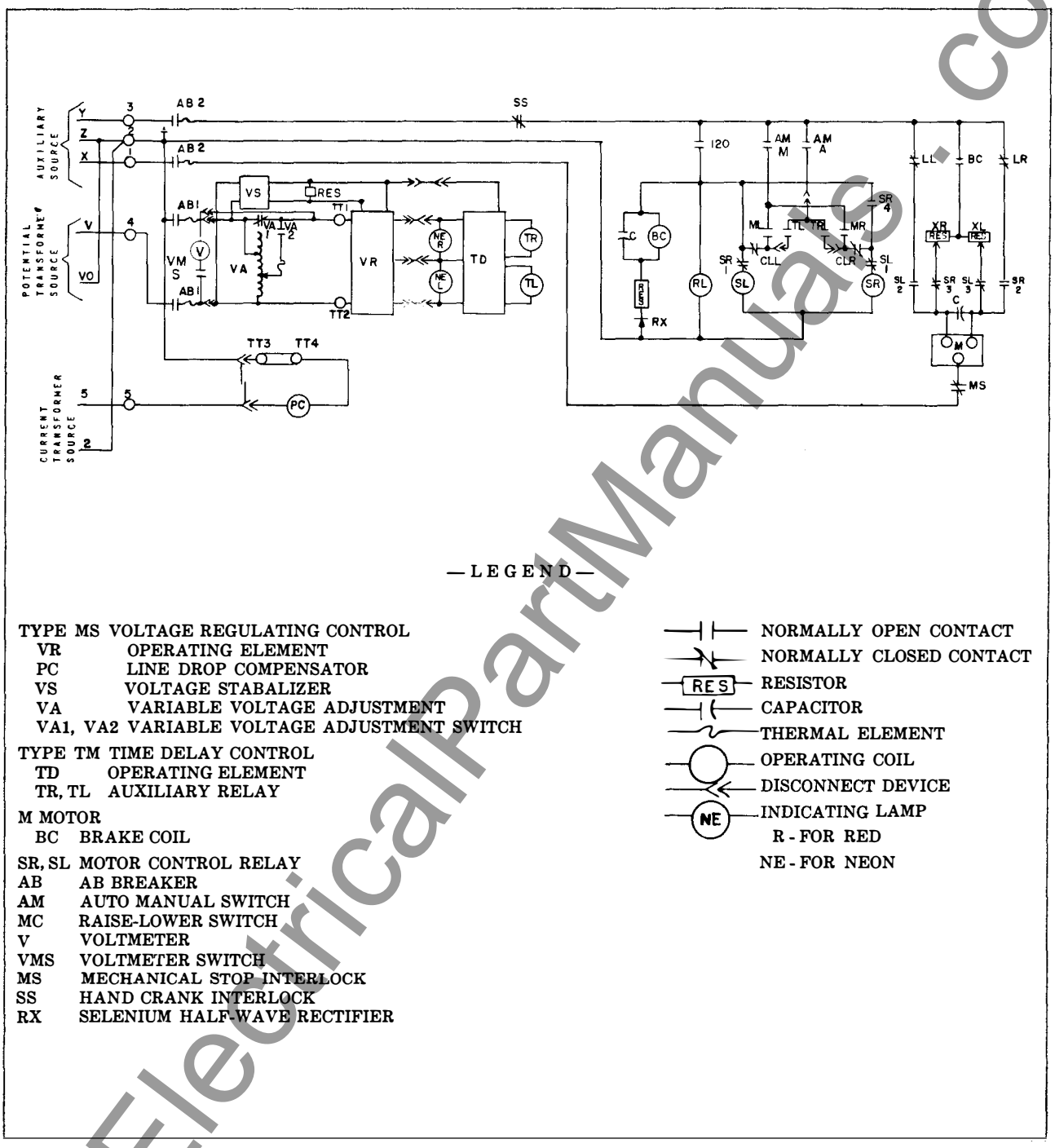


FIG. 8. Typical Schematic Diagram for Type URS Voltage Regulator Control.

M is the tap changer driving motor, located in the oil compartment.

PC is the line drop compensator portion of the MS Voltage Regulating Control.

A mechanical operation counter located on the cam switch assembly is provided to supply a record of the number of tap changer operations.

For some conditions of parallel operation, reverse reactance compensation may be needed. A switch on the front of the Voltage Regulating Control provides a convenient means for accomplishing reversal of the reactance element of the compensator.

VS is a voltage stabilizing transformer used to supply operating voltage to the voltage regulating and time delay control elements VR and TD.

CONTROL CIRCUIT OPERATION

Automatic Operation. Before the regulator can be operated automatically, both AB control breakers must be closed. Closing AB2 energizes the control circuit, except for the voltage regulating control element VR and the time delay element TD. When AB1 is closed, the element VR of the voltage regulating control is energized. An unbalance in applied voltage energizes the time delay element TD. Closing AMA of the Automatic-Manual selector switch completes the set-up for automatic operation.

The voltage regulating control element VR is the initiating element for tap changes when the control is set for "automatic" operation. The control is sensitive to voltage changes on the line which are transmitted to its coils through a voltage transformer connected in one phase of the line. The control is used with a line drop compensator when it is necessary to compensate for the line impedance drop between the regulator and the load center. The line drop compensator is supplied by a current transformer in the regulated line.

WHEN VOLTAGE DROPS: A drop in voltage causes the voltage regulating control to have an output voltage signal which is fed directly into the time delay control element TD, energizing indicating light NER at the same time. If the time delay element remains energized for the set delay time, it will then energize auxiliary relay coil TR which operates to close contact TR. Closing contact TR completes the circuit through the motor control relay coil SR. Energizing the motor control relay, SR, opens contacts SR1 and SR3 and closes contacts SR2 and SR4. Closing contact SR2 energizes the motor to operate the tap changer in the "raise" direction.

While the motor is operating, the 120 cam keeps the RC "DynAC Brake" relay contact BC closed. When the motor control relay opens, SR3 is closed, short circuiting the motor capacitor through SL3, and applying single-phase power to both windings of the motor in parallel, bringing the motor to a smooth, quick stop. After a momentary delay, the RC "DynAC Brake" contact opens, and the unit is ready for further operation.

The reason for using back contact SR1 for lowering operation in preference to a front contact on SL is to return the tap changer to an "On Position" condition, following a power failure during a tap change. When power is restored after such a failure, the motor control relay coil SL is energized through back contact SR1 and cam switch 120 (which is closed when the tap changer is off position), thus returning the tap changer to its next lower position. From this point, voltage adjustment can take place in the usual manner.

The standard Type URS tap changer control is designed for 33-position sequential operation only. When a control is "sequential" the motor control relay will remain energized as long as the voltage applied to the voltage regulator control calls for a tap change. There is only the initial time delay.

Manual Operation: AB2 control breaker must be closed if the tap changer is to be operated manually. AB1 control breaker may be either open or closed. For manual control, contacts AMA of the automatic-manual switch are open and contact AMM is closed. When higher voltage is desired, contact MCR of raise-lower switch is closed, energizing motor control relay coil SR. From this point on, the tap changing, braking, and positioning are the same as for automatic control.

If a voltage lowering operation is desired, contact MCL is closed, energizing motor control relay coil SL. The operation then continues as for automatic control.

MAINTENANCE

Type URS Regulators are designed to operate with a minimum amount of maintenance, but should be given a periodic inspection at least once a year. When maintenance is required, a set of box wrenches, open end wrenches and common hand tools such as pliers and screwdriver are the only tools required.

Most of the operating mechanism operates under oil. All bearings in the main tap changer are oil immersed, but bearings in the air compartment associated with both the operating mechanism and control switches require occasional lubrication with an anticorrosive lubricant. Lubriplate #130-A is recommended.

A periodic inspection of the relays and relay contacts should be made. See Relay Instruction Leaflets (listed in Index) for recommended inspection procedure.

The rate of braking, that is, the point at which the tap changer stops, is adjusted at the factory and should not be changed unless the circuit constants change.

To change the rate of braking, adjust resistors XR and XL. See I.L. 46-713-8 for detailed RC "DynAC Brake" information.

Maintenance of the selector switch contacts will depend to a great extent on the current which they carry.

All main contacts are of the wedge and finger type. With this type of contact, the mechanical forces in the circuit under heavy overloaded do not tend to open the contacts since the forces are in quadrature with the contact pressure forces.

Moving contacts subject to arcing are made of arc-resisting material, and the mating stationary contacts have arc-resisting tips. This construction combines high conductivity with long life.

Replacement should be made before the moving finger shoes have burned sufficiently to reduce the smooth flat contact width to less than ¼ inch and before the stationary contacts burn into the base material to which the arcing tips are brazed. **It is recommended that the entire tap changer be thoroughly inspected at the end of its first year of service, or after its first 35,000 operations, whichever is earlier. The frequency of subsequent inspections can be based on the facts found by this initial inspection.** A complete inspection of the contacts and the operating mechanism should be made at least every third year after the initial inspection.

The oil in the tap changer compartment should be replaced or reconditioned when it tests less than 20 Kv in the standard test cup. Also, the tap changer should not be operated if the oil drops below 16.5 Kv. The oil level in both compartments should be checked at the time of the periodic inspection.

Whenever oil is drained from the tap changer for inspection or maintenance, it is preferable that new, clean, dry, and filtered oil be returned to the tap changer compartment. If for any reason it is found necessary to replace the same oil which was drained from the tap changer, the following precautions must be taken:

1. Be sure the drums used for oil storage are absolutely clean and dry. Inspection of the drums will save much grief.

2. Be sure the oil is filtered before it is returned to the tap changer compartment to remove any carbon, metal particles, or water which might have been present or introduced in handling.

3. The oil should be free of carbon before it is considered satisfactory.

4. After filling the tap changer compartment with oil and before energizing the unit, test at least three representative samples in the standard test cup. The test value should be 25 Kv or better.

5. The tap changer should never be energized when the oil in the housing tests less than 18 Kv in the standard test cup.

The tap changer is equipped with a pressure relief valve to permit the exhausting of gases formed by the interruption of the switching arc in oil. When repainting, care should be exercised that the relief valve be masked or removed to prevent paint clogging the exhaust screen or drain orifice. This screen should be given periodic inspections (at approximately 6-month intervals) for clogging by paint or other foreign material.

The diagram of connections for the control equipment is shown on the wiring diagram furnished with the apparatus and the internal connections for the main regulator are shown on the diagram nameplate.

If for any reason the core and coil assembly should be removed from the tank, it should be stored in a dry place and protected from moisture. Before replacing the core and coil assembly, a determination of the dryness should be made by a megger or a specially designed high resistance voltmeter.

Gaskets should be checked for tightness. Manhole, handhole and inspection plate gaskets may be used repeatedly if cemented only to the removable cover and if care is used when the cover is removed.

SPARE PARTS

Only a minimum of spare parts are required for Type URS tap changer, but it is recommended that a complete set of moving selector contact finger assembles and stationary selector contact blades as well as one set of cover plate gaskets be kept in stock for replacement if necessary.

If a more complete stock is desired, the following additional parts are recommended:

One Motor.

One Motor Control Relay Complete.

SUPPLEMENTARY DATA

* *

This part of the book consists of the supplementary instruction leaflets listed in the Table of Contents, page 3. The leaflets, which follow, are assembled in numerical order.

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