WESTINGHOUSE

INSTRUCTION BOOK

INDUCTION VOLTAGE REGULATORS

Liquid-Immersed, Single-Phase

Types SU and SI

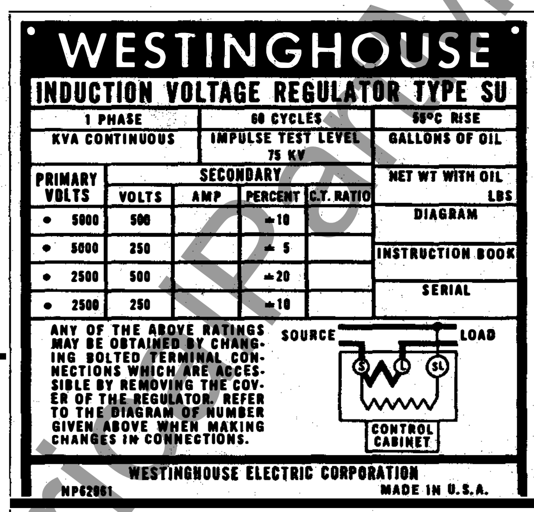
Westinghouse Electric Corporation

I.B. 47-310-5

SPECIAL INQUIRIES

When communicating with Westinghouse regarding the product covered by this Instruction Book, include all data contained on the nameplate attached to the equipment.* Also, to facilitate replies when particular information is desired, be sure to state fully and clearly the problem and attendant conditions.

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



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

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

INDUCTION VOLTAGE REGULATORS

Liquid-Immersed, Single-Phase Types SU and SI

WESTINGHOUSE ELECTRIC CORPORATION
TRANSPORTATION AND GENERATOR DIVISION
EAST PITTSBURGH PLANT • EAST PITTSBURGH, PA.

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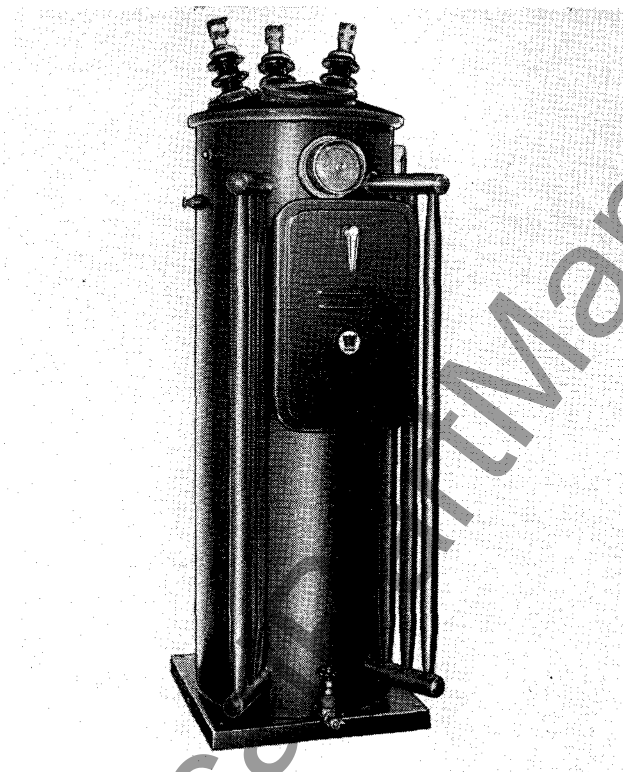


This Instruction Book covers liquid immersed, single phase, induction voltage regulators. The SU or oil-filled line of regulators is in the style series 1796580 to 1796594. The SI or Inerteen-filled line is covered by the style series 1796595 to 1796606. Other SU and SI regulators covered by this book are not designated by style number because of special features designated by the purchaser. Machines having special features are designed similar to the style numbered machine except for the special features.

The SU and SI lines include standard rated machines from 37.5 to 125 KVA at 2.5 or 5.0 KV and from 19.1 to 76.2 KVA at 7.62 KV. All of these machines are equipped for outdoor as well as indoor service.

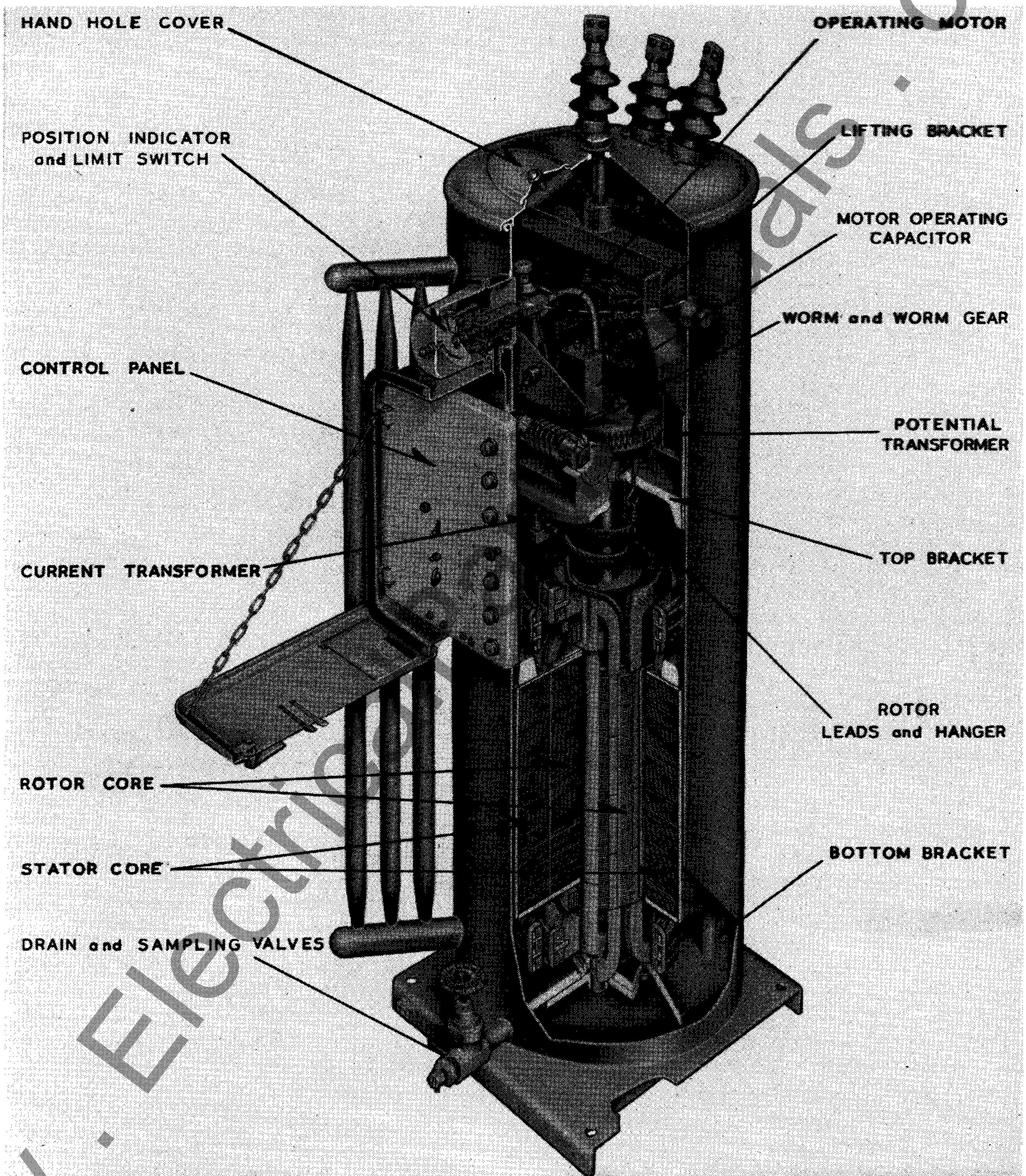


FIG. 1. Cutaway View of Typical Regulator

PART ONE

DESCRIPTION

These regulators can be used separately on single-phase feeders or in conjunction with other single-phase regulators on three-phase lines.

This type of three-phase application of single-phase machines is best suited for unbalanced loads because each regulator operates independently of the others, thus assuring accurate regulation of each phase.

The main windings of the regulator consist of a primary or shunt winding located on the rotor and a secondary or series winding located on the stator (Fig. 1). These windings consist of form-wound coils. They are wound of rectangular copper wire, bakelized into solid, rigid coils and ground insulated with a suitable number of layers of insulating wrapper.

Also located on the rotor is the closed circuit winding known also as the short circuit or tertiary winding. It is wound at right angles to the primary winding and consists of two or more coils of round enamel-insulated wire. The closed circuit coils are wound in partially closed slots and the end turns are insulated with cotton tape. The function of the closed circuit winding is to keep the secondary reactance down when the regulator is in the neutral position.

In operation, the primary winding is connected across the line, while the secondary winding is connected in series with the line. Since one end of each winding is connected to the same point on the line, the two ends are connected together inside the machine and connection to the line is made through a single bushing. This arrangement also insures that the polarity is always correct.

All possible values of raise and lower are realized over a rotation of 180 degrees of the rotor. It is therefore limited to this amount of travel by limit switches and mechanical stops. The limit switches are located inside the position indicator housing behind the dial plate. The mechanical stops are located on the main worm gear.

The operating mechanism consists of a motor-driven, double worm gear reduction unit. The main worm gear or gear segment is made of nodular iron. It is assembled on the rotor shaft with a light press fit and keyed with a tapered gib key. The teeth on this gear are extra wide to provide maximum strength in withstanding short-circuit stresses. The small worm gear is a standard Micarta helical or spiral gear. The main worm is machined from a single piece of steel for maximum strength in withstanding short-circuit stresses. The small worm is a standard type pinned directly to the motor shaft.

The vertically mounted motor is a ball bearing, single phase, capacitor type designed to deliver a high starting torque. It is mounted along with its capacitor on top of the worm housing. Lubrication of the motor and gear reduction unit is unnecessary since they are completely submerged in the insulating liquid.

The top bracket is made of nodular iron and is machined to fit the stator core. The bottom bracket is fabricated and is also machined to fit the stator core. This assures accurate alignment of the rotor which is supported between the brackets on tapered roller bearings. At assembly, the top bracket must be drawn down a small amount. This springs the end brackets slightly to preload the bearings and thus prevent vibration and wear.

Automatic operation is controlled by a magnetic amplifier which responds to changes in the regulator output voltage. A variation in the output voltage disturbs the balance condition of the voltage sensing unit. The voltage sensing unit in turn delivers a signal which is used to trigger the motor operating unit. The motor operating unit in turn excites the motor, causing it to run in the proper direction to restore the balance condition in the voltage sensing unit. This static type of control eliminates all contacts and moving parts and thus reduces maintenance.

A line drop compensator is inserted between the regulator output (reduced to a nominal 125 volts through a potential transformer) and the voltage sensing network. The compensator reproduces in miniature the potential drops which occur in the line between the machine and the load center. The electrical effect of this arrangement is to place the voltage sensing unit at the load center. The compensator, therefore, allows the voltage to be held constant at the load center within the limits of the machine.

Primary and secondary winding connection changes are made by means of copper links on a terminal board mounted on the stator top plate (Fig. 3).

Terminal posts are provided on the control panel for measuring the regulated voltage and the load current flowing through the machine.

RECEIVING, HANDLING AND STORING

When received, the regulator should be carefully inspected for damage which may have occured in transit. The following points should be checked:

1. At room temperature, the liquid level should reach the 25 degree C. mark on the liquid level gage.

2. Type SU and SI regulators are heated under vacuum at the factory to remove moisture, and sealed after returning the pressure to normal to prevent the accumulation of moisture over a long period due to "breathing". If inspection indicates that the seal may have been broken in transit, pressure-test the tank and test the insulating liquid for dielectric strength.

The insulating liquid should take at least 22 KV before breakdown using a 1/10 inch test gap and applying the voltage at 3000 volts per second.

In pressure-testing the tank, an internal pressure of five pounds per square inch should be applied for six hours. There should be no appreciable drop in pressure at the end of this time. The ambient temperature should be maintained as uniform as possible for this test.

3. If possible, check controls for proper operation as described under "OPERATION OF CONTROLS" and "CONTROL PANEL TESTS AND ADJUSTMENTS".

HANDLING

These regulators are shipped bolted to wooden skids long enough to provide stability in moving. A machine may be moved by sliding on these skids or by means of a heavy dolly if one is available. A regulator is most readily handled by means of the lifting pins welded to the sides of the tank if a crane is available. When using a crane, check the weight of the machine as indicated on the nameplate against the capacity of the crane. A machine may also be moved short distances in any direction on metal rollers (See Fig. 2 for details of tank base construction).

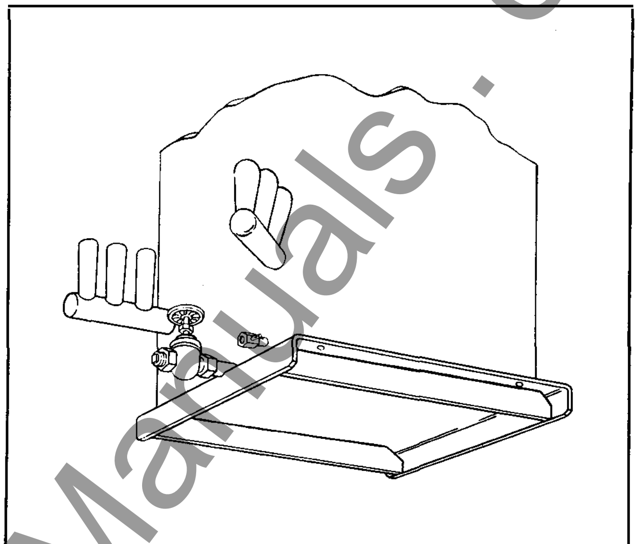


FIG. 2. Bottom View of Tank Base

STORING

When stored for a considerable length of time, the regulator should be placed indoors, if possible, and preferably in a location that is dry and free from large temperature variations. Variations in temperature are conducive to the condensation of moisture in machines when in storage. After SU or SI regulators have been stored for a considerable time, the insulating liquid should be tested for dielectric strength. It should require at least 20 KV to cause breakdown when using a 1/10 inch test gap and applying the voltage at a rate of 3000 volts per second. A lower dielectric strength may be permissible depending upon the age of the insulating liquid. In no case, however, should the liquid be used if its dielectric strength is below 16.5 KV.

INSTALLATION

1. These regulators may be connected either to a de-energized feeder or to a live feeder without interruption of service, if proper precautions are taken. In either case, the following points should be checked first:

a. Make sure that the machine is suitable for the feeder which it is to control by checking the name-plate rating. Feeder voltage regulators having equal raise and lower ranges of regulation (not in excess of 10 percent raise and 10 percent lower) are capable of operating without exceeding the specified temperature rise provided the rated load current is not exceeded and the input and output voltages are within the limits designated by NEMA (See Table No. 14 "EEI-NEMA Preferred Voltage Ratings for A-C Systems and Equipment". NEMA Publication No. 117 dated May, 1949 or subsequent revision).

b. Check the wiring diagram sent with the regulator for special connections which may be slightly different from the typical diagram shown in Fig. 15.

c. Make sure the control supply switch is "off" and the automatic-manual switch is in the "manual" position.

d. Make sure that the machine is in the neutral position as indicated by the mechanical position indicator.

e. After a regulator is installed and before it is actually placed into service, inspect it for possible damage which may have occured in transit or handling. If the seal appears to have been disturbed, pressure-test the regulator and dielectric-test the liquid as outlined under "Receiving, Handling and Storing", Page 7.

2. If the machine is to be connected to a de-energized feeder, the sequence of connections is immaterial. If the regulator is being connected to a live feeder, the connections must be made as follows:

a. Connect the primary or exciting winding across the line (S and SL).

b. Connect the remaining bushing (L) so that the secondary winding is inserted in the line in parallel with a by-pass switch.

c. Open the by-pass switch to place the regulator in service.

d. The control supply switch may now be placed in the "on" position and the controls checked as outlined under "CONTROL PANEL TESTS AND ADJUSTMENTS".

3. To remove a type SU or SI regulator from a feeder without interrupting service:

a. Run the regulator to the "neutral" position by manual control.

b. Turn the control supply switch "off".

c. By-pass the secondary winding (S and L).

d. Open the secondary circuit by disconnecting the L lead.

e. Disconnect the regulator from the line (S and SL).

4. The terminals on these regulators are suitable for use with copper cable, IPS tubing or flat copper bar. See outline drawing supplied with regulator for ranges of conductors that may be used. Any of these conductors can be connected either vertically or horizontally. In addition, the terminals can be rotated through a full 360 degrees for alignment purposes. This should be done by first turning in the clockwise (tightening) direction. If the terminal reaches its limit of travel before the desired position is reached, it should be rotated counter-clockwise to reach the desired position. See Figure 7, Page 13, for details of bushing construction.

CONNECTIONS

Changes in the series-parallel arrangement of the primary and secondary windings are made by

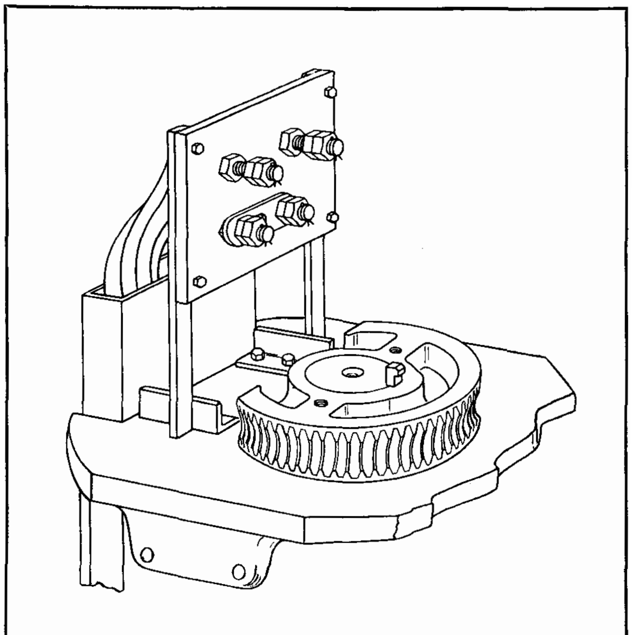


FIG. 3. Terminal Board

means of copper links on a fiber terminal board which is mounted on the stator top bracket (See Fig. 3). To provide access to the terminal board, the hand-hole cover must be removed. The hand-hole cover is fastened to the tank cover by means of a single bolt and cross bar. The bolt is loosened until the cross bar is free to rotate, then the hand-hole cover assembly can be removed as a unit. After removing the hand-hole cover, drain sufficient insulating liquid to expose the terminal board. The connection changes can then be made using the wiring diagram as a guide. Care must be taken not to drop tools or hardware into the regulator while making changes. The insulating liquid and hand-hole cover should be replaced immediately after making connection changes.

Changing the primary connections changes the voltage rating and percent regulation. Provision for this change is therefore made only on double-voltage rated (5 KV) machines. When making such a change, the secondary tap of the control potential transformer must be changed also in accordance with the regulator wiring diagram. This change is made on the control cabinet side of the tank wall feed-through.

Changing the secondary connections changes the current rating, percent regulation and effective current transformer ratio. Provision for changing secondary connections is made on all of these machines except where special considerations eliminate the necessity for it.

Corresponding values of all of the above mentioned variables are tabulated on the nameplate for each possible combination of connections and a marker is placed to indicate what connection is being used at a given time. When changes in the connections are made, they should be indicated by placing the marker before the appropriate column. This is done by removing the nameplate to provide access to the marker which is inserted from the rear.

Unless otherwise specified, the regulator is shipped with windings connected in series and the nameplate marker placed accordingly.

GROUNDING, LIGHTNING PROTECTION AND SHORT-CIRCUIT PROTECTION

Types SU and SI regulators are provided with a copper-faced grounding pad on the front of the tank base. The pad has two ½-13 bolt holes on 1¾ inch centers. The control circuit ground connections are located in the control cabinet at the tank wall feed-through connectors.

For best protection against voltage surges, lightning arresters should be mounted as close to the regulator as possible. An arrester should be connected to each terminal and grounded directly to the regulator tank. For single-phase applications, it is recommended that 3 KV arresters be used on 2.5 KV regulators, 6 KV arresters be used on 5 KV regulators and 9 KV arresters be used on 7.6 KV regulators. For three-phase application, the rating of the arresters should be above the largest possible fault voltage.

The impedance of the induction regulator's secondary winding is too low to provide adequate protection against short-circuit currents. It is therefore recommended that reactors be provided between the source of power and the regulator. The reactance should be large enough to limit the short circuit current to 25 times the full load value. Induction regulators are designed to withstand 25 times full load current for two seconds without damage.

PART FOUR

OPERATION

OPERATION OF MOTOR FROM AN EXTERNAL SOURCE OF POWER

When the regulator is de-energized, the motor may be operated from an external source of power. The connections for such operation are as follows:

1. Open the control supply switch. If this switch is not opened, there will be a tendency to excite the regulator through the motor operating transformer which in turn will become overheated.

2. Place the automatic-manual switch in the "manual" position.

3. If the external source of power is ungrounded, it may now be connected directly between ground and point 19 at the tank wall feed-through. If the external source is grounded, it may be connected in the same manner as an ungrounded source except that care must be taken to connect the grounded supply lead to the grounded side of the control circuits. A grounded power supply may also be used without regard to which line is grounded by first removing the control circuit ground wires. These are the three wires which go to the upper left control cabinet mounting stud.

4. The power may now be applied and the motor operated by means of the manual raise-lower switch. The motor is nominally rated at one-phase, 60 cycles and 230 volts. However, it may be operated at 220 to 250 volts.

DESCRIPTION OF CONTROLS

The controls of these regulators consist of two groups. One group is located in the tank submerged in the insulating liquid while the other is located in the control cabinet.

The tank group includes two potential transformers, a two section current transformer, motor and capacitor.

The motor-operating transformer provides the drive motor with a 250 volt source of power while the output potential transformer provides the control circuits with a nominal 125 volts proportional to the output voltage.

One current transformer section provides 0.29 ampere to the line-drop compensator at full load while the other current transformer section is used to measure load current.

The motor and capacitor are mounted side by side on top of the worm housing. The reversible, single-phase, ball bearing motor is specially designed to develop a high starting torque. Any need for braking is eliminated by the double worm gear drive which has very little tendency to coast or drift. Considerable damping also results from the motor's operating under the insulating liquid. The control supply switch, automatic-manual switch, manual raise-lower switch, voltage test terminals, current test terminals, line-drop compensator, sensitivity adjustment and output voltage with zero compensation (OVZC) adjustment are all located on the front of the hinged control panel (See Fig. 4).

On the back of the panel are located the calibrating rheostat and phase angle selector.

In addition, the line drop compensator network, autotransformer, bias rectifier, constant voltage transformer and voltage sensing unit are mounted on the rear of the panel (See Fig. 5).

Behind the hinged panel on the back of the control cabinet is located the motor operating unit. Above the control cabinet is located the glass position indicator housing which contains the mechanical position indicator and limit switch assembly.

Studies of voltage regulation economics indicate that a closer effective bandwidth appreciably increases the revenue obtained from a specific regulator application. Time delay in the control of a regulator increases the effective bandwidth. Since there are no moving contacts to wear, burn or get out of adjustment, there is no need to limit the number of operations the regulator makes. This completely static control circuit therefore eliminates any need for time delay and permits full utilization of the induction regulator's inherent capacity to maintain close voltage regulation.

OPERATION OF CONTROLS

Control Supply Switch. This sentinel breaker provides power to the control panel from the motor-operating and potential transformers. It contains an overload thermal element in series with the motor-operating circuit. This element operates to open both the motor-operating and potential transformer circuits in case of an overload in the motor-operating circuit. In addition, the potential transformer circuit is fused separately to protect the control circuits.

Automatic-Manual Switch. When this switch is in the "automatic" position, the regulator operation is controlled by the voltage sensing unit and the regulator operates to maintain the output within the limits determined by the control settings. When in the "hand-operated" position, this switch prevents automatic operation, allowing only manual operation under control of the manual raise-lower switch.

Manual Raise-Lower Switch. This switch is operative only when the control supply switch is "on" and the automatic-manual switch is on "hand-operated". Turning the raise-lower switch to the right causes the regulator to run toward the maximum raise position and turning it to the left causes the regulator to run toward the maximum lower position. The movements of the regulator can be observed on the mechanical position indicator.

Output Voltage with Zero Compensation (OVZC). This adjustment is used to set the voltage level at which the voltage sensing unit balances without any effect from line-drop compensation. The ratio of the potential transformer is such that when this adjustment is set at 125, the machine will maintain the line at full rated voltage. In other words, an

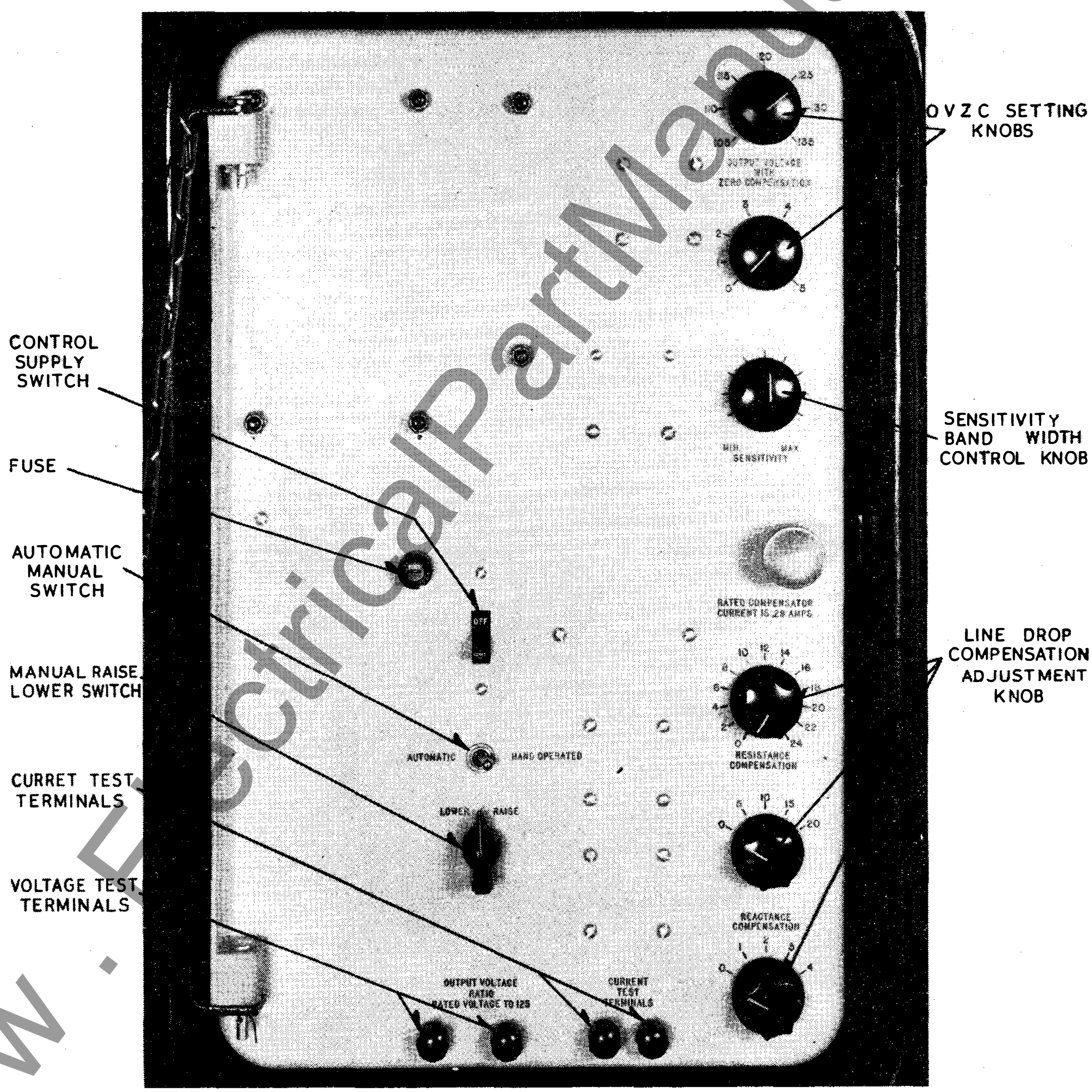


FIG. 4. Front View of Control Panel

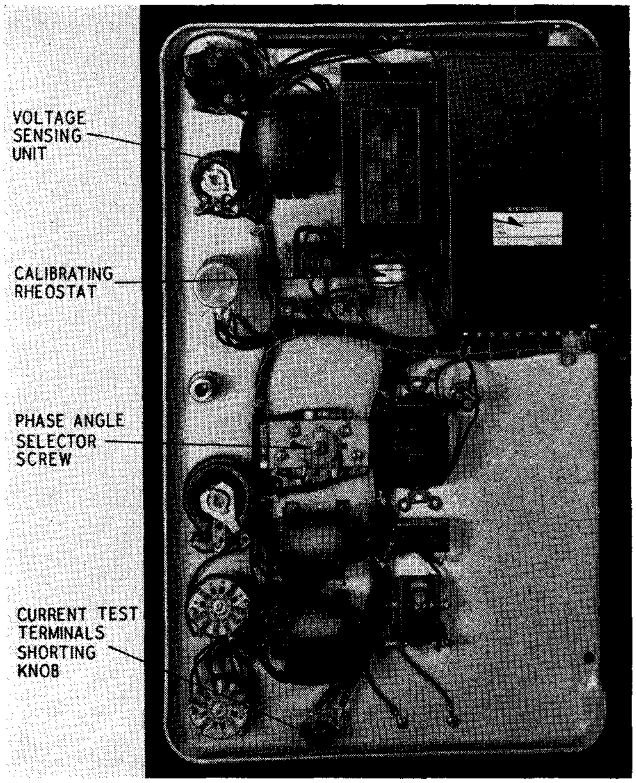


FIG. 5. Rear View of Control Panel

OVZC setting of 125 on the control panel corresponds to the full rated voltage of the machine. The actual adjustment is made by means of a multi-position switch for large increments of 5 volts and a calibrated potentiometer for smaller increments up to 5 volts. The multi-position switch should be set for the nearest 5 volt step below the desired voltage level. The calibrated potentiometer is then set to indicate the amount by which the desired voltage level exceeds the setting of the multi-position switch. The OVZC setting is then the sum of the multi-position switch setting and the calibrated potentiometer setting.

Compensation Adjusting Knobs (Line-Drop Compensator). This setting compensates the control circuits for the varying resistance and reactance drops which occur between the regulator and the load center. The compensator causes the regulator output voltage to vary under different load conditions. The variations in the output voltage of the regulator are such that the voltage is always maintained constant at the load center within the limits of the machine. A separate setting is made for each the resistance and the reactance line drop (See "Line-Drop Compensator Settings", Page 15 for method of calculating settings).

Sensitivity. This adjustment is used to set the regulation band width (increment of voltage over which the machine will not operate to regulate the output). This increment is necessary for stability since a finite change in output voltage must occur before it can be detected by the voltage sensing unit and corrected without hunting.

Phase Angle Selector. The connections of this three-position switch are changed by changing the position of the screw and washer which acts to complete the circuits. The function of the phase angle selector is to compensate for the phase shift between the current transformer and voltage transformer inputs to the control panel when regulators are connected in delta on a three-phase line. For single-phase or wye connected, three-phase applications, the phase selector screw should be placed in the center or "zero-shift" position. See the machine wiring diagram or Fig. 15 for the correct position of this screw on three phase delta operation.

Current and Voltage Test Terminals. Both the current and voltage test terminals can be used with a recording or an indicating meter. The voltage test terminals give a nominal 125 volts and the current test terminals provide a full-load current of 5 amperes. The current test terminal shorting link is located on the back of the panel between the terminals. It consists of a knurled thumb screw assembly which is unscrewed for metering and must be screwed back into position before removing the meter.

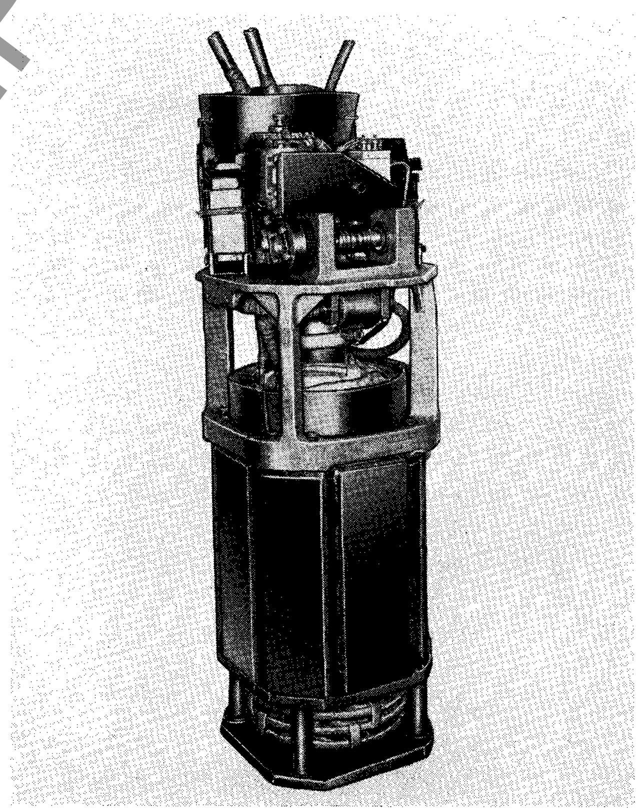


FIG. 6. Regulator Removed from Tank

Voltage Sensing and Motor Operating Units. The voltage sensing unit is a specially designed magnetic amplifier type circuit which provides a signal only when the output voltage of the regulator drifts outside the band width. The signal appears across one pair of terminals when the output voltage is high and across another pair when it is low. When the output voltage is within the limits determined by the control panel settings, the voltage sensing unit provides zero signal at both pairs of terminals.

The motor operating unit is a specially designed magnetic amplifier which utilizes the low power output from the voltage sensing unit to trigger the relatively large amount of power necessary to operate the drive motor.

A constant voltage transformer is used to supply a fixed bias to both the voltage sensing unit and the motor operating unit. The units are adjusted and sealed at the factory and require no further adjustment. No attempt should be made to repair components of the sealed units. If a sealed unit is determined to be malfunctioning, it should be replaced.

CONTROL PANEL TESTS AND ADJUSTMENTS

When testing or setting the regulator controls, a portable voltmeter must be used to read the output voltage. Connect the voltmeter to the output voltage test terminals to read the regulated voltage. A reading of 125 volts on the meter corresponds to the rated voltage of the machine. Set the OVZC adjustment for the desired voltage level as outlined under "OPERATION OF CONTROLS", Page 10. With the automatic-manual switch in the "automatic" position and the compensation setting knobs on "zero", turning the control supply switch on will cause the machine to operate until the reading of the voltmeter agrees with the OVZC setting.

The band width can be determined by measuring its two threshold voltages using two portable voltmeters:

METER A: An accurate a-c instrument of approximately 150 volts full scale to measure the potential at the voltage test terminals.

METER B: A lower reading d-c meter with minimum full scale reading of 15 volts. Accuracy of this meter is not important since it is used only as an "on-off" indicator.

The band width is measured as follows:

1. With the control supply switch in the "off" position, connect Meter A to the voltage test terminals and Meter B to terminals 9-V and 11-V.

2. Turn the control supply switch "on".

3. Place the automatic-manual switch in the "manual" position after the regulator comes to rest.

4. Using the manual raise-lower switch, "inch" the regulator in the lower direction until the reading on voltmeter B suddenly jumps from its original reading of approximately 2 volts to approximately 11 volts.

5. Read voltmeter A to obtain the lower threshold voltage.

6. After running the regulator back with the manual raise-lower switch until voltmeter B reads

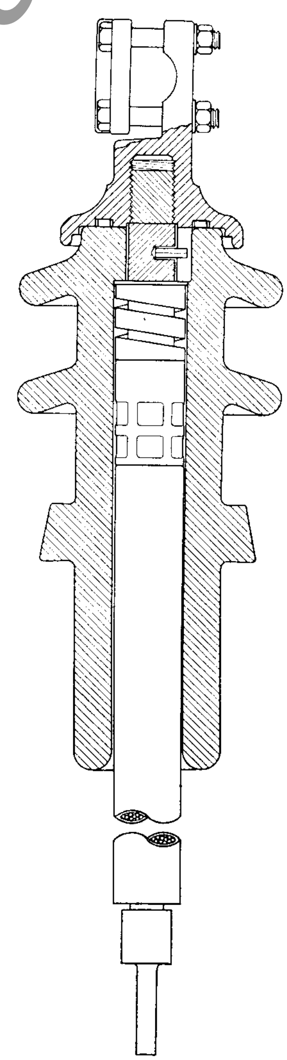


FIG. 7. Cutaway View of Bushing

approximately 2 volts, steps 4 and 5 can be repeated. Use the highest reading obtained to eliminate false readings resulting from overshooting the threshold. Voltage readings must be taken quickly to avoid errors due to fluctuations of the line voltage.

7. Turn the control supply switch "off".

8. Connect voltmeter B to terminals 13-V and 15-V.

9. Turn control supply switch "on".

10. Place the automatic manual switch in the "hand-operated" position after the regulator comes to rest in the automatic position.

11. Using the manual raise-lower switch, "inch" the regulator slowly in the raise direction until the reading on voltmeter B suddenly jumps to approximately 11 volts.

12. Read voltmeter A to obtain the upper threshold voltage.

13. Repeat steps 10 and 11 if necessary to eliminate false readings due to overshooting. Readings must be taken quickly after the voltage sensing

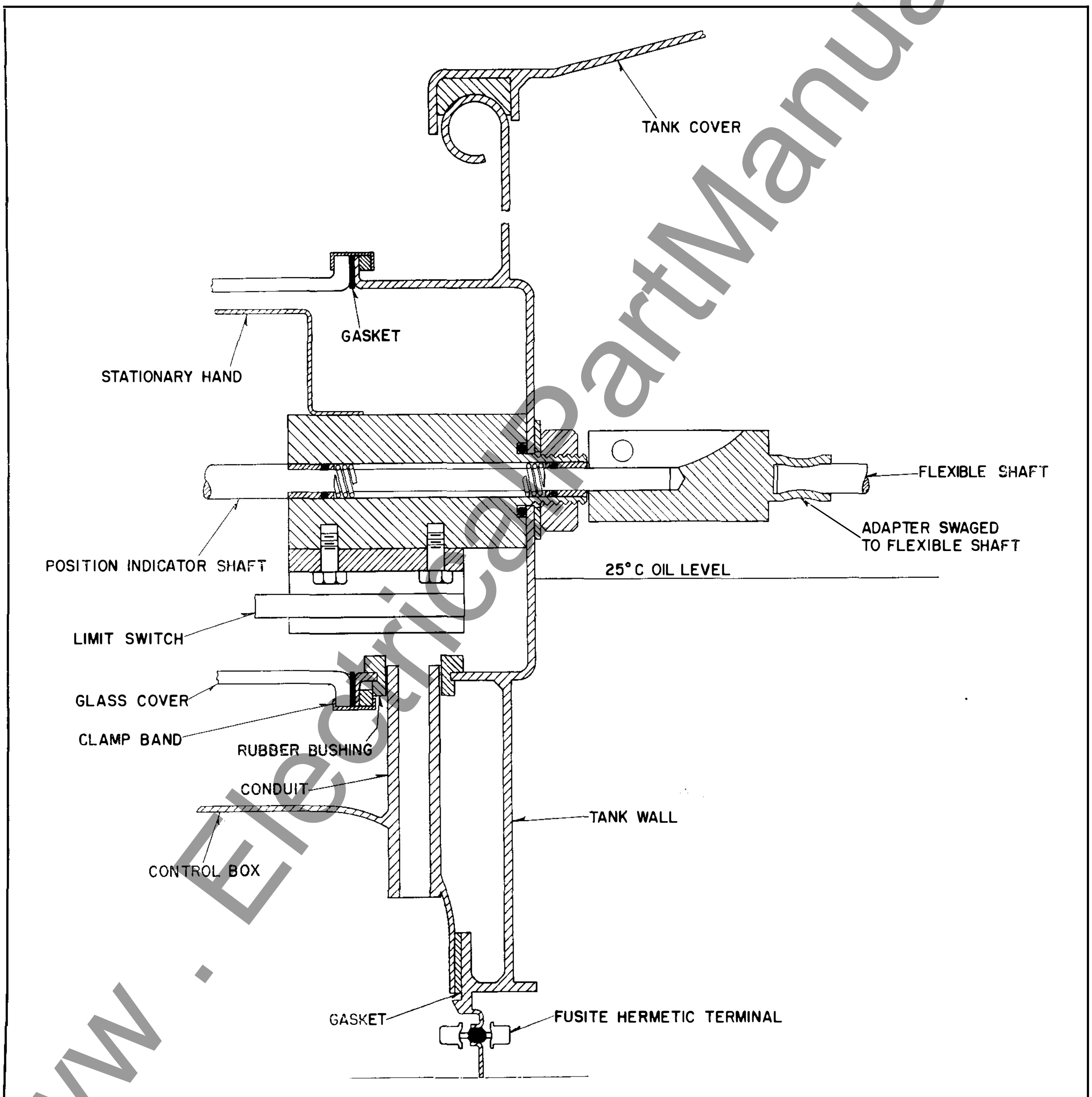


FIG. 8. Cross-Sectional View of Position Indicator

element switches on and the lowest reading obtained is the upper threshold voltage.

The difference between the upper threshold voltage and the lower threshold voltage is the band width. With the sensitivity knob set in the maximum position, a band width of approximately 1 volt is obtained (OVZC setting ± ½ volt). With this knob in the minimum position, a band width of approximately 6 volts is obtained (OVZC setting ± 3 volts).

When voltmeter B indicates an "on" (11 volts) condition, the section of the voltage sensing unit to which it is attached is delivering a signal to its corresponding section in the motor operating unit. This signal causes the motor operating unit to energize the motor. Thus an "on" condition indicates that the motor would be running if the automatic-manual switch were on "automatic". An "off" condition (2 volts) as indicated on meter B represents a condition of "zero signal" output from the voltage sensing unit section. When both voltage sensing unit outputs are delivering zero signal, it indicates that the motor would be at rest if the automatic-manual switch were in the automatic position.

Compounding can be checked by using the same setup as for measuring band width. Starting with voltmeter B indicating an "on" condition "inch" the regulator toward the center of the band until the meter suddenly jumps to the "off" position. This should occur near the center of the band.

After several hours of continuous operation, the adjustment of the calibrating rheostat can be checked by observing that the OVZC setting agrees with the voltmeter reading when the automatic-manual switch is on "automatic" and the sensitivity knob is set on "maximum". The calibrating rheostat is adjusted at the factory with the phase angle selector screw in the center or "no-shift" position. No further adjustment of this rheostat should be necessary unless the phase angle selector screw is moved to another position.

LINE-DROP COMPENSATOR SETTINGS

Correct settings of the line-drop compensator can be obtained by means of the formulas given below. These settings can later be modified if voltage charts taken at the load center indicate variations. The modified settings are generally made on the basis of an error in the value of the length L. Thus if the load center voltage falls at periods of high load, both resistance and reactance compensation are increased, and if the load center voltage rises at periods of high loads, both resistance and reactance compensation are decreased.

The resistance compensation setting can be found by means of the following formula:

$$\text{Resistance Setting} = 125\left(\frac{RLIK}{V} + \frac{Dr}{100}\right)$$

where R is the a-c resistance of the feeder in ohms per conductor per mile.

Table No. 1 gives values of R for various conductor sizes.

L is the length of the feeder in miles.

I is the rated full-load current of the regulator as indicated on the nameplate for the stator connection employed.

K is a constant determined by the application.

For single-phase applications, the constant is 2; and for three-phase applications, it is 1.73.

V is the line-to-line voltage.

Dr is the percent resistance drop which occurs in any transformer and distribution line which may be located between the end of the feeder and the load center. This drop must be calculated on a basis of full-load current in the regulator.

The reactance compensation setting can be calculated by means of the following formula:

$$\text{Reactance Setting} = 125\left(\frac{XLIK}{V} + \frac{Dx}{100}\right)$$

where X is the reactance of the feeder in ohms per mile per conductor.

TABLE NO. 1

SIZE OF CONDUCTOR			R = 60-CYCLE, A-C RESISTANCE IN OHMS PER CONDUCTOR PER MILE AT 50°C
Circular Mils	AWG	Strands	
1,000,000	—	61	0.0685
900,000	—	61	0.0752
800,000	—	61	0.0837
750,000	—	61	0.0888
700,000	—	61	0.0947
600,000	—	37	0.109
500,000	—	37	0.130
400,000	—	19	0.162
300,000	—	19	0.215
250,000	—	19	0.257
211,600	0000	7	0.303
167,806	000	7	0.382
133,077	00	7	0.481
105,535	0	7	0.607
83,690	1	1	0.749
66,370	2	1	0.945
52,630	3	1	1.192
41,740	4	1	1.503
33,100	5	1	1.895
26,250	6	1	2.390
20,820	7	1	3.014
16,510	8	1	3.800

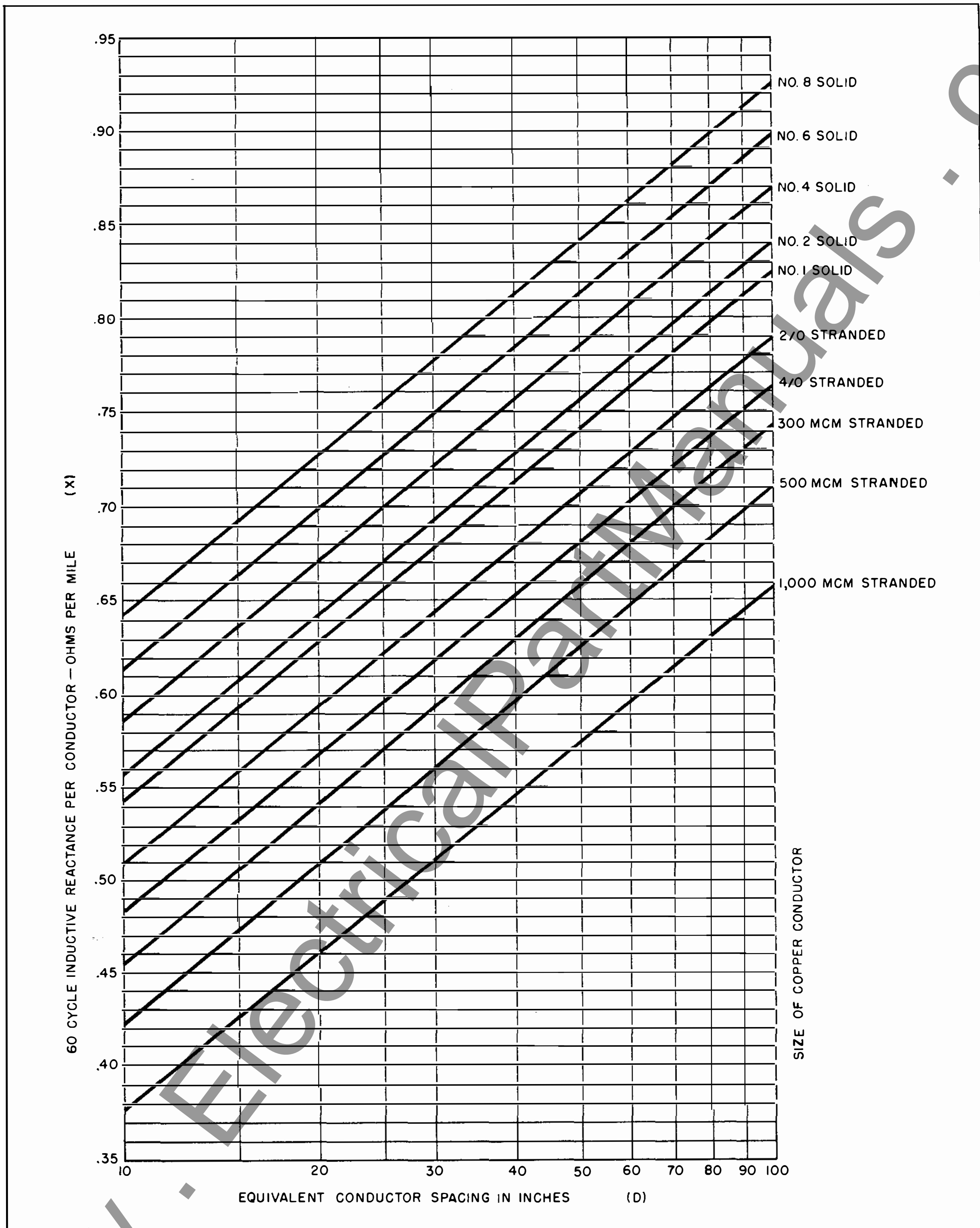


FIG. 9. Reactance Chart (60-Cycle Inductive Reactance vs. Equivalent Conductor Spacing for Various Sizes of Copper Conductor)

The curves in Fig. 9 give values of X for various conductors and equivalent conductor spacings. The equivalent conductor spacing D for single-phase feeders is taken as the distance between conductors. For three-phase feeders, D is equal to the cube root of the product of the three conductor spacings. Thus if the conductors form an equilateral triangle, the spacing between any two conductors is equal to D.

If the conductors are in Line, D is equal to the $\sqrt[3]{2}$ times the spacing between either end conductor and the center one.

L. is the length of the line in miles.

I is the rated full-load current of the regulator as given on the nameplate for the stator connection employed.

K is a constant determined by the application. For single-phase applications, the constant is 2; and for three-phase applications, it is 1.73.

V is the line-to-line voltage.

Dx is the percent reactance drop which occurs in any transformer and transmission line located between the end of the feeder and the load center.

SAMPLE CALCULATIONS

Assume that three 50-kva, 10 percent regulation, Type SU regulators are to be wye-connected to a three-phase feeder. The feeder is rated at 1500 kva and is operated at 4330 volts line to line. Full load current is 200 amperes. The regulators are rated at 2500 volts and 200 amperes full load. Assume that the conductors are No. 4/0, stranded cable mounted in line horizontally with two feet between adjacent conductors. The feeder length is two miles and the percent drop in the transformer and distribution line is 2 percent for both resistance and reactance.

For the assumed conductor size, Table No. 1 gives R = 0.303 ohm per conductor per mile.

This value is then substituted in the resistance setting formula and gives: Resistance Setting =

$$125\left(\frac{0.303 \times 2 \times 200 \times 1.73}{4330}+\frac{2}{100}\right)=8.6 \text{ volts.}$$

For the assumed conditions $D=\sqrt[3]{2} \times 2 \times 12=$ 30.2 inches.

For D = 30.2 inches and No. 4/0 conductor, Fig. 9 gives X = 0.62 ohm per conductor per mile.

Substituted in the reactance setting formula this gives: Reactance Setting =

$$125\left(\frac{0.62 \times 2 \times 200 \times 1.73}{4330}+\frac{2}{100}\right)=14.9 \text{ volts.}$$

MAINTENANCE

LOCATING FAULTY COMPONENTS IN CONTROL CIRCUITS

If the motor does not operate or operates incorrectly on automatic control while functioning properly on manual control, check the following points to determine which component is faulty.

1. The output voltage of the constant voltage transformer (T3 and T4) should be approximately 20.5 to 21.5 volts when the input (T1 and T2) is between 105 and 135 volts. If the load is removed from T3 and T4, the output voltage will be approximately 23 volts if the unit is operating correctly. If the output voltage is considerably outside of these ranges, the constant voltage transformer should be replaced.

2. Measure the output voltage of the bias rectifier. This should be between 16 and 18 volts D.C. If the output is considerably below this value, the rectifier should be replaced.

3. The outputs of the two sections of the voltage sensing unit (9V—11V and 13V—15V) should be a minimum of 10 volts when "on" and a maximum of 2 volts when "off". There should be no stable output between these two limits so that the transition from one to the other as the regulator is operated slowly under manual control should be quite sudden. If the voltage sensing unit does not function in this manner, it should be replaced.

4. If both outputs of the voltage sensing unit are "on" at the same time or if the band width is excessively wide or narrow, check the resistances of the band width adjustment potentiometers against the values given on the wiring diagram. If these potentiometers check out satisfactorily, the trouble is in the voltage sensing unit which should be replaced.

5. If the voltage sensing unit delivers zero signal (both outputs "off") at some voltage other than that of the OVZC setting and the condition cannot be corrected with the calibrating potentiometer, check the calibrating potentiometer resistance against the value given on the wiring diagram. Also check the input to the voltage sensing unit (4V and 7V) when both outputs of the unit are "off". This input should be approximately 120 volts. If the input voltage is correct and the calibrating potentiometer is not defective, the trouble is in the voltage sensing unit and it must be replaced.

6. If all of the units tested up to this point are functioning properly, then the trouble is in the motor operating unit which must be replaced.

INSPECTION OF WEMCO C INSULATING OIL

Approximately once a year or oftener if operating conditions warrant, an inspection of the oil used in Type SU machines should be made. Check the oil level allowing ½-inch increase in oil level for each 10 degrees of oil temperature above 25 degrees C.

Samples of oil for test purposes may be drawn off through the sampling valve located at the base of the tank (Samples of insulating oil should always be drawn off from the bottom since impurities and moisture tend to concentrate there). A dielectric test of the oil should give a breakdown value of at least 16.5 kv on a 1/10 inch test gap. If the oil strength is found to be less than this value, the oil must be filtered or centrifuged. If this does not return the oil's dielectric strength to normal, the oil should be replaced.

The appearance of the oil should be carefully checked as a discoloration may indicate contamination or oxidation. If the condition of the oil is still in question, further testing may be necessary. See Westinghouse Instruction Book 44-820-1 for additional information on oil maintenance.

INSPECTION OF INERTEEN INSULATING FLUID

The inspection of Inerteen is similar in most respects to the inspection of insulating oil. Provision is made, however, to draw off samples of Inerteen from the top. The reason for testing the top Inerteen is that water, the chief contaminant, is lighter than Inerteen and will therefore tend to concentrate near the top. On Inerteen-insulated machines a vent valve identical to the drain valve is provided above the maximum liquid level. This valve facilitates the drawing of samples, since a slight partial vacuum above the liquid coupled with the low liquid pressure near the top may result in a failure of the liquid to flow if the tank is not vented. Bottom samples of Inerteen may be drawn from the drain valve.

The dielectric strength of Inerteen is affected to a greater degree by the presence of moisture than is insulating oil. The greatest of care must therefore be exercised when handling Inerteen to prevent contamination.

For additional information on the maintenance of Inerteen, see I.B. 44-860-1 in the back of this instruction book.

MECHANICAL PARTS INSPECTION

After ten years of operation and at ten year intervals thereafter, a complete inspection of the regulator should be made. It should be taken to a suitable service shop and be completely dismantled for this inspection. The inspection should cover the following points.

1. The rotor leads should be checked for chafing or weakened points which may later cause failures.

2. Windings should be checked for deformed coils due to short-circuit stresses or other abnormal operating conditions.

3. Gears, bearings, limit switches and position indicator should be checked for possible wear or damage due to short-circuit overloads.

4. The air gap should be checked for uniformity. The maximum difference between any two points around the rotor for any position of the rotor should not exceed 0.005 inch.

5. The motor position should be checked to be sure that the motor worm meshes properly with the Micarta spiral gear.

DISASSEMBLY OF MACHINE

Except for minor features such as sampling valves and special materials and finishes for Inerteen, the construction of the SI line is identical to that of the SU line. The following instructions for disassembly and reassembly of the machine, therefore, cover both types of regulators.

1. For a thorough inspection or for repairs, the machine must be removed from the tank. This should be done as follows (See Fig. 1).

a. Remove the bushing terminals by unscrewing them from the bushing lead studs.

b. Remove the cover, complete with bushing porcelains by removing the single one-inch bolt which holds it down.

c. Drain off sufficient liquid to expose the wiring feed-through assembly in the tank wall.

d. Detach the flexible position indicator shaft from the position indicator assembly (Clamp fastened by a 5/16 bolt).

e. Disconnect the control wiring inside the tank from the tank wall feed-through. This is done by merely pulling the leads off since contact is made by means of a plug-on type terminal.

f. Remove the two bolts which fasten the regulator within the tank (One bolt on each side of lifting bracket).

g. The machine may now be raised from the tank by means of a one-inch eye-bolt screwed into the cover bolt pad or by means of a sling and spreader on the lifting bracket cross-bar). The centering plate which is bolted to the bottom bracket, prevents the machine from being placed directly upon a level surface. A pair of blocks may be used to straddle the centering plate or the plate may be removed entirely. This will allow the machine to be placed upon a level surface.

2. When the machine is out of the tank, the terminal board may be removed as follows:

a. Remove all cotter pins, copper links and nuts from the front of the terminal board.

b. Remove the four bolts which fasten the terminal board assembly to the stator top bracket.

c. The terminal board assembly may now be removed, taking care to provide adequate support for the leads.

3. The motor may be removed as follows (See Fig. 10).

a. Disconnect the leads at the motor, taking care to mark them for correct reassembly.

b. Remove the motor (four mounting nuts).

4. The worm gear may now be removed as follows:

a. Pull the control leads out of the way, cutting twine where necessary.

b. Remove the right hand mechanical stop bolt from the worm gear and rotate the rotor in the clockwise direction until the worm and worm gear disengage.

c. Drive the gear segment down as shown in Fig. 11 to release the pressure on the tapered gib key.

d. Remove the gib key using a wedge and monkey wrench as shown in Fig. 12.

e. Remove the worm gear with a heavy wheel-puller or as shown in Fig. 13, using suitable bolts and a bar.

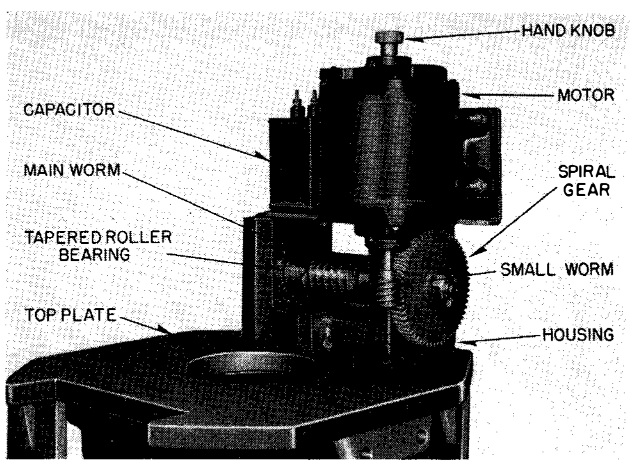


FIG. 10. Gear Reduction Assembly

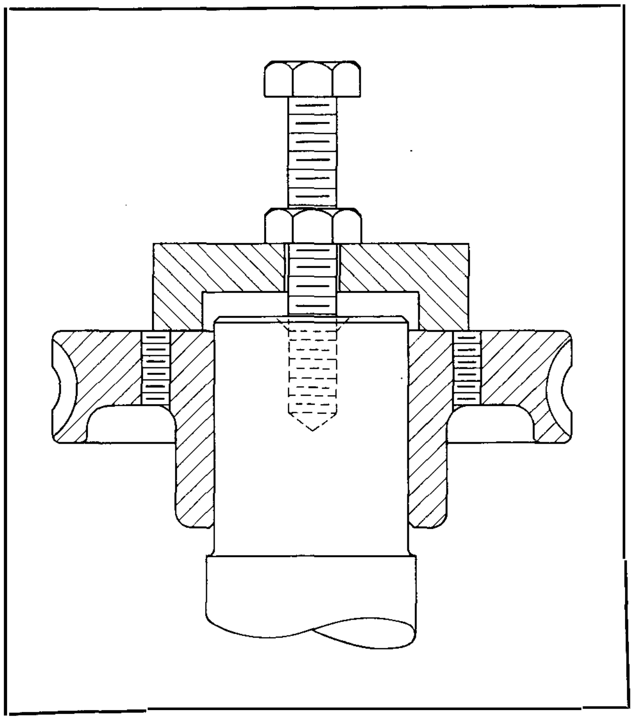


FIG. 11. Lowering Worm Gear

5. The top bracket may now be removed as follows: (See Fig. 10).

a. Remove the current transformer from the bottom of the stator top bracket (four bolts and two cleats).

b. Cut the rotor leads loose from the rotor lead hanger on the underside of the top bracket.

c. Remove the rotor lead cleat which fastens the rotor leads to the left-rear upright arm of the top bracket.

d. Remove the eight bolts which fasten the top bracket to the stator core.

e. Disconnect and free all motor operating and potential transformer leads.

f. The top bracket assembly may now be removed by means of the lifting bracket taking care not to damage the stator coil insulation.

6. With the top bracket assembly removed, the rotor may be removed as follows: (See Fig. 14).

a. Remove the flexible position indicator drive shaft.

b. The rotor may now be raised using an eyebolt in the tapped hole from which the flexible drive shaft was removed. Care must be taken to raise the rotor straight up. The rotor must be raised slowly and carefully to avoid damaging the coils.

7. To remove the worm from the worm housing (See Fig. 10). (This can be done regardless of whether or not the worm gear has been removed.)

a. Remove the damping device which is mounted on the Micarta spiral gear (4 bolts).

b. Remove the cotter pin and castle nut which hold the Micarta spiral gear on the worm shaft.

c. Loosen the Allen-type socket-head setscrew (right side of worm housing) which locks the adjusting nut.

d. Remove the adjusting nut, using a spanner wrench.

e. Drive the worm out by tapping on the left side to drive out the right-hand bearing cup and drive the Micarta spiral gear off the worm shaft. Use soft material, such as brass or wood to prevent damaging the threads.

REASSEMBLY OF MACHINE

When reassembling the machine, a reverse procedure to that used in disassembly should generally be followed. When reassembling the main worm, the adjusting nut should be tightened until the bearing springs are .004 to .006 inch of being solid or completely flattened out. This can be done by tightening the adjusting nut until the springs are flat (as indicated by a sharp increase in drag on the worm when rotated by hand) and then backing it off approximately 15 degrees.

Before replacing the worm gear, heat it in an oven to 130 degrees C. It can then be positioned on the shaft and allowed to cool. Before driving in the tapered key, a block or wedge should be placed between the worm gear hub and the stator top plate to prevent driving the gear farther down. If the key and gear are spot marked before disassembly, they can be more readily returned to their correct positions.

When replacing the motor, position it so that its shaft will be in a vertical plane parallel to one side of the spiral gear. The stop nuts which support the motor should also be adjusted so that the small worm will have a backlash of five to ten degrees.

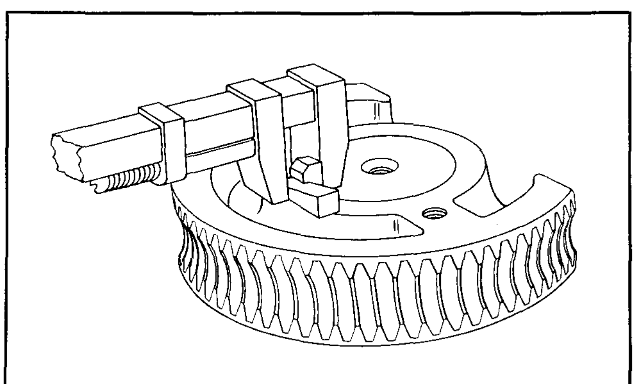


FIG. 12. Removing Gib Key

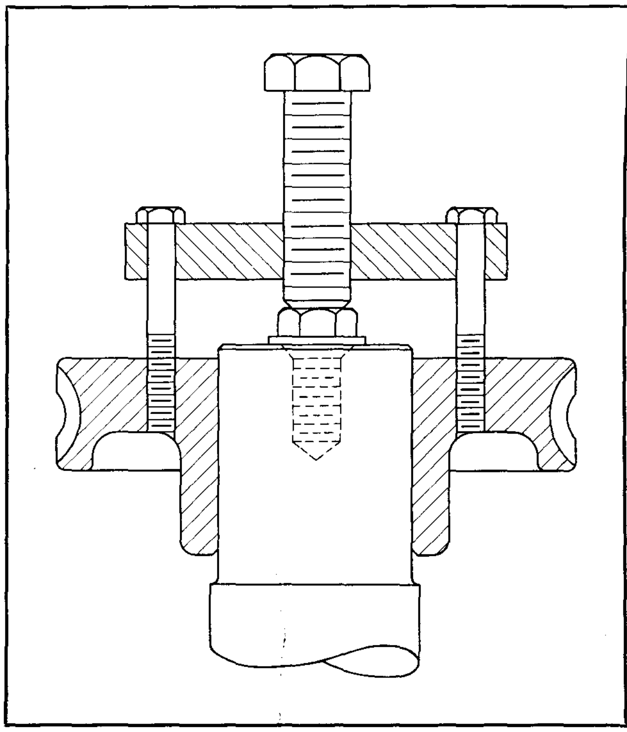
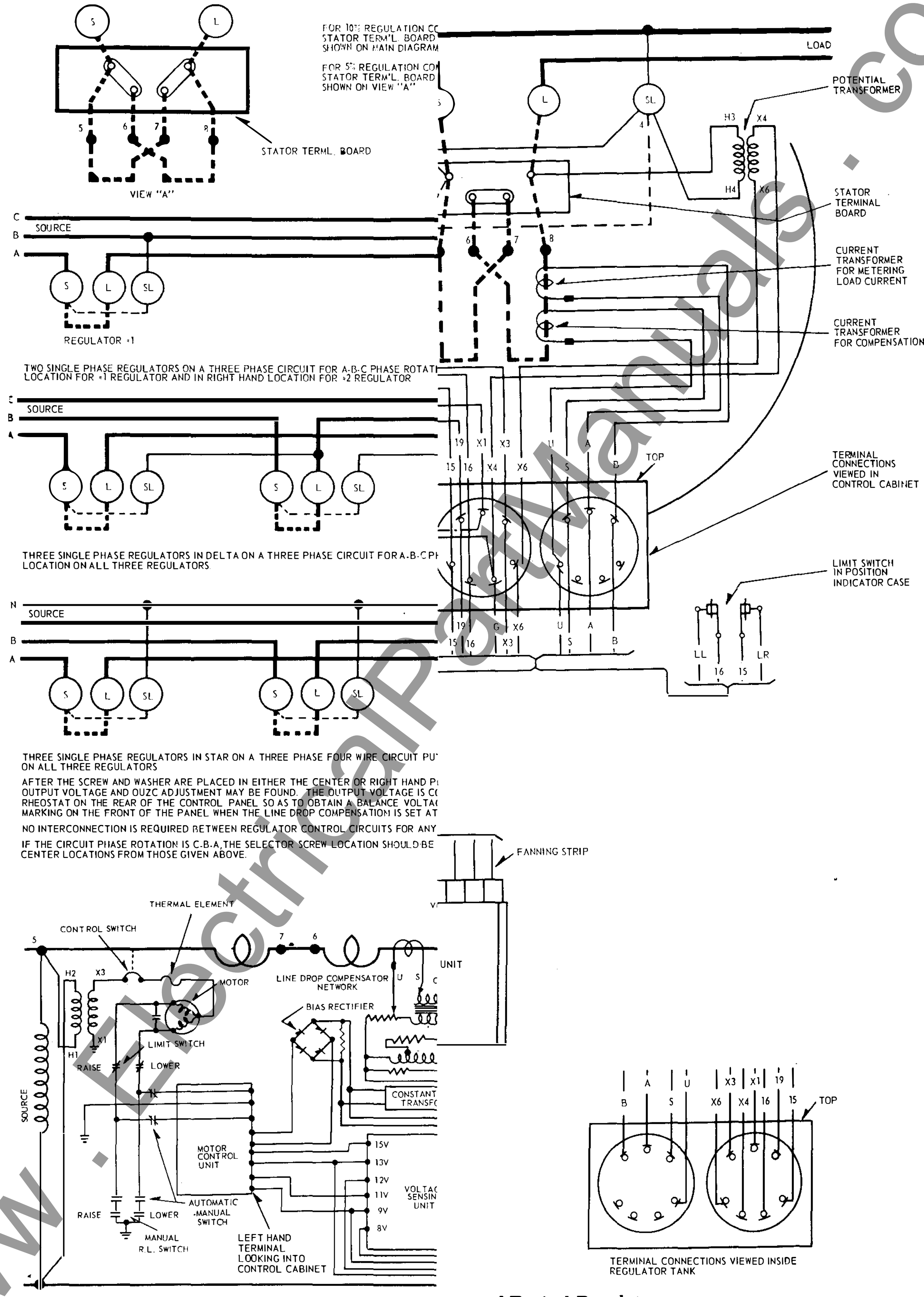


FIG. 13. Raising Worm Gear

Setting the machine on neutral while it is out of the tank facilitates assembly of the position indicator after tanking.

After the machine has been completely assembled, it should be pressure-tested to check its seal. This can be done by applying an internal pressure of five pounds per square inch. There should be no appreciable drop after a six-hour period. Leaks above the liquid can be found by brushing the gasket sealed joints with a suitable solution such as soap and glycerine.

FIG. 14. Rotor



agram of Typical Regulator

RECEIVING • TESTING • RECONDITIONING

INSTRUCTIONS

INERTEEN®

INSULATING FLUID

P.D.S. 7336-9

for

Electrical Apparatus

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

NEW INFORMATION
Printed in U.S.A.

FEBRUARY, 1952
(Rep. 4-56)

INERTEEN* INSULATING FLUID

P.D.S. 7336-9

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid. It has proved its suitability for use in all Westinghouse Inerteen insulated apparatus. In order to insure the proper performance of the apparatus, only Westinghouse Inerteen 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 Inerteen.

* Registered trade-mark for Westinghouse Askarel.

RECEIVING, HANDLING, STORING

SHIPMENT

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

When shipped in drums, the Inerteen 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 Inerteen are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of Inerteen has been unloaded, the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit. If loosened, be sure Inerteen is tested before using, or combining it with good Inerteen.

It is very desirable that Inerteen in drums be stored in a closed room. Outdoor storage of Inerteen is always hazardous to the Inerteen and should be avoided if at all possible. If it is necessary to store Inerteen outside, protection against direct contact of rain and snow should be provided. Drums stored outdoors should be placed so that bungs will be protected from moisture. It is desirable to cover the drums with a tarpaulin.

Cans. Cans containing Inerteen must not be exposed to the weather. Seals should be kept intact until the Inerteen is actually needed.

Screw caps are provided on the cans to use when the Inerteen 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 Inerteen must be tested just 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.

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

The tank should preferably have a convex bottom, allowing for the installation of a drain cock at the lowest point for removing dirt or tank scale which might settle out. As Inerteen is heavier than water, most all of any water present will, in time, rise to the top of the Inerteen. A valve somewhere near the normal top level of the Inerteen should be provided for drawing off water-contaminated Inerteen. Provision for drawing off the Inerteen should also be made near the bottom of the tank.

HANDLING

Caution: Inerteen is a skin irritant. Unnecessary contact with this liquid or its vapor, particularly when it is hot, should be avoided. Especially the eyes, nose, and lips are affected when Inerteen comes in contact with them. Certain safety precautions must be observed when handling Inerteen.

In case Inerteen comes in contact with the skin, the parts affected should be thoroughly washed in soapy water and followed by an application of cold cream. A supply of these materials should be kept available at all times where personnel are working with Inerteen. Continued exposure may cause eruptions on certain individuals due to the absorption of Inerteen through the pores of the skin. Cleanliness among workmen handling Inerteen is a very good safeguard against such effects. Application of castor oil is recommended for the eyes, castor oil or cold cream for the nose and lips.

Hot apparatus should not be opened except in well-ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, the clothing should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves such as Westinghouse S# 1389 974 should be worn when it is necessary to put one's hand into Inerteen or when parts of apparatus must be handled wet.

Mineral oil is completely miscible with Inerteen and it is practically impossible to separate them. Therefore, it is important to avoid contaminating Inerteen with any kind of oil, since its presence changes the non-inflammable and non-explosive characteristics of Inerteen.

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

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

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, Inerteen which has not been filtered should be strained through three 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 Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

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

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

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

When it is necessary to transfer Inerteen 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 Inerteen through an Inerteen conditioner 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 Inerteen will absorb more water at higher temperatures which will be thrown out of solution at lower temperatures. The remainder will be in suspension in the Inerteen and will lower the dielectric strength.

A drum of cold Inerteen when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the Inerteen 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 Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

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

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

Next, heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C. (190°F.) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

Caution: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

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

If it is necessary to refill them for storage, drums which have been used only for clean, dry Inerteen 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 Inerteen, the temperature of the drum and of the Inerteen 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 Inerteen.

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 nearest Westinghouse Office 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 Inerteen.

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

SAMPLING AND INSPECTION

A good fireproof insulating liquid is one that will act as an insulating liquid, will carry the heat away from the apparatus, and is fireproof. Westinghouse Inerteen meets these requirements with the following characteristics:

1. High dielectric strength.
2. Freedom from inorganic acid, alkali, and corrosive sulphur. (To prevent injury to insulation and conductors)
3. Low viscosity. (To provide good heat transfer)
4. Low pour point.
5. Fireproof.

CAUSES OF DETERIORATION

The principal causes of deterioration of Inerteen are:

1. Presence of water.
2. Arcing.

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

Arcing or burning in Inerteen produces finely divided carbon and gases which are mostly hydrogen chloride. Hydrogen chloride in the presence of moisture forms hydrochloric acid which may soon damage the insulation in the apparatus and cause rusting of ferrous materials.

Since hydrogen chloride is formed quickly after the arcing occurs, neither the Inerteen nor the apparatus should be exposed to the atmosphere (which always contains more or less moisture) until an attempt has been made to remove the hydrogen chloride. See Reconditioning, Page 7, for the method of purification.

SAMPLING INERTEEN

The dielectric strength of Inerteen 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 be largely a matter of carelessness in handling.

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for handling Inerteen and servicing Inerteen be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen-resistant stoppers to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naphtha, washed with strong soap suds, and rinsed thoroughly in hot water, and then dried at approximately 110°C. for four hours with neck down in a circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of the Inerteen. In sampling, allow a small amount of Inerteen to run out to flush the sampling connection clean before collecting the sample. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

Quantity of Sample. It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen 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 must be tested to determine if it is suitable for use.

PERIODIC INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service (approximately three months for transformers). Following this, when operating conditions permit, routine sampling and testing of the Inerteen at intervals of six months to one year are suggested. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 22 kv, it should be conditioned. If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below, and also P.L. 44-860. When an appreciable amount of Inerteen is removed from any apparatus, it should be replaced with an equal amount of new Inerteen so that the liquid level in the apparatus is maintained. The Inerteen used for replacement purposes should have a dielectric strength of not less than 30 kv.

INERTEEN TESTING SERVICE

Many users of Inerteen do not have the necessary facilities for testing it. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen 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 (W) S#1608 629, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. *The order sheet must be sent to the nearest Westinghouse Office.*

When samples of Inerteen are received for testing, they are sent to the Plant Laboratory and tested in accordance with methods described under "Testing Methods," which follows and is part of this Instruction Book.

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

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen 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 Inerteen represented should be given as completely as possible.

Power factor test of Inerteen at 60 cycles can be made.

(For details refer to the nearest Westinghouse Office.)

CHARACTERISTICS AND RECONDITIONING

CHARACTERISTICS

Inerteen is chemically stable. It is straw-yellow in color. It is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40 kv. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the caution note under Receiving, Storing, and Handling. (See Page 3.) It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is practically impossible to separate mineral oil and Inerteen.

Inerteen P.D.S. 7336-9 has an improved characteristic so that, when arcing occurs, the insulating materials are not so quickly or so greatly impaired as a result of the liberation of hydrogen chloride. Inerteen 7336-7, which was supplied in Inerteen transformers previous to September 1, 1945, can easily be converted to 7336-9 Inerteen. For complete information on this conversion, request Engineering Data Letter No. 1337-A from any Westinghouse Electric Corporation Office.

Specific Characteristics of Inerteen. As outlined in "Method of Testing Askarels A.S.T.M. D901-49T", the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions
3. Color: (Maximum) 150 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 cycles 77°F (25°C), 4.0 to 4.3
   At 1000 cycles 212°F (100°C), 3.5 to 3.8
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35 kv
   At point of receipt, 30 kv
7. Electrical resistivity: (Minimum) 100×10^9 ohms/cm^3 (212°F (100°C) at 500 volts d-c)
8. Fixed chlorine content: (Minimum) 59.1 percent
9. Free chlorides: Less than 0.10 ppm
10. Neutralization number: Less than 0.010 mg. of NaOH/gram.
11. Pour point: (Maximum) minus 25.6°F (minus 32°C)
12. Refractive index
    At 77°F (25°C), 1.6137 to 1.6157
13. Specific gravity: (Minimum)
    At 60°F/60°F (15.5°C/15.5°C), 1.560
14. Viscosity: (Maximum)
    At 100°F (37.8°C), 54 seconds

RECONDITIONING

Reconditioning will be necessary to remove water, dirt, and hydrogen chloride which may be present and contaminating the Inerteen.

The blotter filter press and the Inerteen conditioner (both of which will be explained later in this book under "Apparatus for Reconditioning") will remove water and dirt deposits which may be present. Of the two methods, the Inerteen conditioner is the most effective in removing these two contaminating agents. Any equipment used for filtering

Inerteen should first be thoroughly cleaned with benzine or naptha. Every trace of any material foreign to Inerteen must be removed. If at all possible separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through the Inerteen. The nitrogen should be passed through the drain valve at the bottom of the apparatus and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the apparatus to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of four to six hours. This will require from two to eight cylinders (220 cu. ft. each) of dry nitrogen, based on apparatus containing 150 to 2000 gallons of Inerteen.

Immediate application of the bubbling process will reduce the destructive action of the hydrochloric acid on the working parts and insulation, thereby making it likely that the materials not damaged by arcing may be used in repairing the apparatus. Also, use of the process will in most cases make it possible to satisfactorily reclaim the arced Inerteen.

After the hydrogen chloride has been removed by the bubbling process, the Inerteen should be reclaimed by use of an Inerteen conditioner.

There is no commercially suitable method for separating transformer oil from Inerteen.

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 testing transformer and the source of supply of energy shall not be less than 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 an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen 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 impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or gasoline, and non-absorbent as far as moisture, Inerteen, or 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 (90°) 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 1/4 in. below the top of the cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Figs. 2, 3, and 4.)

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 Inerteen-free, dry gasoline or benzine until they are entirely free from fibers.

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 Inerteen. 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 Inerteen 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 Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C.) 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 Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

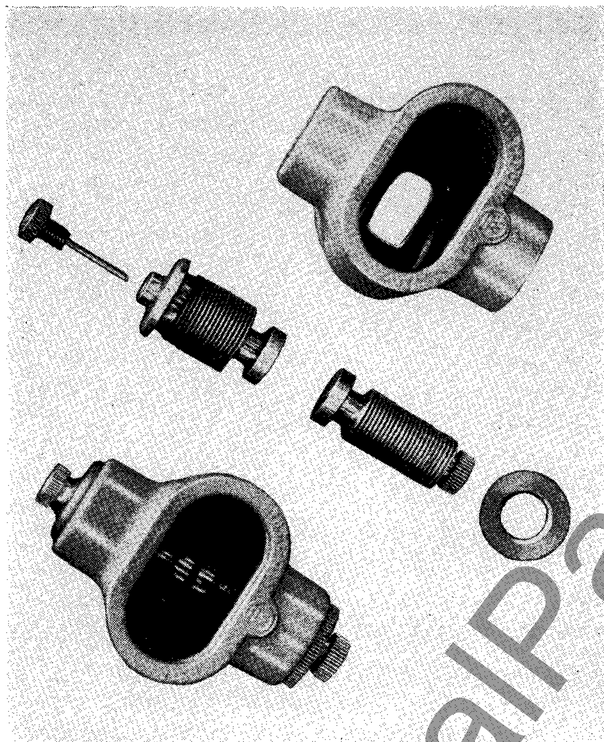


FIG. 1. Fluid Test Cup for Dielectric Test

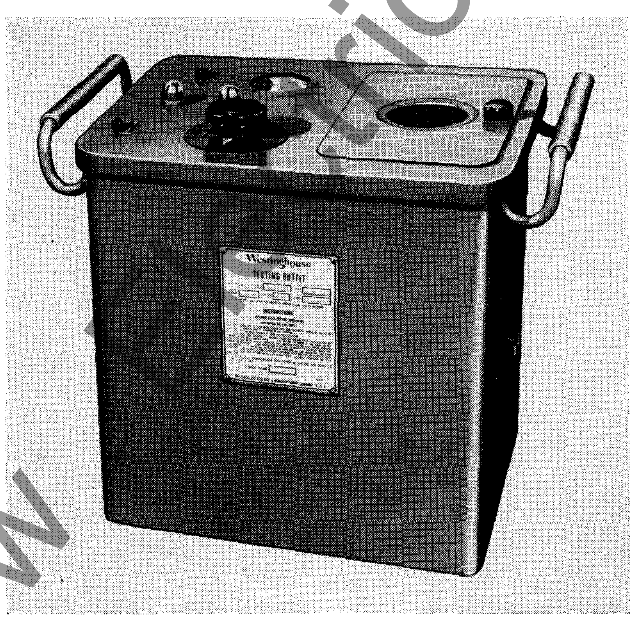


FIG. 2. Portable Oil Testing Set, ½ Kva, 35,000 Volts

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

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

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

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 Inerteen 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 Inerteen 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 Inerteen 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 breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

POUR TEST

Note: The procedures covered by the following instructions for the pour test, and especially the neutralization test, require spec-

ial 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 Inerteen Testing Service. Contact the nearest Westinghouse Office for details.

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

Apparatus. The test jar (see Fig. 4) 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. Inerteen 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).

FIG. 3. Portable Trunk Type Insulating Liquid and Insulating Testing Set, 5 Kva, 30,000/60,000 Volts

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 Inerteen 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 Inerteen is perfectly clear. (Such filtration shall be made at a temperature at least 25°F. (14°C.), above the approximate cloud point.) The Inerteen shall be poured into the test jar, to a height of not less than 2 in. or more than $2\frac{1}{4}$ in. When necessary, the Inerteen 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 Inerteen.

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 Inerteen 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.

During the cooling of the Inerteen, care shall be taken not to disturb the mass of the Inerteen nor to permit the thermometer to shift in the Inerteen.

The temperature of the cooling bath shall be adjusted so that it is below the pour point—approximately -25.6°F (-32°C)—of the Inerteen by not less than 15°F. (8.3°C) nor more than 30°F. (16.7°C), and the cooling bath shall be maintained at this temperature 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 lower 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 Inerteen in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the Inerteen 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 Inerteen 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 Inerteen 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 as the temperature 5°F. (2.8°C.) above this solid point.

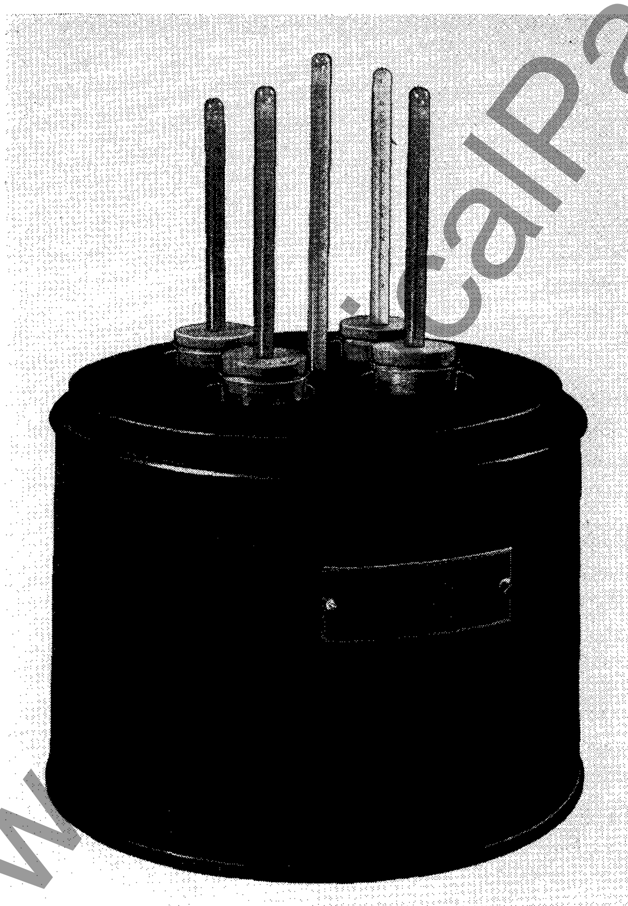


FIG. 4. Apparatus for Pour Test

NEUTRALIZATION TEST

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

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-naptholbenzein per liter of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml Erlenmeyer flask introduce 40 g. of Inerteen 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 Inerteen $= \frac{(A\text{-}B\ (N) \times 56.1}{W}$

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 Inerteen Conditioner is the most effective method of removing moisture, dirt, and other contaminating materials from Inerteen.

2. The filter press is suitable for treating Inerteen containing only small quantities of water and dirt.

INERTEEN CONDITIONER

The Inerteen Conditioner consists of a clay container, clay filter, a motor-driven positive pressure pump, attendant valves, gauges, and relief devices, all mounted on a common base.

The motor and pump are combined as a unit and a strainer is provided on input to the pump to prevent entrance of large particles. The units are designed to operate under working pressures up to 60 psi. However, the usual operating pressure is 30 psi to 40 psi. Excessive pressures are prevented by two automatic by-pass valves. One by-pass valve connected across the pump is set to by-pass the Inerteen at a pressure of 60 psi to 70 psi. The other by-pass valve is connected on the discharge side of the conditioner. This latter by-pass valve, releasing at a pressure of approximately 5 psi, will avoid breaking the transformer relief diaphragm when no other relief is provided. Pump pressures are indicated by a pressure gauge.

Seven GPM Unit. The activated clay is contained in a tank mounted on one end of the filter frame. This tank is provided with a cover which incorporates an air-trap and vent to remove air which might be present in the tank and piping. 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 paper filter to remove practically all of the clay. The paper filter consists of 18 frames and 17 plates, alternately spaced, mounted in a yoke. One sheet of filter paper is used between each plate and frame to provide a gasket seal and remove all traces of clay from the Inerteen. (See Fig. 8)

Three GPM Unit. This unit utilizes two tanks, one within the other. The activated clay is held in the inner tank by suitable screens at top and bottom. The space below the inner tank is completely sealed off from the rest of the space between the two tanks. The cover is of double-deck construction, incorporating the top screen for the inner tank and the solid cover for the outer tank. The Inerteen is pumped into the lower space and is forced up through the activated clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through the fine mesh upper screen and out into the space between the two tanks. The discharge pipe is at the lower end of the outside tank and any air in the Inerteen is trapped in the upper space of the outside tank where it may be drawn off.

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 Inerteen filled apparatus.

One charge of clay is composed of approximately 40 pounds of 15-30 mesh activated clay.* This relatively large volume of clay makes only occasional changes of clay necessary, depending of course on the amount and condition of the Inerteen filtered. Normally one charge will condition approximately 3000 gallons of Inerteen. The coarse granulated clay used gives maximum surface contact between clay and liquid and makes possible a rapid and thorough mixing of the clay and Inerteen to accomplish complete reconditioning of the Inerteen as it passes through the clay tank. The clay granules are removed from the Inerteen by means of fine screen in the 3 GPM filter and by screen and paper in the 7 GPM filter.

The clay never passes through the pump to cause wear on pump parts and consequent loss of pumping capacity. As soon as the charge of activated clay is placed in the tank and the cover clamped in place, the unit is ready for immediate use.

Neither clay nor filter paper can be effectively dried of water after they have once become saturated with Inerteen. Therefore, extreme care should be taken to see that both clay and filter paper are thoroughly dried when placed in the filter.

The clay may be dried in a high temperature oven at 200 deg. C. for six hours and shallow pans are preferred as containers for the clay while drying. A paper drying oven may be used if a high temperature oven is not available, with a drying time extended to approximately twenty-four hours at the oven's highest temperature. The filter paper should be dried six to twelve hours at 85°C. to 100°C.,

* Filter paper and activated clay may be obtained from the Westinghouse Sharon Plant.

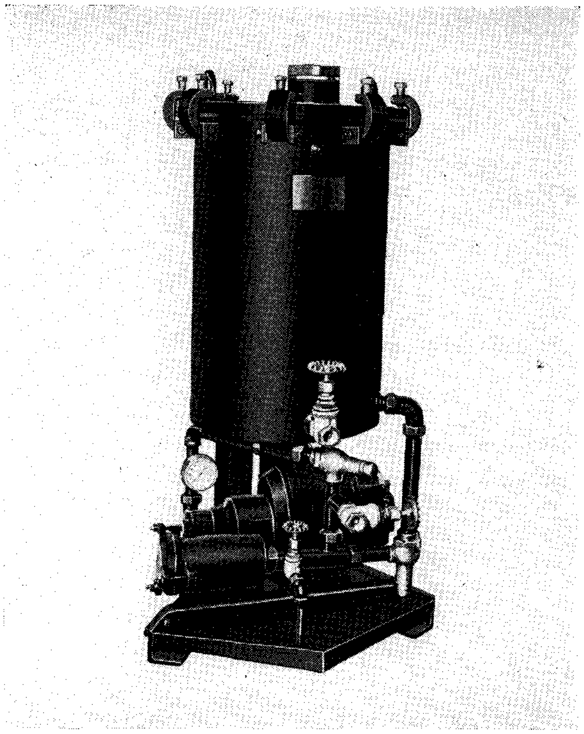


FIG. 5. Three Gallon-per-Minute Conditioner

depending on the condition of the paper and the spacing of the sheets in the oven. Both paper and clay should be placed directly in the filter after the drying process as either, if exposed, will absorb considerable moisture from the atmosphere in a very short time.

Each fresh charge of clay will absorb about three gallons of Inerteen. This should be provided for to prevent depleting the supply in the apparatus, but most of this Inerteen may be recovered when changing clay.

This can be accomplished most effectively by removing the used clay from the filter and placing it in a tank of approximately 30 gallons capacity containing about 5 gallons of water. The tank should have a drain valve at its bottom edge and should be tilted somewhat toward this valve. The clay thus placed in water, having a greater affinity for water, will give up the Inerteen it has absorbed and become saturated with water. The Inerteen being heavier than water will sink to the bottom; the clay and water will float on top. After settling for several hours, most of the Inerteen may be drawn off through the valve. This Inerteen may be reconditioned and used again in recharging the conditioner. The used clay should be discarded.

To Prepare the 7 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the tank with activated clay, 4440-3, to within four inches of the bottom edge of 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 thru 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. Open the air discharge valve. 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 a small amount so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. (If Inerteen is admitted too rapidly, it will tend to pack the clay into the top of the tank.) With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge, and drip pan valves.

To begin conditioning Inerteen in Inerteen filled apparatus, open the apparatus valves. Open the conditioner discharge and suction valves. At intervals open air discharge valve to allow trapped air to escape and close when Inerteen starts to flow through valve. Open drip pan valve at intervals too, to remove Inerteen which may have dripped into the drip pan.

When it is necessary to change the clay, first close the valve in the suction line, close the tank

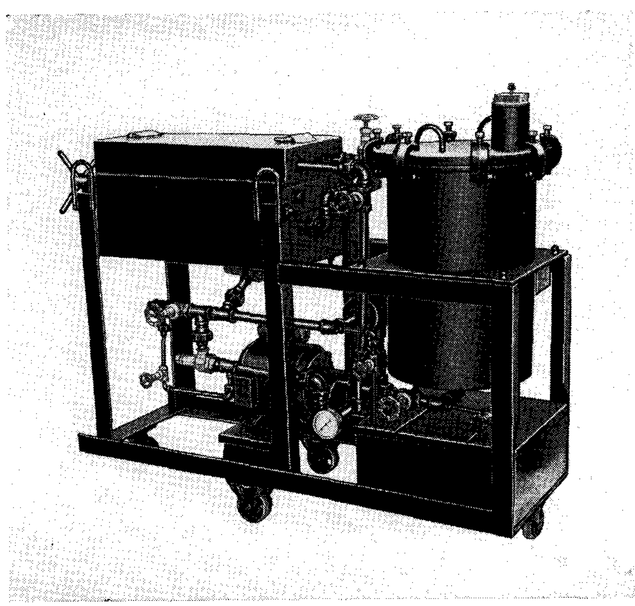


FIG. 6. Seven Gallon-per-Minute Conditioner

inlet and outlet valves, open the tank by-pass valve, the tank drain valve and the air vent 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. 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 and close suction and discharge valves. Slowly back off the pressure screw, permitting the Inerteen trapped in the frames to be released gradually. Then back off the pressure screw completely, open up the press and let the surplus Inerteen drain from the papers. Replace the saturated papers with clean dry paper and retighten the press.

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

To Prepare the 3 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the inner tank with activated clay, 4440-3, to within four inches of the top. Replace screen and cover. Close the discharge and suction valves and open air discharge and drip pan valves about 1/3 open. Start motor and pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons. Not less than five minutes should be required to fill the clay tank and saturate the clay with Inerteen. With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge and drip pan valves.

To begin conditioning Inerteen, open apparatus valves, open the conditioner discharge and suction valves and start motor.

At intervals open air discharge valve to let trapped air escape and close as soon as Inerteen flows from the valve.

When it is necessary to change the clay, first stop motor and close the valves in the suction and discharge lines. Remove discharge hose and open the discharge valve and tank drain valve to permit the Inerteen in the tank and discharge hose to drain into a container. After draining is complete, remove inner tank and dump the clay from the inner tank and refill with fresh clay as previously described. The used clay should be discarded.

BLOTTER FILTER PRESS

The blotter filter press (See Fig. 7) is essentially a number of sets of blotter filter papers in parallel, each set containing several thicknesses. The Inerteen is pumped through filter paper which absorbs the water and strains out the sediment.

Other Classes of Service. Although there are other uses, such as cleaning of low-viscosity insulating compounds, benzine, etc., it is recommended that a cleaning device intended for Inerteen reconditioning should not be used for other classes of work, due to danger of subsequent contamination of the Inerteen.

Capacity. The capacity of these machines, with Inerteen pressure and filtering area fixed, depends on the viscosity of the Inerteen and its freedom from dirt. With fairly clean Inerteen at ordinary room temperature, the capacity of the machines will vary from normal to about 15 percent above normal, depending on the viscosity (which varies with the temperature). It has been found that the best results are obtained when the Inerteen temperature is about 50°C. The average working pressure of these machines is less than 40 psi and the pressure relief valve is set at the factory to by-pass the full flow at from 60 psi to 80 psi.

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

The complete outfit consists of filterpress, motor, strainer, pump, gas trap, pressure gauge, drip pan, wheels, and piping. The piping is arranged so the line can be tested for leaks under pressure. All machines are mounted on a fabricated structural steel frame. The drip pan can be removed by disconnecting one pipe coupling and four bolts. The strainer can be cleaned by disconnecting three bolts. The pumps are of the helical-gear type to insure quietness and smooth flow of Inerteen. The A-30 pump is connected to the motor through flexible couplings. The B-5 and B-10 pumps are mounted directly on the rear motor bracket and driven through a helical reduction gear.

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 Inerteen, 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 Inerteen 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 Inerteen 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 Inerteen.

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 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.

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 Inerteen. The usual procedure is to run the machine for about half an hour (if the Inerteen 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 Inerteen 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 Inerteen is to pump all the Inerteen 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 Inerteen will be clean and dry. If a second tank for holding the Inerteen

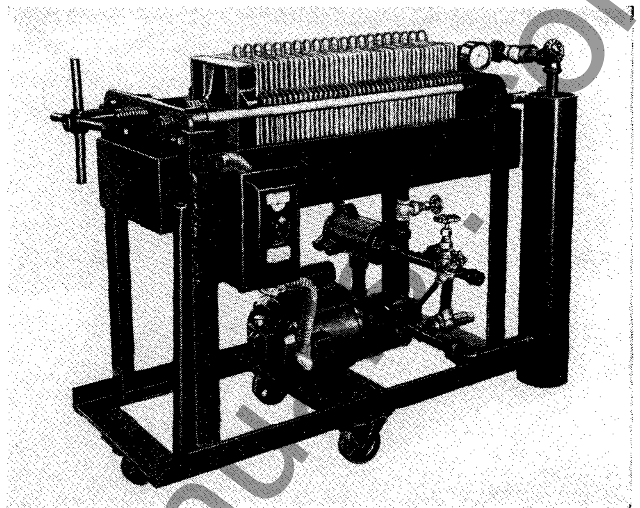


FIG. 7. B-10 Blotter Filter Press

is not available, or if it is desired to filter the Inerteen of apparatus while it is in service, the Inerteen may be pumped from the top of the apparatus tank through the filter and returned to the bottom of the same tank under the surface of the Inerteen. This operation should be continued until the Inerteen in the apparatus tank shows a sufficiently high dielectric strength.

When a large quantity of Inerteen 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.

Filtering through blotter filter papers does not materially reduce organic acidity or improve resistance to emulsification, 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 Inerteen has to be filtered at low temperatures, an additional pump in the pipe line is desirable.

Inerteen in apparatus contaminated by only a small amount of moisture may be reconditioned by drawing the Inerteen from the top of the apparatus tank, passing it through the filter press, and pumping it back into the bottom of the apparatus. The Inerteen should be put through the system until a sample drawn from the top of the apparatus gives satisfactory dielectric values.

Blotter Filter Paper. The filter paper used is a special grade of blotting paper about .025 in. thick; it contains no coloring matter or chemicals which might injure the Inerteen. Five sheets cut to the proper size, 12⅞ in. square for the A sizes and 7¾ 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 Inerteen, 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.

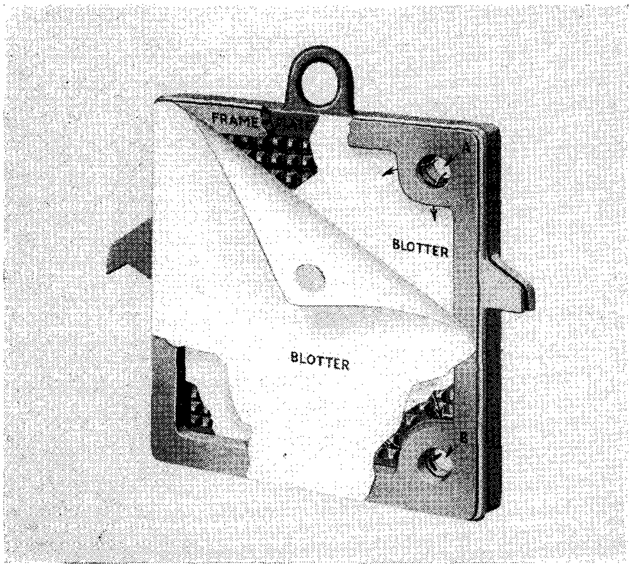


FIG. 8. Blotter Filter Press Frame Showing Blotter Filter Papers in Place

Electric Drying Ovens. Electric drying ovens for use with Type A and Type B filter presses require 2000 watts and 1400 watts respectively. The interior of the ovens is provided with rods for supporting the filter paper to facilitate rapid and thorough drying. 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.

By moving one rod, the Type A oven can be used for drying Type B paper.

The normal capacity of the Type A oven is 240 sheets and the Type B oven is 180 sheets when spaced ¼ inch apart.

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