SIEMENS-ALLIS

installation, operation, and care of

# TYPE TLS LOAD TAP CHANGING EQUIPMENT

Power Regulation Division

01X3223-02

# Description of operation

## GENERAL

Type TLS equipment for changing transformer taps under load consists of,

a *dial switch* for each phase, mounted in an oil-filled compartment on the side of the transformer.

a *mid-tapped auto-transformer* mounted inside the main transformer case, and

an electrically-driven, *quick-break operating mechanism* located in the dial switch compartment, directly connected to the dial switch.

Although the tap changing compartment is completely isolated from the oil in the main tank, the same grade is used in both.

When the current or voltage of the unit exceeds the maximum rating of the tap changer, a series transformer is added. It is located in the main transformer case.

## OPERATING PRINCIPLE

The winding arrangement, number of steps and voltage range vary for individual applications. Examine the nameplate and connection diagram on the transformer or the drawing included with the instruction book for details of the particular arrangement used.

Three fundamental circuits for load tap changing are shown in Figs. 2, 3 and 4. Each covers a 20 percent range in thirty-two 5/8 percent steps. The eight taps from the tapped winding are connected to wide stationary contacts on the dial switch. Two moving contacts, "A" and "B", are connected to opposite ends of the mid-tapped auto-transformer. The distance between these contacts is fixed. They move as a unit from one operating position to the next with snap action.

The fixed space between contacts "A" and "B" is such that in any operating position, they are both on one stationary contact, or, "A" is on one contact while "B" is on the adjacent contact. In moving from one operating position to the next, the arc formed during contact break is completely extinguished before the complete or full tap change is made. The space between the stationary contacts is much greater than the width of a single moving contact so that it *cannot* be bridged.

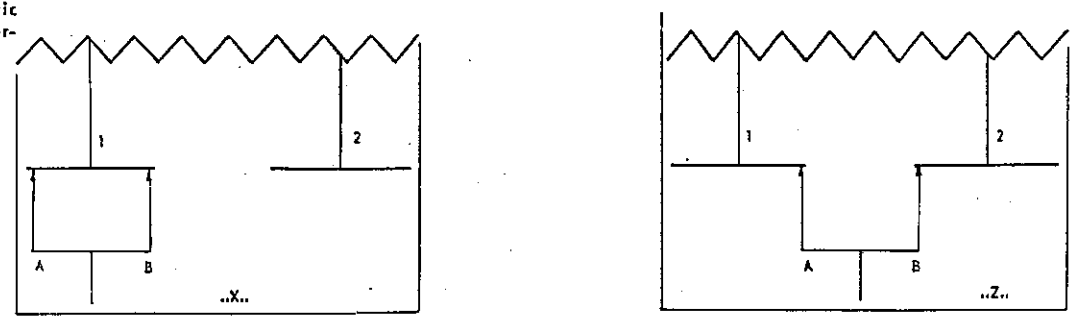
To change taps from position "X," Figure 1, where contacts "A" and "B" are both on contact 1, to position "Z," the moving contacts snap over so that "B" connects to contact "2." But "A" remains on contact "1."

During the interval that "B" is crossing the gap between contacts 1 and 2, the load current is carried entirely by the half of the mid-tapped auto transformer winding connected to "A", but as soon as "B" is in contact with 2, the load current again equally divides between the two halves of the auto transformer winding, and the voltage obtained is midway between that of taps connected to stationary contacts 1 and 2.

To change voltage in the opposite direction the mechanism is reversed. The table gives the operating positions throughout the 20 percent range for the connection diagram shown in Fig. 2.

For 32-step operation, with eight taps as shown in Figs. 2, 3 and 4, a reversing switch is used. It operates automatically when the mechanism passes

FIG. 1 — Schematic diagram of TLS operation cycle.



through the neutral position. The reversing switch performs one of the following functions depending upon the circuit arrangement used:

cuts in or out a fixed portion of turns in the main winding (Fig. 2).

reverses the polarity of the tapped or series winding (Fig. 3).

reverses the polarity of the voltage applied to the series transformer (Fig. 4).

Stationary contact "O" is the neutral position. When the mechanism is on this position, no part of the tapped winding is connected in the load tap changing circuit. The reversing switch can therefore be moved from contact "M" to "K" or vice-versa without breaking any current. The reversing switch moves automatically before the mechanism goes from contact "O" to the first raise or lower position.

TYPICAL SEQUENCE OF OPERATION—
20% RANGE WITH CIRCUIT SHOWN IN FIG. 2
FOR STEP-DOWN OPERATION

| Percent Output Voltage | Position No. | "A" Connected to Tap No. | "B" Connected to Tap No. | Reversing Switch 9 On |
|---|---|---|---|---|
| 90 | 16L | 1 | 1 | |
| 90⅝ | 15L | 1 | 2 | |
| 91¼ | 14L | 2 | 2 | |
| 91⅞ | 13L | 2 | 3 | |
| 92½ | 12L | 3 | 3 | |
| 93⅛ | 11L | 3 | 4 | |
| 93¾ | 10L | 4 | 4 | |
| 94⅜ | 9L | 4 | 5 | K |
| 95 | 8L | 5 | 5 | |
| 95⅝ | 7L | 5 | 6 | |
| 96¼ | 6L | 6 | 6 | |
| 96⅞ | 5L | 6 | 7 | |
| 97½ | 4L | 7 | 7 | |
| 98⅛ | 3L | 7 | 8 | |
| 98¾ | 2L | 8 | 8 | |
| 99⅜ | 1L | 8 | 0 | |
| 100 | N | 0 | 0 | M or K |
| 100⅝ | 1R | 0 | 1 | |
| 101¼ | 2R | 1 | 1 | |
| 101⅞ | 3R | 1 | 2 | |
| 102½ | 4R | 2 | 2 | |
| 103⅛ | 5R | 2 | 3 | |
| 103¾ | 6R | 3 | 3 | |
| 104⅜ | 7R | 3 | 4 | |
| 105 | 8R | 4 | 4 | M |
| 105⅝ | 9R | 4 | 5 | |
| 106¼ | 10R | 5 | 5 | |
| 106⅞ | 11R | 5 | 6 | |
| 107½ | 12R | 6 | 6 | |
| 108⅛ | 13R | 6 | 7 | |
| 108¾ | 14R | 7 | 7 | |
| 109⅜ | 15R | 7 | 8 | |
| 110 | 16R | 8 | 8 | |

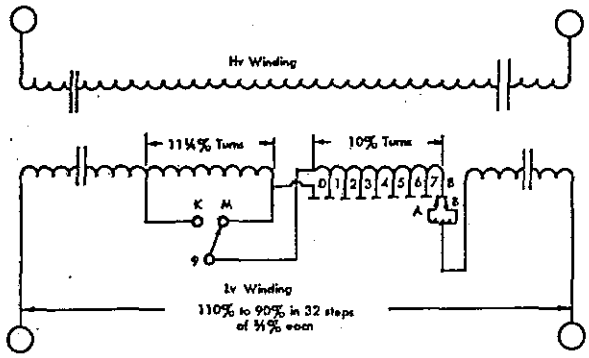



FIG. 2 — Connection diagram of typical load tap changing transformer with single core. The reversing switch cuts in or out 11¼ percent of the main winding. This method is used for majority of power transformers.

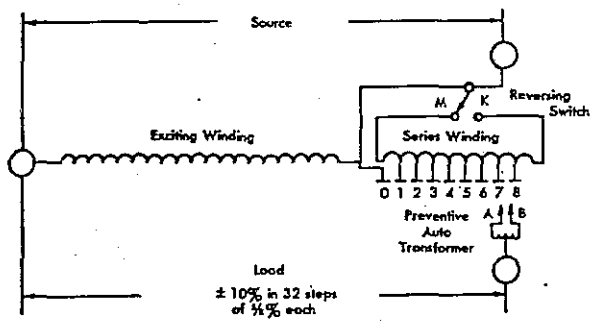



FIG. 3 — Connection diagram of typical regulator with single core. The reversing switch reverses the polarity of the series or tapped portion of the winding.

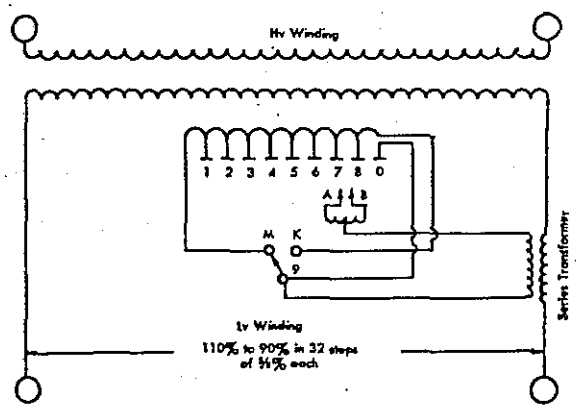



FIG. 4 — Connection diagram of typical LTC transformer with series transformer. The reversing switch reverses the polarity of voltage applied to the series transformer. This method is often used for auto-transformers and in cases where voltage or current of the regulated winding are excessive.

# Major Components

## DIAL SWITCH

The dial switch consists of an outer circle of nine stationary contacts and two inner concentric collector rings, all mounted on a heavy insulating panel. The two rotating contacts, "A" and "B," are mounted on a single bakelite arm, item 4719 (centerfold). Distance between the moving contacts is fixed and they are insulated from each other. Each is connected to its own collector ring.

The connection between moving and stationary parts is made through a pair of contact fingers that wipe on both sides of the stationary contacts. The dynamic forces caused by heavy short-circuit currents, therefore, increase contact pressure.

All contacts are large and arcing surfaces are made of special sinterized alloys which possess excellent arc-resisting qualities. Two bolt terminals are provided on the rear of the dial switch for connecting the tap leads.

## QUICK-BREAK MECHANISM

The rotating arm that carries the tap changer moving contacts is driven by a quick-break mechanism. Mechanism operating cycle is shown in Fig. 5.

The mechanism consists of a stationary index plate (1) with a notch for each operating position, an actuating disc (2) connected to the driving motor, and an interlock disc (4) connected to the drive plate arm. A latch (3) on the interlock disc engages with the slots in the index plate to hold the disc in position. Two driving springs (5) are connected between the actuating disc and the interlock disc and are the only couplings between them. In any balanced position, such as (A), both springs are under initial compression.

When the system calls for a voltage change, the driving motor is energized and the actuating disc (2) rotates as shown in (B). Since the latch holds the interlock disc in place, it cannot move and the compression of the left-hand driving spring is in-

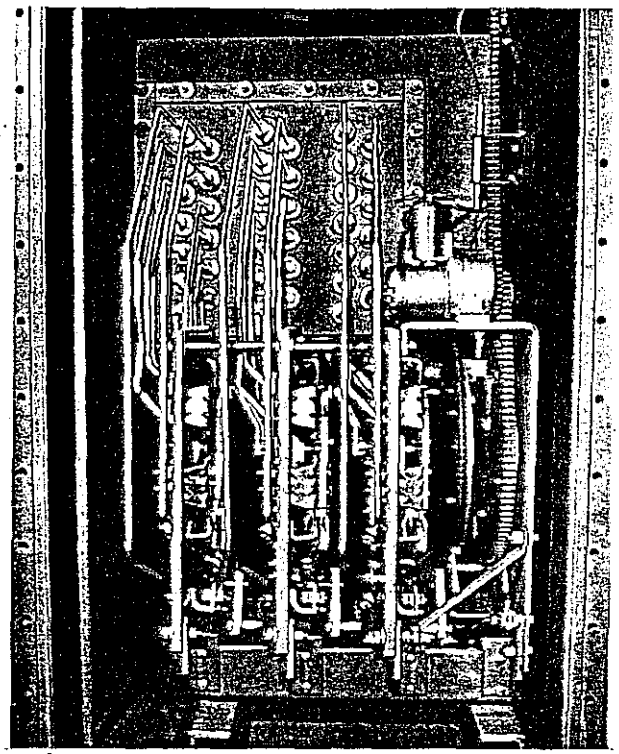


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FIG. 6 — Load tap changing mechanism for three-phase unit, inspection door open.

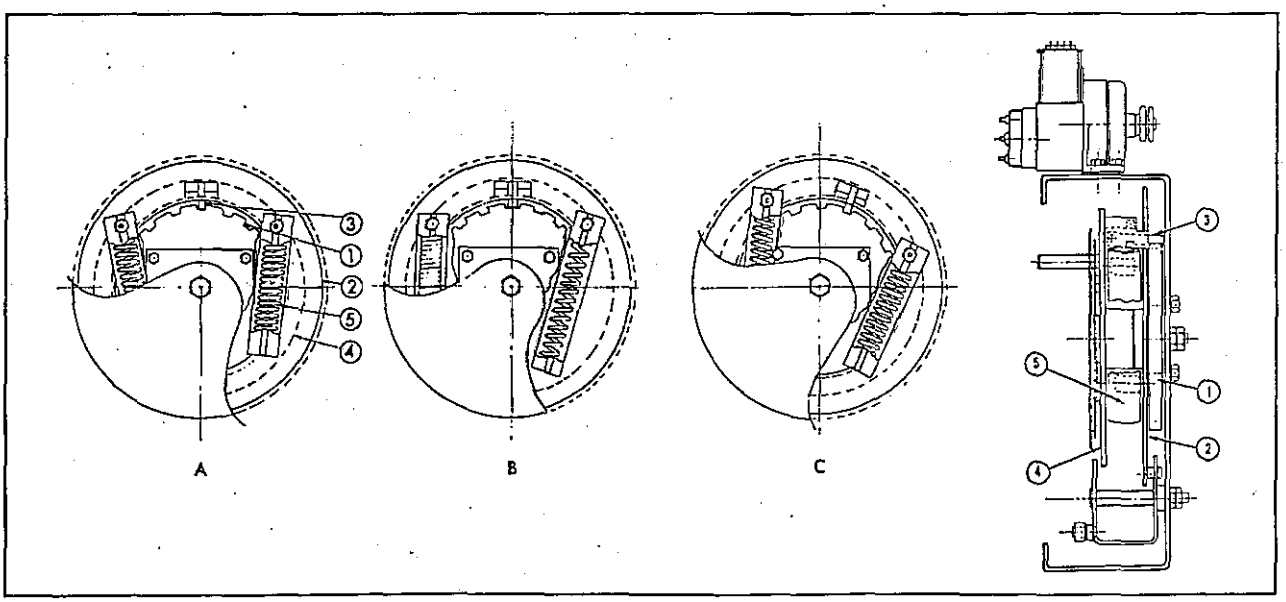



FIG. 5 — Operating cycle of Type TLS Quick-Break mechanism.

creased at the same time that of the right-hand driving spring is decreased. The interlock disc and hence the tap change switch, are held in place by the latch until the driving spring becomes fully energized, then the cam face in the actuating disc lifts the latch in the slot. From position (B) just before the cam has lifted the latch out of the slot, a slight further clockwise rotation lifts the latch completely and allows the force of the spring to move the interlock disc quickly into the next position (C).

As the interlock disc snaps into each position, the de-energized spring and the latch dropping into the slot stop the motion and correctly locate the mechanism in its new position.

With this type of mechanism there is no need for brakes because it is not necessary for the motor to stop in any particular position. The motor may be operated continuously and the mechanism will move the tap changing switch in short, quick steps.

## ASSEMBLED MECHANISM

The complete tap changing mechanism for a three-phase unit is shown inside the oil-sealed case in Fig. 6. All moving parts requiring lubrication are completely submerged in oil. The driving motor is a single-phase, capacitor type and operates on 120-volt, ac.

The position indicator (Fig. 7), is operated mechanically and carries maximum and minimum drag hands to indicate the range passed over since the previous inspection. These drag hands can be reset by pushing the reset button provided in the control compartment. The position indicator moving section is also used to operate the "raise" and "lower" limit switches, which are located in the position indicator housing.

## REMOTE POSITION INDICATOR

When a remote position indicator is required, the Type AS, high-torque, synchronous position indicator is furnished (Fig. 9). It consists of a transmitter, connected directly through a gear arrangement to the mechanism (Fig. 12), and one or more receivers or indicators as required. The transmitter has sufficient torque to accurately operate as many as six remote indicators.

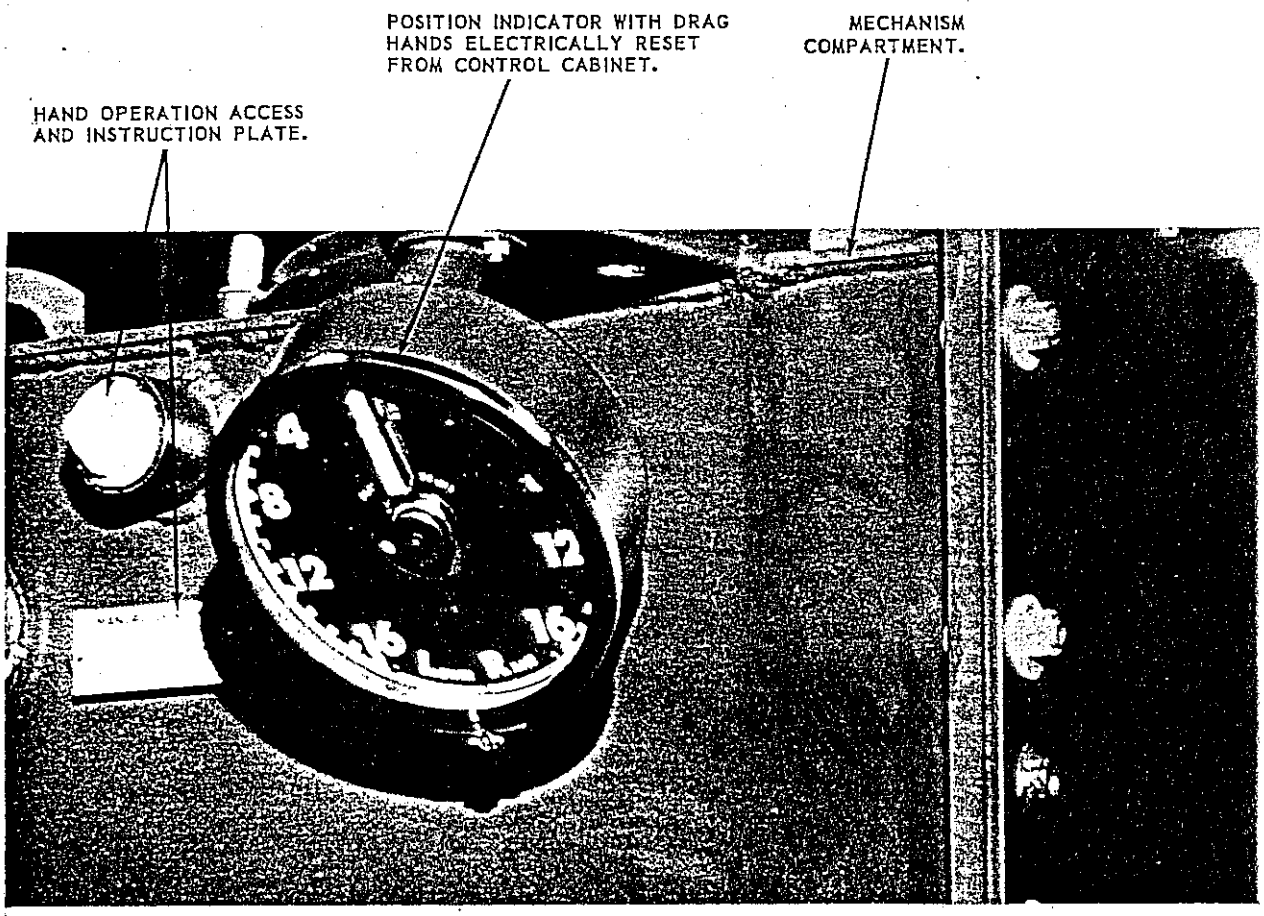



FIG. 7 — Typical view of Position Indicator and Hand Operation access on load tap changer compartment.

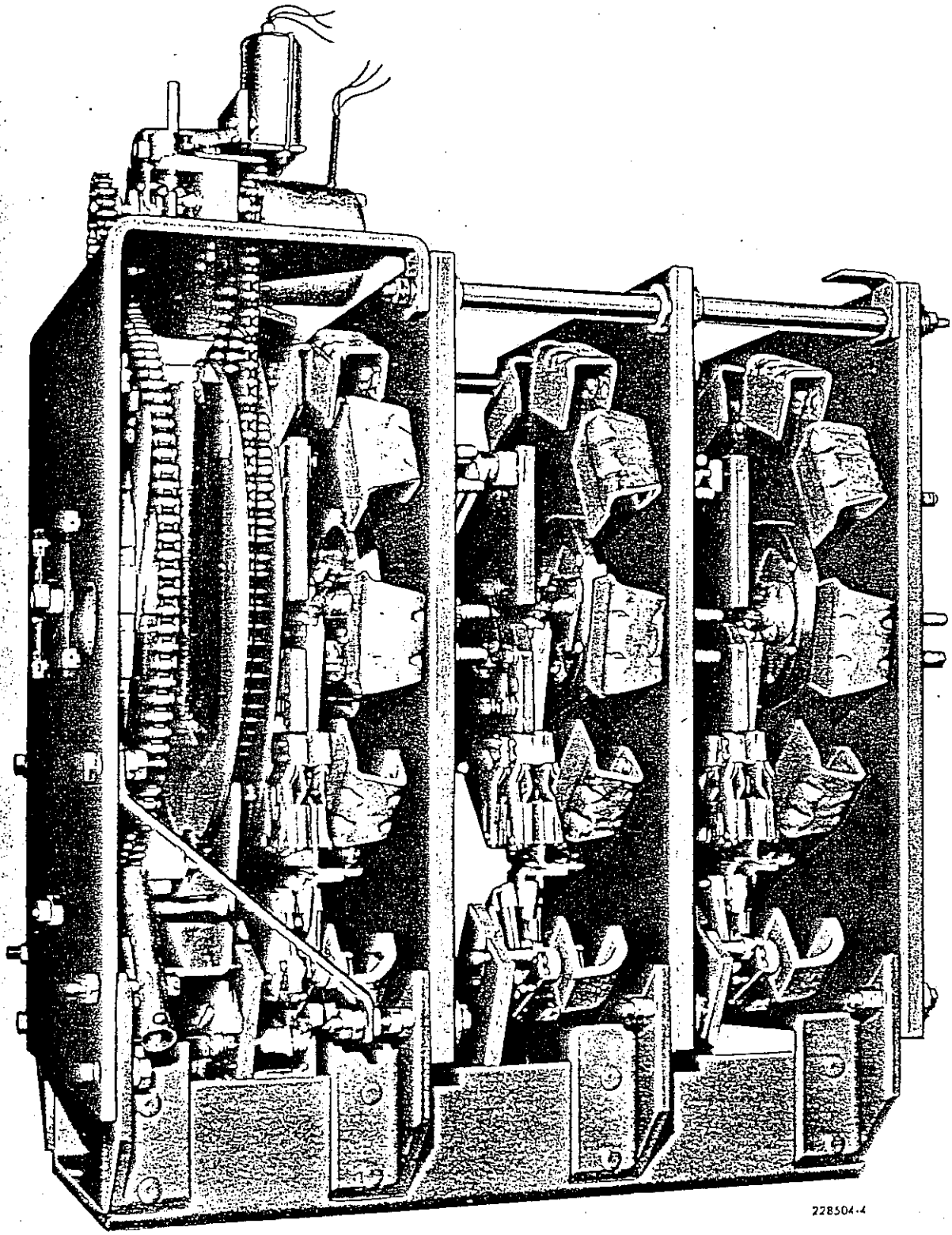
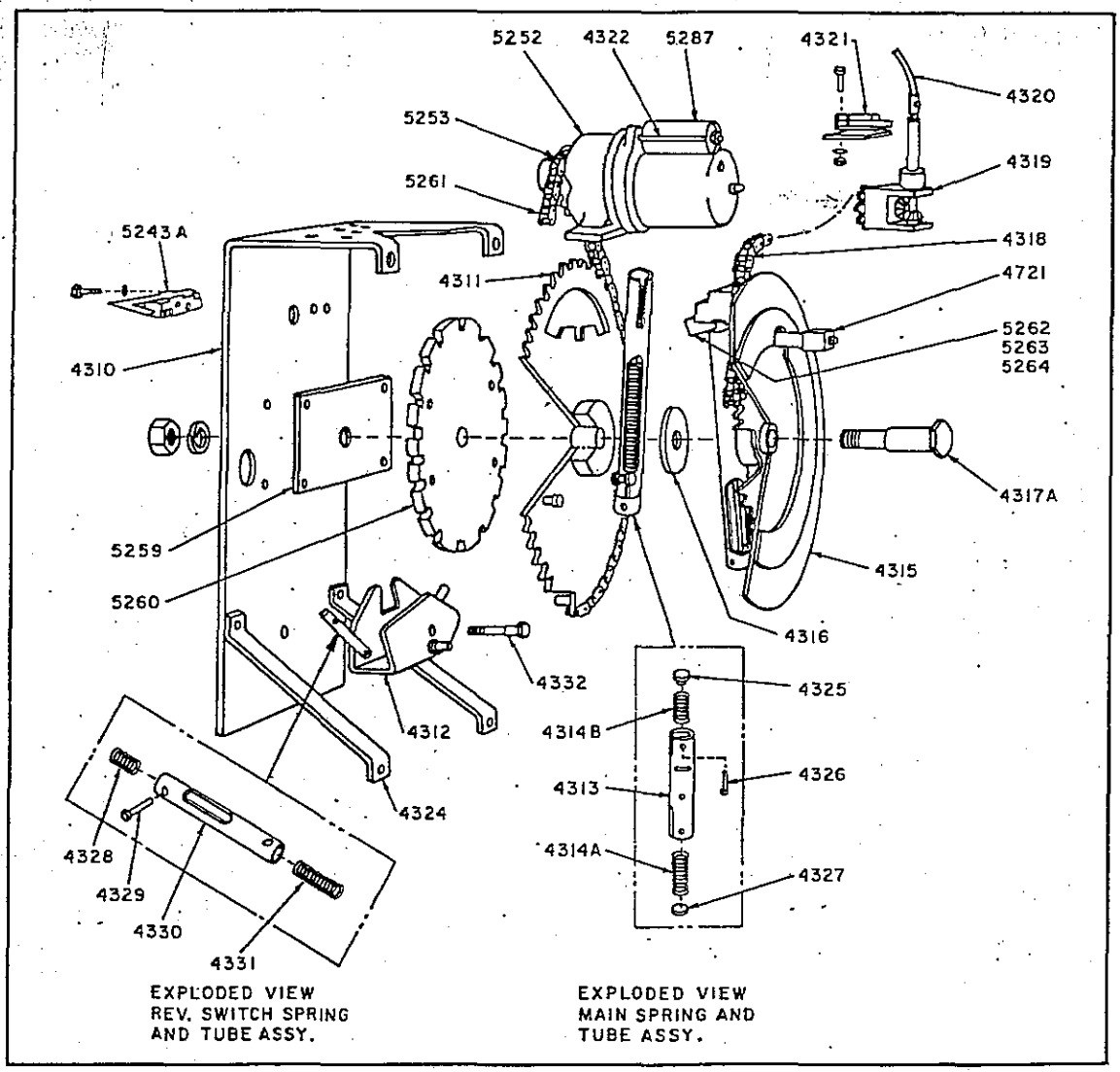



FIG. 12 — Assembled view of Type TLS load tap changer.

# TYPE TLS LOAD TAP CHANGER

## FOR
## THREE PHASE REGULATORS
## AND
## LOAD TAP CHANGING TRANSFORMERS
### (Quick Break Mechanism)



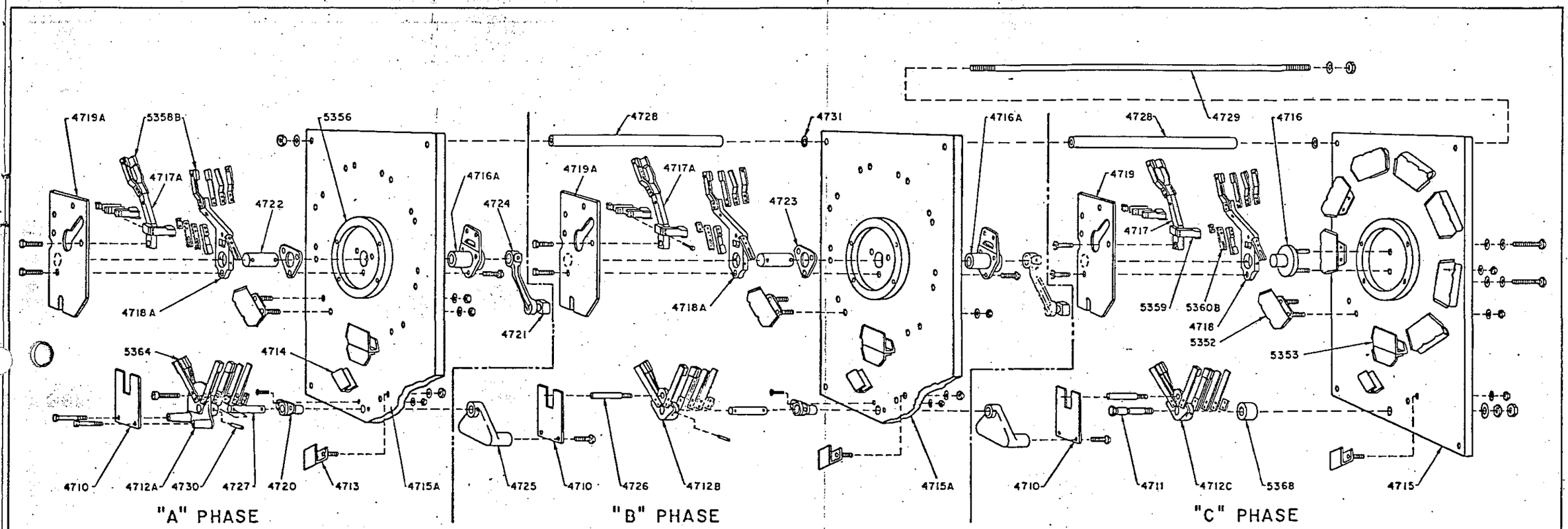

| Item | Description |
|---|---|
| 01-11-4310 | Mounting Frame |
| 4311 | Actuating Disc and Sprocket |
| 4312 | Reversing Switch Drive Arm |
| 4313 | Drive Spring Tube |
| 4314A | Main Drive Spring |
| 4314B | Snubbing Spring |
| 4315 | Interlock Disc and Drive Sprocket Assembly |
| 4316 | Brass Spacer Washer |
| 4317A | Quick Break Mechanism Shaft |
| 4318 | Drive Chain — Position Indicator |
| 4319 | Position Indicator Actuator |
| 4320 | Flexible Shaft |
| 4321 | Operation Counter Switch Assembly |
| 4322 | Capacitor Mounting Bracket |
| 4324 | Brace |
| 4325 | Spring Cap |
| 4326 | Pin |

| Item | Description |
|---|---|
| 01-11-4327 | Spacer Washer |
| 4328 | Snubbing Spring |
| 4329 | Retaining Pin |
| 4330 | Reversing Switch Spring Tube |
| 4331 | Reversing Switch Toggle Spring |
| 4332 | Turned Bolt |
| 4721 | Adjusting Block |
| 5243A | Neutral Switch |
| 5252 | Motor Assembly w/Capacitor & Sprocket |
| 5253 | Motor Sprocket |
| 5259 | Spacer |
| 5260 | Index Plate |
| 5261 | Main Drive Chain |
| 5262 | Latch |
| 5263 | Latch Spring |
| 5264 | Latch Pin |
| 5287 | Motor Capacitor |

*Please specify serial number of unit when ordering parts.

# GANGED DIAL SWITCH ASSEMBLIES

Equipped with Standard Reversing Switch)




**NOTE:** See Fig. 2 Page 3 for Typical Connection Diagram.

| Item | Description | For Phase |
|---|---|---|
| 01-11-4710 | Drive Arm — Reversing Switch | A-B-C |
| 4711 | Shaft — Reversing Switch | C |
| 4712A | Contact Support — Reversing Switch | A |
| 4712B | Contact Support — Reversing Switch | B |
| 4712C | Contact Support — Reversing Switch | C |
| 4713 | Reversing Switch Stationary Contact R.H. | A-B-C |
| 4714 | Reversing Switch Stationary Contact L.H. | A-B-C |
| 4715 | Bakelite Panel | C |
| 4716A | Bakelite Panel | A-B |
| 4716 | Shaft — Collector Hub | C |
| 4716A | Collector Hub | A-B |
| 4717 | Contact Finger Support | C |

**NOTE:** Except for some Reversing Switch components "A and "B Phase are duplicates.

| Item | Description | For Phase |
|---|---|---|
| 01-11-4717A | Contact Finger Support | A-B |
| 4718 | Contact Finger Support | C |
| 4718A | Contact Finger Support | A-B |
| 4719 | Bakelite Drive Arm | C |
| 4719A | Bakelite Drive Arm | A-B |
| 4720 | Bearing | A-B |
| 4721 | Adjusting Block | A-B-C |
| 4722 | Drive Shaft | A-B |
| 4723 | Flange | A-B |
| 4724 | Fork Crank | A-B |
| 4725 | Reversing Switch Drive Casting | B-C |
| 4726 | Reversing Switch Drive Pin | B-C |

| Item | Description | For Phase |
|---|---|---|
| 01-11-4727 | Reversing Switch Drive Shaft | A-B |
| 4728 | Spacer Tube | B-C |
| 4729 | Tie Rod | — |
| 4730 | Drive Pin | A-B |
| 4731 | Spacer Washer | A-B-C |
| 5352 | Stationary Contact — Main | A-B-C |
| 5353 | Stationary Contact — Neutral | A-B-C |
| 5356 | Collector Ring | A-B-C |
| 5358B | Main Finger Assembly | A-B-C |
| 5359 | Collector Ring Finger Assembly | A-B-C |
| 5360B | Collector Hub Finger Assembly | A-B-C |
| 5364 | Reversing Switch Finger Assembly | A-B-C |
| 5368 | Spacer | C |

*Please specify serial numbers of unit when ordering parts.

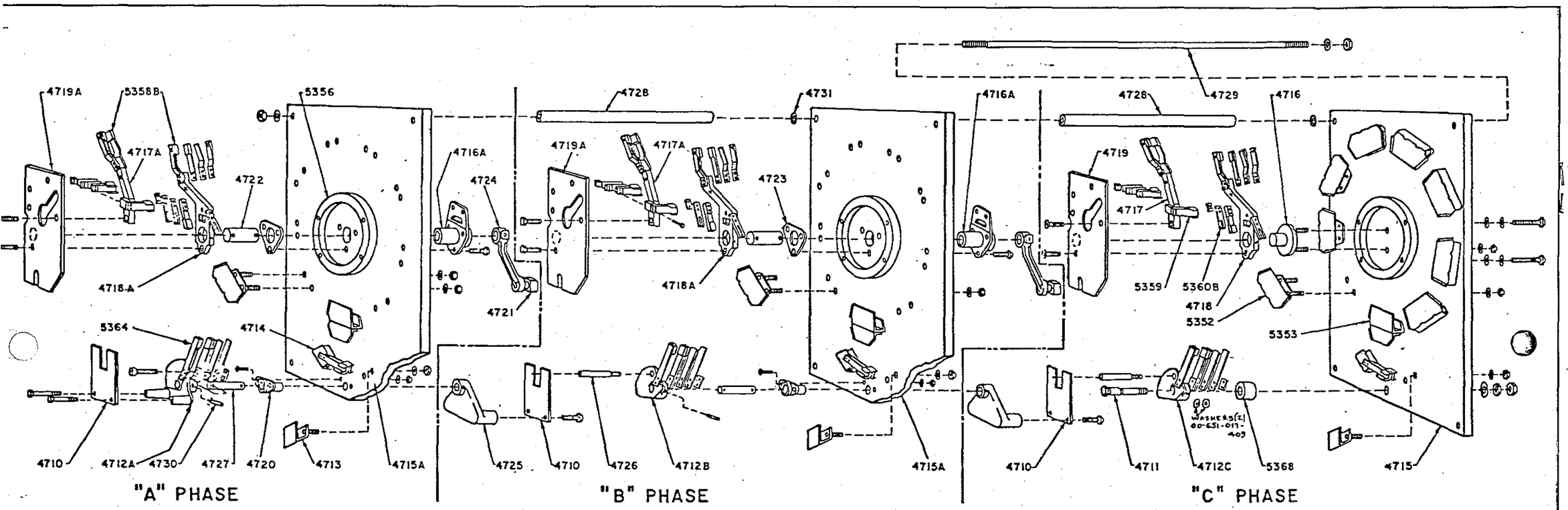
# TLS LOAD TAP CHANGER

FOR

LOAD TAP CHANGING TRANSFORMERS

## GANGED DIAL SWITCH ASSEMBLIES

Equipped with Isolated Reversing Switch




NOTE: See Fig. 2 or Fig. 4 Page 3 for Typical Connection Diagram.

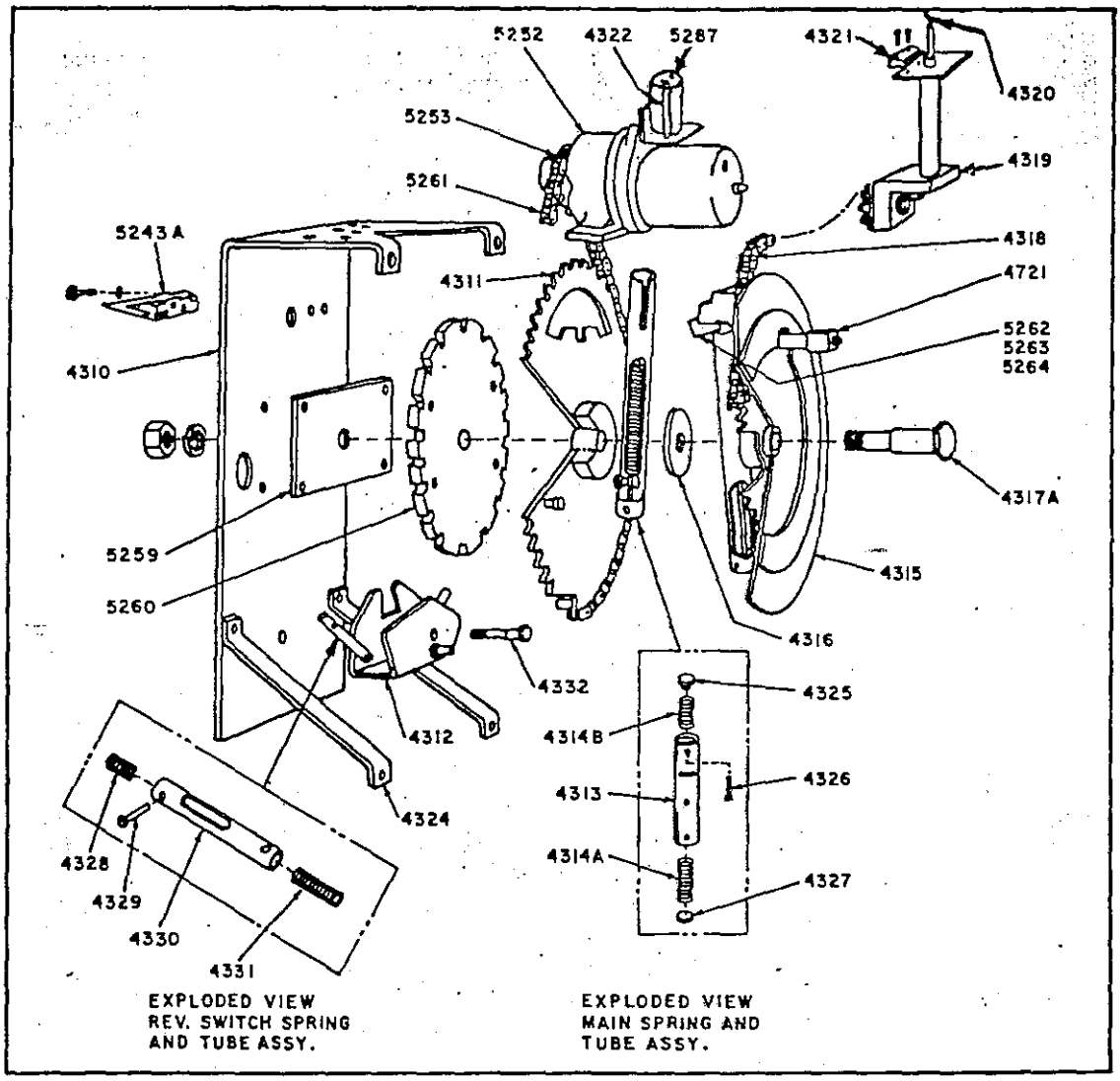
| Item | Description | For Phase |
|---|---|---|
| 01-11-4710 | Drive Arm — Reversing Switch | A-B-C |
| 4711 | Shaft — Reversing Switch | C |
| 4712A | Contact Support — Reversing Switch | A |
| 4712B | Contact Support — Reversing Switch | B |
| 4712C | Contact Support — Reversing Switch | C |
| 4713 | Reversing Switch Stationary Contact R.H. | A-B-C |
| 4714 | Reversing Switch Stationary Contact L.H. | A-B-C |
| 4715 | Bakelite Panel | C |
| 4715A | Bakelite Panel | A-B |
| 4716 | Shaft — Collector Hub | C |
| 4716A | Collector Hub | A-B |
| 4717 | Contact Finger Support | C |

| Item | Description | For Phase |
|---|---|---|
| 01-11-4717A | Contact Finger Support | A-B |
| 4718 | Contact Finger Support | C |
| 4718A | Contact Finger Support | A-B |
| 4719 | Bakelite Drive Arm | C |
| 4719A | Bakelite Drive Arm | A-B |
| 4720 | Bearing | A-B |
| 4721 | Adjusting Block | A-B-C |
| 4722 | Drive Shaft | A-B |
| 4723 | Flange | A-B |
| 4724 | Fork Crank | A-B |
| 4725 | Reversing Switch Drive Casting | B-C |
| 4726 | Reversing Switch Drive Pin | B-C |

| Item | Description | For Phase |
|---|---|---|
| 01-11-4727 | Reversing Switch Drive Shaft | A-B |
| 4728 | Spacer Tube | B-C |
| 4729 | Tie Rod | — |
| 4730 | Drive Pin | A-B |
| 4731 | Spacer Washer | A-B-C |
| 5352 | Stationary Contact — Main | A-B-C |
| 5353 | Stationary Contact — Neutral | A-B-C |
| 5356 | Collector Ring | A-B-C |
| 5358B | Main Finger Assembly | A-B-C |
| 5359 | Collector Ring Finger Assembly | A-B-C |
| 5360B | Collector Hub Finger Assembly | A-B-C |
| 5364 | Reversing Switch Finger Assembly | A-B-C |
| 5368 | Spacer | C |

*Please specify serial number of unit when ordering parts.

# QUICK BREAK MECHANISM




| Item | Description |
|---|---|
| 01-11-4310 | Mounting Frame |
| 4311 | Actuating Disc and Sprocket |
| 4312 | Reversing Switch Drive Arm |
| 4313 | Drive Spring Tube |
| 4314A | Main Drive Spring |
| 4314B | Snubbing Spring |
| 4315 | Interlock Disc and Drive Sprocket Assembly |
| 4316 | Brass Spacer Washer |
| 4317A | Quick Break Mechanism Shaft |
| 4318 | Drive Chain — Position Indicator |
| 4319 | Position Indicator Actuator |
| 4320 | Flexible Shaft |
| 4321 | Operation Counter Switch Assembly |
| 4322 | Capacitor Mounting Bracket |
| 4324 | Brace |
| 4325 | Spring Cap |
| 4326 | Pin |

| Item | Description |
|---|---|
| 01-11-4327 | Spacer Washer |
| 4328 | Snubbing Spring |
| 4329 | Retaining Pin |
| 4330 | Reversing Switch Spring Tube |
| 4331 | Reversing Switch Toggle Spring |
| 4332 | Turned Bolt |
| 4721 | Adjusting Block |
| 5243A | Neutral Switch |
| 5252 | Motor Assembly w/Capacitor & Sprocket |
| 5253 | Motor Sprocket |
| 5259 | Spacer |
| 5260 | Index Plate |
| 5261 | Main Drive Chain |
| 5262 | Latch |
| 5263 | Latch Spring |
| 5264 | Latch Pin |
| 5287 | Motor Capacitor |

*Please specify serial number of unit when ordering parts.

The transmitter and receivers are similar in design and operate from a single-phase, 120-volt, ac source. The rotors are three-winding wye-connected. Only five wires are required between the transmitter and each receiver as shown in the connection diagram (Fig. 8).

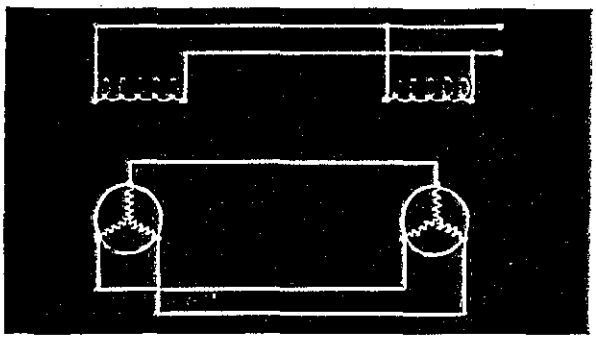


FIG. 8 — Connection diagram for Type AS remote position indicator.

## CONTROL

Load tap changing equipment may be arranged for pushbutton control from the station switchboard or for automatic control. Local control, mounted on the transformer, is always furnished in addition to remote or automatic control.

## MANUAL OPERATION

If automatic control is furnished, a control switch on the panel is used to "raise" or "lower" the voltage or to select automatic operation when desired. If automatic control is not furnished, "raise" and "lower" switches are provided in the control cabinet for manual control.

To move the mechanism to a "raise" position, turn the control switch to "raise" (or operate the manual "raise" switch if so equipped). This will complete the circuit to the drive motor through the "raise" limit switch which is normally closed unless the mechanism is on the maximum "raise" position. The drive motor will then move the mechanism in the "raise" direction.

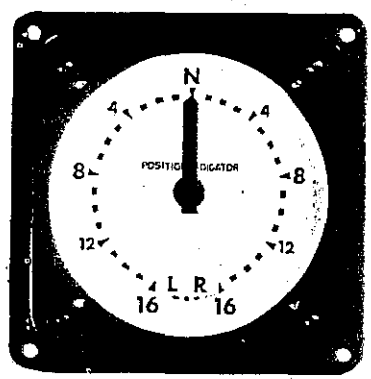



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FIG. 9 — Type AS remote position indicator.

## AUTOMATIC OPERATION

PCS (of Fig. 10) is set on "automatic." Refer to separate instructions for complete details on operation of the automatic control circuit.

## HAND OPERATION

Type TLS equipment may be hand operated by removing the cranking device from the storage clamp inside the control box and inserting it through an access hole in the tank wall to engage with a shaft on the mechanism drive. Normally this access hole is covered with a pipe cap. See Fig. 7.

Removing the cranking device from the storage clamp opens a switch that breaks the circuit to the motor so that the mechanism cannot be operated electrically until the cranking device is returned to the storage clamp.

# Installation and Inspection

## INSTALLING

Type TLS load tap changing equipment is shipped completely assembled on the transformer ready for operation. In some cases, the transformer is shipped with the mechanism compartment filled with oil, although oil for the main tank may be shipped separately. *Make certain the oil is at the proper level and has a dielectric strength of 26 kv minimum in all compartments before energizing the transformer.*

Remove plugs from both upper and lower breather openings in the mechanism compartment. See transformer outline drawing for location. Remove any temporary bracing and blocking. These are marked with tags or painted yellow to distinguish them from permanent parts.

## INSPECTING

The load tap changing equipment has been thoroughly inspected and tested at the factory. However, it is good installation practice to make a thorough examination of the equipment internally and externally before putting the transformer in service. Along with detecting any possible damage or shifting during shipment, such an inspection offers an opportunity for operating, maintenance, and other personnel to become familiar with the mechanism. The following procedure is suggested:

1. Before removing any oil from the tap changer compartment, check the storage containers very closely for contaminants. Clean the containers thoroughly and rinse them with clean transformer oil. Drain the compartment.

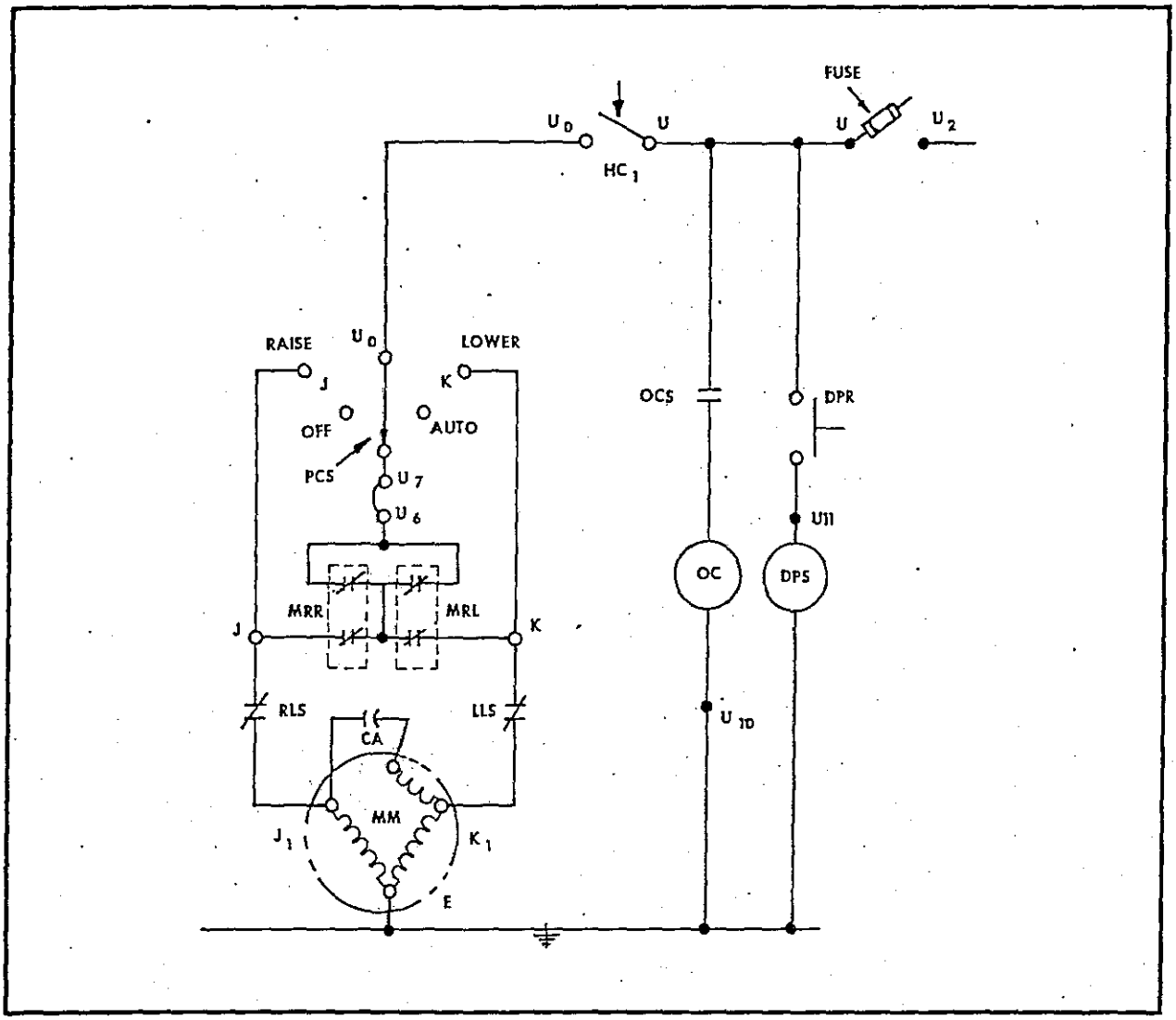


FIG. 10 — Basic TLS Control Diagram. (Before energizing the control, check Schematic Control Diagram included with instruction book. See separate instructions for complete description of Automatic Control when furnished.)

| | | | |
|---|---|---|---|
| CA | Capacitor | MRL | Motor relay — lower |
| DPR | Position indicator drag pointer reset button | MRR | Motor relay — raise |
| DPS | Position indicator drag pointer solenoid | OC | Operation counter |
| HCI | Hand crank disconnect | OCS | Operation counter switch |
| LLS | Lower limit switch | RLS | Raise limit switch |
| MM | Mechanism motor | PCS | Panel Control Switch |

2. Open the large inspection door on the side of the tap changer compartment.

3. Check all nuts, bolts, and connections on the mechanism for tightness. Make certain all locking nuts and similar devices are firmly in place.

4. Examine the bakelite panels carefully for cracks.

5. See that all control wiring connections are tight on terminal blocks, relays, limit switches, and similar places.

6. *Precautions Before Operating.* If the transformer is equipped with automatic control, and if the regular potential source is connected, the panel can be energized by switching the voltage source switch to "Internal." Be sure that fuses on the control panel are good and that they are securely locked in place. Panel selector switch should be on "Off."

A temporary 120-volt 60-cycle supply can also be used. To accomplish this, turn the panel selector switch to "Off" and the voltage source switch to "External." Do not remove the fuses from the *Accu/Stat* control panel. *Note:* Removing both fuses will de-energize control panels potential sensing and mechanism motor circuits regardless of position of voltage source switch. ("Panel" fuse for po-

tential circuit and "Motor" fuse for mechanism motor circuit. Connect the ground side of the 120-volt 60-cycle supply to external unmarked source terminal (white) and the ungrounded side to external source terminal "Ground" (yellow) on the front of the control panel.

*Caution:* Do not connect any voltage source to the voltmeter test terminals as this may energize the transformer windings and bushing terminals to full line voltage through the potential transformer.

While the compartment is open, operate the mechanism by hand to check the linkages.

Observe the reversing switch closely as the mechanism passes through the neutral position. The reversing switch must operate *before* the moving contacts leave stationary contact "O" in either the "raise" or "lower" direction.

If any indication is found of shifting, misalignment, or binding, or if the mechanism fails to operate properly in any way, contact your nearest Siemens-Allis sales office.

7. When the inspection is completed, close the inspection door. Usually, Buna "N" rubber gaskets are used on the inspection door. Such gaskets are reusable. Otherwise, new gaskets are furnished which can be used if necessary.

8. Refill the compartment with oil to the proper level. We recommend that it be passed through a filter press. Test the dielectric strength of the oil after the compartment is filled. It must test at least 26 kV before the unit is energized.

# Maintenance

Type TLS load tap changing equipment is built to withstand severe operating conditions with a minimum amount of maintenance. All moving parts of the tap changer that require lubrication, including the drive motor, are completely immersed in oil. The motor has no commutator, slip rings, brushes, or centrifugal switch. All dial switch contacts are large and sturdy. Those which interrupt current are either made of highly resistant alloys or have inserts of such material.

However, a periodic inspection of the complete mechanism is recommended. If complete inspection is made during installation, the first routine check should be made at the end of the first year or after 20,000 operations, whichever comes first. Make this inspection sooner if the mechanism is not checked initially.

## ROUTINE INSPECTION

Drain the oil and open the side inspection door. Go over the mechanism, checking tightness of all nuts and bolts, as described for initial inspection. In addition, examine the reversing switch contacts for any sign of arcing which would indicate the drive mechanism is out of adjustment. Examine the stationary and moving contacts for wear. Also test the dielectric strength of the oil. Oil testing below 22 kv should be filtered.

This inspection will give an indication of the time to allow before the next one. If the mechanism is tight and contacts show no appreciable wear, two or three years may be allowed. However, a yearly check is desirable and the oil should be checked every 6 months.

It is possible to obtain a good idea as to the condition of the tap changing equipment and also to detect approaching trouble by the sound of the mechanism. Immediately after the transformer is put on the line and the mechanism begins operating, listen carefully to it as it operates under oil. Then periodically (4 to 8 months) operate the mechanism in both the "raise" and "lower" directions and listen for any change in the sound.

Almost any condition that might lead to serious trouble will produce a distinct change in the sound when the equipment operates. By correct interpretation of sound variations, the work of draining the oil and opening the dial switch compartment can be avoided for longer periods of time.