VOLTAGE REGULATORS
AC-DC AUTOMATIC ROTATING CAM TYPES
DESCRIPTION

1. GENERAL

1.01 This section covers the a-c. and d-c. automatic rotating cam type voltage regulators per KS-5016 and KS-5117 used for automatically regulating the voltage of battery charging generators in telephone power plants.

1.02 Each automatic rotating cam type voltage regulator consists of a voltage control coil and plunger operating a balanced contact arm to make and break auxiliary circuits through a motor-driven rotating contact cam, thereby controlling a motor-driven rheostat in a generator field. A tapped controller coil resistance, together with an adjustable controller coil resistance, is provided in series with the voltage control coil to permit the voltage regulation of generators connected to batteries of 49.5, 25 and 23.5 volts approximately, while a compensating rheostat, adjustable from the control panel, is also provided in this circuit to shift the operating voltage range by small amounts to get the exact setting desired. The entire set of apparatus is mounted on a panel enclosed in a metal cabinet.

1.03 The automatic rotating cam type voltage regulators are designed for operation on either a-c. or d-c. power or lighting circuits. The voltage regulation limits are set to meet the requirements of the particular installation.

1.04 The automatic rotating cam type voltage regulator includes a combination of the following major parts.

Voltage Relay Assembly

Motor-Driven Rheostat Assembly

Rheostat Motor Contactors

1.05 The earlier KS-5016 regulator used a horizontal disc with one cam on top and one on the bottom driven at 6 rpm by a series commutator type motor. In the later KS-5117 regulators a vertical disc with 6 cams driven at 1 rpm by a synchronous type motor is employed where a-c. power is available. For the few installations using d-c. power, the KS-5117 regulator retains the series commutator type motor driving a horizontal cam.

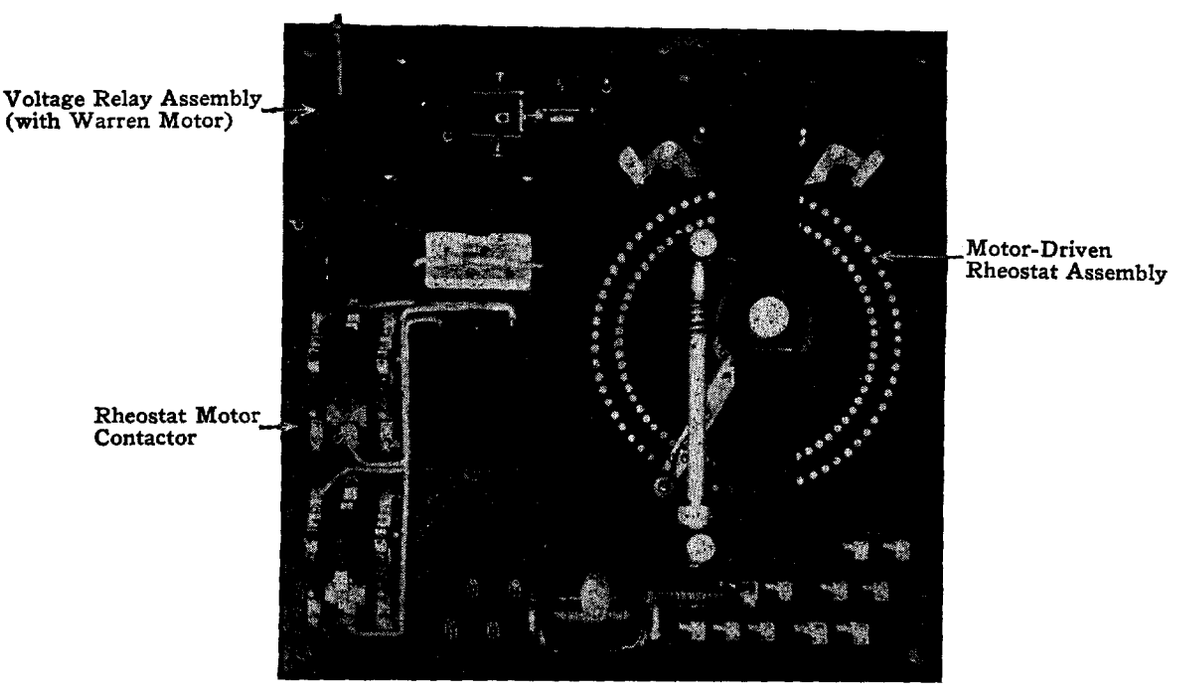


Fig. 1—A-C. Automatic Rotating Cam Type Voltage Regulator
(KS-5117, Front View Shown)

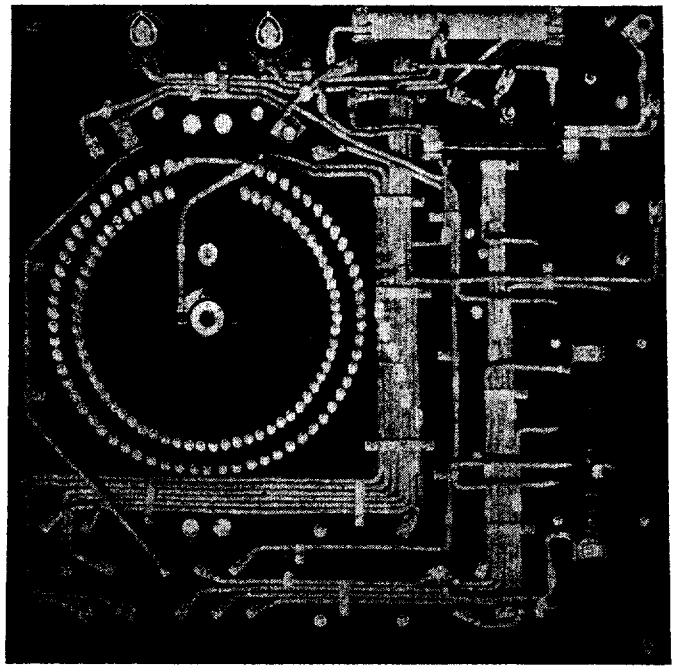


Fig. 2—A-C. Automatic Rotating Cam Type Voltage Regulator
(KS-5117, Rear View Shown)

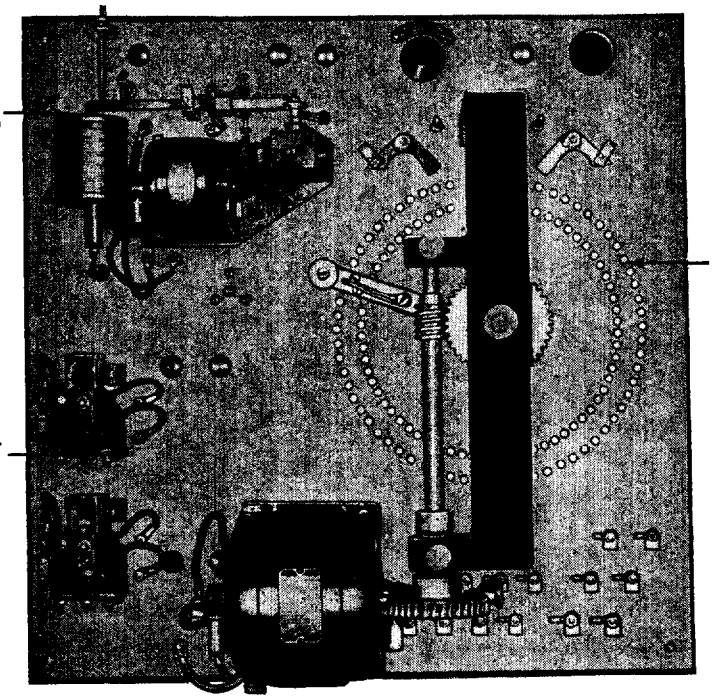


Fig. 3—D-C. Automatic Rotating Cam Type Voltage Regulator
(KS-5117)

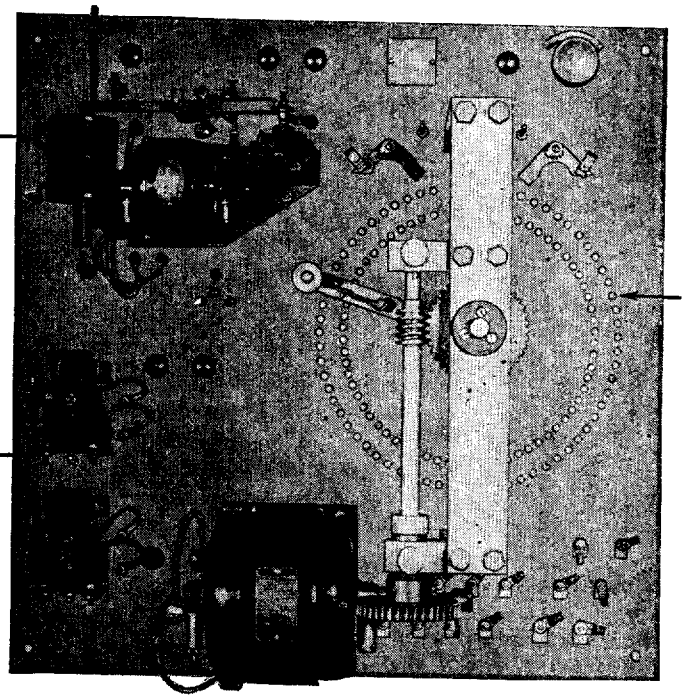


Fig. 4—D-C. Automatic Rotating Cam Type Voltage Regulator
(KS-5016)

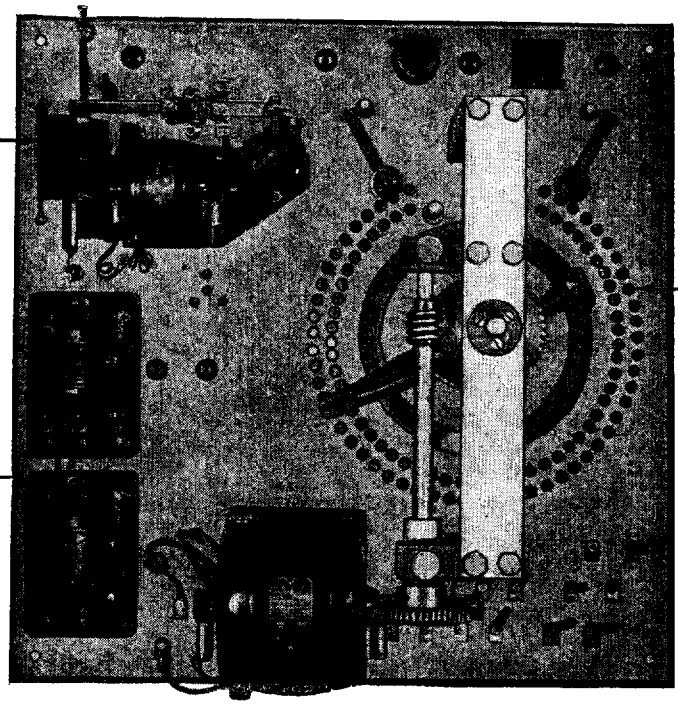


Fig. 5—A-C. Automatic Rotating Cam Type Voltage Regulator
(KS-5016)

2. DESCRIPTION OF APPARATUS

Voltage Relay Assembly

2.01 The voltage relay assembly of the automatic rotating cam type voltage regulator consists of a voltage control coil and plunger, the balanced arm with spring contacts and adjusting spring and the rotating contact cam with its driving motor.

2.02 **Voltage Control Coil:** The voltage control coil (solenoid type) consists of a single winding connected across the points at which the voltage is to be regulated. Within this coil is a movable iron plunger which is attached to one end of the balanced arm. The voltage control coil is mounted vertically on the supporting panel. A guide pin is located in the lower end of the plunger, sliding in a guide pin bushing to keep the plunger centrally located within the coil.

2.03 **Voltage Control Coil Resistances:** In series with the voltage control coil are several resistances used both to compensate for manufacturing variations and to adapt the regulator for use on any one of three voltages.

(a) **Tapped controller coil resistance:** A controller coil resistance of the tapped tubular type adapts the regulator for use with the nominal 48 volt battery (49.5 volt—terminal 2). A tap using part of this resistance is taken off for the 24 volt battery when floating 11 cells. (23.5 volt—terminal 4).

(b) **Adjustable controller coil resistance:** An additional adjustable resistance is in series with this central tap 4 to adapt the regulator either for floating 12 cells or constant voltage charging 11 cells (25 volt—terminal 3). This resistance is provided to enable the factory to exactly and permanently adjust the ratio of the 25 volt tap to the 23.5 volt tap.

(c) **Compensating Rheostat:** In addition to these resistances, which when once set are ordinarily not altered, there is provided in series with the voltage control coil a compensating rheostat to make it possible to shift the voltage regulating point a small amount in either direction to obtain the exact voltage desired. This compensating rheostat is connected next to the coil and affects all of the three taps listed below.

Controller Coil Taps	Nominal Voltage Setting
1-4	23.5
1-3	25.
1-2	49.5

This rheostat also performs an important function in compensating for the voltage drop in the leads from the regulated point to the voltage control coil which requires considerable current. It also compensates for temperature differences in the voltage control coil for winter and summer. A total compensation up to 2.5 volts is provided.

All of these resistances are mounted on the rear of the regulator control panel. The compensating rheostat is adjustable from the front of the panel by a removable tool in earlier models or by a screw driver in later models and is provided with a nameplate indicating the proper direction to raise or lower the voltage at which the regulator functions.

2.04 **Balanced Contact Arm and Spring Contacts:** The balanced contact arm from which the voltage control coil plunger and contact springs are suspended, is made of aluminum and mounted on two hard steel pivot bearings to reduce its inertia and increase its sensitivity. The bearings are made so as to reduce friction to a minimum and are adjustable horizontally. An adjustable spiral or helical spring is attached to the voltage control coil end of the balanced contact arm to support the plunger within the voltage control coil. The movement of the balanced contact arm is limited by an adjustable stop screw arrangement. The flat contact springs are adjusted by means of screws, and are insulated from the arm and from each other. The contacts on the flat springs are made of chemically pure silver, having slightly rounded contact surfaces, and are provided with insulated flexible copper connectors to carry the current. Mounting the contacts on the flat springs eliminates chattering contact with the contact cam.

2.05 **Rotating Contact Cam:** The rotating contact cam is motor-driven through an enclosed reduction gear unit. The rotating contact cam is mounted on the shaft of the associated gear unit, adjustable axially on, and insulated from the shaft. The cam is provided with a means of locking it in position on the shaft. The contacts of the cam are of such size and shape and so spaced that the ratio of the length of the "open" to the "closed" period of the contactor, the operation of which these contacts control, is not less than six to one when the balanced contact arm of the voltage relay is in such a position as to make the lightest contact between the spring contact and cam contact which will close the associated motor contactor positively. The contacts are shaped so that with the balanced contact arm in either of its extreme positions of travel, the spring contact will not catch on the cam contacts so as to cause damage to the contacts or mechanism or to stall the cam drive motor. A flat contact spring bearing on the center of the cam in the case of the a-c. driven regulator and on the hub of the cam in the case of the d-c. driven regulator is used for a connection to the rotating cam.

2.06 **Motors for Driving Rotating Contact Cam:** For driving the rotating contact cams of the regulators, Warren synchronous motors are furnished for a-c. power service and series d-c. motors for d-c. power service. The Warren mo-

tor used is similar in construction to the motor element used in the commercial Telechron electric clocks. The motor is provided with its own enclosed reduction gear and in case of any trouble is replaced as a unit. No adjustments should be made on these motors in the field. The d-c. motors are commercial series wound motors. The motor is provided with bearings of the sleeve type having wick oilers which hang vertically when the motor is mounted on the regulator panel. The commutator has segments of hard-drawn copper of ample wearing depth and has insulation between the segments of selected mica, or micanite. The segments are clamped together by means of "V-shaped" rings fitted into grooves at the ends of the commutator. The motor brushes are rectangular in cross-section, self-lubricating and of such quality as to insure satisfactory operation. The brush holders are of the tubular type. The brushes are held in the holders by threaded cap screws, having moulded insulating caps with knurled edges to permit removing the brushes without the aid of tools. The motor is mounted so that it can readily be replaced without dismounting the regulator panel.

2.07 **Reduction Gear Units for Rotating Contact Cam:** The Warren motor is provided with the necessary gearing enclosed within the motor housing so that the shaft on which the rotating contact cam is mounted runs at the required speed. The motor housing is sealed so that the oil for the gearing and bearings does not escape to the outside of the motor. Where a d-c. motor is used, the reduction gear for the rotating contact cam, except the pinion gear on the motor shaft and the gear associated with it, is totally enclosed in a gear case filled with grease. The shaft of the cam driving motor and the reduction gear shaft are properly aligned so that no binding action of the mechanism occurs. A grease plug is provided on the front of the gear case. The shafts of the reduction gears are provided with a packing arrangement to prevent oil leaking along the shafts where they extend through the cam gear case.

Motor-Driven Rheostat Assembly

2.08 **Rheostat:** The automatic rheostat has 120 or more steps for all regulators except the regulator of the generator having a field current of more than 35 amperes, in which instance not less than 100 steps are used. The contacts are mounted so that there are no short circuits between adjacent steps. The rheostat is constructed so that different resistances can be applied for different charging generators without changing the general construction of the automatic voltage regulator. The contact brushes on the movable arm are self-aligning and designed so that wear will not cause them to jam against the rheostat contact buttons. Flexible copper shunts are provided for good connections between the contact brushes and the rheostat arm.

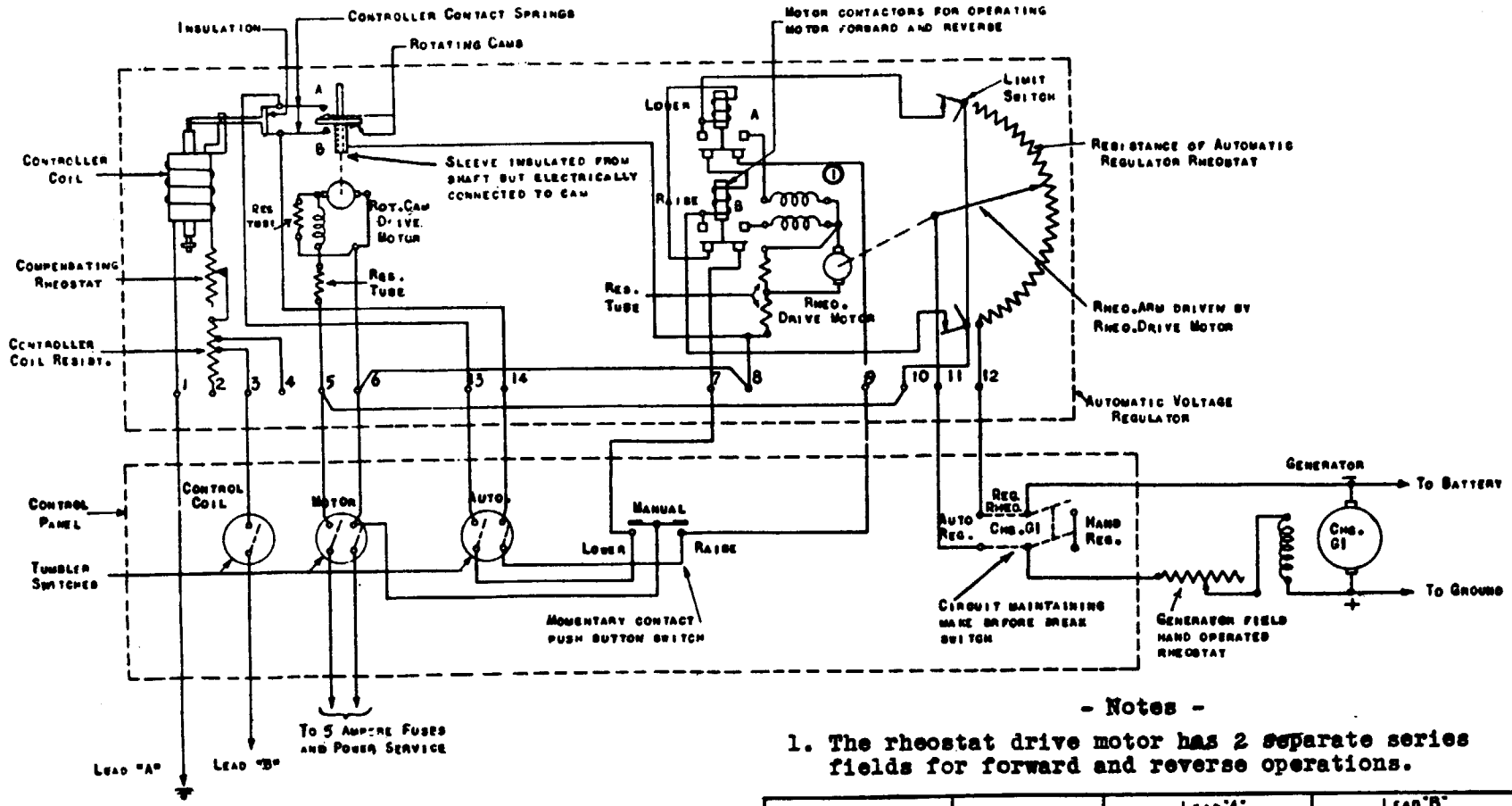
2.09 **Motors for Driving Rheostat:** The a-c. and d-c. motors for driving the rheostat are commercial series-wound motors suitable for operation on the power service of the particular installation. Each motor has two field windings to provide for the rotation of the motor in either direction. The motor is equipped with sleeve bearings capable of taking the thrust of the driving worm in either direction. All bearings have wick oilers hanging vertically when the motor is mounted on the regulator panel. The commutator has segments of hard-drawn copper of ample wearing depth and insulation between the segments of selected mica or micanite. The segments are clamped together by means of "V-shaped" rings, fitted into grooves at the ends of the commutator. The motor brushes are rectangular in cross-section, self-lubricating and of such quality as to insure satisfactory operation. The brush holders are of the tubular type. The brushes are held in the holders by threaded cap screws having moulded insulating caps with knurled edges to permit removing the brushes without the aid of tools. The motor is mounted so that it can readily be replaced without dismounting the regulator panel.

2.10 **Reduction Gear for Rheostat:** An open reduction gear unit is used with the motor-driven rheostat. All of the bearings of the automatic rheostat gearing, except the rheostat shaft bearings, are provided with grease cups for proper lubrication. The back lash in the gearing of the automatic rheostat does not exceed that amount which will allow the contact end of the rheostat arm to be moved ½ inch circumferentially at the outer ring of contacts.

2.11 **Limit Switches:** Limit switches are provided at the two extreme positions of the rheostat. These switches are connected to open the holding coil circuits of the motor contactors and prevent the rheostat arm from traveling past the end contact buttons of the rheostat.

Rheostat Motor Contactors

2.12 The motor contactors are single-pole contactors which in closing connect the associated rheostat motor directly to the power service through the main contacts of the contactor. The coil of the contactor is connected in series with the spring contacts and rotating contact cam of the voltage relay assembly and is energized when the associated spring contact makes contact with the rotating contact cam. The motor contactor has associated auxiliary contacts, open when the motor contactor is closed and closed when the motor contactor is open. The associated auxiliary contacts are connected in series with the coil of the other motor contactor and act as an electrical interlock in the circuit.



- Notes -

1. The rheostat drive motor has 2 separate series fields for forward and reverse operations.

Office	Control of	Lead "A" Connected to Ground Busbar at	Lead "B" Connected to 1-1/3 or 2 Amp. Fuse and
Panel, S x S_1, or Panel or S x S combined with Toll	24 Volt Bat.	48 Volt B.D.F. Panel	24 Volt Bat. Neg. Bus bar at Bat. Panel
Toll or Toll combined with Manual	24 Volt Bat.	Filament Fuse Panel	24 Volt Bat. Neg. Bus bar at Filament Fuse Panel

Fig. 6—Schematic Diagram of Connections

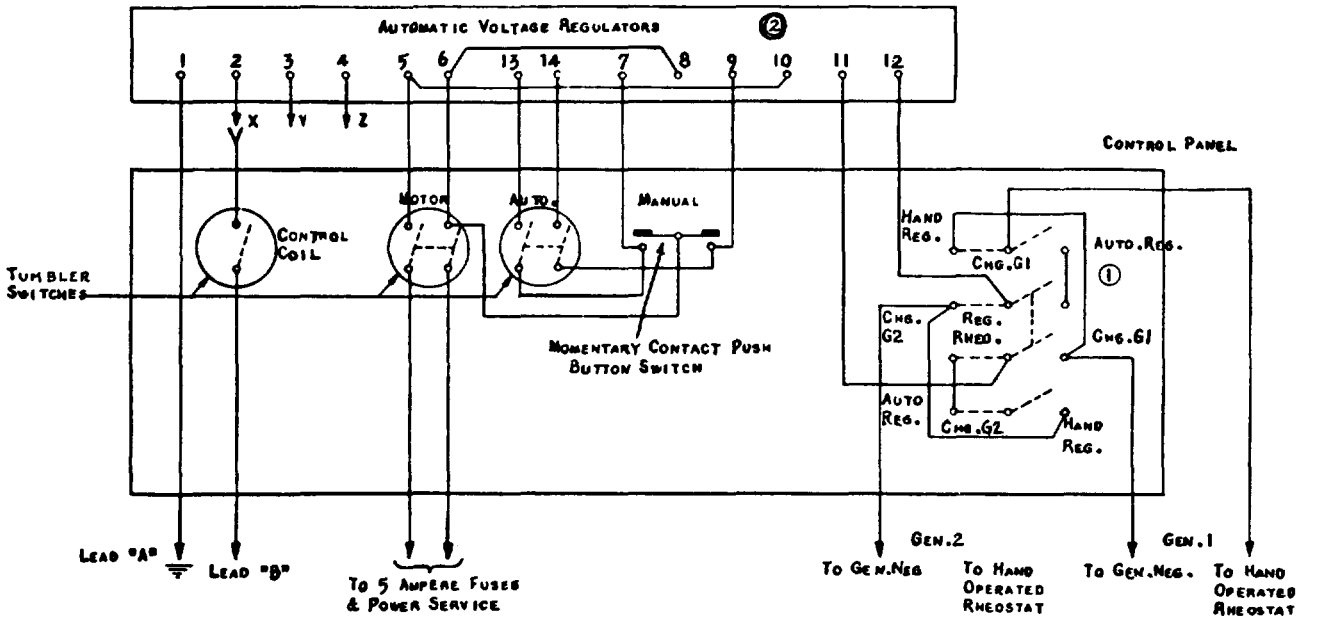
Automatic Voltage Regulator with Control Panel for One 33 Volt Generator
Continuous Floating Routine

Associated Equipment

2.13 On each regulator for operation on a-c. power service, the following equipment is provided for reducing the sparking at the cam and spring contacts. A condenser having a capacity of at least 2 MF in parallel with each rheostat motor contactor coil. The condensers are mounted so as to permit easy replacement. A resistance of 40 ohms and a one-ampere N.E. Code cartridge type fuse in series with the common lead furnish current to the coils of the two rheostat motor contactors.

3. THEORY OF OPERATION

3.01 **Compensation for Low Voltage (Refer to Fig. 6 and Fig. 7):** If the voltage at the regulated points drops outside the setting of the voltage control coil, the control coil plunger will fall causing the lower spring contact to make contact with the rotating cam. When the contact surface of the cam makes contact with the spring contact a circuit is closed from the outside power service through the rotating cam, the lower spring contact, the auxiliary contacts of the Lower contactor, the winding of the Raise contactor and the limit switch, back to the other side of the power service. The Raise contactor is operated while the rotating cam and lower spring contact make contact. The operation of the Raise contactor closes a circuit from the power service leads through the limit switch, the main contacts of the Raise contactor, one of the rheostat drive motor series fields, the motor armature, and back to the other side of the power service. This starts the rheostat drive motor and cuts out resistance in the field circuit until the voltage is raised sufficiently to break the Raise contactor circuit described above, due to the operation of the voltage control coil and spring contact, or to the rotation of the contact cam. If due to the latter case, a further readjustment will be made approximately every ten seconds until the voltage is sufficiently raised. This interval of delay has been introduced to allow time for the voltage of the battery to which the generator is connected to become



Office	Control of	Lead A Connected to Ground Bus Bar at	Lead B Connected to 1-1/3 or 2 Amp. Fuse and
Panel, S x S1, or Panel or S x S combined with Repeaters	24 Volt Bat.	48V B.D.F. Panel	24V Bat. Neg. Busbar at Bat. Panel (Y Wiring)
	48 Volt Bat.	48V B.D.F. Panel	48V Bat. Neg. Busbar at D.F. Panel (X Wiring)
Toll or Toll Combined with Manual	24 Volt Bat.	Filament Fuse Panel	24V Bat. Neg. Busbar at Filament Fuse Panel (Y or Z wiring)

Notes: 1. Double pole "Reg. Rheo." switch mechanically interlocked with 2 single pole circuit maintaining switches.
2. For regulator connections see Fig. 6.

Fig. 7—Schematic Diagram of Connections

Automatic Voltage Regulator with Control Panel for Two 33 or Two 65 Volt Generators Continuous Floating Routine

stable at the new value of charging current. Without the delay, continuous operation of the regulator either up or down, i.e., "hunting," would be likely to occur. In case the rheostat drive motor carries the rheostat arm to the end of its travel in an effort to regulate the voltage, a limit switch will open the circuits of the motor and the Raise contactor, stopping the rheostat drive motor. The operation of the Raise contactor referred to above also opens through its auxiliary contacts the lead from the power service to the winding of the Lower contactor so that both the Raise and Lower field of the rheostat drive motor cannot be energized at the same time.

3.02 **Compensation for High Voltage (Refer to Fig. 6 and Fig. 7):** The operation of the voltage regulator due to high voltage is similar to the above. The raising of the voltage control coil plunger brings the upper spring contact in contact with the rotating cam. When the contact cam makes contact with the upper spring contact, the same circuit from the power line to the rotating cams described above is closed through the upper spring contact, the auxiliary contacts of the Raise contactor, the winding of the Lower contactor and the limit switch, back to the other side of the power service. This operates the Lower contactor which energizes the other field of the rheostat drive motor through the main contacts of this contactor. The rheostat arm is driven in the opposite direction to that described above in order to cut in more field resistance and lower the generator voltage. A limit switch is also provided at this end of the rheostat arm travel which functions similar to the description covered in paragraph 3.01.

3.03 **Table of Resistors:** Behind the panel shown in the previous figures, and enclosed in the steel cabinet, are the resistors attached to the contact buttons on the face plate. These resistors are ordinarily connected in series with the shunt field and the field rheostat of the generator which is to be regulated. The automatic regulator thus acts as an interpolating field rheostat, but has sufficient range and resistance to regulate the output current of the generator from no load to full load or through a substantial part of this range. In order to assist in the operation of these regulators by giving information on expected range and performance, Table 1 is included, listing several of the machines with which this type of regulator is most commonly employed. It is practicable to switch the regulator to control either one of two machines provided their characteristics are similar. When, however, it is desired to control two machines widely differing in output the regulator must generally be selected for the larger machine and will then give only a partial range of regulation for the smaller machine.

TABLE 1

TABLE OF RESISTORS

FOR

CAM TYPE AUTOMATIC VOLTAGE REGULATORS FOR COMMERCIAL AND "M" TYPE GENERATORS

Figures below refer to approximate per cent of current change obtainable—(See Note at end of table)

Resistors			Condition	65-Volt Commercial Type Generators							65-Volt M-Type Generators								
KS-5117 List No.	Ohms	Cap. Amp.		1200 Amp.	750 Amp.	500 Amp.	400 Amp.	300 Amp.	200 Amp.	100 Amp.	M-15	M-10	M-8	M-7	M-6	M-5-1/2	M-5	M-4	M-3
1	24	4	A							100									
			B																
2	10	7	A					100	100							100*	100	100	100
			B							50-60									
3	6.5	9	A													100			
			B					75-90	75-90								75-90	75-90	75-90
4	4.5	10	A				100												
			B					50-70	50-70							80-90	50-70	50-70	50-70
5	3.2	15	A	100	100	100						100*	100*		100*				
			B				60-90	40-50	40-50							60-70			
6	2.5	15	A									100	100		100				
			B	80-90	80-90	80-90	70-80												
7	1.6	20	A								100	100							
			B	65-75	65-75	65-75							80-90		80-90				
8	1.2	20	A																
			B								80-90	80-90	70-80		70-80				

Resistors			Condition	33-Volt Commercial Type Generators							33-Volt M-Type Generators								
KS-5117 List No.	Ohms	Cap. Amp.		1500 Amp.	1000 Amp.	800 Amp.	600 Amp.	400 Amp.	200 Amp	75 Amp.	M-15	M-10	M-8	M-7	M-6	M-5-1/2	M-5	M-4	M-3
2	10	7	A							100*									
			B																
3	6.5	9	A							100									
			B																
4	4.5	10	A																
			B							80-90									
5	3.2	15	A					100	100								100*	100*	100*
			B							60-70									
6	2.5	15	A														100	100	100
			B					80-90	80-90										
7	1.6	20	A	100*	100*	100*	100*									100			
			B					65-75	65-75								70-80	70-80	70-80

TABLE OF RESISTORS (Continued)

CAM TYPE AUTOMATIC VOLTAGE REGULATORS FOR COMMERCIAL AND "M" TYPE GENERATORS

Figures below refer to approximate per cent of current change obtainable—(See Note at end of table)

Resistors			Condition	33-Volt Commercial Type Generators							33-Volt Type Generators								
KS-5117 List No.	Ohms	Cap. Amp.		1500 Amp.	1000 Amp.	800 Amp.	600 Amp.	400 Amp.	200 Amp.	75 Amp.	M-15	M-10	M-8	M-7	M-6	M-5-1/2	M-5	M-4	M-3
8	1.2	20	A	100	100	100	100												
			B					50-60	50-60								50-70	50-70	50-70
9	.55	30	A										100	100	100				
			B	60-70	60-70	60-70	60-70												
10	.45	35	A									100							
			B										100	100	100				
11	.4	45	A								100								
			B									100	90-100	90-100	90-100				

NOTES: Per cent of current change = change in generator current output obtainable with resistor divided by generator current rating while maintaining proper voltage.

Condition A = Regulator gives regulation indicated as well as compensates for maximum lead drop between generator and points to which regulator is connected under busy-hour load for central office and compensates for changes in generator from room to maximum operating temperature.

Condition B = Regulator will give regulation indicated only for constant or operating temperature of generator and compensates only for lead drop during light loads for central office.

*Resistance per step higher than normal and should be used only for emergency operation.