Westinghouse

Type S I

Induction Voltage

Regulators

INSTRUCTION BOOK

Westinghouse Electric & Manufacturing Company
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INDEX

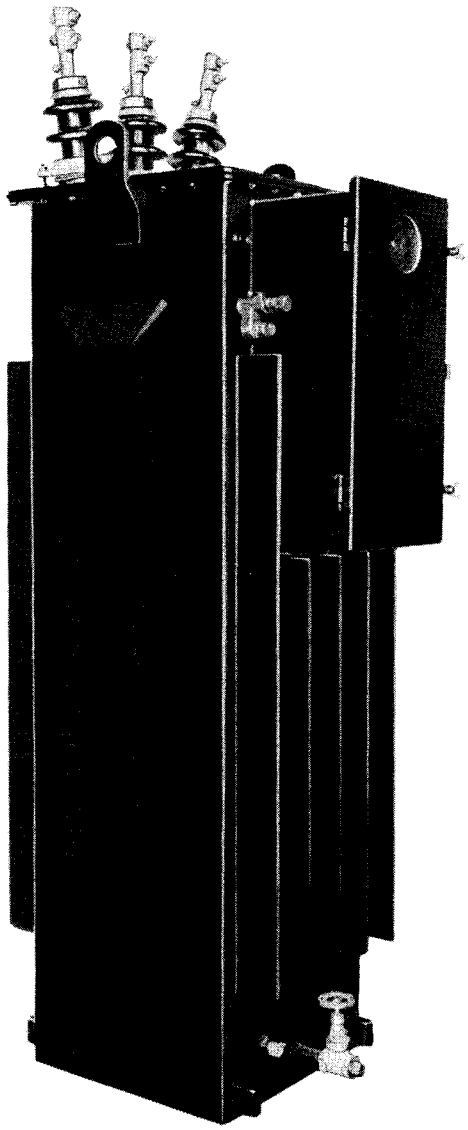


Figure 1

TYPE SI INDUCTION VOLTAGE REGULATORS

Instructions

HANDLING AND STORAGE

Type SI induction regulators are shipped filled with liquid. When regulators are received, they should be checked carefully to be sure that the liquid level is at the proper height and that no damage has occured during shipment or handling. At room temperature or approximately 25°C., liquid should show about 1" in the gauge. The voltage relay moving element should be inspected to be sure that it is properly supported so that it cannot be shaken during shipment or handling which may cause damage to the bearings or other parts. Tanks on this type of regulator are sealed air tight.

If regulators are stored for a considerable length of time, they should be indoors, if possible and preferably where the temperature is nearly uniform. Wide changes in temperature of regulators that are not operating tend to cause moisture condensation. After a regulator has been stored for a considerable time, a test should be made of the liquid for dielectric strength before the regulator is put in service. It should test at least 20,000 volts using a 1/10" test gap.

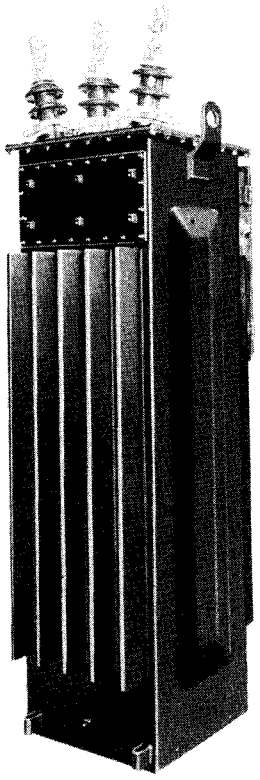


Fig. 2 - Type SI Regulator Showing Rear Hand Hole Plate Which May Be Removed for Making Changes in Connections.

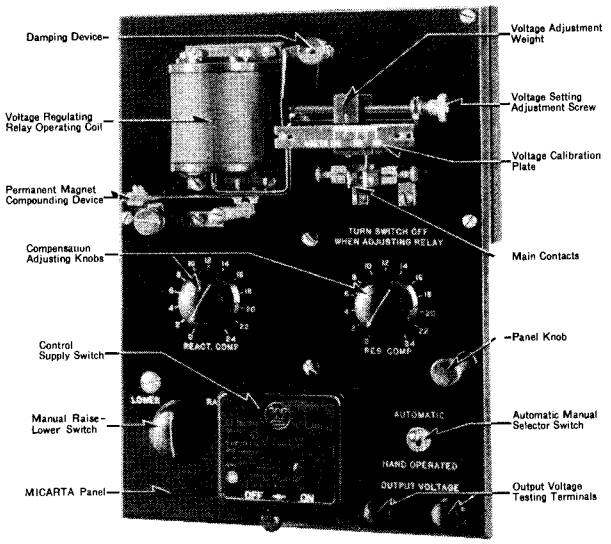


Fig. 3 - Front View of Control Panel

INSTALLATION AND CONNECTIONS

Type SI induction regulators have all accessories self contained. It is only necessary to make connections to the power circuits during installation. If regulators are to be used in delta circuit, either two in open delta or three in closed delta, the position of the selector screw in the rear of the control panel should be placed in the proper location according to the diagram and instructions given for different connections. The diagram sent with the regulator should be checked for special connections which may be slightly different than the standard diagram shown in Figs. No. 5 or 6. The rating on the regulator nameplate should also be checked with the capacity of the circuit in which the regulator is to be operated to prevent improper loading.

To connect a single phase regulator to a live circuit, first check to make sure it is in the neutral position. The primary or exciting winding may then be connected across the line and the secondary or series winding may be connected in parallel with a by-pass switch. Opening the by-pass then puts the regulator in the circuit ready for operation. To disconnect a single phase induction regulator from the circuit, without interrupting service, it should first be run to the neutral position by hand control and then control supply switch opened. The secondary or series winding of the regulator may then be by-passed after which the primary or ex-

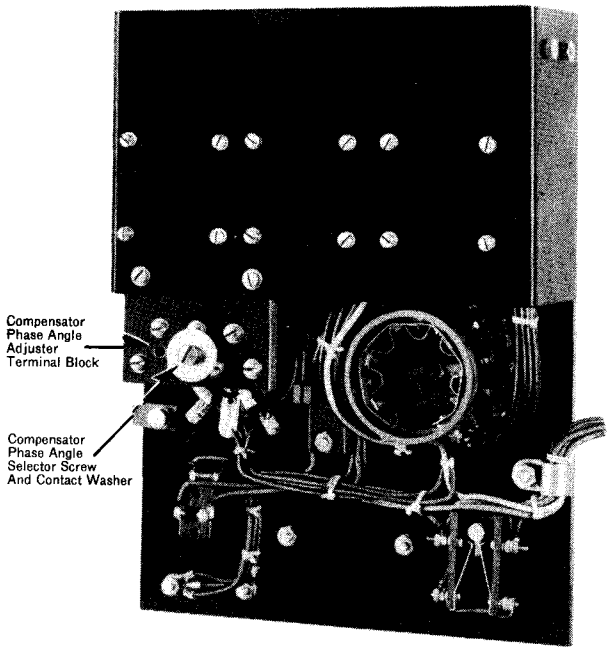


Fig. 4 - Rear View of Control Panel

citing winding may be opened and then the regulator entirely disconnected from the line. The primary of an induction regulator should never be opened when the secondary is in series with the line and carrying load current as high voltages may be induced in the windings.

On both the 2400 and 4800 volt ratings, provision is made for series-parallel connections of the series windings. A change of these connections may be made from the hand hole in the tank cover, if sufficient care is exercised to prevent dropping parts into the regulator, or it may be made by removing the plate on the rear side of the tank. In the latter case, the liquid must be lowered before the plate is removed and a new gasket must be applied when the plate is replaced. See Fig. No. 2. On 4800 volt ratings only, series-parallel connections on the primary are provided for by means of bolted terminals located near the winding. By this means the regulator may be connected for operation on either 2400 or 4800 volts. Only the main regulator connections need to be changed since changing them changes the transformer connections also. It is necessary to remove the regulator from the tank to make this change. Unless otherwise specified, regulators will be shipped connected in series with the nameplate marked accordingly.

Induction regulators should always be protected against voltage surges by means of lightning arresters. They should be mounted on the tank, or as near to the regulator as practical, with an arrester connected to each regulator terminal and the arrester ground wires connected directly to the regulator tank. Tapped holes are provided in the plate on the rear of the tank for mounting arrester brackets. It is recommended that 3 Kv. arresters should be used on 2400 volt regulators and 6 Kv-a. arresters should be used on 4800 volt regulators.

After connections are made, the blocking and supports on the voltage relay should be removed and a check of the balance of the relay should be made with the selector screw of the compensator phase angle adjuster placed in each of the three positions. The difference in the value of balance voltage for each of these three positions should not exceed one volt. This test should be made as a check on the connections and the apparatus which is part of the compensator phase angle adjuster.

Connections for Use With Older Types of Regulators

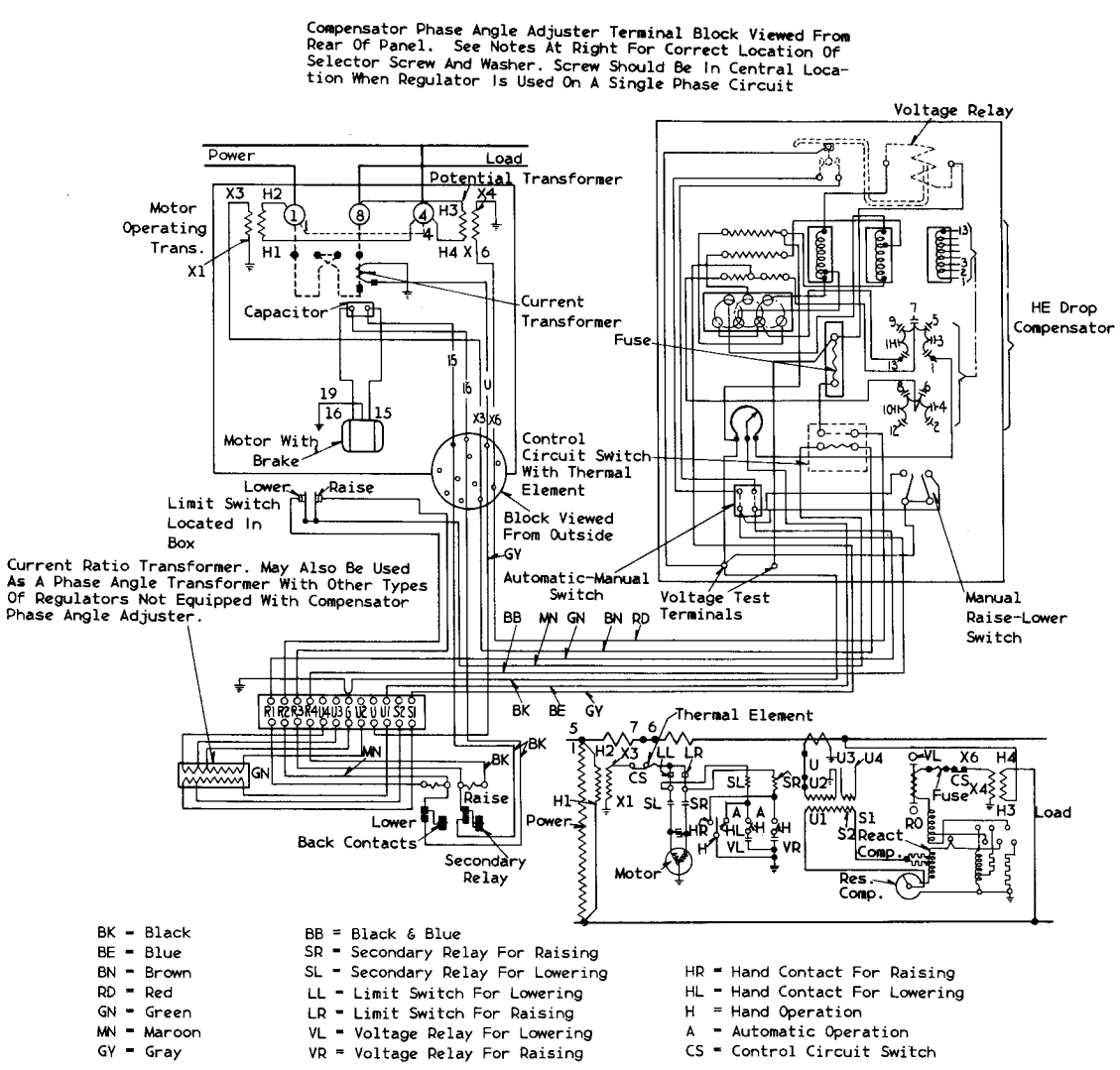
On the type SI regulator (36 to 120 Kv-a. inclusive) a current ratio and phase angle transformer is included, by means of which these regulators may be operated in delta with older type regulators which are not equipped with the compensator phase angle adjuster. When this is done, the phase angle selector screw should be in the center position. Connections for this purpose will be furnished when required to suit the type of old regulator involved.

ADJUSTMENT AND MAINTENANCE OF ACCESSORIES

Before the regulator is put in final operation, the following points should be checked. By pressing down on the voltage relay balance arm so that the pivot shaft is held firmly in the grooved bearing, the clearance between the balance arm and the inside of the operating coil, and the clearance between the balance arm and the sides of the supporting bearing may be noted. The voltage relay contacts should be in line and the adjustment of the stationary contacts should be such that after contact has been made and the regulator has operated, the relay comes back to the balance position. If the regulator tends to overtravel so the relay goes past the balance point, the stationary contact should be moved closer to the moving contact. If the regulator stops too soon so the relay does not come back to the balance point, the stationary contact should be moved farther from the moving contact. The balance weight on the moving element of the voltage relay should be set, by means of the calibrated plate, for the value of non-compensated or load center voltage it is desired to maintain. After the regulator has operated several hours continuously and the voltage relay is at exact balance with zero line drop compensation, the value of voltage shown on the calibrated plate may be checked against that read on a voltmeter connected to the test terminals. If a discrepancy is found, the plate may be adjusted by loosening the screws in the slotted holes and moving the plate as required to indicate the same value as that read on the voltmeter.

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

The two type SG motor operating relays are mechanically interlocked so both cannot be clo-

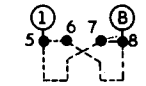


BK = Black
BE = Blue
BN = Brown
RD = Red
GN = Green
MN = Maroon
GY = Gray

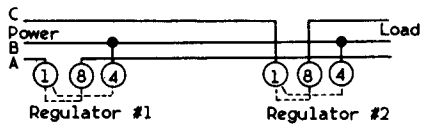
BB = Black & Blue
SR = Secondary Relay For Raising
SL = Secondary Relay For Lowering
LL = Limit Switch For Lowering
LR = Limit Switch For Raising
VL = Voltage Relay For Lowering
VR = Voltage Relay For Raising

HR = Hand Contact For Raising
HL = Hand Contact For Lowering
H = Hand Operation
A = Automatic Operation
CS = Control Circuit Switch

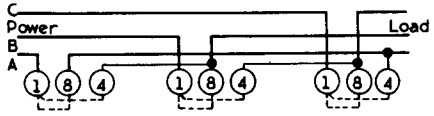
Fig. 5



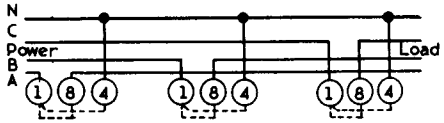
Sketch For Parallel Connection of Stator & Rotor



Two Single Phase Regulators On a Three Phase Circuit. For A-B-C Phase Rotation, Put Selector Screw In Left Hand Location For #1 Regulator And In Right Hand Location For #2 Regulator.



Three Single Phase Regulators In Delta On a Three Phase Circuit. For A-B-C Phase Rotation, Put Selector Screw In Left Hand Location On All Three Regulators.



Three Single Phase Regulators In Star On a Three Phase Four Wire Circuit.

Put Selector Screw In Center Location On All Three Regulators.

After The Screw And Washers Are Placed In Either The Right Hand Or Left Hand Position, A Slight Change In Balance May Be Found On The Voltage Relay. The Relay Should Be Balanced By Moving The Adjusting Weight And The Position Of The Calibration Plate Should Be Changed As Required To Give The Same Reading As Obtained At The Test Terminals At Zero Compensation.

No Interconnection Required Between Regulator Control Circuits For Any Of Above Connections.

Fig. 5A

Figures 5 and 5A - Connection Diagram for Standard Type SI Regulators, 2400 Volts, 36 to 120 Kv-a. Ratings. On 4800 Volt Ratings Connection for 2400 Volt Operation May Be Made At the Rotor Winding After the Regulator has been Removed from the Tank. See Diagram Furnished with Regulator for Details of Connections.

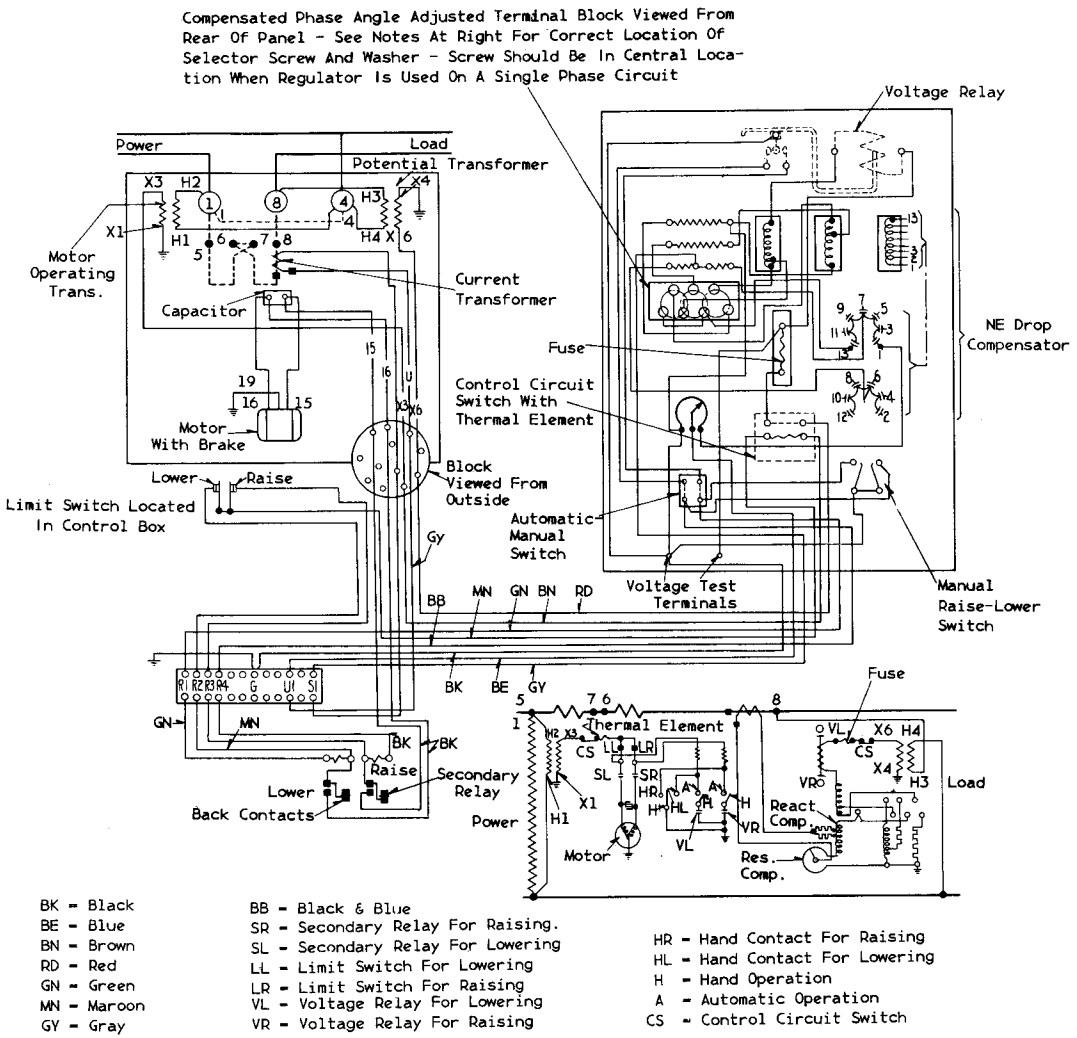


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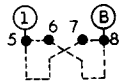
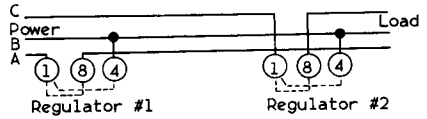
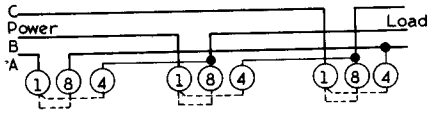
Fig. 6



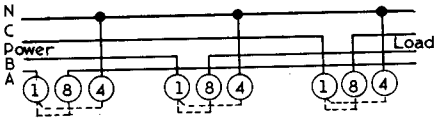
Sketch For Parallel Connection of Stator & Rotor



Two Single Phase Regulators On a Three Phase Circuit. For A-B-C Phase Rotation, Put Selector Screw In Left Hand Location For #1 Regulator And In Right Hand Location For #2 Regulator.



Three Single Phase Regulators In Delta On a Three Phase Circuit. For A-B-C Phase Rotation, Put Selector Screw In Left Hand Location On All Three Regulators.



Three Single Phase Regulators In Star On a Three Phase Four Wire Circuit.

Put Selector Screw In Center Location On All Three Regulators.

After The Screw And Washers Are Placed In Either The Right Hand Or Left Hand Position, A Slight Change In Balance May Be Found On The Voltage Relay. The Relay Should Be Balanced By Moving The Adjusting Weight And The Position Of The Calibration Plate Should Be Changed As Required To Give The Same Reading As Obtained At The Test Terminals At Zero Compensation.

No Interconnection Required Between Regulator Control Circuits For Any Of Above Connections.

Fig. 6A

Figures 6 and 6A - Connection Diagram for Standard Type SI Regulators, 2400 Volts, 12 and 24 Kv-a. Ratings. On 4800 Volt Ratings Connection for 2400 Volt Operation May Be Made at the Rotor Winding After the Regulator has been Removed from the Tank. See Diagram Furnished with Regulator for Details of Connections.

sed at the same time. The clearance between the relays and the interlocking bar is adjustable by means of a slotted hole in the bottom of the control box in which the interlock bar is mounted. The location of the bar should be such that with one relay completely closed, any movement of the other relay in closing will be stopped by the interlock but each relay should be able to close separately without binding.

The change in voltage required to cause the voltage regulating relay to make contact is controlled by the setting of the permanent compounding magnet. To increase the width of the band, the magnet should be moved closer to the soft iron armature on the moving element giving a smaller gap between the magnet and the armature. To decrease the width of the operating band the permanent magnet should be moved farther away from the moving element giving a larger gap between the magnet and the soft iron armature. For usual operating bands such as 1 to 1-1/2 volts ± from the balance voltage, the gap just mentioned should be approximately 1/32".

Resistance line drop compensation is adjusted by means of a rheostat operated by a knob on the front of the panel at the right hand side. The knob is held in the position at which it has been set by friction and may be operated at any position. Reactive line drop compensation is adjusted by means of a tap switch controlled by a knob on the front of the panel on the left hand side. The use of preventive resistors, in the current circuit to the compensator reactor, provides intermediate points of compensation and allows operation at any position of the knob.

Correct settings for line drop compensation are most commonly obtained from calculated values of reactance and resistance line drop from the regulator to the load center reduced to full load regulator rating and 120 volts and later corrected if found necessary from voltage charts taken at the load center. Calculated values are likely to be sufficiently accurate in ratio of resistance to reactance drop and the compensation for both should be increased if load center voltage falls at periods of high loads and both should be decreased if load center voltage rises at periods of high load.

The contacts on both the voltage relay and the motor operating relays are of silver and do not require dressing or polishing. Only inspection is required to be sure that contacts meet evenly and that the contact material has not been worn away. On the SG motor operating relays, the contacts should cause at least 1/32" spring deflection when they are closed.

MAINTENANCE OF LIQUID AND PERIODIC INSPECTION

Inerteen Equipment - Care must be exercised in handling Inerteen to prevent contamination since impurities alter its non-inflammable and electrical characteristics. It must be handled in thoroughly clean containers free from oil. If there is any question concerning the cleanliness of the containers, they should be thoroughly washed with Trichlorbenzene M-6872 and dried before any Inerteen is placed in them. The transformer tank or any of its compartments in which Inerteen is used, must be free from oil and other contaminating materials.

Inerteen should not be mixed with vegetable oils since these materials affect the deterioration, D.C. resistance and otherwise contaminate it. Compounds of asphaltic nature, paraffin and ordinary soldering flux are particularly harmful to Inerteen.

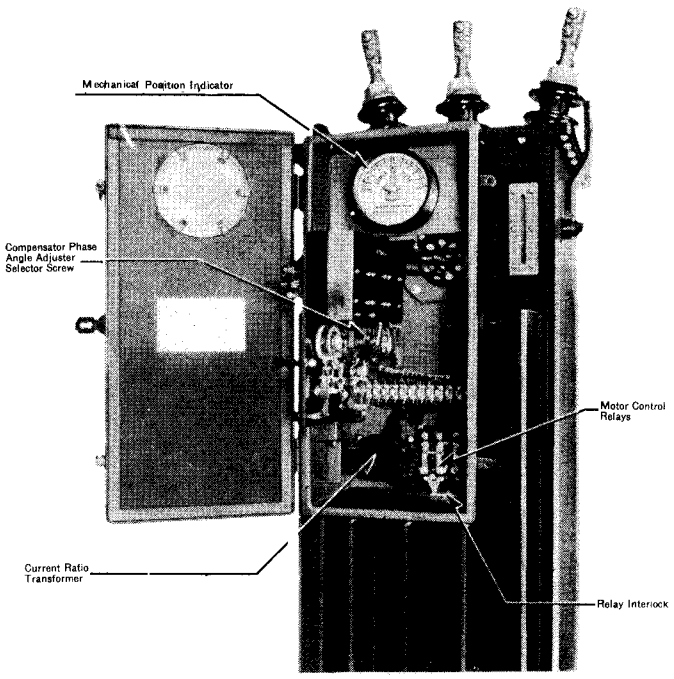


Fig. 7 - Type SI Regulator with Control Box Door Open, Control Panel Swung Out, and Motor Operating Relay Covers Removed.

For soldering, a solution of rosin in alcohol is recommended.

All-metal hose must be used in handling Inerteen since the lining used in most hose is soluble in Inerteen.

Filling Regulators - When it is necessary to fill a regulator with Inerteen one should make sure that all joints are tight; Cement M-7386 should be used for this purpose. Steel pipe or metal hose should be used, and preferably the regulator should be filled through the drain valve. This will keep aeration of the Inerteen to a minimum. See that the air vents are open as the regulator is filled.

It is desirable to fill a regulator by passing the Inerteen through an Inerteen Conditioner If this cannot be done and the Inerteen tests satisfactorily, fill the regulator by passing the Inerteen through three thicknesses of tightly woven white cloth, which has first been washed in Trichlorbenzene M-6872 and dried to remove any sizing. New cloths should be used for at least every two regulators.

When it is necessary to fill Inerteen regulators out-of-doors and particularly on damp days due precaution must be taken to prevent the entrance of moisture into the regulator.

Periodic Inspections

Inerteen - It is desirable that top and bottom samples of Inerteen be taken from each regulator and tested after a short period of operation. When operating conditions permit routine sampling of the Inerteen at intervals of six months is recommended. Accurate records should be kept of such inspections and tests, and if the Inerteen shows a dielectric strength of less than 16 KV the Inerteen Conditioner may be used. This depends somewhat on the load cycle and climatic conditions. If no facilities are available for making dielectric tests on Inerteen, samples should be sent to the Westinghouse Electric & Manufacturing Company, East Pgh., Penna. Each sample of Inerteen should be properly identified by the regulator serial number

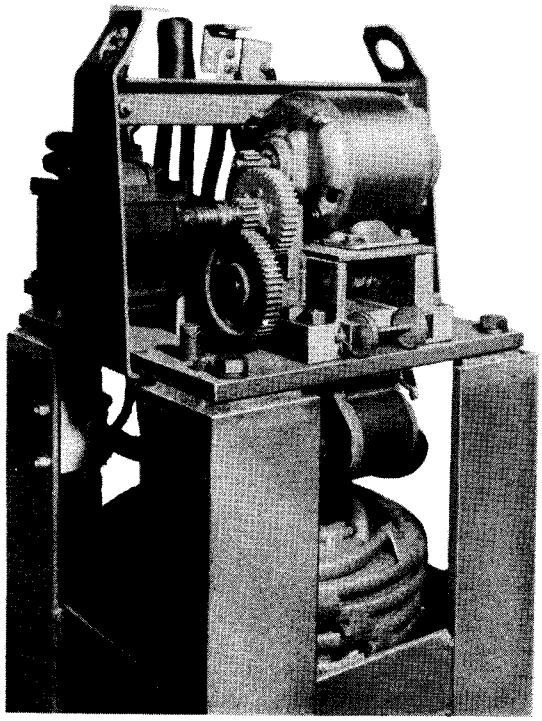


Fig. 8 - Type SI Regulator Removed From the Tank Showing Current Transformer, Operating Motor, and Reduction Gear.

and it should be recorded whether taken from the top or bottom of the tank or from a tank-compartment. Samples should be carefully packed to avoid breakage in transit. When any appreciable amount of Inerteen is removed from a regulator, it should be replaced with an equal amount of new Inerteen of proper dielectric strength so that the liquid level in the transformer is maintained.

Operation of Regulators - It is recommended that a periodic check be made of the operating temperatures of Inerteen regulators and that the temperature of the Inerteen be kept below 90°C. for a maximum-rated self-cooled transformer.

Taking Samples of Inerteen

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for Inerteen be used for no other purpose. Care must be used in obtaining and sealing samples of Inerteen taken from a regulator.

Use only small tin containers with screwed metal-gasket caps or small glass bottles with glass stoppers for holding Inerteen samples.

If it becomes necessary to use other than Factory sampling containers, such containers should be thoroughly rinsed with clean gasoline, washed with strong soap suds and rinsed thoroughly in hot water, and then dried in an oven at approximately 110°C. for one hour. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

It is desirable that samples of Inerteen be removed from a tank or from a drum on clear days only and when the Inerteen is at least as warm as the surrounding air.

The sample of Inerteen should be removed near the surface of the fluid. This can be done readily through the rotary sampling device and valve. It is also recommended that a sample be taken from the bottom of the tank. If the sample is withdrawn through a valve connection, this connection should be flushed by allowing a small amount of Inerteen to run out before collecting the sample. The sample should be immediately placed in the container and the cap screwed on tightly. The sticker on each container should be marked to identify the sample of Inerteen with the regulator from which it was taken and whether taken from the top or bottom.

Before taking samples from a drum, the Inerteen should be allowed to settle for approximately twelve hours. Samples from the top of the drum should be removed by means of a clean glass sneak-thief.

The same precautions to prevent moisture contamination should be used in sampling Inerteen as are observed in taking transformer oil samples. Sampling equipment should be used only for Inerteen.

Dielectric Testing of Inerteen

The same rules and precautions as normally followed in testing oil should be used in testing Inerteen, except as herein stated.

The test cup should be wiped with a clean, dry chamois and thoroughly rinsed with clean gasoline and allowed to dry before being used. The electrode spacing should be checked.

To determine whether the test cup is suitable for testing Inerteen, fill it with dry gasoline and test this under a standard voltage rise of 3 KV per second. If the dielectric strength of the gasoline is not less than 22 KV, the test cup is suitable for testing Inerteen, after the cup has been dried in an oven where the temperature does not exceed 50°C. to remove all traces of gasoline. Care should be exercised in handling gasoline as it is highly inflammable. In testing Inerteen, make only one "shot" per filling of the test cup. Five different fillings should be made and the average result used.

Drying and Filtering Inerteen

Inerteen may be dehydrated and filtered by means of an oil filter press but in order that it may not be contaminated, it is necessary that the filter press be used for Inerteen only.

A different procedure than that followed for oil is required to purify Inerteen. Contamination in Inerteen cannot be removed entirely by filter paper alone. To clean Inerteen thoroughly it must be filtered through "activated clay" which absorbs impurities. In practice, it is only necessary to pass the Inerteen through the clay and to separate the clay mechanically from the Inerteen to obtain clean Inerteen of proper dielectric strength.

The Inerteen Conditioner

The equipment recommended for conditioning Inerteen consists of an activated clay chamber and filter press with suitable inlet and outlet connections and other necessary fittings.

The activated clay is contained in a tank mounted on one end of the filter press. The Inerteen is pumped up through the clay insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the filter press to remove practically all of the clay.

The cover of the tank incorporates an air-trap and vent to avoid pumping air into the transformer which might result from a leak in the suction line. A strainer is provided on the suction side of the pump, so constructed that all dirt collected is removed with the screen. A by-pass connection fitted with a needle valve is used for testing the suction line from the transformer for leaks.

The filter press consists of 15 frames and 16 plates alternately spaced mounted in a yoke. One sheet of blotting paper is used between each plate and frame to provide a gasket-seal and to remove all traces of clay from the Inerteen.

A pressure gage indicates the operation and two-by-pass valves assure safe operation of the Conditioner by preventing excessive pressures and serve as a check to overloading and stalling the motor. One valve, connected across the pump, is set to by-pass the Inerteen at a pressure of 60 to 70 lbs. per square inch. The other valve is provided on the discharge side of the Conditioner connecting to the transformer. This by-pass valve, releasing at a pressure of approximately 5 lbs. per square inch, will avoid breaking the transformer relief diaphragm when no other relief is provided.

To Prepare The Conditioner For Operation

Remove the cover and screen from the clay tank and fill the tank with activated clay, M-6934 to within four inches of the bottom edge on the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "B" size blotting paper between the face of each frame and plate. Care should be used to see that the holes through the plates, frames and paper are in proper alignment before the pressure-screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. With the valve at the transformer closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is therefore considered advisable to condition Inerteen from the top and return it to the bottom of the tank. To begin conditioning Inerteen in a regulator, close the suction test valve and stop the motor. Open the regulator valves. Open the Conditioner discharge and suction valves. Close the drip pan valve and start the motor.

One charge of clay will condition approximately 3000 gallons of Inerteen, depending upon the amount of contamination present.

When it is necessary to change the clay, first close the valve in the suction line, close the tank inlet and outlet valves, open the tank by-pass valve and tank drain valve to permit the free Inerteen in the tank to drain into the lower drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Additional Inerteen may be forced out of the clay by applying air pressure to the air vent. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor, close the tank by-pass valve, the tank inlet valve and the tank drain valve, if these valves are open. Open the tank outlet valve and apply air pressure to the air vent until the free Inerteen has been driven out of the blotting papers. Then release the pressure-screw and remove the papers.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to again resume conditioning the Inerteen.

To Dry Inerteen Regulators

Inerteen regulator should be dried by the short-circuit method with the regulator in its tank immersed in the Inerteen. During the heating and drying process, the top of the tank should be vented to the air to prevent moisture condensation. The desired load current should be obtained by short-circuiting one winding and impressing the proper voltage on the other winding. If the full load impedance of the regulator is not known, it should be obtained from the Westinghouse Electric& Manufacturing Company by identifying the regulator with its serial number.

Regulator windings in Inerteen should first be heated under a partial load. A higher top Inerteen temperature can be obtained more quickly by blanketing the tank with the cover removed to prevent condensation.

If the regulator is at or lower than room temperature at the start of the drying process, from 125% to 150% full load current will hasten

the heating. The temperature should be carefully watched and when the Inerteen reaches a temperature of 60°C., the load should be reduced to obtain an approximately constant Inerteen temperature based on the following table. These temperatures should not be exceeded for a given load.

Short Circuit Amperes in Percent of Load	Max. Temperature of Top Inerteen
50	80
75	75
85	70

The regulator may be dried more quickly if it is possible to filter the Inerteen during the drying process. If the filtering is continuous, care should be taken to keep the Inerteen temperature above 60°C. If moisture condenses on the underside of the cover, the rate of temperature rise should be decreased until condensation ceases. To prevent condensation the tank temperature may be raised by blanketing the tank.

The drying should be continued until dielectric tests of samples of the Inerteen taken from the top and bottom of the tank show 22 KV or higher. The tests should be made in a standard test cup and it is recommended that at least two consecutive tests of both the top and bottom Inerteen be made at least 24 hours apart while the Inerteen is near a maximum temperature. Tests of the Inerteen should not be made during the filtering process.

If Regulators Fail in Service

Should an Inerteen regulator fail in service, the nearest Westinghouse Electric & Manufacturing Company District Office should be notified as soon as possible. Give the rating of the regulator and its serial number and, if possible, the conditions under which the failure took place. Samples of the Inerteen should be taken so that an analysis of it can be made. The regulator should be kept immersed in Inerteen and it is recommended that no work be done on the transformer except under advice from the District Office.

After ten years of operation and at ten year periods, a complete inspection of the regulator should be made by taking it to a suitable service shop where it should be completely dismantled. During this inspection the following points should be checked. The rotor leads should be inspected for chafing or weakened points which may later cause breakages, deformed coils due to short circuit stresses or other abnormal operating conditions and worn parts such as gears, bearings, etc. A check should be made of the air gap which should measure not exceeding .005" difference at any position around the rotor and for any position of the rotor.