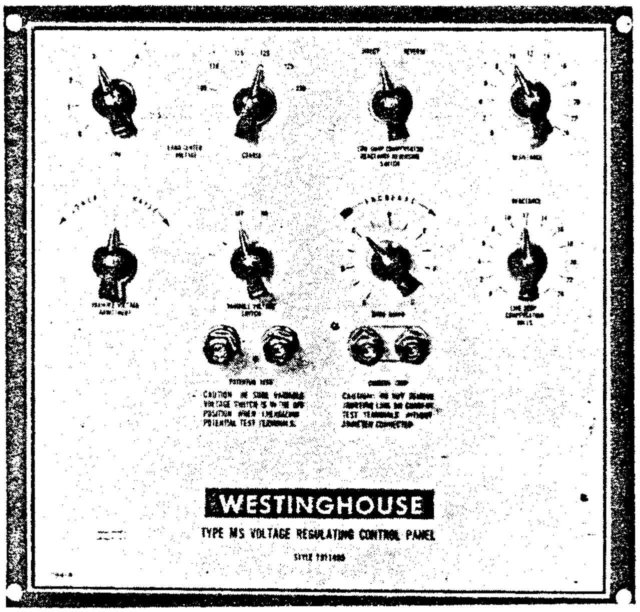
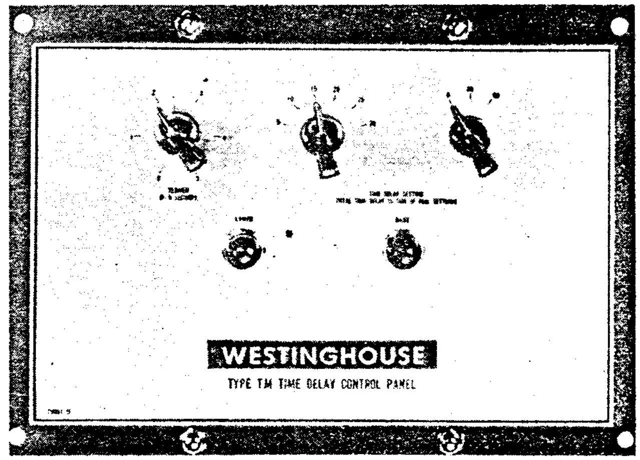
DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

TYPE MS AND TYPE TM
VOLTAGE REGULATING and TIME DELAY RELAYS
For Load Tap Changers





THE TYPE MS VOLTAGE REGULATING RELAY for automatic control of load tap changers consists of a static voltage sensing circuit employing a MAGAMP* magnetic amplifier with external controls for electrically setting the balance voltage, band width, and line-drop compensation.

THE TYPE TM TIME DELAY RELAY for use with the MS voltage regulating control uses a resistance-capacitance timing circuit in conjunction with a neon tube and a MAGAMP* magnetic amplifier to energize auxiliary relays which control the load tap changer motor contactors. Only one setting is required for both "raise" and "lower" operations, this setting being made by external calibrated dials.

RATING

The MS voltage regulating relay and the TM time delay relay have been designed for operation on 60 cycle alternating current systems. The balance voltage can be set at any value desired within the range of 105 to 135 volts, and the band width may be set at any value between ± 1.0 volts and ± 3.0 volts. The time delay may be set to any value, within the range of 5 to 95 seconds.

Separate R and X compensator elements permit independent setting of the 24 volts resistance and 24 volts reactance compensation (both on a 120 volt base) which is available with the standard current of 5 amperes flowing in the current circuit of the control. The 120 volt potential circuit has a burden of 50 volt-amperes and the 5 ampere circuit has a 25 volt-ampere burden.

DESCRIPTION

Voltage Regulating Relay. Detailed pictures of the MS voltage regulating relay are shown in FIGS. 1 and 3. The voltage sensing element containing the components for electrically measuring an unbalance in voltage is a sealed container mounted in back of the control panel as shown in FIG. 3. The components making up the sensing circuit are static devices consisting of a saturating transformer, rectifiers, a Magamp magnetic amplifier and resistors, to insure correct balance voltage under all conditions. An external resistor (R3) for calibrating the balance voltage is mounted on a bracket in back of the MS panel.

External circuit components for electrically setting the balance voltage, the band width, and the

*Trade-Mark

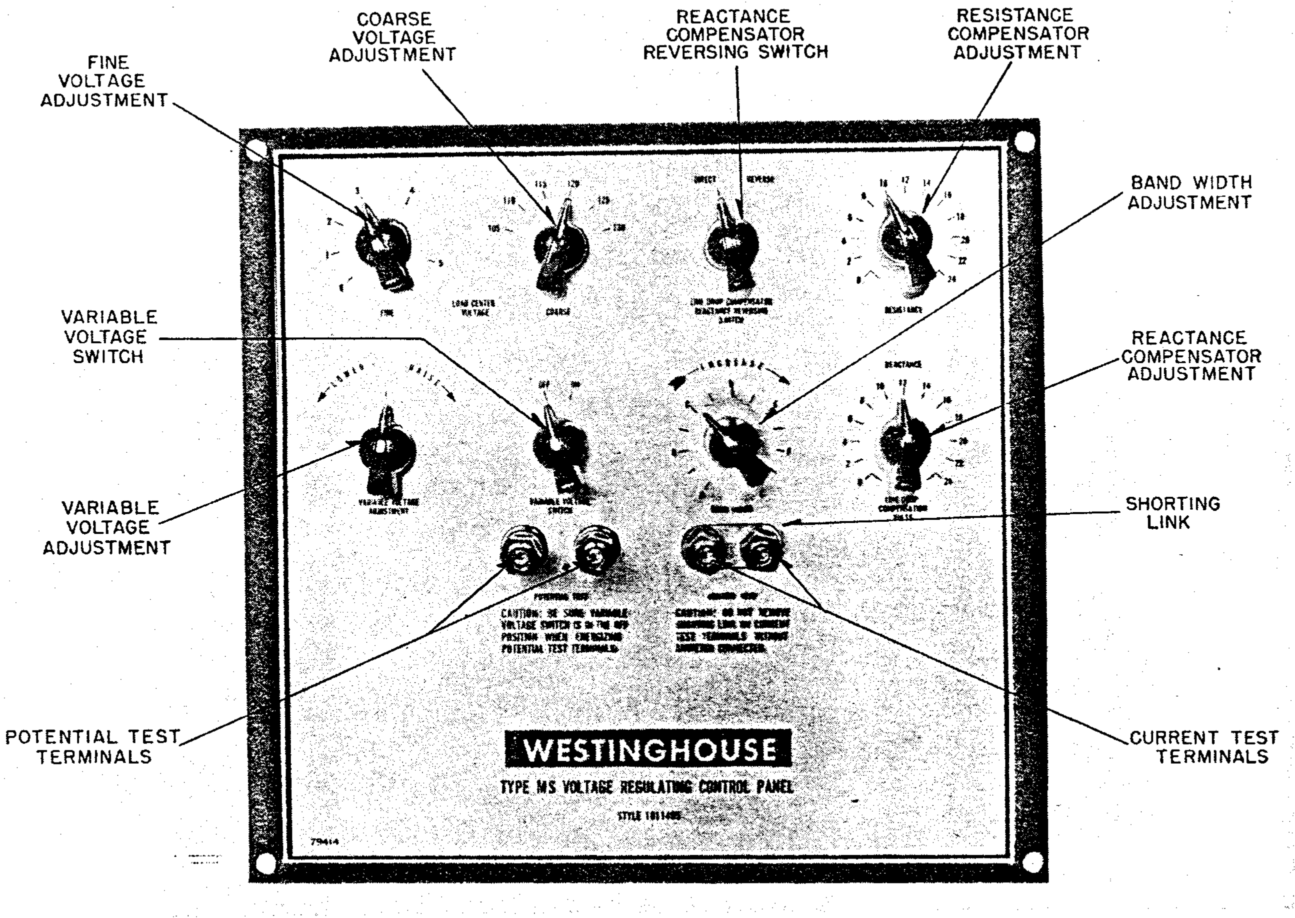


FIG. 1. Front View of MS Voltage Regulating Relay

line drop compensation are mounted on the MS panel as shown in FIGS. 1 and 3. The panel is designed for use as a unit in the complete tap changer control assembly.

An auto-transformer with five-volt taps from 105 to 130 volts plus an additional five-volt vernier tap provides balance voltage settings from 105 to 135 volts. The balance voltage selection is made by means of a non-shorting rotary tap switch for five volt steps and a potentiometer for vernier settings to give intermediate values. Also mounted on the back of the panel with control knobs in front are rheostats for setting the bandwidth and line drop compensation; a rotary type shorting switch for reversing the reactance line drop compensation; a variable auto-transformer and switch for obtaining a variable voltage to assist in setting the bandwidth and voltage level. Intermediate current transformers for the line drop compensator are located back of the control panel.

lectrical connections between the voltage sensing element and the MS control panel are made through the terminal strips on the end of the sensing element. Reference FIG. 11. External connections from the MS voltage regulating relay are made through two AN connectors as shown in FIG. 3. Current and potential test terminals are conveniently located on the front of the panel.

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

Time Delay Relay. The TM time delay relay is shown in detail in FIGS. 2 and 4. An electrical matching network which is energized by the MS voltage regulating relay is sealed in the housing shown in FIG. 4. This matching network provides a reversible polarity voltage signal to be electrically timed by a resistance-capacitance timing circuit. The capacitance element is sealed in the housing. The timing resistance consists of a rheostat plus fixed resistors which are used in steps to provide the

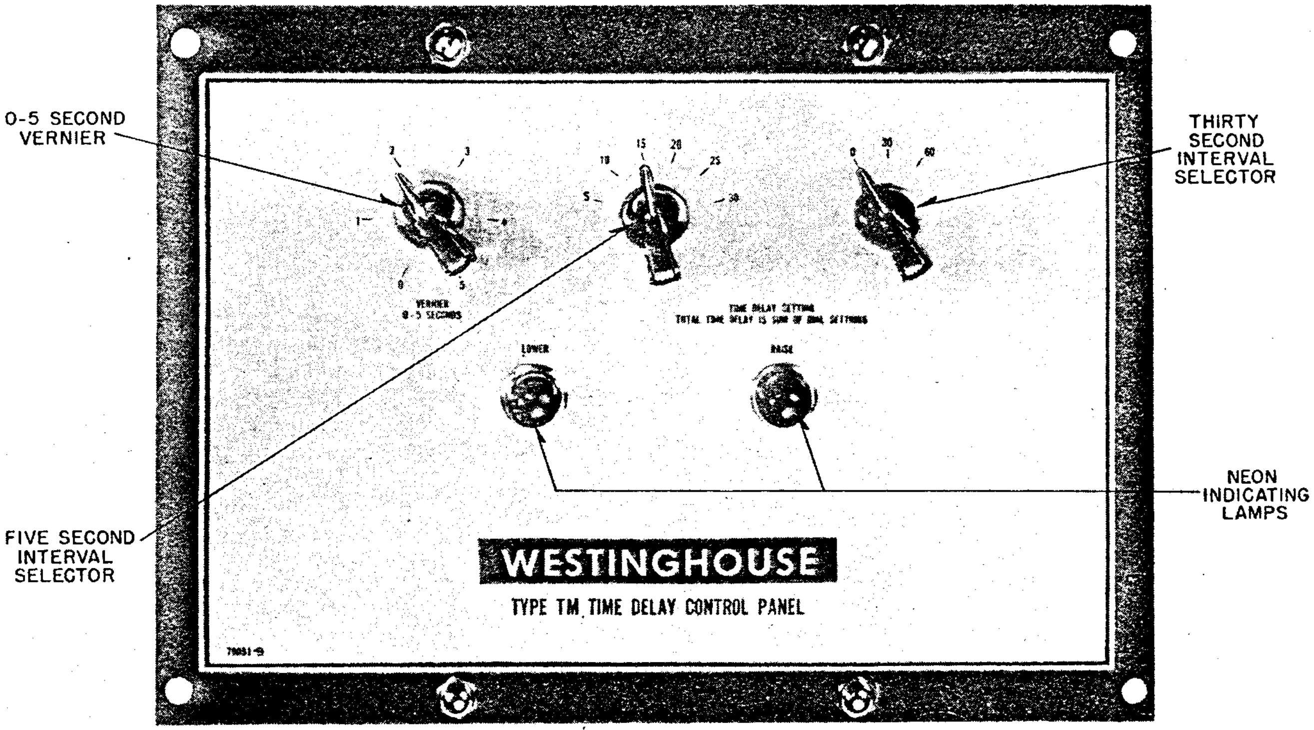


FIG. 2. Front View of TM Time Delay Relay

desired delay setting. The rheostat is attached to the control panel while the fixed resistors are connected between terminals of the tap switches as shown in FIG. 4. A neon tube mounted on the rear of the control panel measures the voltage on the capacitor and, at the set delay, controls a MAGAMP magnetic amplifier which is sealed in the housing. The MAGAMP magnetic amplifier energizes two of the relays shown mounted on the rear of the panel, one relay for "raise" operation and one for "lower" operation, through contacts of the slug relay. The slug relay (NV) introduces a time delay to allow the Magnetic Amplifier to be under positive control, thus preventing malfunction of the "raise" and "lower" relay, when the control is energized initially.

Time delay settings are made by the use of calibrated dials shown in FIG. 2. One tap switch changes the timing resistance in steps to give five-second increments of time delay from five to thirty seconds while a second tap switch provides thirty-second increments from zero to sixty seconds. A rheostat provides a vernier range from zero to five seconds with a dial calibrated in one second increments. The vernier setting is added to the other settings, thus giving intermediate delays.

Two neon lights mounted on the control panel indicate the presence of an input to the timing circuit, or in other words, the presence of an unbalance in the voltage applied to the MS voltage regulating relay. External connections from the TM time delay relay are made through an AN connector.

RECEIVING—HANDLING—STORING

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

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

Handling. The MS voltage regulating relay is in fact an instrument and should be handled as such. It has been designed to be as rugged as possible, but the fact remains that it has better than 1% ac-

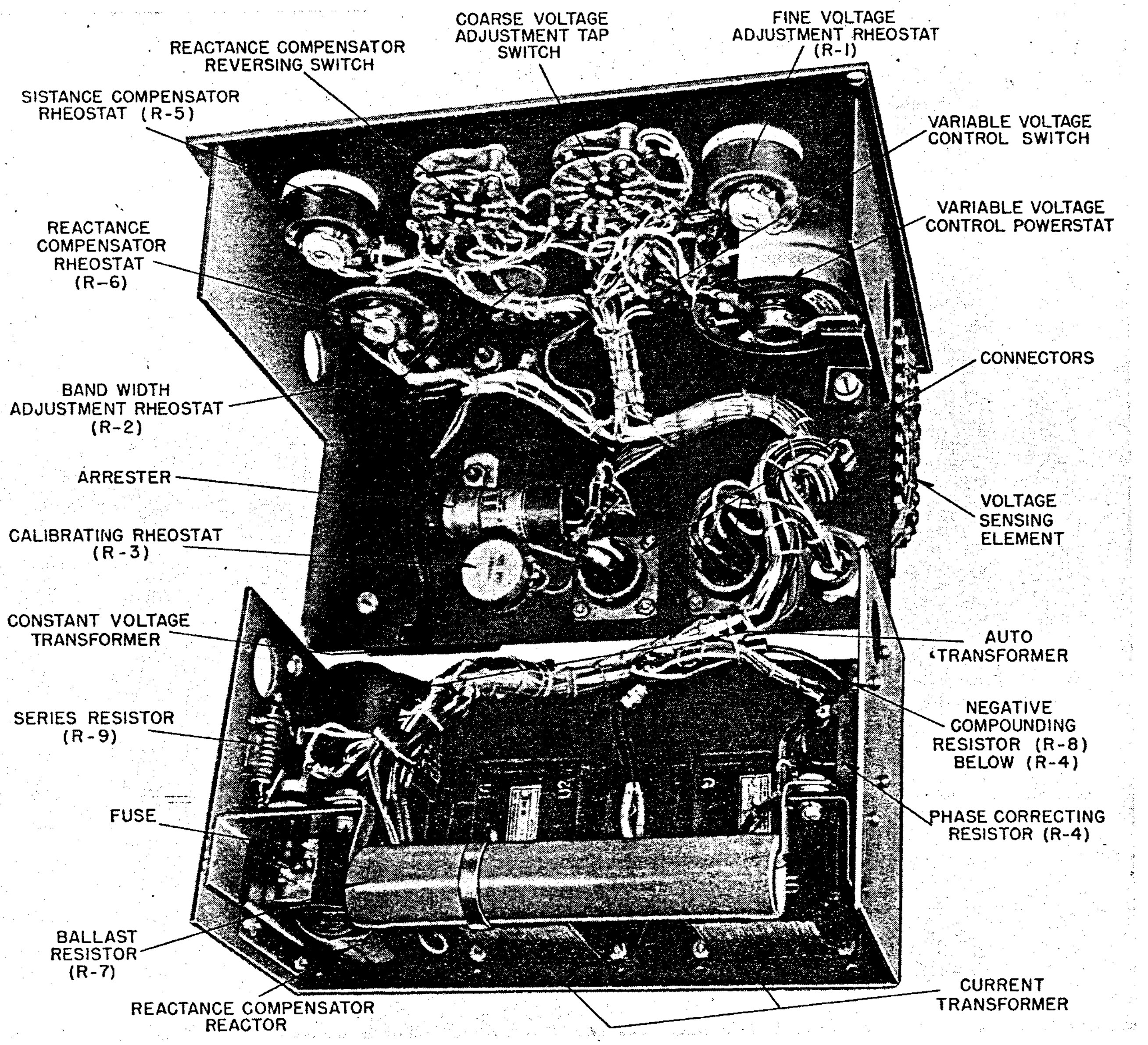


FIG. 3. Rear View of MS Relay Panel

curacy and is thus equivalent to the better, more accurate laboratory voltmeters and should consequently be handled with reasonable care, free from excessive shock and vibration.

These relays have been adjusted and tested before leaving the factory to insure that they meet the required high standards of operation considered essential for such equipment. Whether or not they continue to meet these standards depends upon the treatment accorded them after they leave the factory.

Storing. If the MS and TM relays are to be stored, they should be kept in a clean, dry, moderate temperature location, protected from excessive dust, from atmospheres conducive to condensation and corrosion, and from moisture and the elements.

INSTALLATION

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

TO INSTALL the MS and TM relays in the control compartment, place the back projections of the panels into the cutouts provided in the control compartment (insert from the front of the

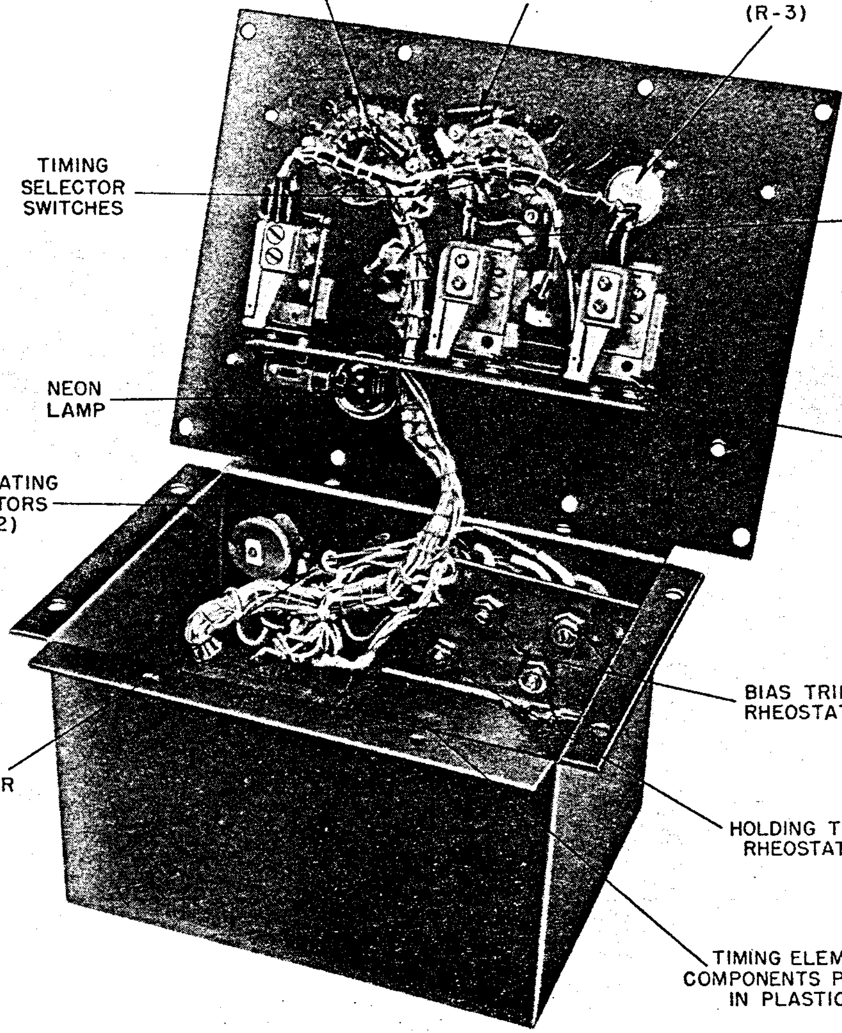


FIG. 4. Rear View of TM Relay Panel

control compartment) and bolt in place at the four corners with the bolts provided for this purpose. Insert the plug connectors from the back of the swinging control panel into the receptacles on the back of the MS and TM panels and the installation is complete.

TO REMOVE the MS and TM panels from the control compartment, disengage the plug connectors from the receptacles and remove the four bolts from the corners of each panel. The four pole connector contains self shorting terminals so that the current transformer is automatically shorted when the plug is removed.

OPERATION

Voltage Regulating Relay. The voltage sensing action of the MS voltage regulating relay is basically a function of the magnetic characteristics of a saturating transformer and the control characteristics of a self saturating MAGAMP magnetic amplifier. Band width and compounding are accomplished by the control characteristics of the amplifier. Line drop compensation is provided by introducing a bias voltage into the sensing circuit which is proportional to the magnitude and phase of the voltage drop on the line.

The voltage sensing circuit measures the value of the input voltage at terminals A4 and B4 of FIG. 5 less the line drop compensation voltage. With proper balance voltage applied to terminals A4 and B4, the output of the voltage sensing circuit is zero. As the applied voltage is either increased above or decreased below the balance value, the sensing circuit has an output voltage signal of one polarity

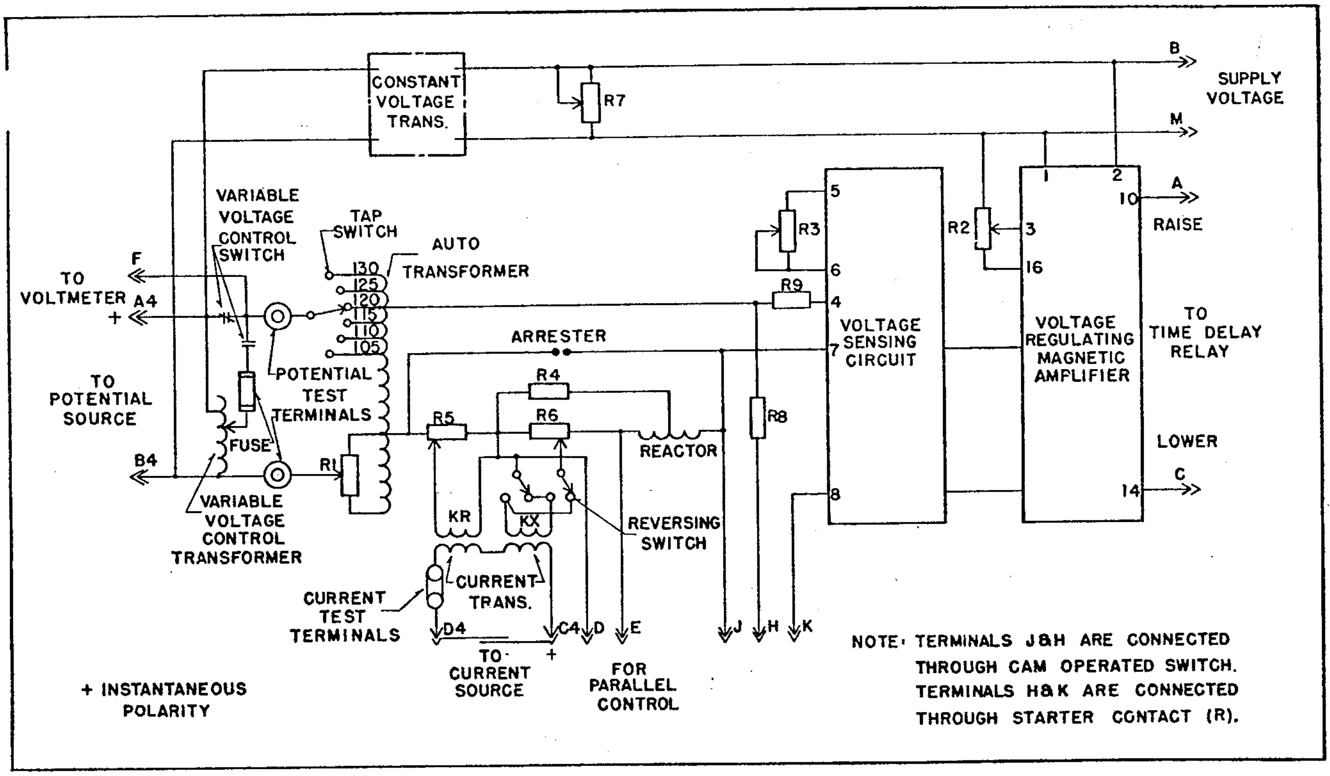


FIG. 5. Schematic Diagram of Type MS Voltage Regulating Relay

or the other depending upon the direction of change from balance voltage. This signal is applied to the lifier circuit having separate outputs for "raise" and "lower" operations. As the change in balance voltage becomes sufficiently large, a signal of the proper polarity from the sensing circuit causes the

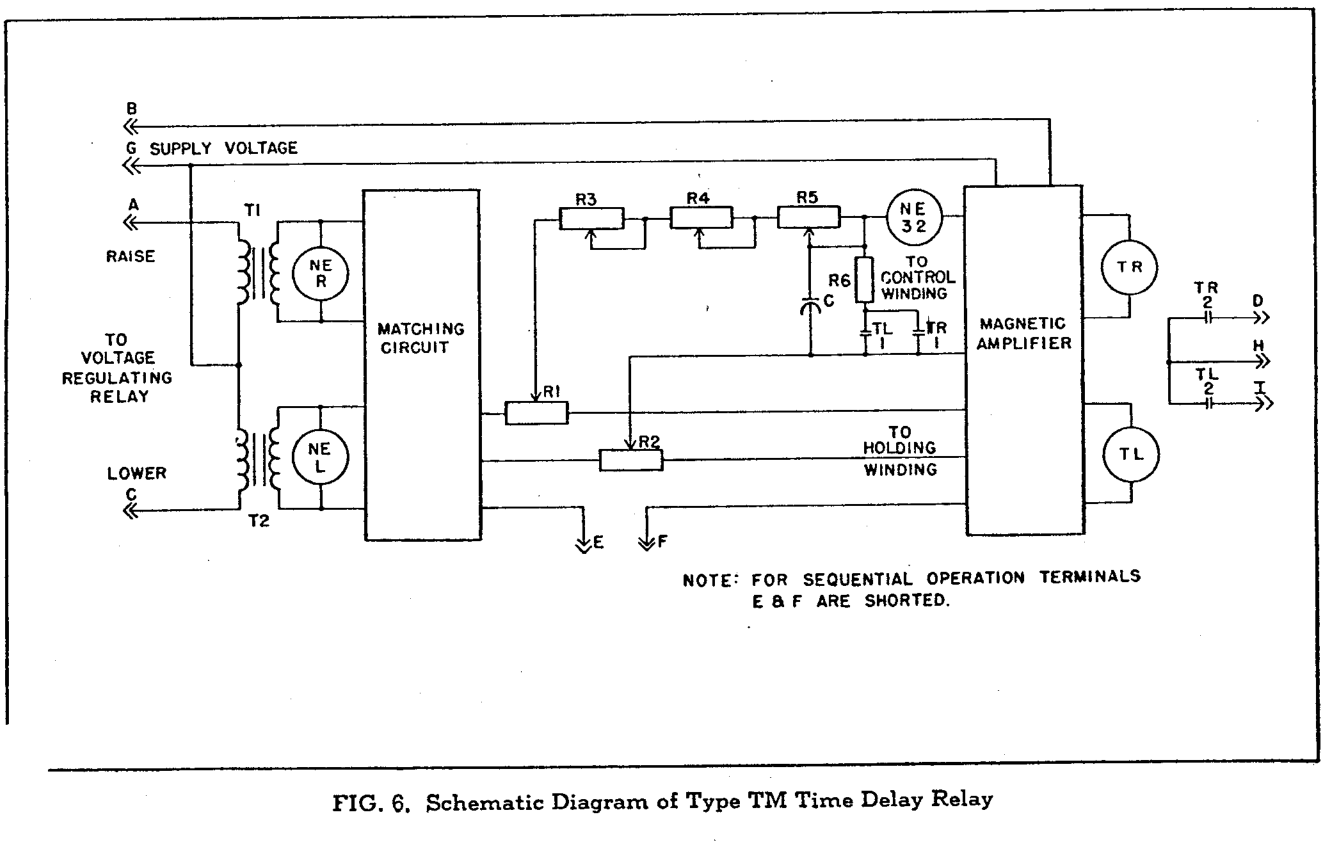


FIG. 6. Schematic Diagram of Type TM Time Delay Relay

amplifier to conduct. The amount of voltage change necessary to cause the amplifier to conduct is determined by the bias applied to the amplifier circuit with the band width setting rheostat. The voltage change back toward balance necessary to cause the amplifier to stop conducting is determined by a fixed amount of positive feedback in the amplifier. This value has been set at the factory to give the proper compounding to insure stable operation of the automatic controls with a minimum number of tap changer operations. By shorting terminals J to H or H to K to J, through a cam operated tap changer switch and relay contact, a signal is given to the sensing circuit to anticipate a correction of voltage by the tap changer.

Input balance voltages from 105 to 135 volts are made possible by an autotransformer with taps on the input side. A vernier (Rl, FIG. 5) provides intermediate values which are added to the tap selection. A rheostat (R2, FIG. 5) is used to vary the bias to the magnetic amplifier, allowing a band width selection from 2 volts to 6 volts.

Line drop compensation is obtained by circulating a current, proportional to the load current, through the line drop compensator network to produce a voltage proportional to the actual drop in a line for which the compensator is adjusted. This voltage is subtracted from the regulator voltage to simulate load center voltage. By adjusting rheostats R5 and R6 of FIG. 5, the compensator can be set to give 0 to 24 volts resistive and reactive compensation (on a 120 volt base with 5 amperes flowing through terminals C4 and D4). Reversed reactance conpensation can be obtained by the reversing switch.

Time Delay Relay. The basic timing function of the TM time delay relay is performed by a resistance-capacitance timing circuit. The time delay is determined by the value of resistance inserted into the resistance-capacitance network. The timing circuit controls a MAGAMP magnetic amplifier which energizes auxiliary relays to operate the tap changer motor contactor.

When a departure from balance voltage exists outside the set band width of the voltage regulating control, a voltage signal is fed into the time delay relay as indicated in Fig. 6, a "raise" signal being fed through transformer T1 or a "lower" signal through transformer T2. Indicating lamps, NER and NEL indicate the presence of an input to the time delay relay. The matching network provides a DC voltage to the timing circuit of a polarity to indicate whether a "raise" or a "lower" operation is required. The matching network also applies a signal voltage directly to a holding winding of the amplifier. After the set time delay, the control winding is energized with a pulse signal through the NE-32 neon lamp. This causes the time delay amplifier to conduct energizing either relay TR or TL depending upon the polarity of voltage being timed. The action of the holding winding keeps the amplifier conducting as long as there is an input to the time delay relay or until the holding winding circuit is interrupted by some other means. Contacts on TR or TL discharge the timing capacitor through resistor R6 (Fig. 6) to immediately reset the timing circuit.

Resistors R1 and R2 (Fig. 6) are used to calibrate the delay dials for "raise" and "lower" operations respectively. These have been set at the factory and should not have to be changed. Delays ranging from 5 to 95 seconds can be obtained by setting variable resistors R3, R4 and R5 (Fig. 6). R3 is a rheostat used to provide intermediate values with the dial marking calibrated in one second increments of time delay. R4 can be changed in five equal steps to provide five second increments of time delay from five to thirty seconds while R5 can be changed in two equal steps to provide thirty second increments. The total delay is the sum of the dial settings, with only one setting required for "raise" and "lower" operations.

The holding winding can be interrupted by a cam operated switch to provide for non-sequential operation of the tap changer. For sequential operation terminals E and F are shorted so that the holding winding is de-energized only when the input to the timing control is removed.

SETTING

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

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

Balance voltage may be corrected by adjusting potentiometer R3, if necessary.

Balance Voltage and Bandwidth Settings Using External Voltage Source. Place the control breaker in the "OFF" position, the variable voltage switch in the "OFF" position, and apply an external regulated power source to the potential test terminals. If the unit is carrying load, set the

compensator dials on zero while the balance voltage and band width settings are made. The balance voltage and band width settings are made as follows:

1. Turn the band width dial to the full clockwise position.

2. Set the coarse-voltage adjustment dial to the dial calibration just below the desired balance voltage. (For example, set on 115 volts for 117 volts balance).

3. Next turn the fine-voltage adjustment dial to the value which when added to the setting above gives the desired balance voltage. (In the example, set on 2 volts).

4. To set the bandwidth and check with the balance voltage setting above, adjust the external applied voltage to be equal to the balance voltage less one half the total band width. (For example, if a band width of 3 volts with balance voltage of 117 volts is desired, adjust the voltage to 115.5 volts).

5. Rotate the band width dial slowly in a counter-clockwise direction until the "Raise" light on the TM panel comes on. These settings now should give the proper balance voltage and band width and may be checked in the step below.

6. Increase the external applied voltage to be equal to the balance voltage plus one half the total band width. (118.5 volts in the example above). The "Lower" light on the TM panel should come on at this value of voltage; however, a slight readjustment of the fine-voltage dial and the band width dial may be necessary. If the light comes on at less than the desired voltage, it indicates a balance voltage setting and a band width setting slightly less than the desired values. If the light comes on at a higher value than the desired value the reverse is indicated. In any case, only a very minor adjustment will be necessary. Both balance voltage and band width can be increased by a clockwise rotation of the fine-voltage adjustment dial and band width adjustment dial respectively.

Balance Voltage and Bandwidth Settings Using Internal Voltage Source. A variable autotransformer is provided on the MS voltage regulating relay for making balance voltage and band width settings using the internal potential transformer as a voltage source. Place the automatic manual switch in the "OFF" position or the "MAN" position, the control breaker in the "ON" position, and the variable voltage switch in the "ON" position. If the unit is carrying load, set the compensator dials on zero while the settings are being made. Using the variable autotransformer on the MS relay panel to vary the voltage, the balance voltage and band width settings are made following the steps listed in the procedure for making settings using an external voltage source.

NOTE: Care should be taken to observe the voltmeter readings during each step of the procedure for making settings to be sure that minor voltage fluctuations of the source voltage do not occur while the settings are being made. After the settings are made, return the variable voltage switch to the "OFF" position.

Line-Drop Compensator Settings. The final settings on the line-drop compensator are usually made by field adjustments, but if the data on the particular line is known, the curves in FIGS. 9 and 10 may be used, and initial values calculated.

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

Dial Setting for Resistance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times R_L \times d \times n.$$

Dial Setting for Reactance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times X_L \times d \times n.$$

Where

$N_{C.T.}$ = current transformer ratio $= \frac{\text{primary current}}{\text{secondary current}}$

N_{POT} = potential transformer ratio $= \frac{\text{primary voltage}}{\text{secondary voltage}}$

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

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

d = miles from unit to load center.

n = 120/balance voltage setting.

A typical three-phase example is as follows:

```
a              b              c
0<----4'---->0<----4'---->0
|<-----------8'----------->|
```

500,000 CM copper conductor, with flat spacing above

Line Voltage = 12000 volts
Current Transformer Ratio = 600/5
Potential Transformer Ratio = 6928/120
Distance from unit to load center = 3.5 miles.
Balance voltage setting = 117 volts.

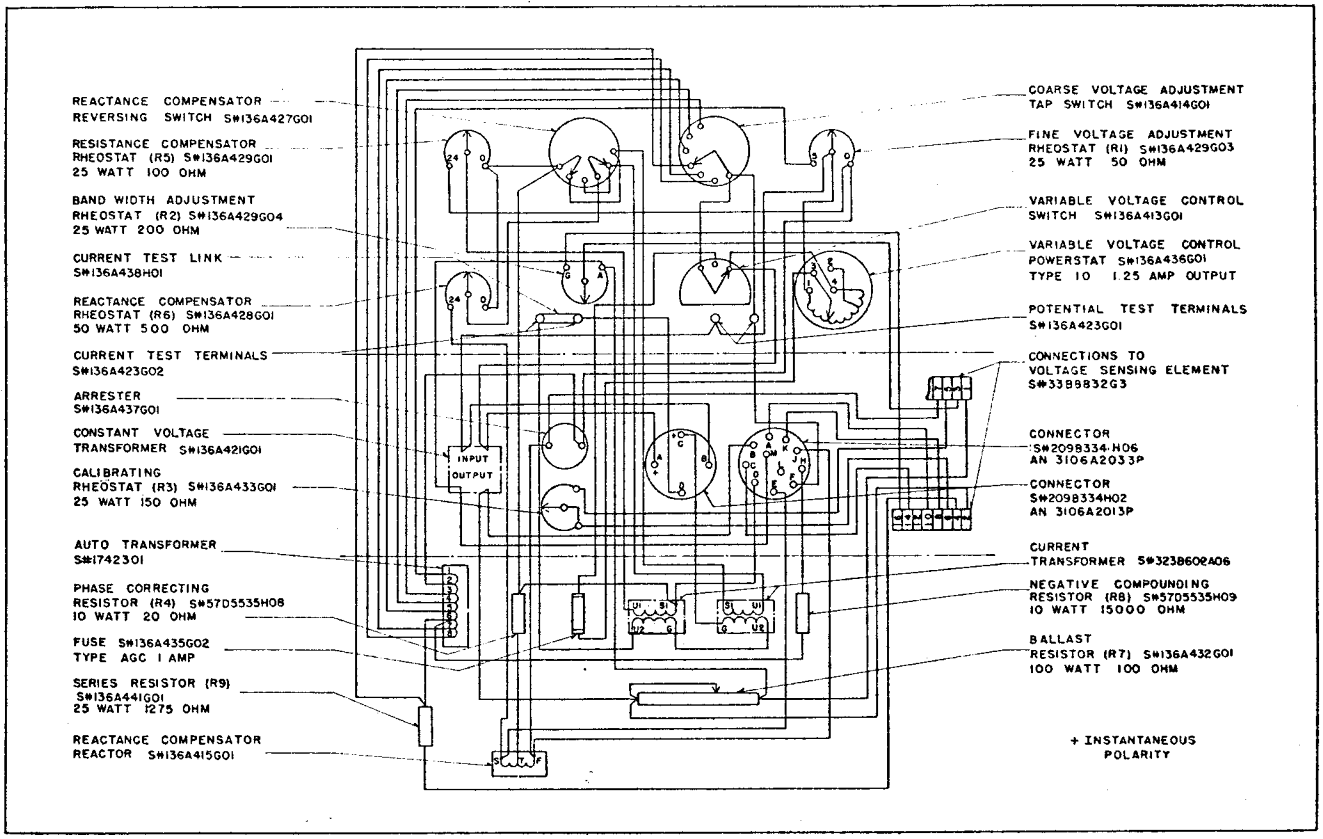


FIG. 7. Wiring Diagram of Type MS Voltage Regulating Relay

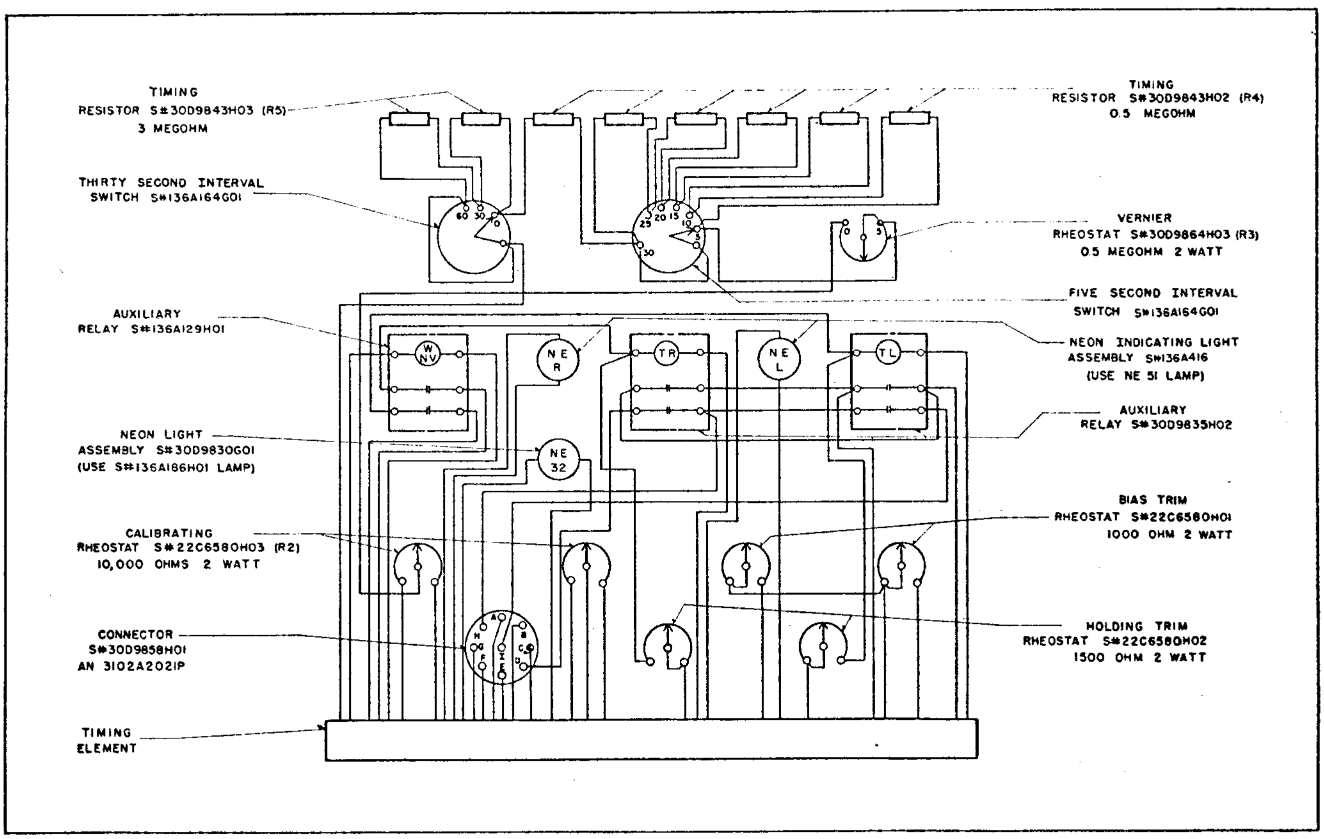


FIG. 8. Wiring Diagram of Type TM Time Delay Relay

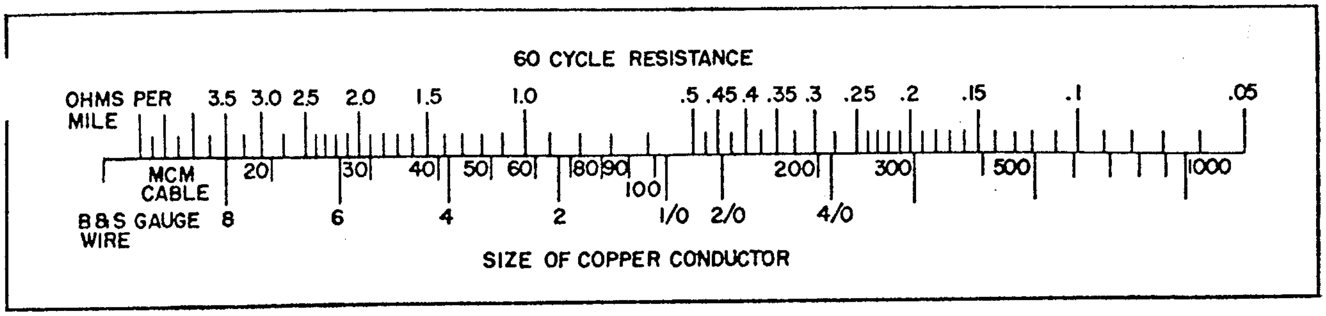


FIG. 9. Resistance Chart, Showing Ohms per Conductor per Mile, 60 Cycle Circuit

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

From FIG. 9:

$R = 0.12$ ohms per mile

From FIG. 10:

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

$X_L = 0.64$ ohms per mile

The line drop compensator resistance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.12 \times 3.5 \times \frac{120}{117} = 4.47$$

The line drop compensator reactance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.64 \times 3.5 \times \frac{120}{117} = 23.9$$

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

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

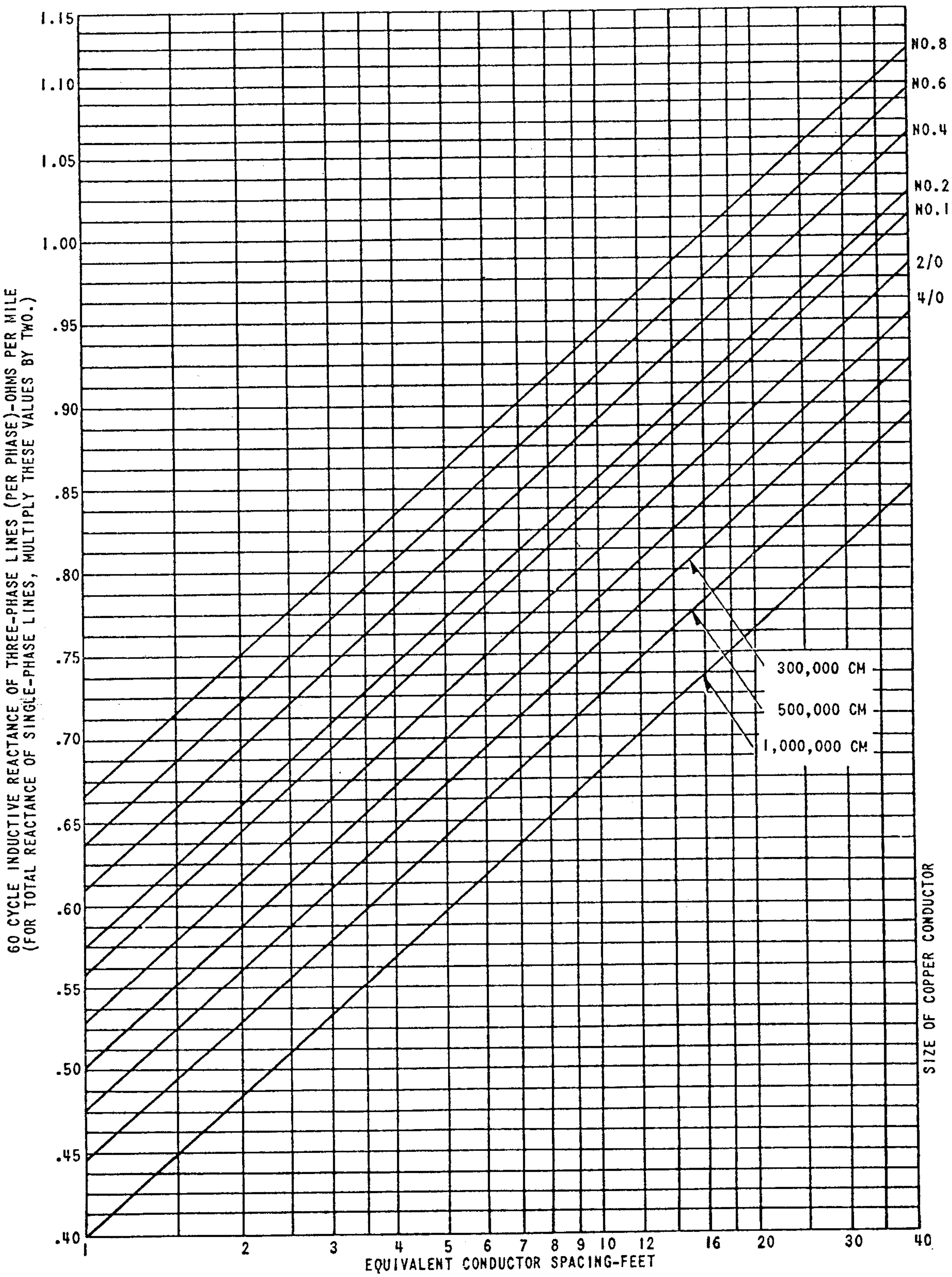
Time Delay Settings. The desired time delay is set with the calibrated dials on the front of the TM control panel. Selection of delays in five second intervals from 5 to 95 seconds can be made. For intermediate settings, a vernier dial calibrated in one-second intervals adds the intermediate value. (Example: For a 37-second delay setting, set the vernier dial on 2 seconds, the five-second interval dial on 5 seconds and the thirty-second interval dial on 30 seconds). Only one setting is required for both "raise" and "lower" operations.

MAINTENANCE

The proper adjustments to insure correct operation have been made at the factory and should not be disturbed. The components of the voltage sensing element of the MS voltage regulating control which are sealed are static components and under normal conditions should require no maintenance. Should the sensing element become inoperative, return the entire MS panel to the Sharon Plant through the nearest District Engineering and Service Office.

The components of the TM time delay control which are sealed in the housing are static components and under normal conditions should require no maintenance. In the event they should become inoperative, return the entire TM panel to the Sharon plant through the nearest District Engineering and Service Office.

In the event any of the components on the MS and TM panels other than the sealed units become inoperative, they may be replaced with renewal parts ordered from the nearest Westinghouse Sales Office or from the Sharon Plant. Should parts be ordered, give the Style or Stock Order number of the equipment as stamped on the nameplate together with the style number and description of the parts required as identified in FIGS. 7 and 8.



EQUIVALENT CONDUCTOR SPACING, D, OF UNSYMMETRICAL THREE PHASE LINES IS GIVEN BY THE EXPRESSION $D = \sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$, WHERE

D_{AB}, D_{BC}, AND D_{CA} ARE THE DISTANCES IN FEET BETWEEN CONDUCTORS DESIGNATED BY THE SUBSCRIPTS.

NOTE:- WHERE $D_{CA} = 2\ D_{AB} = 2\ D_{BC}$; $D = 1.26\ D_{AB}$

FIG. 10. Reactance Chart, Size of Conductor and Spacing, for 3-Phase Lines (per Mile), 60 Cycle Circuit

Trouble Shooting. Observing the suggested symptoms and making the indicated measurements will be helpful to a competent repair technician in determining the cause of misoperation and identifying any damage or unconnected components. The indicated voltages are 60 cycles AC and should be measured with a voltmeter of 1000 ohm per volt sensitivity. The test power supply should be finely adjustable, well regulated, and with low harmonic content.

For convenience in trouble shooting reference Figures 12 and 13.

NOTE: While making tests on the voltage regulating relay, the voltage at terminals 4 and 7 on the voltage sensing unit should never exceed 100 volts.

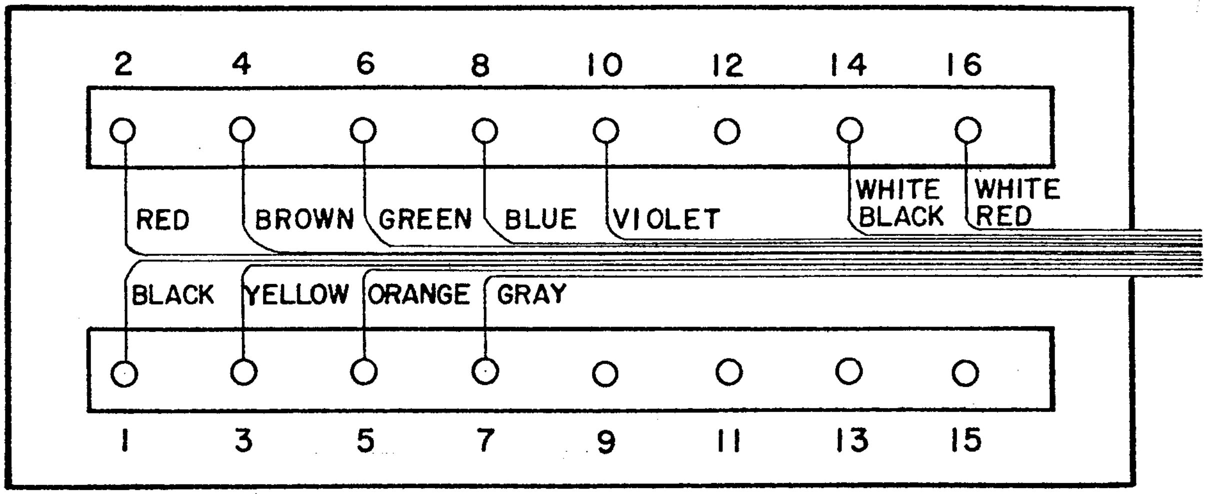
Symptom	Probable Cause	Check
I No Operation	(1) Incorrect setting, disconnected or turned off.	Inspect for proper setting of controls, switches, breakers and for security of connections.
(Neon indicator lights on TM panel do not operate and no output from TM control when the potential voltage is varied above and below balance.)	(2) No input voltage from potential transformer into the MS relay.	(a) The voltage at the potential test terminals is at the voltage level setting. (With no line drop compensation). (b) That the output voltage of the autotransformer is 120 volts. This may be measured between the terminals at the full scale end of the resistance line drop compensator control and the terminal of the coarse voltage adjustment tap switch that would be closed if set for 120 volts. (c) That the voltage between terminals 4 and 7 of the sensing unit is approximately 85 volts.
	(3) No supply voltage from the constant voltage transformer.	(a) The output of the constant voltage transformer at terminals 1 and 2 of the sensing unit (when balanced) is 21±2 volts. The output voltage of the constant voltage transformer without load will be approximately 23 volts.
	(4) Little or no output voltage from the voltage sensing unit and MS control.	(a) That the voltage between voltage sensing element terminals 10 and 1 for a potential transformer voltage below balance or the voltage between terminals 14 and 1 for a potential transformer voltage above balance should be 12±2 volts. (This voltage should also be between C and M of the MS receptacle as well as between terminals A and G, or between C and G of the TM plug.)
II Incorrect Operation **A.** Only one neon light on the TM panel operates and only one output from the TM relay.	(1) Incorrect voltage from potential transformer into MS relay.	(a) As above for no input voltage from potential transformer to MS relay.

Symptom	Probable Cause	Check
	(2) Incorrect voltage out of MS control.	(a) As above for no output voltage from MS control panel.
	(3) Out of calibration—will balance at a voltage other than that set by the control.	(a) Alignment of knobs on the controls. (b) Calibration—adjust R3. (c) Calibrating rheostat resistance .(R3)
	(4) Indicator bulb in-operative.	
B. Both outputs "on" at balance voltage.	(1) Bandwidth too narrow.	(a) Resistance of bandwidth control rheostat. (b) As above for no supply voltage from constant voltage transformer.
	(2) Compounding too great.	(a) Nothing. This characteristic was adjusted at the factory and cannot be corrected in the field. (b) TM relay non-operative and/or terminals E and F are not properly shorted.
C. Neon indicator lights operate normally but no tap changer operations.	(1) Incorrect setting of tap changer controls of disconnected conponents.	(a) For proper settings, proper alignment of control knobs and security of connections. Note: Terminals E and F of TM control panel must be closed through 123 cam operated pilot switch or shorted together.
	(2) Incorrect voltage from MS control panel.	(a) As above for no output voltage of MS control.
	(3) Incorrect or no supply voltage from the constant voltage transformer.	(a) Voltage between terminals B and G of the TM control panel should be 21 ± 2 volts.
	(4) No output from TM control panel.	(a) After the time delay a circuit should be complete between terminals D and H for a raise signal or between A and H for a lower signal.
D. Tap changer operation with no time delay.	(1) Magnetic amplifier incorrectly adjusted or faulty.	Nothing. The adjustment of the rheostats inside the TM control panel was made and locked at the factory and must not be altered since it cannot be corrected in the field. (R6-R7-R8-R9).

If all input voltages, connections, and auxiliary equipment of the sensing unit is correct and the output of the MS relay is incorrect, the voltage sensing unit is defective and must be replaced.

When replacing MS-VR element refer to Fig. 11 for proper location of leads to terminals.

If all input voltages, connections, and auxiliary equipment of the TM time delay relay are correct and the output of the time delay relay is incorrect the TM time delay relay is defective and must be replaced.



VOLTAGE MEASUREMENTS AT TERMINALS INDICATED WITH ALL CONNECTIONS MADE BETWEEN TM AND MS.

TERMINALS 1 TO 2 =	21	±2	VOLTS AC	(TM NON-OPERATED)
TERMINALS 4 TO 7 =	85	±5	VOLTS AC	
TERMINALS 1 TO 10 =	12	±2	VOLTS AC	(TM OPERATED)
TERMINALS 1 TO 14 =	12	±2	VOLTS AC	(TM OPERATED)
TERMINALS 1 TO 10 =	0.6	±0.3	VOLTS AC	(TM NON-OPERATED)
TERMINALS 1 TO 14 =	0.6	±0.3	VOLTS AC	(TM NON-OPERATED)

FIG. 11.

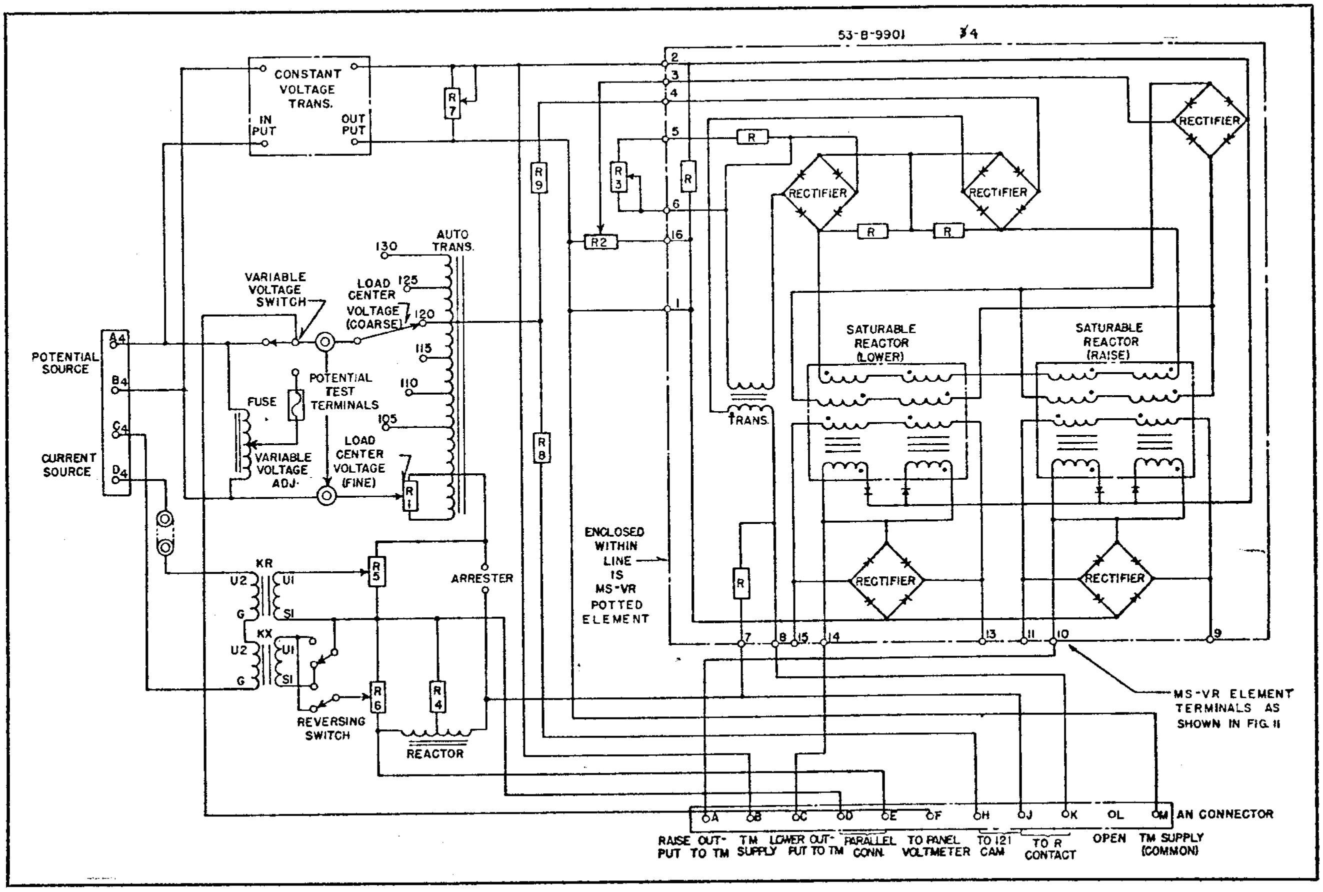

53-B-9901
CONSTANT VOLTAGE TRANS.
IN PUT
OUT PUT
AUTO TRANS.
VARIABLE VOLTAGE SWITCH
LOAD CENTER VOLTAGE (COARSE)
POTENTIAL SOURCE
CURRENT SOURCE
FUSE
POTENTIAL TEST TERMINALS
VARIABLE VOLTAGE ADJ.
LOAD CENTER VOLTAGE (FINE)
ARRESTER
REVERSING SWITCH
REACTOR
ENCLOSED WITHIN LINE IS MS-VR POTTED ELEMENT
SATURABLE REACTOR (LOWER)
SATURABLE REACTOR (RAISE)
RECTIFIER
TRANS.
MS-VR ELEMENT TERMINALS AS SHOWN IN FIG. 11
AN CONNECTOR
RAISE OUTPUT TO TM
TM SUPPLY
LOWER OUTPUT TO TM
PARALLEL CONN.
TO PANEL VOLTMETER
TO 121 CAM
TO R CONTACT
OPEN
TM SUPPLY (COMMON)

FIG. 12.

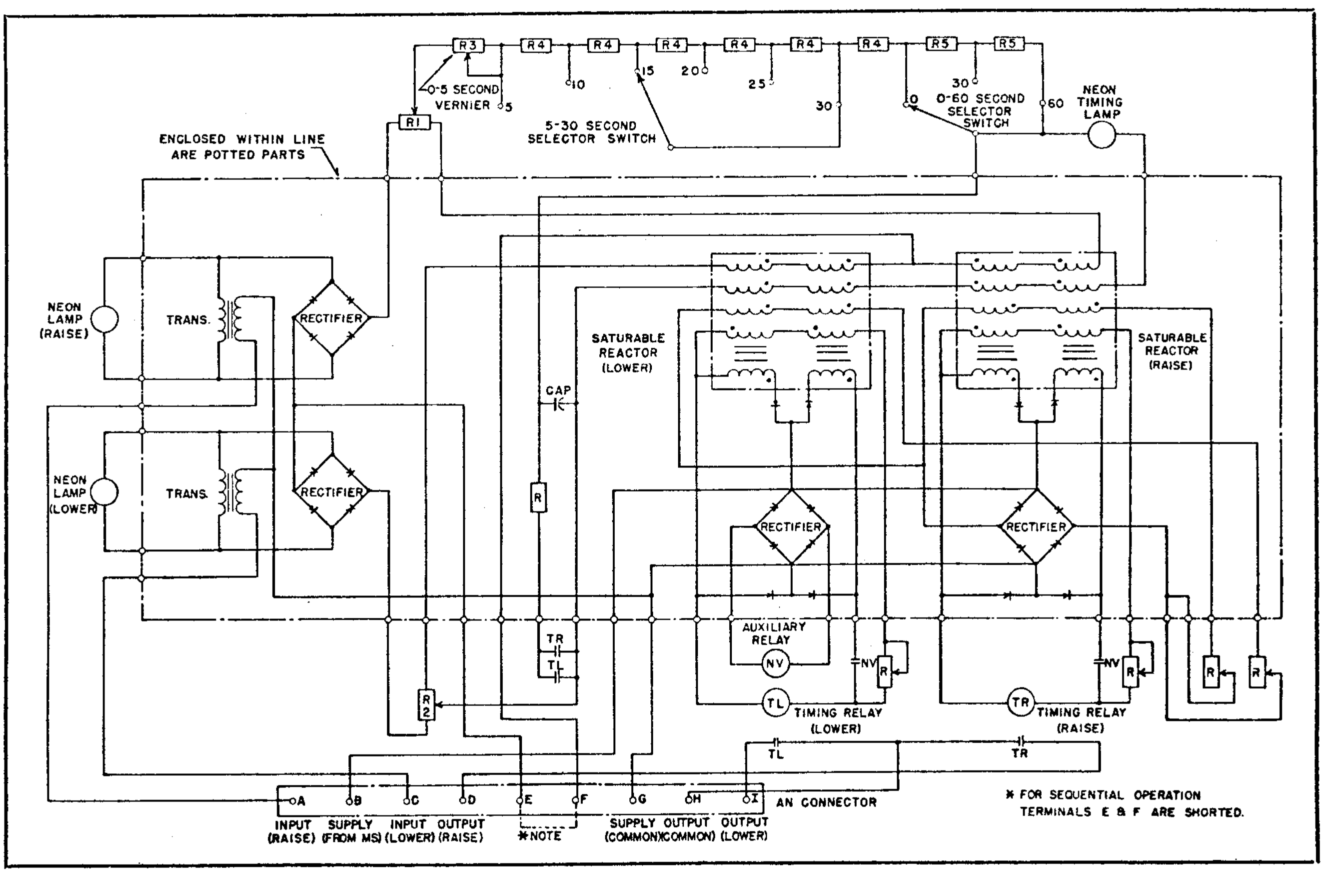
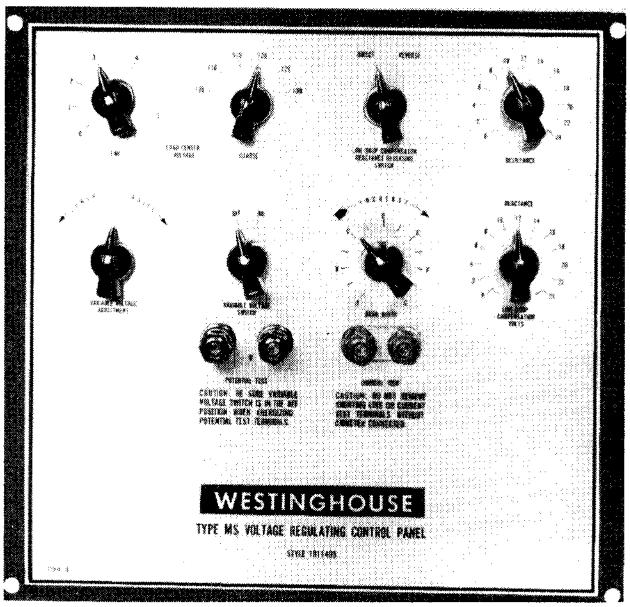

0-5 SECOND VERNIER
5-30 SECOND SELECTOR SWITCH
0-60 SECOND SELECTOR SWITCH
NEON TIMING LAMP
ENCLOSED WITHIN LINE ARE POTTED PARTS
NEON LAMP (RAISE)
NEON LAMP (LOWER)
TRANS.
RECTIFIER
SATURABLE REACTOR (LOWER)
SATURABLE REACTOR (RAISE)
CAP
AUXILIARY RELAY
TIMING RELAY (LOWER)
TIMING RELAY (RAISE)
AN CONNECTOR
INPUT (RAISE)
SUPPLY (FROM MS)
INPUT (LOWER)
OUTPUT (RAISE)
*NOTE
SUPPLY (COMMON)
OUTPUT (COMMON)
OUTPUT (LOWER)
* FOR SEQUENTIAL OPERATION TERMINALS E & F ARE SHORTED.

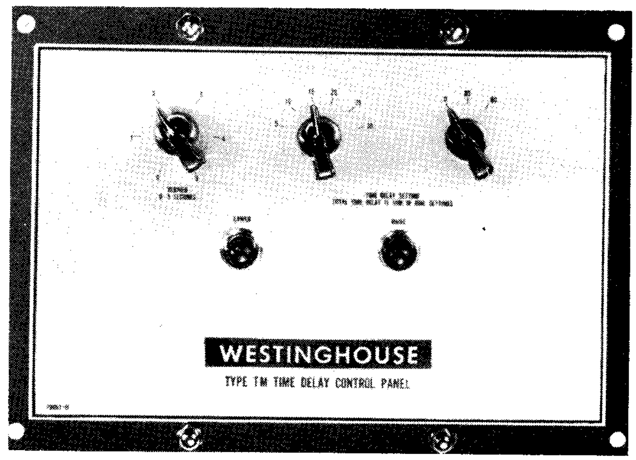
FIG. 13.

DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

TYPE MS AND TYPE TM
VOLTAGE REGULATING and TIME DELAY RELAYS
For Load Tap Changers





THE TYPE MS VOLTAGE REGULATING RELAY for automatic control of load tap changers consists of a static voltage sensing circuit employing a magnetic amplifier with external controls for electrically setting the balance voltage, band width, and line-drop compensation.

THE TYPE TM TIME DELAY RELAY for use with the MS voltage regulating control uses a resistance-capacitance timing circuit in conjunction with a neon tube and a magnetic amplifier to energize auxiliary relays which control the load tap changer motor contactors. Only one setting is required for both "raise" and "lower" operations, this setting being made by external calibrated dials.

RATING

The MS voltage regulating relay and the TM time delay relay have been designed for operation on 60 cycle alternating current systems. The balance voltage can be set at any value desired within the range of 105 to 135 volts, and the band width may be set at any value between ± 1.0 volts and ± 3.0 volts. The time delay may be set to any value, within the range of 5 to 95 seconds.

Separate R and X compensator elements permit independent setting of the 24 volts resistance and 24 volts reactance compensation (both on a 120 volt base) which is available with the standard current of 5 amperes flowing in the current circuit of the control. The 120 volt potential circuit has a burden of 50 volt-amperes and the 5 ampere circuit has a 25 volt-ampere burden.

DESCRIPTION

Voltage Regulating Relay. Detailed pictures of the MS voltage regulating relay are shown in FIGS. 1 and 3. The voltage sensing element containing the components for electrically measuring an unbalance in voltage is a sealed container mounted in back of the control panel as shown in FIG. 3. The components making up the sensing circuit are static devices consisting of a saturating transformer, rectifiers, a magnetic amplifier and resistors, to insure correct balance voltage under all conditions. A resistor (R3) for calibrating the balance voltage is mounted on the back of the MS panel.

External circuit components for electrically setting the balance voltage, the band width, and the

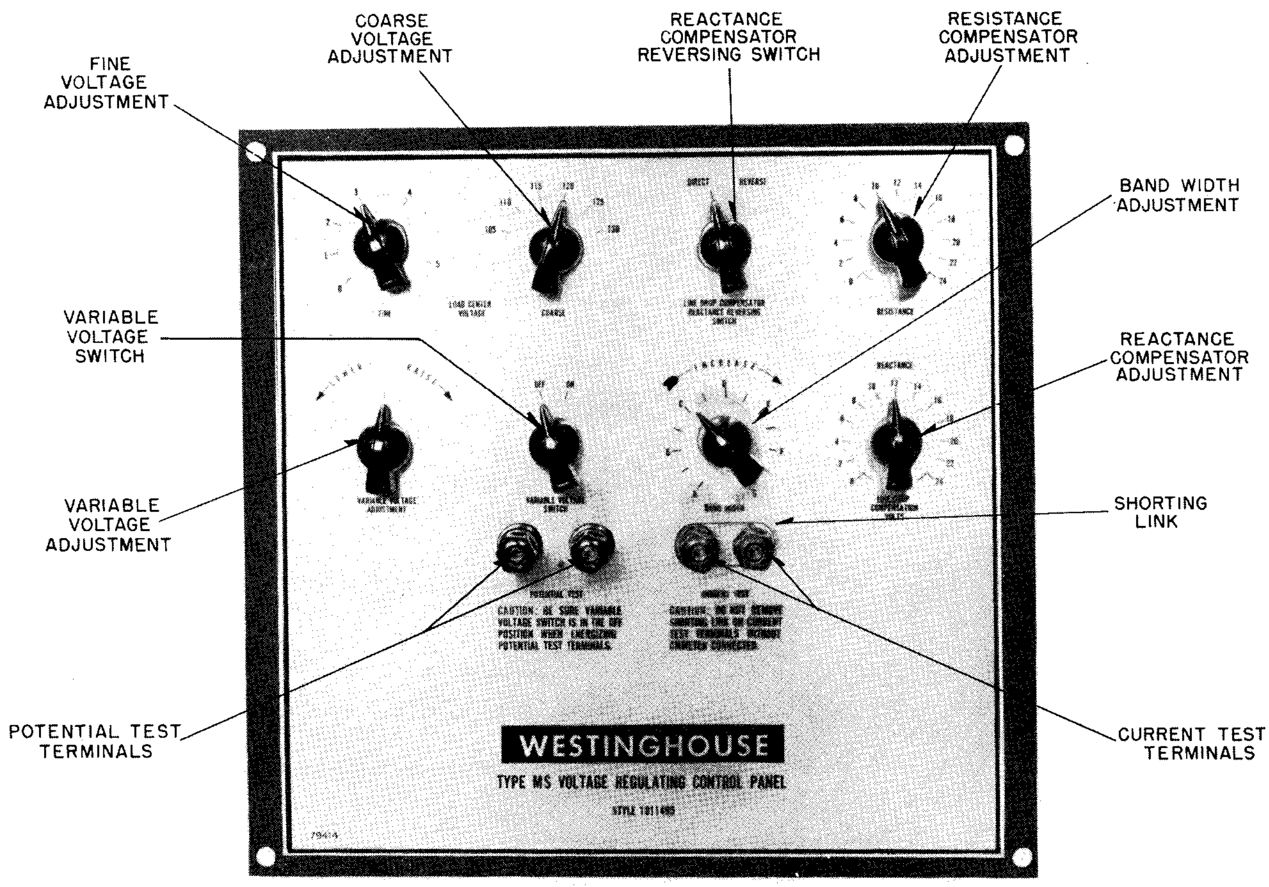


FIG. 1. Front View of MS Voltage Regulating Relay

line drop compensation are mounted on the MS panel as shown in FIGS. 1 and 3. The panel is designed for use as a unit in the complete tap changer control assembly.

An auto-transformer with five-volt taps from 105 to 130 volts plus an additional five-volt vernier tap provides balance voltage settings from 105 to 135 volts. The balance voltage selection is made by means of a non-shorting rotary tap switch for five volt steps and a potentiometer for vernier settings to give intermediate values. Also mounted on the back of the panel with control knobs in front are rheostats for setting the bandwidth and line drop compensation; a rotary type shorting switch for reversing the reactance line drop compensation; a variable auto-transformer and switch for obtaining a variable voltage to assist in setting the bandwidth and voltage level. Intermediate current transformers for the line drop compensator are located in back of the control panel.

Electrical connections between the voltage sensing element and the MS control panel are made through the terminal strips on the end of the sensing element. Reference FIG. 11. External connections from the MS voltage regulating relay are made through two AN connectors as shown in FIG. 3. Current and potential test terminals are conveniently located on the front of the panel.

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

Time Delay Relay. The TM time delay relay is shown in detail in FIGS. 2 and 4. An electrical matching network which is energized by the MS voltage regulating relay is sealed in the housing shown in FIG. 4. This matching network provides a reversible polarity voltage signal to be electrically timed by a resistance-capacitance timing circuit. The capacitance element is sealed in the housing. The timing resistance consists of a rheostat plus fixed resistors which are used in steps to provide the

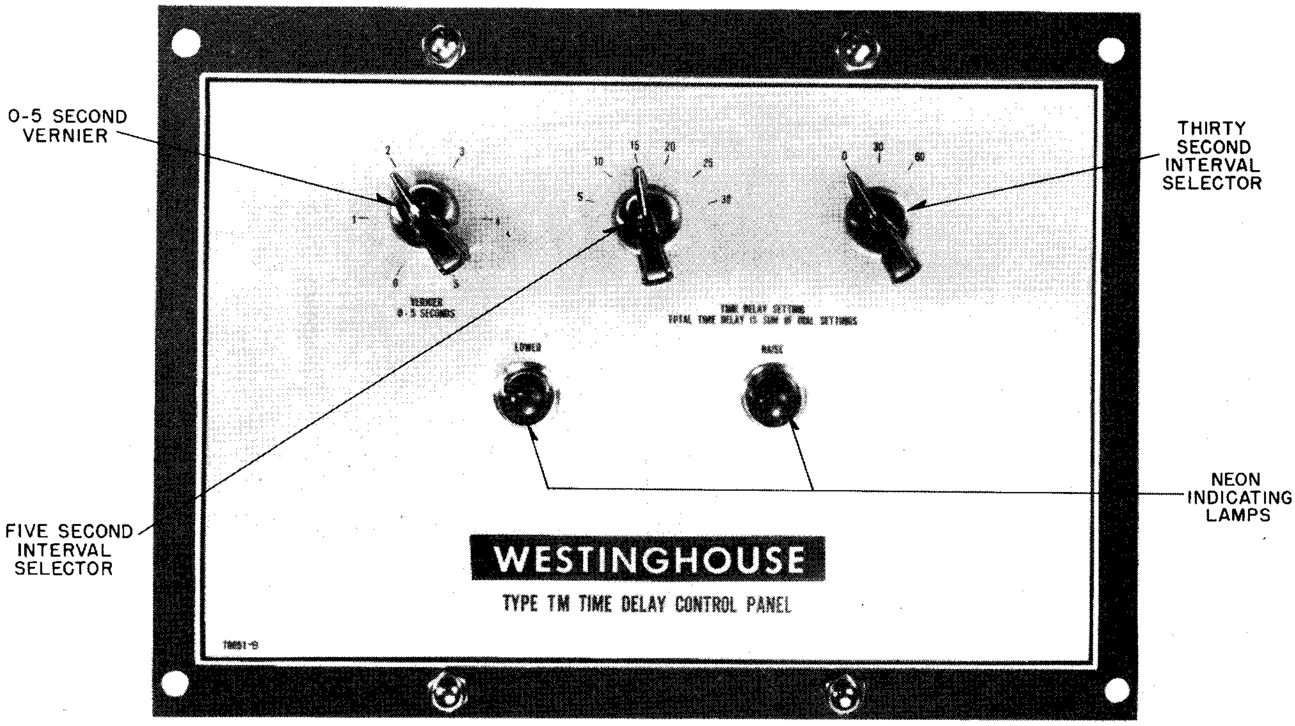


FIG. 2. Front View of TM Time Delay Relay

desired delay setting. The rheostat is attached to the control panel while the fixed resistors are connected between terminals of the tap switches as shown in FIG. 4. A neon tube mounted on the rear of the control panel measures the voltage on the capacitor and, at the set delay, controls a MAGAMP magnetic amplifier which is sealed in the housing. The magnetic amplifier energizes two of the relays shown mounted on the rear of the panel, one relay for "raise" operation and one for "lower" operation, through contacts of the slug relay. The slug relay (WNV) introduces a time delay to allow the Magnetic Amplifier to be under positive control, thus preventing malfunction of the "raise" and "lower" relay, when the control is energized initially.

Time delay settings are made by the use of calibrated dials shown in FIG. 2. One tap switch changes the timing resistance in steps to give five-second increments of time delay from five to thirty seconds while a second tap switch provides thirty-second increments from zero to sixty seconds. A rheostat provides a vernier range from zero to five seconds with a dial calibrated in one second increments. The vernier setting is added to the other settings, thus giving intermediate delays.

Two neon lights mounted on the control panel indicate the presence of an input to the timing circuit, or in other words, the presence of an unbalance in the voltage applied to the MS voltage regulating relay. External connections from the TM time delay relay are made through an AN connector.

RECEIVING—HANDLING—STORING

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

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

Handling. The MS voltage regulating relay is in fact an instrument and should be handled as such. It has been designed to be as rugged as possible, but the fact remains that it has better than 1% ac-

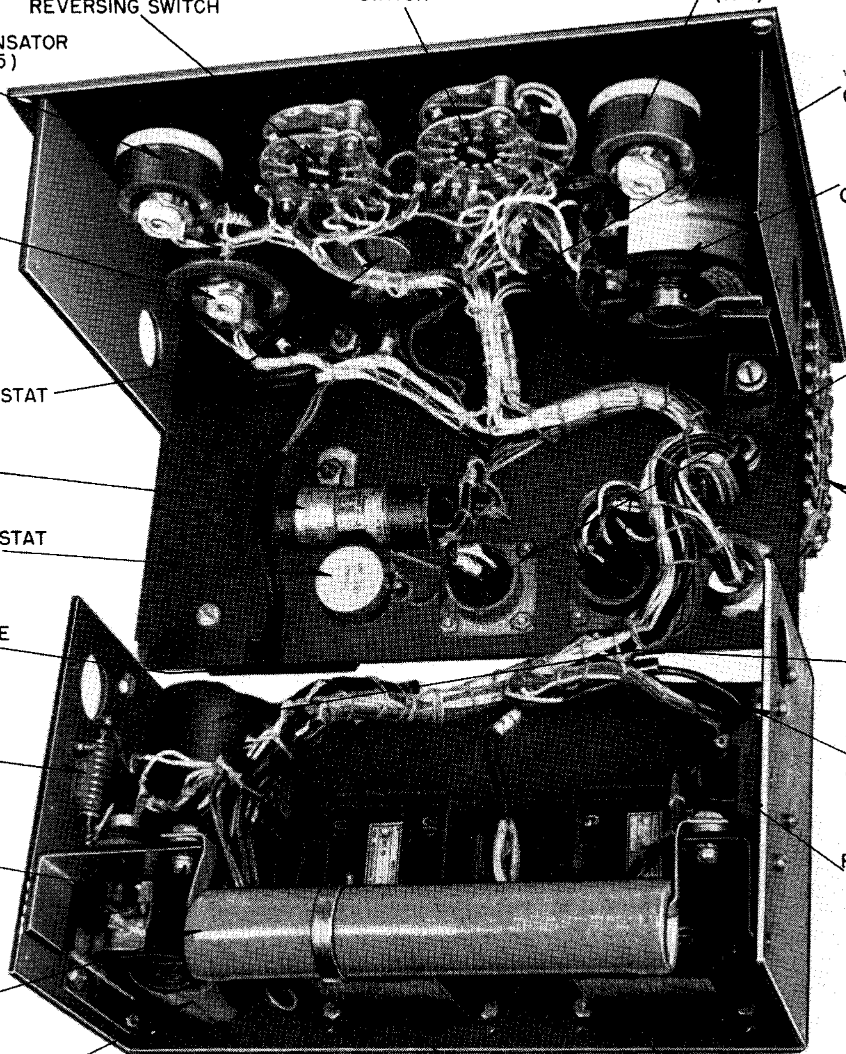


FIG. 3. Rear View of MS Relay Panel

curacy and is thus equivalent to the better, more accurate laboratory voltmeters and should consequently be handled with reasonable care, free from excessive shock and vibration.

These relays have been adjusted and tested before leaving the factory to insure that they meet the required high standards of operation considered essential for such equipment. Whether or not they continue to meet these standards depends upon the treatment accorded them after they leave the factory.

Storing. If the MS and TM relays are to be stored, they should be kept in a clean, dry, moderate temperature location, protected from excessive dust, from atmospheres conducive to condensation and corrosion, and from moisture and the elements.

INSTALLATION

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

TO INSTALL the MS and TM relays in the control compartment, place the back projections of the panels into the cutouts provided in the control compartment (insert from the front of the

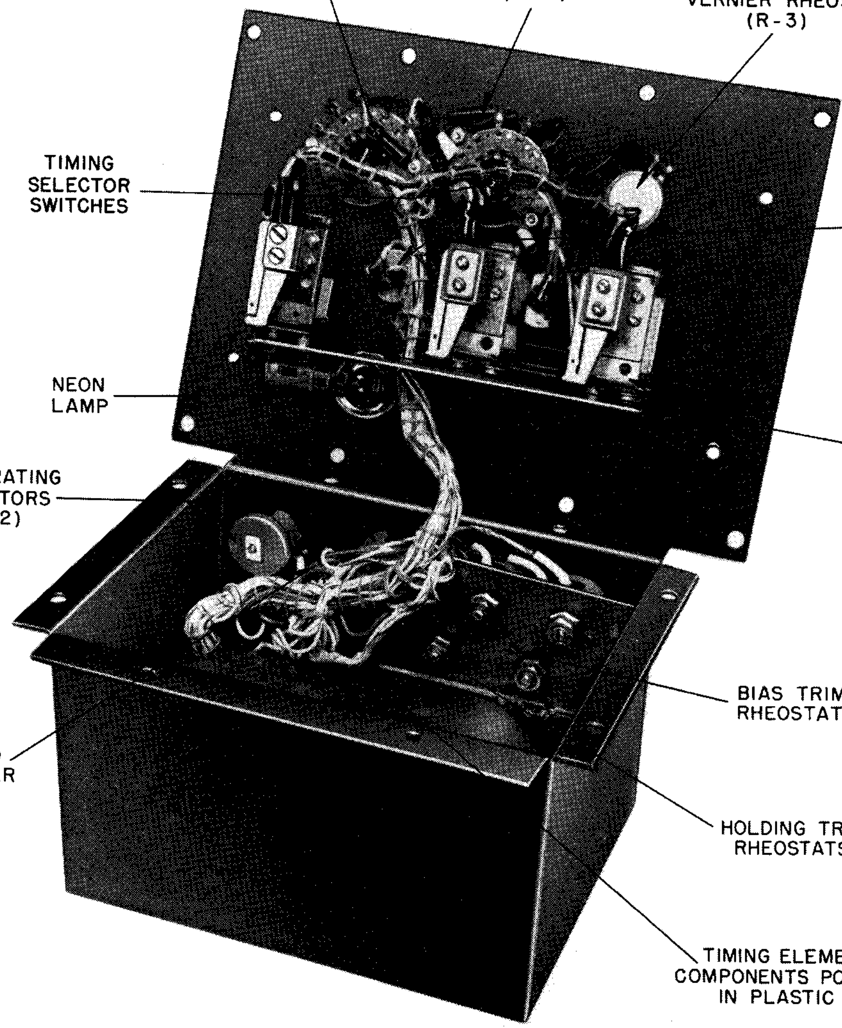


FIG. 4. Rear View of TM Relay Panel

control compartment) and bolt in place at the four corners with the bolts provided for this purpose. Insert the plug connectors from the back of the swinging control panel into the receptacles on the back of the MS and TM panels and the installation is complete.

TO REMOVE the MS and TM panels from the control compartment, disengage the plug connectors from the receptacles and remove the four bolts from the corners of each panel. The four pole connector contains self shorting terminals so that the current transformer is automatically shorted when the plug is removed.

OPERATION

Voltage Regulating Relay. The voltage sensing action of the MS voltage regulating relay is basically a function of the magnetic characteristics of a saturating transformer and the control characteristics of a self saturating MAGAMP magnetic amplifier. Band width and compounding are accomplished by the control characteristics of the amplifier. Line drop compensation is provided by introducing a bias voltage into the sensing circuit which is proportional to the magnitude and phase of the voltage drop on the line.

The voltage sensing circuit measures the value of the input voltage at terminals A4 and B4 of FIG. 5 less the line drop compensation voltage. With proper balance voltage applied to terminals A4 and B4, the output of the voltage sensing circuit is zero. As the applied voltage is either increased above or decreased below the balance value, the sensing circuit has an output voltage signal of one polarity

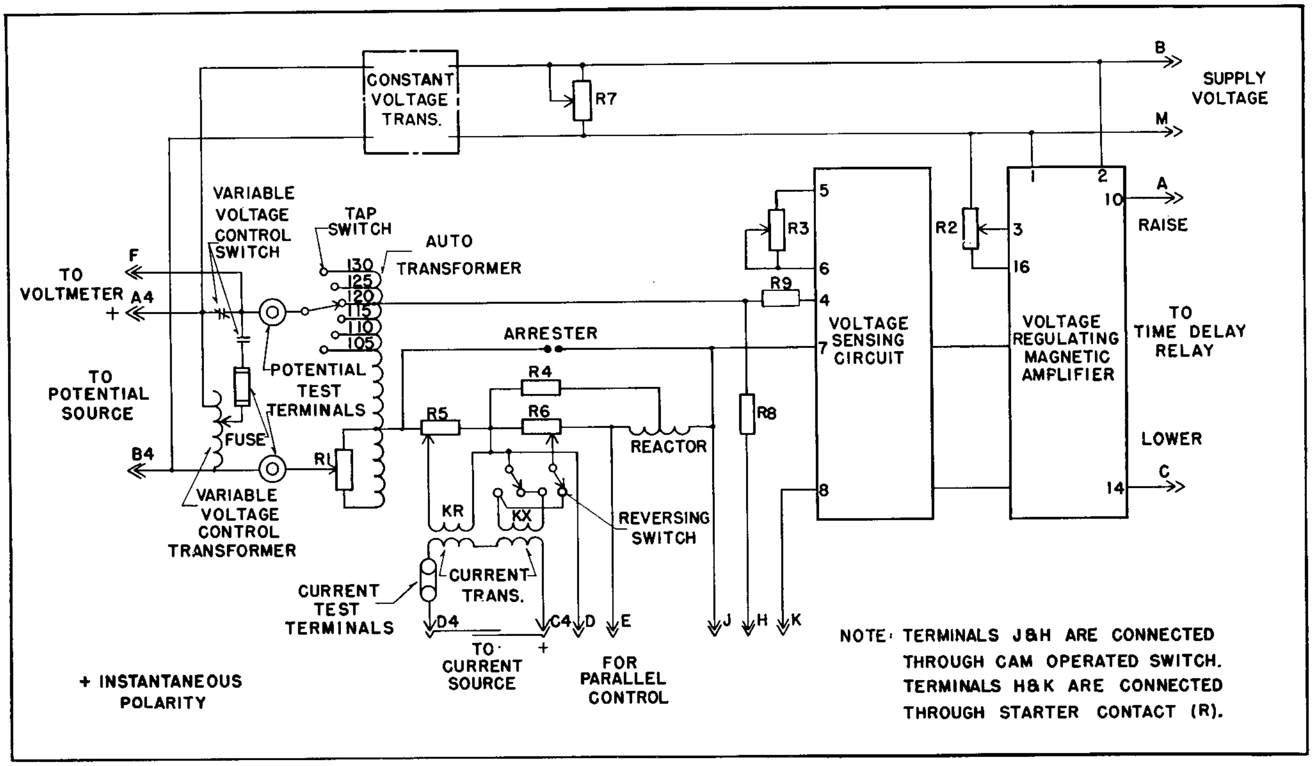


FIG. 5. Schematic Diagram of Type MS Voltage Regulating Relay

or the other depending upon the direction of change from balance voltage. This signal is applied to the amplifier circuit having separate outputs for "raise" and "lower" operations. As the change in balance voltage becomes sufficiently large, a signal of the proper polarity from the sensing circuit causes the

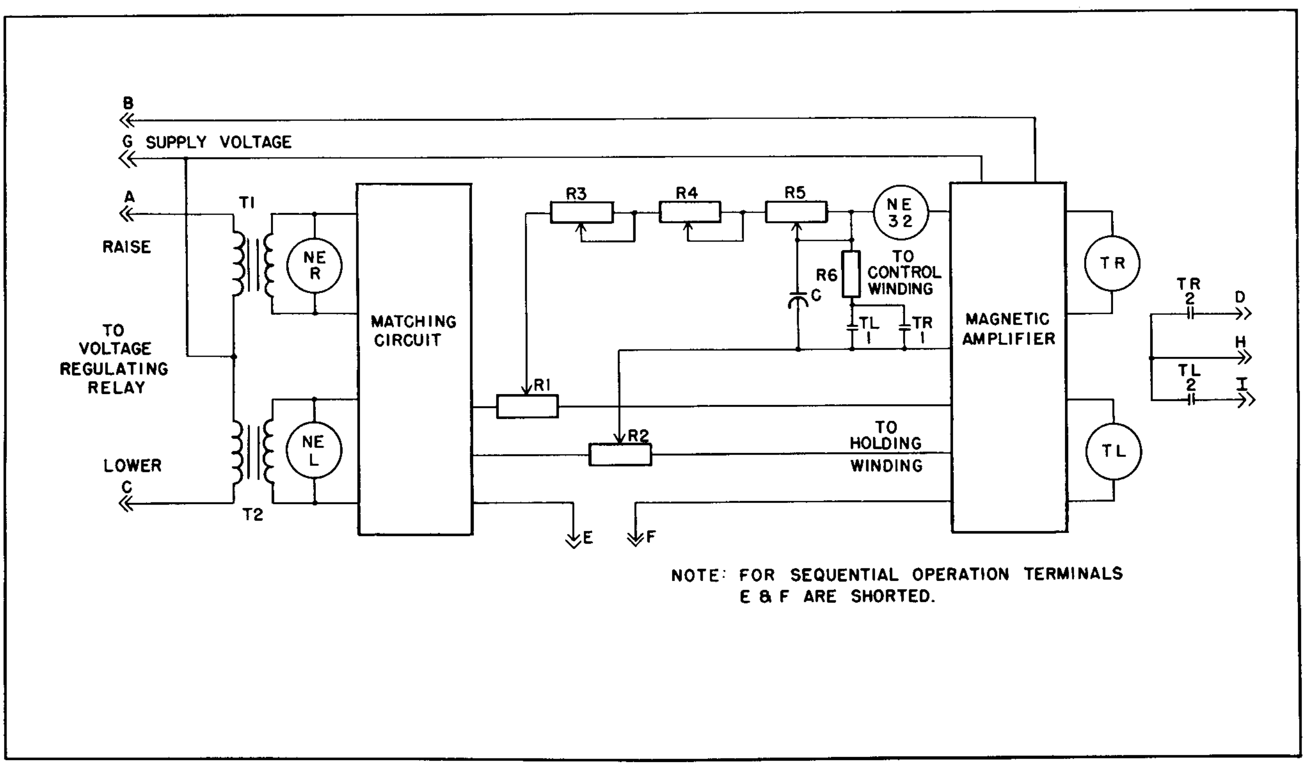


FIG. 6. Schematic Diagram of Type TM Time Delay Relay

amplifier to conduct. The amount of voltage change necessary to cause the amplifier to conduct is determined by the bias applied to the amplifier circuit with the band width setting rheostat. The voltage change back toward balance necessary to cause the amplifier to stop conducting is determined by a fixed amount of positive feedback in the amplifier. This value has been set at the factory to give the proper compounding to insure stable operation of the automatic controls with a minimum number of tap changer operations. By shorting terminals J to H or H to K to J, through a cam operated tap changer switch and relay contact, a signal is given to the sensing circuit to anticipate a correction of voltage by the tap changer.

Input balance voltages from 105 to 135 volts are made possible by an autotransformer with taps on the input side. A vernier (Rl, FIG. 5) provides intermediate values which are added to the tap selection. A rheostat (R2, FIG. 5) is used to vary the bias to the magnetic amplifier, allowing a band width selection from 2 volts to 6 volts.

Line drop compensation is obtained by circulating a current, proportional to the load current, through the line drop compensator network to produce a voltage proportional to the actual drop in a line for which the compensator is adjusted. This voltage is subtracted from the regulator voltage to simulate load center voltage. By adjusting rheostats R5 and R6 of FIG. 5, the compensator can be set to give 0 to 24 volts resistive and reactive compensation (on a 120 volt base with 5 amperes flowing through terminals C4 and D4). Reversed reactance compensation can be obtained by the reversing switch.

Time Delay Relay. The basic timing function of the TM time delay relay is performed by a resistance-capacitance timing circuit. The time delay is determined by the value of resistance inserted into the resistance-capacitance network. The timing circuit controls a magnetic amplifier which energizes auxiliary relays to operate the tap changer motor contactor.

When a departure from balance voltage exists outside the set band width of the voltage regulating control, a voltage signal is fed into the time delay relay illustrated in Fig. 6, a "raise" signal being fed through transformer T1 or a "lower" signal through transformer T2. Indicating lamps, NER and NEL indicate the presence of an input to the time delay relay. The matching network provides a DC voltage to the timing circuit of a polarity to indicate whether a "raise" or a "lower" operation is required. The matching network also applies a signal voltage directly to a holding winding of the amplifier. After the set time delay, the control winding is energized with a pulse signal through the NE-32 neon lamp. This causes the time delay amplifier to conduct, energizing either relay TR or TL, depending upon the polarity of voltage being timed. The action of the holding winding keeps the amplifier conducting as long as there is an input to the time delay relay or until the holding winding circuit is interrupted by some other means. Contacts on TR or TL discharge the timing capacitor through resistor R6 (Fig. 6) to immediately reset the timing circuit.

Resistors Rl and R2 (Fig. 6) are used to calibrate the delay dials for "raise" and "lower" operations respectively. These have been set at the factory and should not have to be changed. Delays ranging from 5 to 95 seconds can be obtained by setting variable resistors R3, R4 and R5 (Fig. 6). R3 is a rheostat used to provide intermediate values with the dial marking calibrated in one second increments of time delay. R4 can be changed in five equal steps to provide five second increments of time delay from five to thirty seconds while R5 can be changed in two equal steps to provide thirty second increments. The total delay is the sum of the dial settings, with only one setting required for "raise" and "lower" operations.

The holding winding circuit can be interrupted by a cam operated switch to provide for non-sequential operation of the tap changer. For sequential operation terminals E and F are shorted so that the holding winding is de-energized only when the input to the timing control is removed.

SETTING

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

Apply normal voltage to the relays for a period of one hour before making settings, to allow all parts to become stabilized at the operating temperature.

Balance voltage may be corrected by adjusting potentiometer R3, if necessary.

Balance Voltage and Band width Settings Using External Voltage Source. The potential circuit control breaker and the variable voltage switch must be in the "OFF" position before applying an external regulated power source to the potential test terminals. If the unit is carrying load, set the

compensator dials on zero while the balance voltage and band width settings are made. The balance voltage and band width settings are made as follows:

1. Turn the band width dial to the full clockwise position.

2. Set the coarse-voltage adjustment dial to the dial calibration just below the desired balance voltage. (For example, set on 115 volts for 117 volts balance).

3. Next turn the fine-voltage adjustment dial to the value which when added to the setting above gives the desired balance voltage. (In the example, set on 2 volts).

4. To set the band width and check with the balance voltage setting above, adjust the external applied voltage to be equal to the balance voltage less one half the total band width. (For example, if a band width of 3 volts with balance voltage of 117 volts is desired, adjust the voltage to 115.5 volts).

5. Rotate the band width dial slowly in a counterclockwise direction until the "Raise" light on the TM panel comes on. These settings now should give the proper balance voltage and band width and may be checked in the step below.

6. Increase the external applied voltage to be equal to the balance voltage plus one half the total band width. (118.5 volts in the example above). The "Lower" light on the TM panel should come on at this value of voltage; *however, a slight readjustment of the fine-voltage dial and the band width dial may be necessary.* If the light comes on at less than the desired voltage, it indicates a balance voltage setting and a band width setting slightly less than the desired values. If the light comes on at a higher value than the desired value the reverse is indicated. In any case, only a very minor adjustment will be necessary. Both balance voltage and band width can be increased by a clockwise rotation of the fine-voltage adjustment dial and band width adjustment dial respectively.

Balance Voltage and Band width Settings Using Internal Voltage Source. A variable autotransformer is provided on the MS voltage regulating relay for making balance voltage and band width settings using the internal potential transformer as a voltage source. Place the automatic manual switch in the "OFF" position or the "MAN" position, the control breaker in the "ON" position, and the variable voltage switch in the "ON" position. If the unit is carrying load, set the compensator dials on zero while the settings are being made. Using the variable autotransformer on the MS relay panel to vary the voltage, the balance voltage and band width settings are made following the steps listed in the procedure for making settings using an external voltage source.

NOTE: Care should be taken to observe the voltmeter readings during each step of the procedure for making settings to be sure that minor voltage fluctuations of the source voltage do not occur while the settings are being made. After the settings are made, return the variable voltage switch to the "OFF" position.

Line-Drop Compensator Settings. The final settings on the line-drop compensator are usually made by field adjustments, but if the data on the particular line is known, the curves in FIGS. 9 and 10 may be used, and initial values calculated.

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

Dial Setting for Resistance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times R_L \times d \times n.$$

Dial Setting for Reactance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times X_L \times d \times n.$$

Where

$N_{C.T.}$ = current transformer ratio = $\frac{\text{primary current}}{\text{secondary current}}$

N_{POT} = potential transformer ratio = $\frac{\text{primary voltage}}{\text{secondary voltage}}$

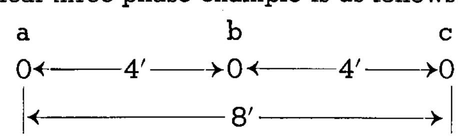
R_L = resistance per conductor from unit to load center, in ohms per mile.

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

d = miles from unit to load center.

n = 120/balance voltage setting.

A typical three-phase example is as follows:



500,000 CM copper conductor, with flat spacing above

Line Voltage = 12000 volts
Current Transformer Ratio = 600/5
Potential Transformer Ratio = 6928/120
Distance from unit to load center = 3.5 miles.
Balance voltage setting = 117 volts.

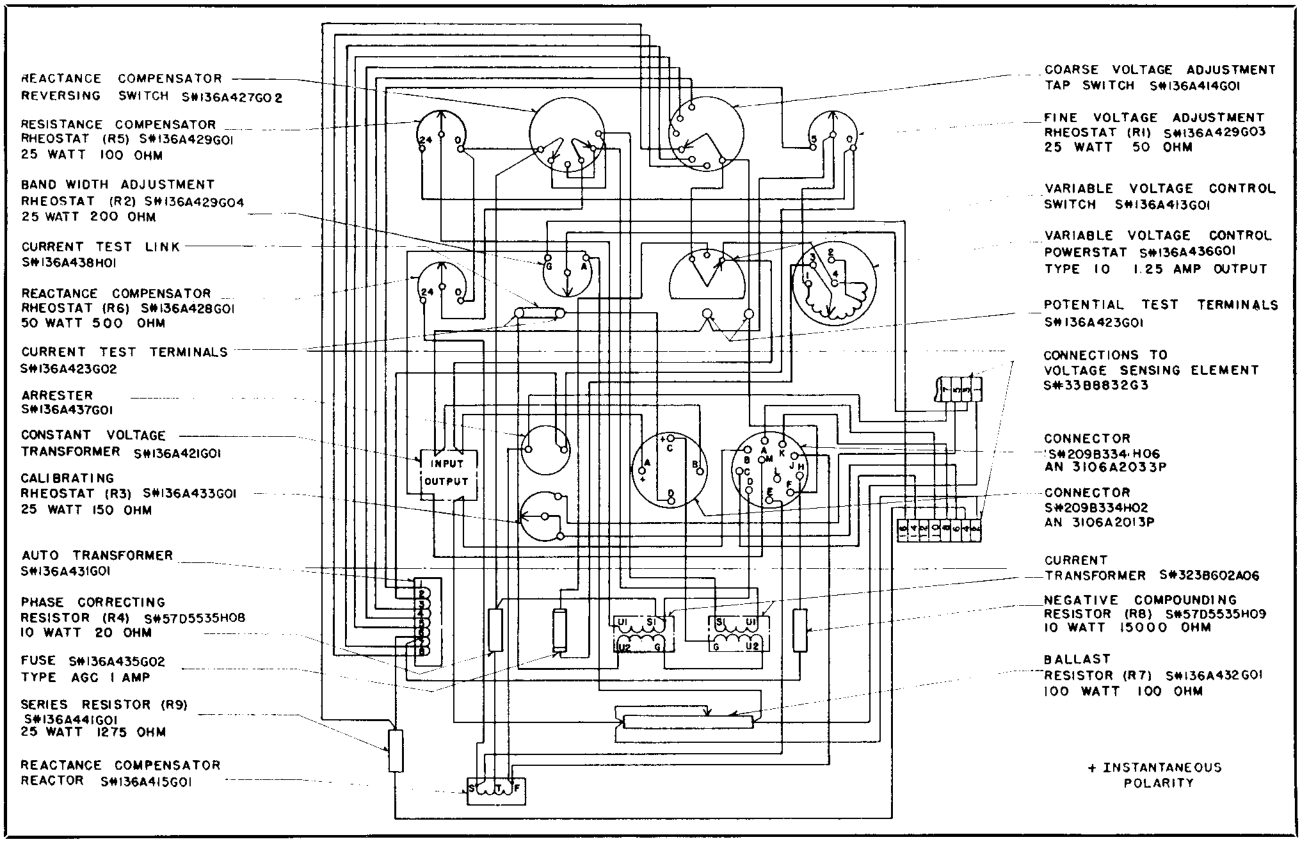


FIG. 7. Wiring Diagram of Type MS Voltage Regulating Relay

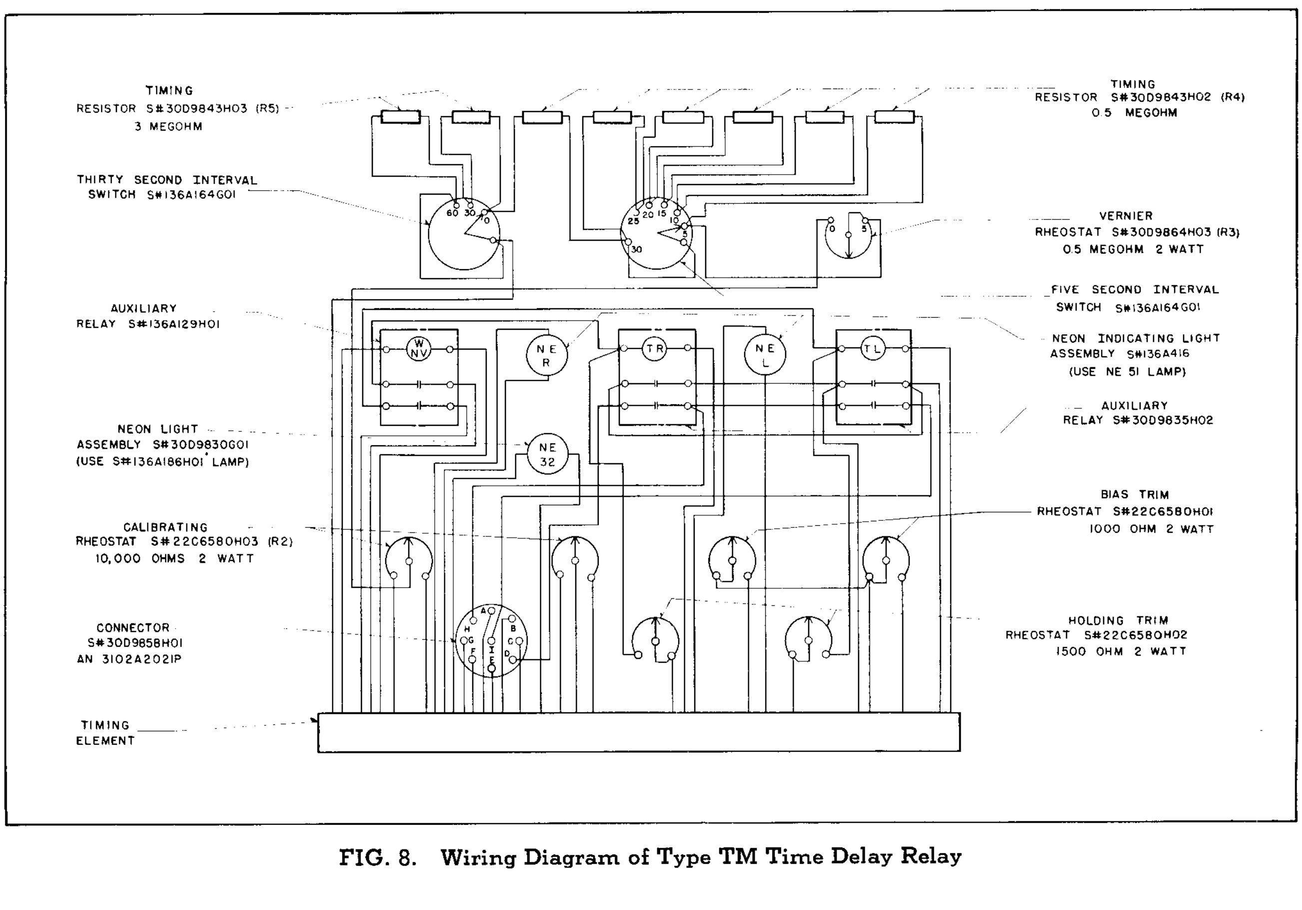


FIG. 8. Wiring Diagram of Type TM Time Delay Relay

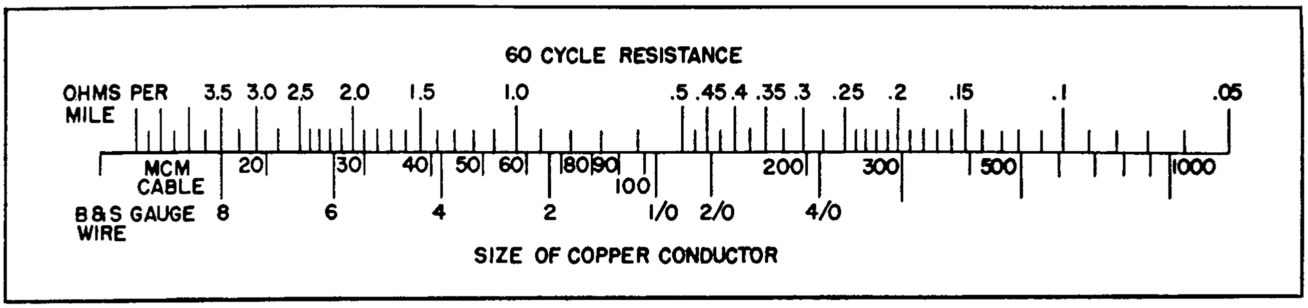


FIG. 9. Resistance Chart, Showing Ohms per Conductor per Mile, 60 Cycle Circuit

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

From FIG. 9:

$R = 0.12$ ohms per mile

From FIG. 10:

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

$X_L = 0.64$ ohms per mile

The line drop compensator resistance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.12 \times 3.5 \times \frac{120}{117} = 4.47$$

The line drop compensator reactance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.64 \times 3.5 \times \frac{120}{117} = 23.9$$

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

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

Time Delay Settings. The desired time delay is set with the calibrated dials on the front of the TM control panel. Selection of delays in five second intervals from 5 to 95 seconds can be made. For intermediate settings, a vernier dial calibrated in one-second intervals adds the intermediate value. (Example: For a 37-second delay setting, set the vernier dial on 2 seconds, the five-second interval dial on 5 seconds and the thirty-second interval dial on 30 seconds). Only one setting is required for both "raise" and "lower" operations.

Trouble Shooting. Make all checks possible with the units in place on the transformer control panel to avoid unplugging or removal of units from the panel. When it becomes necessary to check controls at a point remote from the transformer, the following adapters will be found useful. They may be ordered through the nearest District Engineering and Service Office.

Interconnection Adapter—S#606D988G01 (Suitable for direct connection between MS and TM relays).

Power Connection Adapter—S#606D989G01 (For connecting 120 volt A.C. source into MS relay socket).

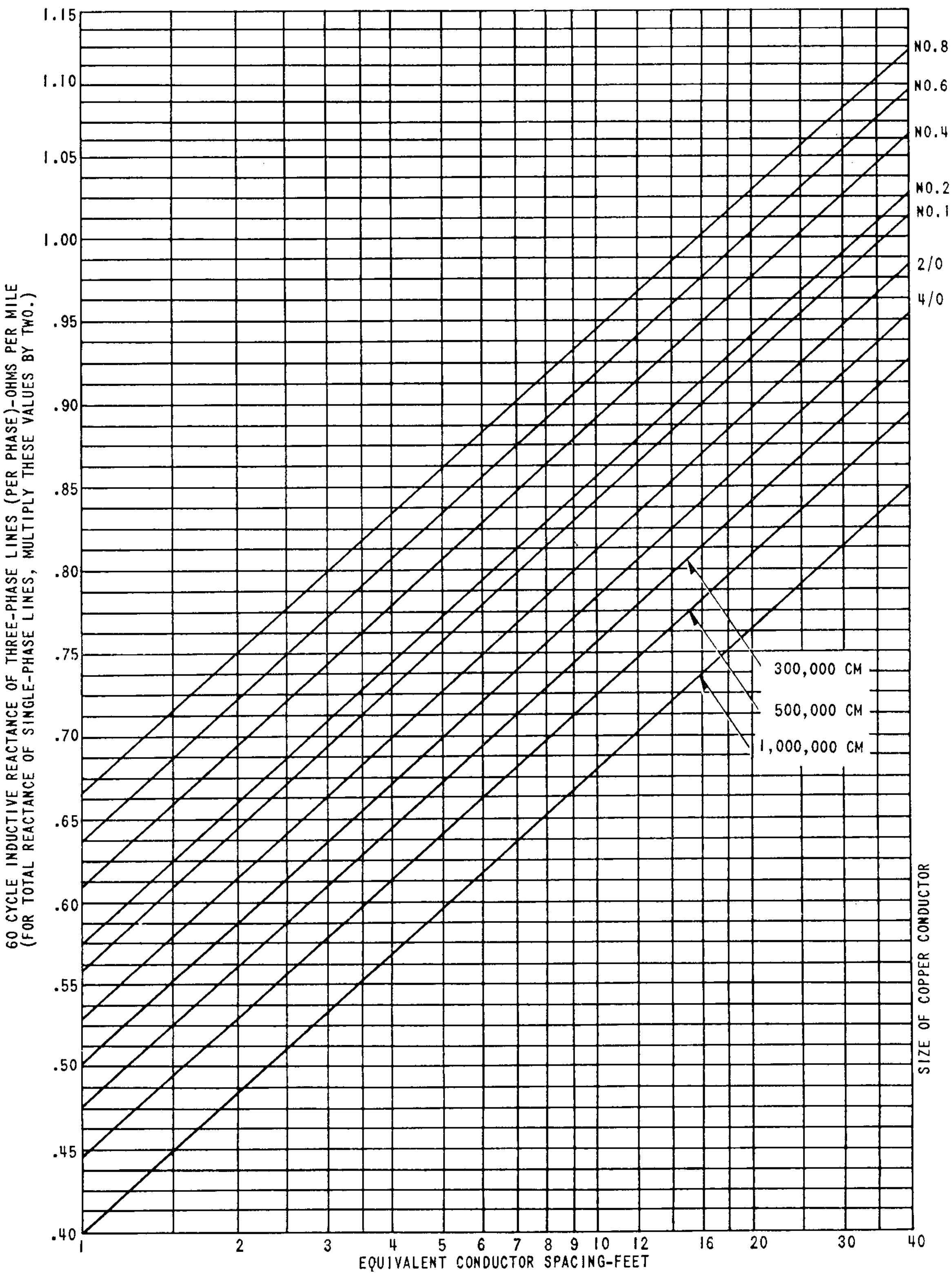
With the variable voltage control switch in the "ON" position, the voltage input to the MS relay may be varied by means of the variable voltage adjustment for test or demonstration purposes. The response of the TM relay to MS signals may be noted by observing the raise and lower indicator lamps on the TM relay and by continuity checks from H to D or H to I respectively as shown in FIG. 13.

MAINTENANCE

The proper adjustments to insure correct operation have been made at the factory and should not be disturbed. The components of the voltage sensing element of the MS voltage regulating control which are sealed are static components and under normal conditions should require no maintenance. Should the sensing element become inoperative, request replacement through the nearest District Engineering and Service Office.

The components of the TM time delay control which are sealed in the housing are static components and under normal conditions should require no maintenance. In the event they should become inoperative, request replacement through the nearest District Engineering and Service Office.

In the event any of the components on the MS and TM panels other than the sealed units become inoperative, they may be replaced with renewal parts ordered from the nearest Westinghouse Sales Office or from the Sharon Plant. Should parts be ordered, give the Style or Stock Order number of the equipment as stamped on the nameplate together with the style number and description of the parts required as identified in FIGS. 7 and 8.



EQUIVALENT CONDUCTOR SPACING, D, OF UNSYMMETRICAL THREE PHASE LINES IS GIVEN BY THE EXPRESSION $D=\sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$, WHERE

D_{AB}, D_{BC}, AND D_{CA} ARE THE DISTANCES IN FEET BETWEEN CONDUCTORS DESIGNATED BY THE SUBSCRIPTS.

NOTE:- WHERE $D_{CA} = 2\ D_{AB} = 2\ D_{BC}$; $D = 1.26\ D_{AB}$

FIG. 10. Reactance Chart, Size of Conductor and Spacing, for 3-Phase Lines (per Mile), 60 Cycle Circuit

Trouble Shooting. Observing the suggested symptoms and making the indicated measurements will be helpful to a competent repair technician in determining the cause of misoperation and identifying any damage or unconnected components. The indicated voltages are 60 cycles AC and should be measured with a voltmeter of 1000 ohm per volt sensitivity. The test power supply should be finely adjustable, well regulated, and with low harmonic content.

For convenience in trouble shooting reference Figures 12 and 13.

NOTE: While making tests on the voltage regulating relay, the voltage at terminals 4 and 7 on the voltage sensing unit should never exceed 100 volts.

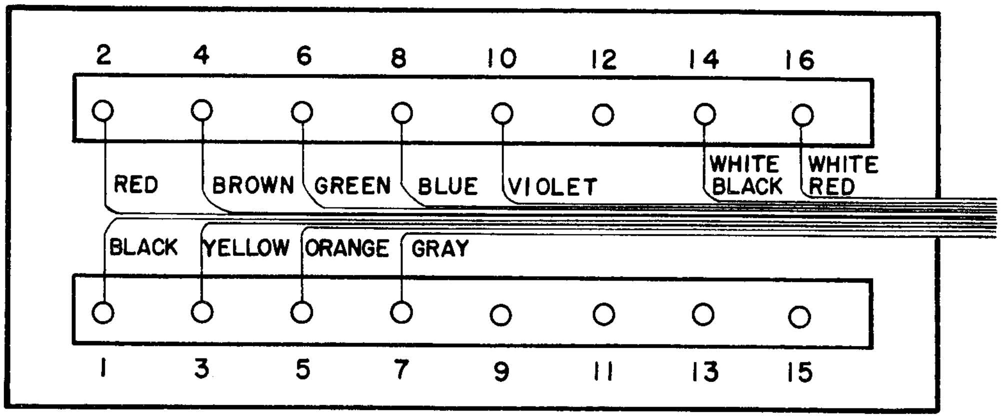
Symptom	Possible Cause	Check
I No Operation	(1) Incorrect setting, disconnected or turned off.	Inspect for proper setting of controls, switches, breakers and for security of connections.
(Neon indicator lights on TM panel do not operate and no output from TM control when the potential voltage is varied above and below balance.)	(2) No input voltage from potential transformer into the MS relay.	(a) For possible absence of voltage across the potential terminals. (b) For possible absence of voltage at output terminals of the autotransformer. This may be measured between the terminals at the full scale end of the resistance line drop compensator control and the terminal of the coarse voltage adjustment tap switch. (c) For possible absence of voltage between terminals 4 and 7 of the sensing unit.
	(3) No supply voltage from the constant voltage transformer.	The output of the constant voltage transformer at terminals 1 and 2 of the sensing unit (when balanced) is 21 ± 2 volts. The output voltage of the constant voltage transformer without load will be approximately 23 volts. (Measure with rectifier type voltmeter.)
	(4) Little or no output voltage from the voltage sensing unit and MS control.*	That the voltage between voltage sensing element terminals 10 and 1 for a potential transformer voltage below balance or the voltage between terminals 14 and 1 for a potential transformer voltage above balance should be 12 ± 2 volts. (This voltage should also appear between A and M, or between C and M of the MS receptacle as well as between terminals A and G, or between C and G of the TM plug.)
II Incorrect Operation		
A. Only one neon light on the TM panel operates and only one output from the TM relay.	(1) Incorrect voltage from potential transformer into MS relay.	(a) With 120 volts at output of autotransformer, the voltage between terminals 4 and 7 of the sensing unit when balanced is approximately 85 volts. If the voltage measured at this point is persistently above or below 85 volts determine whether the cause is internal or external. (b) Variable voltage switch may have been unintentionally left in the "ON" position.

Symptom	Possible Cause	Check
Only one neon light on the TM panel operates and only one output from the TM relay.	(2) Incorrect voltage out of MS control.	Same as for I (4).
	(3) Out of calibration—will balance at a voltage other than that set by the control.	(a) Alignment of knobs on the controls. (b) Calibration—adjust R3. (c) Calibrating rheostat resistance .(R3)
	(4) Indicator bulb in-operative.	
B. Both MS outputs "on" at balance voltage.	(1) Band width too narrow.	(a) Resistance of band width control rheostat. (b) As above for no supply voltage from constant voltage transformer.
	(2) Compounding too great.	(a) This characteristic was adjusted at the factory and cannot be corrected in the field. (b) TM relay non-operative and/or terminals E and F are not properly shorted.
C. Neon indicator lights operate normally but no tap changer operations.	(1) Incorrect setting of tap changer controls or disconnected conponents.	For proper settings, proper alignment of control knobs and security of connections. Note: Terminals E and F of TM control panel must be closed through 123 cam operated pilot switch or shorted together.
	(2) Incorrect voltage from MS control panel.	Same as for I (4).
	(3) Incorrect or no supply voltage from the constant voltage transformer.	(a) Voltage between terminals B and G of the TM control panel should be 21 ± 2 volts. Same as for I (3).
	(4) No output from TM control panel.**	After the time delay a circuit should be complete between terminals D and H for a raise signal or between I and H for a lower signal.
D. Tap changer operation with no time delay.	(1) Magnetic amplifier incorrectly adjusted or faulty.	The adjustment of the rheostats inside the TM control panel was made and locked at the factory and must not be altered since it cannot be corrected in the field. (R6-R7-R8-R9.)

*If all input voltages, connections, and auxiliary equipment of the sensing unit is correct and the output of the MS relay is incorrect, the voltage sensing unit is defective and must be replaced.

When replacing MS element refer to Fig. 11 for proper location of leads to terminals.

**If all input voltages, connections, and auxiliary equipment of the TM time delay relay are correct and the output of the time delay relay is incorrect the TM time delay relay is defective and must be replaced.



VOLTAGE MEASUREMENTS AT TERMINALS INDICATED
WITH ALL CONNECTIONS MADE BETWEEN TM AND MS.

TERMINALS 1 TO 2 =	21	±2	VOLTS AC (TM NON-OPERATED)
TERMINALS 4 TO 7 =	85	±5	VOLTS AC
TERMINALS 1 TO 10 =	12	±2	VOLTS AC (RAISE LIGHT ON)
TERMINALS 1 TO 14 =	12	±2	VOLTS AC (LOWER LIGHT ON)
TERMINALS 1 TO 10 =	0.6	±0.3	VOLTS AC (TM NON-OPERATED)
TERMINALS 1 TO 14 =	0.6	±0.3	VOLTS AC (TM NON-OPERATED)

FIG. 11. Voltage Test Limits at MS Relay Terminals

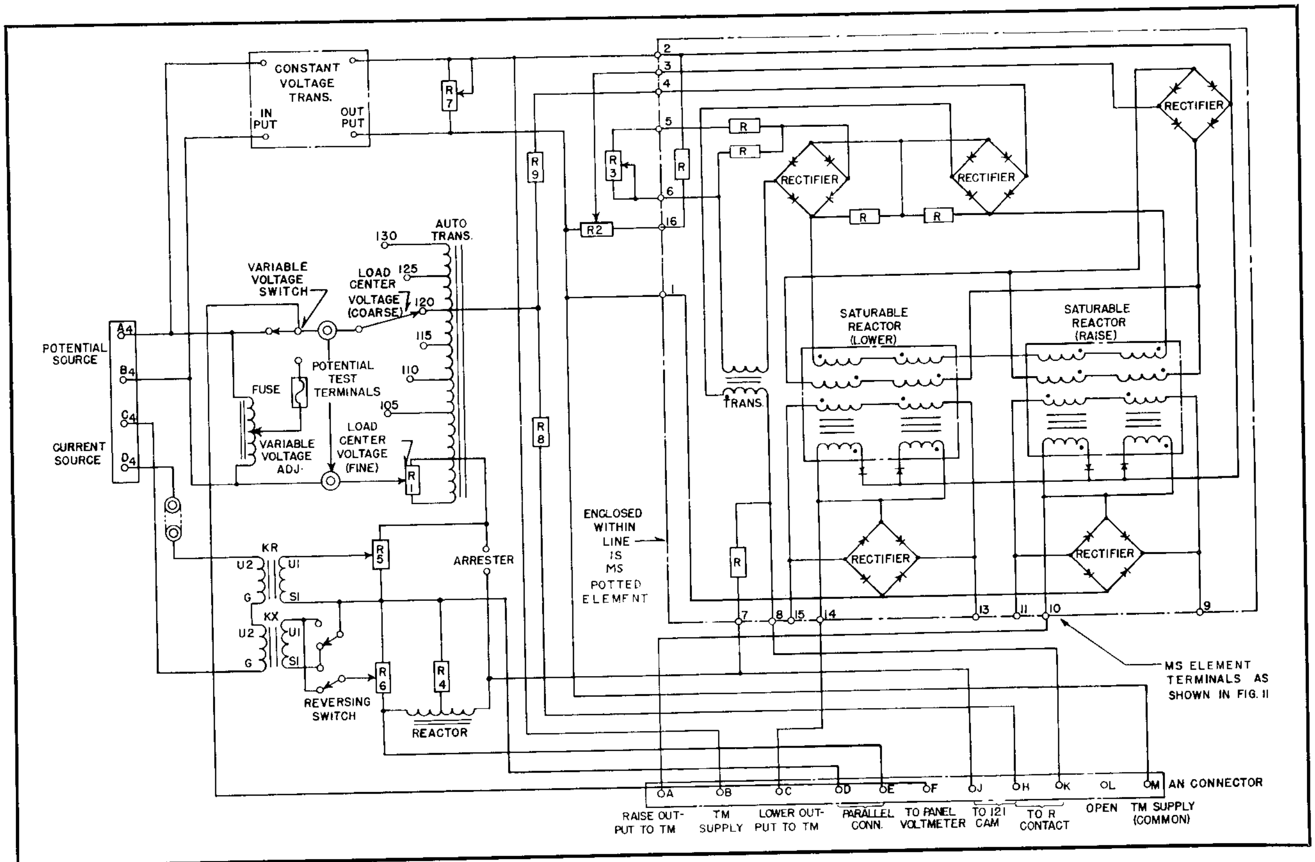


FIG. 12. MS Relay—Diagram of Internal Connections

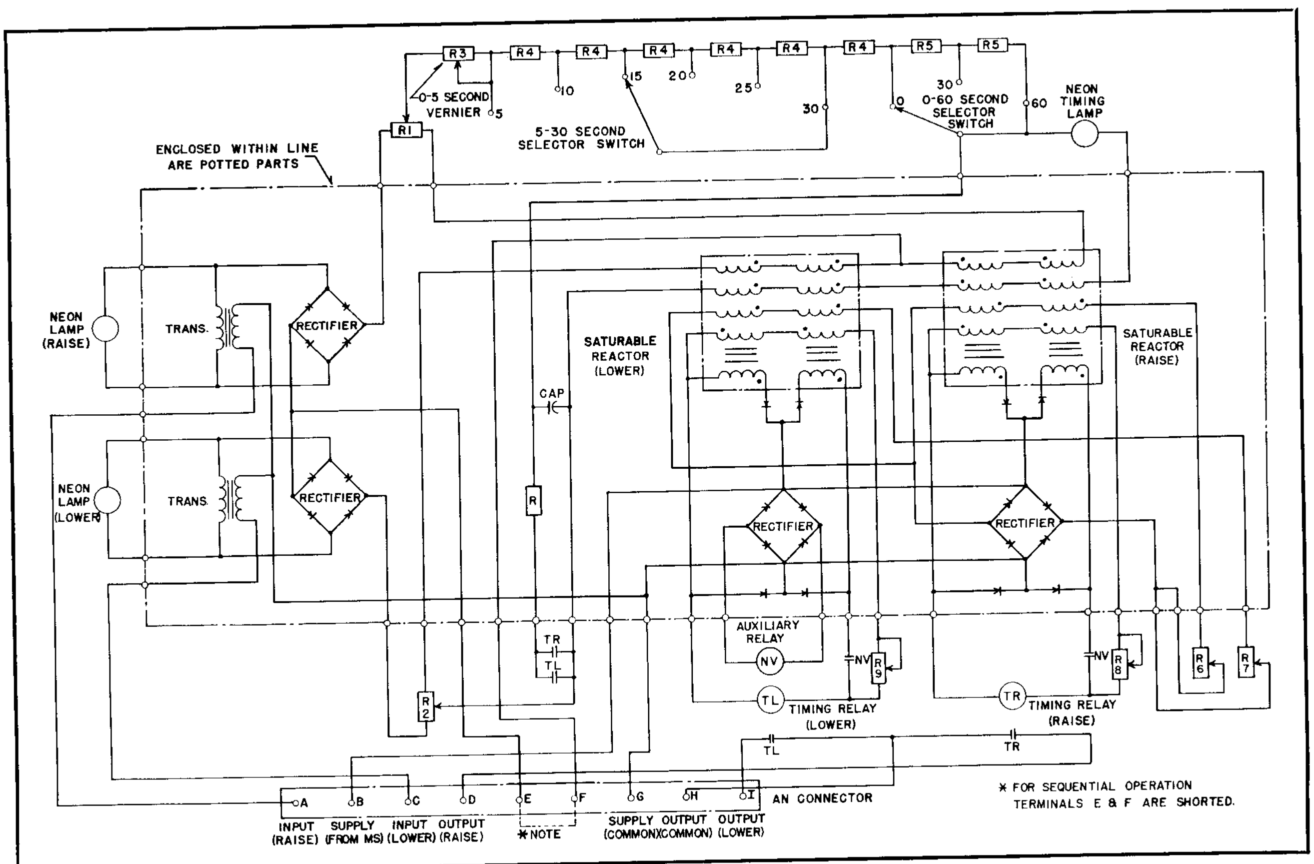


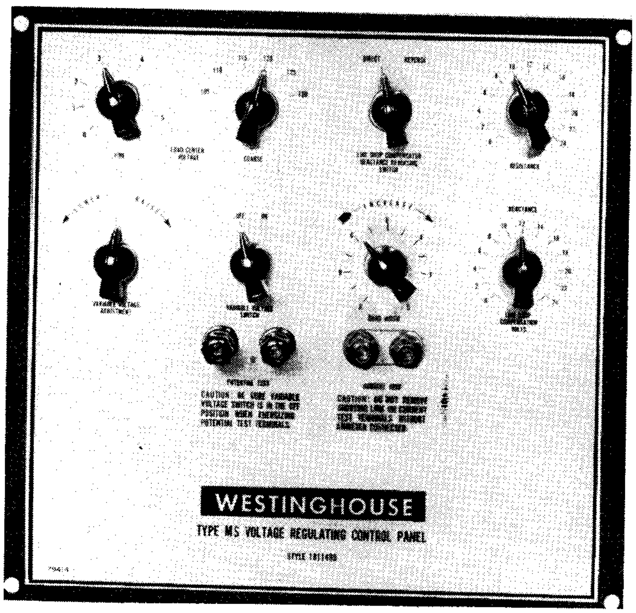
FIG. 13. TM Relay—Diagram of Internal Connections

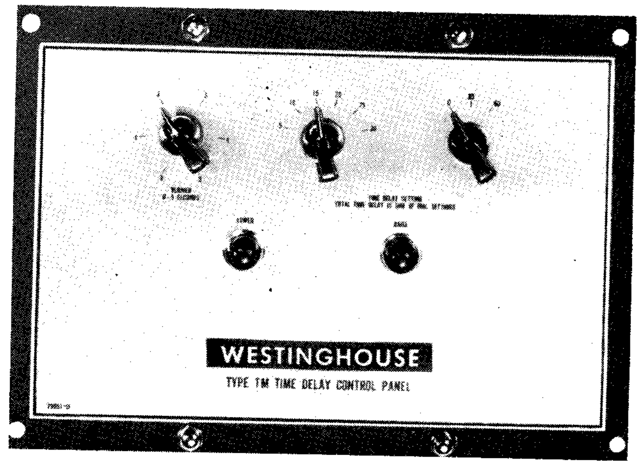
WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
(Rep. 6-60) Printed in U.S.A.

DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

TYPE MS AND TYPE TM
VOLTAGE REGULATING and TIME DELAY RELAYS
For Load Tap Changers





THE TYPE MS VOLTAGE REGULATING RELAY for automatic control of load tap changers consists of a static voltage sensing circuit employing a MAGAMP* magnetic amplifier with external controls for electrically setting the balance voltage, band width, and line-drop compensation.

THE TYPE TM TIME DELAY RELAY for use with the MS voltage regulating control uses a resistance-capacitance timing circuit in conjunction with a neon tube and a MAGAMP* magnetic amplifier to energize auxiliary relays which control the load tap changer motor contactors. Only one setting is required for both "raise" and "lower" operations, this setting being made by external calibrated dials.

RATING

The MS voltage regulating relay and the TM time delay relay have been designed for operation on 60 cycle alternating current systems. The balance voltage can be set at any value desired within the range of 105 to 135 volts, and the band width may be set at any value between ± 1.0 volts and ± 3.0 volts. The time delay may be set to any value, within the range of 5 to 95 seconds.

Separate R and X compensator elements permit independent setting of the 24 volts resistance and 24 volts reactance compensation (both on a 120 volt base) which is available with the standard current of 5 amperes flowing in the current circuit of the control. The 120 volt potential circuit has a burden of 50 volt-amperes and the 5 ampere circuit has a 25 volt-ampere burden.

DESCRIPTION

Voltage Regulating Relay. Detailed pictures of the MS voltage regulating relay are shown in FIGS. 1 and 3. The voltage sensing element containing the components for electrically measuring an unbalance in voltage is a sealed container mounted in back of the control panel as shown in FIG. 3. The components making up the sensing circuit are static devices consisting of a saturating transformer, rectifiers, a Magamp magnetic amplifier and resistors, to insure correct balance voltage under all conditions. An external resistor (R3) for calibrating the balance voltage is mounted on a bracket in back of the MS panel.

External circuit components for electrically setting the balance voltage, the band width, and the

*Trade-Mark

SUPERSEDES ADVANCE I.L. 47-431-6

OCTOBER, 1957

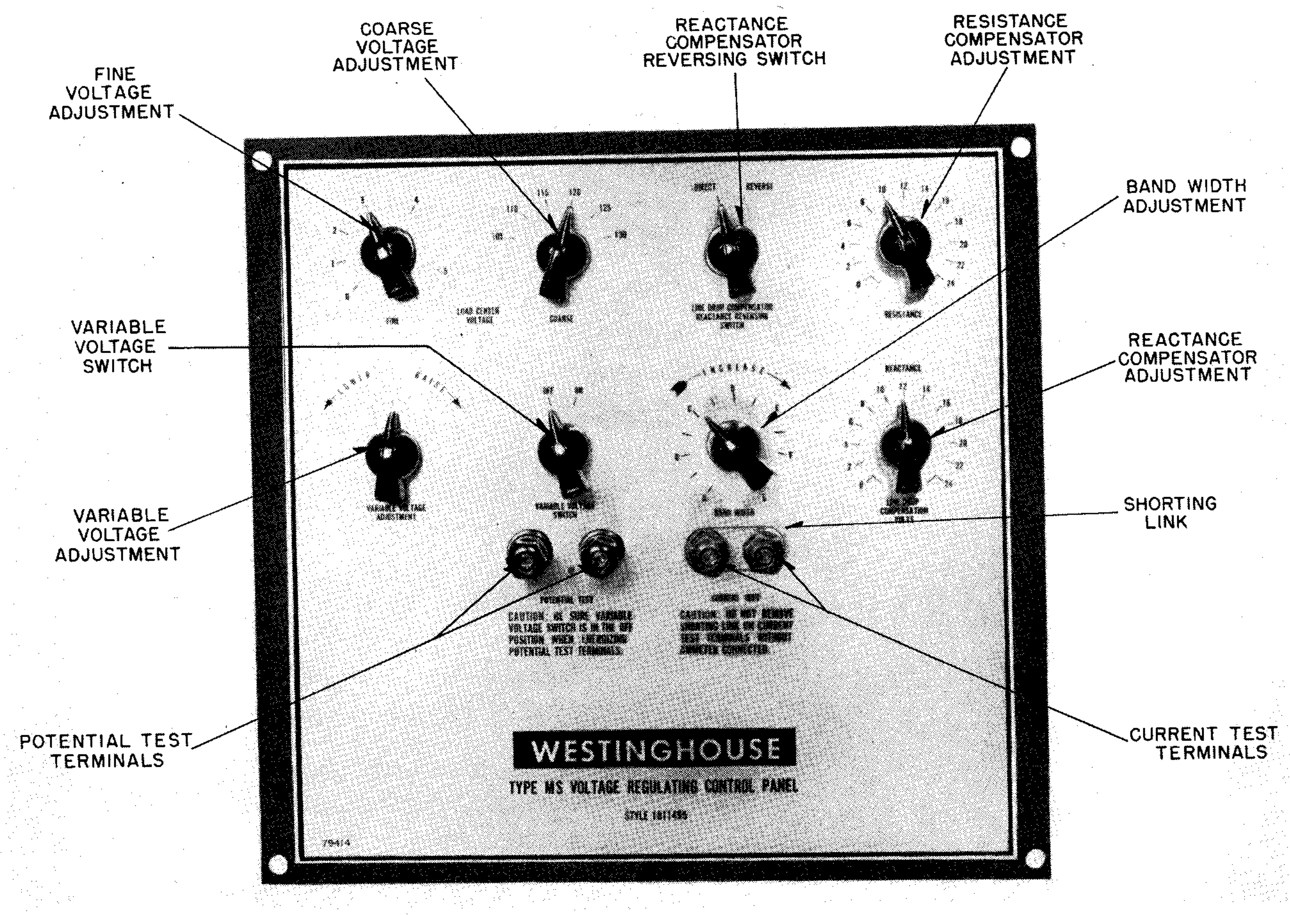


FIG. 1. Front View of MS Voltage Regulating Relay

line drop compensation are mounted on the MS panel as shown in FIGS. 1 and 3. The panel is designed for use as a unit in the complete tap changer control assembly.

An auto-transformer with five-volt taps from 105 to 130 volts plus an additional five-volt vernier tap provides balance voltage settings from 105 to 135 volts. The balance voltage selection is made by means of a non-shorting rotary tap switch for five volt steps and a potentiometer for vernier settings to give intermediate values. Also mounted on the back of the panel with control knobs in front are rheostats for setting the bandwidth and line drop compensation; a rotary type shorting switch for reversing the reactance line drop compensation; a variable auto-transformer and switch for obtaining a variable voltage to assist in setting the bandwidth and voltage level. Intermediate current transformers for the line drop compensator are located in back of the control panel.

Electrical connections between the voltage sensing element and the MS control panel are made through the terminal strips on the end of the sensing element. Reference FIG. 11. External connections from the MS voltage regulating relay are made through two AN connectors as shown in FIG. 3. Current and potential test terminals are conveniently located on the front of the panel.

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

Time Delay Relay. The TM time delay relay is shown in detail in FIGS. 2 and 4. An electrical matching network which is energized by the MS voltage regulating relay is sealed in the housing shown in FIG. 4. This matching network provides a reversible polarity voltage signal to be electrically timed by a resistance-capacitance timing circuit. The capacitance element is sealed in the housing. The timing resistance consists of a rheostat plus fixed resistors which are used in steps to provide the

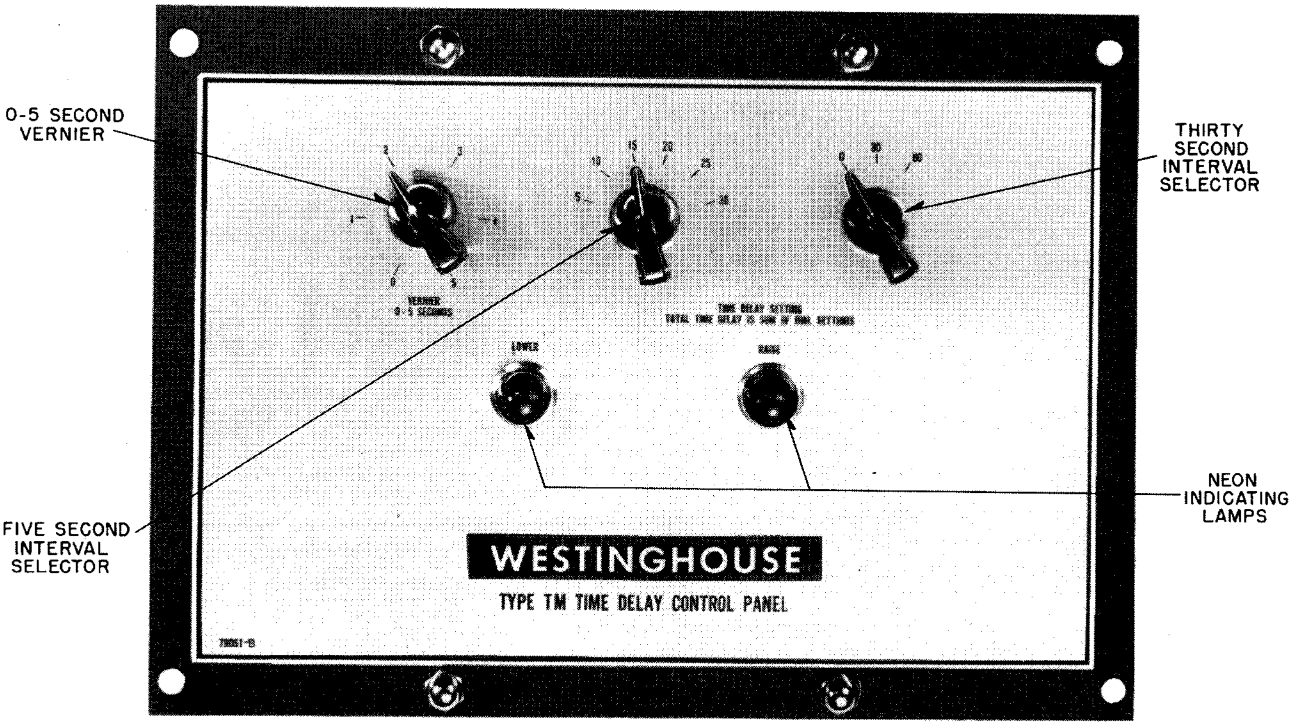


FIG. 2. Front View of TM Time Delay Relay

desired delay setting. The rheostat is attached to the control panel while the fixed resistors are connected between terminals of the tap switches as shown in FIG. 4. A neon tube mounted on the rear of the control panel measures the voltage on the capacitor and, at the set delay, controls a MAGAMP magnetic amplifier which is sealed in the housing. The MAGAMP magnetic amplifier energizes two of the relays shown mounted on the rear of the panel, one relay for "raise" operation and one for "lower" operation, through contacts of the slug relay. The slug relay (NV) introduces a time delay to allow the Magnetic Amplifier to be under positive control, thus preventing malfunction of the "raise" and "lower" relay, when the control is energized initially.

Time delay settings are made by the use of calibrated dials shown in FIG. 2. One tap switch changes the timing resistance in steps to give five-second increments of time delay from five to thirty seconds while a second tap switch provides thirty-second increments from zero to sixty seconds. A rheostat provides a vernier range from zero to five seconds with a dial calibrated in one second increments. The vernier setting is added to the other settings, thus giving intermediate delays.

Two neon lights mounted on the control panel indicate the presence of an input to the timing circuit, or in other words, the presence of an unbalance in the voltage applied to the MS voltage regulating relay. External connections from the TM time delay relay are made through an AN connector.

RECEIVING—HANDLING—STORING

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

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

Handling. The MS voltage regulating relay is in fact an instrument and should be handled as such. It has been designed to be as rugged as possible, but the fact remains that it has better than 1% ac-

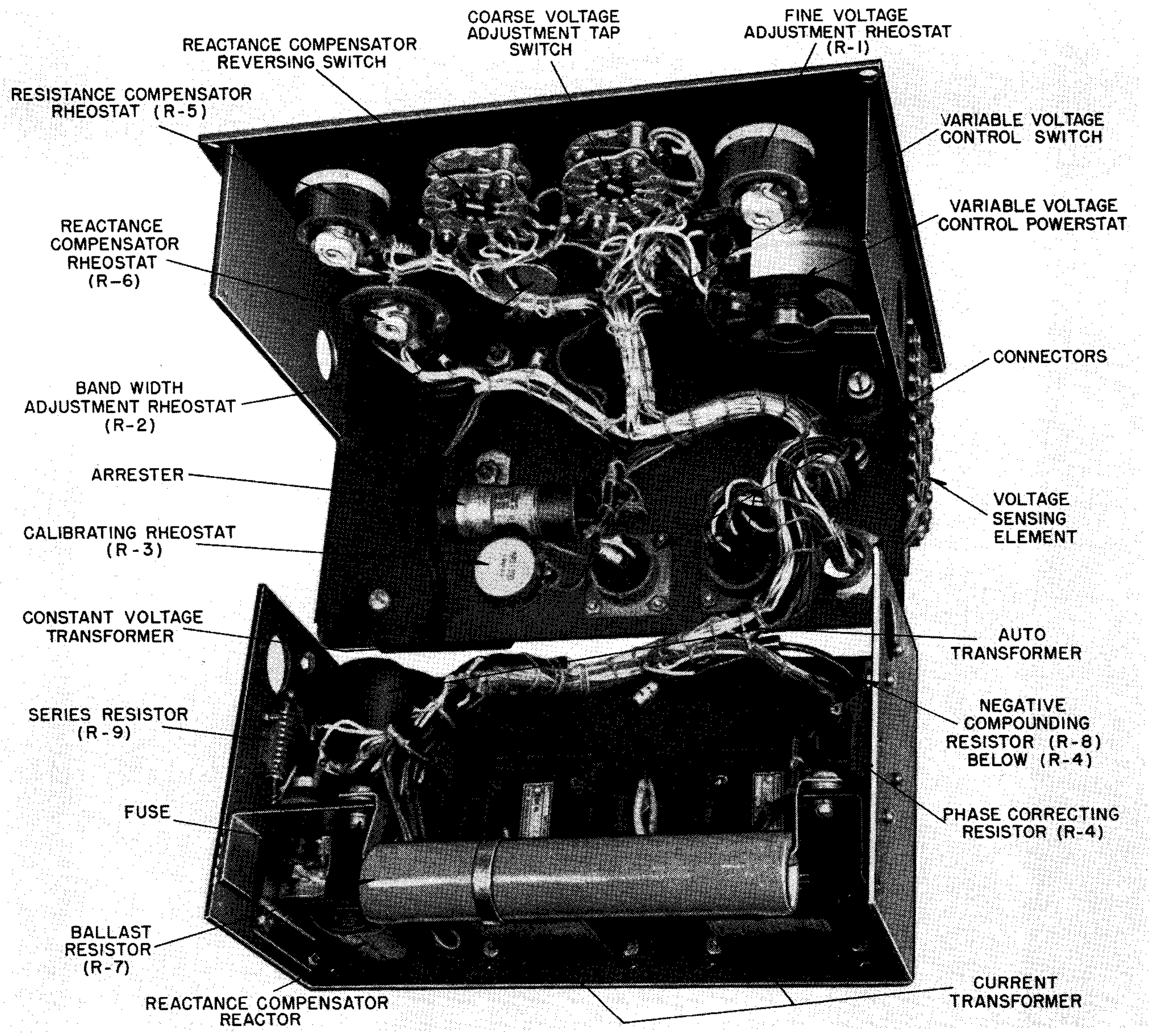


FIG. 3. Rear View of MS Relay Panel

curacy and is thus equivalent to the better, more accurate laboratory voltmeters and should consequently be handled with reasonable care, free from excessive shock and vibration.

These relays have been adjusted and tested before leaving the factory to insure that they meet the required high standards of operation considered essential for such equipment. Whether or not they continue to meet these standards depends upon the treatment accorded them after they leave the factory.

Storing. If the MS and TM relays are to be stored, they should be kept in a clean, dry, moderate temperature location, protected from excessive dust, from atmospheres conducive to condensation and corrosion, and from moisture and the elements.

INSTALLATION

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

TO INSTALL the MS and TM relays in the control compartment, place the back projections of the panels into the cutouts provided in the control compartment (insert from the front of the

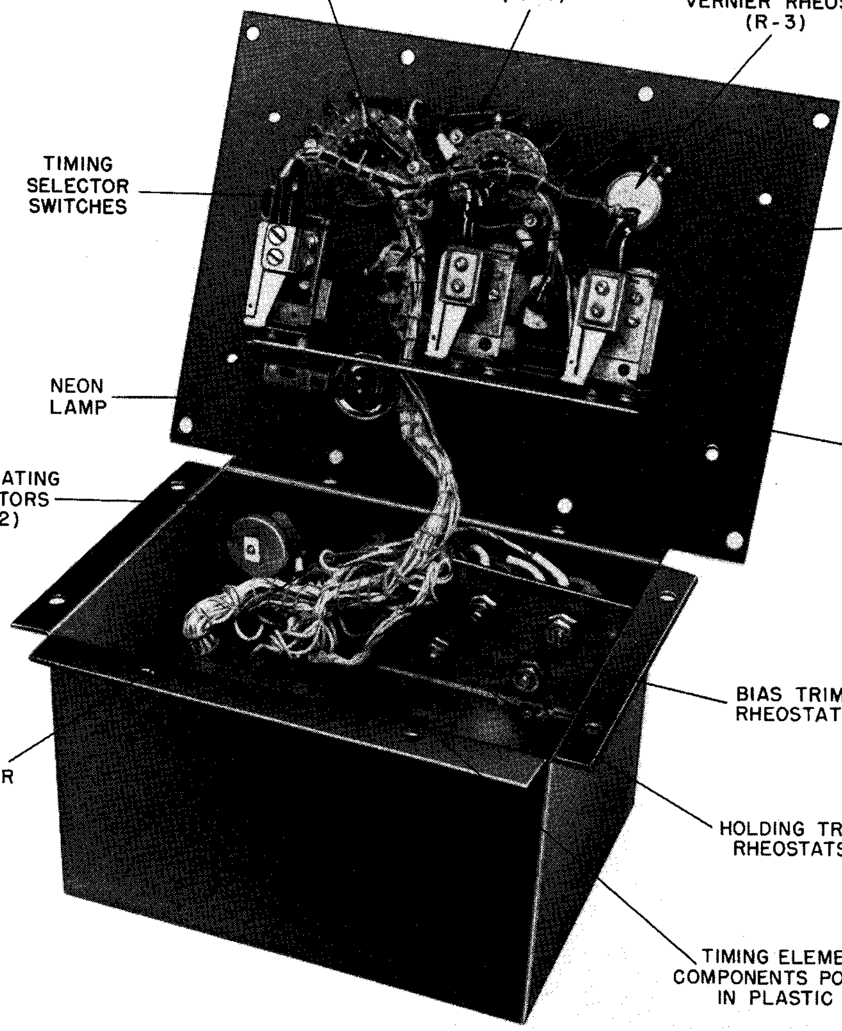


FIG. 4. Rear View of TM Relay Panel

control compartment) and bolt in place at the four corners with the bolts provided for this purpose. Insert the plug connectors from the back of the swinging control panel into the receptacles on the back of the MS and TM panels and the installation is complete.

TO REMOVE the MS and TM panels from the control compartment, disengage the plug connectors from the receptacles and remove the four bolts from the corners of each panel. The four pole connector contains self shorting terminals so that the current transformer is automatically shorted when the plug is removed.

OPERATION

Voltage Regulating Relay. The voltage sensing action of the MS voltage regulating relay is basically a function of the magnetic characteristics of a saturating transformer and the control characteristics of a self saturating MAGAMP magnetic amplifier. Band width and compounding are accomplished by the control characteristics of the amplifier. Line drop compensation is provided by introducing a bias voltage into the sensing circuit which is proportional to the magnitude and phase of the voltage drop on the line.

The voltage sensing circuit measures the value of the input voltage at terminals A4 and B4 of FIG. 5 less the line drop compensation voltage. With proper balance voltage applied to terminals A4 and B4, the output of the voltage sensing circuit is zero. As the applied voltage is either increased above or decreased below the balance value, the sensing circuit has an output voltage signal of one polarity

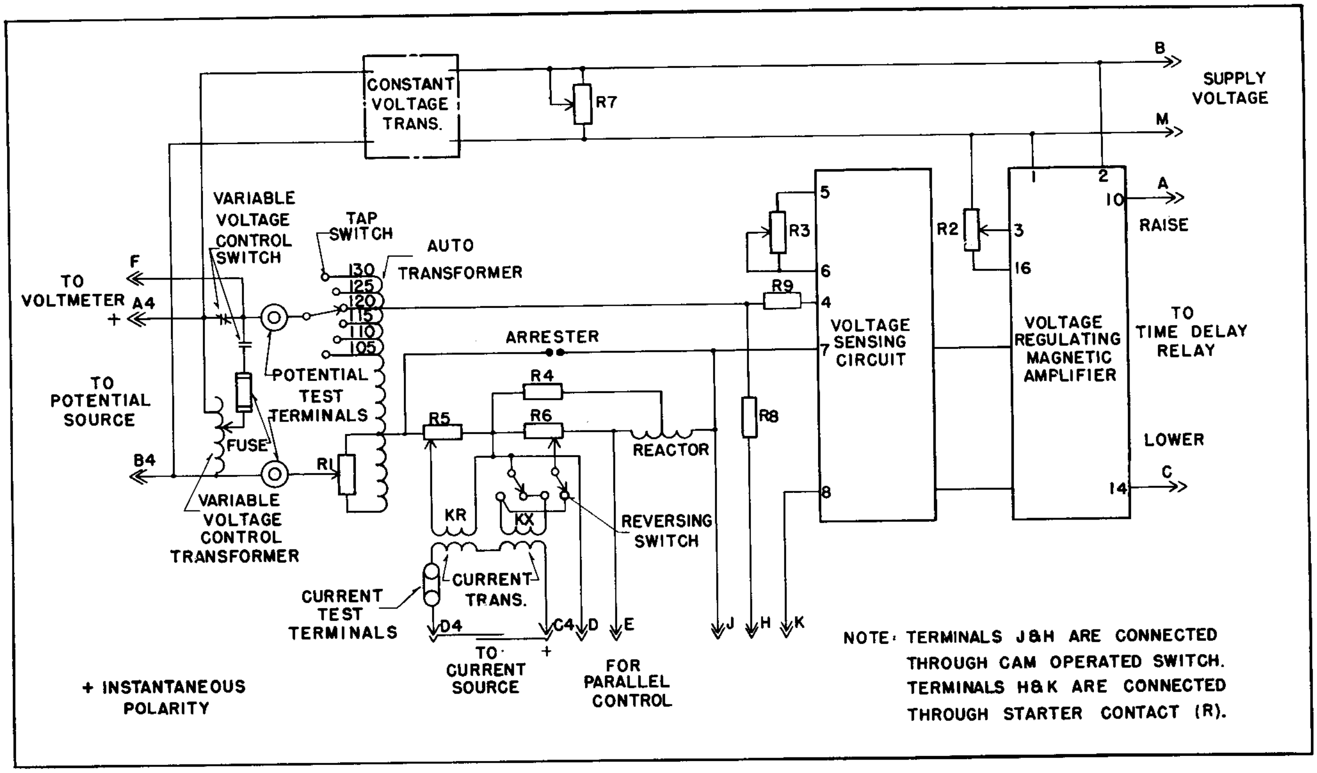


FIG. 5. Schematic Diagram of Type MS Voltage Regulating Relay

or the other depending upon the direction of change from balance voltage. This signal is applied to the amplifier circuit having separate outputs for "raise" and "lower" operations. As the change in balance voltage becomes sufficiently large, a signal of the proper polarity from the sensing circuit causes the

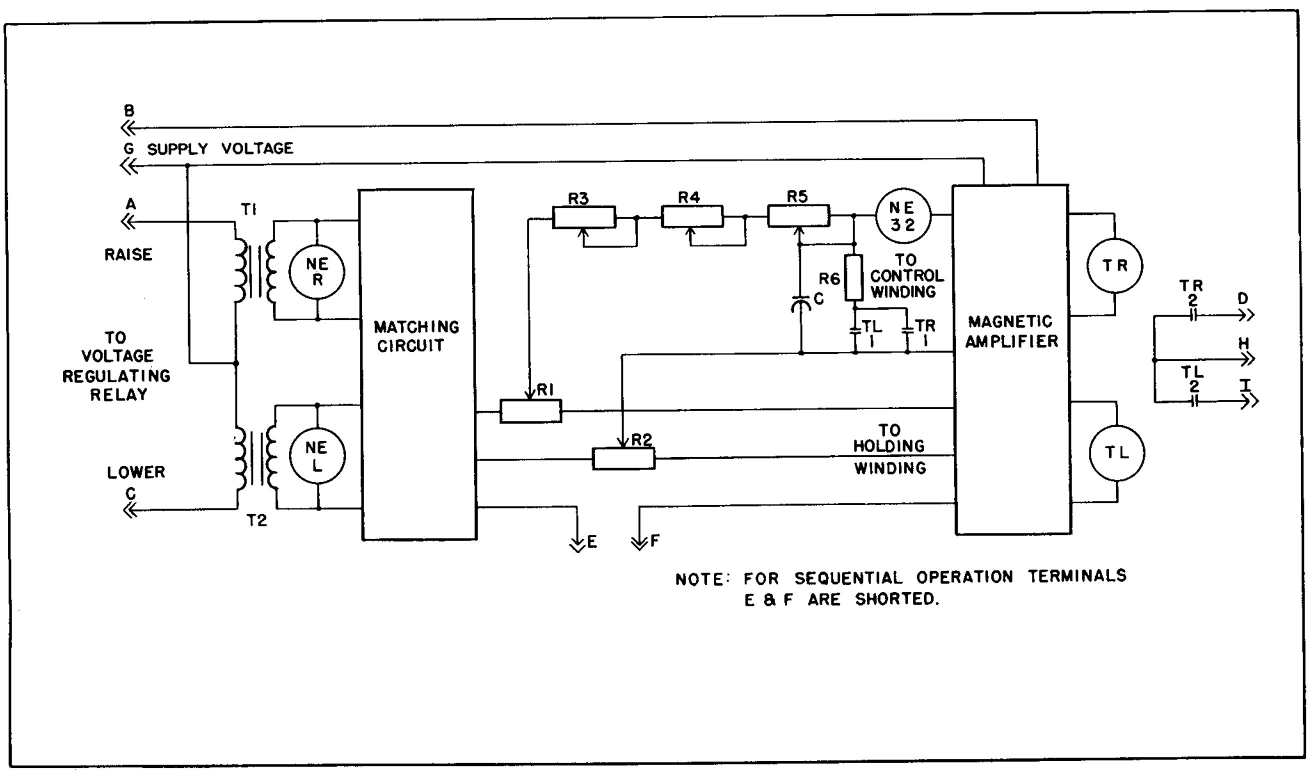


FIG. 6. Schematic Diagram of Type TM Time Delay Relay

amplifier to conduct. The amount of voltage change necessary to cause the amplifier to conduct is determined by the bias applied to the amplifier circuit with the band width setting rheostat. The voltage change back toward balance necessary to cause the amplifier to stop conducting is determined by a fixed amount of positive feedback in the amplifier. This value has been set at the factory to give the proper compounding to insure stable operation of the automatic controls with a minimum number of tap changer operations. By shorting terminals J to H or H to K to J, through a cam operated tap changer switch and relay contact, a signal is given to the sensing circuit to anticipate a correction of voltage by the tap changer.

Input balance voltages from 105 to 135 volts are made possible by an autotransformer with taps on the input side. A vernier (Rl, FIG. 5) provides intermediate values which are added to the tap selection. A rheostat (R2, FIG. 5) is used to vary the bias to the magnetic amplifier, allowing a band width selection from 2 volts to 6 volts.

Line drop compensation is obtained by circulating a current, proportional to the load current, through the line drop compensator network to produce a voltage proportional to the actual drop in a line for which the compensator is adjusted. This voltage is subtracted from the regulator voltage to simulate load center voltage. By adjusting rheostats R5 and R6 of FIG. 5, the compensator can be set to give 0 to 24 volts resistive and reactive compensation (on a 120 volt base with 5 amperes flowing through terminals C4 and D4). Reversed reactance conpensation can be obtained by the reversing switch.

Time Delay Relay. The basic timing function of the TM time delay relay is performed by a resistance-capacitance timing circuit. The time delay is determined by the value of resistance inserted into the resistance-capacitance network. The timing circuit controls a MAGAMP magnetic amplifier which energizes auxiliary relays to operate the tap changer motor contactor.

When a departure from balance voltage exists outside the set band width of the voltage regulating control, a voltage signal is fed into the time delay relay as indicated in Fig. 6, a "raise" signal being fed through transformer Tl or a "lower" signal through transformer T2. Indicating lamps, NER and NEL indicate the presence of an input to the time delay relay. The matching network provides a DC voltage to the timing circuit of a polarity to indicate whether a "raise" or a "lower" operation is required. The matching network also applies a signal voltage directly to a holding winding of the amplifier. After the set time delay, the control winding is energized with a pulse signal through the NE-32 neon lamp. This causes the time delay amplifier to conduct energizing either relay TR or TL depending upon the polarity of voltage being timed. The action of the holding winding keeps the amplifier conducting as long as there is an input to the time delay relay or until the holding winding circuit is interrupted by some other means. Contacts on TR or TL discharge the timing capacitor through resistor R6 (Fig. 6) to immediately reset the timing circuit.

Resistors Rl and R2 (Fig. 6) are used to calibrate the delay dials for "raise" and "lower" operations respectively. These have been set at the factory and should not have to be changed. Delays ranging from 5 to 95 seconds can be obtained by setting variable resistors R3, R4 and R5 (Fig. 6). R3 is a rheostat used to provide intermediate values with the dial marking calibrated in one second increments of time delay. R4 can be changed in five equal steps to provide five second increments of time delay from five to thirty seconds while R5 can be changed in two equal steps to provide thirty second increments. The total delay is the sum of the dial settings, with only one setting required for "raise" and "lower" operations.

The holding winding can be interrupted by a cam operated switch to provide for non-sequential operation of the tap changer. For sequential operation terminals E and F are shorted so that the holding winding is de-energized only when the input to the timing control is removed.

SETTING

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

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

Balance voltage may be corrected by adjusting potentiometer R3, if necessary.

Balance Voltage and Bandwidth Settings Using External Voltage Source. Place the control breaker in the "OFF" position, the variable voltage switch in the "OFF" position, and apply an external regulated power source to the potential test terminals. If the unit is carrying load, set the

compensator dials on zero while the balance voltage and band width settings are made. The balance voltage and band width settings are made as follows:

1. Turn the band width dial to the full clockwise position.

2. Set the coarse-voltage adjustment dial to the dial calibration just below the desired balance voltage. (For example, set on 115 volts for 117 volts balance).

3. Next turn the fine-voltage adjustment dial to the value which when added to the setting above gives the desired balance voltage. (In the example, set on 2 volts).

4. To set the bandwidth and check with the balance voltage setting above, adjust the external applied voltage to be equal to the balance voltage less one half the total band width. (For example, if a band width of 3 volts with balance voltage of 117 volts is desired, adjust the voltage to 115.5 volts).

5. Rotate the band width dial slowly in a counter-clockwise direction until the "Raise" light on the TM panel comes on. These settings now should give the proper balance voltage and band width and may be checked in the step below.

6. Increase the external applied voltage to be equal to the balance voltage plus one half the total band width. (118.5 volts in the example above). The "Lower" light on the TM panel should come on at this value of voltage; however, a slight readjustment of the fine-voltage dial and the band width dial may be necessary. If the light comes on at less than the desired voltage, it indicates a balance voltage setting and a band width setting slightly less than the desired values. If the light comes on at a higher value than the desired value the reverse is indicated. In any case, only a very minor adjustment will be necessary. Both balance voltage and band width can be increased by a clockwise rotation of the fine-voltage adjustment dial and band width adjustment dial respectively.

Balance Voltage and Bandwidth Settings Using Internal Voltage Source. A variable autotransformer is provided on the MS voltage regulating relay for making balance voltage and band width settings using the internal potential transformer as a voltage source. Place the automatic manual switch in the "OFF" position or the "MAN" position, the control breaker in the "ON" position, and the variable voltage switch in the "ON" position. If the unit is carrying load, set the compensator dials on zero while the settings are being made. Using the variable autotransformer on the MS relay panel to vary the voltage, the balance voltage and band width settings are made following the steps listed in the procedure for making settings using an external voltage source.

NOTE: Care should be taken to observe the voltmeter readings during each step of the procedure for making settings to be sure that minor voltage fluctuations of the source voltage do not occur while the settings are being made. After the settings are made, return the variable voltage switch to the "OFF" position.

Line-Drop Compensator Settings. The final settings on the line-drop compensator are usually made by field adjustments, but if the data on the particular line is known, the curves in FIGS. 9 and 10 may be used, and initial values calculated.

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

Dial Setting for Resistance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times R_L \times d \times n.$$

Dial Setting for Reactance Compensation =

$$5 \times \frac{N_{C.T.}}{N_{POT}} \times X_L \times d \times n.$$

Where

$N_{C.T.}$ = current transformer ratio = $\frac{\text{primary current}}{\text{secondary current}}$

N_{POT} = potential transformer ratio = $\frac{\text{primary voltage}}{\text{secondary voltage}}$

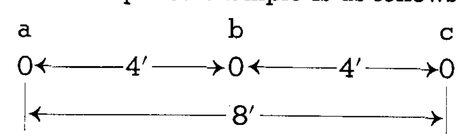
R_L = resistance per conductor from unit to load center, in ohms per mile.

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

d = miles from unit to load center.

n = 120/balance voltage setting.

A typical three-phase example is as follows:



500,000 CM copper conductor, with flat spacing above

Line Voltage = 12000 volts
Current Transformer Ratio = 600/5
Potential Transformer Ratio = 6928/120
Distance from unit to load center = 3.5 miles.
Balance voltage setting = 117 volts.

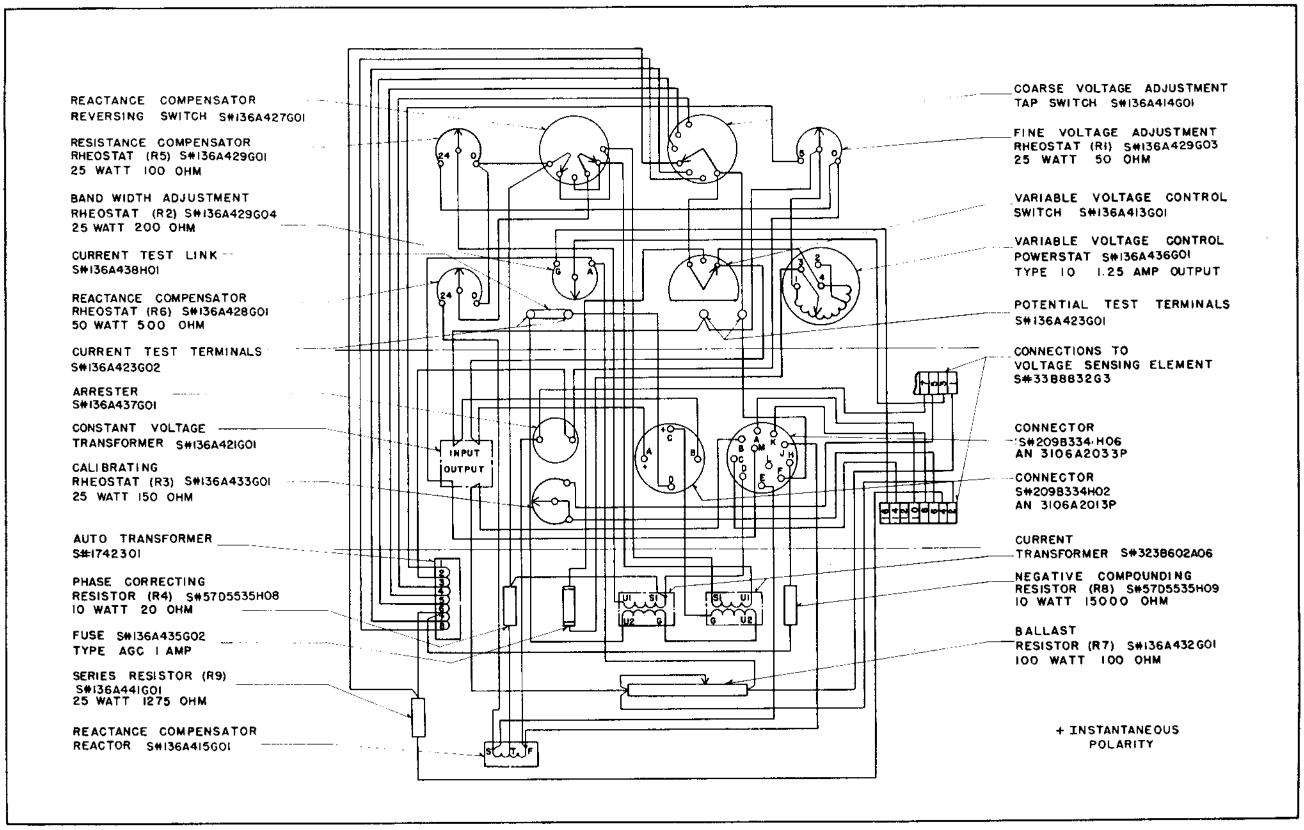


FIG. 7. Wiring Diagram of Type MS Voltage Regulating Relay

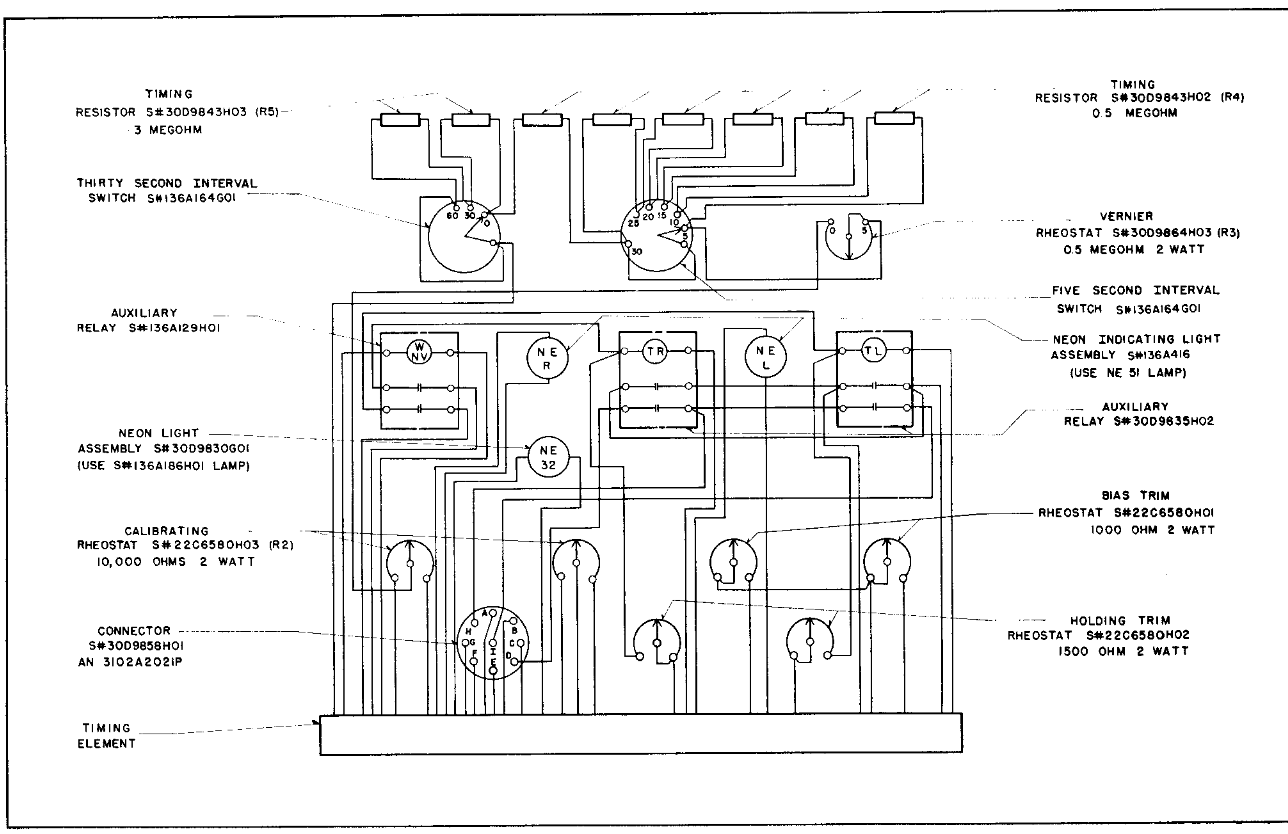


FIG. 8. Wiring Diagram of Type TM Time Delay Relay

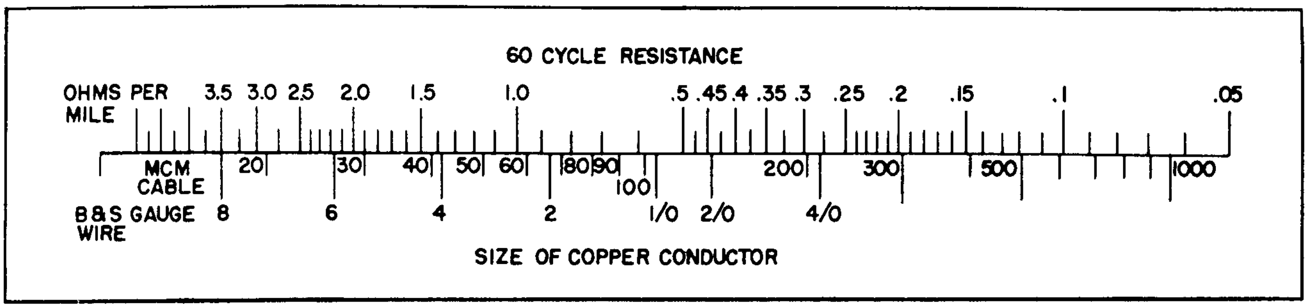


FIG. 9. Resistance Chart, Showing Ohms per Conductor per Mile, 60 Cycle Circuit

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

From FIG. 9:

$R = 0.12$ ohms per mile

From FIG. 10:

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

$X_L = 0.64$ ohms per mile

The line drop compensator resistance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.12 \times 3.5 \times \frac{120}{117} = 4.47$$

The line drop compensator reactance setting is:

$$\frac{5 \times 600/5}{6928/120} \times 0.64 \times 3.5 \times \frac{120}{117} = 23.9$$

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

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

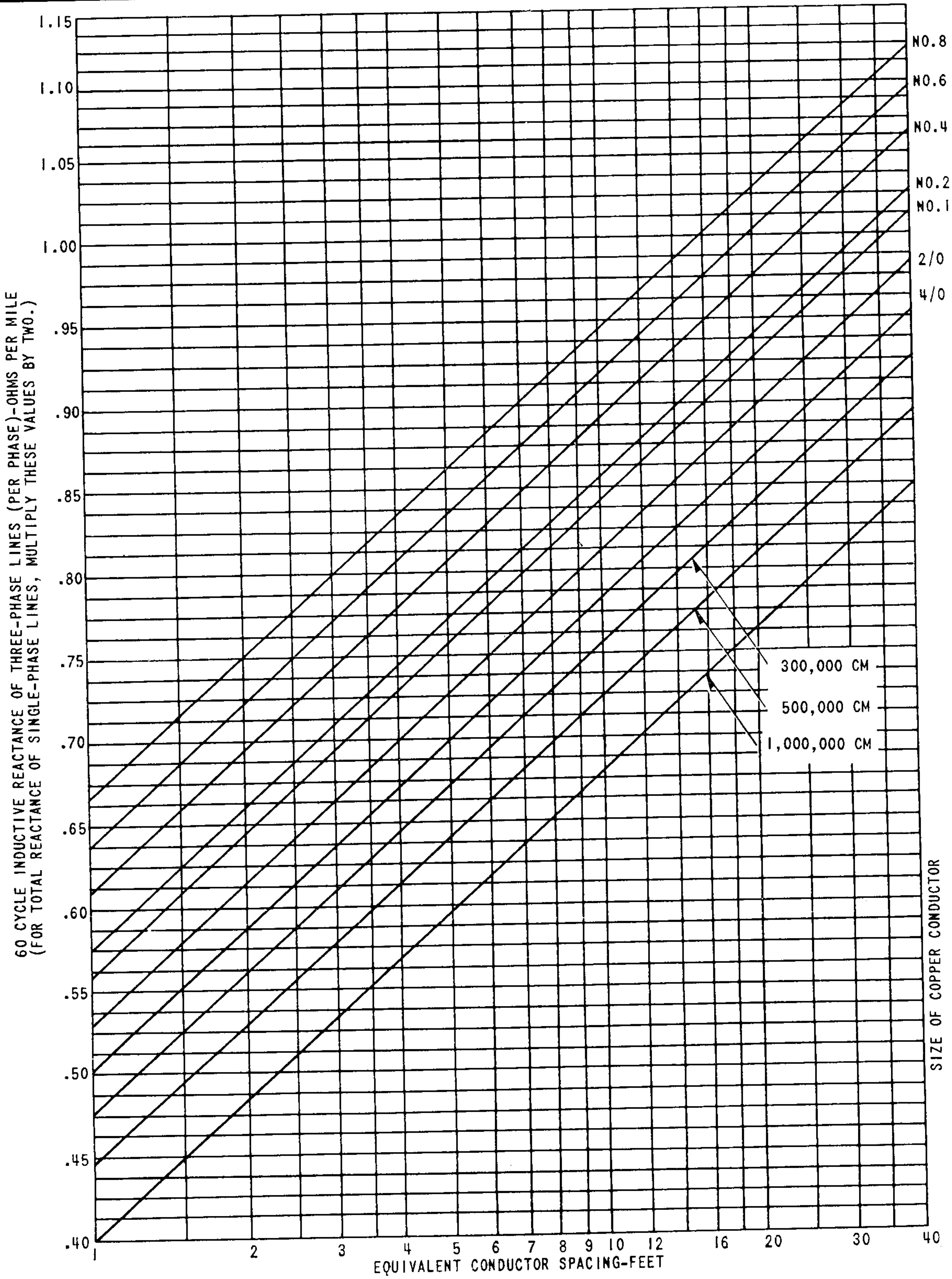
Time Delay Settings. The desired time delay is set with the calibrated dials on the front of the TM control panel. Selection of delays in five second intervals from 5 to 95 seconds can be made. For intermediate settings, a vernier dial calibrated in one-second intervals adds the intermediate value. (Example: For a 37-second delay setting, set the vernier dial on 2 seconds, the five-second interval dial on 5 seconds and the thirty-second interval dial on 30 seconds). Only one setting is required for both "raise" and "lower" operations.

MAINTENANCE

The proper adjustments to insure correct operation have been made at the factory and should not be disturbed. The components of the voltage sensing element of the MS voltage regulating control which are sealed are static components and under normal conditions should require no maintenance. Should the sensing element become inoperative, return the entire MS panel to the Sharon Plant through the nearest District Engineering and Service Office.

The components of the TM time delay control which are sealed in the housing are static components and under normal conditions should require no maintenance. In the event they should become inoperative, return the entire TM panel to the Sharon plant through the nearest District Engineering and Service Office.

In the event any of the components on the MS and TM panels other than the sealed units become inoperative, they may be replaced with renewal parts ordered from the nearest Westinghouse Sales Office or from the Sharon Plant. Should parts be ordered, give the Style or Stock Order number of the equipment as stamped on the nameplate together with the style number and description of the parts required as identified in FIGS. 7 and 8.



EQUIVALENT CONDUCTOR SPACING, D, OF UNSYMMETRICAL THREE PHASE LINES IS GIVEN BY THE EXPRESSION $D=\sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$, WHERE

D_{AB}, D_{BC}, AND D_{CA} ARE THE DISTANCES IN FEET BETWEEN CONDUCTORS DESIGNATED BY THE SUBSCRIPTS.

NOTE:- WHERE $D_{CA} = 2\ D_{AB} = 2\ D_{BC}$; $D = 1.26\ D_{AB}$

FIG. 10. Reactance Chart, Size of Conductor and Spacing, for 3-Phase Lines (per Mile), 60 Cycle Circuit

Trouble Shooting. Observing the suggested symptoms and making the indicated measurements will be helpful to a competent repair technician in determining the cause of misoperation and identifying any damage or unconnected components. The indicated voltages are 60 cycles AC and should be measured with a voltmeter of 1000 ohm per volt sensitivity. The test power supply should be finely adjustable, well regulated, and with low harmonic content.

For convenience in trouble shooting reference Figures 12 and 13.

NOTE: While making tests on the voltage regulating relay, the voltage at terminals 4 and 7 on the voltage sensing unit should never exceed 100 volts.

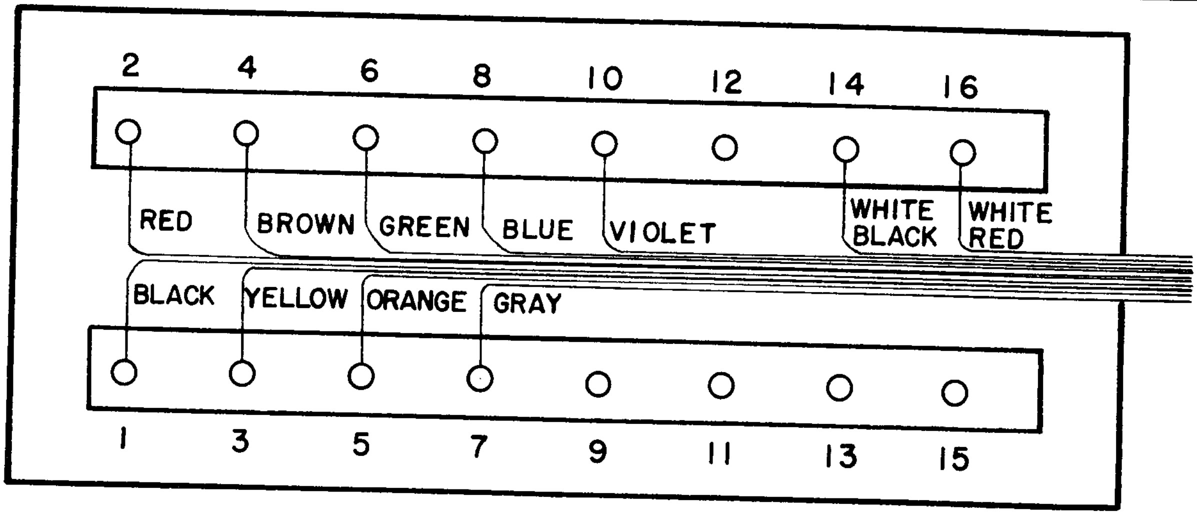
Symptom	Probable Cause	Check
I No Operation	(1) Incorrect setting, disconnected or turned off.	Inspect for proper setting of controls, switches, breakers and for security of connections.
(Neon indicator lights on TM panel do not operate and no output from TM control when the potential voltage is varied above and below balance.)	(2) No input voltage from potential transformer into the MS relay.	(a) The voltage at the potential test terminals is at the voltage level setting. (With no line drop compensation). (b) That the output voltage of the autotransformer is 120 volts. This may be measured between the terminals at the full scale end of the resistance line drop compensator control and the terminal of the coarse voltage adjustment tap switch that would be closed if set for 120 volts. (c) That the voltage between terminals 4 and 7 of the sensing unit is approximately 85 volts.
	(3) No supply voltage from the constant voltage transformer.	(a) The output of the constant voltage transformer at terminals 1 and 2 of the sensing unit (when balanced) is 21±2 volts. The output voltage of the constant voltage transformer without load will be approximately 23 volts.
	(4) Little or no output voltage from the voltage sensing unit and MS control.	(a) That the voltage between voltage sensing element terminals 10 and 1 for a potential transformer voltage below balance or the voltage between terminals 14 and 1 for a potential transformer voltage above balance should be 12±2 volts. (This voltage should also be between C and M of the MS receptacle as well as between terminals A and G, or between C and G of the TM plug.)
II Incorrect Operation **A.** Only one neon light on the TM panel operates and only one output from the TM relay.	(1) Incorrect voltage from potential transformer into MS relay.	(a) As above for no input voltage from potential transformer to MS relay.

Symptom	Probable Cause	Check
	(2) Incorrect voltage out of MS control.	(a) As above for no output voltage from MS control panel.
	(3) Out of calibration—will balance at a voltage other than that set by the control.	(a) Alignment of knobs on the controls. (b) Calibration—adjust R3. (c) Calibrating rheostat resistance .(R3)
	(4) Indicator bulb in-operative.	
B. Both outputs "on" at balance voltage.	(1) Bandwidth too narrow.	(a) Resistance of bandwidth control rheostat. (b) As above for no supply voltage from constant voltage transformer.
	(2) Compounding too great.	(a) Nothing. This characteristic was adjusted at the factory and cannot be corrected in the field. (b) TM relay non-operative and/or terminals E and F are not properly shorted.
C. Neon indicator lights operate normally but no tap changer operations.	(1) Incorrect setting of tap changer controls of disconnected conponents.	(a) For proper settings, proper alignment of control knobs and security of connections. Note: Terminals E and F of TM control panel must be closed through 123 cam operated pilot switch or shorted together.
	(2) Incorrect voltage from MS control panel.	(a) As above for no output voltage of MS control.
	(3) Incorrect or no supply voltage from the constant voltage transformer.	(a) Voltage between terminals B and G of the TM control panel should be 21±2 volts.
	(4) No output from TM control panel.	(a) After the time delay a circuit should be complete between terminals D and H for a raise signal or between A and H for a lower signal.
D. Tap changer operation with no time delay.	(1) Magnetic amplifier incorrectly adjusted or faulty.	Nothing. The adjustment of the rheostats inside the TM control panel was made and locked at the factory and must not be altered since it cannot be corrected in the field. (R6-R7-R8-R9).

If all input voltages, connections, and auxiliary equipment of the sensing unit is correct and the output of the MS relay is incorrect, the voltage sensing unit is defective and must be replaced.

When replacing MS-VR element refer to Fig. 11 for proper location of leads to terminals.

If all input voltages, connections, and auxiliary equipment of the TM time delay relay are correct and the output of the time delay relay is incorrect the TM time delay relay is defective and must be replaced.



VOLTAGE MEASUREMENTS AT TERMINALS INDICATED WITH ALL CONNECTIONS MADE BETWEEN TM AND MS.

TERMINALS 1 TO 2 = 21	±2	VOLTS AC	(TM NON-OPERATED)
TERMINALS 4 TO 7 = 85	±5	VOLTS AC	
TERMINALS 1 TO 10 = 12	±2	VOLTS AC	(TM OPERATED)
TERMINALS 1 TO 14 = 12	±2	VOLTS AC	(TM OPERATED)
TERMINALS 1 TO 10 = 0.6	±0.3	VOLTS AC	(TM NON-OPERATED)
TERMINALS 1 TO 14 = 0.6	±0.3	VOLTS AC	(TM NON-OPERATED)

FIG. 11.

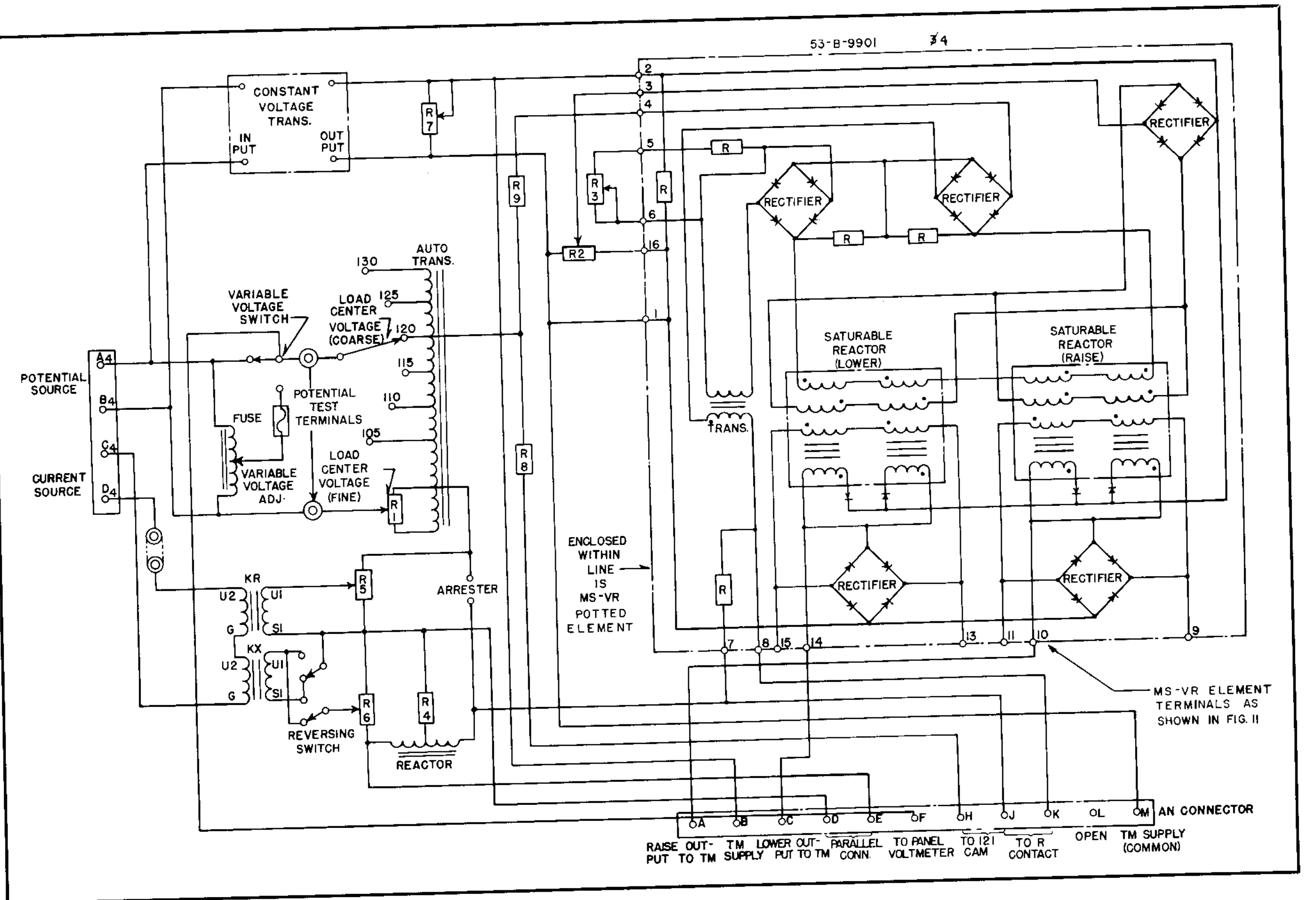

53-B-9901
CONSTANT VOLTAGE TRANS.
IN PUT
OUT PUT
AUTO TRANS.
VARIABLE VOLTAGE SWITCH
LOAD CENTER VOLTAGE (COARSE)
POTENTIAL TEST TERMINALS
FUSE
VARIABLE VOLTAGE ADJ.
LOAD CENTER VOLTAGE (FINE)
POTENTIAL SOURCE
CURRENT SOURCE
ARRESTER
REVERSING SWITCH
REACTOR
ENCLOSED WITHIN LINE IS MS-VR POTTED ELEMENT
SATURABLE REACTOR (LOWER)
SATURABLE REACTOR (RAISE)
RECTIFIER
TRANS.
MS-VR ELEMENT TERMINALS AS SHOWN IN FIG. II
AN CONNECTOR
RAISE OUT-PUT TO TM
TM SUPPLY
LOWER OUT-PUT TO TM
PARALLEL CONN.
TO PANEL VOLTMETER
TO 121 CAM
TO R CONTACT
OPEN
TM SUPPLY (COMMON)

FIG. 12.

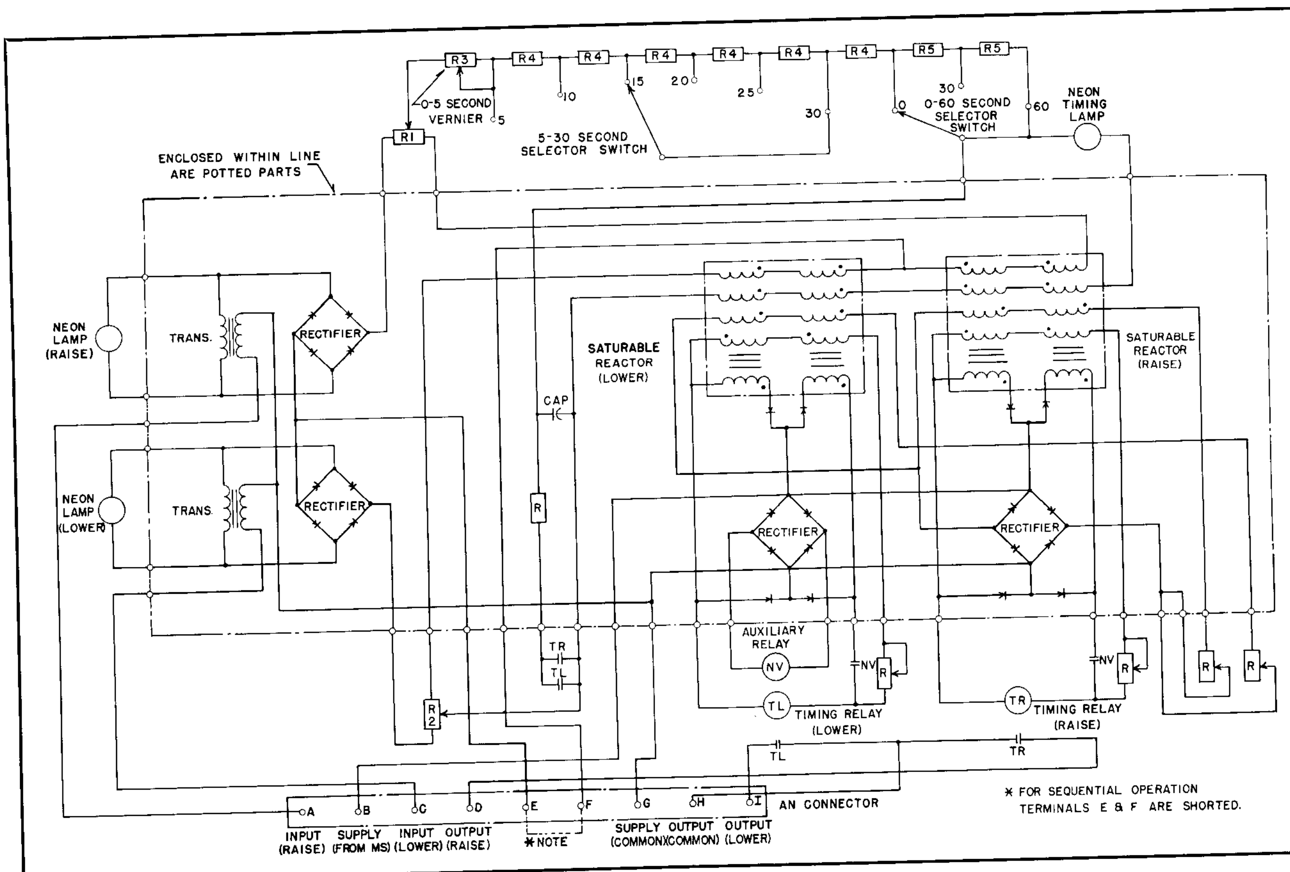

0-5 SECOND VERNIER
5-30 SECOND SELECTOR SWITCH
0-60 SECOND SELECTOR SWITCH
NEON TIMING LAMP
ENCLOSED WITHIN LINE ARE POTTED PARTS
NEON LAMP (RAISE)
NEON LAMP (LOWER)
TRANS.
RECTIFIER
SATURABLE REACTOR (LOWER)
SATURABLE REACTOR (RAISE)
CAP
AUXILIARY RELAY
TIMING RELAY (LOWER)
TIMING RELAY (RAISE)
AN CONNECTOR
INPUT (RAISE)
SUPPLY (FROM MS)
INPUT (LOWER)
OUTPUT (RAISE)
* NOTE
SUPPLY (COMMON)
OUTPUT (COMMON)
OUTPUT (LOWER)
* FOR SEQUENTIAL OPERATION TERMINALS E & F ARE SHORTED.

FIG. 13.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
Printed in U.S.A.