AUTOMATIC ELECTRIC COMPANY'S 25-AMPERE AND 80-AMPERE AUTOMATIC VOLTAGE REGULATOR SWITCHES OPERATIONS

1. GENERAL

1.1 The Automatic Electric Company's automatic voltage regulator switches are used in PBX's to vary the number of counter E.M.F. cells in battery discharge circuits (to maintain the output voltage within a narrow range), and to control the starting and stopping of associated charging equipment (through control relays) for charging the battery.

1.2 Section 2 of this specification describes the automatic voltage regulator switches and will be called ***"Description"***.

1.3 Section 3 of this specification describes the operation of these switches and will be called ***"Operation"***.

1.4 Section 4 of this specification describes the various conditions which may interfere with the proper operation of these switches and will be called ***"General Troubles"***.

1.5 The following figures are attached to and form a part of this specification.

Figure 1 – Automatic Electric Company's automatic voltage regulator switch, 25 amperes.

Figure 2 – Automatic Electric Company's automatic voltage regulator switch, 80 amperes.

2. DESCRIPTION

2.01 ***General:*** The automatic voltage regulator switch consists of a counter E.M.F. cell switch, a series motor and a set of spring assemblies all mounted on a power panel. This switch is furnished in two sizes, viz., 25 ampere and 80 ampere capacities.

2.1 ***Switch Assembly:*** The switch assembly consists essentially of the following parts:

2.11 ***Switch Arm:*** The switch arm (20) is permanently fixed (brazed) to the switch shaft (13) and rotates through an arc of 180°. Two limit spring assemblies (21) and (23) and an associated cam (24) limit the angular travel of the switch arm and will be described later. The switch arm cuts in or out counter E.M.F. cells and completes the control circuit for starting and stopping the charging equipment.

2.12 ***Switch Shaft and Bearing:*** The switch shaft (13) passes through and is supported by the bearing (10) mounted on the power panel. A bearing collar (2) limits the end play to the proper amount. The switch shaft carries a worm wheel (5) driven by a small motor and worm (4). This worm wheel in turn rotates the switch arm (20). The bearing is provided with an oil carrying groove and oil hole for the lubrication of the switch shaft.

2.13 ***Main Contact Brush:*** The main contact brush (19) consists of a flat, soft copper, self-aligning shoe hinged to the switch arm (20) and is provided with a compression thumb screw (17) and small coiled spring which maintains the proper pressure of the brush upon the main and intermediate contacts (18) to insure good electrical contact. The main contact brush is of sufficient width to cover entirely a single contact or to make contact with two consecutive contacts (one main and the intermediate) simultaneously when the switch is in operation.

2.14 ***Auxiliary Contact Brush:*** The auxiliary contact brush (15) is of the flat spring type and is fastened to the switch arm (20) by a brush spring (14) and two bolts which also hold the main contact brush (19). The auxiliary contact brush engages its associated auxiliary

contacts (16) within the lower half of the sloping part of surface of the contact.

2.15 ***Adjustable Control Brush:*** The adjustable contact brush (9) is attached to the end of the switch shaft (13) by a thumb screw (12) and may be adjusted, by rotating it about its axis to predetermine the number of counter E.M.F. cells which may be cut into the circuit before the charging source is cut off. The adjustable contact brush makes contact with its associated contact stud (8) when the switch arm (20) is centered over the main contact (18) associated with the counter E.M.F. cell corresponding to the number opposite the pointer of the adjustable contact brush.

2.2 ***Contacts***

2.21 ***Main and Intermediate Contacts:*** The main and intermediate contacts (18) are of two types; flat, round, copper buttons for the 25 ampere switches; and flat, oval shaped segments for the 80 ampere switches. Both types are provided with studs extending through the panel, each with a nut and locking washer for mounting purposes. An additional mounting screw is fastened from the rear of the panel to secure each main and intermediate contact of the 80 ampere switch in place. The contacts are in alignment circumferentially and radially and equi-spaced over an arc of 180°. The contacts are divided into ten main and nine intermediate contacts so spaced that the main contact brush (19) in passing over them will make contact with one main and the next intermediate contact simultaneously without breaking the battery circuit. The main and associated intermediate contacts are connected by current limiting resistors (6).

2.22 ***Auxiliary Contacts:*** The auxiliary contacts (16) are mounted on the front of the panel in an arrangement similar to the main and intermediate contact mounting, and are aligned radially with the main and intermediate contacts (18). The contact surfaces of the auxiliary contacts are conical so that the auxiliary contact brush (15) engages the auxiliary contacts within the lower half of the contact surfaces. The auxiliary contacts are all strapped together by links at the rear of the panel. These contacts complete the electrical circuit through associated relays for the control of the switch.

2.23 ***Adjustable Contact Stud:*** The adjustable contact stud (8) is a single conical copper contact similar to and mounted in the same manner as the auxiliary contacts (16) on the slate panel.

2.3 ***Motor:*** The motor used to drive the switch arm (20) is of the commercial series wound type, provided with two separate field windings for the operation of the motor in either direction. The motor is mounted on the rear of the panel by four mounting bolts (7) with the motor shaft at right angles to the switch shaft (13). Two wick oilers (1) are provided in the motor end shields to lubricate the motor bearings (3).

A four-lead terminal block is furnished with the motor. One side of the armature is connected to terminal "A". The other side of the armature, together with one side of each field winding, is connected to terminal "S". The other ends of the field windings are connected to terminals "RF" and "LF" respectively. When the terminals "A" and "RF" are connected to the − and + terminals respectively of the DC supply, the switch arm (20) will rotate to the right. When the terminals "A" and "LF" are connected to the − and + terminals respectively of the DC supply the switch arm will rotate to the left.

2.4 ***Worm Drive:*** The worm drive consists of a worm (4) fastened to the motor shaft by a set screw (22) and a fibre worm wheel (5) mounted directly on the switch shaft (13). The worm wheel is secured in place by a set screw in the 25 ampere switch and by a Woodruff key and a set screw in the 80 ampere switch. The worm and worm wheel are mounted so that their center lines are parallel and there is no excessive back lash or binding of the switch arm (20).

2.5 ***Limit Spring Assemblies:*** Two limit spring assemblies (21) and (23) are mounted on the rear of the panel, and arranged so that either assembly may be operated by a cam (24), mounted on the worm wheel collar. Each spring assembly consists of one normally open contact (closed when operated) and one normally closed contact (open when operated). One spring assembly is operated when the switch arm (20) is at its limit of travel in either direction. Stop pins (11) are provided as an extra precaution

for preventing the over-travel of the switch arm should the spring assemblies fail to function properly.

2.6 *Cam:* The spring assemblies (21) and (23) are operated by a cam (24) attached by a set screw to the worm wheel collar. The cam rotates with the worm wheel collar and operates a spring assembly as the switch arm (20) approaches its limit of travel in either direction.

2.7 ***Theory of Operation:*** The automatic voltage regulator switch functions to maintain the battery voltage within the required limits as follows: The motor armature and field circuits are energized from the storage battery through the auxiliary contacts and control relays actuated by a high-low voltage relay. Assuming that the battery has been fully charged and all the counter E.M.F. cells have been cut in; then as the battery discharges, the load voltage falls below the allowable lower voltage limit. The low voltage relay and associated control relays operate, and the switch motor rotates the switch arm (20) to the left cutting out a counter E.M.F. cell (bringing the voltage within the specified range) and momentarily short-circuits the motor armature with the field excited, thus dynamically braking the motor. As the load voltage again drops below the lower limit the switch arm is rotated still farther, cutting out additional counter E.M.F. cells thus maintaining the battery voltage at or above the required lower voltage limit until all the counter E.M.F. cells have been cut out, and the main contact brush (19) makes contact with the first main contact (18). The limit spring assembly (21) will then be operated, (preventing further rotation of the switch arm to the left), starting the charging equipment and placing the battery on charge. As the battery voltage rises and the upper voltage limit is reached, with the counter E.M.F. cells cut out, the high voltage relay and associated control relays operate and reverse the direction of rotation of the switch motor. The switch motor rotates the switch arm to the right cutting in counter E.M.F. cells as required to maintain the voltage within the specified limits. When the number of counter E.M.F. cells corresponding to the number opposite the pointer of the adjustable contact brush (9) have been cut in, the adjustable contact brush makes contact with its associated conical stud, opening the associated control relay circuit, and stopping the switch motor and charging equipment. Should the adjustable contact circuit not function (due to trouble), the switch arm will pass on to the last main contact where cam (22) will operate the limit spring assembly (23). Limit spring assembly (23) in operating, through an associated control circuit, prevents further rotation of the switch arm to the right by momentarily short-circuiting the motor armature with the field excited, thus dynamically braking the motor, and stops the charging equipment. The cycle of operation described is repeated as the battery again discharges.

3. OPERATION

3.1 *General:* The operation of the automatic voltage regulator switch is entirely automatic and should require no attention from the operator other than periodical tests and inspections.

3.2 *Setting:* Loosen the thumb screw and rotate the adjustable contact brush and integral pointer to cut in or out the required number of counter E.M.F. cells for the particular installation as covered by circuit information or job specification. Tighten the thumb screw.

4. GENERAL TROUBLES

4.1 The incorrect functioning of the automatic voltage regulator switch (except for minor mechanical difficulties) will usually be caused by an open circuit, failure of the contacts or relays, failure of the motor or binding of moving parts of the switch.

4.2 A few of the possible troubles, the cause and action to be taken are outlined below.

4.21 *Motor Fails to Start*

CAUSE	ACTION
Limit spring assembly not operated	Adjust cam or springs so that the spring assembly will be operated.

CAUSE	ACTION
Defective motor winding	Repair or replace motor.
Dirty motor commutator	Clean.
Auxiliary contact brush not making contact	Adjust auxiliary contact brush.
Moving parts binding	Clean, adjust or replace.
Loose connections	Tighten.
Limit spring assembly contact trouble	Clean and smooth contacts.

4.22 *Switch Shaft Binding*

CAUSE	ACTION
Dirt or grit in bearing	Clean switch shaft bearing and lubricate with clean oil.
Insufficient end play	Readjust switch shaft bearing collar.
Gear trouble	Adjust or replace gears as necessary.

4.23 *Motor Bearings Binding*

CAUSE	ACTION
Dirt or grit in bearing	Clean out bearing and lubricate with new lubricant.
Bent motor shaft	Replace motor.
Insufficient lubrication	Clean out bearing and provide with sufficient lubricant.

4.24 *Motor Windings Overheated*

CAUSE	ACTION
Switch shaft binding	See paragraph 4.22.
Main contact brush or brushes rough causing excessive friction	Clean and smooth main contact brush and main and intermediate contacts if necessary. Adjust the compression screw to give the required pressure.

4.25 *Switch Arm Does Not Rotate*

CAUSE	ACTION
Main contact brush rough causing excessive friction	Clean, smooth and replace, if necessary, main or intermediate contacts or main contact brush.
Switch shaft binding	See paragraph 4.22.
Gear trouble	Inspect and replace gears if necessary.
Motor fails to start	See paragraph 4.21.

4.26 *Motor Fails to Stop*

CAUSE	ACTION
Spring assemblies not operated	Adjust cam so that spring assemblies will be operated.
Adjustable contact brush does not make contact with adjustable stud	Adjust contact brush so that it makes good electrical contact with its associated contact stud.
Contact trouble	Clean and smooth contacts of limit spring assemblies.

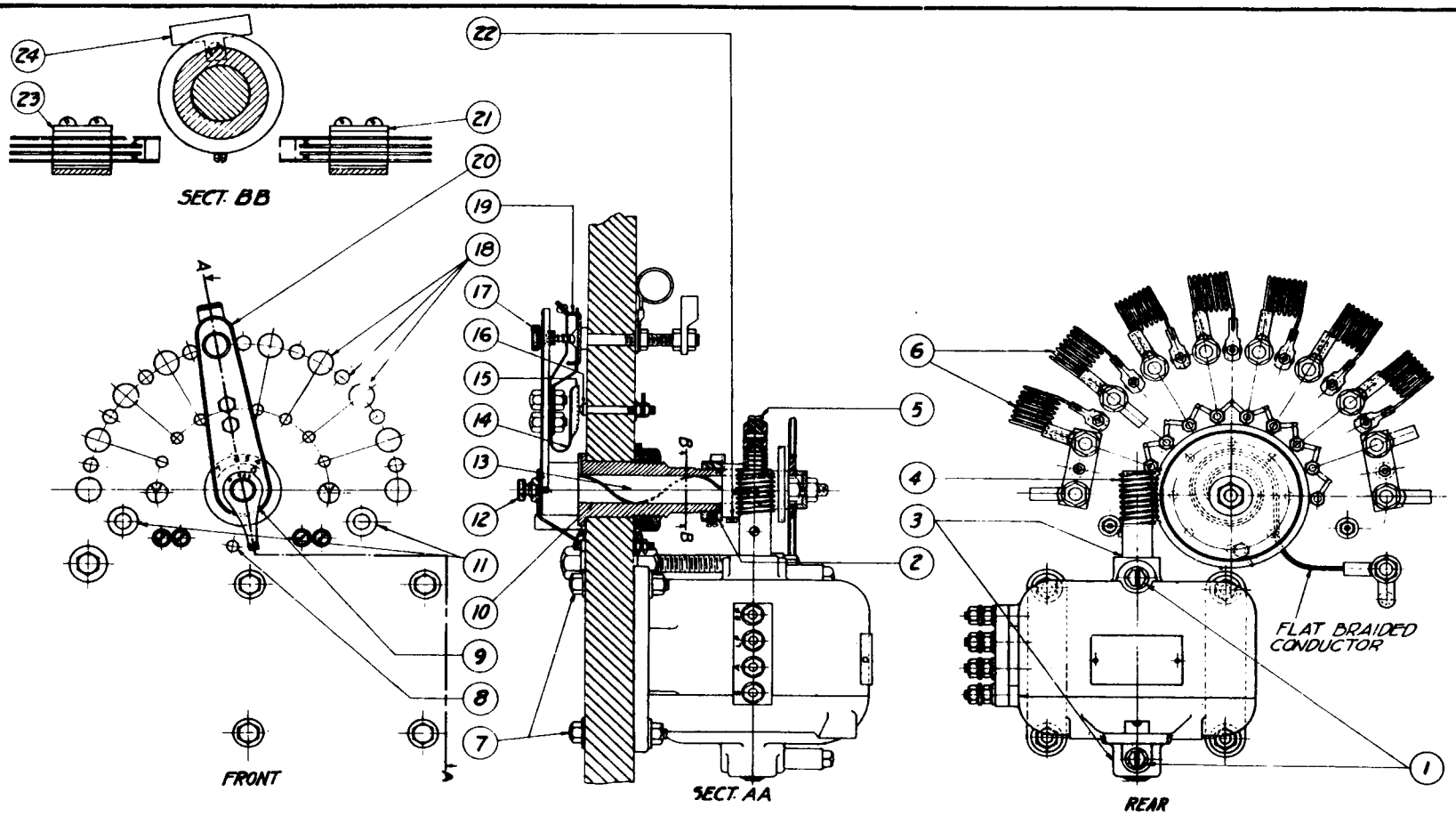

TABLE OF NOMENCLATURE

1	WICK OILERS	6	RESISTORS	11	STOP PINS	16	AUXILIARY CONTACTS	21	LIMIT SPRING ASSEMBLY
2	BEARING COLLAR	7	MOTOR MOUNTING BOLTS	12	THUMB SCREW	17	COMPRESSION THUMB SCREW	22	WORM WHEEL COLLAR SET SCREW
3	MOTOR BEARINGS	8	ADJUSTABLE CONTACT STUD	13	SWITCH SHAFT	18	MAIN & INTERMEDIATE CONTACTS	23	LIMIT SPRING ASSEMBLY
4	WORM	9	ADJUSTABLE CONTACT BRUSH	14	BRUSH SPRING	19	MAIN CONTACT BRUSH	24	CAM
5	WORM WHEEL	10	SWITCH SHAFT BEARING	15	AUXILIARY CONTACT BRUSH	20	SWITCH ARM		

FIG. 1

AUTOMATIC ELECTRIC COMPANY'S
AUTOMATIC VOLTAGE REGULATOR SWITCH- 25 AMPERES

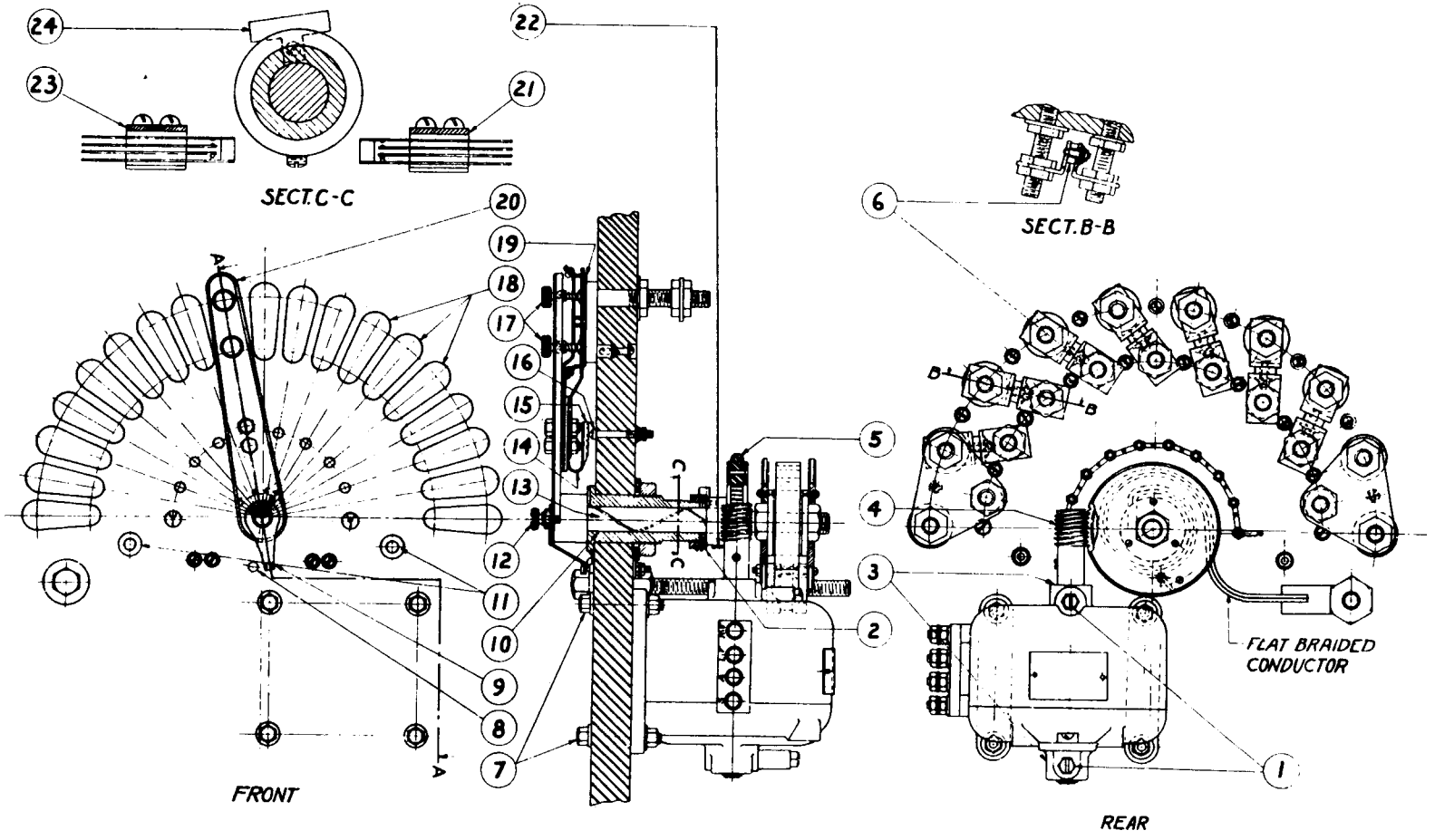

TABLE OF NOMENCLATURE

1. WICK OILERS	6. CARBON RESISTORS	11. STOP PINS	16. AUXILIARY CONTACTS	21. LIMIT SPRING ASSEMBLY
2. BEARING COLLAR	7. MOTOR MOUNTING BOLTS	12. THUMB SCREW	17. COMPRESSION THUMB SCREWS	22. WORM WHEEL COLLAR SET SCREW
3. MOTOR BEARINGS	8. ADJUSTABLE CONTACT STUD	13. SWITCH SHAFT	18. MAIN & INTERMEDIATE CONTACTS	23. LIMIT SPRING ASSEMBLY
4. WORM	9. ADJUSTABLE CONTACT BRUSH	14. BRUSH SPRING	19. MAIN CONTACT BRUSH	24. CAM
5. WORM WHEEL	10. SWITCH SHAFT BEARING	15. AUXILIARY CONTACT BRUSH	20. SWITCH ARM	

FIG. 2

AUTOMATIC ELECTRIC COMPANY'S
AUTOMATIC VOLTAGE REGULATOR SWITCH - 80 AMPERES