INSTRUCTION BOOK

File #111

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

Westinghouse Electric Corporation

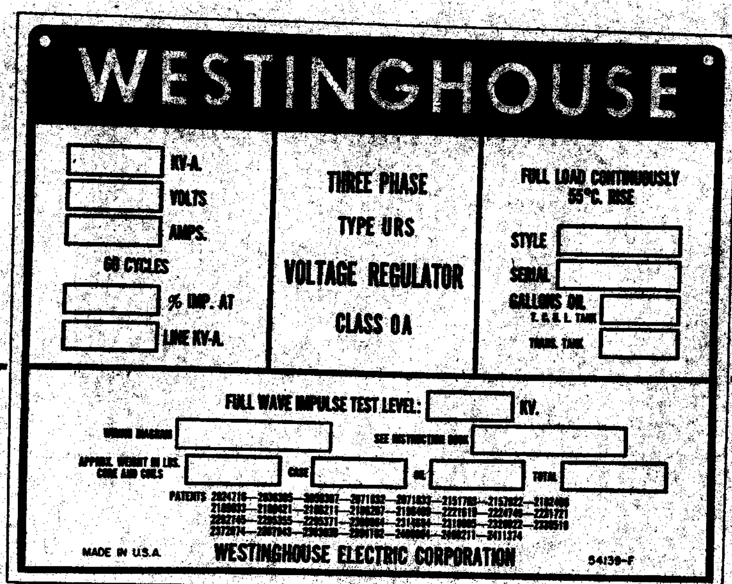
I.B. 41-310-1

SPECIAL INQUIRIES

When communicating with Westinghouse regarding the product covered by this Instruction Book, include all data contained on the nameplate attached to the equipment.*

Also, to facilitate replies when particular information is desired, be sure to state fully and clearly the problem and attendant conditions.

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



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

DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES ADVANCE I.B. 47-410-1

EFFECTIVE JUNE, 1951

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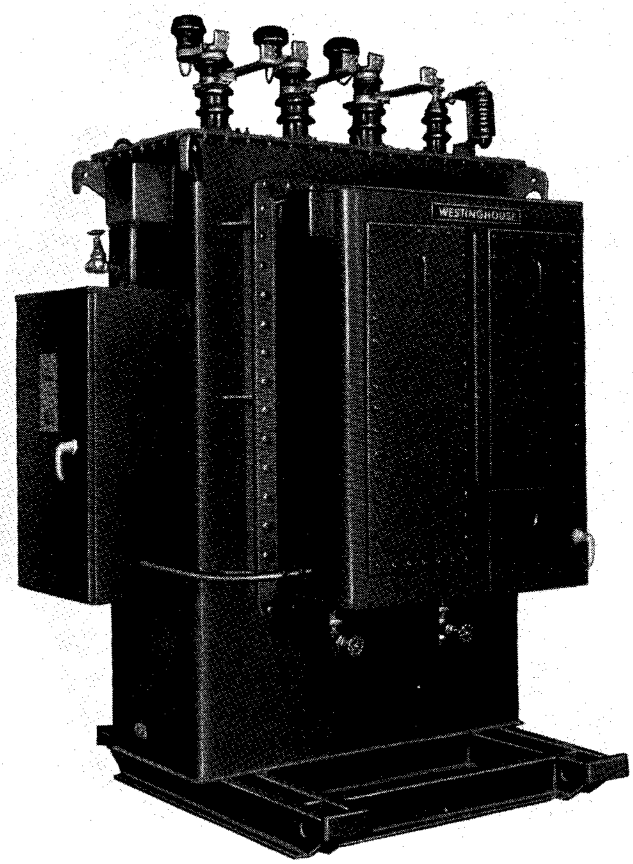
*The supplementary instruction leaflets are assembled *in numerical order* in the back of the book.



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 tap changer which operates over a tapped regulating autotransformer, 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 tap-changing-under-load with a minimum of attention and maintenance in service.

Surge Protection. Standard Type "USR" Step-Voltage Regulators are designed to meet the basic impulse level corresponding to the regulator voltage class in accordance with the NEMA, ASA and AIEE standards. The basic impulse level is obtained by adequate insulation of the core and coils and the use of by-pass arresters.

Thus the insulation of the "URS" Regulators is guaranteed to withstand the surge voltages specified by NEMA, ASA and AIEE 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.

DESCRIPTION

The Type URS Voltage Regulator consists of a regulating auto-transformer, a preventive auto-transformer, auxiliary transformer, Type URS tap changer, and all necessary control components. 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.

These parts are designed and assembled into an integral sealed unit of weatherproof construction for outdoor service. Completely assembled, it is only necessary to connect the unit to the line for placing into service. No further auxiliary equipment other than that built into the unit is required.

A completely assembled Type URS Regulator is shown in the frontispiece. (Also see Fig. 1.) It comprises three distinct compartments; the main tank which contains all of the transformer core and coil assemblies, the tap changer compartment containing the tap changer and the tap changer operating mechanism, and the control cabinet which includes the automatic control equipment of the tap changer. The tap changer compartment is bolted on 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 barrier. The control equipment is mounted on a hinged steel panel in a separate cabinet which is mounted on the side of the transformer tank.

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 with jack lugs for convenience in installing or moving.

Sufficient inspection plates in 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, and magnetic type oil gauges are provided in 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.

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 AIEE 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

A completely assembled Type URS tap changer, except for cover plates, is shown in Figure 3. Figure 2 shows a cutaway view of the tap changer.

The tap changer compartment contains the motor operated driving mechanism, polarity 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 polarity, that is, shifting the vector relationship of the regulating winding to obtain boost or buck voltage.

The selector switches of the Type URS tap changer consist of the stationary contacts, two moving contacts, and two sliding contact connections to 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 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 the Micarta arm, which carries the rear moving contact, and arranged to

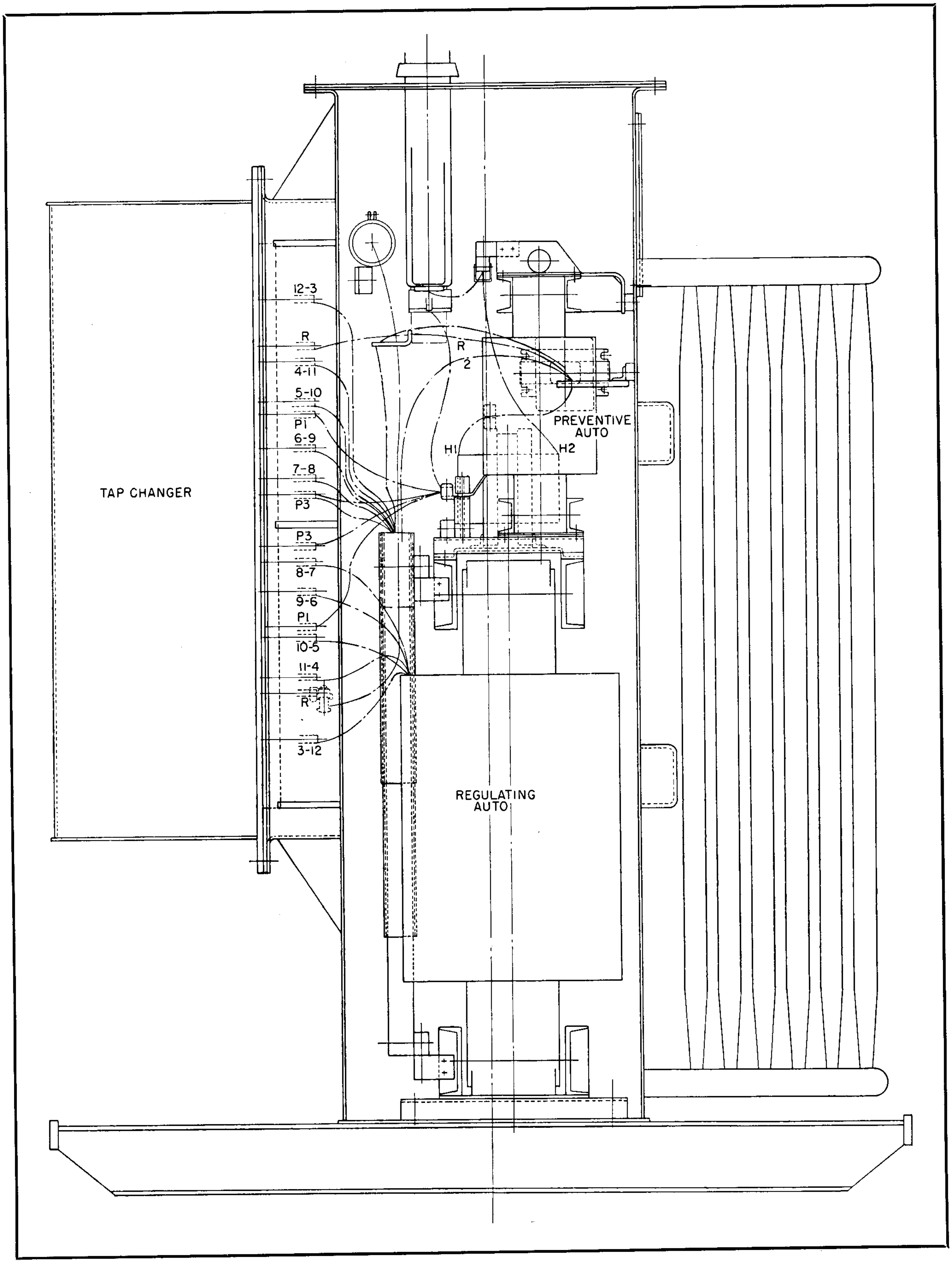


FIG. 1. General Side View of Type URS Voltage Regulator.

slide on a central collector disc. This copper disc is mounted on the main barrier plate connected to the transformer as are 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, and connection to the transformer is made through the main 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 barrier plate as previously described.

Figure 2 shows the URS tap changer and operating mechanism with parts cut away to illustrate the construction and operation of those portions normally hidden in a single view.

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-changer housing. A shaft is extended through the bottom of the main housing into an air compartment which houses the "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 "DynAC Brake" is used.

Through one Micarta to steel and two steel to steel spur gear reductions and one steel to steel bevel-gear assembly, the motor is coupled to the main vertical drive shaft. The lower phase is driven from the shaft of the last gear reduction. A steel bevel gear take-off couples the main shaft to the upper horizontal shaft leading to the phase assemblies. 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 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 horizontal 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 another 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, position indicator, mechanical stop, "DynAC Brake" and hand cranking arrangements. Electrical connections from the motor are brought into the air compartment through stud type porcelain bushings with Cork Neoprene gaskets.

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 door 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.

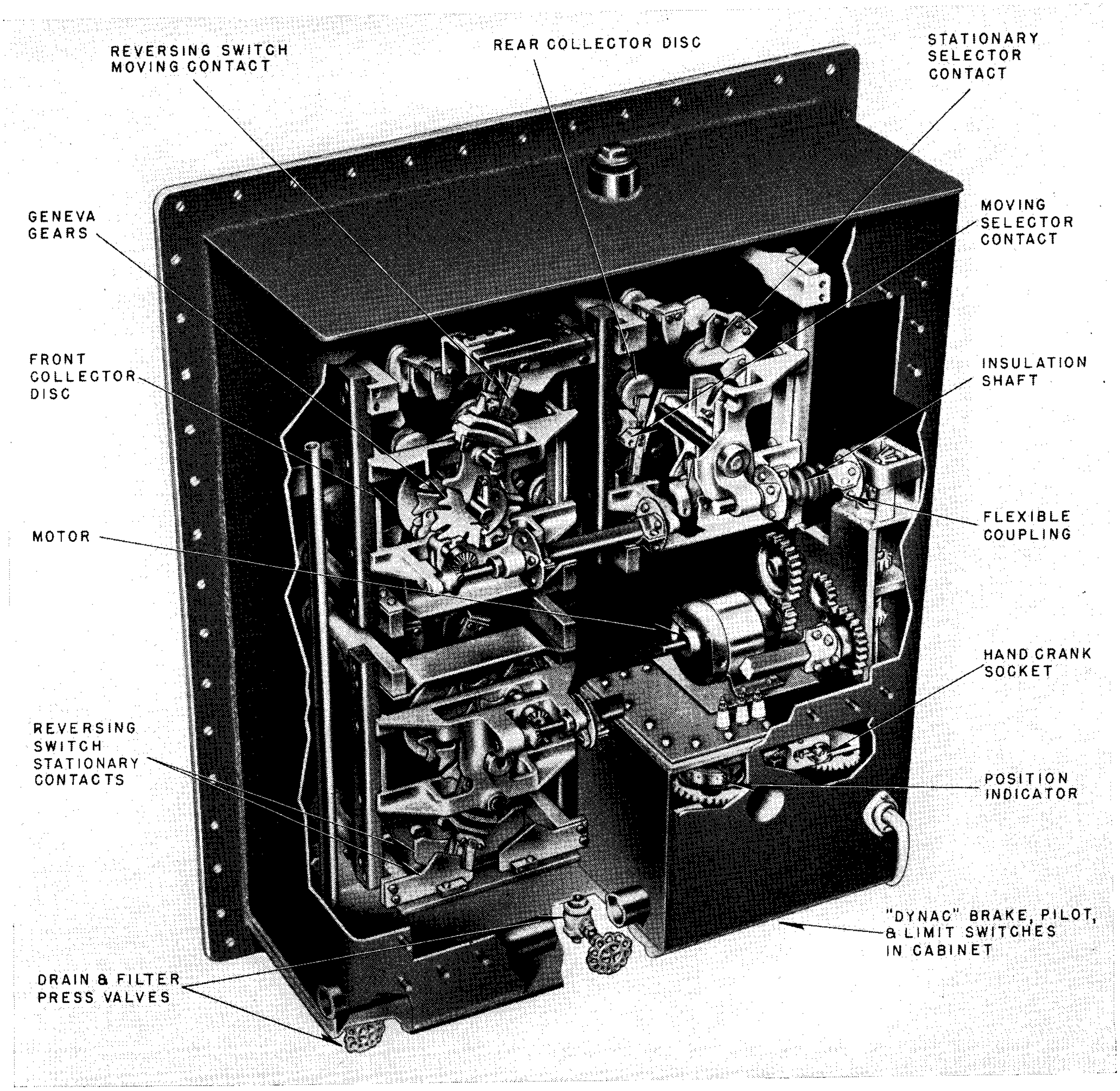


FIG. 2. Cutaway View of URS Tap Changer.

Through steel spur gears, auxiliary shafts are driven at the several 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 the "DynAC Brake" and a mechanical operation counter to record the number of tap changer operations.

A shaft is included which travels ten degrees per position. This shaft turns a drum engraved with the tap changer position numbers. A stationary pointer indicates tap changer position. A transparent window in the air compartment door permits observation of the position indicator without opening the door. Friction retarded pointers indicate maximum and minimum travel of the tap changer. On this same shaft are cams which actuate limit switches to prevent electrical operation of the tap changer beyond its end position in either direction.

Note: These cams do not limit mechanical operation by the hand crank.

From this shaft, also, is driven a cam which releases a spring actuated mechanism should the tap changer be moved appreciably beyond its end position in either direction. This mechanism inserts a

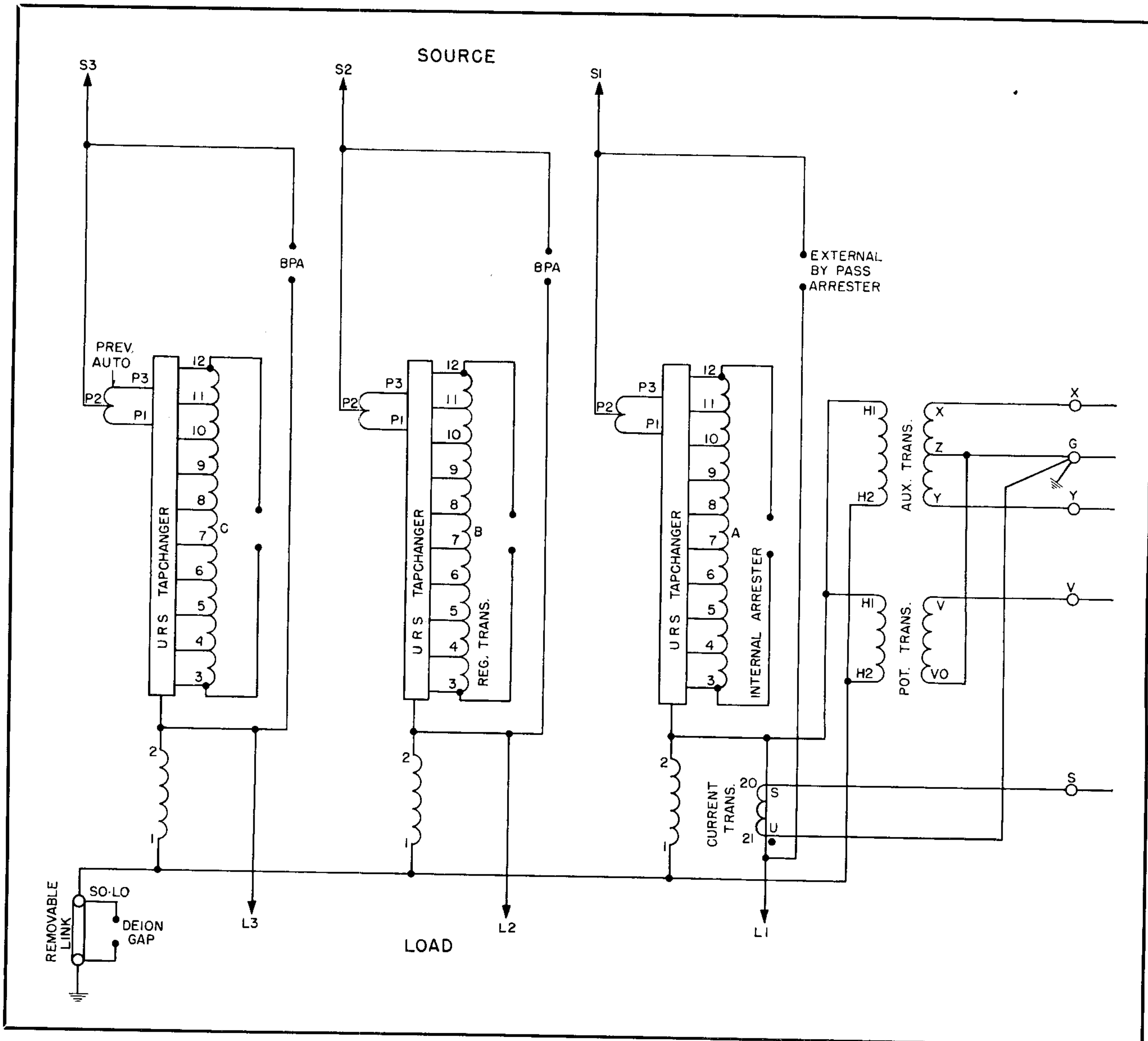


FIG. 4. Three-Phase Type URS Voltage Regulator Connection Diagram.

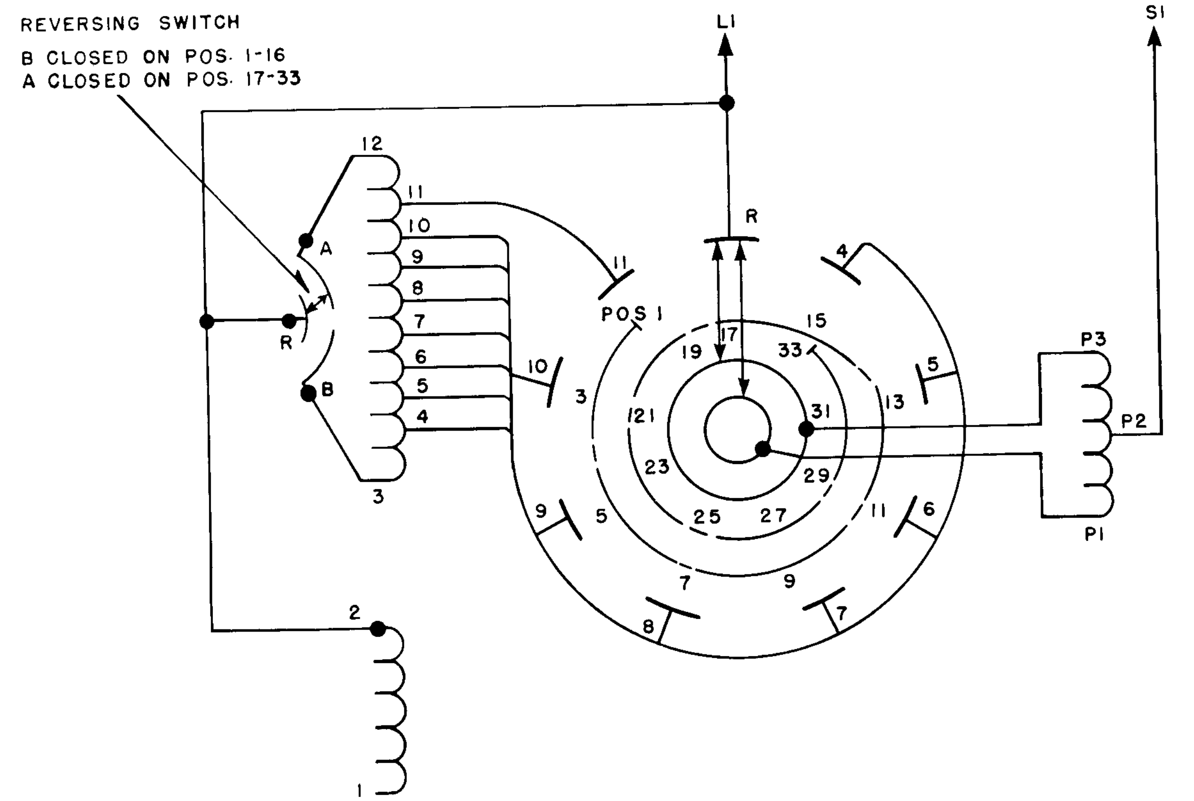
Figure 5 shows the tap changer in its neutral position, with both moving contacts on stationary contact R, the preventive auto short circuited, the reversing switch connecting R to A, and none of the tapped section of transformer winding connected into the circuit. This is position 17.

In changing from position 17 to position 18, 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 on 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 18 to position 19, 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.

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 17 to position 16, the reversing switch first acts to select the opposite polarity for the tapped section of the winding. Before



CONTACT	POSITION																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
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. 5. Typical Schematic Connection Diagram of One Phase of Regulator and Sequence Chart of Tap Changer Positions.

contact P1 leaves stationary contact R, the reversing switch moving contact moves from stationary contact A to stationary contact B. Prior to completion of this motion, the moving contact connected to P1 leaves stationary contact R, and after tap 3 is connected to tap 2, contacts stationary contact 4. 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 16 to position 15, 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 and S1.

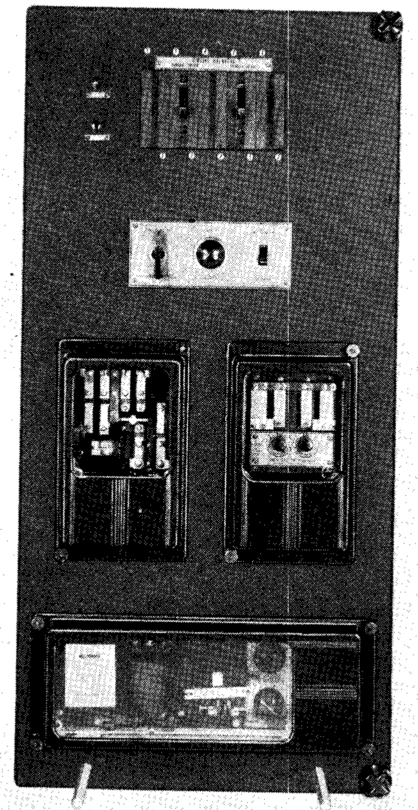


FIG. 6. Typical Control Panel.

PRINCIPLE OF CONTROL OPERATION

A typical control panel for the Type URS Regulator is shown in Figure 6. The control circuit is shown schematically in Figure 7.

The panel is of steel and is in a steel cabinet mounted on the side of the regulator. A hinged mounting is used so that both front and rear of the panel are readily accessible for inspection and maintenance. The control relays and equipment are all of the Flexitest case construction for semi-flush mounting. A Type FT test plug is recommended for use with the Flexitest relays for ease of testing. The Flexitest case construction allows the relay mechanism to be easily disassembled for inspection, testing, adjusting and remounting.

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 ensuring that once a tap change is initiated it will be carried through to completion.

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

4. The prevention of the tap changer mechanism running past the limit positions.

5. Indication of tap 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 Figure 7. An automatic-manual switch, "AM", enables the selection of automatic or manual operation by the closing of "AMA" or "AMM" respectively. The voltage regulating relay "PP" is responsive to voltage changes in the regulated line and initiates tap changer operations automatically. "PNV" is the no voltage relay, connected to prevent automatic operation to maximum boost if AB1 is inadvertently opened, or purposely opened for testing.

Type TH time delay relays are provided to override minor voltage fluctuations and avoid many needless tap changer operations. The heater operated contacts HR and HL operate to give the time delay. AR and AL are secondary contacts. 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.

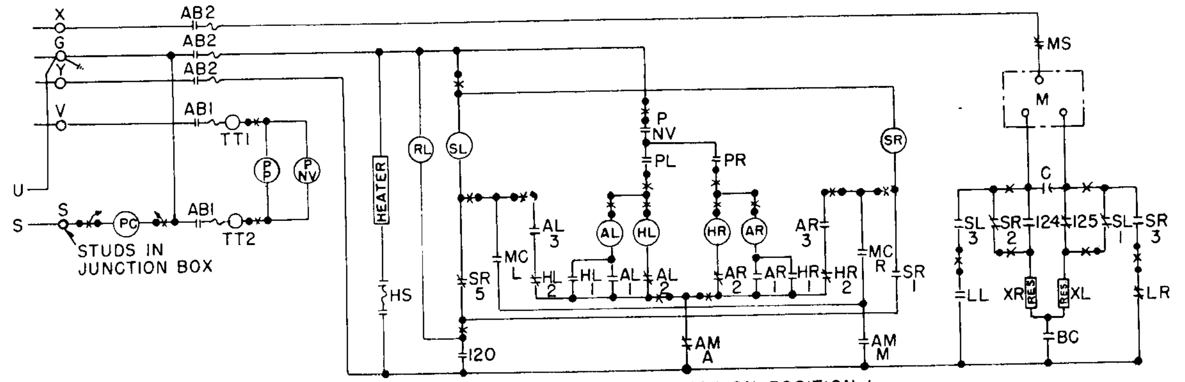
An interlock switch MS is mounted in such a manner that either the operation of the mechanical stop or the moving of the hand crank shaft from its out-of-mesh position will de-energize the motor. Thus the unit will not attempt to operate electrically while the crank is engaged.

Type AB control breakers are provided to disconnect the control circuits from the supply transformers, and to protect the supply transformers from short circuits. Terminals X, G, Y, and V receive their potential from the auxiliary and potential transformers, and terminals S and U receive current from the current transformers.

BC is the "DynAC Brake" contact. The "DynAC Brake" is a pneumatic time delay relay, operated by a cam in the control assembly.

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.



CONDITIONS SHOWN FOR MAXIMUM BUCK ON POSITION 1

LEGEND

VOLTAGE REGULATING RELAY
PP OPERATING COIL
PR,PL CONTACTS
PNV NO VOLTAGE DEVICE
PC LINE DROP COMPENSATOR
TIME DELAY RELAY
HR,HL HEATER
AR,AL CONTACTOR
SR,SL MOTOR CONTROL RELAY
M MOTOR
BC BRAKE CONTACTS
AM AUTO MANUAL SWITCH
TT1,TT2 TEST TERMINALS

MC RAISE LOWER SWITCH
AB BREAKER
MS MECHANICAL LOCK SWITCH
HS HEATER SWITCH AND THERMOSTAT
FLEXITEST RELAY DISCONNECT SWITCH
NORMALLY OPEN CONTACT
NORMALLY CLOSED CONTACT
RESISTOR
THERMAL ELEMENT
CAPACITOR
OPERATING COIL
INDICATING LAMP (R FOR RED)
FLEXITEST RELAY DISCONNECT SWITCH (CURRENT SHORTING TYPE)

FIG. 7. Schematic Diagram of URS Voltage Regulator Control.

LR is a limit switch, open on position 33 and beyond, and closed on positions 1 through 32.

LL is a limit switch, open on position 1 and below, and closed on positions 2 through 33.

124 is a braking limit switch, closed on position 33 and beyond, and open on positions 1 through 32.

125 is a braking limit switch, closed on position 1 and below, and open on positions 2 and 33.

XL and XR are the brake resistors in series with SL1 and SR2 respectively.

SR and SL are the coils of an interlocked double throw motor contactor mounted on the panel in a separate compartment. The coils act to open and close contacts of the same designation (i.e., SR1, SL2, etc.).

C is the motor capacitor, mounted in the air compartment of the tap changer.

RL is a red lamp on the control panel which indicates when the tap changer is off position, or when the voltage regulating relay calls for either a raise or lower operation from positions 33 or 1 respectively.

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

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 relay P and the NV relay. When AB1 is closed, the NV relay coil is energized closing the NV interlock contacts; also the coil P of the voltage regulating relay is energized. Closing AMA of the Automatic-Manual selector switch completes the set-up for automatic operation.

The voltage regulating relay P is the initiating element for tap changes when the control is set for "automatic" operation. The relay 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 relay is usually 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. For some conditions of parallel operation, reverse reactance compensation may be needed. Links on the front of the line drop compensator provide convenient means for accomplishing reversal of the reactance element of the compensator.

When Voltage Drops: A drop in voltage causes voltage regulating relay "raise" contact PR to close, energizing time-delay relay heater HR. If the heater in this relay remains energized long enough, the bimetal will operate a Micro Switch. Operation of the Micro Switch opens contact HR2 and closes contact HR1. Closing contact HR1 energizes the auxiliary contactor coil AR, which operates to open contact AR2 and close contacts AR1 and AR3. Opening contact AR2 de-energizes the bimetal heater HR, allowing the bimetal to cool. Closing contact AR1 shunts the Micro Switch contact HR1 and holds the auxiliary contactor AR closed as long as PR remains closed. When the bimetal has cooled to the temperature determined by the time setting, it allows the Micro Switch to return to its original position, opening HR1 and closing HR2. If the auxiliary contactor AR is still held closed by PR through AR1, then AR3 is still closed and the reclosing of HR2 completes the circuit, energizing the motor control relay SR. Energizing the motor control relay, SR, opens contacts SR2 and SR5, and closes contacts SR1 and SR3. Closing contact SR3 energizes the motor to operate the tap changer in the "raise" direction.

While the motor is operating, a cam keeps the "DynAC" time delay relay contact BC closed. When the auxiliary contactor opens, SR2 is closed, short circuiting the capacitor through SL1, 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 "DynAC Brake" contact opens, and the unit is ready for further operation.

The reason for using back contact SR5 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 SR5 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.

Protection Against "No-Voltage": The no-voltage relay (PNV) is connected across the voltage regulating relay voltage. The "make" contact of this no-voltage relay is connected in the automatic control circuit and is closed when the relay is energized.

When voltage is removed from the voltage regulating relay circuit the voltage regulating relay closes PR, which will initiate a tap change in the raise direction. The tap changer would operate to the extreme raise or boost position as long as the voltage remained off on the voltage regulating relay circuit only. To prevent this condition, the no-voltage relay contact is inserted in the automatic control circuit so that, upon failure of voltage on the primary relay, the automatic circuit is also opened. The tap changer will remain on the position it is on at that time. When voltage is restored, the no-voltage relay is re-energized, closing the "make" contact. The automatic control then resumes its operation in the normal 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 regulating relay contacts remain closed. 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, contact AMA of automatic manual switch is open and contact AMM is closed. When higher voltage is desired, contact MCR of raise-and-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, no special tools are necessary.

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

A periodic inspection of the relays and relay contacts should be made. It is not necessary to keep the contacts of the relays used in this control polished as on the older types of relays. If the contacts should

become worn to an uneven shape, they may be smoothed and re-shaped with a very fine file and readjusted.

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. Slower braking and, consequently, later stopping is achieved by increasing the resistor setting, which adds more resistance to the circuit. Faster braking and earlier stopping may be obtained by decreasing the resistor setting, which decreases the resistance of the circuit. See I.L. 46-713-7 for detailed "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 overload do not tend to open the contacts since the forces are in quadrature with the contact pressure forces.

All contacts subject to arcing are faced or are made of arc-resisting and high-melting point alloy giving long life to the contacts.

Replacement should be made before the moving finger shoes have burned sufficiently to reduce the smooth flat contact area by more than half, and before the insert of arc resisting material at the edges of the stationary contacts is burned away. 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; and that the frequency of subsequent inspections be based on the facts found by this 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 not be allowed to deteriorate to the point where it tests less than 15 Kv in the standard test cup. 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 15 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.

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 assemblies and stationary selector contact blades be kept in stock for replacement if necessary.

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

One Motor.

One Set of "DynAC Brake" Contacts.

One Motor Contactor Complete.

One Set Cover Plate Gaskets.

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.

SUPPLEMENTARY DATA

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This part of the book consists of the supplementary instruction leaflets listed in the Table of Contents, page 2. The leaflets, which follow, are assembled in numerical order.

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DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES ADVANCE I.B. 47-410-1

EFFECTIVE JUNE, 1951

When Voltage Drops: A drop in voltage causes voltage regulating relay "raise" contact PR to close, energizing time-delay relay heater HR. If the heater in this relay remains energized long enough, the bimetal will operate a Micro Switch. Operation of the Micro Switch opens contact HR2 and closes contact HR1. Closing contact HR1 energizes the auxiliary contactor coil AR, which operates to open contact AR2 and close contacts AR1 and AR3. Opening contact AR2 de-energizes the bimetal heater HR, allowing the bimetal to cool. Closing contact AR1 shunts the Micro Switch contact HR1 and holds the auxiliary contactor AR closed as long as PR remains closed. When the bimetal has cooled to the temperature determined by the time setting, it allows the Micro Switch to return to its original position, opening HR1 and closing HR2. If the auxiliary contactor AR is still held closed by PR through AR1, then AR3 is still closed and the reclosing of HR2 completes the circuit, energizing the motor control relay SR. Energizing the motor control relay, SR, opens contacts SR2 and SR5, and closes contacts SR1 and SR3. Closing contact SR3 energizes the motor to operate the tap changer in the "raise" direction.

While the motor is operating, a cam keeps the "DynAC" time delay relay contact BC closed. When the auxiliary contactor opens, SR2 is closed, short circuiting the capacitor through SL1, 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 "DynAC Brake" contact opens, and the unit is ready for further operation.

The reason for using back contact SR5 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 SR5 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.

Protection Against "No-Voltage": The no-voltage relay (PNV) is connected across the voltage regulating relay voltage. The "make" contact of this no-voltage relay is connected in the automatic control circuit and is closed when the relay is energized.

When voltage is removed from the voltage regulating relay circuit the voltage regulating relay closes PR, which will initiate a tap change in the raise direction. The tap changer would operate to the extreme raise or boost position as long as the voltage remained off on the voltage regulating relay circuit only. To prevent this condition, the no-voltage relay contact is inserted in the automatic control circuit so that, upon failure of voltage on the primary relay, the automatic circuit is also opened. The tap changer will remain on the position it is on at that time. When voltage is restored, the no-voltage relay is re-energized, closing the "make" contact. The automatic control then resumes its operation in the normal 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 regulating relay contacts remain closed. 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, contact AMA of automatic manual switch is open and contact AMM is closed. When higher voltage is desired, contact MCR of raise-and-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, no special tools are necessary.

immersed, but bearings in the air compartment require occasional lubrication with an anticorrosive lubricant. Lubriplate #130-A is recommended.

A periodic inspection of the relays and relay contacts should be made. It is not necessary to keep the

become worn to an uneven shape, they may be smoothed and re-shaped with a very fine file and readjusted.

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. Slower braking and, consequently, later stopping is achieved by increasing the resistor setting, which adds more resistance to the circuit. Faster braking and earlier stopping may be obtained by decreasing the resistor setting, which decreases the resistance of the circuit. See I.L. 46-713-7 for detailed "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 overload do not tend to open the contacts since the forces are in quadrature with the contact pressure forces.

All contacts subject to arcing are faced or are made of arc-resisting and high-melting point alloy giving long life to the contacts.

Replacement should be made before the moving finger shoes have burned sufficiently to reduce the smooth flat contact area by more than half, and before the insert of arc resisting material at the edges of the stationary contacts is burned away. 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; and that the frequency of subsequent inspections be based on the facts found by this 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 not be allowed to deteriorate to the point where it tests less than 15 Kv in the standard test cup. 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 15 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.

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 assemblies and stationary selector contact blades be kept in stock for replacement if necessary.

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

One Motor.

One Set of "DynAC Brake" Contacts.

One Motor Contactor Complete.

One Set Cover Plate Gaskets.

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.

SUPPLEMENTARY DATA

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This part of the book consists of the supplementary instruction leaflets listed in the Table of Contents, page 2. The leaflets, which follow, are assembled in numerical order.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover, and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Six different size cases are available to accommodate the various relay elements and flexible terminal arrangements for either flush or projection mounting. These are designated as S10, S20, M10, M20, L10, L20. S refers to the small; M, the medium; and L, the large size chassis frame. The numbers refer to the possible number of test switch positions, 10 or 20.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. There are two cover nuts on the S size case and four on the L and M size cases. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. The chassis operated shorting switch located behind the current test switch prevents open circuiting the current transformers when the current type test switches are closed.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated red handle switch should not be closed until after the chassis has been latched in place and all of the black handle switches closed.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

SUPERSEDES I.L. 41-070.1C

EFFECTIVE APRIL 1948

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

The ammeter test plug can be inserted in the current test jaws after opening the knife-blade switch to check the current thru the relay, as shown in Fig. 1. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and the leads are carried out thru holes in the back of the insulated handle.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw, as shown in Fig. 2.

Testing In Case

With all blades in the full open position, the ten circuit test plug Fig. 3 can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above, under "Electrical Circuits."

Testing Out of Case

With the chassis removed from the base, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

An internal schematic is available for each individual relay showing the schematic internal wiring. The outlines of the various cases are as follows:

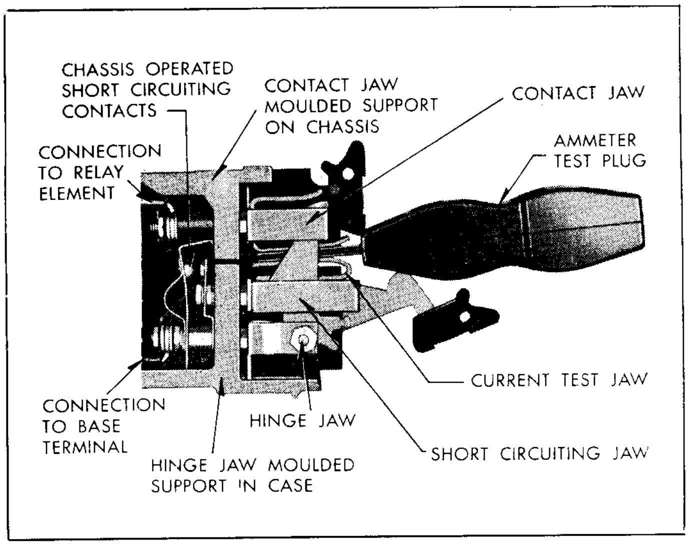


Fig. 1—Ammeter Test Plug In Testing Position.

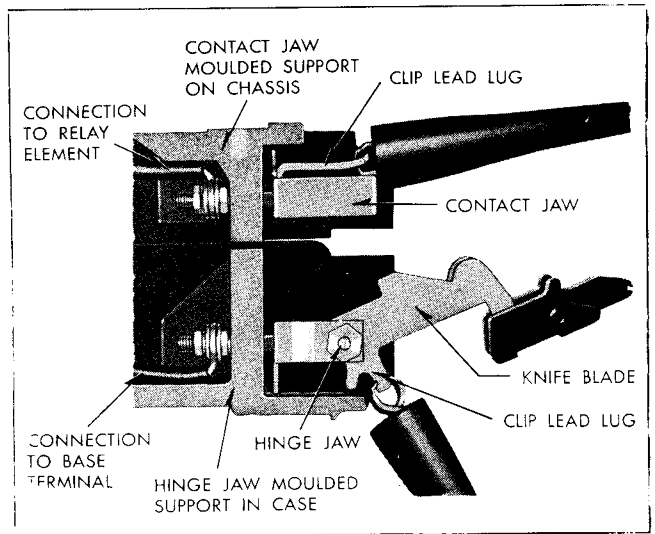


Fig. 2—Spring Clip Leads May Be Used For Testing.

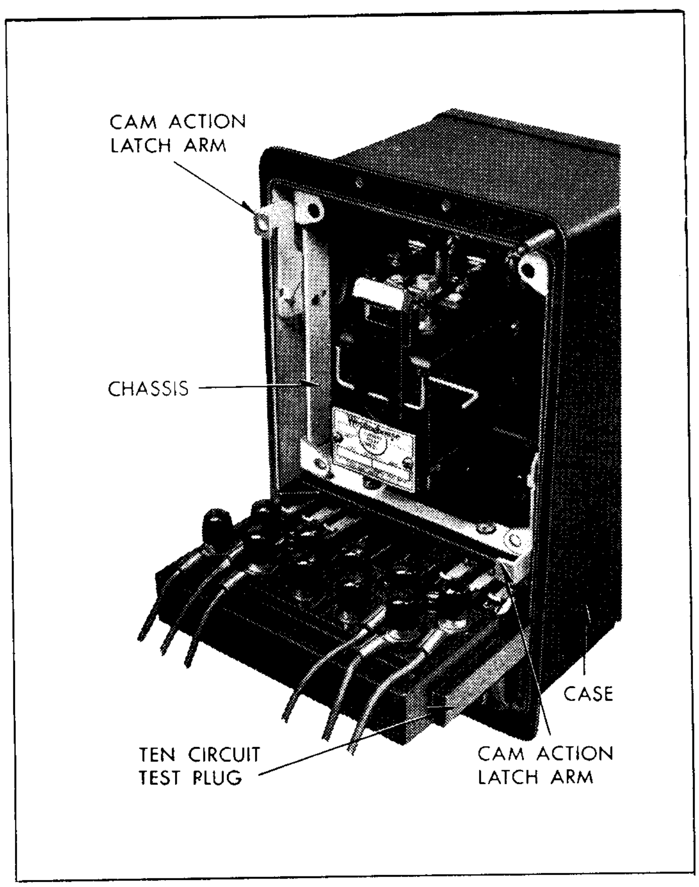


Fig. 3—Multi-Circuit Test Plug In Testing Position.

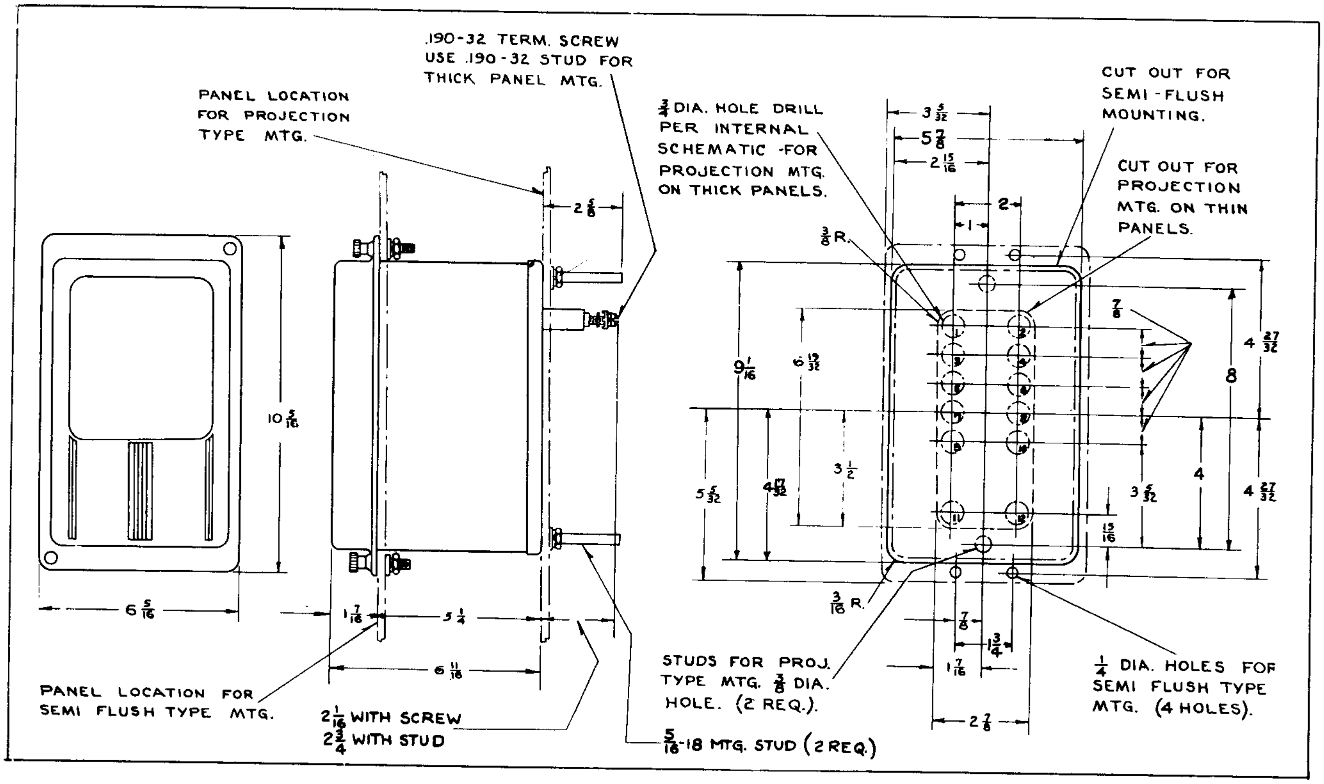


Fig. 4—Outline and Drilling Plan for the S10 Semi-flush (9B-1901) or Projection (9B-2020) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

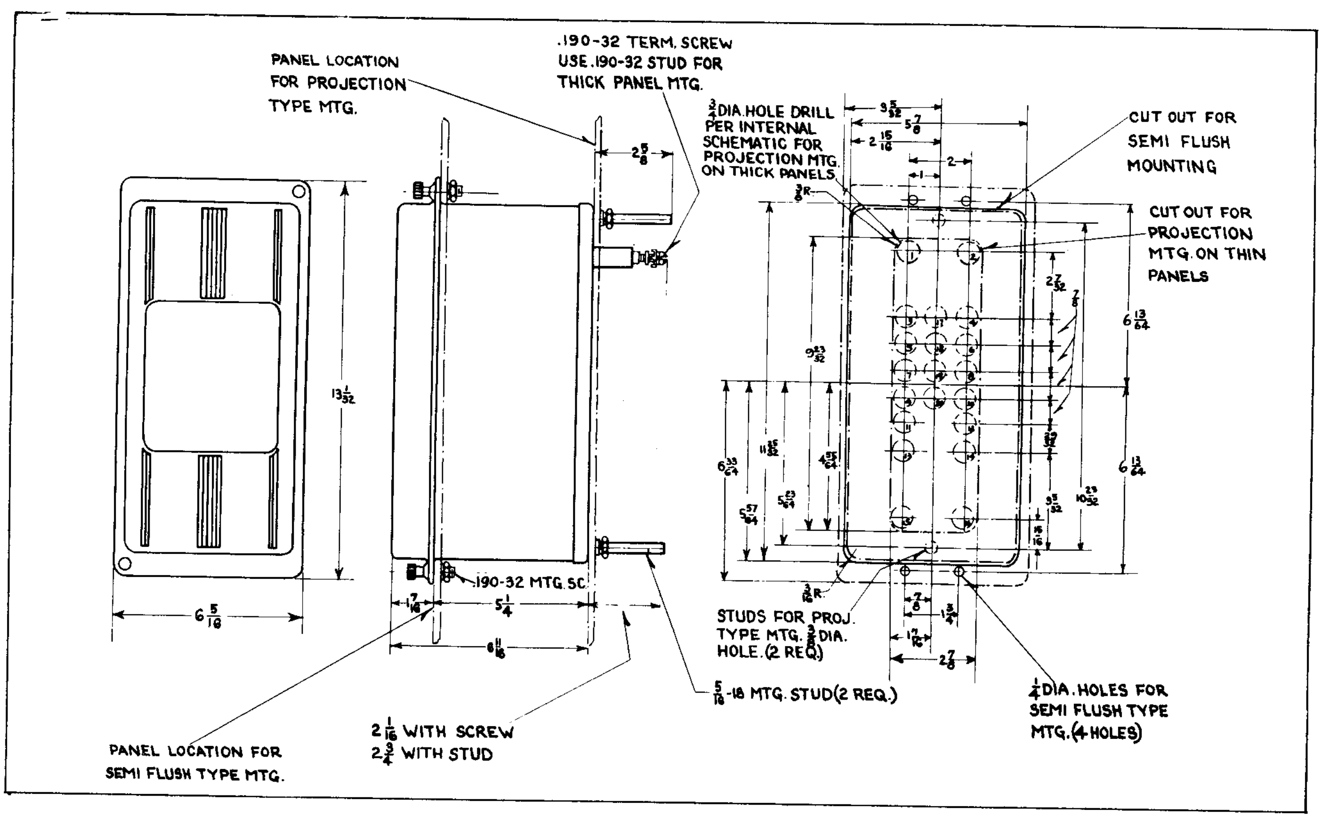


Fig. 5—Outline and Drilling Plan for the S20 Semi-flush (9B-2040) or Projection (9B-2041) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

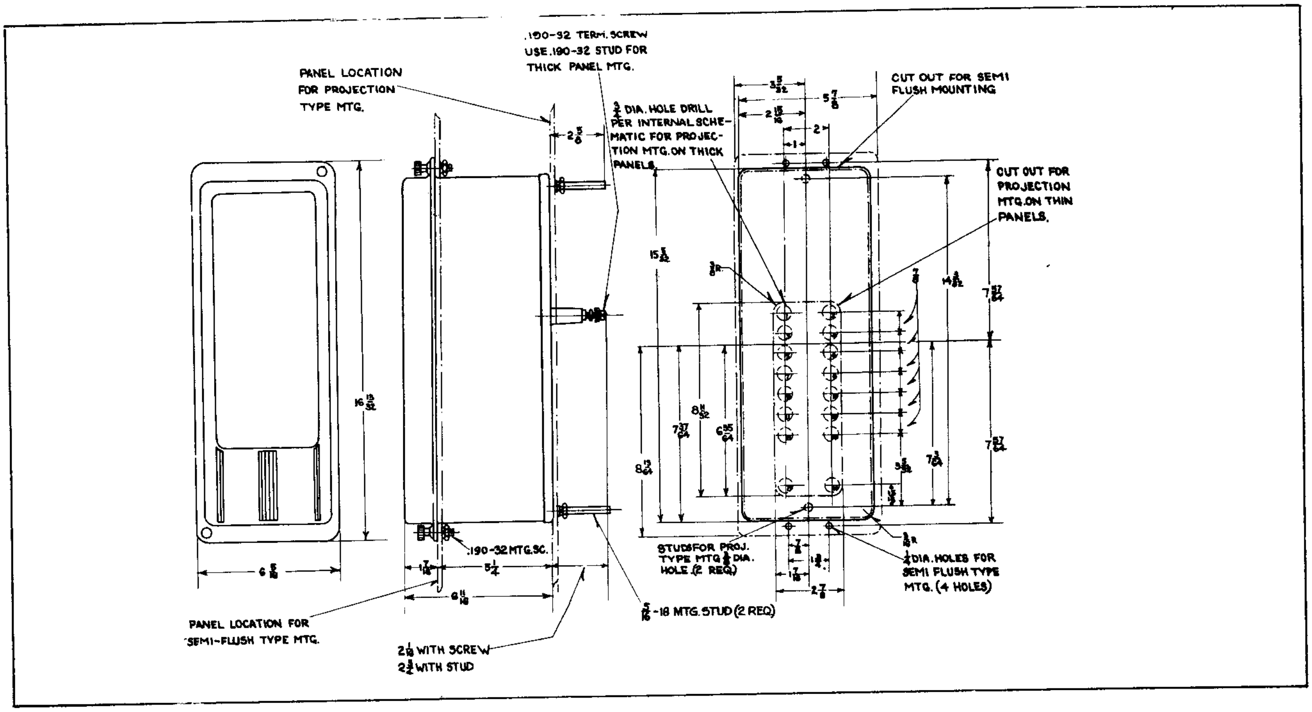


Fig. 6—Outline and Drilling Plan for the M10 Semi-flush (9B-1903) or Projection (9B-2021) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

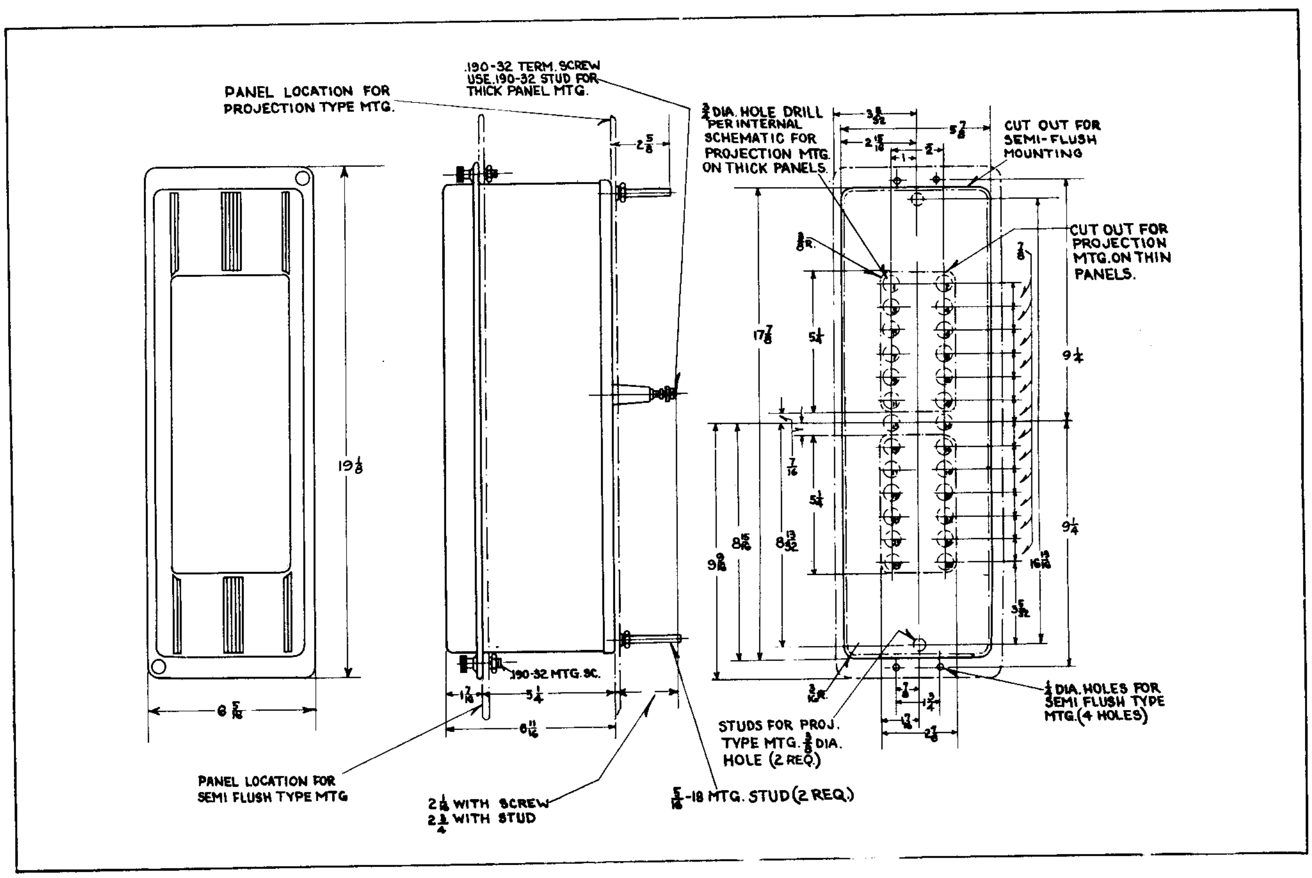
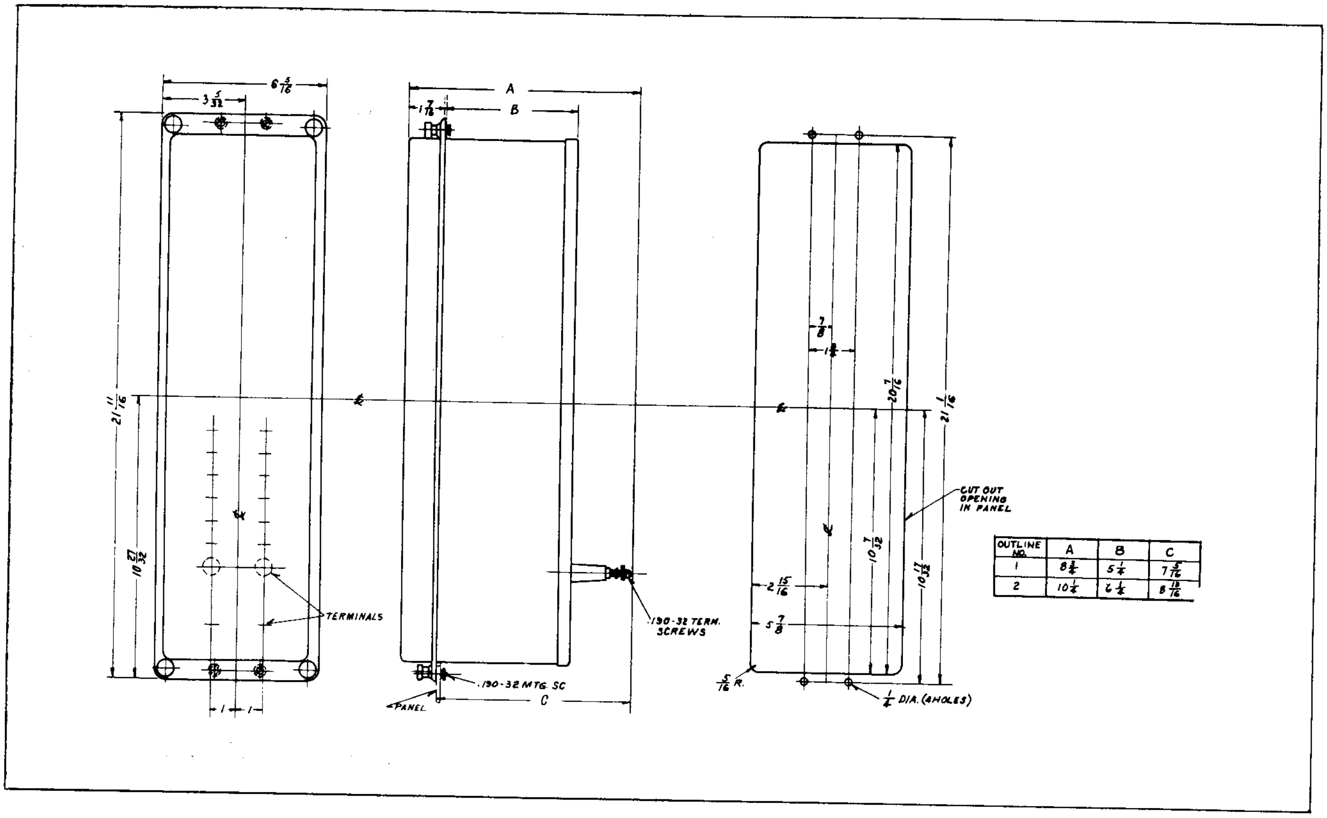


Fig. 7—Outline and Drilling Plan for the M20 Semi-flush (9B-1905) or Projection (9B-2022) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.



OUTLINE NO.	A	B	C
1	8¾	5¼	7 5/16
2	10¼	6¼	8 13/16

Fig. 8—Outline And Drilling Plan For The L10 Semi-Flush Type FT Case. For Reference Only. (9-B-2042)

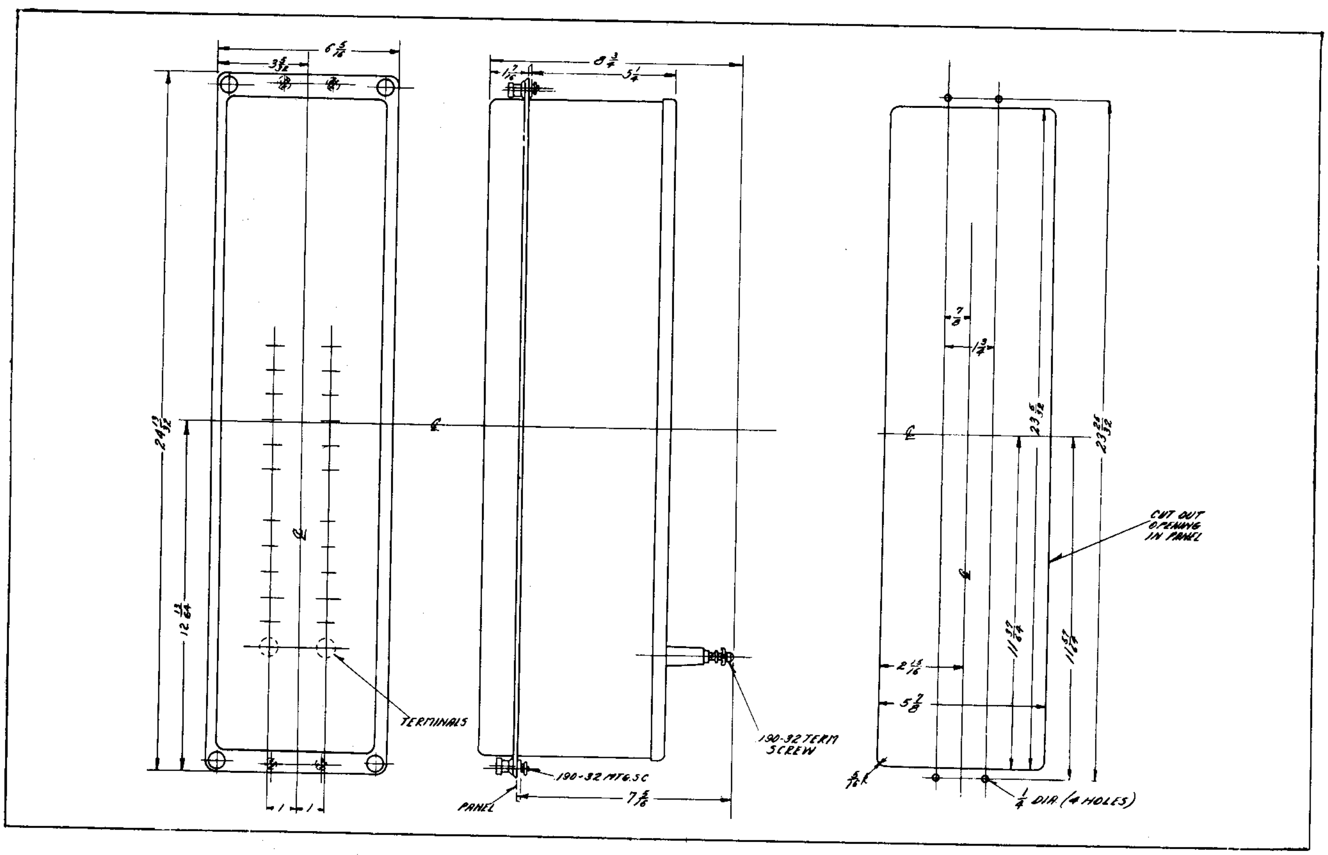


Fig. 9—Outline And Drilling Plan For The L20 Semi-Flush Type FT Case. For Reference Only. (9-B-2044)

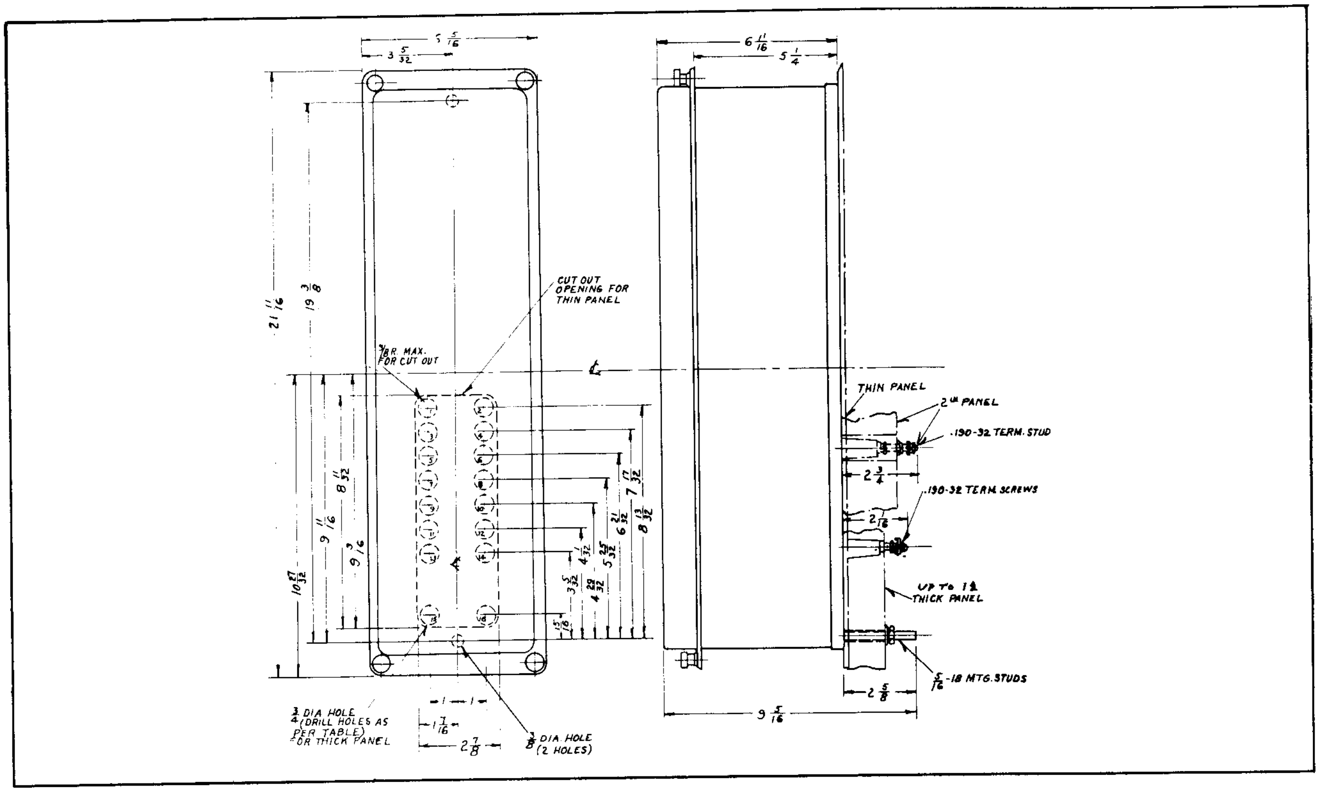


Fig. 10—Outline And Drilling Plan For The L10 Projection Type FT Case. See The Internal Schematic For The Terminals Supplied. For Reference Only. (9-B-2043)

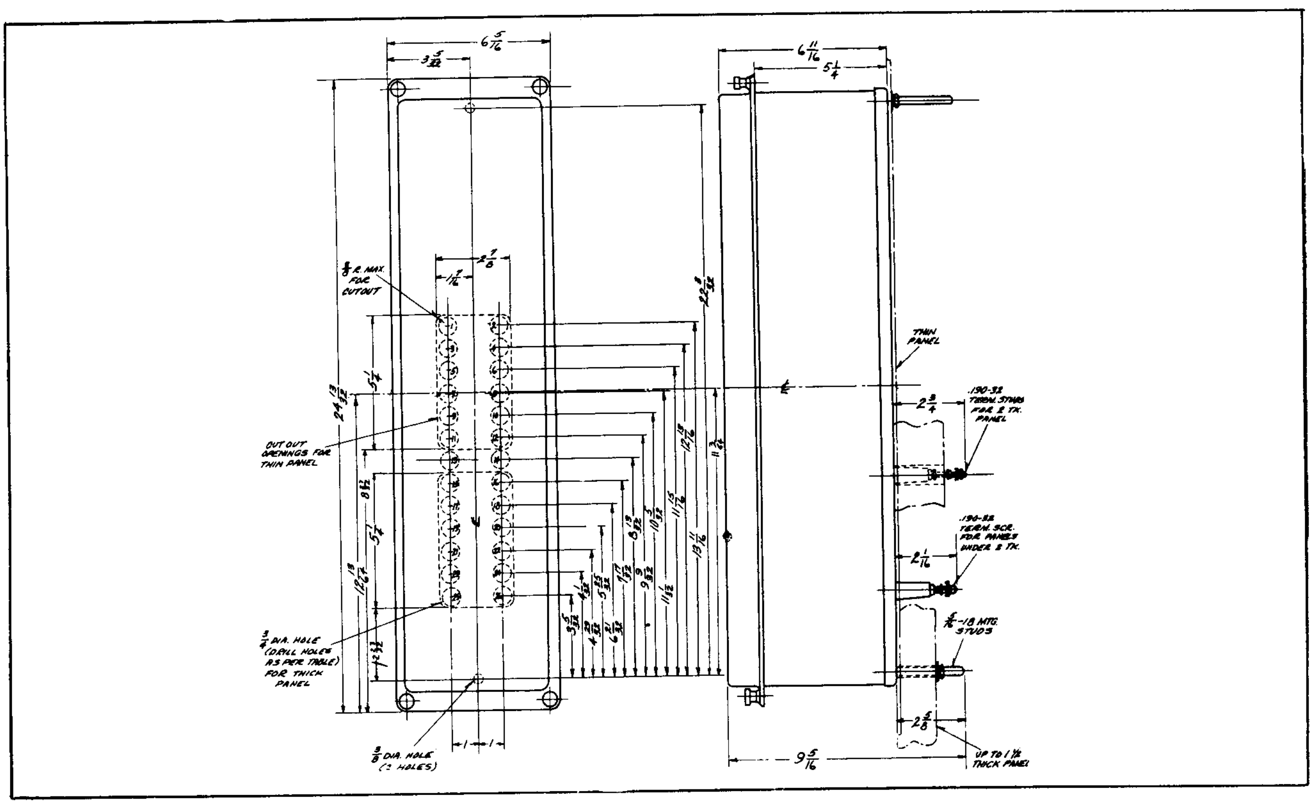


Fig. 11—Outline And Drilling Plan For The L20 Projection Type FT Case. See The Internal Schematic For The Terminals Supplied. For Reference Only. (9-B-2045)

WESTINGHOUSE ELECTRIC CORPORATION
METER DIVISION

NEWARK, N.J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SG MECHANICALLY INTERLOCKED AUXILIARY RELAY FOR STEP VOLTAGE REGULATORS STYLES 1274697 AND 1339369

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type SG mechanically interlocked auxiliary relay is used in the control circuit of step voltage regulators to energize the tap changer motor in the "raise" or the "lower" directions after other relays in the circuit indicate that a tap change should be made. It consists of two magnetic contactors which can be energized individually, with their armatures mechanically interlocked so that both armatures can not be closed simultaneously. It may be used in any other application for which its construction and electrical circuits make it suitable.

CONSTRUCTION

NOTE: This instruction leaflet pertains only to the style numbers given in the title. For general instructions on the type SG auxiliary relay, see I.L. 41-350.

The type SG mechanically interlocked auxiliary relay consists of two electromagnets mounted on a common insulating sub-base with a bar centrally pivoted between the two armatures so that both armatures can not be closed simultaneously. The armature of each element of relay S#1274697 carries four moving contact fingers. These engage stationary contacts to provide a total of six make and three break contacts, as shown in the internal wiring diagram. This relay is assembled in a cast iron base with glass cover. The armature of one element of relay S#1339369 has four moving contact fingers similar to relay S#1274697, although only three fingers are used. The second element has a two-contact armature as in the standard SG auxiliary relay. A total of two break, two make, and one break-make contacts are provided. Relay S#1339369 is assembled in the type FT case, which provides test switches in the relay circuits and permits easy removal of the relay element for inspection or maintenance.

CHARACTERISTICS

Each element of the relay will pick up at a voltage 80% or less of the rated voltage, provided the other element is deenergized. Because of the heavier armature and larger number of contacts, and because the application does not require continuous duty, the energy consumption is allowed to be somewhat greater than in the standard SG auxiliary relay and the coils should not be energized continuously. The burden of each electromagnet is approximately 19 v.a. at 115 volts, 60 cycles. The contacts will carry 12 amperes and will interrupt 30 amperes at 115 volts, 60 cycles.

RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover, and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window

SUPERSEDES I.L. 41-350.1A

EFFECTIVE AUGUST 1950

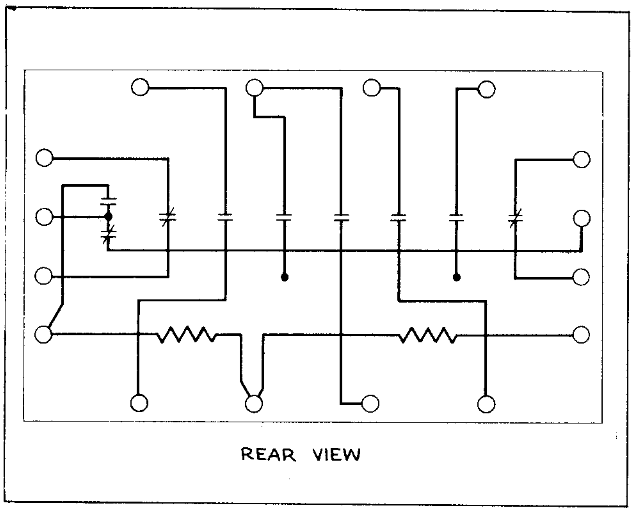


Fig. 1—Internal Schematic of S#1274697 Type SG Relay in the Projection Case.

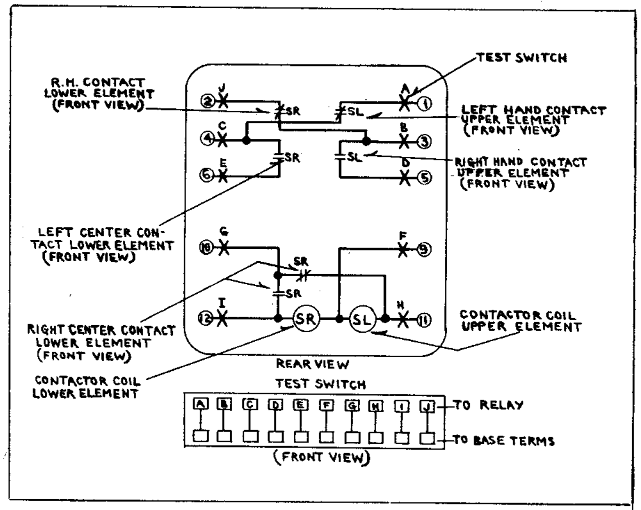


Fig. 2—Internal Schematic of S#1339369 A Type SG Relay in the Type FT Case.

which fits over the front of the case with the switches closed. The chassis is a frame that houses the relay elements and supports the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches.

The order of opening the switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagram. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches.

Testing

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

Voltage between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug.

Testing Out of Case

With the chassis removed from the base, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the standard cases and the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

The position of the break contact posts should be adjusted to obtain approximately 1/8 inch gap (except approximately 3/16 inch gap for the make contact of the two-pole element of S#1339369-A relay) between the moving contact and the make contact. The make contacts should have 3/64" to 1/16" follow and the break contacts should have 1/32" follow or more. All make contacts or all break contacts on the same element should close at approximately the same armature position. The position of the interlock arm post should be adjusted so that with either armature closed and the interlock arm touching it, the opposite end of the arm will be approximately 1/64" from the second armature. The interlock arm should not permit the make contacts of one element to touch until the make contacts of the other element are open approximately 1/16" or more.

The armatures and the interlock arm should operate freely, and the moving contact arms should operate freely on their guide pins.

All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

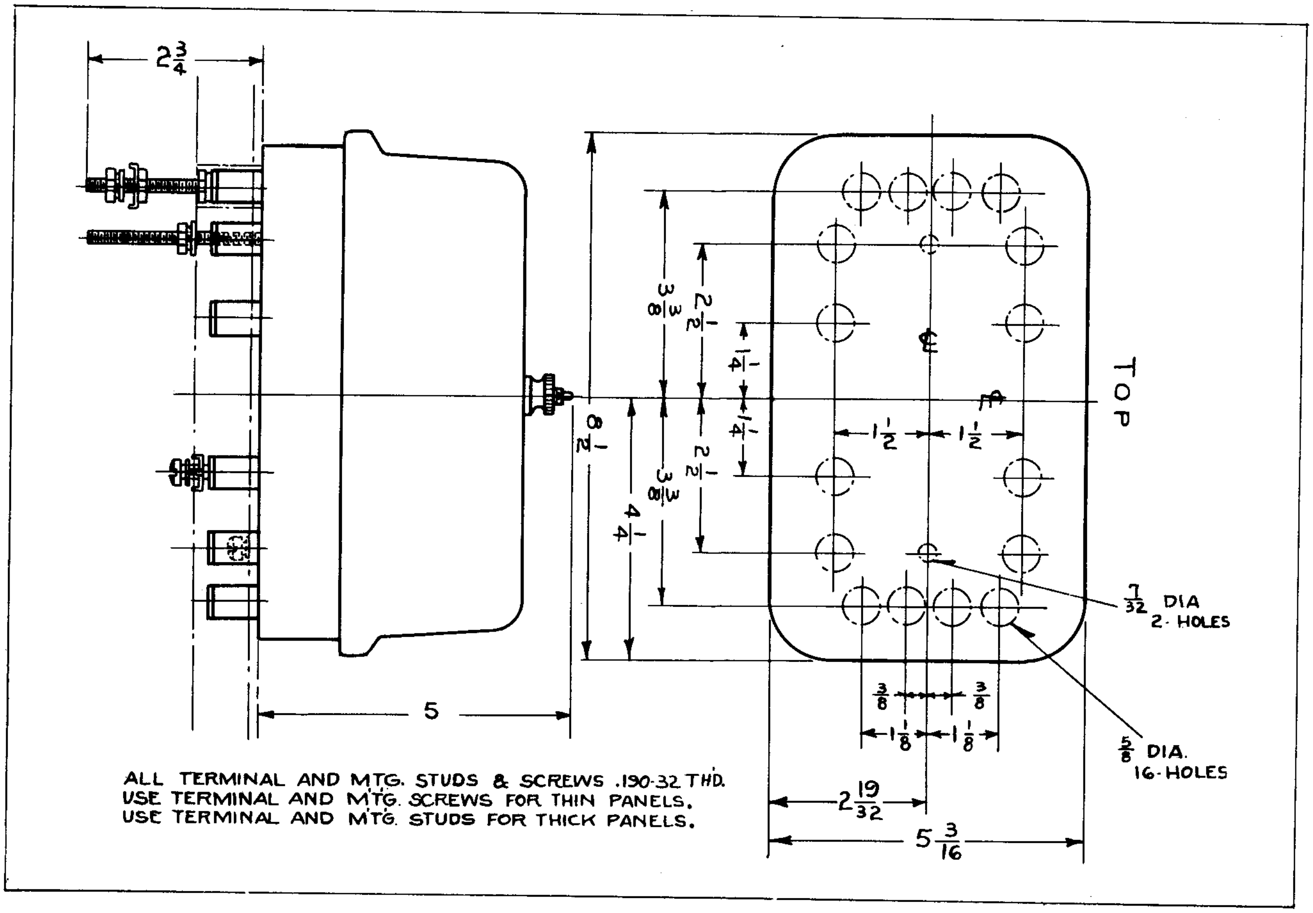


Fig. 3—Outline & Drilling Plan for the Projection Case. For Reference Only.

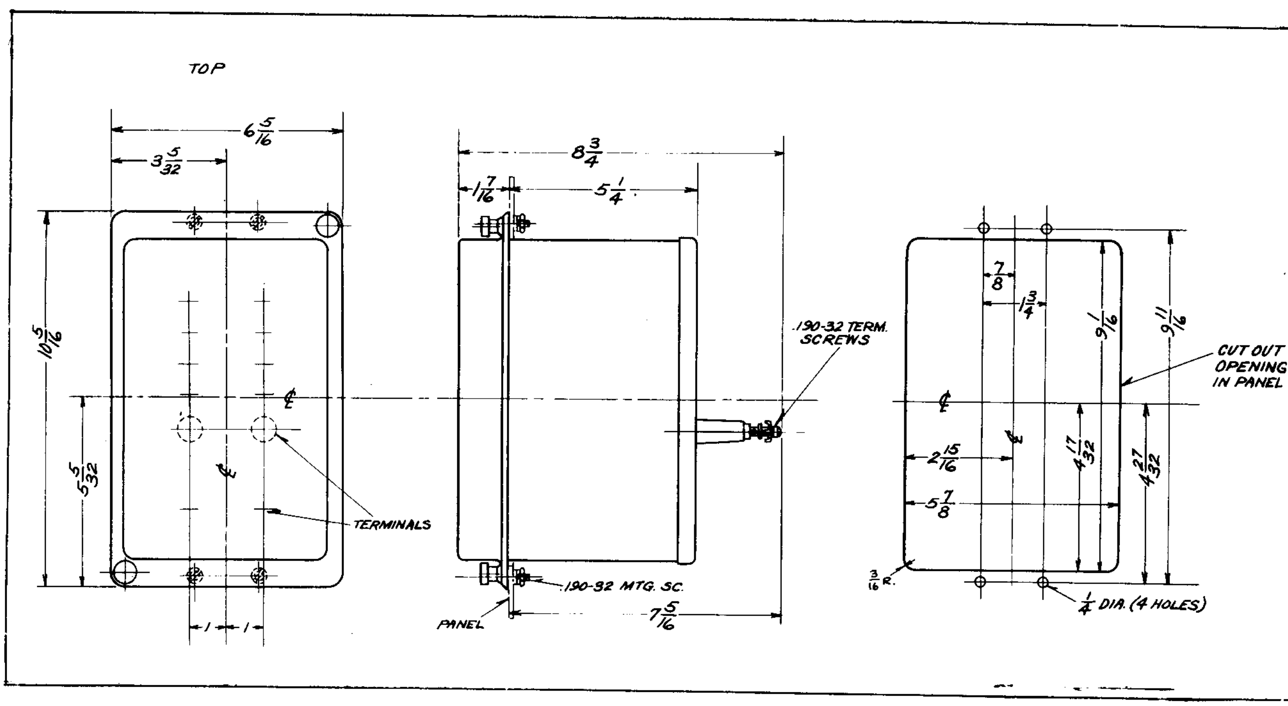


Fig. 4—Outline & Drilling Plan for the S10 Semi-flush Type FT Case. For Reference Only.

INSTALLATION • OPERATION • MAINTENANCE
INSTRUCTIONS

TYPE TH THERMAL TIMING RELAY

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type TH thermal timing relay is a simple and rugged time delay device devoloped expressly to meet the requirements of Westinghouse tap-changing-under-load equipment, where reliability of operation and freedom from maintenance are items of major importance. The relay also may be used in other applications where its characteristics are suitable. As adjusted at the factory, the time delay on a recycling basis can be varied from approximately 15 seconds with the control knob set on the MIN dial position, to approximately 60 seconds with the knob on the MAX position, with 120 volts applied to the relay. A 105 to 135 volt variation of applied voltage has negligible effect on the relay timing when the control knob is set on the MIN position. When set on the MAX position, the effect of voltage variation is more noticeable, but the relay timing is still within the calibration limits. The standard relay is designed for use on a 120 volt 60 cycle circuit. Special relays can be supplied for certain other voltages and frequencies if required.

Two timing elements are required in the control of a tap-changing equipment. The type TH relay is available both with a single timing element in a projection mounted case (Fig.1), and as a duplex timing relay containing two timing elements in an 8 terminal Flexitest case (Fig.4).

The complete operating cycle of the relay is composed of two parts; (1) the time required for the bimetal actuating system to deflect under the influence of heat and operate a micro switch, and (2) the time required for the bimetal system to cool until the micro switch resets. The mechanical construction of the relay is rugged, simple and reliable, with a minimum number of moving parts. The entire assembly is enclosed in a dust-proof case and after installation will require only a routine inspection to keep it in operating condition.

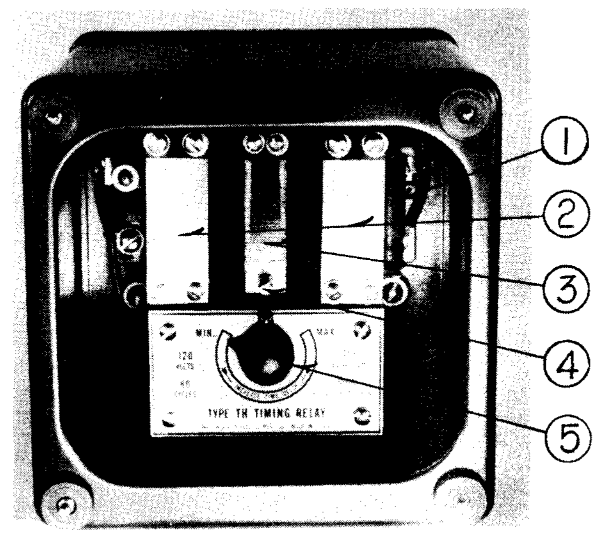


Fig. 1—Type TH Single-Element Thermal Timing Relay. 1—Resistor, 2—Side Bimetal Strips, 3—Heater Coil and Center Bimetal Strip, 4—"F" Bimetal Screw, 5—"T" Timing Screw.

CAUTION The relay is designed specifically for application on Westinghouse regulators and tap-changing-under-load equipment and when so used should give a minimum of well over a million operations. If used otherwise, the effect of possible higher current in the controlled circuit upon the life of the relay should be considered.

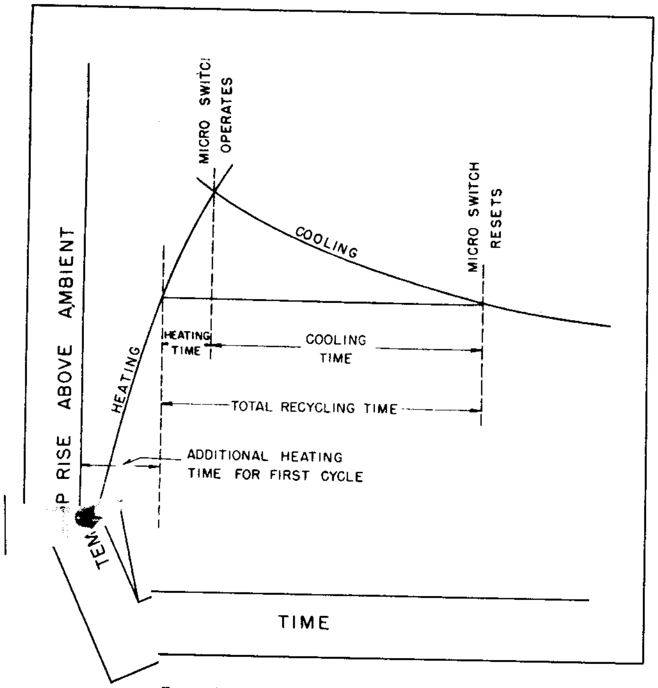


Fig. Time-Temperature Characteristic of the Type ...lay.

...g the circuit between terminals 3 ... relay is reset by de-energizing ... the auxiliary contactor.

Fig. 2—...

T... 7— tact... ...lled circuits of the duplex relay ... terminals 1 and 3, and between 2 ... 8). The duplex relay does not ... corresponding to contact **A**-11 of ...ement relay.

The threr sys P

RELAYS IN TYPE FT CASE

The type TH duplex timing relay is supplied in the S size FT case. The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case; the case cover and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in

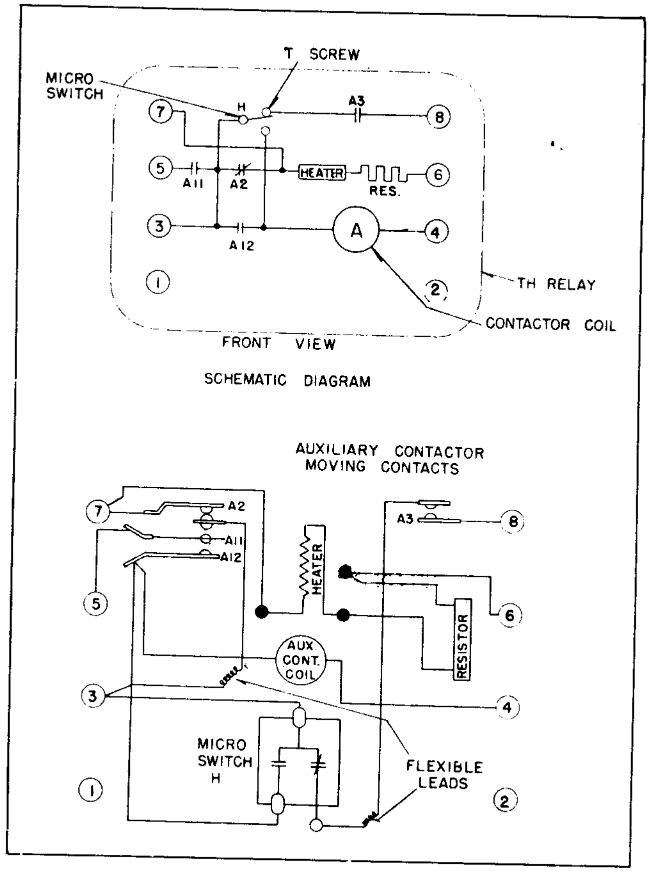


Fig. 7—Schematic and Wiring Diagrams of the Type TH Single-Element Relay.

and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the two corners. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate

chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated, or out of the case as follows:

Testing In Service

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and com-

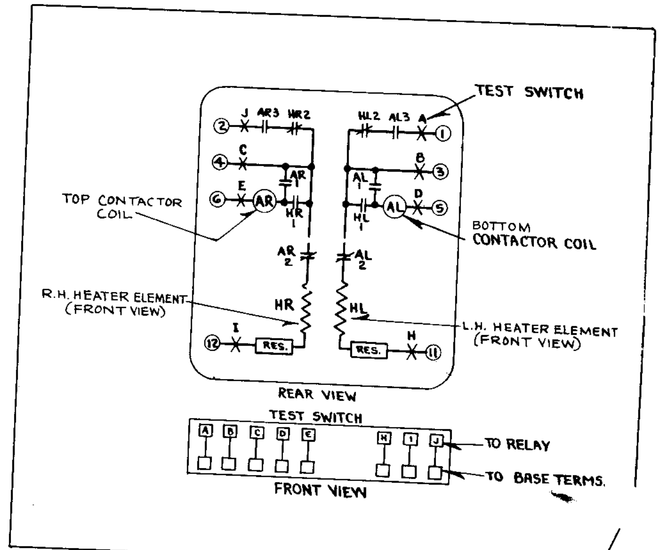


Fig. 8—Schematic Diagram of Type TH Du...elay.

pletely isolates the relay circuit the external connections by means of sting barrier on the plug. The ex...est circuits are connected to t...ting posts. The plug is inserted to... test jaws with the binding pos... the top test switch jaws ...ng posts down.

The external test circuits ... b... the relay elements by #2 test clip le... stead of the test plug.

Testing Out of Case

With the chassis removed from the base relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have ,een changed, the relay taken apart for repairs, or it it is desired to check the adjuntments at regular maintenance periods, the instructions below should be followed:

;ontacts should be periodically cleaned fine file. S#1002110 file is recom- for this purpose. The use of abrasive .l for cleaning contacts is not recom- because of the danger of embedding articles in the face of the soft silver us impairing the contact.

.l moving contacts of the duplex relay, and RH moving contact of the single-element elay, should deflect 3/64" when the armature is closed. The inner end of the terminal strip for the LH make contact of the single-element relay should just touch the contact back-up spring when the armature is open. Both the moving and the stationary LH make contacts will deflect when the armature closes and the moving contact deflection should be approximately 1/32". Sufficient contact deflection is important, both to provide good electrical circuits and to avoid any possibility of having residual magnetism hold the armature closed when de-energized, after the plating has been worn from the pole faces by numerous operations. The contact gaps should be 1/8" to 5/32" (sum of <u>both</u> gaps on LH side of single-element relay) and the outward travel of the armature should be limited by the back stationary contact and not by the tongue of the yoke which projects through the opening in the armature between the hinge points.

If the adjustment of the timing screw or the bimetals is disturbed, the instructions below may be used as a guide in restoring the normal adjustment of the relay. If only the bimetal assembly requires replacement, no re-adjustment should be necessary in the timing dial but only in the adjusting screws at the movable end of the center bimetal. Should the timing screw assembly be replaced, the only adjustment required should be in the timing screw, none in the bimetal system. But if the micro switch is replaced, both the timing screw and the bimetal screw will have to be readjusted.

1. <u>Equipment Required</u>

   a) A source of 120 volt, 60 cycle power.

   b) A high impedance circuit tester. An ohm meter or a neon glow lamp connected as a circuit indicator is recommended.

<u>WARNING:</u> - If any appreciable current is passed through the micro switch contact during adjustment, the switch contacts may be damaged.

2. <u>To Adjust Timing Screw "T"</u>

   a) Connect circuit tester in series with power source and apply to terminals 3 and 4 of the single-element relay, or terminals 3 and 5 or 4 and 6 of the duplex relay.

   b) Check operation of micro switch by pressing bimetal screw "F". The micro switch should close the circuit and operate the indicator. When "F" screw is released, micro switch should open indicator circuit.

   c) Remove knob from timing screw "T". Turn screw clockwise until circuit indicator shows that micro switch normally-open contacts are just barely closed. From this position turn screw counter-clockwise slightly over one-eighth (1/8) turn. This is the approximate MIN setting. Replace knob on screw shaft with pointer at MIN position and tighten set screw.

d) Recheck micro switch operation.

3. To Adjust Bimetal Screw "F"

a) Follow instructions given in section 2-a and 2-b.

b) Turn screw "F" clockwise until circuit indicator shows that micro switch normally-open contacts just barely stay closed when "F" screw is pressed down and then released. From this position, turn screw counter-clockwise one and one-quarter (1-1/4) complete turns. The center bimetal strip must be at the same temperature as the side strips during this adjustment.

4. To Check Timing Adjustment

(Note: Contact designations and terminal numbers in the following paragraphs apply to the single-element relay. Refer to Figs. 7 and 8 and make corresponding connections when checking the duplex relay).

a) Place a short-circuiting jumper across contact A-3. Insulate contact A-12 with a piece of stiff paper. Place cover on relay.

b) Connect circuit indicator as follows: If ohm-meter is used, connect between terminals 3 and 8: if glow lamp circuit tester is used, connect between terminals 4 and 8 of relay. Place a test jumper between terminals 4 and 6 and connect 120 volt, 60 cycle power source to terminals 3 and 6.

c) Timing cycle will begin when supply voltage is turned on. The heating portion of the cycle will be complete when the indicator shows that its circuit has been opened.

d) Note that the first cycle will take longer time than subsequent cycles, due to the additional time required for the bimetal temperature rise and resultant deflection to reach the point at which the micro switch resets. This is shown diagramatically in Fig. 4. Adjustment should not be made on the basis of the first cycle but on the average of several subsequent cycles following immediately after the first. All times referred to in this leaflet are "re-cycling" time defined as the average time consumed by a complete cycle consecutively following the first cycle.

e) When properly adjusted the time of one complete re-cycling operation should be between 11 and 16-1/2 seconds with pointer on "T" set at MIN, and between 54 and 69 seconds with pointer at MAX. Individual readings should not vary more than approximately [illegible] seconds at MIN or 3 seconds at MAX. [illegible] cycling times for these two [illegible] the knob are both high [illegible] correction may be made by [illegible] position of the knob on [illegible]

f) If adjustment of "F" screw [illegible] closer adjustment may be [illegible] necessary by turning scr[illegible] F [illegible] revolution steps. Clockwise [illegible] will increase re-cycling time; [illegible] clockwise rotation will decrease [illegible]

IMPORTANT: Readjustment should not be made either element unless its factory adjustment has been disturbed.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

At 120 volts, 60 cycles, the contactor element burden is 11 voltamperes at approximately 50% power-factor. The heater circuit burden is 18 watts.

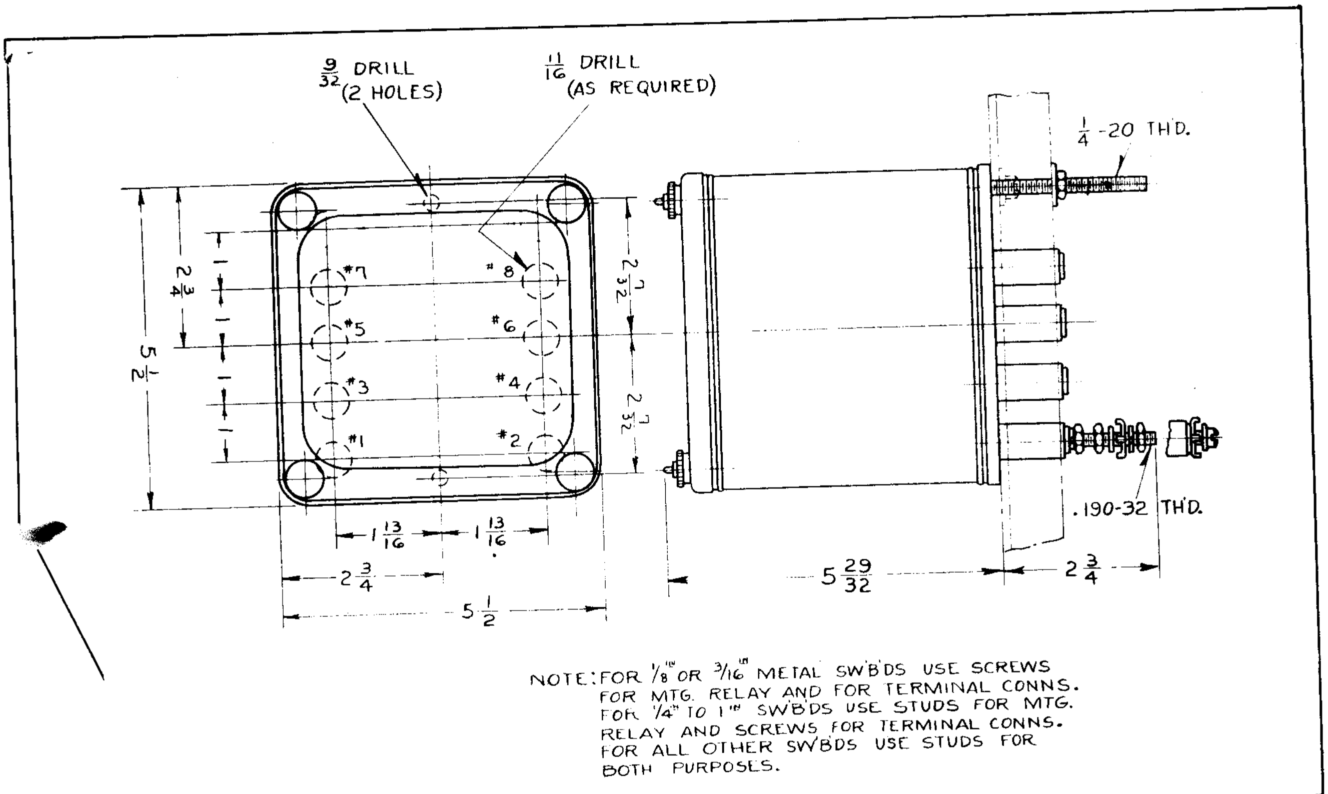


Fig. 9—Outline and Drilling Plan for the Type TH Single-Element Relay.

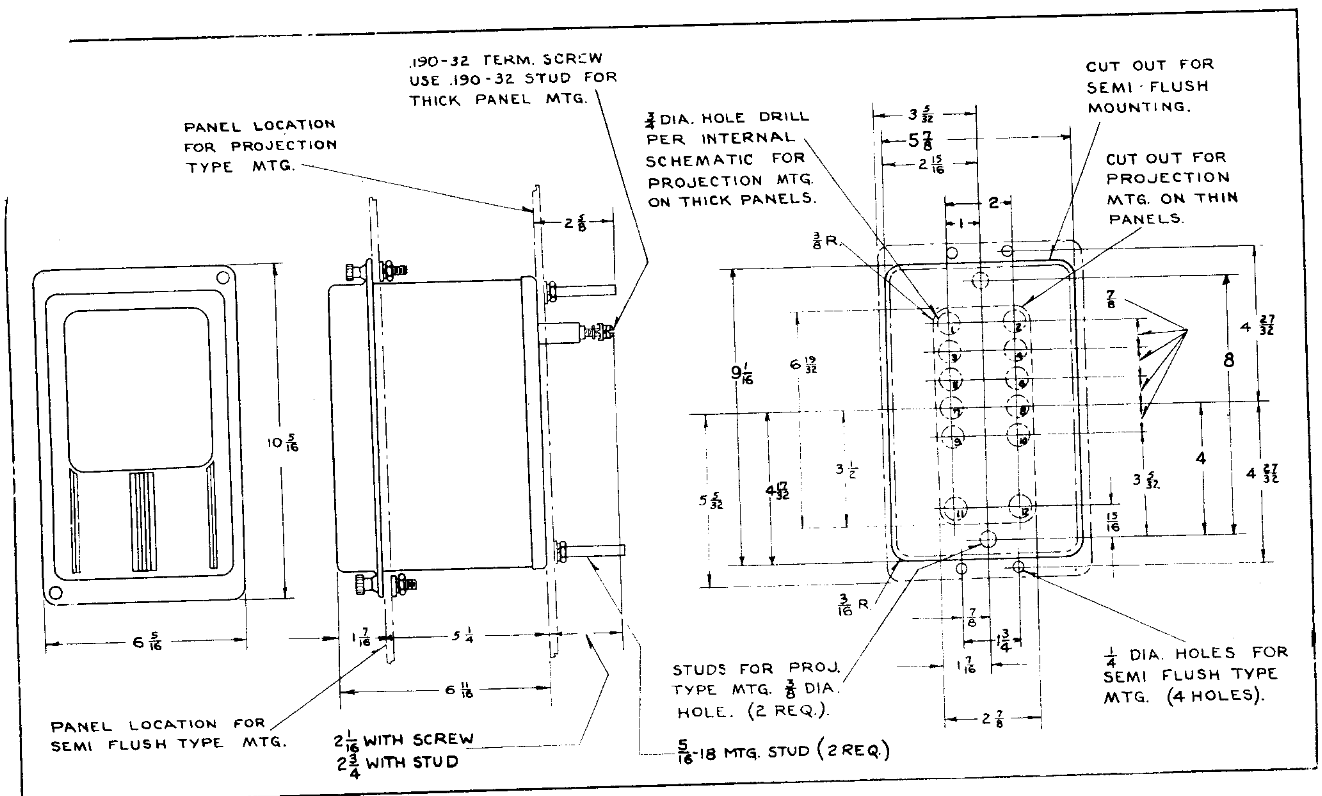


Fig. 10—Outline and Drilling Plan for the Type TH Duplex Relay. See Internal Schematic for the Terminals Supplied. For Reference Only.

I. B. 44-820-1

HANDLING • INSPECTION • MAINTENANCE

INSTRUCTIONS

WEMCO C

INSULATING OIL

P. D. S. 2772

for

Electrical Apparatus

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT
SHARON, PA.

EAST PITTSBURGH PLANT
EAST PITTSBURGH, PA.

SUPERSEDES I. B. 65-000-1

EFFECTIVE JUNE, 1947
(Rep. 3-51)

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WEMCO C INSULATING OIL

P. D. S. 2772

Wemco C insulating oil is a development of the Westinghouse Electric Corporation in cooperation with oil refiners. It has proven its suitability for use in all Westinghouse oil-insulated apparatus. In order to insure the proper performance of the apparatus, only Wemco C oil should be used.

This publication gives the instructions for handling, inspection and maintenance which experience has shown are important in obtaining the best service from the insulating oil.

PART ONE

RECEIVING, STORING AND HANDLING

SHIPMENT

Wemco C oil is shipped in tank cars, drums or cans. The modern tank cars are usually lagged to prevent rapid fluctuations in temperature during transit and thus reduce the amount of expansion and contraction of oil. Changes in the volume of the oil due to temperature changes tend to cause breathing in of moist air resulting in condensation of moisture inside the tank, and lowering of the dielectric strength of the oil.

The oil and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water.

The cans are of metal. The cans as well as the oil are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of oil has been unloaded the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit.

It is very desirable that oil in drums be stored in a closed room. Outdoor storage of oil is always hazardous and should be avoided if at all possible. If it is necessary to store oil outside, protection against direct precipitation of rain and snow should be provided. Drums stored outdoors should be placed on timbers so as to be clear of the ground. They should always be placed on their sides, with bungs approximately 45 degrees from the bottom. *Drums should never be turned up on end.* It is desirable to cover them with a tarpaulin.

Cans. Cans containing oil must not be exposed to the weather. Seals should be kept intact until the oil is actually needed. It is not necessary to make dielectric tests on oil in sealed cans.

Screw caps are provided on the cans to use when the oil is only partially removed after hermetic seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded.

Storage Tank. The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

It is desirable to maintain the temperature of the oil and tank a little above the temperature of the surrounding air as this prevents condensation of moisture in the tank which would affect the dielectric strength of the oil.

The tank should preferably have a convex bottom, allowing the installation of a drain cock at the lowest point for removing any free water or dirt which might settle out. When a cylindrical tank is installed with its axis horizontal, one end should be a little lower than the other, with a drain cock at the lowest point, and the oil supply pipe should enter at the opposite end of the tank. The oil may enter and leave the tank by the same pipe, but this should be at some distance from the bottom to prevent stirring up any settlings when the tank is being filled. It is desirable that the pipe be provided with a swing joint and float, so that it will automatically move with the change in oil level and remain near the surface of the oil.

FIRE PROTECTION

Important: While the Wemco C oil furnished with circuit breakers and transformers will not take fire unless brought to a very high temperature, it should be remembered that under abnormal conditions such a temperature can be reached, so that proper precaution against fire should be taken. Suitable means should always be provided for drawing off oil from storage tanks and extinguishing fire. The best way to extinguish burning oil is to smother the flames so that the supply of fresh air is cut off. Chemical fire extinguishers are effective, but water should not be used unless it is applied by a special atomizing spray nozzle.

HANDLING

Note: The oil should be sampled and tested, except when received in cans, before being transferred from the container to the apparatus, particularly in cases where the wire lock-seal has been broken. In cases where the apparatus is received with the oil installed, the oil should be sampled and tested before the apparatus is put into service, as described later in this book.

When putting a new circuit breaker or transformer into service, see that the tank is free from moisture and foreign material.

When carbonized oil is removed from a circuit breaker or transformer in service, thoroughly clean the interior of the apparatus so that the new oil will not be contaminated. This may be done by flushing with clean insulating oil and wiping with clean, dry, lint-free cotton cloths. Cotton waste is undesirable because of the lint which may be introduced into the oil.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, oil which has not been filtered should be strained through two or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths may be stretched across a funnel of large size and should be renewed at frequent intervals.

Important: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with oil, and to prevent the entrance of water and dirt during the transfer of the oil to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not practicable, protection against moisture must be provided.

All vessels used for transferring the oil should be carefully inspected to see that they are absolutely dry and free from dirt.

Important: Always use a metal or oil proof hose when handling the oil. A hose made of natural rubber should not be used. Oil can easily become contaminated from the sulphur in the natural rubber, and should not be allowed to come in contact with it.

When it is necessary to transfer oil from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the oil through a blotter press or centrifuge at room temperature. A similar procedure is also advisable in the case of apparatus erected inside and later exposed to cold weather; the reason being that oil will dissolve more water at higher temperatures which will be thrown out of solution at lower temperatures. The excess will appear in suspension in the oil and will lower the dielectric strength.

A drum of cold oil when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the oil as it flows from the drum. Before breaking the seal the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

Cleaning Contaminated Drums. The cleaning of drums which have contained used insulating oil requires great care in order to insure a thoroughly clean drum. It is preferable to return such drums to the refinery where adequate cleaning facilities are available, rather than to attempt to clean them. If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum.

Caution: Do not use a steel pipe because of the danger of a spark igniting the vapor.

Heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C (190°F- for sixteen hours. Screw the bung on tightly before removing drum from the oven. Use a new washer with the bung to insure a tight seal. A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.

Caution: An open flame must always be kept away from the oven to prevent igniting inflammable gases.

Refilling Drums. The practice of refilling drums with oil is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the oil is likely to become contaminated.

If it is necessary to refill them for storage, drums which have been used only for oil in good condition should be reserved for this purpose. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with oil, the temperature of the drum and of the oil should be at least 5.5°C (10°F) higher than the air, but the temperature of the drum need not be the same as that of the oil.

A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the oil refineries and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the oil.

Drums to be refilled with oil for storage should be plainly marked with paint for identification.

SAMPLING AND INSPECTION

REQUIREMENTS FOR INSULATING OIL

The requirements for good insulating oil used in transformers are not inconsistent with the requirements for oil used in circuit breakers. Wemco C oil is particularly well suited for both applications and for either indoor or outdoor service. In transformers the oil provides an electrical insulating medium which also will carry the heat away from the windings. In circuit breakers, the oil serves primarily as an electrical insulating medium which interrupts the arc when the circuit breaker operates. Wemco C oil meets these requirements:

1. High dielectric strength.

2. Freedom from inorganic acid, alkali and corrosive sulphur (to prevent injury to insulation and conductors).

3. Low viscosity (to provide good heat transfer in transformers; in circuit-breakers, to aid in dissipating the products formed by the arc when the circuit is interrupted).

4. Good resistance to emulsification (so that any moisture entering the apparatus, or carbon formed by arcing in the circuit-breaker, will settle to the bottom of the tank; water in suspension is a menace to safe operation).

5. Freedom from sludging under normal conditions.

6. Low pour point.

7. Low specific gravity.

CAUSES OF DETERIORATION OF OIL

Transformers. The principal causes of deterioration of insulating oil in transformers are:

1. Presence of water.

2. Oxidation.

Condensation from moist air due to breathing of the transformer, especially when the transformer is not continuously in service, may injure oil. (The moist air drawn into the transformer condenses moisture on the surface of the oil and inside of the tank.) The oil may also be contaminated with water through leakage such as from leaky cooling coils or covers.

Sludge is an oxidation product, the amount formed in a given oil being dependent upon the temperature and the time of exposure of the oil to the air. By careful refining, the components of oil which are most readily oxidized to form sludge can be removed, so as to provide an insulating oil which will not sludge under normal operating conditions.

Note: Excessive temperatures may cause sludging of any transformer oil regardless of how well it is refined.

Transformer oil which has begun to sludge will continue to do so after it has been reconditioned by means of the centrifuge or filter press, as these methods of reconditioning do not remove the deterioration products which are in process of formation but have not yet been precipitated as sludge. Proven and accepted methods are not yet available in the field that will completely remove the oxidation products which are encountered in transformer service and bring sludged oil back to its original condition. (It is not economical to send used oil to the refinery for re-refining as they will allow only fuel oil price, which would probably be less than the cost of transportation.)

Another effect of oxygen is to gradually produce organic or "fatty" acids in oil in service. These should not be confused with the mineral acids such as sulphuric acid used in refining, as in small amounts the former do not have a deteriorating effect upon insulation.

Circuit Breakers. The principal causes of deterioration of insulating oil in circuit breakers are:

1. Presence of water.

2. Carbonization of the oil (caused by operation of the circuit breaker).

Insulating oils may receive water through condensation on the surface of the oil or on the inside of the tank due to the entrance of moist air, and, of course, by direct leakage.

All oil in circuit breakers is subject to carbonization due to arcing between the contacts. Part of the carbon formed is deposited on the mechanism and at the bottom of the tank while the remainder continues in suspension in the oil.

Carbonization takes place not only when the circuit breaker opens heavy short circuits, but also whenever an arc is formed, even during such light service as the opening of the charging current of the line, and this latter service, repeated, may eventually produce enough carbon to be a source of trouble.

The carbon reduces the dielectric strength of the oil, lowers the surface resistance of the insulation if water is present, and also lowers resistance to emulsification. The carbon alone may not be detected by the dielectric test, particularly if the oil is free from moisture.

In cold weather, a larger amount of carbon is formed than in warm weather because of the increased viscosity of the oil at low temperatures. Also the carbon is not as readily dispersed through the oil.

SAMPLING OIL FROM SHIPPING CONTAINERS

The dielectric strength of oil is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. Many of the low dielectric test results reported from the field have been caused by carelessness in sampling. The following instructions, based on the specifications of the American Society for Testing Materials, must be followed to assure accurate results:

Sample Bottle. The sample container shall be made of clear glass, of at least 8 oz. capacity, and shall be cleaned and dried. The glass bottle is preferable to the metal container as it may be examined to see if it is clean. It also allows visual inspection of the oil before testing, particularly as regards free water and solid impurities. However, any samples to be tested for color or sludge-forming characteristics must be kept in the dark, as light produces changes in these properties. This is not necessary for any other tests. Use only good quality cork and use new cork for each sample.

The clean, dry bottle shall be thoroughly rinsed with benzine or dry lead-free gasoline which has previously withstood a dielectric test of at least 25 kv in a standard test cup, and shall be allowed to drain. It is preferable to heat the bottle and cork to a temperature of 100°C (212°F) for one hour after thoroughly draining. The bottle shall then be tightly corked and cork and neck of the bottle dipped in melted paraffin.

Important: Glass jars having rubber gaskets or stoppers should not be used. Oil can easily become contaminated from the sulphur in natural rubber.

Thiefs for Sampling. A convenient and simple thief (see Figure 1) for use with 50 gal. drums may be made of tin as follows:

Length 36 in., diameter 1¼ in. with cone shaped caps over the ends and openings at the ends ⅜ in. in diameter. Three legs equally spaced around the thief at the bottom, and long enough to hold the opening ⅛ in. from the bottom of the container being sampled, aid in securing a good representative sample. Two rings soldered to the opposite sides of the tube at the outer end will be found convenient for holding the thief by slipping two fingers through them and leaving the thumb free to close the opening. In an emergency a piece of glass tubing 36 in. long may be used. For the tank cars, a thief employing a trap at the bottom may be used. (See Figure 2.)

The thief shall be suitable for reaching the bottom of the container and the sample shall be taken with the thief not more than about ⅛ in. from the bottom.

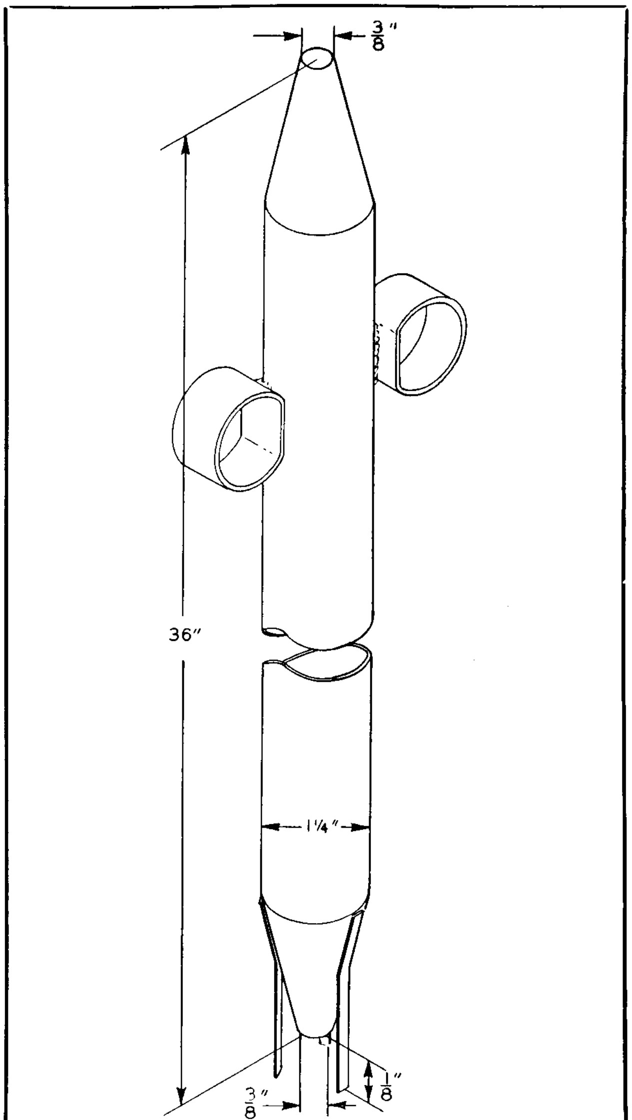

FIG. 1. Drum Thief

Procedure. Thiefs should be cleaned *before and after use* by rinsing with dry lead-free gasoline; be sure that no lint or other fibrous material remains on them. When not in use they should be kept in a hot, dry cabinet or compartment at a temperature not less than 37.8°C (100°F), and shall

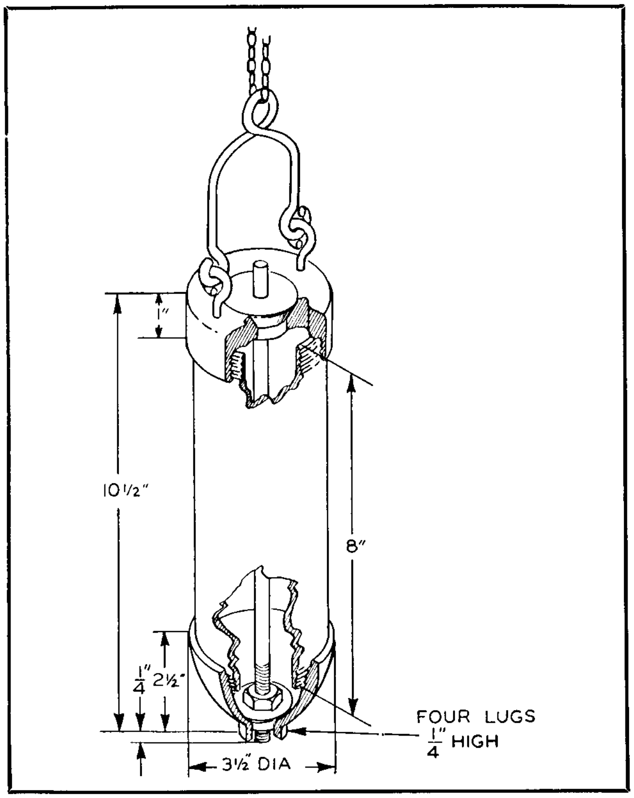

FIG. 2. Tank Car Thief

be stored in a vertical position in a rack having a suitable drainage receptacle at the base.

Samples shall not be drawn from containers indoors until the oil is at least as warm as the surrounding air. Cold oil may condense enough moisture on the surface from a humid atmosphere to seriously affect its insulating properties. Sampling oil from containers out of doors is undesirable, due to the possibility of condensation of moisture, and should be avoided whenever possible. (Samples should never be taken in the rain.)

The drums shall be lined up preferably on their sides, bungs up and numbered. The bungs shall be unsealed and removed and laid with the oily side up beside the bungholes. The unstoppered sampling receptacle can be placed on the opposite side of the bungholes. The top hole of the thief shall be closed with the thumb, the thief quickly thrust to the bottom of the container and the thumb removed. When the thief is filled, the thumb shall be replaced, the thief quickly withdrawn and the contents allowed to flow into the sampling receptacle. The lower holes shall not be closed with the fingers of the other hand. The free hand shall be used to guide the stream of oil by touching the thief only when necessary. The oil shall not be allowed to flow over the hand or fingers before it flows into the sampling receptacle.

When the sampling receptacle is filled, it shall be closed quickly and the bung replaced in the container and tightened. The sampling receptacle shall be taken under cover to the testing laboratory as quickly as feasible.

After using, thoroughly clean all thiefs and sampling receptacles as outlined above.

The tank cars of oil shall be sampled by introducing the thief through the manhole on top of the car, the cover of which shall be removed carefully so as not to contaminate the oil with dirt. The sample shall be taken as near as possible to the bottom of the tank car. This shall not be done while rain or snow is falling.

When separate samples are being taken from a consignment or part of a consignment, care should be exercised to prevent contaminating the samples. A separate thief shall be used for each sample or the thief previously used shall be well drained and then thoroughly washed with oil from the next container to be sampled; the oil thus used for washing should be thrown away before the next sample is taken. (Enough thiefs shall be provided to insure thorough drainage of each thief after rinsing with oil to be sampled before using it to withdraw the actual sample.) For obtaining only a few samples, two thiefs are sufficient, but for obtaining a large number of samples (for example, sampling a carload of drummed oil) six or more thiefs are desirable.

When one average sample of a consignment or batch is being taken, the same thief may be used throughout the sampling operation, and it is not necessary to rinse the thief with oil before taking any of the portions that go to make up the total average sample.

Quantity of Sample. It is recommended that one 8 oz. bottle of oil be taken as a sample for dielectric tests, and one quart sample be taken when complete physical and chemical tests are to be made. At least one sample should be taken from a tank car of oil. One sample may be taken from each drum, or if desired, a composite sample may be made from oil from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums have been stored exposed to the weather, a sample from each drum shall be tested. The sample of oil should be examined for free water, and if any is noted the sample and bottle should be discarded, as sample would not be suitable for dielectric test. If the sample is being taken from a tank car, sufficient liquid should be drawn from the bottom of the tank to remove all free water before obtaining another sample of oil for the dielectric test.

SAMPLING OIL FROM APPARATUS

When taking samples of oil from apparatus in which a thief cannot be used, use the sampling valve and follow the procedure outlined above as far as practicable.

Care should be taken to procure a sample which fairly represents the oil at the bottom of the tank. A sufficient amount of oil should therefore be drawn off before the sample is taken, to insure that the sample will not be that which was stored in the sampling pipe. For this reason, the valve and the drain pipe should be sufficiently small to be emptied with convenience and yet sufficiently large to give an even flow of oil and avoid clogging by sediment. A ¼ in. pipe and valve is recommended. This, of course, may be separate from the drainage pipe and valve or it may be connected to the drainage valve by means of a suitable reducer.

It is of prime importance that the sample of insulating oils be kept free from water and other impurities.

Moisture may find its way into insulating oil in several ways. The oil is frequently shipped in metal drums, and if these are exposed to rain, moisture may enter around the threads of the bung, or through imperfections in the seams. In water-cooled transformers, the portions of the water pipes which extend above the oil level are always heavily lagged with a heat-insulating material. If this lagging is damaged, moisture in the air inside of the transformer may condense on the cold water pipe and may run down into the oil. Another source to which the presence of moisture in large transformers is sometimes attributed, is the "breathing" of the transformer. When the transformer carries a load and becomes warm, both the oil and the air in the tank expand, and if there is a vent, part of the air will be forced out of the tank. When the load is cut off and the transformer cools, this action is reversed, and a corresponding volume of air is drawn into the tank from the atmosphere. This air carries a certain amount of moisture, which is condensed as the air becomes cooler, and collects on the cover and tank wall.

If the apparatus is installed outdoors, care should be taken to prevent contamination of the sample by rain, snow, etc.

A glass bottle is recommended as a sampling receptacle, so that any water present may readily be seen.

If the sample contains free water it is not suitable for dielectric test and the sample and bottle should be discarded. Sufficient liquid should be drawn from the bottom of the tank to remove all free water before obtaining another sample of oil for the dielectric test.

In order to make sure that the dielectric strength is up to its proper value, the insulating oil in any piece of apparatus should be tested before its initial operation, and at regular intervals thereafter.

PERIODIC INSPECTION

Oil may deteriorate in service even under what seems to be the most favorable conditions. The more handling an insulating oil receives, the greater the opportunity for contamination unless adequate precautions are taken.

Important: Therefore, it is essential to provide for periodic inspection and test, and to purify the oil whenever necessary in order to maintain it in good condition.

Note: A periodic inspection and reconditioning schedule is not essential for oil in transformers equipped with the Inertaire device; such oil should last indefinitely without need for reconditioning, provided the Inertaire equipment is properly maintained.

Regular inspection and tests of insulating oils by central stations and other large users of these oils have convinced them of the necessity of this practice. Where these inspections and tests have been systematically followed it has been found that failure of the apparatus from burnouts, due to the fact the oil had become contaminated with moisture and sediment, has been reduced to a minimum and has resulted in greater economy of operation. In view of the importance of the subject, it is, therefore, recommended that all companies, in the interest of good service, adopt some system of oil inspection and test.

The frequency of inspecting and testing depends upon the service to which the apparatus is subjected, and the construction of and the materials used in the apparatus.

Circuit breakers which are called upon to open the circuit frequently under heavy loads require more frequent inspection and reconditioning of the oil than those subjected to lighter duty.

Transformers subjected to heavy duty should be more frequently inspected than those in normal or light service.

It is recommended that operators prepare a schedule for inspection based on the operating conditions. Reference to the station log, together with the record of dielectric tests of the oil, should determine the frequency of inspection and test.

The period between successive inspections should never be longer than six months or until experience indicates that the time between tests can be extended. When the dielectric strength of the oil drops to 20 kv in the standard dielectric test (see page 14) the oil should be looked upon with suspicion. In no case should the dielectric strength be allowed to drop below 16.5 kv.

Inspection of oil should include:

Checking Oil Level. It is essential that the proper oil level be maintained. Low oil level may cause breakdown of insulation or flashover of bushing in any apparatus, or failure of circuit breaker to open heavy overloads properly.

Checking Dielectric Strength. The oil should be tested regularly for dielectric strength and purified when the tests show need of it. The testing should be systematized and complete records kept. It is particularly important to check the dielectric strength after exposure to severe overload operation in a circuit breaker.

Checking for Carbonization. The presence of carbon in circuit breaker oil introduces a hazard, due to the tendency of the carbon to lower the dielectric strength of the oil, and also to deposit on insulating surfaces, thereby reducing the insulation resistance.

Visual inspection of the oil samples should be made and if any appreciable amount of carbon is present the oil should be reconditioned even though the dielectric test is good.

Important: Certain washing compounds have been used by some operating companies to assist in separating the carbon from the oil. Investigation in the Westinghouse laboratories has shown that these compounds leave the oil in poor condition. Customers are warned against using any form of chemical treatment that has not been investigated and recommended by Westinghouse Electric Corporation.

Checking for Sludge. Transformers should be regularly examined for evidence of sludge. A visual inspection will indicate its presence. Appreciable amounts of sludge may clog the oil ducts and interfere with heat transfer. It is essential that such oil be reconditioned immediately and when put in service again should be carefully watched to see that the proper dielectric strength is maintained and that the oil is reconditioned again before sludge has formed to such an extent as to interfere with the operation of the transformer. *Oil which has once sludged, will, after being reconditioned, sludge more quickly than the first time.*

WESTINGHOUSE OIL TESTING SERVICE

Many users of transformers and large oil circuit breakers do not have the necessary facilities for testing insulating oil. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an oil testing service to provide a careful test by experienced engineers, and a prompt report of test results.

A special 8 oz. oil sample bottle and mailing container,* (W) style # 310368, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse District Office.

After drawing the sample of oil, the customer should seal the bottle and mail it to the Westinghouse Engineering Laboratory at East Pittsburgh, Pa. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. The label carries an envelope in which the customer should enclose his order covering the work of testing.

When samples of oil are received for testing they are sent to the engineering testing laboratory and tested for dielectric strength in accordance with methods described on page 14.

As soon as the test has been made, a report giving five breakdown test readings and the average of these is sent by mail directly to the person in the customer's organization who has been designated on the order to receive it.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination. (The customer should plainly indicate the type of service desired.)

This service consists of an examination of the oil by a competent oil chemist. Recommendations will be made as to the suitability of the oil for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the oil represented should be given as completely as possible. Samples should be approximately one quart.

Power factor test of oil at 60 cycles can be made. Unless otherwise requested, the test will be made at a stress of 30 volts per mill.

(For details refer to the nearest Westinghouse District Office.)

* The bottle and the container will not be returned to the customer.

PURIFICATION AND RECONDITIONING

PURITY OF OIL

Wemco C oil is clear and nearly water-white in color. It is free from water, acid, alkali and deleterious sulphur compounds.

The oil is carefully refined so as to have a high resistance to emulsion; that is, the water is not held in suspension but quickly separates out. This is particularly essential in circuit-breaker service since this apparatus cannot be tightly closed like a transformer and some moisture may be introduced into the oil. Wemco C oil has been designed with this particular property in mind and precipitates water and carbon promptly. However, certain impurities develop while the oil is in service and these impurities must be removed to insure safe operation of the apparatus. The source and kind of impurities developed in the oil depend upon the type of apparatus in which it is used.

In circuit-breaker service, each time the circuit is opened some carbon is formed in the oil, even though only the charging current is being interrupted. The resistance to emulsion of the oil is also lessened, both by a change in the oil and by the presence of carbon in the oil. Oil which has been subjected to arc action in the circuit breaker tends to slowly form organic acids, which further tend to lower its resistance to emulsion. The major portion of the carbon slowly precipitates to the bottom of the tank, but the more finely divided carbon has a tendency to remain suspended in the oil, and lower the dielectric strength. Both carbon and moisture are attracted to the insulating surfaces of the bushings by the electrostatic field, and when so deposited, lower the insulation resistance of the terminals from line to ground.

Oil in transformers is generally subjected to heat, oxidation and sometimes to moisture. Heat in the presence of oxygen produces a gradual physical and chemical change in oil and the extent of this change will depend upon the amount of heat, time and the catalytic action of exposed metals in the apparatus to which it is subjected. High temperature over a short period of time or somewhat lower temperature over a long period of time affect the characteristics of the oil, particularly in the development of organic acidity and sludge.

Heat in the presence of oxygen affects the unsaturated hydro-carbons, at first through formation of organic acids and later by precipitation in the form ordinarily called sludge.

RECONDITIONING

The reconditioning of oil used in circuit breakers and transformers consists principally of the removal of water, carbon and sludge and the restoration of resistance to emulsification, thereby putting the oil in the best condition to separate out any water which may later be introduced.

The three types of equipment in general use for simple reconditioning of oil in transformers and circuit breakers are: the centrifuge, the blotter filter press, and the combination centrifuge and filter press. (See Part Five.) The combination of centrifuge with chemical treatment is particularly well adapted to the reconditioning of carbonized circuit-breaker oil.

INTERCHANGEABILITY

Wemco C oil may be used in transformers after arcing in circuit breakers, provided all carbon is removed and the purified oil meets the following values:

1. Specific Gravity: 15.5 C, .898 max.
2. Viscosity: Saybolt at 37.8 C (100 F), 60 secs. max.
3. Flash Point: 135 C (275 F) min.
4. Pour Test: −45.6 C (−50 F) max.
5. S. E. Number: 35 secs. max.
6. Neutralization Number: Mg KOH per gram of oil, 0.08 max.
7. Corrosive Sulphur: None
8. Dielectric Strength: 22 kv min. in a standard test cup.

Important: In general, when small quantities of oil have been contaminated with fire extinguishing agents, it is preferable to replace the oil rather than to attempt to reclaim it.

Insulating oil which has been contaminated with carbon tetrachloride or soda sulphuric acid cannot be reclaimed. (It would have to be refined.)

When large quantities of oil have been contaminated with other fire extinguishing agents, the reclaiming of the oil will depend upon the kind and degree of contamination. There may be factors other than the fire extinguishing agent (for instance, high temperatures cracking the oil, carbonized insulation, etc.) which should be considered. Any question should be referred to the nearest Westinghouse District Office.

PART FOUR

TESTING METHODS

Instructions for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

DIELECTRIC STRENGTH TEST

Apparatus. The transformer and the source of supply of energy shall not be less than ½ kva, and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by any approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the oil takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kva or less, as the current is limited by the regulation of the transformer.

The test cup for holding the sample of oil shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline, and nonabsorbent as far as moisture, mineral oil and gasoline are concerned.

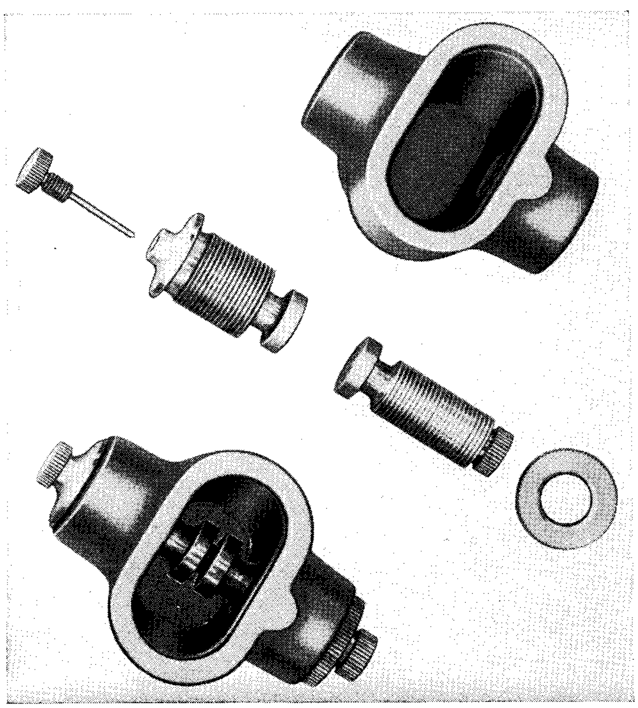

FIG. 3. Oil or Fluid Test Cup for Dielectric Test

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1¼ in. below the top of the cup. (A suitable test cup is shown in Figure 3, and portable testing outfits in Figures 4, 5 and 6.)

Procedure. The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with oil-free dry gasoline or benzine until they are entirely free from fibres.

The test cup shall be filled with dry, lead-free gasoline or benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25 kv, the cup shall be considered in suitable condition for testing the oil. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the oil which is being tested, and the test made at once, or the electrodes should be thoroughly dried before using.

The temperature of the test cup and of the oil when tested shall be the same as that of the room, which should be between 20 and 30 C (68 and 86 F). Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion to avoid introducing air, so as to mix the oil thoroughly before filling the test cup. This is even more important with used oil than with new oil as the impurities may settle to the bottom and the test may be misleading.

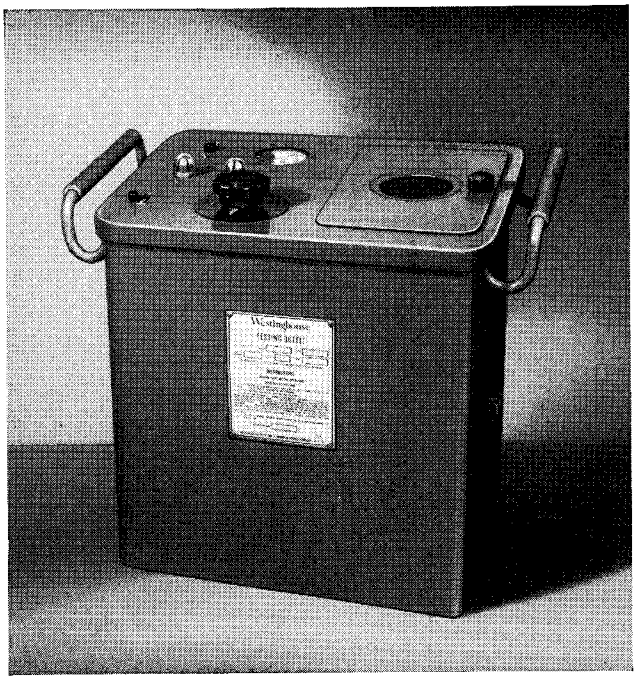

FIG. 4. Portable Oil Testing Set ½ kva, 35,000 volts

The cup shall be filled with oil to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The oil shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

Provision shall be made for opening the circuit as promptly as possible after breakdown has occurred, in order to prevent unnecessary carbonization of the oil. After each puncture, the testing vessel shall be jarred to loosen particles of carbon adhering to the electrodes and the oil gently agitated but not with sufficient violence to introduce air bubbles.

Five breakdowns shall be made on each filling, after which the vessel shall be emptied and refilled with fresh oil from the original sample. The test shall be continued until the averaged values of at least three fillings do not differ from their mean by more than 10 per cent.

Report. The report shall include the volts (rms value) at each puncture, the average voltage for each of the three or more fillings, grand average voltage, and the approximate temperature of the oil at the time of the test.

POUR TEST

The pour point of a petroleum oil is the lowest temperature at which this oil will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Apparatus. The test jar (see Figure 6) shall be clear glass, of cylindrical shape, approximately 1¼ in. inside diameter and 4½ to 5 in. high, with a flat bottom. An ordinary 4 oz. oil sample bottle may be used if the test jar is not available.

The cork shall fit the test jar, and shall be bored centrally to accommodate the test thermometer.

The thermometer shall conform to A.S.T.M. specifications for pour test. It may be ordered as: A.S.T.M. thermometer low cloud and pour, 56.7 C (-70 F) to +21.1 C (70 F).

The jacket shall be of glass or metal and shall be watertight, of cylindrical form, flat bottomed, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

A disc of cork or felt ¼ in. thick and of the same diameter as the inside of the jacket shall be placed in the bottom of the jacket.

The ring gasket shall be about $\frac{3}{16}$ in. thick, made to fit snugly around the outside of the test jar and

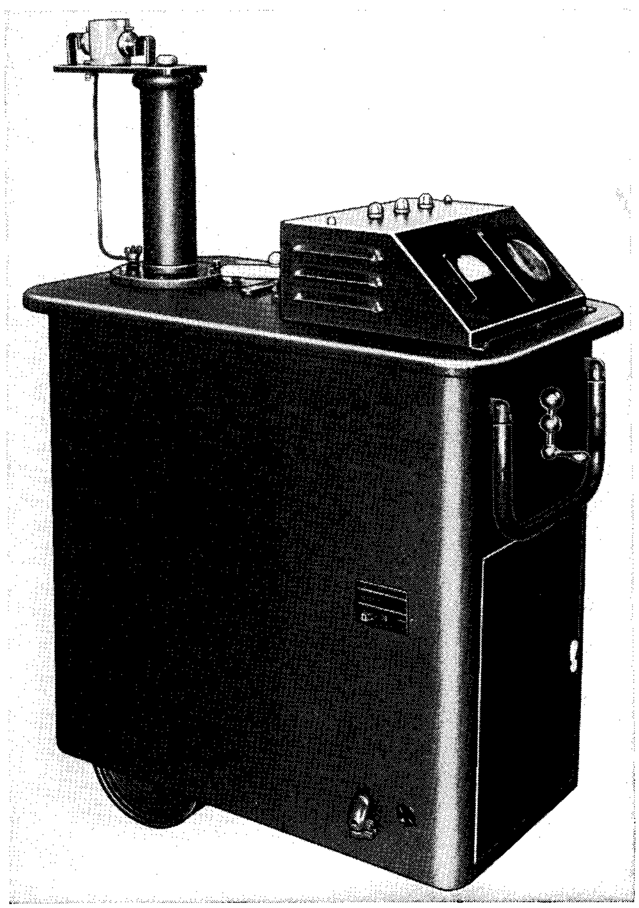

FIG. 5. Portable Truck Type Oil and Insulation Testing Set, 5 kva, 30,000/60,000 volts

loosely inside the jacket. This gasket may be made of cork, felt or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

The cooling bath shall be of a type suitable for obtaining the required temperature. The size and shape of the bath are optional but a support suitable for holding the jacket firmly in a vertical position is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperature may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

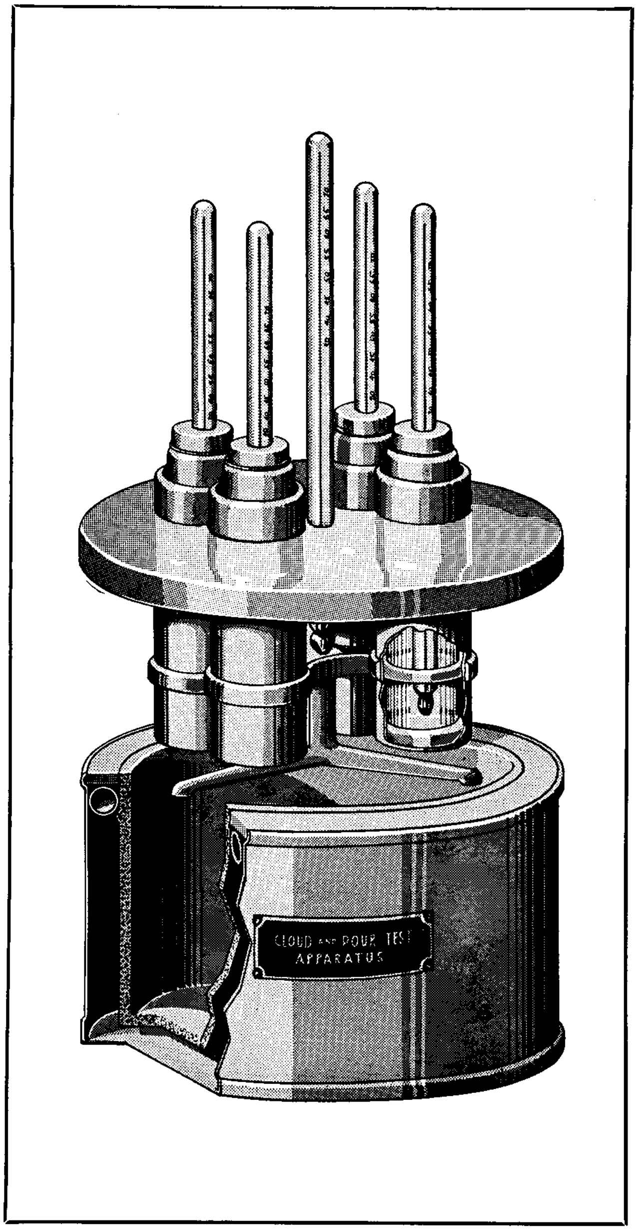

FIG. 6. Apparatus for Pour Test

Procedure. The oil to be tested shall be brought to a temperature at least 14 C (25 F) above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear. (Such filtration shall be made at a temperature at least 14 C (25 F), above the approximate cloud point.) The oil shall be poured into the test jar, to a height of not less than 2, or more than 2¼ in. When necessary, the oil shall be heated in a water bath just enough so it will pour into the test jar.

The test jar shall be tightly closed by the cork carrying the test thermometer in a vertical position in the center of the jar; the thermometer bulb should be immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the oil.

Heat without stirring to a temperature of 46.1 C (115 F) in a bath maintained at not higher than 47.8 C (118 F). The oil shall then be cooled to 32.2 C (90 F) in air or in a water bath approximately 25 C (77 F) in temperature. Oils with which the low-cloud and pour-test thermometer can be used from the beginning of the test shall be cooled to 15.6 C (60 F) in any convenient manner before placing that thermometer in position.

The cork or felt disc shall be placed in the bottom of the jacket and the test jar, with the ring gasket, 1 in. above the bottom, shall be inserted into the jacket. The disc, gasket and inside of jacket shall be clean and dry.

After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

The temperature of the cooling bath shall be adjusted so that it is below the pour point of the oil by not less than 8.3 C (15 F) nor more than 16.7 C (30 F), and this temperature shall be maintained throughout the test. The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 11.1 C (20 F) above the expected pour point, at each test-thermometer reading which is a multiple of 2.8 C (5 F), the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds, as noted by a stop watch or other accurate timing device, and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 2.8 C (5 F) below the previous reading.

The test shall be continued in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken at the temperature 2.8 C (5 F) above this solid point.

STEAM EMULSION TEST

The S. E. test gives a good indication of the resistance to emulsification of the oil, or its ability to throw down moisture and carbon developed through arcing in a circuit breaker. (This property of an oil is impaired when the oil has been exposed to the operation of a circuit breaker.)

Apparatus. The steam generator (see Figure 7) shall be made of either metal or glass of at least one-liter capacity, capable of withstanding the heat necessary for continued use in the production of steam. It shall be fitted with three outlets with suitable connections for rubber tubing. In the case of a metal generator, a large opening for filling and a suitable water gauge shall be a necessary part of the apparatus.

The baths shall be glass, with a capacity of 3 to 3½ liters and a depth of 7½ to 9 in. A good-quality battery jar or beaker is entirely satisfactory.

Heat for the steam generator shall be supplied by a suitable gas burner or electric hot plate. The separating bath may be heated by any convenient means, including an auxiliary steam line.

The oil container shall be a 25 by 200 mm test tube, graduated from zero or from 10 to 50 cc in cubic centimeters, each even 5 cc line to encircle the tube.

The steam piping or the steam delivery tube shall consist of a piece of thin-wall glass tubing, not less than 2.3 nor more than 2.7 mm inside diameter, and 12 in. in length. The steam pipe shall be cut off diagonally at an angle of 30 degrees with the axis of the tube at the discharge orifice, and shall be bent at right angles 10 in. from the discharge orifice.

Accessories shall consist of suitable wooden or metal frames or holders for holding all containers in a vertical position in the baths; thermometers for the separating and emulsifying baths (floating type thermometers of suitable range); thermometers for the oil container tube (engraved-stem type, of

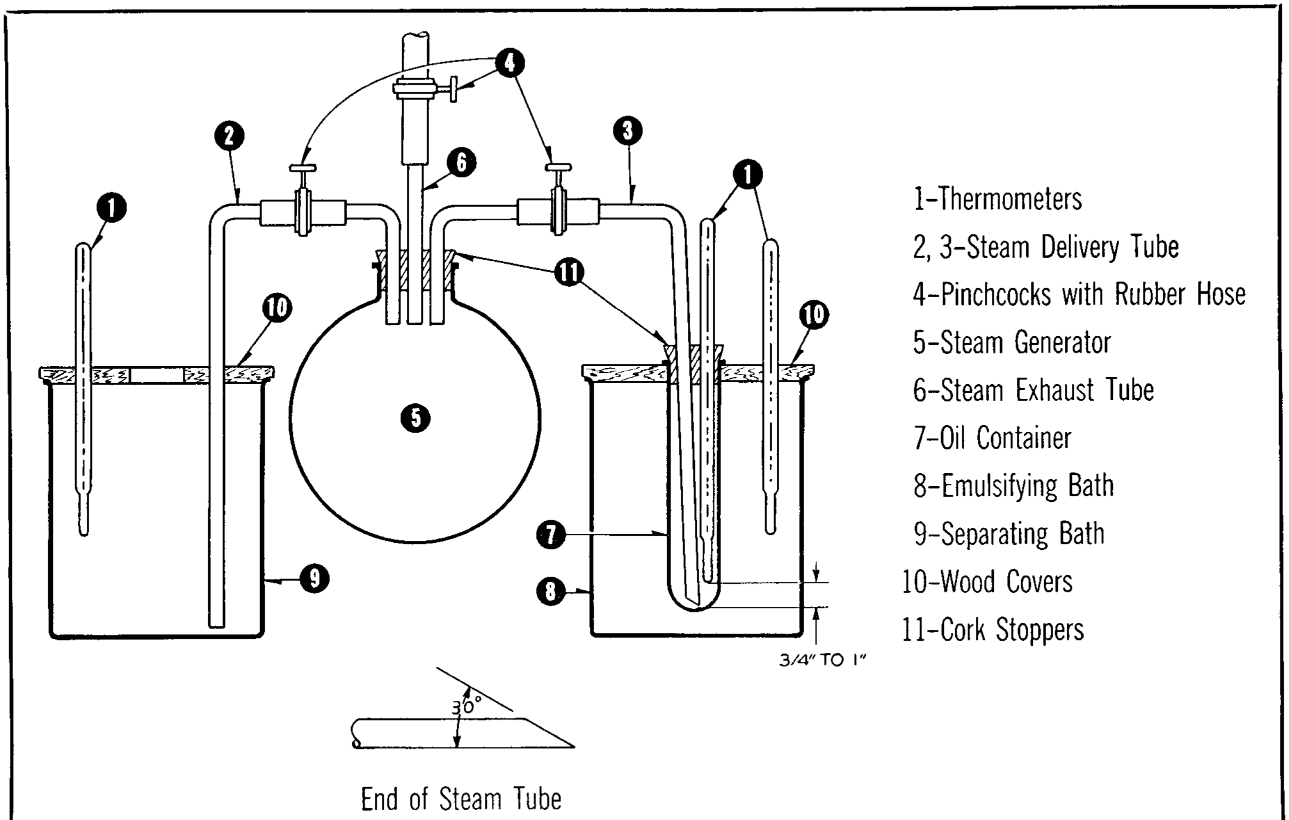

FIG. 7. Apparatus for S. E. Test

suitable range, graduated in .55 C (1 F), 5 to 7 mm in diameter); corks, rubber tubing and screw pinchcocks.

Procedure. The apparatus shall be assembled as shown in Figure 7. The steam generator shall be filled one-half full of water and heat applied. The baths shall be filled with 3 liters plus or minus 60 cc of water. The temperature in the separating bath shall be raised to and maintained at 93.3 to 95 C (200 to 203 F).

Caution: Care must be taken if glass battery jars are used, as direct heating by flame or electric hot point may cause breakage. Use of steam in this case insures against breakage.

The temperature of the emulsifying bath shall be brought to not less than 19.4 C (67 F) nor more than 25.6 C (78 F) at the start of the test, and is not controlled thereafter. Twenty cubic centimeters of the oil to be tested shall be measured in the oil container at room temperature and the latter placed in the holder of the emulsifying bath. The steam pipe, or delivery tube, shall be connected to the steam generator with suitable rubber tubing, and screw pinchcocks placed as shown in Figure 7.

Care shall be taken to see that the apparatus, particularly the oil container, oil container thermometer and steam delivery tube, are chemically clean before using. Care shall also be taken to prevent any foreign materials from entering the steam generator as any contamination of the steam renders the test valueless.

Emulsification. The steam delivery tube line shall be steamed out until all condensation disappears. A cork having two openings with the thermometer in one, shall be placed in the mouth of the oil container. The thermometer shall be adjusted so that the bottom of the bulb is ¾ to 1 in. from the bottom of the oil container. The steam delivery tube shall be inserted through the second opening in the cork. This fitting shall be loose so that the end of the steam delivery tube shall touch the center of the bottom of the oil container. Steam shall be admitted at a rate that will maintain the temperature of the oil, as shown on the thermometer in the oil container, between 87.8 C (190 F) and 90.6 C (195 F). (The usual time necessary for the temperature of the oil to come to this point is 45 to 75 seconds, depending on its character.)

This control shall be effected by manipulation of the pinchcocks on the steam delivery line and steam exhaust line from the steam generator. The steam supply shall be sufficient at all times to cause a generous discharge from the exhaust line. Steaming shall be continued until the volume of condensed steam and oil in the oil container tube is 40 cc plus or minus 3 cc. The time required for this operation shall be 4 to 6.5 minutes, depending on the quality of the oil, altitude, etc. If condensed water amounts to 20 cc in less than 4 minutes, it shall be taken as an indication of wet steam or incomplete steam out of the line, and the test shall be repeated.

The apparent volume in the tube near the end of the steaming operation is approximately 12 to 15 cc greater than the actual volume due to displacement caused by steam, thermometer and steam delivery tube.

Separation. The steam delivery tube shall be withdrawn as soon as the required volume is obtained. The oil container shall be transferred immediately to the separating bath which shall be maintained at 93.3 to 95 C (200 to 203 F). It is extremely important that the temperature of the separating bath be maintained within the given limits. As soon as the oil container has been transferred to the separating bath, immediately start the stop watch and observe the contents of the oil container continuously through the walls of the bath and note the volume of the separated oil layer, reading from the bottom of the oil meniscus. The cork containing the thermometer should be removed after placing the oil container and contents in the separating bath. No difference shall be made between clear and turbid oil. The reading in seconds shall be taken when the volume of the separated oil reaches 20 cc and this time in seconds shall be the S. E. Number.

In cases where the interface between more or less clear oil and the emulsion is not a clear, straight, horizontal line, the position of such a line is carefully estimated to the nearest 0.5 cc.

On oils which separate into three layers having top (clear or turbid) oil; middle (lacy or creamy) emulsion; bottom (clear or milky) water; the S. E. Number is derived from the top layer.

NEUTRALIZATION TEST

The Neutralization Number is the weight in milligrams of potassium hydroxide required to neutralize the acid in one gram of oil.

Solutions Required. Aqueous Potassium Hydroxide (1 cc 5 mg. KOH). Dissolve 5.1 g of potassium hydroxide, c.p., in one liter of freshly boiled and cooled distilled water. Add a very small amount of barium hydroxide, sufficient to precipitate any potassium carbonate present. Standardize this solution against Bureau of Standards certified benzoic acid, using phenolphthalein as an indicator according to the relation:

$$\frac{5 \text{ mg. KOH}}{x \text{ mg benzoic acid}} = \frac{56.104 \text{ g KOH}}{122.048 \text{ g benzoic acid}}$$

1 cc of KOH = 10.88 mg. benzoic acid

This weight of benzoic acid is required for standardization; make necessary adjustments so that the value of potassium hydroxide equals 5 mg. KOH per cc.

The weight of benzoic acid should be dissolved in 50 cc of 95 per cent alcohol and titrated cold. For blank, use same amount of alcohol and correct the titration.

Note: Fit the solution bottle with a guard tube of soda lime to prevent access of carbon dioxide. The solution should be standardized at necessary intervals.

Neutralized 95 Per Cent Alcohol. Add a few drops of phenolphthalein and neutralize carefully the alcohol to a very faint pink end point with some of the above prepared alkali solution.

Phenolphthalein Indicator. Dissolve 10 g of the indicator in 1 liter of 95 per cent alcohol, preferably ethyl alcohol. Use 1 cc of this strength for titration.

Weight of Oil. Approximately 20 g weighed accurately.

Volume of Solvent. 100 cc of a mixture of 1.1 neutralized alcohol and distilled water.

Procedure. Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if necessary.

The color change is noted in the alcohol water layer.

Calculation. $\frac{\text{(Cubic centimeters of KOH) x 5}}{\text{Weight of oil taken}} =$ mg KOH per 1 g of oil

PART FIVE

MEMORANDUM

MEMORANDUM

INSTRUCTIONS

PRESSURE RELIEF VALVE

Style No. 1576 123

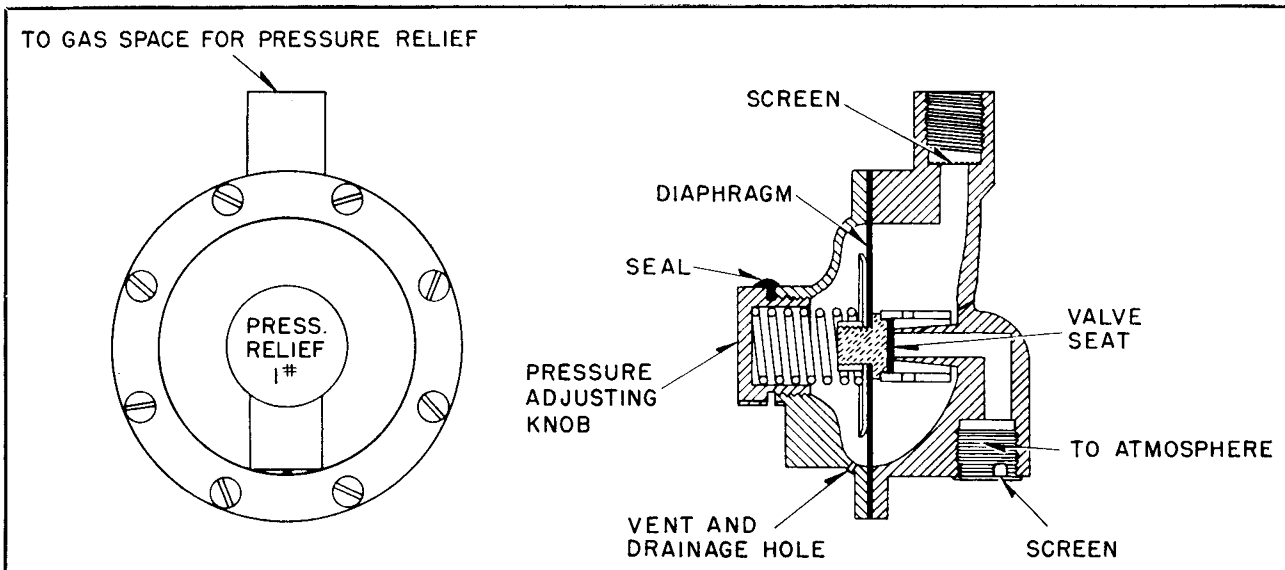

FIG. 1 Pressure Relief Valve

THE GAS SPACE above the oil in the URS Tap Changer is vented to the outside air by a uni-directional relief device; its general construction is shown in Fig. 1. When the pressure exceeds one pound per square inch, the gas space is vented to the outside air to reduce the pressure to this limiting value. As the pressure diminishes, the relief valve closes to prevent in-breathing; oxygen and moisture are thus kept out of the tap changer compartment. The tap changer is designed to withstand the resulting negative pressures. A screen is provided for both the inlet and exhaust ports of the relief valve to keep foreign material and insects out.

The relief valve is set at the factory and its adjusting knob sealed with solder. The out-breathing pressure is stenciled on the adjusting knob.

Adjustment. The adjustment of the pressure relief valve should not be changed unless absolutely necessary, in which case the following procedure is to be observed:

1. Remove the solder seal by scraping away the solder. *Do not attempt to remove the solder by melting* as excessive heat may damage the diaphragm.

2. Unscrew (counter-clockwise) the adjusting screw from the pressure relief device.

3. *Scrape the solder from the threads.* This is absolutely necessary to prevent the solder-coated threads from galling when the plug is screwed back into the relief device.

4. Screw plug into the relief device until the proper out-breathing pressure is obtained. Screwing the plug in, to the right, increases the out-breathing pressure. Before resealing the relief valve setting, its operation should be checked several times to permit the spring and diaphragm to adjust themselves to the new setting.

5. Seal the relief valve setting with a drop or two of solder, being careful to avoid overheating of the diaphragm.

Caution: Remove valve before painting equipment to prevent clogging vents with paint. Be sure vents are open at all times.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES I.L. 46-712-1

EFFECTIVE MAY, 1950

(Rep. 6-51) Printed in U.S.A.

INSTRUCTIONS

TYPE SU VOLTAGE REGULATING RELAYS

Adjustment On Step Regulators

TYPE SU VOLTAGE REGULATING RELAYS on Step Regulators are adjusted as follows:

1. Press down the balance arm firmly into the pivot bearings and, by moving the left-hand tip of the balance arm from front to rear, note that there is a definite location where the balance arm shaft fits in the V of the stationary bearing fairly near to the center of its movement as limited by the clearance of the plunger inside the operating coil.

Caution: Be sure there is no interference between any of the mechanical parts, coil and plunger, etc.

2. Remove the magnetic circuit adjusting or "hold-in" screw on top of the voltage coil.

3. *Primary Relay with Friction Damping Device.* With rear washer of the damping device pushed back and resting on the steady pin, and the arm balanced by applied voltage, note that the arm swings freely up and down when the control switch is opened and closed without being restricted by friction.

4. *Primary Relay with Dynamic Compensator.* Set the compensator on zero. The damping due to the compensator cannot be totally removed. Therefore, the check for friction must be carefully made in this case to distinguish "excess" friction from that inherent in the compensator. Note that the arm swings freely up and down when the control switch is opened and closed.

5. With the contacts adjusted so they will not engage until the left hand tip of the arm is 1/8 in. above or below the tips of the compounding magnet, adjust the compounding magnet gap so the tip of the balance arm will break away from the compounding magnet by raising or lowering the applied voltage by an amount equal to the desired operating band width. Reducing the gap increases the amount of voltage change required and increasing the gap reduces the amount of voltage change required.

6. *Primary Relay with Friction Damping Device.* Replace the rear damping device washer to its normal position and adjust the damping device spring so only sufficient pressure will be supplied to stabilize the balance arm within approximately four swings when the control switch is thrown off and on.

7. *Primary Relay with Dynamic Compensator.* The balance arm should be stabilized within approximately four swings when the control switch is thrown off and on. Return the compensator setting to the desired value.

8. Adjust the contact spacing so the regulator will restore the voltage, raising or lowering, to a value midway between those required to cause operation. Note that at the mid-voltage value, the left tip of the balance arm will stand slightly above the center of the compounding magnet pole tips. Increasing the contact spacing causes the voltage to be corrected farther after contact is made and decreasing the spacing causes it to be corrected less.

9. Set the voltage to a value which will just close the "lower" contacts. This will be about one volt above the balance voltage. Adjust the left stationary contact until its spring is deflected about 1/2 its travel. Replace the hold-in screw turning it in until it moves the plunger a little further into the coil. Lock screw in place. Lower the applied voltage to the balance voltage; if the relay fails to return to its balance position the hold-in screw should be backed off slightly.

10. Obtain the desired value of voltage to balance the relay by moving the balance weight on the top of the balance arm by means of the adjusting screw.

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

NEW INFORMATION

EFFECTIVE SEPTEMBER, 1949

(Rep. 6-51) Printed in U.S.A.

INSTRUCTIONS

CORK-NEOPRENE GASKETS STYLE NO. 7249-9

For "URS" Tap Changers and "URS" Regulators

The gaskets used for sealing the various openings and flanges of the "URS" Tap Changers and "URS" Regulators are made of Cork-Neoprene composition.

In use, cork-neoprene gaskets retain their resilient properties indefinitely when compressed to approximately two-thirds their original thickness.

Gasket stops are not used on the "URS" Tap Changers and "URS" Regulators, since cork-neoprene will not creep if reasonable care is exercised when the gaskets are installed.

Note: It is very important that all openings in the tap changer and regulator case be tightly closed before putting a unit into operation. This is necessary whether the unit is for indoor or outdoor operation. For all liquid filled tap changers and regulators, the bushing flanges, main cover, manhole covers, etc., must be oil and gas tight.

GASKET INSTALLATION

Metal surfaces must be thoroughly cleaned of old paint, varnish, gasket cement, scale, etc. The gasket material should be cut into strips of the proper width to conform to the contour of the parts to be joined together. Where it is necessary to use spliced pieces, the end should be scarfed permitting an overlap of four times the thickness of the gasket, maintaining full thickness along the lap. Manhole, handhole and small cover plate gaskets may be used repeatedly if cemented only on one side and if care is used when cover is removed. Inspect before resealing to make certain that the gasket has not cracked or peeled.

For other sealed joints, it is recommended that both surfaces of gasket and metal be coated with cement. Apply a liberal coating of gasket cement M-7386-1, Style No. 471880-E (1 quart can) or Style No. 1150419 (1 pint can,) and allow it to dry one hour before putting the gasket in place. Lapped joints must be thoroughly coated with cement. When the parts are put together, make certain that the gasket is properly located and remains in place.

Tighten enough bolts spaced opposite each other to securely clamp the gasket in place. Proceed to gradually tighten the bolts by going from one bolt to another bolt on the opposite side until all bolts have been tightened with approximately the same amount of torque. Do not completely tighten any bolt before tightening the others. Tighten bolts uniformly.

LEAKAGE TESTS

The best protection against leakage, after a unit has been opened, is to use a new gasket properly cemented to thoroughly cleaned surfaces.

Liquid filled unit tanks, the nameplates of which indicate that they are good for filling under a complete vacuum, may be tested in the field with an internal pressure of ten pounds per square inch above the atmosphere. All other tanks may be tested in the field at a pressure of five pounds per square inch.

The tap changer compartment must have the pressure relief valve removed and the tank connection capped before testing.

Note: A cleaning unit powered with an electric motor has been developed by Westinghouse, and may be used in the cleaning of gasket contact surfaces. For further information write to Renewal Parts Section.

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SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

NEW INFORMATION

EFFECTIVE SEPTEMBER, 1949
(Rep. 6-51) Printed in U.S.A.

INSTRUCTIONS

MECHANICAL STOP FOR "URS" TAP CHANGER

Cam-operated switches insure that the "URS" Tap Changer positively 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 Fig. 1 of this leaflet.

A mechanical stop disk bearing massive bosses on its top surface is mounted on the main drive-shaft in the operating mechanism compartment. The position indicator drum is geared to the main drive-shaft and has on its top surface a boss which has a separate adjusting screw for each of the two limit positions and set-screws to lock the setting of these adjusting screws. The bosses on the mechanical stop disk are so spaced that when the stop bar enters the wide space the tap changer is stopped with its 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.

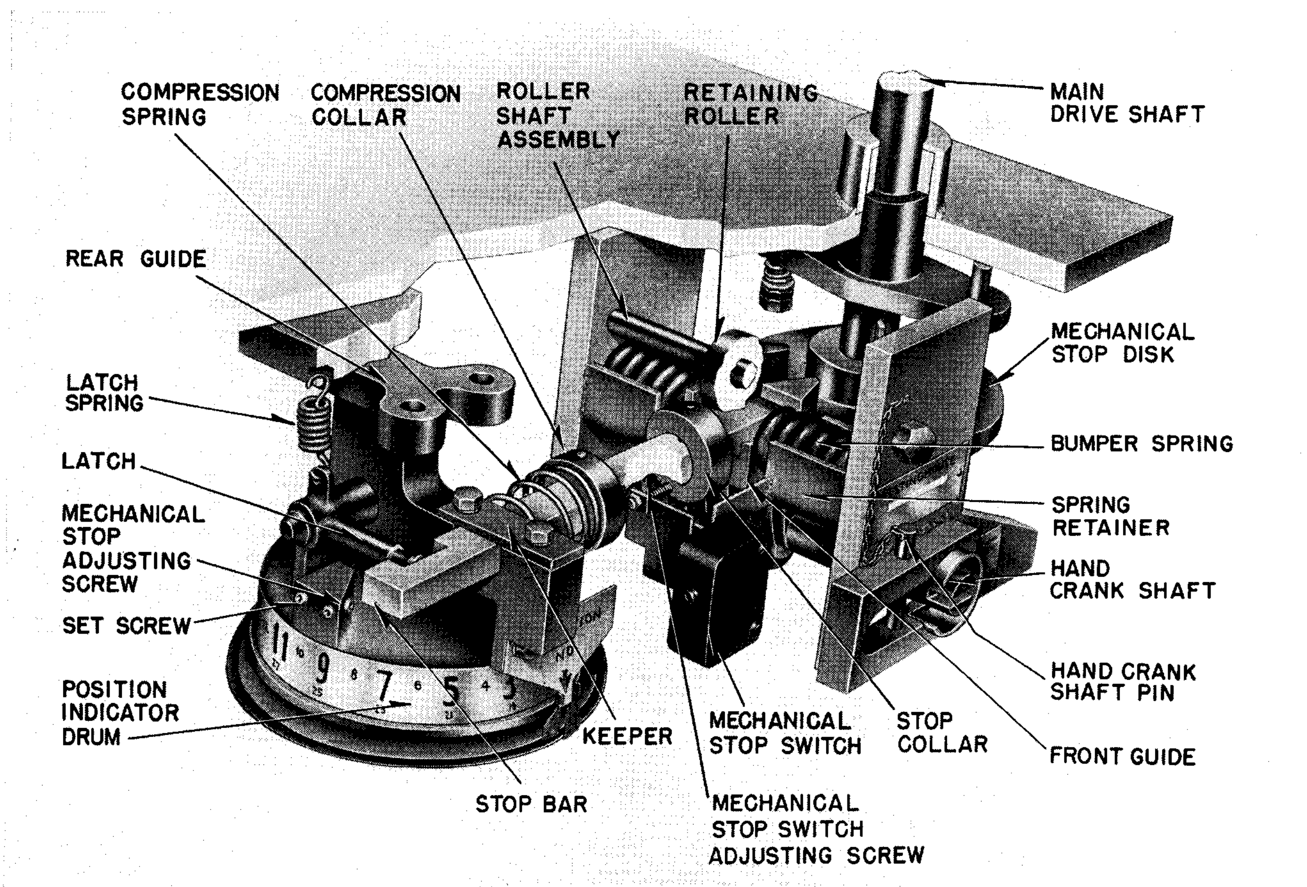

FIG. 1. Cutaway View of "URS" Tap Changer Mechanical Stop

SUPERSEDES I.L. 46-713-5

EFFECTIVE JUNE, 1950

WESTINGHOUSE

INSTRUCTIONS

CONCENTRIC LEAD BUSHING

For Type "URS" Step Regulator

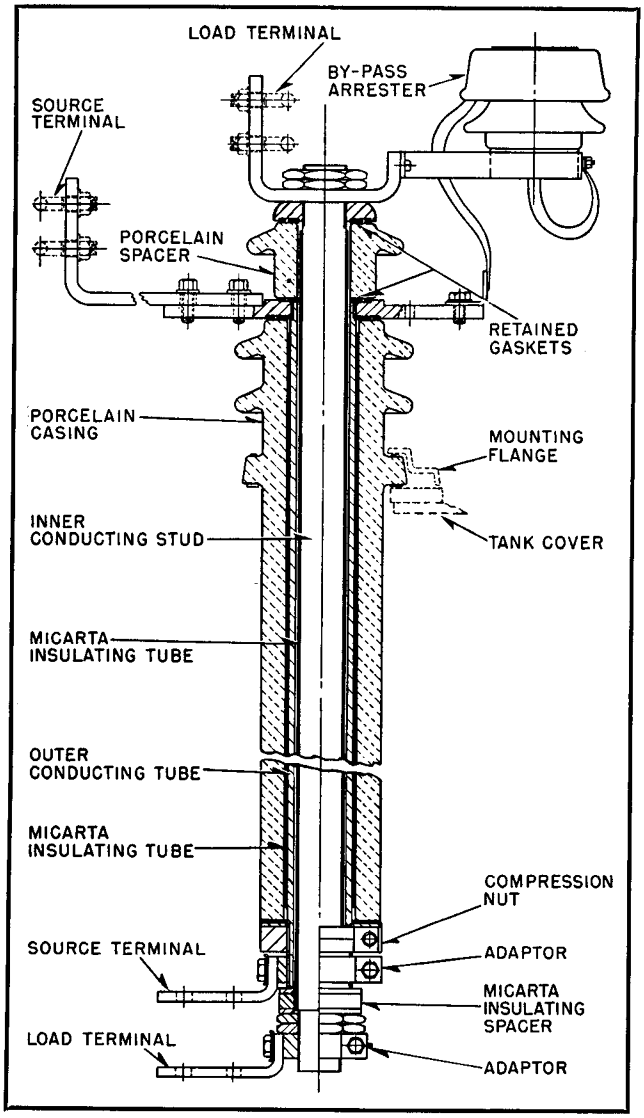

FIG. 1. Concentric Lead Bushing for Type URS Step Regulator

THIS CONCENTRIC LEAD BUSHING was designed specifically for use in Westinghouse Type URS Step Voltage Regulators. Its construction is unique in that both source and load leads of one phase are contained in a single porcelain casing.

It will be noted from Fig. 1, which shows a cross-sectional view of the bushing, that the bushing contains two conductors; an inner stud and an outer conducting tube, separated by a Micarta insulating tube. At the bottom of the bushing a cylindrical Micarta spacer is used as insulation

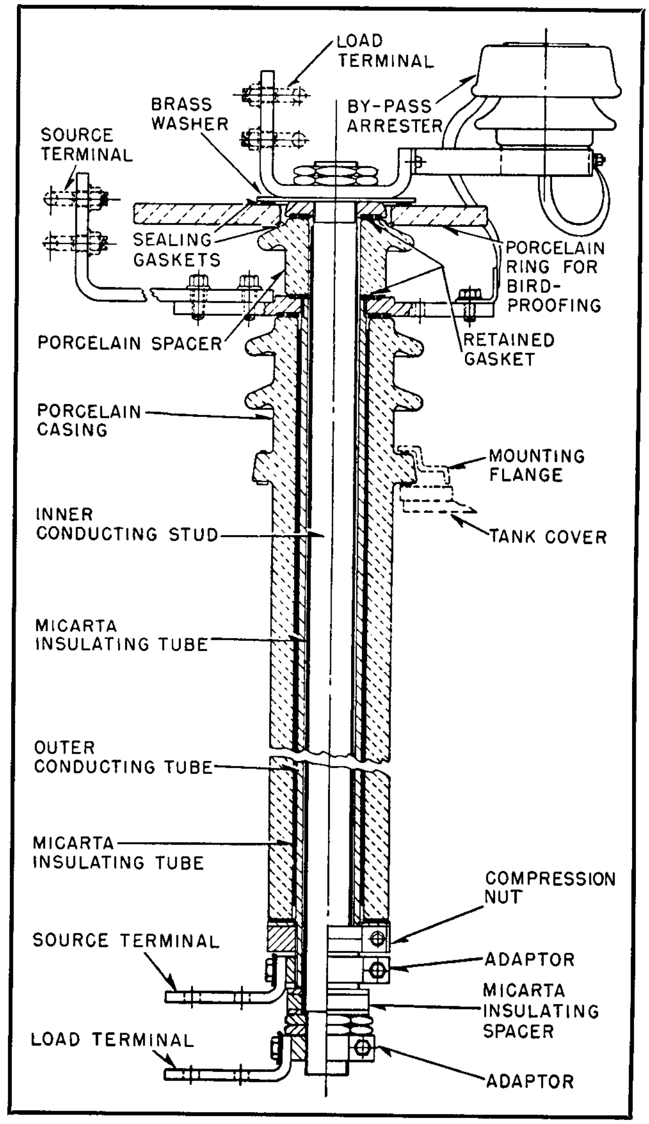

FIG. 2. Concentric Lead Bushing with Bird-proofing for Type URS Step Regulator

between the two terminals. Insulating separation is obtained between terminals at the top of the bushing by means of a porcelain spacer.

The bird-proof concentric lead bushing is shown by Fig. 2. A porcelain ring is inserted between the terminals at the top of the bushing to render the construction bird-proof. The standard concentric lead bushing with a skirted porcelain spacer separating the upper source and load terminals may very easily be converted to the bird-proof concentric lead bushing by the addition of the porcelain ring, a brass washer, and two gaskets. (The older concentric lead bushing with a plain cylindrical porcelain spacer separating the upper source and load terminals is not adaptable to bird-proofing.)

The porcelain casing from a conventional Westinghouse bulk type bushing is used so that the bushings may be mounted using standard mounting flanges and hardware. Gasketing practice is the same as for conventional Westinghouse bulk type bushings used extensively on distribution and power transformers.

Source and load terminals at the top of the bushing have been designed so that they can be used in the position shown in Fig. 1 and Fig. 2 or rotated 180 degrees. This permits direction of source and load-line take-off to be reversed by simply changing arrangement of bushing terminals without disturbing either the bushing or the internal connections of the regulator.

The electrical characteristics of the bushing conductors to ground are the same as for standard bushings. The insulation between conductors has been designed to withstand the maximum abnormal 60 cycle voltages which may appear during switching and line faults. The impulse voltage appearing across the bushing terminals is held to a value well within the strength of the insulation between conductors by a by-pass arrester which connects across the line terminals of the bushing.

WESTINGHOUSE ELECTRIC CORPORATION
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DESCRIPTION • ADJUSTMENT • MAINTENANCE

INSTRUCTIONS

DynAC Brake *

The Alternating Current Dynamic Brake

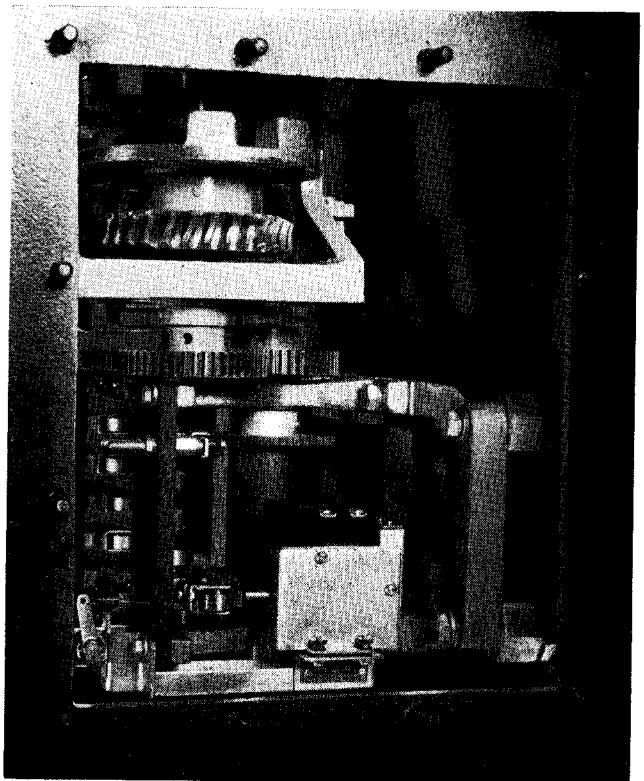


FIG. 1. "DynAC Brake" As Installed on URS Cam Switch Assembly

THE "DYNAC BRAKE" (pronounced "dine-ack") is a totally new means for the rapid deceleration of reversible capacitor type motors as used on tap changer drive mechanisms or other applications where quick acting electrical braking is required.

The "DynAC Brake" operates instantly when driving power is removed to give a smooth application of braking power with a minimum of strain on the motor shaft.

DESCRIPTION

The "DynAC Brake" is available in two styles: "Type M" where mechanical operation is desirable (see Fig. 2), and "Type E" solenoid-operated for other applications (Fig. 3).

The "Type M DynAC Brake" consists of the "DynAC" time delay relay complete with the mounting bracket, a cam operated brake arm, and brake resistors. The time delay relay and mounting bracket constitute one assembly and the resistors constitute another assembly. These assemblies are mounted in the cam switch compartment (air chamber) of the tap changer.

The "Type E DynAC Brake" consists of a solenoid operated time delay relay and its accompanying resistors mounted on a common base. It is normally mounted back of the control panel in the control compartment.

The basic mechanism of both types is the "DynAC" time delay relay (Fig. 4). This is a pneumatically controlled device which gives an application of power for braking of exactly the right duration. It has a built-in overtravel feature on the bellows operating plunger to ensure proper operation at all times, without necessity of exacting travel adjustments.

SEQUENCE OF OPERATION

The contacts of the "DynAC" time delay relay are closed mechanically or electrically by the cam switch assembly of the tap changer. This sets up the braking circuit which is completed by the closing of the back contacts of the motor control relay when the relay is de-energized. The "DynAC Brake" thus applies single-phase a-c power directly to both windings of the motor from the same supply leads for a sufficient length of time (as determined by the time delay setting) to permit the motor to come to rest. This braking power is removed by the "DynAC" time delay relay, after the mechanical or electrical force, which closed the contacts, has been removed by the proper positioning of the tap changer.

This gives alternating current dynamic braking action, bringing the motor to a quick, smooth stop.

NEW INFORMATION

* Trade-Mark

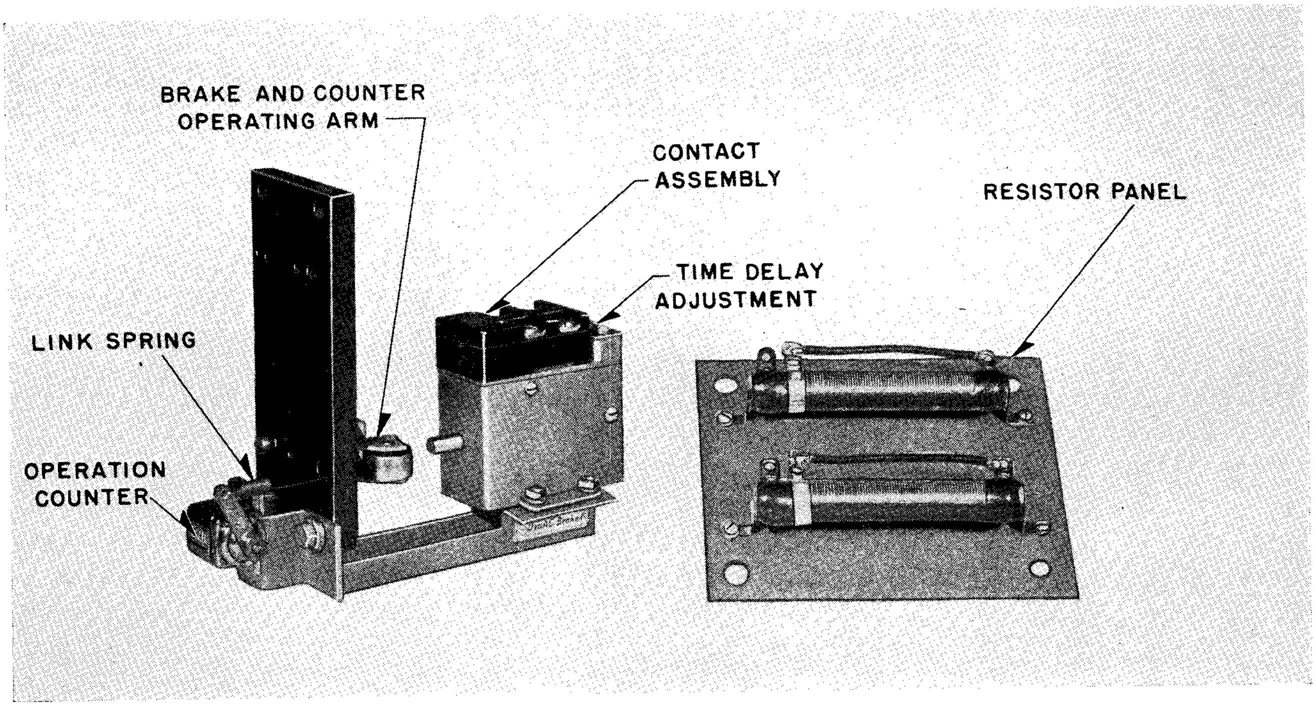


FIG. 2. "Type M DynAC Brake" for Mechanical Operation, with Mounting Bracket, Cam-Operated Brake Arm, and Brake Resistor Panel

ADJUSTMENT

The only major adjustment necessary is on the length of the time delay. The time from the removal of pressure from the plunger until the opening of the contacts of the "DynAC" time delay relay (snapping of the switch) should be approximately one half to one second. Turning the adjusting screw clockwise decreases the time delay, counter-clockwise increases the time delay. An approximate adjustment is made by turning the adjusting screw to the maximum delay setting and then reducing the delay by four full turns of the adjusting screw. See Fig. 4.

The XR and XL resistors serve two functions. One function is to prolong the life of contacts "SL1" and "SR2" of the motor control relay by limiting the capacitor discharge current when the capacitors are short circuited by these contacts. The other function is to control the positioning of the cam switch rollers on the lobes of the cams. This fine adjustment, which in the majority of cases is not required, may be desirable because of slight variations in different motors and mechanisms or extremely wide variations in voltage supply. The resistance is divided between leads 124 and 125 to balance the braking torque in the two directions of operation.

Increasing the XL resistance (Fig. 5) decreases the braking torque applied as the motor is stopped after an operation in the "Lower" direction, hence the unit will stop with the "120" cam roller further onto the lobe of the "120" cam. Increasing the XR resistance gives the same effect in the raise direction. Since there is an interaction of the currents which pass through these resistors, it is sometimes necessary to readjust the XL resistance after the XR is adjusted, and vice versa.

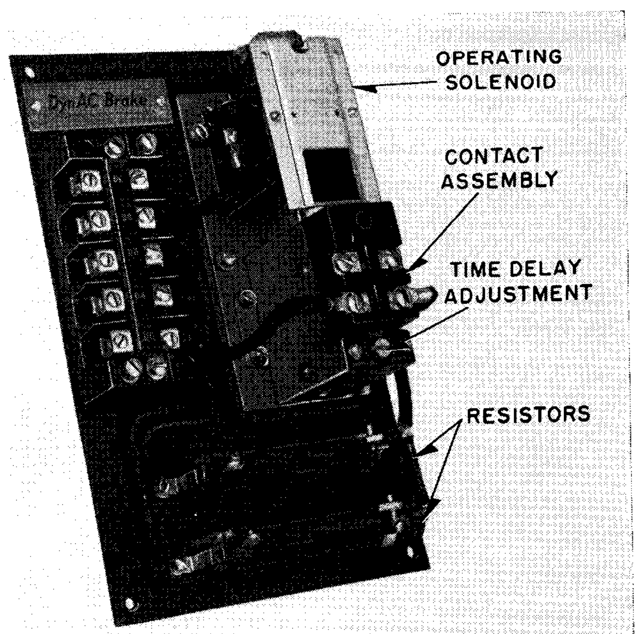


FIG. 3. "Type E DynAC Brake", Solenoid-Operated, with Brake Resistors on Common Base

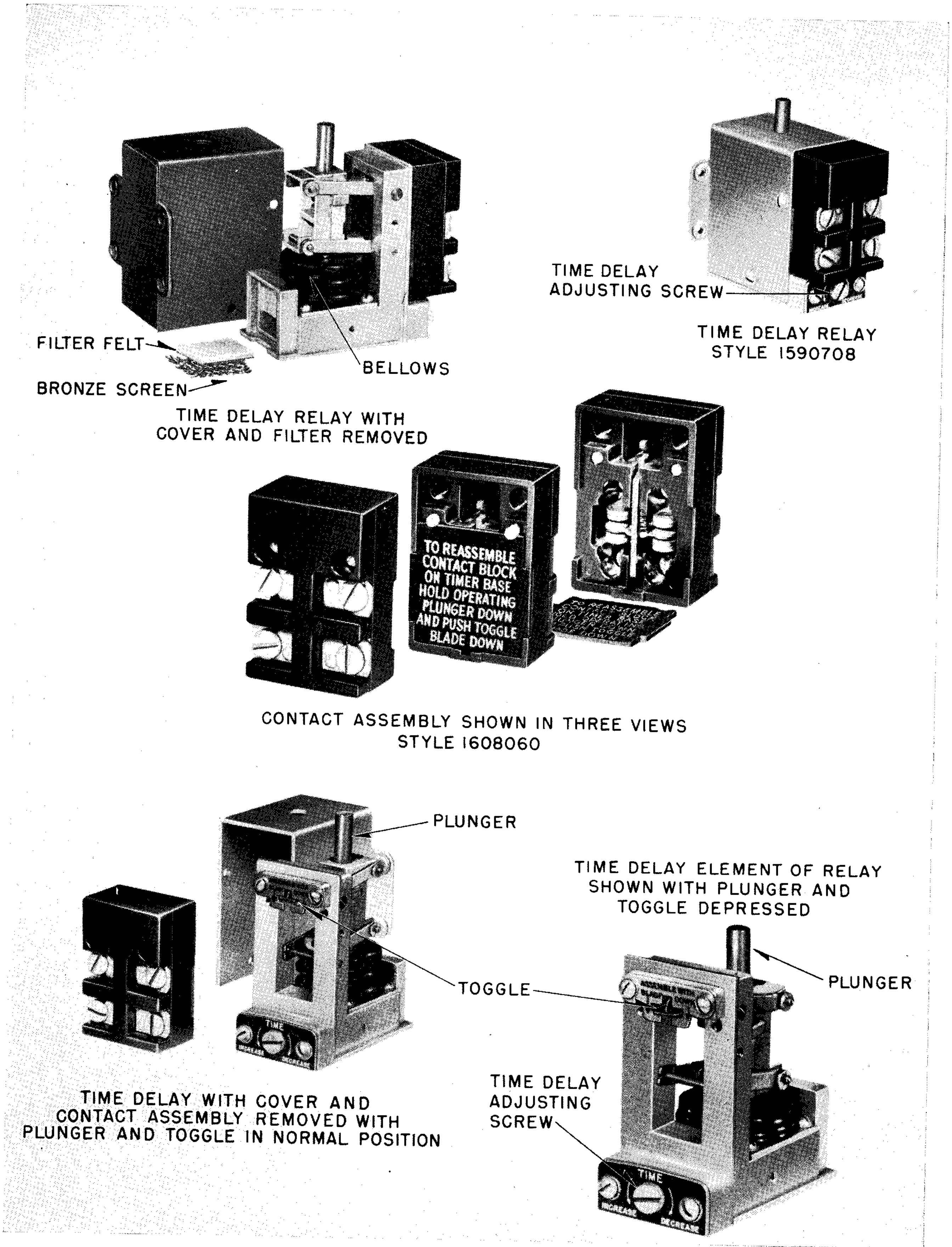


FIG. 4. Various Views of "DynAC Brake" Time Delay Relay and Contact Assembly

MAINTENANCE

The contacts of the time delay relay should be checked for cleanliness and future life at regular maintenance periods. It is recommended that this be done each time the selector contacts of the tap changer are inspected. This inspection may be accomplished by removal of the two mounting screws which fasten the contact assembly to the time delay mechanism. The plunger and toggle must be depressed when the contact assembly is being replaced (Fig. 4).

In extremely dusty locations the time delay mechanism should be removed from its case by the removal of the four screws, two on each side of the case, and the case thoroughly cleaned. The bronze screen should be removed from the recess and the filter felt cleaned with carbon tetrachloride prior to assembly (Fig. 4).

RENEWAL PARTS

The following renewal parts are available from the Sharon Works, Westinghouse Electric Corporation, through the nearest Westinghouse Sales Office:

Complete Solenoid Operated Time
Delay Relay (110 Volt Coil)..S# 1590 746 (Fig. 7)
Time Delay Unit............S# 1590 708 (Fig. 4)
Contact Assembly...........S# 1608 060 (Fig. 4)
Resistor...................S# 1590 776 (Fig. 5)

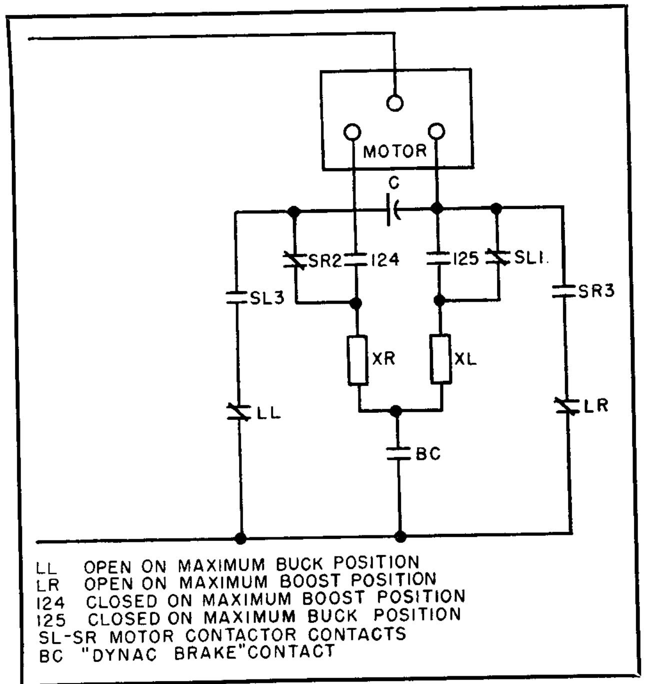


FIG. 6. Schematic Diagram of "DynAC Brake" Connections

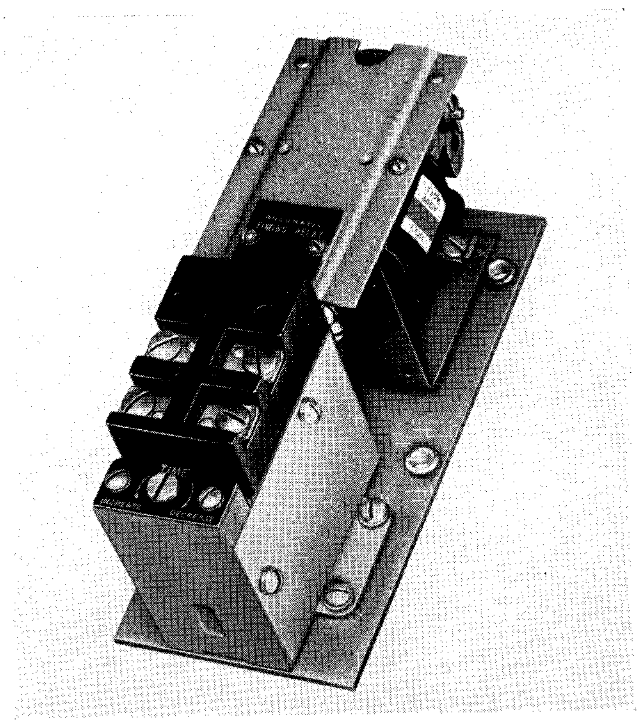


FIG. 7. Complete Solenoid Operated Time Delay (110 Volt Coil) S# 1590 746

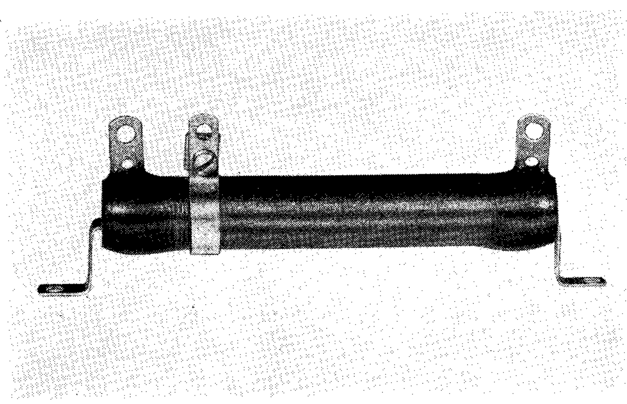


FIG. 5. Resistor S# 1590 776

DESCRIPTION • INSTALLATION

INSTRUCTIONS

LIQUID LEVEL INDICATORS

Magnetic Type

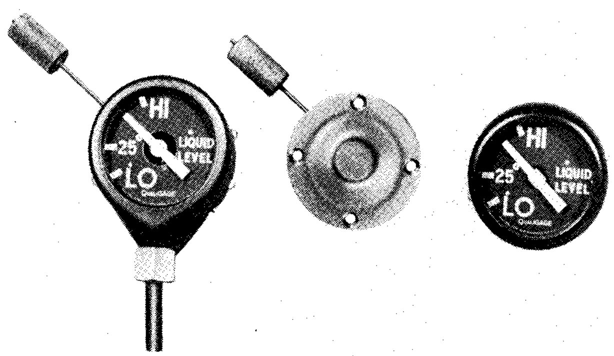


FIG. 1. Bezel with Alarm (left); Body with Float and Rod at Back (center); Bezel without Alarm Contacts.

MAGNETIC TYPE LIQUID LEVEL INDICATORS, designed for application on Westinghouse transformers or related apparatus, are self-contained, dial-reading, weatherproof, submersible, shock-proof, float-operated instruments suitable for use with oil or Inerteen.

Contacts for operating the alarm circuits of a bell, light, or small relay systems can be furnished as integral parts in either size of level indicator.

These indicators are usually shipped mounted on the transformer case, or equipment, and require no maintenance.

DESCRIPTION

These indicators are precision instruments consisting of two main parts, the bezel and the body, and are interchangeable for the same size of device. See Fig. 1. The bezel, or outer assembly, includes the calibrating dial and indicating needle. It is hermetically sealed and should not be subjected to a vacuum since the internal pressure might break the glass. The dial has a purple background with yellow markings for high visibility. The indicating needle, also painted yellow, is directly mounted on the forward end of a shaft, the other end of which carries a powerful actuating magnet. The bezel, when in place, covers and protects the mounting screws with which the body is attached to the flange on the transformer tank wall or equipment.

The body is sealed against oil leakage to the outside and encloses another powerful magnet opposite the magnet in the bezel and is coupled through a shaft to the float arm. See Fig. 2. In operation, any motion of the float arm rotates the body magnet, which in turn positively displaces the bezel magnet, thus moving the indicating needle.

In indicators with alarm contacts, a micro switch enclosed in the bezel is actuated at a predetermined position by the motion of the needle shaft. Micro switch ratings are given in Table No. 1. Alarm leads are brought through the underside of the bezel by means of a new triple seal connector, Fig. 3, which consists of the following:

1. Three protruding terminals molded in the case and a locating pin to prevent making incorrect connections.

2. A rubber insulator which has three terminals to mate with the terminals in the case and a hole

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R = .026*
125 AC	5	5
250 AC	2.5	2.5
125 DC	0.5	0.05
250 DC	0.25	0.025

*Equal to or less than .026. If greater, refer to factory for adjusted ratings.

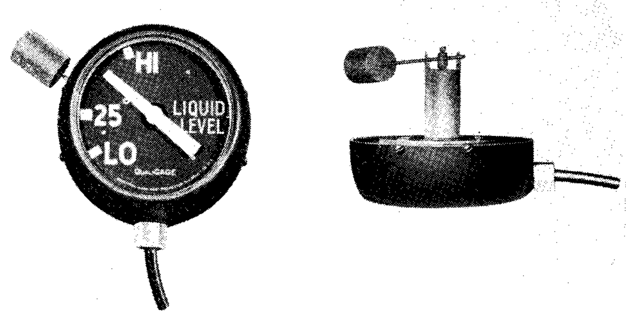


FIG. 2. Side and Front View, Medium Size Float Directly Connected.

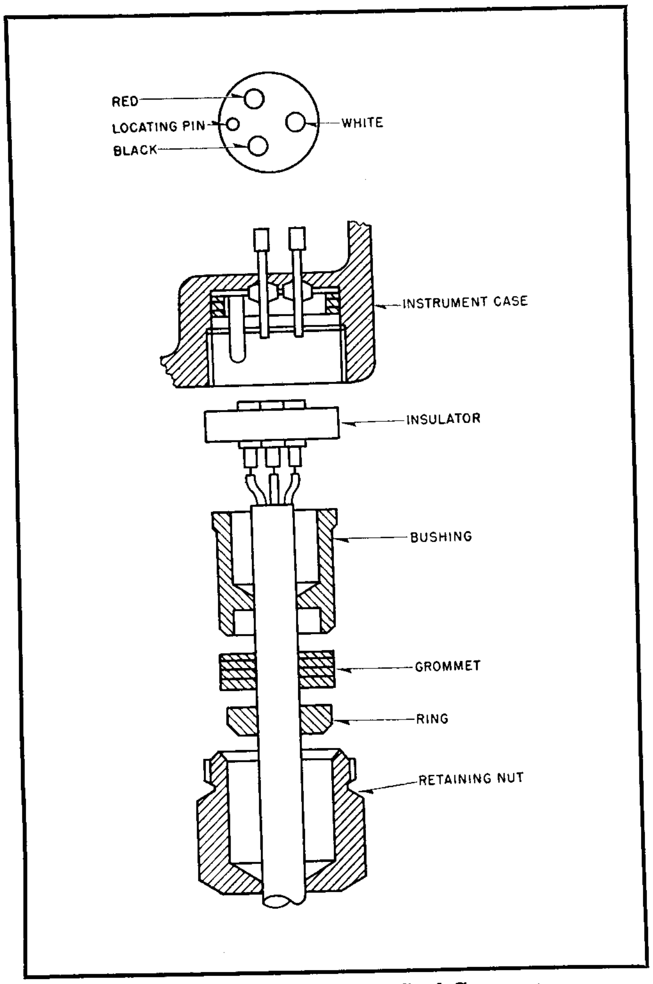


FIG. 3. Diagram of Triple Seal Connector.

through the rubber insulator for location of the locating pin. The ends of the lead wires are tinned and crimped into the terminals on the insulator.

3. A bushing to compress the insulator against the instrument case.

4. A grommet to make a seal between the rubber covered cable and the bushings.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

The connection diagram is shown in Fig. 4.

For indicators that are installed at the factory, the tank is filled to the level which corresponds to a liquid temperature of 25 degrees C, and this level is considered normal. Should the tank be filled at any other temperature, Table No. 2 should be used to determine plus or minus levels from normal. If these allowances are not made, excessive pressures may be built up in sealed tanks or excessive breathing may be produced in Inertaire units, causing a high rate of loss of nitrogen, or the low level alarm may be caused to operate unnecessarily due to the insufficiency of liquid.

If any part of it is damaged, the bezel can be replaced without disturbing the rest of the instrument and without loss of oil. Bezels with alarm contacts can replace the ones without such contacts and vice-versa, if desired.

INSTALLATION

Instruments are usually shipped in place. If shipped separately or if replacement of the body is made, check the operation of the float over its entire range to see that it operates freely and that the needle follows the movement of the float. Draw up the body tightly against the gasket between it and the mounting flange to make a tight joint.

Coat the gasket on both sides and edges with red gasket cement (S# 1150 419, pint can or S# 471 880, quart can). Allow to dry for 15 minutes. Apply a second coat of cement, wipe off excess from the edges and put gasket in place. Mount the instrument and tighten the bolts. Put the bezel in place and tighten the holding screws on the side. If alarm contacts are used, make proper connections to the conduit box.

RENEWAL PARTS

If repairs to the instrument are necessary, contact the nearest Westinghouse Office.

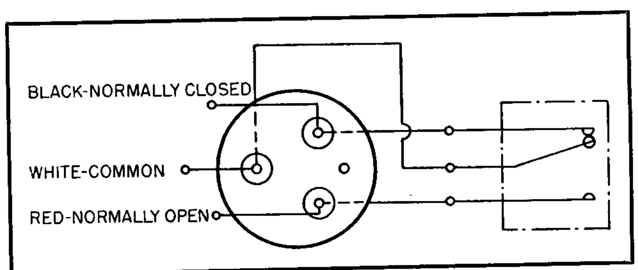


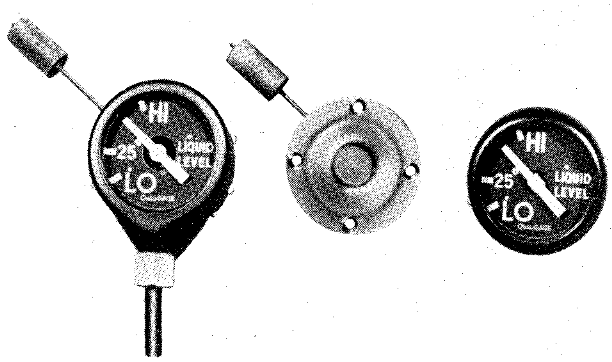
FIG. 4. Connection Diagram for Alarm Leads.

TABLE NO. 2

AVERAGE LIQUID TEMP. (°C)	CORRECT FILLING LEVEL (PERCENT OF SCALE ABOVE OR BELOW 25° C)
85 (High)	100
70	75
55	50
40	25
25 (Normal)	0
10	-50
-5 (Low)	-100

DESCRIPTION • INSTALLATION
INSTRUCTIONS

LIQUID LEVEL INDICATORS
Magnetic Type



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2. A rubber insulator which has three terminals to mate with the terminals in the case and a hole

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250 DC	0.25	0.025

*Equal to or less than .026. If greater, refer to factory for adjusted ratings.

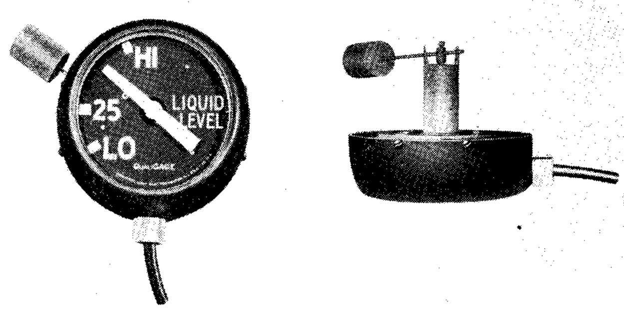

FIG. 2. Side and Front View, Medium Size Float Directly Connected.

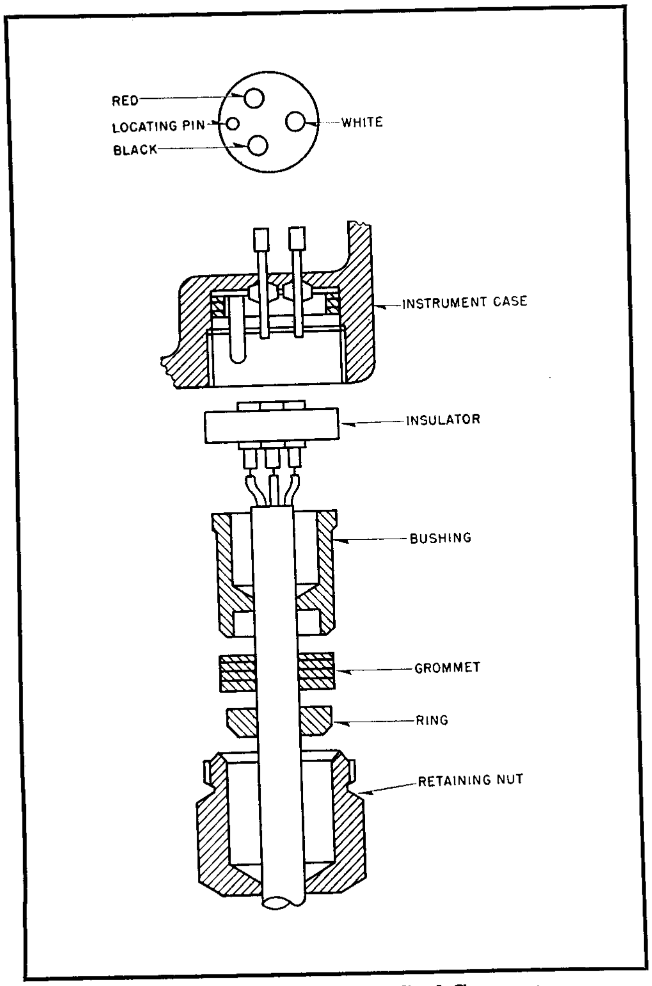

FIG. 3. Diagram of Triple Seal Connector.

through the rubber insulator for location of the locating pin. The ends of the lead wires are tinned and crimped into the terminals on the insulator.

3. A bushing to compress the insulator against the instrument case.

4. A grommet to make a seal between the rubber covered cable and the bushings.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

The connection diagram is shown in Fig. 4.

For indicators that are installed at the factory, the tank is filled to the level which corresponds to a liquid temperature of 25 degrees C, and this level is considered normal. Should the tank be filled at any other temperature, Table No. 2 should be used to determine plus or minus levels from normal. If these allowances are not made, excessive pressures may be built up in sealed tanks or excessive breathing may be produced in Inertaire units, causing a high rate of loss of nitrogen, or the low level alarm may be caused to operate unnecessarily due to the insufficiency of liquid.

If any part of it is damaged, the bezel can be replaced without disturbing the rest of the instrument and without loss of oil. Bezels with alarm contacts can replace the ones without such contacts and vice-versa, if desired.

INSTALLATION

Instruments are usually shipped in place. If shipped separately or if replacement of the body is made, check the operation of the float over its entire range to see that it operates freely and that the needle follows the movement of the float. Draw up the body tightly against the gasket between it and the mounting flange to make a tight joint.

Coat the gasket on both sides and edges with red gasket cement (S# 1150 419, pint can or S# 471 880, quart can). Allow to dry for 15 minutes. Apply a second coat of cement, wipe off excess from the edges and put gasket in place. Mount the instrument and tighten the bolts. Put the bezel in place and tighten the holding screws on the side. If alarm contacts are used, make proper connections to the conduit box.

RENEWAL PARTS

If repairs to the instrument are necessary, contact the nearest Westinghouse Office.

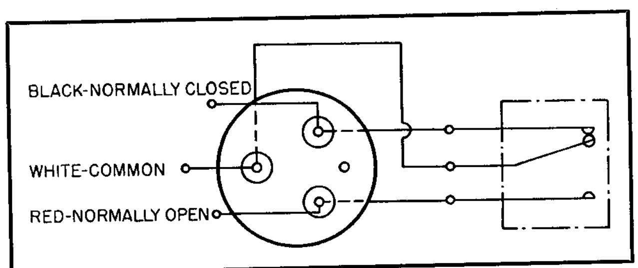

FIG. 4. Connection Diagram for Alarm Leads.

TABLE NO. 2

AVERAGE LIQUID TEMP. (°C)	CORRECT FILLING LEVEL (PERCENT OF SCALE ABOVE OR BELOW 25° C)
85 (High)	100
70	75
55	50
40	25
25 (Normal)	0
10	-50
-5 (Low)	-100

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I. L. 46-716-4A

DESCRIPTION • INSTALLATION

INSTRUCTIONS

TEMPERATURE INDICATORS

Dial Type

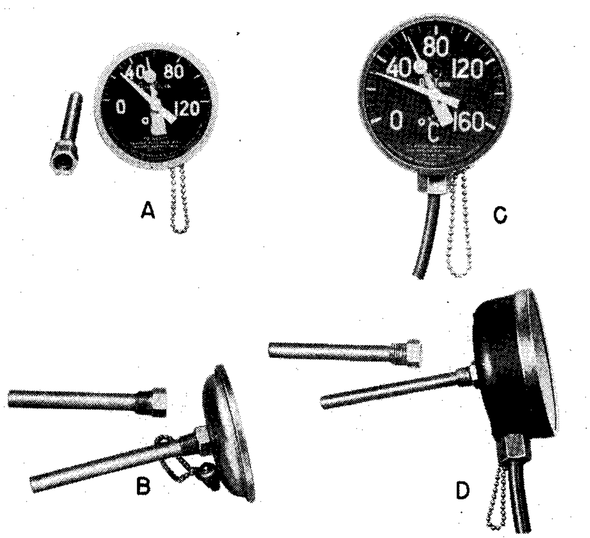

FIG. 1. (A) Front and (B) Side View of Indicator Without Alarm Connections; (C) Front and (D) Side View of Indicator With Alarm Connections

TEMPERATURE INDICATORS, designed for application on Westinghouse transformers or related apparatus to indicate liquid temperatures, are self-contained, weatherproof and submersible instruments of the dial type, operated by means of bimetallic elements immersed in the liquid.

They are usually shipped mounted on the transformer cases, require no maintenance, and are suitable for oil or Inerteen.

DESCRIPTION

This indicator is a dial type precision instrument whose needle is directly coupled to a bimetallic spiral actuating element in the stem, which fits closely into a well. The well is of thin-walled construction and screws into a fitting on the transformer case making an oil-tight connection. The instrument is weatherproof and submersible. The dial is calibrated in degrees centigrade and is easily read because of the contrasting purple face with yellow characters, graduations, and indicating pointer.

A maximum indicating pointer, red in color, is used to indicate the maximum temperature reached between readings. This hand is reset by wiping a magnet across the face of the dial. The magnet must be held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain on the instrument case to prevent misplacing after using and is self-supporting in a metallic socket on the under side of this case. The method of resetting the maximum indicating pointer is shown in Fig. 3.

There are two types of thermometers available—one without alarm connections shown in Fig. 1, A and B, and one with alarm connections shown in Fig. 1, C and D. When alarm connections are required, the latter one will be supplied with the new triple seal connection, the details of which are shown in Fig. 2. This connector consists of:

1. Three protruding terminals molded in the case and a locating pin to prevent making incorrect connections.

2. A rubber insulator which has three terminals to mate with the terminals in the case and a hole through the rubber insulator for location of the

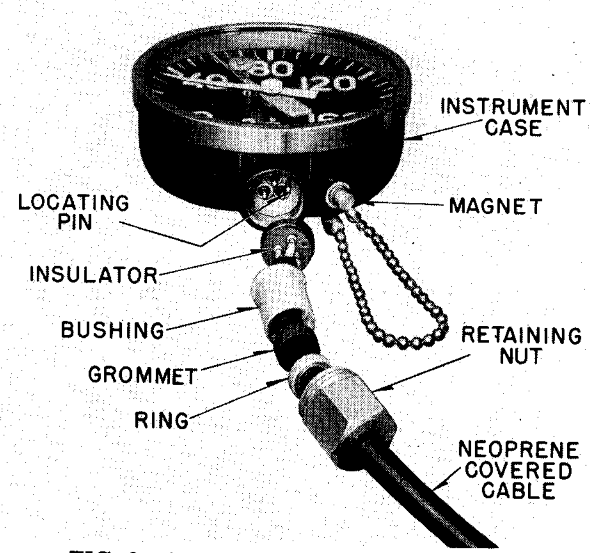

FIG. 2. Triple Seal Connection Details

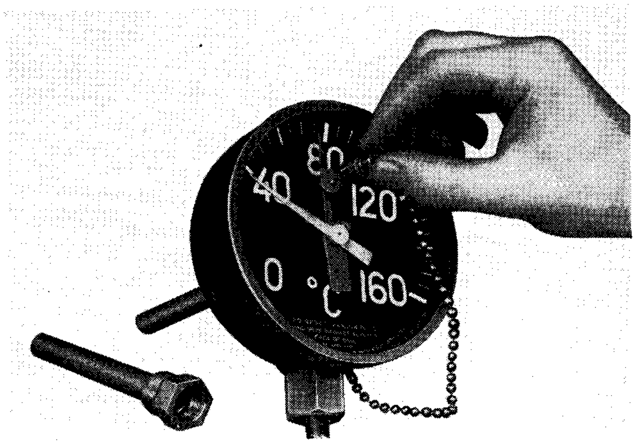

FIG. 3. Method of Resetting Maximum Indicating Pointer

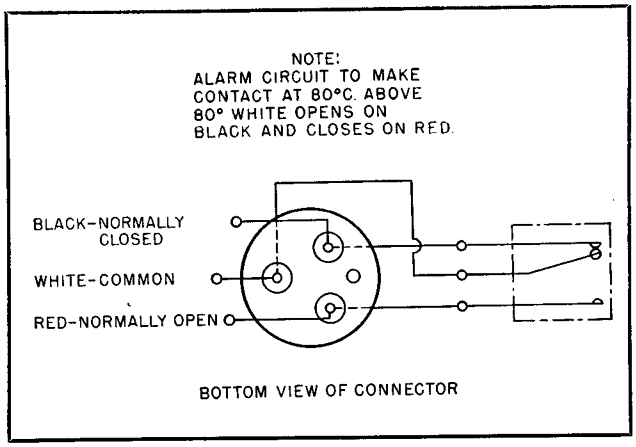

FIG. 4. Connection Diagram for Alarm Contact Leads

locating pin. The ends of the lead wires are tinned and crimped into the terminals on the insulator.

3. A bushing to compress the insulator against the instrument case.

4. A grommet to make a seal between the rubber covered cable and the bushing.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

The micro-switch in the indicator with alarm connections is factory set to operate at 80 degrees C. ***This setting cannot be changed.*** The ratings for this switch are given in Table No. 1 while the connection diagram is shown in Fig. 4.

INSTALLATION

The indicators are usually shipped mounted in place. To install them when shipped as a separate item, remove the pipe plug from the mounting coupling. Treat threads on the well-to-wall connection with Westinghouse thread cement (Style No. 1150 419, pint can or Style No. 471 880, quart can) and screw the well securely in place, making an oil-tight connection. Then screw the indicator in place being careful that the dial is in reading position. The indicator can be removed from the well in the tank wall without the loss of liquid.

The instrument may be mounted at eye level (A, Fig. 5) or can be mounted at a higher level and tilted so that it can be read easily when mounted high (B, Fig. 5).

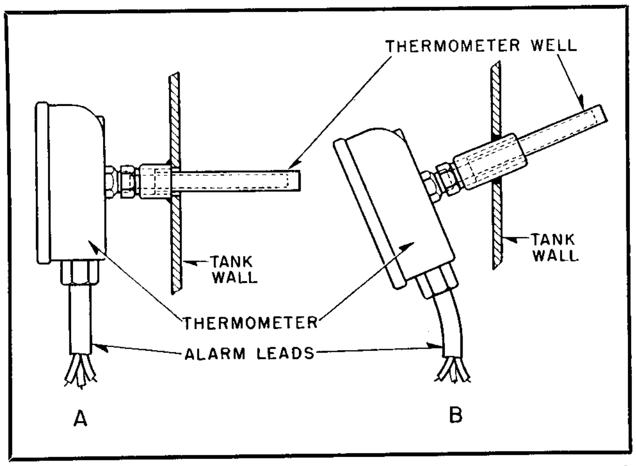

FIG. 5. Indicator Mounted (A) Vertical and (B) Tilted Downward

TABLE NO. I

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R = .026*
125 A-C	5	5
250 A-C	2.5	2.5
125 D-C	0.5	0.05
250 D-C	0.25	0.025

*Equal to or less than .026. If greater, refer to factory for adjusted rating.

RENEWAL PARTS

If it becomes necessary to repair the instrument, contact the nearest Westinghouse District Office. Complete instructions will then be given by the District Engineering & Service Division for the return of the instrument to the factory at Sharon, Pa., to have it repaired and placed in first class condition.

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HANDLING • INSTALLATION • MAINTENANCE

INSTRUCTIONS

BULK TYPE BUSHINGS

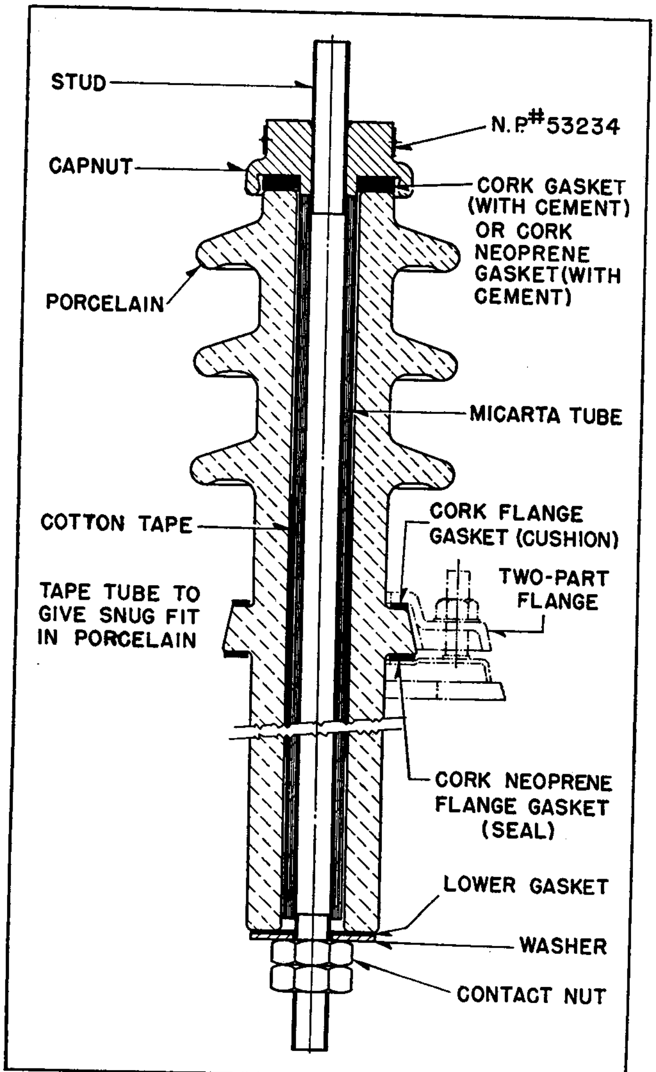

FIG. 1. Cross Section of a Typical Bulk Type Bushing.

BULK TYPE BUSHINGS are used for voltage classes of 25 Kv and lower. The standard bulk type bushings consist of single-piece wet-process porcelains with a lead through the center. Type J-2 bushings have solid copper studs while Type J-1 bushings have copper tubes through which a bare copper cable carries the current. For low voltage classes the leads are centered within the porcelains with cotton tape. For higher voltage classes a Micarta tube is inserted between the leads and the porcelains. The lead and the metal cap are sweated together to form a solder-seal joint. A gasket cemented to the cap and porcelain forms a gas-tight seal. At the lower end a cushion gasket is placed between the porcelain and the washer against which the locknut is tightened to complete the assembly of the porcelain and the lead.

Note: Cork-neoprene sealing gaskets are used on bushings for oil-filled transformers and cork gaskets for Inerteen-filled transformers.

HANDLING AND STORING

Care must be taken in handling not to crack the porcelain or damage its surface. Instead of a solid lead, some of the older bulk-type bushings have a cable lead on which the insulation may be damaged if not handled properly.

Store spare bulk-type bushings in a clean dry place.

INSTALLATION

Bulk type bushings are usually shipped mounted in place on the transformer. The bushing is mounted on the cover by a collar on the porcelain which fits into a recess in a pressed metal boss welded to the cover. A gasket cemented between the collar and the boss provides a cushion for the porcelain and forms a gas-tight joint. Care must be taken to prevent breaking or chipping the mounting collar where the gasket seat is made when it is necessary to install the bushings after delivery. Two gaskets are used, one above and one below the collar. The upper one acts as a cushion between the split clamping flange and the collar; the lower gasket is a seal between the porcelain and the cover boss.

When tightening down the split flange, there should be no pressure contact between metal and porcelain. Tighten the nuts gradually all the way around until both gaskets are evenly compressed.

SUPERSEDES I.L.46-718-1

EFFECTIVE JANUARY, 1949

MAINTENANCE AND REPAIR

Inspect the bushings periodically for broken or cracked porcelains and faulty gaskets. Power factor tests are not necessary since they will not show defects in these bushings.

For all bulk-type bushings for 6600 volts and over the exposed metal parts below the cover should be under oil.

Damaged porcelains and gaskets can be replaced in the field with new parts. When there is further damage, a complete bushing should be ordered from the factory. Include the stock order and serial number of the transformer as well as the data on the bushing nameplate when ordering spare parts or complete bushings.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

"DE-ION" ARRESTERS

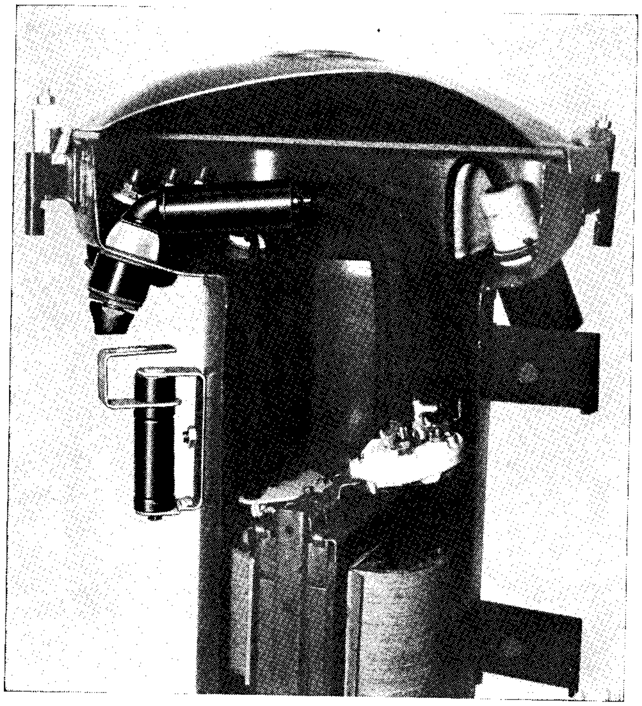

FIG. 1. "De-ion" Arrester Mounted Internally

THE "DE-ION" ARRESTER is a device which provides surge or lightning protection for electrical equipment. It differs from a plain gap in that it interrupts any power follow current within one-half cycle. It is designed to handle exceptionally high surge currents and will even discharge direct strokes of lightning successfully. Internally and externally mounted units are shown in Figures 1 and 2, respectively.

RECEIVING

"De-ion" arresters will normally be shipped assembled with the apparatus with which they are to be used. In any case where they are not, care should be taken to see that they are not stored in any place where water could enter the discharge opening of the arresters or where their packing may become water soaked. Humidity should also not be excessive (over 80% R.H.) for extended periods of time.

INSTALLATION

The "De-ion" arresters will normally be installed and adjusted at the factory on the apparatus with which they are to be used. However, when received, the air gaps should be checked to make certain that they still are in adjustment. The series gap should be set at $\frac{1}{2}$ inch and the shunt gap at $\frac{9}{16}$ inch as shown in Fig. 3.

The sketches in Figure 3 show typical internal and external mountings; mechanical details will differ on some apparatus.

OPERATION

The "De-ion" arrester consists of two metal electrodes separated by a slotted fiber diffuser section. When an excessive voltage appears across the terminals of the arrester, a flashover takes place from one electrode through the slots of the diffuser section to the other electrode. The voltage between the two electrodes then drops immediately to a very low value. Should this flashover

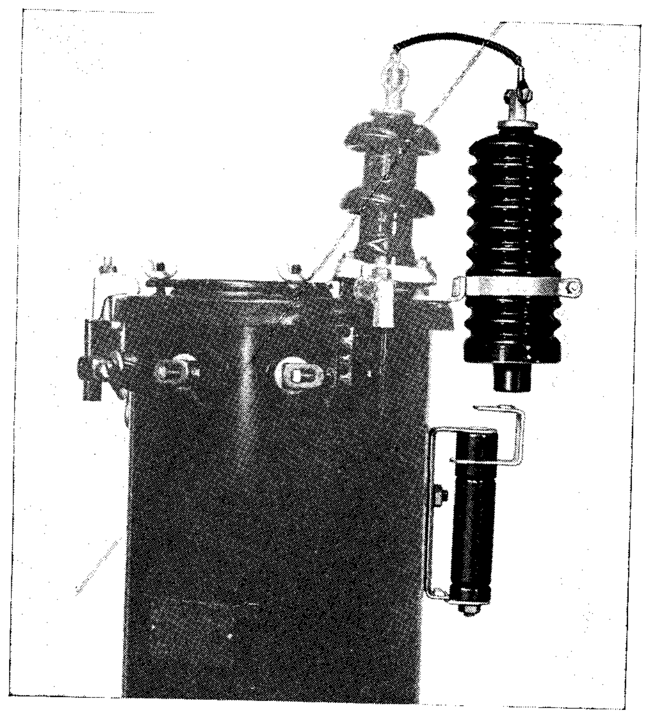

FIG. 2. "De-ion" Arrester Mounted Externally

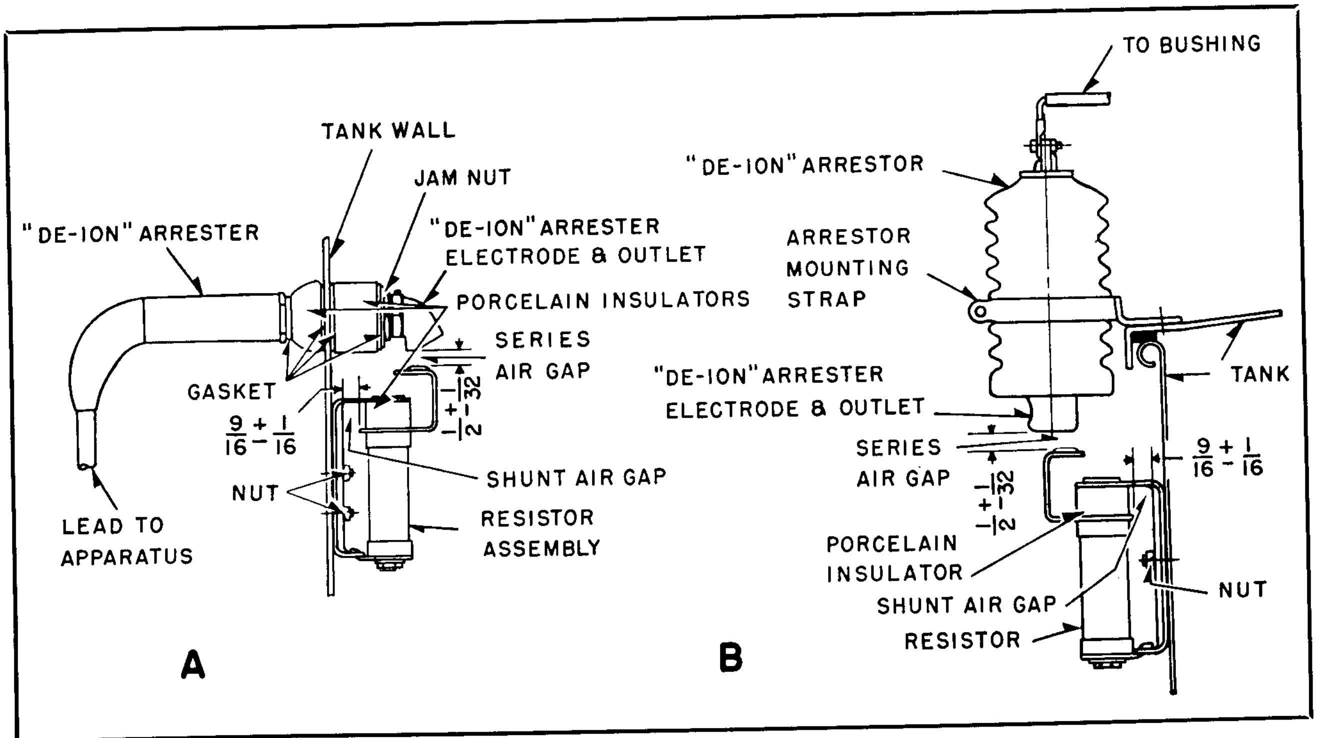

FIG. 3. "De-ion" Arrester: (A) Typical Internal Mounting; (B) Typical External Mounting

take place at a time when the power voltage is of sufficient magnitude to produce and maintain an arc against the deionizing action of the arrester, a flow of power current will follow the surge. This power current is limited to a value less than 500 amperes by the resistor which is in series.

The heat from the current which flows through the slots of the fiber diffuser causes gas to be driven off from the slot walls. This gas mixes into the electrical discharge in such a way that at the first current zero of the power current, the discharge is deionized by the un-ionized gas and the current is not built up in the opposite direction. There is no minimum power current below which the arrester will not interrupt.

There is a series air gap between the "De-ion" arrester and resistor. The purpose of this gap is to prevent any possibility of leakage current through the "De-ion" arrester.

The resistor is provided with a shunt protective gap which flashes over when the surge current reaches about 10,000 amperes. This limits the voltage, due to IR drop, which would be applied to the electrical equipment and also by-passes around the resistor the large amount of energy in a direct stroke. Experience has shown that when surge currents are in excess of 10,000 amperes, the deionizing action of the surge current alone is sufficient to prevent power follow current so that the resistor is not needed and it can be shunted out by the gap.

MAINTENANCE

Normally, no maintenance is required of "De-ion" arresters. If the apparatus to which the "De-ion" arresters are applied is reconditioned, care should be taken to keep paint off all porcelain surfaces. Neither the resistor nor the arrester proper (internal mounted arresters) should be refinished with a type of paint which might have electrical conduction properties.

RENEWAL PARTS

In case renewal parts are required, these should be ordered through the nearest Westinghouse sales office. A description of the part wanted should be given as well as the serial and stock order number appearing on the nameplate of the complete apparatus. Due to manufacturing problems, repair part details will not be furnished for the "De-ion" arrester proper; instead a complete new arrester will be shipped. Repair resistors or mounting details may be ordered, however. When installing "De-ion" arresters inside other apparatus, care should be used to mount the arresters in exactly the same position as the original arresters so that adequate electrical clearance will be maintained from the high voltage ends of the arresters.

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INSTALLATION • ADJUSTMENT • MAINTENANCE

INSTRUCTIONS

VOLTAGE REGULATING RELAY

Style No. 1511 723 With Compensator

For Step Type Regulators

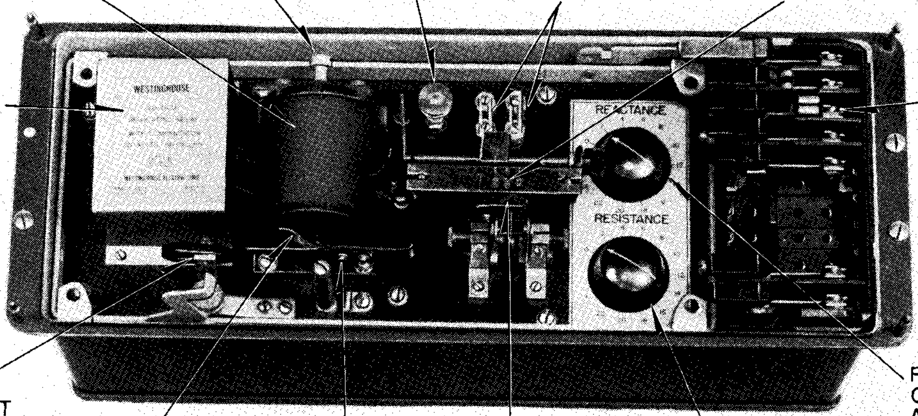

FIG. 1. Front View with Relay in Case (Cover Removed)

VOLTAGE REGULATING RELAY Style No. 1511 723 is of the alternating current solenoid type. Compounding is obtained by means of a permanent magnet. Adjustments for different values of balance voltage are made by shifting a counterweight along a scale which is calibrated in volts.

CONSTRUCTION

The Flexitest type of construction employs a metal case with a tight-fitting removable cover having a glass front. Fig. 1 shows the voltage regulating relay with the cover removed. The complete relay unit is mounted on a chassis which is readily removable from the Flexitest case by opening all the test switches at the right of the case and pulling out the holding levers at the top and bottom. This disengages the chassis from the case and the complete relay is then lifted out by means of the holding levers. See Fig. 2.

The operating parts have been combined into a single moving element which is mounted on a square shaft resting on a knife edge. This construction provides a very sturdy bearing with a negligible amount of friction. The shaft and bracket are made of nitrided steel which is exceptionally hard and resistant to wear and corrosion. A damping device is attached to the beam and is adjustable to provide stability to the action of the relay.

The contacts are made of silver, which results in long life and smooth contact points. They are designed to eliminate contact "sticking".

A "no-voltage" device is included as part of the main assembly with its operating coil connected across the potential source of the voltage regulating relay, and its contacts in series with the common point of the voltage regulating relay contacts. See Fig. 4. This device prevents control mechanism operation in case of voltage failure supplying the voltage regulating relay coil.

SUPERSEDES I.L. 46-736-7

EFFECTIVE JUNE, 1950

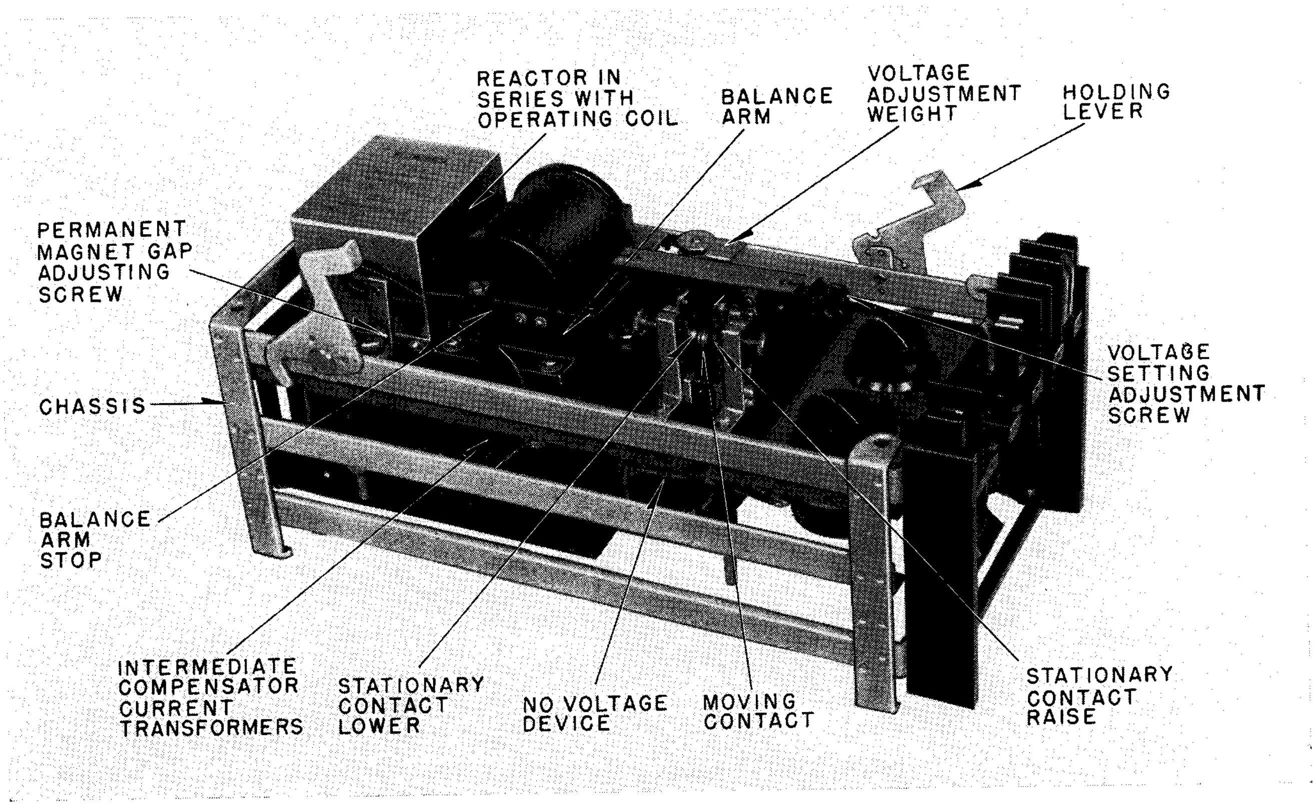

FIG. 2. View of Voltage Regulating Relay and Compensator (Removed from Case)

INSTALLATION

This relay is usually shipped mounted on the tap changer control panel. Before putting into service, the blocking should be removed and its operation checked as follows:

Press down on the relay balance arm so that the pivot shaft is held firmly in the grooved bearing. There should be clearance between the balance arm and the inside of the operating coil, also clearance between the balance arm and the sides of the supported bearing. To adjust the clearance, loosen the two screws which hold the balance arm to the moving part of the bearing and move the arm until it lines up and then retighten these screws. The relay contacts should be in line and should not require any other adjustment, except as specified in the adjustment procedure.

A damping device mounted at the rear of the balance arm and connected to the arm by a link is for the purpose of supplying the required amount of friction to give stability to the relay. This device should not require adjustment and if the relay appears to be slow or sluggish in operation, the relay should be checked carefully for friction at other points before changing the adjustment of the damping device. If the voltage relay balance arm moves too freely and swings excessively, the spring tension should be increased on the damping device by moving the adjusting nut a fraction of a turn.

ADJUSTMENT

The voltage regulating relay is usually adjusted to make contact on a plus or minus 1½ or 2-vol change across the relay coil.

To change the adjustment of the relay, it is desirable to have a source of variable voltage with a range of approximately +5 volts from the normal voltage on the regulator control circuit. A 50-ohm, 25-watt variable rheostat Model H, No. 0149, supplied by the Ohmite Manufacturing Company, Chicago, Ill., can be conveniently used for making the voltage change as described herein. Connect this rheostat in series with the voltage regulating coil and vary it as required. If the regulator is carrying load, the line compensator if used should be set at zero. Be sure to place the Type AB supply circuit breaker in the "off" position before applying an external voltage to the control circuit test terminals.

Fig. 3 shows a voltage regulating relay with its various parts identified. Each part has an important function which should be clearly understood. As the steps in adjusting this relay are

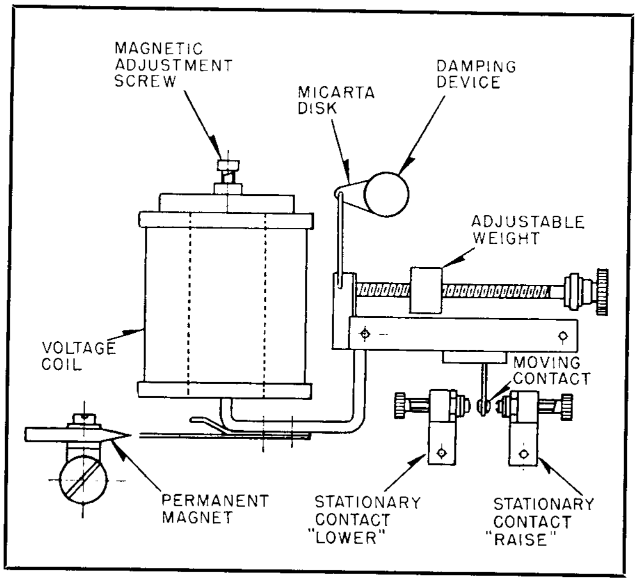

FIG. 3. Voltage Regulating Relay Assembly

followed, the effect that each part contributes to the successful operation of the relay will be apparent.

Checking for Mechanical Friction. If friction is present, it will result in a sluggish or erratic relay. To make this check, the following steps should be taken (see Fig. 3):

1. Revolve the permanent magnet about 90 degrees.

2. Lift the small round Micarta disk on the damping device to relieve the damping effect of the tension spring. This can be easily done by pulling this disk back and then catching it on the pin that protrudes to normally keep this disk in place.

3. Remove the magnetic circuit adjusting screw on top of the voltage coil.

4. Open the stationary contacts wide, seeing that the leaf spring on each stationary contact has a travel of approximately $3/32$ inch.

5. Apply a voltage to the test terminals until the beam balances. The weight should be near the middle of the scale.

Under these conditions and if no friction is present, the beam will float without any apparent interference, its movement corresponding to any slight voltage fluctuation.

Upon striking the beam lightly, it will oscillate up and down and gradually come to rest.

However, if there is dirt or foreign material on the knife bearing, or if the end of the beam is rubbing the inside of the solenoid due to misalignment, these movements of the beam will not be smooth and the beam will come to an abrupt stop when it is struck lightly. The bearing should be examined to make certain it is free of any foreign material which would hamper consistent performance of the relay. The surfaces of this knife bearing are of steel, nitrided to a very high hardness and require no lubrication.

Setting the Balance Beam Weight. To adjust the balance beam weight until it balances at the desired balance voltage, proceed as follows:

1. Replace the magnetic circuit adjusting screw on top of the coil. Turn the screw fully down and back off approximately two turns. This is the position of the screw which will give the best operating characteristics to the relay especially on small voltage bands.

2. Turn the permanent magnet to its operating position, and set it with about $1/16$-inch gap between the tip of the beam and the face of the magnet.

3. Apply the desired balance voltage to the coil and adjust the position of the weight until the beam will balance opposite the permanent magnet. This can be most easily done if the tip of the beam is lightly held between the finger tip at the balance position while the position of the weight is adjusted to the point where the beam will remain balanced when released.

4. It is, of course, necessary that the position of the weight remain fixed after it is once set. This is accomplished by a spring washer between the end of the beam and the thumb nut which is used to adjust the position of the weight. Check to be certain that there is sufficient friction here to prevent ordinary vibrations from turning the thumb nut, thus resulting in a change of calibration.

Damping Adjustment. After the relay is balanced, next proceed to make it less susceptible to slight voltage fluctuations and vibrations. This is done by restoring the damping disk to its proper position and turning the small nut at the end of the spring until the desired spring pressure on the disk is obtained. Very little spring pressure is required to effect an appreciable damping. From the condition of "free spring" with the adjusting nut just touching the spring, one and one-half ($1\frac{1}{2}$) turns of the nut will usually result in sufficient damping. This should cause the balance arm to stabilize within approximately four swings when the control switch is thrown off and on.

Setting Band Width. To set the desired voltage band width; that is, the voltage above and below the balance value at which the beam will move to close its contacts:

and replace in the horizontal position. This position is indicated by dotted lines in Fig. 4 (diagram of voltage regulating relay and compensator).

Caution: Do not remove these links unless the secondary of the line current transformer is short circuited as these links carry the current from the secondary of the line current transformer.

OPERATION

Correct settings for line-drop compensation are most commonly obtained from calculated values of reactance and resistance line drop from the regulator to the load center reduced to full load regulator rating and 120 volts, and later corrected if necessary, from voltage charts taken at the load center.

Calculated values are likely to be sufficiently accurate in ratio of resistance to reactance drop. The compensation for both should be increased if load center voltage falls at periods of high loads and decreased if load center voltage rises at periods of high load.

The regulated voltage may be read between terminals "F" and "G" of the primary relay if separate test terminals are not available. The load center voltage may be read from the scale on the beam of the relay, when balanced.

MAINTENANCE

Voltage Regulating Relay. The amount of relay maintenance which may be required will depend largely upon the voltage conditions existing on the circuit and the degree of sensitivity to which the voltage regulating relay is adjusted. It is recommended that during the first few months of service, inspection be made at rather frequent intervals to prevent excessive tap changer operation. After satisfactory operation is once established, inspections at periods of six months to one year should be sufficient.

It is not necessary to keep the contacts on this relay polished as on older types of relays, since the contacts on this relay are made by rolling rather than by sliding action.

If the contacts on the relay should become worn to an uneven shape, they may be smoothed and reshaped with fine sandpaper and readjusted.

Caution: Do not lubricate the bearings. Keep cover tight.

Compensator. Since the rheostats are very seldom moved after adjustment, there is small chance that they will require any maintenance other than an occasional blowing out to remove any dust which may have accumulated.

Renewal Parts. Order renewal parts from the nearest Westinghouse Sales Office or from the Sharon Plant. Give the style or stock order number and serial number as stamped on the regulator nameplate, together with description of parts required (see Figs. 1 and 2).

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1. Set the permanent magnet with a very small air gap between the tip of the beam and the face of the magnet (1/32 inch or less) using adjusting screw.

2. Gradually increase the voltage to the value of the upper band limit. For example, this would be 2 volts above the balance value for a plus and minus 2-volt band.

3. By means of the knurled adjusting screw, located below the permanent magnet, increase the air gap between the magnet and beam until the beam just breaks away from balance and moves up into the coil.

Note: There is a change in voltage across the coil of about one volt when the beam is moved from the extreme bottom to the top of its travel. For this reason, the voltage should be read at the instant the beam breaks away.

4. Manually return the beam to balance and decrease the voltage to the balance value.

5. Gradually decrease the voltage from the balance value until the beam just breaks away and falls to its bottom stop. Note the voltage at the instant it breaks away.

If it is observed that the beams fall out too soon, adjust the position of the weight on beam to the right slightly until the beam will fall out at the desired voltage. If the beam does not fall out until some voltage below the desired value, adjust the position of the weight to the left slightly until beam falls out at the desired value. These adjustments should be very slight. A large adjustment will affect the upper limit.

In making the final adjustments of the band width, for small voltage bands, the position of the magnetic circuit adjusting screw, the position of the weight on the beam, and the position of the permanent magnet should be carefully coordinated to obtain the correct break-away voltages.

Adjusting the Compounding. The final adjustment or the adjustment of the stationary contacts determine the "compounding" of the relay. The "compounding" is the difference between the voltage at which the contact will close and the voltage at which the contact opens. The compounding can be increased by increasing the contact spacing and decreased by decreasing the contact spacing. It is recommended that at least 3/4-volt compounding be used; that is, with a plus and minus two-volt band and 3/4-volt compounding, the contacts should open at plus or minus 1 1/4 volts.

1. With the beam at its upper limit of travel, set the voltage to the value at which it is desired that these contacts open.

2. By means of the contact adjusting screw, gradually move the left-hand stationary contact inward until the beam will just return to balance. Make certain that the contacts are open at balance.

3. With the beam at its lower limit of travel, set the voltage to the value at which it is desired that this contact open.

4. By means of the contact adjusting screw, gradually move the right-hand stationary contact inward until the beam will just return to balance. Make certain that both contacts are open to balance position.

Final Checking. The relay now being fully adjusted, its over-all operation should be checked. Increase and decrease the voltage from the balance value and observe the voltages at which the contacts make and break. When assured that the operation is satisfactory, tighten the locking nut on the magnetic circuit adjusting screw, and mark the position of the weight on the metal plate below it.

Plus and Minus 1-Volt Band Widths. When voltage band widths of plus and minus 1 volt are required, it is necessary to replace the standard permanent magnet with a smaller more pointed one, Style No. 1080 890, and make adjustments as described above.

Note: The smaller magnet may be ordered from the nearest Westinghouse Sales Office.

The line-drop compensator for use with the voltage regulating relay consists of two rheostats, one for resistance compensation and one for reactance compensation. They are connected to the voltage regulating relay coil series reactor and two small intermediate current transformers, the secondaries of which supply the required current to the compensator. The primary windings are arranged for connecting to the main current transformer supplying the compensator circuit.

The compensator is mounted in the same chassis with the primary relay so as to form a single unit. The rheostats for the resistance and reactance compensation are mounted on the rear of the primary relay panel and are operated by dials accessible from the front. These are set to a desired degree of compensation as indicated by an engraved steel plate having a graduated scale.

The two intermediate current transformers are mounted on a plate suspended from the primary relay panel and their primaries are connected to the compensation reversing posts with removable links so that when the links are connected in the vertical position as shown in Fig. 1, normal compensation is obtained. To obtain reverse reactance compensation, remove both links from the posts

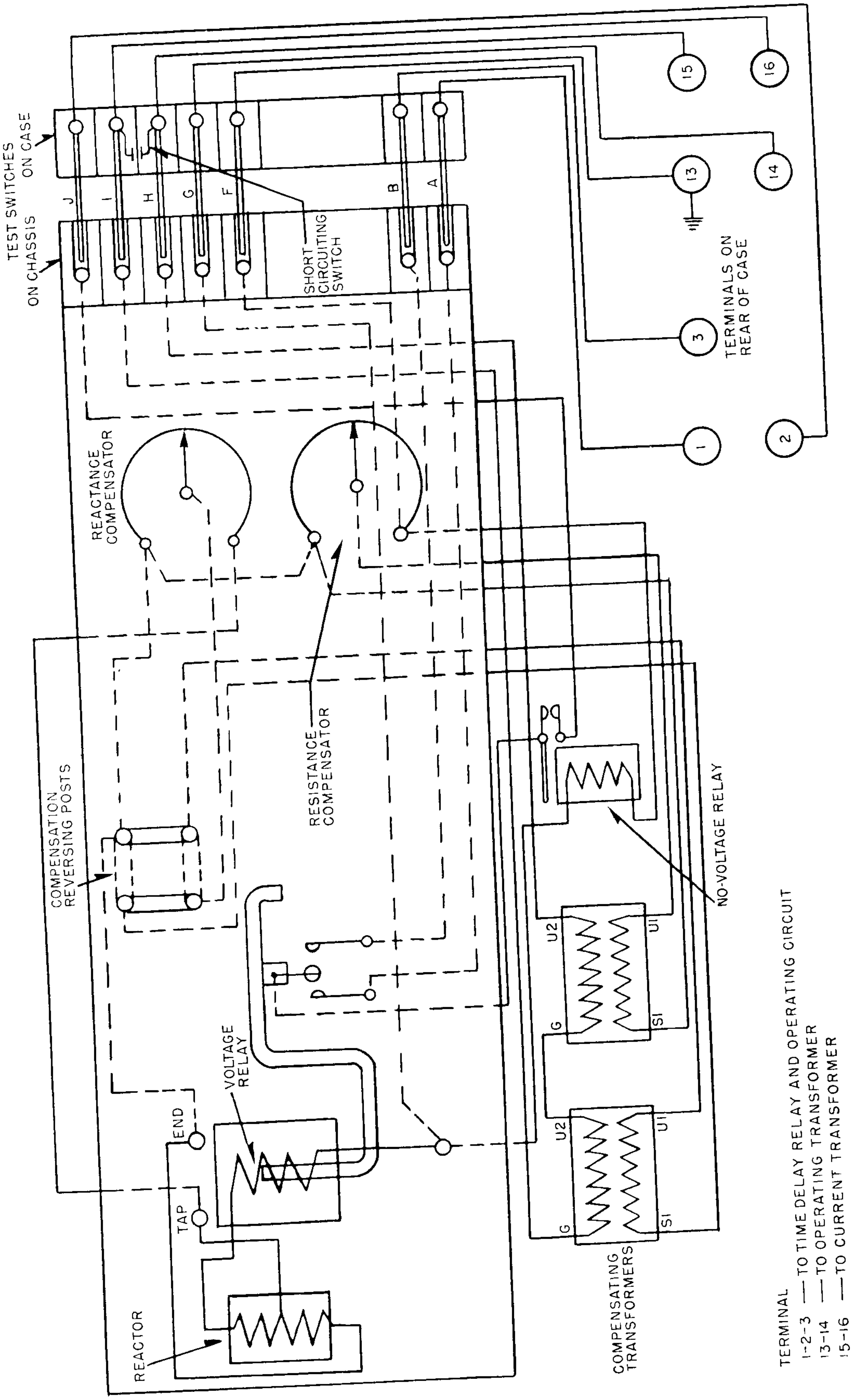

FIG. 4. Diagram of Voltage Regulating Relay and Compensator

DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE AB DE-ION CIRCUIT BREAKERS

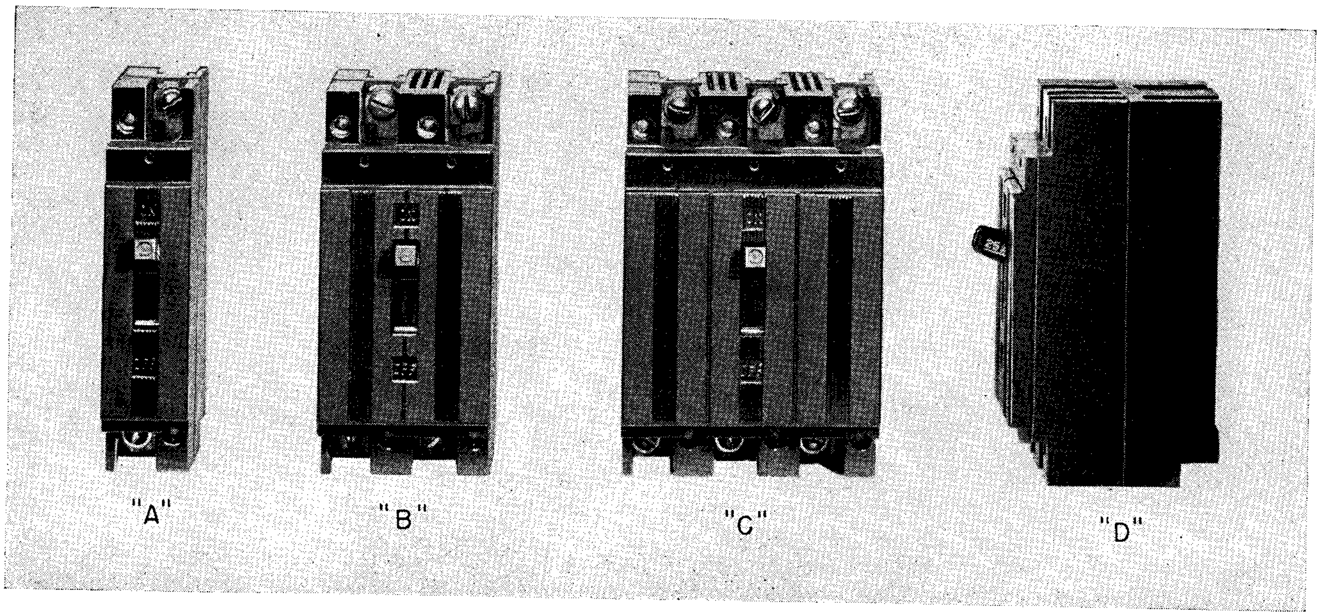

FIG. 1. Type "AB" De-ion Breakers: "A", Single-pole; "B", Two-pole; "C", Three-pole; "D", Side View of Three-pole

TYPE "AB" DE-ION BREAKERS with thermal overload trip as used on Westinghouse tap changer equipment are intended to prctect from overloads the auxiliary transformer windings that supply power for the control. The mechanism is completely enclosed in a sealed case and requires no maintenance.

CONSTRUCTION AND OPERATION

The case baffles, which resist entrance of dust into the mechanism, and also the operating lever, are moulded from insulating material. The breaker is dead front, only the terminals being exposed, and it is not necessary to open the sealed case to make connections.

Figure 1, ("A", "B" and "C") shows the front views of the single, double and three pole breakers respectively. Figure 1, "D", shows a side view.

The butt type contacts are operated by a spring toggle which snaps them either open or closed with a quick make and break action. When released due to overload, the toggle is trip free from the handle so that it is impossible to hold the contacts closed on a fault.

The contacts open in front of a De-ion grid stack and the proper magnetic circuit is set up by the current to move the arc off the contacts and into the grid. The De-ion grid divides the arc into a series of short arcs and on the first current zero, the arc is extinguished by the action of a large number of cathodes in series.

When De-ion Breakers are mounted in the transformer oil they have openings in the case opposite the De-ion grids to allow free circulation of oil.

The breaker is tripped on overload by a bi-metal latch which is calibrated to carry full load continuously but to trip eventually on 125% load. On high overloads, the bi-metal has inverse time characteristics which make it almost instantaneous on short circuits.

When the breaker trips from overload, the handle moves to a mid-position which gives a visible indication that the breaker has tripped. Before the breaker can be closed again, it has to be reset by

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pushing the operating handle downward and then closed by raising handle. On multipole units, the separate bi-metal trip mechanisms are connected by an insulated common trip bar so that an overload on one element will trip all elements.

MAINTENANCE

The entire mechanism is enclosed in its moulded case and sealed at the factory against tampering and to insure permanent calibration of the bi-metals. As the contacts are protected by the de-ion chamber against burning, no maintenance is necessary.

RENEWAL PARTS

In case the breaker should become inoperative or damaged a new one should be ordered from the nearest Westinghouse Electric Corporation Sales Office or directly from the Sharon, Pa. Plant giving serial and stock order number as stamped on the transformer nameplate, and style number and rating of breaker.

WESTINGHOUSE ELECTRIC CORPORATION
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SHIPPING • UNPACKING

INSTRUCTIONS

SHIPMENT OF TRANSFORMERS IN OIL

SHIPMENT

When transformers are shipped in oil they are usually shipped in their own tanks, but sometimes when other requirements make it desirable the transformers may be shipped in a special shipping tank.

Transformers with radiators are usually shipped in their own tank, but with some or all of the radiators removed. The radiator flanges on the tank are covered by blind flanges. The detached radiators are always crated and shipped separately. Where radiator valves are used it is unnecessary to drain the oil from the tank to install the radiators. The additional transformer oil for the removed radiators is usually shipped in tightly sealed drums.

Some of the bracing in a transformer may be put on for shipment only. The transformer core is always braced or tied securely to the tank wall in large transformers to take care of shocks received in shipment. If the transformer is removed from the tank for inspection during installation, it is unnecessary to replace these tie plates if there is no possibility of reshipment.

Sometimes special blocking or bracing that may interfere with normal operation is used for shipment. In such cases, it is essential that this special bracing be removed before the transformers are placed in service. Where special bracing is to be removed, the outline drawing will contain notes of instruction regarding it. The outline drawing should always be checked for such instructions.

The general practice is to ship as many detail parts and bushings in place as is safe and as shipping clearances will permit. Where it is necessary to remove bushings, the openings in the cover or tank wall are covered with blind flanges for shipment. Any bushings and detail parts removed for shipment are always boxed separately and are to be mounted when the transformers are installed.

Core Form Transformers. In most cases core form transformers can be shipped in their own tanks in an upright position.

It is occasionally necessary with large transformers to have a joint in the tank so that the top section may be removed for shipment. Either the regular cover or a special shipping cover is bolted on the top of the lower section of the tank for shipment. If a special cover is used it is sometimes made with a box-like structure which makes room for terminal boards, etc., which extend up beyond the top of the lower section of the tank. The tank is usually filled until the oil extends up into this box. **Care must be taken to lower the oil below the joint before removing this cover.**

Shell Form Transformers. Shell form transformers are usually made with form-fit tanks. When the form-fit tank is used, transformers may be shipped in the upright position or lying down in a horizontal position. The bracing for units in the form-fit tanks is usually arranged so that it need not be removed. In exceptional cases, particularly when the transformer is shipped horizontally, it may be necessary to use additional bracing for shipment. In such cases, the outline drawing will contain notes calling attention to the necessity of removing any special bracing.

Occasionally, shell form transformers are placed in octagonal or rectangular tanks. The larger sized units may require sectionalized tanks with special covers to meet height limitations in shipment. If a hat-shaped cover is used, care must be taken to lower the oil below the joint before removing this cover. The outline drawing will indicate when special covers are used in shipment.

UNPACKING

When a transformer is shipped in its own tank with oil, unpacking is a simple matter. It is ready to be set in place when the crating or bracing is removed.

The transformer should be examined carefully to ascertain whether it has been damaged in shipment and whether all parts are in place and in good condition.

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SHIPMENT OF TRANSFORMERS

All bushings and accessories that are shipped separately should be thoroughly protected against moisture until they are installed. Care should be exercised during the installation of these parts to protect the transformer against the possibility of any moisture entering. As an extra precaution against moisture having entered the transformer during shipment or installation, the dielectric strength of the oil should be tested before the transformer is put in service. The dielectric strength of the oil when tested in a standard cup should be not less than 22 kv.

If a transformer is shipped with oil in a shipping tank, the shipping tank should not be opened until the transformer case is in place ready to receive the transformer. The shipping tank should not be opened until temperature of the transformer is the same or higher than the air temperature, to avoid moisture from condensation. The greatest care should be taken to avoid getting moisture in the transformer while transferring it from the shipping tank to its case.

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INSTRUCTIONS

DETERMINATION OF DRYNESS and METHODS OF DRYING OUT

All transformers are dry when they leave the factory, but since they may absorb more or less moisture during shipment and storage, they should not be put into service until it has been determined that the oil and insulation are dry enough for safe operation. The higher the voltage, the more chances there are of trouble from moisture, and the greatest care should be exercised to make sure that the moisture is practically eliminated.

Dryness of Oil and Windings. When a transformer has been shipped assembled in its case with the oil, four or five samples of oil should be drawn from the bottom of the case and tested. If the average of these tests show a breakdown value of not less than 22,000 volts on a standard 1/10″ gap test cup, the insulation and oil are in a satisfactory condition for service. If the average breakdown value is less than 22,000 volts the oil must be dried. Whether the windings must also be dried should be determined as described under "Insulation Resistance", after the oil has been drawn off. If the insulation resistance is of the proper value, drying of the windings is unnecessary and the transformer may be put into service as soon as the dry oil has been put into the case, provided there has been no delay in drying the oil and returning it to the case.

When a transformer is shipped without either oil or dry nitrogen gas, drying out will be necessary, except in the cases of transformers 500 kv-a. and under, and of less than 7500 volts. These latter transformers should be tested for dryness before being put into service.

There is no absolute method of telling when the insulation of a transformer is dry, but proper measurements of insulation resistance from the high voltage windings to the low voltage windings and to the core and from the low voltage windings to the core, will serve as approximate means of determining its condition.

Insulation resistance measured with the transformer cold, is greater than when measured with it hot and is also greater out of oil than when immersed in oil. Therefore, in order to determine the condition of the insulation, the transformer should first be heated up out of oil, preferably by both internal and external heat to the temperature of approximately 60° to 70°C. After it has reached this temperature, it should be maintained there for 24 hours. The insulation resistance may then be taken and, in general, it may be said that if it does not measure less than 1 megohm for every 1000 volts of rated line voltage, drying out will usually be unnecessary. If it measures less than this, drying out will usually be necessary. If necessary this method of determining dryness, without drying out, may be used with some benefit up to 500 kv-a. and 23,000 volts.

Method of Measurement. The most satisfactory method of measuring the insulation resistance is by a megger. This instrument is very convenient to use and indicates the megohm resistance directly. In the absence of the megger, a high resistance voltmeter, specially designed for the purpose, may be used. Such a voltmeter usually has a resistance of one megohm. Sufficiently accurate results cannot be obtained from an ordinary voltmeter. Five hundred to six hundred volts direct-current should be used in making measurements by the voltmeter method.

The method of measurement is to read first, the voltage of the line and then to connect the resistance to be measured in series with the voltmeter and take a second reading.

Insulation Resistance. The method of calculating the insulation resistance is given by the following formula:

$$R = \frac{r\,(V-v)}{v} \text{ in which}$$

V = voltage of line.

v = voltage reading with insulation in series with voltmeter.

r = resistance of voltmeter.

R = resistance of insulation.

The method of connection for the measurement is given in Fig. 1. With a voltmeter having a resistance of one megohm, the calculation is somewhat simplified, since r = one and the formula becomes

$$R = \frac{V-v}{v} = \frac{V}{v} - 1 \text{ megohm}$$

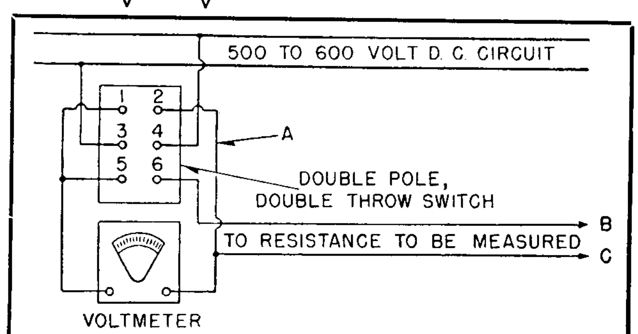

FIG. 1. Connections for Measuring Insulation Resistance

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EFFECTIVE MAY, 1949

Connection. Since high resistances are being measured, great care must be taken to insulate thoroughly all wiring used for making the connections. The best way is to use wires stiff enough to support themselves so that they can be run directly between the points to be connected without any intervening supports.

The voltmeter should be placed on a table that rests on dry, well-insulated supports. A double-pole, double-throw oil switch is preferable to an ordinary switch mounted on a marble base, because the insulation resistance between the jaws is much greater.

In making connections to the transformer, wire C should be connected to the high-voltage winding when the insulation resistance of the latter is being measured, wire B being connected to the low-voltage winding or to the core, according to whether the measurement is being made from the high-voltage to the low-voltage winding, or from the high-voltage winding to the core. When the insulation resistance from the low-voltage winding to the core is being measured, wire C should be connected to the low-voltage winding and wire B to the core.

Check-Readings. After the connections have all been made, check-readings should be taken to insure that there is no appreciable leakage of currents between the switch jaws. To do this, close the switch on 5 and 6 (See Fig. 1) and note very accurately the voltmeter reading. Then disconnect wire A from 2 and leave the end hanging loose in the air so that it does not touch anything, and, with the switch closed on 5 and 6 as before, take another reading very accurately. If this reading is appreciably less than the first one, the insulation resistance across the switch jaws is too low. In such cases, all readings of insulation resistance must be taken with wire A disconnected.

In reading the line voltage, connect wire A again and close the switch on 1 and 2.

Important. In making insulation resistance measurements by the voltmeter method, accurate results can only be obtained by paying careful attention to the above instructions.

METHODS OF DRYING OUT

There are four methods that may be followed in drying out transformers,

1. By internal heat.

2. By external heat.

3. By internal and external heat.

4. By heating in oil.

Of the above methods, the order in which their use is recommended, if there is any choice of methods that can be used, is as follows: 3, 2, 1, 4.

Method 3 is the one recommended by Westinghouse, and it should be used whenever possible. The other methods are much slower and less positive.

Methods 1 and 4 are particularly unreliable and slow for large or high-voltage transformers and are not recommended.

1. Drying Out by Internal Heat. For this method, alternating-current is required. The transformer should be placed in its case without the oil and the cover left off to allow free circulation of air. The low-voltage winding should be short-circuited and sufficient voltage impressed across the high-voltage winding to circulate enough current through the coils to maintain the temperature at from 80° to 90°C. measured by resistance. About one-fifth of normal full-rated current is generally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers but will generally be approximately ½ per cent to 1½ per cent of normal voltage of the winding at normal frequency.

The end terminals of the winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat in series with the high-voltage winding.

This method of drying out is superficial and slow and should only be used with small transformers, and then only when local conditions prohibit the use of the other methods.

2. Drying Out by External Heat. The transformer may be placed in its own tank without oil. Externally heated air is blown into the tank at the bottom through the main oil valve. A small blower or fan should be used to get the proper circulation. It is necessary to force as much of the heated air as possible up through the ducts in the transformer windings. To accomplish this, baffles should be placed between the core and the case, closing off as much of the space as possible.

The best way to obtain the heated air is by blowing the air through grid resistors. The resistors should be placed in a fire-proof box. The temperature limits are the same as for method 1. The temperature of the air entering from the grids should not exceed 125°C. Measure the temperature of the windings by resistance measurements frequently to make sure that the transformer is not overheated.

The heat may also be obtained by direct combustion, but it is essential that none of the products of combustion be allowed to enter the transformer case. Heating the air by combustion is not recommended except where electric current is not available.

If for any reason it is not expedient to place the transformer in its own tank, it may be placed in a wooden box with holes near the bottom and top for circulating warm air. The same precautions as given for drying in its own tank should be taken to see that the air is forced to circulate through the oil ducts in the insulation.

It is essential that every precaution be taken to prevent fire when drying out by this method. The set-up must be watched very carefully during the entire drying. If the blower should stop, the grid current should be turned off at once to prevent overheating.

3. Drying Out by Internal and External Heat. This is a combination of methods 1 and 2. The transformer should be placed in its own tank, if possible, and all precautions taken as outlined under method 2. The current circulated in the windings should, of course, be less than when method 1 alone is used.

4. Drying Out by Heating In Oil. For this method the transformer is submerged in oil and the heat is generated similar to method 1. The moisture is driven from the coils and insulation into the oil, and is removed from the oil by evaporation into the air or filtering, or by both evaporation and filtering.

The temperature of the windings should be maintained at 80° to 90°C. as determined by resistance measurement. The oil should be maintained at as high a temperature as possible to keep a safe temperature in the windings. To bring the oil up to a temperature sufficient to evaporate the moisture into the air, it will be necessary to reduce or cut off the water in a water-cooled transformer, and to limit the radiation in a self-cooled transformer. The radiation may be limited by lagging the tank, or a portion of it, with some suitable heat insulating material. If external radiators are used, the oil circulation in the radiators should be prevented by closing the radiator valves or by lowering the oil level below the top radiator connections.

It is essential that plenty of ventilation be provided in the air space above the oil, in order that the moisture may evaporate from the oil. The manhole covers may be raised and, if necessary, forced ventilation used. If the ventilation is not sufficient, moisture will condense on the cover and drip into the oil. If this occurs, the ventilation should be increased or the temperature of the oil reduced.

Filtering the oil will aid materially in removing the moisture, and hasten the process of drying.

The rate of evaporation depends on the temperature of the oil and the ventilation, but special care should be used to see that the windings and insulation, which are at a higher temperature than the oil, do not reach a dangerous temperature.

DRYING OUT PROCEDURE

Time Required for Drying. There is no definite length of time for drying. One to three weeks will generally be required for methods 1, 2, and 3, depending upon the condition of the transformer, the size, the voltage and the method of drying used. Method 4 will take a great deal longer time than the other methods.

Details to Be Regarded. If the initial insulation resistance be measured at ordinary temperatures, it may be high, although the insulation is not dry, but as the transformer is heated up it will drop rapidly.

As the drying proceeds at a constant temperature, the insulation resistance will generally increase gradually until towards the end of the drying period, when the increase will become more rapid. Sometimes the resistance will rise and fall a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working its way out through the outer portions which were dried at first. As temperature variations may cause great changes in insulation resistance the temperature should be kept as constant as possible. Measurements should be taken every few hours during the drying period.

Resistance Curve. A curve of the insulation resistance measurements should be plotted with time as abscissa and resistance as ordinates. By observation, the knee of the curve (i.e. the point where the insulation resistance begins to increase less rapidly) can be determined. The total drying period should be about 115 per cent of the time preceding the passing of the knee of the curve.

Precautions to Be Observed In Drying Out. As the drying temperature approaches the point where fibrous materials deteriorate, great care must be taken to see that there are no points where the temperature exceeds 90°C. Several thermometers should be used and they should be placed well in among the coils near the top and screened from air currents. Ventilating ducts offer particularly good places in which to place some of the thermometers. As the temperature rises rapidly at first, the thermometers must be read at intervals of about 1/2 hour. In order to keep the transformer at a constant temperature for insulation resistance measurements, one thermometer should be placed where it can be read without removing or changing position. The other thermometers should be shifted about until the hottest points are found, and should remain at these points throughout the drying period. Wherever possible, the temperature should be checked by making use of the increase-of-resistance method.

Caution: When the transformer is received from the factory, it is soaked with oil and in an inflammable condition. While hot, it may be ignited very easily by an arc or flame of any kind. It is well to have a chemical extinguisher or a supply of sand at hand for use in case of necessity.

It is not safe to attempt the drying out of transformers without giving them constant attention.

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WESTINGHOUSE

INSTRUCTIONS

STANDARD OUTSIDE FINISH
for Westinghouse Oil Insulated Transformer Tanks

The standard outside finish for Westinghouse medium and large transformer tanks consists of three air dried coats of paint. Each coat is usually flowed on. The color of the first and second coats are different so as to obtain a contrast between adjacent coats, thus insuring that each coat is continuous and of sufficient thickness. The third or final coat is of a dark blue-gray color.

Note. The second or intermediate coat is a ***mixture*** *of the primer and finish paints, one part primer paint to three parts finish paint by volume. These paints can be applied satisfactorily by flowing, dipping, spraying or brushing.*

The transformer tanks and many of the accessories attached, being constructed of steel, are normally susceptible to rusting. Therefore, in order to prevent rusting of exposed steel surfaces on all Westinghouse transformers, careful attention must be given to the following fundamental steps when repainting exposed steel surfaces:

1. All exposed steel surfaces must be thoroughly cleaned and prepared for the application of the protective coats of paint since the proper preparation of the surfaces to be finished is an important factor to securing a satisfactory and lasting finish.

Regardless of how good the paint may be, it will fail as a protector if applied over a wet, dirty, rusty or greasy surface. Rust and scale will absorb and hold moisture. Therefore, in order to obtain a durable finish, it is absolutely essential that no moisture be sealed in by the application of paint. For large areas, a clean dry surface with sufficient roughness for good adhesion of the priming coat can be obtained by shot or sand blasting the exposed surfaces of the transformer tank.

2. The careful application of a high grade durable quality paint is essential to guarantee a lasting finish.

The two factors that determine the quality of any paint are the pigment and vehicle. The pigment gives the color and body of the paint and the vehicle holds the pigment particles in place and forms a continuous adherent film. Although attention is generally centered upon the selection of the pigment, many tests show that the vehicle of a paint is the first of these two components to disintegrate. Therefore, it is important that a paint of this quality be used to obtain a satisfactory finish. Westinghouse primer paint No. 7164-1 and finish paint No. 7165-1 meet these requirements and are recommended.

Important. Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of scraper or sandpaper, applying a coat of Primer Paint No. 7164-1 and allow it to dry for at least 24 hours, then apply a coat of Finish Paint No. 7165-1.

Note. For small marred spots which do not penetrate the paint film to the parent metal, only the finish paint is necessary after cleaning, although due to the indefinite life of this finish, a protective coating should be applied as soon as possible.

Finish paint is packaged in one-pint containers and designated as style number 302509.

Primer paint No. 7164-1 is not packaged in small quantities but if required, can be purchased through the nearest sales or service office.

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SUPERSEDES I.L. 3151

EFFECTIVE DECEMBER, 1946

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INSTRUCTIONS

CLEANING TRANSFORMER INSULATION

There are times when it may become necessary to clean transformer insulation because of the accumulation of dust, grease, sludge or carbon deposits. The method for cleaning varies with the type of transformers.

DRY-TYPE TRANSFORMERS

Dust, free of oil or grease, may be removed by wiping with a clean dry rag or by using a vacuum cleaner equipped with a brush attachment. The vacuum cleaner is preferred for large areas. Dust may be blown from inaccessible parts, but any dust removed by blowing is scattered and much of it will settle on other parts from which it must be removed as outlined above. The air must contain no moisture and care must be observed so that the insulation materials are not damaged by excessive air velocity.

Should grease or oil get upon the insulation it may be removed by wiping dry with a clean dry cloth.

Loose carbon deposits may be removed by brushing and/or wiping with clean dry cloths. Defective insulation should be replaced.

OIL-FILLED TRANSFORMERS

Loose coatings of sludge and dirt may be removed by wiping with cloths saturated with transformer oil. Tightly adhering or heavy coatings of sludge may require a light brushing with a bristle brush, followed by a wash with transformer oil.

Sludge, dirt and oil-carbon deposits may often be effectively removed by spraying clean, dry, transformer oil upon and around the insulation with sufficient velocity to thoroughly wash and clean it. An air-ejector type nozzle should be used. Defective insulation should be replaced.

Important: Do not use knives, screw drivers or other sharp objects to clean coils since the use of these objects may cut the insulation.

INERTEEN-FILLED TRANSFORMERS

Normally, the cleaning of insulation is not necessary for Inerteen transformers because Inerteen does not sludge. However, should it be necessary to remove a deposit of dirt, it may be done by wiping with a cloth saturated with clean Inerteen or trichlorbenzene.

When arcing occurs in Inerteen, the insulation is attacked by the products of decomposition of the Inerteen and usually requires replacing. The products of decomposition of Inerteen 7336-8 now used in transformers have less effect on insulation than those from the earlier types of Inerteens. Hence it is more likely that the insulation in these transformers, not affected by direct arcing, may be used again.

For precautions in handling Inerteen refer to instruction book on Inerteen Transformers I.B. 5802.

Important: Carbon tetrachloride should never be used for cleaning the insulation of either liquid filled or dry type transformers because it is nearly impossible to remove all of the carbon tetrachloride used for cleaning purposes, and during the natural operation of the transformers, the remaining carbon tetrachloride will form hydrochloric acid which will cause corrosion of metal parts and detrimentally affect the insulation.

This general procedure is not to be followed when specific instructions accompany the apparatus.

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NEW INFORMATION

EFFECTIVE MAY, 1947
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INSTRUCTIONS

REPAIRING WELD LEAKS

This instruction leaflet is intended to give general instructions concerning recommended practices for repairing a weld leak in power transformers or their auxiliaries. Variations of these instructions may be desirable for special repair tasks, but normally the weld leak may be successfully sealed if these instructions are followed.

TRANSFORMER CASES AND FITTINGS

Transformer cases and their fittings are fabricated from 3/16″ to 1/2″ thick welding quality low carbon steel. The welds are deposited manually using shielded arc welding electrodes, other than some case seams which are automatically welded by the submerged arc welding process.

To repair a weld leak in a case seam or around one of the fittings the following is recommended:

1. Check the liquid level in relation to the area to be welded. It should be 4″ or more above the area to be welded. Should the area to be welded be above the liquid level or if the liquid has been removed from the case, blanket the transformer with dry nitrogen.

2. De-energize the transformer and pull a vacuum of several pounds per square inch above the liquid to stop the liquid leak. This may be done with a vacuum pump or by sealing all fittings on the case and draining sufficient oil to obtain the necessary vacuum.

Note: Vacuum is not always required, especially when a sweating leak is to be repaired and the case wall is relatively thick.

3. Peen the weld leak closed, if possible, with the ball end of a ball-peen hammer or with a blunt or round-nosed chisel.

4. Grind or scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine.

5. Select several Westinghouse 1/8″ diameter type FP electrodes, S# 1528 911, for 50# packages. This is an all-purpose, coated electrode adaptable to down-hand, horizontal or vertical welding. It is classed as an E-6012 type by the American Welding Society. Either a-c or d-c welding current may be used. When d-c power is used, straight polarity is preferred, that is, the electrode is negative.

The welding machine is adjusted to supply the desired welding current. Some value between 115 to 125 amperes should be used, depending upon the welding operator's ability and the individual task at hand.

6. Apply a string bead sealing weld over the weld defect in a single, quick pass. This weld should be deposited horizontally or vertically depending upon circumstances. If the weld is deposited vertically, it is recommended that it be made downward to drive any liquid seepage ahead of the weld.

Successive beads are deposited adjacent and over the first sealing bead, or a single pass may be weaved across it to complete the weld. If the beads are deposited horizontally, deposit these beads from the top down if any liquid seepage is present; otherwise they may be deposited upward if preferred. Remove the slag from the deposited weld before depositing each successive weld bead or pass.

Liquid interferes with the welding operation and the quality of the deposited metal. It should be wiped off with a dry cloth. All welds should be deposited in a sequence as above to prevent any liquid seepage interfering with the welding operation other than the final sealing at the lowest point of the weld leak.

7. Clean and brush the repaired area and apply touch-up paint.

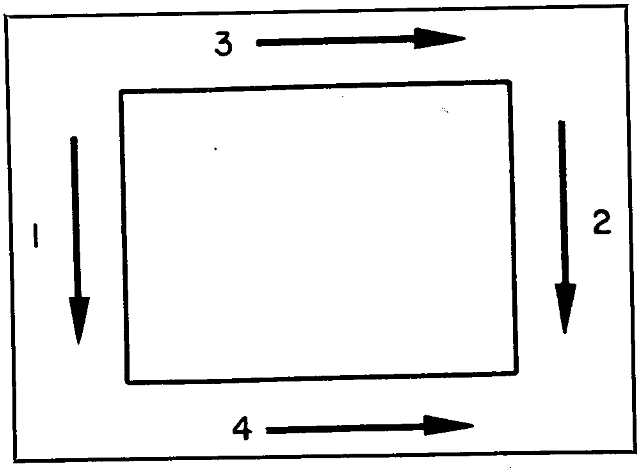

FIG. 1. Welding Sequence for Patch

Alternate Method Using a Patch. A patch may be welded to the transformer case to repair a leak as an alternate to the method above. The recommended method is as follows:

1. De-energize the transformer and pull a vacuum, peen the weld, clean the weld area, check the liquid level, select the 1/8″ FP electrodes and adjust the welding machine as above.

2. Fit a patch of 3/16″ or 1/4″ thick steel over the area to be sealed. Tack this patch in place, then weld it to the transformer case by welding the sides first, vertically downward, then horizontally across the top of the patch and finally horizontally across the bottom. This welding sequence is recommended to prevent any liquid interfering with or contaminating the weld. (See Fig. 1.)

3. Clean and brush the repaired area and apply touch-up paint.

TUBULAR COOLERS

The Westinghouse swaged tube cooler consists of from two to ten 2″ diameter x .063″ wall thickness riser tubes with swaged ends inserted into, and arc welded to, two 2 3/8″ diameter x .093″ wall thickness header tubes for assemblies of eight riser tubes or less and 2 3/8″ diameter x .125″ wall thickness header tubes for assemblies of nine or ten riser tubes. The wall thickness of the swaged end of the riser tube at the point it is welded to the header tube is approximately .093″.

Tube cooler assemblies without swaged riser tubes are made from 1 1/2″ extra-heavy pipe or 9/64″ or 5/16″ wall thickness tubing welded to 2″ extra-heavy-pipe headers.

To repair a weld leak in a tube cooler assembly or in the weld attaching the headers to the case the following is recommended:

1. De-energize the transformer and pull a vacuum above the liquid to stop the liquid leak. This is essential when repairing the swaged tube coolers.

2. Peen the weld leak closed if possible with blunt or round-nosed chisels.

3. Scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine. Remove any liquid on the surface to be welded.

4. Select several Westinghouse 3/32″ diameter type S Welectrodes, S# 1082 207, for 50# packages. This is a coated electrode with low penetrating characteristics designed for sheet metal welding. It is classed as an E-6013 type electrode by the American Welding Society. It may be used with either d-c (straight polarity preferred) or a-c. The recommended current setting is 50-60 amperes.

5. Seal the leak with a single, quick weld bead. Apply the bead horizontally, vertically or overhead as the occasion demands. If vertically, weld downward. When sealing a weld joining the header to the case, start at the top of the header and weld downward around its periphery to the bottom of the header. Always weld so that any oil seepage will flow away from the weld rather than into it.

Weld beads must be small and made quickly to prevent burning through the tube walls. An arrangement of mirrors may aid in repairing a weld that can be reached, but is not in the welding operator's direct line of vision.

6. Clean and brush the repaired area and apply touch-up paint.

FIN-TYPE RADIATORS

The Westinghouse fin-type radiator consists of inflated elements gas welded to each other and to a .109″ thick formed header. A 1″ thick flange is arc welded to each header. The elements are made from two sheets of .057″ thick mild steel continuously resistance welded along their outer edges and with two intermediate seams to cause lobes to form in the element during the inflating operation.

Repairing an intermediate seam between elements is not recommended in the field. The radiator should be returned to the Sharon Plant so that a new element may be assembled.

To repair weld leaks around the header flange, along the outer edge of the elements or in the edge weld where the elements join the header or each other, the following procedure is recommended:

1. Close the radiator valves between the radiator and the transformer case. Drain the liquid from the radiator and remove the radiator from the transformer case.

2. Grind or scrape the paint from the area to be repaired. Also remove any liquid, dirt or foreign matter.

3. If the weld to be repaired is around the header flange use 1/8″ diameter FP electrodes with current settings between 115 to 125 amperes. Weld horizontally around the flange.

4. If the weld to be repaired is along the edge of the elements or is the weld joining the elements to each other or the header—gas welding should be used. Use a slightly reducing flame. Preheat the area to be welded then concentrate the flame on the weld seam, about 2″ away from the weld leak, and bring a local area to the welding temperature. As the edges of the adjacent parts melt and flow together move forward slowly with a slight weaving motion until 2″ past the weld leak. If a filler metal must be added use a 1/16″ diameter soft iron gas welding rod (PDS#5793) or a 1/16″ wide strip sheared from a 1/16″ thick clean mild steel sheet.

When repairing the resistance weld along the edges of the radiator elements the welding operator must make certain that the edges of the elements are fused sufficiently deep to penetrate into the resistance weld.

5. Clean and brush the repaired area and apply touch-up paint.

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INSTRUCTIONS

TYPE SL HIPERSIL CORE FORM TRANSFORMERS

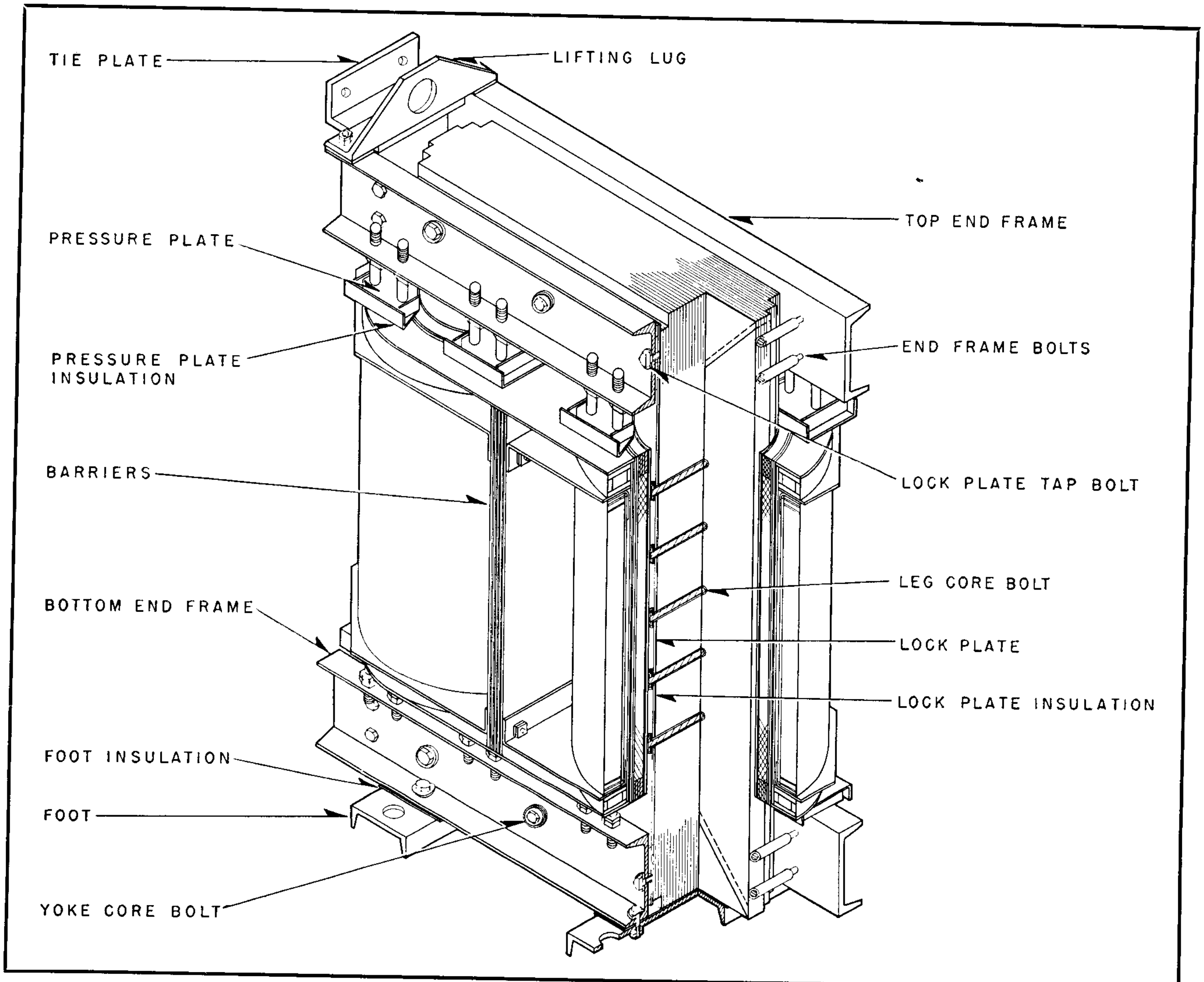

FIG. 1. Sectional View of a Single-Phase Core Form Transformer

WINDINGS

TYPE SL TRANSFORMERS are equipped with windings made from special electrolytic oxygen-free copper conductor. This copper conductor is manufactured without melting by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special copper conductor prevents insulation failures resulting from surface imperfections in the conductor.

The insulation applied to each conductor consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought out from the center of the coil stack. With this arrangement the tapped portion of the winding is not exposed to line surges, and the electrical centers are more nearly balanced on all connections.

SUPERSEDES I.L. 47-610-1A

EFFECTIVE MARCH, 1951

FIG. 2. Cylindrical Coil Winding

All coils are circular in form and, in general, may be classified as follows:

CYLINDRICAL COILS

The cylindrical coil for voltages 8.7 kv. and less consists of one or more layers of insulated conductors wound on an insulating cylinder. Each conductor consists of a number of copper ribbons of suitable cross-section in parallel which are properly transposed to minimize eddy losses. Micarta collars of suitable form are placed at the ends of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that coil temperature gradients are kept uniformly low.

CONTINUOUS-WOUND PANCAKE COILS

The continuous-wound pancake coil for voltages above 8.7 kv. consists of a number of circular disc coil sections, of rectangular strap conductor with one turn per layer, wound by a continuous process with no joints at section connections. The conductor may consist of one or more copper ribbons of suitable cross-section and where multi-conductors are used in parallel, they are properly transposed throughout the coil to minimize eddy losses. The circular disc sections are wound on vertical insulating spacers placed over an insulating cylinder. Radial spacers which dovetail with the vertical spacers separate the various sections from each other. Heavy insulating collars are placed at the ends of the coil for electrical and mechanical strength. The thickness of the coil section is the width of the conductor and each conductor is exposed to the cooling medium. The edges of the conductor do not touch; only the flat sides are in contact, thus eliminating the danger of mechanical forces cutting the insulation. This type of winding gives the highest capacity per unit of space and permits free circulation of the cooling medium. Hot spots are eliminated and high thermal efficiency results.

DOUBLE-SECTION PANCAKE COILS

The double-section pancake coil, in general, is used for voltages above 8.7 kv. and current ratings in excess of two hundred and fifty amperes and for very large coils. It consists of two circular disc sections of rectangular strap conductor with one turn per layer. The conductor may consist of one or more ribbons of suitable cross-section. When copper ribbons are used in parallel, they are properly transposed between the sections to keep eddy losses to a minimum. The circular disc sections are spaced from each other by insulating washers or radial spacers. The thickness of the coil section is the width of the conductor and each conductor is exposed to the cooling medium. The edges of the conductor do not touch; only the flat sides are in contact, thus eliminating the danger of mechanical forces cutting the insulation.

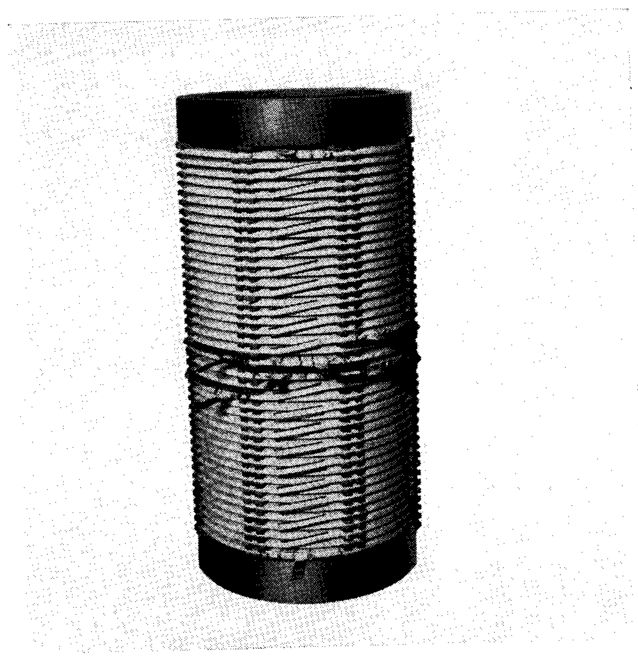

FIG. 3. Continuous-Wound Pancake Coil Winding

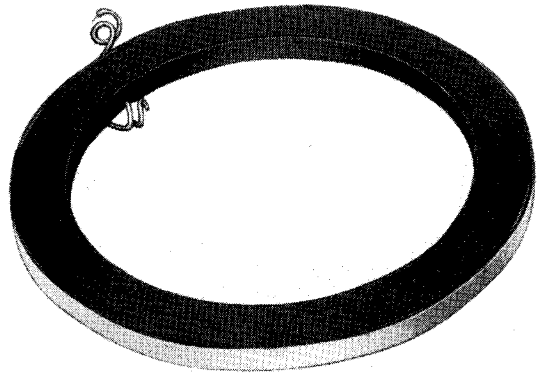

FIG. 4. Round-Wire Pancake Coil

ROUND-WIRE PANCAKE COILS

The round-wire pancake coil (Fig. 4) is used for high voltages and current ratings of less than ten amperes where it is necessary to obtain a large number of turns in a minimum space. It is circular in form and consists of a number of layers with several turns of round paper-covered, enameled wire per layer. This coil is wound on an insulating foundation ring with a length equal to the thickness of the coil. The layers of conductor are spaced from each other by insulating sleeves or crimped paper. The sleeve insulation consists of a strip of folded paper around the end turns forming a double thickness of paper insulation between the layers of conductor. The crimped paper insulation has an extension at each end of the layer. Where it extends beyond the conductor it is crimped forming a small collar.

These sleeves and crimped paper insulating strips are coated with a thermo-setting plastic. When the coils are wound they are heated in an oven and this plastic softens, filling the voids between adjacent turns and between turns and layer material. After cooling the plastic sets and forms a bond between turns and layer material making a mechanically rigid coil.

Reinforcing segments are placed in the coil near the outer edge during the winding and are spaced so that they are directly under the radial spacers. The width of the segments is the same as the length of the insulating foundation ring. This construction gives maximum mechanical strength due to the fact that the pressure on the coil stack is transmitted from coil to coil through the foundation ring and the segments, thereby eliminating pressure on the wires of the coil.

HELITRAN COILS

The Helitran coil is spirally wound and, in general, is used for medium voltage and high current. The conductor consists of several insulated copper ribbons in parallel properly transposed throughout the winding to reduce the eddy losses to a minimum. This coil is wound over vertical insulating spacers on a heavy insulating tube with the layers spaced from each other by radial insulating spacers. The radial and vertical insulating spacers are dovetailed together giving electrical and mechanical separation and providing ventilating ducts for the circulation of the cooling medium. The ends of the winding are rigidly held in place by properly anchoring the leads and by the use of heavy insulating collars at the ends of the coil. This type of coil construction gives high insulation strength and uniformly low temperature gradients.

ASSEMBLY OF WINDINGS

Coils of the cylindrical type require no further individual assembly after winding.

Continuous wound pancake coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

Double section pancake coils are assembled on stacks on their insulating cylinder. They are sep-

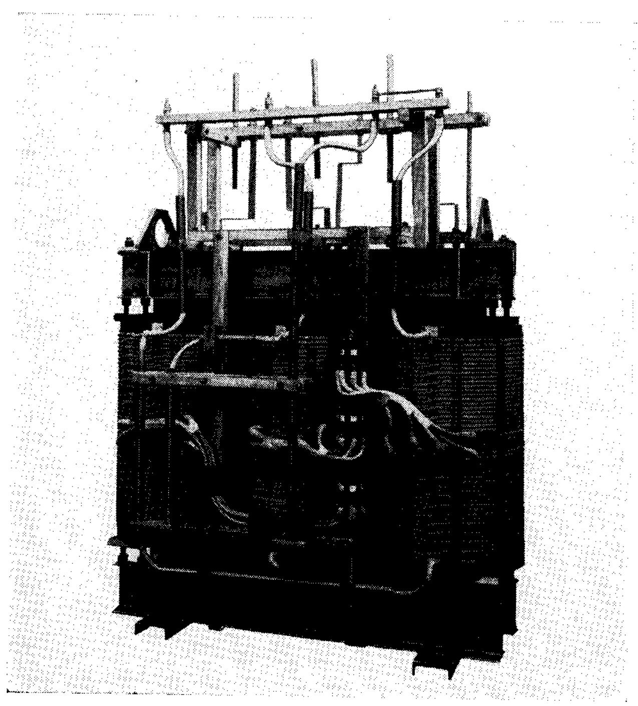

FIG. 5. Core and Coils of a Three Phase Transformer

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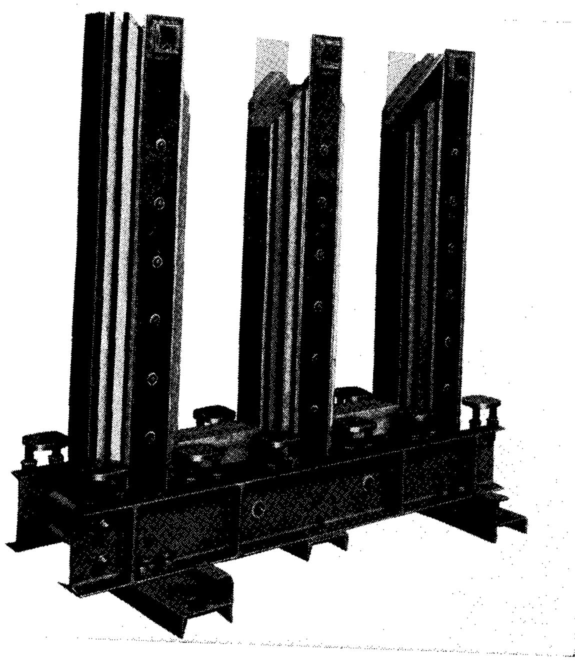

FIG. 6. Partial Hipersil Core Assembly for a Three-Phase Transformer

arated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The joints between coils are made by brazing, no solder being used. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Round wire pancake coils are assembled in stacks on their insulating cylinder. They are separated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Helitran coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

The high and low voltage windings are assembled concentrically on the core with the low voltage winding nearest the core leg. The low voltage winding is centered on the core leg by four maple rods driven tightly in four corners of the cruciform leg between the core and the low voltage insulating cylinder. The high voltage winding is separated from the low voltage winding by one or more insulating cylinders and vertical spacing strips. For the higher voltages the cylinders have insulating angle rings interleaved with them at the ends.

At the ends of the stacks of coils are placed heavy insulating collars interleaved where necessary with angles and washers. These give the required insulation strength and a mechanical structure between the coils and pressure plates which is more than adequate to withstand the mechanical forces set up under short circuit.

All leads, except the very short ones, are run in insulating tubes and are rigidly supported at frequent intervals. They present a neat appearance and are free from vibration or distortion under short circuits.

INSULATION

The major insulation of Type SL transformers consists of insulating cylinders and oil ducts so proportioned as to give the necessary dielectric strength and, at the same time, allow the cooling oil to flow naturally across at least one side of all turns. All units are designed to withstand the standard A.I.E.E. impulse and low frequency tests. Impulse strength is obtained by predetermining the stress at each point of the winding and providing at each point the necessary insulation. This is done by placing at the ends of the stacks of coils an insulated static plate and using uniform insulation throughout, based on the maximum stress at any point. Shields or constructions which offer

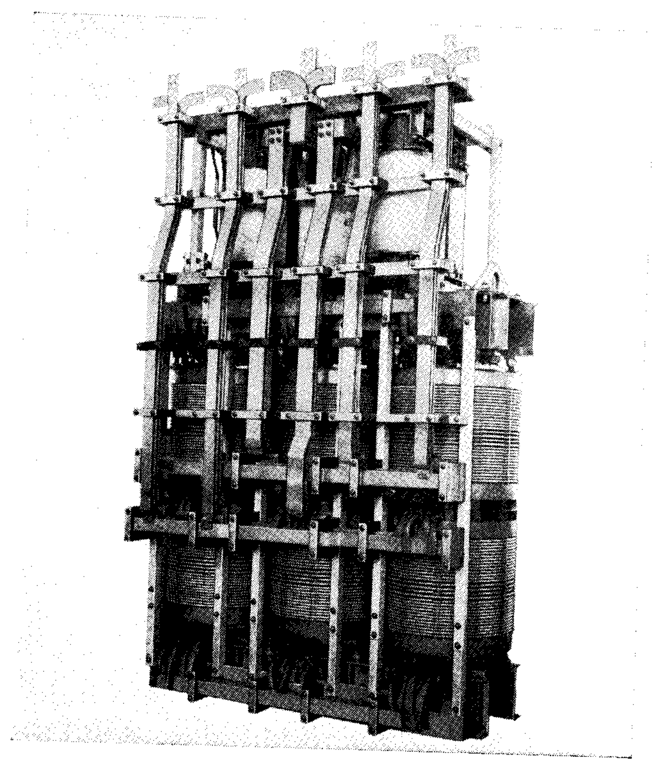

FIG. 7. Core and Coils for 12-Phase, 6000 Kw., 600 Volt Rectifier Transformer with Interphase Transformers Mounted on Upper End Frame

insulation hazards to other coils and to ground, as well as interfere with oil circulation, are not used.

TREATMENT

After assembly the core and coils are preheated, and then thoroughly dried under vacuum in a heated oven. While still hot and under vacuum they are impregnated with transformer oil.

ASSEMBLY OF CORE

The cores for Type SL Transformers are made from Hipersil, high permeability, cold-rolled material which carries twenty to thirty per cent more flux than the hot-rolled silicon steel it replaced. The use of this material gives a transformer of higher efficiency with from twenty to twenty-five per cent reduction in total weight.

The magnetic circuit for the Type SL transformer is rectangular in shape with a rectangular opening, or openings. It is built up of I-plate Hipersil laminations which are stepped in width so as to produce an approximately circular iron section. In order to avoid conditions at the corners in which the flux must pass across the direction of the grain the I-plates are cut with 45 degree angles at each end. Punchings for the yoke are made slightly wider than the corresponding leg punchings in order to obtain an overlap as shown in Fig. 1. With this design the flux path at the corner is parallel with the grain of the material in both the yoke and the leg punchings.

On each side of the top and bottom members of the core is bolted a steel channel or end frame. The coils are clamped between steel pressure plates which are adjustable by means of jack screws extending through the top flange of the bottom end frame and the bottom flange of the top end frame. The clamping forces and the short circuit forces in the winding are such that they tend to separate the top and bottom end frames. The end frames are prevented from spreading by means of steel lock plates extending the full height of the core. Stops welded to the lock plates engage stops welded on the end frames and provide the means to transmit the short circuit and clamping forces from the end frames to the lock plates.

The lock plates are bolted to each side of the leg punchings with insulated heat-treated core bolts and are insulated from the leg with sheets of pressboard.

Between the pressure plates and the coils there are placed heavy insulating rings, which distribute the pressure uniformly over the circumference of the coils. Both the high voltage and the low voltage coil stacks are pressed while hot to a predetermined height, which is the same for both. They are then assembled on the core and both stacks are clamped by the same pressure plates. This system has two important results: First; clamping each stack under pressure while hot permits building with an accurately determined column length. Second; the use of a common pressure system for both stacks assures assembly with the electrical centerlines in the same horizontal plane and prevents any subsequent shifting. Since the stress developed on short circuit depends on a vertical displacement of the electrical center-lines, the method used on these transformers to build and brace the coils is ideally suited to minimize such stresses.

HANDLING AND BRACING

The core and coil structure is lifted as a unit by means of lifting lugs bolted to the top end frames and located as near as practical over the center of the outer legs. The transformer is centered in its tank by pins welded to the tank bottom which bear against channel feet bolted to the bottom end frames. At the top of the core, tie plates are bolted to the lifting lugs and to pads welded to the tank wall. The bolts and nuts used with the tie plates are of heat treated steel and are locked with bolt fasteners or Dieter nuts.

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WESTINGHOUSE

INSTRUCTION BOOK

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

Westinghouse Electric Corporation

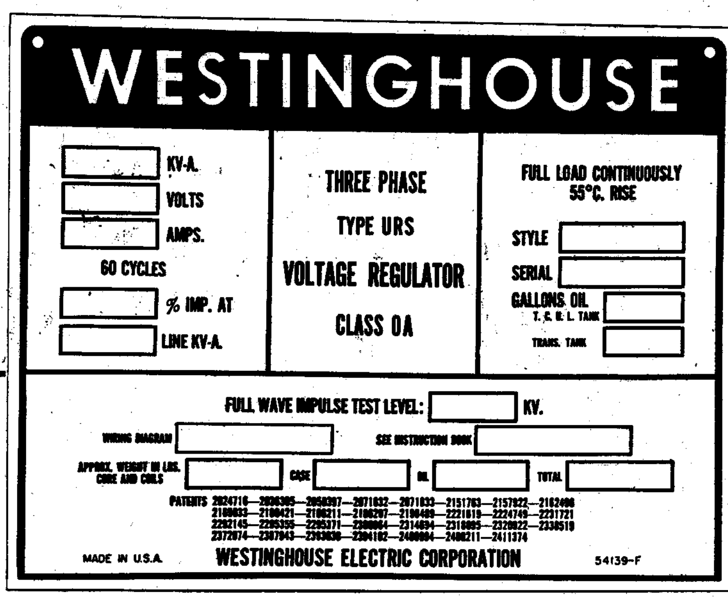
I.B. 47-410-1A

SPECIAL INQUIRIES

When communicating with Westinghouse regarding the product covered by this Instruction Book, include all data contained on the nameplate attached to the equipment.*

Also, to facilitate replies when particular information is desired, be sure to state fully and clearly the problem and attendant conditions.

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



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

DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES I.B. 47-410-1

MAY, 1953

Printed in U.S.A.

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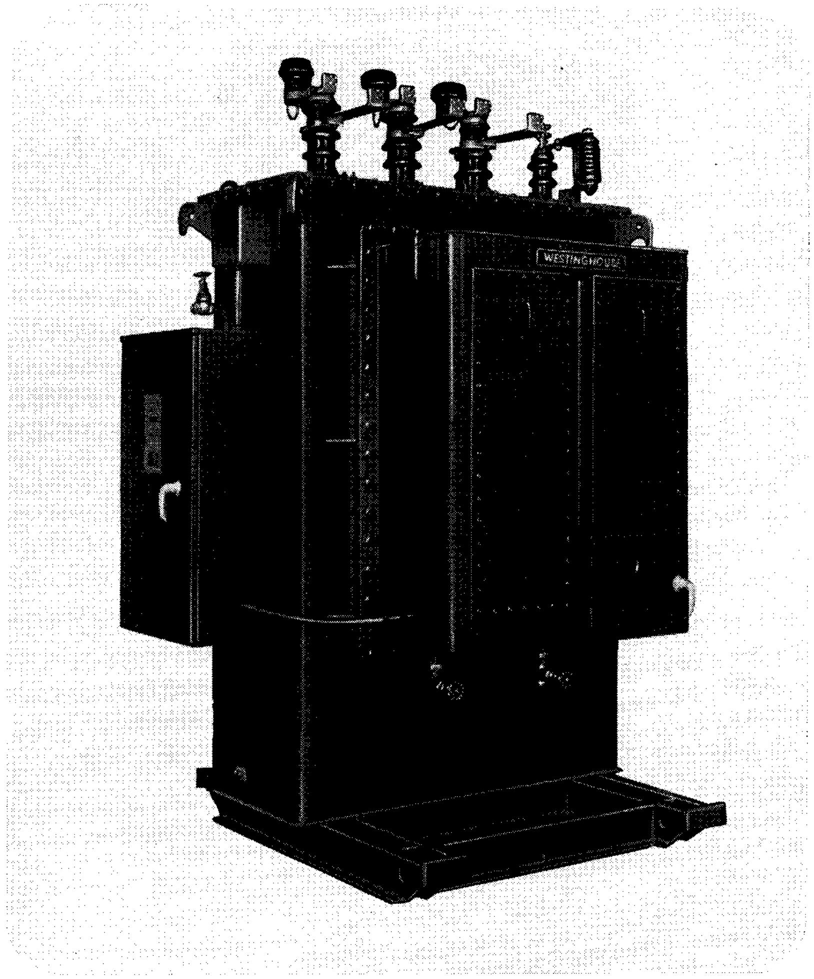
*The supplementary instruction leaflets are assembled ***in numerical order*** in the back of the book.



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 tap changer which operates over a tapped regulating autotransformer, 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 tap-changing-under-load 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, ASA and AIEE standards. The basic impulse level is obtained by adequate insulation of the core and coils and the use of by-pass arresters.

Thus the insulation of the "URS" Regulators is guaranteed to withstand the surge voltages specified by NEMA, ASA and AIEE 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.

DESCRIPTION

The Type URS Voltage Regulator consists of a regulating auto-transformer, a preventive auto-transformer, auxiliary transformer, Type URS tap changer, and all necessary control components. 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.

These parts are designed and assembled into an integral sealed unit of weatherproof construction for outdoor service. Completely assembled, it is only necessary to connect the unit to the line for placing into service. No further auxiliary equipment other than that built into the unit is required.

A completely assembled Type URS Regulator is shown in the frontispiece. (Also see Fig. 1.) It comprises three distinct compartments; the main tank which contains all of the transformer core and coil assemblies, the tap changer compartment containing the tap changer and the tap changer operating mechanism, and the control cabinet which includes the automatic control equipment of the tap changer. The tap changer compartment is bolted on 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 barrier. The control equipment is mounted on a hinged steel panel in a separate cabinet which is mounted on the side of the transformer tank.

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 with jack lugs for convenience in installing or moving.

Sufficient inspection plates in 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, and magnetic type oil gauges are provided in 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.

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 AIEE 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

A completely assembled Type URS tap changer, except for cover plates, is shown in Figure 3. Figure 2 shows a cutaway view of the tap changer.

The tap changer compartment contains the motor operated driving mechanism, polarity 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 polarity, that is, shifting the vector relationship of the regulating winding to obtain boost or buck 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 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 the Micarta arm, which carries the rear moving contact, and arranged to

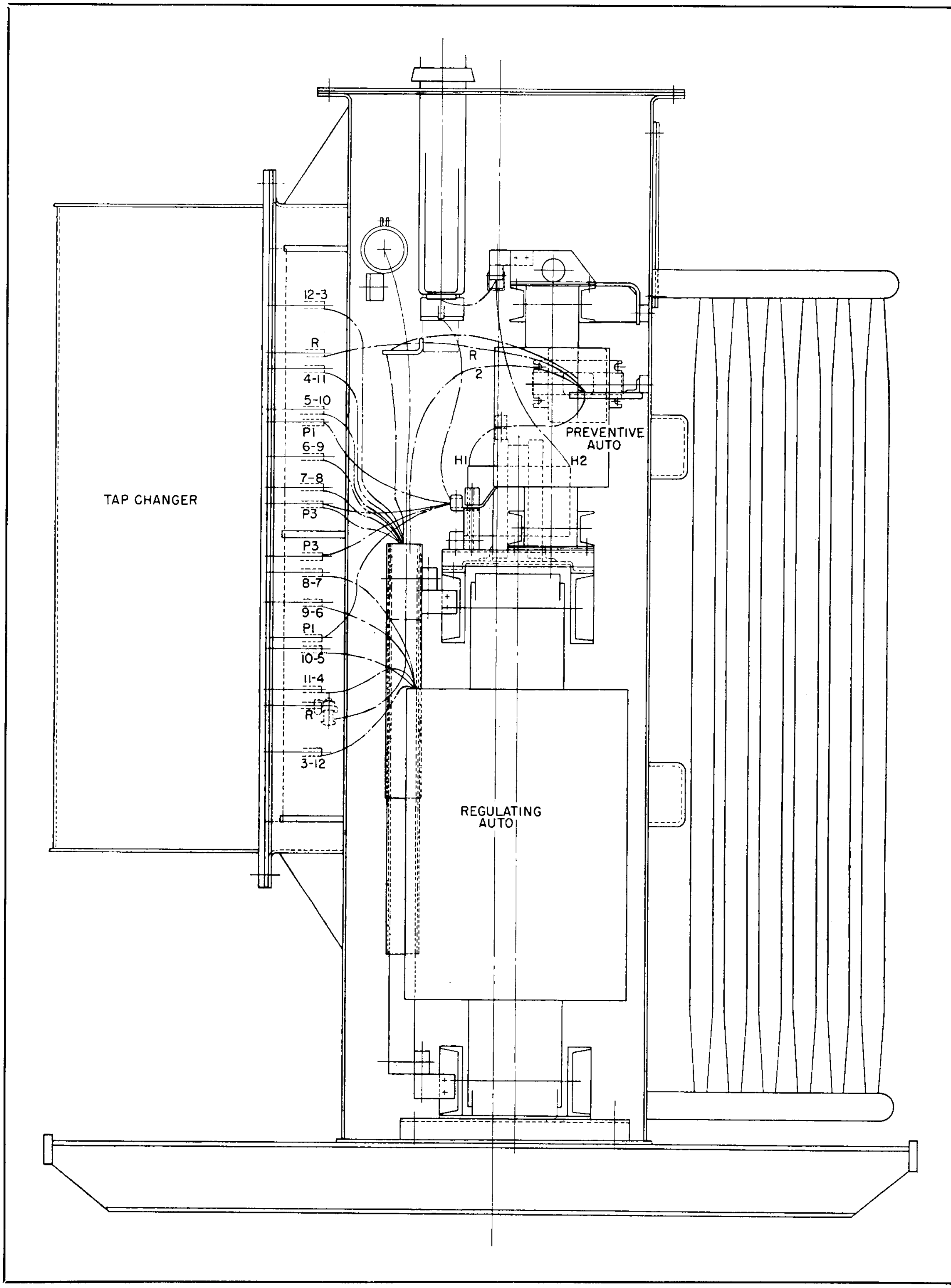


FIG. 1. General Side View of Type URS Voltage Regulator.

slide on a central collector disc. This copper disc is mounted on the main barrier plate connected to the transformer as are 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, and connection to the transformer is made through the main 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 barrier plate as previously described.

Figure 2 shows the URS tap changer and operating mechanism with parts cut away to illustrate the construction and operation of those portions normally hidden in a single view.

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-changer housing. A shaft is extended through the bottom of the main housing into an air compartment which houses the "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 "DynAC Brake" is used.

Through one Micarta to steel and two steel to steel spur gear reductions and one steel to steel bevel-gear assembly, the motor is coupled to the main vertical drive shaft. The lower phase is driven from the shaft of the last gear reduction. A steel bevel gear take-off couples the main shaft to the upper horizontal shaft leading to the phase assemblies. 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 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 horizontal 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 another 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, position indicator, mechanical stop, "DynAC Brake" and hand cranking arrangements. Electrical connections from the motor are brought into the air compartment through stud type porcelain bushings with Cork Neoprene gaskets.

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 door 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.

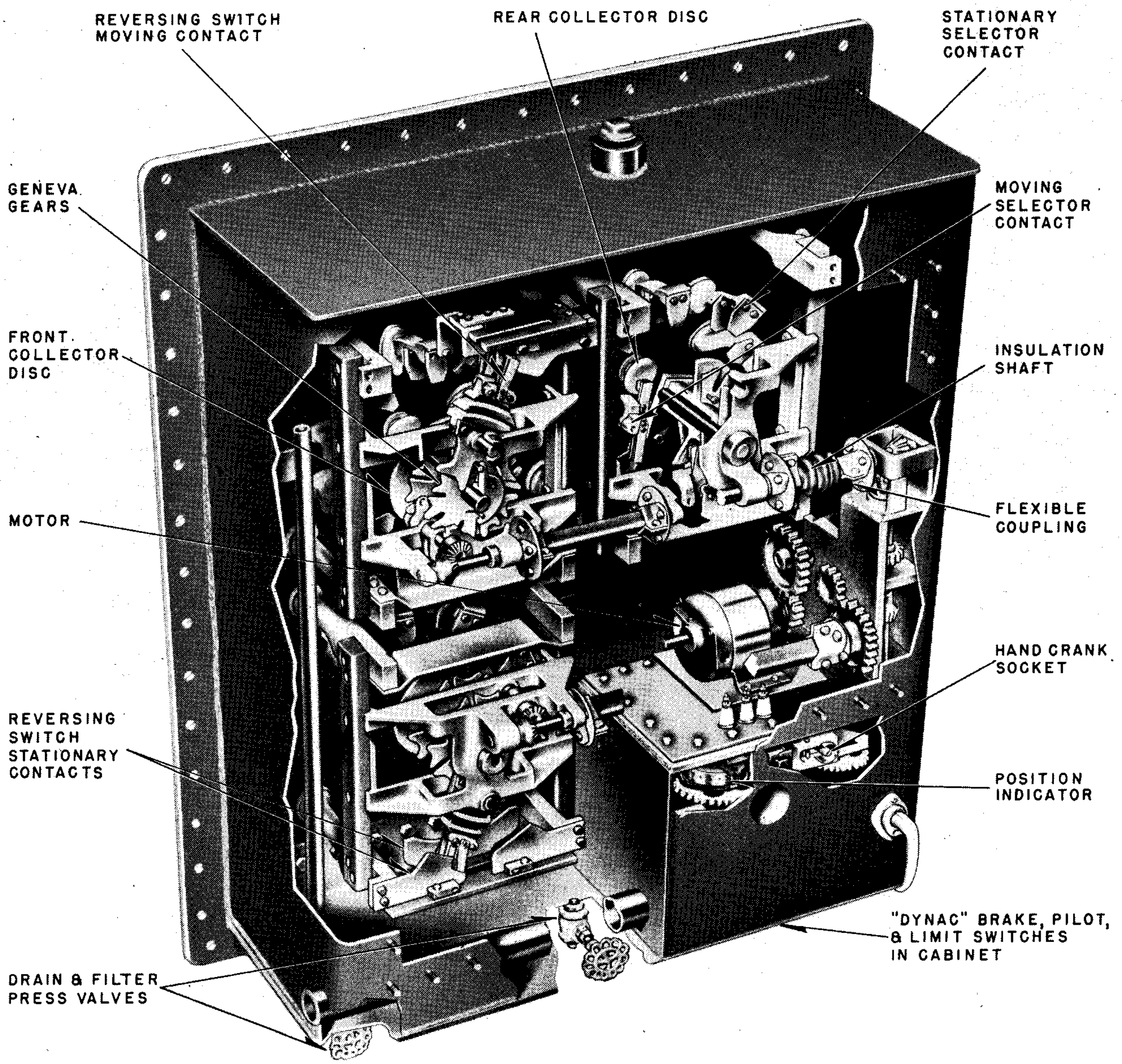


FIG. 2. Cutaway View of URS Tap Changer.

Through steel spur gears, auxiliary shafts are driven at the several 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 the "DynAC Brake" and a mechanical operation counter to record the number of tap changer operations.

A shaft is included which travels ten degrees per position. This shaft turns a drum engraved with the tap changer position numbers. A stationary pointer indicates tap changer position. A transparent window in the air compartment door permits observation of the position indicator without opening the door. Friction retarded pointers indicate maximum and minimum travel of the tap changer. On this same shaft are cams which actuate limit switches to prevent electrical operation of the tap changer beyond its end position in either direction.

Note: These cams do not limit mechanical operation by the hand crank.

From this shaft, also, is driven a cam which releases a spring actuated mechanism should the tap changer be moved appreciably beyond its end position in either direction. This mechanism inserts a steel plunger into a slot in a bronze cam mounted on the main operating shaft, providing a definite mechanical stop which prevents further motion. The motion of the plunger also opens an auxiliary switch, removing all power from the motor circuit. The mechanical stop operates to limit either electrical or hand crank motion.

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 cam 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, accurately interchangeable parts may be obtained from the Westinghouse Electric Corporation.

All interlocking switches are of self-aligning, bridging contact type with heavy silver contact buttons. A wiping contact action assures reliable operation.

The principal parts of the operating mechanism are shown in Figure 2.

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. This unidirectional breather 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, and the upper filter press connection is piped from just below the oil level to the bottom of the housing for easy access.

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.

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 on the base 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 usally 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.

Remove any blocking from the relays 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.

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

Operate the tap changer over its entire range electrically by means of an external source of voltage. Open the potential auxiliary transformer source at the AB control breakers and connect the external 110/220-volt, single-phase source to the control side of the breakers.

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-auxiliary transformers. Refer to the

wiring diagram furnished with each unit.

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.

The voltage regulating relay should balance at the normal secondary voltage of the potential transformer. Refer to the regulator instruction plate for this voltage value.

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. 46-736-7 for detailed information on the compensator adjustment.

Remove the test voltages and close the AB control breakers.

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.

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. The metal diagram instruction plate attached to the control cabinet door, shows the terminal connections. 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 turn the "automatic-manual" switch to the "manual" position and operate the tap changer over its entire range and back to the neutral position by means of the "raise-lower" switch.

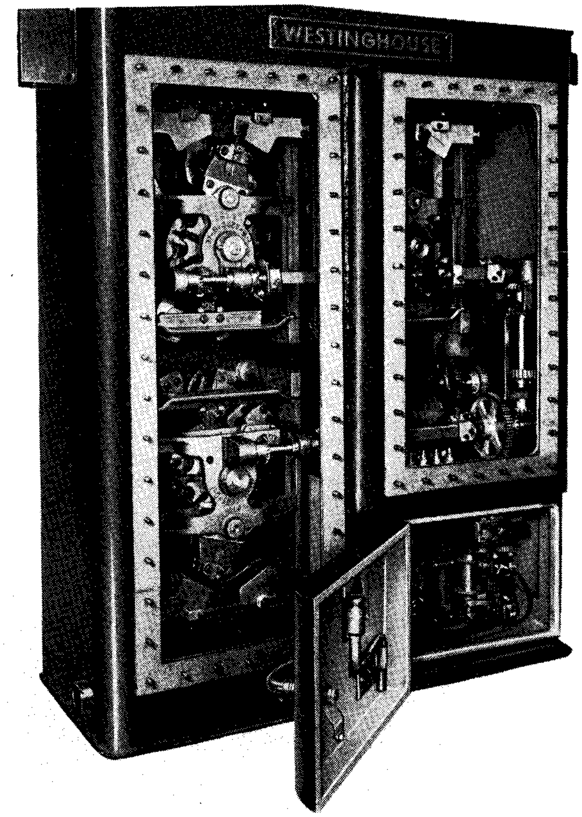


FIG. 3. URS Tap Changer with Cover Plates Removed.

OPERATION

PRINCIPLE OF REGULATOR OPERATION

The schematic diagram of connections of the Type URS Regulator is shown in Figure 4. The sequence of operation of the Type URS Regulator tap changer is shown in Figure 5. A series transformer (not shown) is used in the larger current or voltage classes. The schematic diagram of connections of one phase shown in Figure 5 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.

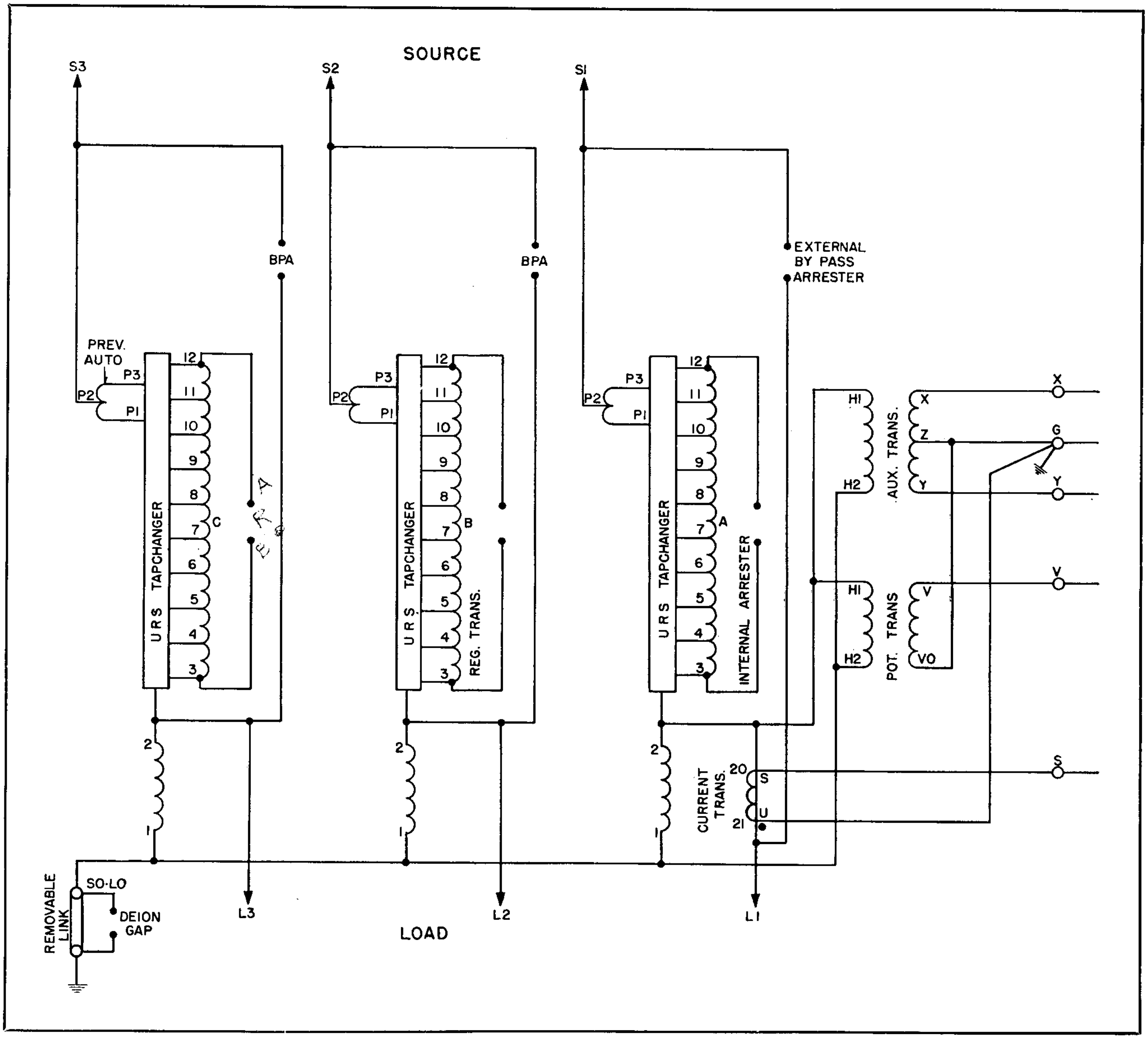


FIG. 4. Three-Phase Type URS Voltage Regulator Connection Diagram.

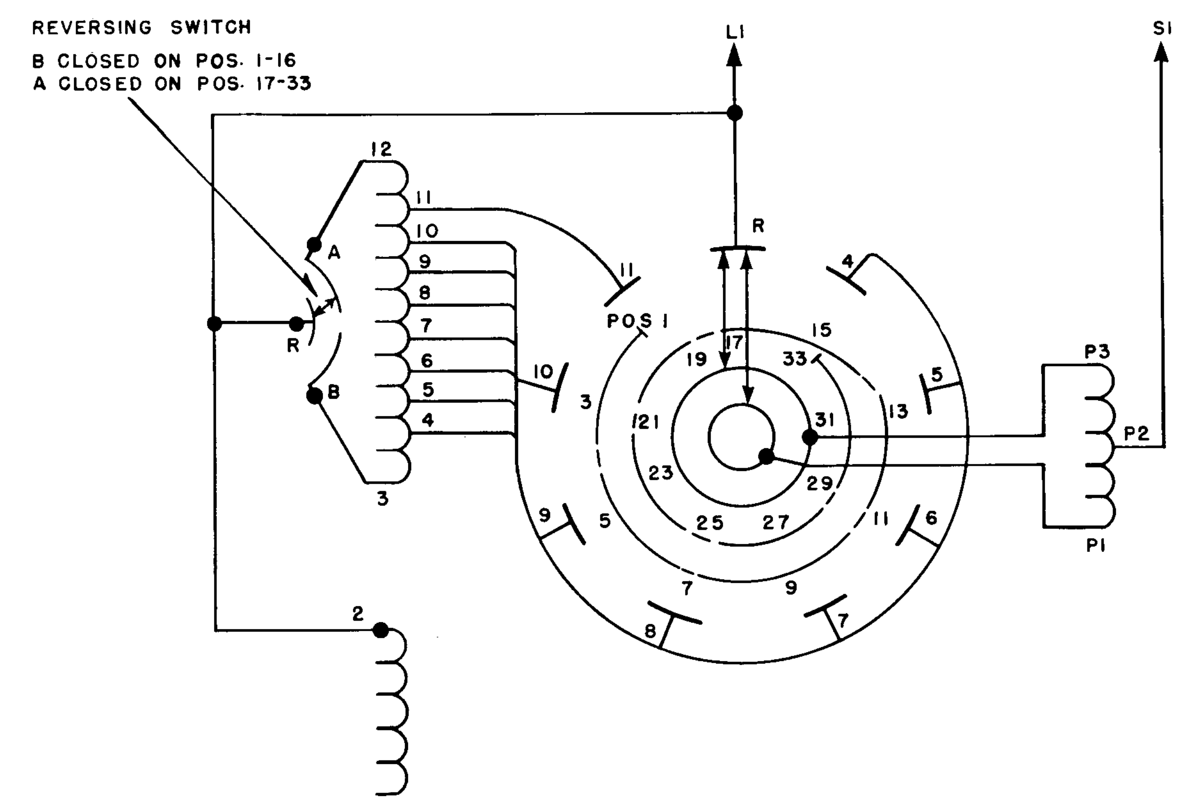
Figure 5 shows the tap changer in its neutral position, with both moving contacts on stationary contact R, the preventive auto short circuited, the reversing switch connecting R to A, and none of the tapped section of transformer winding connected into the circuit. This is position 17.

In changing from position 17 to position 18, 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 on 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 18 to position 19, 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.

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 17 to position 16, the reversing switch first acts to select the opposite polarity for the tapped section of the winding. Before



CONTACT	POSITION																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
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. 5. Typical Schematic Connection Diagram of One Phase of Regulator and Sequence Chart of Tap Changer Positions.

contact P1 leaves stationary contact R, the reversing switch moving contact moves from stationary contact A to stationary contact B. Prior to completion of this motion, the moving contact connected to P1 leaves stationary contact R, and after tap 3 is connected to tap 2, contacts stationary contact 4. 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 16 to position 15, 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 and S1.

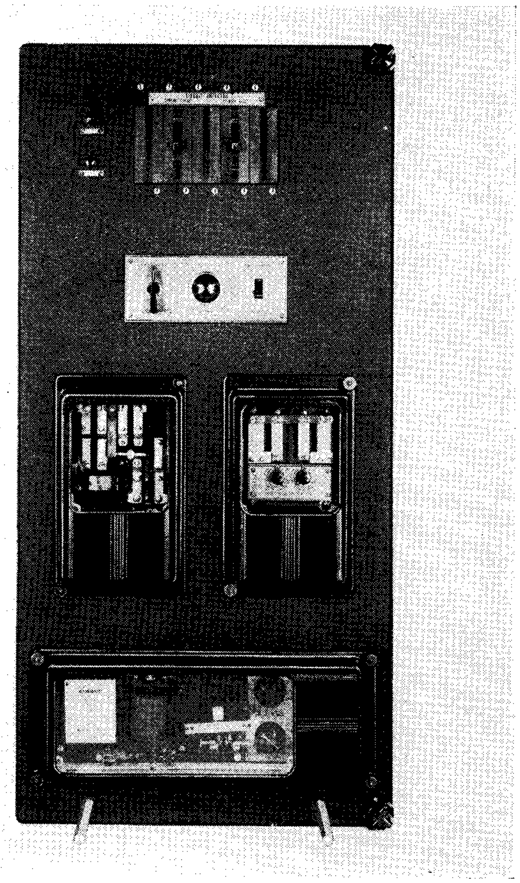


FIG. 6. Typical Control Panel.

PRINCIPLE OF CONTROL OPERATION

A typical control panel for the Type URS Regulator is shown in Figure 6. The control circuit is shown schematically in Figure 7.

The panel is of steel and is in a steel cabinet mounted on the side of the regulator. A hinged mouting is used so that both front and rear of the panel are readily accessible for inspection and maintenance. The control relays and equipment are all of the Flexitest case construction for semi-flush mounting. A Type FT test plug is recommended for use with the Flexitest relays for ease of testing. The Flexitest case construction allows the relay mechanism to be easily disassembled for inspection, testing, adjusting and remounting.

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 ensuring that once a tap change is initiated it will be carried through to completion.

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

4. The prevention of the tap changer mechanism running past the limit positions.

5. Indication of tap 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 Figure 7. An automatic-manual switch, "AM", enables the selection of automatic or manual operation by the closing of "AMA" or "AMM" respectively. The voltage regulating relay "PP" is responsive to voltage changes in the regulated line and initiates tap changer operations automatically. "PNV" is the no voltage relay, connected to prevent automatic operation to maximum boost if AB1 is inadvertently opened, or purposely opened for testing.

Type TH time delay relays are provided to override minor voltage fluctuations and avoid many needless tap changer operations. The heater operated contacts HR and HL operate to give the time delay. AR and AL are secondary contacts. 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 in such a manner that either the operation of the mechanical stop or the moving of the hand crank shaft from its out-of-mesh position will de-energize the motor. Thus the unit will not attempt to operate electrically while the 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 short circuits. Terminal X, G, Y, and V receive their potential from the auxiliary and potential transformers, and terminals S and U receive current from the current transformers.

BC is the "DynAC Brake" contact. The "DynAC Brake" is a pneumatic time delay relay, operated by a cam in the control assembly.

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.

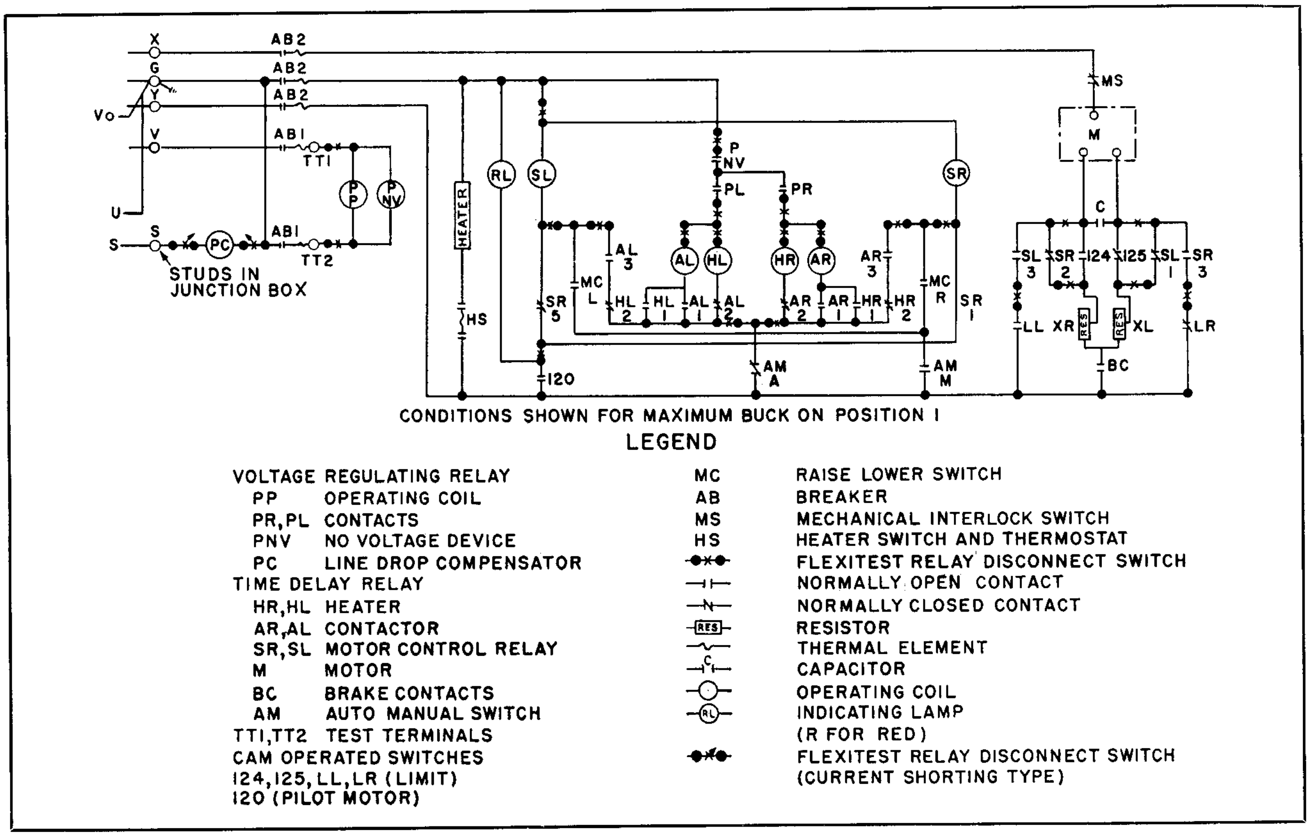


FIG. 7. Schematic Diagram of URS Voltage Regulator Control.

LR is a limit switch, open on position 33 and beyond, and closed on positions 1 through 32.

LL is a limit switch, open on position 1 and below, and closed on positions 2 through 33.

124 is a braking limit switch, closed on position 33 and beyond, and open on positions 1 through 32.

125 is a braking limit switch, closed on position 1 and below, and open on positions 2 through 33.

XL and XR are the brake resistors in series with SL1 and SR2 respectively.

SR and SL are the coils of an interlocked double throw motor contactor mounted on the panel in a separate compartment. The coils act to open and close contacts of the same designation (i.e., SR1, SL2, etc.).

C is the motor capacitor, mounted in the air compartment of the tap changer.

RL is a red lamp on the control panel which indicates when the tap changer is off position, or when the voltage regulating relay calls for either a raise or lower operation from positions 33 or 1 respectively.

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

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 relay P and the NV relay. When AB1 is closed, the NV relay coil is energized closing the NV interlock contacts; also the coil P of the voltage regulating relay is energized. Closing AMA of the Automatic-Manual selector switch completes the set-up for automatic operation.

The voltage regulating relay P is the initiating element for tap changes when the control is set for "automatic" operation. The relay 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 relay is usually 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. For some conditions of parallel operation, reverse reactance compensation may be needed. Links on the front of the line drop compensator provide convenient means for accomplishing reversal of the reactance element of the compensator.

When Voltage Drops: A drop in voltage causes voltage regulating relay "raise" contact PR to close, energizing time-delay relay heater HR. If the heater in this relay remains energized long enough, the bimetal will operate a Micro Switch. Operation of the Micro Switch opens contact HR2 and closes contact HR1. Closing contact HR1 energizes the auxiliary contactor coil AR, which operates to open contact AR2 and close contacts AR1 and AR3. Opening contact AR2 de-energizes the bimetal heater HR, allowing the bimetal to cool. Closing contact AR1 shunts the Micro Switch contact HR1 and holds the auxiliary contactor AR closed as long as PR remains closed. When the bimetal has cooled to the temperature determined by the time setting, it allows the Micro Switch to return to its original position, opening HR1 and closing HR2. If the auxiliary contactor AR is still held closed by PR through AR1, then AR3 is still closed and the reclosing of HR2 completes the circuit, energizing the motor control relay SR. Energizing the motor control relay, SR, opens contacts SR2 and SR5, and closes contacts SR1 and SR3. Closing contact SR3 energizes the motor to operate the tap changer in the "raise" direction.

While the motor is operating, a cam keeps the "DynAC" time delay relay contact BC closed. When the auxiliary contactor opens, SR2 is closed, short circuiting the capacitor through SL1, 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 "DynAC Brake" contact opens, and the unit is ready for further operation.

The reason for using back contact SR5 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 SR5 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.

Protection Against "No-Voltage": The no-voltage relay (PNV) is connected across the voltage regulating relay voltage. The "make" contact of this no-voltage relay is connected in the automatic control circuit and is closed when the relay is energized.

When voltage is removed from the voltage regulating relay circuit the voltage regulating relay closes PR, which will initiate a tap change in the raise direction. The tap changer would operate to the extreme raise or boost position as long as the voltage remained off on the voltage regulating relay circuit only. To prevent this condition, the no-voltage relay contact is inserted in the automatic control circuit so that, upon failure of voltage on the primary relay, the automatic circuit is also opened. The tap changer will remain on the position it is on at that time. When voltage is restored, the no-voltage relay is re-energized, closing the "make" contact. The automatic control then resumes its operation in the normal 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 regulating relay contacts remain closed. 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, contact AMA of automatic manual switch is open and contact AMM is closed. When higher voltage is desired, contact MCR of raise-and-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, no special tools are necessary.

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

A periodic inspection of the relays and relay contacts should be made. It is not necessary to keep the contacts of the relays used in this control polished as on the older types of relays. If the contacts should

become worn to an uneven shape, they may be smoothed and re-shaped with a very fine file and readjusted.

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. Slower braking and, consequently, later stopping is achieved by increasing the resistor setting, which adds more resistance to the circuit. Faster braking and earlier stopping may be obtained by decreasing the resistor setting, which decreases the resistance of the circuit. See I.L. 46-713-7 for detailed "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 overload do not tend to open the contacts since the forces are in quadrature with the contact pressure forces.

All contacts subject to arcing are faced or are made of arc-resisting and high-melting point alloy giving long life to the contacts.

Replacement should be made before the moving finger shoes have burned sufficiently to reduce the smooth flat contact area by more than half, and before the insert of arc resisting material at the edges of the stationary contacts is burned away. 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; and that the frequency of subsequent inspections be based on the facts found by this 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 not be allowed to deteriorate to the point where it tests less than 15 Kv in the standard test cup. 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 15 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.

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 assemblies and stationary selector contact blades be kept in stock for replacement if necessary.

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

One Motor.

One Set of "DynAC Brake" Contacts.

One Motor Contactor Complete.

One Set Cover Plate Gaskets.

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.

SUPPLEMENTARY DATA

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This part of the book consists of the supplementary instruction leaflets listed in the Table of Contents, page 2. The leaflets, which follow, are assembled in numerical order.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover, and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Six different size cases are available to accommodate the various relay elements and flexible terminal arrangements for either flush or projection mounting. These are designated as S10, S20, M10, M20, L10, L20. S refers to the small; M, the medium; and L, the large size chassis frame. The numbers refer to the possible number of test switch positions, 10 or 20.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. There are two cover nuts on the S size case and four on the L and M size cases. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. The chassis operated shorting switch located behind the current test switch prevents open circuiting the current transformers when the current type test switches are closed.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated **red handle** switch should not be closed until **after** the chassis has been latched in place and all of the black handle switches closed.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

The ammeter test plug can be inserted in the current test jaws after opening the knife-blade switch to check the current thru the relay, as shown in Fig. 1. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and the leads are carried out thru holes in the back of the insulated handle.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw, as shown in Fig. 2.

Testing In Case

With all blades in the full open position, the ten circuit test plug Fig. 3 can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above, under "Electrical Circuits."

Testing Out of Case

With the chassis removed from the base, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

An internal schematic is available for each individual relay showing the schematic internal wiring. The outlines of the various cases are as follows:

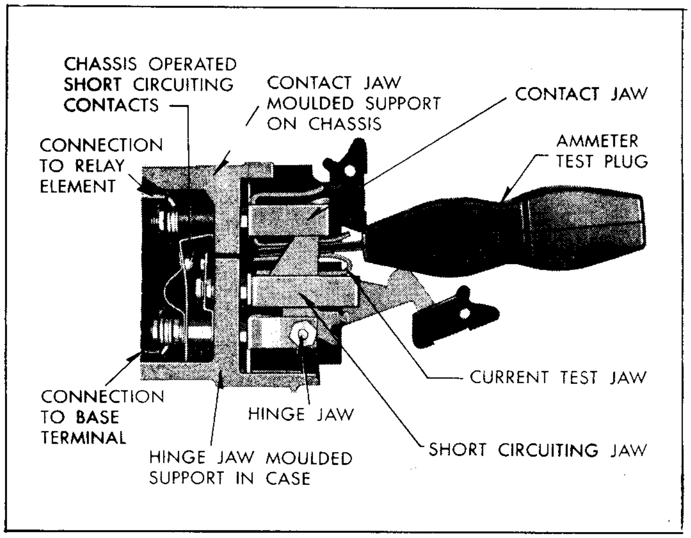

Fig. 1—Ammeter Test Plug In Testing Position.

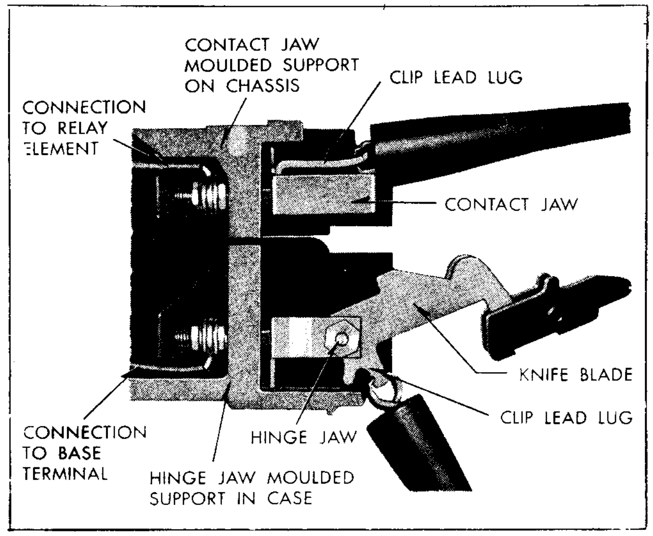

Fig. 2—Spring Clip Leads May Be Used For Testing.

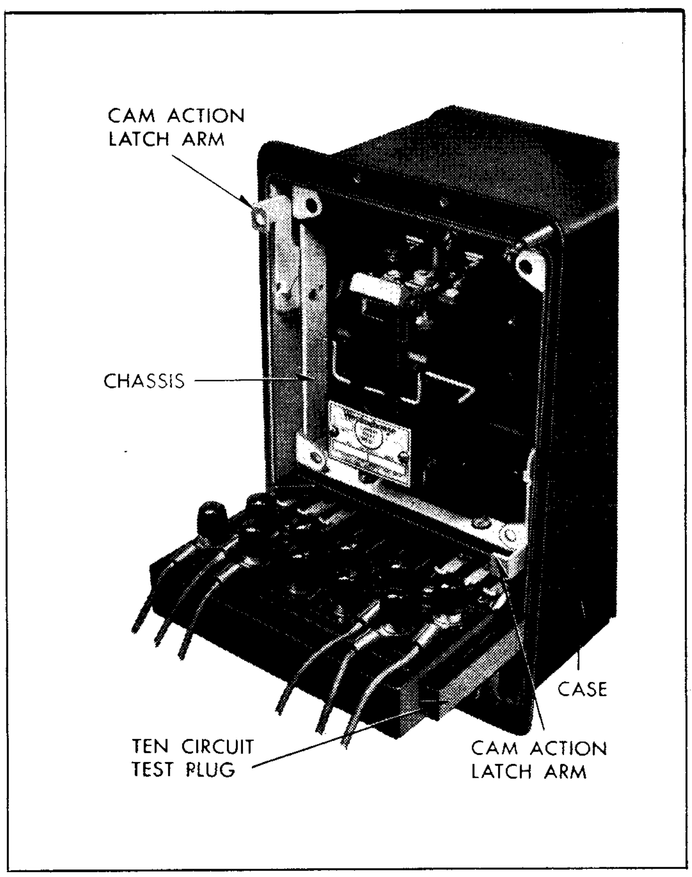

Fig. 3—Multi-Circuit Test Plug In Testing Position.

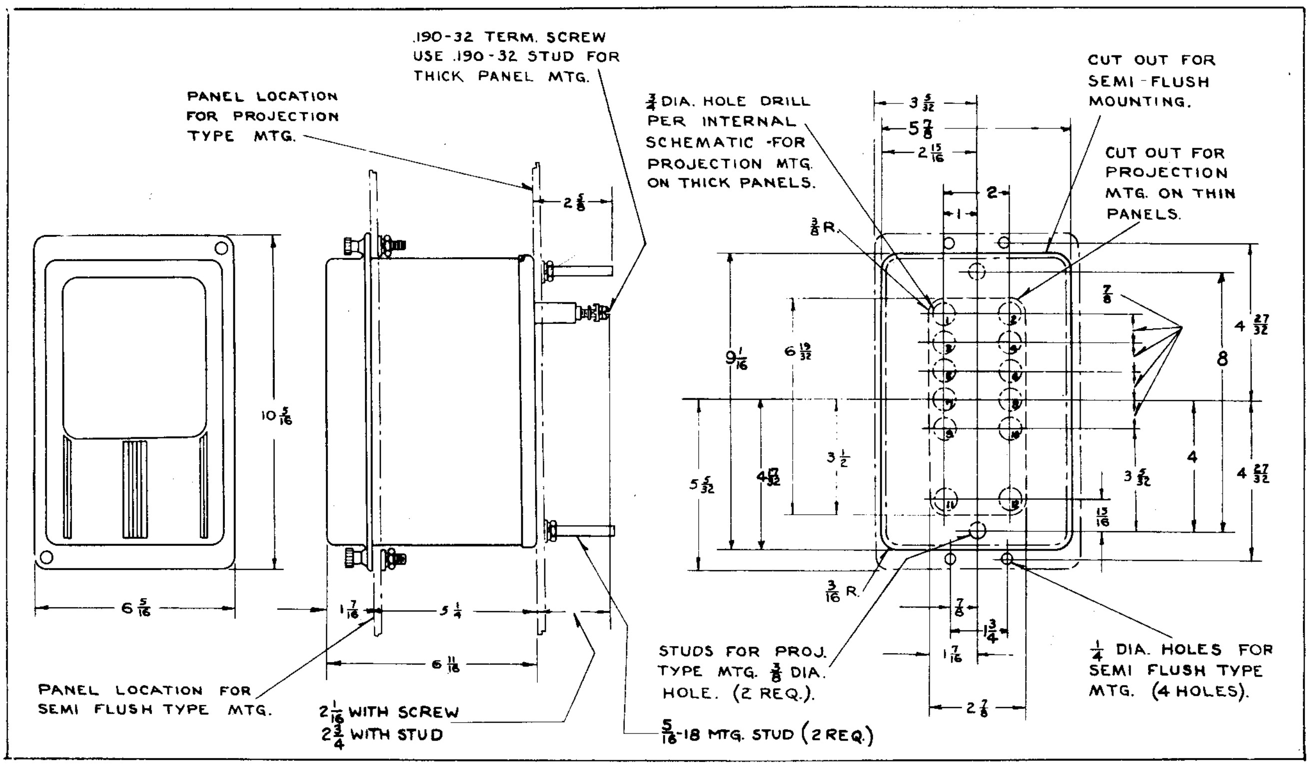

Fig. 4—Outline and Drilling Plan for the S10 Semi-flush (9B-1901) or Projection (9B-2020) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

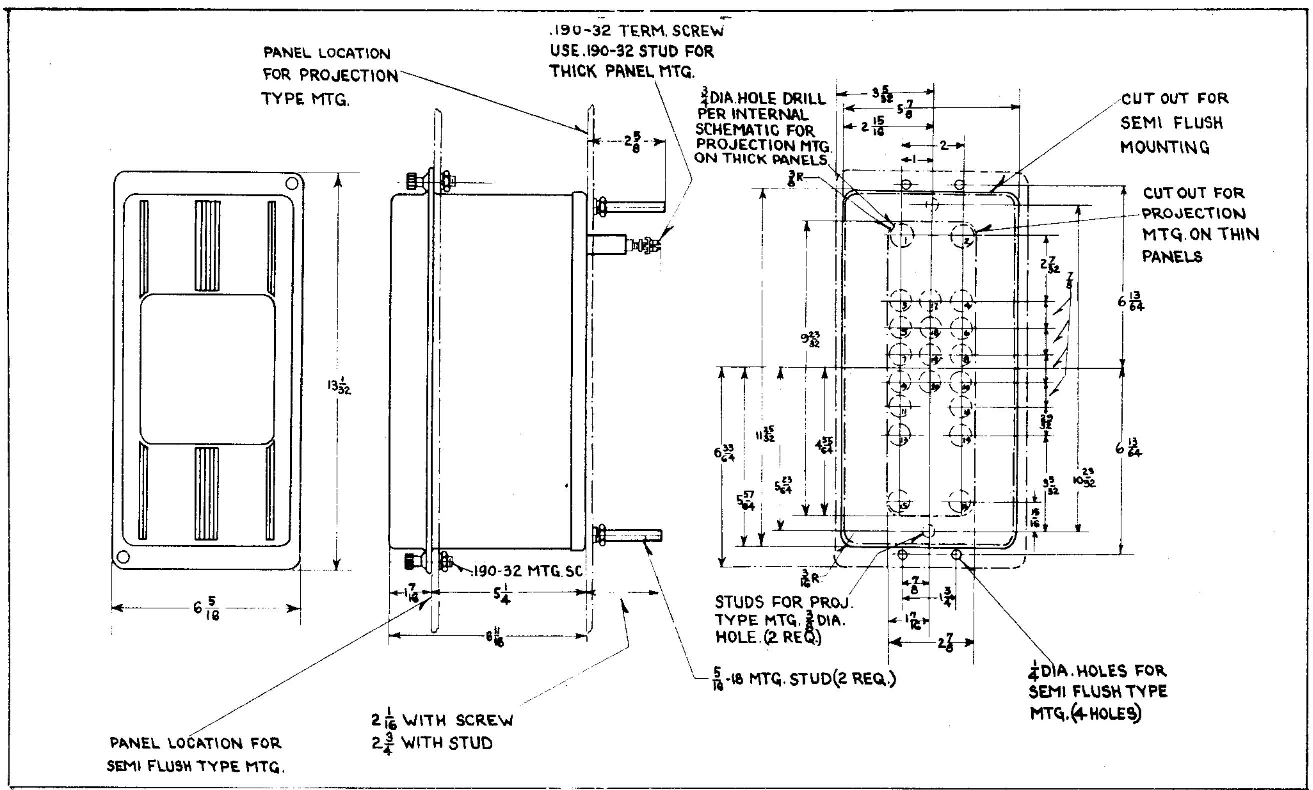

Fig. 5—Outline and Drilling Plan for the S20 Semi-flush (9B-2040) or Projection (9B-2041) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

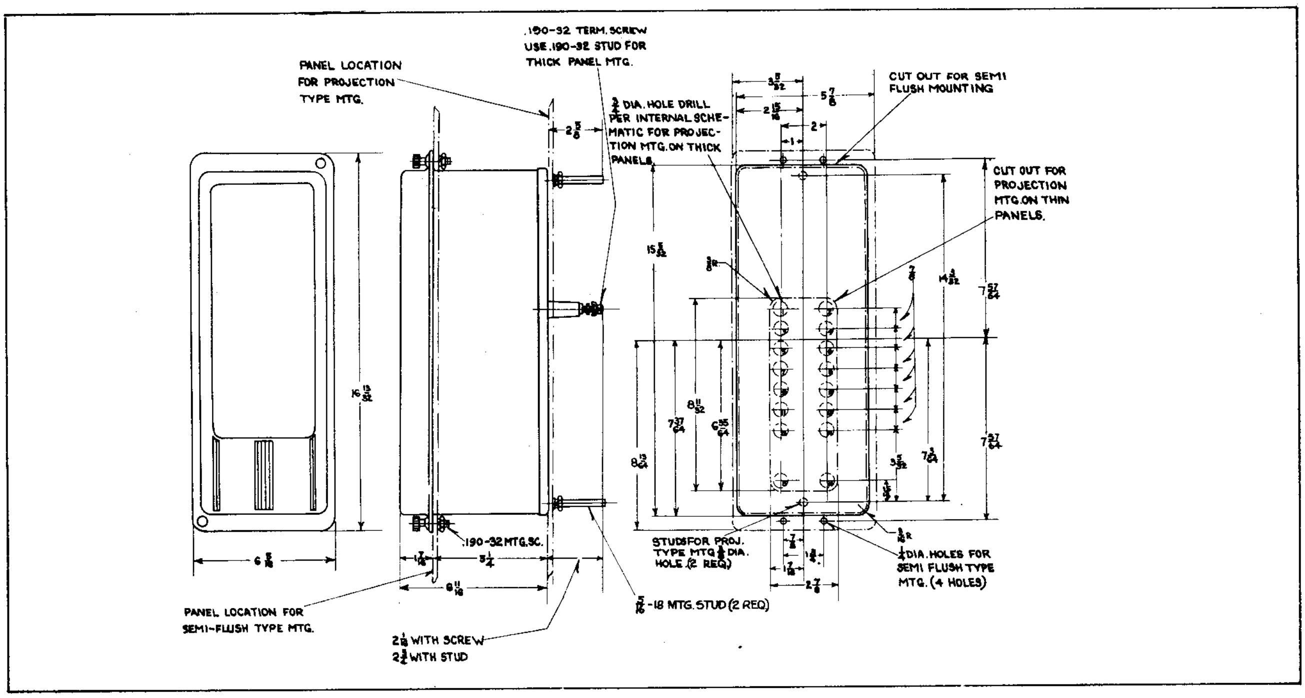

Fig. 6—Outline and Drilling Plan for the M10 Semi-flush (9B-1903) or Projection (9B-2021) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

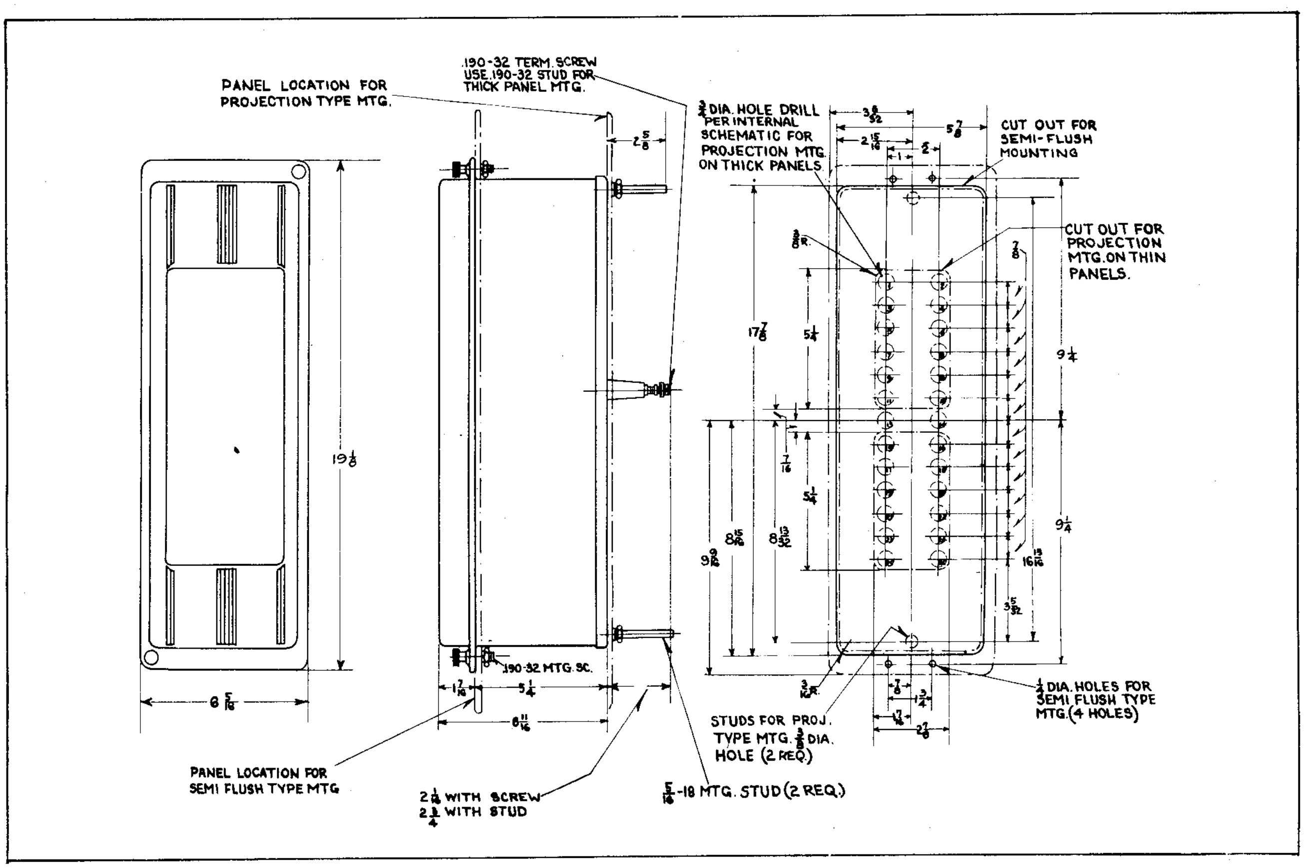

Fig. 7—Outline and Drilling Plan for the M20 Semi-flush (9B-1905) or Projection (9B-2022) Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

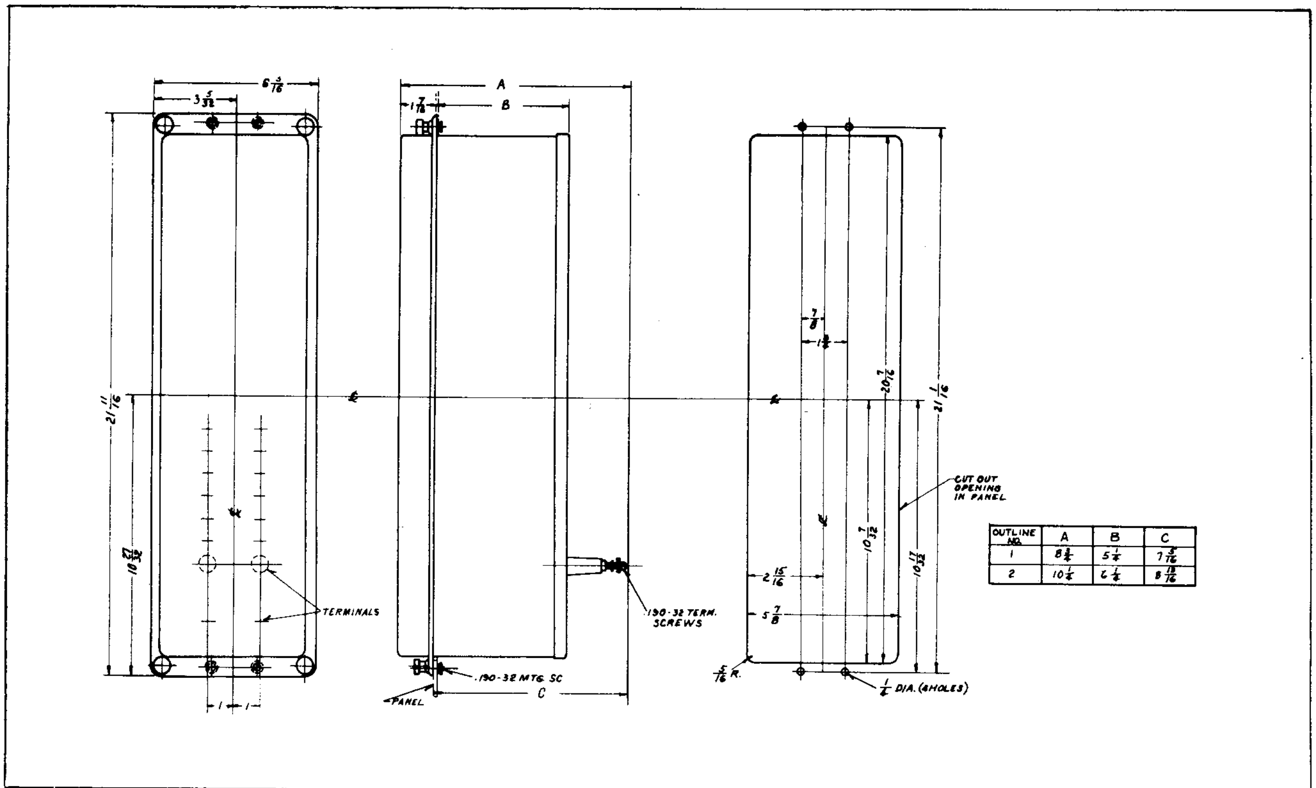

Fig. 8—Outline And Drilling Plan For The L10 Semi-Flush Type FT Case. For Reference Only. (9-B-2042)

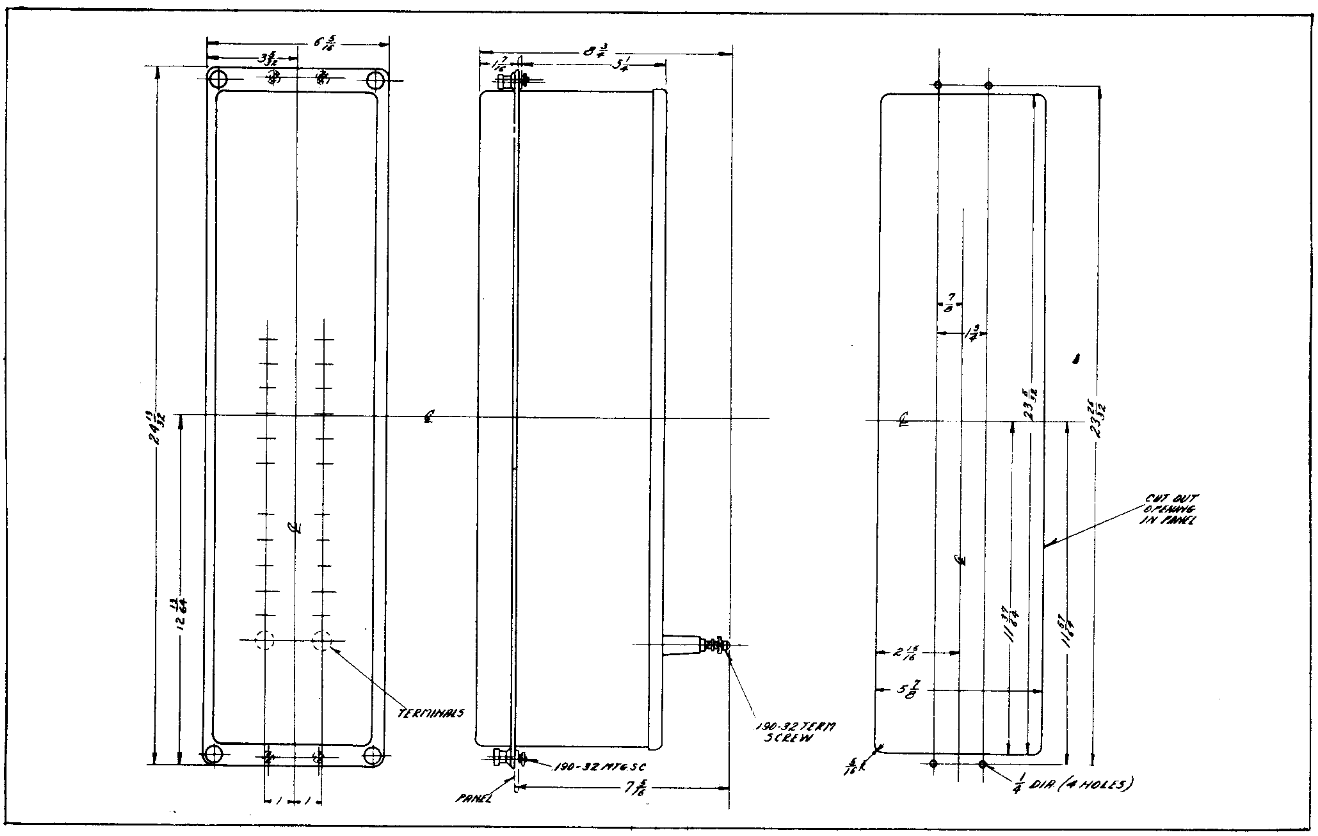

Fig. 9—Outline And Drilling Plan For The L20 Semi-Flush Type FT Case. For Reference Only. (9-B-2044)

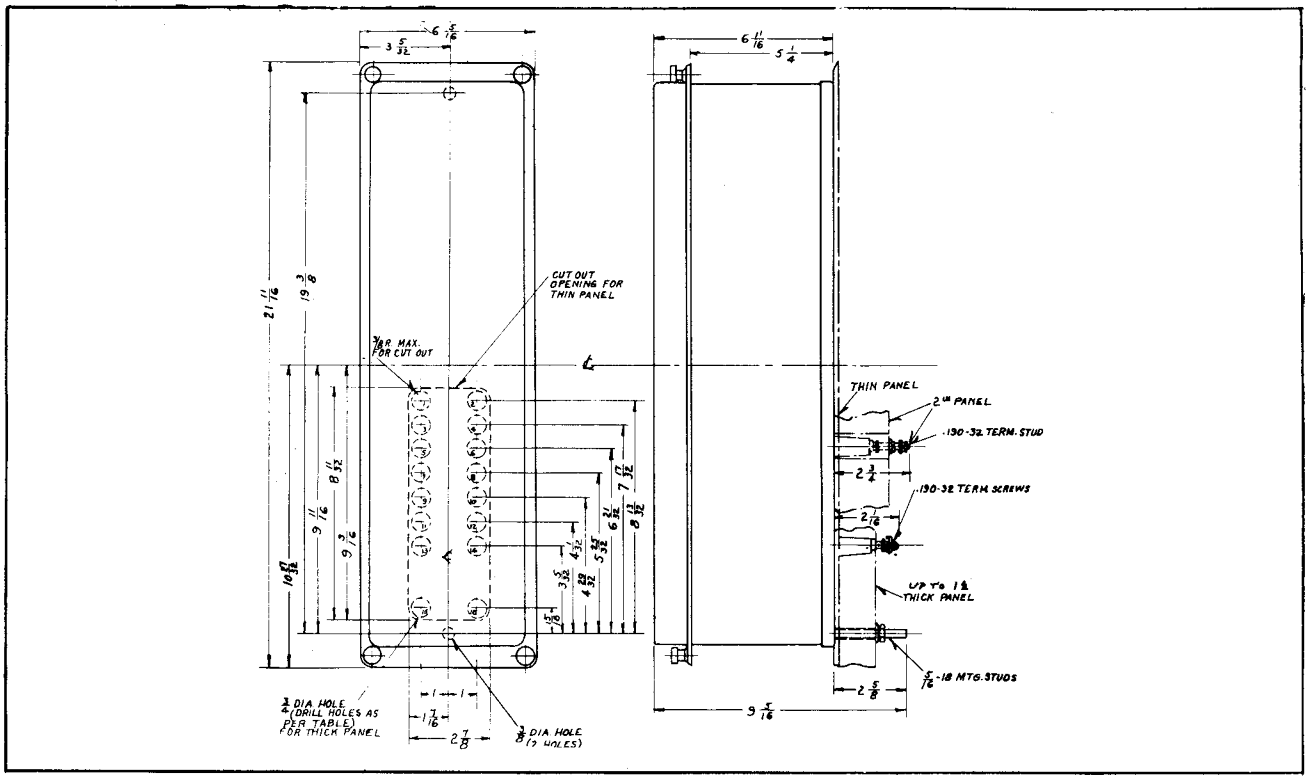

Fig. 10—Outline And Drilling Plan For The L10 Projection Type FT Case. See The Internal Schematic For The Terminals Supplied. For Reference Only. (9-B-2043)

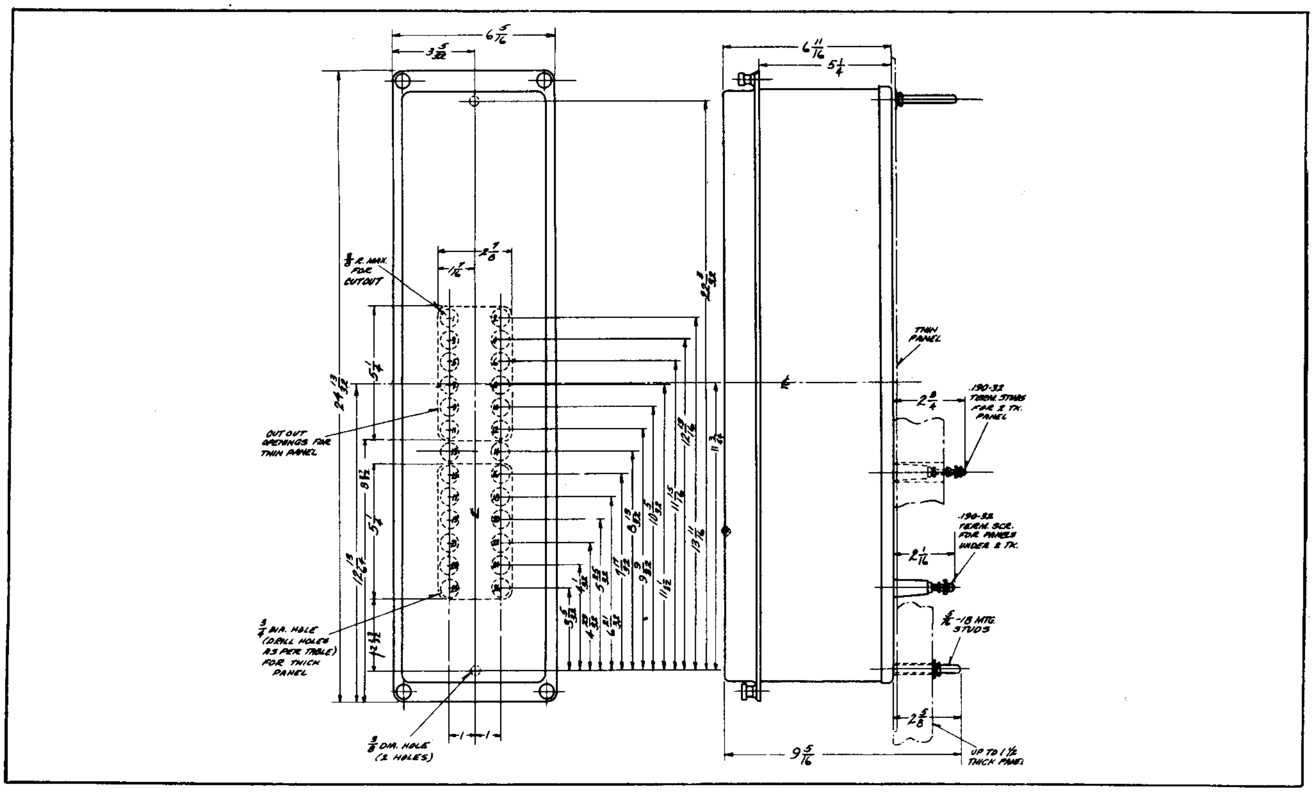

Fig. 11—Outline And Drilling Plan For The L20 Projection Type FT Case. See The Internal Schematic For The Terminals Supplied. For Reference Only. (9-B-2045)

WESTINGHOUSE ELECTRIC CORPORATION
METER DIVISION
NEWARK, N.J.
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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SG MECHANICALLY INTERLOCKED AUXILIARY RELAY FOR STEP VOLTAGE REGULATORS STYLES 1274697 AND 1339369

CAUTION Before putting relays into service, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type SG mechanically interlocked auxiliary relay is used in the control circuit of step voltage regulators to energize the tap changer motor in the "raise" or the "lower" directions after other relays in the circuit indicate that a tap change should be made. It consists of two magnetic contactors which can be energized individually, with their armatures mechanically interlocked so that both armatures can not be closed simultaneously. It may be used in any other application for which its construction and electrical circuits make it suitable.

CONSTRUCTION

NOTE: This instruction leaflet pertains only to the style numbers given in the title. For general instructions on the type SG auxiliary relay, see I.L. 41-350.

The type SG mechanically interlocked auxiliary relay consists of two electromagnets mounted on a common insulating sub-base with a bar centrally pivoted between the two armatures so that both armatures can not be closed simultaneously. The armature of each element of relay S#1274697 carries four moving contact fingers. These engage stationary contacts to provide a total of six make and three break contacts, as shown in the internal wiring diagram. This relay is assembled in a cast iron base with glass cover. The armature of one element of relay S#1339369 has four moving contact fingers similar to relay S#1274697, although only three fingers are used. The second element has a two-contact armature as in the standard SG auxiliary relay. A total of two break, two make, and one break-make contacts are provided. Relay S#1339369 is assembled in the type FT case, which provides test switches in the relay circuits and permits easy removal of the relay element for inspection or maintenance.

CHARACTERISTICS

Each element of the relay will pick up at a voltage 80% or less of the rated voltage, provided the other element is deenergized. Because of the heavier armature and larger number of contacts, and because the application does not require continuous duty, the energy consumption is allowed to be somewhat greater than in the standard SG auxiliary relay and the coils should not be energized continuously. The burden of each electromagnet is approximately 19 v.a. at 115 volts, 60 cycles. The contacts will carry 12 amperes and will interrupt 30 amperes at 115 volts, 60 cycles.

RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover, and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window

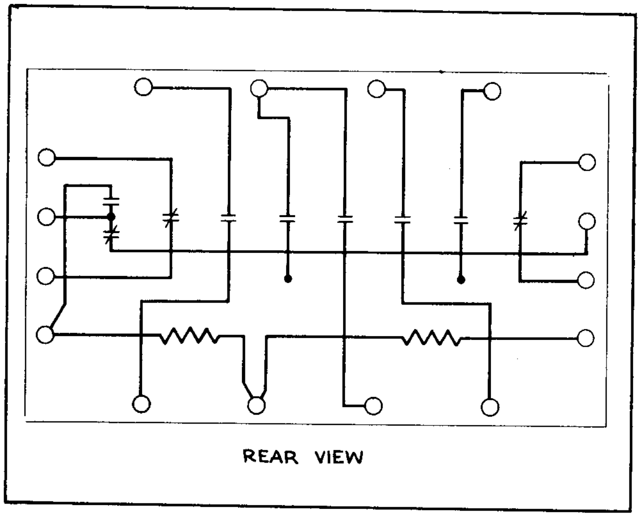

Fig. 1—Internal Schematic of S#1274697 Type SG Relay in the Projection Case.

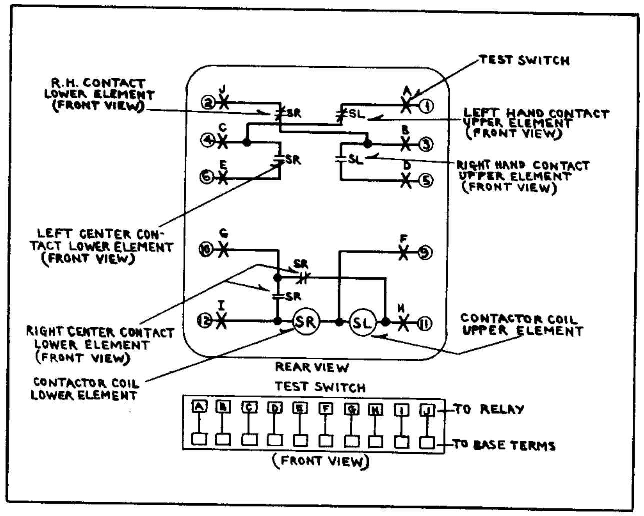

Fig. 2—Internal Schematic of S#1339369 A Type SG Relay in the Type FT Case.

which fits over the front of the case with the switches closed. The chassis is a frame that houses the relay elements and supports the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches.

The order of opening the switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagram. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches.

Testing

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

Voltage between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug.

Testing Out of Case

With the chassis removed from the base and in its normal upright position, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the standard cases and the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

The position of the break contact posts should be adjusted to obtain approximately 1/8 inch gap (except approximately 3/16 inch gap for the make contact of the two-pole element of S#1339369-A relay) between the moving contact and the make contact. The make contacts should have 3/64" to 1/16" follow and the break contacts should have 1/32" follow or more. All make contacts or all break contacts on the same element should close at approximately the same armature position. The position of the interlock arm post should be adjusted (by loosening, adjusting and retightening the two nuts on the post) so that with either armature closed and the interlock arm touching it, and with the second armature in its normal de-energized position, the opposite end of the interlock arm will be 1/64" or more from the second armature. If there is no clearance, relay operation may be noisy and excessive wear of the interlock arm may result. The deenergized positions of the armatures must be limited by the back contacts and not by the tongues which extend through the openings at the lower ends of the armatures. The interlock arm should not permit the make contacts of one element to touch until the make contacts of the other element are open approximately 1/16" or more.

The armatures and the interlock arm should operate freely, and the moving contact arms should operate freely on their guide pins.

All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended for this purpose. Excessive removal of material should be avoided. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

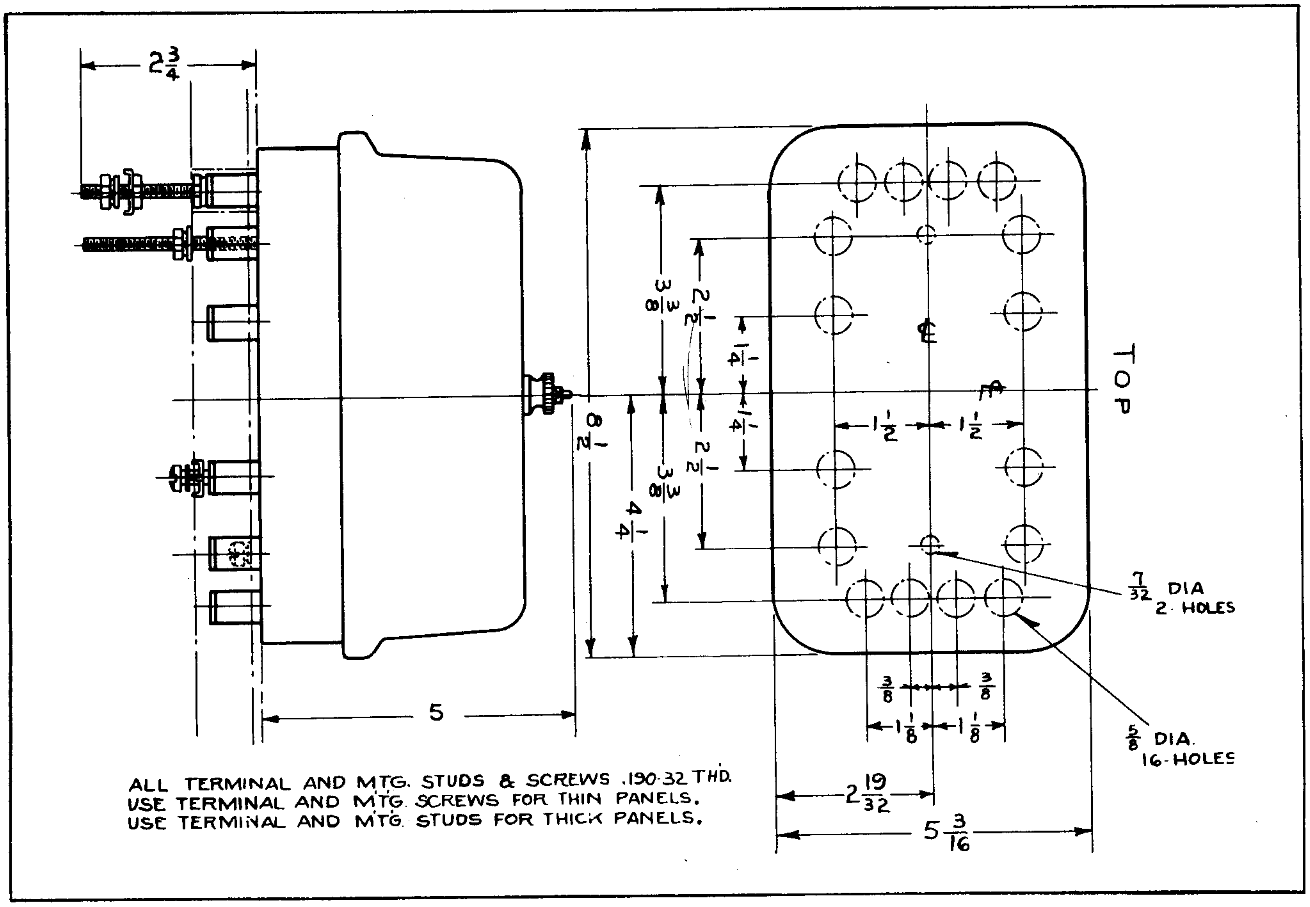

Fig. 3—Outline & Drilling Plan for the Projection Case. For Reference Only.

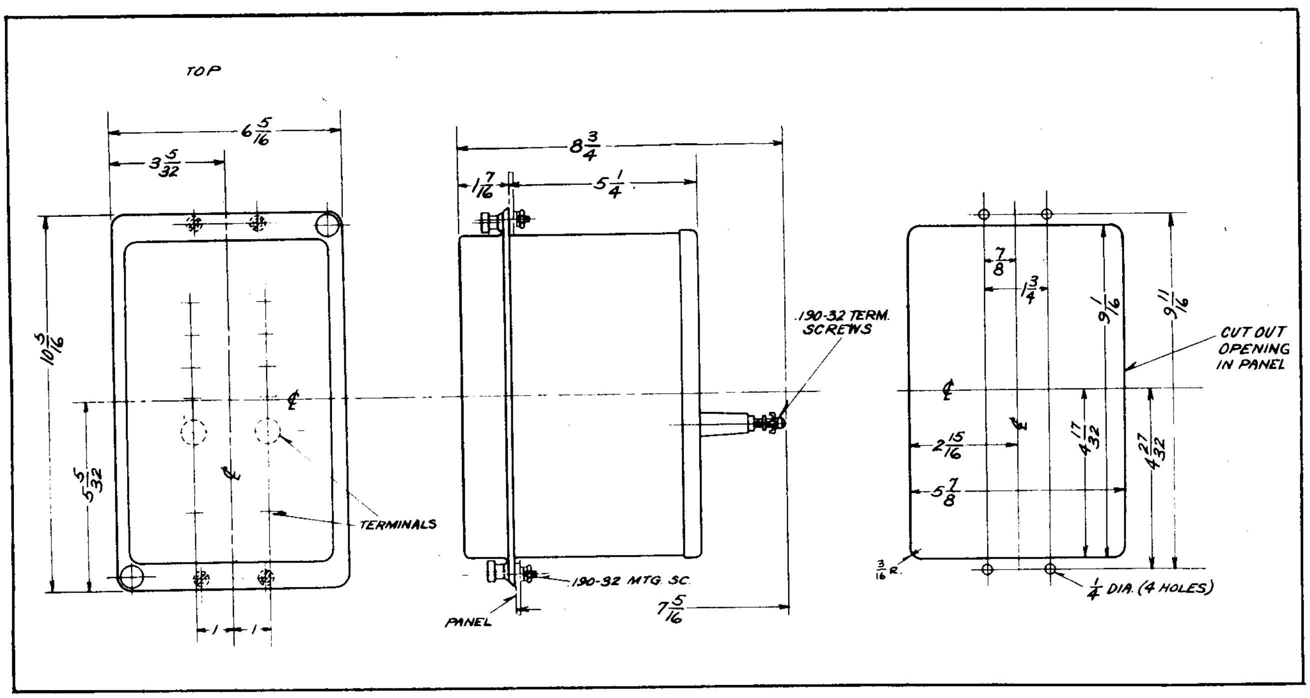

Fig. 4—Outline & Drilling Plan for the S10 Semi-flush Type FT Case. For Reference Only.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TH THERMAL TIMING RELAY

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type TH thermal timing relay is a simple and rugged time delay device devoloped expressly to meet the requirements of Westinghouse tap-changing-under-load equipment, where reliability of operation and freedom from maintenance are items of major importance. The relay also may be used in other applications where its characteristics are suitable. As adjusted at the factory, the time delay on a recycling basis can be varied from approximately 15 seconds with the control knob set on the MIN dial position, to approximately 60 seconds with the knob on the MAX position, with 120 volts applied to the relay. A 105 to 135 volt variation of applied voltage has negligible effect on the relay timing when the control knob is set on the MIN position. When set on the MAX position, the effect of voltage variation is more noticeable, but the relay timing is still within the calibration limits. The standard relay is designed for use on a 120 volt 60 cycle circuit. Special relays can be supplied for certain other voltages and frequencies if required.

Two timing elements are required in the control of a tap-changing equipment. The type TH relay is available both with a single timing element in a projection mounted case (Fig.1), and as a duplex timing relay containing two timing elements in an 8 terminal Flexitest case (Fig.4).

The complete operating cycle of the relay is composed of two parts; (1) the time required for the bimetal actuating system to deflect under the influence of heat and operate a micro switch, and (2) the time required for the bimetal system to cool until the micro switch resets. The mechanical construction of the relay is rugged, simple and reliable, with a minimum number of moving parts. The entire assembly is enclosed in a dust-proof case and after installation will require only a routine inspection to keep it in operating condition.

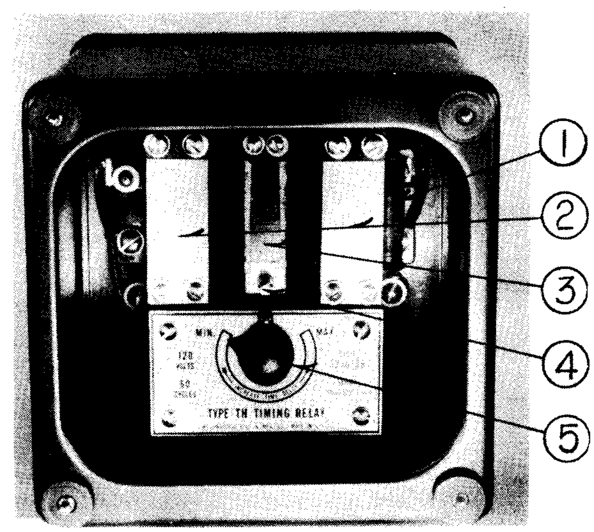

Fig. 1—Type TH Single-Element Thermal Timing Relay. 1—Resistor, 2—Side Bimetal Strips, 3—Heater Coil and Center Bimetal Strip, 4—"F" Bimetal Screw, 5—"T" Timing Screw.

CAUTION The relay is designed specifically for application on Westinghouse regulators and tap-changing-under-load equipment and when so used should give a minimum of well over a million operations. If used otherwise, the effect of possible higher current in the controlled circuit upon the life of the relay should be considered.

SUPERSEDES I.L. 41-369D

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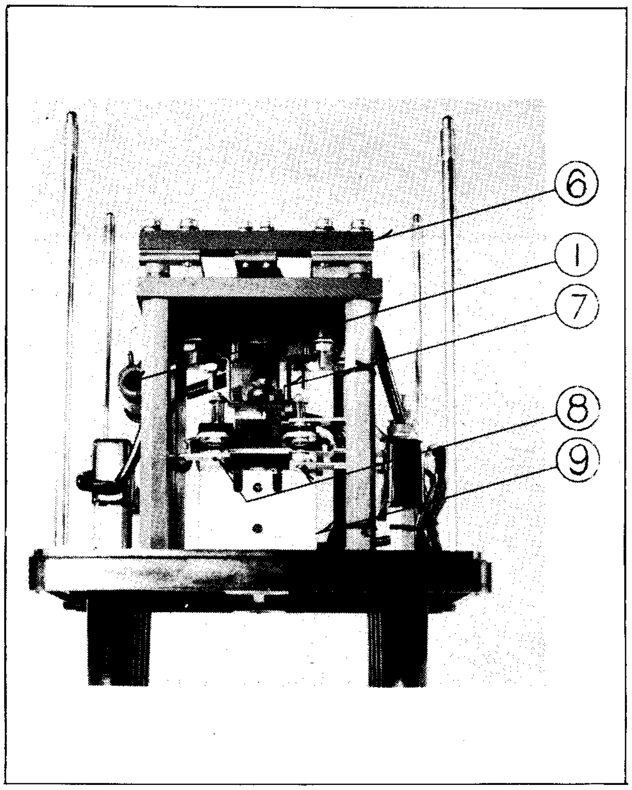

Fig. 2—Top Views of the Type TH Single-Element Thermal Timing Relay. 1—Resistor, 6—Bimetal Assembly, 7—Micro Switch, 8—Contacts, 9—Auxiliary Contactor.

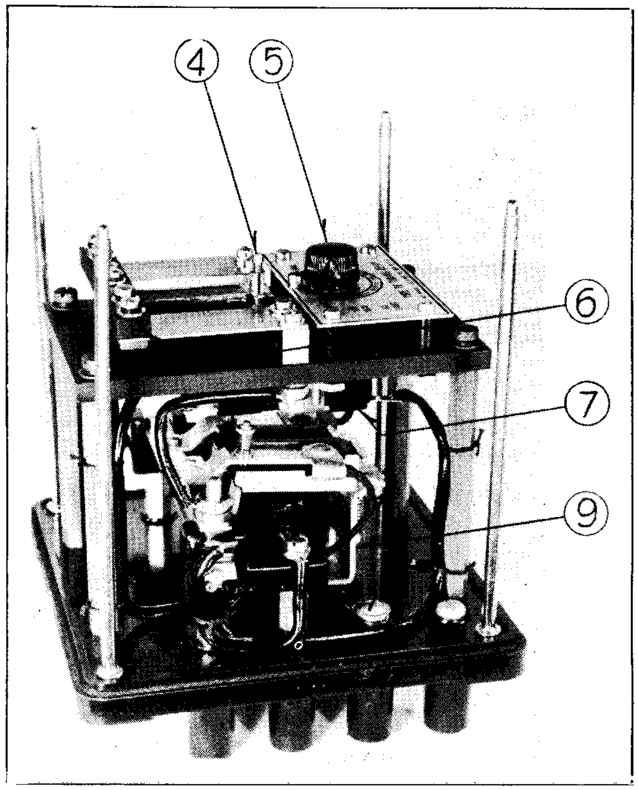

Fig. 3—Side View of the Type TH Single-Element Thermal Timing Relay. 4—"F" Bimetal Screw, 5—"T" Timing Screw, 6—Bimetal Assembly, 7—Micro Switch, 9—Auxiliary Contactor.

CONSTRUCTION

The type TH relay consists essentially of three elements: (1) a bimetal actuating system, (2) a micro switch operated by the pressure exerted by the bimetal system, and (3) an auxiliary magnetic contactor.

The Bimetal System

The bimetal system of the single-element relay consists of three elements mounted in the front part of the relay, directly behind the glass cover of the case. The center strip is equipped with a heater coil and represents the actuating element of the relay. On heating, this strip bends and exerts a pressure on the operating plunger of the micro switch. The two side bimetal strips eliminate the effect of ambient temperature on the relay operation. The moving end of the center bimetal is equipped with a self-locking adjusting screw. The position of this screw is properly adjusted before the relay is shipped from the factory and should not require any readjustment in the field. The duplex relay has a bimetal system consisting of four bimetal strips. The two inside strips are equipped with heater coils and actuate separate micro switches, while the two outside strips provide compensation for ambient temperature changes. The heater coils are never energized simultaneously by the tap changer control, and the two timing elements have a negligible effect on each other.

The Micro Switch

The micro switches are mounted on the rear of a Micarta panel and in front of the magnetic contactor. The micro switch is a snap action single-pole double-throw switch, operated by the pressure exerted by the bimetal assembly. The normally-open contact is fixed

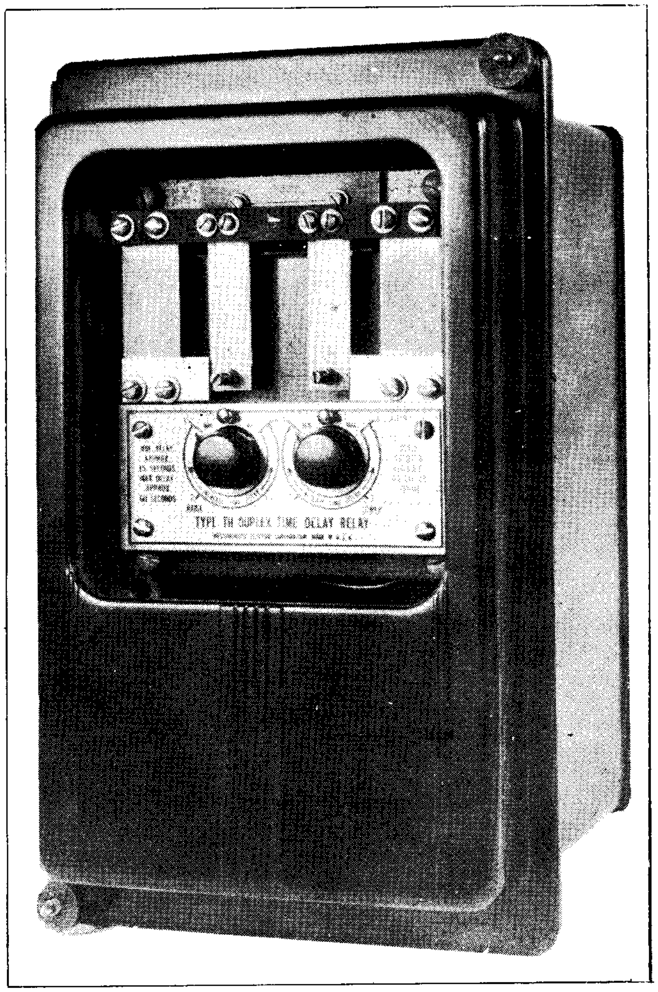

Fig. 4—The Type TH Duplex Thermal Timing Relay.

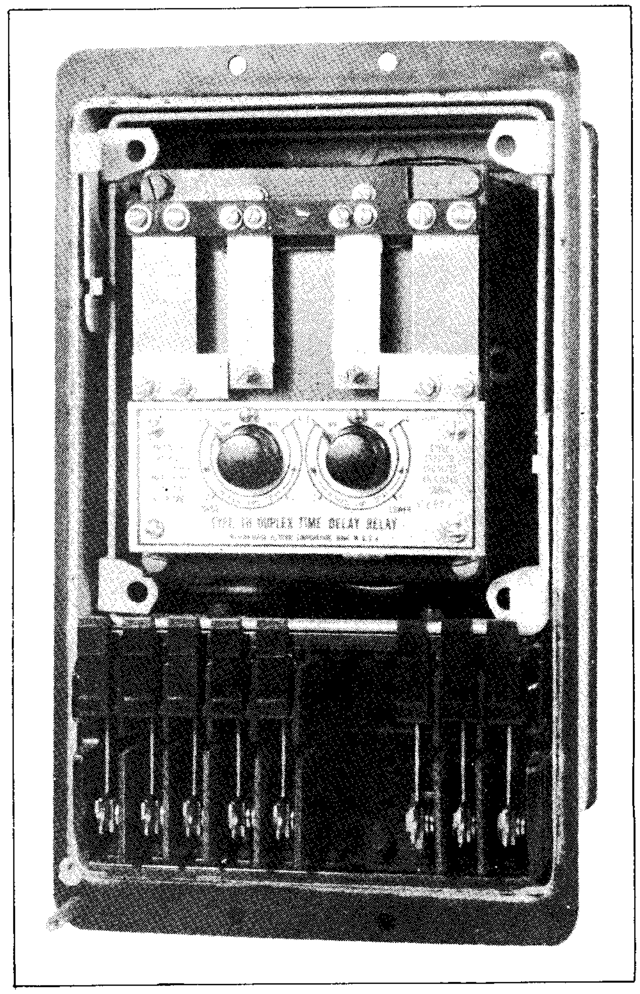

Fig. 5—The Type TH Duplex Thermal Timing Relay With Cover Removed, Showing Test Switches.

while the normally-closed contact is movable, thus providing for adjustment of the relay timing cycle. The normally-closed contact is mounted on the end of the timing screw which extends forward through a bushing in the Micarta panel and has an adjusting knob on its front end. Variation of timing is obtained by turning the knob to the required position as determined by the indication of the pointer on the dial.

The Auxiliary Contactor

The auxiliary contactor of the single-element relay is mounted on the relay base behind the micro switch. It carries the necessary contacts to enable the utilization of both the heating and cooling periods for timing. The two contactors of the duplex relay are similarly mounted on the relay sub-base.

OPERATION

The circuit controlled by the single-element relay is included between terminals 3 and 8 as shown in Fig. 7. This circuit is opened at contact A-3 when the relay is de-energized. The relay is energized by placing voltage on terminals 3 and 6, thus initiating the bimetal heating period. When the bimetal temperature rise reaches a pre-determined value, the micro switch operates, opening the circuit between terminal 3 and contact A-3 and closing the circuit through the coil of the auxiliary contactor. Operation of the latter closes contacts A-11, A-12, and A-3, and opens contact A-2, which discontinues the heating of the bimetal. When the bimetal has cooled to a predetermined temperature rise above ambient, the micro switch returns to its original position,

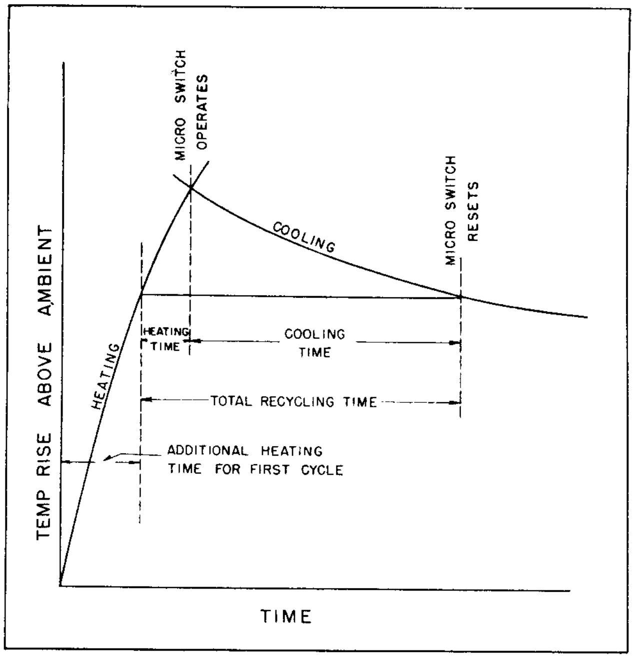

Fig. 6—The Time-Temperature Characteristic of the Type TH Relay.

thus closing the circuit between terminals 3 and 8. The relay is reset by de-energizing the coil, of the auxiliary contactor.

The controlled circuits of the duplex relay are between terminals 1 and 3, and between 2 and 4 (Fig. 8). The duplex relay does not have contacts corresponding to contact **A-11** of the single-element relay.

RELAYS IN TYPE FT CASE

The type TH duplex timing relay is supplied in the S size FT case. The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case; the case cover and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in

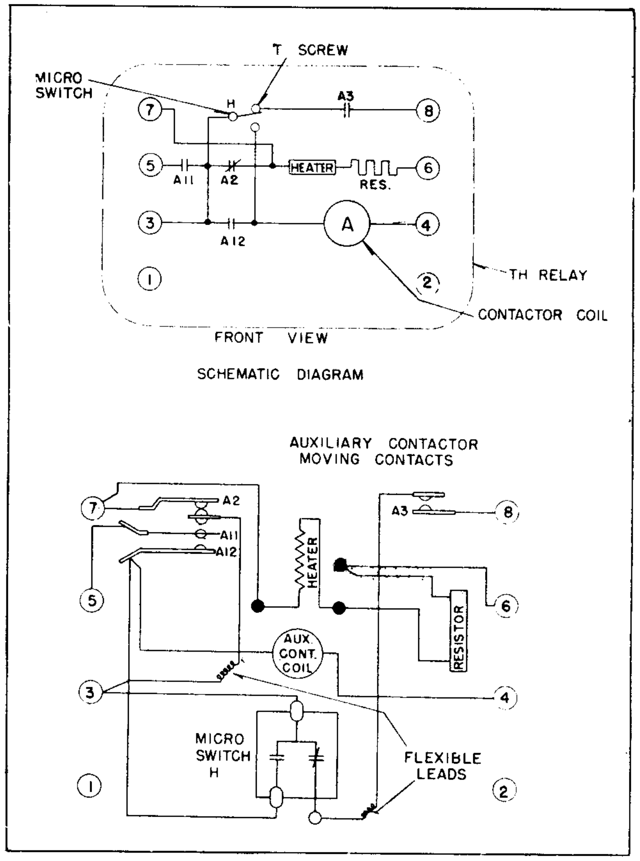

Fig. 7—Schematic and Wiring Diagrams of the Type TH Single-Element Relay.

and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the two corners. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate

chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated, or out of the case as follows:

Testing In Service

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and com-

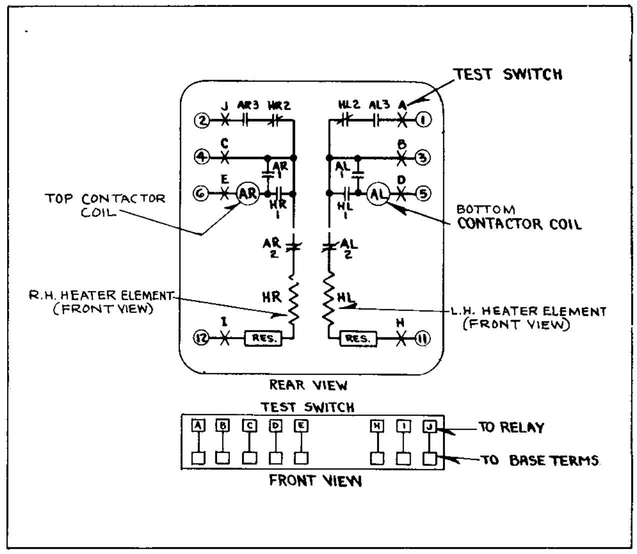

Fig. 8—Schematic Diagram of Type TH Duplex Relay.

pletely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug.

Testing Out of Case

With the chassis removed from the base, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos .or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or it it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed:

All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

All moving contacts of the duplex relay, and the RH moving contact of the single-element relay, should deflect 3/64" when the armature is closed. The inner end of the terminal strip for the LH make contact of the single-element relay should just touch the contact back-up spring when the armature is open. Both the moving and the stationary LH make contacts will deflect when the armature closes and the moving contact deflection should be approximately 1/32". Sufficient contact deflection is important, both to provide good electrical circuits and to avoid any possibility of having residual magnetism hold the armature closed when de-energized, after the plating has been worn from the pole faces by numerous operations. The contact gaps should be 1/8" to 5/32" (sum of both gaps on LH side of single-element relay) and the outward travel of the armature should be limited by the back stationary contact and not by the tongue of the yoke which projects through the opening in the armature between the hinge *points. This tongue should be bent if necessary so that it has good clearance to the armature opening with the armature open or closed. The armature should have a minimum of approximately .010" end play on its knife-edge bearings.

If the adjustment of the timing screw or the bimetals is disturbed, the instructions below may be used as a guide in restoring the normal adjustment of the relay. If only the bimetal assembly requires replacement, no re-adjustment should be necessary in the timing dial but only in the adjusting screws at the movable end of the center bimetal. Should the timing screw assembly be replaced, the only adjustment required should be in the timing screw, none in the bimetal system. But if the micro switch is replaced, both the timing screw and the bimetal screw will have to be readjusted.

1. Equipment Required

   a) A source of 120 volt, 60 cycle power.

   b) A high impedance circuit tester. An ohm meter or a neon glow lamp connected as a circuit indicator is recommended.

   WARNING: - If any appreciable current is passed through the micro switch contact during adjustment, the switch contacts may be damaged.

2. To Adjust Timing Screw "T"

   a) Connect circuit tester in series with power source and apply to terminals 3 and 4 of the single-element relay, or terminals 3 and 5 or 4 and 6 of the duplex relay.

   b) Check operation of micro switch by pressing bimetal screw "F". The micro switch should close the circuit and operate the indicator. When "F" screw is released, micro switch should open indicator circuit.

   c) Remove knob from timing screw "T". Turn screw clockwise until circuit indicator shows that micro switch normally-open contacts are just barely closed. From this position turn screw counter-clockwise slightly over one-eighth (1/8) turn. This is the approximate MIN setting. Replace knob on screw shaft with pointer at MIN position and tighten set screw.

d) Recheck micro switch operation.

3. To Adjust Bimetal Screw "F"

a) Follow instructions given in section 2-a and 2-b.

b) Turn screw "F" clockwise until circuit indicator shows that micro switch normally-open contacts just barely stay closed when "F" screw is pressed down and then released. From this position, turn screw counter-clockwise one and one-quarter (1-1/4) complete turns. The center bimetal strip must be at the same temperature as the side strips during this adjustment.

4. To Check Timing Adjustment

(Note: Contact designations and terminal numbers in the following paragraphs apply to the single-element relay. Refer to Figs. 7 and 8 and make corresponding connections when checking the duplex relay).

a) Place a short-circuiting jumper across contact A-3. Insulate contact A-12 with a piece of stiff paper. Place cover on relay.

b) Connect circuit indicator as follows: If ohm-meter is used, connect between terminals 3 and 8: if glow lamp circuit tester is used, connect between terminals 4 and 8 of relay. Place a test jumper between terminals 4 and 6 and connect 120 volt, 60 cycle power source to terminals 3 and 6.

c) Timing cycle will begin when supply voltage is turned on. The heating portion of the cycle will be complete when the indicator shows that its circuit has been opened.

d) Note that the first cycle will take longer time than subsequent cycles, due to the additional time required for the bimetal temperature rise and resultant deflection to reach the point at which the micro switch resets. This is shown diagramatically in Fig. 4. Adjustment should not be made on the basis of the first cycle but on the average of several subsequent cycles following immediately after the first. All times referred to in this leaflet are "re-cycling" time defined as the average time consumed by a complete cycle consecutively following the first cycle.

e) When properly adjusted the time of one complete re-cycling operation should be between 11 and 16-1/2 seconds with pointer on "T" set at MIN, and between 54 and 69 seconds with pointer set at **MAX**. Individual readings should not vary more than approximately 2 seconds at MIN or 3 seconds at **MAX**. If the re-cycling times for these two positions of the knob are both high or both low, correction may be made by changing the position of the knob on screw "T".

f) If adjustment of "F" screw has been made closer adjustment may be affected when necessary by turning screw "F" in 1/16 revolution steps. Clockwise rotation will increase re-cycling time; counter-clockwise rotation will decrease time.

IMPORTANT: Readjustment should not be made on either element unless its factory adjustment has been disturbed.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

At 120 volts, 60 cycles, the contactor element burden is 11 voltamperes at approximately 50% power-factor. The heater circuit burden is 18 watts.

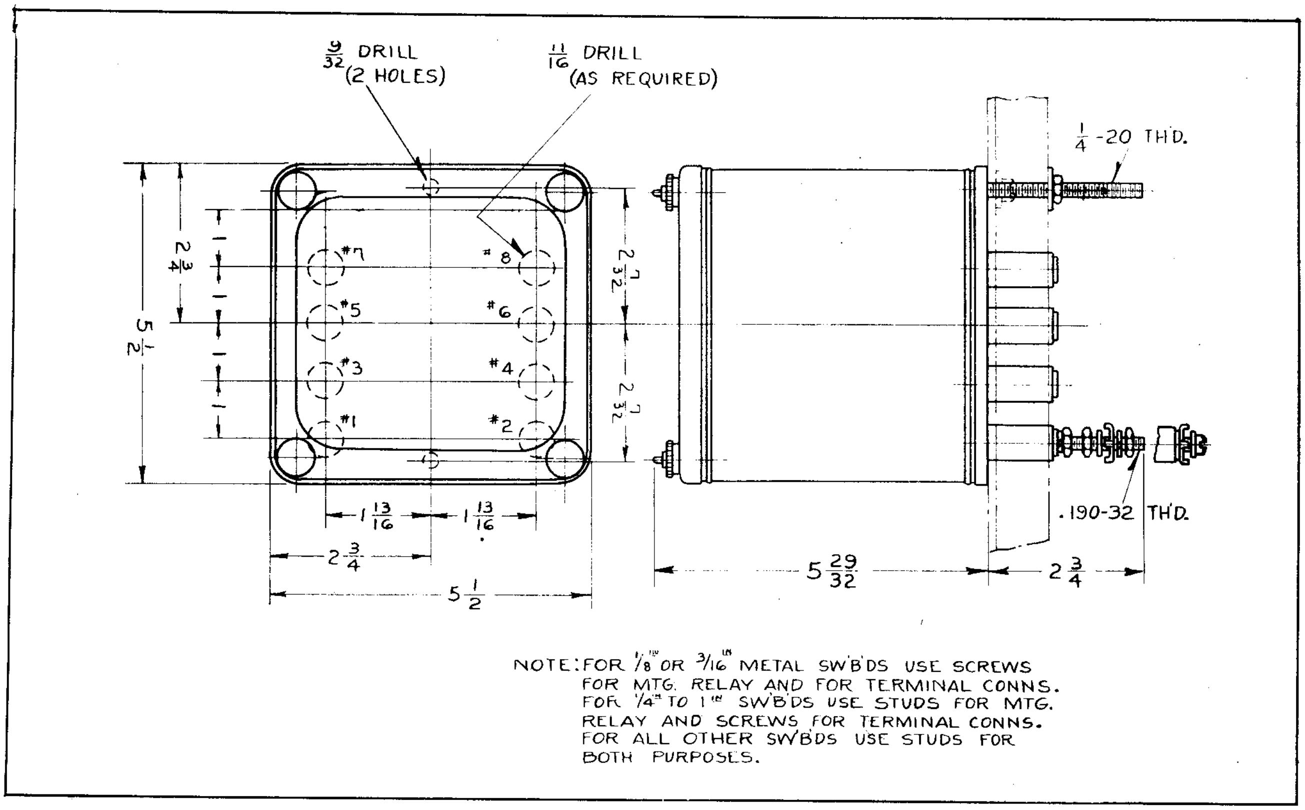

Fig. 9—Outline and Drilling Plan for the Type TH Single-Element Relay.

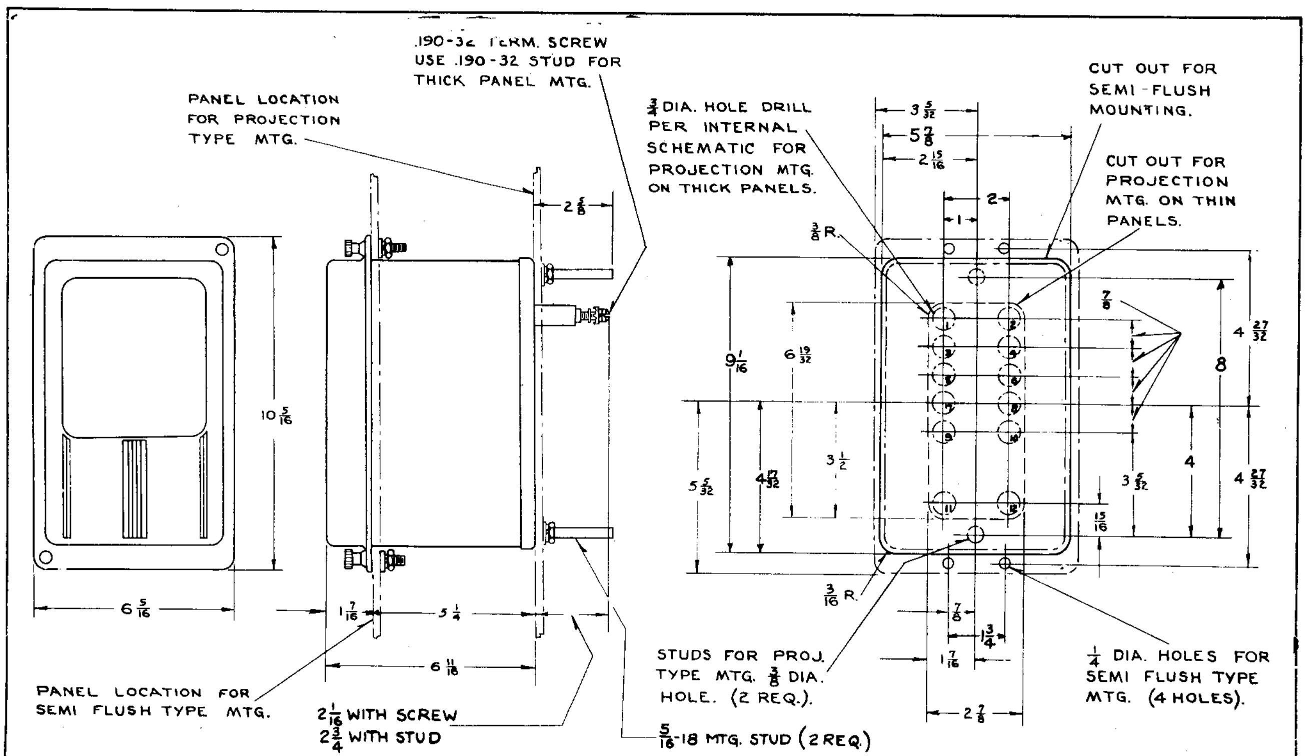

Fig. 10—Outline and Drilling Plan for the Type TH Duplex Relay. See Internal Schematic for the Terminals Supplied. For Reference Only.

I.B. 44-820-1A

HANDLING • INSPECTION • MAINTENANCE

INSTRUCTIONS

WEMCO® C

INSULATING OIL

P. D. S. 2772

for

Electrical Apparatus

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • **EAST PITTSBURGH PLANT**

SHARON, PA. **EAST PITTSBURGH, PA.**

SUPERSEDES I.B. 44-820-1

MARCH, 1953

TABLE OF CONTENTS

WEMCO® C INSULATING OIL

P. D. S. 2772

Wemco C insulating oil is a development of the Westinghouse Electric Corporation in cooperation with oil refiners. It has proven its suitability for use in all Westinghouse oil-insulated apparatus. In order to insure the proper performance of the apparatus, only Wemco C oil should be used.

This publication gives the instructions for handling, inspection and maintenance which experience has shown are important in obtaining the best service from the insulating oil.

RECEIVING, STORING AND HANDLING

SHIPMENT

Wemco C oil is shipped in tank cars, drums or cans. Modern tank cars are usually equipped with breathers and are well gasketed to protect from moisture. These precautions are taken to overcome the effect of changes in volume of the oil due to temperature variations.

When shipped in drums, the oil and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water.

When shipped in cans, the cans as well as the oil are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of oil has been unloaded, the bung should be examined for damage or leaks. It is possible for bungs to become loosened by change in temperature or rough handling in transit. It is recommended that oil from drums be tested before using, or combining with good oil.

It is very desirable that oil in drums be stored in a closed room. Outdoor storage of oil is always hazardous to the oil and should be avoided if at all possible. If it is necessary to store oil outside, protection against direct action of rain and snow should be provided. Drums stored outdoors should be placed on timbers so as to be clear of the ground. They should always be placed so that the bungs will be protected from moisture. They should be covered with a tarpaulin.

Cans. Cans containing oil must not be exposed to the weather. Seals should be kept intact until the oil is actually needed. It is not necessary to make dielectric tests on oil in sealed cans.

Screw caps are provided on the cans to use when the oil is only partially removed after hermetic seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded but the oil must be tested before using.

Storage Tank. The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

In larger storage systems, it is desirable to provide equipment to supply dry air for breathing purposes. This is often accomplished by the use of a breather making use of silica gel or aluminum oxide as the drying medium.

The tank should preferably have a convex bottom, allowing the installation of a drain cock at the lowest point for removing any free water or dirt which might settle out. When a cylindrical tank is installed with its axis horizontal, one end should be a little lower than the other, with a drain cock at the lowest point, and the oil supply pipe should enter at the opposite end of the tank. The oil may enter and leave the tank by the same pipe, but this should be at some distance from the bottom to prevent stirring up any settlings when the tank is being filled. It is desirable that the pipe be provided with a swing joint and float, so that it will automatically move with the change in oil level and remain near the surface of the oil.

FIRE PROTECTION

Important: While Wemco C oil will not take fire unless brought to a high temperature (305 F), it should be remembered that under abnormal conditions such a temperature can be reached, so that proper precaution against fire should be taken. The best way to extinguish burning oil is to smother the flames so that the supply of fresh air is cut off. Chemical fire extinguishers are effective, but water should not be used unless it is applied by a special atomizing spray nozzle.

HANDLING

Note: The oil should be sampled and tested, except when received in cans, before being transferred from the container to the apparatus. In cases where the apparatus is received with the oil installed, the oil should be sampled and tested before the apparatus is put into service, as described later in this book.

When putting new oil-filled apparatus into service, see that the tank is free from moisture and foreign material.

When carbonized oil is removed from apparatus in service, thoroughly clean the interior of the apparatus so that the new oil will not be contaminated. This may be done by flushing with clean insulating oil and wiping with clean, dry, lint-free cotton cloths. Cotton waste is undesirable because of the lint which may be introduced into the oil.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, oil which has not been filtered should be strained through two or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths may be stretched across a funnel of large size and should be renewed at frequent intervals.

Important: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with oil, and to prevent the entrance of water and dirt during the transfer of the oil to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not practicable, protection against moisture must be provided.

All vessels used for transferring the oil should be carefully inspected to see that they are absolutely dry and free from dirt.

Important: Always use a metal or oil proof hose when handling the oil. A hose made of natural rubber must not be used. Oil may easily become contaminated from the sulphur in the natural rubber, and should not be allowed to come in contact with it.

When it is necessary to transfer oil from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the oil through a blotter press or centrifuge at room temperature. A similar procedure is also advisable in the case of apparatus erected inside and later exposed to cold weather; the reason being that oil will dissolve more water at higher temperatures which will be thrown out of solution at lower temperatures. The remainder will appear in suspension in the oil and will lower the dielectric strength.

A drum of cold oil when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the oil as it flows from the drum. Before breaking the seal the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

Cleaning Contaminated Drums. The cleaning of drums which have contained used insulating oil requires great care in order to insure a thoroughly clean drum. It is preferable to return such drums to the refinery where adequate cleaning facilities are available, rather than to attempt to clean them. If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum.

Caution: Do not use a steel pipe because of the danger of a spark igniting the vapor.

Heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C (190°F) for sixteen hours. Screw the bung on tightly before removing drum from the oven. Use a new washer with the bung to insure a tight seal. A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.

Caution: An open flame must always be kept away from the oven to prevent igniting inflammable gases.

Refilling Drums. The practice of refilling drums with oil is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the oil is likely to become contaminated.

If it is necessary to refill them for storage, drums which have been used only for oil in good condition should be reserved for this purpose. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with oil, the temperature of the drum and of the oil should be at least 5.5°C (10°F) higher than the air, but the temperature of the drum need not be the same as that of the oil.

A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the oil refineries and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the oil.

Drums to be refilled with oil for storage should be plainly marked with paint for identification. For procedure in returning drums to refinery see Price List 44-820. (Cans and five gallon drums are not returnable.)

SAMPLING AND INSPECTION

REQUIREMENTS FOR INSULATING OIL

The requirements for proper insulating oil for use in transformers are not inconsistent with requirements for oil used in circuit breakers, tap changers, reclosers, and other uses where arcing occurs. Wemco C oil is particularly well suited for each classification of service and for either indoor or outdoor use.

In transformers, the oil provides an electrical insulating medium as well as a method of carrying away heat from the windings.

In circuit breakers and other apparatus subject to arcing, the insulating characteristic of the oil becomes predominate in suppressing the arc.

Wemco C oil is derived from crude pertroleum by fractional distillation, and its nearly water whiteness (Union Colorimeter 2.0 maximum) shows its degree of refinement. It contains no moisture, asphalt, tar, vegetable or animal oils. It has the following characteristics:

1. Wemco C oil has high dielectric strength. It offers a minimum of 26,000 volts test at point of shipment and at least 22,000 volts test at point of destination. The dielectric constant is 2.2.

2. It is free of inorganic acid, alkali, corrosive sulphur, and corrosive compounds, thus does not attack insulation or conductors.

3. Because of its low viscosity (60 sec. maximum at 37.8°C (100°F) Saybolt Universal) it provides good heat transfer in transformers, and is better able to dissipate the arcing products in circuit breakers, tap changers, and other arcing contact apparatus. The viscosity at 0°C (32°F) is 280 sec. maximum.

4. Its steam emulsion number (maximum 25 seconds) shows its resistance to emulsification, which is of importance in throwing moisture out of suspension, allowing it to settle to the bottom of the tank.

5. Wemco C oil gives freedom from sludging under normal operating conditions.

6. Low pour point of minus 50°F (minus 45.6°C) allows use under unusual weather conditions.

7. Low specific gravity of 0.898 gives ease of handling and low weight for oil-filled equipment. The weight per gallon is 7.5 pounds.

8. The flash point of Wemco C oil is 275°F (135°C) and the fire point is 305°F (152°C). Usual precautions should be taken in handling and storage and when oil is already near its flash or fire point.

9. The specific heat of Wemco C oil is approximately 0.488, and its coefficient of expansion is 0.000725 at 0°C (32°F) and 0.000755 at 100°C (212°F).

10. Zero is the precipitation number of Wemco C oil.

11. Interfacial tension tests on Wemco C oil give a minimum result of 40 dynes per square centimeter.

CAUSES OF DETERIORATION OF OIL

Transformers. Deterioration of oil is a problem to which must thought and research has been devoted. Westinghouse Sealedaire, Inertaire, Thermosiphon, and expansion tank transformers are expressions of this research in methods of preventing deterioration.

Generally speaking, however, the principal causes of deterioration of insulating oils are:

1. Presence of moisture.

2. Oxidation.

3. Excessive temperature.

Condensation from moist air due to breathing of the transformer, especially when the transformer is not continuously in service, may injure oil. (The moist air drawn into the transformer condenses moisture on the surface of the oil and inside of the tank.) The oil may also be contaminated with water through leakage such as from leaky cooling coils or covers.

Sludge is an oxidation product, the amount formed in a given oil being dependent upon the temperature and the time of exposure of the oil to the air. By careful refining, the components of oil which are most readily oxidized to form sludge can be removed, so as to provide an insulating oil which will not sludge under normal operating conditions.

Note: Excessive temperatures may cause sludging of any transformer oil regardless of how well it is refined.

Transformer oil which has begun to sludge will continue to do so after it has been reconditioned by means of the centrifuge or filter press, as these methods of reconditioning do not remove the deterioration products which are in process of formation but have not yet been precipitated as sludge.

Reconditioning by means of fuller's earth and vacuum dehydration will remove many of these deterioration products, and if improved by reinhibiting, will greatly extend the sludge-free life of the oil.

Another effect of oxygen is to gradually produce organic or "fatty" acids in oil in service. These should not be confused with the mineral acids such as sulphuric acid used in refining, as in small amounts the former do not have a deteriorating effect upon insulation.

Circuit Breakers. The principal causes of deterioration of insulating oil in circuit breakers or other arc producing apparatus, are:

1. Presence of water.

2. Carbonization of the oil (caused by operation of the circuit breaker).

Insulating oils may receive water through condensation on the surface of the oil or on the inside of the tank due to the entrance of moist air, and, of course, by direct leakage.

All oil in circuit breakers is subject to carbonization due to arcing between the contacts. Part of the carbon formed is deposited on the mechanism and at the bottom of the tank while the remainder continues in suspension in the oil.

Carbonization takes place not only when the circuit breaker opens heavy short circuits, but also whenever an arc is formed, even during such light service as the opening of the charging current of the line, and this latter service, repeated, may eventually produce enough carbon to be a source of trouble.

The carbon reduces the dielectric strength of the oil, lowers the surface resistance of the insulation if water is present, and also lowers resistance to emulsification. The carbon alone may not be detected by the dielectric test, particularly if the oil is free from moisture.

In cold weather, a larger amount of carbon is formed than in warm weather because of the increased viscosity of the oil at low temperatures. Also the carbon is not as readily dispersed through the oil.

SAMPLING OIL FROM SHIPPING CONTAINERS

The dielectric strength of oil is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to have been largely a matter of carelessness in handling. The following instructions, based on the specifications of the American Society for Testing Materials, must be followed to assure accurate results:

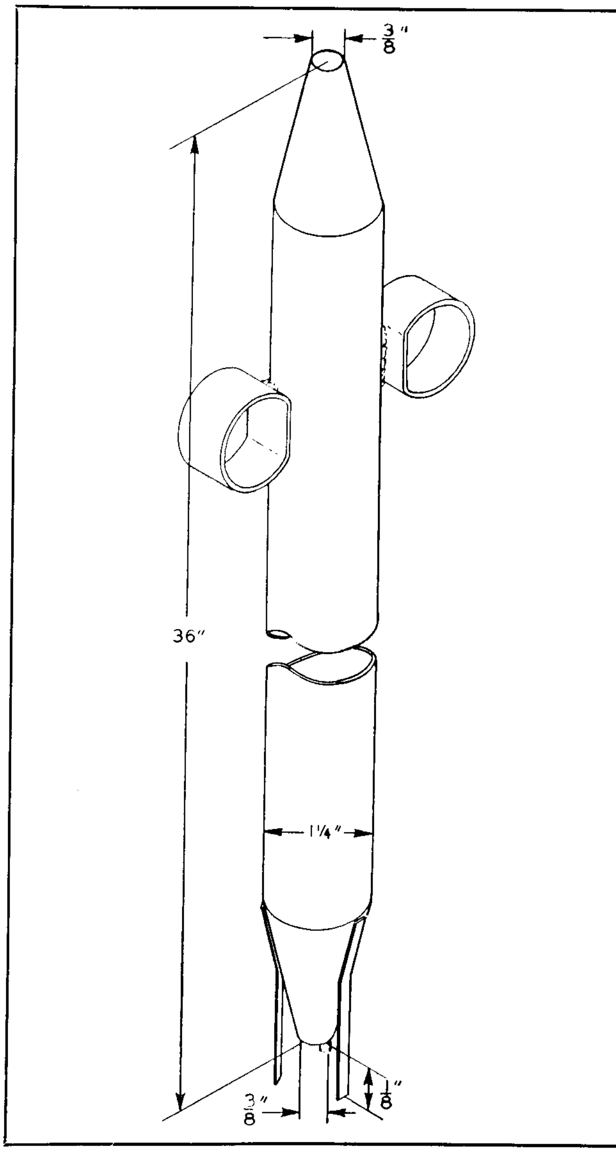

FIG. 1. Drum Thief.

Sample Bottle. The sample container shall be made of clear glass, of at least 16 oz. capacity, and shall be cleaned and dried. The glass bottle is preferable to a metal container as it may be examined to see if it is clean. It also allows visual inspection of the oil before testing, particularly as regards free water and solid impurities. However, any samples to be tested for color or sludge-forming characteristics must be kept in the dark, as light produces changes in these properties. This is not necessary for any other tests.

The clean, dry bottle shall be thoroughly rinsed with benzine or dry lead-free gasoline which has previously withstood a dielectric test of at least 25 kv in a standard test cup, and shall be allowed to drain. It is preferable to heat the bottle and cap to a temperature of 100°C (212°F) for one hour after

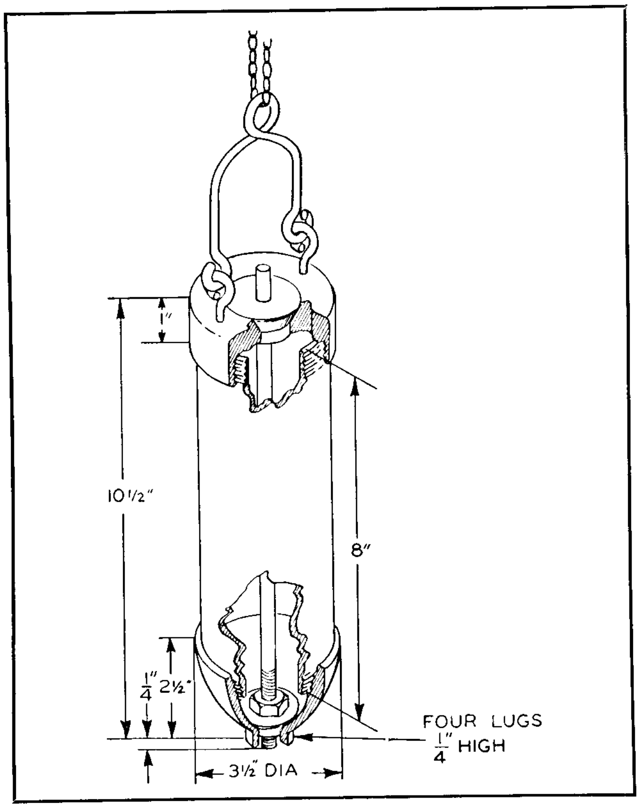

FIG. 2. Tank Car Thief.

thoroughly draining. The bottle shall then be tightly capped and the neck of the bottle dipped in melted paraffin.

Important: Glass jars having rubber gaskets or stoppers must not be used. Oil may easily become contaminated from the sulphur in natural rubber.

Thieves for Sampling. A convenient and simple thief (see Fig. 1) for use with 55 gal. drums may be made of tin as follows:

Length 36 in., diameter 1¼ in. with cone shaped caps over the ends and openings at the ends ⅜ in. in diameter. Three legs equally spaced around the thief at the bottom, and long enough to hold the opening ⅛ in. from the bottom of the container being sampled, aid in securing a good representative sample. Two rings soldered to the opposite sides of the tube at the outer end will be found convenient for holding the thief by slipping two fingers through them and leaving the thumb free to close the opening. In an emergency a piece of glass tubing 36 in. long may be used. For the tank cars, a thief employing a trap at the bottom may be used. (See Fig. 2.)

The thief shall be suitable for reaching the bottom of the container and the sample shall be taken with the thief not more than about ⅛ in. from the bottom.

Procedure. Thieves should be cleaned *before and after use* by rinsing with dry lead-free gasoline; be sure that no lint or other fibrous material remains on them. When not in use they should be kept in a hot, dry cabinet or compartment at a temperature not less than 37.8°C (100°F), and shall be stored in a vertical position in a rack having a suitable drainage receptacle at the base.

Samples shall not be drawn from containers indoors until the oil is at least as warm as the surrounding air. Cold oil may condense enough moisture on the surface from a humid atmosphere to seriously affect its insulating properties. Sampling oil from containers out of doors is undesirable, due to the possibility of condensation of moisture, and should be avoided whenever possible. (Samples should never be taken in the rain.)

The drums shall be assembled in line, with bungs up, and numbered. The bungs shall be unsealed and removed and laid with the oily side up beside the bungholes. The unstoppered sampling receptacle can be placed on the opposite side of the bungholes. The top hole of the thief shall be closed with the thumb, the thief quickly thrust to the bottom of the container and the thumb removed. When the thief is filled, the thumb shall be replaced, the thief quickly withdrawn and the contents allowed to flow into the sampling receptacle. The lower holes shall not be closed with the fingers of the other hand. The free hand shall not be used to guide the stream of oil except by touching the thief, and this only when necessary. The oil shall not be allowed to flow over the hand or fingers before it flows into the sampling receptacle.

When the sampling receptacle is filled, it shall be closed quickly and the bung replaced in the container and tightened. The sampling receptacle shall be taken under cover to the testing laboratory as quickly as feasible.

After using, thoroughly clean all thieves and sampling receptacles as outlined above.

The tank cars of oil shall be sampled by introducing the thief through the manhole on top of the car, the cover of which shall be removed carefully so as not to contaminate the oil with dirt. The sample shall be taken as near as possible to the bottom of the tank car. This shall not be done while rain or snow is falling.

When separate samples are being taken from a consignment or part of a consignment, care should be exercised to prevent contaminating the samples. A separate thief shall be used for each sample or the thief previously used shall be well drained and then thoroughly washed with oil from the next container to be sampled; the oil thus used for washing should be thrown away before the next sample is taken. (Enough thieves shall be provided to insure thorough drainage of each thief after rinsing with oil to be sampled before using it to withdraw the actual sample.) For obtaining only a few samples, two thieves are sufficient, but for obtaining a large number of samples (for example, sampling a carload of drummed oil) six or more thieves are desirable.

When one average sample of a consignment or batch is being taken, the same thief may be used throughout the sampling operation, and it is not necessary to rinse the thief with oil before taking any of the portions that go to make up the total average sample.

Quantity of Sample. It is recommended that one 8 oz. bottle of oil be taken as a sample for dielectric tests, and a one quart sample be taken when complete physical and chemical tests are to be made. At least one sample should be taken from a tank car of oil. One sample may be taken from each drum, or if desired, a composite sample may be made from oil from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums have been stored exposed to the weather, a sample from each drum shall be tested. The sample of oil should be examined for free water, and if any is noted, the drum of oil should be put through a blotter filter press and resampled for dielectric strength.

If the sample is being taken from a tank car, and water appears, follow the same procedure.

SAMPLING OIL FROM APPARATUS

When taking samples of oil from apparatus in which a thief cannot be used, use the sampling valve and follow the procedure outlined above as far as practicable.

Care should be taken to procure a sample which fairly represents the oil at the bottom of the tank. A sufficient amount of oil should therefore be drawn off before the sample is taken, to insure that the sample will not be that which was stored in the sampling pipe. For this reason, the valve and the drain pipe should be sufficiently small to be emptied with convenience and yet sufficiently large to give an even flow of oil and avoid clogging by sediment. A 1/4 in. pipe and valve is recommended. This, of course, may be separate from the drainage pipe and valve or it may be connected to the drainage valve by means of a suitable reducer.

It is of utmost importance that the sample of insulating oil represents the actual condition of the oil in the apparatus. Every precaution should be taken to keep the sample and container free from foreign impurities or moisture.

Moisture may find its way into insulating oil in several ways. The oil is frequently shipped in metal drums, and if these are exposed to rain, moisture may enter around the threads of the bung, or through imperfections in the seams. In water-cooled transformers, the portions of the water pipes which extend above the oil level are always heavily lagged with a heat-insulating material. If this lagging is damaged, moisture in the air inside of the transformer may condense on the cold water pipe and may run down into the oil. Another source to which the presence of moisture in large transformers is sometimes attributed, is the "breathing" of the transformer. When the transformer carries a load and becomes warm, both the oil and the air in the tank expand, and if there is a vent, part of the air will be forced out of the tank. When the load is cut off and the transformer cools, this action is reversed, and a corresponding volume of air is drawn into the tank from the atmosphere. This air carries a certain amount of moisture, which is condensed as the air becomes cooler, and collects on the cover and tank wall. Of course, in Westinghouse Inertaire, Sealedaire, Thermosiphon, or expansion tank transformers, moisture will appear in the oil only through improper maintenance or failure of equipment.

If the apparatus is installed outdoors, care should be taken to prevent contamination of the sample by rain, snow, etc.

A glass bottle is recommended as a sampling receptacle, so that any water present may readily be seen.

If the sample contains free water it is not suitable for dielectric test and the sample and bottle should be discarded. A second sample should be taken after at least two quarts of oil have been withdrawn. If free water still exists in the sample, the oil in the apparatus should be put through a blotter filter press and resampled for dielectric strength.

In order to make sure that the dielectric strength is up to its proper value, the insulating oil in any piece of apparatus should be tested before its initial operation, and at regular intervals thereafter.

PERIODIC INSPECTION

Oil may deteriorate in service even under what seems to be the most favorable conditions. The more handling an insulating oil receives, the greater the opportunity for contamination unless adequate precautions are taken.

Important: Therefore, it is essential to provide for periodic inspection and test, and

to purify the oil whenever necessary in order to maintain it in good condition.

Regular inspection and tests of insulating oils by central stations and other large users of these oils have convinced them of the necessity of this practice. Where these inspections and tests have been systematically followed it has been found that failure of the apparatus from burnouts, due to the fact the oil had become contaminated with moisture and sediment, has been reduced to a minimum and has resulted in greater economy of operation. In view of the importance of the subject, it is, therefore, recommended that all companies, in the interest of good service, adopt some system of oil inspection and test.

The frequency of inspecting and testing depends upon the service to which the apparatus is subjected, and the construction of and the materials used in the apparatus.

Note: A periodic inspection and reconditioning schedule is not essential for oil in Inertaire or Sealedaire transformers; such oil should last indefinitely without need for reconditioning, provided the Inertaire equipment is properly maintained.

Circuit breakers which are called upon to open the circuit frequently under heavy loads require more frequent inspection and reconditioning of the oil than those subjected to lighter duty.

Transformers subjected to heavy duty should be more frequently inspected than those in normal or light service.

It is recommended that operators prepare a schedule for inspection based on the operating conditions. Reference to the station log, together with the record of dielectric tests of the oil, should determine the frequency of inspection and test. The period between successive inspections should never be longer than six months or until experience indicates that the time between tests can be extended. When the dielectric strength of the oil drops to 20 kv in the standard dielectric test (see page 13) the oil should be looked upon with suspicion. In no case should the dielectric strength be allowed to drop below 16.5 kv.

Inspection of oil should include:

Checking Oil Level. It is essential that the proper oil level be maintained. Low oil level may cause breakdown of insulation or flashover of bushing in any apparatus, or failure of circuit breaker to open heavy overloads properly.

Checking Dielectric Strength. The oil should be tested regularly for dielectric strength and purified when the tests show need of it. The testing should be systematized and complete records kept. It is particularly important to check the dielectric strength after exposure to severe overload operation in a circuit breaker.

Checking for Carbonization. The presence of carbon in circuit breaker oil may introduce a hazard, due to the tendency of the carbon to lower the dielectric strength of the oil, and also to deposit on insulating surfaces, thereby reducing the insulation resistance.

Visual inspection of the oil samples should be made and if any appreciable amount of carbon is present the oil should be reconditioned even though the dielectric test is good.

Important: Certain washing compounds have been used by some operating companies to assist in separating the carbon from the oil. Investigation in the Westinghouse laboratories has shown that these compounds leave the oil in poor condition. Customers are warned against using any form of chemical treatment that has not been investigated and recommended by Westinghouse Electric Corporation.

Checking for Sludge. Transformers should be regularly examined for evidence of sludge. A visual inspection will indicate its presence. Appreciable amounts of sludge may clog the oil ducts and interfere with heat transfer. It is essential that such oil be reconditioned immediately and when put in service again should be carefully watched to see that the proper dielectric strength is maintained and that the oil is reconditioned again before sludge has formed to such an extent as to interfere with the operation of the transformer. *Oil which has once sludged, will, after being reconditioned, sludge more quickly than the first time.*

WESTINGHOUSE OIL TESTING SERVICE

Many users of transformers and large oil circuit breakers do not have the necessary facilities for testing insulating oil. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an oil testing service to provide a careful test by experienced engineers, and a prompt report of test results.

Two special 16 oz. sample bottles per mailing container (Westinghouse Sampling Set Style #1608 629) as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse office.

After drawing the sample of oil, the customer should seal the bottle with care, and mail it to the Westinghouse Electric Corp., Plant Laboratory, Sharon, Pa. The details of this transaction have been simplified by the inclusion in the Sampling

Set of an instruction sheet and a printed return label. The instructions cover the taking of the sample and its proper preparation for mailing, and the label carries an envelope for enclosing customer's order covering the testing work. (Also see details given in Price List 44-820).

If customer desires to use his own bottles, he should be sure to obtain Form 24670 from the Westinghouse Office. Lack of this form will cause much delay in various accounting procedures involved, and thereby delay the test. Samples should be taken in accordance with ASTM D-117. Note that the bottles and containers involved will not be returned to the customer.

When samples of oil are received for testing they are sent to the engineering testing laboratory and tested for dielectric strength in accordance with methods described in ASTM D-117.

As soon as the test has been made, a report giving five breakdown test readings, and the average of these, is sent by mail directly to the person in the customer's organization who has been designated on the order to receive it.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination. (The customer should plainly indicate the type of service desired).

This service consists of an examination of the oil by a competent oil chemist. Recommendations will be made as to the suitability of the oil for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the oil represented should be given as completely as possible. Samples should be not less than one pint.

Other tests available include a complete Physical and Chemical Examination; a power factor test; and the establishment of a Power Factor Curve from 25°C to 100°C.

The Physical and Chemical Examination encompasses tests of acid and base numbers, color, interfacial tension test, pour point, specific gravity, and viscosity.

A combination is offered of the dielectric test, the acid and base number test, the interfacial tension test, and the power factor test. This combination covers those tests most often requested for general purposes.

(For further details on available tests, refer to the nearest Westinghouse Office.)

PURIFICATION AND RECONDITIONING

PURITY OF OIL

Wemco C oil is clear and nearly water-white in color. It is free from water, acid, alkali and deleterious sulphur compounds.

The oil is carefully refined so as to have a high resistance to emulsion; that is, the water is not held in suspension but quickly separates out. This is particularly essential in circuit-breaker service since this apparatus cannot be tightly closed like a transformer and some moisture may be introduced into the oil. Wemco C oil has been designed with this particular property in mind and precipitates water and carbon promptly. However, certain impurities develop while the oil is in service and these impurities must be removed to insure safe operation of the apparatus. The source and kind of impurities developed in the oil depend upon the type of apparatus in which it is used.

In circuit-breaker service, each time the circuit is opened some carbon is formed in the oil, even though only the charging current is being interrupted. The resistance to emulsion of the oil is also lessened, both by a change in the oil and by the presence of carbon in the oil. Oil which has been subjected to arc action in the circuit breaker tends to slowly form organic acids, which further tend to lower its resistance to emulsion. The major portion of the carbon slowly precipitates to the bottom of the tank, but the more finely divided carbon has a tendency to remain suspended in the oil, and lower the dielectric strength. Both carbon and moisture are attracted to the insulating surfaces of the bushings by the electrostatic field, and when so deposited, lower the insulation resistance of the terminals from line to ground.

Oil in transformers is generally subjected to heat, oxidation and sometimes to moisture. Heat in the presence of oxygen produces a gradual physical and chemical change in oil and the extent of this change will depend upon the amount of heat, time and the catalytic action of exposed metals in the apparatus to which it is subjected. High temperature over a short period of time or somewhat lower temperature over a long period of time affect the characteristics of the oil, particularly in the development of organic acidity and sludge.

Heat in the presence of oxygen affects the unsaturated hydro-carbons, at first through formation of organic acids and later by precipitation in the form ordinarily called sludge.

RECONDITIONING

The reconditioning of oil used in circuit breakers and transformers consists principally of the removal of water, carbon and sludge and the restoration of resistance to emulsification, thereby putting the oil in the best condition to separate out any water which may later be introduced.

The four types of equipment in general use for simple reconditioning of oil in transformers and circuit breakers are: the centrifuge, the blotter filter press, the combination centrifuge and filter press and the combination fullers earth and vacuum dehydration process. (See Part Five.) The combination of centrifuge with chemical treatment is particularly well adapted to the reconditioning of carbonized circuit-breaker oil.

Important: In general, when small quantities of oil have been contaminated with fire extinguishing agents, it is preferable to replace the oil rather than to attempt to reclaim it.

Insulating oil which has been contaminated with carbon tetrachloride or soda sulphuric acid cannot be reclaimed. (It would have to be refined.)

When large quantities of oil have been contaminated with other fire extinguishing agents, the reclaiming of the oil will depend upon the kind and degree of contamination. There may be factors other than the fire extinguishing agent (for instance, high temperatures cracking the oil, carbonized insulation, etc.) which should be considered. Any question should be referred to the nearest Westinghouse Office.

TESTING METHODS

Instructions for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

DIELECTRIC STRENGTH TEST

Apparatus. The transformer and the source of supply of energy shall not be less than ½ kva, and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by any approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the oil takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kva or less, as the current is limited by the regulation of the transformer.

The test cup for holding the sample of oil shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline, and nonabsorbent as far as moisture, mineral oil and gasoline are concerned.

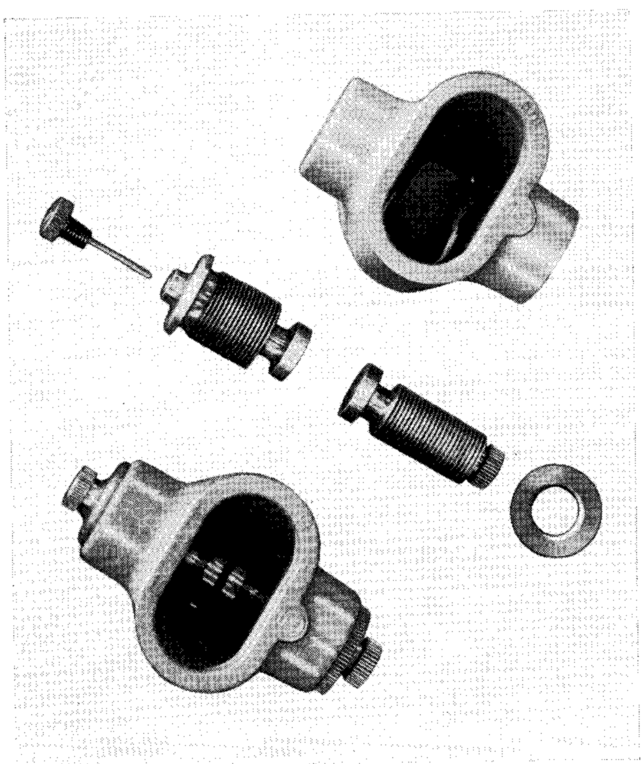

FIG. 3. Oil or Fluid Test Cup for Dielectric Test.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1¼ in. below the top of the cup. (A suitable test cup is shown in Fig. 3, and portable testing outfits in Figs. 4 and 5.)

Procedure. The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with oil-free dry gasoline or benzine until they are entirely free from fibres.

The test cup shall be filled with dry, lead-free gasoline or benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25 kv, the cup shall be considered in suitable condition for testing the oil. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the oil which is being tested, and the test made at once, or the electrodes should be thoroughly dried before using.

The temperature of the test cup and of the oil when tested shall be the same as that of the room, which should be between 20 and 30 C (68 and 86 F). Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion to avoid introducing air, so as to mix the oil thoroughly before filling the test cup. This is even more important with used oil than with new oil as the impurities may settle to the bottom and the test may be misleading.

INSTRUCTIONS

PRESSURE RELIEF VALVE

Style No. 1576 123

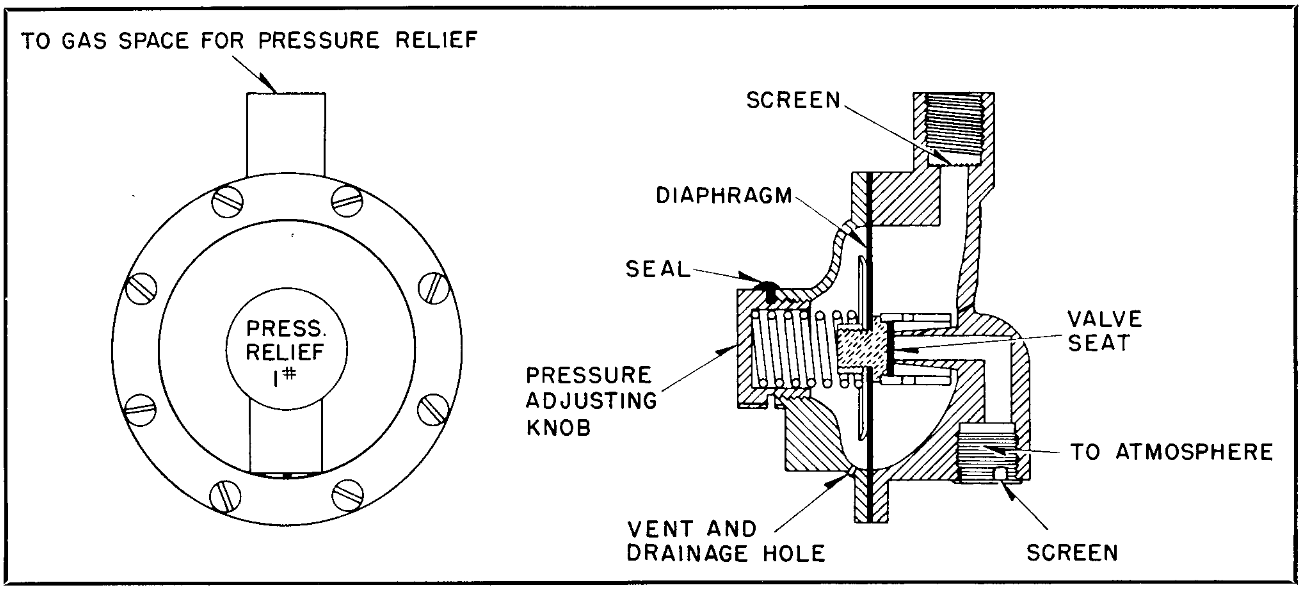

FIG. 1 Pressure Relief Valve

THE GAS SPACE above the oil in the URS Tap Changer is vented to the outside air by a unidirectional relief device; its general construction is shown in Fig. 1. When the pressure exceeds one pound per square inch, the gas space is vented to the outside air to reduce the pressure to this limiting value. As the pressure diminishes, the relief valve closes to prevent in-breathing; oxygen and moisture are thus kept out of the tap changer compartment. The tap changer is designed to withstand the resulting negative pressures. A screen is provided for both the inlet and exhaust ports of the relief valve to keep foreign material and insects out.

The relief valve is set at the factory and its adjusting knob sealed with solder. The out-breathing pressure is stenciled on the adjusting knob.

Adjustment. The adjustment of the pressure relief valve should not be changed unless absolutely necessary, in which case the following procedure is to be observed:

1. Remove the solder seal by scraping away the solder. *Do not attempt to remove the solder by melting* as excessive heat may damage the diaphragm.

2. Unscrew (counter-clockwise) the adjusting screw from the pressure relief device.

3. *Scrape the solder from the threads.* This is absolutely necessary to prevent the solder-coated threads from galling when the plug is screwed back into the relief device.

4. Screw plug into the relief device until the proper out-breathing pressure is obtained. Screwing the plug in, to the right, increases the out-breathing pressure. Before resealing the relief valve setting, its operation should be checked several times to permit the spring and diaphragm to adjust themselves to the new setting.

5. Seal the relief valve setting with a drop or two of solder, being careful to avoid overheating of the diaphragm.

Caution: Remove valve before painting equipment to prevent clogging vents with paint. Be sure vents are open at all times.

WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES I.L. 46-712-1

MAY, 1950

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INSTRUCTIONS

TYPE SU VOLTAGE REGULATING RELAYS

Adjustment On Step Regulators

TYPE SU VOLTAGE REGULATING RELAYS on Step Regulators are adjusted as follows:

1. Press down the balance arm firmly into the pivot bearings and, by moving the left-hand tip of the balance arm from front to rear, note that there is a definite location where the balance arm shaft fits in the V of the stationary bearing fairly near to the center of its movement as limited by the clearance of the plunger inside the operating coil, and by the cover plate on the bearing.

Note: Be sure there is no interference between any of the mechanical parts, coil and plunger, etc. On primary relays with dynamic compensators, clean the rheostat contact surface and brush contact and set on zero compensation. These surfaces may be cleaned by turning the rheostat knob back and forth over its entire range several times. Some customers clean the rheostat surfaces by brushing them with carbon tetrachloride.

2. Remove the magnetic circuit adjusting or "hold-in" screw on top of the voltage coil. Rotate the permanent magnet so that its poles point away from the panel. Adjust contacts wide apart.

3. ***Primary Relay with Friction Damping Device.*** With rear washer of the damping device pushed back and resting on the steady pin, and the arm balanced by applied voltage, note that the arm swings freely up and down without being restricted by friction when the control switch is opened and closed.

4. ***Primary Relay with Dynamic Compensator.*** Set the compensator on zero. The damping due to the compensator cannot be totally removed. Therefore, the check for friction must be carefully made in this case to distinguish "excess" friction from that inherent in the compensator. Note that the balance arm should be stabilized within approximately four swings when the control switch is thrown off and on with the test voltage maintained at the value for which the relay would balance.

5. ***Primary Relay with Friction Damping Device.*** Replace the rear damping device washer to its normal position and adjust the damping device spring so only sufficient pressure will be supplied to stabilize the balance arm within approximately four swings when the control switch is thrown off and on with the test voltage maintained at the value required to balance the relay.

6. With the relay balanced, replace the magnetic circuit adjusting screw (see part 2). Turn the screw down until the balance arm tip moves upward about 1/8 inch.

7. Align the tip of the permanent magnet with the balance beam.

With the contacts adjusted so they will not engage until the left hand tip of the arm is 1/8 inch above or below the tips of the compounding magnet, adjust the compounding magnet gap so the tip of the balance arm will break away from the compounding magnet by raising or lowering the applied voltage by an amount equal to the desired operating band width. Reducing the gap increases the amount of voltage change required and increasing the gap reduces the amount of voltage change required. Read voltage at instant of "snap-away".

8. Adjust the contact spacing so the regulator will restore the voltage, raising or lowering, to a value midway between those required to cause operation. Note that at the mid-voltage value, the left tip of the balance arm will stand slightly above the center of the permanent magnet pole tips. Increasing the contact spacing causes the voltage to be corrected farther after contact is made and decreasing the spacing causes it to be corrected less. Turning the magnet circuit adjusting screw in increases this compounding also. If the magnetic circuit adjusting screw is moved, the balance voltage point as well as the compounding will be changed.

9. Obtain the desired value of voltage to balance the relay by moving the balance weight on the top of the balance arm by means of the adjusting screw.

10. Adjust the compensator to maintain desired load-center voltage.

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SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
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INSTRUCTIONS

CORK-NEOPRENE GASKETS P.D.S. NO. 7249-9

For "URS" Tap Changers and "URS" Regulators

The gaskets used for sealing the various openings and flanges of the "URS" Tap Changers and "URS" Regulators are made of Cork-Neoprene composition.

In use, cork-neoprene gaskets retain their resilient properties indefinitely when compressed to approximately three-fourths their original thickness.

Gasket stops are not used on the "URS" Tap Changers and "URS" Regulators, since cork-neoprene will not creep if reasonable care is exercised when the gaskets are installed.

Note: It is very important that all openings in the tap changer and regulator case be tightly closed before putting a unit into operation. This is necessary whether the unit is for indoor or outdoor operation. For all liquid filled tap changers and regulators, the bushing flanges, main cover, manhole covers, etc., must be oil and gas tight.

GASKET INSTALLATION

Metal surfaces must be thoroughly cleaned of old paint, varnish, gasket cement, scale, etc. The gasket material should be cut into strips of the proper width to conform to the contour of the parts to be joined together. Where it is necessary to use spliced pieces, the end should be scarfed permitting an overlap of four times the thickness of the gasket, maintaining full thickness along the lap. Manhole, handhole and small cover plate gaskets may be used repeatedly if cemented only on one side and if care is used when cover is removed. Inspect before resealing to make certain that the gasket has not cracked or peeled.

For other sealed joints, it is recommended that both surfaces of gasket and metal be coated with cement. Apply a liberal coating of gasket cement M-7386-1, Style No. 4718 80-E (1 quart can) or Style No. 1150 419 (1 pint can,) and allow it to dry one hour before putting the gasket in place. Lapped joints must be thoroughly coated with cement. When the parts are put together, make certain that the gasket is properly located and remains in place.

Tighten enough bolts spaced opposite each other to securely clamp the gasket in place. Proceed to gradually tighten the bolts by going from one bolt to another bolt on the opposite side until all bolts have been tightened with approximately the same amount of torque. Do not completely tighten any bolt before tightening the others. Tighten bolts uniformly.

LEAKAGE TESTS

The best protection against leakage, after a unit has been opened, is to use a new gasket properly cemented to thoroughly cleaned surfaces.

Liquid filled unit tanks, the nameplates of which indicate that they are good for filling under a complete vacuum, may be tested in the field with an internal pressure of ten pounds per square inch above the atmosphere. All other tanks may be tested in the field at a pressure of five pounds per square inch.

The tap changer compartment must have the pressure relief valve removed and the tank connection capped before testing.

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SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES I. L. 46-713-3A
Printed in U.S.A.

OCTOBER, 1952
(Rep. 4-53)

INSTRUCTIONS

MECHANICAL STOP FOR "URS" TAP CHANGER

Cam-operated switches insure that the "URS" Tap Changer positively 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 Fig. 1 of this leaflet.

A mechanical stop disk bearing massive bosses on its top surface is mounted on the main drive-shaft in the operating mechanism compartment. The position indicator drum is geared to the main drive-shaft and has on its top surface a boss which has a separate adjusting screw for each of the two limit positions and set-screws to lock the setting of these adjusting screws. The bosses on the mechanical stop disk are so spaced that when the stop bar enters the wide space the tap changer is stopped with its 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.

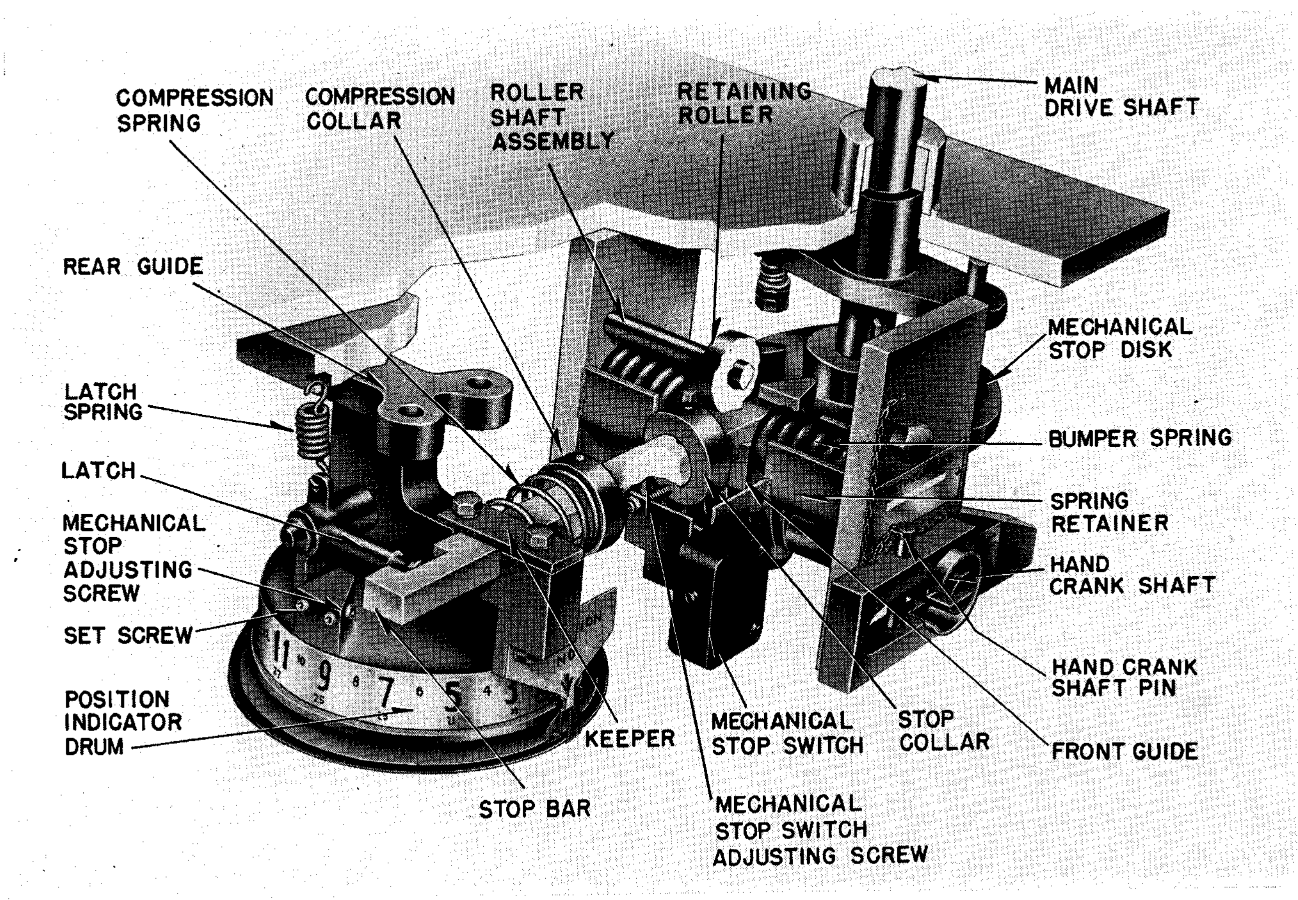


FIG. 1. Cutaway View of "URS" Tap Changer Mechanical Stop

SUPERSEDES I.L. 46-713-5

EFFECTIVE JUNE, 1950

WESTINGHOUSE

INSTRUCTIONS

CONCENTRIC LEAD BUSHING

For Type "URS" Step Regulator

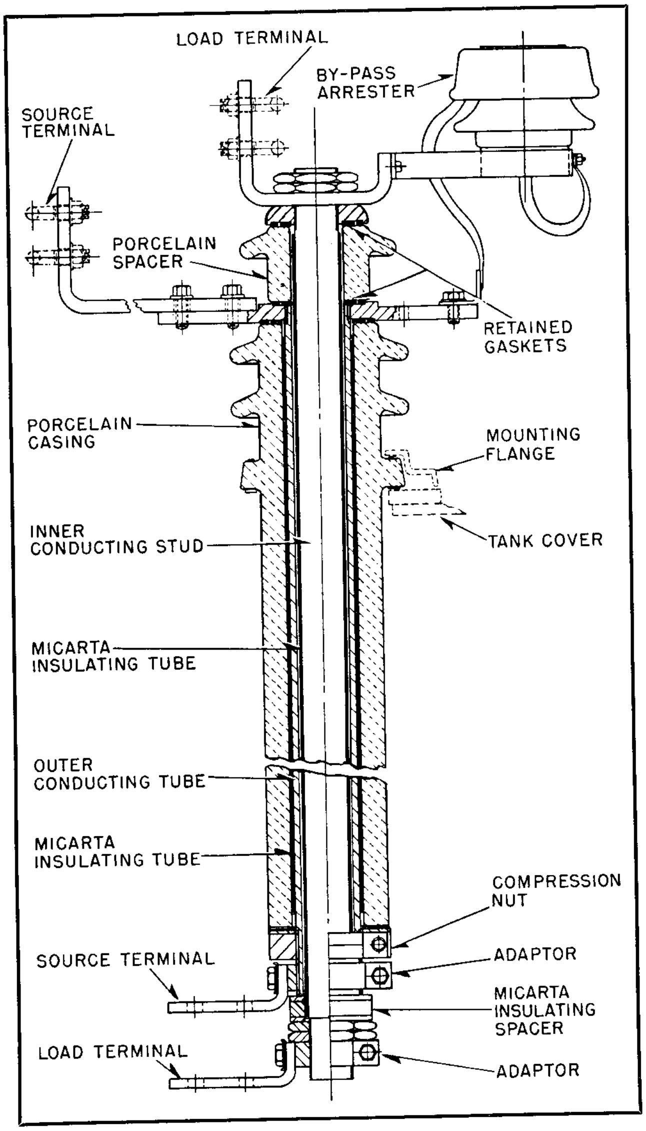


FIG. 1. Concentric Lead Bushing for Type URS Step Regulator

THIS CONCENTRIC LEAD BUSHING was designed specifically for use in Westinghouse Type URS Step Voltage Regulators. Its construction is unique in that both source and load leads of one phase are contained in a single porcelain casing.

It will be noted from Fig. 1, which shows a cross-sectional view of the bushing, that the bushing contains two conductors; an inner stud and an outer conducting tube, separated by a Micarta insulating tube. At the bottom of the bushing a cylindrical Micarta spacer is used as insulation

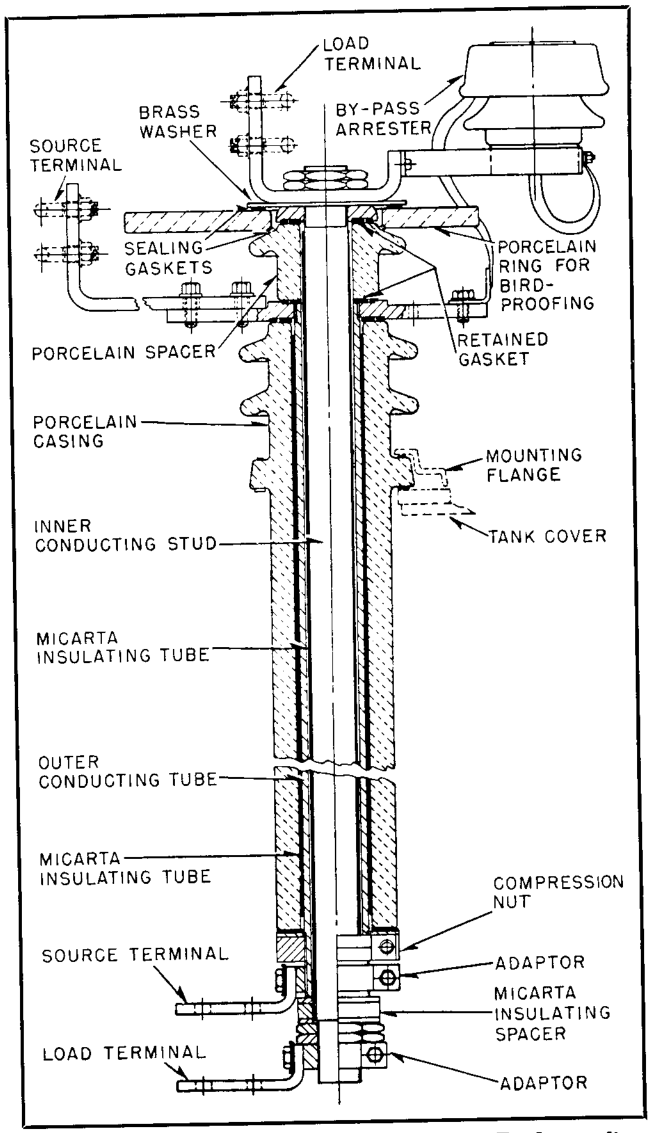


FIG. 2. Concentric Lead Bushing with Bird-proofing for Type URS Step Regulator

SUPERSEDES ADVANCE I. L. 46-713-6A

FEBRUARY, 1951

CONCENTRIC LEAD BUSHING

between the two terminals. Insulating separation is obtained between terminals at the top of the bushing by means of a porcelain spacer.

The bird-proof concentric lead bushing is shown by Fig. 2. A porcelain ring is inserted between the terminals at the top of the bushing to render the construction bird-proof. The standard concentric lead bushing with a skirted porcelain spacer separating the upper source and load terminals may very easily be converted to the bird-proof concentric lead bushing by the addition of the porcelain ring, a brass washer, and two gaskets. (The older concentric lead bushing with a plain cylindrical porcelain spacer separating the upper source and load terminals is not adaptable to bird-proofing.)

The porcelain casing from a conventional Westinghouse bulk type bushing is used so that the bushings may be mounted using standard mounting flanges and hardware. Gasketing practice is the same as for conventional Westinghouse bulk type bushings used extensively on distribution and power transformers.

Source and load terminals at the top of the bushing have been designed so that they can be used in the position shown in Fig. 1 and Fig. 2 or rotated 180 degrees. This permits direction of source and load-line take-off to be reversed by simply changing arrangement of bushing terminals without disturbing either the bushing or the internal connections of the regulator.

The electrical characteristics of the bushing conductors to ground are the same as for standard bushings. The insulation between conductors has been designed to withstand the maximum abnormal 60 cycle voltages which may appear during switching and line faults. The impulse voltage appearing across the bushing terminals is held to a value well within the strength of the insulation between conductors by a by-pass arrester which connects across the line terminals of the bushing.

DYNAC BRAKE

MAINTENANCE

The contacts of the time delay relay should be checked for cleanliness and future life at regular maintenance periods. It is recommended that this be done each time the selector contacts of the tap changer are inspected. This inspection may be accomplished by removal of the two mounting screws which fasten the contact assembly to the time delay mechanism. The plunger and toggle must be depressed when the contact assembly is being replaced (Fig. 4).

In extremely dusty locations the time delay mechanism should be removed from its case by the removal of the four screws, two on each side of the case, and the case thoroughly cleaned. The bronze screen should be removed from the recess and the filter felt cleaned with carbon tetrachloride prior to assembly (Fig. 4).

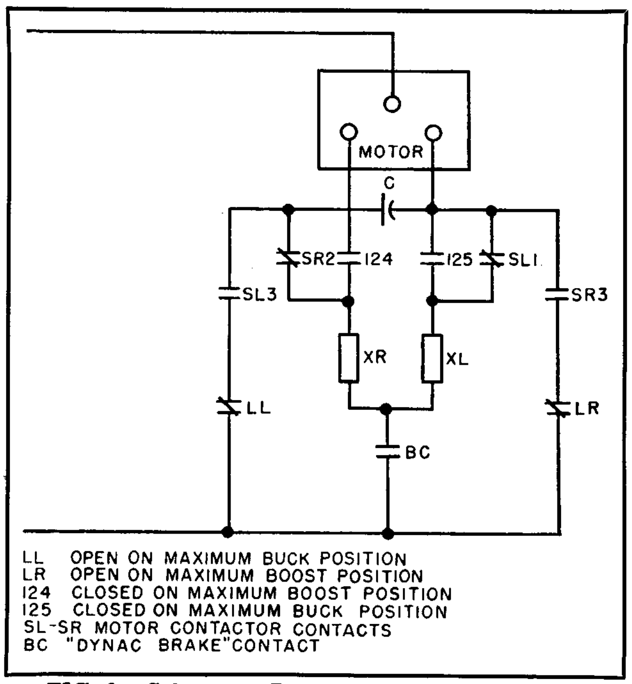


FIG. 6. Schematic Diagram of "DynAC Brake" Connections

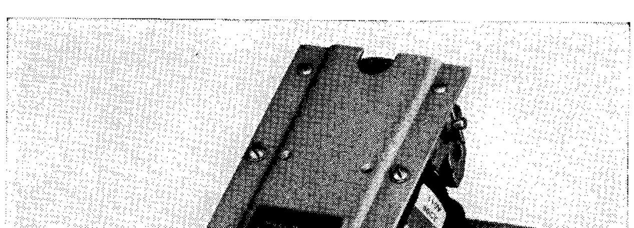
RENEWAL PARTS

The following renewal parts are available from the Sharon Works, Westinghouse Electric Corporation, through the nearest Westinghouse Sales Office:

Complete Solenoid Operated Time

Delay Relay (110 Volt Coil)..S# 1590 746 (Fig. 7)

Time Delay Unit............S# 1590 708 (Fig. 4)



DESCRIPTION • INSTALLATION

INSTRUCTIONS

LIQUID LEVEL INDICATORS

Magnetic Type

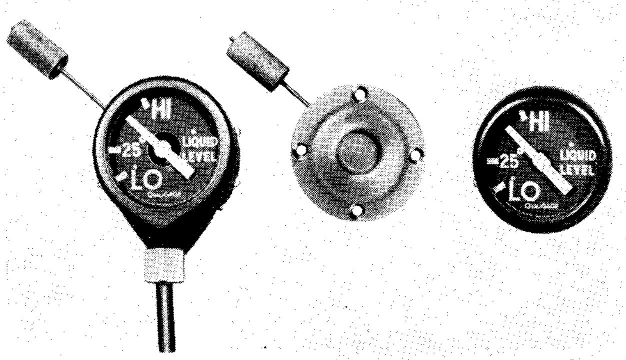


FIG. 1. Bezel with Alarm (left); Body with Float and Rod at Back (center); Bezel without Alarm Contacts.

MAGNETIC TYPE LIQUID LEVEL INDICATORS, designed for application on Westinghouse transformers or related apparatus, are self-contained, dial-reading, weatherproof, submersible, shock-proof, float-operated instruments suitable for use with oil or Inerteen.

Contacts for operating the alarm circuits of a bell, light, or small relay systems can be furnished as integral parts in either size of level indicator.

These indicators are usually shipped mounted on the transformer case, or equipment, and require no maintenance.

DESCRIPTION

These indicators are precision instruments consisting of two main parts, the bezel and the body, and are interchangeable for the same size of device. See Fig. 1. The bezel, or outer assembly, includes the calibrating dial and indicating needle. It is hermetically sealed and should not be subjected to a vacuum since the internal pressure might break the glass. The dial has a black background with yellow markings for high visibility. The indicating needle, also painted yellow, is directly mounted on the forward end of a shaft, the other end of which carries a powerful actuating magnet. The bezel, when in place, covers and protects the mounting screws with which the body is attached to the flange on the transformer tank wall or equipment.

The body is sealed against oil leakage to the outside and encloses another powerful magnet opposite the magnet in the bezel and is coupled through a shaft to the float arm. See Fig. 2. In operation, any motion of the float arm rotates the body magnet, which in turn positively displaces the bezel magnet, thus moving the indicating needle.

In indicators with alarm contacts, a micro switch enclosed in the bezel is actuated at a predetermined position by the motion of the needle shaft. Micro switch ratings are given in Table No. 1. Alarm leads are brought through the underside of the bezel by means of a new triple seal connector, Fig. 3, which consists of the following:

1. Three protruding terminals molded in the case and a locating pin to prevent making incorrect connections.

2. A rubber insulator which has three terminals to mate with the terminals in the case and a hole

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R = .026*
125 AC	5	5
250 AC	2.5	2.5
125 DC	0.5	0.05
250 DC	0.25	0.025

*Equal to or less than .026. If greater, refer to factory for adjusted ratings.

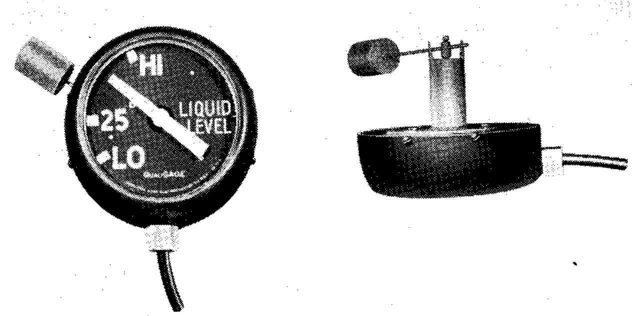


FIG. 2. Side and Front View, Medium Size Float Directly Connected.

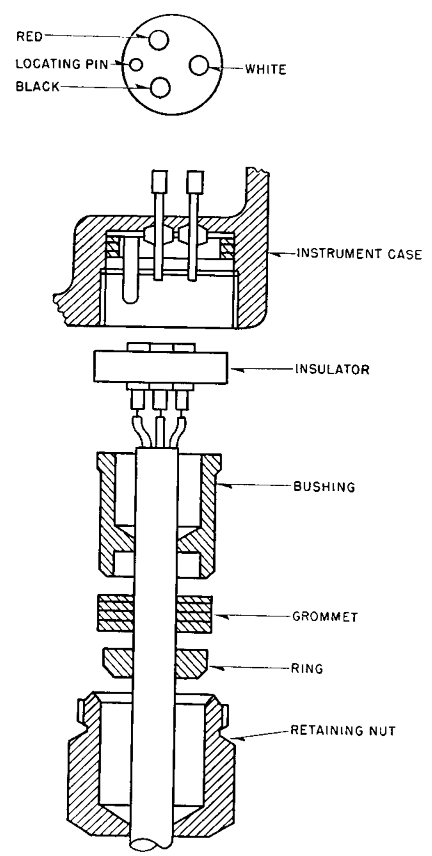


FIG. 3. Diagram of Triple Seal Connector.

through the rubber insulator for location of the locating pin. The ends of the lead wires are tinned and crimped into the terminals on the insulator.

3. A bushing to compress the insulator against the instrument case.

4. A grommet to make a seal between the rubber covered cable and the bushings.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

The connection diagram is shown in Fig. 4.

For indicators that are installed at the factory, the tank is filled to the level which corresponds to a liquid temperature of 25 degrees C, and this level is considered normal. Should the tank be filled at any other temperature, Table No. 2 should be used to determine plus or minus levels from normal. If these allowances are not made, excessive pressures may be built up in sealed tanks or excessive breathing may be produced in Inertaire units, causing a high rate of loss of nitrogen, or the low level alarm may be caused to operate unnecessarily due to the insufficiency of liquid.

If any part of it is damaged, the bezel can be replaced without disturbing the rest of the instrument and without loss of oil. Bezels with alarm contacts can replace the ones without such contacts and vice-versa, if desired.

INSTALLATION

Instruments are usually shipped in place. If shipped separately or if replacement of the body is made, check the operation of the float over its entire range to see that it operates freely and that the needle follows the movement of the float. Draw up the body tightly against the gasket between it and the mounting flange to make a tight joint.

Coat the gasket on both sides and edges with red gasket cement (S# 1150 419, pint can or S# 471 880, quart can). Allow to dry for 15 minutes. Apply a second coat of cement, wipe off excess from the edges and put gasket in place. Mount the instrument and tighten the bolts. Put the bezel in place and tighten the holding screws on the side. If alarm contacts are used, make proper connections to the conduit box.

Important: When checking circuits through this instrument it is necessary to follow Table 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing micro-switches of similar capacities.

RENEWAL PARTS

If repairs to the instrument are necessary, contact the nearest Westinghouse Office.

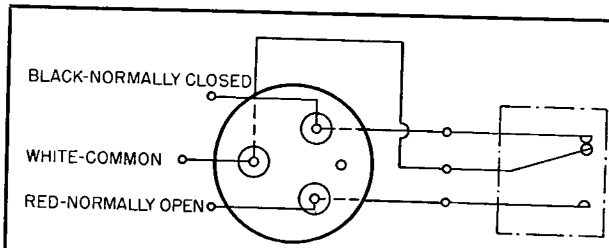


FIG. 4. Connection Diagram for Alarm Leads.

TABLE NO. 2

AVERAGE LIQUID TEMP. (°C)	CORRECT FILLING LEVEL (PERCENT OF SCALE ABOVE OR BELOW 25° C LEVEL)
85 (High)	100
70	75
55	50
40	25
25 (Normal)	0
10	-50
-5 (Low)	-100

DESCRIPTION • INSTALLATION

INSTRUCTIONS

TEMPERATURE INDICATORS

Dial Type

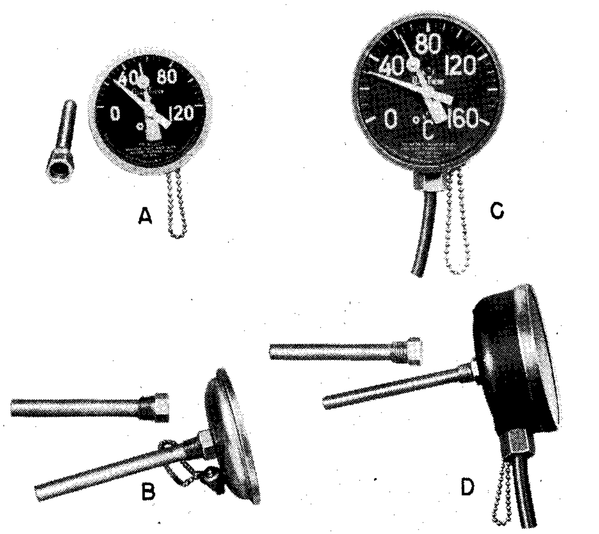


FIG. 1. (A) Front and (B) Side View of Indicator Without Alarm Connections; (C) Front and (D) Side View of Indicator With Alarm Connections.

TEMPERATURE INDICATORS, designed for application on Westinghouse transformers or related apparatus to indicate liquid temperatures, are self-contained, weatherproof and submersible instruments of the dial type, operated by means of bimetallic elements immersed in the liquid.

They are usually shipped mounted on the transformer cases, require no maintenance, and are suitable for oil or Inerteen.

DESCRIPTION

This indicator is a dial type precision instrument whose needle is directly coupled to a bimetallic, spiral actuating element in the stem, which fits closely into a well. The well is of thin-walled construction and screws into a fitting on the transformer case, making an oil-tight connection.

Note: Do not fill the well with a solid or liquid before inserting the stem of the indicator since this may damage the instrument without appreciably helping in the transfer of heat from the oil to the heat sensitive element. The indicator should not be tightened in the well any more than is necessary to place the dial in an upright position.

The dial is calibrated in degrees centigrade and is easily read because of the contrasting black face with yellow characters, graduations, and indicating pointer.

A maximum indicating pointer, red in color, is used to indicate the maximum temperature reached between readings. This hand is reset by wiping a magnet across the face of the dial. The magnet must be held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain on the instrument case to prevent misplacing after using and is self-supporting in a metallic socket on the under side of this case. The method of resetting the maximum indicating pointer is shown in Fig. 3.

There are two types of indicators available—one without alarm connections shown in Fig. 1, A and B, and one with alarm connections shown in Fig. 1, C and D. When alarm connections are required, the latter one will be supplied with the

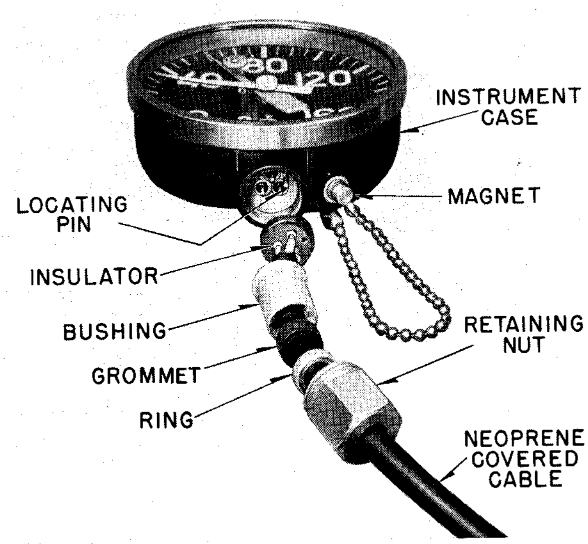


FIG. 2. Triple Seal Connection Details.

SUPERSEDES I.L. 46-716-4B

EFFECTIVE NOVEMBER, 1952

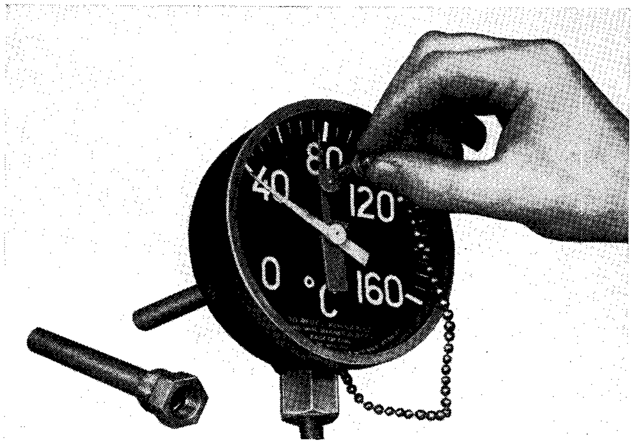


FIG. 3. Method of Resetting Maximum Indicating Pointer.

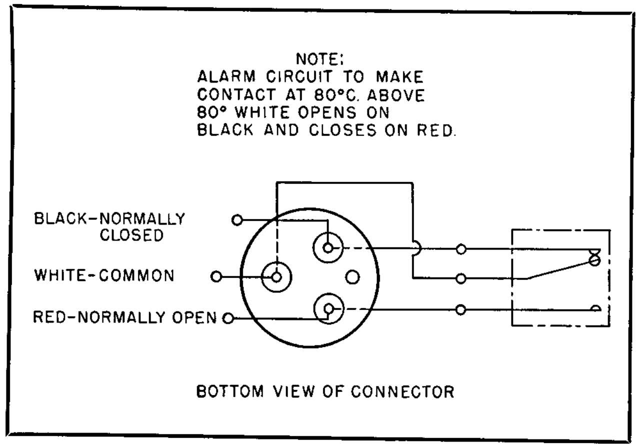


FIG. 4. Connection Diagram for Alarm Contact Leads.

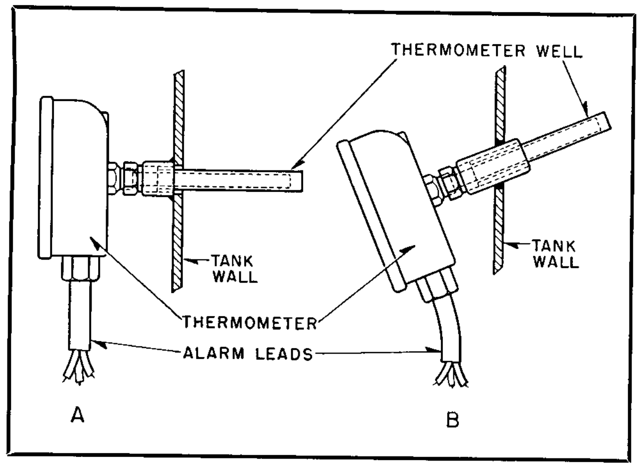


FIG. 5. Indicator Mounted (A) Vertical and (B) Tilted Downward.

new triple seal connection, the details of which are shown in Fig. 2. This connector consists of:

1. Three protruding terminals molded in the case and a locating pin to prevent making incorrect connections.

2. A rubber insulator which has three terminals to mate with the terminals in the case and a hole through the rubber insulator for location of the locating pin. The ends of the lead wires are tinned and crimped into the terminals on the insulator.

3. A bushing to compress the insulator against the instrument case.

4. A grommet to make a seal between the rubber covered cable and the bushing.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

The microswitch in the indicator with alarm connections is factory set to operate at 80 degrees C. The switch is adjustable over a range of ±10°C in relation to the above mentioned value. The switch opens at 5°C less than the closing temperature. The ratings for this switch are given in Table No. 1 while the connection diagram is shown in Fig. 4.

Field Test. Remove the indicator from its well and submerge the stem up to the brass fitting in a closely temperature-controlled, well agitated oil bath. Check the temperature by placing a thermocouple or other accurate temperature measuring device on the stem about two inches from the end. The indicator should be accurate within ±2 degrees C, allowing a minimum of 15 minutes for the indicator to come up to temperature. To adjust the switch to a different value in the indicator with adjustable alarm, remove the sealing plug at the top of the case. Make the proper adjustment of the switch through the opening in the case, and then re-seal the case with the sealing plug.

Important. When changing the alarm setting on those temperature indicators with adjustable contacts, be sure to use any non-setting sealing compound on the threads of the sealing plug. Plastic Lead Seal #8138-3 is recommended. Loose or improperly sealed plugs will allow moisture to collect in the indicators, and cause eventual shorting of electrical circuits or deterioration of dial markings.

INSTALLATION

The indicators are usually shipped mounted in place. To install them when shipped as a separate item, remove the pipe plug from the mounting coupling. Treat threads on the well-to-wall connection with Westinghouse thread cement (Style No. 1150 419, pint can or Style No. 471 880, quart can) and screw the well securely in place, making an oil-tight connection. Then screw the indicator in place, being careful that the dial is in reading position. The indicator can be removed from the well in the tank wall without the loss of liquid.

The instrument may be mounted at eye level (A, Fig. 5) or can be mounted at a higher level and tilted so that it can be read easily when mounted high (B, Fig. 5).

Table No. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R—.026*
125 AC	10	10
250 AC	5	5
125 DC	0.5	0.05
250 DC	0.25	0.025

*Equal to or less than .026. If greater, refer to factory for adjusted rating.

Important: When checking circuits through this instrument it is necessary to follow Table No. 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing micro-switches of similar capacities.

RENEWAL PARTS

If it becomes necessary to repair the instrument, contact the nearest Westinghouse Office. Complete instructions will then be given by the District Engineering & Service Division for the return of the instrument to the factory at Sharon, Pa., to have it repaired and placed in first class condition.

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SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
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WESTINGHOUSE

HANDLING • INSTALLATION • MAINTENANCE

INSTRUCTIONS

BULK TYPE BUSHINGS

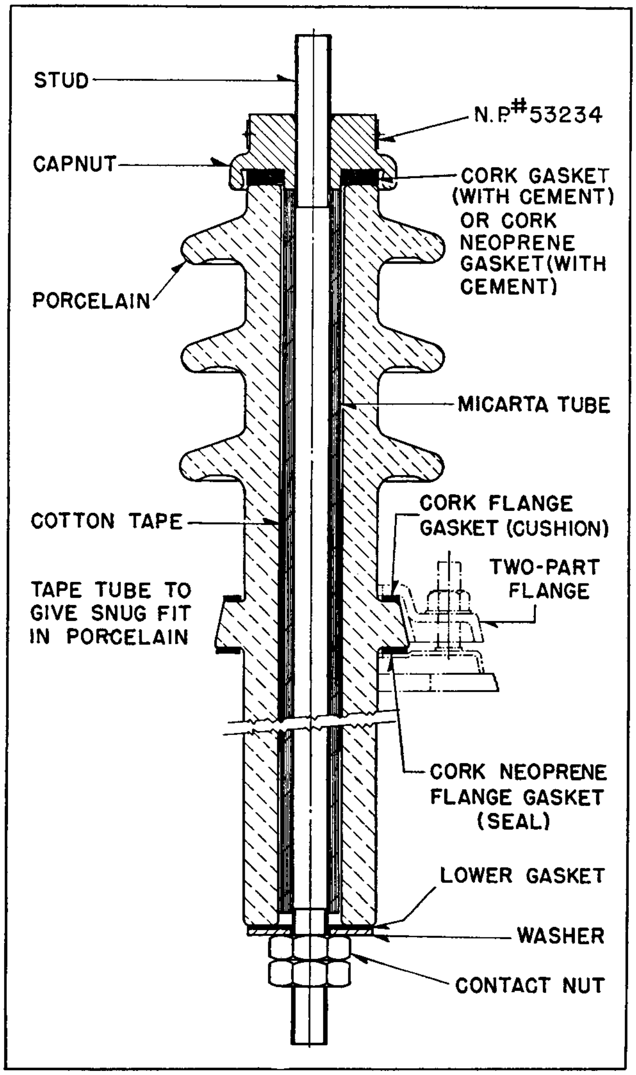

FIG. 1. Cross Section of a Typical Bulk Type Bushing

BULK TYPE BUSHINGS are used for voltage classes of 25 Kv and lower. The standard bulk type bushings consist of single-piece wet-process porcelains with a lead through the center. Type J-2 bushings have solid copper studs while Type J-1 bushings have copper tubes through which a bare copper cable carries the current. For low voltage classes the leads are centered within the porcelains with cotton tape. For higher voltage classes a Micarta tube is inserted between the leads and the porcelains. The lead and the metal cap are sweated together to form a solder-seal joint. A gasket cemented to the cap and porcelain forms a gas-tight seal. At the lower end a cushion gasket is placed between the porcelain and the washer against which the locknut is tightened to complete the assembly of the porcelain and the lead.

Note: Cork-neoprene sealing gaskets are used on bushings for oil-filled transformers and cork gaskets for Inerteen-filled transformers.

HANDLING AND STORING

Care must be taken in handling not to crack the porcelain or damage its surface. Instead of a solid lead, some of the older bulk-type bushings have a cable lead on which the insulation may be damaged if not handled properly.

Store spare bulk-type bushings in a clean dry place.

INSTALLATION

Bulk type bushings are usually shipped mounted in place on the transformer. The bushing is mounted on the cover by a collar on the porcelain which fits into a recess in a pressed metal boss welded to the cover. A gasket cemented between the collar and the boss provides a cushion for the porcelain and forms a gas-tight joint. Care must be taken to prevent breaking or chipping the mounting collar where the gasket seat is made when it is necessary to install the bushings after delivery. Two gaskets are used, one above and one below the collar. The upper one acts as a cushion between the split clamping flange and the collar; the lower gasket is a seal between the porcelain and the cover boss.

When tightening down the split flange, there should be no pressure contact between metal and porcelain. Tighten the nuts gradually all the way around until both gaskets are evenly compressed.

SUPERSEDES I.L.46-718-1

EFFECTIVE JANUARY, 1949

MAINTENANCE AND REPAIR

Inspect the bushings periodically for broken or cracked porcelains and faulty gaskets. Power factor tests are not necessary since they will not show defects in these bushings.

For all bulk-type bushings for 6600 volts and over the exposed metal parts below the cover should be under oil.

Damaged porcelains and gaskets can be replaced in the field with new parts. When there is further damage, a complete bushing should be ordered from the factory. Include the stock order and serial number of the transformer as well as the data on the bushing nameplate when ordering spare parts or complete bushings.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

"DE-ION" ARRESTERS

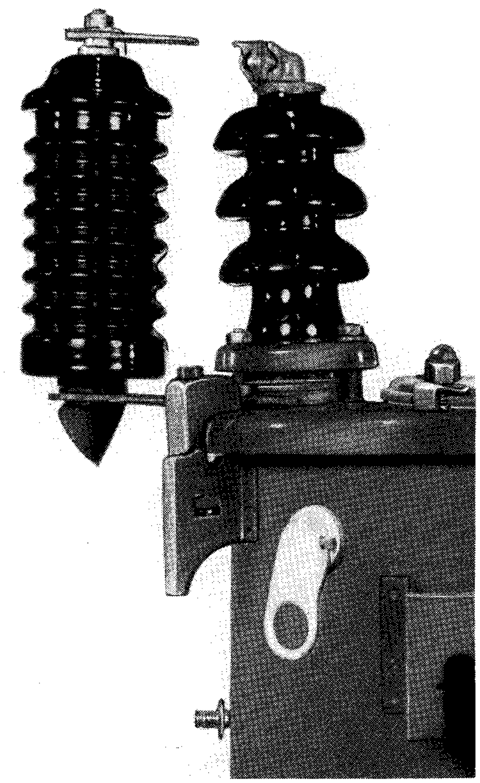

FIG. 1. Cover Mounted De-Ion Arrester.

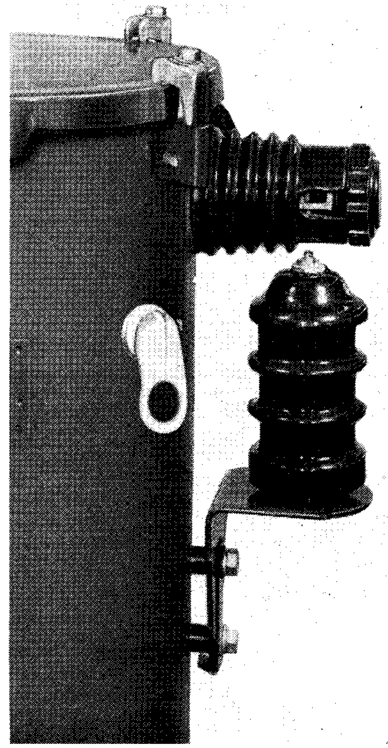

FIG. 2. Wall Mounted De-Ion Arresters.

THE DE-ION ARRESTER is a device which provides surge or lightning protection for electrical equipment. It differs from a plain gap in that it interrupts any power follow current within one-half cycle. It is designed to handle exceptionally high surge currents and will even discharge direct strokes of lightning successfully. Cover and wall mounted units are shown in Figs. 1 and 2, respectively.

RECEIVING

"De-ion" arresters will normally be shipped assembled with the apparatus with which they are to be used. When installed on apparatus in service, the variations of weather conditions have no deteriorating effect. However, the extended temperature or humidity conditions imposed by storage, whether by storage on apparatus, or storage individually, may impose conditions that should be avoided. See that they are not stored in any place having an extreme humidity or high temperature. Avoid storing where water may enter discharge vent of arrester or where the packaging may become water soaked. Exposure of arrester in storage to relative humidity in excess of 70 per cent or below 30 per cent or to heat output of space heaters or radiators for extended periods is not recommended.

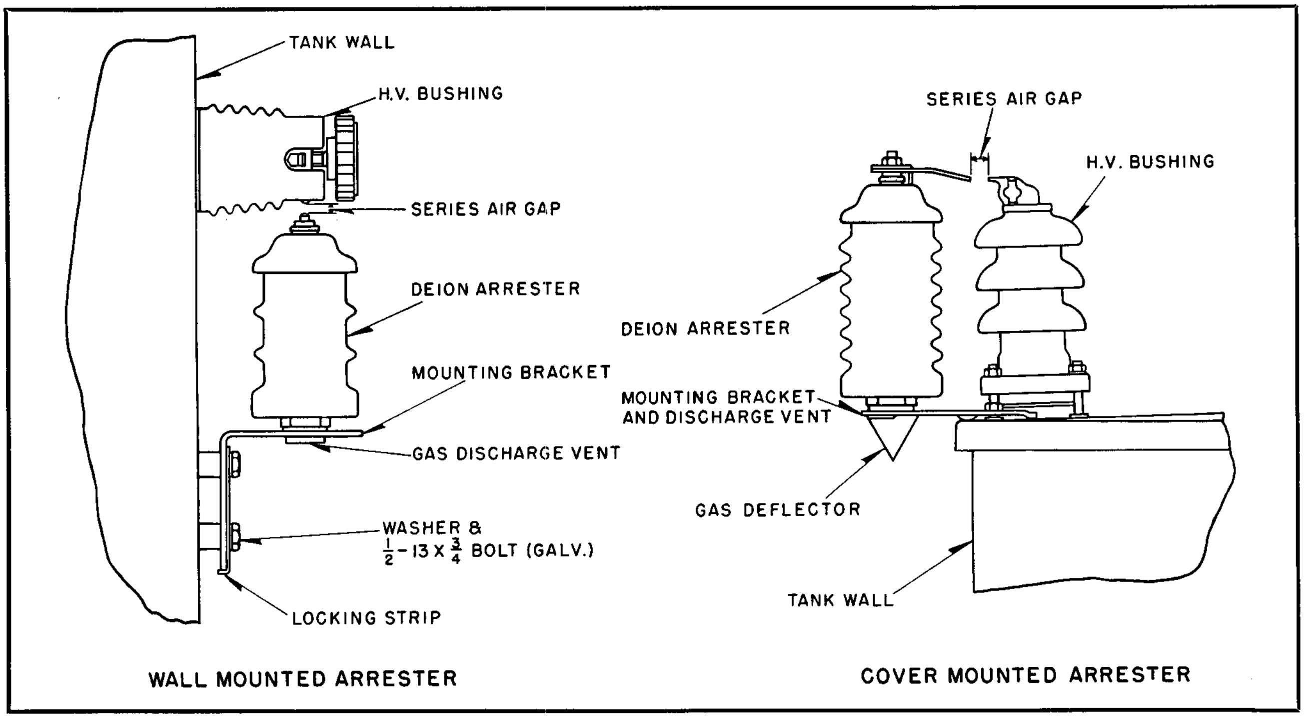

FIG. 3. Schematic Drawing of Typical De-Ion Arresters.

INSTALLATION

The "De-ion" arresters will normally be installed and adjusted at the factory on the apparatus with which they are to be used. However, when received, the air gaps should be checked to make certain that they still are in adjustment. The series gap should be set according to the following tabulation:

VOLTAGE CLASS	GAP SPACING
3 kv	¼ inch
6 kv	⅜ inch
9 kv	½ inch
15 kv	¾ inch

The sketches in Fig. 3 show typical cover and wall mountings; mechanical details will differ on some apparatus.

OPERATION

The "De-ion" arrester consists of a heavy walled vulcanized fibre tube into which steel electrodes are fitted at top and bottom. Between these is mounted a diffuser. This diffuser is made up of a stack of interleaved rings and disks of vulcanized fibre, forming an electrical and mechanical barrier which almost fills the bore of the tube. When an excessive voltage appears across the terminals of the arrester, a sparkover occurs from one electrode around the diffuser and over to the other electrode. This establishes a by-pass for the surge, so that the voltage on the terminal drops immediately to a low value. Simultaneously, a current flows in the arrester under the pressure of the surge voltage, which of course follows the narrow path between the outer surface of the diffuser and the inner wall of the fibre tube.

This preliminary action could be obtained on a simple rod gap which would safely divert the surge to ground. However, a secondary action is required, because after the path to ground is broken down by the surge discharge, the 60 cycle current can flow to ground also. A rod gap will not arrest this flow of current. But when this flow takes place within the narrow fibre-lined annular space between the top and bottom electrode, this power arc is extinguished very rapidly—usually at the first current-zero in the wave.

The explanation for this is found in the reaction of vulcanized fibre when in contact with an arc. Instead of "tracking" - i.e., burning with a resulting deposit of carbon, it evolves large quantities of gas. This is driven out in the arc stream, where it mixes with the ionized particles of the arc. This "de-ionizing" action neutralizes the conducting particles and restores to the electrode space its former insulating qualities in an exceedingly short space of time. The fibre walls themselves remain clean and free of any deposit, ready to function in the same way on the next discharge.

The series air gap at the top or line end of the arrester is for isolating it from the line. That is, it prevents the passage of any leakage current, reduces the electrical stress on the fibre and eliminates mechanical attachment to the line, with a corresponding improvement in convenience and safety.

MAINTENANCE

Normally, no maintenance is required of "De-ion" arresters. If the apparatus to which the "De-ion" arresters are applied is reconditioned, care should be taken to keep paint off all porcelain surfaces. If the outer surface of the fibre tube is refinished, a quick-air-drying synthetic varnish should be used which retains the high insulation necessary over the arrester. This is important because this external or "flashover" level must always be higher than the internal or "sparkover" level.

RENEWAL PARTS

In case renewal parts are required, these should be ordered through the nearest Westinghouse office. A description should be given of the parts wanted, as well as the serial and stock order or style number appearing on the nameplate of the complete apparatus. Due to manufacturing problems, repair part details except as noted will not be furnished for the "De-ion" arrester proper; instead, a complete new arrester will be shipped. Repair porcelains or mounting details may be ordered, however. When installing "De-ion" arresters, care should be used to mount the arresters in the same position as the original arresters so that adequate electrical clearance will be maintained from the high voltage end of the arrester, as well as the proper adjustment at the series gap.

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WESTINGHOUSE

INSTALLATION • ADJUSTMENT • MAINTENANCE

INSTRUCTIONS

VOLTAGE REGULATING RELAY

Style No. 1511 723 With Compensator

For Step Type Regulators

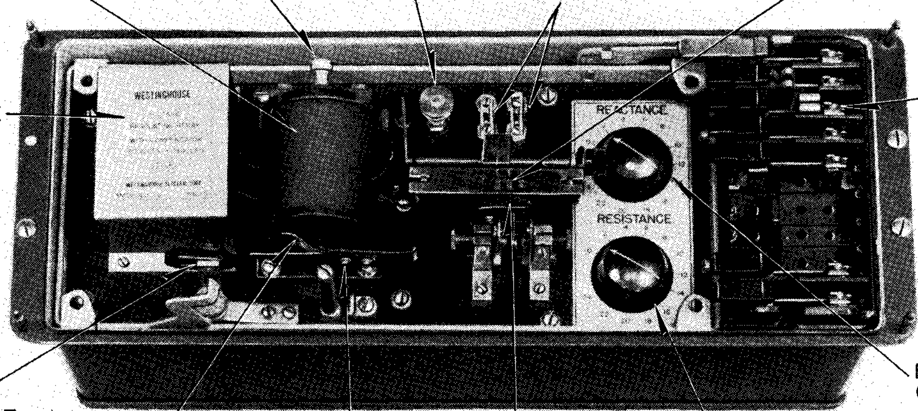

FIG. 1. Front View with Relay in Case (Cover Removed)

VOLTAGE REGULATING RELAY Style No. 1511 723 is of the alternating current solenoid type. Compounding is obtained by means of a permanent magnet. Adjustments for different values of balance voltage are made by shifting a counterweight along a scale which is calibrated in volts.

CONSTRUCTION

The Flexitest type of construction employs a metal case with a tight-fitting removable cover having a glass front. Fig. 1 shows the voltage regulating relay with the cover removed. The complete relay unit is mounted on a chassis which is readily removable from the Flexitest case by opening all the test switches at the right of the case and pulling out the holding levers at the top and bottom. This disengages the chassis from the case and the complete relay is then lifted out by means of the holding levers. See Fig. 2.

The operating parts have been combined into a single moving element which is mounted on a square shaft resting on a knife edge. This construction provides a very sturdy bearing with a negligible amount of friction. The shaft and bracket are made of nitrided steel which is exceptionally hard and resistant to wear and corrosion. A damping device is attached to the beam and is adjustable to provide stability to the action of the relay.

The contacts are made of silver, which results in long life and smooth contact points. They are designed to eliminate contact "sticking".

A "no-voltage" device is included as part of the main assembly with its operating coil connected across the potential source of the voltage regulating relay, and its contacts in series with the common point of the voltage regulating relay contacts. See Fig. 4. This device prevents control mechanism operation in case of voltage failure supplying the voltage regulating relay coil.

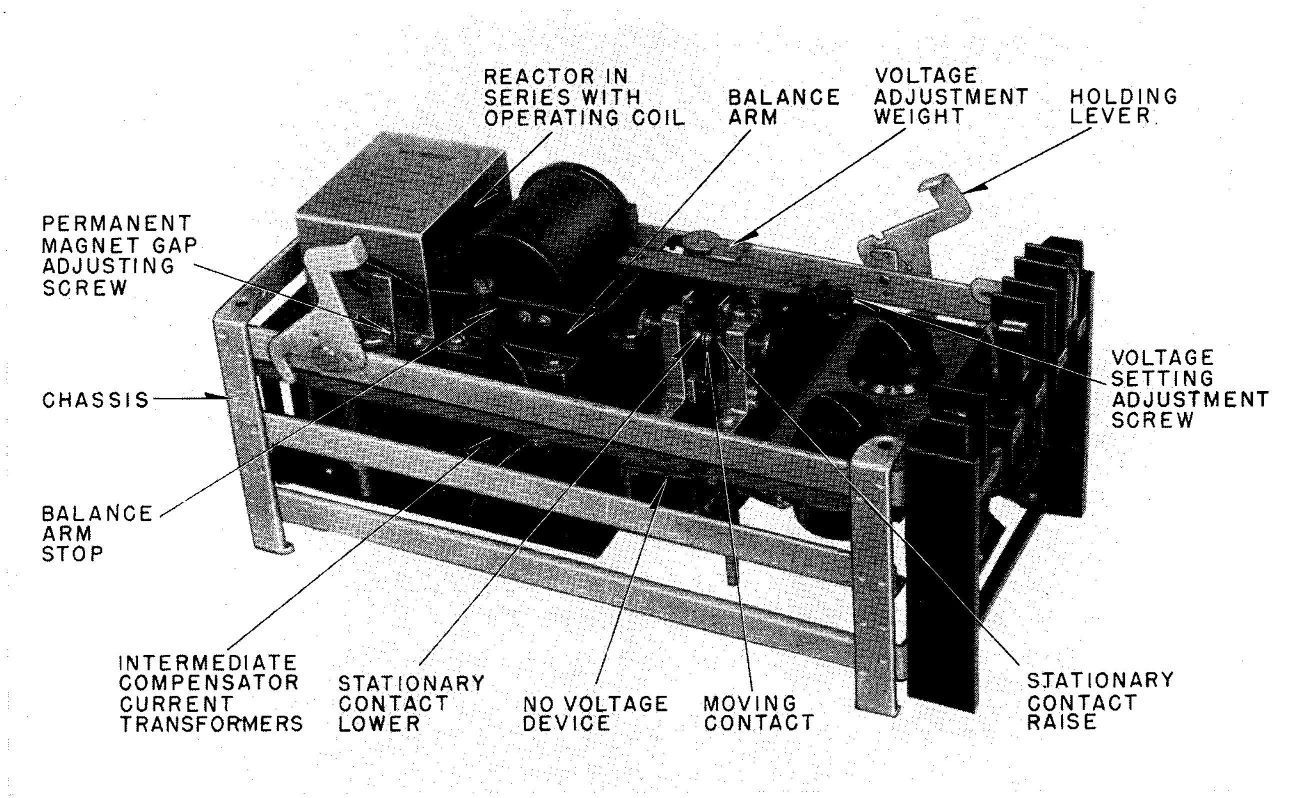

FIG. 2. View of Voltage Regulating Relay and Compensator (Removed from Case)

INSTALLATION

This relay is usually shipped mounted on the tap changer control panel. Before putting into service, the blocking should be removed and its operation checked as follows:

Press down on the relay balance arm so that the pivot shaft is held firmly in the grooved bearing. There should be clearance between the balance arm and the inside of the operating coil, also clearance between the balance arm and the sides of the supported bearing. To adjust the clearance, loosen the two screws which hold the balance arm to the moving part of the bearing and move the arm until it lines up and then retighten these screws. The relay contacts should be in line and should not require any other adjustment, except as specified in the adjustment procedure.

A damping device mounted at the rear of the balance arm and connected to the arm by a link is for the purpose of supplying the required amount of friction to give stability to the relay. This device should not require adjustment and if the relay appears to be slow or sluggish in operation, the relay should be checked carefully for friction at other points before changing the adjustment of the damping device. If the voltage relay balance arm moves too freely and swings excessively, the spring tension should be increased on the damping device by moving the adjusting nut a fraction of a turn.

ADJUSTMENT

The voltage regulating relay is usually adjusted to make contact on a plus or minus 1½ or 2-volt change across the relay coil.

To change the adjustment of the relay, it is desirable to have a source of variable voltage with a range of approximately +5 volts from the normal voltage on the regulator control circuit. A 50-ohm, 25-watt variable rheostat Model H, No. 0149, supplied by the Ohmite Manufacturing Company, Chicago, Ill., can be conveniently used for making the voltage change as described herein. Connect this rheostat in series with the voltage regulating coil and vary it as required. If the regulator is carrying load, the line compensator if used should be set at zero. Be sure to place the Type AB supply circuit breaker in the "off" position before applying an external voltage to the control circuit test terminals.

Fig. 3 shows a voltage regulating relay with its various parts identified. Each part has an important function which should be clearly understood. As the steps in adjusting this relay are

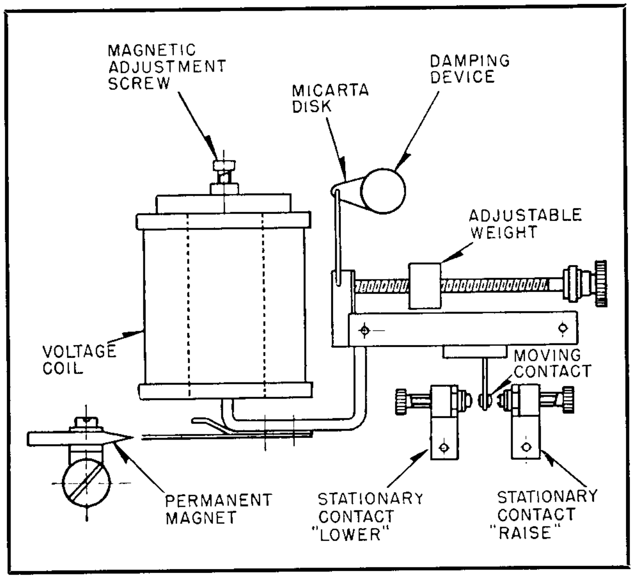

FIG. 3. Voltage Regulating Relay Assembly

followed, the effect that each part contributes to the successful operation of the relay will be apparent.

Checking for Mechanical Friction. If friction is present, it will result in a sluggish or erratic relay. To make this check, the following steps should be taken (see Fig. 3):

1. Revolve the permanent magnet about 90 degrees.

2. Lift the small round Micarta disk on the damping device to relieve the damping effect of the tension spring. This can be easily done by pulling this disk back and then catching it on the pin that protrudes to normally keep this disk in place.

3. Remove the magnetic circuit adjusting screw on top of the voltage coil.

4. Open the stationary contacts wide, seeing that the leaf spring on each stationary contact has a travel of approximately 3/32 inch.

5. Apply a voltage to the test terminals until the beam balances. The weight should be near the middle of the scale.

Under these conditions and if no friction is present, the beam will float without any apparent interference, its movement corresponding to any slight voltage fluctuation.

Upon striking the beam lightly, it will oscillate up and down and gradually come to rest.

However, if there is dirt or foreign material on the knife bearing, or if the end of the beam is rubbing the inside of the solenoid due to misalignment, these movements of the beam will not be smooth and the beam will come to an abrupt stop when it is struck lightly. The bearing should be examined to make certain it is free of any foreign material which would hamper consistent performance of the relay. The surfaces of this knife bearing are of steel, nitrided to a very high hardness and require no lubrication.

Setting the Balance Beam Weight. To adjust the balance beam weight until it balances at the desired balance voltage, proceed as follows:

1. Replace the magnetic circuit adjusting screw on top of the coil. Turn the screw fully down and back off approximately two turns. This is the position of the screw which will give the best operating characteristics to the relay especially on small voltage bands.

2. Turn the permanent magnet to its operating position, and set it with about 1/16-inch gap between the tip of the beam and the face of the magnet.

3. Apply the desired balance voltage to the coil and adjust the position of the weight until the beam will balance opposite the permanent magnet. This can be most easily done if the tip of the beam is lightly held between the finger tip at the balance position while the position of the weight is adjusted to the point where the beam will remain balanced when released.

4. It is, of course, necessary that the position of the weight remain fixed after it is once set. This is accomplished by a spring washer between the end of the beam and the thumb nut which is used to adjust the position of the weight. Check to be certain that there is sufficient friction here to prevent ordinary vibrations from turning the thumb nut, thus resulting in a change of calibration.

Damping Adjustment. After the relay is balanced, next proceed to make it less susceptible to slight voltage fluctuations and vibrations. This is done by restoring the damping disk to its proper position and turning the small nut at the end of the spring until the desired spring pressure on the disk is obtained. Very little spring pressure is required to effect an appreciable damping. From the condition of "free spring" with the adjusting nut just touching the spring, one and one-half (1½) turns of the nut will usually result in sufficient damping. This should cause the balance arm to stabilize within approximately four swings when the control switch is thrown off and on.

Setting Band Width. To set the desired voltage band width; that is, the voltage above and below the balance value at which the beam will move to close its contacts:

and replace in the horizontal position. This position is indicated by dotted lines in Fig. 4 (diagram of voltage regulating relay and compensator).

Caution: Do not remove these links unless the secondary of the line current transformer is short circuited as these links carry the current from the secondary of the line current transformer.

OPERATION

Correct settings for line-drop compensation are most commonly obtained from calculated values of reactance and resistance line drop from the regulator to the load center reduced to full load regulator rating and 120 volts, and later corrected if necessary, from voltage charts taken at the load center.

Calculated values are likely to be sufficiently accurate in ratio of resistance to reactance drop. The compensation for both should be increased if load center voltage falls at periods of high loads and decreased if load center voltage rises at periods of high load.

The regulated voltage may be read between terminals "F" and "G" of the primary relay if separate test terminals are not available. The load center voltage may be read from the scale on the beam of the relay, when balanced.

MAINTENANCE

Voltage Regulating Relay. The amount of relay maintenance which may be required will depend largely upon the voltage conditions existing on the circuit and the degree of sensitivity to which the voltage regulating relay is adjusted. It is recommended that during the first few months of service, inspection be made at rather frequent intervals to prevent excessive tap changer operation. After satisfactory operation is once established, inspections at periods of six months to one year should be sufficient.

It is not necessary to keep the contacts on this relay polished as on older types of relays, since the contacts on this relay are made by rolling rather than by sliding action.

If the contacts on the relay should become worn to an uneven shape, they may be smoothed and reshaped with fine sandpaper and readjusted.

Caution: Do not lubricate the bearings. Keep cover tight.

Compensator. Since the rheostats are very seldom moved after adjustment, there is small chance that they will require any maintenance other than an occasional blowing out to remove any dust which may have accumulated.

Renewal Parts. Order renewal parts from the nearest Westinghouse Sales Office or from the Sharon Plant. Give the style or stock order number and serial number as stamped on the regulator nameplate, together with description of parts required (see Figs. 1 and 2).

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1. Set the permanent magnet with a very small air gap between the tip of the beam and the face of the magnet (1/32 inch or less) using adjusting screw.

2. Gradually increase the voltage to the value of the upper band limit. For example, this would be 2 volts above the balance value for a plus and minus 2-volt band.

3. By means of the knurled adjusting screw, located below the permanent magnet, increase the air gap between the magnet and beam until the beam just breaks away from balance and moves up into the coil.

Note: There is a change in voltage across the coil of about one volt when the beam is moved from the extreme bottom to the top of its travel. For this reason, the voltage should be read at the instant the beam breaks away.

4. Manually return the beam to balance and decrease the voltage to the balance value.

5. Gradually decrease the voltage from the balance value until the beam just breaks away and falls to its bottom stop. Note the voltage at the instant it breaks away.

If it is observed that the beams fall out too soon, adjust the position of the weight on beam to the right slightly until the beam will fall out at the desired voltage. If the beam does not fall out until some voltage below the desired value, adjust the position of the weight to the left slightly until beam falls out at the desired value. These adjustments should be very slight. A large adjustment will affect the upper limit.

In making the final adjustments of the band width, for small voltage bands, the position of the magnetic circuit adjusting screw, the position of the weight on the beam, and the position of the permanent magnet should be carefully coordinated to obtain the correct break-away voltages.

Adjusting the Compounding. The final adjustment or the adjustment of the stationary contacts determine the "compounding" of the relay. The "compounding" is the difference between the voltage at which the contact will close and the voltage at which the contact opens. The compounding can be increased by increasing the contact spacing and decreased by decreasing the contact spacing. It is recommended that at least 3/4-volt compounding be used; that is, with a plus and minus two-volt band and 3/4-volt compounding, the contacts should open at plus or minus 1 1/4 volts.

1. With the beam at its upper limit of travel, set the voltage to the value at which it is desired that these contacts open.

2. By means of the contact adjusting screw, gradually move the left-hand stationary contact inward until the beam will just return to balance. Make certain that the contacts are open at balance.

3. With the beam at its lower limit of travel, set the voltage to the value at which it is desired that this contact open.

4. By means of the contact adjusting screw, gradually move the right-hand stationary contact inward until the beam will just return to balance. Make certain that both contacts are open to balance position.

Final Checking. The relay now being fully adjusted, its over-all operation should be checked. Increase and decrease the voltage from the balance value and observe the voltages at which the contacts make and break. When assured that the operation is satisfactory, tighten the locking nut on the magnetic circuit adjusting screw, and mark the position of the weight on the metal plate below it.

Plus and Minus 1-Volt Band Widths. When voltage band widths of plus and minus 1 volt are required, it is necessary to replace the standard permanent magnet with a smaller more pointed one, Style No. 1080 890, and make adjustments as described above.

Note: The smaller magnet may be ordered from the nearest Westinghouse Sales Office.

The line-drop compensator for use with the voltage regulating relay consists of two rheostats, one for resistance compensation and one for reactance compensation. They are connected to the voltage regulating relay coil series reactor and two small intermediate current transformers, the secondaries of which supply the required current to the compensator. The primary windings are arranged for connecting to the main current transformer supplying the compensator circuit.

The compensator is mounted in the same chassis with the primary relay so as to form a single unit. The rheostats for the resistance and reactance compensation are mounted on the rear of the primary relay panel and are operated by dials accessible from the front. These are set to a desired degree of compensation as indicated by an engraved steel plate having a graduated scale.

The two intermediate current transformers are mounted on a plate suspended from the primary relay panel and their primaries are connected to the compensation reversing posts with removable links so that when the links are connected in the vertical position as shown in Fig. 1, normal compensation is obtained. To obtain reverse reactance compensation, remove both links from the posts

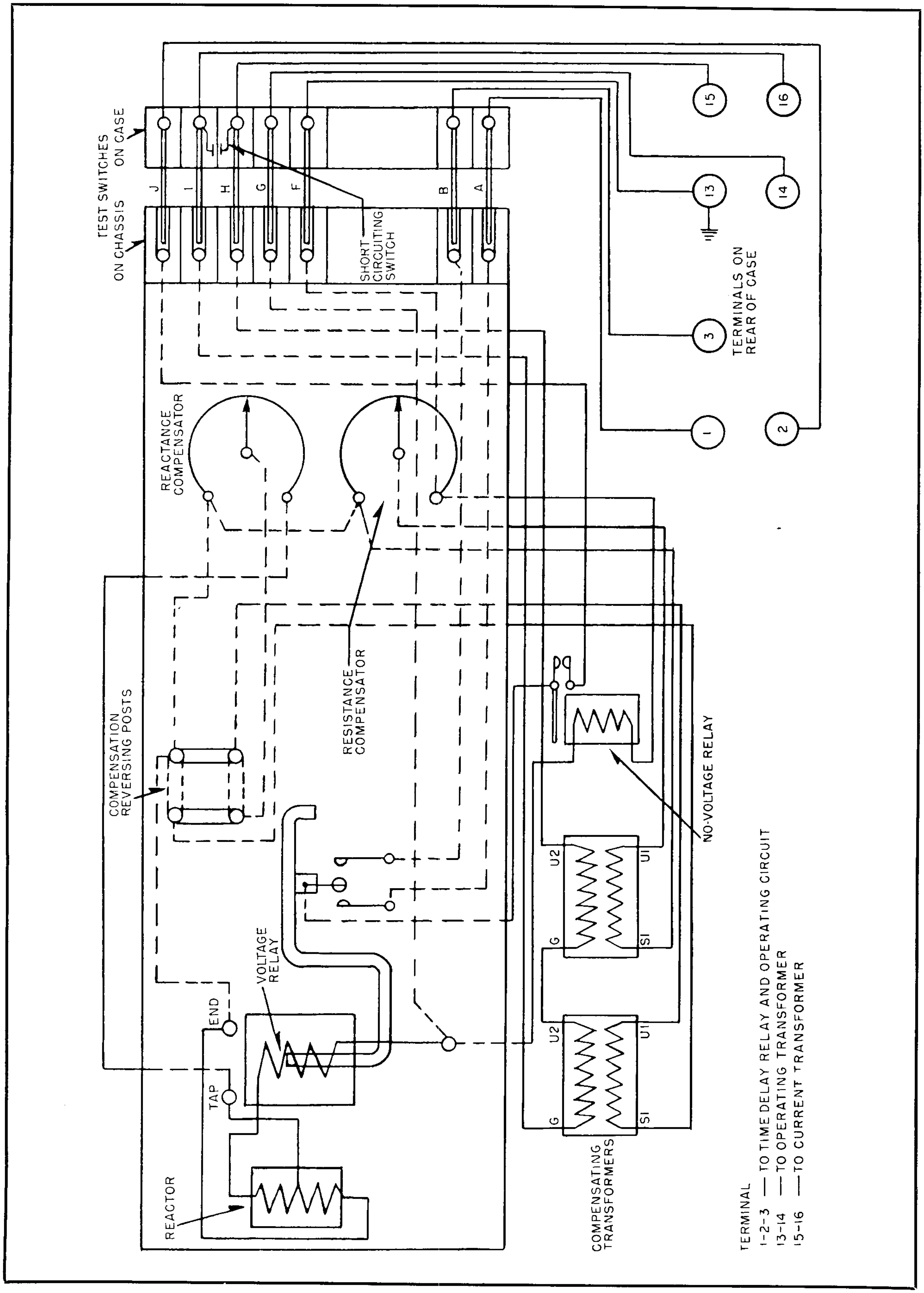

FIG. 4. Diagram of Voltage Regulating Relay and Compensator

DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE AB DE-ION CIRCUIT BREAKERS

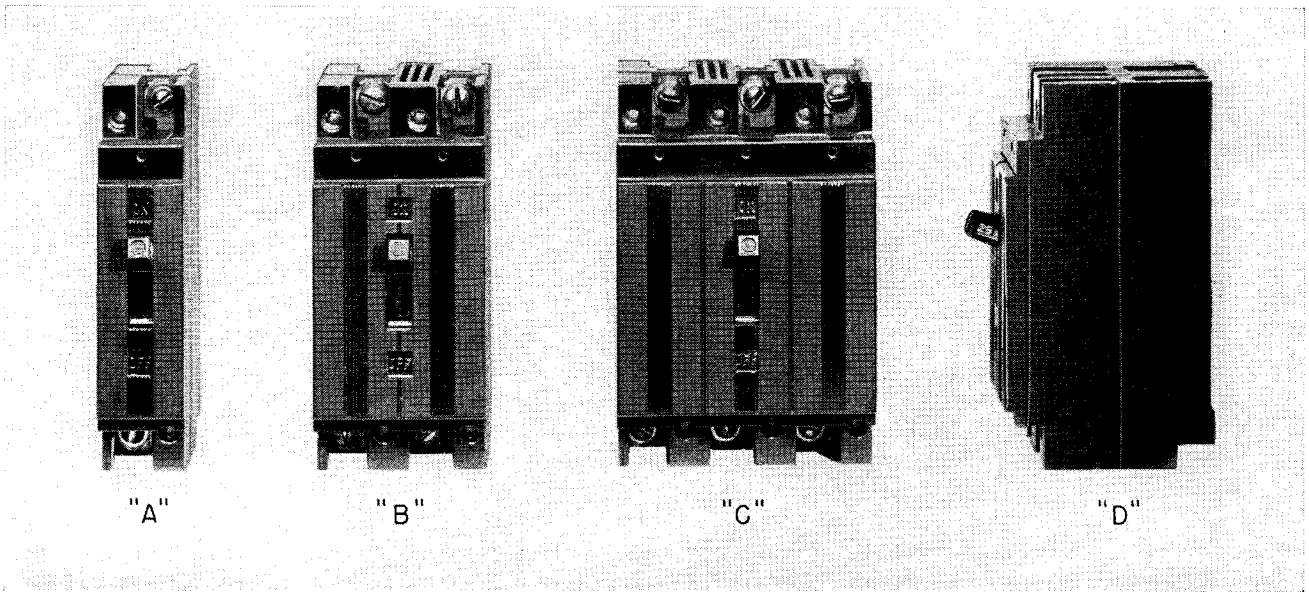

FIG. 1. Type "AB" De-ion Breakers: "A", Single-pole; "B", Two-pole; "C", Three-pole; "D", Side View of Three-pole

TYPE "AB" DE-ION BREAKERS with thermal and magnetic overload trip as used on Westinghouse tap changer equipment are intended to protect from overloads the auxiliary transformer windings that supply power for the control. The mechanism is completely enclosed in a sealed case and requires no maintenance.

CONSTRUCTION AND OPERATION

The case baffles, which resist entrance of dust into the mechanism, and also the operating lever, are moulded from insulating material. The breaker is dead front, only the terminals being exposed, and it is not necessary to open the sealed case to make connections.

Figure 1, ("A", "B" and "C") shows the front views of the single, double and three pole breakers respectively. Figure 1, "D", shows a side view.

The butt type contacts are operated by a spring toggle which snaps them either open or closed with a quick make and break action. When released due to overload, the toggle is trip free from the handle so that it is impossible to hold the contacts closed on a fault.

The contacts open in front of a De-ion grid stack and the proper magnetic circuit is set up by the current to move the arc off the contacts and into the grid. The De-ion grid divides the arc into a series of short arcs and on the first current zero, the arc is extinguished by the action of a large number of cathodes in series.

When De-ion Breakers are mounted in the transformer oil they have openings in the case opposite the De-ion grids to allow free circulation of oil.

The breaker is tripped on overload by a bi-metal and magnetic latch which is calibrated to carry full load continuously but to trip eventually on 125% load. On high overloads, the breaker has inverse time characteristics which make it almost instantaneous on short circuits.

When the breaker trips from overload, the handle moves to a mid-position which gives a visible indication that the breaker has tripped. Before the breaker can be closed again, it has to be reset by

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pushing the operating handle downward and then closed by raising handle. On multipole units, the separate trip mechanisms are connected by an insulated common trip bar so that an overload on one element will trip all elements.

MAINTENANCE

The entire mechanism is enclosed in its moulded case and sealed at the factory against tampering and to insure permanent calibration. As the contacts are protected by the de-ion chamber against burning, no maintenance is necessary.

RENEWAL PARTS

In case the breaker should become inoperative or damaged a new one should be ordered from the nearest Westinghouse Electric Corporation Sales Office or directly from the Sharon, Pa. Plant giving serial and stock order number as stamped on the transformer nameplate, and style number and rating of breaker.

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SHIPPING • UNPACKING

INSTRUCTIONS

SHIPMENT OF TRANSFORMERS IN OIL

SHIPMENT

When transformers are shipped in oil they are usually shipped in their own tanks, but sometimes when other requirements make it desirable the transformers may be shipped in a special shipping tank.

Transformers with radiators are usually shipped in their own tank, but with some or all of the radiators removed. The radiator flanges on the tank are covered by blind flanges. The detached radiators are always crated and shipped separately. Where radiator valves are used it is unnecessary to drain the oil from the tank to install the radiators. The additional transformer oil for the removed radiators is usually shipped in tightly sealed drums.

Some of the bracing in a transformer may be put on for shipment only. The transformer core is always braced or tied securely to the tank wall in large transformers to take care of shocks received in shipment. If the transformer is removed from the tank for inspection during installation, it is unnecessary to replace these tie plates if there is no possibility of reshipment.

Sometimes special blocking or bracing that may interfere with normal operation is used for shipment. In such cases, it is essential that this special bracing be removed before the transformers are placed in service. Where special bracing is to be removed, the outline drawing will contain notes of instruction regarding it. The outline drawing should always be checked for such instructions.

The general practice is to ship as many detail parts and bushings in place as is safe and as shipping clearances will permit. Where it is necessary to remove bushings, the openings in the cover or tank wall are covered with blind flanges for shipment. Any bushings and detail parts removed for shipment are always boxed separately and are to be mounted when the transformers are installed.

Core Form Transformers. In most cases core form transformers can be shipped in their own tanks in an upright position.

It is occasionally necessary with large transformers to have a joint in the tank so that the top section may be removed for shipment. Either the regular cover or a special shipping cover is bolted on the top of the lower section of the tank for shipment. If a special cover is used it is sometimes made with a box-like structure which makes room for terminal boards, etc., which extend up beyond the top of the lower section of the tank. The tank is usually filled until the oil extends up into this box. **Care must be taken to lower the oil below the joint before removing this cover.**

Shell Form Transformers. Shell form transformers are usually made with form-fit tanks. When the form-fit tank is used, transformers may be shipped in the upright position or lying down in a horizontal position. The bracing for units in the form-fit tanks is usually arranged so that it need not be removed. In exceptional cases, particularly when the transformer is shipped horizontally, it may be necessary to use additional bracing for shipment. In such cases, the outline drawing will contain notes calling attention to the necessity of removing any special bracing.

Occasionally, shell form transformers are placed in octagonal or rectangular tanks. The larger sized units may require sectionalized tanks with special covers to meet height limitations in shipment. If a hat-shaped cover is used, care must be taken to lower the oil below the joint before removing this cover. The outline drawing will indicate when special covers are used in shipment.

UNPACKING

When a transformer is shipped in its own tank with oil, unpacking is a simple matter. It is ready to be set in place when the crating or bracing is removed.

The transformer should be examined carefully to ascertain whether it has been damaged in shipment and whether all parts are in place and in good condition.

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SHIPMENT OF TRANSFORMERS

All bushings and accessories that are shipped separately should be thoroughly protected against moisture until they are installed. Care should be exercised during the installation of these parts to protect the transformer against the possibility of any moisture entering. As an extra precaution against moisture having entered the transformer during shipment or installation, the dielectric strength of the oil should be tested before the transformer is put in service. The dielectric strength of the oil when tested in a standard cup should be not less than 22 kv.

If a transformer is shipped with oil in a shipping tank, the shipping tank should not be opened until the transformer case is in place ready to receive the transformer. The shipping tank should not be opened until temperature of the transformer is the same or higher than the air temperature, to avoid moisture from condensation. The greatest care should be taken to avoid getting moisture in the transformer while transferring it from the shipping tank to its case.

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INSTRUCTIONS

DETERMINATION OF DRYNESS and METHODS OF DRYING OUT

All transformers are dry when they leave the factory, but since they may absorb more or less moisture during shipment and storage, they should not be put into service until it has been determined that the oil and insulation are dry enough for safe operation. The higher the voltage, the more chances there are of trouble from moisture, and the greatest care should be exercised to make sure that the moisture is practically eliminated.

DRYNESS OF OIL AND WINDINGS

When a transformer has been shipped assembled in its case with the oil, four or five samples of oil should be drawn from the bottom of the case and tested. If the average of these tests shows a breakdown value of not less than 22,000 volts on a standard 1/10″ gap test-cup, the insulation and oil are in a satisfactory condition for service. If the average breakdown value is less than 22,000 volts, the oil must be dried. Whether the windings must also be dried should be determined as described under "Insulation Resistance" after the oil has been drawn off. If the insulation resistance is of the proper value, drying of the windings is unnecessary and the transformer may be put into service as soon as the dry oil has been put into the case, provided there has been no delay in drying the oil and returning it to the case.

When a transformer is shipped without either oil or dry nitrogen gas, drying out will be necessary, except in the cases of transformers 500 kva, and under, and of less than 7500 volts. These latter transformers should be tested for dryness before being put into service.

There is no absolute method of determining when the insulation of a transformer is dry, but proper measurements of insulation resistance will serve as an approximate indication of its condition.

Insulation Resistance. Insulation resistance measured with the transformer cold is greater than when measured with it hot and is also greater out of oil than when immersed in oil. It is the out-of-oil resistance that is used as the standard of comparison. Therefore in order to determine the condition of the insulation, the transformer should first be heated to a temperature of 60° to 70°C. After it has reached this temperature, it should be maintained there for 24 hours. The insulation resistance out of oil may then be taken and, in general, it may be said that if it does not measure less than 1 megohm for every 1,000 volts of rated line voltage, drying out will usually be unnecessary. If it measures less than this, drying out will usually be necessary.

INSULATION RESISTANCE CORRECTION TABLES

TABLE A	TABLE B CORRECTION FACTORS (Use either column)	
Resistance Measured in Air At:	To determine Resistance in Air at 75°C DIVIDE by:	To determine Resistance in Air at 75°C MULTIPLY by:
—15°C	64.0	.0156
—10°C	51.0	.0196
—5°C	40.3	.0248
0°C	32.0	.0312
5°C	25.4	.0393
10°C	20.1	.0497
15°C	16.0	.0625
20°C	12.7	.0787
25°C	10.1	.0990
30°C	8.00	.125
35°C	6.35	.157
40°C	5.04	.198
45°C	4.00	.250
50°C	3.17	.315
55°C	2.52	.397
60°C	2.00	.500
65°C	1.59	.629
70°C	1.26	.794
75°C	1.00	1.00
80°C	.794	1.26
85°C	.629	1.59
90°C	.500	2.00
95°C	.397	2.52
100°C	.315	3.17
105°C	.250	4.00
110°C	.198	5.04
115°C	.157	6.35
120°C	.125	8.00

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DECEMBER, 1951

There may be cases where conditions prevent heating up the transformer, but facilities are available for removing the oil from the transformer. In this case the insulation resistance should be corrected to a reference temperature of 75° centigrade using the tables shown on Page 1. These correction factors are suggested for insulation out of oil. Insulation in oil will have a resistance that will be approximately 1/2 to 1/4 of the resistance of the same unit out of oil at the same temperature.

METHOD OF MEASUREMENT

Megger. The most satisfactory method of measuring the insulation resistance is by a megger. This instrument is very convenient to use and indicates the megohm resistance directly. In order to secure uniform results, measurements of insulation resistance with the megger type of instrument should follow a regular procedure.

The recommended practice in measuring insulation resistance is to always ground the tank and the core iron or be sure they are grounded. Short-circuit each winding of the transformer at the bushing terminals. Resistance measurements are then made between each winding and all other windings grounded. Windings are never left floating for insulation resistance measurements. Solidly grounded windings must have the ground removed in order to measure the insulation resistance of the winding to other windings grounded. If the ground cannot be removed as in the case of some windings with solidly grounded neutrals, the insulation resistance of the winding cannot be measured. It is then treated as part of the grounded section of the circuit.

For example, in the case of a three-winding transformer, the high-voltage, tertiary-voltage, and low-voltage windings are each short circuited by connecting their terminals together. The high voltage winding insulation resistance is measured by connecting the high voltage terminals to the line or resistance terminal of the megger. The low voltage and tertiary-voltage windings are connected together and to ground and to the ground terminal of the megger. The guard terminal of the megger, if the instrument has a guard terminal, is not used but left floating. The resistance measured is commonly designated the H-LTG resistance. Likewise the other windings are measured and the measurements called T-HLG and L-HTG resistances. Two-winding transformers would have only two resistances, H-LG and L-HG.

The instrument used to measure the resistance should have a voltage output of at least 500 volts. The maximum insulation resistance to be measured must be less than the megohm rating of the instrument. Resistance readings at the extreme upper end of the instrument scale are not reliable. Where this condition exists an instrument capable of measuring a higher resistance should be used. The measuring lead should be air insulated from all other leads and from ground and grounded objects in order to prevent misleading results due to measuring conductor insulation resistance instead of the transformer insulation resistance.

The megger type of instrument may be motor driven, hand cranked or supplied by a rectifier built in the instrument. If a motor driven or a rectifier instrument is used the insulation resistance indicated by the instrument should be recorded approximately one minute after the voltage from the instrument is applied to the transformer. In other words the voltage from the instrument should be applied for one minute before recording the resistance value. In the case of the hand cranked instrument the time interval after starting to crank the instrument until recording the resistance value indicated should not be less than 30 seconds and preferably should be approximately one minute. This reduction in time is permissible due to the difficulty of cranking a megger continuously for one minute. In any case the time interval during which the voltage is applied should be consistent throughout the tests and should be recorded with the insulation resistance values. All measurements should be made with the same procedure to avoid errors and to obtain comparative results.

Voltmeter. In the absence of a megger or similar type of instrument a high resistance voltmeter, usually specially designed for the purpose, may be used. These voltmeters usually have an internal resistance of one megohm. Sufficiently accurate results cannot be obtained using an ordinary voltmeter. Five hundred to six hundred volts should be used in making measurements by the voltmeter method. The usual precautions are necessary to prevent hazards due to the high voltage.

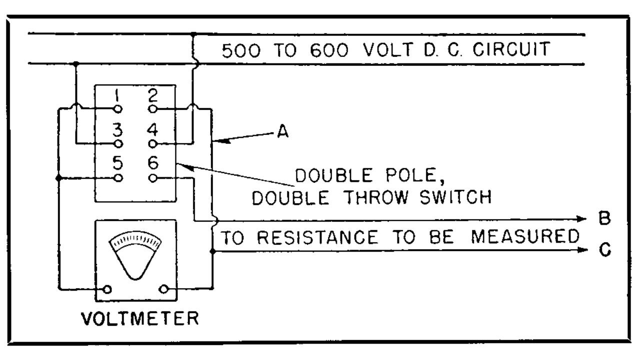

FIG. 1. Connections for Measuring Insulation Resistance.

DETERMINATION OF DRYNESS

The method of measurement is to read first the voltage of the line, and then to connect the resistance to be measured in series with the voltmeter and take a second reading. The same general procedure in taking the insulation resistance measurements should be followed as that explained under the megger method of measurement.

The method of calculating the insulation resistance is given by the following formula:

$$R = \frac{r\,(V\text{-}v)}{v} \quad \text{in which}$$

V = voltage of line.
v = voltage reading with insulation in series with voltmeter.
r = resistance of voltmeter.
R = resistance of insulation.

The method of connection for the measurement is given in Fig. 1. With a voltmeter having a resistance of one megohm, the calculation is somewhat simplified, since r = one and the formula becomes:

$$R = \frac{V - v}{v} = \frac{V}{v} - 1 \text{ megohm}$$

Since high resistances are being measured, great care must be taken to thoroughly insulate all wiring used for making connections. The best way is to use wires stiff enough to support themselves so that they can be run directly between the connected points without intervening supports.

The voltmeter should be placed on a table that rests on well insulated, dry supports. A double-pole double-throw oil switch is preferable to an ordinary air switch mounted on a marble or slate base because the insulation between the jaws is much greater.

In making connections to the transformer, wire "C" should be connected to the high-voltage winding when the insulation resistance of the latter is measured. Wire "B" is connected to the low-voltage winding, the core and ground. If one side of the direct current circuit is grounded, this must be the grounded side of the circuit. It is preferable to use an ungrounded d-c circuit and have the only ground on the circuit through wire "B". When the insulation resistance of the low-voltage winding is being measured, wire "C" is connected to the low voltage winding, wire "B" being connected to the high-voltage winding, the core and ground.

Check Readings. Check readings should be taken after the connections have been made to insure that there is no appreciable leakage of current between the switch jaws. To do this, close switch on 5 and 6 (Fig. 1) and note very accurately the voltmeter reading. Then disconnect wire "A" from 2 and leave the end hanging loose in the air so that it does not touch anything. With the switch closed on 5 and 6 as before, take another voltmeter reading very accurately. If this reading is appreciably lower than the first one, the insulation resistance across the switch jaws is too low. In such cases all readings of insulation resistance must be taken with wire "A" disconnected.

In reading the line voltage connect wire "A" again and close the switch on 1 and 2.

Important: In making insulation resistance measurements by the voltmeter method accurate results can be obtained only by following the above instructions with great care.

METHODS OF DRYING OUT.

The primary objective of any method of drying out is to remove the moisture from the insulation of the transformer. There are four methods that may be followed:

1. By internal heat.
2. By external heat.
3. By internal and external heat.
4. By heating and applying vacuum.

The order in which the use of the above methods is recommended, if there is any choice of the methods that can be used, is 4, 3, 2, 1.

Method 4 is the one recommended by Westinghouse and should be used whenever possible. The other methods are much slower and less positive in the drying. In using any of the methods the drying cannot be accomplished in less than 72 hours of drying time. Some cases may require as much as four or five weeks depending on the amount of moisture to be removed, the method of drying used and the size and voltage of the transformer.

Method 1 is slow for large or high voltage transformers and is not recommended.

Methods 2 and 3 require longer times than method 4, but properly used give satisfactory drying where a vacuum pump is not readily available.

1. Drying Out by Internal Heat. Alternating current is required for this method. The transformer should be placed in its case without oil and with the manhole cover removed to allow free circulation of air. The low-voltage winding should be short-circuited and sufficient voltage impressed across the high-voltage winding to circulate enough current through the coils to maintain the coil temperature at 80° to 90°C as measured by winding resistance. About one-fifth of normal full-rated current is generally sufficient to do this. The iming period. The variation of plotted resistance values from the mean curve becomes less as the moisture works out of the insulation. The drying should be continued until consistently high values of resistance are obtained for at least four consecutive measurements covering a period of at least sixteen hours of the drying period. (See Fig. 2)

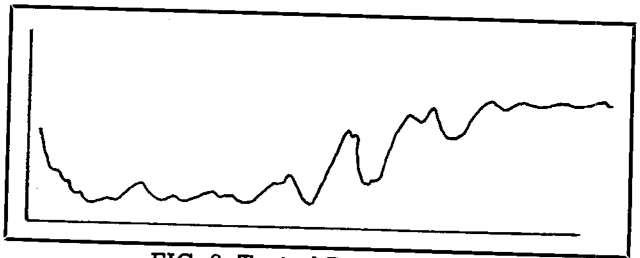

FIG. 2 Typical Drying Curve.

Precautions To Be Observed In Drying Out. As the drying temperature approaches the point where organic fibrous materials deteriorate, great care must be taken to keep the winding temperature as measured by winding resistance below 90°C. It is considered good practice to try to keep from exceeding 80°C. This allows a 10°C margin for errors in measurement and for the difficulty of controlling the temperature.

Caution. When the transformer is received from the factory it is soaked with oil and in an inflammable condition. It may be ignited very easily by an arc, spark or flame of any kind. Smoking near a transformer during the process of drying out should not be permitted. It is essential that adequate fire fighting equipment be at hand during the drying process. It is recommended that only an inert gas be used for extinguishing a fire if one should occur. Carbon tetrachloride, soda-acid, foamite or water type fire extinguishers should not be used as they cause considerable additional damage. The extinguishing equipment may be in the form of several large fire extinguishers or cylinders of inert gas; such as, carbon dioxide or nitrogen. The gas may be piped direct to the transformer tank in order to flood the tank rapidly with gas if a fire starts. All personnel concerned with the work of drying should be fully informed as to the procedure to be followed if a fire occurs. Each person should know exactly what to do if a fire starts. Alertness in extinguishing a fire may mean the difference between a total loss and only minor damage and will greatly reduce the expense and time required to repair a transformer.

It is not safe to attempt the drying out of transformers without constant attention by competent personnel.

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pressed voltage necessary to circulate this current varies within wide limits among different transformers. This voltage will generally be approximately ½ percent to 1½ percent of the normal voltage of the winding at normal frequency.

The end terminals of the full winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat or a regulator in series with the high-voltage winding.

This method of drying out is superficial and slow and should be used only with small transformers and then only when local conditions prohibit the use of one of the other methods.

2. Drying Out by External Heat. The transformer may be placed in its own tank without oil and externally heated air blown into the tank at the bottom through the main oil drain valve. A small blower or fan should be used to get proper circulation of the air through the transformer. It is essential to force as much heated air as possible up through the ducts in the coil and insulation assembly. Baffles may be necessary between the core and coils and the tank wall to close off as much air leakage space as possible to force the air up through the ducts.

The best way to obtain heated air is by blowing air through hot grid resistors. The grids should be placed in a fireproof box. The air flow is then from the blower through the air drier, through the drain valve, up through the ducts, and out of the manhole. The resistors should be placed in a fireproof box with the necessary duct-work carrying the hot air also of fireproof material. The temperature limits of the windings are the same as in method 1. The temperature of the air entering from the air heater should not exceed 115°C. Measure the temperature of the windings frequently by resistance measurements to be sure they are not overheated.

The heat may also be obtained by actual combustion. In this case it is essential that none of the products of combustion be allowed to enter the transformer tank. Heating the air by direct combustion is not recommended except where electric current is not available.

If for any reason it is not expedient to place the transformer in its own tank, it may be placed in a wooden box with air inlets at the bottom and air vents near the top. The same precautions as given for drying in its own tank should be taken to see that the air is forced to circulate through the oil ducts in the insulation.

It is essential that every precaution be taken to prevent fire when drying out by this method. The set-up must be watched very carefully during the entire drying period. If the blower should stop, the heater must be shut off at once to prevent severe overheating.

3. Drying Out by Internal and External Heat. This is a combination of methods 1 and 2. The transformer should be placed in its own tank and all precautions taken as outlined under methods 1 and 2. The current circulated in the windings should be less than when method 1 is used alone and likewise the entering air temperature will be somewhat less, to keep the windings from exceeding 90°C.

4. Drying Out by Heating and Applying Vacuum. This is a combination of heating and vacuum drying that will give rapid, thorough drying. The transformer in its own tank is heated by method 1, 2, or 3 until the winding temperature measured by resistance is 80°C to 90°C. The sources of heat are then regulated to maintain this temperature for at least 24 hours in order to have the transformer uniformly and thoroughly heated. The sources of heat are then shut off and the transformer tank sealed. A vacuum is applied to the transformer tank through the upper filter press or other connection in the top of the tank. The vacuum should reduce the pressure to as low a value as possible. The highest vacuum permitted by the tank design is stated on the instruction plate. The pressure should not be reduced below that allowed by the instruction plate statement. If the instruction plate does not give this information, the Westinghouse Elec. Corp., Sharon, Pa. should be consulted before applying any vacuum to the tank.

In the case of full-vacuum tanks the evacuating equipment should be capable of producing a continuous vacuum of at least 28 inches of mercury in the transformer tank. The rate of removal of moisture is increased by the use of a high vacuum with the corresponding depression of the boiling point of water.

The vacuum is maintained by continuous pumping until the temperature of the windings drops about 40°C measured by resistance. At this point the pumping is discontinued, the vacuum is released and the heating resumed to bring the windings again up to 80° to 90°C. The insulation resistance is then measured to check the progress of the drying. The process described above is then repeated until the insulation-resistance-vs-drying-time curve indicates that the windings and insulation are dry.

The number of heating and vacuum drying cycles necessary will depend upon the amount of insulation to be dried and on its moisture content. The minimum number of drying cycles will be at least three, the maximum may be as many as seven or more complete cycles in extreme cases. Drying time will require from one to two or more weeks depending on the number of drying cycles necessary.

Drying may be accelerated by obtaining more uniform heat distribution in the insulation where facilities are available for readily transferring and storing the oil in the transformer.

The procedure is as follows: The transformer, in its own tank and filled to the normal oil level, is heated by circulating full load or 1¼ times full load current through the full windings as described in method 1. Self-cooled units with radiators may be heated by closing the radiator valves on all except 2 or 3 radiators. These valves are left open to allow oil circulation through the transformer thereby obtaining more uniform heating of the insulation by the hot oil. Forced-oil-cooled units should have at least one oil pump running.

The temperature of the windings should not be allowed to exceed 80° to 90°C as measured by winding resistance. If check measurements during the heating period indicate that this temperature range will be over-shot, the current should be reduced.

Top oil temperature serves as a good indication of the heating of the internal parts of a transformer. A constant value of top oil temperature indicates that the heating for a constant input has reached an equilibrium condition. Thus, after the top oil temperature has been constant for four hours and the winding temperature constant in the range of 80° to 90°C the heating may be assumed to have reached an equilibrium condition. The current is then shut off and the oil transferred from the transformer to the storage tank as rapidly as possible. The insulation resistance is measured and the tank sealed. Vacuum is then applied as previously described.

When the temperature of the windings as measured by resistance drops to about 40°C the oil is allowed to flow back into the transformer without releasing the vacuum. The vacuum increases the rate of oil transfer but considerable care is necessary to prevent oil from being drawn over into the vacuum line. Extreme care should be used in this regard if a reciprocating type of vacuum pump is being used as they have very small clearance compared to air compressors. A slight amount of oil in the cylinder may result in a blown gasket or fractured or blown cylinder head.

The vacuum is released after the transformer is filled to the normal oil level and the heating cycle started. If facilities are available for maintaining an oil temperature of about 90°C during the storage period the heating cycle of the transformer will be shortened.

DRYING OUT PROCEDURE.

Time Required. There is no definite length of time required for drying out a transformer. One to four weeks or more will generally be required for methods 1, 2 and 3 depending upon the condition of the transformer, the size, the voltage and the method of drying used. Method 4 will generally be more rapid than methods 1, 2 or 3. In general, any power transformer will require at least one week of drying time regardless of the method used.

Details to be Regarded. If the initial insulation resistance be measured at ordinary temperatures, it may be high even though the insulation is not dry, but as the transformer is heated up it will drop rapidly. An insulation resistance of 100 megohms measured at 25°C is only 9.9 megohms at 75°C. The one megohm rule applies only in the range of 60° to 80°C.

The insulation resistance measured at a constant temperature will generally have a gradually increasing trend as the drying proceeds. Towards the end of the drying period the increase will become more rapid. Sometimes the resistance will rise and fall a short range one or more times before reaching a steady high point. This is caused by moisture working its way out from the interior of the insulation through the outer portions of the insulation which were dried first. Large changes in the measured insulation resistance may be caused by temperature variations. Insulation resistance measurements should be made at the same temperature in so far as it is possible to do so. Measurements should be taken at about four-hour intervals when drying by methods 1, 2, or 3 and at the end of each heating cycle after the oil is drained but before applying vacuum when using method 4.

Resistance Curve. A curve of the insulation resistance measurements should be plotted with time as abscissa and resistance as ordinates. The resistance points plotted should be the measured resistance corrected to a temperature of 75°C. The drying curve will generally show wide variations in the resistance values during the first part of the dry-

INSTRUCTIONS

STANDARD OUTSIDE FINISH

for Westinghouse Oil Insulated Transformer Tanks

The standard outside finish for Westinghouse medium and large transformer tanks consists of three air dried coats of paint. Each coat is usually flowed on. The color of the first and second coats are different so as to obtain a contrast between adjacent coats, thus insuring that each coat is continuous and of sufficient thickness. The third or final coat is of a dark blue-gray color.

Note. The second or intermediate coat is a mixture of the primer and finish paints, one part primer paint to three parts finish paint by volume. These paints can be applied satisfactorily by flowing, dipping, spraying or brushing.

The transformer tanks and many of the accessories attached, being constructed of steel, are normally susceptible to rusting. Therefore, in order to prevent rusting of exposed steel surfaces on all Westinghouse transformers, careful attention must be given to the following fundamental steps when repainting exposed steel surfaces:

1. All exposed steel surfaces must be thoroughly cleaned and prepared for the application of the protective coats of paint since the proper preparation of the surfaces to be finished is an important factor to securing a satisfactory and lasting finish.

Regardless of how good the paint may be, it will fail as a protector if applied over a wet, dirty, rusty or greasy surface. Rust and scale will absorb and hold moisture. Therefore, in order to obtain a durable finish, it is absolutely essential that no moisture be sealed in by the application of paint. For large areas, a clean dry surface with sufficient roughness for good adhesion of the priming coat can be obtained by shot or sand blasting the exposed surfaces of the transformer tank.

2. The careful application of a high grade durable quality paint is essential to guarantee a lasting finish.

The two factors that determine the quality of any paint are the pigment and vehicle. The pigment gives the color and body of the paint and the vehicle holds the pigment particles in place and forms a continuous adherent film. Although attention is generally centered upon the selection of the pigment, many tests show that the vehicle of a paint is the first of these two components to disintegrate. Therefore, it is important that a paint of this quality be used to obtain a satisfactory finish. Westinghouse primer paint No. 7164-1 and finish paint No. 7165-1 meet these requirements and are recommended.

Important. Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of scraper or sandpaper, applying a coat of Primer Paint No. 7164-1 and allow it to dry for at least 24 hours, then apply a coat of Finish Paint No. 7165-1.

Note. For small marred spots which do not penetrate the paint film to the parent metal, only the finish paint is necessary after cleaning, although due to the indefinite life of this finish, a protective coating should be applied as soon as possible.

Finish paint is packaged in one-pint containers and designated as style number 302509.

Primer paint No. 7164-1 is not packaged in small quantities but if required, can be purchased through the nearest sales or service office.

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(Rep. 4-53)

INSTRUCTIONS

CLEANING TRANSFORMER INSULATION

There are times when it may become necessary to clean transformer insulation because of the accumulation of dust, grease, sludge or carbon deposits. The method for cleaning varies with the type of transformers.

DRY-TYPE TRANSFORMERS

Dust, free of oil or grease, may be removed by wiping with a clean dry rag or by using a vacuum cleaner equipped with a brush attachment. The vacuum cleaner is preferred for large areas. Dust may be blown from inaccessible parts, but any dust removed by blowing is scattered and much of it will settle on other parts from which it must be removed as outlined above. The air must contain no moisture and care must be observed so that the insulation materials are not damaged by excessive air velocity.

Should grease or oil get upon the insulation it may be removed by wiping dry with a clean dry cloth.

Loose carbon deposits may be removed by brushing and/or wiping with clean dry cloths. Defective insulation should be replaced.

OIL-FILLED TRANSFORMERS

Loose coatings of sludge and dirt may be removed by wiping with cloths saturated with transformer oil. Tightly adhering or heavy coatings of sludge may require a light brushing with a bristle brush, followed by a wash with transformer oil.

Sludge, dirt and oil-carbon deposits may often be effectively removed by spraying clean, dry, transformer oil upon and around the insulation with sufficient velocity to thoroughly wash and clean it. An air-ejector type nozzle should be used. Defective insulation should be replaced.

Important: **Do not use knives, screw drivers or other sharp objects to clean coils since the use of these objects may cut the insulation.**

INERTEEN-FILLED TRANSFORMERS

Normally, the cleaning of insulation is not necessary for Inerteen transformers because Inerteen does not sludge. However, should it be necessary to remove a deposit of dirt, it may be done by wiping with a cloth saturated with clean Inerteen or trichlorbenzene.

When arcing occurs in Inerteen, the insulation is attacked by the products of decomposition of the Inerteen and usually requires replacing. The products of decomposition of Inerteen 7336-8 now used in transformers have less effect on insulation than those from the earlier types of Inerteens. Hence it is more likely that the insulation in these transformers, not affected by direct arcing, may be used again.

For precautions in handling Inerteen refer to instruction book on Inerteen Transformers.

Important: **Carbon tetrachloride should never be used for cleaning the insulation of either liquid filled or dry type transformers because it is nearly impossible to remove all of the carbon tetrachloride used for cleaning purposes, and during the natural operation of the transformers, the remaining carbon tetrachloride will form hydrochloric acid which will cause corrosion of metal parts and detrimentally affect the insulation.**

This general procedure is not to be followed when specific instructions accompany the apparatus.

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EFFECTIVE JULY, 1951
(Rep. 4-53)

INSTRUCTIONS

REPAIRING WELD LEAKS

This instruction leaflet is intended to give general instructions concerning recommended practices for repairing a weld leak in power transformers or their auxiliaries. Variations of these instructions may be desirable for special repair tasks, but normally the weld leak may be successfully sealed if these instructions are followed.

TRANSFORMER CASES AND FITTINGS

Transformer cases and their fittings are fabricated from 3/16″ to 1/2″ thick welding quality low carbon steel. The welds are deposited manually using shielded arc welding electrodes, other than some case seams which are automatically welded by the submerged arc welding process.

To repair a weld leak in a case seam or around one of the fittings the following is recommended:

1. Check the liquid level in relation to the area to be welded. It should be 4″ or more above the area to be welded. Should the area to be welded be above the liquid level or if the liquid has been removed from the case, blanket the transformer with dry nitrogen.

2. De-energize the transformer and pull a vacuum of several pounds per square inch above the liquid to stop the liquid leak. This may be done with a vacuum pump or by sealing all fittings on the case and draining sufficient oil to obtain the necessary vacuum.

Note: Vacuum is not always required, especially when a sweating leak is to be repaired and the case wall is relatively thick.

3. Peen the weld leak closed, if possible, with the ball end of a ball-peen hammer or with a blunt or round-nosed chisel.

4. Grind or scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine.

5. Select several Westinghouse 1/8″ diameter type FP electrodes, S# 1528 911, for 50# packages. This is an all-purpose, coated electrode adaptable to down-hand, horizontal or vertical welding. It is classed as an E-6012 type by the American Welding Society. Either a-c or d-c welding current may be used. When d-c power is used, straight polarity is preferred, that is, the electrode is negative.

The welding machine is adjusted to supply the desired welding current. Some value between 115 to 125 amperes should be used, depending upon the welding operator's ability and the individual task at hand.

6. Apply a string bead sealing weld over the weld defect in a single, quick pass. This weld should be deposited horizontally or vertically depending upon circumstances. If the weld is deposited vertically, it is recommended that it be made downward to drive any liquid seepage ahead of the weld.

Successive beads are deposited adjacent and over the first sealing bead, or a single pass may be weaved across it to complete the weld. If the beads are deposited horizontally, deposit these beads from the top down if any liquid seepage is present; otherwise they may be deposited upward if preferred. Remove the slag from the deposited weld before depositing each successive weld bead or pass.

Liquid interferes with the welding operation and the quality of the deposited metal. It should be wiped off with a dry cloth. All welds should be deposited in a sequence as above to prevent any liquid seepage interfering with the welding operation other than the final sealing at the lowest point of the weld leak.

7. Clean and brush the repaired area and apply touch-up paint.

EFFECTIVE AUGUST, 1950

NEW INFORMATION

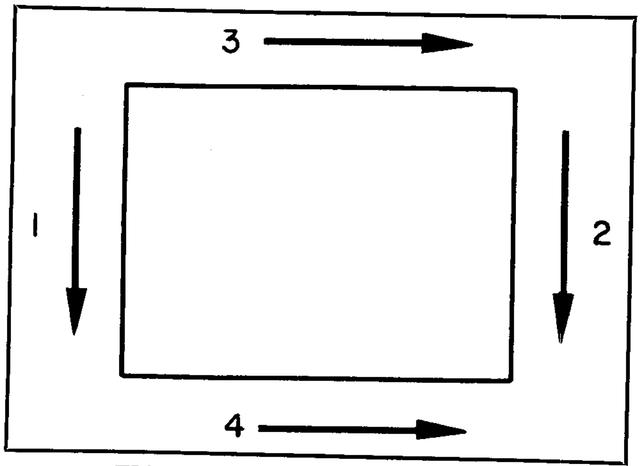

FIG. 1. Welding Sequence for Patch

Alternate Method Using a Patch. A patch may be welded to the transformer case to repair a leak as an alternate to the method above. The recommended method is as follows:

1. De-energize the transformer and pull a vacuum, peen the weld, clean the weld area, check the liquid level, select the $\frac{1}{8}$″ FP electrodes and adjust the welding machine as above.

2. Fit a patch of $\frac{3}{16}$″ or $\frac{1}{4}$″ thick steel over the area to be sealed. Tack this patch in place, then weld it to the transformer case by welding the sides first, vertically downward, then horizontally across the top of the patch and finally horizontally across the bottom. This welding sequence is recommended to prevent any liquid interfering with or contaminating the weld. (See Fig. 1.)

3. Clean and brush the repaired area and apply touch-up paint.

TUBULAR COOLERS

The Westinghouse swaged tube cooler consists of from two to ten 2″ diameter x .063″ wall thickness riser tubes with swaged ends inserted into, and arc welded to, two $2\frac{3}{8}$″ diameter x .093″ wall thickness header tubes for assemblies of eight riser tubes or less and $2\frac{3}{8}$″ diameter x .125″ wall thickness header tubes for assemblies of nine or ten riser tubes. The wall thickness of the swaged end of the riser tube at the point it is welded to the header tube is approximately .093″.

Tube cooler assemblies without swaged riser tubes are made from $1\frac{1}{2}$″ extra-heavy pipe or $\frac{9}{64}$″ or $\frac{5}{16}$″ wall thickness tubing welded to 2″ extra-heavy-pipe headers.

To repair a weld leak in a tube cooler assembly or in the weld attaching the headers to the case the following is recommended:

1. De-energize the transformer and pull a vacuum above the liquid to stop the liquid leak. This is essential when repairing the swaged tube coolers.

2. Peen the weld leak closed if possible with blunt or round-nosed chisels.

3. Scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine. Remove any liquid on the surface to be welded.

4. Select several Westinghouse $\frac{3}{32}$″ diameter type S Welectrodes, S# 1082 207, for 50# packages. This is a coated electrode with low penetrating characteristics designed for sheet metal welding. It is classed as an E-6013 type electrode by the American Welding Society. It may be used with either d-c (straight polarity preferred) or a-c. The recommended current setting is 50-60 amperes.

5. Seal the leak with a single, quick weld bead. Apply the bead horizontally, vertically or overhead as the occasion demands. If vertically, weld downward. When sealing a weld joining the header to the case, start at the top of the header and weld downward around its periphery to the bottom of the header. Always weld so that any oil seepage will flow away from the weld rather than into it.

Weld beads must be small and made quickly to prevent burning through the tube walls. An arrangement of mirrors may aid in repairing a weld that can be reached, but is not in the welding operator's direct line of vision.

6. Clean and brush the repaired area and apply touch-up paint.

FIN-TYPE RADIATORS

The Westinghouse fin-type radiator consists of inflated elements gas welded to each other and to a .109″ thick formed header. A 1″ thick flange is arc welded to each header. The elements are made from two sheets of .057″ thick mild steel continuously resistance welded along their outer edges and with two intermediate seams to cause lobes to form in the element during the inflating operation.

Repairing an intermediate seam between elements is not recommended in the field. The radiator should be returned to the Sharon Plant so that a new element may be assembled.

REPAIRING WELD LEAKS

To repair weld leaks around the header flange, along the outer edge of the elements or in the edge weld where the elements join the header or each other, the following procedure is recommended:

1. Close the radiator valves between the radiator and the transformer case. Drain the liquid from the radiator and remove the radiator from the transformer case.

2. Grind or scrape the paint from the area to be repaired. Also remove any liquid, dirt or foreign matter.

3. If the weld to be repaired is around the header flange use 1/8″ diameter FP electrodes with current settings between 115 to 125 amperes. Weld horizontally around the flange.

4. If the weld to be repaired is along the edge of the elements or is the weld joining the elements to each other or the header—gas welding should be used. Use a slightly reducing flame. Preheat the area to be welded then concentrate the flame on the weld seam, about 2″ away from the weld leak, and bring a local area to the welding temperature. As the edges of the adjacent parts melt and flow together move forward slowly with a slight weaving motion until 2″ past the weld leak. If a filler metal must be added use a 1/16″ diameter soft iron gas welding rod (PDS# 5793) or a 1/16″ wide strip sheared from a 1/16″ thick clean mild steel sheet.

When repairing the resistance weld along the edges of the radiator elements the welding operator must make certain that the edges of the elements are fused sufficiently deep to penetrate into the resistance weld.

5. Clean and brush the repaired area and apply touch-up paint.

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WESTINGHOUSE

INSTRUCTIONS

TYPE SL HIPERSIL CORE FORM TRANSFORMERS

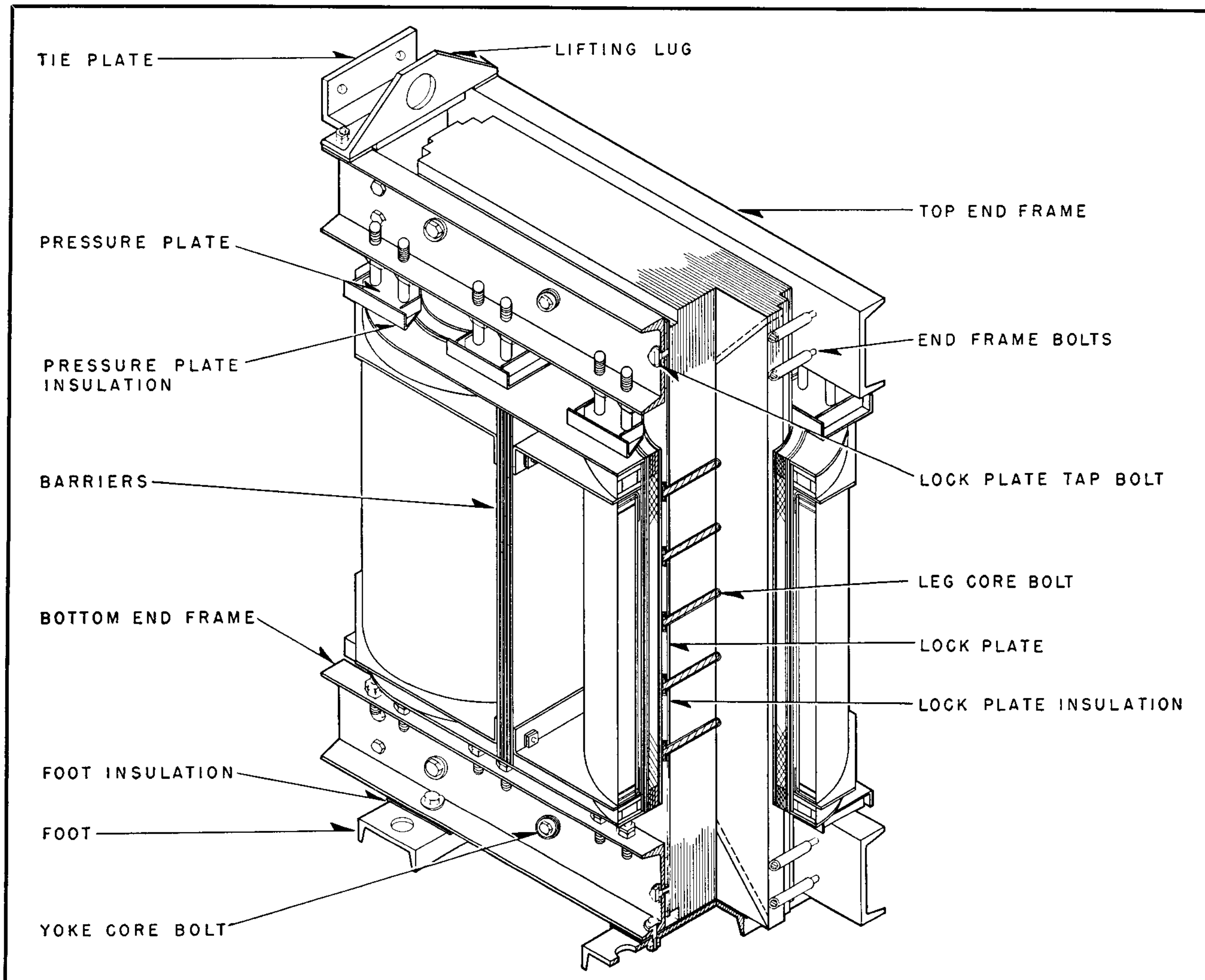

FIG. 1. Sectional View of a Single-Phase Core Form Transformer.

WINDINGS

TYPE SL TRANSFORMERS are equipped with windings made from special electrolytic oxygen-free copper conductor. This copper conductor is manufactured without melting by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special copper conductor prevents insulation failures resulting from surface imperfections in the conductor.

The insulation applied to each conductor consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought out from the center of the coil stack. With this arrangement the tapped portion of the winding is not exposed to line surges, and the electrical centers are more nearly balanced on all connections.

SUPERSEDES I.L. 47-610-1B

JUNE, 1952

FIG. 2. Cylindrical Coil Winding.

All coils are circular in form and, in general, may be classified as follows:

CYLINDRICAL COILS

The cylindrical coil for voltages up to 8.7 kv, inclusive, and for any kva rating, consists of one or more layers of insulated conductors wound on an insulating cylinder. Each conductor consists of a number of copper ribbons of suitable cross-section in parallel which are properly transposed to minimize eddy losses. Collars of suitable form and material are placed at the ends of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that coil temperature gradients are kept uniformly low.

The cylindrical coil can also be used on transformers with small kva ratings and voltages in the 15, 25 and 34.5 kv classes by use of static cylinders, located at the line end of the windings, to distribute impulse stresses and minimize impulse oscillations.

When cylindrical coils are used for these higher insulation classes, the high and low voltage coils are wound as a complete unit with the high-low insulation built in. If it should be necessary to replace either the high or low voltage winding, the complete high-low coil assembly must be ordered for replacement.

CONTINUOUS-WOUND PANCAKE COILS

The continuous-wound pancake coil for voltages 15 kv to 69 kv inclusive consists of a number of circular disc coil sections, of rectangular strap conductor with one turn per layer, wound by a continuous process with no joints at section connections. The conductor may consist of one or more copper ribbons of suitable cross-section and where multi-conductors are used in parallel, they are properly transposed throughout the coil to minimize eddy losses. The circular disc sections are wound on vertical insulating spacers placed over an insulating cylinder. Radial spacers which dovetail with the vertical spacers separate the various sections from each other. Heavy insulating collars are placed at the ends of the coil for electrical and mechanical strength. The thickness of the coil section is the width of the conductor and the sides of the coil section are the edges of the conductor (see Fig. 3), thus the flat sides only are in contact, eliminating the danger of mechanical forces cutting the insulation and also, each conductor is exposed to the cooling medium. This type of winding gives the highest capacity per unit of space and permits free circulation of the cooling medium. Hot spots are eliminated and high thermal efficiency results.

The continuous-wound pancake coil for 92 kv class and above is manufactured the same as described above except that the turns are wound re-entrant to obtain a high series capacitance. This will give better distribution of impulse stresses and minimum impulse oscillations in the winding.

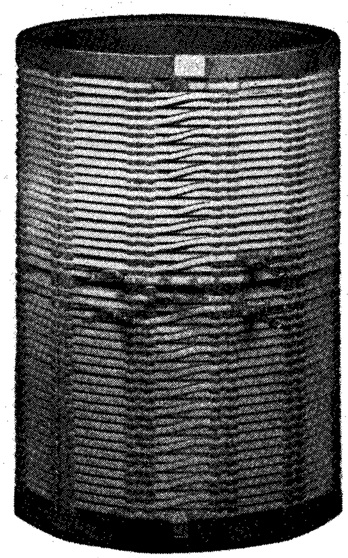

FIG. 3. Continuous-Wound Pancake Coil Winding.

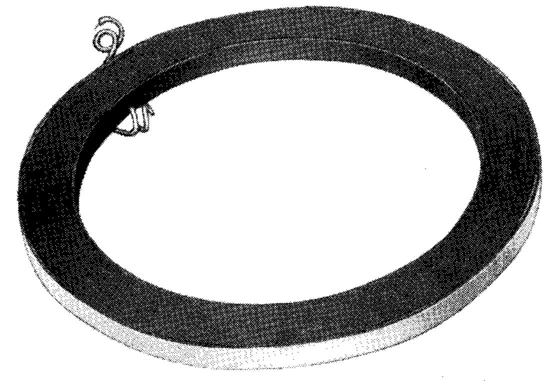

FIG. 4. Round-Wire Pancake Coil.

ROUND-WIRE PANCAKE COILS

The round-wire pancake coil (Fig. 4) is used for high voltages and current ratings of less than ten amperes where it is necessary to obtain a large number of turns in a minimum space. It is circular in form and consists of a number of layers with several turns of round paper-covered, enameled wire per layer. This coil is wound on an insulating foundation ring with a length equal to the thickness of the coil. The layers of conductor are spaced from each other by insulating sleeves or crimped paper. The sleeve insulation consists of a strip of folded paper around the end turns, forming a double thickness of paper insulation between the layers of conductor. The crimped paper insulation has an extension at each end of the layer. Where it extends beyond the conductor it is crimped, forming a small collar.

These sleeves and crimped paper insulating strips are coated with a thermo-setting plastic. When the coils are wound they are heated in an oven and this plastic softens, filling the voids between adjacent turns and between turns and layer material. After cooling, the plastic sets and forms a bond between turns and layer material, making a mechanically rigid coil.

Reinforcing segments are placed in the coil near the outer edge during the winding and are spaced so that they are directly under the radial spacers. The width of the segments is the same as the length of the insulating foundation ring. This construction gives maximum mechanical strength due to the fact that the pressure on the coil stack is transmitted from coil to coil through the foundation ring and the segments, thereby eliminating pressure on the wires of the coil.

HELITRAN COILS

The Helitran coil is spirally wound and, in general, is used for medium voltage and high current. The conductor consists of several insulated copper ribbons in parallel properly transposed throughout the winding to reduce the eddy losses to a minimum. This coil is wound over vertical insulating spacers on a heavy insulating tube with the layers spaced from each other by radial insulating spacers. The radial and vertical insulating spacers are dovetailed together giving electrical and mechanical separation and providing ventilating ducts for the circulation of the cooling medium. The ends of the winding are rigidly held in place by properly anchoring the leads and by the use of heavy insulating collars at the ends of the coil. This type of coil construction gives high insulation strength and uniformly low temperature gradients.

ASSEMBLY OF WINDINGS

Coils of the cylindrical type require no further individual assembly after winding.

Continuous wound pancake coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

Double section pancake coils are assembled on stacks on their insulating cylinder. They are sep-

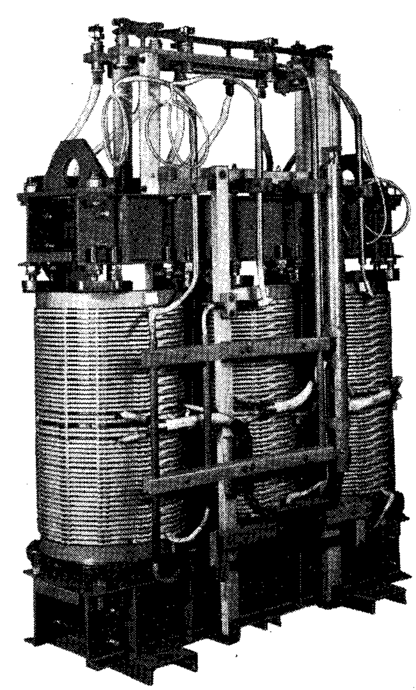

FIG. 5. Core and Coils of a Three Phase Transformer.

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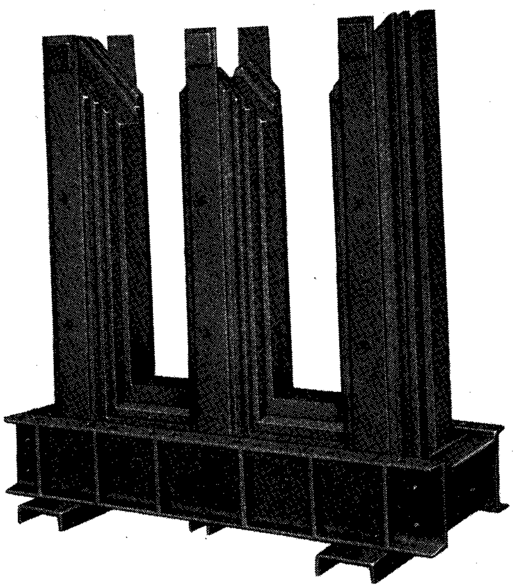

FIG. 6. Partial Hipersil Core Assembly For a Three-Phase Transformer.

arated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The joints between coils are made by brazing, no solder being used. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Round wire pancake coils are assembled in stacks on their insulating cylinder. They are separated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Helitran coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

The high and low voltage windings are assembled concentrically on the core with the low voltage winding nearest the core leg. The low voltage winding is centered on the core leg by four maple rods driven tightly in four corners of the cruciform leg between the core and the low voltage insulating cylinder. The high voltage winding is separated from the low voltage winding by one or more insulating cylinders and vertical spacing strips. For the higher voltages the cylinders have insulating angle rings interleaved with them at the ends.

At the ends of the stacks of coils are placed heavy insulating collars interleaved where necessary with angles and washers. These give the required insulation strength and a mechanical structure between the coils and pressure plates which is more than adequate to withstand the mechanical forces set up under short circuit.

All leads, except the very short ones, are run in insulating tubes and are rigidly supported at frequent intervals. They present a neat appearance and are free from vibration or distortion under short circuits.

INSULATION

The major insulation of Type SL transformers consists of insulating cylinders and oil ducts so proportioned as to give the necessary dielectric strength and, at the same time, allow the cooling oil to flow naturally across at least one side of all turns. All units are designed to withstand the standard A.I.E.E. impulse and low frequency tests. Impulse strength is obtained by predetermining the stress at each point of the winding and providing at each point the necessary insulation. This is done by placing at the ends of the stacks of coils an insulated static plate and using uniform insulation throughout, based on the maximum stress at any point. Shields or constructions which offer

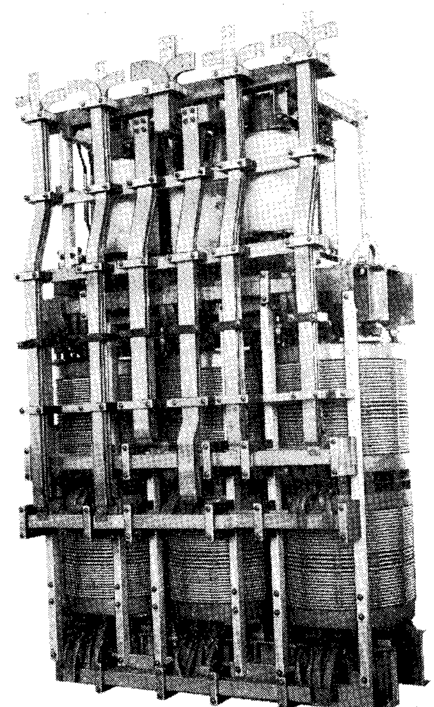

FIG. 7. Core and Coils for 12-Phase, 6000 Kw., 600 Volt Rectifier Transformer with Interphase Transformers Mounted on Upper End Frame.

insulation hazards to other coils and to ground, as well as interfere with oil circulation, are not used.

TREATMENT

After assembly the core and coils are preheated, and then thoroughly dried under vacuum in a heated oven. While still hot and under vacuum they are impregnated with transformer oil.

ASSEMBLY OF CORE

The cores for Type SL Transformers are made from Hipersil, high permeability, cold-rolled material which carries twenty to thirty per cent more flux than the hot-rolled silicon steel it replaced. The use of this material gives a transformer of higher efficiency with from twenty to twenty-five per cent reduction in total weight.

The magnetic circuit for the Type SL transformer is rectangular in shape with a rectangular opening, or openings. It is built up of I-plate Hipersil laminations which are stepped in width so as to produce an approximately circular iron section. In order to avoid conditions at the corners in which the flux must pass across the direction of the grain, the I-plates are cut with 45 degree angles at each end. Punchings for the yoke are made slightly wider than the corresponding leg punchings in order to obtain an overlap as shown in Fig. 1. With this design the flux path at the corner is parallel with the grain of the material in both the yoke and the leg punchings.

On each side of the top and bottom members of the core is bolted a steel channel or end frame. The coils are clamped between steel pressure plates which are adjustable by means of jack screws extending through the top flange of the bottom end frame and the bottom flange of the top end frame. The clamping forces and the short circuit forces in the winding are such that they tend to separate the top and bottom end frames. The end frames are prevented from spreading by means of steel lock plates extending the full height of the core. Stops welded to the lock plates engage stops welded on the end frames and provide the means to transmit the short circuit and clamping forces from the end frames to the lock plates.

The lock plates are bolted to each side of the leg punchings with insulated heat-treated core bolts and are insulated from the leg with sheets of pressboard.

Between the pressure plates and the coils there are placed heavy insulating rings, which distribute the pressure uniformly over the circumference of the coils. Both the high voltage and the low voltage coil stacks are pressed while hot to a predetermined height, which is the same for both. They are then assembled on the core and both stacks are clamped by the same pressure plates. This system has two important results: First; clamping each stack under pressure while hot permits building with an accurately determined column length. Second; the use of a common pressure system for both stacks assures assembly with the electrical centerlines in the same horizontal plane and prevents any subsequent shifting. Since the stress developed on short circuit depends on a vertical displacement of the electrical center-lines, the method used on these transformers to build and brace the coils is ideally suited to minimize such stresses.

HANDLING AND BRACING

The core and coil structure is lifted as a unit by means of lifting lugs bolted to the top end frames and located as near as practical over the center of the outer legs. The transformer is centered in its tank by pins welded to the tank bottom which bear against channel feet bolted to the bottom end frames. At the top of the core, tie plates are bolted to the lifting lugs and to pads welded to the tank wall. The bolts and nuts used with the tie plates are of heat treated steel and are locked with bolt fasteners or Dieter nuts.

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