



INSTRUCTION BOOK

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

— Westinghouse Electric Corporation —

L. B. 47-200-1

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.

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



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 compar-

son. 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 Resistance Measured in Air At:	TABLE B CORRECTION FACTORS (Use either column)	
	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

DETERMINATION OF DRYNESS

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.

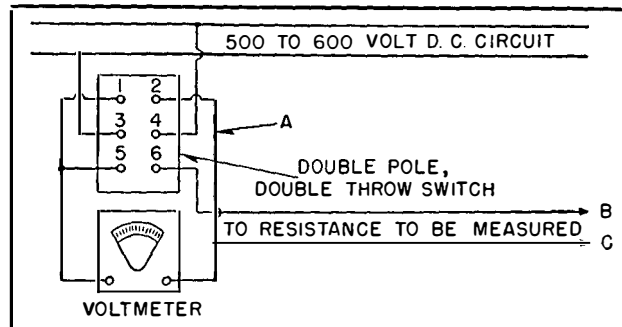


FIG. 1. Connections for Measuring Insulation Resistance.

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:

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

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 $r = 1$ 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 three methods that may be followed:

1. By internal heat.
2. By external heat.
3. 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 3, 2, 1.

Method 3 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.

Method 2 requires longer time than method 3, but properly used gives 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 with oil and with the manhole cover removed to allow free circulation of air in the gas space. 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

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to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers. This voltage will generally be approximately $\frac{1}{2}$ percent to $1\frac{1}{2}$ percent of the normal voltage of the winding at normal frequency. The cooling tubes or radiators should be blanketed to prevent air circulation and thus heat loss. Otherwise the power requirements will be excessive.

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 slow and is most effective with small transformers and then only when local conditions prohibit the use of one of the other methods.

The drying by this method may be accelerated by continuously filtering the oil during the drying. This will remove moisture rapidly from the oil and promote the drying process. Frequent changes of blotters in the filter press are necessary to achieve the full benefit of using the filter.

Another method of heating may be used on large transformers when they are filled with oil. An electric heater may be constructed using standard oil-immersion heating elements. This is an oil tight sheet metal box with an oil inlet near the bottom and an oil outlet in the top near the opposite side from the inlet. The immersion heaters are inserted in the top of the box. Oil is pumped out of the bottom of the transformer through the heater and back into the top of the transformer. It is usually necessary to have a screen in the oil intake line to the pump to prevent any possibility of jamming. This is particularly true using positive displacement pumps.

The pump capacity should be sufficient to provide a complete change of oil in the transformer approximately once an hour.

The immersion heating capacity necessary is about $1\frac{1}{4}$ times the estimated tank radiation plus convection heat dissipation based on a tank wall temperature of 85°C . The heating capacity can be reduced by blanketing the cooling surfaces to reduce their effectiveness.

The oil temperature in the heater must not exceed 90°C . A thermometer well and thermometer or

thermocouple is necessary in the top oil near the outlet of the heating chamber. Heating elements can be cut out of the heating circuit to control the temperature of the oil leaving the heater.

The pump power supply and the heating circuit must be interlocked so that if the power supply to the pump fails, the heater will automatically be shut off. This is necessary to prevent severe overheating of the oil in the heater in case the pump stops.

The drying can be accelerated by either continuously filtering the oil or by applying a high vacuum (28 inches of mercury or higher) to the gas space of the transformer. In case the vacuum is used, all the piping and fixtures in the oil circuit must be designed to withstand a full vacuum. If a filter press is used, the filter press oil circuit should, preferably, be separated from the heating oil circuit. The capacity of the filter press is ordinarily limited to 10 GPM or less. This would not be sufficient oil circulation for heating purposes under ordinary circumstances.

Automatic control of the oil heaters based on the 90°C oil temperature is easy to install. Automatic control of the temperature is well worth the extra expense involved in the additional safety of operation provided by preventing excessive oil temperatures.

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. A 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.

It is essential, with this method of drying, to have sufficient blower capacity. The blower rating required may be estimated on the basis of one cubic foot of free air per minute for each ten kva of transformer rating.

The air inlet opening or openings should have a cross-sectional area of at least twenty square inches for each 1000 cfm of air supplied. The manhole is generally used for the air exit, thus the air exit cross-sectional area is easy to obtain. In any case, the

exit section area should not be less than the total inlet area.

It is desirable to have several inlet openings in order to insure good air distribution. The total cross-section area of drain, radiator or other openings at the bottom of large power transformers generally will not provide sufficient area for using this method of drying.

Example: 30000 kva transformer:

The minimum blower capacity required is 3000 cubic feet per minute free air. A larger blower could be used, but one of lower capacity should not be used.

The minimum total cross-section area of the air inlet openings should be at least 60 square inches. If openings of this area are available, this method could be used. Using a 16 inch diameter manhole for the exit, the area is 201 square inches and is satisfactory.

The method of heating the air must be selected in view of local conditions where the drying is performed. In some cases electric heaters may be used, in others steam to heat exchangers may be used. In some cases heating indirectly by fuel combustion may be the only method available. This might be by gas or fuel oil. The hot products of combustion are circulated through a heat exchanger to exclude the products of combustion from the air being heated. Any method using fuel combustion for heat generation must completely exclude and seal the products of combustion from the air being circulated through the transformer.

The air heating surface of either the electric heaters or the indirect combustion heat exchangers must be large enough to keep the surface temperature below the metal scaling point. Particles of hot scale blown into the insulation could result in serious trouble. It is necessary to be extremely careful in both of these methods of heating to be sure that no sparks or incandescent particles can be blown into the transformer. This is particularly true with electric heaters where poor electrical contacts must be guarded against.

Close continuous control of the temperature of the hot air entering the transformer is necessary. The air temperature should not exceed a maximum of 90°C. Air temperatures in excess of this may

cause spontaneous combustion in the oil treated insulation.

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 over-heating. Do not try to accelerate the heating by circulating current in the transformer windings. The transformers are designed to be cooled by a liquid. The heat generated in the windings by circulating current with the assembly in air may allow extreme temperatures to develop and damage the windings and insulation.

Automatic air temperature control and complete interlocking of blower and heater controls are desirable. The interlocking should be such that failure of control voltages, failure of blower power or failure of the heat source will completely shut down the process. A failure resulting in shutdown should require manual restarting of the equipment. The advantage of automatic control in obtaining satisfactory drying using this method cannot be over-emphasized.

3. 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 or 2, 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 twenty-four hours in order to have the transformer uniformly and thoroughly heated. The sources of heat are then shut off. If method 1 is used, remove the oil. The transformer tank is 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 Electric Corporation,

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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 in method 1 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 and 2, depending upon the condition of the transformer, the size, the voltage and method of drying used. Method 3 will generally be more rapid than methods 1 or 2. 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 in-

creasing 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 or 2 and at the end of each heating cycle but before applying vacuum when using method 3.

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 drying 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)

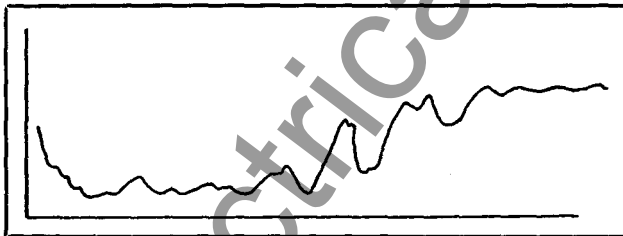


FIG. 2 Typical Drying Curve.

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.



WESTINGHOUSE ELECTRIC CORPORATION

SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

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I N S T R U C T I O N S

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.

WESTINGHOUSE ELECTRIC CORPORATION
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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
SHARON, PA.

EAST PITTSBURGH PLANT
EAST PITTSBURGH, PA.

SUPERSEDES I.B. 44-820-1
(Rep. 6-54)

MARCH, 1953

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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. 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 settleings 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 benzene, 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 bung hole 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 petroleum 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, Inertiaire, 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 re-

inhibiting, 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:

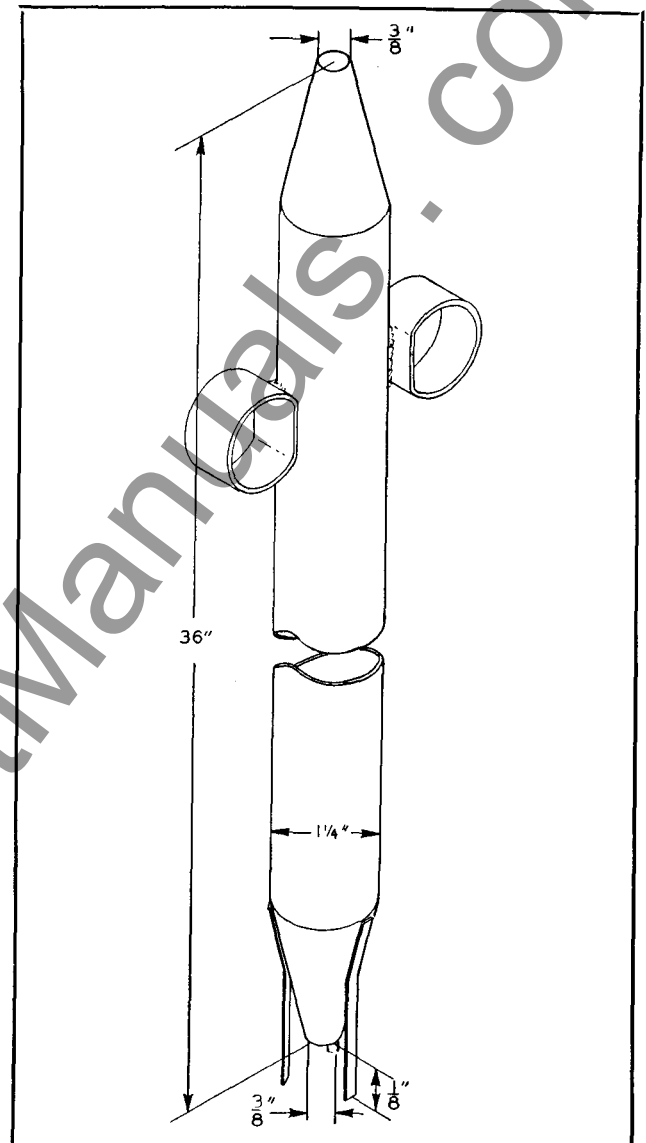


FIG. 1. Drum Thief.

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

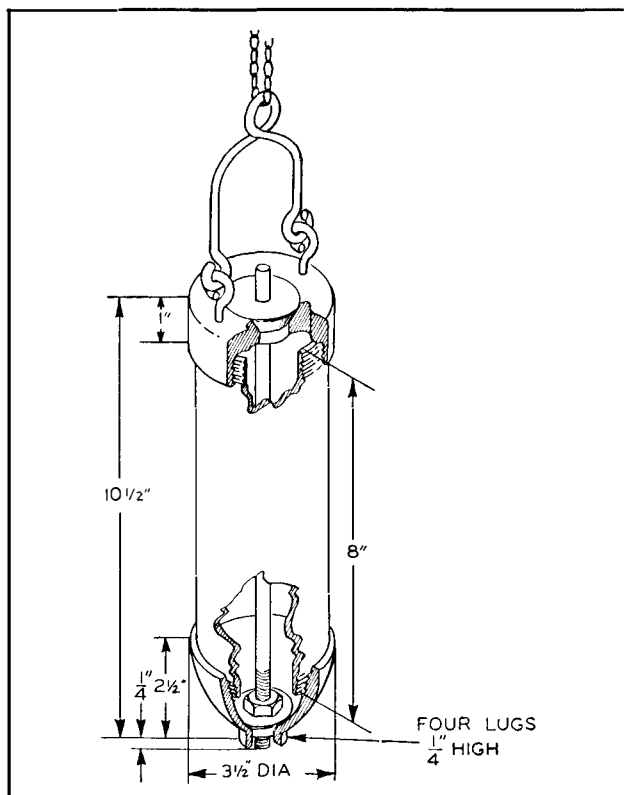


FIG. 2. Tank Car Thief.

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 $1\frac{1}{4}$ in. with cone shaped caps over the ends and openings at the ends $\frac{3}{8}$ in. in diameter. Three legs equally spaced around the thief at the bottom, and long enough to hold the opening $\frac{1}{8}$ 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 $\frac{1}{8}$ in. from the bottom.

Procedure. Thieves should be cleaned *before and after use* by rinsing with dry lead-free gaso-

line; 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 car-load 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 $\frac{1}{4}$ 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 Inertiaire, 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

SAMPLING AND INSPECTION

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 Inertiaire or Sealedaire transformers; such oil should last indefinitely without need for reconditioning, provided the Inertiaire 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 $\frac{1}{2}$ 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.

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 $1\frac{1}{4}$ 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.

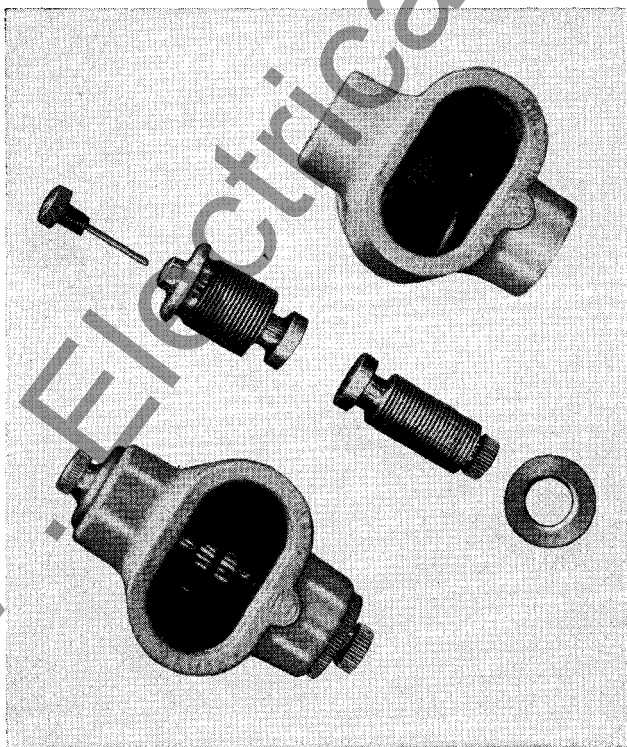


FIG. 3. Oil or Fluid Test Cup for Dielectric Test.

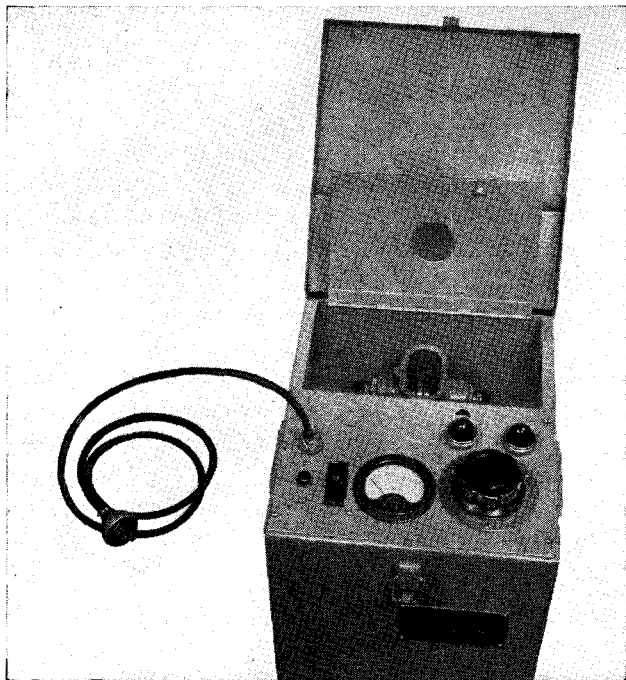


FIG. 4. Portable Oil Testing Set ½ Kva, 35,000 Volts.

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 testing. 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.

TESTS

a. Except as specified in (b) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall

be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

b. When oil is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of oil available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the oil may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value, a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (a).

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



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

POUR TEST

Note: The procedures covered by the following instructions for the pour test, and especially the neutralization test, require special equipment. The neutralization test must be made by a competent chemist, preferably one specializing in this particular field. Customers who do not possess these facilities are offered, at nominal cost, the use of the Westinghouse Oil Testing Service. Contact the nearest Westinghouse Office for details.

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 Fig. 6) shall be clear glass, of cylindrical shape, approximately 1 $\frac{1}{4}$ in. inside diameter and 4 $\frac{1}{2}$ 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, -70°F (-56.7°C) to 70°F (21.1°C).

The jacket shall be of glass or metal and shall be watertight, of cylindrical form, flat bottomed, about 4 $\frac{1}{2}$ in. deep, with inside diameter $\frac{1}{2}$ in. greater than outside diameter of the test jar.

A disc of cork or felt $\frac{1}{4}$ 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 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.

Procedure. The oil to be tested shall be brought to a temperature at least 25°F (14°C) 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 25°F (14°C) 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 2 $\frac{1}{4}$ 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 $\frac{1}{8}$ in. below the surface of the oil.

Heat without stirring to a temperature of 115°F (46.1°C) in a bath maintained at not higher than 118°F (47.8°C). The oil shall then be cooled to 90°F (32.2°C) in air or in a water bath approximately 77°F (25°C) in temperature.

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

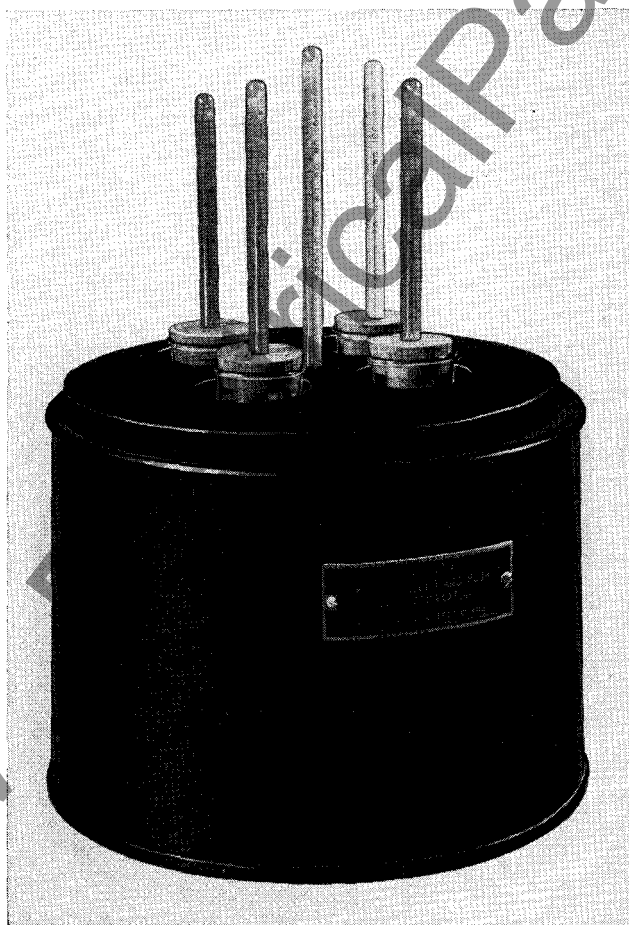


FIG. 6. Apparatus for Pour Test.

TESTING METHODS

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 15°F (8.3°C) nor more than 30°F (16.7°C), 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 20°F (11.1°C) above the expected pour point, at each test-thermometer reading which is a multiple of 5°F (2.8°C), 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 5°F (2.8°C) 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 5°F (2.8°C) 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 Fig. 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.

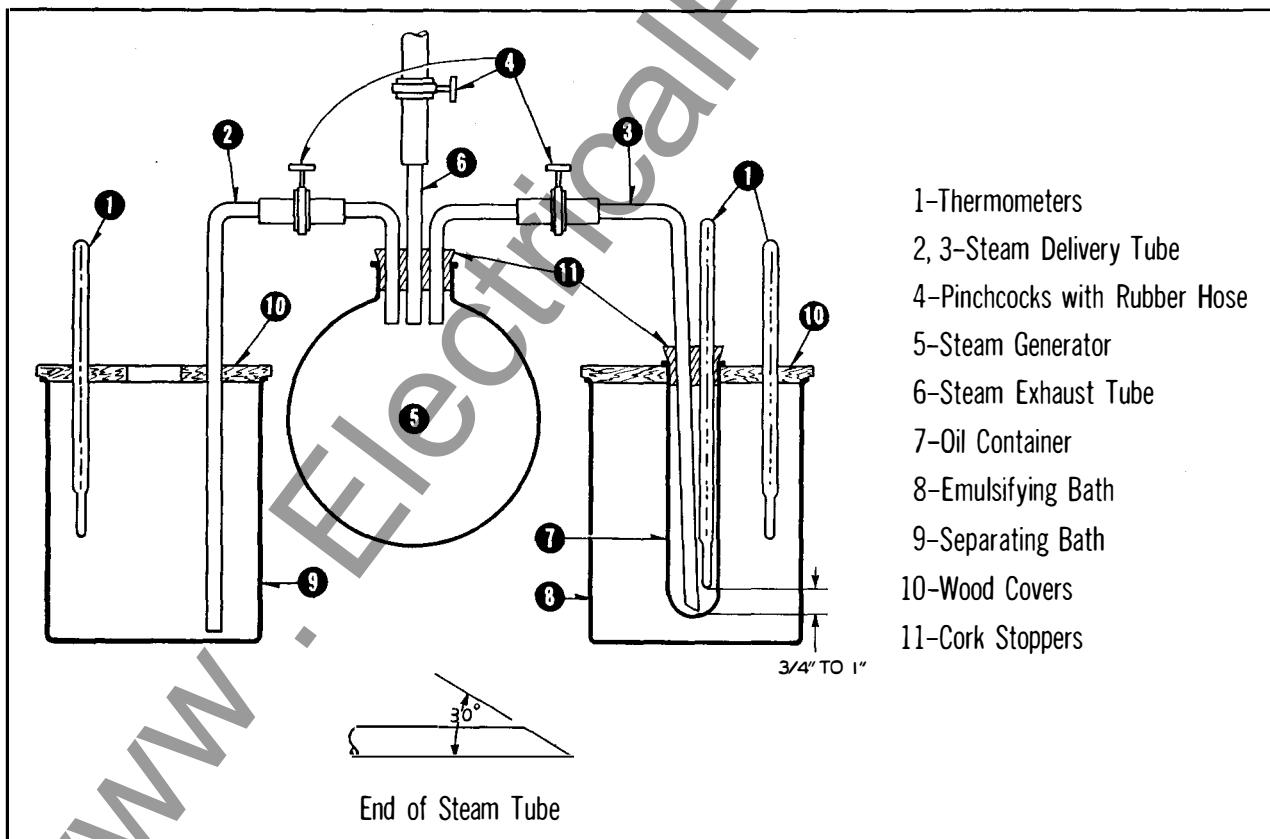


FIG. 7. Apparatus for Steam Emulsion Test.

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

Procedure. The apparatus shall be assembled as shown in Fig. 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 200 to 203°F (93.3 to 95°C).

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 67°F (19.4°C) nor more than 78°F (25.6°C) 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 Fig. 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 $\frac{3}{4}$ 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 190°F (87.8°C) and 195°F (90.6°C). (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 condensation water alone 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 200 to 203°F (93.3 to 95°C). 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.

TESTING METHODS

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. The Steam Emulsion Number of new Wemco C oil is 25 sec. maximum.

NEUTRALIZATION TEST

The Neutralization Number is the weight in milligrams of potassium hydroxide required to neutralize the acid in one gram of oil. The Neutralization Number of new Wemco C oil is 0.03 maximum.

Solutions Required.

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1 N)—add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. Ba (OH)₂ and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard

tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent—Add 500 ml. of c.p. benzene and 5 ml. of water to 495 ml. of c.p. anhydrous isopropyl alcohol.

c. Alpha-Naphtholbenzein Indicator Solution—Prepare a solution containing 10 g. of alpha-naphtholbenzein per liter of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml. Erlenmeyer flask introduce 40 g. of Wemco C oil weighed accurately. Add 100 ml. of the titration solvent and 3 ml. of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg. KOH per g. of Wemco C oil = $\frac{(A-B)(N) \times 56.1}{W}$

A = ml. KOH solution required for sample.

B = ml. KOH solution required for blank.

N = normality of KOH solution.

W = grams of sample used.

APPARATUS FOR RECONDITIONING

There are several types of reconditioning apparatus available, the relative advantages of each of which are as follows:

1. The centrifuge, connected as a separator, may be used where there are large quantities of water present in the oil, without waiting for it to settle out, and connected as a clarifier, for removing small quantities of water. It will remove sludge and coarse carbon particles but not all finely divided carbon.

2. The filter press is suitable for reconditioning oil containing small quantities of water and will remove finely divided carbon and sludge. It will not materially reduce organic acidity or improve the resistance to emulsification except as this is caused by the presence of carbon.

3. The combination centrifuge and filter press, passing the oil first through the centrifuge, may be used advantageously in the removal of large quantities of carbon and water. It unites the exceptional qualities of the centrifuge with the excellent characteristics of the blotter press. This flexibility of operation makes it very desirable as standard equipment in the reconditioning of insulating oil for the removal of large quantities of carbon from the oil. However, the clogging of the pores of the filter reduces the output of this combination.

4. The combination of fuller's earth filtering with vacuum removal of moisture and gases is a more complete form of reconditioning in that it improves all the characteristics of the used oil. Some users of oil carry the improvement further by adding inhibitors in order to extend the sludge-free life of the oil.

The final criterion of the effectiveness of any method of reconditioning insulating oil is the quality of the reconditioned oil.

Oil which has been reconditioned should always be tested for dielectric strength before being passed into the apparatus tank. It is also recommended that the dielectric test, the neutralization number test, the interfacial tension test and the power factor test be applied at intervals to all oil, either used or reconditioned. (See Oil Testing Service, Page 10).

The dielectric strength of reconditioned oil should be at least 22 kv when tested as described in Testing Methods.

The S. E. Number of reconditioned oil should not be over 35 seconds for Wemco C oil when tested

by the method described in Testing Methods, and not over 75 seconds for Wemco C oil received prior to July 11, 1924.

The neutralization value of reconditioned oil should not be over 0.08 mg. of KOH per gram of oil with no trace of alkali when tested as described in Testing Methods.

BLOTTER FILTER PRESS

The blotter filter press (see Fig. 9) is probably most widely used for the reconditioning of insulating oils which have become unfit for use due to the presence of carbon or other foreign matter. It is essentially a number of sets of filter papers in parallel, each set containing several thicknesses. The oil is pumped through the filter paper which absorbs the water and strains out the sediment.

Note: Cleaning devices intended for reconditioning of insulating oil should never be used for other types of work, due to the danger of contaminating the oil.

Capacity. The capacity of these machines, with oil pressure and filtering area fixed, depends on the viscosity of the oil and its freedom from dirt. With fairly clean oil at ordinary room temperature, the capacity of the machines will vary from normal to about 15 per cent above normal, depending on the viscosity (which varies with the temperature). It has been found that the best results are obtained when the oil temperature is about 50°C. The average working pressure of these machines is less than 40 lbs. per square inch and the pressure relief valve is set at the factory to by-pass the full flow at 70 lbs.

Apparatus. These are four standard sizes of Westinghouse filter presses: B-5, B-10, A-30 and A-60. The letter designates the size of filter paper; the number indicates the relative capacity in gallons per minute.

The complete outfit consists of filter press, motor, strainer, pump, gas trap, pressure gauge, drip pan, casters, and piping. The piping is arranged so the suction line can be tested for leaks under pressure.

The strainer can be cleaned by unscrewing a plug. The pumps are of the positive pressure type and are directly connected to the motor through flexible couplings.

APPARATUS FOR RECONDITIONING

Four lifting loops are provided for use if the filter press is to be lifted by crane.

The filter press proper is made up of a series of cast iron plates and frames assembled alternately, with the filter papers between them. By means of a screw and cast-iron end block, the plates, frames and papers are forced tightly together. Except for a machined rim which serves as a joint to prevent the escape of oil, the plates are cast with small pyramids on both surfaces.

The plates and frames have holes in two corners and supporting lugs at the sides. The plates have handles cast on the top edge. When the plates and frames are assembled with the filter papers between, the holes form the inlet and outlet. The frames have the holes in the upper corner connected by small ducts to the middle of the frame. The plates have ducts leading from the surface of the plate to the hole in the lower corner. (See Fig. 8.)

The oil enters under pressure at the top corner through the inlet formed by the holes in the frames, plates, and filter papers, flows into the frames through the same ducts, and completely fills the chamber formed by the frame and two sets of filter paper. As there are no outlet ducts in the frame, the oil is forced through the paper and flows along the grooves between the rows of pyramids and out through the ducts provided at the lower corner of the plates. The dry filter paper takes up the moisture and removes the sediment from the oil.

Operation. The filter press is made ready for operation by placing a set of five sheets of filter paper, that have been thoroughly dried in an electric oven, between each filter plate and frame. The

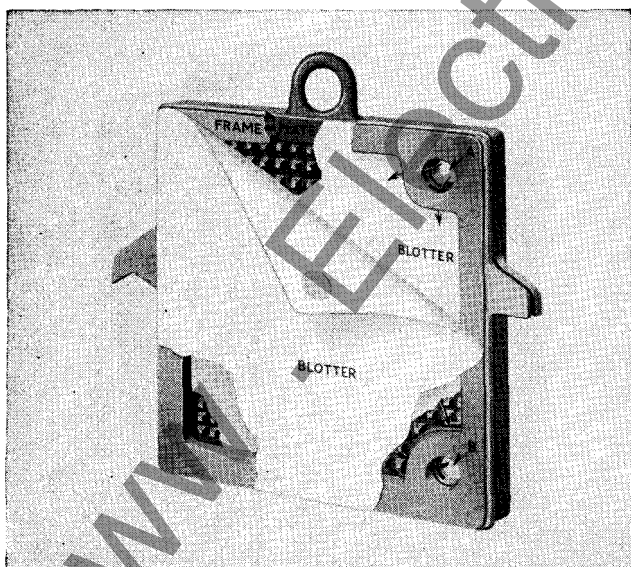


FIG. 8. Filter Press Frame with Blotters in Place.

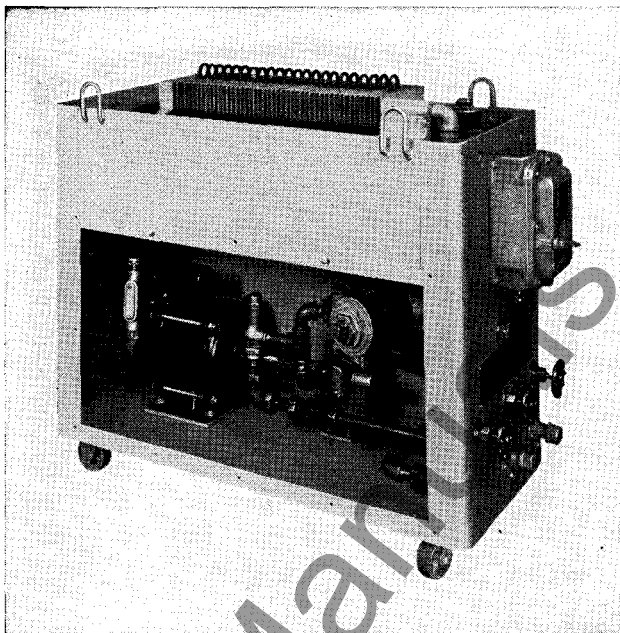


FIG. 9. B-10 Filter Press with Top and Side Panel Removed. (Explosion-Proof Model).

holes in the filter paper must line up with the holes in the plates and frames. The sediment is strained out by the first layer of paper and the moisture is taken up by the capillary action of the paper.

Oil which has only a very small quantity of moisture may be satisfactorily reclaimed by the filter press, but when a large quantity of water is to be removed, the centrifuge or combination centrifuge and filter press is preferred, and is also more economical.

If any moisture remains, it indicates that the filter papers are saturated with moisture and should be renewed. No rule can be given as to how often the papers must be changed, as this depends entirely on the condition of the oil. The usual procedure is to run the machine for about half an hour (if the oil is not in very bad condition) and then shut down; remove one sheet from the inlet side of each set and put in a new sheet on the outlet side of each set. (The frame is the inlet side and the plate is the outlet side.) Frequent dielectric tests should be made during this procedure as wet oil may necessitate recharging the filter press with a full set of papers before the five sheets have been removed in succession.

The quickest method of filtering a quantity of oil is to pump all the oil through the filter and into another tank which is clean and dry. If care is taken to change the filter papers before they become saturated, the oil will be clean and dry. If a second tank for holding the oil is not available, or if it is desired to filter the oil of a transformer while

it is in service, the oil may be pumped from the bottom of the tank through the filter and returned to the top of the same tank under the surface of the oil to prevent aeration. This operation should be continued until the oil in the tank shows a sufficiently high dielectric strength.

When a large quantity of oil is to be filtered, time may be saved by using two filter presses, one of which may be operated while the other is being recharged.

The filter press is not intended to remove large amounts of free water from the oil. Obviously the changing of filter papers necessary for obtaining dry oil would so reduce the capacity as to make this method of reconditioning impractical. In such cases, the water may be removed by a centrifuge, or should be allowed to settle out and be drawn off from the bottom of the container before passing the oil through a filter press.

With badly fouled oil, it may be necessary to pass the oil through the filter press several times to take out the more finely divided carbon which is not caught on the filter papers, especially when they are new. The efficiency of the filter press for removing carbon increases as the pores of the filter papers become partly clogged. This produces a material slowing-down in the rate of flow through the filter papers.

Filtering through filter papers does not materially reduce organic acidity or improve resistance to emulsification except as the latter is affected by the presence of carbon, although the dielectric strength may be restored to a satisfactory value.

The capacity of the filter press is much reduced when operating at low temperatures.

When the oil has to be lifted at low temperatures, an additional pump in the pipe line is desirable.

Oil in transformers contaminated by only a small amount of moisture may be reconditioned by drawing the oil from the bottom of the tank, passing it through the filter press or centrifuge and pumping it back into the top of the transformer, preferably at a point below the surface of the oil. The oil should be put through the system until a sample drawn from the bottom of the transformer gives satisfactory dielectric values.

Pumping the oil from a circuit-breaker tank to the purifying outfit and directly back to the tank is not desirable, as the clean oil is again contaminated by the carbonized oil remaining in the tank. Also, it is then impossible to clean the carbon deposit from the surfaces inside the tank. Do not filter oil from a



FIG. 10. B-10 Filter Press Fully Assembled. Model Shown Has Explosion-Proof Motor and Motor Starter.

circuit-breaker while the breaker is in service on an energized line.

Filter Paper. The filter used is a special grade of blotting paper about .025 in. thick; it contains no coloring matter or chemicals which might injure the oil. Five sheets cut to the proper size, $12\frac{7}{8}$ in. square for the A sizes and $7\frac{3}{4}$ in. square for the B sizes, and with holes punched to correspond with the holes in the plates and frames, are used between each plate and the adjacent frames.

To obtain the best results in reconditioning oil, the paper must be perfectly dry when first placed in the press. Filter paper always takes up moisture if exposed to the air for any length of time and for this reason care must be used in handling. The standard paper is carried in packages containing one ream carefully wrapped in waxed paper and covered with heavy wrapping paper.

Drying Ovens. An electric oven is used for drying the filter paper. The oven is substantially built of sheet iron with double walls. Adjustable slides are provided near the top of the oven for regulating the temperature and the circulation of air through the oven.

These ovens are furnished in two sizes, designated by Types A and B, to correspond to the sizes of filter paper. Type A ovens are used for large size paper that is used in the A size filter presses; Type B oven is used with the B filter presses. By moving one rod, the Type A oven can be used for drying size B paper.

APPARATUS FOR RECONDITIONING

The filter papers are held in a vertical position in a rack and supported by rods through the holes in the corners of the papers. When the door in the front of the oven is opened, the rack may be withdrawn and the filter paper conveniently inserted or withdrawn. (The paper should be dried for about 24 hours before being used, but this time can be decreased, depending upon the condition of the paper and degree of heat.)

Electric drying ovens for use with Type A and Type B filter presses require 2000 watts and 1400 watts respectively. An automatic thermostat having a range of 65°C to 120°C is provided for maintaining uniform oven temperature. The thermostat is adjusted at the factory for 100°C, the recommended value, and the setting marked so that the operator may conveniently reset thermostat to 100°C if adjustment is changed.

The standard thermostat-equipped oven is suitable for alternating current only. Ovens to operate on direct current are special and are equipped with a thermometer and a manually operated three-heat switch. Ovens are listed for 115/230 volts single-

phase, but 230/460 volt single-phase ovens can be supplied when required.

The normal capacity of the Type A oven is 240 sheets and the Type B oven is 180 sheets when spaced 1/4 inch apart.

CENTRIFUGE

The centrifuge is the most convenient equipment known for removing water from oil. It also removes solid material other than finely divided carbon. The temperature of the oil should be maintained at 48.9 to 51.7 C (120 to 125 F) in order to insure removal of all the water at full capacity of the machine. A higher temperature gives no advantage, and, if excessive, will permit the oil to carry more moisture through in solution. (A 6 kw heater will raise the oil about 15.6 C (60 F) per 100 gallons per hour.) The centrifuge equipment may be arranged to act as a separator, discharging the oil and water by different outlets, or as a clarifier, discharging the oil but retaining the water and other impurities in the bowl*.

*For further details, see manufacturer's information.

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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.

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INSTALLATION AND MAINTENANCE

SL Core Form Transformer	I.L. 47-610-1C
Shipment of Transformer in Oil	I.L. 47-600-6
Wemco Oil	I.B. 44-820-1A
Cork Neoprene Gaskets	I.L. 46-713-3B
Determination of Dryness	I.L. 47-600-10C
Standard Outside Finish	I.L. 47-600-12
Cleaning Transformer Insulation	I.L. 47-600-23A
Repairing Weld Leaks	I.L. 47-600-27

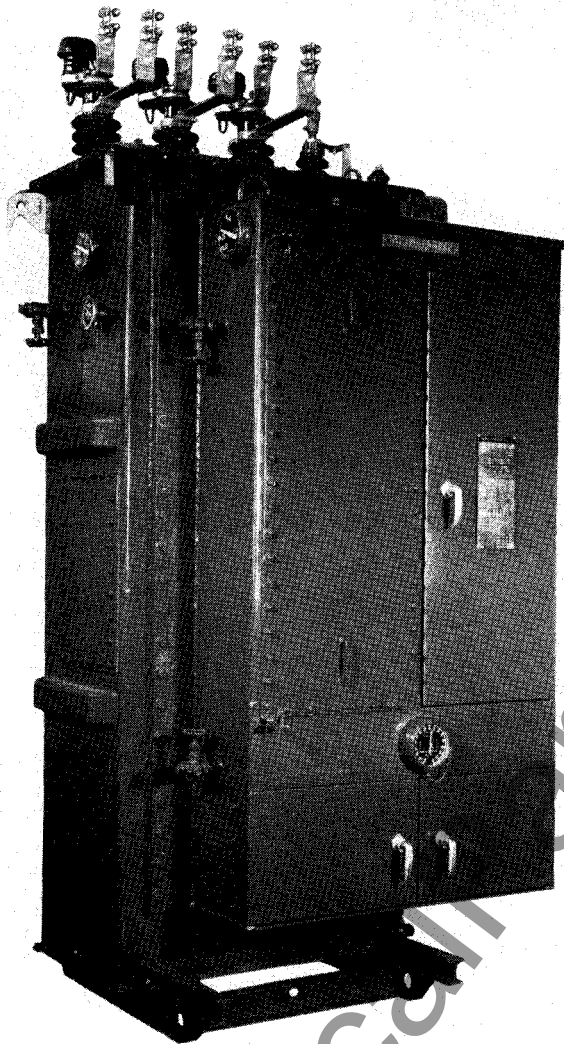
ACCESSORIES

Type "RM" Autovalve Lightning Arrester	I.L. 46-740-5
De-ion AB Circuit Breakers	I.L. 46-744-1A
RC DynAC Brake	I.L. 46-713-8
Bulk Type Bushings	I.L. 46-718-1A
Liquid Level Indicators	I.L. 46-714-3D
Dial Type Temperature Indicators	I.L. 46-716-4D
Dial Type Thermometer for Air Blast Equipped Regulators	I.L. 46-716-5E
Air Blast Cooling	I.L. 46-735-1E
Pressure Relief Valve	I.L. 46-712-1A
Concentric Lead Bushings	I.L. 46-713-6A

RELAYS

Relays in Type FT Case	I.L. 41-070.1D
SG Relays	I.L. 41-350.1D
TH Relays	I.L. 41-369.F
SJS Voltage Regulating Relay	I.L. 47-431-4
RA-35 Voltmeter	I.L. 43-350-G

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

TYPE URS VOLTAGE REGULATOR

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

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

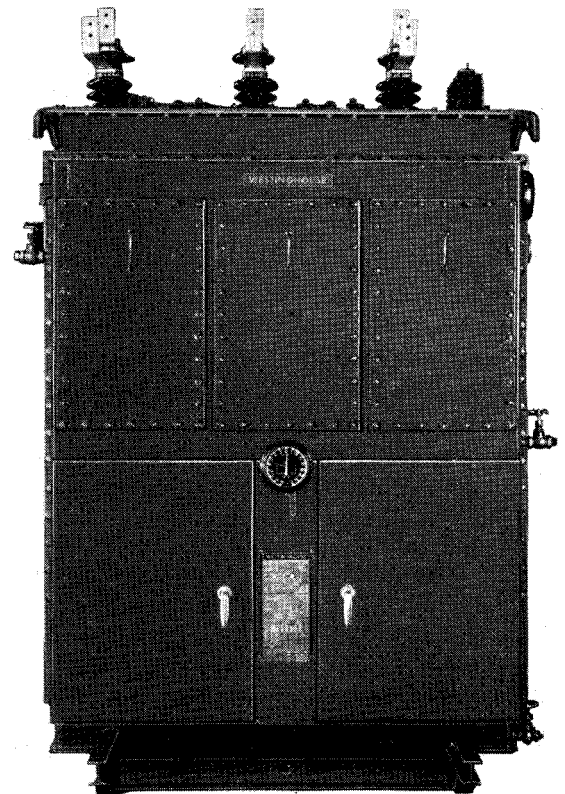
This regulator is used primarily to maintain a constant normal voltage on transmission lines and distribution feeders. Regulation is accomplished by the use of a Type URS Load Tap Changer which operates over a tapped regulating auto-transformer, selecting the proper voltage tap and polarity relation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

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

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

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

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



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

DESCRIPTION

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

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

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

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

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

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

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

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

TRANSFORMER CORE AND COILS

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

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

TAP CHANGER

Figure 2 shows a cutaway view of the tap changer.

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

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

Each stationary contact consists of a copper alloy foot mounted on the main isolating and insulating

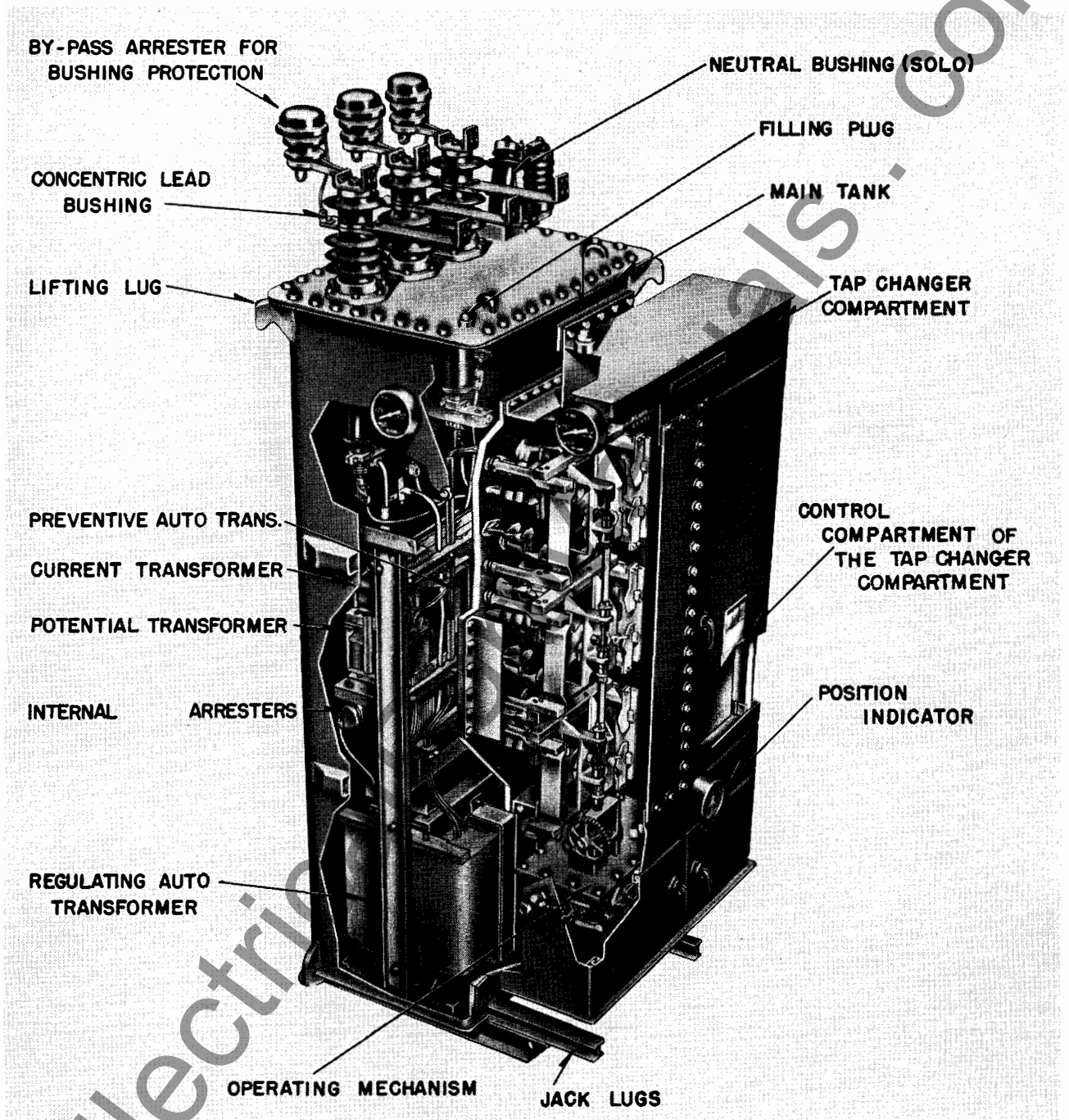


FIG. 1. Cutaway View of Type URS Voltage Regulator.

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 a Micarta arm, which

REVERSING SWITCH

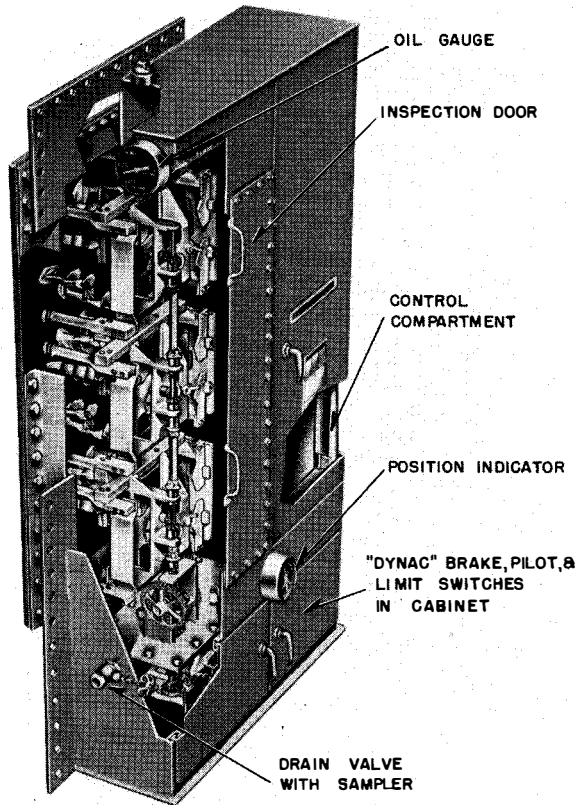


FIG. 2. Cutaway View of Type URS Tap Changer with Vertical Phase Arrangement.

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

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

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

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

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

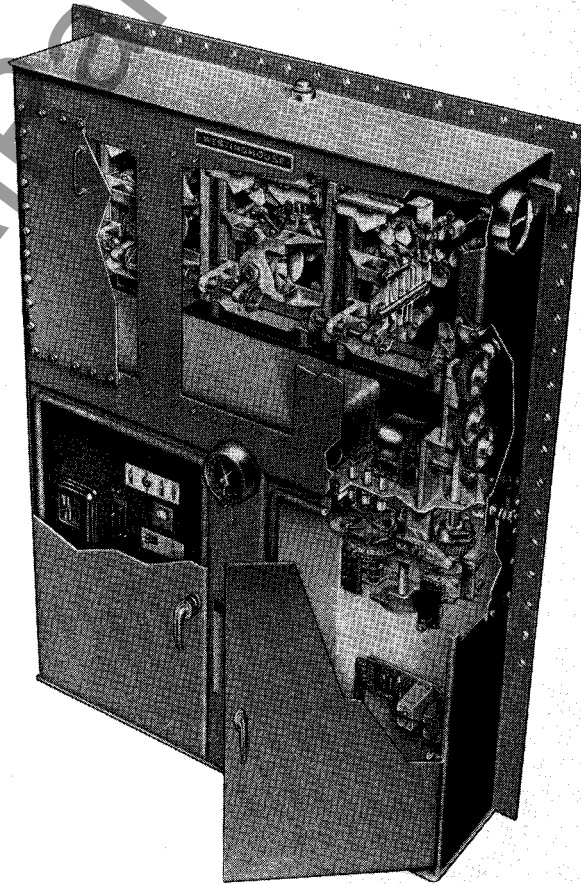


FIG. 2A. Cutaway View of Type URS Tap Changer with Horizontal Phase Arrangement.

REVERSING SWITCH
MOVING CONTACT

REVERSING SWITCH
STATIONARY CONTACTS

MOVING
SELECTOR CONTACTS

STATIONARY
SELECTOR CONTACTS

FRONT COLLECTOR DISC

GENEVA GEARS

INSULATING SHAFT

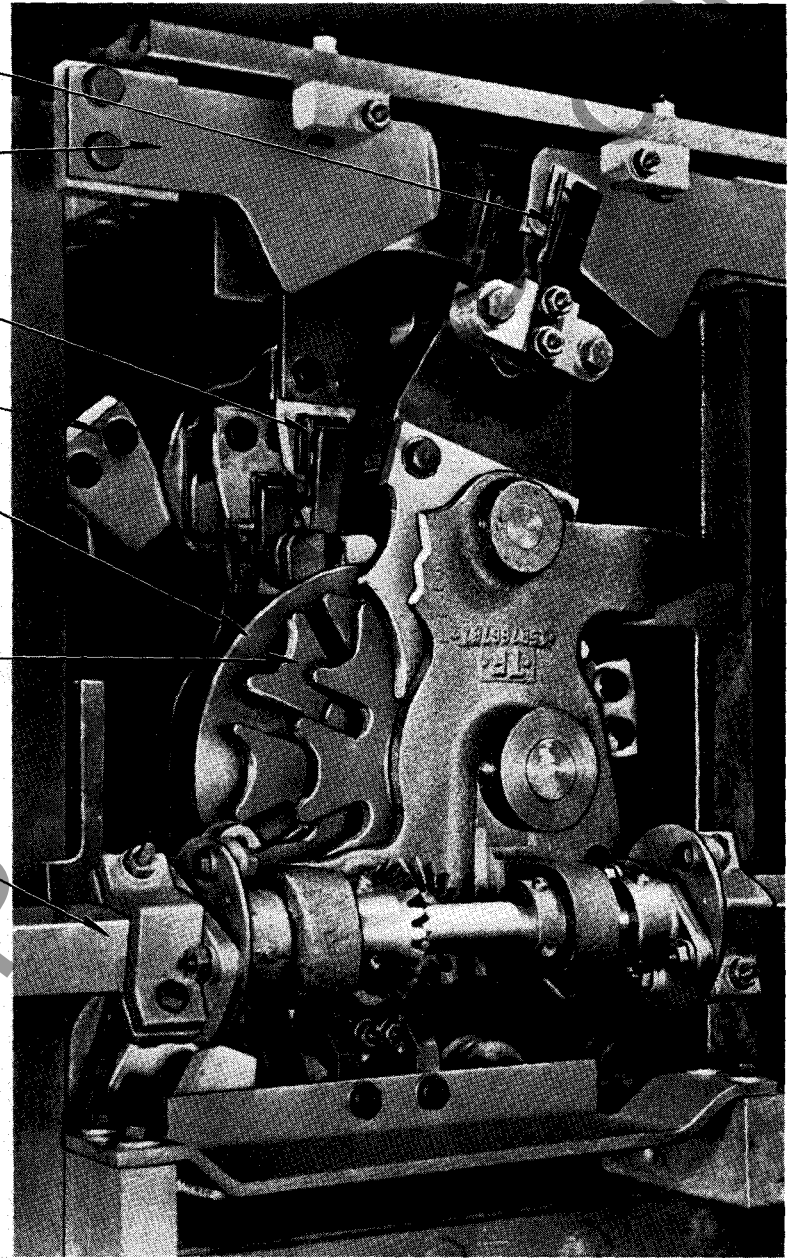


FIG. 2B. Sectional View of Type URS Selector Switch Assembly.

OPERATING MECHANISM

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

The driving motor is a 230-volt, a-c single-phase, reversible, capacitor-start, capacitor-run motor espe-

cially designed for operation under oil. Its capacitor is mounted in the air compartment. For positive stopping, the RC "DynAC Brake" is used.

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

DESCRIPTION

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

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

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

CAM SWITCH ASSEMBLY

The air compartment contains the cam switches, mechanical stop, RC "DynAC Brake" and hand cranking arrangements. Electrical connections from the motor are brought into this compartment through 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 for the crank when not in use. An interlocking switch is provided which removes all power from the motor when the worm is moved from its out-of-mesh position.

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

A shaft is included which travels ten degrees per position. This shaft is connected to the dial type position indicator having resettable maximum-mini-

mum hands. The indicator is located on the face of the tap changer. This shaft may also be used to drive a "Synchrotie®" transmitter for remote position indication, or for other special switching or indicating systems.

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

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

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

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

MECHANICAL STOP

The cam-operated switches insure that the URS tap changer will not run beyond the limits of its operating range; however, as an additional safeguard, a mechanical stop is provided so that even

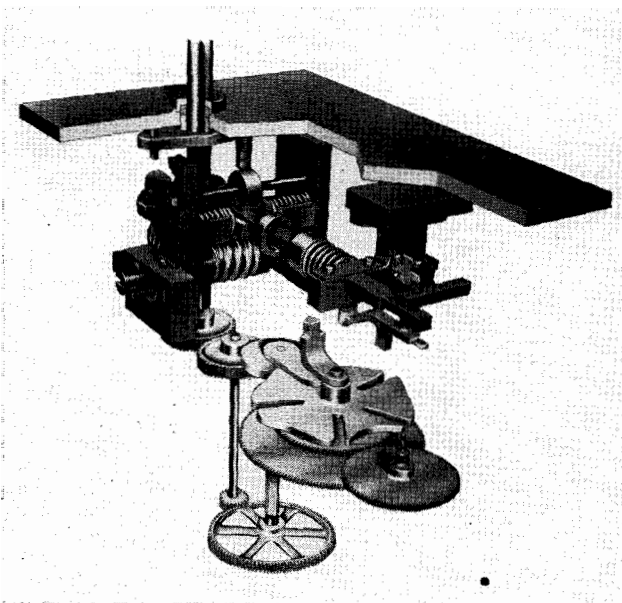


FIG. 3. Tap Changer Mechanical Stop for the Vertical Phase Arrangement.

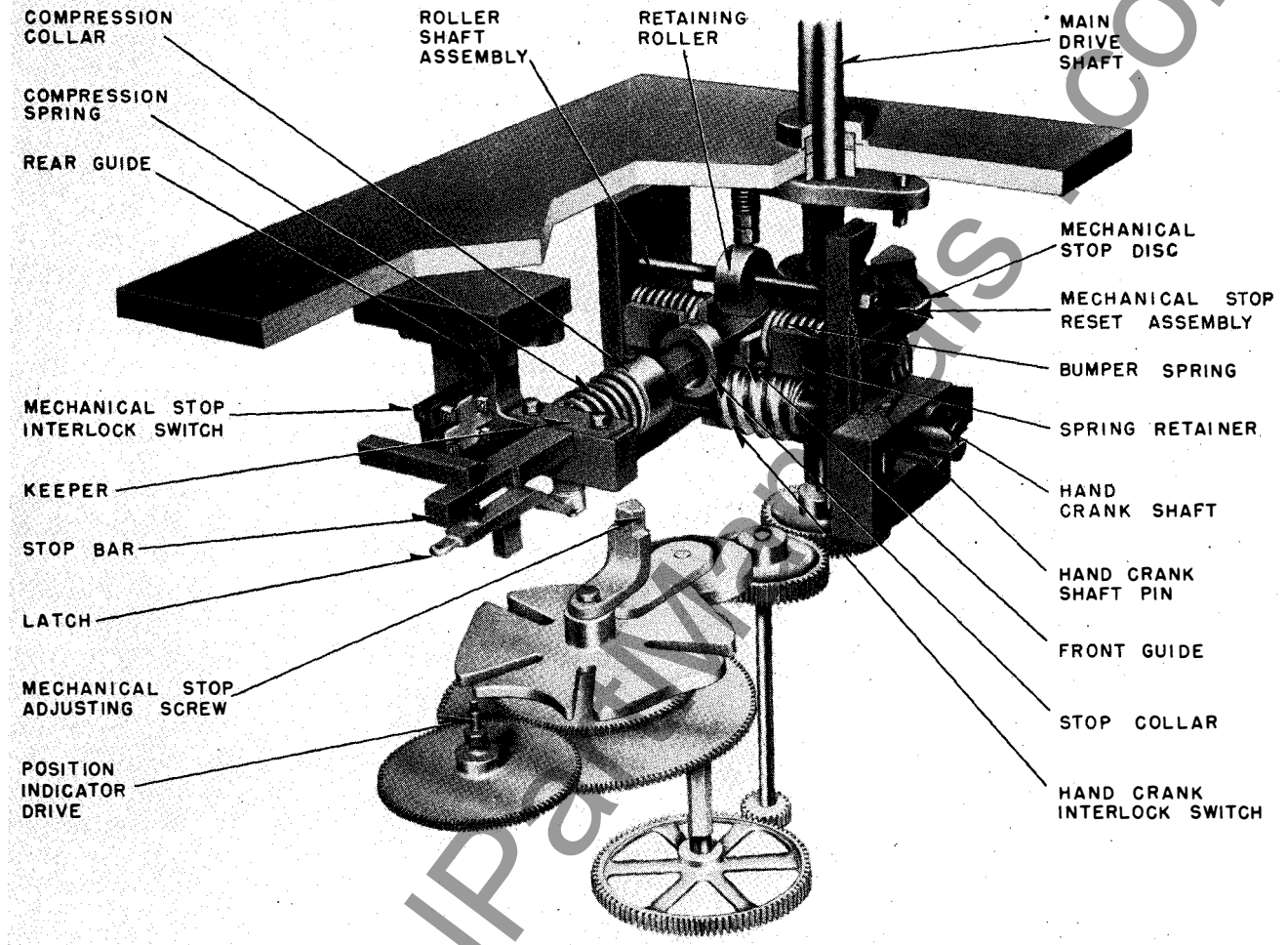


FIG. 3A. Tap Changer Mechanical Stop for the Horizontal Phase Arrangement.

though jumpers had been put across the contacts of the limit switches, the tap changer would be positively stopped before the moving contact fingers could leave the stationary selector switch contacts. The stop mechanism is illustrated in Figs. 3 and 3A.

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

The mechanical stop disc, having large bosses on its top surface, is mounted on the main drive-shaft in the operating mechanism compartment. The

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

The stop bar is a rectangular bar of steel which is spring loaded and is held in its normal position by a tripping latch. The tripping latch is counter-balanced by a spring so that the normal position of the latch roller is at the centerline of the stop bar. The latch roller resets into a slot in the stop bar. The slot in this bar has circular ends so that the roller is forced to the lateral center of the slot even without the spring counter-balance. When the

DESCRIPTION

mechanical stop adjusting screw strikes the tripping latch, the latch roller is forced out of the slot in the stop bar permitting the compression spring on the stop bar to push the bar into the wide space between the disc bosses, positively preventing the tap changer from making any further movement. The stop bar is supported in a front and rear guide. A keeper holds the bar in the rear guide while a retaining roller keeps the bar in the channel provided in the front guide. The retaining roller is free to move along its axis at right angles to the length of the stop bar, being held in place by the channel in which the stop bar slides. The front guide channel is held in a balanced position between two heavy springs which serve to absorb the energy of the system when the stop disc strikes the stop bar. A collar near the front end of the stop bar limits the forward thrust into the stop disc when the stop bar is tripped.

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

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

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

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

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

1. De-energize the control circuit and turn the tap changer beyond its limit positions by hand. With the location of the 120 switch cam roller on the center of the lobe of the 120 cam as a reference, check the angular movement of the 120 cam shaft as the mechanical stop is tripped. The set screw locking the adjusting screw should then be released

and the adjusting screw should be turned in or out to make the stop trip correspondingly later or earlier as required. The mechanical stop should trip with the 120 cam shaft at 30° from its reference position. This is approximately $\frac{5}{8}$ of a hand crank turn.

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

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

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

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

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

1. De-energize the unit.

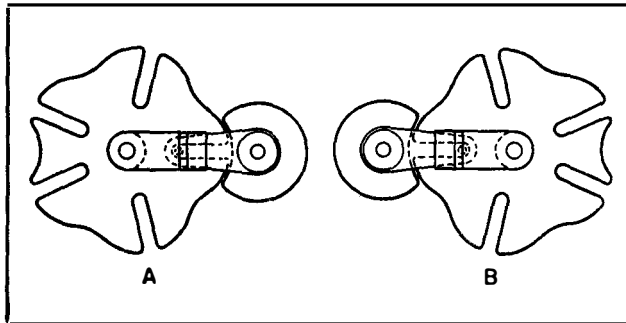


FIG. 4. Geneva Gearing for Type URS Cam Switch Unit (Position Shown is for Position O)

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

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

MATCH MARKS

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

1. The tap changer is set on the neutral position O.
2. The selector contacts are exactly on position on stationary contact R.
3. A straight edge placed across the wide space between bosses on the stop disc is parallel to the side wall of the tap changer compartment.
4. The match marks (small arrows) on the front of the stop disc are in a vertical line with

- similar match marks to the side of the hand crank shaft on its front bearing support.
5. The cam assembly is lined up with the 120 cam switch roller on the center of the 120 cam lobe which has the arrow on its bottom surface.
6. The position indicator is in agreement with the location of the tap changer contacts (on the mid range position or O).
7. The match marks on the gears between cam shafts of the control switch assembly are in line.
8. The large end of all taper pins is toward the front of the tap changer with the smaller end to the back.
9. The Geneva Gearing used for the limit switch shaft is as shown in Fig. 4.

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

HOUSING

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

INSTALLATION

RECEIVING AND HANDLING

Immediately upon receiving the regulator, an inspection should be made of all parts to make sure that no damage has resulted during shipment. If damage or injury is evident, file a claim with the transportation company at once, and promptly notify the nearest Westinghouse Sales Office. If the unit is to be stored for a time before installing, a dry place should be selected. If indoor storage is not practical, an energized heater (250 watts for normal

conditions) should be placed in the bottom of the air compartment to protect the control equipment from moisture condensation.

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

INSTALLATION

unit. A jack should not be used on any other part of the regulator.

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

INSTALLING

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

1. Remove any blocking from 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.

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

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

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

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

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

6. Set the line drop compensator dials for proper resistance and reactance compensation of the line between the regulator and the load center. Refer to I.L. 47-431-3 for detailed information on the compensator adjustment.

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

8. Remove the test voltages.

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

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

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

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

Connect the regulator to the line making sure to connect the "S" leads to the source and the "L" leads to the load, regardless of whether the regulator is to be connected to the sending or receiving end of the line. Care should be taken to see that all connections are properly made, as a wrong connection may cause serious damage. If possible, the voltage should be brought up slowly so that any trouble may be found before damage can result. Close the AB control breakers and operate the tap changer over its entire range and back to the neutral position by means of the "raise-lower" switch. Turn the "automatic-manual" switch to the "automatic" position if this is desired.

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

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

OPERATION

PRINCIPLE OF REGULATOR OPERATION

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

The tapped section of the transformer winding is shown between 3 and 12, with taps 4 to 11 inclusive

connected to the stationary contacts of the selector switches of corresponding numbers. Taps 3 and 12 are connected to the reversing switch stationary contacts, and tap 2 to the stationary selector contact R, and reversing switch moving contact R. Terminals P1 and P3 of the preventive auto transformer are connected to the two moving contact fingers of the selector switches.

Fig. 6 shows the tap changer in its neutral position, with both moving contacts on stationary contact R, the preventive auto short circuited, the rever-

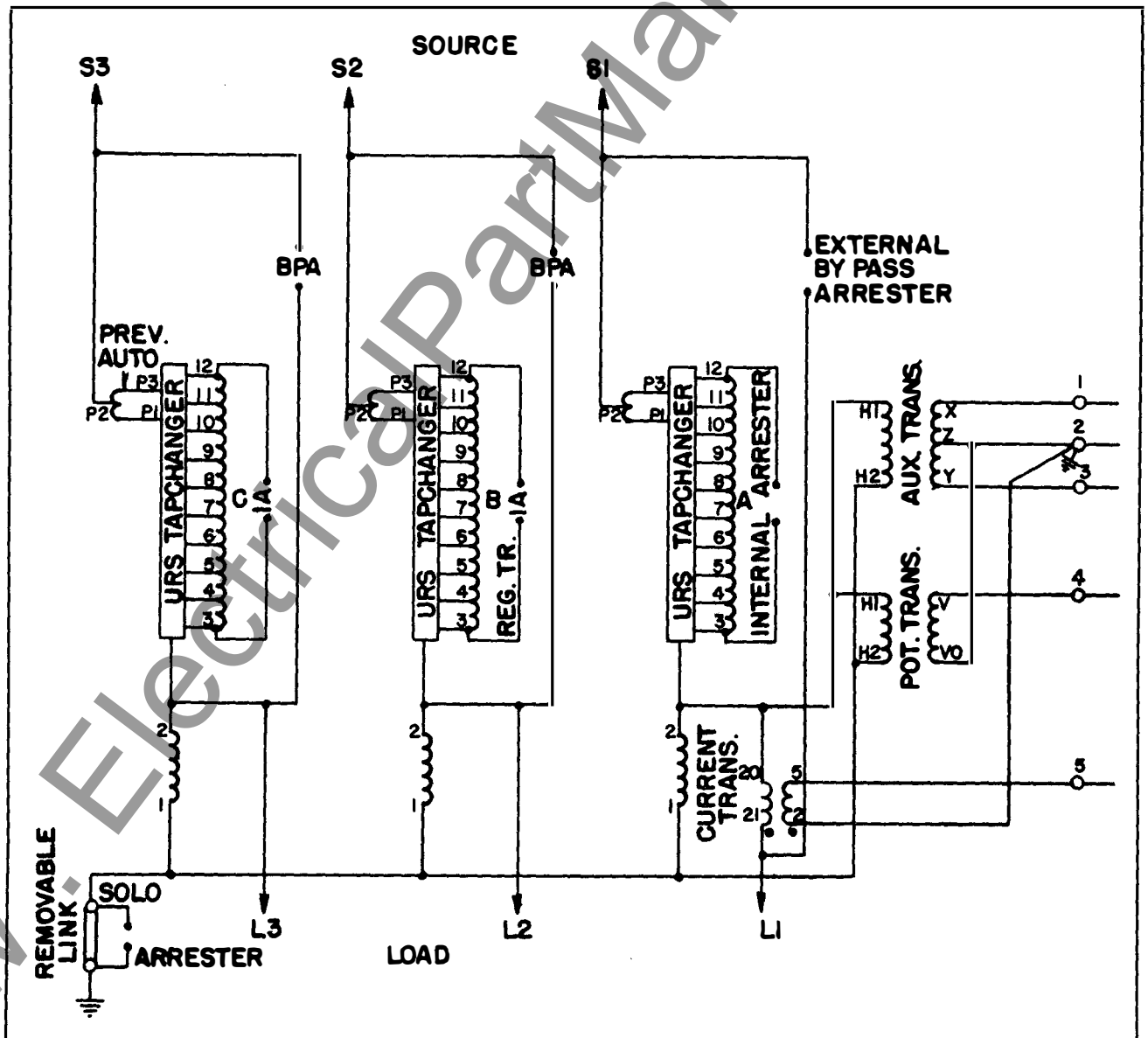


FIG. 5. Three Phase Type URS Voltage Regulator Connection Diagram.

OPERATION

sing switch connecting R to A, and none of the tapped section of transformer winding connected into the circuit. This is position 0.

In changing from position 0 to position 1R, a bridging position midway between position 0 and position 2R, the moving contact connected to P3 leaves stationary contact R and moves to stationary contact 11. This connects the preventive auto transformer across taps 12 and 11, and causes the number of effective turns in the winding between S1 and 1 to be decreased by half the number of turns of the

tapped section 11-12. By thus increasing the volts per turn in the fixed winding between 1 and 2, the voltage appearing between L1, L2 and L3 is increased.

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

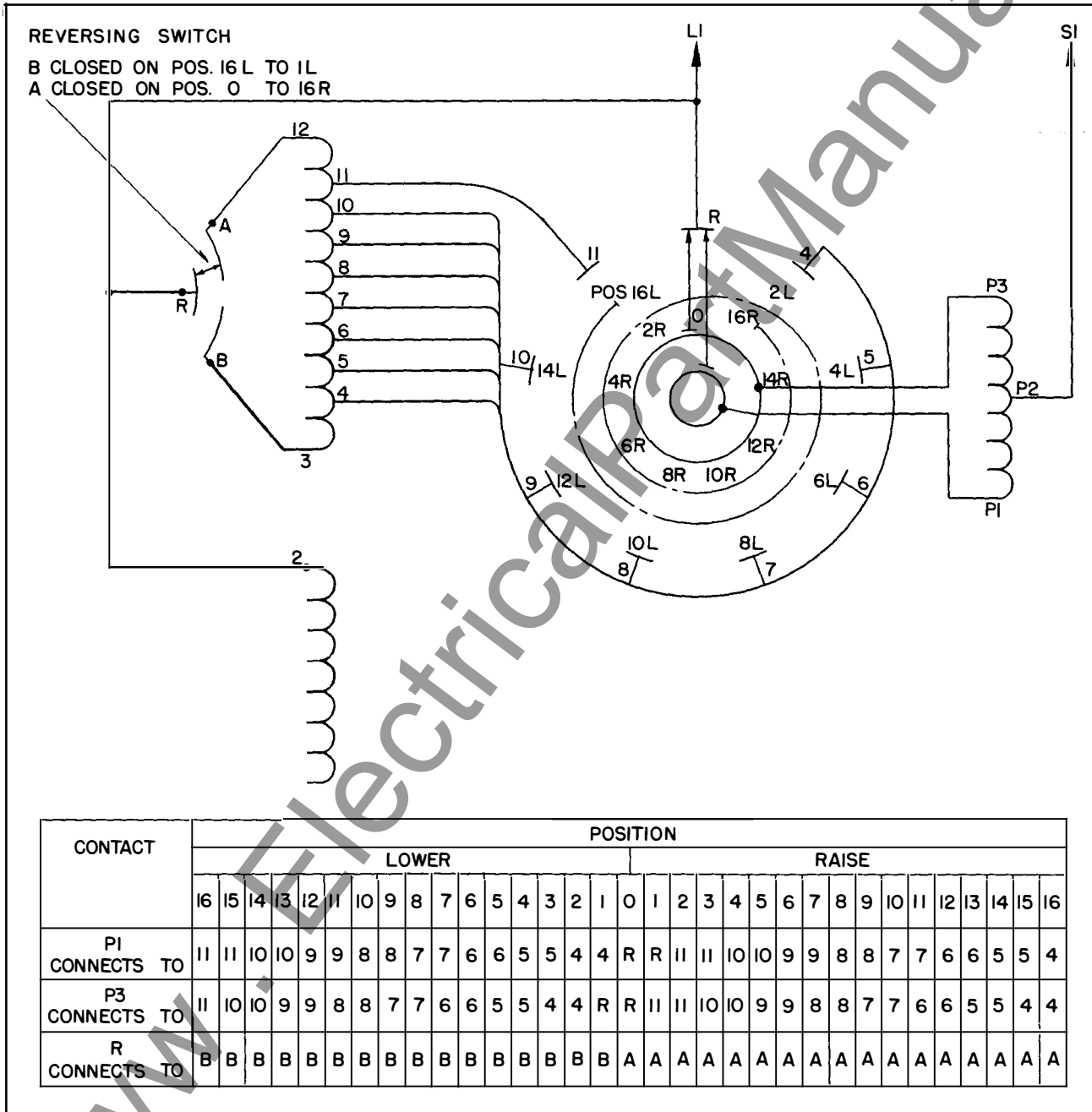


FIG. 6. Typical Schematic Connection Diagram of One Phase of Regulator and Sequence Chart of Tap Changer Positions.

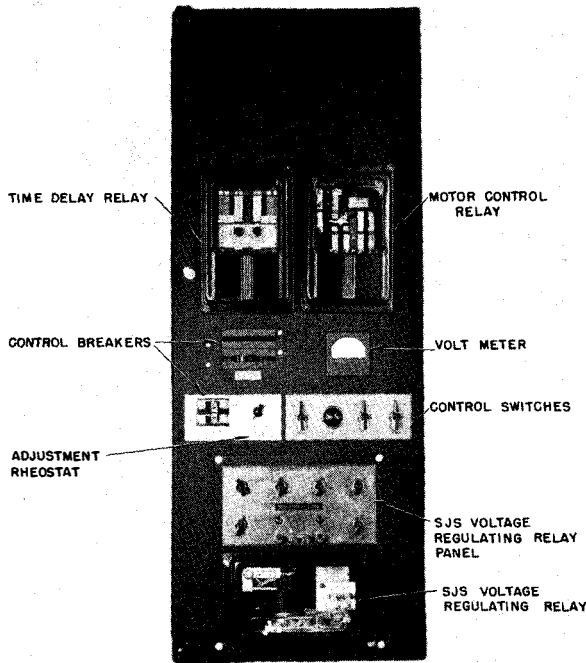


FIG. 7. Typical Control Panel for Vertical Phase Arrangement Tap Changer.

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

In changing from position 0 to position 1L, the reversing switch acts to reverse the connections to the tapped winding and contact P1 moves to stationary contact 4. The sequence is as follows: R-A opens, P1-R opens, R-B closes, P1-4 closes. This connects the preventive auto transformer across taps 3 and 4, and causes the number of effective turns in the winding to be increased by half the number of turns in the tapped section 3-4. By thus decreasing the volts per turn in the fixed winding between 1 and 2, the voltage between L1, L2 and L3 is decreased.

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

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

PRINCIPLE OF CONTROL OPERATION

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

The panel is of steel and is in a steel compartment mounted on the side or bottom of the tap changer. A hinged mounting is used so that both front and rear of the panel is readily accessible for inspection and maintenance. The control relays and equipment are all of the Flexitest case construction for semi-flush mounting. The Flexitest case construction allows the relay mechanism to be easily disassembled for inspection, testing, adjusting and remounting. A potential test plug and a current test plug are supplied with each order for use in testing these relays.

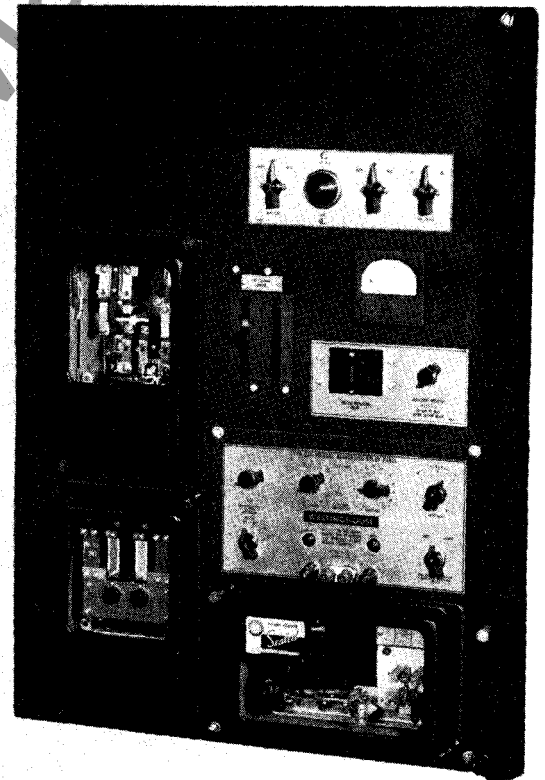


FIG. 7A. Typical Control Panel for Horizontal Phase Arrangement Tap Changer.

FUNCTIONS

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

1. Initiate the operation of the tap changer motor to cause a tap change.
2. Provide means for ensuring that once a tap change is initiated it will be carried through to completion.

OPERATION

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

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

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

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

The schematic control circuit for automatic or manual control of a Type URS Tap Changer is shown in Figure 8. An automatic-manual switch, "AM", enables the selection of automatic or manual operation by the closing of the "AMA" or "AMM" contacts respectively. The SJS Voltage Regulating Relay is responsive to voltage changes in the regulated line and initiates tap changer operations automatically. "NV" is the no voltage device connected to prevent automatic operation to maximum boost if ABl 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 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 to de-energize the motor in the event of a mechanical stop operation. In addition, another interlock switch IS is mounted to de-energize both the motor and the control circuit when using the hand crank and manually operating the tap changer. Thus, the unit cannot be operated electrically if either the mechanical stop has tripped or the hand crank is engaged.

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

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

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

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

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

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

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 control relay mounted on the control panel. The coils act to open and close contacts of the same designation (i.e., SR1, SL2, etc.).

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

NEL and NER are two indicating lights incorporated into the Voltage Regulating Relay. These lights give visual indication as to which contact of the Voltage Regulating Relay is closed, NEL operates from the PL contact and NER operates from the PR contact. These lights eliminate the guesswork as to which contact is closed and also as to when the contacts close.

V is the voltmeter used to measure the voltage being applied to the SJS Voltage Regulating Relay.

RH is an adjustment rheostat used to adjust the input voltage to the SJS Voltage Regulating Relay during times of Relay Calibration. This rheostat is to be returned to the zero "0" position after calibrating the relay and before returning the SJS Voltage Regulating Relay into a position of control over the regulator.

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

PC is the line drop compensator portion of the SJS Voltage Regulating Relay.

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

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

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

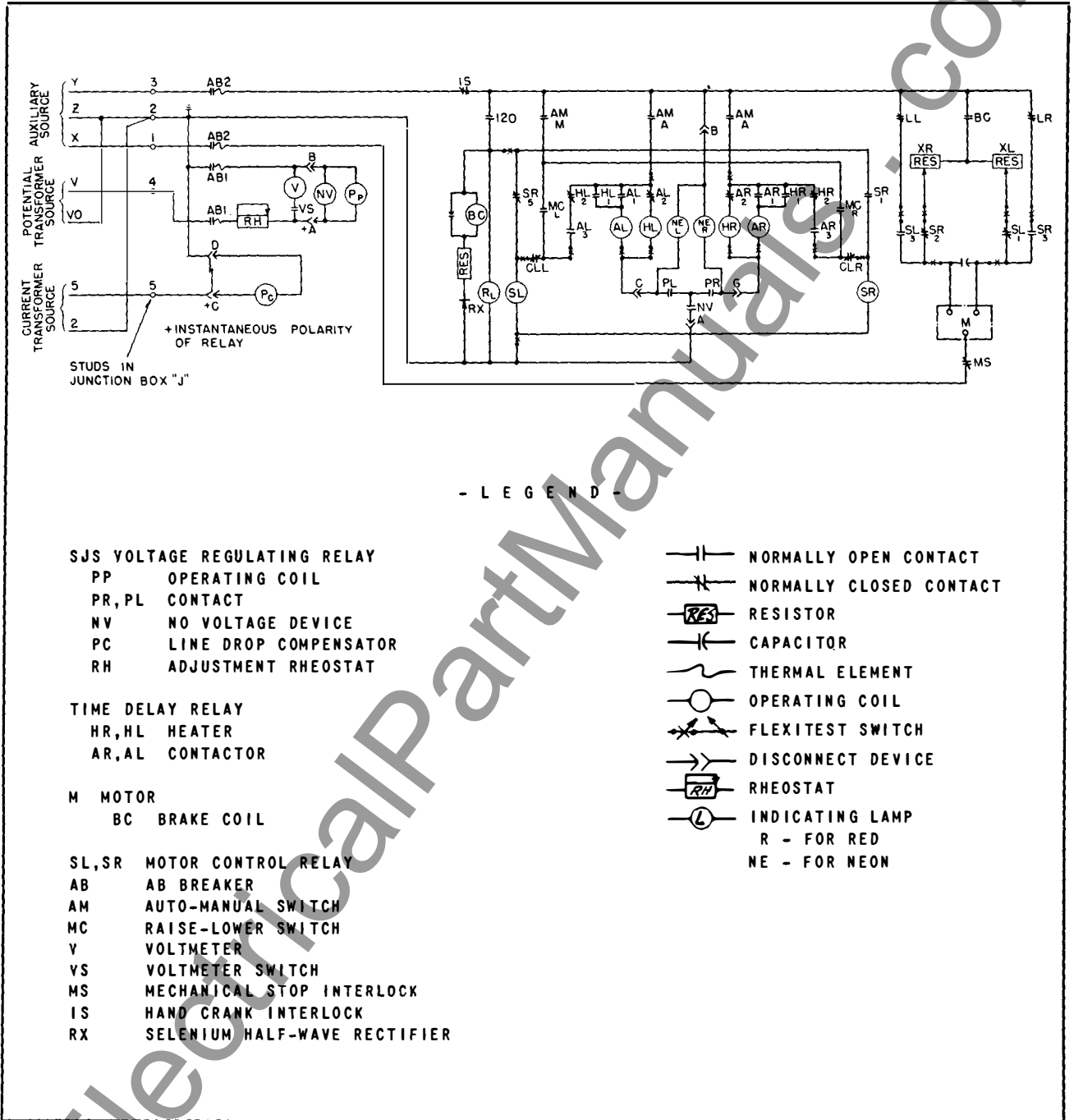


FIG. 8. Typical Schematic Diagram for Type URS Voltage Regulator Control.

relay coil PP and the NV device. When AB1 is closed, the NV device coil is energized closing the NV interlock contact; also the coil PP 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 coil PP 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 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.

OPERATION

When Voltage Drops: A drop in voltage causes voltage regulating relay "raise" contact PR to close energizing time-delay relay heater HR and indicating light NER. 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, the 120 cam keeps the RC "DynAC Brake" relay contact BC closed. When the motor control relay opens, SR2 is closed, short circuiting the motor 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 RC "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.

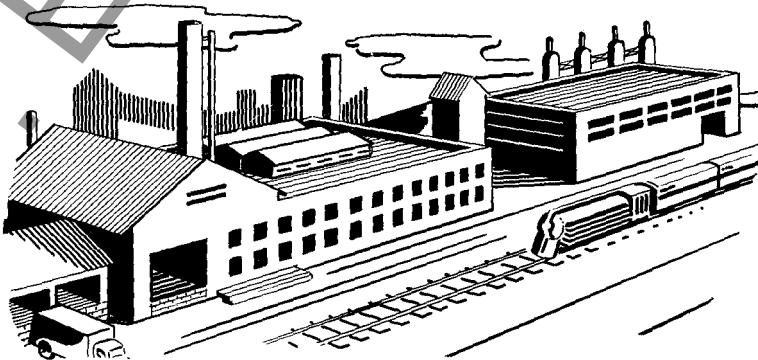
Protection Against "No-Voltage". The no-voltage device (NV) is connected across the voltage regulating relay voltage. The "make" contact of no-voltage relay is connected in the automatic control circuit and is closed when the relay is energized.

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, contacts AMA of the automatic-manual switch are open and contact AMM is closed. When higher voltage is desired, contact MCR of raise-lower switch is closed, energizing motor control relay coil SR. From this point on, the tap changing, braking, and positioning are the same as for automatic control.

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



MAINTENANCE

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

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

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

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

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

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

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

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

Replacement should be made before the moving finger shoes have burned sufficiently to reduce the smooth flat contact width to less than $\frac{1}{4}$ inch and before the stationary contacts burn into the base material to which the arcing tips are brazed. *It is recommended that the entire tap changer be thoroughly inspected at the end of its first year of service, or after its first 35,000 operations, whichever is earlier. The fre-*

quency of subsequent inspections can be based on the facts found by this initial inspection. A complete inspection of the contacts and the operating mechanism should be made at least every third year after the initial inspection.

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

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

1. Be sure the drums used for oil storage are absolutely clean and dry. Inspection of the drums will save much grief.
2. Be sure the oil is filtered before it is returned to the tap changer compartment to remove any carbon, metal particles, or water which might have been present or introduced in handling.
3. The oil should be free of carbon before it is considered satisfactory.
4. After filling the tap changer compartment with oil and before energizing the unit, test at least three representative samples in the standard test cup. The test value should be 25 Kv or better.
5. The tap changer should never be energized when the oil in the housing tests less than 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

SUPPLEMENTARY DATA

the apparatus and the internal connections for the main regulator are shown on the diagram nameplate.

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

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

SPARE PARTS

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

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

- One Motor.
- One Set of "DynAC Brake" Contacts.
- One Motor Control Relay Complete.

SUPPLEMENTARY DATA

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



INSTRUCTIONS

TYPE SL HIPERSIL CORE FORM TRANSFORMERS

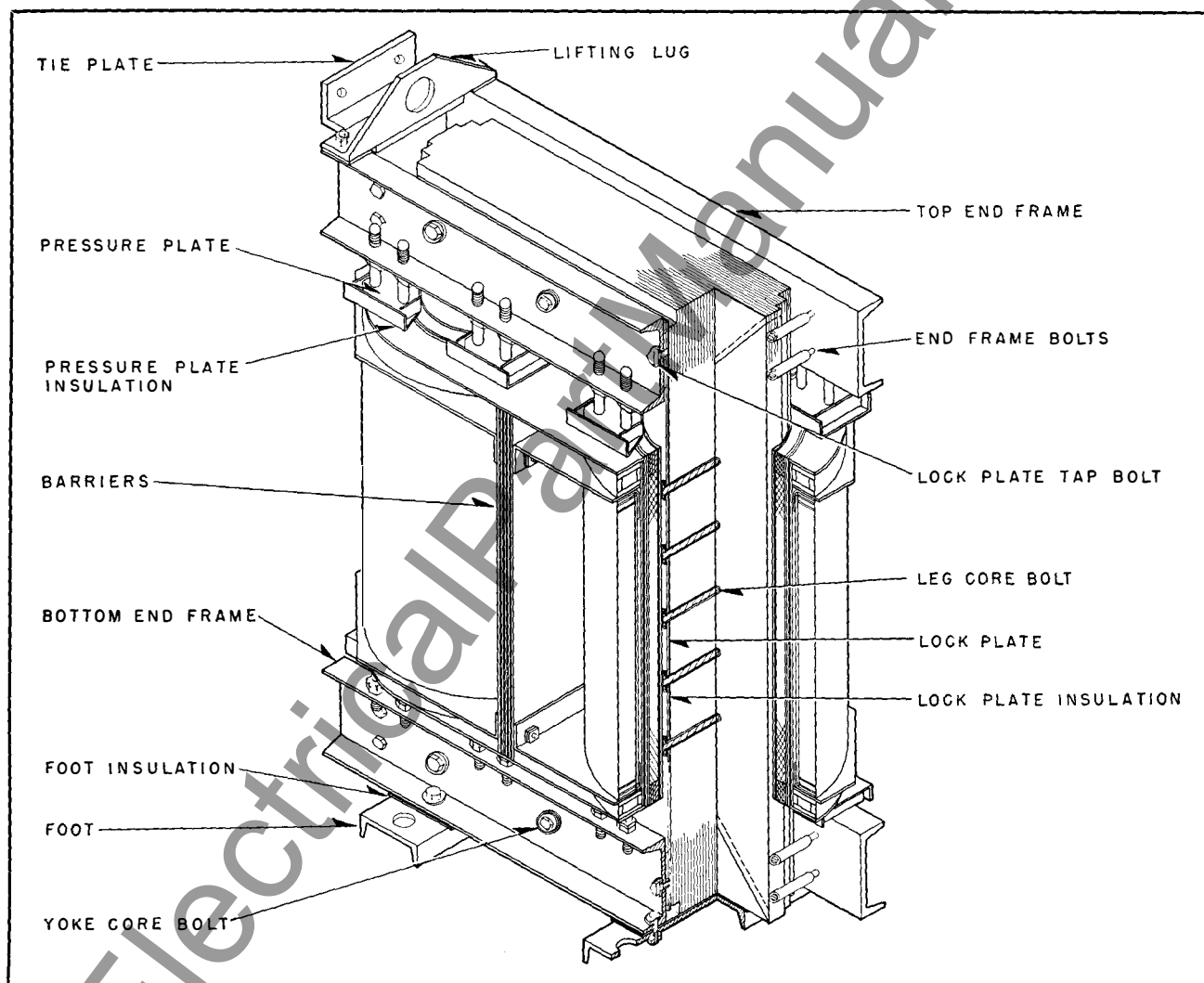


FIG. 1. Sectional View of a Single-Phase Core Form Transformer.

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 result-

ing 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.

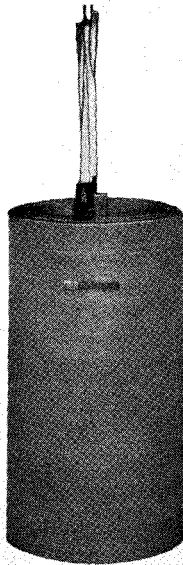


FIG. 2. Cylindrical Coil Winding.

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.

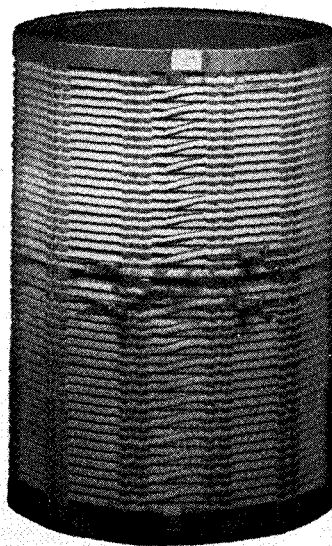


FIG. 3. Continuous-Wound Pancake Coil Winding.

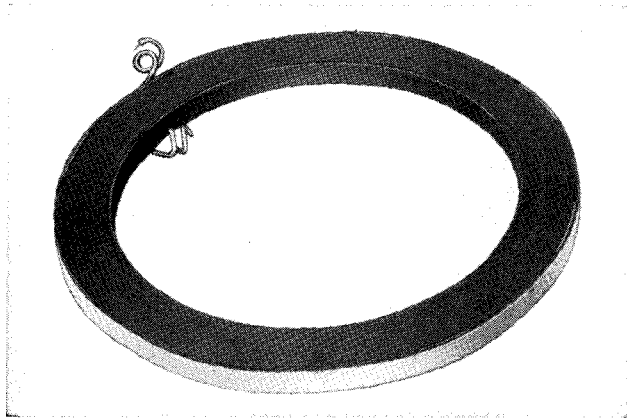


FIG. 4. Round-Wire Pancake Coil.

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-

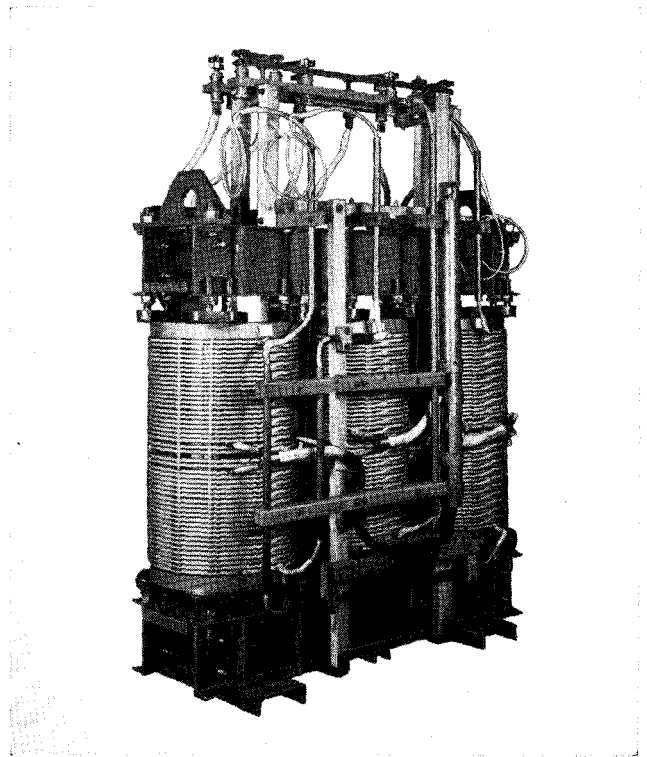


FIG. 5. Core and Coils of a Three Phase Transformer.

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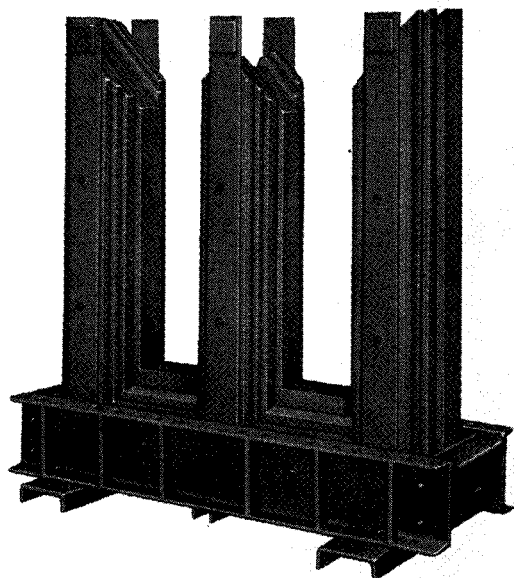


FIG. 6. Partial Hipersil Core Assembly For a Three-Phase Transformer.

parated 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

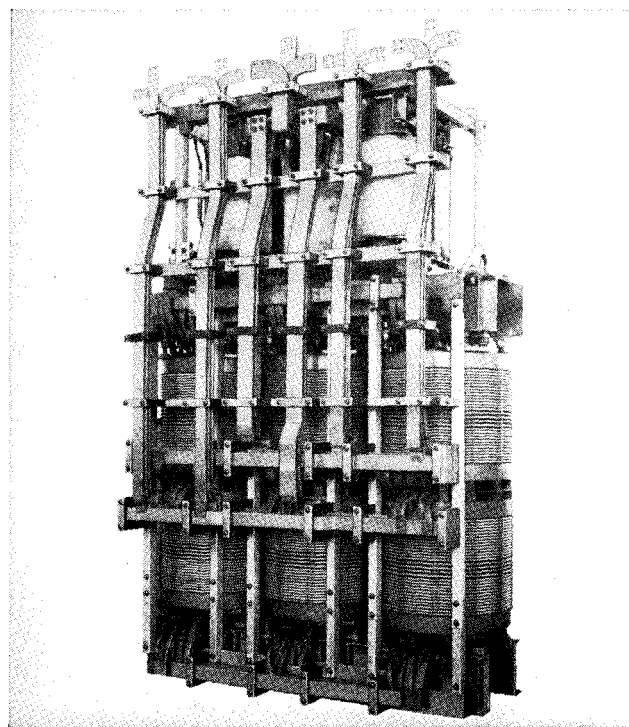


FIG. 7. Core and Coils for 12-Phase, 6000 Kw., 600 Volt Rectifier Transformer with Interphase Transformers Mounted on Upper End Frame.

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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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.

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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I N S T R U C T I O N S

The RC "DynAC Brake"

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

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

DESCRIPTION

The RC "DynAC Brake" is made in two forms, one for use with the 120 cam switch and the other with the 121 cam switch of the tap changer operating mechanism.

In either case, the basic brake circuit is composed of the following material:

- a. One 30 micro-farad capacitor.
- b. Two 2 ohm variable resistors.
- c. One SG relay.
- d. One selenium half-wave rectifier.

When used with the 121 cam switch, the above equipment except for the 2 ohm resistors is mounted on its own panel and is usually located in a remote control cabinet. Figure 1 shows the arrangement of the equipment for this form of the RC "DynAC Brake".

Figure 2 shows the arrangement of the equipment when used with the 120 cam switch. Here, in addition to all of the aforementioned equipment, is mounted the motor capacitor and a 400 ohm resistor.

In either case, the apparatus is connected together electrically per the following:

The coil of the SG relay is paralleled across the capacitor. The SG relay coil and

capacitor parallel combination is connected in series with the selenium half-wave rectifier. The contacts of the SG relay are connected in series with the parallel circuits formed by the two 2 ohm resistors, back contacts of the motor operating relay and the motor windings. Refer to Figure 3 for the schematic circuit as described above.

When the RC "DynAC Brake" is used with the 120 cam switch, a 400 ohm resistor, as previously mentioned, is connected in series with the selenium half-wave rectifier as well as the SG relay coil and capacitor combination. This resistor is used to introduce a time delay into the RC "DynAC Brake" circuit to permit the motor control relay to complete its operation prior to the closing of the RC "DynAC Brake" contacts. See Figure 4 for the schematic of above outlined circuit.

The time delay mentioned in the previous paragraph is a result due to the addition of the 400 ohm resistor, forming a resistance - capacitance circuit. As the selenium half-wave rectifier gives a pulsating D. C. voltage, the capacitor will require a length of time to build up to the maximum value of the impressed D. C. voltage. The resistor will increase this time value as the current, which will flow until the capacitor is completely charged, will result in an IR drop across the resistor. Figure 5 shows a comparison in time values required, in curve form, when charging a capacitor by means of a D. C. voltage with and without an additional resistor in the circuit.

For convenience, the entire circuit, outlined above will henceforth be referred to as the RC "DynAC Brake" relay. Schematically it will be shown as a relay, labeled BC, with a set of contacts in the motor circuit as already explained.

SEQUENCE OF OPERATION

First, consider the RC "DynAC Brake"

shown in Figure 1. Here the RC "DynAC Brake" is connected in series with a 121 cam switch as shown in Figure 6. The complete operation of the RC "DynAC Brake" and associated equipment is as follows:

- a. Close the MCR contacts. This will energize the SR relay coil.
- b. The SR relay will operate, closing contacts SR1 and SR3 and opening contacts SR2 and SR5.
- c. Closing of the SR3 contacts will energize the motor, causing it to operate in a raise direction.
- d. Shortly after the motor has started to operate, the 120 and 121 cam switches will close. (This is a mechanical operation entirely dependent upon a mechanical moving of the tap changer and not any electrical function).
- e. The 120 cam switch, upon closing, will "seal-in" the motor control relay through the SR1 contacts. This will assure continuous energization of the tap changer motor until just before the next position of the tap changer is reached.
- f. The 121 cam, which operated identically with the 120 cam, will energize the Selenium half-wave rectifier, SG relay coil and capacitor combination of the RC "DynAC Brake" relay. Within two to three cycles, the voltage across the capacitor will have built up to a value large enough to energize the SG relay and thus cause the BC contacts to close. However, at this time, no action on the tap changer motor will result as the back contacts of the motor control relay, SR2, will be open. Even so the circuit for breaking has now been set up and merely requires closing of the SR2 contact to function.

As the unit approaches its next mechanical position, the 120 and 121 cam switches will open, and the braking power will be applied in the following manner:

- a. The 120 and 121 cam switches operate to open approximately 25° of shaft rotation prior to position.
- b. Opening of the 120 cam switch will de-energize the SR relay causing the SR2 contacts to close.
- c. Closing of the SR2 contacts will apply single phase AC power to both of the motor windings simultaneously, causing the motor to be braked electrically. The application of single phase AC to both windings simultaneously is accomplished because the BC contact is closed, setting up two parallel paths - one winding through the SR2 contact and its associated resistor and the other winding through the SL1 contact and its associated resistor.
- d. As the 121 cam switch opens simultaneously with the 120 cam switch, the AC supply to the RC "DynAC Brake" relay is removed as the relay is deenergized. However, as the capacitor will have to discharge through the SG relay coil, the SG relay will remain closed for approximately 20 to 25 cycles, causing the tap changer motor to come to a smooth, quick, electrical stop without using any mechanical breaking means. As the motor braking time is 8 to 10 cycles, the 20 to 25 cycle time required for the RC "DynAC Brake" relay to open its BC contact will assure positive braking before opening of the brake circuit. (The BC contact in series with the two motor windings and motor control relay back contacts parallel combination).

The operation of the control circuit when operating in the lower direction is the same as described for operation in the raise direction except as follows:

- a. Close MCL instead of MCR.
- b. Relay SL will be energized instead of SR.
- c. Contacts SL1 will open and SL3 will close instead of SR1 and SR3 closing and SR2 and SR5 opening.
- d. Tap changer motor will operate in the lower direction rather than the raise direction.
- e. The SL relay will be "sealed-in" by means of the SR5 contacts.
- f. Braking circuit will be completed by

closing the SL1 contacts instead of the SR2 contacts.

Now, let us consider the RC "DynAC Brake" shown in Figure 2. This RC "DynAC Brake" will be connected into the circuit as shown in Figure 7. The operation of the RC "DynAC Brake" and associated control equipment is as follows:

- a. Close the MCR contacts. This will energize the SR relay coil as long as the CLR cam switch is closed.
- b. The SR relay will operate, closing contacts SR1 and SR3 and opening contacts SR2 and SR5.
- c. Closing of the SR3 contacts will energize the tap changer motor, causing it to operate in a raise direction.
- d. At the same time as the SR3 contacts close, the SR1 contacts will also close. The closing of the SR1 contacts will energize the RC "DynAC Brake" relay, BC.

Within 4 to 6 cycles after the RC "DynAC Brake" relay has been energized, the BC contacts will close, setting up the braking circuit. However, this circuit cannot be completed until the SR relay has been de-energized, closing the SR2 contacts.

- e. Shortly after the tap changer motor has started to operate in the raise direction, the 120 cam switch will be mechanically closed, acting to "seal-in" the SR relay through its SR1 contacts as well as the RC "DynAC Brake" relay.

As the tap changer approaches its next mechanical position, the 120 cam switch will open, deenergizing both the SR relay and the RC "DynAC Brake" relay. The sequence of braking will then be the same as previously described for the other form of the RC "DynAC Brake".

If we now consider the operation of the RC "DynAC Brake" of Figure 2 when operating in the lower direction, we will see a slight difference in the initial operation only. The operation of the RC "DynAC Brake" and associated control equipment is as follows:

- a. First close the MCL contacts. This will energize the SL relay and the RC "DynAC Brake" relay simultaneously. The RC "DynAC Brake" relay will be energized through the SR5 contact. As the two relays, the SL and the RC "DynAC Brake", are energized simultaneously, it has been necessary to introduce an additional time delay into the RC "DynAC Brake" relay to assure that the SL motor control relay will have definitely completed its operation prior to the closing of the BC contacts of the RC "DynAC Brake" relay. This delay has been obtained by the introduction of a 400 ohm resistor in the RC "DynAC Brake" relay. This additional resistor, used only in the RC "DynAC Brake" relay of Figure 2, has been fully explained both as to its purpose and how it accomplishes same under the DESCRIPTION portion of this Instruction Leaflet.

After the RC "DynAC Brake" has been energized and the tap changer motor is operating, the rest of the operations is the same as previously described.

NOTE: When the tap changer control is set for automatic operation, the unit may not stop on every position but will depend upon the automatic control scheme employed. If the standard sequential operation is used, the unit will make as many stops as required by the Voltage Regulating Relay and then brake to a stop after the Voltage Regulating Relay has relinquished control. The sequence of operation previously described will be applicable except the Voltage Regulating Relay will initiate the tap changer operation instead of the MCL or MCR contacts.

ADJUSTMENT

As the time delay required for proper braking action is set at the factory, no adjustment of this feature is required in the field.

The XR and XL resistors serve two functions. One is to prolong the life of the motor control relay back contacts, SL1 and SR2 by limiting the motor capacitor discharge current when it is short-circuited by these same contacts. The other is to control the positioning of the cam switch rollers on

the lobes of their respective cams, 120 and/or 121. This fine adjustment, normally not required, may be desirable due to slight variations in the motors and/or mechanical drives or extremely wide variations in voltage supply. The resistance is divided between the SL1 and SR2 leads to obtain balanced braking torque for either direction of operation.

By increasing the XL resistance, the braking torque applied is decreased when operating in the lower direction, hence the unit will stop with the 120 and/or the 121 cam roller farther on the lobe of its associated cam. By increasing the XR resistance, the same phenomena is obtained for operating in the raise direction. Since there is an interaction between the two resistors, XL and XR, it may sometimes become necessary to readjust the one resistor after adjusting the other.

MAINTENANCE

The contacts of the RC "DynAC Brake" relay should be checked for cleanliness and future life at regular maintenance periods. It is recommended that this be done each and every time the selector contacts of the tap changer are inspected.

RENEWAL PARTS

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

SG Relay - Complete	S#1546999
Selenium Rectifier	S#1742191
400 Ohm Resistor	S#1742055
2 Ohm Resistor	S#1590776
Capacitor	S#1743278

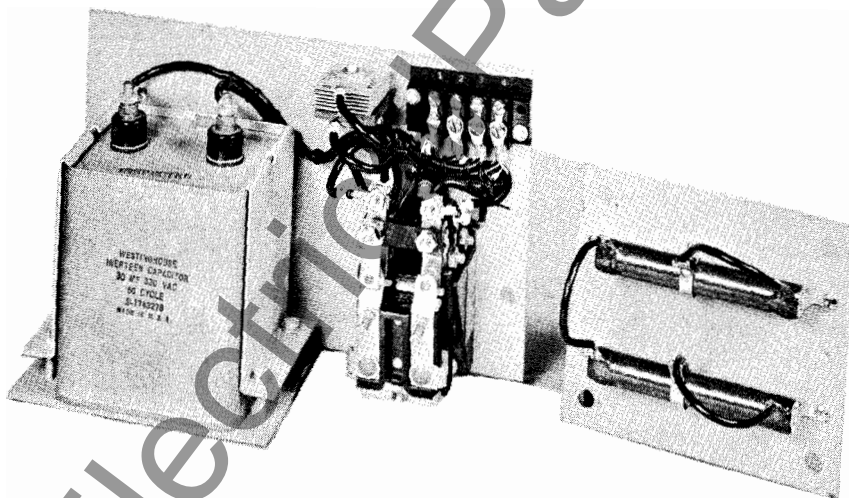


FIG. 1

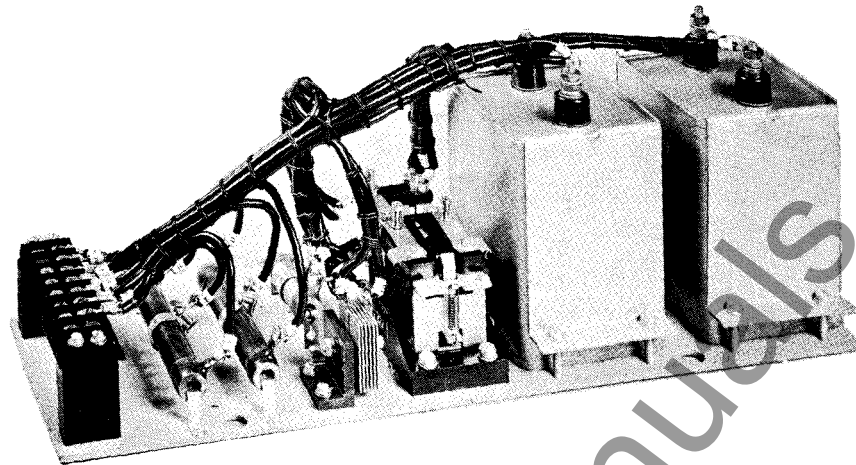


FIG. 2

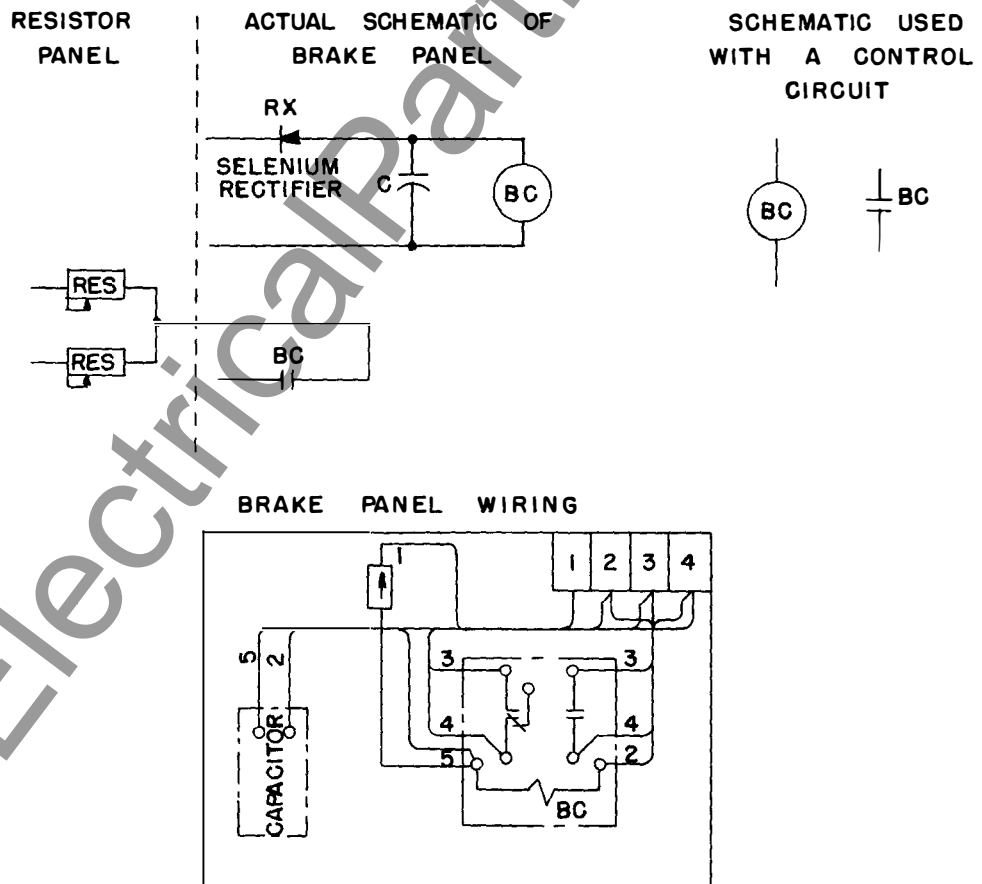


FIG. 3

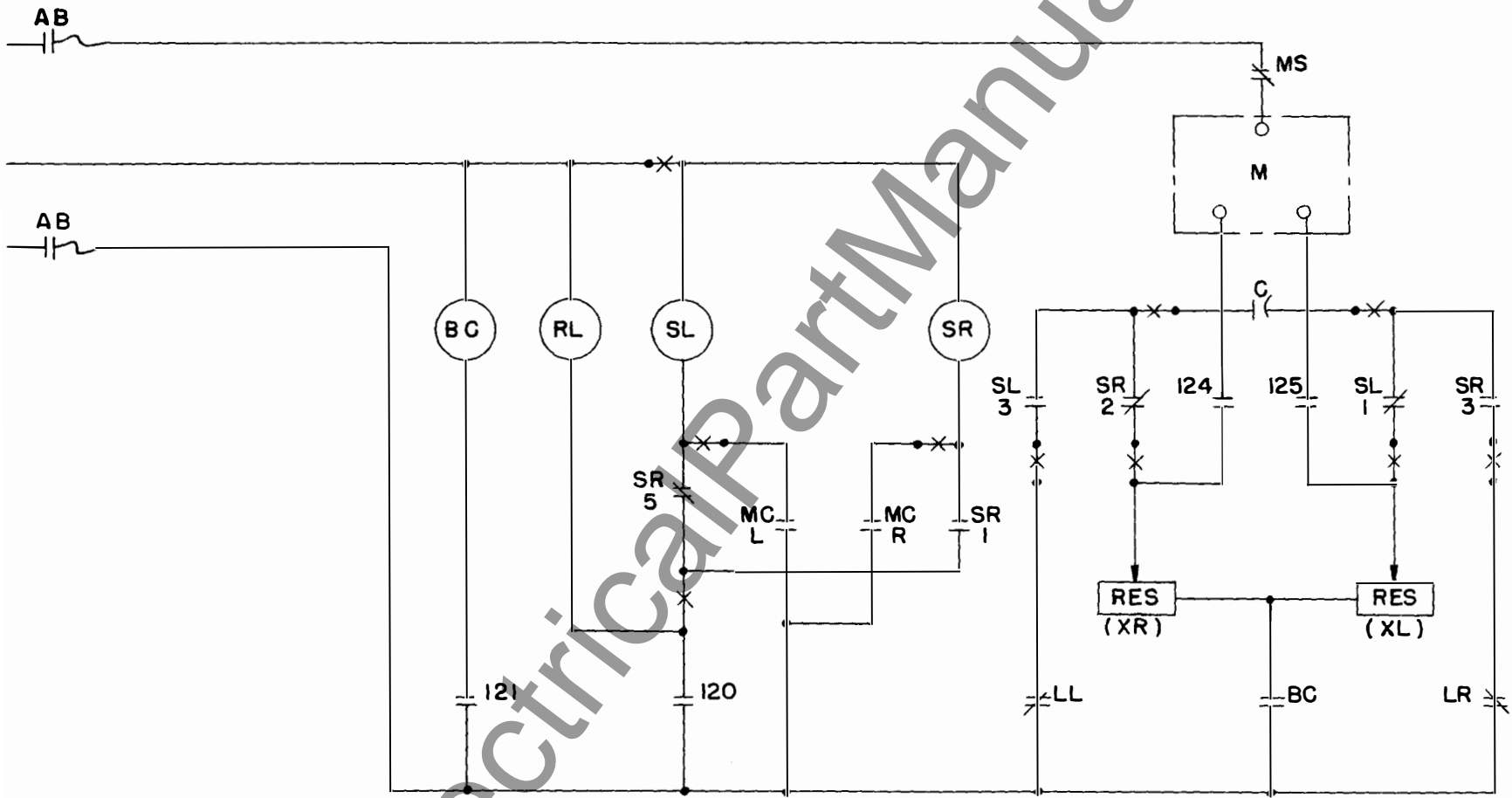


FIG. 6

TAP CHANGER ON NEUTRAL POSITION

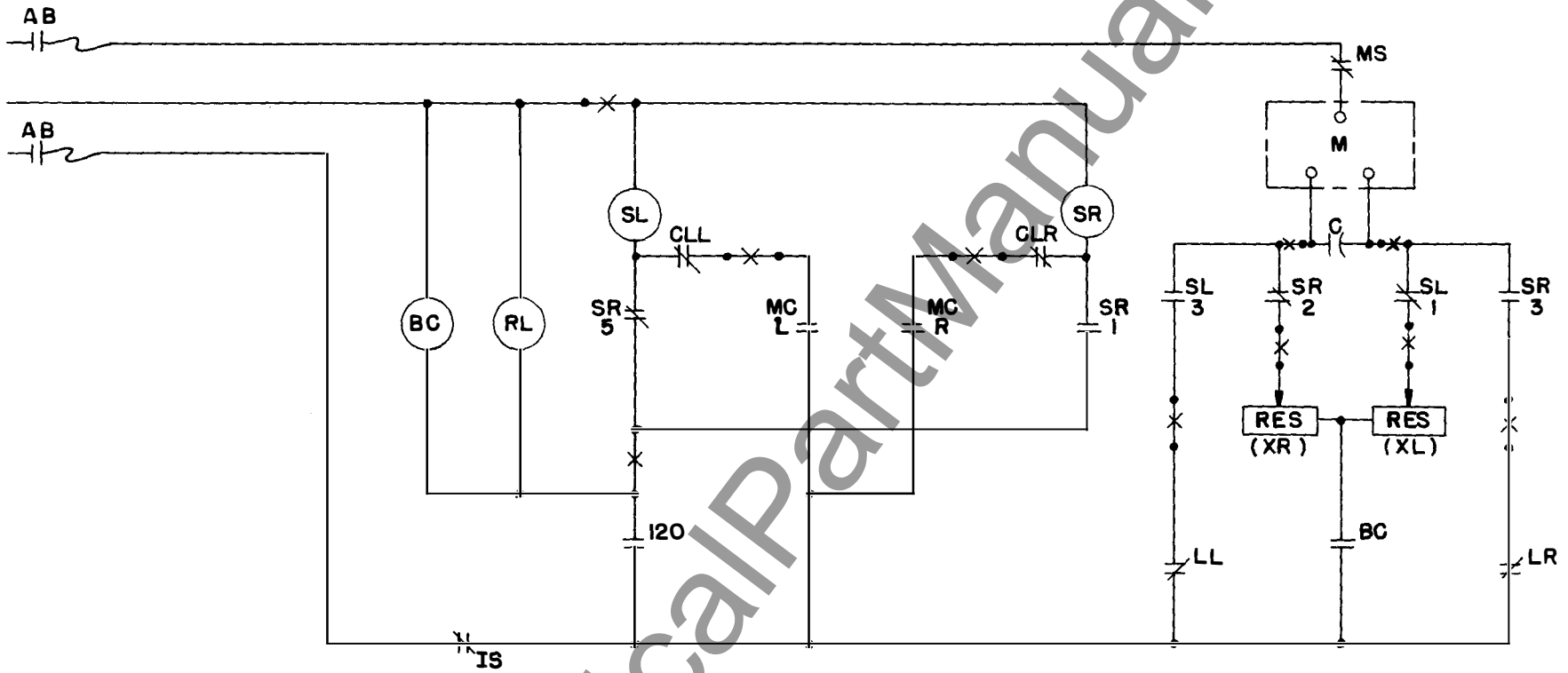


FIG. 7

TAP CHANGER ON NEUTRAL POSITION



I N S T R U C T I O N S

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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I N S T R U C T I O N S

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 trichlorobenzene.

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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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 $\frac{3}{16}$ " to $\frac{1}{2}$ " 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 $\frac{1}{8}$ " 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.



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INSTRUCTIONS

TYPE RM AUTOVALVE LIGHTNING ARRESTERS

For Protection of Dry Type Transformers



FIG. 1. End-Mounting Type RM Autovalve Lightning Arrester.

TYPE RM AUTOVALVE LIGHTNING ARRESTERS are designed for the protection of rotating machinery and dry type air insulated transformers. This leaflet is concerned only with this type of arrester when used with dry type transformers.

The RM arrester is a valve type arrester having a low protective ratio, that is, ratio of maximum impulse voltage on discharge to maximum crest 60 cycle voltage. Because of this characteristic, it is ideally suited to the protection of dry type transformers which have a low impulse ratio or ratio of impulse strength to 60 cycle strength.

CONSTRUCTION

There are two different types of RM arresters used in ASL transformers differing in external appearances and mounting methods but having the same operating characteristics. Examples of the two types are shown in Figures 1 and 2.

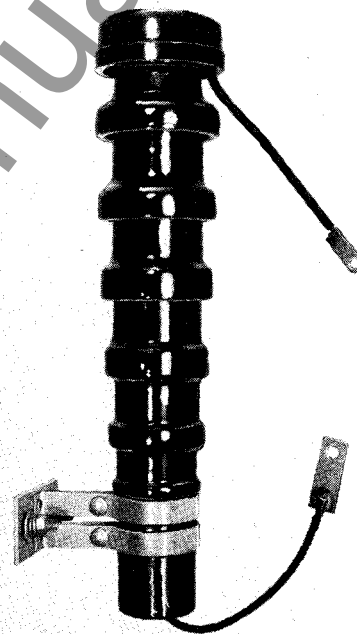


FIG. 2. Bracket-Mounting Type RM Autovalve Lightning Arrester.

The arrester in Figure 1 is a special arrester consisting of a porcelain casing with smooth bands having a casting cemented on one end. This casting is galvanized cast-iron and serves both as a ground terminal and a means of mounting the arrester. At the other end of the arrester is the line connection consisting of a stud with clamp type terminal for #6 to 2/0 solid copper wire.

The arrester in Figure 2 is a conventional type arrester consisting of a porcelain casing with a porcelain cap on the line end. The line and ground connections are cables equivalent to #6 conductors. The arrester is mounted by means of a bracket clamping the lower portion of the arrester.

INSTALLATION

Lightning arresters for use on dry type transformers are shipped separately and must be mounted on the transformer during its installation.

TYPE RM AUTOVALVE ARRESTERS

Before unpacking, examine the containers for any visible signs of damage or abuse. Any damage should be noted carefully. Unpack the parts carefully and examine for breakage or other damage. Inspect particularly the porcelains for any breakage. If damage exists, save the containers and packing material and notify the Carrier.

Shortages should be checked with the Carrier, or if the shortages are not the fault of the Carrier, with the nearest Westinghouse Sales Office. If parts do not agree with packing list, contact the nearest Westinghouse representative, giving him the order reading and other identification.

Mounting supports with proper drilling for bolting of the arresters and connectors from the arresters to the line terminals are provided with the transformers. See outline drawing of transformer for the location of arrester.

TESTING

The Type RM arresters used on dry type transformers have resistance shunted gaps and therefore, a transformer winding will not megger infinity when an arrester is connected to the winding. For example, if a 500 volt megger is used, the following minimum values of megger readings may be expected:

MINIMUM MEGGER READINGS	
Arrester Rating	Readings on 500 Volt Megger
*3 kv	11 Megohms
*4.5 kv	17 Megohms
6 kv	25 Megohms
7.5 kv	32 Megohms
9 kv	40 Megohms
12 kv	55 Megohms
15 kv	70 Megohms

*Arresters of the 3 and 4.5 kv ratings with style numbers higher than 1,616,000 will megger infinity.

MAINTENANCE

Because of the sealed design, there is no maintenance required on Westinghouse Type RM Autovalve arresters. In locations where dirt and soot collect, it is recommended that the arresters be cleaned periodically.

RENEWALS

Should renewals be required, order per style number on arrester or specify as arresters for Westinghouse transformer giving serial number as marked on the transformer nameplate.



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DESCRIPTION • OPERATION • MAINTENANCE INSTRUCTIONS

TYPE AB DE-ION CIRCUIT BREAKERS

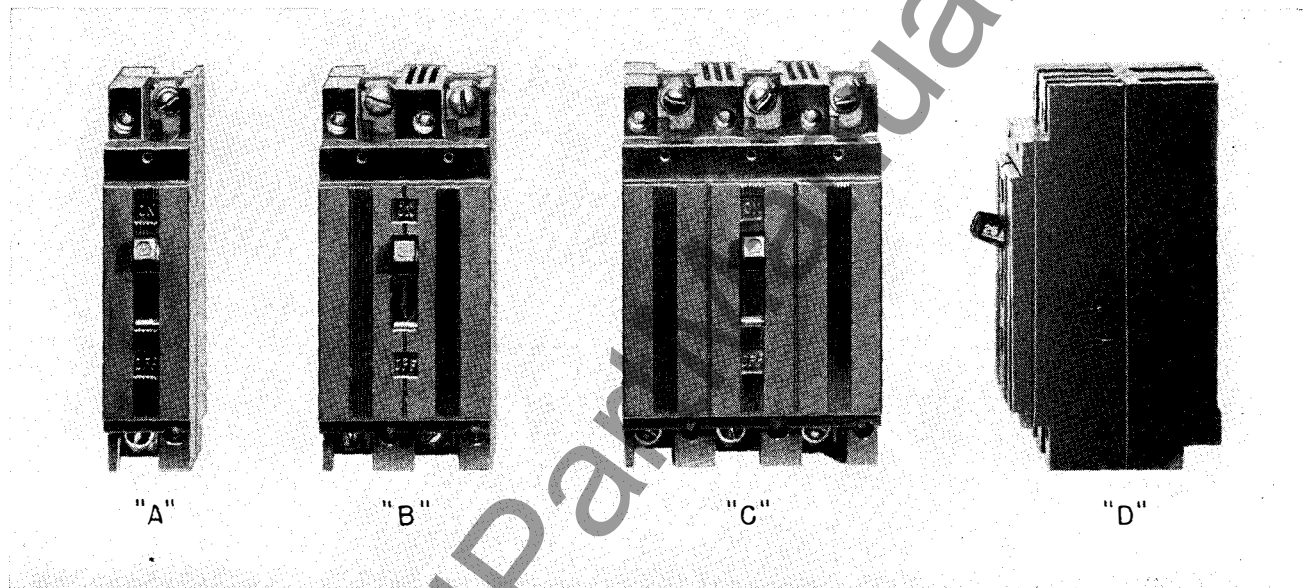


FIG. 1. Type "AB" De-ion Breakers: "A", Single-pole; "B", Two-pole; "C", Three-pole; "D", Side View of Three-pole

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

TYPE AB DE-ION CIRCUIT BREAKERS

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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HANDLING • INSTALLATION • MAINTENANCE I N S T R U C T I O N S

BULK TYPE BUSHINGS

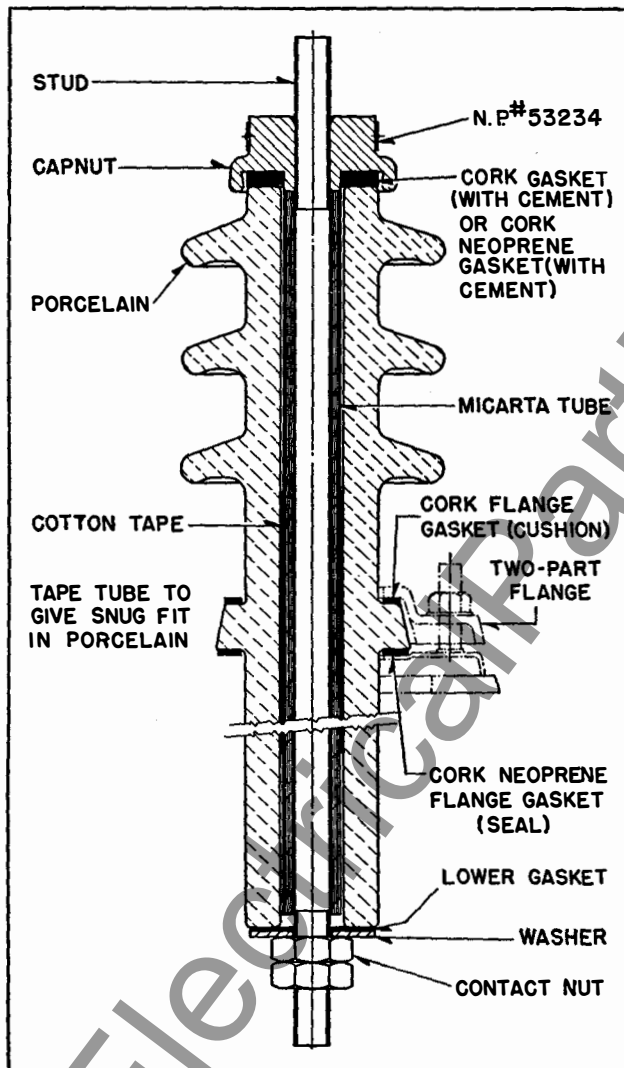


FIG. 1. Cross Section of a Typical Bulk Type Bushing.

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.

BULK TYPE BUSHINGS

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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DESCRIPTION • INSTALLATION INSTRUCTIONS

LIQUID LEVEL INDICATORS Magnetic Type

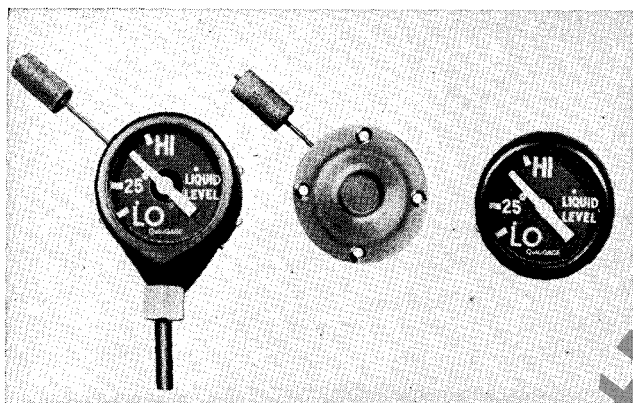


FIG. 1. Bezel with Alarm (left); Body with Float and Rod at Back (center); Bezel without Alarm Contacts.

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

Contacts for operating the alarm circuits of a bell, light, or small relay system 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 in the case and a hole 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.

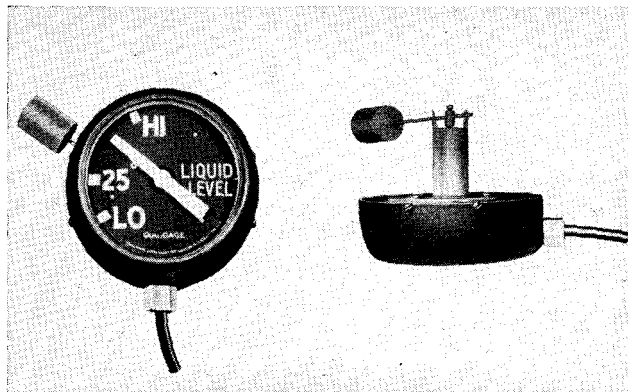


FIG. 2. Side and Front View. Medium Size Float Directly Connected.

LIQUID LEVEL INDICATORS

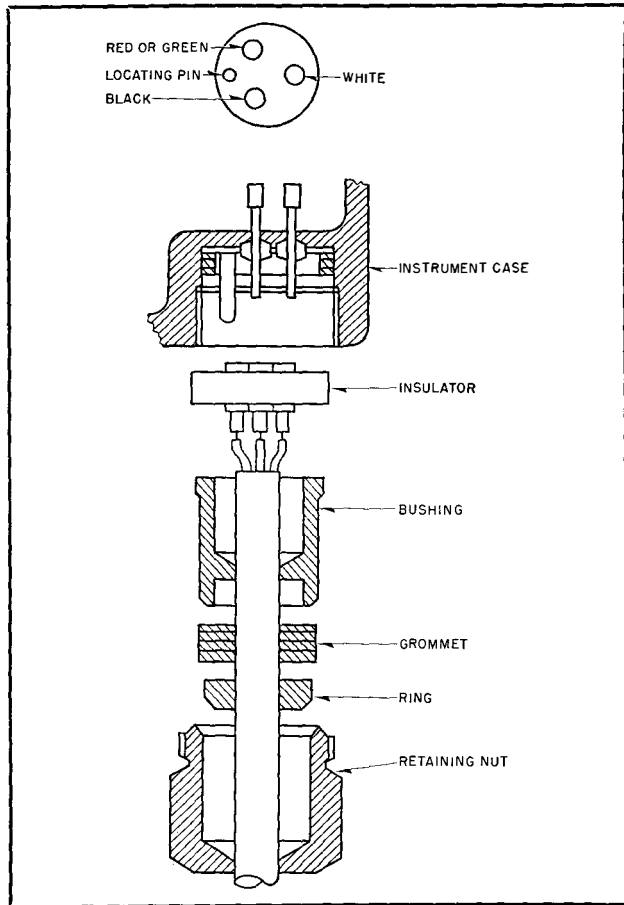


FIG. 3. Diagram of Triple Seal Connector.

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 Inertia 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.

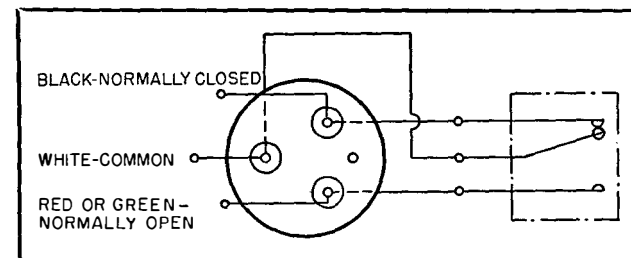


FIG. 4. Connection Diagram for Alarm Leads.

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	-33
-5	-67
-20 (Low)	-100



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DESCRIPTION • INSTALLATION INSTRUCTIONS

TEMPERATURE INDICATORS

Dial Type

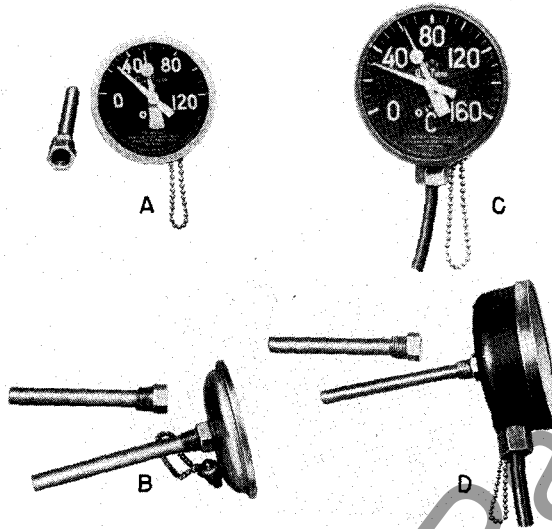


FIG. 1. (A) Front and (B) Side View of Indicator Without Alarm Connections; (C) Front and (D) Side View of Indicator With Alarm Connections.

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

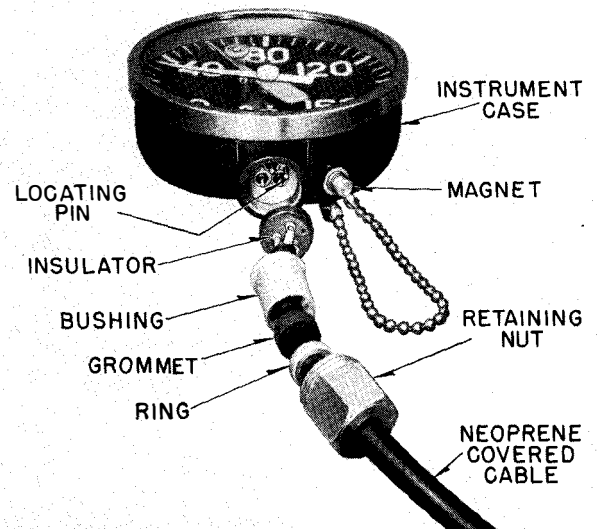


FIG. 2. Triple Seal Connection Details.



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DESCRIPTION • INSTALLATION INSTRUCTIONS

TEMPERATURE INDICATOR Two Switch—Dial Type

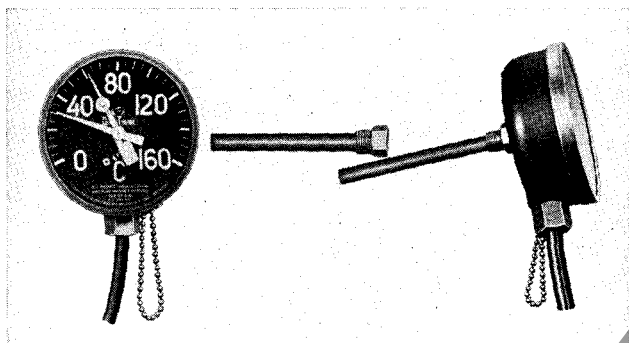


FIG. 1. Front and Side View of Indicator.

THE TWO SWITCH TEMPERATURE INDICATOR designed for application on Westinghouse transformers or related apparatus, is used where both fan control and alarm circuits are required. This leaflet covers the type of indicator which depends on the hot oil temperature. It is a dial type instrument operated by a bimetallic element, and is made weatherproof and submersible.

The two switches of the indicator are set at different temperature levels, the lower level switch controls the fan circuit, and the higher level switch controls the alarm circuit. The fan circuit serves to give added cooling when the transformer temperature comes within the range of the switch. The alarm circuit operates at a higher temperature range to give warning in case the fans, for any reason, do not limit the temperature to a proper range. The circuits are separate so that both a-c and d-c may be used.

The indicator is usually shipped mounted on the transformer case, requires no maintenance, and is suitable for use in oil or Inerteen.

DESCRIPTION

The indicator (Fig. 1) 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 the tank wall making an oil tight connection. *NOTE: Do not fill the well with a solid or liquid before inserting the stem of the thermometer since*

this may damage the instrument without appreciably helping in the transfer of heat from the oil to the sensitive element. The thermometer should not be tightened in the well any more than is necessary to place the dial in an upright position. The instrument can be removed from the well in the tank wall without the loss of liquid and without lowering the oil level. The instrument is weatherproof and submersible. 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 easily reset by wiping a magnet across the face of the dial providing the magnet is held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain in the instrument case to prevent misplacing after using and is self-supporting in a metallic socket near the underside of the case. The method of resetting the maximum indicating pointer is shown in Fig. 3.

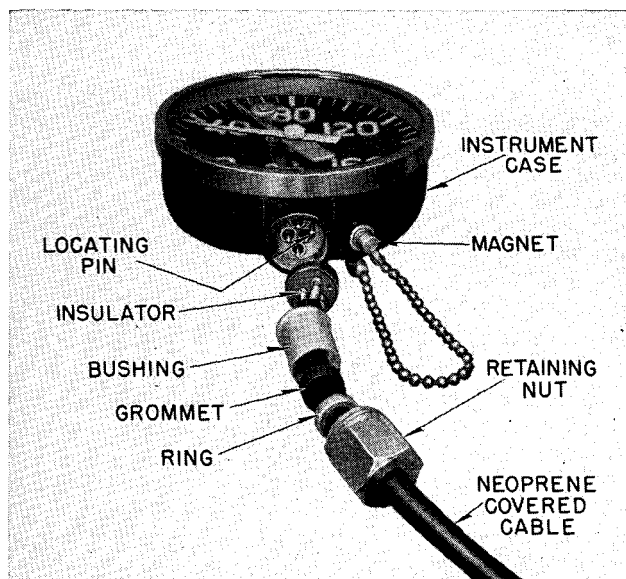


FIG. 2. Triple Seal Connection Details.

TEMPERATURE INDICATOR

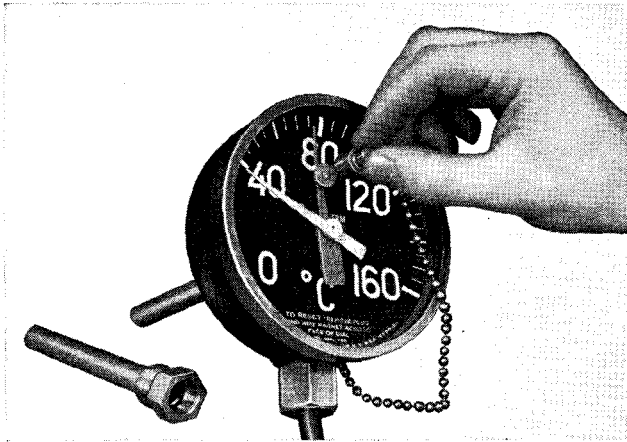


FIG. 3. Method of Resetting Maximum Indicating Pointer.

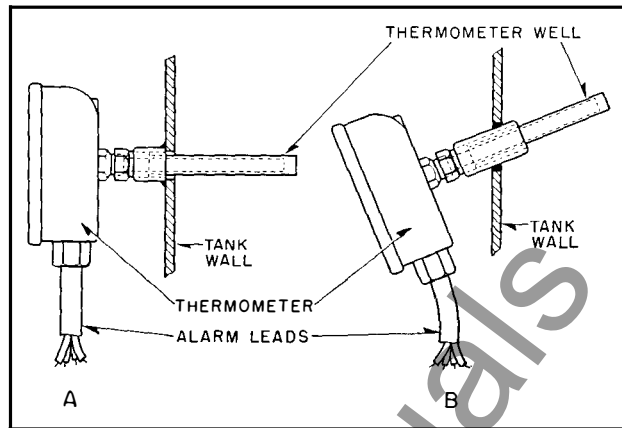


FIG. 4. Indicator Mounted Vertical (A) and Tilted Downward (B).

The alarm leads are brought through the underside of the case by means of a triple seal connector, the details of which are shown in Fig. 2. This connector consists of the following:

1. Four protruding terminals molded in the case and a locating pin to prevent making incorrect connections.
2. A rubber insulator which has four terminals to mate with the terminals in the case, and a hole to match the locating pin. The ends of the leads are tinned and crimped into the terminals of 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.

There are two micro-switches in this type temperature indicator. Switch #1 is set to close at 60°C. for the fan circuit, and Switch #2 closes at 80°C. for the alarm circuit. The switches are adjustable over a range of $\pm 10^\circ\text{C}$. in relation to the above mentioned values. The switches open at 5°C less than the closing temperature. The ratings for the switches are given in Table No. 1, and the connection diagram is shown in Fig. 5.

Field Test. Remove the thermometer from its well and submerge the stem up to the brass fitting in a closely controlled temperature, well agitated, oil bath. Check the temperature by placing a thermo-couple or other accurate temperature measuring device on the stem about two inches from the end. The thermometer should be accurate within $\pm 2^\circ\text{C}$. (allowing 15 minutes for the thermometer to come up to temperature). To adjust a switch to a different value, remove the corresponding numbered sealing plug at the top of the case. Make the proper adjustment of the switch through the opening in the case, and then reseal 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.

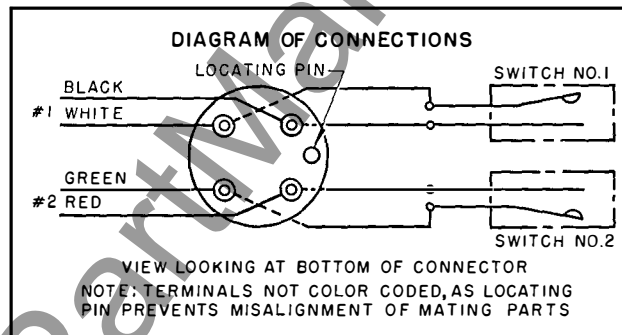


FIG. 5. Connection Diagram for Alarm Contact Leads.

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R = .026*
125 A-C	10	10
250 A-C	5	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.

INSTALLATION

The instrument is shipped fixed to the tank wall, so that no installation is necessary. When mounted at a high point, the indicator may be tilted so that it can be read easily from ground level (See Fig. 4).

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.



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DESCRIPTION • INSTALLATION • OPERATION INSTRUCTIONS

FORCED-AIR COOLING EQUIPMENT UNIT FAN ASSEMBLY

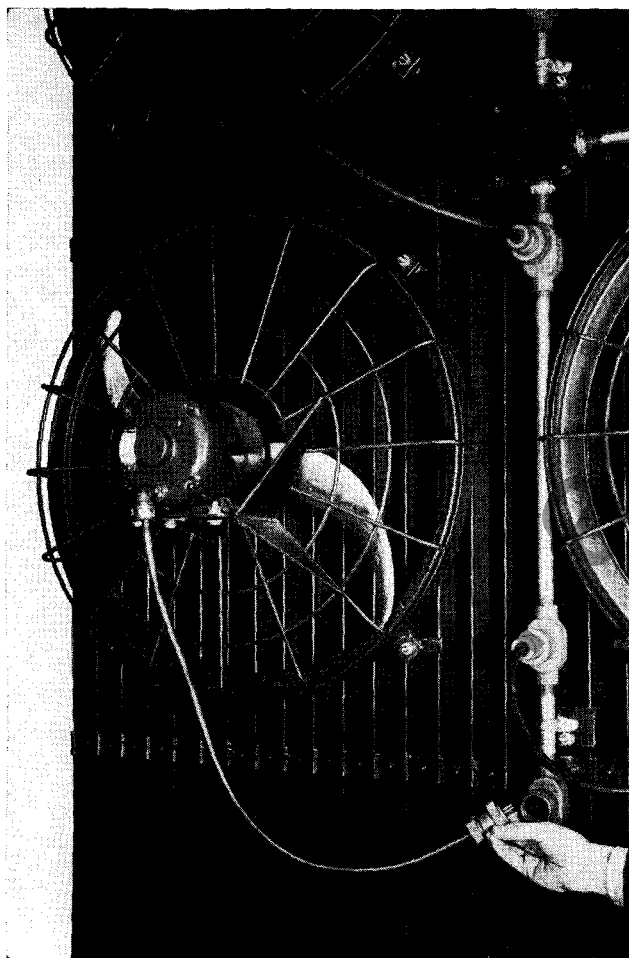


FIG. 1. Bank Type Radiator Forced-Air Equipment.

Westinghouse manufactures three types of forced-air cooling equipment for use on OA/FA (oil-insulated air-cooled, forced air-cooled) transformers: The bank type for radiators, the cooler tube type, and the portable type. The control equipment for all types is the same. An occasional inspection and greasing of motors is required after installation, as described later.

Standard unit fan assemblies are furnished with single or three-phase motors. Single-phase motors are capacitor-start, capacitor-run, with the capacitor

mounted in a cylindrical case attached to the motor. Both single and three-phase motors are equipped with internally placed thermoguards for protection.

Fan motors are wired in parallel; each motor is equipped with a polarized weatherproof attachment plug that can be disconnected from the supply line by unscrewing counter-clockwise and pulling out. Individual motors may be disconnected without disturbing the wiring in the supply line.

Rotation of the fan blade is counter-clockwise when looking at the motor from the lead end. Pipe plugs are omitted from the underside of each end cap to eliminate condensation inside the motor.

Bank Type Radiator Forced-Air Equipment. The bank or multi-fan unit type forced-air equipment consists of a number of fans mounted on the side of the first of a group of radiators. Such an arrangement is shown in Fig. 1.

The Westinghouse type radiator with its expanded cooling elements arranged in parallel rows provides a group of continuous ducts. The blast of air from the fans is directed through this duct system, thereby greatly increasing the normal convection characteristics.

This type of forced-air equipment is applicable only to the Westinghouse radiator. The radiators must be mounted in alignment in banks to provide the proper duct system.

Tube Cooler Type Forced-Air Equipment. The tube cooler type forced-air equipment consists of unit fans which are mounted near the bottom of the tank and under the tubular cooling elements. The air stream is directed upward so that the natural convection of both the tubes and tank wall is increased.

Fig. 2 shows the arrangement of this type of auxiliary equipment.

FORCED-AIR COOLING EQUIPMENT

may be obtained from the Lima Motor Division, through the nearest Westinghouse Office.

Painting. Good practice dictates that apparatus should be kept protected with paint. The entire air blast equipment, except the propeller, should be painted at regular intervals.

Inspection. A regular thorough inspection should be made of the equipment to insure the best service.

Renewal Parts. When ordering renewal parts, send a complete description of the particular part and the transformer serial number to the nearest Westinghouse Office.



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INSTRUCTIONS

PRESSURE RELIEF VALVE

Style No. 1576 123

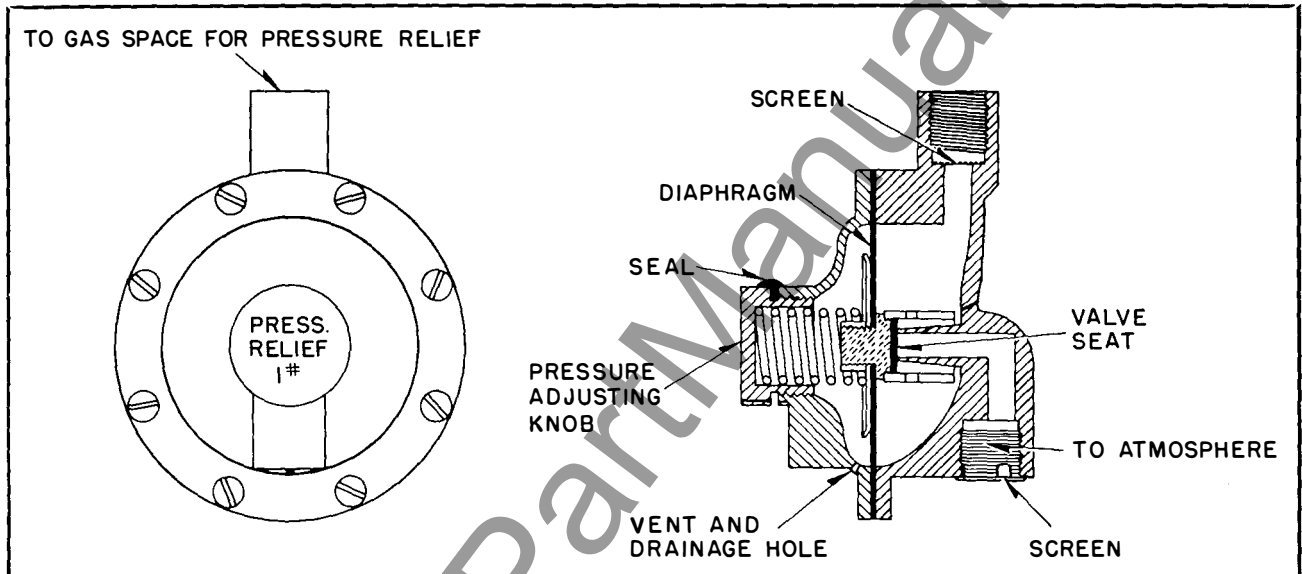


FIG. 1 Pressure Relief Valve

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.

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INSTRUCTIONS

CONCENTRIC LEAD BUSHING

For Type "URS" Step Regulator

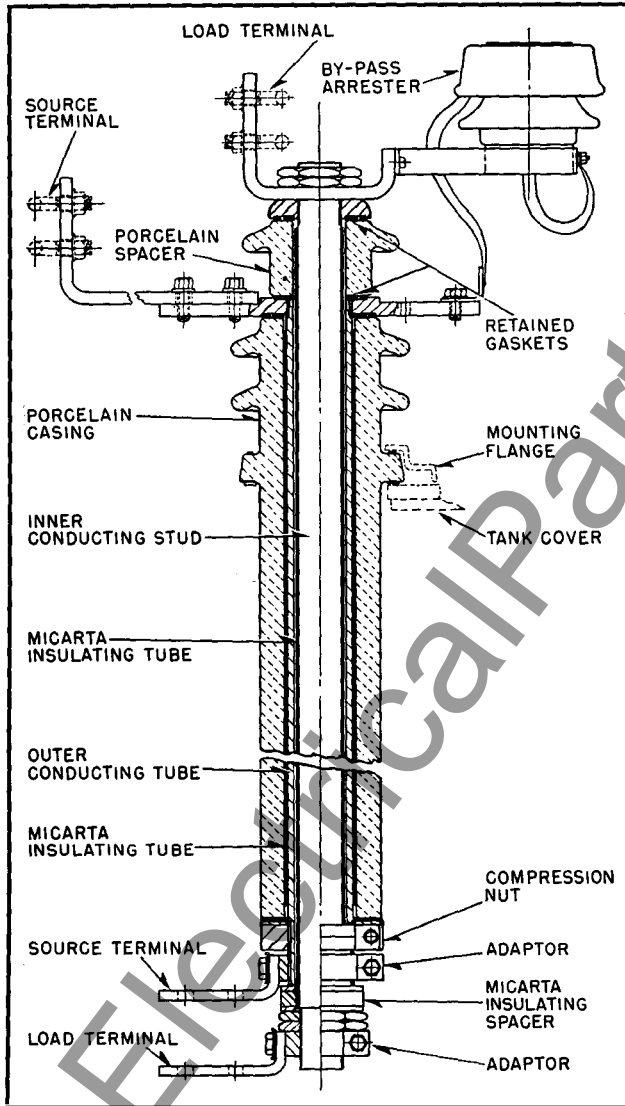


FIG. 1. Concentric Lead Bushing for Type URS Step Regulator

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

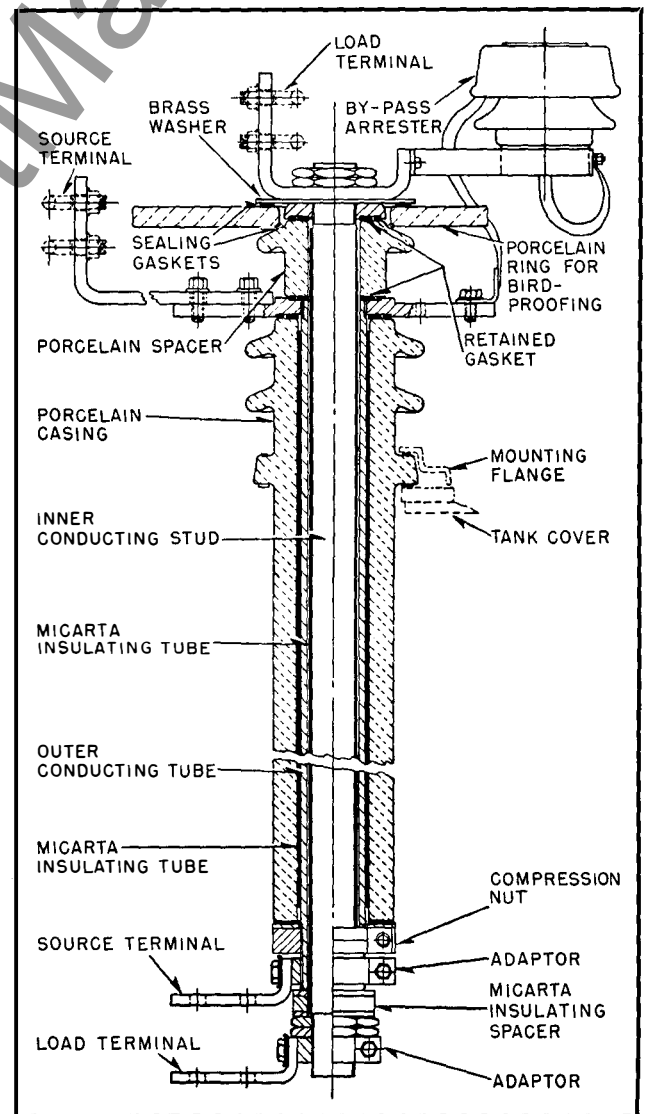


FIG. 2. Concentric Lead Bushing with Bird-proofing for Type URS Step Regulator

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.



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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.



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 dia-

gram. 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

TYPE SG RELAY

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 name plate data.

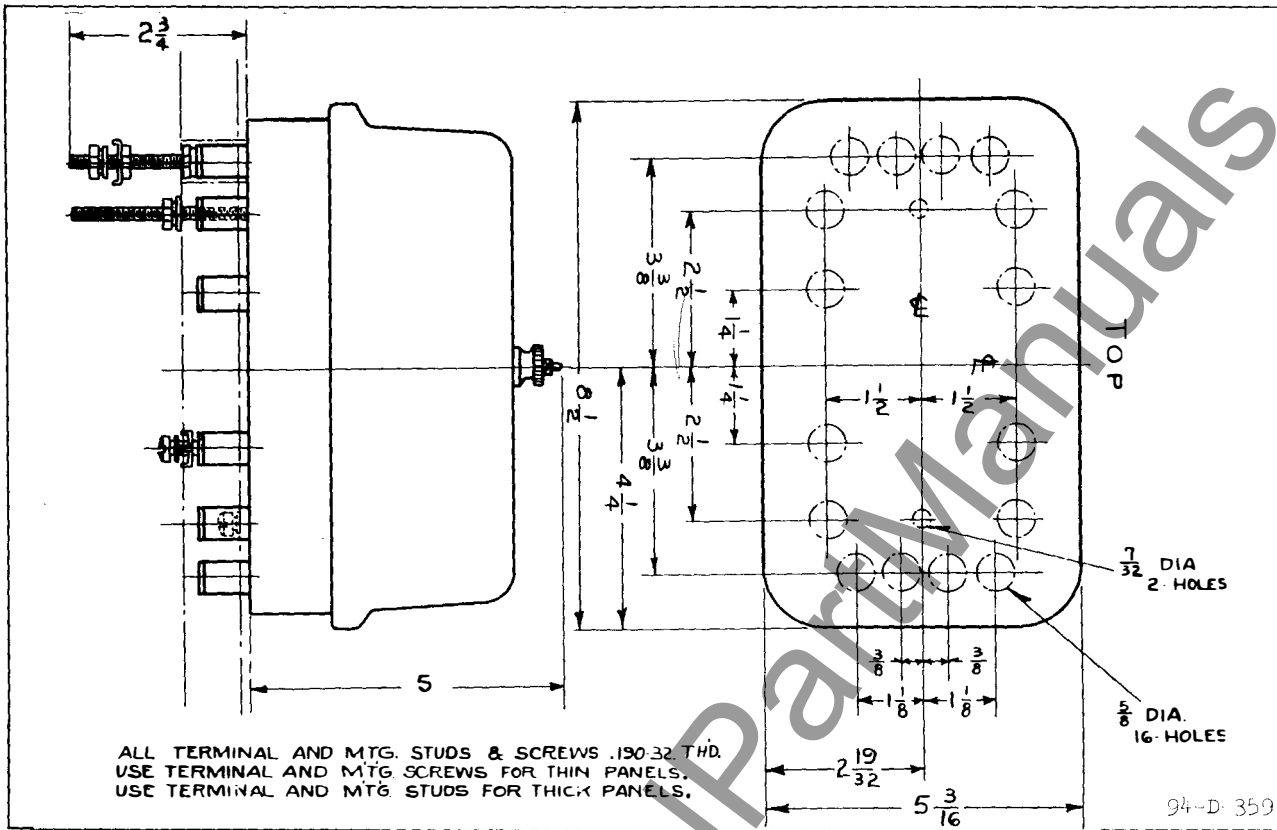


Fig. 3—Outline & Drilling Plan for the Projection Case. For Reference Only.

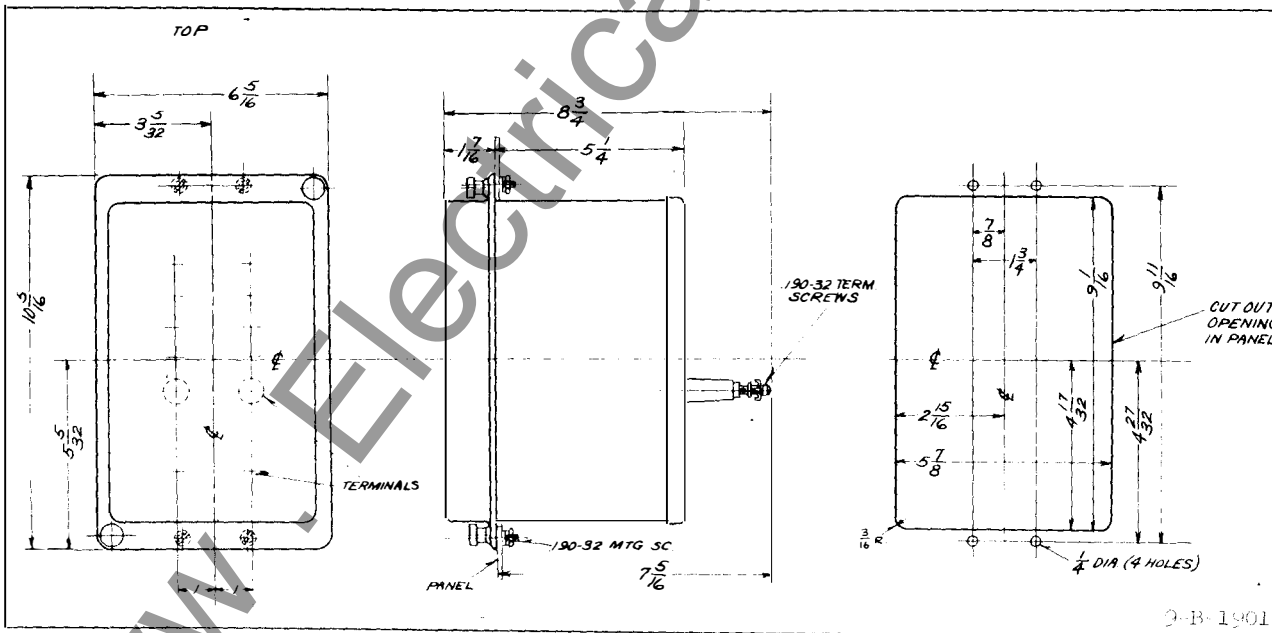


Fig. 4—Outline & Drilling Plan for the S10 Semi-flush Type FT Case. For Reference Only.

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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 developed 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 90 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.

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

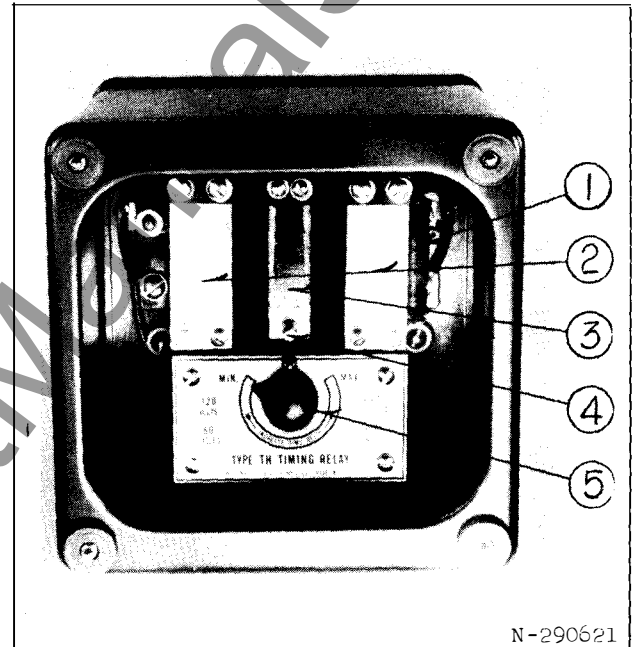


Fig. 1—Type TH Single-Element Thermal Timing Relay.
1—Resistor, 2—Side Bimetal Strips, 3—Heater Coil and Center Bimetal Strip, 4—"F" Bimetal Screw, 5—"T" Timing Screw.

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.

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 or possible higher current in the controlled circuit upon the life of the relay should be considered.

EFFECTIVE AUGUST 1953

SUPERSEDES I.L. 41-369E
Change from superseded issue.

TYPE TH RELAY

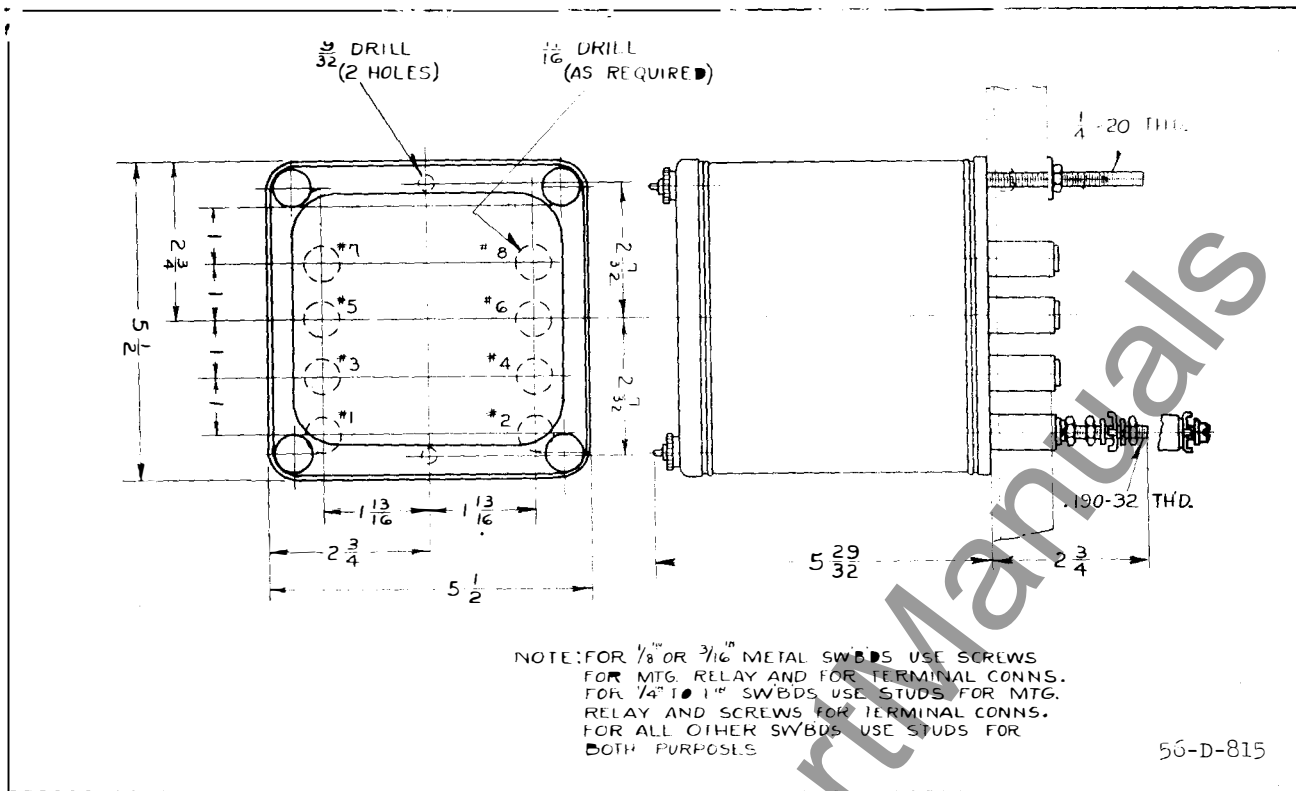


Fig. 9—Outline and Drilling Plan for the Type TH Single-Element Relay.

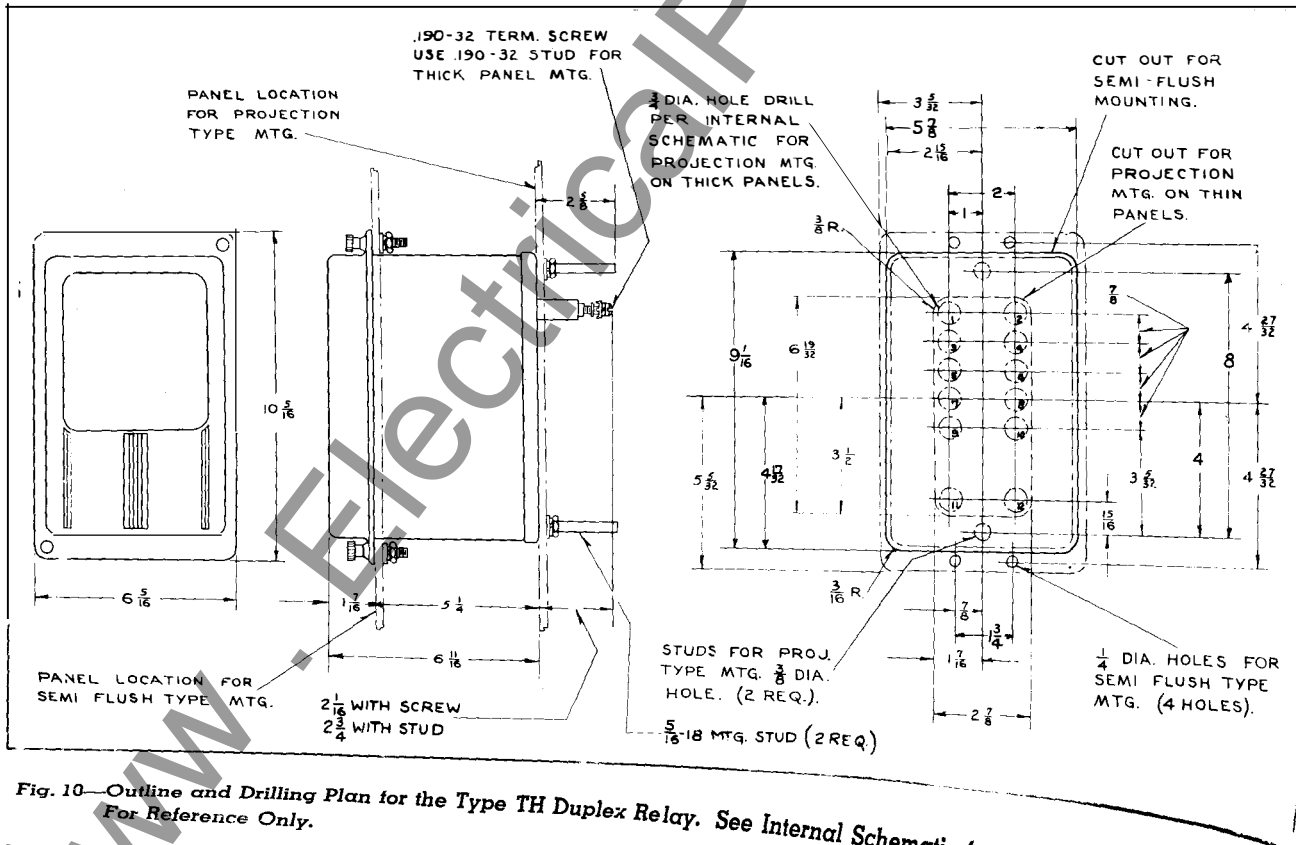


Fig. 10—Outline and Drilling Plan for the Type TH Duplex Relay. See Internal Schematic for the Terminals Supplied. For Reference Only.



DESCRIPTION • INSTALLATION • OPERATION INSTRUCTIONS

VOLTAGE REGULATING RELAY TYPE SJS FOR LOAD TAP CHANGERS



The **TYPE SJS VOLTAGE REGULATING RELAY** for automatic control of load tap changers is of the balanced beam, alternating current, solenoid type. The voltage sensitive element is factory adjusted and sealed in a case having a tight fitting cover with a glass front.

The **TYPE SJS VOLTAGE REGULATING RELAY PANEL** contains the circuit components for electrically setting the balance voltage, band width, and line-drop compensation. Settings may be made quickly and conveniently from the front of the panel by means of the respective knobs.

RATING

The SJS voltage regulating relay and the SJS voltage regulating relay panel have been designed for operation on 60 cycle alternating current systems. The balance voltage can be set at any value in the range of 105 to 135 volts and the

band width may be set at any value between ± 1.0 volt and ± 3.0 volts.

Separate R and X compensator elements permit independent setting of the 24 volts resistance and the 24 volts reactance compensation (both on a 120 volt base) which is available with the standard current of 5 amperes flowing in the current circuit of the relay. The 120 volt potential circuit has a burden of 25 volt-amperes and the 5 ampere current circuit has a 15 volt-ampere burden.

DESCRIPTION

Voltage Regulating Relay. Detailed pictures of the SJS voltage regulating relay are shown in Figs. 1, 2, 3, and 4. The main coil, mounted on the front of the Micarta[®] base, provides a balance pull on the armature at a specific voltage. A ballast reactor, in series with the main coil to minimize temperature effects, is mounted on the rear of the Micarta[®] base. The armature which provides the voltage sensing movement is supported by a hinge spring assembly as shown in Fig. 5. The hinge spring is of reinforced, solid leaf construction, held to close tolerances in production to obtain the cor-

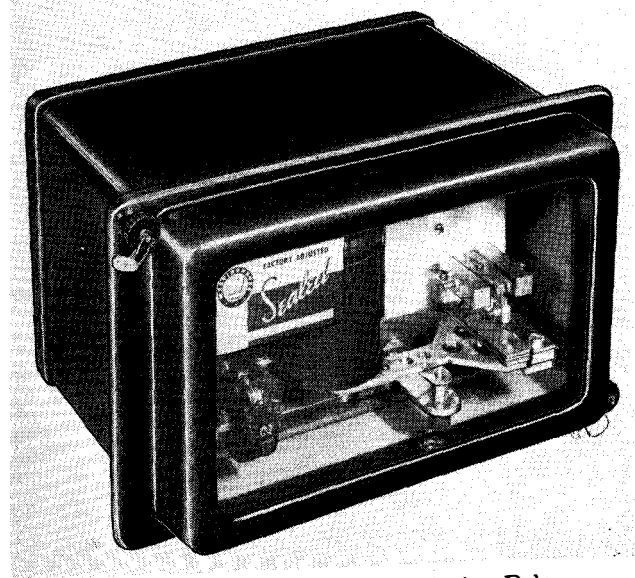


FIG. 1. Type SJS Voltage Regulating Relay

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—35 LINE— MINIATURE PANEL INSTRUMENTS THREE AND ONE-HALF-INCH CLASSIFICATION INSTRUCTIONS

Cases—The first letter in type designates the form of case used.

N=Round flush moulded case, 3½" diameter flange mounting.

R=Rectangular Flush Moulded Case, 3" x 3½" flange mounting.

S=Round Projection moulded case, 3½" diameter case mounting.

U=Rectangular projection moulded case, 3" x 3½" case mounting.

V=Round Flush Moulded Case, 3¾" diameter flange mounting.

Mechanisms

The second letter in type designates the principle of operation

A—Repulsion Moving Iron.

X—Permanent Magnetic Moving Coil

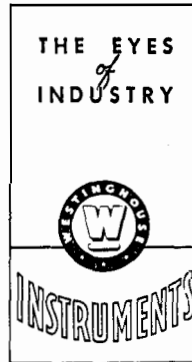
C—Rectifier plus X

T—Thermocouple plus X

Insulation—All Type "35" moulded case instruments are insulated for 750 volt service between terminals and panel, unless otherwise specified.

Dial Notes—Reference to type, style number, use of external components if required, calibration data, etc., are marked on the dial.

Magnetic Panels—Types X-35, A-35, T-35, and C-35 are calibrated for use with non-magnetic panels unless otherwise specified. A-35 instruments read high about 1% when mounted on 1/8 to 1/4 inch magnetic panels unless calibrated for such panels. Types X-35, T-35, and



C-35 may read low from ½ to 6% if mounted in a panel of magnetic material, unless calibrated for that particular panel.

External Fields—This being an unshielded instrument, the following precautions should be taken to prevent influence greater than ½ of 1% due to external fields.

1. A-35 instruments above 15 amperes should have their leads brought directly down at least 6 inches before turning. Other leads carrying currents of the order of 50 amperes should be spaced at least 6 inches from all A-35 instruments.
2. All instruments should be mounted at least 4 inches between centers.

Instruments with very high sensitivity have very strong permanent magnets and should be spaced at least 8 inches from other instruments.

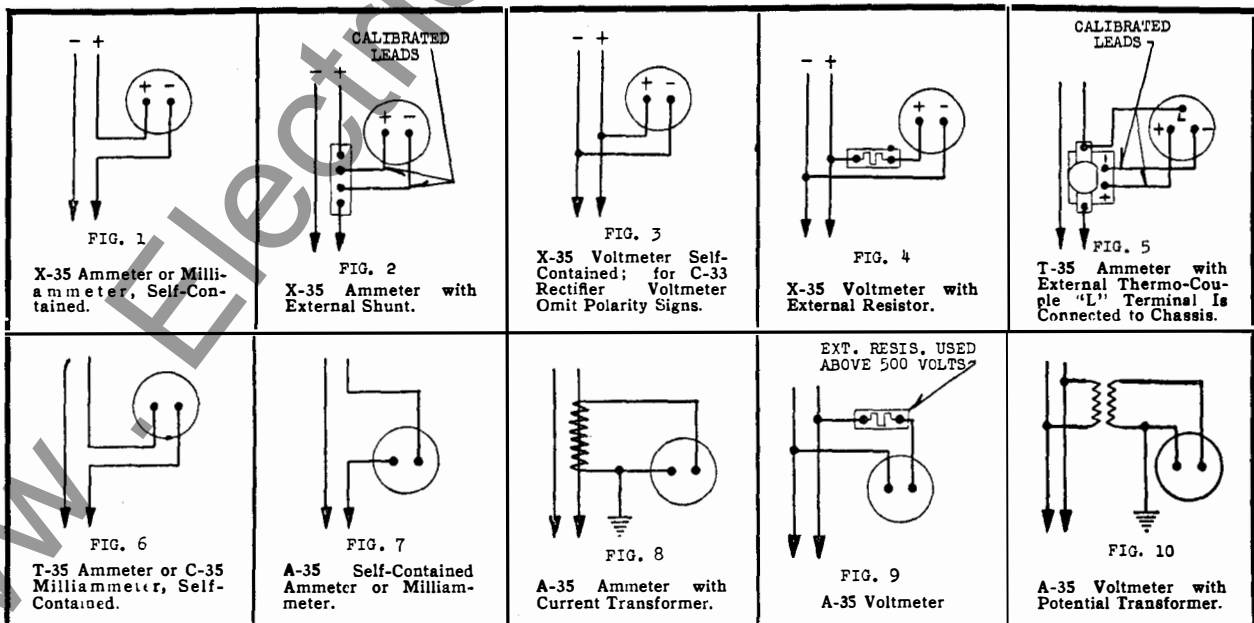
Grounding—When voltmeters are used with an external resistor on voltages higher than the insulation rating, one terminal should be kept at ground potential. Ammeters with external shunts must use specified leads. If the circuit voltage exceeds the insulation rating, the ammeter or shunt should be connected in the grounded side of the circuit.

Radio frequency ammeters with external thermocouples must use specified leads.

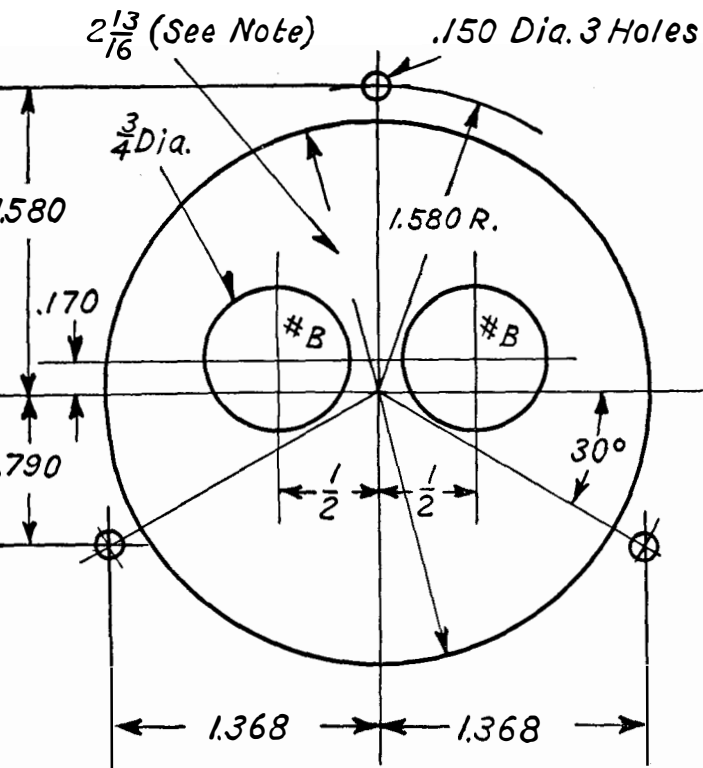
Radio frequency ammeters, particularly those with separate thermocouples, should be arranged with suitable filters or grounding connections to minimize capacity currents.

Repairs and Renewal Parts—Repair work can be done most satisfactorily at the factory. When returning an instrument for repairs, obtain a return material tag from your nearest Westinghouse Sales Office to assure proper identification at the factory.

Orders for renewal parts should include the name of the part, the style number of the instrument and other data marked on the dial.

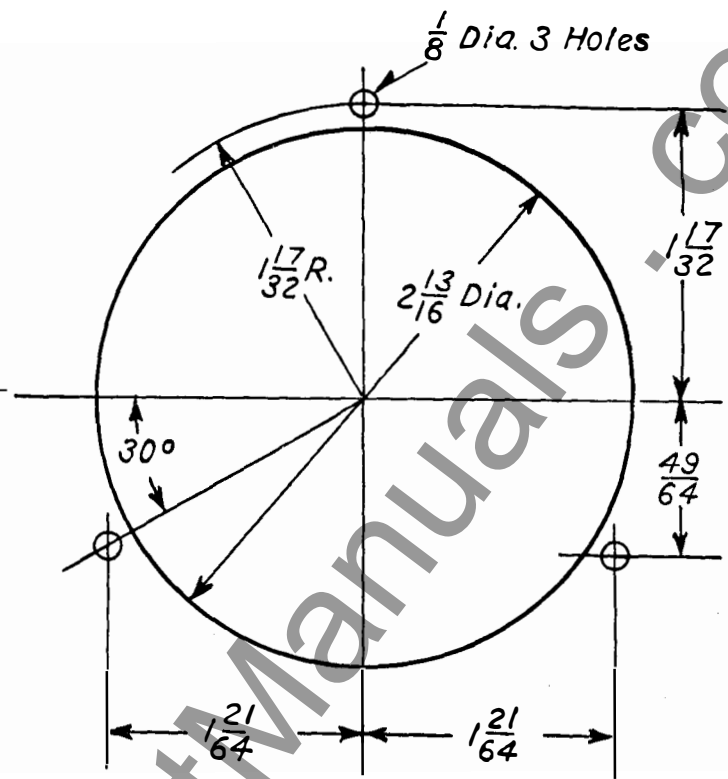


Note: All connections of instruments proper are rear view with dial upright.

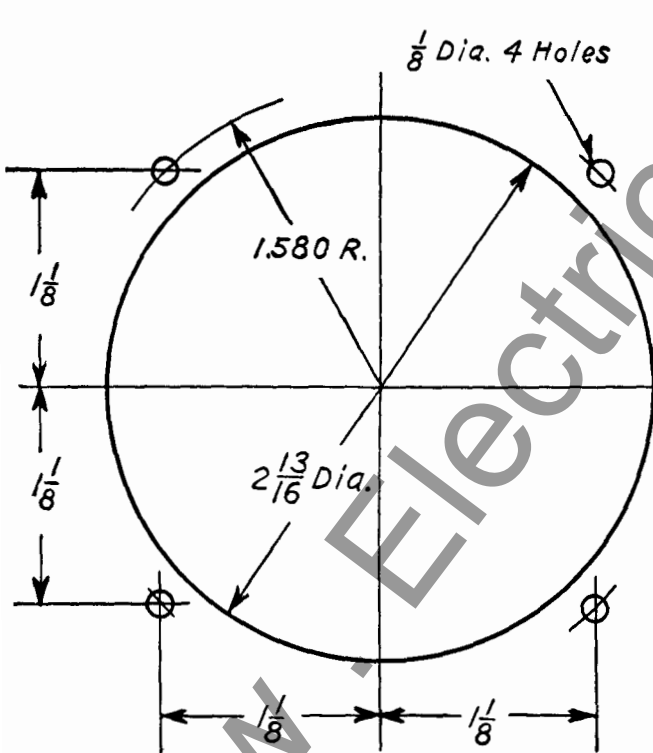


Drilling Plan
 Fig. 11—NA-35, SA-35, NX-35, SX-35 NC-35,
 SC-35, NT-35 and ST-35

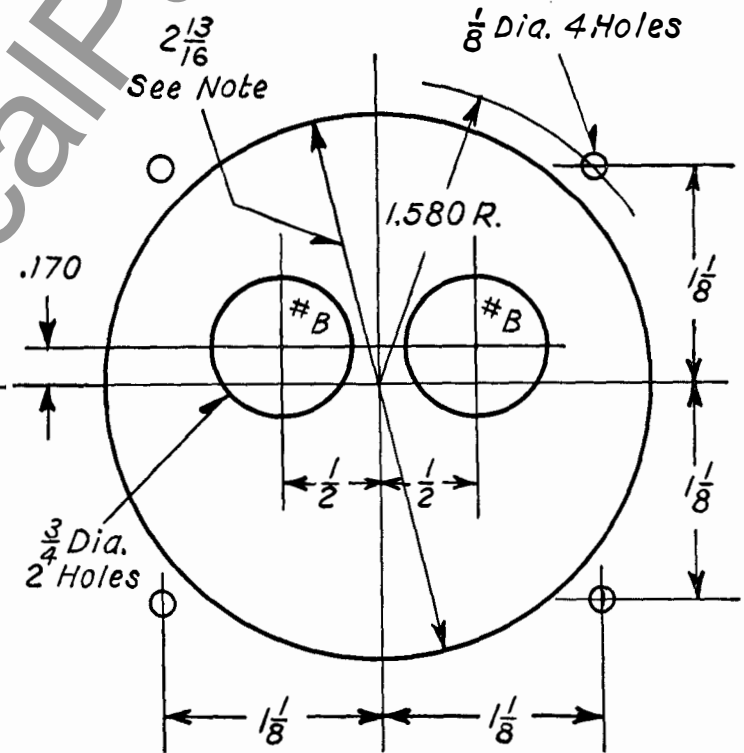
Note: The small holes #B may be used instead of the large hole for insulated panel mounting of all S-35 instruments.



Drilling Plan
 Fig. 12—VA-35, VX-35, VC-35 and VT-35



Drilling Plan
 Fig. 13—RA-35, RX-35, RC-35 and RT-35



Drilling Plan
 Fig. 14—UA-35, UX-35, UC-35 and UT-35
 Note: The small holes #B may be used instead of the large hole for insulated panel mounting.



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 developed 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 90 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.

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

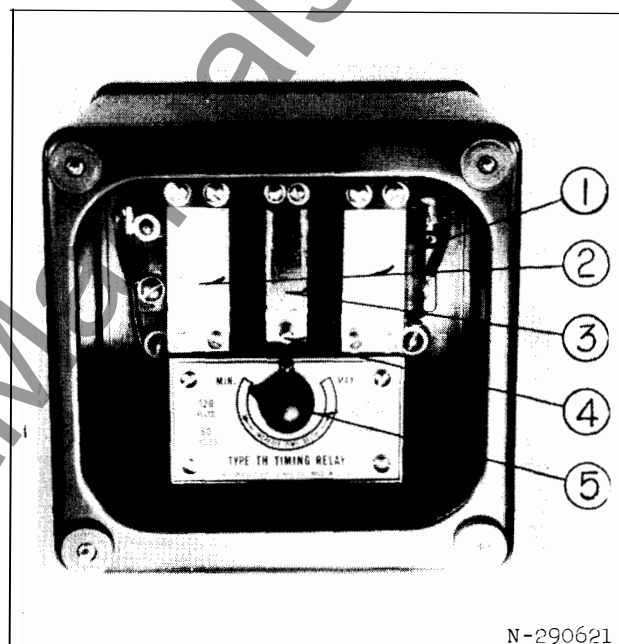


Fig. 1—Type TH Single-Element Thermal Timing Relay.
1—Resistor, 2—Side Bimetal Strips, 3—Heater Coil and Center Bimetal Strip, 4—“F” Bimetal Screw, 5—“T” Timing Screw.

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.

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 or possible higher current in the controlled circuit upon the life of the relay should be considered.

SUPERSEDES I.L. 41-369E

* Denotes change from superseded issue.

EFFECTIVE AUGUST 1953

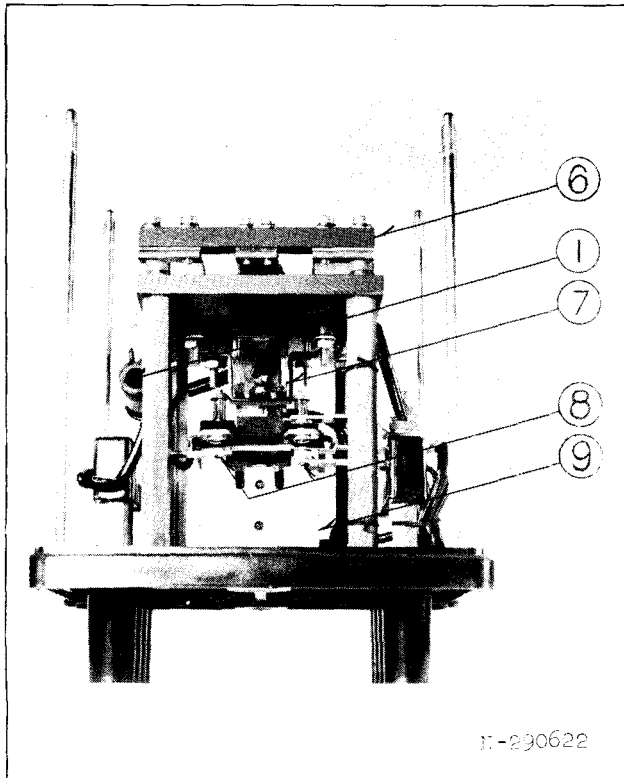


Fig. 2—Top Views of the Type TH Single-Element Thermal Timing Relay. 1—Resistor, 6—Bimetal Assembly, 7—Micro Switch, 8—Contacts, 9—Auxiliary Contactor.

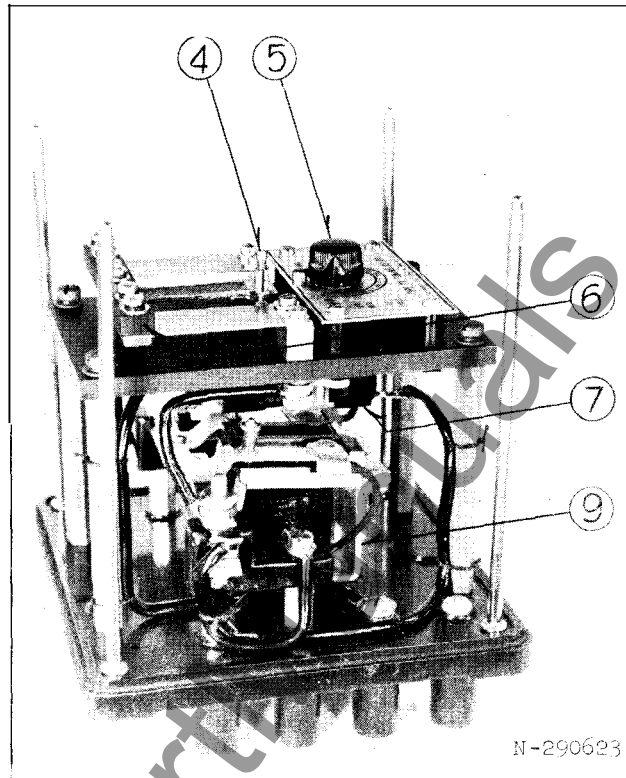


Fig. 3—Side View of the Type TH Single-Element Thermal Timing Relay. 4—"F" Bimetal Screw, 5—"T" Timing Screw, 6—Bimetal Assembly, 7—Micro Switch, 9—Auxiliary Contactor.

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 adjust-

ing 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

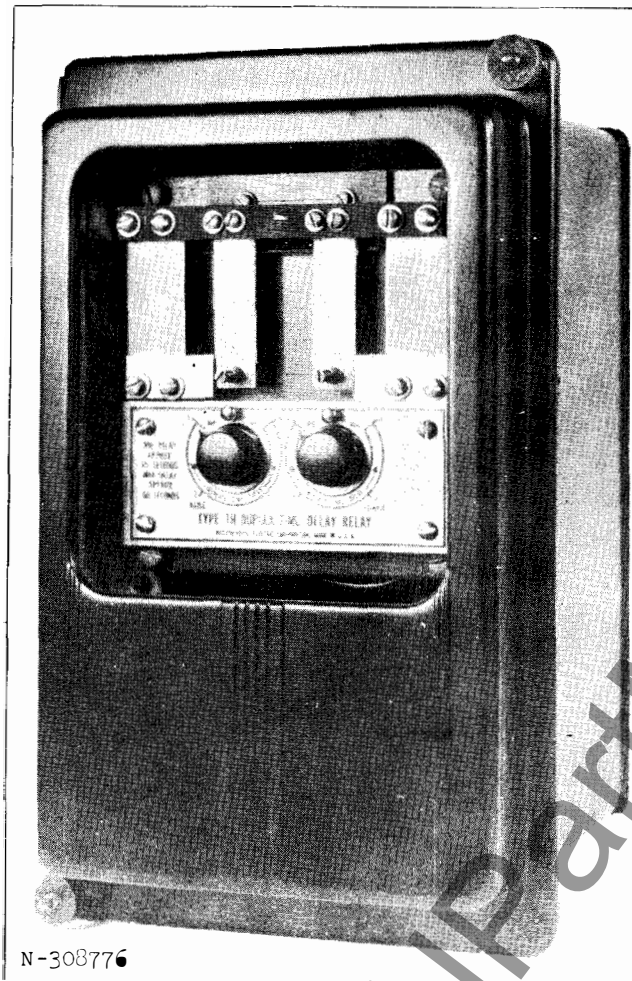


Fig. 4—The Type TH Duplex Thermal Timing Relay.

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.

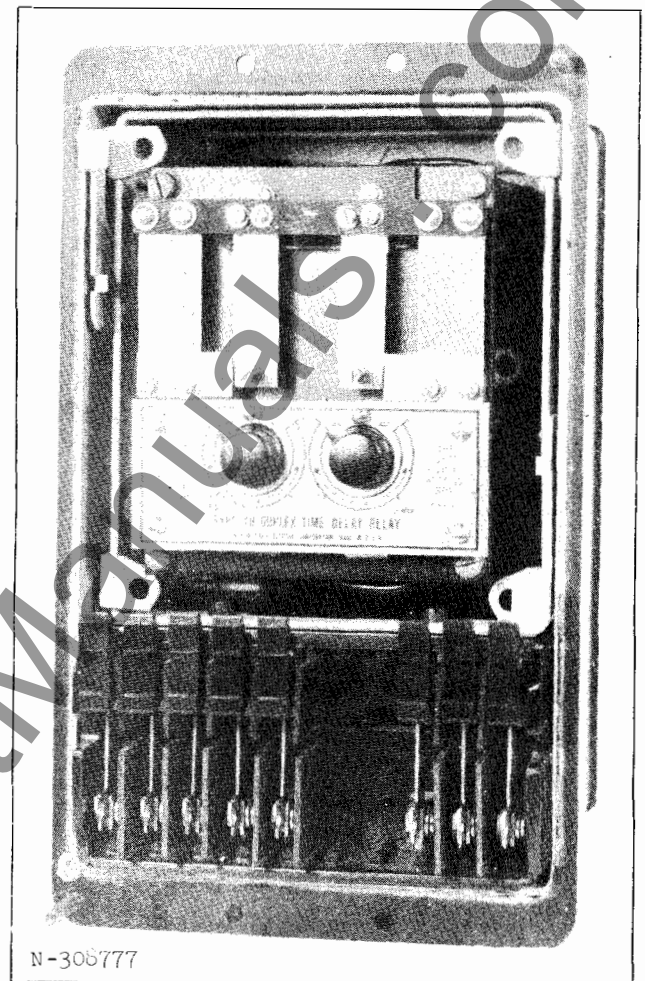


Fig. 5—The Type TH Duplex Thermal Timing Relay With Cover Removed, Showing Test Switches.

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 pre-determined temperature rise above ambient, the micro switch returns to its original position,

TYPE TH RELAY

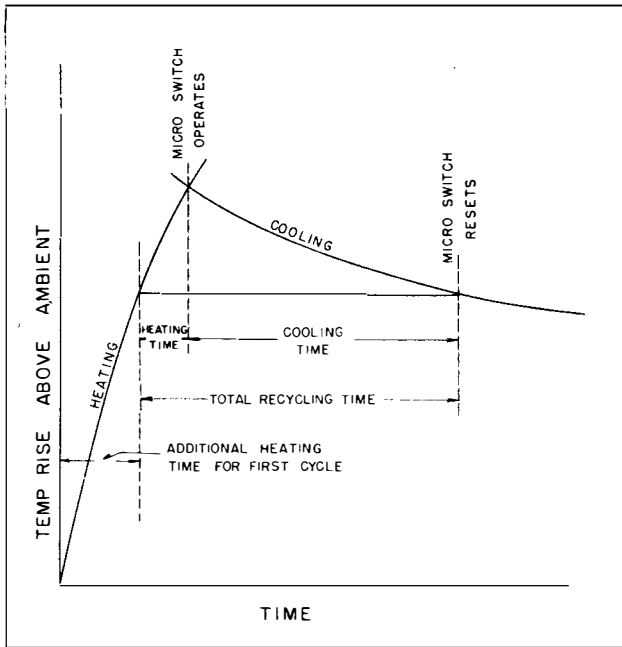


Fig. 6—The Time-Temperature Characteristic of the Type TH Relay.

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

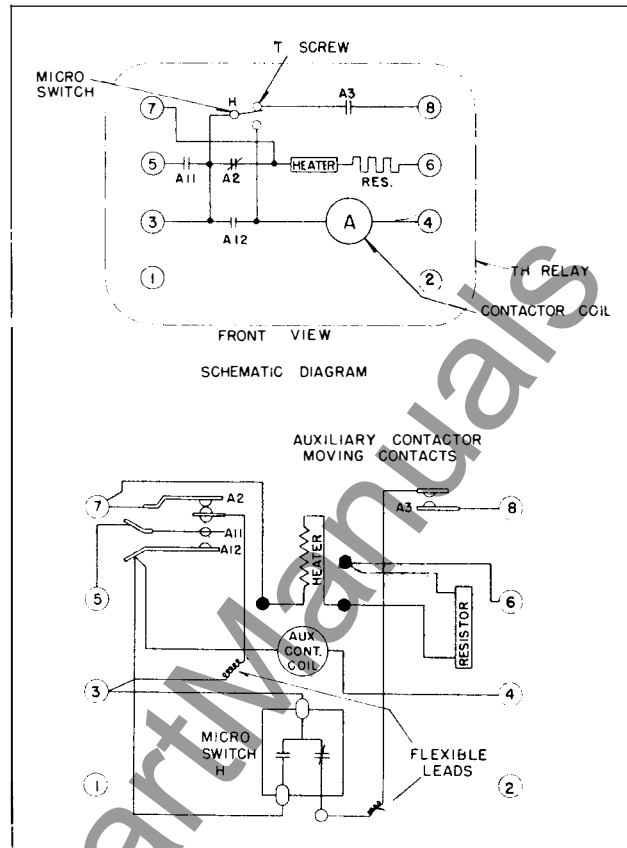


Fig. 7—Schematic and Wiring Diagrams of the Type TH Single-Element Relay.

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-

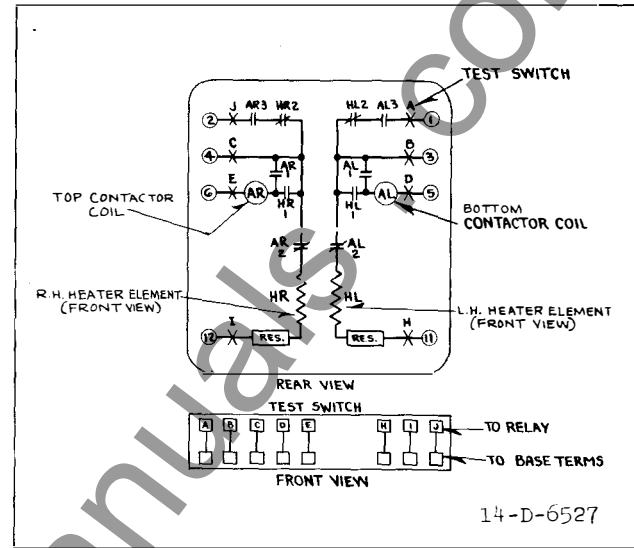


Fig. 8—Schematic Diagram of Type TH Duplex Relay.

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

TYPE TH RELAY

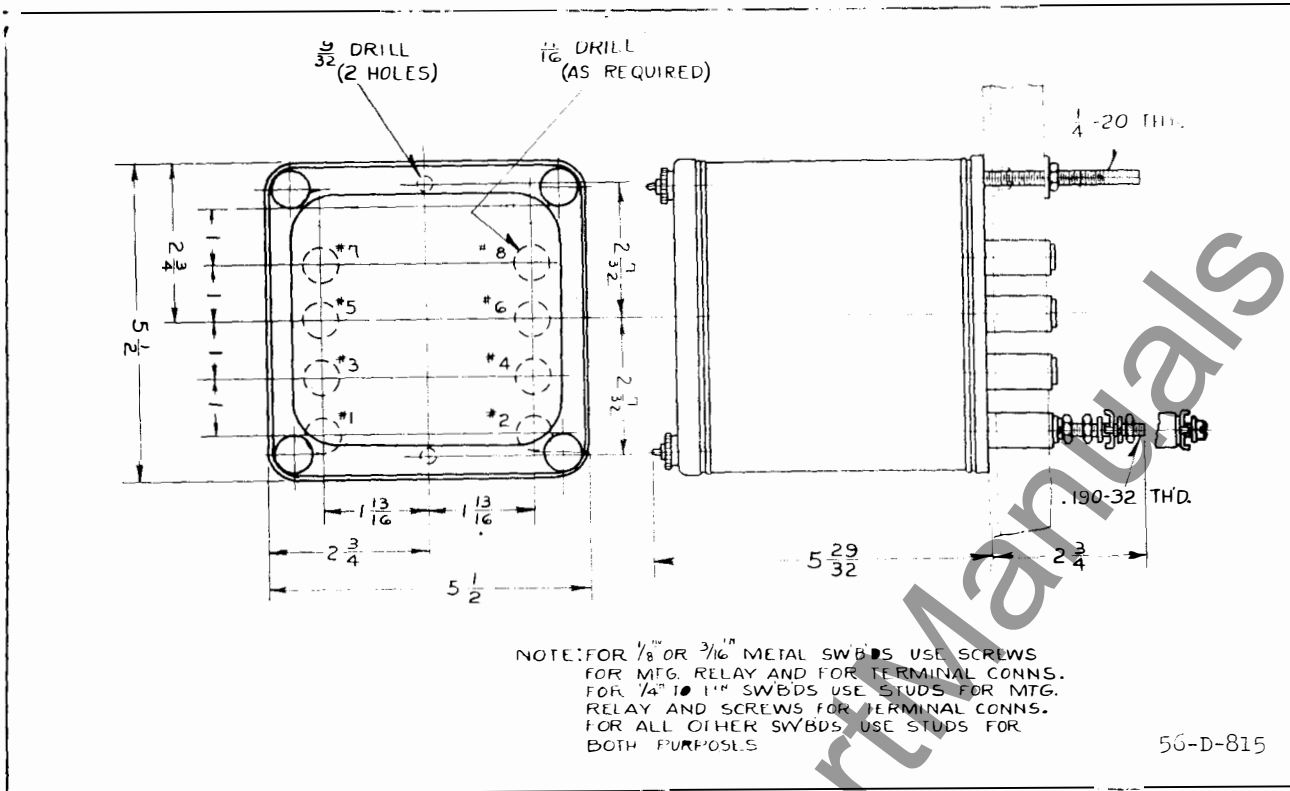


Fig. 9—Outline and Drilling Plan for the Type TH Single-Element Relay.

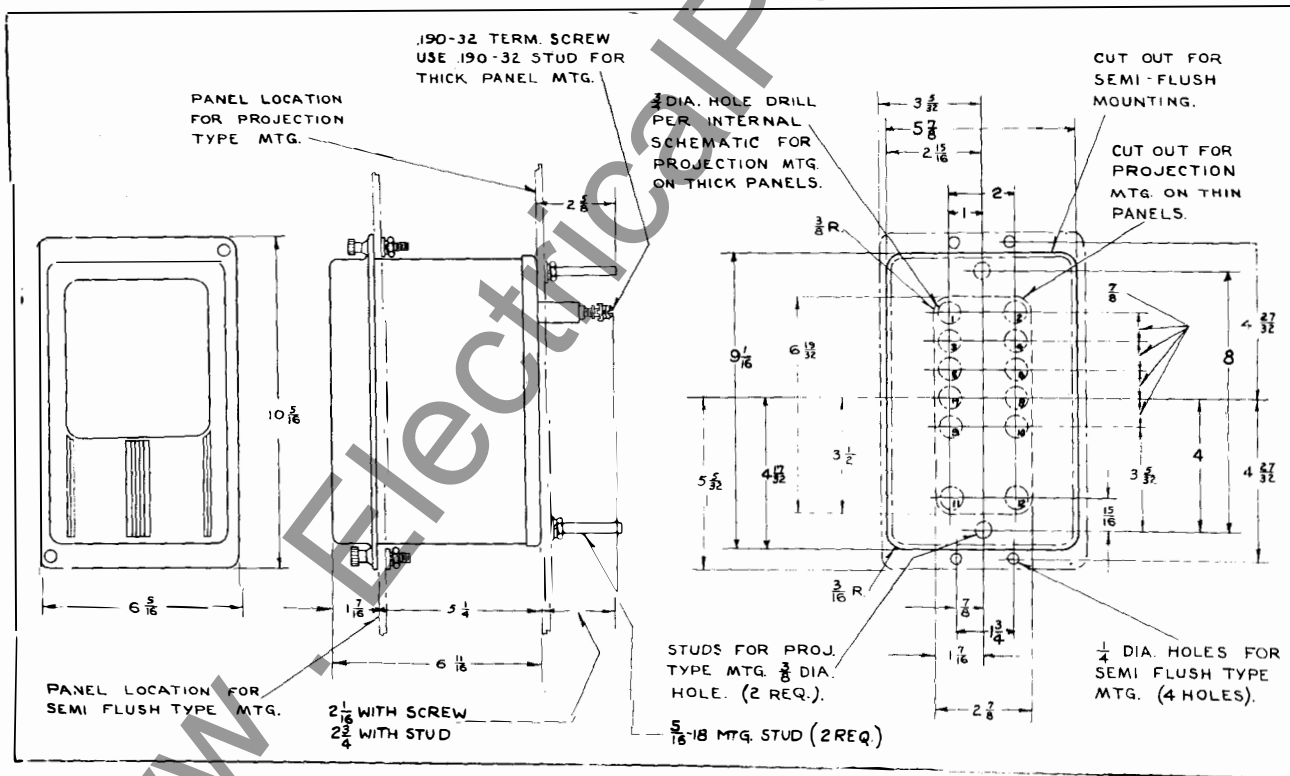


Fig. 10—Outline and Drilling Plan for the Type TH Duplex Relay. See Internal Schematic for the Terminals Supplied. For Reference Only.



DESCRIPTION • INSTALLATION • OPERATION
I N S T R U C T I O N S

**VOLTAGE REGULATING RELAY
 TYPE SJS
 FOR LOAD TAP CHANGERS**



The **TYPE SJS VOLTAGE REGULATING RELAY** for automatic control of load tap changers is of the balanced beam, alternating current, solenoid type. The voltage sensitive element is factory adjusted and sealed in a case having a tight fitting cover with a glass front.

The **TYPE SJS VOLTAGE REGULATING RELAY PANEL** contains the circuit components for electrically setting the balance voltage, band width, and line-drop compensation. Settings may be made quickly and conveniently from the front of the panel by means of the respective knobs.

RATING

The SJS voltage regulating relay and the SJS voltage regulating relay panel have been designed for operation on 60 cycle alternating current systems. The balance voltage can be set at any value desired within the range of 105 to 135 volts and the

band width may be set at any value between ± 1.0 volt and ± 3.0 volts.

Separate R and X compensator elements permit independent setting of the 24 volts resistance and the 24 volts reactance compensation (both on a 120 volt base) which is available with the standard current of 5 amperes flowing in the current circuit of the relay. The 120 volt potential circuit has a burden of 25 volt-amperes and the 5 ampere current circuit has a 15 volt-ampere burden.

DESCRIPTION

Voltage Regulating Relay. Detailed pictures of the SJS voltage regulating relay are shown in Figs. 1, 2, 3, and 4. The main coil, mounted on the front of the Micarta[®] base, provides a balance pull on the armature at a specific voltage. A ballast reactor, in series with the main coil to minimize temperature effects, is mounted on the rear of the Micarta[®] base. The armature which provides the voltage sensing movement is supported by a hinge spring assembly as shown in Fig. 5. The hinge spring is of reinforced, solid leaf construction, held to close tolerances in production to obtain the cor-

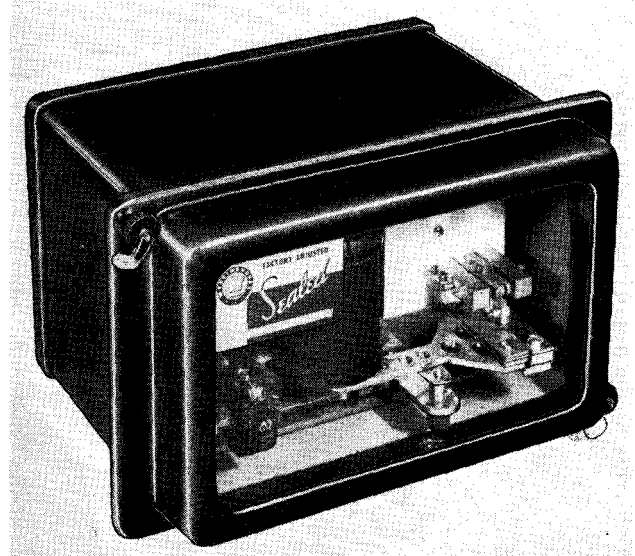


FIG. 1. Type SJS Voltage Regulating Relay

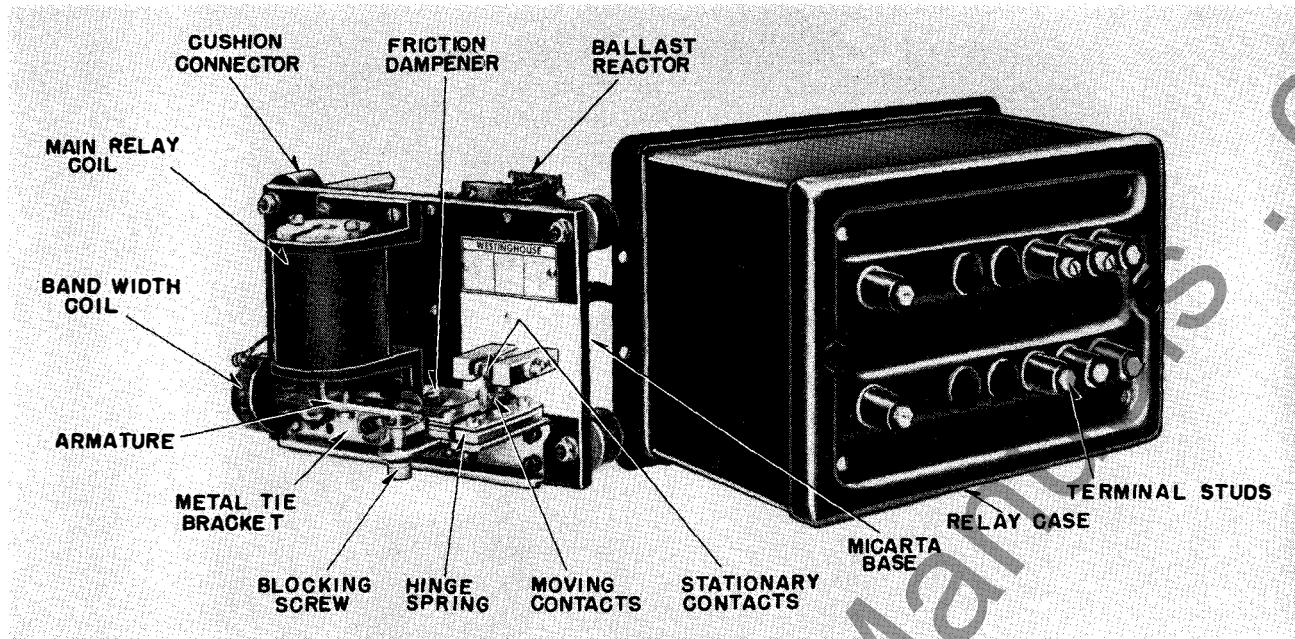


FIG. 2. Front View of SJS Relay Element Assembly and Rear View of Case

rect spring rate for the desired sensitivity of the relay. The hinge spring is supported from a metal tie bracket which also supports the band width coil, insuring accurate control of the setting of the gap between the band width pole and the armature extension tip. A friction damper gives sufficient damping action to insure stable operation of the moving element.

The moving contact is fastened to the armature while the stationary contacts are mounted on the Micarta® base. A white background behind the contact assembly allows better observation of the contact operation during routine inspections. The factory adjusted back-up leaf spring on each of the stationary contacts assures proper operation of the contacts and consequently prolongs their life. The contact spacing has been set at the factory to provide adequate compounding. Contact material is of silver, and the contacts have been designed to give trouble free operation for the life of the relay.

The micarta base is fastened to the metal case through cushion connectors which provide a shock absorbing mounting for the relay element assembly. This gives added protection to the unit during shipment in addition to reducing vibration effects when in operation on the tap changer. A tight fitting glass front cover encloses the voltage regulating relay which has been properly adjusted at the factory and which requires no further adjustment or maintenance in the field. The moving element is secured during shipment by means of a locking screw arrangement easily accessible through the

small hole in the bottom of the cover. The hole through which the locking is removed, is closed with a convenient snap cover.

Voltage Regulating Relay Panel. External circuit components for electrically setting the balance voltage, the band width, and the line drop compensation are mounted on the SJS voltage regulating relay panel as shown in Figs. 4 and 6. The panel is designed for use as a unit in the complete tap changer control assembly.

An auto-transformer with five-volt taps from 105 to 130 volts plus an additional five-volt vernier tap provides balance voltage settings from 105 to 135 volts. The balance voltage selection is made by means of a non-shorting rotary tap switch for five volt steps and a potentiometer for vernier settings to give intermediate values. Mounted on the back of the panel with control knobs in front are rheostats for setting the band width and line drop compensation, plus a rotary type shorting switch for reversing the reactance compensation. Intermediate current transformers for the line drop compensator are located in back of the relay panel. A calibrating resistor and a potential dividing resistor are included in the panel assembly. A no-voltage relay is just below the connector receptacles. Neon lights on the front of the panel show when the relay contacts are closed.

Electrical connections between the SJS relay and the SJS relay panel are made through the terminal studs on the rear of the relay case. Current and

potential test terminals are conveniently located on the front of the panel.

A General Radio type 274MB plug is supplied and may be used as an ammeter plug to connect the ammeter to the current test terminals before the shorting link is removed or (with a wire connecting the sides of the plug) as a shorting bar while the shorting link is removed and the ammeter is connected with spade terminals.

RECEIVING—HANDLING—STORING

The SJS relay and relay panel will usually be shipped assembled as a unit of the complete tap changer control assembly and the instructions for receiving, handling and storing the control will suffice. However, it may be desirable to have such information more readily available; it is, therefore, recorded here for convenience.

Receiving. Immediately upon receipt of the SJS relay panel, make a careful examination for any evidence of damage sustained in transit. If any damage is found or suspected, file a claim promptly with the transportation company and notify the nearest Westinghouse Sales Office.

Handling. The SJS voltage regulating relay is in fact an instrument and should be handled as such. It has been designed with cushion connectors, a reinforced hinge spring and other items to make it as rugged as possible, but the fact remains that it has better than 1% accuracy and is thus equivalent to the better, more accurate laboratory voltmeters and should consequently be handled with reasonable care, free from excessive shock and vibration.

This relay has been adjusted and tested before leaving the factory to insure that it meets the required high standards of operation considered essential for such equipment. Whether or not it continues to meet these standards depends upon the treatment accorded it after it leaves the factory.

Note: The armature should be blocked at any time that the SJS relay panel is moved, or at any time that the control or unit, on which the SJS relay panel is mounted, is moved. Blocking instructions are given under the heading of "ARMATURE BLOCKING".

Storing. If the SJS relay panel is to be stored, it should be kept in a clean, dry, moderate temperature location, protected from excessive dust, from atmospheres conducive to condensation and corrosion, and from moisture and the elements.

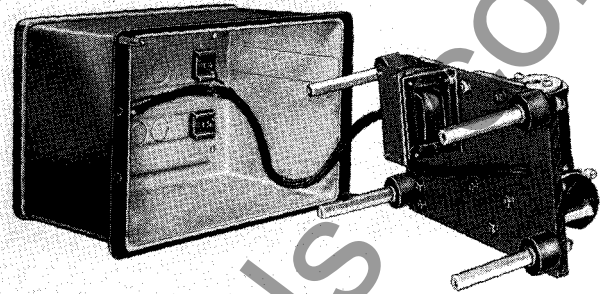


FIG. 3. Back of SJS Relay Base and Inside View of Relay Case

INSTALLATION

Since the SJS voltage regulating relay panel will usually be shipped assembled as a unit of the complete tap changer control, the SJS relay panel will have been installed at the factory and further installation will be required only for the complete unit equipment as described in its instruction book. However, since the SJS voltage regulating relay panel has been designed with the drawout feature to permit removal for meter room or laboratory setting or testing, where this feature is desired, instruction for installation will be useful.

To install the SJS voltage regulating relay panel in the control, place the back projections of the relay panel into the cutout provided in the control (insert from the front of the control) and bolt in place at the four corners with the bolts provided for this purpose. Insert the plug connectors from the back of the swinging control panel into the receptacles on the back of the SJS relay and installation is complete.

To remove the SJS voltage regulating relay panel from the control, disengage the two plug connectors from the receptacles and remove the four bolts from the corners of the relay panel. The four pole connector contains self shorting terminals so that the current transformer is automatically shorted when the plug is removed.

Note: The armature should be blocked at any time that the relay panel is moved, or at any time that the control or unit, on which the relay is mounted, is moved. Blocking instructions are given under the heading of "ARMATURE BLOCKING".

To prepare for use simply unblock the armature as described under the heading of "ARMATURE BLOCKING". It is unnecessary to remove the relay cover or break the seals to inspect, install or remove, block or unblock, or to operate the relays or to make the required settings.

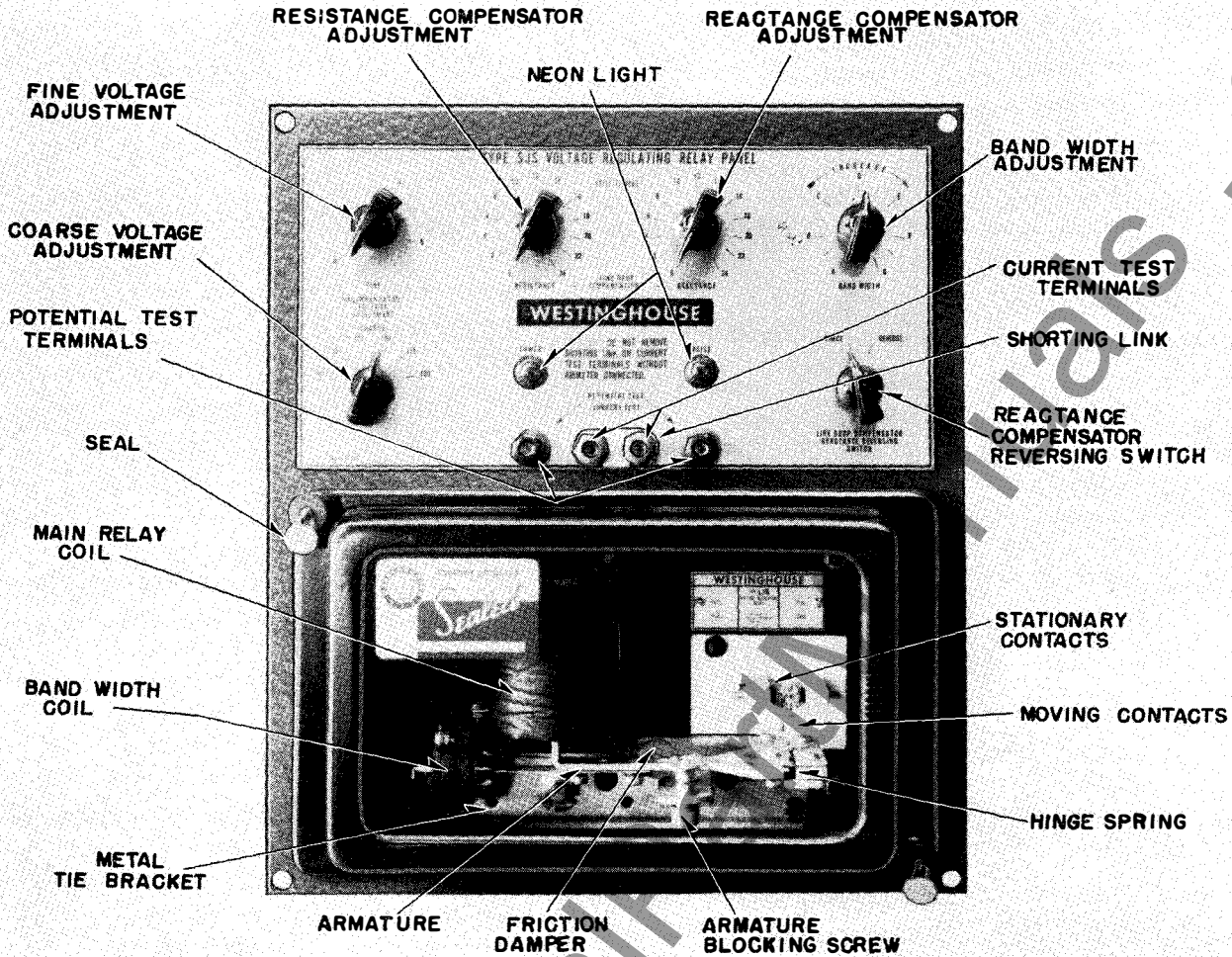


FIG. 4. Front View of SJS Relay and SJS Relay Panel

ARMATURE BLOCKING

Caution: Before blocking or unblocking the SJS relay be sure that the control breakers are in the "OFF" position; for when the control circuit is energized, there is a potential of 120 volts between the blocking screw and the case (the case is grounded).

To Block Armature: See Fig. 7.

1. Open the control breakers.
2. Remove the snap button hole plug from the bottom of the cover.
3. Advance the $\frac{5}{16}$ inch cap screw until it lifts the armature to the horizontal position where the armature tip is directly opposite the center pole of the band width coil. It is necessary to have the armature in this horizontal position before final clamping to prevent damage to the hinge spring on final clamping.

4. Screw the #6-32 machine screw (inner captive screw) into the armature, using a small screw driver ($\frac{1}{8}$ inch wide blade), and tighten securely.

5. Replace the snap button hole plug in the bottom of the cover.

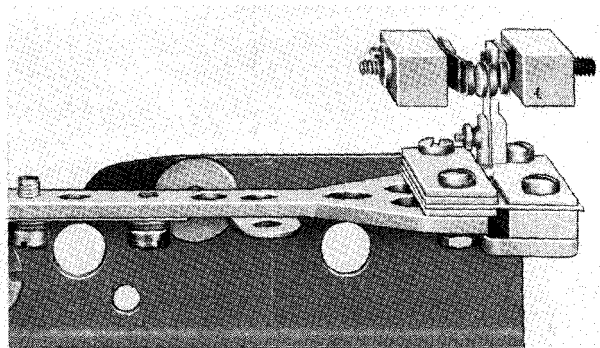


FIG. 5. Hinge Spring Assembly

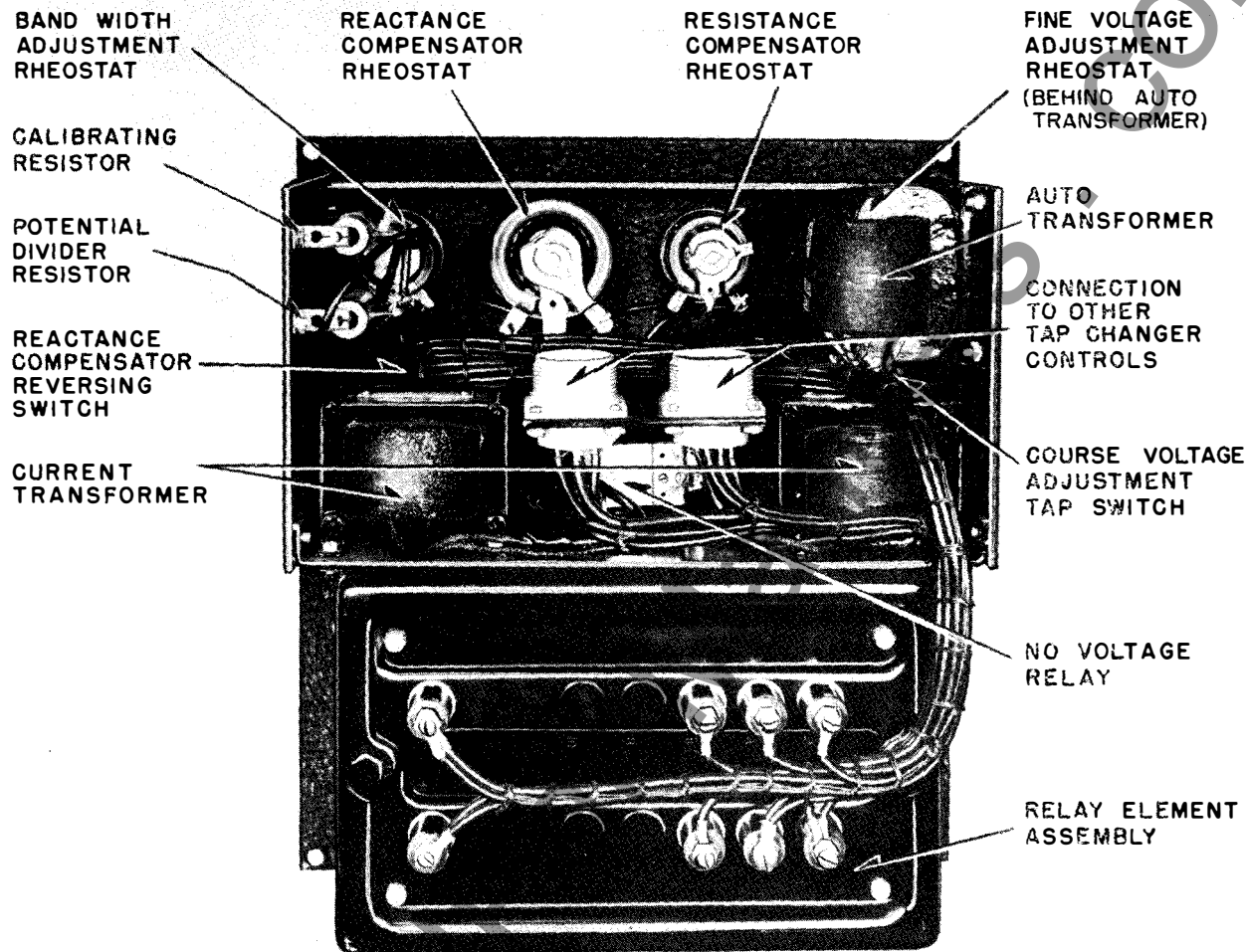


FIG. 6. Back View of SJS Relay and SJS Relay Panel with Back Cover Removed to Show External Electrical Components

To Unblock Armature: See Fig. 7.

1. Open the control breakers.
2. Remove the snap button hole plug from the bottom of the cover.
3. Unscrew the #6-32 machine screw (inner captive screw) from the armature.
4. Retract the $\frac{5}{16}$ inch cap screw until the retaining ring comes in contact with the screw bracket. It is necessary to retract the cap screw to allow the armature freedom of movement.
5. Replace the snap button hole plug in the bottom of the cover.

OPERATION

The voltage sensing action of the SJS relay is basically a function of the solenoid pull of the main coil and the attraction of the band width electromagnet on the hinge spring supported armature.

Compounding is accomplished by the action of the band width coil and is determined by the amount of armature travel from balance position. Line drop compensation is provided by introducing a voltage which is directly proportional to the actual voltage drop on the line.

With the proper balance voltage applied to terminals A_4 and B_4 , Fig. 8, the armature is held in a balance position by the main coil solenoid action. At balance, the rotational force of the armature, due to its weight, just exactly balances the solenoid action of the main coil, and the hinge spring is undeflected. As the applied voltage is either increased or decreased a sufficient amount, this balance no longer exists and the armature is either raised above or dropped below balance position, closing either PL or PR contacts. The amount of voltage change necessary to cause the armature to change from balance position is determined by the excitation of the band width coil and the gap

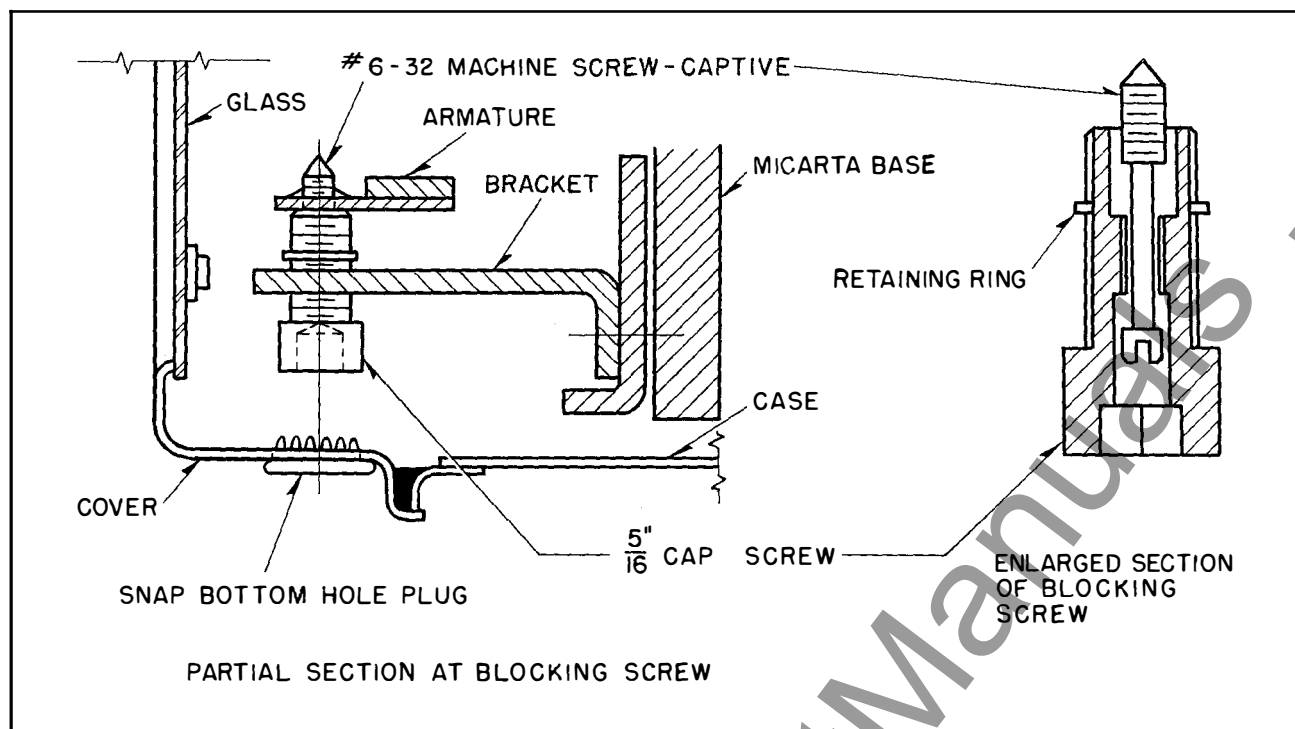


FIG. 7. Details of Armature Blocking

between the band width center pole and the armature extension tip. The magnetic attraction of the band width pole on the armature extension tip, combined with the action of the hinge spring, causes a snap-action deflection of the armature, thus giving a positive contact make and break. The voltage change required to return the armature to balance is determined by the distance the armature travels and has been set at the factory to provide proper compounding.

Input balance voltages from 105 to 135 volts are made possible by an auto transformer with taps on the input side. A vernier (R1, Fig. 8) provides intermediate values which are added to the tap selection. A rheostat (R2, Fig. 8) is used to vary the excitation to the band width coil (BW, Fig. 8), allowing a band width selection from ± 1.0 volt to ± 3.0 volts.

Line drop compensation is accomplished by causing a voltage drop to appear across R5 and the ballast reactor which is proportional to the magnitude and phase of the actual drop on the line. Intermediate current transformers supply the current for the compensator network. The compensator can be set to give from 0 to 24 volts (on 120 volt base with 5 amperes flowing in the primary of the intermediate current transformers) resistive and reactive compensation by adjusting rheostats R5 and R6 respectively. Reverse reactance compensation

as required for certain installations can be obtained by the reversing switch shown in Fig. 8.

The ballast reactor also serves to introduce a large reactance relative to the resistance in the circuit containing the main coil. This makes the effect of resistance change due to temperature variations virtually negligible.

A no-voltage relay (P-NV) with contacts in the common lead of the PR and PL contacts prevents a voltage-change signal in the event of a potential failure to the voltage regulating relay.

SETTINGS

The SJS relay settings for balance voltage, band width, and line drop compensation are all electrical settings made with the unit mounted in the tap changer control cabinet, using either the potential transformer or an external voltage source for excitation. If it is desired to check the relay out of the tap changer control cabinet, the entire SJS relay panel may be easily removed by taking out the four bolts at the corners of the relay panel and disconnecting the plugs at the rear of the panel.

Apply normal voltage to the relay and relay panel for a period of three hours before making settings, to allow all parts to become stabilized at the operating temperature.

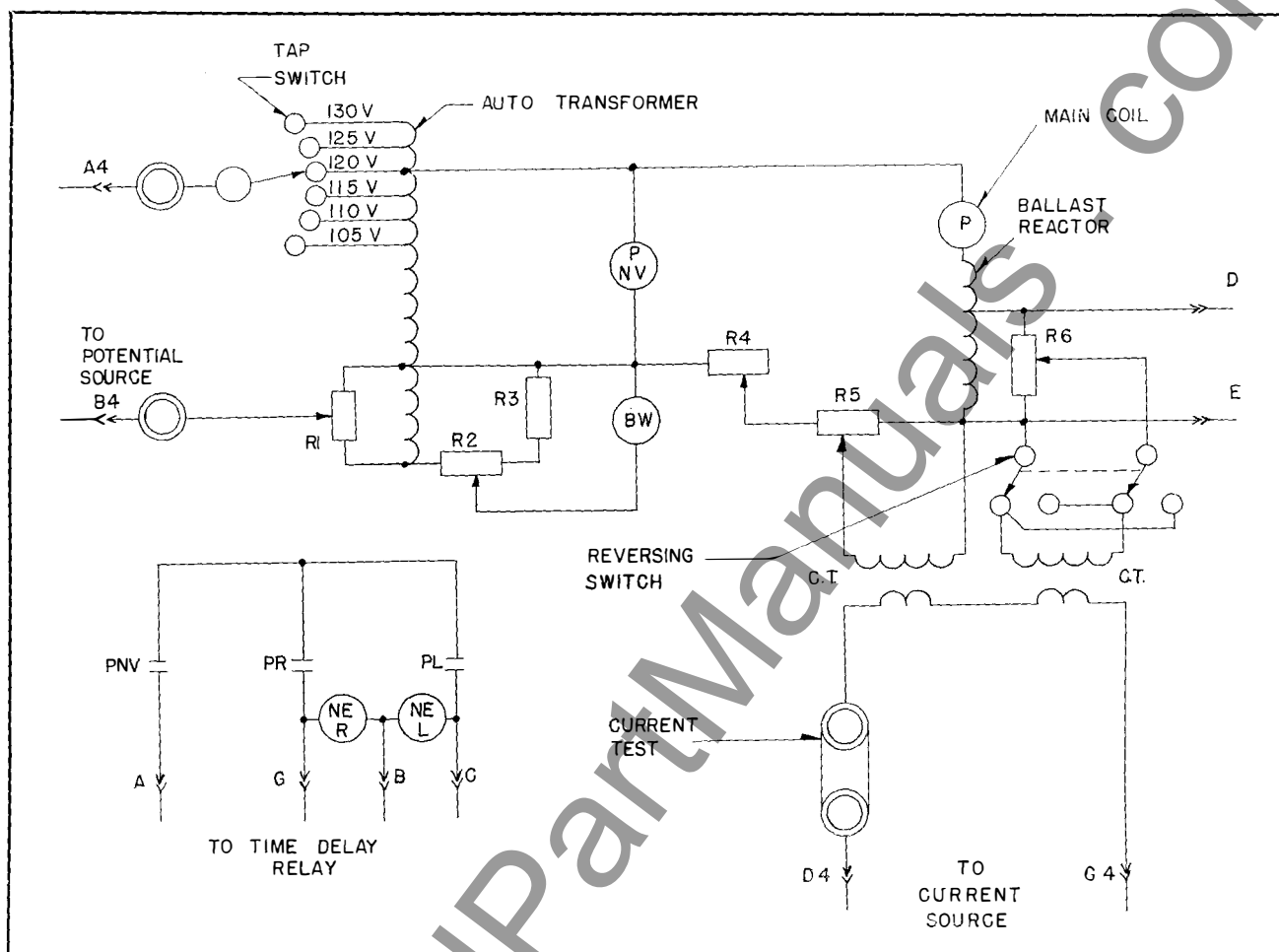


FIG. 8. Schematic Diagram of Type SJS Voltage Regulating Relay and Controls

Balance Voltage and Band Width Settings Using External Voltage Source. Place the control breaker in the "OFF" position, and apply an external regulated power source to the potential test terminals. If the unit is carrying load, set the compensator dials on zero while the balance voltage and band width settings are made. The balance voltage and band width settings are made as follows:

1. Turn the band width dial to the full clockwise position.
2. Set the coarse-voltage adjustment dial to the dial calibration just below the desired balance voltage. (For example, set on 115 volts for 117 volt balance).
3. Next turn the fine-voltage adjustment dial to the value which when added to the setting above give the desired balance voltage. (In the example, set on 2 volts).
4. To set the band width and check with the balance voltage setting above, adjust the applied

voltage to the value below balance at which it is desired to have the relay close its PR contacts. (For example, if a band width of ± 1.5 volt with balance voltage of 117 volts is desired, adjust the voltage to 115.5 volts).

5. Rotate the band width dial slowly in a counter-clockwise direction until the PR contact closes. These settings now should give the proper balance voltage and band width and may be checked in the step below.

6. Increase the applied voltage to the value above balance voltage at which the relay should close its PL contact. (118.5 volts in the example above.) The PL contact should close at this value of voltage; however, a slight readjustment of the fine-voltage dial and the band width dial may be necessary. If the contact closes at less than the desired voltage, it indicates a balance voltage setting and a band width setting slightly less than the desired values. If the contact closes at higher than the desired value the reverse is indicated. In all

SJS VOLTAGE REGULATING RELAY

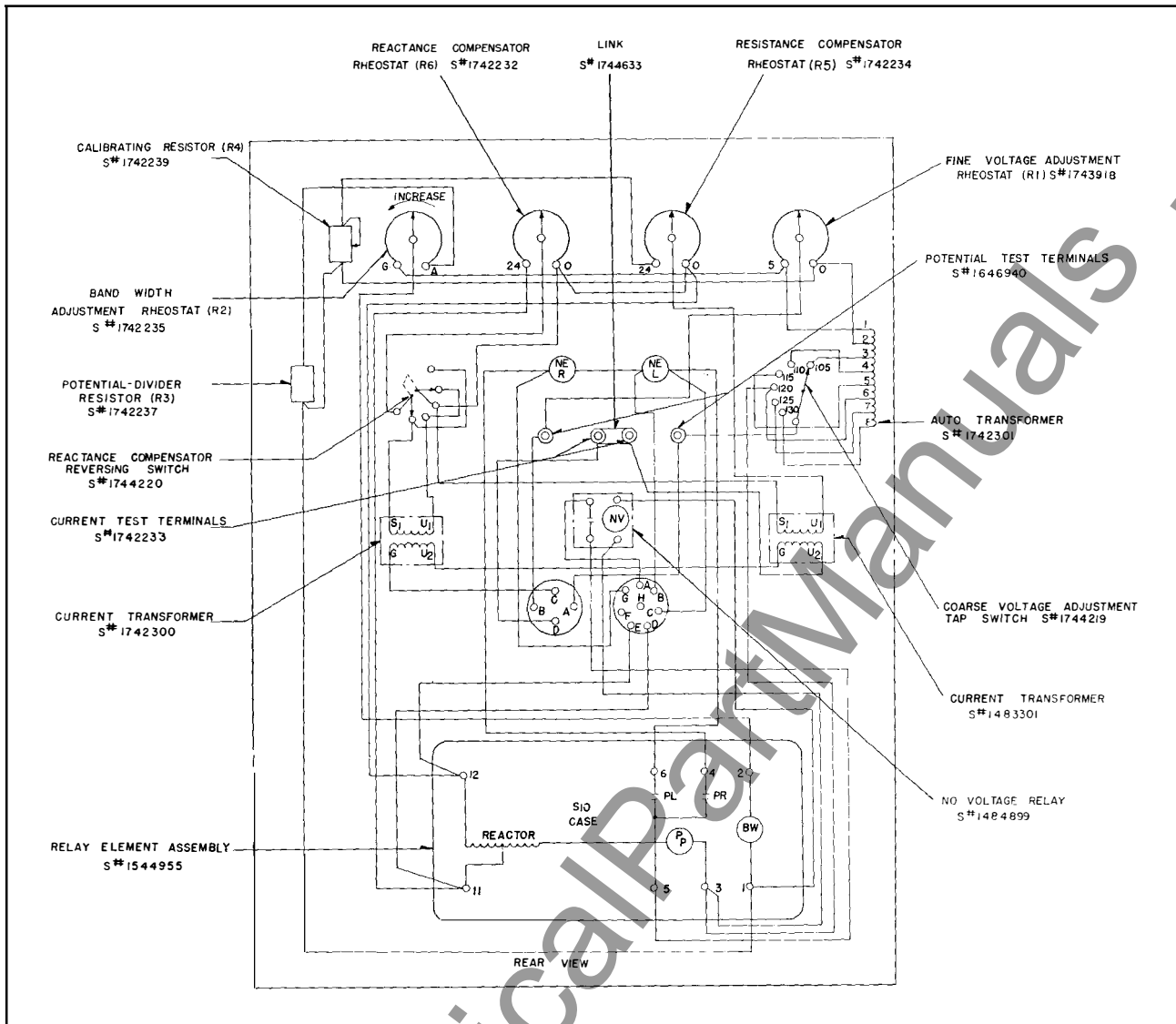


FIG. 9. Wiring Diagram of Type SJS Voltage Regulating Relay and Panel

cases, only a very minor adjustment will be necessary. Both balance voltage and band width can be increased by a clockwise rotation of the fine-voltage adjustment dial and band width adjustment dial respectively.

Balance Voltage and Band Width Settings Using Internal Voltage Source. To use the internal potential transformer as a voltage source for setting the balance voltage and band width of the SJS relay, place the control breaker in the "ON" position and the automatic-manual switch in the "MAN" position. If the unit is carrying load, set the compensator dials on zero while the balance voltage and band width settings are made. Operate the tap changer manually to give approximately the balance voltage desired at the test terminals. Then proceed as follows:

1. Turn the band width dial to the full clockwise position.
2. Using both the coarse—and fine—voltage adjustment dials, set to a value above the applied voltage which will cause the PR contact to just make. Record the dial settings, adding the fine value to the coarse value.
3. Next, reduce the voltage adjustment settings below the applied voltage to a value which will cause the PL contact to just make. Record the dial settings, adding the fine value to the coarse value.
4. Take the average of the two dial settings in steps 2 and 3. Add to this average value the side band desired, that is, one-half the total voltage band. Set the resultant value on the voltage adjustment dials. (Example: An average of settings in steps 2

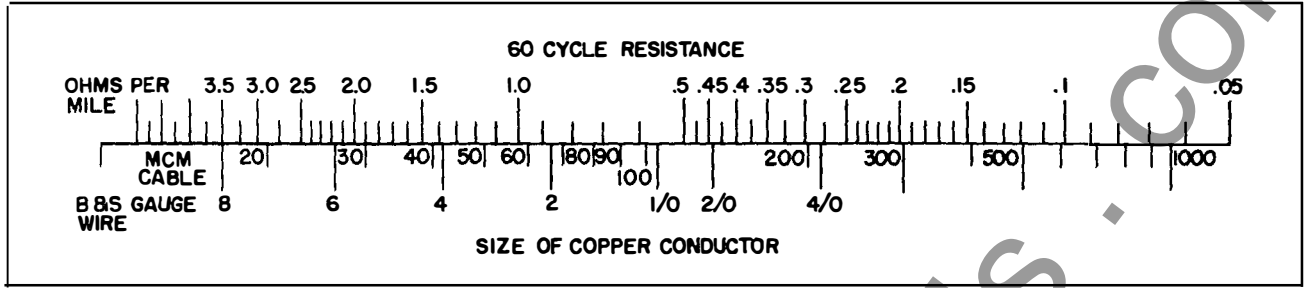


FIG. 10. Resistance Chart, Showing Ohms per Conductor, per Mile, 60 Cycle Circuit

and 3 might be 120 volts. A band width of ± 1.5 volts is desired. Therefore set the dials to read 121.5 volts).

5. Rotate the band width dial slowly in a counter-clockwise direction until the PR contact just closes. This setting of the band width dial will now give the desired band width.

6. Now, reset the voltage adjustment dials to the balance voltage desired, adding the fine setting to the coarse setting.

7. Put the automatic-manual switch in the "AUTO" position.

Line-Drop Compensator Setting. The line-drop compensator for use with the voltage regulating relay consists of two rheostats, one for resistance compensation and one for reactance compensation. The dials of these rheostats are so designed that the settings represent the amount of bias voltage on the primary relay with 5 amps flowing in the line-drop compensator circuit and are proportional to the volts of compensation at the load center. The rheostats 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 secondaries are connected to the compensation reversing switch so that when in the normal position as shown in Fig. 9, normal compensation is obtained.

The settings on the line-drop compensator may most satisfactorily be made by field adjustments, but if the data on the particular line is known, the curves in Figs. 10 and 11 may be used, and values calculated.

The proper line-drop compensator settings can be derived by the use of the following expressions:

Dial Setting for Resistance Compensation = $5 \times \frac{N_{C.T.}}{N_{POT.}} \times R_L \times d.$

Dial Setting for Reactance Compensation = $5 \times \frac{N_{C.T.}}{N_{POT.}} \times X_L \times d.$

Where

$N_{C.T.}$ = current transformer ratio

$$= \frac{\text{primary current}}{\text{secondary current}}$$

$N_{POT.}$ = potential transformer ratio

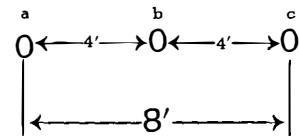
$$= \frac{\text{primary voltage}}{\text{secondary voltage}}$$

R_L = resistance per conductor from unit to load center, in ohms per mile.

X_L = inductive reactance per conductor from unit to load center, in ohms per mile.

d = miles from unit to load center.

A typical three-phase example is as follows:



500,000 CM copper conductor, with flat spacing shown above.

Line Voltage = 12000 volts

Current Transformer Ratio = 600/5

Potential Transformer Ratio = 6928/120

Distance from unit to load center = 3.5 miles.

SJS VOLTAGE REGULATING RELAY

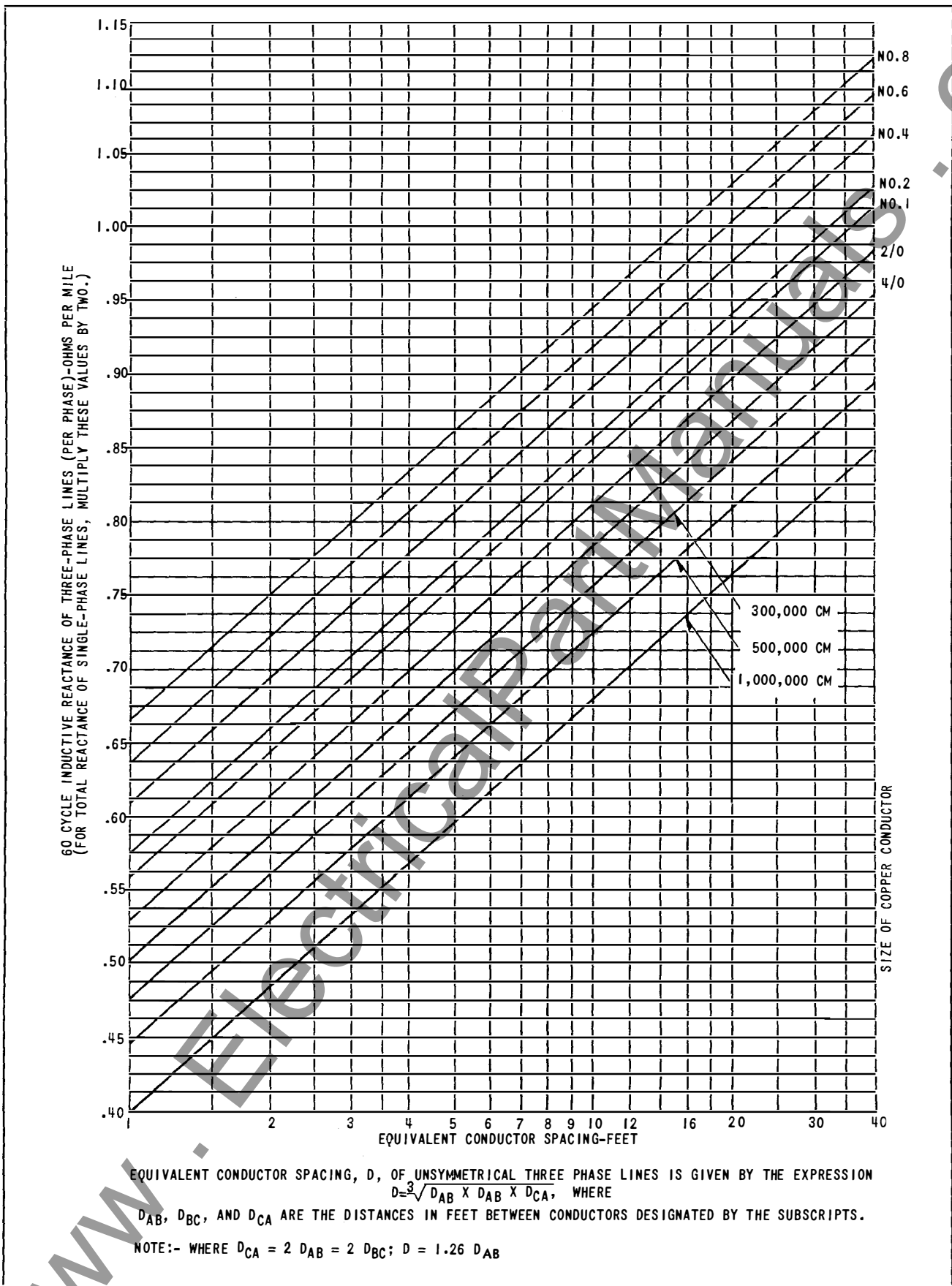


FIG. 11. Reactance Chart, Size of Conductor and Spacing, for 3-Phase Lines (per Phase), 60 Cycle Circuit

A unit energizes a typical distribution circuit whose characteristics are given above. Determining the constants for this circuit on a per phase basis,

From Fig. 11:

$$R_L = 0.12 \text{ ohms per mile}$$

From Fig. 10:

$$D = \sqrt[3]{4 \times 4 \times 8} = 5.04 \text{ feet}$$

$$X_L = 0.64 \text{ ohms per mile}$$

The line-drop compensator resistance setting is:

$$\frac{5 \times 600/5}{6928/120} \times .12 \times 3.5 = 4.36$$

The line-drop compensator reactance setting is:

$$\frac{5 \times 600/5}{6928/120} \times .64 \times 3.5 = 23.3$$

These settings may be adjusted as found necessary as shown by load center voltage measurements.

If reverse reactance compensation is necessary, it may be obtained by merely changing the reactance reversing switch to the reverse position. This is a shorting-switch which keeps the current circuit closed until the switching is completed.

MAINTENANCE

The proper adjustments to insure correct operation have been made at the factory and should not be disturbed. The relay element assembly has been sealed for guaranteed performance and should be returned to the factory with the seal unbroken in case the relay does not operate satisfactorily. The large, silver contacts have been designed to operate for the life of the relay without maintenance. They do not need to be polished.

In the event the SJS relay itself should become inoperative, do not break the seal or remove the relay from the panel, but return the entire SJS relay and panel to the Sharon Plant through the nearest District Engineering and Service Office.

In the event any of the components on the relay panel other than the SJS relay itself become inoperative, they may be replaced with renewal parts ordered from the nearest Westinghouse Sales Office or from the Sharon Plant. Should parts be ordered, give the Style or Stock Order number of the equipment as stamped on the nameplate together with the Style number and description of the parts required as identified in Fig. 9.

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 CHARLESTON 23, W. VA., 179 Summers St., P.O. Box 911
 CHARLOTTE 1, N. C., 210 East Sixth St.
 CHATTANOOGA 2, TENN., Volunteer State Life Bldg., Georgia Ave. & East 9th St.
 CHICAGO, ILL., Merchandise Mart Plaza
 CINCINNATI 2, OHIO, 207 West Third St.
 CLEVELAND 13, OHIO, 1370 Ontario St.
 COLUMBIA, S. C., 1608 Gladden St., P.O. Box 5283
 COLUMBUS 15, OHIO, 262 N. 4th St.
 CORPUS CHRISTI, TEXAS, 334 Katie Bldg., 205 N. Chaparral St.
 DALLAS 1, TEXAS, 1232 Fidelity Union Life Bldg.
 DAVENPORT, IOWA, 2212 E. 12th St.
 DAYTON 2, OHIO, 32 North Main St.
 DENVER, COLO., 910 Fifteenth St.
 DES MOINES 8, IOWA, 1408 Walnut St.
 DETROIT 32, MICH., 5757 Trumbull Ave., P.O. Box 502
 DULUTH 2, MINN., 408 Bradley Bldg., 10 East Superior St.
 EL PASO, TEXAS, 718 Mills Bldg.
 EMERYVILLE 8, CALIF., 5815 Peladeau St.
 ERIE 2, PA., 1003 State St.
 EVANSVILLE 8, IND., 106 Vine St.
 FAIRMONT, W. VA., 10th and Beltline Sts., P.O. Box 1147
 FERGUS FALLS, MINN., 101 1/2 W. Lincoln Ave.
 FORT WAYNE 2, IND., 124 Washington St.
 FT. WORTH 2, TEXAS, 1205 Electric Bldg.
 FRESNO 1, CALIF., 2608 California Ave.
 GRAND RAPIDS 2, MICH., 148 Monroe Ave., N.W.
 GREENSBORO, N. C., 1008 Pamlico Drive, P.O. Box 3072
 GREENVILLE, S. C., 160 W. Tallulah Drive, P.O. Box 1591
 HAGERSTOWN, MD., 5 Public Square
 HAMMOND, IND., 6341 Indianapolis Blvd.
 HARTFORD 3, CONN., 119 Ann St.
 HOUSTON 2, TEXAS, 507 Dallas Ave.
 HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150
 HUNTSVILLE, ALA., 1802 Alabama St., P.O. Box 42
 INDIANAPOLIS 9, IND., 137 S. Pennsylvania St.
 JACKSON, MICH., 120 West Michigan Ave.
 JACKSON, MISS., Fonder Station, P.O. Box 4296
 JACKSONVILLE 6, FLA., 545 E. 4th St., P.O. Box Drawer K
 JOHNSON CITY, N. Y., 419 Grand Ave.
 JOHNSTOWN, PA., Wallace Bldg., 406-410 Main St.
 KANSAS CITY 6, MO., 101 W. Eleventh St.
 KINGSPORT, TENN., 145 Commerce St.
 KNOXVILLE 8, TENN., Gay and Clinch St.
 LAKE CHARLES, LA., P.O. Box 1336
 LINCOLN, NEBR., 401 Federal Securities Bldg.

LITTLE ROCK, ARK., 707 Boyle Bldg., 103 W. Capitol St.
 LONG BEACH, CALIF., 849 W. 12th St.
 LOS ANGELES 17, CALIF., 600 St. Paul Ave.
 LOUISVILLE 2, KY., 332 West Broadway
 MADISON 3, WIS., 1022 E. Washington Ave.
 MEDFORD, ORE., 1233 Court St.
 MEMPHIS 3, TENN., 825 Exchange Bldg., 130 Madison Ave.
 MIAMI 32, FLA., 730 Ingraham Bldg.
 MILWAUKEE 2, WIS., 538 N. Broadway
 MINNEAPOLIS 13, MINN., 2303 Kennedy St., N.E.
 MOBILE, ALA., 1605 Merchants Nat'l Bank Bldg.
 NASHVILLE 4, TENN., 401-6th Ave. S.
 NEWARK 2, N. J., 1180 Raymond Blvd.
 NEW HAVEN 8, CONN., 42 Church St., P.O. Box 1817
 NEW ORLEANS 12, LA., 1226 Whitney Bldg., 288 St. Charles St.
 NEW YORK 5, N. Y., 40 Wall St.
 NIAGARA FALLS, N. Y., 253 Second St.
 NORFOLK 10, VA., 915 W. 21st St.
 OKLAHOMA CITY 2, OKLA., 120 N. Robinson St.
 OLEAN, N. Y., Exchange Nat'l Bank Bldg., 201 N. Union St.
 OMAHA 2, NEBR., 117 North Thirteenth St.
 PEORIA 3, ILL., 2800 N. Adams St.
 PHILADELPHIA 4, PA., 3001 Walnut St.
 PHOENIX, ARIZ., 1110 N. 21st Ave., P.O. Box 6144
 PITTSBURGH 30, PA., 306 4th Ave., P.O. Box 1017
 PORTLAND 4, ORE., 309 S. W. Sixth Ave.
 PROVIDENCE 3, R. I., 51 Empire St.
 RALEIGH, N. C., P.O. Box 2146
 READING, PA., 524 Court St.
 RICHMOND 19, VA., Travelers Bldg., 1110 East Main St.
 RIVERSIDE, CALIF., Suite 12, 3614-9th St.
 ROANOKE 4, VA., 303 1st St., S.W.
 ROCHESTER 11, N. Y., 1 McKee Rd.
 ROCKFORD, ILL., 323 South Main St.
 RUTLAND, VT., 98 Merchants Row
 SACRAMENTO 14, CALIF., 1720-14th St.
 SAGINAW, MICH., 221 So. Jefferson St.
 ST. LOUIS, MO., 411 North Seventh St.
 SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
 SAN ANTONIO 5, TEXAS, 115 W. Travis St.
 SAN DIEGO 1, CALIF., 525 "E" St.
 SAN FRANCISCO 8, CALIF., 410 Bush St.
 SAVANNAH, GA., 204 Realty Bldg., P.O. Box 2008
 SEATTLE 4, WASH., 3451 East Marginal Way
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 SIOUX CITY 7, IOWA, 1005 Dace St.
 SOUTH BEND 4, IND., 216 East Wayne St.
 SPARTANBURG, S. C., 331 High Point Road, P.O. Box 289
 SPOKANE 1, WASH., North 1023 Monroe St.
 SPRINGFIELD, ILL., 607 E. Adams St., P.O. Box 37
 SPRINGFIELD 3, MASS., 26 Vernon St.
 SYRACUSE 4, N. Y., 700 W. Genesee St.
 TACOMA 2, WASH., 1930 Pacific Ave.
 TAMPA, FLA., 608 Tampa St.
 TOLEDO 4, OHIO, 245 Summit St.
 TRENTON 8, N. J., 28 W. State St.
 TULSA 3, OKLA., 600 S. Main St.
 UTICA 2, N. Y., 255-257 N. Genesee St.
 WALLA WALLA, WASH., Denny Bldg., P.O. Box 182
 WASHINGTON 6, D. C., 1625 "K" St., N.W.
 WATERLOO, IOWA, 300 West 3rd St.
 WATERTOWN, N. Y., 245 State St.
 WHEELING, W. VA., 12th and Main St. (Nat'l. Bank of W. Va.)
 WICHITA, KANS., 211 So. Main St.
 WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
 WILLIAMSPORT, PA., 221 Williamsport Bldg., 460 Market St.
 WORCESTER 8, MASS., 507 Main St.
 YORK, PA., 11 W. Market St.
 YOUNGSTOWN 3, OHIO, 25 E. Boardman St.

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 BRIDGEPORT 8, CONN., 540 Grant St.
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 FAIRMONT, W. VA., 10th and Beltline Sts., P.O. Box 1147
 FORT WORTH 7, TEXAS, 100 Rupert St.
 HILLSIDE 5, N. J., 1441 Chestnut Ave.

HOUSTON 20, TEXAS, 5730 Clinton Dr.
 HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1150
 INDIANAPOLIS 25, IND., 551 West Merrill St., P.O. Box 1535
 JOHNSTOWN, PA., 107 Station St.
 KANSAS CITY 6E, MO., 1300 Oak St.
 LOS ANGELES, CALIF., 3383 E. Gage Ave., P.O. Box 629, Huntington Park
 MILWAUKEE 9, WIS., 1900 W. Cornell St.
 MINNEAPOLIS 13, MINN., 2303 Kennedy St., N. E.
 PHILADELPHIA 4, PA., 3001 Walnut St.
 PHILADELPHIA 34, PA., Erie Ave. & "D" St.
 PITTSBURGH 8, PA., 843 N. Lang Ave.
 PORTLAND 12, ORE., 626 North Tillamook St.
 PROVIDENCE 3, R. I., 16 Elbow St.
 ST. LOUIS 10, MO., 1601 S. Vandeventer Ave.
 SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
 SEATTLE 4, WASH., 3451 East Marginal Way
 SPRINGFIELD 1, MASS., 395 Liberty St.
 SUNNYVALE, CALIF. (Sunnyvale Plant), P.O. Box 37
 SYRACUSE 4, N. Y., 700 West Genesee St.
 UTICA 1, N. Y., 113 N. Genesee St.
 WILKES-BARRE, PA., 267 N. Pennsylvania Ave.

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AKRON 8, OHIO, 106 S. Main St.
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 BALTIMORE 2, MD., 501 St. Paul Pl.
 BEAUMONT, TEXAS, 515 American National Bank Bldg.
 BIRMINGHAM 3, ALA., 1407 Comer Bldg.
 BOSTON 10, MASS., 10 High St.
 BUFFALO 3, N. Y., Ellicott Square Bldg.
 BUTTE, MONT., 1 East Broadway
 CHARLOTTE 1, N. C., 210 East Sixth St.
 CHICAGO, ILL., Merchandise Mart Plaza
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 CLEVELAND 13, OHIO, 1370 Ontario St.
 COLUMBUS 15, OHIO, 262 N. 4th St.
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 DAVENPORT, IOWA, 2212 E. 12th St.
 DENVER, COLO., 910 Fifteenth St.
 DES MOINES 8, IOWA, 1408 Walnut St.
 DETROIT 32, MICH., 5757 Trumbull Ave., P.O. Box 502
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 OMAHA 2, NEBR., 117 N. 13th St.
 PHILADELPHIA 4, PA., 3001 Walnut St.
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 ST. LOUIS, MO., 411 North Seventh St.
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 SAN DIEGO 1, CALIF., 525 "E" St.
 SAN FRANCISCO 8, CALIF., 410 Bush St.
 SEATTLE 4, WASH., 3451 East Marginal Way
 SPOKANE 1, WASH., N. 1023 Monroe St.
 SYRACUSE 4, N. Y., 700 W. Genesee St.
 TOLEDO 4, OHIO, 245 Summit St.
 UTICA 2, N. Y., 255-257 Genesee St.
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