Installation, Operation and Maintenance Manual for Type VR-1™ Single-Phase, Step Type Regulators

ATTENTION!

Read and understand the information contained in this Instruction Manual before installing/operating/maintaining your Prolec GE Voltage Regulator.

The product covered by this manual must be installed, operated and maintained exclusively by specialized and qualified personnel.

DISTRIBUTION DIVISION

Installation, Operation and Maintenance Manual for Distribution Transformers Single-phase, Step Type Regulators (VR-1).

Capacity	Nominal Voltage	Rated Current	Impedance

Serial Number	Shipping Date	Authorized Signature and Seal

LETTER OF GUARANTEE

Prolec GE USA, LLC guarantees the apparatus specified herein against any defect of Design, Construction, Material and Workmanship.

By this Warranty, we undertake to repair or replace, as necessary, L.A.B. manufactures, all equipment or part of which is found defective within twelve (12) months from the date of energization or eighteen (18) months from the date of shipment, whichever occurs first, and provided that we are given written notice upon discovery of the defect detailing the fault found referred to in the previous paragraph and the circumstances in which it occurred.

This being Warranty against design or manufacturing defects; Our commitment is void in case of improper installation, operation or maintenance, or carried out by unqualified personnel, as well as accidental or fortuitous circumstances, such as the lack of adequate protection of the equipment against over-currents, surges or overloads, atmospheric discharges, fires, mistreatment in transport or maneuver, in addition to not providing evidence of satisfactory results of tests carried out prior to energization, etc.

To maintain the validity of this Warranty, no modifications must be made to the design or characteristics of the equipment, without prior authorization from the factory.

The spare parts, components, consumables and accessories of the product covered by this Warranty, as well as further reports for its claim, can be obtained from the address shown below:

Prolec GE USA, LLC
7000 W. Bert Kouns Industrial Loop
Shreveport, LA 71129
Telephone: (318) 687-6600 Fax: (318) 683-5391

INDEX

1. INTRODUCTION 6
2. RECEIVING 6
2.1 Shipping Damage 6
2.2 Storage 6
2.3 Warranty 6
3. INSTALLATION 6
3.1 Inspecting 6
3.1.1 General 6
3.1.2 Sealed Tank Regulator 7
3.2 Checking Regulator Controls and Control Settings Prior to Energization 8
3.3 Exciting the Regulator High Voltage Windings from an External Supply 9
3.4 Mounting 9
3.5 Surge Protection 10
3.6 Three-Phase Connections 11
3.7 Short-Circuit Rating 11
3.8 Overloading Single-phase Step Voltage Regulators 11
3.9 Power Connections 11
3.10 Connecting into Service 12
3.11 Removing from Service 12
3.12 Test for Phase Sequence 14
3.13 Voltage Regulator for Grounded-Y Circuits 16
3.14 Other Than Rated Voltage 16
3.15 Voltage Regulator PT Ratio 17
3.15.1 Source PT Ratio Test 17
3.15.2 Load PT Ratio Test 18
3.16 Handhole Cover Removal 19
3.17 Handhole Cover Installation 19
4. OPERATION 21
4.1 Control Interface Instructions 21
4.2 Load Bonus Feature 22
4.3 Removing the Indicator Dial Assembly 23
5. MAINTENANCE 23
5.1 Inspecting the Regulator while Energized 23
5.2 Untanking 24
5.3 Replacing the Internal Clamp Bushing 25
5.4 Contact Inspection 26
6. TROUBLE SHOOTING 28
6.1 Control Interface Test Points 28
6.2 Typical Diagrams 34
7. PARTS LIST 38

FIGURES & TABLES

Figure 1. 7
Figure 2. 9
Figure 3. 10
Figure 4. 10
Figure 5. 11
Figure 6. 13
Figure 7. 15
Figure 8. 17
Figure 9. 20
Figure 10. 21
Figure 11. 19
Figure 12. 20
Figure 13. 22
Figure 14. 29
Figure 15. 33
Figure 16. 34
Figure 17. 35
Figure 18. 36
Figure 19. 37
Figure 20. 39
Figure 21. 39
Figure 22. 39
Figure 23. 40
Figure 24. 40
Figure 25. 41
Figure 26. 41
Figure 27. 41
Figure 28. 41
Figure 29. 42
Figure 30. 42

TABLES

Table 1. 8
Table 2. 10
Table 3. 16
Table 4. 22
Table 5. 25
Table 6. 26
Table 7. 27
Table 8. 29

1. INTRODUCTION

The Prolec GE Type VR-1 step voltage regulator (Figure 1.) is essentially a single-phase, regulating autotransformer. A tapped series winding and motor-operated, tap-selector switch afford dependable voltage regulation from 10 percent above to 10 percent below line voltage in thirty-two, 5/8 percent steps.

The VR-1 Regulator is automatically controlled by the Prolec GE VRC GE-2011 or customer specified control module, which responds to changes in the system voltage to initiate the desired tap change.

To help maintain dependable service with minimum maintenance, read these instructions carefully before installing or operating your Prolec GE step voltage regulator.

2. RECEIVING

2.1 Shipping Damage

Immediately upon receipt of the regulator, carefully examine the outside of the equipment to determine any damage or shortage that might have been incurred during transit. If injury or rough handling is evident, file damage claim with the transportation company immediately and notify your Prolec GE respresentative or GE account manager promptly.

2.2 Storing

If the regulator is not installed immediately, store in a clean, dry place.

2.3 Warranty

Your Prolec GE VR-1 regulator warranty shall expire twelve (12) months from the date of energization or eighteen (18) months from date of shipment, whichever occurs first and provided written notice upon discovery of defect.

3. INSTALLATION

3.1 Inspecting

3.1.1 General

Each regulator is shipped completely assembled and filled with the correct amount of oil. The switching mechanism is in the neutral position, and the voltage bandcenter is set for a normal voltage of 120 volts and a 1.5-volt bandwidth.

Carefully inspect the regulator, particularly the porcelain bushings. If there is any evidence or suspicion that moisture has entered the tank, dry the regulator and filter the oil before putting the unit in service. After drying, clean off any dirt or dust inside the tank with dry insulation oil under pressure.

Avoid the use of cottonwaste or similar material, which may become caught in the mechanism. Oil should be visible in the sight gauge at all times.

> *Warning: Static charges can be developed when oil flows in pipes, hoses, and tanks. Oil Leaving a filter press may be charged to over fifty thousand volts (50,000 V). To accelerate dissipation of the charge in the oil, ground the filter press, the tanka nd all the windings (if accessible). Conduction through oil is slow; therefore, it is desirable to maintain these grounds for at least one (1) hour after the oil flow has stopped. Remove explosive gas mixtures from any container into*

which oil is flowing. Arcs can occur from the free surface of the charged oil even though previous grounding precautions have been taken.

3.1.2 Sealed-Tank Regulator

The sealed-tank regulator has a volume of gas, initially air, above the insulating liquid that is sealed from the atmosphere. Normally there is no inward or outward flow of air or moisture with temperature change, so that oxidation of the insulating liquid is held at a minimum. As a result, the dielectric strength of the insulating liquid is maintained at a high value over long period of operation.

Warning: To avoid possible injury, pull ring on pressure relief to manually equalize internal tank pressure before attempting to remove the tank cover, remove the hand hole cover, or take an oil sample.

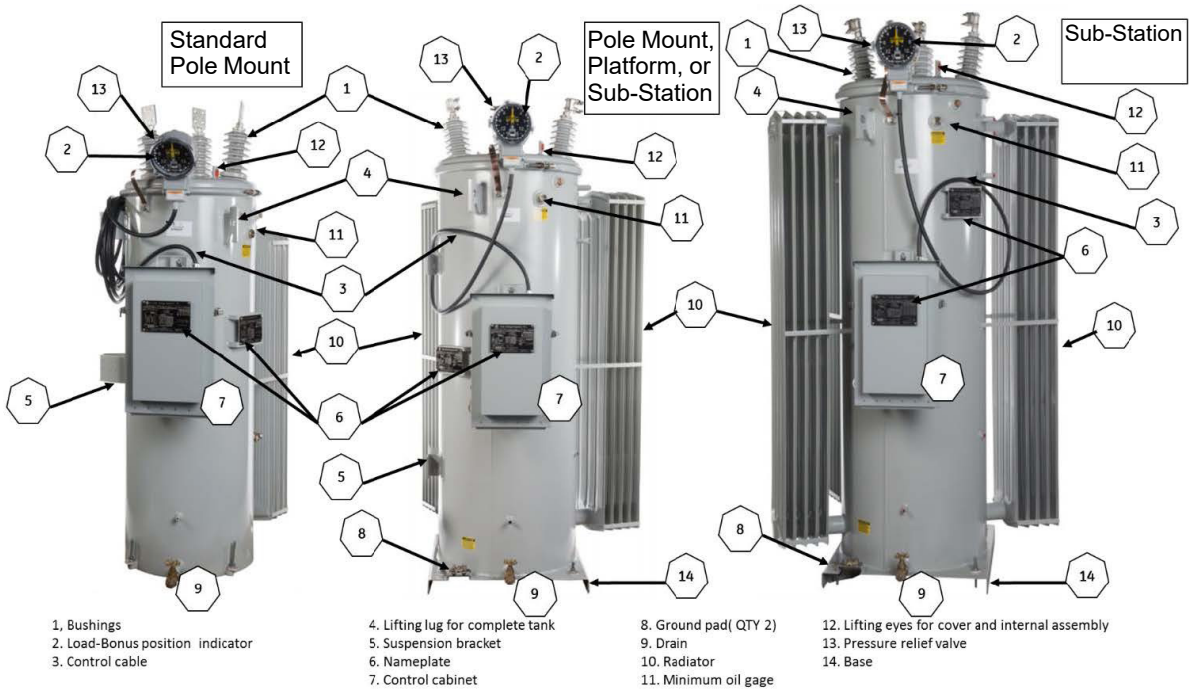


Figure 1. External views of Type VR-1 step voltage regulators

Note: The control cabinet is non-removable if the regulator is energized.

The GE-2011 control and approved third party controls are designed to be removed from the cabinet for service. The current transformer (CT) shorting switch is mounted in the control cabinet and shorts the current transformer when closed. Disconnect the Potential Transformer (PT) power switch moving it to the open position. Disconnect the cable by opening the Molex connection to the control module or the control module cable. The control module can now be removed from the control cabinet hinges.

To remove the control cabinet and cable from voltage regulator:
1. De-energize the voltage regulator
2. Loosen the two captive screws fastening the cable housing to the bottom of the position indicator.
3. Squeeze the top of the ears on the connectors and gently pull them from the mating connector.
4. Loosen the cabinet mounting hardware and remove the control cabinet.

Warning: Do not energize the voltage regulator unless the control cabinet and the current transformer shorting switch is in place.

Check the oil level. Oil must always be visible in the oil sight gauge since the gauge is located at minimum oil level. To determine or adjust the 25°C oil level, remove the handhole cover (after relieving the tank pressure). The 25°C (77°F) level is indicated at the right of the handhole on the inside wall of the tank (looking at the control side of the regulator). Approximate oil level variations either side of the 77°F (25°C) line are 0.2 to 0.25 inches per 10°F change in oil temperature.

If the regulator has been in storage for a considerable length of time, the oil should be tested according to ASTM D-877, with flat disk electrodes, one inch in diameter, spaced 0.1 inch apart.

Filter the oil if the dielectric strength is less than 22 kV. The care of the oil and method of sampling and testing are given in another publication which will be furnished upon request.

3.2 Checking Regulator Controls & Control Settings Prior to Energization

Warning: Short circuit and ground the high voltage terminals of the regulator as a safeguard against dangerous voltage from accidental excitation of the high voltage windings.

All VR-1 regulators equipped with a GE-2011 control are programmed at the factory with the following settings listed in the table below prior to shipment, unless otherwise specified by the customer:

Table 1. Bandcenter, Bandwidth, Time Delay & Line Drop Compensation Set Point Ranges

Function	Set point Range	Increment	Default Setting
Bandcenter	100.0 V - 135.0 V	0.1 V	120 V
Bandwidth	1.0 V - 10 V	0.1 V	2.0 V
Time Delay	5 sec - 120 sec	1 sec	30 sec
Inverse Time Delay	5 sec - 10 sec	1 sec	30 sec
LDC Resistance	-24 V - +24 V	1 V	0 V
LDC Reactance	-24 V -+24 V	1 V	0 V
LDC-Z	0 V - 24 V	1 V	0 V
Output Selection Pulse	Pulsed or Continuous 0 - 12	.1	Pulsed 7

Note: Default set points cannot be changed when, Level 1 password is enabled & not known by the user.

GE 2011 Control operations with external power source:

1. Place the MOTOR CONTROL switch to manual. The RAISE/LOWER switch is spring loaded and will be in the OFF position.

2. Move the VOLTAGE SOURCE switch to EXTERNAL, See Figure 2. This automatically disconnects the internal power to the control. Apply 120 VAC 50/60HZ to the EXTERNAL INPUT terminals. Be sure to connect the low side of the external source to the left terminal (color white) and the hot lead of the external supply to the right terminal (color black).

Caution: Do not apply power to the meter out terminals. Application of power to the meter out terminals can cause a dangerous high voltage on the voltage regulator high voltage terminals located on the tank cover.

3. The control will display a sequence of information such as the control model number, serial number, software version, date, time, and defaults to the Local Voltage, which will be the value of the power supply used to energize the control.

4. Using the UP, DOWN and ENTER buttons: press the UP button until the display indicates 'BIAS VOLTAGE' – TEST MODE – Press the ENTER button. Press the UP button to simulate increasing the voltage input until the LOWER indicator LED comes on. After a couple tap changes, place the MOTOR CONTROL switch to AUTO and after the time delay expires the regulator should then start operating to lower the voltage. Return the MOTOR CONTROL switch to MANUAL. Press the DOWN button to simulate increasing the voltage input until the RAISE indicator comes on. Place the MOTOR CONTROL switch to AUTO and after the time delay expires the regulator should then start operating to lower the voltage. After a couple tap changes, place the MOTOR CONTROL switch to MANUAL.

5. Press the ENTER button to cancel the BIAS VOLTAGE and return to the BIAS VOLTAGE screen in the menu.

6. Place the Motor control switch in the "MANUAL" position and engage the Raise/Lower switch to the "LOWER" position and run the Regulator to the Neutral position.

7. Once the Regulator reaches the Neutral position, the Neutral Light on the adapter panel will illuminate. The yellow pointer on the position indicator should point to "0".

3.3 Exciting the Regulator High Voltage Windings from an External Supply

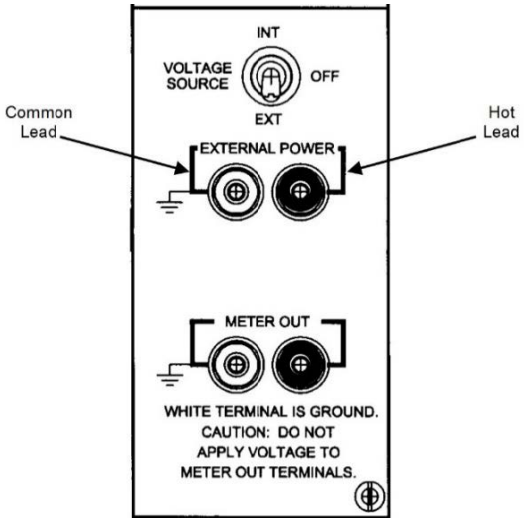


Figure 2. GE 2011 External Power

If it is desired to test the regulator internally in all positions with an external high voltage power supply, an exciting transformer of suitable size should be used. When a transformer with too low kVA rating is used, a noticeable voltage drop may occur in the supply circuit for odd-numbered positions of the regulator. This is caused by the additional exciting current required to excite the reactor in the bridging position. This voltage drop does not indicate any fault within the regulator. If a small exciting transformer must be used as a source of voltage, the correct ratio can be obtained by simultaneously reading the input and output voltage. For checking the voltage ratio, excite the S-SL bushing with 120 volts. Read the output on the L-SL. The exciting current at this level will not cause regulation of the supply.

3.4 Mounting

Mount the regulator on a pole or platform. If the control cabinet is to be separately mounted, run control cable between the indicator plug and the control cabinet. A kit is available for mounting the control cabinet at the base of the pole. For information, consult your Prolec GE representative or GE account manager.

Regulators can be connected into a live circuit if suitable devices, as indicated in Fig. 5, are in the circuit. If they are not provided, de-energize the line before proceeding with the installation.

Thoroughly ground the regulator tank. If the control cabinet is mounted separately, ground it by means of the cabinet ground stud. Connect the bushing terminals to the line in accordance with the applicable arrangement in Fig. 2 and 3. Allow sufficient flexibility in the lead connections to prevent mechanical strains, due to expansions or contractions, which might break the porcelain.

3.5 Surge Protection

Prolec distribution surge arresters (Figure 4.) should be mounted on the source and load side of the regulator to provide the clearance values listed in Table 1. The chart indicates the minimum suggested strike clearance from the line clamp of the arrester to the nearest ground metal. For proper arrester rating, refer to NEMA-LAI-1965, Appendix A, “Selection of Arrester Rating”.

Table 2. Surge Arrester Clearances

Regular Voltage Class (kv-rms)	Minimum Suggested Clearance (mm)
2.5	4 in. (102 mm)
5.0	5 in. (217 mm)
7.62	6 in. (153 mm)
13.8	6 in.(153 mm)
14.4	9.5 in. (242 mm)
20.0	9.5 in. (242 mm)

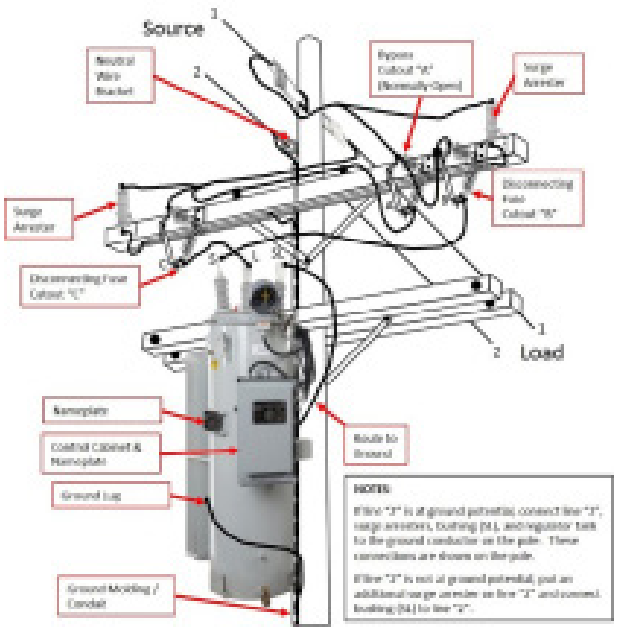


Figure 3. Typical SIngle-Phase Installation

Some installation requirements may necessitate inversion of the standard mounting brackets, which will increase the clearance where necessary. The weld-nuts on the tank are spaced to accept either an EEI-NEMA bracket or a bracket for transformer-mounted arresters.

If the arresters are not mounted on the regulator, they should be installed within 10 feet (3.05 meters) of the regulator and the ground of the arrester should be connected directly to the ground lug of the regulator tank.

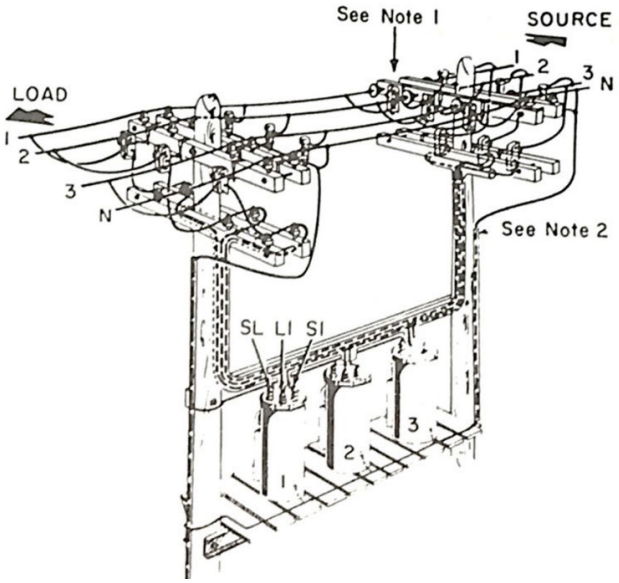


Figure 4. Typical Three-Phase Installation

Additional protection against line surges is provided by ZENOX by-pass protectors, which are mounted inside the tank and connected in parallel with the series windings.

Notes:
1. The three bypass cutouts are mounted on the side of the crossarm toward the installation for clarity of the illustration. Mount these bypass cutouts on the opposite side of the crossarm with the same line connections as shown.
2. Tie surge arrester grounds together and connect to tank ground lug.

3.6 Three-Phase Connections

The line connections for three-phase operations are shown in Figure 4.

Note the Type VR-1 regulator cannot be operated in Y connection with the bank-neutral isolated. When these regulators are Y connected, the neutral of the regulator bank must be effectively connected to the system neutral, preferably by the fourth wire. Without this interconnection, Y connection is hazardous, as the individual and independent voltage control of each phase can cause unequal turn ratios between phases, resulting in shifting of an isolated neutral with extreme distortion of phase voltages.

Figure 5. Distribution Surge Arrester

3.7 Short-Circuit Rating

The impedance of a regulator is practically negligible for reducing short-circuit current. The impedance of the feeder up to the point at which the regulator is installed should be sufficient to limit the short-circuit current in the regulator to the value for which it is designed. It is recommended that feeder current-limiting reactors be installed on the feeder to keep the short-circuit current within the required limits.

Short-circuit rating on any position is 40 times the rated current at +10 percent regulation for 0.8 seconds. For short-circuit duration above 0.8 seconds, the permissible short-circuit current is reduced to keep the product $\mathbf{I^2t}$ product constant. In this formula, **"I"** is the short-circuit current and **"t"** is the time in seconds. For instance, if the regulator is rated 2500 volts, 400 amperes, at +10 percent regulation, $\mathbf{I^2t} = (400 \times 40)^2 \times 0.8 = \mathbf{205 \times 10^6}$. For a short-circuit duration of 2 seconds, $2I^2 = \mathbf{205 \times 10^6}$ and I = 10,100 amperes.

3.8 Overloading Single-phase Step Voltage Regulators

The regulator can be overloaded in accordance with the ANSI Guide for Loading Step Voltage Regulators, Appendix C57.95-1984.

3.9 Power Connections

The Type VR-1 single-phase step voltage regulator may be connected in single or three-phase circuits in accordance with the connections shown in Figure 5. For these connections, proper grounds, surge arresters and bypass switching devices suitable for the line current are used. The regulator must also be on the neutral position. Before proceeding, the following precautions are necessary:

1. Regulator must be permanently grounded using grounding provision. Do not remove ground conductor while the regulator is energized. Grounding conductor size should be in accordance with National Electrical Code requirements.

2. To avoid damage to windings, the bypass switch "A" must never be closed with load current flowing through the regulator unless the regulator is first brought to the neutral position and the control power turned OFF. In closed delta banks:

    a. All three regulators must be operated to the neutral position.
    b. The control power turned OFF
    c. All units bypassed before removal of any unit from service.

3. Device "D" must always be closed first when connecting the regulator into service and opened last when removing the regulator from service to prevent possible injury to personnel or damage to the regulator due to abnormal voltage peaks.

3.10 Connecting Into Service

Note: If your regulator is for a 24940-GRDY/14400 or 34500GRDY/19920 volt circuit, read the instructions under section entitled "REGULATOR FOR GROUNDED-Y CIRCUITS" carefully before installing.

Warning: High Voltage-Current Transformer Circuitry. Do not disconnect the connectors inside this cover unless the Voltage Regulator is de-energized.

Warning: Do not bypass the voltage regulator unless the neutral position is verified by the neutral indicator light.

The instructions for *CONNECTING INTO SERVICE* and *REMOVING FROM SERVICE* without interrupting the load are given in detail below. Refer to the connection shown in Figure 6.

1. By-pass switch "A" in series with the line should be closed, and load "C" and "D" and source "B" disconnect switches should be open.
2. Close load (SL) disconnect switch "D" first.
3. Close source (S) disconnect switch "B".
4. GE-2011 Control Instructions (see GEH-7298 for detailed operation instructions):

   a. Place the power supply switch to INTERNAL (see Note 1, Fig. 6).

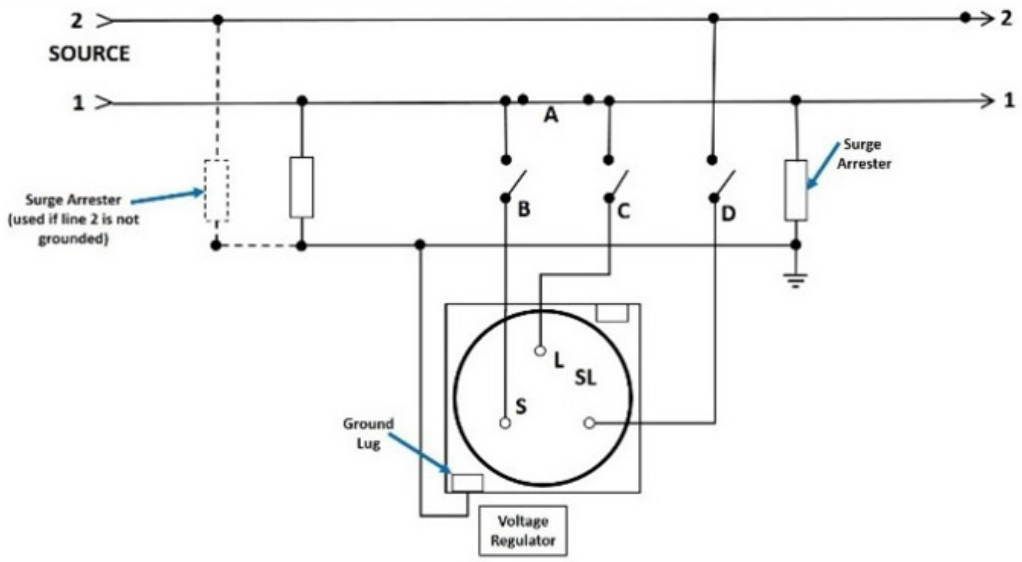
   b. Place the motor control switch to MANUAL.
   c. Initiate the control switch to RAISE or LOWER to operate the regulator switch mechanism to NEUTRAL (position "0") as shown on the position indicator. The NEUTRAL position lamp mounted on the adapter panel will light (see Note 1, Fig. 6). Return the control switch to the OFF position.

   d. Place the INTERNAL/EXTERNAL power switch to OFF.
5. Close load disconnect switch "C".
6. Open by-pass switch "A".
7. Visually check the bandcenter, bandwidth and time-delay settings.
8. Visually check the line drop compensation settings.
9. Place the power supply switch to INTERNAL.
10. Place the motor control switch to AUTO.

3.11 Removing from Service

1. Operate the regulator switch mechanism to NEUTRAL (position "0") as shown on the position indicator. The NEUTRAL position lamp mounted on the circuit board will light. In closed delta banks, all three regulators must be moved to NEUTRAL position.
2. Turn the control power OFF. In delta hook-ups, turn all controls OFF.
3. Close by-pass switch "A". In delta banks, by-pass all three units.
4. Open load disconnect switch "C" and then open source "B".
5. Open disconnect switch "D" last.

Warning: Do not use any automatic circuit opening elements between the line and the SL bushing, such as: fuses, cutouts or circuit breakers. This connection should never be opened unless the regulator is in the neutral position. When the connection to the SL bushing is open, the regulator acts as a current transformer with an open circuit secondary. Dangerous voltages are induced in the series windings if any load current flows in the series winding.



A. One voltage regulator, single phase circuit

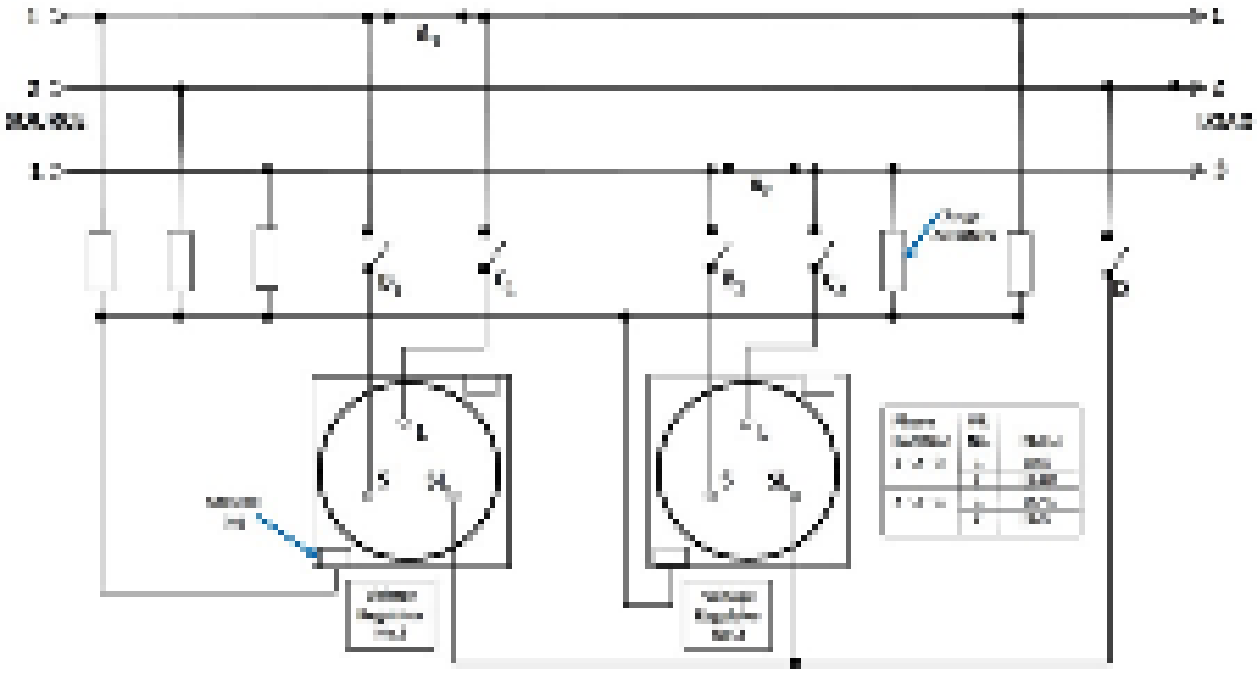


Figure 6. Regulator Connections (6A & 6B)

Notes:

1. The control power and Internal-Off-External, function (not shown) is located on the regulator control adapter panel. Refer to the control instruction book for location of the switches detailed in the placing into service and removing from service procedures.

2. Bypass switch "A" and disconnect switches "B"', "C", and "D" must be suitable for interrupting magnetizing current.

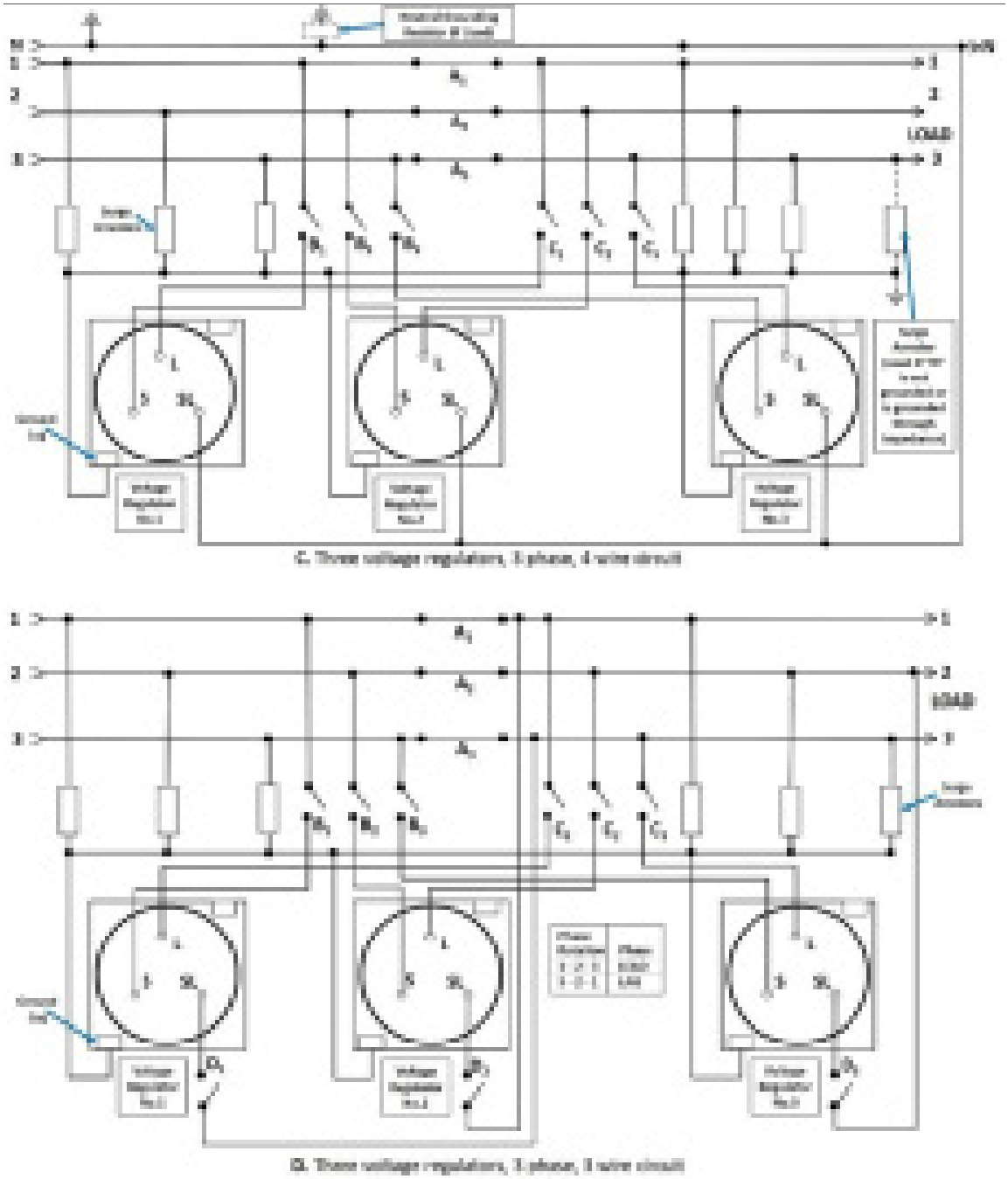


Figure 6. Regulator Connections (6C & 6D) continued

3.12 Test for Phase Sequence

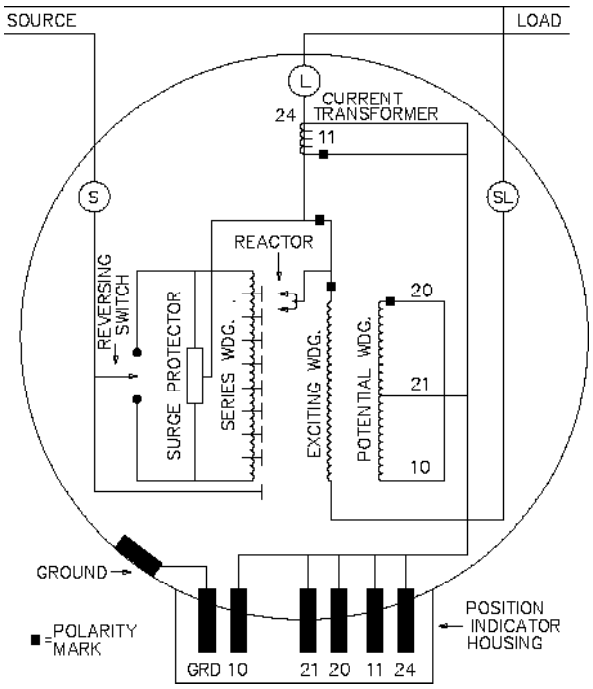
For a known system of phase rotation, the regulators carrying the leading or lagging currents can be determined as shown in Figs. 6B and 6D.

If the system phase sequence is not known, use the following method of obtaining the proper phase relationship. The test should be made when the regulators are carrying appreciable load.

For two regulators in an open delta system:

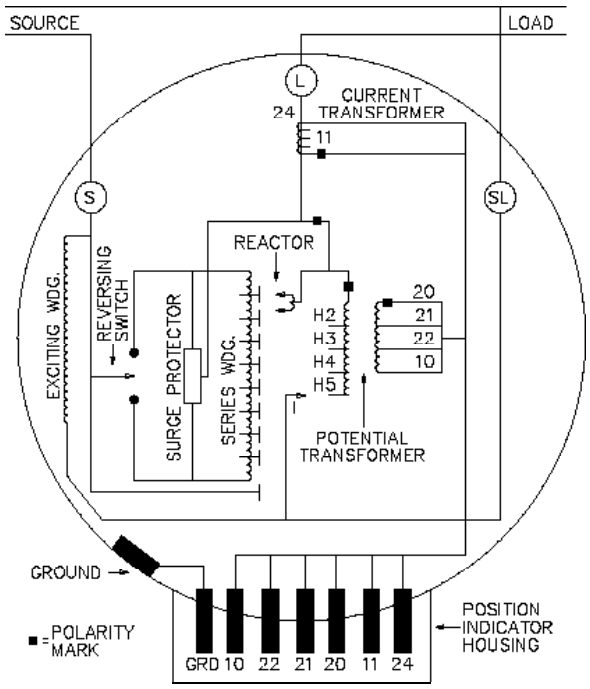
1. Connect the regulators for normal open delta operation. See Figure 6B.
2. Set the motor control switch to AUTO.
3. Set the resistance (R) and reactance (X) adjustments on the line drop compensators of both units to zero.
4. Set the voltage level on each unit to 120 volts.
5. Set “X” on each regulator to 10 volts, leaving “R” on zero. Place the LDC ON/OFF switch to ON. Measure the output voltages of each regulator after the mechanism has operated to bring the voltage control to a balance condition (both band and edge indicators are OFF).
6. The regulator with the higher output voltage near the maximum raise position, as observed on the position indicator, is in the lagging phase; the other is on the leading phase.

For three single-phase regulators connected in a delta bank (Fig. 6D) carrying nearly balanced load and power factor of better than 80 percent, proceed with steps 2,3,4, and 5 as described above. If all three regulators raise their voltages, they carry lagging currents. Otherwise, if all three regulators lower their voltages, they carry leading currents.



Catalog Numbers: 33D7072 through 7720
8050 through 8667
3025, 3050, 3075
4025, 4050
5038
6069

Figure 7A. Schematic diagram showing connections of regulator for load excited units



Catalog Numbers: 33D3100 through 3167
4100 through 4333
5076 through 5509
6138, 6274
8833

Figure 7B. Schematic diagram showing connections of regulator for source excited units

Figure 7. Voltage Regulator Winding Arrangements

3.13 Voltage Regulator for Grounded-Y Circuits

The step voltage regulator rated 19920/34500 volts is designed for use on 34500 grounded-Y circuits. This regulator is designed with two 150 kV BIL class line bushings (S and L). The neutral is brought to a 95 kV BIL bushing (SL).

Regulators rated 14400/24940 volts are designed for use on either 14400 delta or 24940 grounded-Y circuits. A tap is provided for operation at 7200 volts delta or 12470 Y operation at reduced capacity. The current rating of the regulator must not be exceeded when operating at the lower voltages.

The regulator is designed with two 150 kV BIL line bushings (S and L) and a 95 kV BIL neutral bushing (SL).

When operating on a 25 kV or 34.5 kV circuit, the SL bushing must be solidly grounded or grounded through an impedance that will limit the low frequency and impulse from neutral to ground to 95 kV BIL.

3.14 Other Than Rated Voltage

All regulators, except those of the 19920-volt rating, are provided with taps on the potential transformer for reduced voltage operation. These taps make it possible to obtain the proper voltage for the control circuit. When operated at other than rated voltage, the regulator k VA must be reduced unless otherwise specified on the nameplate.

Except for certain operating voltages for 7620-volt regulators, all ratios of potential transformers may be changed by changing the connection of jumpers on the power disconnect circuit board located in the upper right hand corner of the control cabinet. Other connections are to be changed inside the regulator tank. For proper connections, see the regulator nameplate.

Table 3. Standard Potential Ratios

Rated Voltages	Operating Voltages	Potential Ratios	Voltage Levels of Voltage Sensors
2500/4330Y	2500 2400	20.8:1 20:1	120 120
5000/8660Y	5000 4800 2500	41.7:1 40:1 20.8:1	120 120 120
7620/13200Y	7960 7620 7200 5000 4800 4330 4160 2500 2400	66.3:1 63.5:1 60:1 47.7:1 40:1 36.1:1 34.7:1 20.8:1 20:1	120 120 120 120* 120* 120* 120* 120* 120*
13800	13800 13200 12000	115:1 110:1 100:1	120 120 120
14400/24940Y	14400 7200	120:1 60:1	120 120
34500Y/19920	19920	166:1	120

**Taps are not provided on voltage regulators rated less than 75 kVa*

When it becomes necessary to change potential transformer connections inside the tank, this can be accomplished by reaching through the handhole and changing the connection at the potential-transformer terminal board (see Fig. 8). The lead connection is of the quick-disconnect bayonet type, and reconnection can be easily made by pulling the lead off the terminal board terminal and pushing the lead receptacle onto the desired blade. The terminal board is clearly stamped to identify the potential transformer leads.

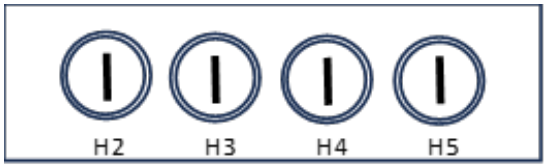


Figure 8. Potential Transformer Terminal Board Hand-Hole Opening View

3.15 Voltage Regulator PT Ratio

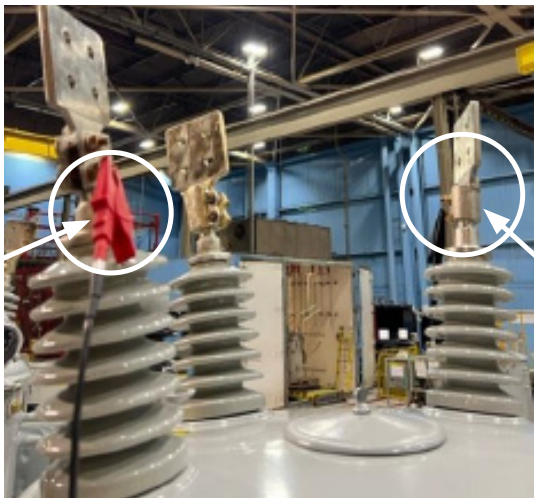
3.15.1 Source PT Ratio Test

The regulator must be de-energized and in the Neutral position prior to performing ratio test. Instructions are written for DTR Model 8510 single-phase tester (3-Phase TTR can also be used however, the test lead color will vary).

- Connect the red Lead (H1) to the Source (S) bushing and the black Lead (H2) to the Source-Load (SL) bushing.
- Open the control cabinet door, using the thumb screw, unlatch control module from door jam to access the knife switches located in bottom left of cabinet.
- Connect Black lead (X2) to Ground stud and the red Lead (X1) to the top terminal of the knife switch labeled “Source”.

The tested ratio value should coincide with the “Pot Ratio” - shown adjacent to the voltage setting identified with the white pin on the nameplate. For example, if the unit was shipped connected for 7200 V, the white pin would be inserted in the hole adjacent to 7200 V on the nameplate and the “Pot Ratio” will be 60:1 (If correct ratio is not obtained, check HV tap setting inside the tank – refer to Step-Voltage Regulator Nameplate.

Red Lead (H1) connection to Source (S) Bushing



Black Lead (H2) connection to Source-Load (SL) Bushing

3.15.2 Load PT Ratio Test

Regulator must be de-energized and in the Neutral position prior to performing ratio test. Instructions are written for DTR Model 8510 single-phase tester (3-Phase TTR can also be used however, the test lead color will vary).

- Connect the red Lead (H1) to the Load (L) bushing, and the black Lead (H2) to the Source-Load (SL) bushing.
- Open the control cabinet door, using the thumb screw, unlatch control module from door jam to access the knife switches located in bottom left of cabinet.
- Connect black Lead (X2) to Ground stud, and the red Lead (X1) to the top terminal of the knife switch labeled “Load”.

The tested ratio value should coincide with the “Pot Ratio” shown adjacent to the voltage setting identified by the white pin on the nameplate. For example, if the unit was shipped connected for 7200V, the white pin would be inserted in the hole adjacent to 7200V on the nameplate and the “Pot Ratio” will be 60:1. (If correct ratio is not obtained, check HV tap setting inside the tank – refer to Step-Voltage Regulator Nameplate on page 20.

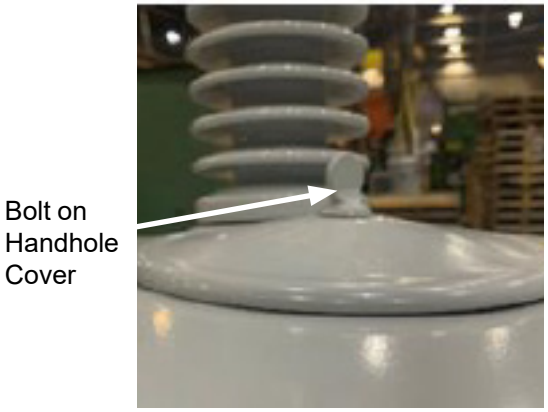
Red Lead (H1) connection to Load (L) Bushing

Black Lead (H2) connection to Source-Load (SL) Bushing

3.16 Handhole Cover Removal

Regulator must be de-energized prior to removing the handhole cover. Make sure the cover is dry and free of dirt or debris.

- Release the internal pressure using the pull-ring on pressure relief device located on the position indicator support.
- Using a 10” crescent wrench, loosen the bolt until the handhole cover freely moves.
- Lift up on the Handhole cover and slide to one side to free the channel that secures it to the main cover.
- Once the handhole cover is removed, you will have access to the High Voltage taps for the Source & Load PT (See nameplate on following page).

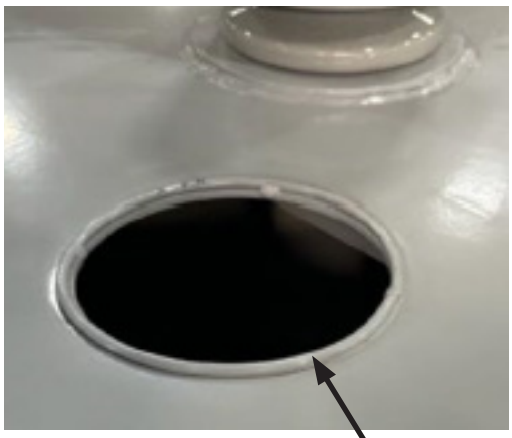


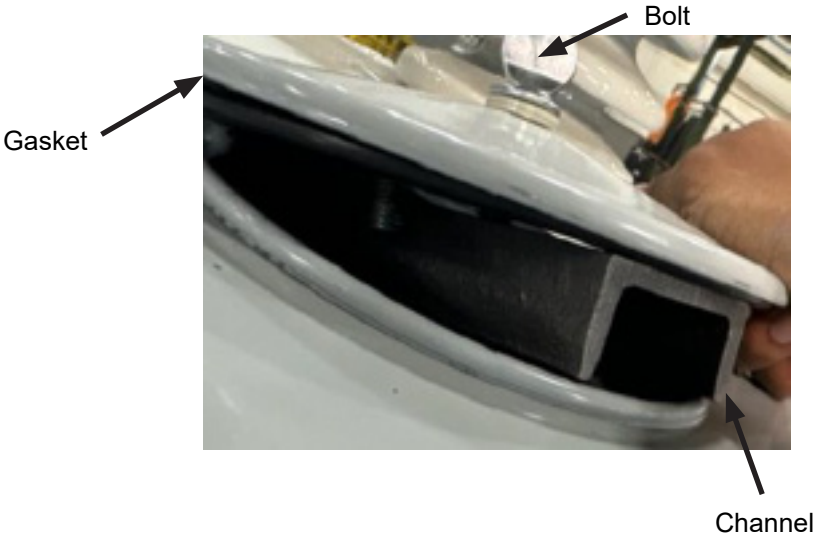
Pull-Ring on Pressure Relief Device

3.17 Handhole Cover Installation

To install the handhole cover, follow steps listed below:

1. Make sure that the main cover is dry and free of oil, dirt or debris.
2. Insert channel into handhole and make sure that gasket is seated outside of the gasket retaining ring.
3. Using a torque wrench, torque bolt to 110 – 120 inch-lbs.





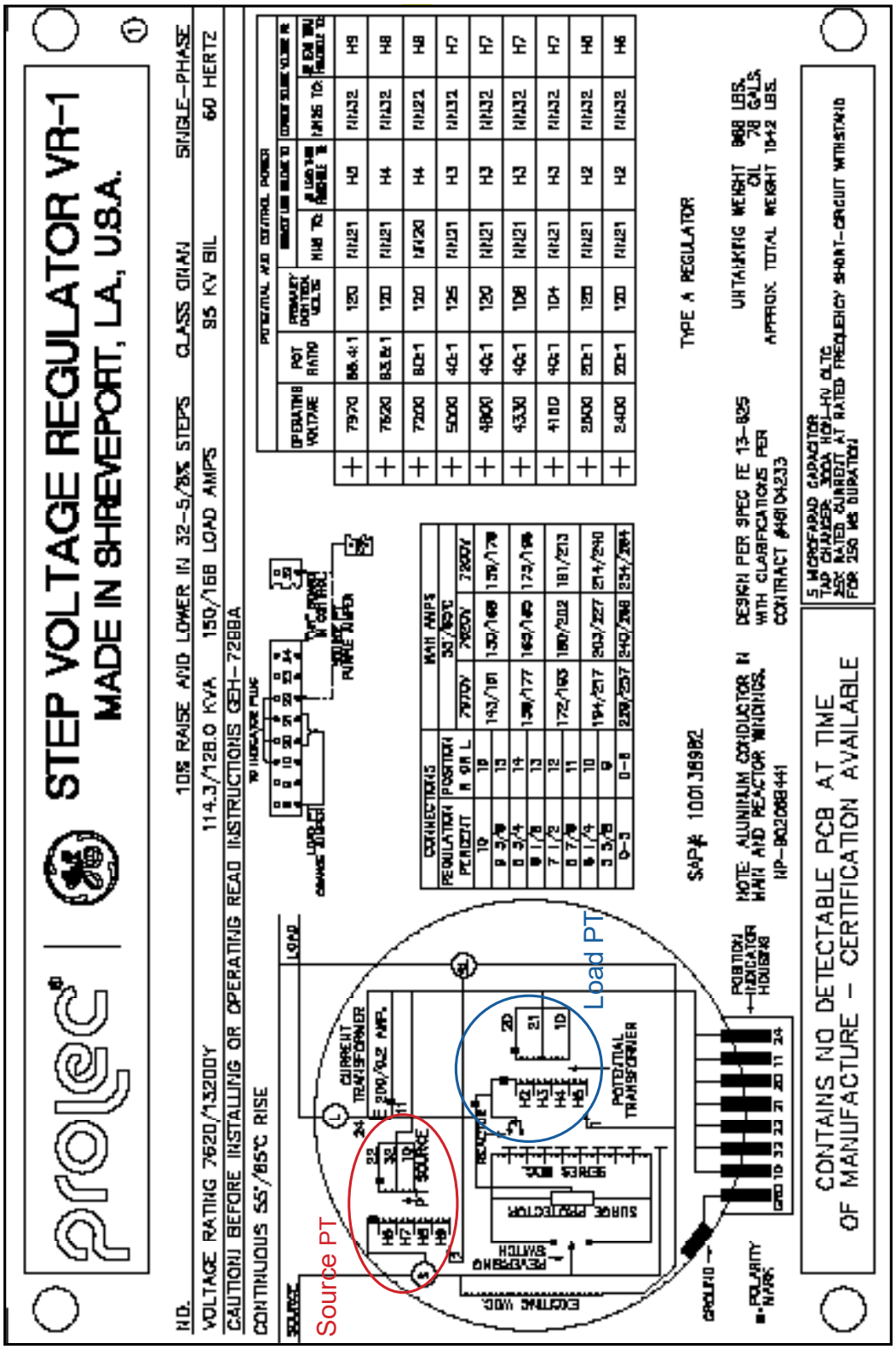


Figure 9. Nameplate - Step Voltage Regulator Type A

4. OPERATION

4.1 Control Interface Instructions

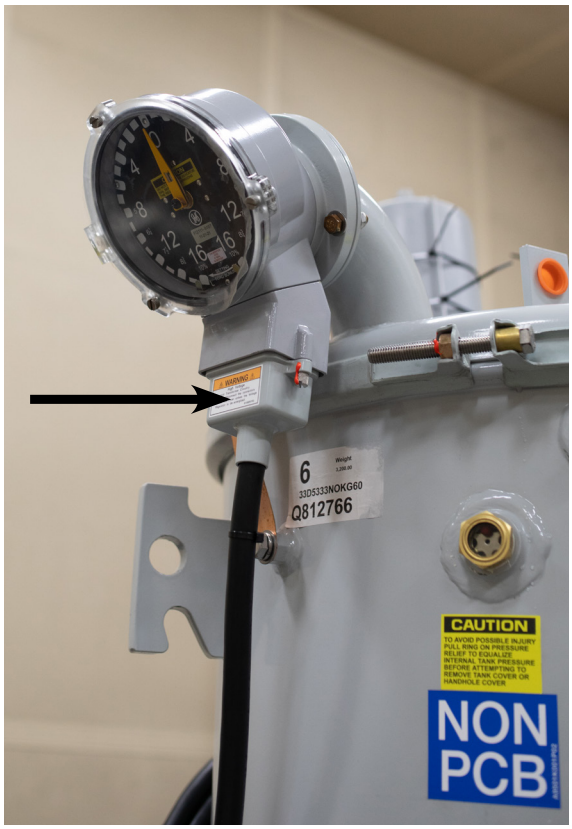


Figure 10. Control Interface

Warning: High Voltage – Current Transformer circuitry. Do not disconnect the electrical connections inside the housing at the bottom of the position indicator unless the voltage regulator is de-energized.

Caution: High Voltage -- Current Transformer circuitry. Do not energize the voltage regulator unless the control and the current transformer shorting device in the control are connected.

The control cabinet is designed to remain in place for service of the electronic control. A disconnect switch mounted in the control cabinet short circuits the current transformer when the switch is closed.

1. To de-energize the electronic control, open the PT switch and close the CT shorting switch.
2. Disconnect the blue plug from the control module by pressing the extraction levers on each side.
3. Using a Phillips head screwdriver, remove the four screws that are used to attach the control module to the adapter panel.

Note: The current transformer is shorted when the CT shorting switch is closed. (See diagram 0305E100 sheet 1).

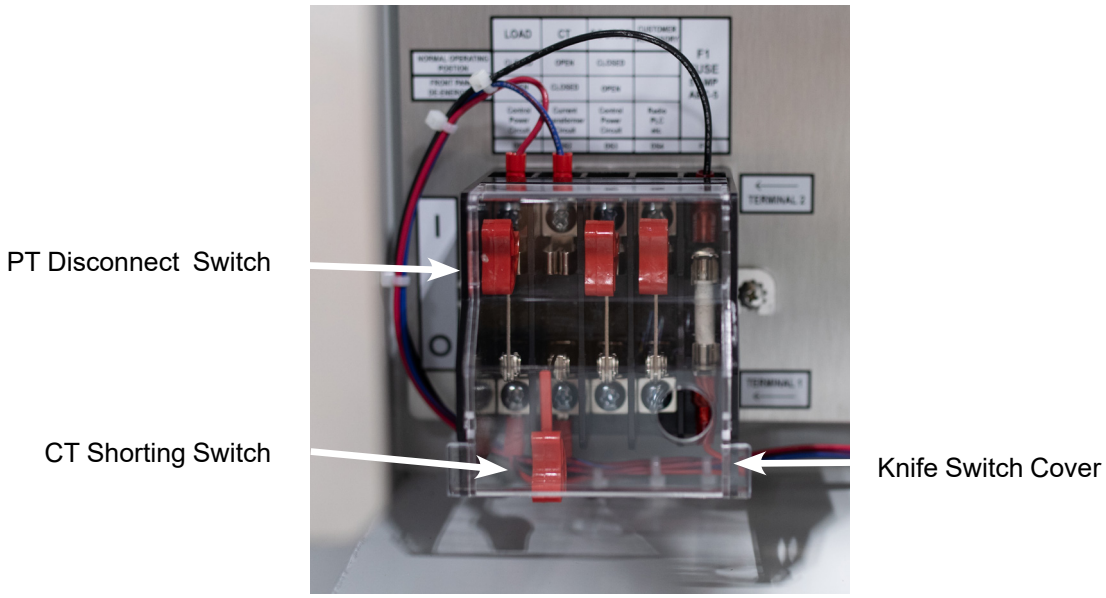


Figure 11. CT Shorting Switch & PT Disconnect Switch

Warning: Exposed Electrical Connections. Do not touch any exposed electrical connections unless the voltage regulator is de-energized or insulated tools or gloves are used. See instruction book for procedure to de-energize voltage regulator.

4.2 Load Bonus Feature

The load-bonus feature provides a means of operating the regulator at increased load by decreasing the range of regulation in 1 ¼ percent steps. Load current may be increased up to 160 percent of rated current when operated at ± 5 percent regulation (with a limit of 668 amperes). Percentages of current ratings for various ranges of regulation are:

Table 4. Percentages of Current Ratings for Various Ranges of Voltage Regulation

Range of Voltage	10	8.75	7.5	6.26	5
Current Rating	100	110	120	135	160

Refer to nameplate for current ratings at load-bonus settings. To make adjustments, set the limit switches to the desired regulation range by lifting the knob and moving it to the desired setting (Figure 12.).

Note: The regulator does not need to be de-energized when making regulation adjustments.

To reset the drag hands on the load-bonus position indicator, press the drag-hand reset button on the drag- hand reset button on the lower left corner of the GE-2994 Adapter Panel. Drag hands will reset automatically.

Figure 12. Load-Bonus Position Indicator

4.3 Removing the Indicator Dial Assembly

Warning: Do not remove the indicator dial before deenergizing the regulator.

With the regulator on Neutral, loosen the three screws and open the indicator-glass assembly. Remove the three self-tapping screws located on the outside perimeter of the dial face. Carefully pull out the dial assembly which contains the pointer, drag-hand assemblies, and limit switches. The operation counter switch and drag-hand solenoid will be exposed when the dial assembly is removed. To remove the dial assembly completely, remove the flag terminals from the limit switches and disconnect the leads to the solenoid.

After the dial assembly has been replaced, the indicator pointer should be centered on “0”. To do this, attach one end of the flexible shaft to the indicator. Temporarily detach the bottom end of the flexible shaft from the mechanism. Rotate the flexible shaft to “zero-in” the pointer.

5. MAINTENANCE

5.1 Inspecting the Regulator while Energized

At regular intervals, as determined by service, inspect the regulator to make sure it is operating properly and to detect and correct any trouble which may interfere with efficient service.

To check the operation, it is not necessary to untank the regulator. Run the regulator to its “Raise” and “Lower” limit positions by using the manual control switch to test the limit switches.

By manual control, run the regulator in either direction a few steps then turn regulator back to AUTO to check the voltage sensor. After a time delay (30 seconds as set by factory), the tap selector will operate and come to rest.
The devices in the control cabinet require very little maintenance.

Caution: If the electronic control panel is to be removed from the control cabinet for service, the control panel should be de-energized by opening the PT disconnect switch and closing the CT shorting switch located in the cabinet.

5.2 Untanking

Warning: De-energize the regulator before untanking.

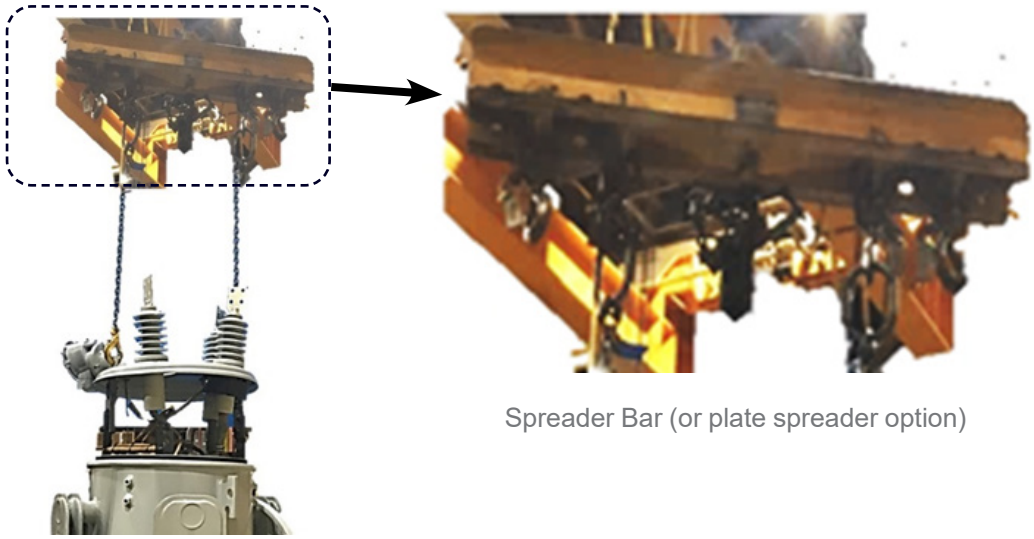
Warning: To avoid possible injury, pull ring on pressure relief to equalize internal tank pressure before attempting to remove tank cover or handhole cover.

To untank the regulator, proceed as follows:

1. Release the internal pressure using the pull-ring on the pressure relief and remove the cover band.
2. Remove the bolts holding the control housing support to the tank wall. They are located just below the control housing.
3. Lift the cover-suspended regulator from tank, using the lifting eyes on the top of the cover. The use of a spreader bar is recommended. See Figure 13.

After untanking the regulator, the switch mechanism can be operated through the control circuit.

Warning: Before applying power to operate the mechanism, short-circuit and ground the bushings as a safeguard against dangerous voltages from accidental excitation of the high voltage windings.



Spreader Bar (or plate spreader option)

Cover Connections

Figure 13. Recommended Un-tanking Type VR-1 Step Voltage Regulator, showing use of Tank Spreader Bar when lifting Interior & Cover.

Caution: Exposure to atmosphere is occasionally necessary to untank regulators for maintenance. The following rules must be applied.

1. Internal assemblies may be exposed to the atmostphere for a maximim of eight hours without requiring re-baking.
2. Internal assemblies exposed to the atmostphere for more than eight hours must be re-baked for a minimum of 14 hours at 110°C.
3. After re-baking, return the internal assemblies to the tank, and flood the tank with oil within two hours.
4. No more than two re-bakes should be allowed in any event. Total re-bakes time should never exceed 32 hours at 110°C.
5. If facilities are available, it is recommended that the units be oil-filled under vacuum.

To operate the mechanism, move the power supply switch to the "OFF" position. This will automatically disconnect the internal power to the control. Then connect an external power source of 120 volts, 60 HZ to the VOLTAGE IN terminals and move the power supply switch to the EXTERNAL position. By placing the motor control switch to MANUAL, the mechanism can now be operated in either the RAISE or LOWER direction. The minimum oil level is indicated in the oil sight gauge.

When retanking the cover-suspended internal assembly, proceed as follows:

1. Rotate the assembly to the approximate tanking position by noting the location of the control housing hold down bolts.
2. After the internal assembly is lowered into place, tap the cover with a rubber hammer around the edge to properly seal the gasket while tightening the cover band.
3. Bolt the control housing support to the tank wall.

A punch mark identified "25°C LEVEL" is located on the inside of the tank wall in the area of the L and SL bushings. The level at 25°C (77°F) can be observed through the handhole opening from the indicator side above the cover. Check the dielectric strength of the oil. If 22 kV or below, filter the oil to restore the dielectric strength to 26 kV or more.

5.3 Replacing the Internal Clamp Bushing

Release any internal pressure before removing the cover band and bottom control support bolts. Remove the bushing terminal cap. Lift the regulator internal-and-cover assembly (using the cover lifting eyes) approximately 18 inches.

As a safety measure for working under a suspended load, slide a round, steel bar through the large holes in the two upright angles. The bar length should be long enough to extend several inches beyond the tank rim. The suggested bar diameters are as follows:

Table 5. Untanking Support Bar Diameters

Tank Diameter (In.)	Bar Diameter (in.)
19, 21	0.750
24, 25.5	0.875
28	1.00

Loosen the three screws on the holder and remove the garter spring. The porcelain can then be removed from the cover. Replace the bushing porcelain, spring, and holder. Torque the screws to 25 - 45 in-lbs. Equalize the torque on all three screws.

5.4 Contact Inspection

Table 7 is given as a guide for inspecting the contacts of the regulator based on minimum life. It should be used for the first inspection. It is recognized that many variables affect the contact life such as load factor, overload, service, short circuit, etc.

Total contact life can be determined after this inspection based on the amount of arcing material left in proportion to that which has been eroded.

Refer to the regulator nameplate for the rating; then determine the contact inspection point from Figure 14.

On the same basis, other VR-1 regulators rated less than 100 kVA and not appearing in Table 7 can operate in excess of 1 million tap changes before inspection is required. This equates to more than 25 years for normal service. Variables affecting contact life must be considered.

The moving contacts and the tips of the stationary contacts are made of an arc-resistant material as shown in Sketch A., Figure 14. Note dimensions in Table 6.

Normal contact wear will produce a contact erosion. (See Sketch B., Figure 14.)

The contacts are satisfactory for service until either the stationary or moving contacts are worn to the condition shown in Sketch C., Figure 14., at which time the entire set of stationary and moving contacts must be replaced.

Table 6. Arconite Dimensions in Inches (mm) on Stationary Contacts
Reference Number R2033

Switch	T	L
Low Current	0.188 (4.8)	0.125 (3.2)
Mid Current	0.250 (6.4)	0.156 (4)
High Current & High Voltage	0.250 (6.4)	0.188 (4.8)

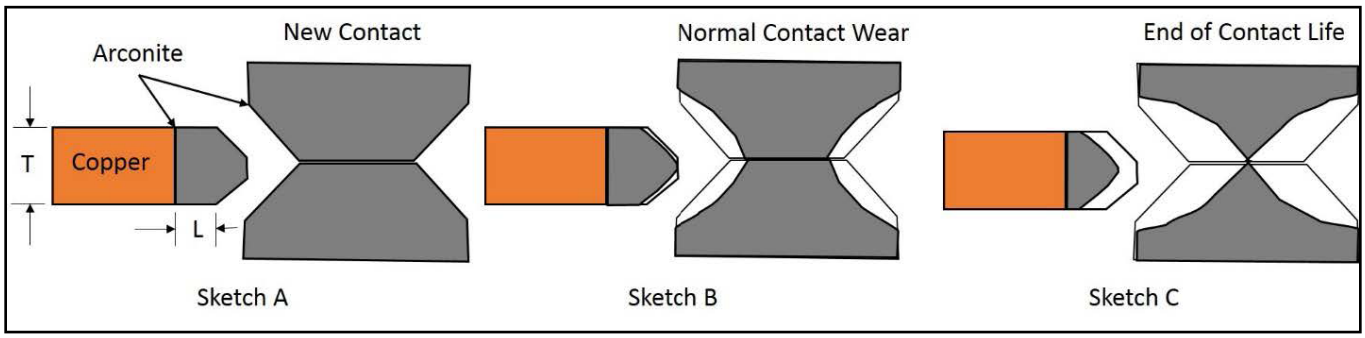


Figure 14. Contact Wear (See Tables 6 and 7)

Table 7. Expected Minimum Number of Operations

kVA	VOLTS	AMP	LIFE	INSPECT	SWITCH SIZE
100	2500	400	1950000	1450000	HC
100	5000	200	2000000	1500000	MC
100	19920	50	2000000	1500000	HV
114.3	7620	150	600000	450000	LC
125	2500	500	1100000	840000	HC
125	5000	250	2000000	1500000	MC
138	13800	100	1250000	960000	LC
144	14400	100	2000000	1500000	HV
167	2500	668	620000	460000	HC
167	5000	334	1300000	1000000	HC
167	7620	219	1100000	830000	MC
200	19920	100	2000000	1500000	HV
207	13800	150	2000000	1500000	HC
250	5000	500	560000	420000	HC
250	7620	328	930000	700000	HC
276	13800	200	1350000	1000000	HC
288	14400	200	1100000	830000	HV
333	5000	668	310000	230000	HC
333	7620	437	550000	410000	HC
333	14400	230	740000	560000	HV
333	19920	167	1150000	870000	HV
400	19920	200	850000	640000	HV
414	138000	300	660000	490000	HC
416	7620	546	310000	230000	HC
416	14400	289	540000	410000	HV
432	14400	300	510000	380000	HV
500	14400	347	230000	170000	HV
509	7620	668	180000	130000	HC
576	14400	400	230000	170000	HV

Compiled with reference to actual contact life tests of several selected ratings.

LC = Low Current Switch
MC = Mid Current Switch
HC = High Current Switch
HV = High Voltage Switch

On the same basis, other VR-1 regulators rated less than 100 kVA and not shown in Table 7 can operate in excess of 1,000,000 tap changes before inspection is required. This is typically more than 25 years for normal service. Again, many variables affecting contact life must also be considered.

6. TROUBLE SHOOTING

6.1 Control Interface Test Points

Besides the general precautions to be taken when troubleshooting electrical apparatus, there are also the following precautions which are particular to the static control.

Warning:

1. TROUBLESHOOTING entails working with energized equipment, caution should be taken to avoid personal shock.

2. Discharge capacitors by short circuiting terminals or leads before reconnecting any circuit.

3. Before disconnecting any plug connection in the control panel, de-energize the control by opening the PT disconnect switch and closing the CT shorting switch located in the bottom left corner of the control box.

4. High Voltage—Current transformer circuitry. Do not disconnect the connectors inside this control cabinet cover unless the voltage regulator is de-energized.

5. If an external power supply is used for testing the control, remove this power supply before switching to internal power supply.

6. Short-circuit the current transformer secondary's. If left open-circuited, current transformers develop secondary voltages hazardous to personnel.

7. Do not remove the indicator dial before de-energizing the voltage regulator.

Within the chart, when necessary, these warnings are repeated to further emphasize their significance.

Table 8. Trouble Shooting Chart

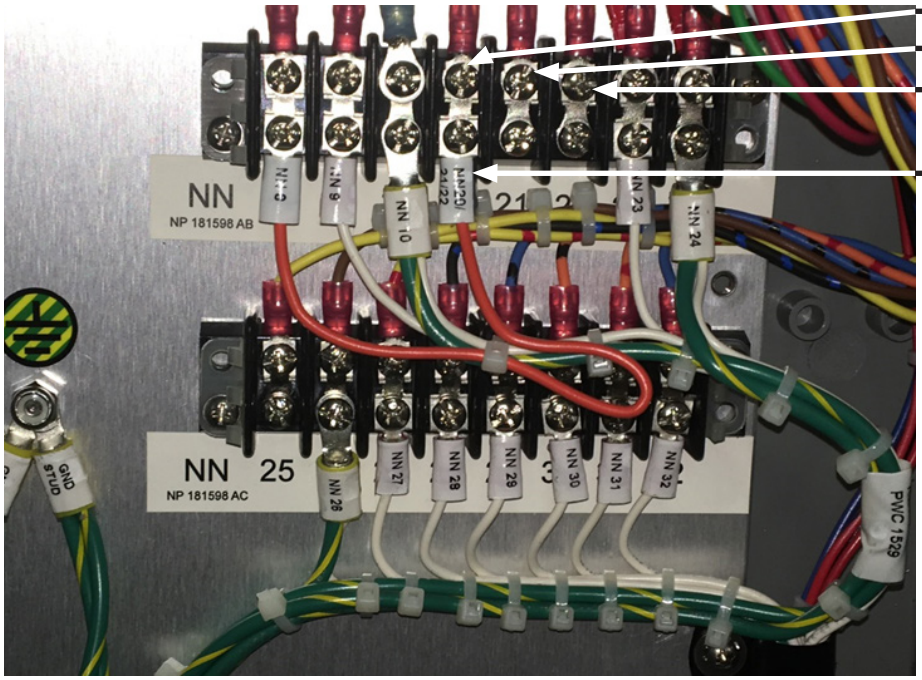
Trouble	Cause	Remedy
Regulator will not operate either automatically or manually or remains in maximum lower or maximum raise position.	Loss of sensing signal from the regulator.	Check for control sensing voltage at the voltage test terminals on the front of the control panel with an AC voltmeter. If no voltage occurs at this point, either the external power supply switch or the circuit breaker is defective. Check for sensing voltage between NN-9 and NN-10. If no voltage appears at these terminals, refer to nameplate for proper jumper connection from terminal board NN-20, NN-21, NN-22 to NN-9. If jumper is correct, the problem is outside the controls. If voltage does appear at this point, check for faulty external power supply switch or a faulty circuit breaker.
	Motor circuit is not functioning properly or the control switch may be defective.	If correct voltage is measured at the voltage test terminals, place the motor control switch to RAISE position (check to ensure the regulator is not in the maximum RAISE position). Place an AC voltmeter (150-volt scale) between NN-27 and NN-26. If voltage is not measured here, the control switch is faulty. If voltage does appear here, the motor circuit is defective.
	Indicator limit switches are not operating properly.	Check the position-indicator switch mechanism. Refer to MAINTENANCE section concerning removal of the indicator dial. *Warning: Before removing the indicator dial assembly, de-energize the regulator.*
Regulator functions manually but not automatically in either raise or lower direction	Defective DC power supply located on the component board assembly	Check the sensing circuits and relay voltage supply circuits by setting the Control Switch to TEST and observing the band-edge indicator lights. This check is made with 120-volts, supplied to the control from either the internal regulator supply or an external source. To use an external source, attach power supply leads to the test terminals marked EXTERNAL and place the Power Supply switch on External. Vary the voltage level adjustment control in and out of the bandwidth, above and below 120-volts. If the band-edge indicating lights (high and low) show the correct voltage level, the voltage supply to the relay in correct. If they do not, check the DC voltage per Table 5.
	Defective time-delay circuit	If the timing circuit does not function, the silicon rectifier SCR1 will not conduct and complete the ground circuit for the relays. Test time-delay rheostat R25 with a multi-test meter. *Warning: Before disconnecting any plug connector between the control panel, component board and nn terminal board or disconnecting any connection to the NN terminal board, remove the control cable flug from the bottom of the position indicator housing. Remove the external power supply used for testing when trouble shooting is completed.* The range will be from 0 to 2.5 megohms ± 10 percent. This is done by disconnecting the multipin plug located in the lower right-hand corner of the A1 circuit board. Replace the rheostat if it is defective. If the rheostat is normal, the problem will be located on the board assemply. Replace the component board.
	Defective motor leads	If the relays pick up and drop out properly but the motor does not become energized, check the motor leads at NN-26, NN-27 and NN-28.

Trouble	Cause	Remedy
Regulator runs to maxiumum RAISE or maximum LOWER limit	Defective relays	If the sensing circuits are functioning properly, check for sticking relays. Replace relays if they are defective.
	Defective line drop compensation circuit	Place the line drop compensation On/Off switch to OFF. Check the balance point of the sensing circuit. If incorrect, proceed below to 3rd Caurse/Remedy. If the balance point is correct, turn the resistance and reactance adjustment to 0. Place the LDC On/Off switch to ON. The balance point should not shift. If it does, replace the LDC circuit board A2.
	Loss of sensing voltage from T1 transformer (Regulator runs to maximum raise)	Check C2 and lead voltage per Table 5. If voltage is correct, measure Q1 collector voltage per Table 5. If the voltage is correct, proceed to isolate the problem to the component board by disconnecting R29 (the voltage level rheostat) and R28 (the bandwidth rheostat). This is done by disconnecting the multipin plug located in the upper right-hand corner of the A1 circuit board just above the relays. With a multi-purpose meter, check voltage level adjust rheostat R29 for a range of 0 - 425 ohms ± 10 percent. Also, check the continuity between panel ground and rheostat terminals to make sure the terminals are not grounded. Replace the rheostat if it is defective. Check each layer of the potentiometer R28 for resistance value range of 0 to 10 ohms ± 2 percent. If the rheostats agree with correct ranges and ground test, the sensing circuits locate don the board are defective. Replace the component board.
Incorrect level or control cannot be balanced.	Defective sensing circuits	Check the circuits as in Illustration 2. Check reference voltage which should be approximately 5.9 volts. Refer to Table 5.
	Position-indicator plug not fastened securely	If the position-indicator plug is not fastened securely so the shorting pin is not spreading the CT shorting jack to break the short, a grounding of either side of the CT will result. Check the position-indicator plug for proper alignment or interference, and fasten securely.

Trouble	Cause	Remedy
Regulator operates frequently	Incorrect Bandwidth	Place the Control Switch on the TEST position. Connect an AC voltmeter to the output test terminals. Adjust and check the desired bandwidth by rotating the Bandwidth knob on the control panel. To check the bandwidth rheostat R28, disconnect the regulator internal or external supply to the control panel. Disconnect the multipin plug located in the upper-right-hand corner of the A1 circuit board after ensuring the control bacle has been removed from the bottom of the position-indicator housing. With a multi-purpose meter, check the resistance of each layer of R28. Each should be 10 ohms ± 2 percent. Also, check for shorting between the panel ground and terminals of each layer. Replace the bandwidth rheostat if it is defective. If normal, replace the component board.
	Time-delay setting is too low or the circuits are malfunctioning	Place the control in a balanced condition within the bandwidth. Start of the time delay is initiated when the control is instantaneously placed out of the bandwidth by use of the level adjust potentiometer. The time between throwing the control out of the bandwidth and when the motor energizes is the time delay. If this is drastically different (± 20 percent) from the calibrated setting, the time-delay circuit is malfunctioning. Calibrate this by adjusting R37. If it cannot be calibrated, remove the component board.
Regulator bucks when load increases	Reversed polarity in either the current transformer or potential transformer	Reverse the current transformer leads in the control cabinet by disconnecting leads NN24 and NN23 (at the terminal board) and reversing the connections. Warning: Short-circuit the current transformer so the secondary will not become open-circuited. (The current transformer is short-circuited automatically by removing the control-cable plug from the bottom of the position-indicator housing.)
Regulator operates frequently	Incorrect Bandwidth	Place the Control Switch on the TEST position. Connect an AC voltmeter to the output test terminals. Adjust and check the desired bandwidth by rotating the Bandwidth knob on the control panel. To check the bandwidth rheostat R28, disconnect the regulator internal or external supply to the control panel. Disconnect the multipin plug located in the upper-right-hand corner of the A1 circuit board after ensuring the control bacle has been removed from the bottom of the position-indicator housing. With a multi-purpose meter, check the resistance of each layer of R28. Each should be 10 ohms ± 2 percent. Also, check for shorting between the panel ground and terminals of each layer. Replace the bandwidth rheostat if it is defective. If normal, replace the component board.
	Time-delay setting is too low or the circuits are malfunctioning	Place the control in a balanced condition within the bandwidth. Start of the time delay is initiated when the control is instantaneously placed out of the bandwidth by use of the level adjust potentiometer. The time between throwing the control out of the bandwidth and when the motor energizes is the time delay. If this is drastically different (± 20 percent) from the calibrated setting, the time-delay circuit is malfunctioning. Calibrate this by adjusting R37. If it cannot be calibrated, remove the component board.

Trouble	Cause	Remedy
Regulator bucks when load increases	Reversed polarity in either the current transformer or potential transformer	Reverse the current transformer leads in the control cabinet by disconnecting leads NN24 and NN23 (at the terminal board) and reversing the connections. Warning: Short-circuit the current transformer so the secondary will not become open-circuited. (The current transformer is short-circuited automatically by removing the control-cable plug from the bottom of the position-indicator housing.)
Line-drop compensator is not functioning in either reactance or resistance or both	Shorting switch is closed	Remove the position-indicator plug and check the shorting pin for physical defects. If it is defective, replace it. If the shorting pin is normal, reconnect the position-indicator plug and secure it tightly to be sure the shorting pin is disengaging the shorting jack.
	LDC On/Off switch in OFF position	Set switch to ON position
	R65 or T3 is defective	Disconnect the position-indicator control plug form the bottom of the position-indicator housing; then disconnect the harnessed red nine-point connector-plug between the control panel and the circuit component board. Warning: Short-circuit the current transformer secondaries. If left open-circuited, current transformers develop secondary voltages hazardous to personnel. The current transformer is short-circuited automatically when the control-cable plug is removed from the bottom of the position-indicator housing. Check the primary resistance of T3 by measuring with an ohmeter across pins number 3 and 4 in the red plug going to the front of the panel. The LDC On/Off switch should be in the ON position. The reading should be 2.8 ohms ± 1. Check the secondary winding of T3 by measuring with an ohmeter across terminals number 3 and 4 on the transformer. The reading should be 16 ohms ± 5.
Line drop compensator is not functioning in either reactance or resistance or both.	Defective LDC circuit board	Proceed as indicated in Trouble III, 2. Trouble-shoot control with test set-up as indicated under “Calibration”. Refer to control theory for explanation of circuit.
	Defective current transformer	If all components in 1, 2, 3 and 4 are normal, but no compenation exists, a defective current transformer is the probable cause.
Motor does not operate	Motor or motor capacitor may be faulty.	1. Disconnect the four (4) leads from the capacitor terminals, apply 240 volts, 60 hertz to the terminals. Read the current in the line. This reading should be approximately 0.36 amperes. *Caution: Discharge the capacitor before reconnecting the leads.* 2. Reconnect the capacitor, and apply 120 volts directly to the motor. Refer to control diagram for connections

Without Resistor Mod



With Resistor Mod

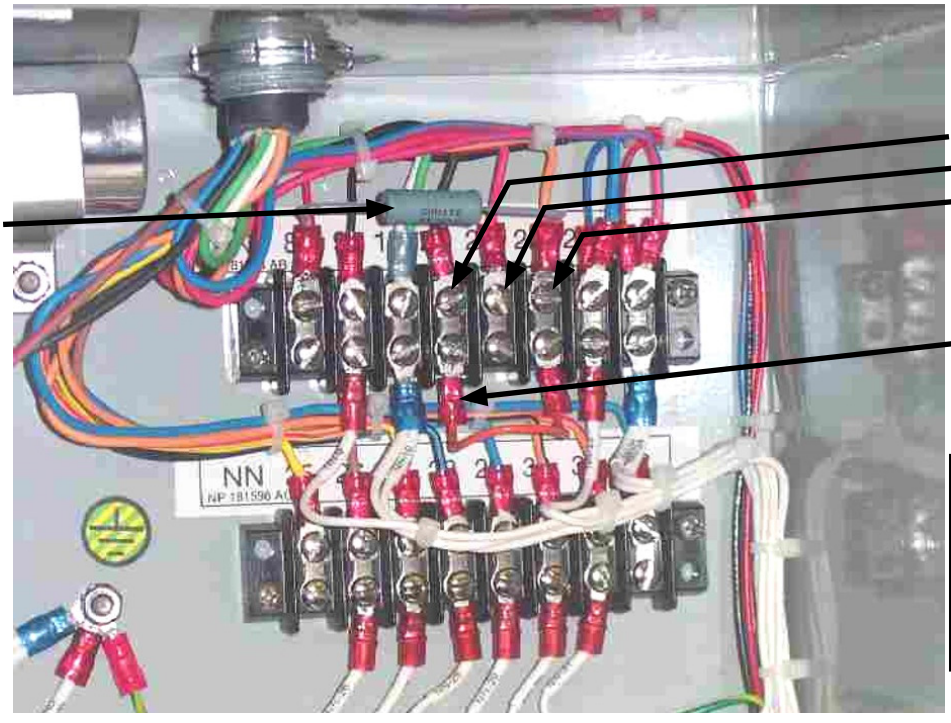


Figure 15. NN Terminal Boards and Jumper Mod Identification

Caution: See nameplate on regulator for jumper connection information. If nameplate on control is referred to, check to see if nameplate on is the same as regulator. Refer to the nameplate on the regulator if they are not the same.

6.2 Typical Diagrams

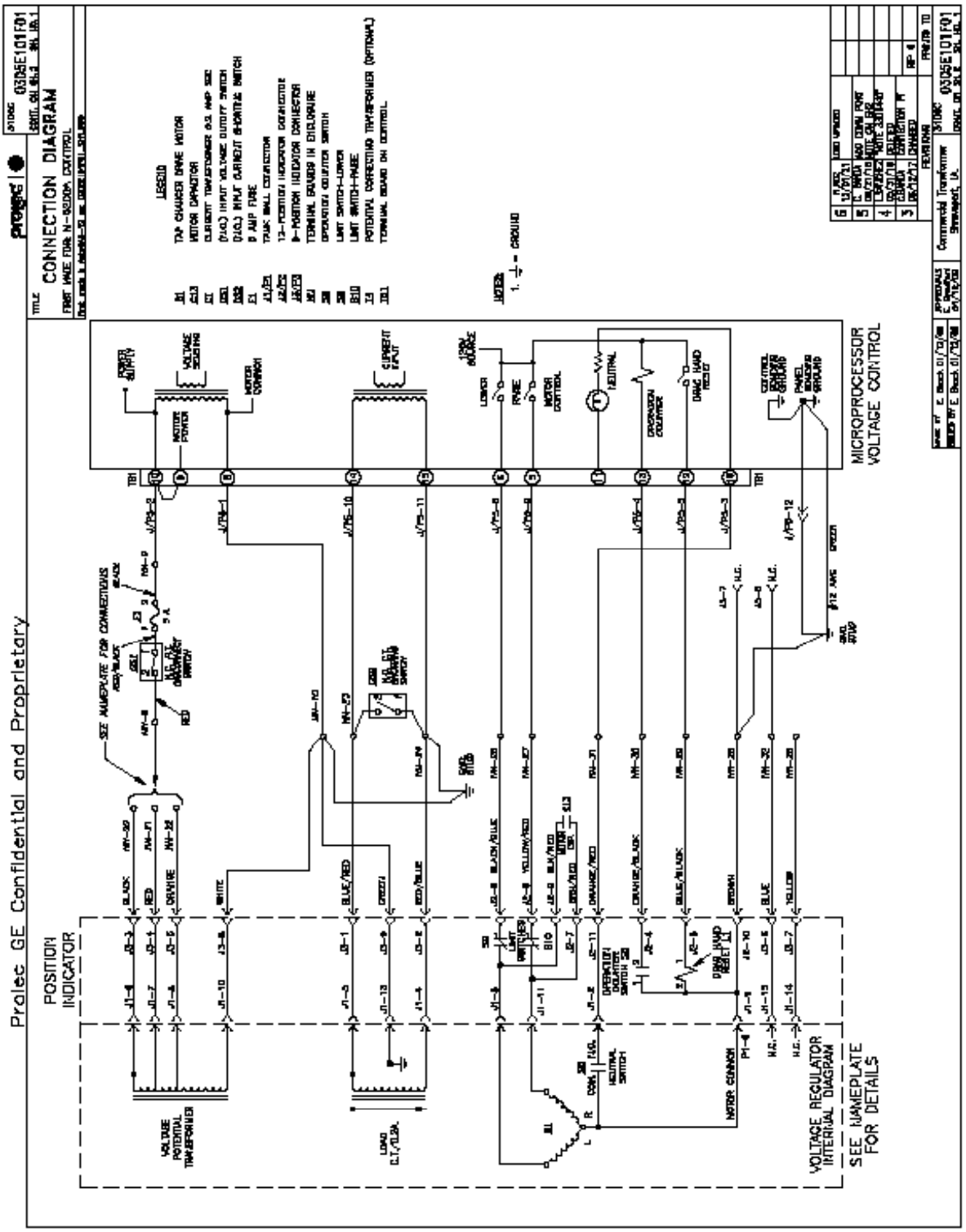


Figure 16. Diagram - Control Interface

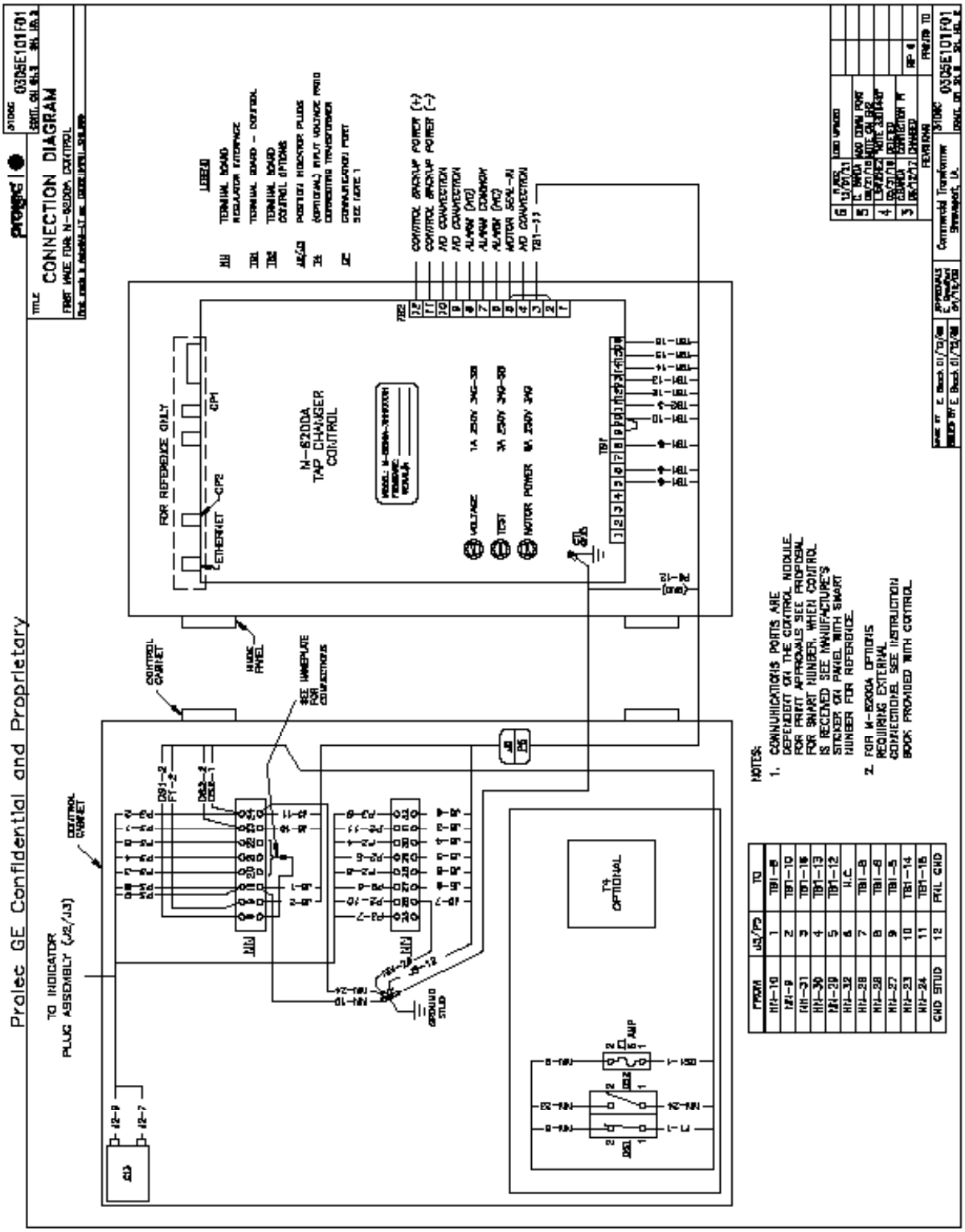


Figure 17. Diagram - Voltage Regulator

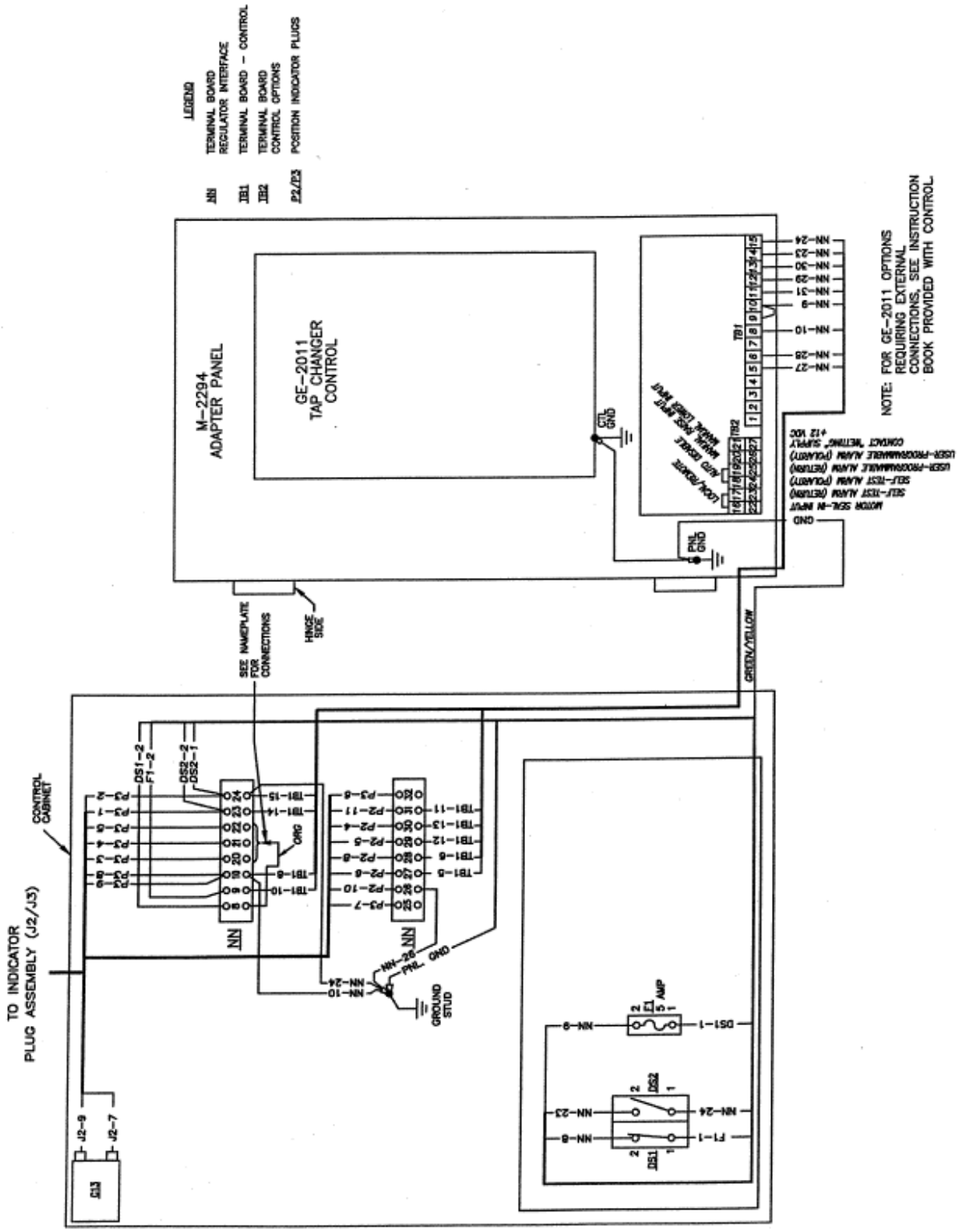


Figure 18. Diagram - Control Cabinet

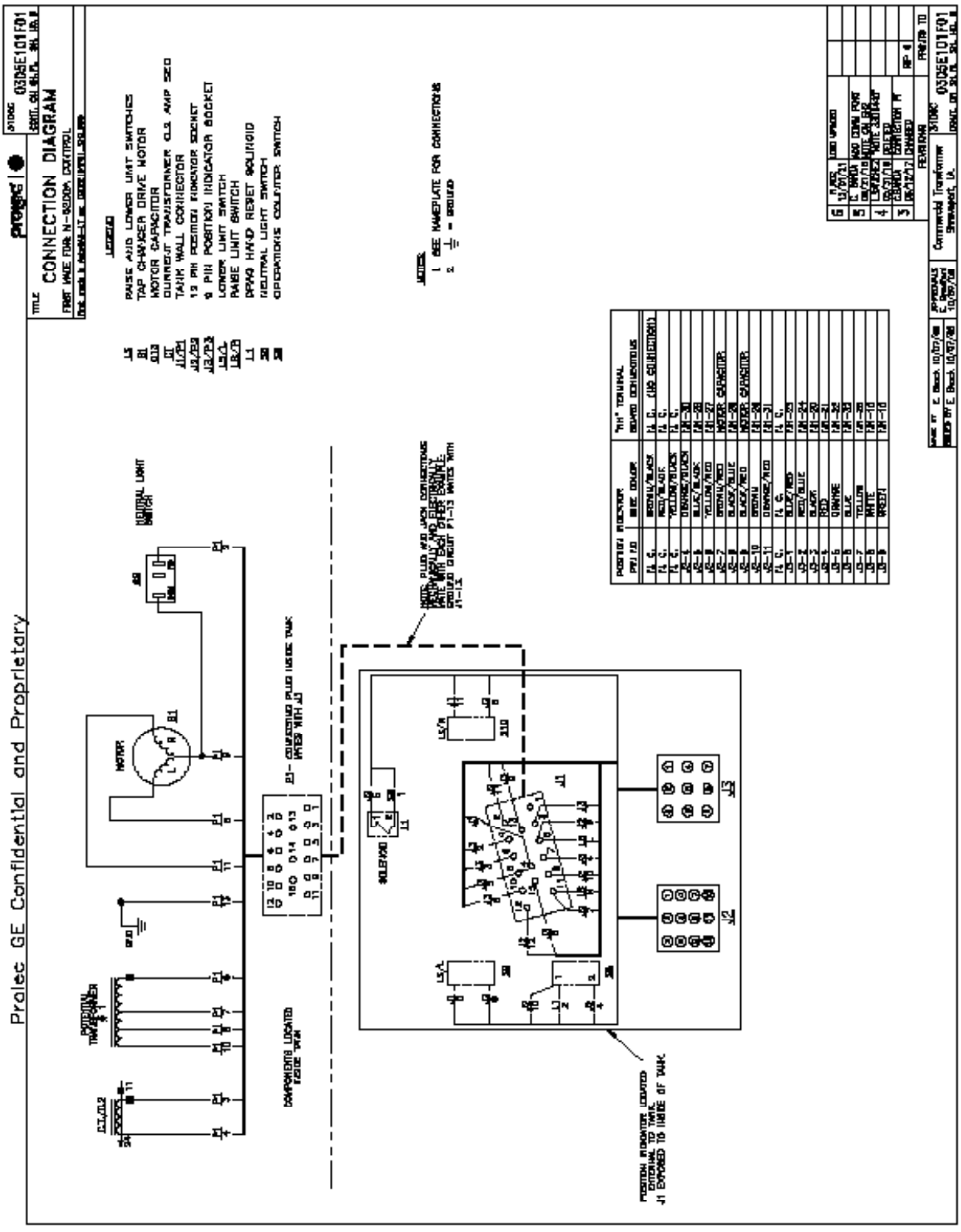


Figure 19. Diagram - Position Indicator

7. PARTS LIST

Provide your Prolec GE sales representative or your GE account manager with ALL of the following information:

REGULATOR SERIAL NUMBER (found on the regulator nameplate)

TYPE OF REGULATOR (All parts of this book are for type VR-1, single phase step voltage regulators of standard design.)

QUANTITY OF EACH PART REQUIRED (as shown in manual)

REFERENCE NUMBER OF EACH PART (as shown in manual)

DESCRIPTION OF EACH PART (as shown in manual)

For pricing information, contact your Prolec GE sales representative or GE account manager.

Figure 20. External VR-1

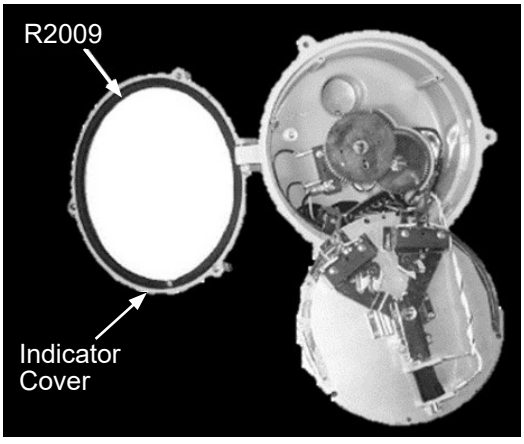


Figure 22 .Load-Bonus Position Indicator

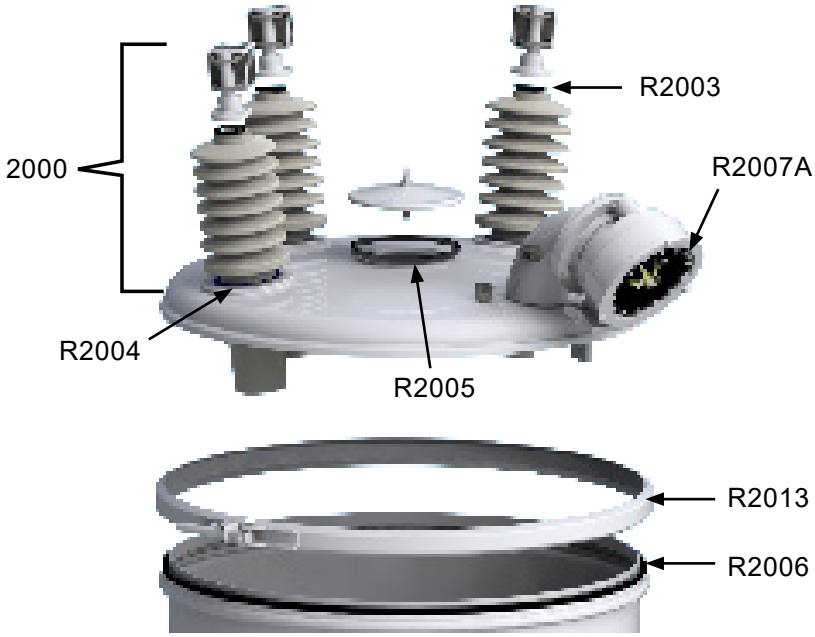


Figure 21. Cover and Accessories

Figure No.	Reference No.	Description
21	2000	High voltage bushing assembly complete
20	R2001	Bushing porcelain
20	R2002	Bushing terminal
21	R2003	Bushing terminal gasket
21	R2004	Bushing gasket cover
21	R2005	Handhole gasket
21	R2006	Cover gasket
21, 22	R2007A	Load-bonus position indicator
22	R2008A	Load-bonus indicator glass assembly kit
22	R2009	Indicator gasket
20	2010	Control-cabinet assembly
*	R2011	Sample plug
21	R2013	Cover band
22	R1900	Indicator dial and switch assembly
22	R1901	Solenoid
22	R1902	Counter switch

*Not Illustrated

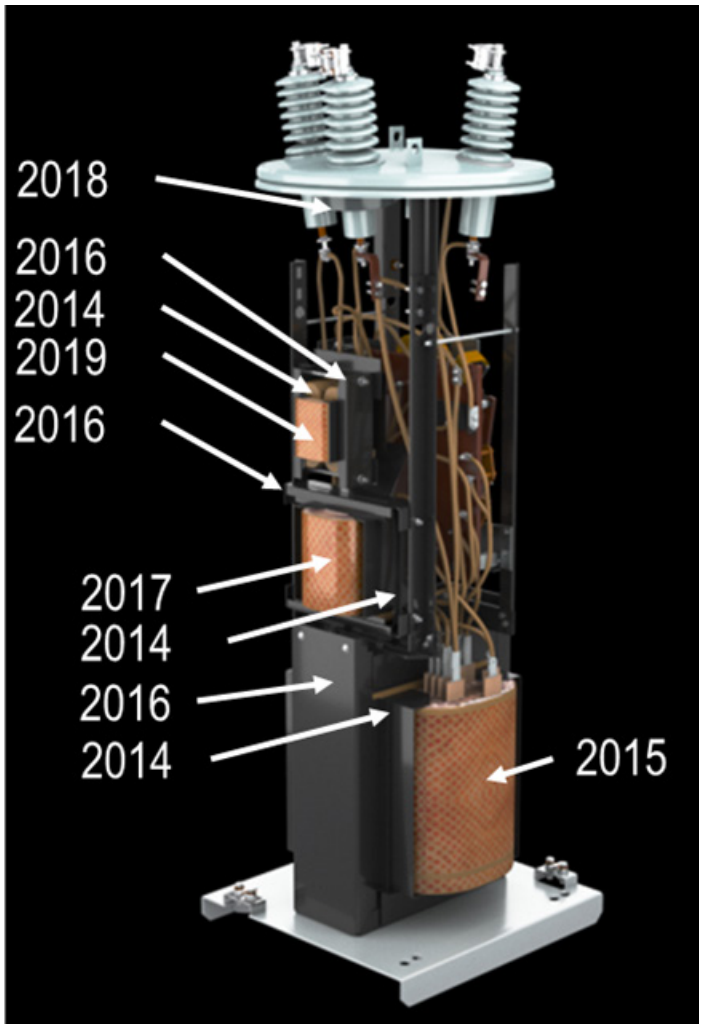


Figure 23. Type VR-1, Reactor Side

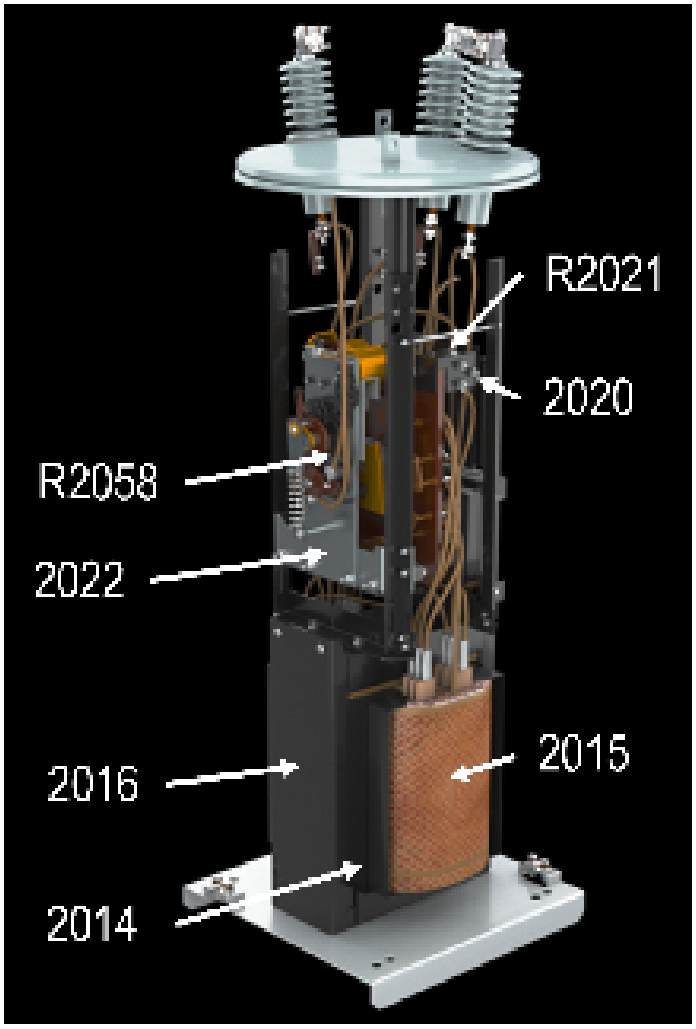


Figure 24. Type VR-1, Mechanism Side with Control Cabinet Removed

Figure No.	Reference No.	Description
23, 24	2014	Core
23, 24	2015	Coil
23, 24	2016	Clamps
23	2017	Reactor
23	2018	Current Transformer
23	2019	Potential Transformer
24	2020	XENOX Surge Bypass Protector Assembly
24	R2021	XENOX Disks
24	2022	Switch Mechanism
24	R2058	Fexible Shaft

Figure 25. High-Current Switching Mechanism

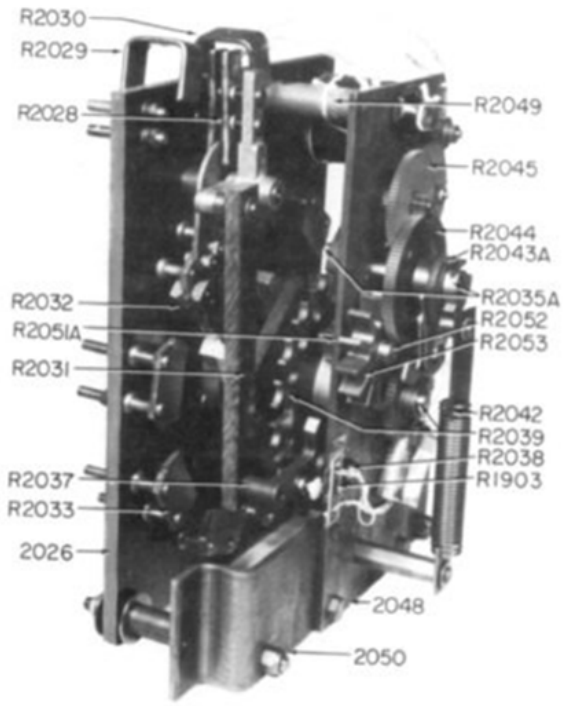


Figure 26. Mid-Current Switching Mechanism

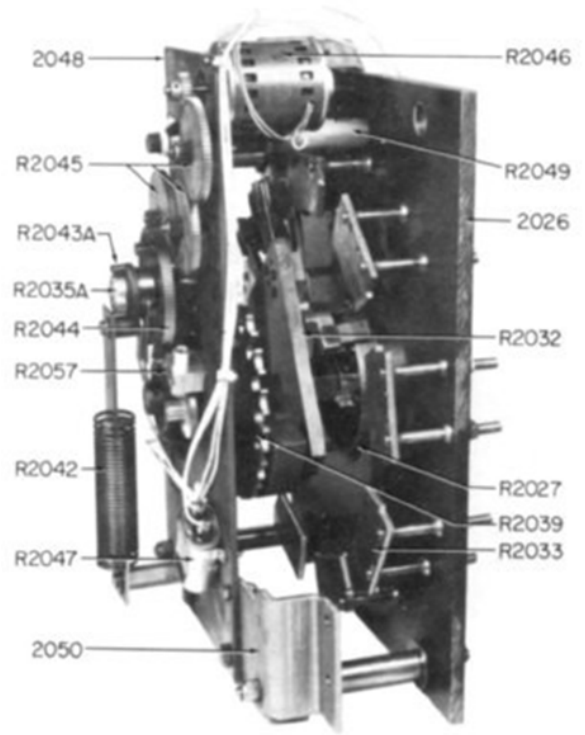


Figure 27. High-Current Switching Mechanism

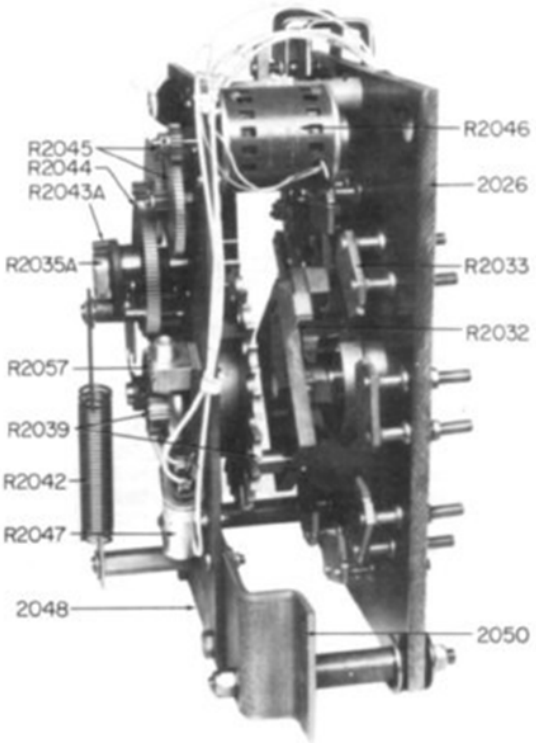


Figure 28. Mid-Current Switching Mechanism

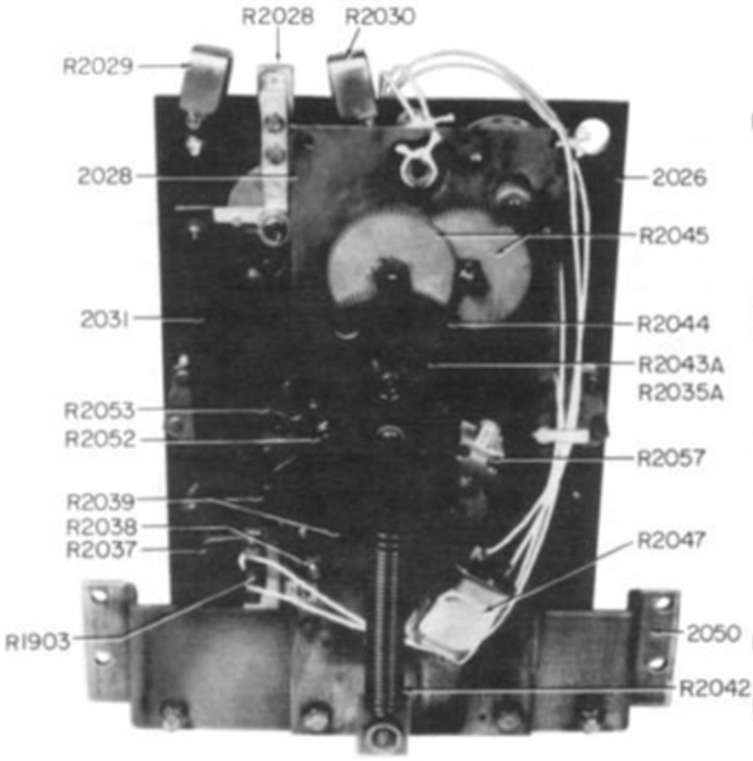


Figure 29. Mid-Current Switching Mechanism

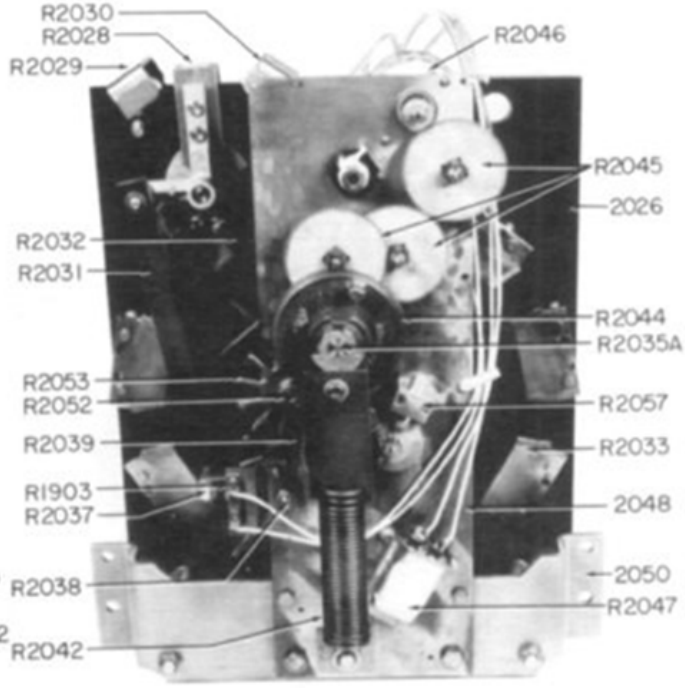


Figure 30. High-Current Switching Mechanism

Unit and Cover Part References

Figure No.	Ref. No.	Description
25, 26, 29, 30	R1903	Neutral Light Switch Assembly
25, 26, 27, 28, 29, 30	2026	Contact Panel Assembly
22, 27	R2027	Slip RIng Assembly
25, 26, 29, 30	R2028	Reversing Switch Moving Contact Assembly
25, 26, 29, 30	R2029	Reversing Switch Stationary Contact Assembly (Lower)
25, 26, 29, 30	R2030	Reversing Switch Stationary Contact Assembly (Raise)
25, 26, 30	R2031	Reversing Switch Connector Rod
25, 26, 27, 28, 30	R2032	Moving Contact Assembly
25, 26, 28, 30	R2033	Stationary Contact Assembly
30	2034	Moving Contact Stud
26, 27, 28, 29, 30	R2035A	Crankshaft Assembly
25, 26, 29, 30	R2037	Geneva Segment
26, 27, 29, 30	R2038	Shaft for Geneva Segment
25, 26, 27, 28, 29, 30	R2039	Geneva Gear and Shaft Assembly
25, 26, 27, 28, 29, 30	R2042	Spring Assembly
25, 26, 27, 28, 29, 30	R2043A	Driver and Hook Assembly
25, 26, 27, 28, 29, 30	R2044	Gear
25, 26, 27, 28, 29, 30	R2045	Gears (Motor Reduction)
27, 28, 30	R2046	Motor and Pinion Gear
27, 28, 29, 30	R2047	Capacitor (Possibly in Control Cabinet)
25, 26, 27, 30	2048	Motor Drive Panel Assembly
21, 22, 23	R2049	Spacer Assembly
25, 26, 27, 28, 29, 30	2050	Base
25, 26	R2051A	Gear, Shaft, Impeller Assembly
25, 26, 29, 30	R2052	Shaft for Impeller
25, 26, 29, 30	R2053	Impeller
27, 28, 29, 30	R2057	Indicator Motor Gear Assembly
24	2058	Flexible Shaft

LOCATIONS

MEXICO

APODACA
Blvd. Carlos Salinas de Gortari km. 9.25
Apodaca, NL
66600 MX
+52 (81) 8030 2000

USA

SHREVEPORT
7000 W Bert Kouns Industrial Loop
Shreveport, LA 71129
+1 (318) 687 6600

WAUKESHA
400 S Prairie Ave.
Waukesha, WI 53186
+1 (262) 547 0121

GOLDSBORO
2701 US Highway 117 South
Goldsboro, NC 27530
+1 (919) 734 8900

DALLAS
9011 Governors Row
Dallas, TX 75247
+1 (214) 637 4434

BRAZIL

CANOAS
Avenida Guilherme Schell, 11500
Canoas, RS 92.420-820
+55 (51) 3477-8686

For more information:
info@prolec.energy

prolec.energy

IOM-DTVR1-GEH7299A