GE Energy

Commercial Transformers

Shreveport, Louisiana

Type VR-1™ Single-phase Step Type Regulators

Installation – Operation - Maintenance

GEH-7299A Rev 1 (11/06)

GEH–7299

WARNINGS, CAUTIONS, AND NOTES AS USED IN THIS PUBLICATION

WARNINGS Warning notices are used in this publication to emphasize that hazardous voltages, currents, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

Warning notices are also used for situations in which inattention or lack of equipment knowledge could cause either personal injury or damage to equipment.

CAUTIONS Caution notices are used for situations in which equipment might be damaged if care is not taken.

NOTES Notes call attention to information that is especially significant to understanding and operating the equipment.

This document is based on information available at the time of its publication. While efforts have been made to ensure accuracy, the information contained herein does not cover all details or variations in hardware and software, nor does it provide for every possible contingency in connection with installation, operation, and maintenance. Features may be described herein that are not present in all hardware and software systems. GE Energy assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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REFERENCES For information on servicing and repairing the controls, refer to the appropriate manual listed below:

For details on the GE-2011 voltage regulator control, refer to GEH-7298.
For details on the GE-2011B voltage regulator control, refer to GEH-7301.
For details on the GE-2011C voltage regulator control, refer to GEH-7302.

Contents

List of Figures & Tables

TYPE VR-1
SINGLE-PHASE STEP-VOLTAGE REGULATOR

INTRODUCTION

The General Electric Type VR-1 step voltage regulator (Fig. 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 GE-2011 control 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 General Electric step voltage regulator.

RECEIVING

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 the nearest General Electric Company Sales Office promptly.

STORING

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

WARRANTY

Your General Electric VR-1 regulator is warranted for one year against any defect in workmanship or material.

INSTALLATION

INSPECTING

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 2-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 cotton waste or similar material which might become caught in the mechanism.

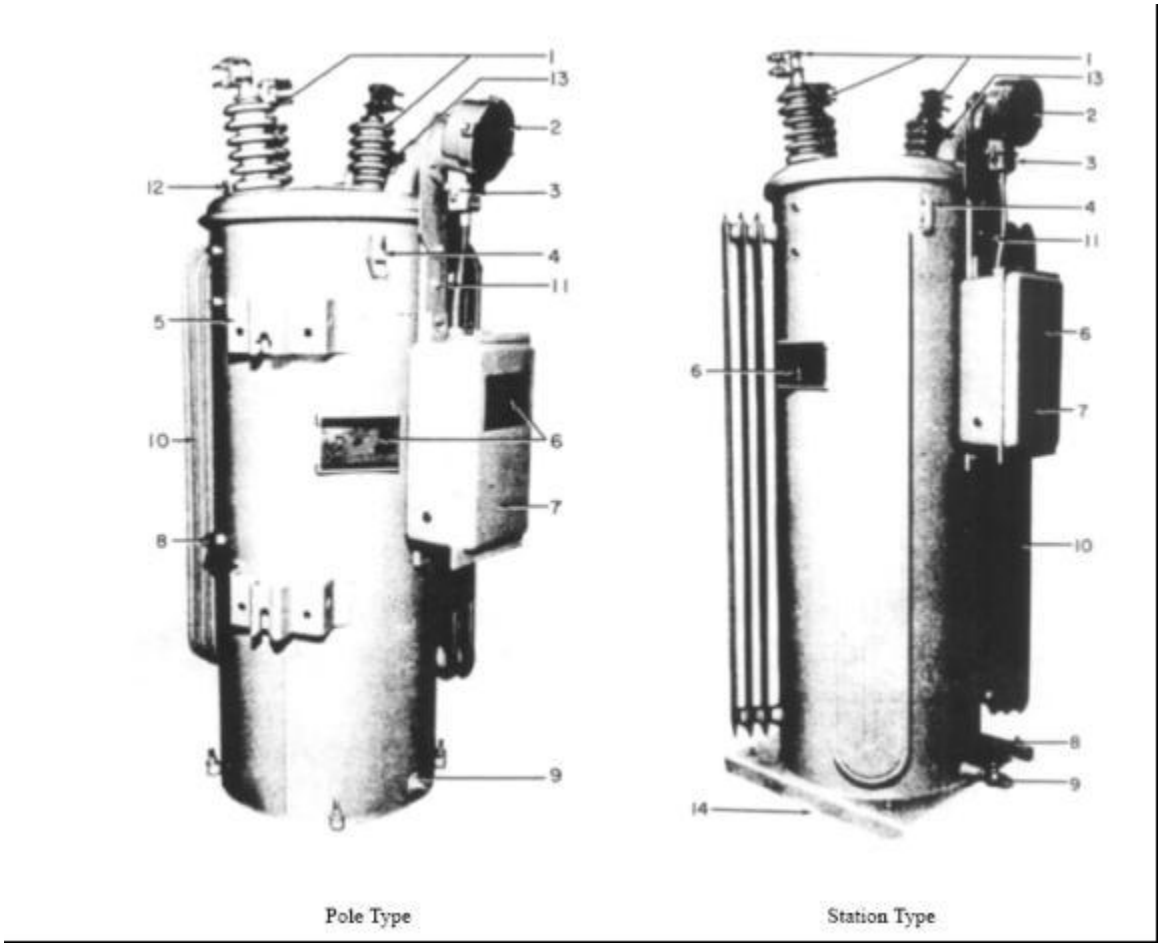
Oil should be visible in the sight gage at all times.

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. TO ACCELERATE DISSIPATION OF THE CHARGE IN THE OIL, GROUND THE FILTER PRESS, THE TANK AND ALL THE WINDINGS (IF ACCESSIBLE) DURING OIL FLOW INTO ANY TANK. CONDUCTION THROUGH OIL IS SLOW; THEREFORE, IT IS DESIRABLE TO MAINTAIN THESE GROUNDS FOR AT LEAST AN HOUR AFTER THE OIL FLOW HAS BEEN 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 THE PREVIOUS GROUNDING PRECAUTIONS HAVE BEEN TAKEN.

Sealed-tank Regulator

The sealed-tank regulator has a volume of gas, initially air, above the insulating liquid that is sealed from the atmosphere. There is normally no inward nor 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 EQUALIZE INTERNAL TANK PRESSURE BEFORE ATTEMPTING TO REMOVE TANK COVER OR HANDHOLE COVER.



Pole Type **Station Type**

1, Bushings
2. Load-Bonus position indicator
3. Control cable plug
4. Lifting lug for complete tank
5. Suspension bracket
6. Nameplate
7. Control cabinet
8. Ground pad
9. Drain
10. Radiator
11. Minimum oil gage
12. Lifting eyes for cover and internal assembly
13. Pressure relief valve
14. Base

NOTE: The control cabinet is non-removable if the regulator is energized. The GE-2011 control is designed to be removed from the GE-2994 adapter panel for service. The current shorting switch is mounted in the control cabinet and shorts the current transformer when closed.

To remove the control cabinet:

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 DEVICE IS IN PLACE.

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

Check the oil level. Oil must always be visible in the oil sight gage since the gage 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.

CHECKING REGULATOR CONTROLS AND 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 prior to shipment:

FUNCTION	SETPOINT RANGE	INCREMENT	DEFAULT SETTING
Bandcenter	100.0 V to 135.0V	0.1V	120.0 V
Bandwidth	1.0V to 10 V	0.1V	2.0V
Time Delay	5 seconds to 120 seconds	1 second	30 seconds
Inverse Time Delay	5 seconds to 120 seconds	1 second	30 seconds
LDC Resistance	-24 V to + 24 V	1V	0V
LDC Reactance	-24 V to + 24 V	1 V	0V
LDC-Z	0 V to 24 V	1 V	0 V
Output Selection Pulse	Pulsed or Continuous 0 to 12	 .1	Pulsed 7

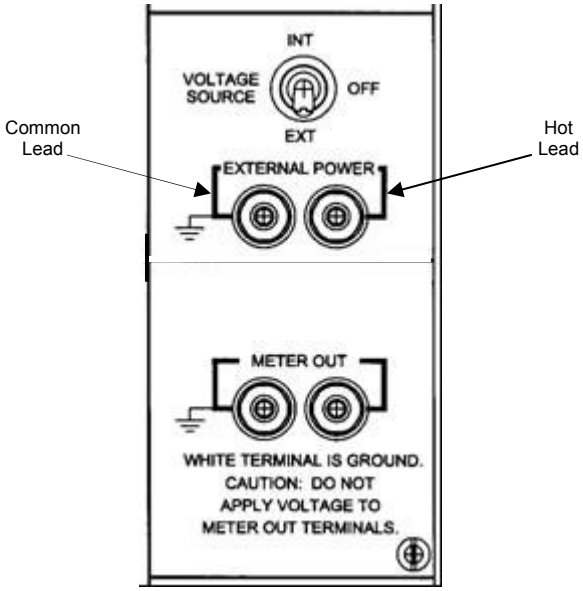
Bandcenter, Bandwidth, Time Delay & Line Drop Compensation Setpoint Ranges

NOTE: The default setpoints cannot be changed if the Level 1 password is enabled and not know by the user.

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. This automatically disconnects the internal power to the control. Apply 120 50/60HZ AC 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 REGULATOR HIGH VOLTAGE TERMINALS LOCATED ON THE COVER.

120 50/60 HZ VAC



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".

EXCITING THE REGULATOR HIGH VOLTAGE WINDINGS FROM AN EXTERNAL SUPPLY

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 of too low a 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.

MOUNTING

Mount the regulator on a pole or a 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 the nearest General Electric Sales Office.

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 Figs. 2 and 3. Allow sufficient flexibility in the lead connections to prevent mechanical strains, due to expansions or contractions, which might break the porcelain.

SURGE PROTECTION

General Electric Distribution surge arresters (Fig. 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".

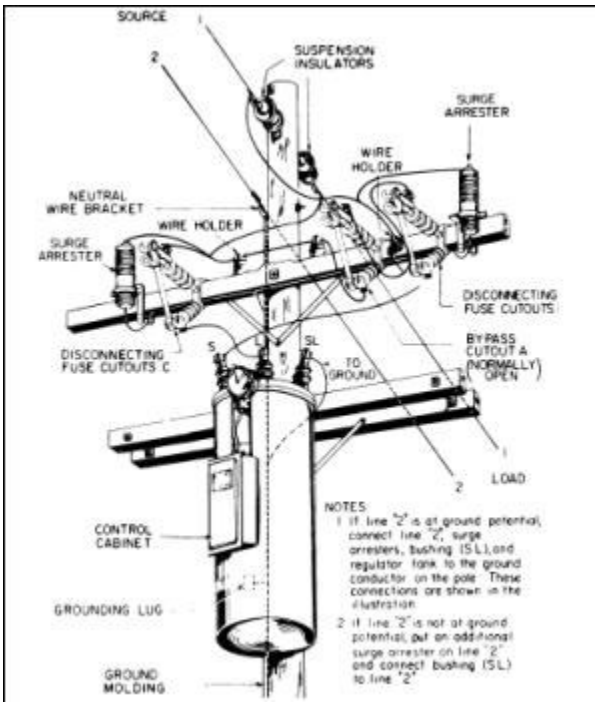


Fig. 2. Typical single-phase installation

TABLE 1
SURGE ARRESTER CLEARANCES

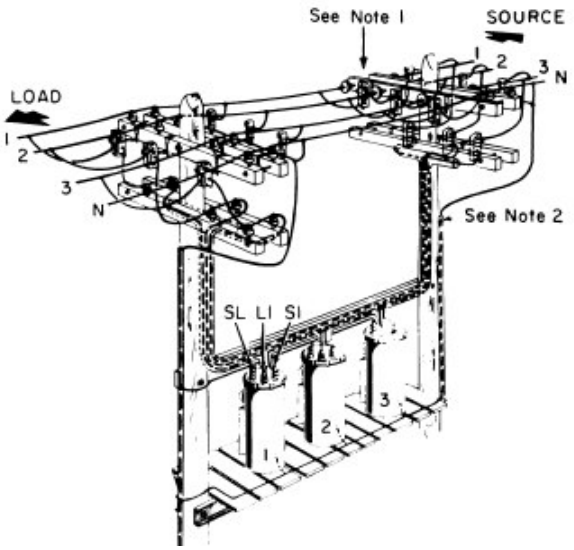
Regulator Voltage Class (KV-RMS)	Minimum Suggested Clearance (Inches)
2.5	4 (102 mm)
5.0	5 (127 mm)
7.62	6 (153 mm)
13.8	6 (153 mm)
14.4	9.5 (242 mm)
20.0	9.5 (242 mm)

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.

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 by-pass cutouts are mounted on the side of the crossarm toward the installation for clarity of illustration. Mount these by-pass 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.

Fig. 3. Typical three-phase installation

Fig.4. Distribution surge arrester

THREE-PHASE CONNECTIONS

The line connections for three-phase operations are shown in Fig. 5.

Note that 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.

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 I^2t product constant. In this formula, I is the short-circuit current and it is the time in seconds. For instance, if the regulator is rated 2500 volts, 400 amperes, at + 10 percent regulation, $I^2t = (400 \times 40)^2 \times 0.8 = 205 \times 10^6$. Then for a short-circuit duration of 2 seconds, $2I^2 = 205 \times 10^6$ and I = 10 100 amperes.

OVERLOADING REGULATORS

The regulator can be overloaded in accordance with the ANSI Guide for Loading Step Voltage Regulators, Appendix C57.95-1955.

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 Fig. 5. For these connections, proper grounds, surge arresters and by-pass 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 N E C REQUIREMENTS.*

2. *TO AVOID DAMAGE TO WINDINGS, THE BY-PASS 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 ALL THREE REGULATORS MUST BE OPERATED TO THE NEUTRAL POSITION AND THE CONTROL POWER TURNED OFF AND ALL UNITS BY-PASSED 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.*

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 REGULATOR UNLESS THE NEUTRAL IS VERIFIED BY THE NEUTRAL INDICATOR..*

The instructions for CONNECTING INTO SERVICE and REMOVING FROM SERVICE without interrupting the load are given in detail in the following paragraphs. Refer to the connection shown in Fig. 5.

1. By-pass Switch "A" in series with the line should be closed, and the 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. 5)

   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). 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.

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.

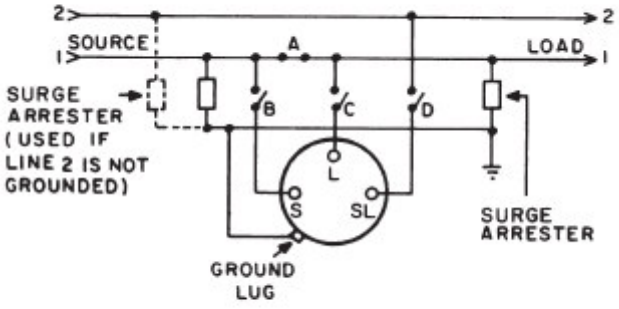
3. Close By-pass Switch "A". In delta banks, by-pass all three units.

4. Open Load Disconnect Switch "C" and then Open Source "B".

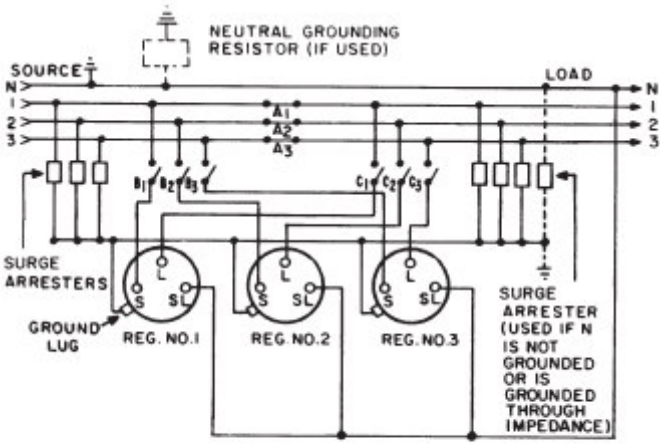
5. Open Disconnect Switch "D" last.

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.

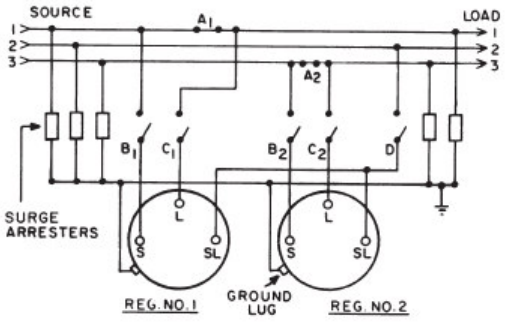
Fig 5 Regulator connections



A. One regulator, single-phase circuit

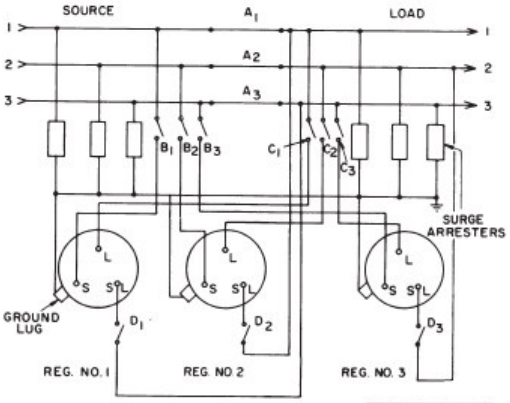


C. Three regulators, 3-phase, 4-wire circuit



PHASE ROTATION	REG NO.	PHASE
1-2-3	1	LAG
	2	LEAD
3-2-1	1	LEAD
	2	LAG

B. Two regulators, 3-phase, 3-wire circuit



PHASE ROTATION	PHASE
1-2-3	LEAD
3-2-1	LAG

D. Three regulators, 3-phase, 3-wire circuit

NOTE 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.

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

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. 5B and 5D.

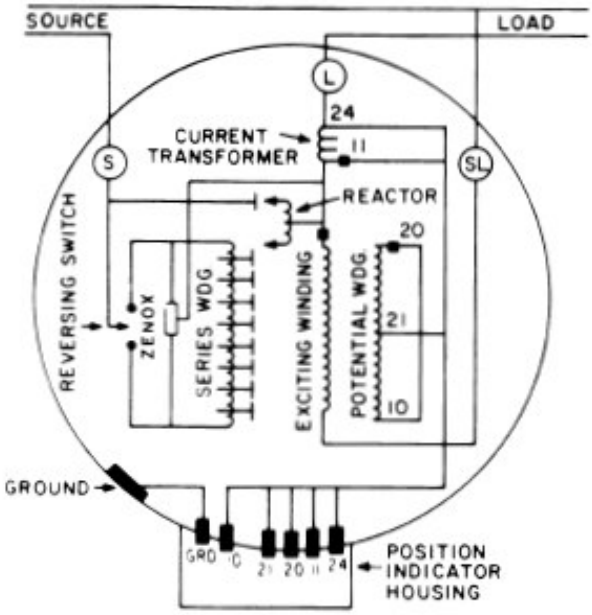
If the system phase sequence is not known, use the following method of obtaining the proper phase relationship. The test should be made when the regulators are carrying appreciable load.

For two regulators in an open delta system:

1. Connect the regulators for normal open delta operation. See Fig. 5B.
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 (nearer the maximum raise position as observed on the position indicator) is lagging phase; the other is on the leading phase.

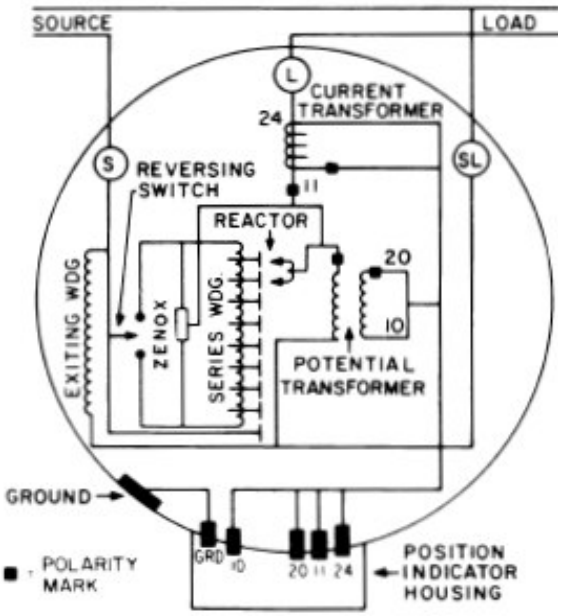
For three single-phase regulators connected in a delta bank (Fig. 5D) carrying nearly balanced load and power factor of better than 80 percent, proceed with Steps 2,3,4, and 5, as described above.

If all three regulators raise their voltages, they carry lagging currents. Otherwise, if all three regulators lower their voltages, they carry leading currents.



CAT NOS. 33D---
7072 THRU 7720
8050 THRU 8667
3025, 3050, 3075, 4025,
4050, 5038
6069

Fig. 6a. Schematic diagram showing connections of Regulator for load excited units.



CAT NOS. 33D---
3100 THRU 3167
4100 THRU 4333
5076 THRU 5509
6138, 6274
8833

Fig. 6b. Schematic diagram showing connections of Regulator for source excited units.

Fig. 6. Regulator winding arrangements

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.

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 KVA must be reduced unless otherwise specified on the nameplate.

With the exception of 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 2 lists the standard potential ratios.

TABLE 2
STANDARD POTENTIAL RATIOS

RATED VOLTAGES	OPERATING VOLTAGES	POTENTIAL RATIOS	VOLTAGE LEVELS OF VOLTAGE SENSORS
2500/4330Y	2500	20.8:1	120
	2400	20:1	120
5000/8660Y	5000	41.7:1	120
	4800	40:1	120
	2500	20.8:1	120
7620/13200Y	7960	66.3:1	120
	7620	63.5:1	120
	7200	60:1	120
	5000	47.7:1	120*
	4800	40:1	120*
	4330	36.1:1	120*
	4160	34.7:1	120*
	2500	20.8:1	120*
	2400	20:1	120*
13800	13800	115:1	120
	13200	110:1	120
	12000	100:1	120
14400/ 24940Y	14400	120:1	120
	7200	60:1	120
34500Y/ 19920	19920	166:1	120

*These taps are not provided on 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. 7). 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.

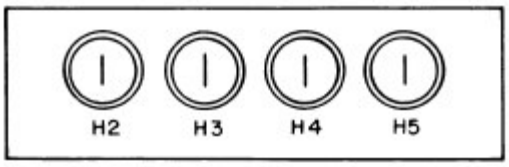


Fig.7. Potential transformer terminal board hand-hole opening view

OPERATION
Control Interface Instructions

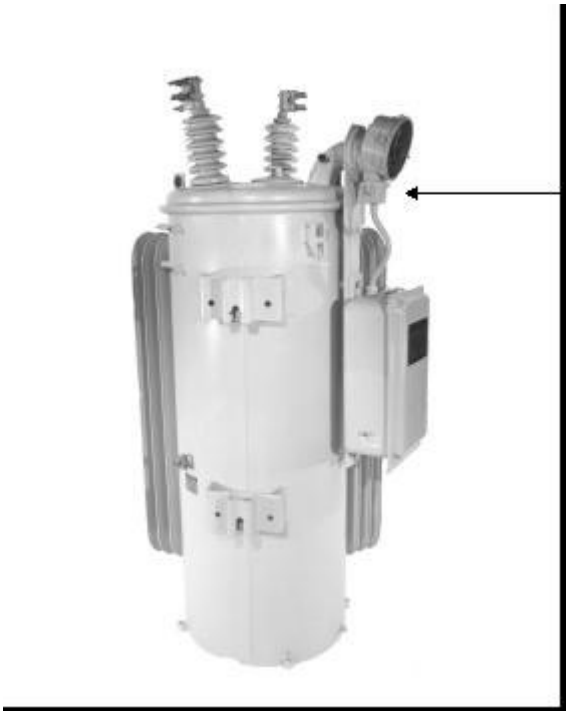


Fig 8 Control Interface

Operating Instructions

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).

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 or the current transformer is short circuited by shorting the pins at the bottom of the position indicator.

Fig 9 CT shorting switch and 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.

OPERATION

LOAD-BONUS FEATURE

The load-bonus feature provides a means of operating the regulator at increased load by decreasing the range of regulation in 1.25 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:

Range of Voltage (Percent)

10	8.75	7.5	6.26	5

Current Rating (Percent)

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 (Fig. 10).

NOTE: *The regulator need not 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.

1. Limit switch adjusting knob (lower)
2. Limit switch adjusting knob (raise)

Fig. 10. Load-bonus position indicator

REMOVING THE INDICATOR-DIAL ASSEMBLY

WARNING: *DO NOT REMOVE THE INDICATOR DIAL BEFORE DE-ENERGIZING 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.

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, and then turn regulator back to AUTO to check the voltage sensor. After a time delay (30 seconds as set at the factory), the tap selector will operate and come to rest.

The devices in the control cabinet require very little maintenance.

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.

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.

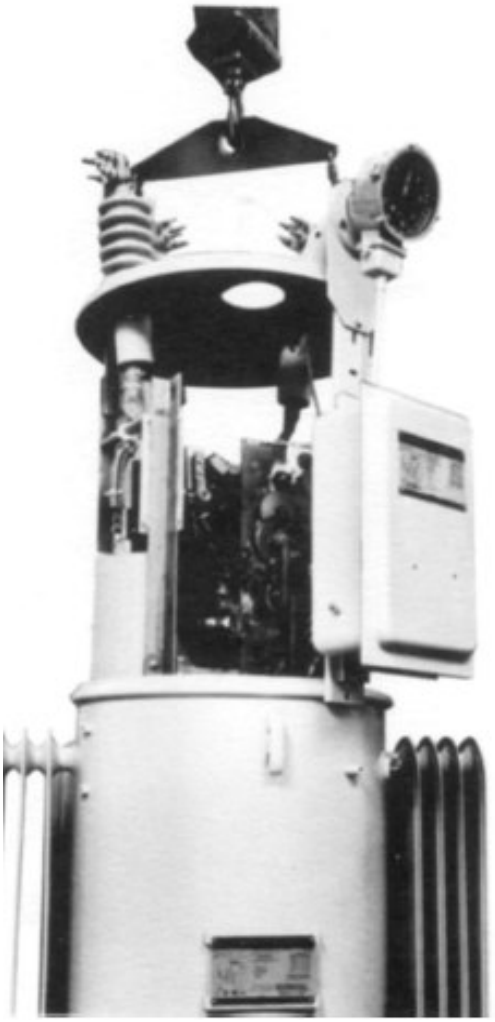


Fig. 11. Untanking Type VR-1 step voltage regulator, showing use of tank spreader bar when lifting regulator from tank.

CAUTION: EXPOSURE TO ATMOSPHERE
IT IS OCCASIONALLY NECESSARY TO UNTANK REGULATORS FOR MAINTENANCE. THE FOLLOWING RULES MUST BE APPLIED.

1. INTERNAL ASSEMBLIES MAY BE EXPOSED TO THE ATMOSHERE FOR A MAXIMUM OF EIGHT HOURS WITHOUT REQUIRING RE-BAKING.
2. INTERNAL ASSEMBLIES EXPOSED TO THE ATMOSPHERE FOR MORE THAN EIGHT HOURS MUST BE RE-BAKED FOR A MINIMUM OF 14 HOURS AT 110 C.
3. AFTER REBAKING, 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, AND TOTAL REBAKE TIME AT 110 C SHOULD NEVER EXCEED 32 HOURS.
5. IF FACILITIES ARE AVAILABLE, IT IS RECOMMENDED THAT THE UNITS BE OIL-FILLED UNDER VACUUM.

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 Fig. 11)

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

WARNING: BEFORE APPLING 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.

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 gage.

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 has been 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 the "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 , and, if found to be 22 kv or below, filter the oil to restore the dielectric strength to 26 kv or more.

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:

TANK DIAMETERS (inches)	BAR DIAMETERS (inches)
19, 21	0.750
24, 25.5	0.875
28	1.00

Table 3 Untanking support bar diameters

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.

CONTACT INSPECTION

Table 5 is given as a guide for inspecting the contacts of the regulator on the basis of 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 on the basis of 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 Fig. 12.

On the same basis, other VR-1 regulators rated less than 100 KVA and not appearing in Table 5 can operate in excess of 1 million tap changes before inspection is required. This will be more than 25 years for normal service. Again the many variables that affect 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, Fig. 12. Note Dimensions in Table 4.

Normal contact wear will produce a contact erosion such as shown in Sketch B, Fig. 12.

The contacts are satisfactory for service until either the stationary or moving contacts are worn to the condition as shown in Sketch C, Fig. 12, at which time the entire set of stationary and moving contacts must be replaced.

TABLE 4
ARCONITE DIMENSIONS IN INCHES (AND MILLIMETERS)
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	0.250 (6.4)	0.188 (4.8)
HIGH VOLTAGE	0.250 (6.4)	0.188 (4.8

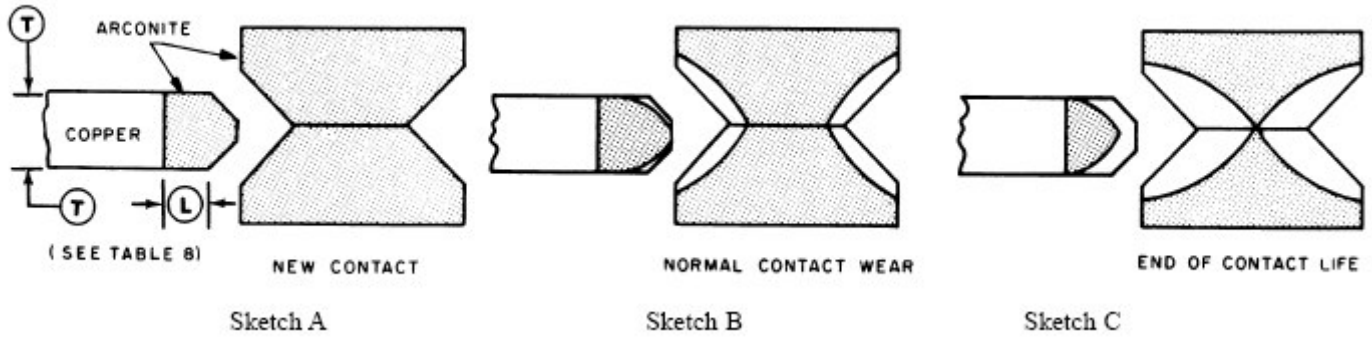


Fig.12. Contact wear (See Tables 4 and 5)

TABLE 5

EXPECTED MINIMUM NUMBER OF OPERATIONS
(USED AS A GUIDE FOR CONTACT REPLACEMENT ON BASIS OF CURRENT IN TABULATION BELOW)

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

The above table is 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 appearing in Table 5 can operate in excess of 1,000,000 tap changes before inspection is required. This will be more than 25 years for normal service. Again the many variables that affect contact life must be considered.

TROUBLESHOOTING

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: SINCE TROUBLE SHOOTING ENTAILS WORKING WITH ENERGIZED EQUIPMENT, CAUTION SHOULD BE TAKEN TO AVOID PERSONAL SHOCK.

WARNING: DISCHARGE CAPACITORS BY SHORT CIRCUITING TERMINALS OR LEADS BEFORE RECONNECTING TO ANY CIRCUIT.

WARNING: 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.

WARNING: *HIGH VOLTAGE—CURRENT TRANSFORMER CIRCUITRY. DO NOT DISCONNECT THE CONNECTORS INSIDE THIS COVER UNLESS THE VOLTAGE REGULATOR IS DE-ENERGIZED.*

WARNING: IF AN EXTERNAL POWER SUPPLY IS USED FOR TESTING THE CONTROL, REMOVE THIS POWER SUPPLY BEFORE SWITCHING TO INTERNAL POWER SUPPLY.

WARNING: SHORT-CIRCUIT THE CURRENT TRANSFORMER SECONDARIES. IF LEFT OPEN-CIRCUITED, CURRENT TRANSFORMERS DEVELOP SECONDARY VOLTAGES HAZARDOUS TO PERSONNEL.

WARNING: *DO NOT REMOVE THE INDICATOR DIAL BEFORE DE-ENERGIZING THE REGULATOR.*

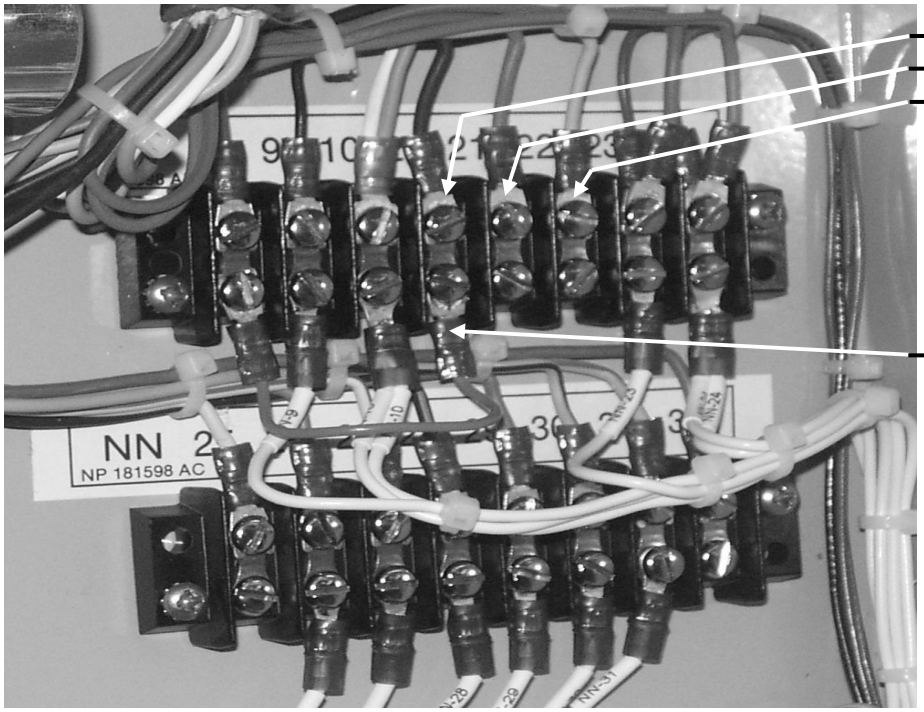
Within the chart, when necessary, these warnings are repeated to further emphasize their significance.

TROUBLE-SHOOTING CHART

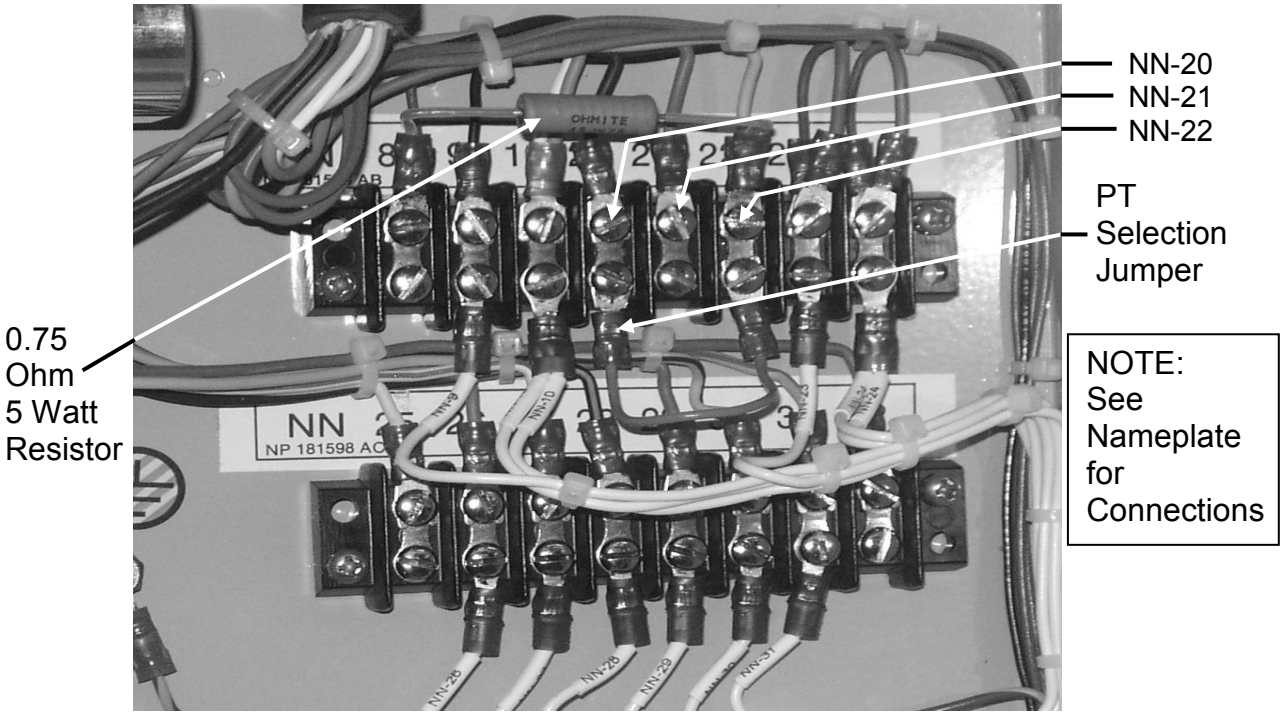
TROUBLE	CAUSE	REMEDY
I. Regulator will not operate either automatically or manually or remains in maximum lower or maximum raise position.	1. Loss of sensing signal from the regulator.	1. Using an AC voltmeter check for control sensing voltage at the voltage test terminals, on the front of the control panel. If no voltage occurs at this point, either the external power supply switch or the fault current limiter is defective. Check for sensing voltage at NN-20, NN-21 or NN-22 and ground per the nameplate. If no voltage appears at these terminals, the problem is outside the controls and probably inside the regulator tank.
	2. Motor circuit is not functioning properly or the control switch may be defective.	2. Place the Motor Control switch to "Manual" position and place the Manual switch to Raise. Check the voltage on terminal board NN-27. If approximately 120 vac is detected then the problem is most likely in the regulator motor circuit. See Fig # 14 for further trouble shooting the regulator motor circuit.
	3. Indicator limit switches are not operating properly.	1. 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.

TROUBLE-SHOOTING CHART

TROUBLE	CAUSE	REMEDY
II. Regulator functions manually but not automatically in either the raise or lower direction.	1. Defective Control	2. See control instruction book. GE-2011 see GEH-7298 GE-2011B see GEH-7301 GE-2011C see GEH-7302
III. Regulator runs to maximum raise or maximum lower limit.	1. Control	1. See control instruction book.
IV. Regulator operates frequently.	1. Incorrect bandwidth 2. Time-delay setting is too low or the circuits are malfunctioning.	1. See control instruction book. 2. See control instruction book.
V. Regulator bucks when load increases.	1. Reversed polarity in either the current transformer or line drop compensation settings.	1. See control instruction book.
VI. Line drop compensator is not functioning in either reactance or resistance or both.	1. Shorting switch is closed. 2. LDC values are not programmed. 3. Defective current transformer.	1. Measure the voltage between NN-23 and NN-24. The voltage should be proportional to the load current and about 0.25 VAC at full load current rating of the regulator. 2. Program the LDC values. See the control instruction book. 3. If all components in 1 and 2 are normal, but no compensation exists, a defective current transformer could be the probable cause.
VII. Motor does not operate	1. Motor or motor capacitor may be faulty.	1. Disconnect the two leads from the capacitor terminals, apply 240 volts, 60 hertz to the terminals. And 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

CAUTION: See the nameplate on the regulator for jumper connection information. If the nameplate on the control is referred to make sure that it is the same one as on the regulator. If they are not the same, refer to the nameplate on the regulator.

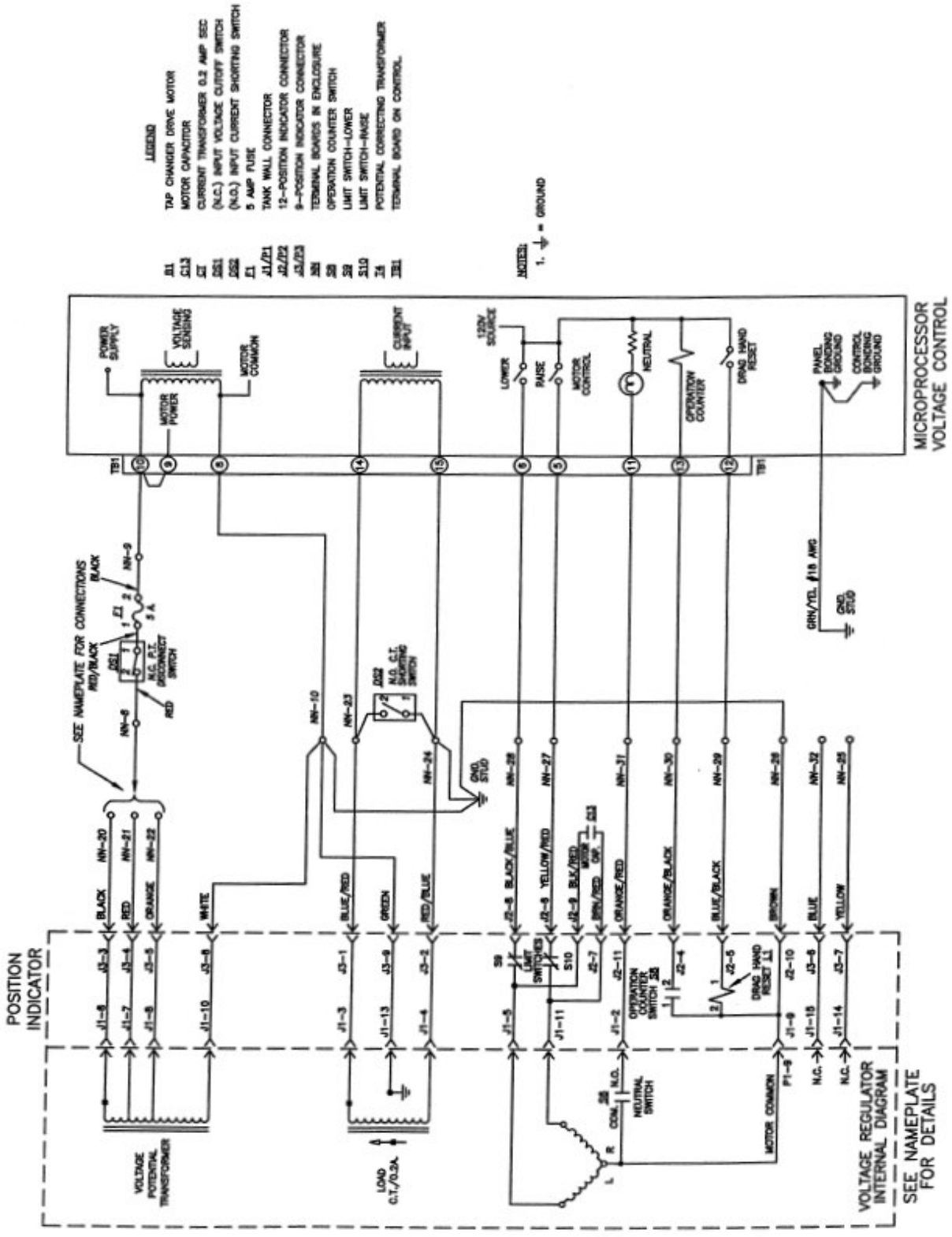


Figure 14
Typical Regulator / Control Interface Diagram

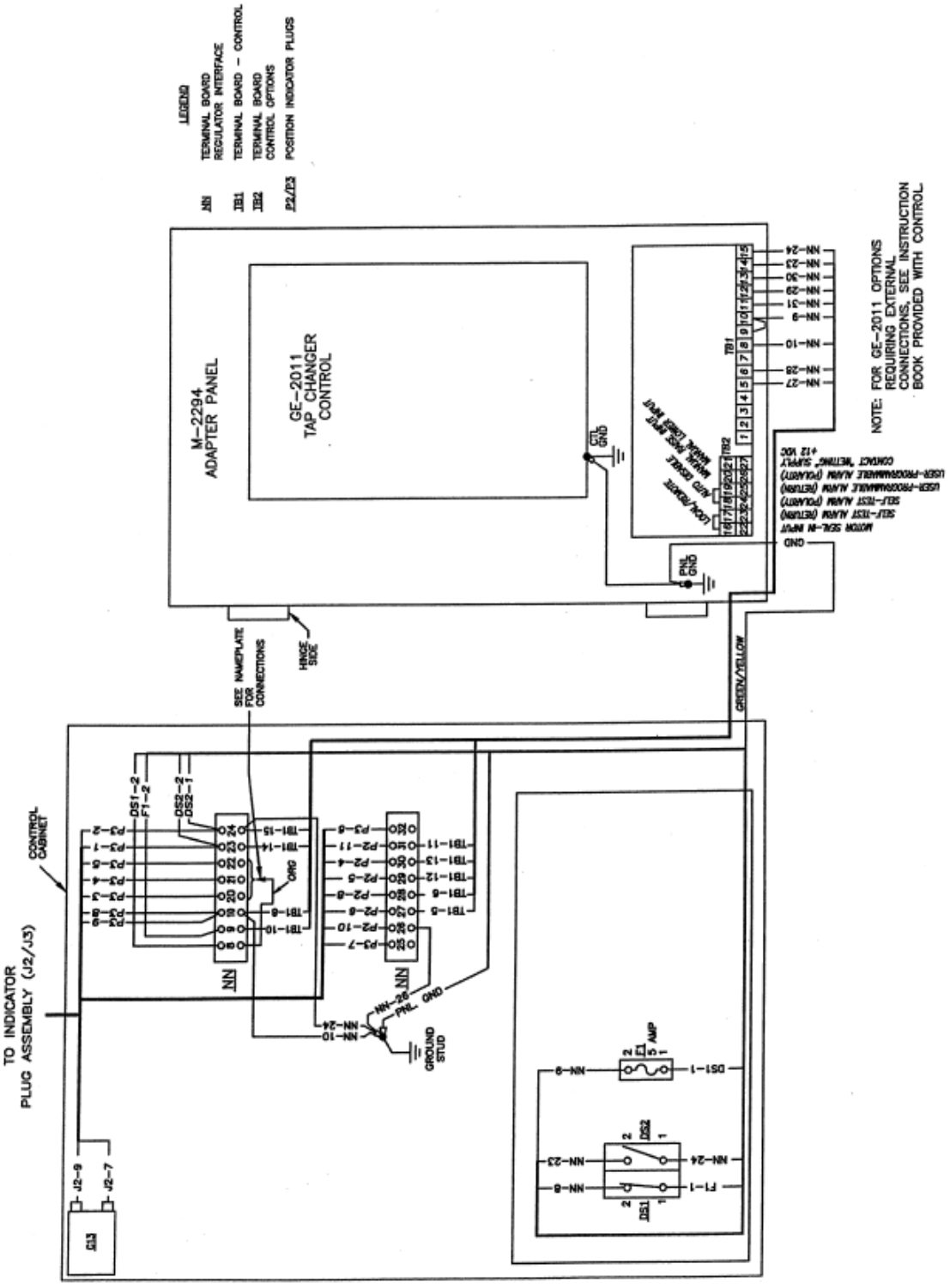
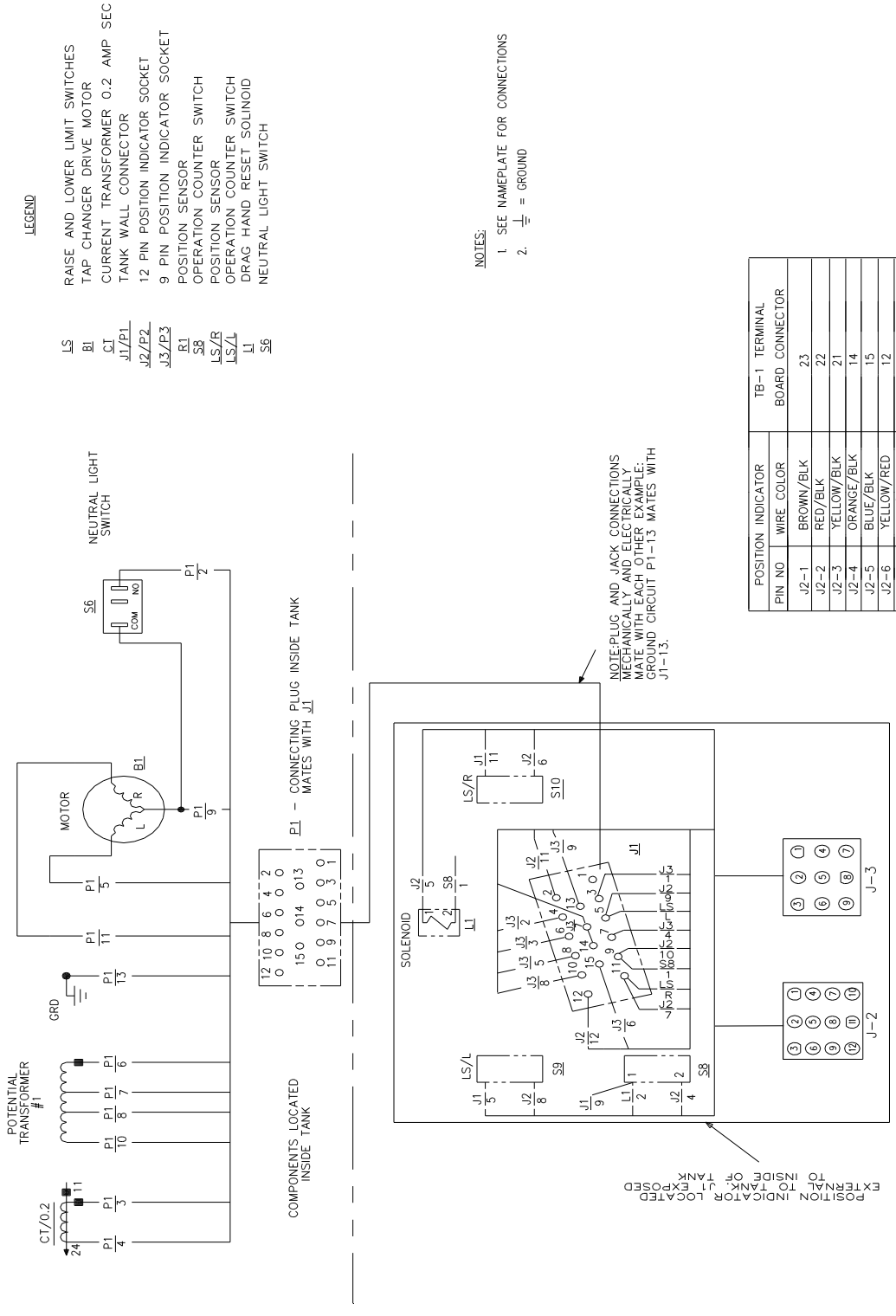


Figure 15
Typical Regulator Diagram



POSITION INDICATOR		TB-1 TERMINAL
PIN NO	WIRE COLOR	BOARD CONNECTOR
J2-1	BROWN/BLK	23
J2-2	RED/BLK	22
J2-3	YELLOW/BLK	21
J2-4	ORANGE/BLK	14
J2-5	BLUE/BLK	15
J2-6	YELLOW/RED	12
J2-7	BRN/RED	MOTOR CAPACITOR
J2-8	BLK/BLUE	11
J2-9	BLK/RED	MOTOR CAPACITOR
J2-10	BROWN	16
J2-11	ORANGE/RED	13
J2-12		N.C.
J3-1	BLUE/RED	18/CT PROT
J3-2	RED/BLUE	GND STUD /20 /CT PROT
J3-3	BLK	3
J3-4	RED	4
J3-5	ORANGE	5
J3-6	BLUE	9
J3-7	YELLOW	8
J3-8	WHITE	GND STUD /20 /CT PROT
J3-9	GREEN	GND STUD /7 /1

PARTS LIST

Furnish your nearest General Electric Sales Representative 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

REFERENCE NUMBER OF EACH PART (as shown in this book)

DESCRIPTION OF EACH PART (as shown in this book)

The General Electric "Triple-R" Parts Service Program offers you extra-swift shipment of common replacement items. Regulator parts shown in this book having reference numbers prefixed by the letter "R" will be on their way within 48 hours of the receipt of your order at our factory.

For pricing information, refer to the General Electric Apparatus Handbook section entitled "Feeder Voltage Regulators," or contact your nearest General Electric Sales Representative.

NOTE: SHIPMENT OF PARTS NOT BEARING THE "R" PREFIX WILL BE DEPENDENT UPON THE AVAILABILITY OF THE PARTS REQUESTED. IN CASES WHERE "R" PARTS AND "NON-R" PARTS APPEAR ON THE SAME ORDER, YOU WILL RECEIVE TWO SHIPMENTS, UNLESS YOU SPECIFICALLY REQUEST THAT A SINGLE SHIPMENT BE MADE. SHOULD YOU REQUEST SINGLE SHIPMENT, ANY PARTS BEARING THE "R" PREFIX WILL NOT RECEIVE TRIPLE-R RAPID PARTS SERVICE.

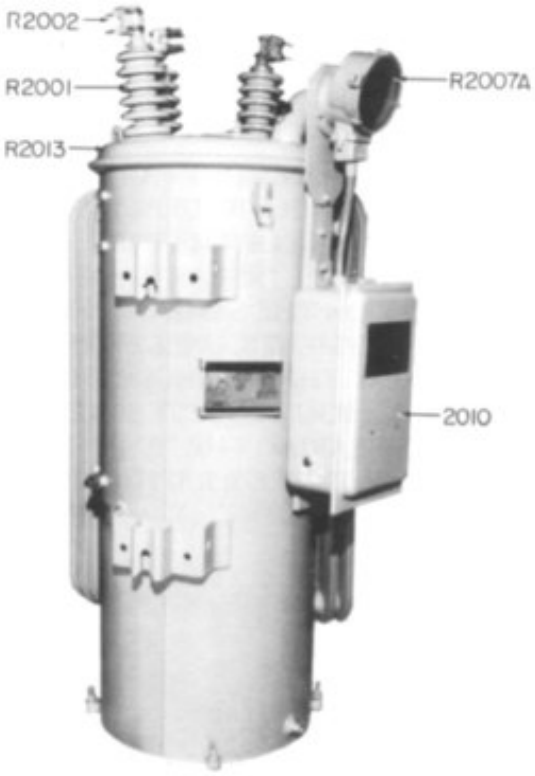


Fig. 16 Side, external

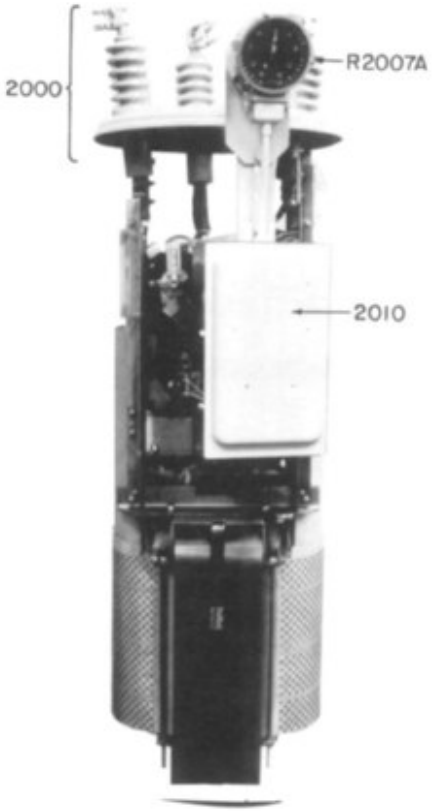


Fig 17 Front, untanked

Fig. 18 Load-bonus position indicator

Fig. No.	Ref. No.	Description
17	2000	High voltage bushing assembly - compete.
16	R2001	Bushing porcelain
16	R2002	Bushing terminal
*	R2003	Bushing terminal gasket
*	R2004	Bushing gasket cover
*	R2005	Hand-hole gasket
*	R2006	Cover gasket
16-17	R2007A	Load-bonus position indicator
18	R2008A	Load-bonus indicator glass assembly kit
*	R2009	Indicator gasket
16-17	2010	Control-cabinet assembly
*	R2011	Sample plug
18	R2013	Cover band
18	R1900	Indicator dial and switch assembly
18	R1901	Solenoid
18	R1902	Counter switch

* Not illustrated

Fig. 19 Type VR-1, reactor side

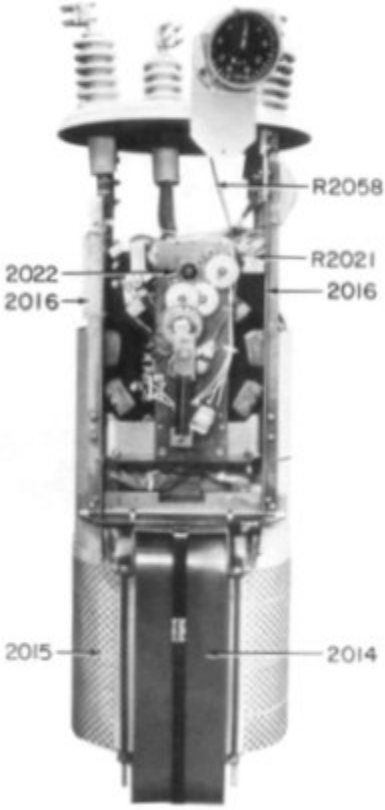


Fig. 20 Type VR-1, mechanism side with control cabinet removed.

Fig. No.	Ref. No.	Description
19-20	2014	Core
19-20	2015	Coil
19-20	2016	Clamps
19	2017	Reactor
19	2018	Current transformer
19	2019	Potential transformer
*	2020	ZENOX suurge bypass protector assembly
20	R2021	ZENOX disks
20	2022	Switch mechanism
20	R2058	Flexible shaft

* Not illustrated

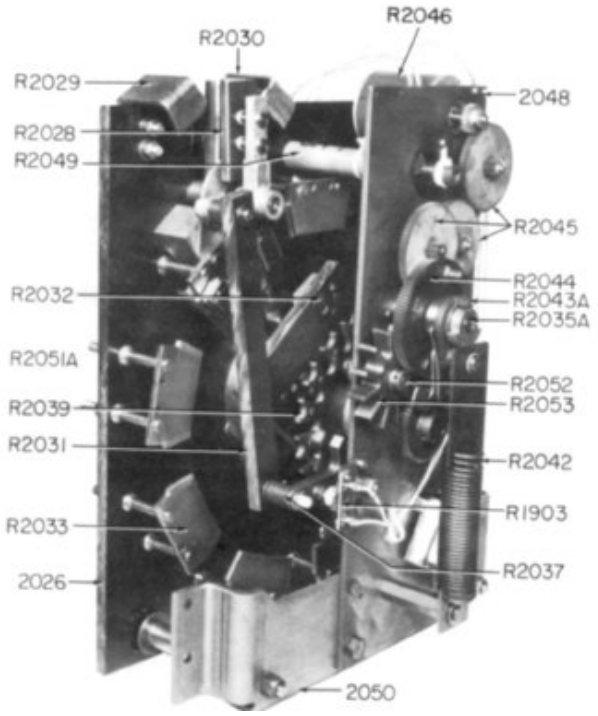


Fig. 21 High-current switching mechanism

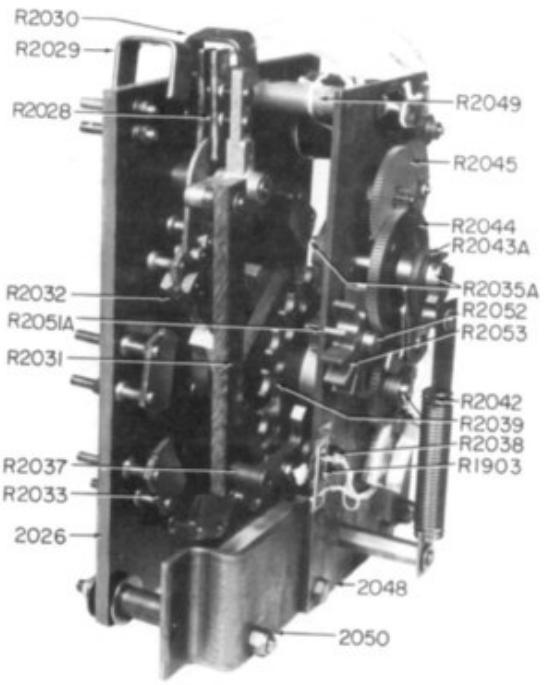


Fig. 23 Mid-current switching mechanism

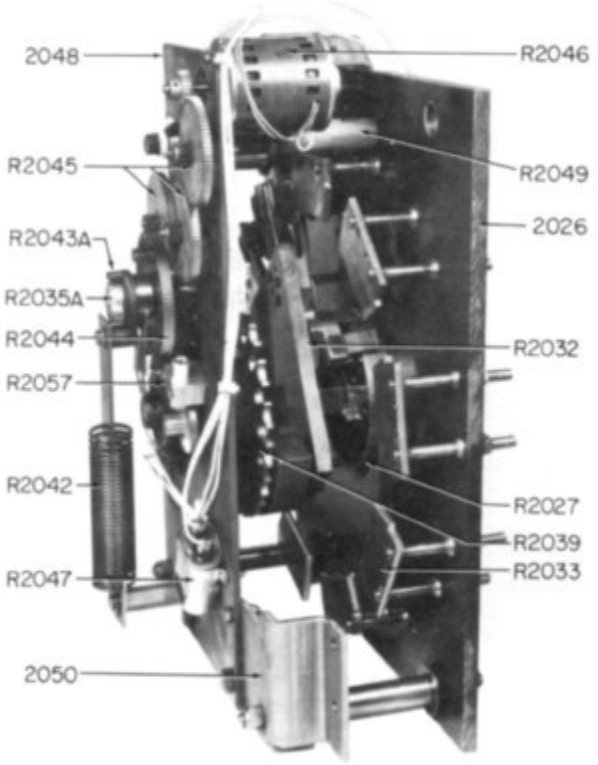


Fig. 22 High-current switching mechanism

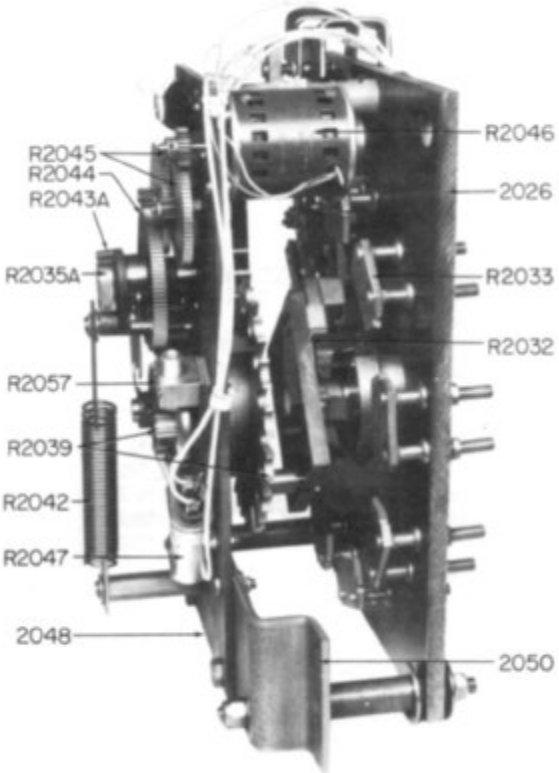


Fig. 24 Mid-current switching mechanism

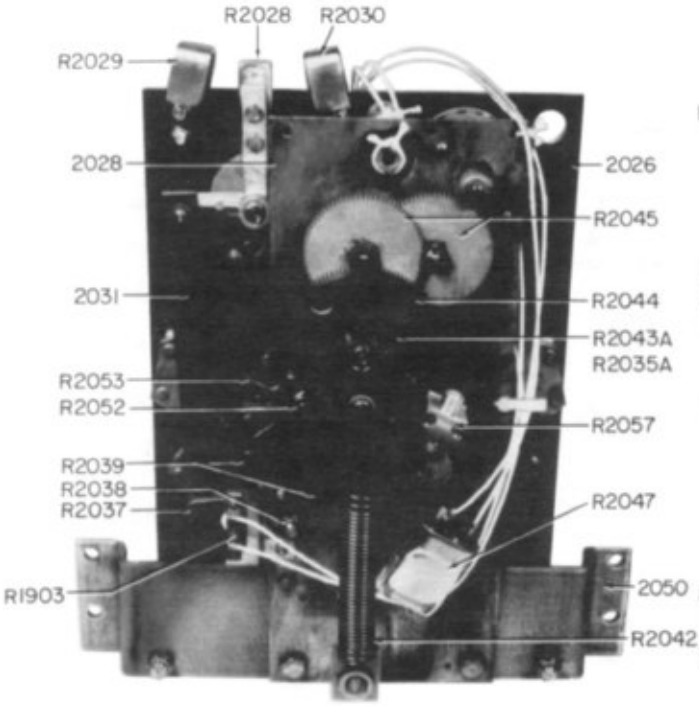


Fig. 25 Mid current switching mechanism

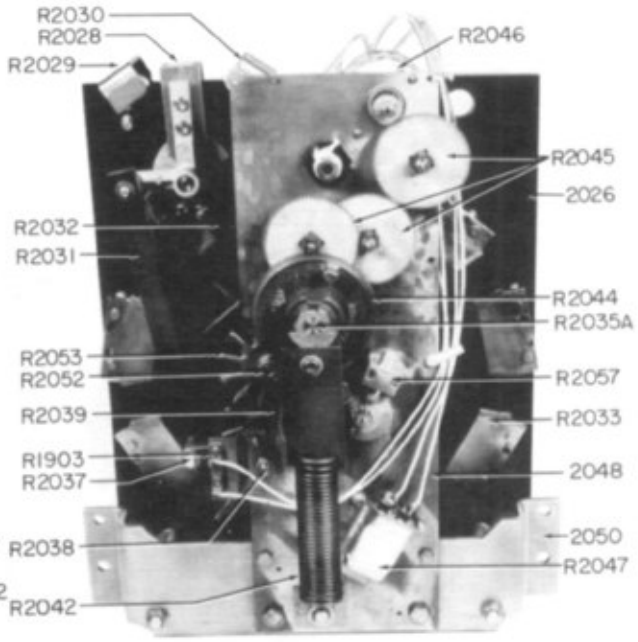


Fig. 26 High-current switching mechanism

Fig. No.	Ref. No.	Description
21-23-25-27	R1903	Neutral-light switch assembly
21-22-23-24-25-26-27	2026	Contact-panel assembly
22-27	R2027	Slip-ring assembly
21-23-25-26-27-	R2028	Reversing-switch moving-contact assembly
21-23-25-26-27-	R2029	Reversing-switch stationary-contact assembly (lower)
21-25-26-27-	R2030	Reversing-switch stationary-contact assembly (raise)
21-23-25-26-27-	R2031	Reversing-switch connector rod
21-22-23-24-27-	R2032	Moving contact assembly
21-22-23-24-26-27	R2033	Stationary contact assembly
27	R2034	Moving contact stud
21-22-23-24-25-26-27	R2035A	Crankshaft assembly
21-23-25-26-27	R2037	Geneva segment
23-25-26-27	R2038	Shaft for geneva segment
21-22-23-24-25-26-27	R2039	Geneva gear and shaft assembly
21-22-23-24-25-26-27	R2042	Spring assembly
21-22-23-24-25-27	R2043A	Driver and hook assembly
21-22-23-24-25-26-27	R2044	Gear
21-22-23-24-25-26-27	R2045	Gears (motor reduction)
21-22-24-26-27	R2046	Motor and pinion gear
22-24-25-26-27	R2047	Capacitor (may be located in control cabinet)
21-22-23-24-25-26-27	2048	Motor drive panel assembly
21-22-23	R2049	Spacer assembly
21-22-23-24-25-26-27	2050	Base
21-23-27	R2051A	Gear, shaft, impeller assembly
21-23-25-26-27	R2052	Shaft for impeller
21-23-25-26-27	R2053A	Impeller
22-24-25-26-27	R2057	Indicator miter-gear assembly
27	R2058	Flexible shaft

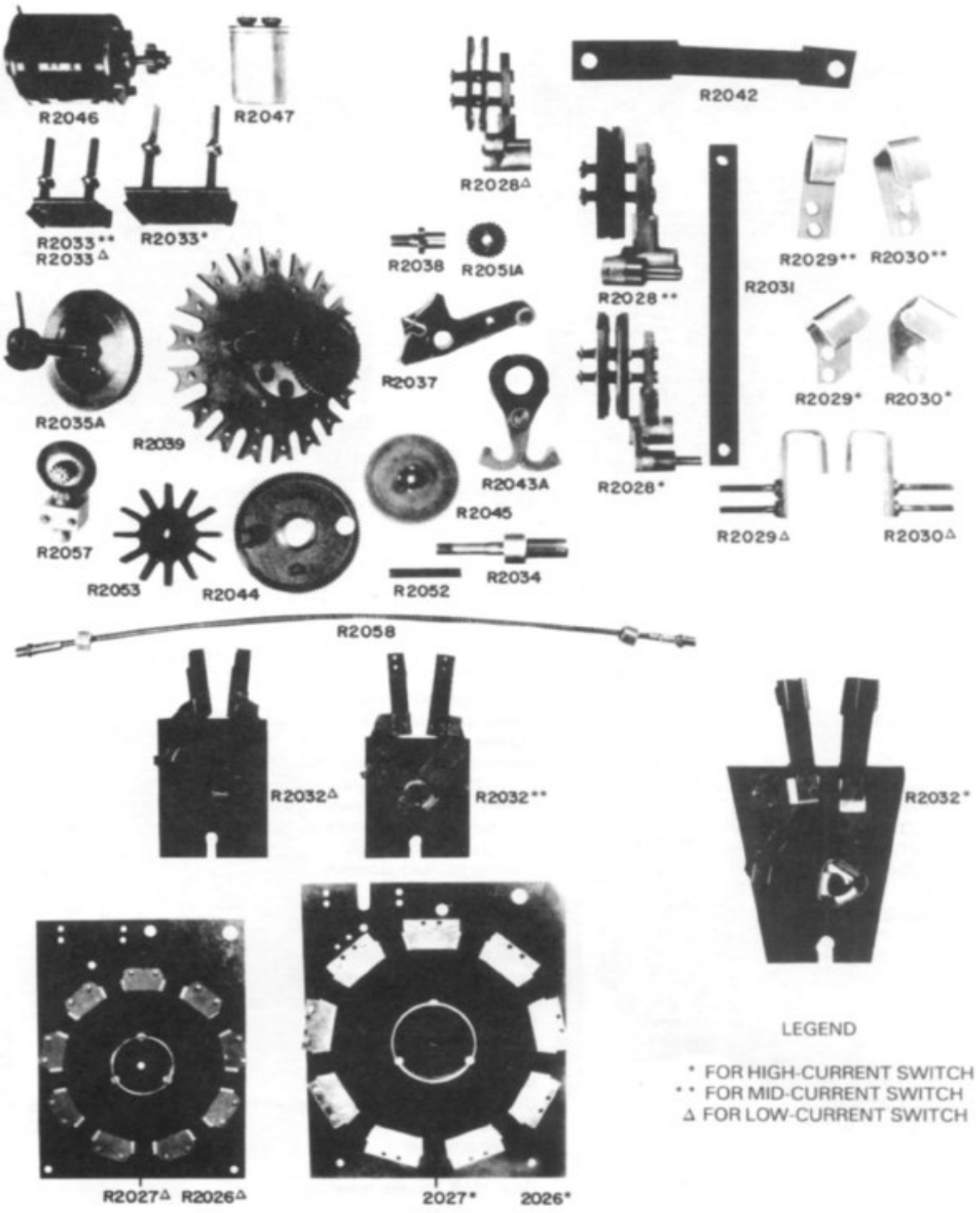


Fig. 27 Parts for switching mechanism Type VR-1 voltage regulator

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