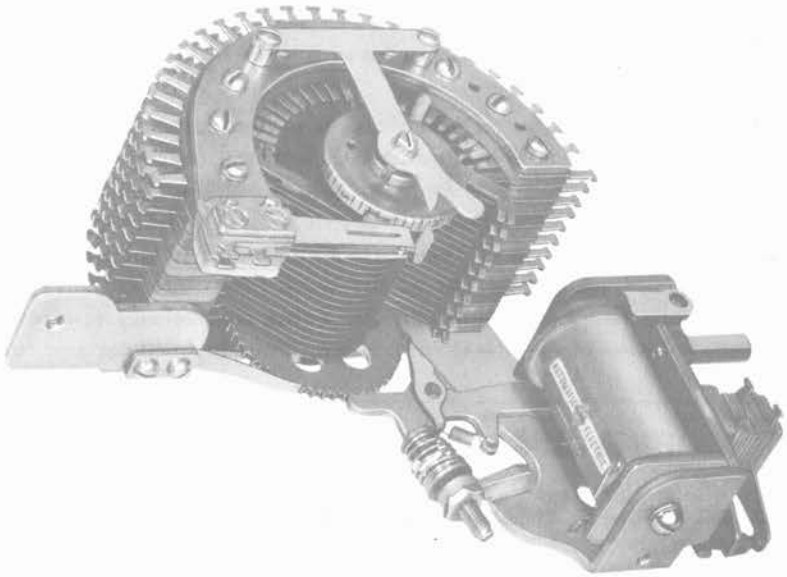
Rotary Stepping Switches 961-473

# ROTARY STEPPING SWITCHES



Technical bulletin 961-473

AUTOMATIC ELECTRIC

GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS


*Factory, development laboratories, and general office at Northlake, Illinois, U.S.A.*

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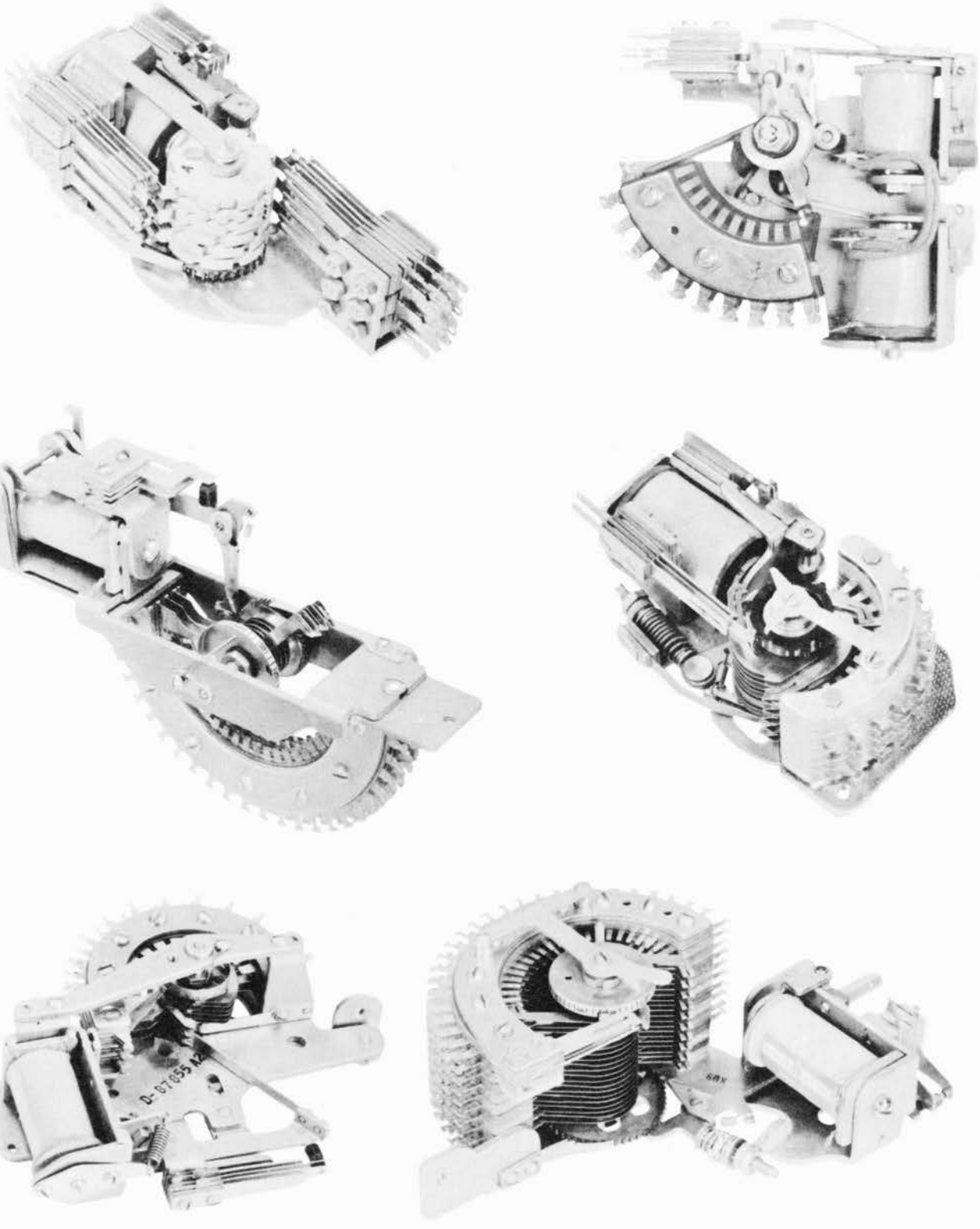


*Rotary stepping switches.*

# ROTARY STEPPING SWITCHES

## 1. GENERAL

Connections in some automatic telephone systems and many industrial control functions are accomplished by small, high-speed rotary stepping switches acting in response to electrical control pulses. These rugged devices require only minor adjustment and maintenance in the field.

### 1.1 Rotary Stepping Switches

Rotary stepping switches (frontispiece) are sturdily constructed selecting mechanisms consisting of the following:

a. A driving mechanism.

b. A number of pairs of wipers fixed to a rotating shaft.

c. Bank levels (equal in number to pairs of wipers), all assembled to a frame. (A bank level is an arc of contacts separated from each other by an insulating material.)

When a pulse is fed to the switch, the driving mechanism rotates the shaft and wipers around the bank contacts – one step per pulse. When the wipers are resting on a bank contact, a circuit is completed through each pair of wipers and the associated bank contact to perform the control function desired.

Though not true rotary stepping switches, type OCS relays are also covered in this bulletin. OCS relays use a rotary switch driving mechanism to rotate a number of cam discs. Armature spring fingers ride the crest of the cams and open and/or close a fixed number of relay spring pile-ups to control secondary circuits as the cams rotate.

### 1.2 Rotary Stepping Switch Classification

Rotary stepping switches are classed either as unidirectional or around-and-return switches. Unidirectional switches step in one direction only. Wipers are so arranged that when all bank contacts have been traversed, the switch is in its reset or "normal" position. Such a switch must be stepped to its normal position after each use. Around-and-return switches step in one direction to the selected contact; and when the selected circuit is no longer needed, the switch is reset by operation of a release magnet which returns the wipers to the normal position along a path which is opposite to the direction in which the switch was stepped.

### 1.3 Use of Rotary Stepping Switches

#### 1.3.1 Telephone system use.

Rotary stepping switches are used in automatic telephone systems in the following ways:

a. As linefinders.

b. As connectors.

c. As allotter switches.

d. For trunk distribution.

e. For ring-code selector.

f. For dialed number registration.

g. For sequence control.

#### 1.3.2 Industrial use.

In industrial signaling and control, rotary stepping switches are used in increasingly greater numbers for applications requiring selection, distribution, totalizing, and counting. Typical applications include:

a. Counting and routing of materials on conveyors.

b. Sequence control of machine tool operations.

c. Remote control of substations.

d. Control of radio transmitters and monitoring of programs.

e. Control of airport lighting and radio beacons.

f. Remote control of aircraft signaling systems.

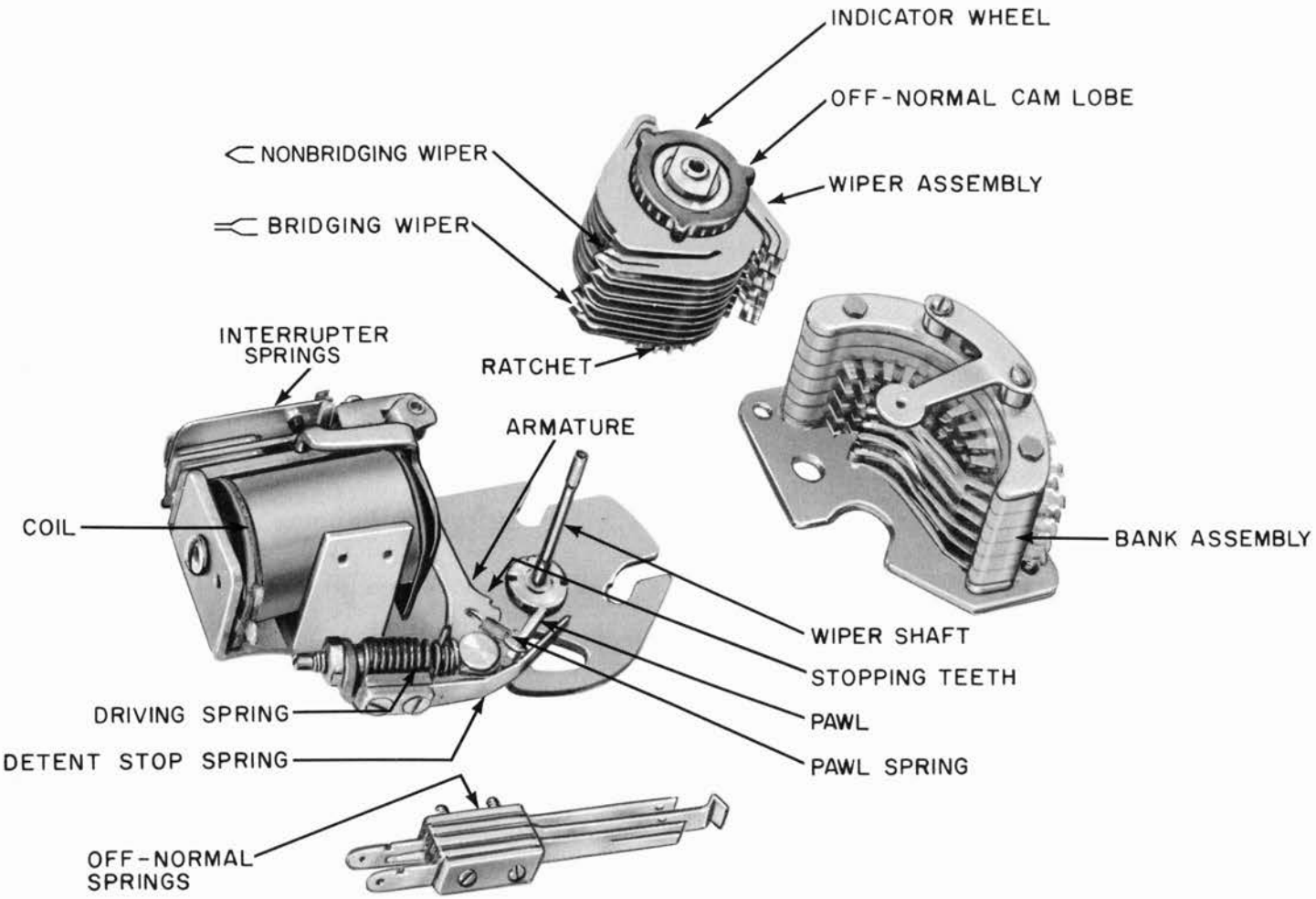



*Figure 1. Typical rotary switch components.*

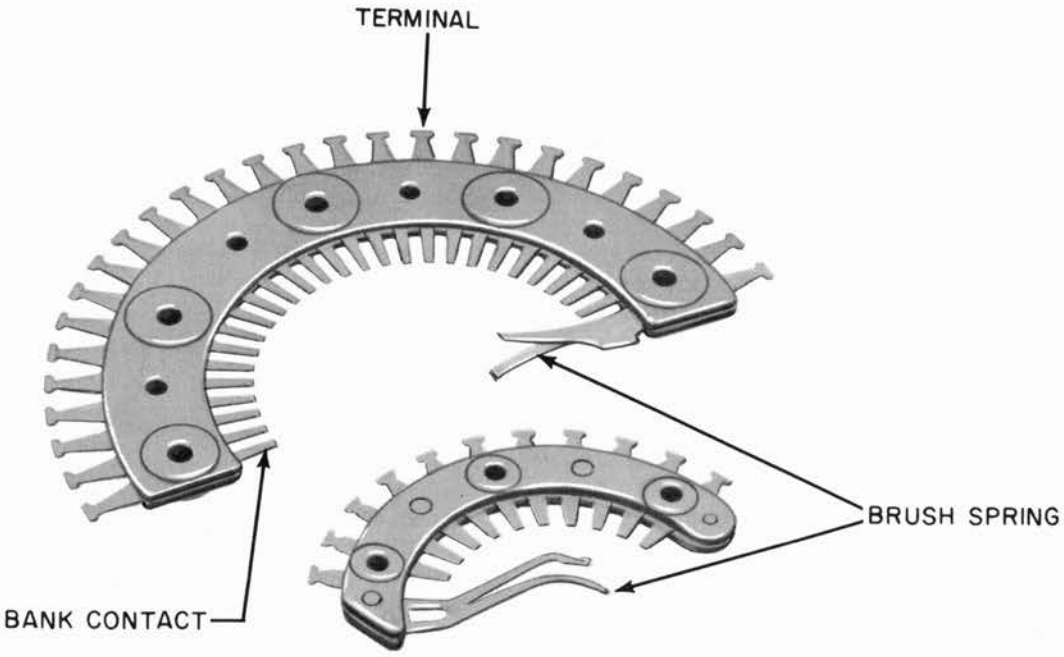



*Figure 2. Typical molded bank levels.*

g. Remote control of motor speeds by varying field resistance.

h. Remote control of current supply equipment for arc welding.

i. Automatic control of tear gas release in burglar protection systems.

## 2. MECHANICAL COMPONENTS AND OPERATION

A rotary stepping switch consists of three main assemblies mounted on a metal frame. These assemblies, illustrated in figure 1, are the bank assembly, the wiper assembly, and the driving mechanism.

### 2.1 The Bank Assembly

#### 2.1.1 Laminated levels.

The bank assembly is built up from the appropriate number of bank levels. A bank level may appear in either of two functionally identical forms. The older, laminated level is assembled of a layer of insulating material, a layer of contacts, and another layer of insulating material. This form will continue to be used on the minor switch, and type 13, 14, and 26 rotary switches. The newer, molded level (figure 2) is produced by inserting the contacts into a mold and, under heat and pressure, forcing plastic molding compound between and around the contacts. This form will appear on the type 40, 44, and 45 rotary stepping switches and on any new type switch which may be introduced.

Each bank level consists of insulating material, contacts, and wiper brush springs.

#### 2.1.2 Molded levels.

The insulating material is either phenolic plastic laminate or polyester sheet, used in the assembled levels, or glass fiber filled Diallyl Phthalate (DAP) plastic molding compound used in the molded levels. Normally, the contacts are made of phosphor bronze, but for special applications where contact resistance is critical, silver-inlaid or gold-plated contacts can be built into a level at the customer's option. Gold-plated contacts may be used in almost any environment; silver-inlaid contacts may be used only in controlled environments because of silver's readiness to oxidize and because of the poor conductivity of silver oxide.

#### 2.1.3 Wiper brush springs.

There are two types of functionally identical wiper brush springs in use. One type is made of a single thickness of contact material with the brush end split, and the other end forming a terminal. The split tips are bent apart and tensioned. The other type of brush spring is made of two thicknesses of contact material. At the brush tip end, the two thicknesses of contact material are bent apart and tensioned; at the other end, the two thicknesses of material are pressed together forming a terminal. When the switch is assembled, these bent tips make electrical contact at all times with the associated wipers of that level.

### 2.2 Wiper Assembly

#### 2.2.1 Components.

The wiper assembly consists of a ratchet and hub assembly, a wiper blade for each bank level, and an indicator and off-normal cam.

The components of the wiper assembly are permanently assembled. Each wiper blade is made up of two phosphor-bronze springs. The ends of the wiper springs are bent into wiper tips which make electrical contact with both sides of a bank terminal. Wipers are designed so that when one pair of tips is in contact with the bank, the other(s) is not in contact.

#### 2.2.2 Wiper tips.

There are two kinds of wiper tips: bridging and nonbridging, both of which are often supplied on the same wiper assembly.

a. Bridging wipers have long flat tips (figure 1) which, during rotation, permit the wiper to engage the next bank contact before breaking away from the previous contact. Bridging wipers are used when the circuit through them must be continuous and unbroken.

b. Nonbridging wiper tips (figure 1), during rotation, leave one bank contact before engaging the next, avoiding electrical interconnection between circuits of adjoining bank contacts.

### 2.3 The Driving Mechanism

There are two types of driving mechanisms: indirect and direct. The indirect-drive mechanism is "cocked" when the motor magnet is energized, and steps when the motor magnet is de-energized. The direct-driving mechanism steps when the magnet is energized. This type of driving mechanism is peculiar to the minor switch.

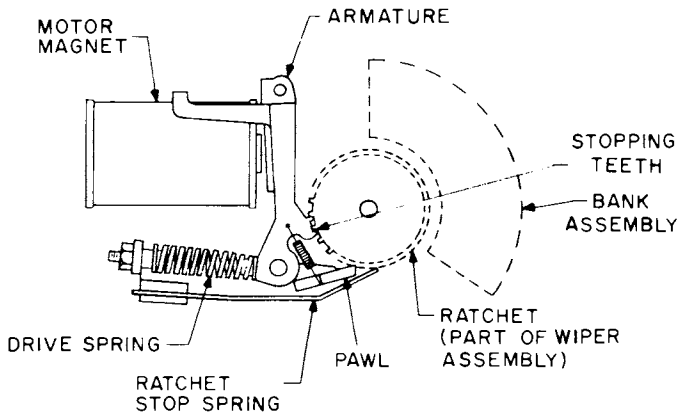



*Figure 3. Indirect-drive mechanism.*

2.3.1 Indirect drive.

The indirect-drive mechanism (see figure 3) consists of a motor magnet and armature, a drive pawl, a drive spring, a detent stop spring, and armature stopping teeth. When the motor magnet is energized, the armature is attracted to the magnet, compressing the drive spring, setting the pawl into the next ratchet tooth, and disengaging the stopping teeth from the ratchet (figure 5). When the motor magnet is de-energized, the drive spring acts on the armature causing the pawl to rotate the ratchet and wipers. When the pawl has completed its travel, the stopping teeth engage the ratchet teeth to prevent overthrow (excessive advance of the wipers).

2.3.2 Direct drive.

The direct-drive mechanism (figure 4) consists of a rotary magnet and armature, a drive pawl, and a rotary armature restoring spring. When the rotary magnet is energized, the armature is attracted to the magnet core. The armature motion pushes the pawl into the ratchet teeth, rotating the ratchet and wipers one step. When the rotary magnet is de-energized, the pawl is returned to its original position by the action of the rotary armature restoring spring. The direct-drive mechanism is released by an associated release mechanism consisting of a release magnet and armature, a ratchet dog, a release-armature restoring spring, and a wiper assembly restoring spring. When the release magnet is energized, the armature is attracted to the magnet and the ratchet dog is removed from the ratchet. The wipers are reset to their normal position by the wiper assembly restoring spring. When the release magnet is de-energized, the ratchet dog is again engaged into the ratchet teeth by action of the release-armature restoring spring.

2.4 Off-normal and Interrupter Springs

2.4.1 Off-normal springs (figure 1).

Off-normal springs are used to control or operate auxiliary circuits and with the interrupter springs can be used to home the switch to its normal position. When the wipers are stepped from their normal or home position,

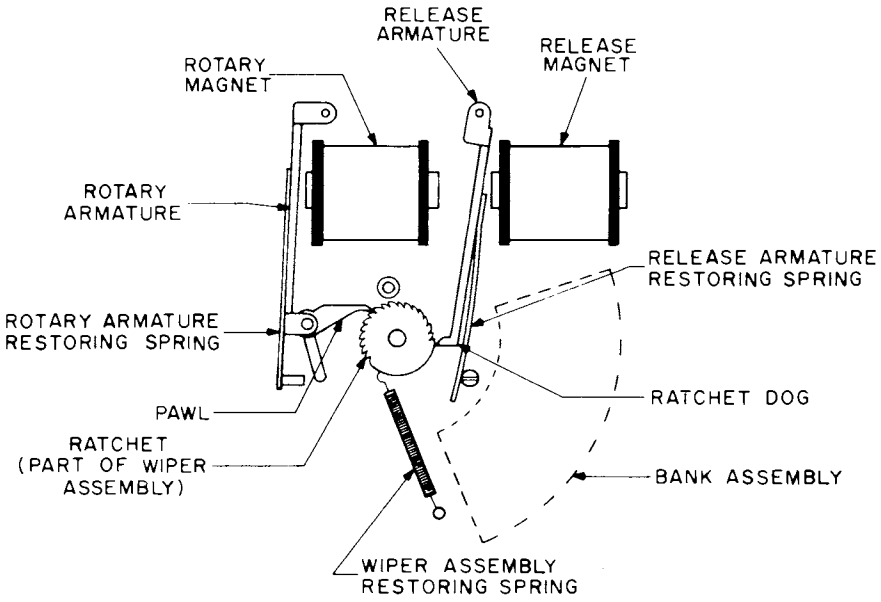



*Figure 4. Direct-drive mechanism.*

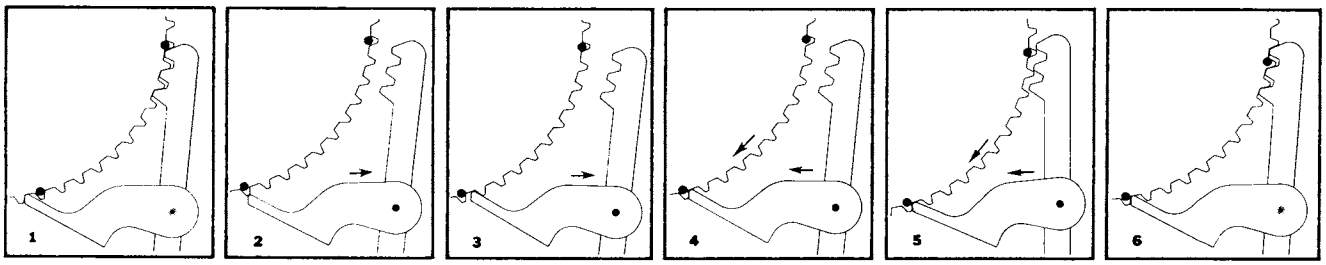



*Figure 5. Pawl and stopping teeth action.*

the off-normal springs operate, and restore when the wipers return to their home position.

2.4.2 Interrupter springs.

Interrupter springs are used to control an auxiliary circuit or to provide a self-interrupting operate circuit for the motor magnet. Interrupter springs are operated when the armature is moved toward the magnet.

## 3. ELECTRICAL CHARACTERISTICS

The electrical operating components of rotary switches are the motor (or rotary) magnet, the interrupter and off-normal springs, the wipers, the brush springs, and (in the case of the minor switch) the release magnet. Their mechanical operation and physical description are discussed in section 2.

### 3.1 Coils

Magnet coils, operating at the voltage for which they were designed, will stand continuous pulsing indefinitely. Coils can be supplied for special conditions such as high humidity, or prolonged, continuous operation. When coils are to be held energized for long periods of time, a limiting resistance should be inserted in series with the coil (see figure 6), after the switch is operated. An extra pair of break (form B) interrupter springs can be used to perform this function.

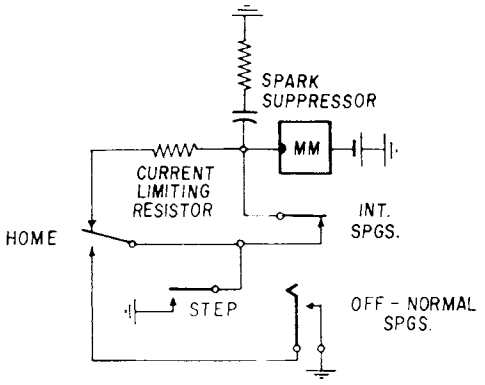



*Figure 6. Limiting holding current of motor magnet.*

### 3.2 Insulation Breakdown

Bank and wiper assemblies on the type 44 and type 45 rotary switches are tested to withstand an a-c insulation breakdown test at 1250 rms. Insulation can be supplied which will withstand breakdown at higher voltages.

### 3.3 Current-carrying Capacity

A wiper, resting on a bank contact, can safely carry 3 amperes, a.c. or d.c. A circuit should be opened before stepping the wiper away from the bank contact. When this cannot be done, limit the load to be broken to 11.5 watts (0.1 ampere at 110 volts) to prolong wiper and bank contact life.

### 3.4 Contact Protection (Spark Suppression)

Contact ratings (section 3.3) are based on the use of adequate spark suppression equipment. If spark suppression is not provided, contact life will be reduced. Usually adequate spark suppression is obtained by connecting a series capacitor and resistor in parallel with the (operating) contacts. The resistor-capacitor values listed in TABLE I are for use with standard coils for the switch type shown.

3.4.1 Noninductive resistors.

For alternating current, a noninductive resistor alone may be effective if slight current loss is allowed. Under certain conditions, a noninductive resistor of high value connected across the load terminals is often effective. For improvement, use this method with those described above.

3.4.2 Silicon carbide varistors.

Silicon carbide varistors (figure 7) are available for use as spark suppressors with type 44 and type 45 rotary switches and with the OCS relay. The resistance of a varistor varies approximately as the square of the applied voltage. When voltage is applied to the magnet-coil circuit, the varistor draws very little current; when the magnet-coil circuit is opened, the varistor offers a low-resistance path to short circuit the high-voltage surge caused by the collapse of the magnetic field.

## TABLE I. COILS AND CONTACT PROTECTION

| Type 13 (25 point), Type 14 (50 point), and Type 26 (11 point) Rotary Switches. | | | | |
|---|---|---|---|---|
| Operate Volts d.c. | Coil Resistance Ohms | Capacitor μf | Noninductive Resistor Ohms | Varistor |
| 6 | 4.4 | 0.5 | 10 | |
| 12 | 9.4 | 0.5 | 10 | |
| 24 | 30 | 1.0 | 125 | |
| 48 | 100 | 1.0 | 200 | |
| 60 | 190 | 1.0 | 200 | |
| 110 | 650 | 0.2 | 200 | |
| Type 40 (10 point), Type 44 (11 point) Rotary Switches, and OCS Relay. | | | | |
| Operate Volts d.c. | Coil Resistance Ohms | Capacitor μf | Noninductive Resistor Ohms | Varistor |
| 6 | 1.9 | 2.0 | 3 | |
| 12 | 7 | 0.5 | 10 | |
| 24 | 30 | 0.4 | 75 | RY-56 |
| 3-level Switch | | | | |
| 48 | 140 | 0.2 | 100 | RY-57 |
| 6-level Switch | | | | |
| 48 | 120 | 0.2 | 150 | RY-57 |
| 60 | 155 | 0.2 | 150 | RY-57 |
| 110 | 650 | 0.03 | 500 | RY-58 |
| Type 45 (26 point) Rotary Switch. | | | | |
| Operate Volts d.c. | Coil Resistance Ohms | Capacitor μf | Noninductive Resistor Ohms | Varistor |
| 6 | 1.75 | 3.0 | 2.5 | |
| 12 | 9.4 | 2.0 | 10 | |
| 24 | 30 | 0.2 | 50 | RY-56 |
| 48 | 100 | 0.2 | 200 | RY-57 |
| 60 | 190 | 0.1 | 200 | RY-57 |
| 110 | 650 | 0.03 | 200 | RY-58 |

NOTE: See TABLE IV for Minor Switch Coil Data.

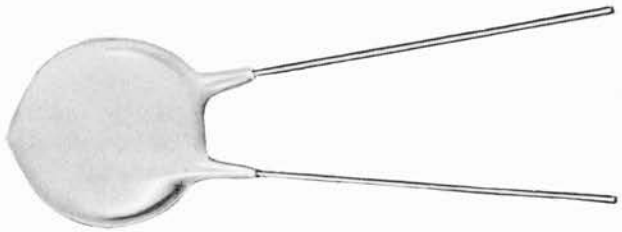


*Figure 7. Silicon carbide varistor.*

3.4.3 Resistor-capacitors.

Switches are normally factory adjusted (speeded) for use with a resistor-capacitor spark suppressor. When a switch is ordered to be furnished with a varistor, the switch will be adjusted for the varistor. If any other method of spark suppression is to be used, the switch will have to be readjusted in the field for proper operation.

3.5 Precious Metal Contacts

The standard phosphor-bronze bank contacts and wipers have sufficient contact wipe and pressure to insure reliability when switching circuits of normal control power levels. They are not suitable for use in circuits where contact resistance is critical. For thermocouple or strain-gage switching or in a circuit where measurements at low power are being made, gold-plated contacts must be used for satisfactory results. Gold plating does not alter the maximum carrying capacity of the switch contacts and may be used under almost any conditions of ambient atmosphere.

Silver-inlaid bank contacts and silver-plated wipers may be used when low-contact resistance and low microphonic noise level are required. These contacts should be used only in controlled atmospheres because of silver's readiness to oxidize (tarnish). Silver inlay does not alter the maximum carrying capacity of the switch contacts.

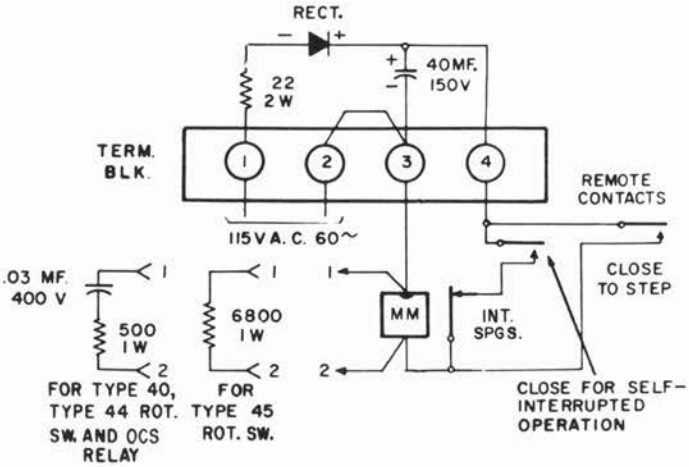



*Figure 8. A-c rectifier – schematic diagram.*

3.6 A-c Operation

The type 40, type 44, and type 45 rotary switches and the OCS relay may be used with 115 volt, 60 cycle alternating current by using a suitable rectifier unit (figure 8). Control switching must be done on the d-c side of the rectifier only.

3.7 Rotary Stepping Switch Pulse Range

Current pulses, from a pulsing relay to a switch motor magnet, may be established by the operation of a standard telephone dial. These interruptions in the circuit of the pulsing relay, at the impulse springs of the dial, consist of a closed circuit period and an open circuit period referred to as "percent make" and "percent break" respectively. The length of the closed circuit period or the open circuit period is a percent of the length of the

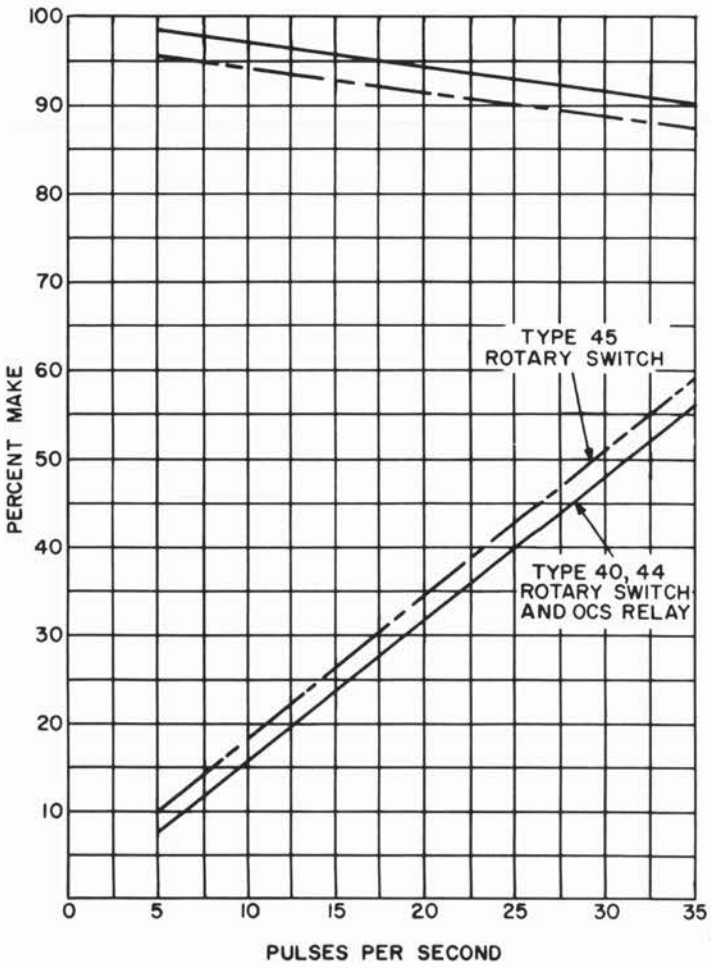



*Figure 9. Operating range – type 40 and type 44 rotary switch and OCS relay.*

entire pulse period. A comparison of speed-pulse ratio curves between four-level, type 44 and type 45 rotary switches at 48 volts is shown in figure 9.

These curves show that the percent make of the entire pulse period required for switch magnet operation increases as pulsing speeds increase. That is, the percent make required for switch magnet operation becomes larger; until at 35 pulses-per-second, the maximum pulse limit for the switch has been reached.

The curve, located in the upper portion of the graph, indicates the greatest length of pulse (at various speeds) that will allow sufficient time for the magnet to properly restore. The complement of any value on this upper curve is the shortest percent break required for satisfactory switch magnet release.

The upper and lower curves, therefore, define the limiting conditions between which a pulse to the switch magnet may vary. At 10 pulses-per-second, the lower curve shows that the shortest pulse that will operate the switch magnet is approximately 18 percent make for the type 45 switch (.018 seconds, operate time); and the longest pulse that will give satisfactory operation is 95 percent make (.095 seconds) or 5 percent break (.005 seconds, release time). In this case, the percent-make values and time values in milliseconds are the same, because there are 100 milliseconds for each impulse (10 pulses-per-second).

At 15 pulses-per-second, the total time for an impulse period is .067 seconds; and referring to the lower curve, this equals 26.5 percent make required for operation which, by proportion, gives .018 seconds minimum operate time.

Switch magnet operate time (in seconds) changes but little with changes in impulse speed for a given voltage. Longer operate times, that is a longer pulse (higher percent make), are necessary for low voltages because of the slower rate at which the current builds up in the switch-magnet coil.

Figure 10 shows pulse-ratio curves which define the limiting conditions for the type 13 (25 point) and type 26 (11 point) rotary stepping switches. Figure 11 contains the pulse-ratio curves for the minor switch.

## 4. ELECTRICAL STEPPING CONTROL AND OPERATION

The operation of rotary stepping switches may be either manually controlled, or controlled by an automatic self-interrupted circuit.

For automatic operation, the interrupter springs are connected into the operating circuit and the switch acts as a non-numerical or self-cycling device. It will automatically search its bank contacts for a special circuit condition such as the presence-of-ground or battery, the absence-of-ground, etc.

For manually controlled operation, pulses may be transmitted to the switch magnet coil from a dial, push button, or other remote control device.

Two typical circuit arrangements for the operation and remote control of equipment are shown in figures 12 and 13.

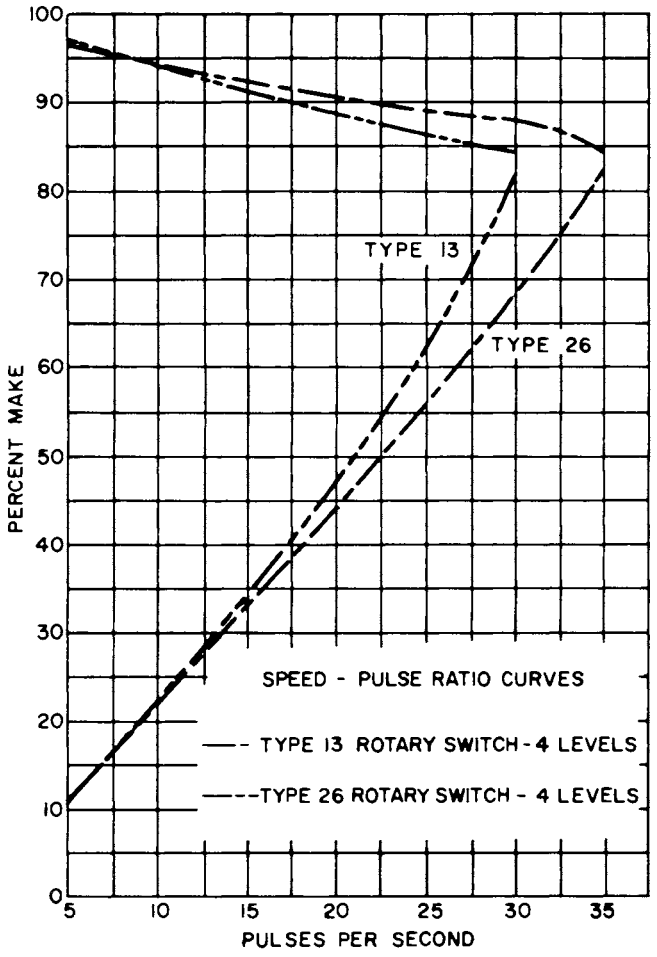



*Figure 10. Operating range – type 13 and type 26 rotary switch.*

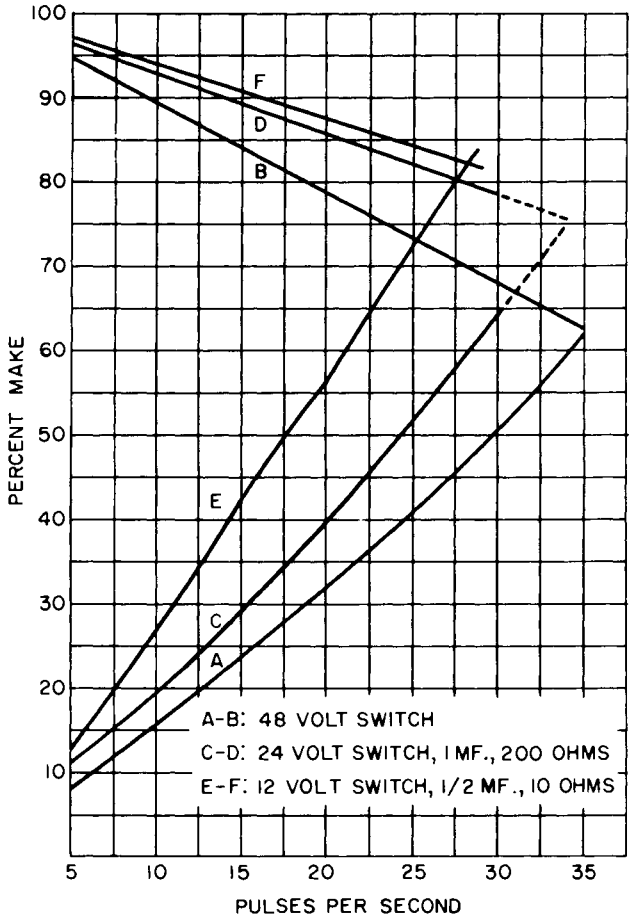



*Figure 11. Operating range – minor switch.*

4.1 Typical Control Circuit – Minor Switch (Figure 12)

4.1.1 Stepping the switch.

Operation of a nonlocking DIAL key closes the circuit for relay A. (The DIAL key must be held operated.) The operation of relay A closes ground from the back contacts of relay B through make springs of relay A, and the normally closed off-normal springs of the minor switch to battery through the relay C coil. Relay C operates to prepare a pulsing path to the rotary (ROT.) magnet.

The desired digit is dialed. The first opening of the dial springs, as the dial restores, causes relay A to release and close ground from the back contacts of relays B and A through the make springs of relay C to the secondary winding of relay C. Ground is also closed to the ROT. magnet of the minor switch. The energization of the ROT. magnet steps the wiper assembly to the first set of bank contacts. The forward movement of the wiper assembly opens one pair and closes the other pair of off-normal springs. Opening the normally closed pair of off-normal springs opens the operating circuit for relay C. However, relay C is held operated through its make springs in parallel with the ROT. magnet.

The closing of the dial impulse springs, at the end of the first pulse, will reoperate relay A to remove ground from the holding winding for relay C and the rotary magnet. The rotary magnet is de-energized and therefore releases, but the slow-releasing characteristics of relay C cause it to remain momentarily in the operated position.

The second opening of the dial impulse springs, for the second pulse, again releases relay A to close ground to the holding circuit for relay C and to the rotary magnet. Relay C remains operated during the interval between successive dial pulses, and the rotary magnet is reenergized to step the wipers ahead one step.

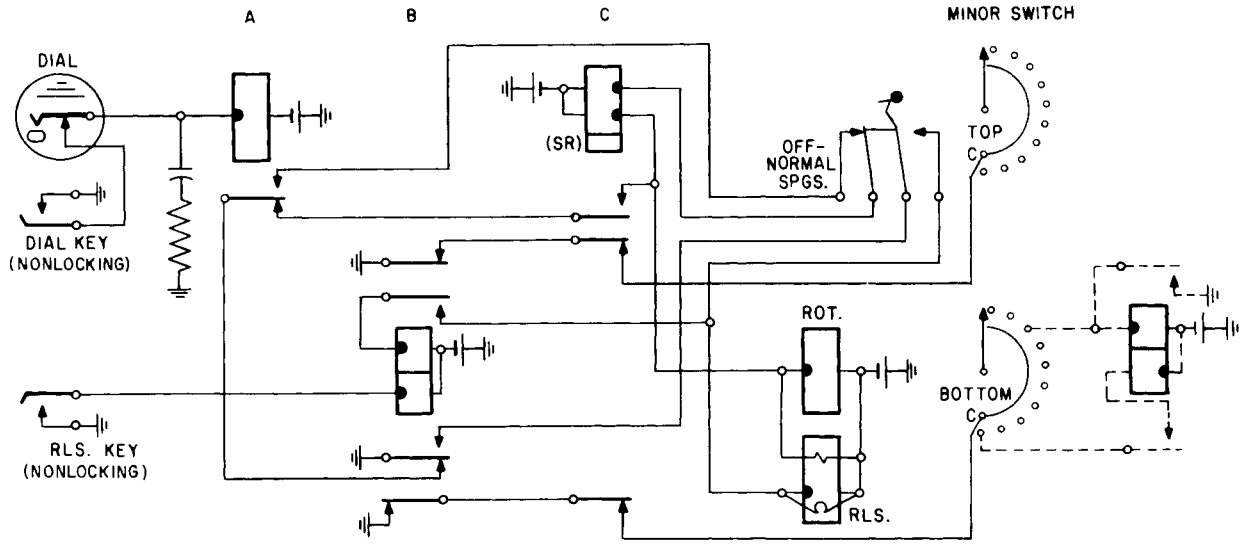



*Figure 12. Typical remote control circuit – minor switch.*

NOTE: The control methods used for rotary stepping switches in general are not applicable to the minor switch.

The dial comes to rest at the completion of the series of pulses corresponding to the digit dialed. Relay A reoperates but relay C, after the expiration of its slow-release interval, releases. Release of the DIAL key restores relay A.

4.1.2 External control circuit selection.

A control relay has been connected to the third contact of the bottom level of bank contacts (see figure 12). When relay C releases, at the end of the three pulses for digit three, the wipers are resting on the third set of bank contacts. Ground, through the back contacts of relay B, relay C, and the common bank contact C, is closed to the control relay via the wiper. The control relay operates and locks to an external ground at its own contacts. Operation of the control relay in turn performs the required control function.

In a similar manner, a control relay may be connected to each bank contact. By dialing different digits, various relays are energized to perform separate control operations.

4.1.3 Circuit release.

Momentary operation of the RLS key (see figure 12) closes ground to relay B. The operation of relay B closes ground to the RLS magnet of the minor switch via the make contacts of relay B and the make pair of off-normal springs. This causes the operation of the RLS magnet which restores the wipers to normal. The operation of relay B also removes ground from the lower or BOTTOM bank preventing false operation of any control relays while the wipers are restoring. The off-normal springs reoperate opening the release magnet and the relay B locking circuits.

4.1.4 External control circuit release.

Digit "0" is dialed to discontinue the external control function (see figure 12). This time the wipers will stop on the 10th bank contact, which is wired to the secondary winding of the control relay. Relay C, upon restoring, grounds this lead setting up a magnetic field which opposes that in the primary winding of the control relay. The control relay restores. When the RLS key is operated, the circuit is restored to normal.

4.1.5 Safety feature.

The nonlocking DIAL key or push button makes it impossible to operate this circuit except when manually holding the key in its operated position. The key automatically restores when the operator removes his hand. This arrangement prevents false operation of equipment by an accidental or unauthorized manipulation of the dial. The DIAL key may be concealed to further reduce the possibility of false operation.

4.2 Typical Control Circuit – Rotary Stepping Switch (Figure 13)

4.2.1 Stepping the switch.

Operation of the DIAL key operates relay A which, in turn, closes ground to operate relay B. The desired digit is dialed. Relay A releases on the first opening of the dial springs, as the dial is restoring. With relay A normal, ground is closed via make contacts of relay B to slow-releasing relay C and the motor magnet MM. Both relay C and the motor magnet operate.

At the end of the first pulse, the dial springs close and relay A reoperates. Ground is removed from the motor magnet MM and relay C and is returned to the winding of relay B. The slow-release characteristics of relays B and C cause them to remain operated during the restoration of the dial. Relay B will remain

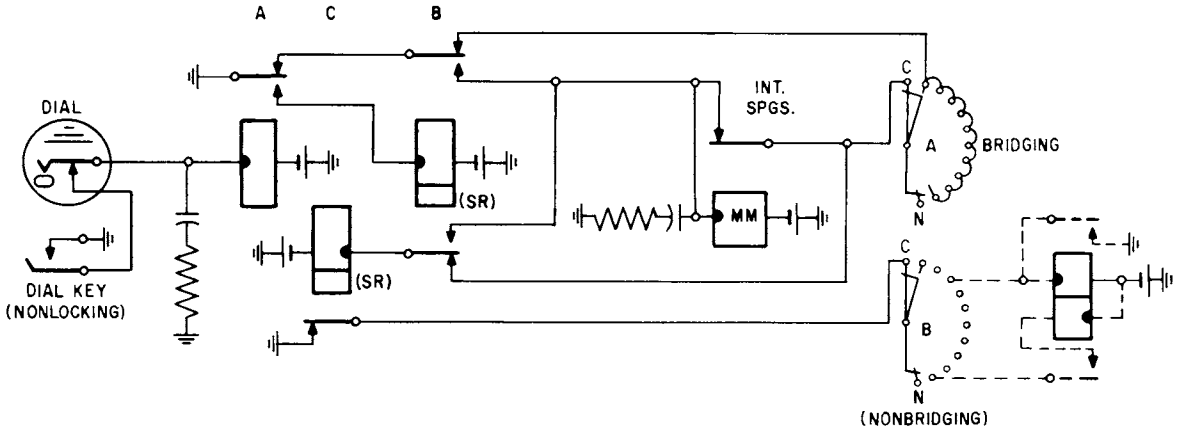



*Figure 13. Typical remote control circuit – rotary stepping switch.*

operated while relay A is normal; and relay C will remain operated while relay A is operated. The motor magnet MM, however, de-energizes with each reoperation of relay A and steps the wiper assembly one step until the dial has restored.

4.2.2 External control circuit selection.

The dial restores after a series of pulses, and relays A and B remain operated. Relay C, at the expiration of its slow-release interval, restores closing ground via the wiper brush contact to the particular control relay connected to the bank terminal on which the wipers rest. This control relay operates and locks to an external ground through its make contacts.

4.2.3 Circuit release.

The restoration of the DIAL key releases relay A which releases relay B, and ground is closed via the normally closed contacts of relays A and B, strapped level A bank contacts over two paths: via the now closed contacts of relay B to operate relay C, and via the interrupter springs to operate motor magnet MM. Energizing motor magnet MM operates the armature of the switch which opens the interrupter springs and de-energizes motor magnet MM, etc. This alternate operating and releasing of the switch under control of its interrupter springs, steps the wiper assembly to the home or normal-bank terminal. At this point, the strapping of the level A bank terminals is discontinued, and the operating circuit for the motor magnet MM is opened. The switch remains on the home bank contacts.

Relay C is held operated by the ground supplied through the strapped bank contacts and associated wiper until the switch has reached its home position. Relay C then releases. Relay C, when operated, removes ground from the wiper of level B (nonbridging) to prevent false operation of other control relays as the wipers sweep over bank contacts. The operated control relay is held operated by an external ground through its make contacts.

Bridging wipers maintain the operating ground for motor magnet MM and relay C, between bank contacts, while the switch is being stepped to normal.

4.2.4 External control circuit release.

The digit "0" is dialed to release the external control circuit. This is similar to the arrangement described in the preceding section 4.1.4.

4.3 OCS Relay Remote Control

The basic methods for controlling rotary stepping switches, by remote pulses and automatically by self-interruption, also apply to the OCS relay. In the relay, a cam replaces the wiper assembly and spring assemblies replace the bank contacts. Pulsing the rotary magnet rotates the cams, which are divided into cut and uncut portions, thus closing and opening spring assemblies to control external circuits.

As a remote controlled switch, the relay circuit arrangement usually includes secondary controls for homing, step absorption, or both. Step absorption is necessary to reduce the 36-step cycle to the number required.

4.3.1 Remote control with homing.

Figure 14 shows the basic operate and homing controls. Cam No. 1 is usually used for homing control and has a one-step cut. Its springs, referred to as off-normal springs, open in the home position.

Pulses, via the operate lead, step the cam assembly. Cam No. 1 closes its springs, after the first step, and prepares the homing control to the motor magnet. Other cams pulse their springs according to the divisions of cut and uncut portions. When the homing switch is closed, the motor magnet will step the cams self-interruptedly to the home position. Cam No. 1 opens the off-normal springs. The one homing notch in cam No. 1 assumes that the OCS relay makes the 36-step revolution for each useful work cycle of the controlled device. If the controlled device does its task in 18 or less steps, the OCS relay cam can be cut to control two or more work cycles for each revolution. In this case, separate homing notches (if required) can be provided for each work cycle.

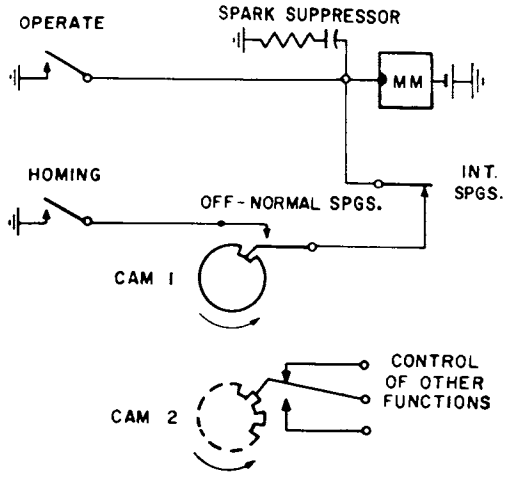



***Figure 14. Remote control and homing circuit – OCS relay.***

4.3.2 Remote control with step absorption and homing.

Step absorption reduces the 36-step cycle of the standard relay to any number required for one work cycle. Its operation is similar to that of homing control except that the cams recycle each time through a definite predetermined number of steps. Cam No. 1, depending upon the number of steps to be absorbed, may have more than a one-step cut. For recycling, in general, a homing control is usually used with the step-absorption circuit. Figure 15 illustrates a typical circuit arrangement. Assuming a work cycle of 33 steps, cam No. 1 is cut for three steps. The remaining cams are designed, as required, to operate their cam springs for only 33 steps.

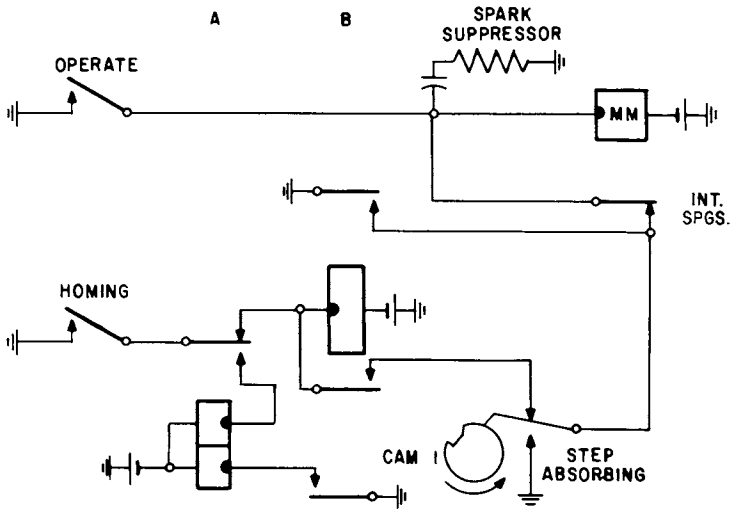



*Figure 15. Typical control circuit with both homing and step absorption.*

The homing control has been prepared by cam No. 1 for 33 steps. At step 33, operate pulsing ceases and cam No. 1 drops to close the step-absorbing ground to the motor magnet. The cam assembly is automatically stepped three times and three steps are absorbed. Having reached the home position, cam No. 1 raises and removes the step-absorbing ground from the motor magnet; and the relay comes to rest at its normal position.

Closing the homing switch operates relay B. Relay B locks to ground at its contacts, operates relay A, and causes the motor magnet MM to step self-interruptedly. Relay A locks to ground at the homing switch. The motor magnet MM steps the cams to position 33 where relay B releases. However, cam No. 1 continues to operate motor magnet MM for three more steps. In position 36, cam No. 1 opens the motor magnet circuit. When the homing switch is opened, relay A releases.

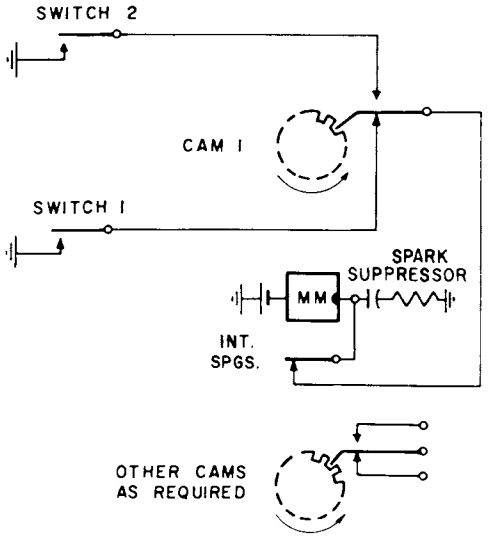



*Figure 16. OCS relay replacing two coil latch relays.*

4.3.3 Remote control with replacement for a two-coil latch relay.

The OCS relay is sometimes used to replace a two-coil latch relay operated over two separate leads. The control circuit shown in figure 16 illustrates this arrangement.

All cams are notched on every other step. The operation of switch 1 closes a circuit through the springs of cam No. 1 and the interrupter springs to the motor magnet MM. The relay takes one step, self-interruptedly, and changes the position of all cam springs. The circuit is now prepared for switch 2. Further closures of switch 1 will have no effect on the relay until switch 2 has been operated to restore the relay to normal.

4.4 Automatic Hunting – Selecting a Circuit

4.4.1 Absence-of-ground searching (figure 17).

The arrangement shown in figure 17 searches for an absence-of-ground. A start ground from a control relay's contacts or from a key (via the normal contact, the wipers, and the rotary switch interrupter springs) energizes the motor magnet MM. The motor magnet armature opens the interrupter springs, which in turn open the motor magnet operate circuit. Motor magnet MM restores, closes the interrupter springs, and the wipers are stepped to the first bank contact (via the wiper) and the interrupter springs again energize motor magnet MM. The energized motor magnet MM opens its interrupter springs which cause motor magnet MM to restore and to step the wipers to the second bank contacts. This process is repeated at every bank contact marked by ground. When

the wipers are stepped to a bank contact marked by absence-of-ground, the operate circuit for motor magnet MM is incomplete and further stepping is prevented.

4.4.2 Ground searching (figure 18).

The arrangement shown in figure 18 searches for the presence-of-ground. A start ground from a control relay's contacts or from a start key (via the break contacts of a stopping relay and the rotary switch's interrupter springs) energizes motor magnet MM. The motor magnet armature opens the interrupter springs which in turn open the motor magnet operate circuit. Motor magnet MM restores, closes the interrupter springs, and the wipers are stepped to the first bank contact. The first

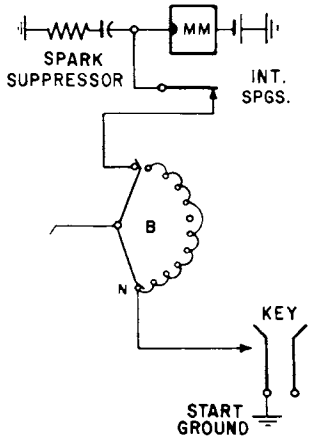



*Figure 17. Self-interrupted searching for absence-of-ground.*

bank contact is marked by an absence-of-ground and the start ground again energizes motor magnet MM. The energized motor magnet MM opens its interrupter springs which in turn cause the motor magnet MM to restore and step its wipers to the next bank contact. This process is repeated at every bank contact marked by absence-of-ground. When the wipers are stepped to a bank contact marked by a presence-of-ground, the circuit from the bank contact is completed to the stopping relay which operates. Operated, the stopping relay opens the operate path to motor magnet MM and prevents further stepping. The stopping relay should be fast operating to open motor magnet MM circuit before it energizes completely.

4.5 Control of Consecutive Operation of Separate Circuits (Figure 19)

The circuit, consisting of two slow-to-operate relays (A and B) and a rotary stepping switch, will supply pulses of a constant time duration (length) at regularly spaced time intervals

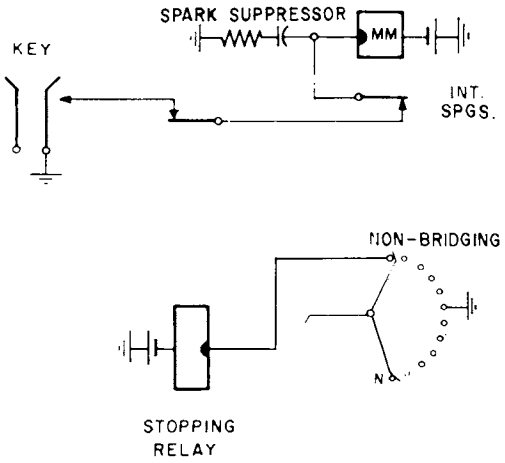



*Figure 18. Self-interrupted searching for presence-of-ground.*

under the control of a single start input. When the start circuit is closed, relay A operates after its slow-to-operate delay interval; and via its make contacts, closes a circuit to operate relay B. After its slow-to-operate time interval, relay B operates, releases relay A, and via its make contacts, energizes motor magnet MM. Released, relay A releases relay B, which in turn de-energizes motor magnet MM. When motor magnet MM restores, the wipers are stepped to the next bank contact. This cycle is repeated and each bank contact is grounded successively as long as the external start circuit is closed.

This circuit permits the use of rotary switch bank contacts and wipers for many other purposes. In this case, a series of ground pulses is sent out through the successive contacting of the rotary switch bank by an associated ground-connected wiper. The slow-to-release

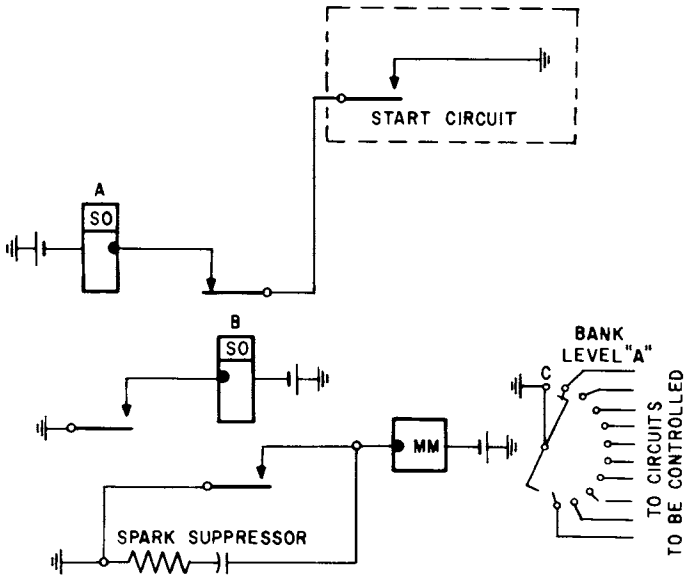



*Figure 19. Pulse sending.*

and slow-to-operate characteristics of relays A and B provide a time interval between successive steps of the switch, and consequently, between pulses from the bank contacts. This time interval is equal to the sum of the operate and release times of the two relays.

### 4.6 Timed Pulses (Figure 20)

The circuit shown in figure 20 is used to generate pulses similar to those produced in the arrangement of figure 19. However, a definite number of pulses, or some multiple of that number, is produced each time the starting key is closed regardless of the interval of time the starting key remains closed. The switch and circuit will also mechanically create a time interval equal to the time of rotation of the wipers across the bank contacts.

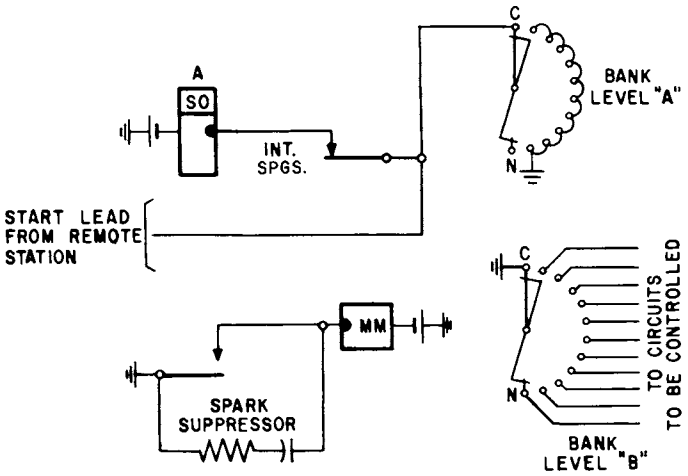



*Figure 20. Pulse producing.*

Relay A is initially operated from ground over the start lead from a remote station and through the normally closed rotary switch interrupter springs. Relay A operates to energize motor magnet MM of the stepping switch. Operation of the motor magnet armature opens the interrupter springs which in turn open the circuit to relay A. At the expiration of its slow-to-release interval, relay A restores; opening the operating circuit for the motor magnet. The wipers step to the first bank contact. When the wipers step off-normal, ground from the strapped banks of level A is extended through the associated wiper and the interrupter springs to relay A coil. This arrangement alternately operates and releases relay A, causing the switch to rotate its wipers, and successively ground the bank contacts of level B. When contact 11 is reached, the switch will remain at normal unless the start lead is still grounded. If grounded, the above cycle is repeated.

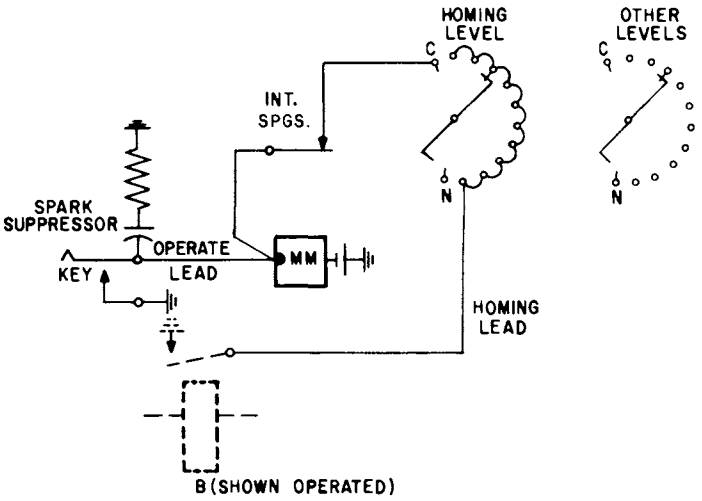



*Figure 21. Restoring rotary switch to normal via wired level.*

Relay A is slow to operate and slow to release. This aids in the creation of a time interval between steps of the rotary switch. Relay A can be adjusted to vary this interval and to produce the desired timing.

### 4.7 Return to Normal Position (Homing)

Rotary stepping switches usually incorporate facilities which (through various arrangements) will cause the wipers to restore to their normal position at the completion of a switching operation. This is called homing and may be done in two ways. One method uses the interrupter springs while the second also uses the switch's off-normal springs. (See section 4.7.3 for the method of restoring a minor switch.)

#### 4.7.1 Homing by a wired switch level.

Figure 21 illustrates this method of restoring a rotary switch to its normal position. All bank contacts of one level, except the home position, are strapped and wired to a homing lead. A bridging wiper is associated with this level and is connected to motor magnet MM through the interrupter springs. Upon completion of a switching operation, via the operate lead, the wipers will be resting on bank contacts other than the home position. Relay B, which was operated during this switching operation, releases and grounds the wired contacts of the homing level. This ground is extended, through the wiper and interrupter springs, to the motor magnet as long as the wiper is engaged with a wired contact. Thus, the motor magnet will step the switch, self-interruptedly, until its wipers reach the home position (the unwired contact number 11 in figure 21).

4.7.2 Homing by off-normal springs (figure 22).

The motor magnet in this case is connected through the interrupter springs and off-normal springs to a homing circuit. This circuit can be under the control of a relay, such as relay A, which is held operated during the switching procedure. The off-normal springs close when the switch wipers step off the home position to prepare a circuit to the magnet coil. The release of the operate circuit releases relay A which grounds the homing circuit to magnet coil MM. Motor magnet MM now steps the wipers self-interruptedly to the home position. At this point the off-normal springs open and remove ground from motor magnet MM. The switch remains in its home position.

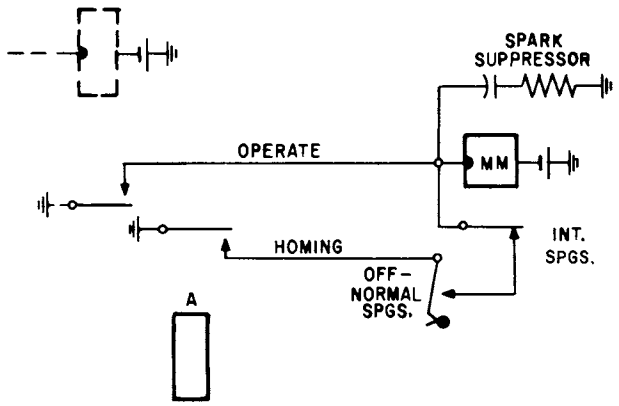



*Figure 22. Restoring rotary switch to normal via off-normal springs.*

4.7.3 Restoring the minor switch.

The release facility of the minor switch is an integral part of the switch design and no optional method exists. The circuit of the release coil (figure 23) is prepared through the off-normal springs when the wipers are stepped off the home position. The wipers are stepped against the pull of a coil spring; a detent on the ratchet dog holds them in position against this pull (see section 6). When the switching circuit is released, relays A and B restore, and ground through the now closed off-normal springs

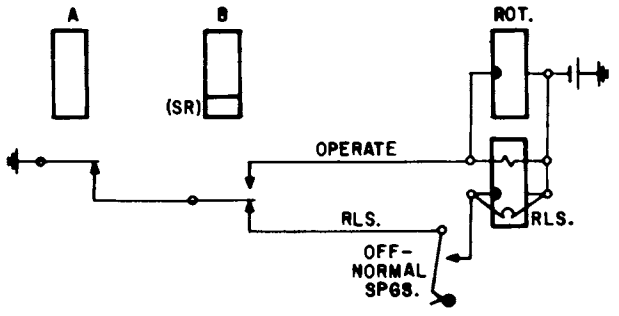



*Figure 23. Restoring minor switch to normal.*

energizes the release magnet (RLS). The release armature operates and withdraws the ratchet dog from the ratchet causing the coil spring to pull the wipers to their home position. When the wipers reach the home position, the off-normal springs open and remove ground from the release magnet.

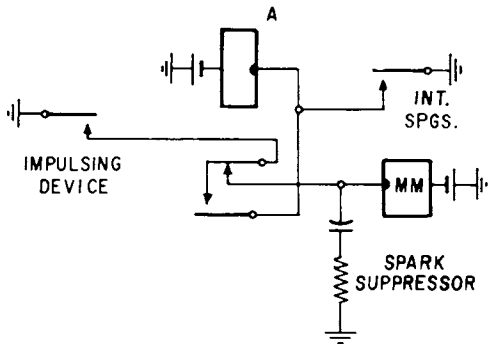



*Figure 24. Pulse inversion circuit for direct drive rotary switch.*

4.8 Pulse Inversion (Figure 24)

An indirect-drive switch can be made to act as a direct-drive switch. The motor magnet MM operates on closure of the start circuit switch. Relay A operates and opens the circuit for the motor magnet. The motor magnet MM steps the wipers one step ahead. Relay A locks to the pulse from the start switch until it is opened.

## 5. OPERATING CONDITIONS AND PREVENTIVE MAINTENANCE

### 5.1 General Operating Considerations

No definite figure for service life of rotary switches can be given. However, as the result of repeated laboratory tests and extensive field observations, certain figures representing the minimum expected life of rotary switches without repair or replacement of parts, have been fairly well established.

The life of a rotary stepping switch depends on operating conditions and the maintenance care it receives. Protection from gritty dust and reasonable attention to lubrication procedures will assure longer life for individual parts. This is especially necessary during the first 500,000 operations, while the switch is being "worn in."

The wiper life of these switches is also affected by atmospheric conditions. Cleaning of the banks is recommended, as part of the lubrication procedures, to remove abrasive dust before applying an oil film.

Wipers should not open and close electrical circuits that tend to spark if maximum life of the parts is required. Even tiny sparks tend to burn away the lubricant and roughen the banks and wipers, producing wear. When wipers are used for the control of electrical circuits, provide a good method of spark suppression to assure maximum wiper life (see section 3.4).

Rotary stepping switches contain certain design and adjustment characteristics that are important factors in providing long life with minimum maintenance. For example, magnet coils of the lowest inductance possible that will give the required amount of power and still be self-protective are used. Adjustments are specified that provide the shortest practical armature stroke in order to obtain maximum power. Restoring spring tensions are such that positive operation is assured without adding unnecessary load and wear. Armatures strike against the magnet coil cores instead of the member they drive. This assures long life for the pawl and its bearing.

## 5.2 Preventive Maintenance

Preventive maintenance is a systematic series of operations performed at regular intervals to eliminate major breakdowns, interruptions in service, and to keep the equipment operating efficiently. The importance of preventive maintenance cannot be overemphasized. Preventive maintenance should, therefore, be considered as a series of routine inspections which provide insurance against operational failure and major repairs. This section is intended as a guide for personnel performing basic preventive maintenance services.

### 5.2.1 Procedures.

Most of the parts used in rotary stepping switches require routine preventive maintenance, but differ in the amount and kind of preventive maintenance required. Frequency of preventive maintenance tests and inspections is governed by the type and age of the equipment, and the conditions under which it must operate.

NOTE: Preventive maintenance practice, performed at regular intervals, will minimize deterioration of the equipment throughout the entire period of operation. The extent of deterioration of the equipment depends on the method of maintenance used from the time it is put into operation and not after deterioration has already begun.

### 5.2.2 Inspection.

Make a periodic inspection of the equipment in order to detect minor defects and signs of worn, damaged, or corroded parts which may later cause trouble. Although these minor defects may not have interfered with the performance of the equipment, correcting them, before they lead to major breakdowns, saves valuable time and effort. Inspection consists of observing all parts of the equipment carefully, noticing their color, placement, state of cleanliness, and signs of wear or corrosion. Inspect for the following conditions:

a. Overheating. Look for discoloration, blistering, or bulging of the parts on the surface of a cover; leakage of insulating compounds, and excessive oxidation of metal contact surfaces.

b. Placement. See that all leads are in their original positions, that insulation has not become damaged, and that soldered connections are in good condition.

c. Cleanliness. Carefully examine all recesses for dust accumulation, especially between adjacent terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

d. Tightness. Check any connection or mounting which appears to be loose. CAUTION: Do not tighten screws, bolts, and nuts carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken. Do not confuse adjusting screws with mounting screws. Perform cleaning operations carefully in order not to damage equipment or change its adjustment.

e. Lubrication, Observe the condition of the grease or oil on the switch shafts, bearings, and other moving parts requiring lubrication.

## 5.3 Rotary Stepping Switch Cleaning

Remove any covers from the switches. Dust the covers inside and out with a clean, dry cloth. Clean the switch as follows:

a. Clean the coils with a hand vacuum cleaner, loosening dust with a clean 1/2 inch paint brush. Hold the cleaner nozzle close to dusting area.

b. Clean rotary switch armatures and cores by inserting a piece of clean bond paper between them. Apply a slight pressure to the armature, remove the pressure, and then remove the paper. Repeat the procedure, until dirt is no longer deposited on the paper.

c. Clean interrupter and off-normal contacts with a contact cleaner (burnisher). First, clean the contact cleaner with a dry cloth. When cleaning normally open contacts, place the contact cleaner (flat) between the contacts, and press the contacts together. With the contacts closed, move the cleaner blade back and forth two or three times. When cleaning normally closed contacts, the spring pressure between the contacts and the blade is usually sufficient for the cleaning operation.

NOTE: See paragraph e. below for special instructions for cleaning gold-plated contacts.

d. Clean switch banks periodically using a bank cleaning tool covered with dry cotton sleeving (TABLE II). Position the tool between two bank levels and rotate the handle back and forth through an arc of about 90°, keeping the tool in alignment with the bank contacts. When the contacts are clean, move the cleaning tool to the next level and repeat the cleaning procedure until all contacts in all banks have been cleaned. After cleaning, lubricate the bank contacts as indicated for the particular switch (section 6 through 11). Replace sleeving after it has been used to clean the top and bottom surfaces of one level contacts.

e. Clean gold-plated bank contacts and wipers as in paragraph d. above. CAUTION: Use special care to keep abrasive materials from gold-plated contacts, including dust and dirt. Discard sleeving after each use to prevent damage to plated surfaces through contamination of the material with dust and gritty particles.

TABLE II. TOOLS AND EQUIPMENT FOR ROTARY STEPPING SWITCHES

| Item | Part Number | Used With |
|---|---|---|
| Adjuster, spring | H-20179-1 | 13, 14, 26 |
| | H-20777 | Minor switch |
| | H-24600 | |
| | H-42873 | |
| Adjuster, stepping tool | H-881384-1 | 40, 44, OCS |
| Assembly tool, wiper | H-50829-1 | Minor switch |
| Brush, artist, sable, No. 4 | H-880843 | All switches |
| Cleaner, contact | H-882553-1 | |
| Cleaning tool | H-47386-1 | |
| | H-56628-1 | 13, 14 |
| | H-56628-2 | 13, 14, 26, 45 |
| | H-56628-4 | 40, 44 |
| Gage, thickness | H-46795-50 | All switches |
| Pliers, duckbill | H-50620 | 40, 44, 45, OCS |
| Sleeving (webbing), cleaning, cotton, dry | H-542539-A | All switches |
| Wrench, double open end | | |
| 1/4" and 7/32" | H-7062 | 13, 14, 26 |
| 1/4" and 3/16" | H-880772-1 | 40, 44, 45, OCS |
| 5/16" and 1/2" | H-880771-1 | 45 |
| 3/8" and 7/16" | H-880773-1 | 40, 44, 45, OCS |
| Wrench, single open end, 5/8" | H-23865 | 13, 14, 26 |
| Wrench, socket, 3/8" | H-7085-1 | 13, 14, 26 |

NOTE: For complete description, see appropriate A. E. Co. Catalog.

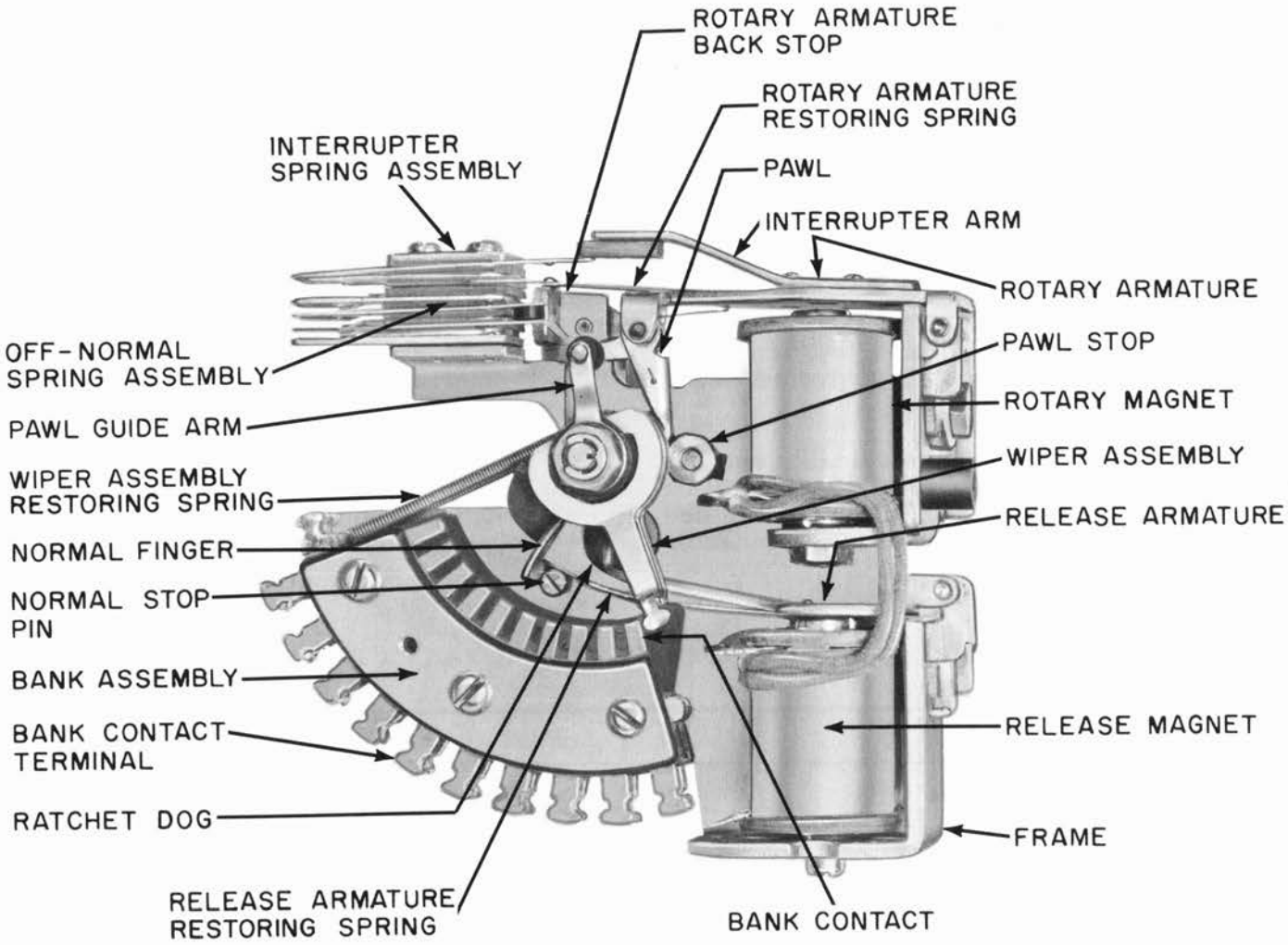



*Figure 25. Minor switch assembly details.*

5.4 Adjustment

Adjustment instructions and requirements for each switch are included in sections 6 through 11. The tools and equipment required for maintenance are listed in TABLE II.

5.5 Lubrication

5.5.1 General.

The purpose of lubrication is to provide a film of oil between a fixed part and its associated moving part, or between two moving parts, to reduce friction so that there will be a minimum of wear. This makes for smoother operation. It is only necessary to apply that amount of lubricant which can produce the desired film. Excessive lubrication should be avoided.

a. Whenever practicable, bearings and surfaces should be cleaned before the lubricant is applied. This practice is particularly applicable to those surfaces and bearings which are normally exposed.

b. Lubricant containing graphite should not be added when the surface requiring graphite lubricant appears to be sufficiently covered with graphite. If the existing graphite on the surface appears to be excessively dry, apply a small amount of spindle oil to the surface. If the graphite is caked or appears to contain grit, the surface should be thoroughly cleaned and relubricated with the graphite lubricant.

c. After the switches have been properly lubricated, they should be operated several times so that the lubricant will work into the bearings. Excess oil on nonbearing and nonoperating surfaces should be removed.

d. Each rotary switch has its own lubrication requirements. See sections 6 through 11. Lubricate switches in accordance with those requirements at the intervals prescribed.

e. Approved lubricants are listed in TABLE IV.

5.5.2 Lubricant measures.

To control the amount of lubricant, a standard measure has been established. This standard measure assures that approximately the correct amount of lubricant will be applied. This measure is defined as follows: DIP – A dip is defined as that amount of oil retained in the bristles of a No. 4 artist's sable rigger brush after it has been dipped into a lubricant to a depth of 3/8 inch and then drawn across the edge of a container to remove any surplus oil.

## 6. MINOR SWITCH

### 6.1 General Description

The minor switch (figure 25) is a direct-driven type rotary switch. Pulses to its rotary magnet step a set of wipers in a rotary motion over a bank of contacts. The designation "minor" was applied to this switch because of its original use as an auxiliary or minor switch in telephone systems. It is used to select a ringing frequency, register the digit dialed, and other special functions.

The minor switch has many industrial applications because of its small size, its simplicity of construction and control, and because it remains in any selected position without current consumption, in contrast with a relay-closed circuit. With normal cleaning and maintenance routines, the minor switch may be expected to have a minimum life, without parts failure, of 3,500,000 cycles.

The bank assembly of a minor switch consists of one to three levels, depending on the circuit requirements. A three-level switch, operating at 48 volts, steps aproximately 20 steps-per-second from external control pulses. The switch is not arranged to step self-interruptedly. Its wipers remain in the selected position until the ratchet dog is disengaged from the wiper assembly ratchet by energizing the release magnet. When the wiper spring restores, the wipers return to their normal position. A typical control circuit is illustrated in figure 12.

### 6.2 Coil Information

The coils shown in TABLE III are commonly used on the minor switch.

TABLE III. MINOR SWITCH COIL INFORMATION

| Operate Volts d.c. | Coil Location | Resistance Coil Winding | Combined Coil Resistance |
|---|---|---|---|
| 24 | Rotary | Inductive 48 Ohms N.I. Shunt 700 Ohms | 45 Ohms |
| 24 | Release | Inductive 68 Ohms N.I. Shunt 700 Ohms | 62 Ohms |
| 48 | Rotary | Inductive 155 Ohms N.I. Shunt 900 Ohms | 132 Ohms |
| 48 | Release | Inductive 275 Ohms N.I. Shunt 900 Ohms | 211 Ohms |

**Other coils are available for d-c operation from 6 to 110 volts d.c. Switch dimensions are as follows: overall height is 4-1/2 inches; width 1-1/2 inches; length (from mounting surface) 3-5/8 inches. It weighs from 13 to 19 ounces.**

6.3 Main Assemblies

The main assemblies of the minor switch are the bank assembly, the wiper assembly, the driving and releasing mechanism, and the off-normal and interrupter spring assembly.

The details of the assemblies are shown in figure 25.

6.3.1 Bank assembly.

This assembly consists of one to three levels depending on circuit requirements. Each level has two sets of contacts separated by a phenolic insulator. The upper set contains 10 separate contacts, while the bottom surface is usually a solid segment (a common contact). Individual contacts can replace this segment, if desired.

Each level is associated with a pair of wipers, which merely close a circuit from a selected upper bank contact to the common contact below. Slotted mounting holes permit alignment of bank contacts to the wipers.

6.3.2 Wiper assembly.

The wiper shaft is staked to the switch. The wiper assembly is placed over this shaft and held in place with a lock washer. The slot, in the wiper shaft, serves as an oil vent for lubricating the bearing surface. The wiper assembly consists of up to three pairs of wipers, a ratchet wheel, a wiper stop, and the operating arm for the off-normal contact springs. These parts are assembled on a hub, which is threaded at one end, and held in place with a hexagonal nut. The wipers normally rest off the bank contacts when the switch is in the home position. The wiper stop and the wiper stop block prevent the wipers from restoring beyond the home position.

6.3.3 The driving and releasing mechanism.

The minor switch is a direct-driven unit. That is, its wipers advance during the operation of the rotary magnet armature. An adjustable pawl stop limits wiper "overthrow" during the pulsing period. A spring, attached to the rotary armature with two machine screws, is tensioned to provide a positive restoration of the armature after each operation. Between steps and after stepping has been completed, the wipers are held in place on the bank contacts by the ratchet dog of the release armature.

As the wiper assembly is being advanced over the bank, the wiper assembly restoring spring tension increases. When the release magnet circuit is closed, its armature operates and withdraws the ratchet dog from the ratchet. The wipers are restored under the power of the wiper assembly restoring spring.

When desired, the release armature restoring coil spring and mechanism can be substituted for the normally-used leaf restoring spring (see figure 25).

6.3.4 Off-normal and interrupter spring assemblies.

The off-normal springs are attached to the switch frame with two machine screws. Slotted mounting holes permit the alignment of these springs with the operating arm of the wiper assembly. Off-normal springs operate with the first step of the wipers and restore when the switch returns to the home position.

The interrupter springs are also mounted on the off-normal spring assembly. They are actuated by the interrupter arm, attached to the rotary armature, with each step of the switch.

Interrupter springs are used to open, close, or transfer an external circuit with each step of the switch.

6.4 Mounting

The switch frame is drilled and tapped for mounting one switch either parallel or at right angles to a mounting surface as illustrated in figure 26.

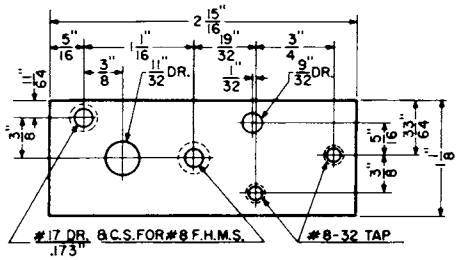



***Figure 26. Minor switch mounting bracket.***

A plate can be supplied for mounting a minor switch on two relay spaces of a jack-in relay base. Mounting and switch dimensions are shown in figure 27. A plate 13-1/4 inches long and 2 inches wide can be supplied for mounting a total of ten switches.

6.5 Preventive Maintenance

The minor switch should be inspected, and adjusted as necessary, in the following order:

6.5.1 Wiper assembly.

a. The wiper assembly nut shall be securely tightened.

b. The upper spring of each pair of wipers shall not be out of alignment (vertically) with the lower spring of a wiper more than 1/64 inches.

c. The upper wiper shall not be out of alignment (vertically) with the lower wiper of a wiper assembly more than 1/32 inches unless otherwise specified on the wiper assembly drawing.

d. The tips of a pair of wiper springs shall be separated approximately .015 inches with the wiper off the bank.

e. Each wiper spring shall be tensioned to have a follow of approximately 1/16 inches (measured at the tip) when its opposing spring is deflected.

f. The springs of a wiper shall exert approximately equal tension on the bank contacts, so that there shall be no perceptible rise or fall of the wiper as a whole, as it passes onto or off the bank.

g. Wiper assembly shall not bind on its axis.

NOTE: On switches using the wiper assembly collar, the collar shall be positioned so that the wiper assembly has no more than .005 inches vertical play.

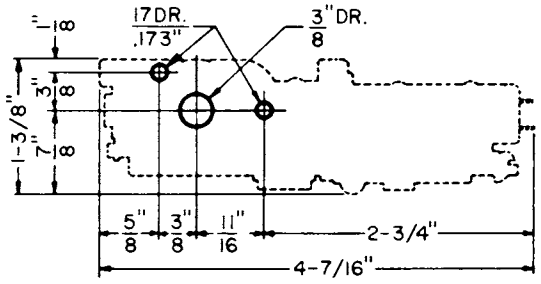



*Figure 27. Minor switch mounting dimensions.*

h. The off-normal arm roller shall turn freely on its axis.

i. The normal finger shall make contact with the normal stop pin 1/64 inches, with the wiper assembly pulled toward the wiper spring-retaining clip or collar.

j. The normal finger shall not make contact with the wiper assembly restoring spring as the wipers operate or restore.

k. The wiper assembly restoring spring shall have just enough tension to restore the shaft to normal from the second and ninth bank contacts when the release armature is operated manually.

l. When the oil slot does not extend to the end of the shaft, the oil hole in the wiper assembly collar shall be in approximate alignment with the oil slot in the shaft.

NOTE: When the switches are mounted in vertical positions or in such a way that it is not practical to apply oil to the collar in its original position of assembly, the collar shall be relocated in the most convenient position for oiling and tightened. The oil hole shall be above the horizontal center line through the shaft when the switch is mounted in either vertical position.

On switches using the spring type wiper assembly retaining clip, the vertical play is preset and cannot be adjusted but must be perceptible. No special precautions are necessary to align the spring-retaining clip and the shaft oil slot.

6.5.2 Release armature.

A ratchet dog at the end of the release armature holds the wipers in their correct position on each contact. A leaf type restoring spring is provided to hold the dog in the ratchet teeth. Its tension is controlled by specifying values of current which will and will not operate the release armature.

a. Release armature shall be approximately parallel to the end of the heelpiece.

b. The armature shall clear the heelpiece, and the gap between the armature and heelpiece with the armature electrically operated shall be maximum .004 inches.

c. The release armature shall not bind on its bearings or on the heelpiece and shall have perceptible side play.

d. The engaging surface and edge of the ratchet dog shall be well aligned with the ratchet teeth and shall be adjusted to hold the wiper tips approximately on the centers of the bank contacts. If the armature is bent to meet this requirement, recheck the alignment.

e. The release armature shall have a stroke measured between the armature and coil core of .020 inches plus or minus .002 inches unless otherwise specified on the associated switch adjustment sheet.

f. The release armature spring shall be tensioned as specified on the associated switch adjustment sheet. This should result in a ratchet dog pressure of 25-40 grams.

g. The ratchet arm shall not strike its restoring spring with the release armature operated.

h. The release armature spring shall not make contact with the normal finger or the switch frame.

6.5.3 Bank assembly.

The bank assembly should be positioned on the frame so that the wipers pass over the contacts correctly.

a. The bank assembly shall be set, with the wiper assembly released, so that the wiper tips rest at a distance equal to one rotary step from the first contact, (or approximately equal to the distance between the centers of two adjacent bank contacts).

NOTE: When the home position is the first contact, the wiper shall center on the first contact when the wiper assembly is released.

b. The bank assembly shall be set so that the tips of the wipers pass over the approximate center of the visible length of each bank contact, and come to rest approximately on the center of each bank contact, with respect to the width of the contact.

c. When banks have elongated embossings in the insulators, the wiper tips shall ride over the embossing a minimum of 1/64 inches from either end.

NOTE: When banks have round embossings in the insulators, the wiper tips shall ride over the middle third of the diameter of the embossings.

6.5.4 Rotary armature.

When the rotary armature is operated, its pawl engages the ratchet teeth and steps the wiper assembly one step. A leaf type spring attached to the rotary armature restores the rotary armature when the rotary magnet is de-energized.

a. The rotary armature shall be approximately parallel to the end of the heelpiece.

b. The armature shall clear the heelpiece. The gap between the armature and heelpiece, with the armature electrically operated, shall be a maximum of .004 inches.

c. The rotary armature shall not bind on its bearings or on the heelpiece and shall have perceptible side play.

d. The depth of the rotary armature stroke shall be set, so that the ratchet dog drops in on each ratchet tooth with a maximum clearance of .006 inches between the ratchet dog and tooth when the armature is operated electrically.

e. The rotary armature shall strike the core before the pawl strikes the stop. With the rotary armature electrically operated, there shall be rotary play in the wiper assembly, but this play shall not exceed .020 inches measured at the wiper tips. The pawl stop is not intended to stop the rotary armature in its stroke. Such an adjustment would result in rapid wear of the pawl and ratchet.

f. The rotary armature back stop shall be set to allow an armature stroke (measured between the armature and coil core) of .030 inches, plus or minus .002 inches, unless otherwise specified on the associated switch adjustment sheet. With the above adjustment, the rotary pawl will just clear the ratchet teeth when the armature is in its unoperated position. This is accomplished by bending the pawl guide arm.

g. The rotary armature restoring spring shall be tensioned as specified on the associated switch adjustment sheet.

h. The rotary armature restoring spring shall clear the end of the armature at all times and shall be set with its lower edge approximately parallel to the main surface of the frame.

i. The end of the rotary armature restoring spring shall ride freely on its bearing point on the frame.

j. The surface of the frame on which the rotary armature restoring spring bears shall be smooth.

k. The rotary armature restoring spring mounting screws shall not strike the rotary magnet as the armature operates.

NOTE: When the associated adjustment sheet specifies testing with the wipers on the tenth contact, the armature need not operate completely on the operate requirements, but the pawl must strike the ratchet hub.

6.5.5 Pawl guide arm.

The arm attached to the rotary pawl should be adjusted so that the pawl strikes the proper tooth when the rotary armature operates, yet the pawl must clear the ratchet teeth when the rotary armature is in unoperated position.

The pawl guide arm shall be set with the wiper assembly rotated one or more steps so that as the rotary armature is operated by hand there is a space of approximately .015 inches between the pawl guide arm and the switch frame just before or just as the wiper assembly begins to move.

6.5.6 Pawl.

a. The pawl shall be well aligned with the ratchet teeth, shall operate freely on its bearing, and shall not bind on the switch frame.

b. The pawl spring shall hold the pawl guide arm against the switch frame with a minimum pressure of 50 grams and a maximum pressure of 100 grams.

c. The normal finger shall be set so that the pawl strikes the tenth tooth of the ratchet, counting clockwise from the restoring spring hook, in the same relative position in which it strikes the other teeth. The requirement in paragraph 6.5.3a will have to be checked, if it is necessary to bend the normal finger.

6.5.7 Off-normal springs.

The off-normal springs are usually provided to open the circuit to the release magnet when the wipers restore to home position. They may, however, perform other functions. The adjustment of the off-normal springs should insure good electrical contact on both make or break contacts.

a. With the wipers resting on the first bank contact on which the spring assembly is to be fully operated, there shall be a perceptible clearance between the off-normal arm bushing and the main lever spring.

b. Make or break contact assemblies shall have a minimum contact separation of .008 inches.

c. With the wiper assembly off-normal, the lever springs shall have a minimum contact pressure of 20 grams on the contacts. Back contact springs shall have perceptible follow as the wiper assembly moves off-normal.

d. With the wipers resting on the first bank contact on which the spring assembly is to be fully operated, the bushing on the first lever contact spring may touch the main lever spring, but the stud of the first lever contact spring shall not follow when the main lever spring is deflected sufficiently to clear it.

e. The flat, bent end of the operating spring shall normally rest approximately on the center of the off-normal roller length.

f. The off-normal arm bushing shall engage the curved tip of the first lever spring so as to insure the proper restoration of the spring assembly when the wipers are released from either the first or last bank contact. The off-normal arm shall not cause the first lever spring to become unnecessarily bent or bowed as it is engaged by the off-normal arm bushing.

g. The off-normal spring assembly bracket shall not prevent the wiper assembly from rotating onto the tenth contact.

h. The operating spring shall clear the end of the rotary armature with the armature operated and the wiper assembly off-normal.

6.5.8 Interrupter springs.

The interrupter springs are usually used for pulsing an external circuit. The adjustment of the interrupter springs should insure good electrical contact on both make and break contacts.

a. The interrupter arm shall be formed as necessary to meet the requirements of the spring pile-up.

b. The interrupter arm buffer shall overlap the lever spring by a minimum 1/32 inches and shall clear the break spring, if any, by a minimum of 1/32 inches.

c. Interrupter springs shall be gauged according to the associated switch adjustment sheet. Unless otherwise specified, the variation allowed for inspection shall insure that the springs make or break when a gauge .002 inches less than the specified value is placed between the rotary armature and the coil core; and shall not make or break when a gauge .002 inches greater than the specified value is placed between the armature and coil core when the magnet is energized.

d. Unless otherwise specified, when the first contact from the interrupter arm is a break contact, the lever spring shall be tensioned from 40 to 60 grams against the break contact spring measured at the point where the armature buffer strikes the lever spring.

e. When the first contact from the interrupter arm is a make contact, the lever spring shall rest against the interrupter arm buffer with a pressure of 10 to 20 grams, measured where the lever spring strikes the buffer with the rotary armature unoperated.

6.5.9 Lubrication (figure 28).

The minor switch should be lubricated at 50,000, 100,000 and 250,000 operations and after every 500,000 operations or six month

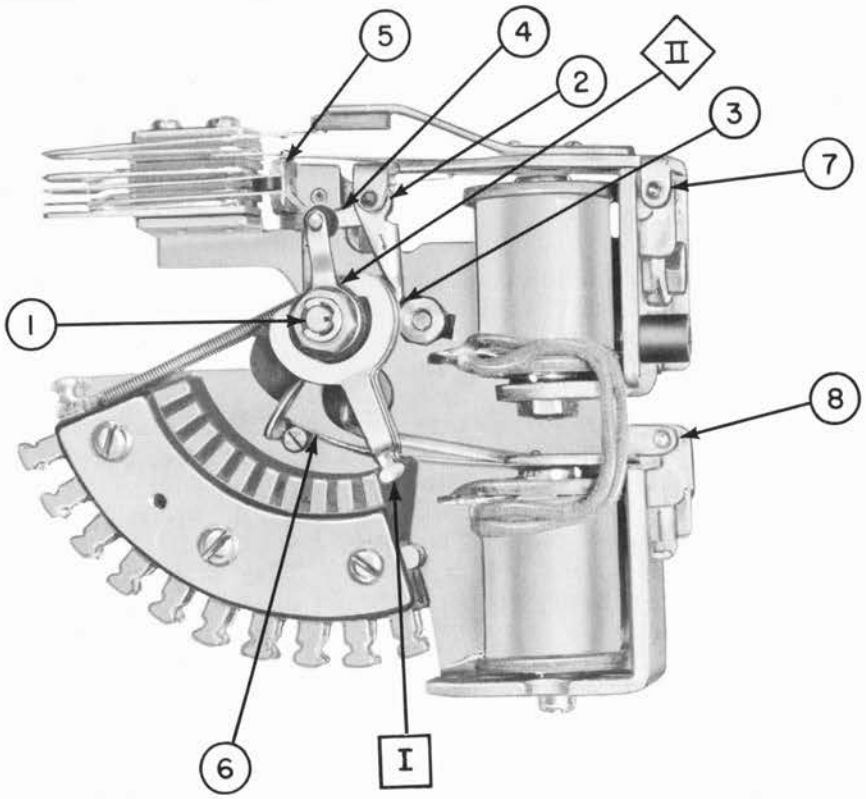



*Figure 28. Minor switch lubrication.*

period thereafter (whichever is first). Clean the switch thoroughly and lubricate following steps a. through d. below (see TABLE IV).

NOTE: If the switch is to be subjected to temperatures of -20° F and lower, substitute low-temperature lubricant (spec. 5563) for graphite oil lubricant, grade C (spec. 5232); and standard dial lubricant (spec. 5660) for blended lubricating oil (spec. 5684).

a. Apply spindle oil (spec. 5231) to:

[I] The wiper tips. NOTE: This lubricant should be applied by immersing a sheet of paper or thin fibre in the spindle oil, withdrawing it and at the same time wiping off all excess oil, then passing the sheet between the wiper tips of each pair.

b. Apply one dip of graphite oil lubricant grade C (spec. 5232) to:

◇II◇ The ratchet teeth.

If the switch has been disassembled, the following procedure should be adhered to. Wipe the parts to be lubricated as clean as possible.

c. Distribute one dip of blended lubricating oil (spec. 5684) among the following points in the order named:

(1) The shaft bearings, before the wiper assembly is assembled to the shaft.

(2) The pawl bearing.

(3) The pawl stop, at the point where it is engaged by the pawl.

(4) The pawl guide arm bearing surface on the frame.

(5) The rotary armature spring bearing surface on the frame.

(6) The release armature spring bearing surface on the normal stop pin.

d. Distribute one dip of blended lubricating oil (spec. 5684) between the following points in the order named:

(7) The rotary armature bearing pin, where it touches the bearing yoke.

(8) The release armature bearing pin, where it touches the bearing yoke.

## 7. SERIES OCS RELAY

### 7.1 General Description

The OCS relay (figure 29) is a shock-resistant, cam-type, unidirectional, rotary stepping switch. Its simple design results in a compact,

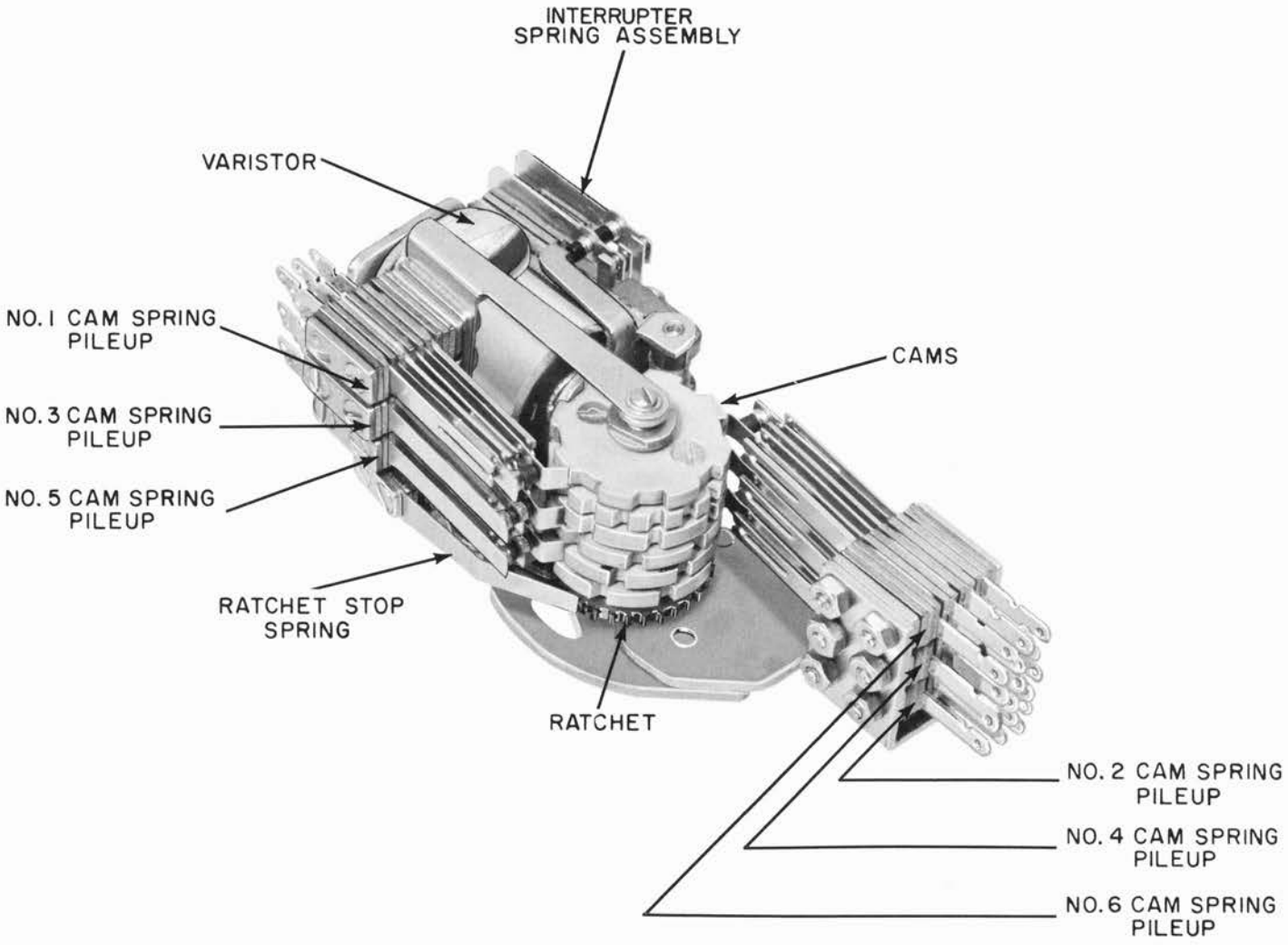



*Figure 29. OCS relay assembly details.*

durable, lightweight, fast-stepping, relay requiring minimum adjustment in the field. The OCS relay can be supplied with up to six cams, associated cam springs, and armature actuated interrupter springs. Since it is shock resistant, it is sometimes specified as a replacement for the less rugged latch-in type relays.

The motor magnet can be remote-pulse controlled or automatically stepped through its interrupter springs. The driving mechanism provides a positive nonoverthrow stopping feature to prevent overstepping during its fast cycling. A 3-cam relay operating on 48 volts d.c. rotates approximately 65 steps-per-second for automatic (self-interrupted) operation and up to 35 steps-per-second for remote-pulse controlled operation.

The driving mechanism is an adaptation of the type 44 rotary switch mechanism, and is an indirect-drive type. The cams are advanced during the restoration of the armature when the magnet coil is de-energized.

Refer to TABLE I for coil voltages, coil resistances, spark suppression data, and capacitor values. A compact half-wave rectifier can be supplied with this relay when it has to be operated on 50-60 cycle 115 volts a.c. The assembly contains the necessary filter and spark suppression components. The rectifier is mounted separately. Relays with up to 3 cams and up to 6 springs per cam can be sealed in hermetic enclosure AE-6100.

7.2 Main Assemblies

The main assemblies (figure 29) of the OCS relay are the driving mechanism, the cam assembly, and contact spring assemblies.

7.2.1 Driving mechanism.

The driving mechanism, consisting of a magnet coil, an armature, a coiled drive spring, a pawl, and pawl spring is mounted on the frame.

A ratchet stop spring holds the cams in place between steps of the switch. The interrupter

springs may be used to step the switch automatically (self-interrupted), to control external circuits, or both. Available interrupter spring combinations are: 1C, 2B, 1B1A, 1C1A, 1C1B, 2C, 1A2B, and 2A1B.

7.2.2 Cam assembly.

This assembly consists of a bearing hub, cams, spacers, and a ratchet wheel. The hub is a seamless steel tube reamed out to provide a bearing surface. One end is threaded for a spanner nut. The ratchet wheel is pressed and brazed to the other end. After case hardening, spacers and cams are assembled on the hub and fastened to the ratchet wheel with two machine screws. During assembly, the cams are aligned with respect to each other to provide proper pulsing sequence.

One end of the shaft is staked to the switch frame. The other end is drilled and tapped for fastening the shaft supporting bracket. OCS relays, having one or two cams, use a shorter shaft eliminating the supporting bracket (there are also 4-cam relays). The hub assembly is placed over this shaft. The undercut portion of the shaft is filled with low-temperature grease during assembly to provide a bearing surface that lasts for the life of the switch. Additional grease is needed when replacing a cam assembly.

Ratchet wheels with 36 teeth are usually supplied. On special order, ratchet wheels with 30 or 32 teeth can be furnished. The cam is divided into a maximum of 36 intervals of alternate on-off operations (18 operate and 18 nonoperate) or any combination of operated or nonoperated intervals.

The operation of the off-normal springs, when used, is usually assigned to the top cam. Cams are numbered from top to bottom. For a six cam assembly, the one nearest the supporting bracket is cam No. 1 and the one nearest the ratchet wheel is cam No. 6.

7.2.3 Contact spring assemblies.

Springs, with twin contacts of palladium-silver are normally supplied. They can be used to make or break a noninductive load of 150 watts at a maximum of 3 amperes. For higher current or wattage capacities, springs with a single silver cadmium oxide contact are furnished when specified.

OCS relays may be specified with up to 7 springs per cam or 6 springs per cam when a hermetic enclosure is used. Any arrangement of the A, B, or C spring combinations is permitted. However, to obtain maximum life and high-speed stepping for relays with three or more cams; the number of springs per cam may have to be limited depending on the pulsing sequence for each cam. Extreme shock and vibration specifications can only be met when small spring combinations and special spring designs are used.

The spring assemblies for relays with up to three cams are mounted on the frame alongside the motor magnet coil. The 5-cam or 6-cam

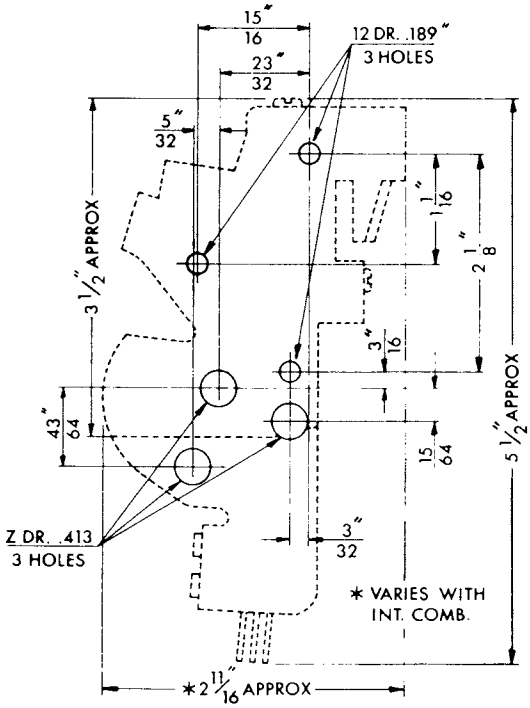
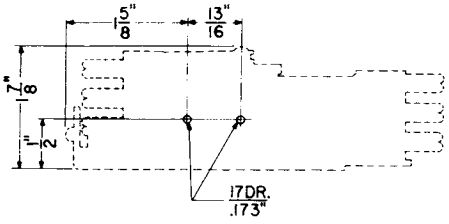
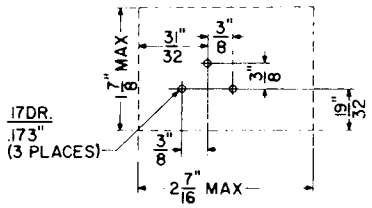



*Figure 30. OCS relay mounting dimensions.*




*a. Base mounting.*




*b. Shelf mounting.*

*Figure 31. OCS relay mounting brackets.*

relay will mount three sets as above, while the remaining two or three are assembled on an extension bracket fastened to the relay frame. The 4-cam relay will mount two spring assemblies alongside the motor magnet coil and two on the extension bracket. This provides a balanced assembly.

### 7.3 Mounting

The switch frame is drilled and tapped for mounting with three 8-32 machine screws (not furnished). NOTE: Use a short screw, a long one may damage the coil. If the relay is installed as shown in figure 30, a shock-resistant mounting is provided; since the total length of the frame is held flush with the mounting surface. With this mounting, the relay can be designed to withstand vibration up to 10.5G, or shock and acceleration up to 5G at 55 to 500 cps vibration, or up to 25G of 10 to 55 cps vibration with a maximum excursion of .030 inches. Other available mountings are shown in figure 31.

### 7.4 Preventive Maintenance

Extensive tests on the OCS relay have shown that the only two adjustments normally requiring attention are the tension of the drive spring (margining) and the gauging of the interrupter springs. The driving mechanism itself is adjusted in the factory and should not require further attention. Tension of the drive spring is controlled with a micrometer screw. A simple setting of the interrupter springs' contact gap may be necessary to obtain smooth self-interrupted stepping. The armature stroke will not require adjustment in the field. Inspect and adjust the OCS relay as follows:

#### 7.4.1 Armature.

When the armature is operated, the pawl is positioned in the next tooth of the ratchet wheel. The coil-type spring restores the armature when the magnet is de-energized, rotating the cam assembly one step. Then the teeth on the armature engage the ratchet wheel teeth. For proper operation, there must be no bind in the armature assembly. Check the armature air line and check the pawl spring tension:

a. The armature shall not bind on its bearings.

b. The armature shall clear the heelpiece, and a .004 inch gauge shall be tight and a .0015 inch gauge shall be loose, in the airline, with the armature electrically operated. The armature shall be parallel to the heelpiece as gauged visually.

c. The pawl shall not bind on its bearings.

d. The pawl tip shall rest against the ratchet wheel with a minimum pressure of 130 grams and a maximum pressure of 175 grams, with the armature in the unoperated position.

e. The sides of the pawl (along its length) shall be parallel to the sides of the ratchet wheel, and the tip of the pawl shall be parallel to the edge of the ratchet wheel as gauged by eye.

f. The armature stopping teeth shall not project beyond either edge of the ratchet wheel by more than .010 inches in any position allowed by play in the armature bearings. The edge of the pawl shall project a minimum of 1/64 inches or a maximum of 3/64 inches beyond the cam side of the ratchet wheel in any position allowed by play in the armature and pawl bearings.

g. (When replacing the armature only.) With the ratchet stop spring held away from the ratchet, the armature in the unoperated position and the play between the ratchet wheel and armature stopping teeth taken up in the direction of the cam rotation; the pawl shall not bind when it is lifted out of the ratchet wheel.

   With the play taken up in the direction opposite to cam rotation, there shall be a clearance (maximum .008 inches) between the normally engaged surfaces of the stopping teeth and the ratchet teeth. On 32-step OCS relays there is no play!

NOTE: The above requirements are met by selecting the correct shim or shims (.006 inches, .010 inches, or .014 inches) and placing it or them between the yoke and heelpiece. The thinnest suitable shim or combination of shims should be used to avoid interference between the stopping teeth and the top surface of the ratchet wheel as the armature restores. These shims are not furnished with the replacement armature and should be ordered separately.

The relay should step manually after meeting the above requirements.

#### 7.4.2 Ratchet stopping spring.

The ratchet stopping spring is provided to hold the cam assembly in place while the armature pawl is being prepared for the next step. Check the ratchet stopping spring tension and position:

a. The ratchet stopping spring shall be tensioned against the ratchet wheel to a minimum pressure of 75 grams to a maximum of 125 grams, measured at the tip of the spring.

b. With the armature in the unoperated position, the ratchet stopping spring shall clear the armature and the pawl by a minimum of 1/32 inches.

c. With the play between the pawl and the ratchet wheel taken up in the direction opposite the cam rotation and the armature in the unoperated position, there shall be perceptible to .003 inches maximum clearance between the ratchet stopping spring tip and radial surface of the ratchet wheel.

d. The tip of the ratchet stopping spring shall project a minimum 1/64 inches beyond the cam side of the ratchet wheel and shall be parallel to the edge of the ratchet wheel as gauged by eye.

7.4.3 Armature driving spring.

A coil-type spring restores the armature when the magnet is de-energized, driving the cam assembly. An adjustment screw and locknut are provided. The proper pressure required is specified on the relay adjustment sheet. Check the driving spring tension as follows:

a. The armature driving spring pressure shall be adjusted in accordance with the associated relay adjustment sheet.

b. The armature shall completely restore from the operated position when retarded by hand and allowed to restore slowly on any step.

7.4.4 Interrupter springs.

The interrupter springs are actuated by an arm on the armature of the switch. To secure long, trouble-free life and correct operation of the switch, the contact pressures must be maintained and also the position of the armature in its stroke when the springs make or break contact. Check the tension and the gauging of the interrupter springs as follows:

a. With the armature electrically operated, the portion of the armature arm which actuates the spring buffer shall be parallel to the frame as gauged by eye and shall clear the frame a minimum .010 inches. The spring buffer shall be perpendicular to the armature spring and shall not project more than .005 inches beyond the edge of the armature arm.

b. Contacts shall not be out of alignment (judged visually) by more than 40% of their base diameter.

c. The interrupter springs shall be gauged as specified in the associated relay adjustment sheet by inserting a gauge of the proper value between the armature and the coil core. Unless otherwise specified on the relay adjustment sheet, a variation from the values specified of plus or minus .001 inches shall be allowed for inspection.

d. Break springs shall have minimum contact pressure of 275 grams and a maximum pressure of 400 grams. When there are two sets of interrupter break springs, each set shall have a minimum of 150 grams and a maximum of 200 grams contact pressure!

e. There shall be a minimum of .003 inches difference between the break and the make gauging of any break-make combination.

f. Both contacts of a pair shall make or break within .002 inches of each other as gauged visually.

g. Contact gap on make or break shall be .008 minimum.

NOTE: The break spring shall be adjusted after gauging to give a smooth uniform speed of the voltage for which the relay is to be used.

7.4.5 Cam pulsing springs.

Normally, one set of cam pulsing springs is provided to open homing circuits when the cams are in the home position. The other cams are provided to perform other functions. Adjustment of the cam pulsing springs should insure good electrical contact on both the make and break springs. Check the cam pulsing springs, as outlined below. See section 7.4.6 for special adjustment of cam pulsing springs against blank cams.

a. The tip of the cam spring shall be located in the center third of a slot when the relay is in the unoperated position.

b. Cam springs shall require a minimum of 35 grams and a maximum of 55 grams tension (measured at the contacts) to open; this includes damper springs, when specified.

c. Make or break springs shall have a minimum contact separation of .015 inches.

d. Both contacts of a pair shall make or break within .002 inches of each other as gauged visually.

e. In combinations where a second pair of springs are break springs, the buffer of the second lever spring shall clear the first lever spring by a minimum of space that

is perceptible and a maximum of .003 inches when the combinations are not operated by the lands of the cam.

f. In spring pile-ups, with more than one set of back contacts, there shall be a minimum pressure of 50 grams and a maximum pressure of 70 grams required to open. Contacts shall open simultaneously, as judged visually, except when all 3 cams have large spring pile-ups, then sequence opening of contacts shall be permitted.

g. All damper springs shall be approximately flat against associated springs and there shall be a minimum of 22 grams tension against associated springs when the contact spring is deflected in the direction of the damper spring.

h. Normally when adjusting spring pile-ups, where the cam springs have contacts welded on them, the cam spring shall be adjusted to clear the cut-in cam by a minimum space that is perceptible and a maximum of .003 inches as gauged visually. When cam springs do not have any contacts on them, then they shall be adjusted with minimum tension floating, (no back tension), and a maximum 5 grams against the cut-in cam, as gauged by touch.

i. A negative bow (dog leg) is permissible on make or break springs of power-contact pile-ups when adjusting to insure proper contact alignment.

7.4.6 Special adjustment of cam pulsing springs against blank cams.

a. Straighten and tension springs.

b. Set the break contacts at approximately .020 inches clearance in the operated position.

c. Tension the cam spring against the cam with approximately 40 grams tension.

d. Tension the stop springs against cam springs and against break springs at approximately 40 grams.

e. If the combination has make contacts, set contact pressure at approximately 25 grams.

7.4.7 Self-interrupted speed test.

An over-all check on the adjustment of the relay equipped with interrupter springs may be made by running the relay self-interruptedly. If the relay does not operate smoothly, all adjustments should be rechecked.

7.4.8 Lubrication (figure 32).

The OCS relay should be lubricated before being put into service after 30,000 revolutions

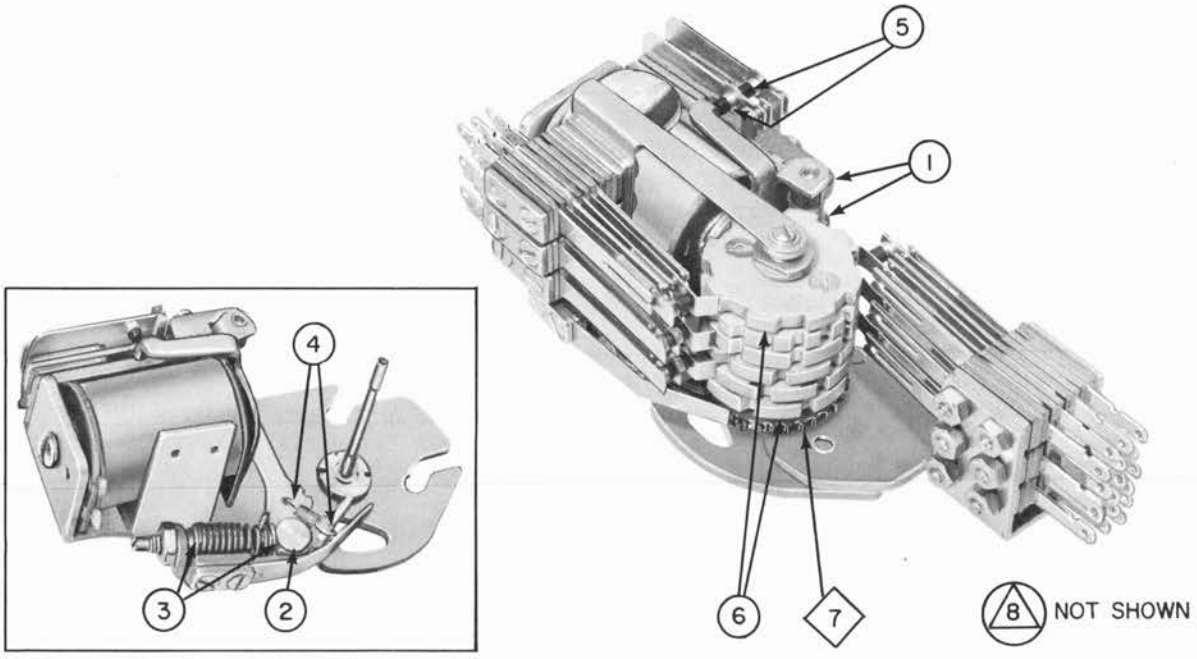



*Figure 32. OCS relay lubrication.*

or three months (whichever is first), after 150,000 revolutions or six months (whichever is first), and after each additional 150,000 revolutions or six months (whichever is the most frequent).

NOTE: For low-temperature lubrication instructions, contact Automatic Electric Company, Northlake, Illinois.

When lubricating, clean the brush before using a different lubricating oil. Clean the relay thoroughly and lubricate following steps a. through f. below:

a. Distribute one dip of blended lubricating oil (spec. 5684) between:

   (1) Each of the yoke bearings (4 places).

b. Apply one dip of blended lubricating oil (spec. 5684) to:

   (2) The pawl bearing, where the pawl and pawl bearing pin contact the armature.

c. Distribute, evenly, one dip of blended lubricating oil (spec. 5684) to the following points:

   (3) The driving spring seats and coils.

   (4) The pawl spring mounting holes and coils.

   (5) The interrupter spring buffers.

d. Distribute a thin coat of blended lubricating oil (spec. 5684) to the following point.

   (6) Two-thirds of the circumference of every fibre cam. NOTE: There must not be sufficient lubricant on any of the cams to "pile up" behind the operating portion of the springs as the cams are rotated.

e. Apply two dips of graphite oil lubricant grade C (spec. 5232) to:

   (7) The ratchet teeth, while the wiper assembly is rotating.

f. If the switch is disassembled, proceed as follows:

   (8) Fill the undercut portion of the wiper shaft with plastic petroleum grease (spec. 5694). Apply a small amount of grease to the end of the shaft opposite the mounting hub before the shaft is assembled into the hub. NOTE: Wiper shafts are lubricated for the life of the wiper assembly. Relubricate the shaft only when replacing wiper assemblies.

Wipe the lubricant from all parts and surfaces not intended to be lubricated.

## 8. TYPE 13 (25-POINT) AND TYPE 14 (50-POINT) ROTARY SWITCHES

### 8.1 General Description (Figure 33)

These switches are relatively high-speed, heavy-duty, single-motion, magnet-driven stepping devices. The wiper assembly is indirectly driven. The wipers advance when the armature is restoring after the coil is de-energized. The switches can be operated self-interruptedly through its interrupter springs or by remote-controlled pulses. These switches have no off-normal springs.

#### 8.1.1 Type 13 rotary switch.

The type 13 rotary switch is arranged for 25-point operation. Wiper tips are spaced 180° apart for each level. In one full revolution, the wipers will have traversed each bank contact twice.

#### 8.1.2 Type 14 rotary switch.

The type 14 rotary switch is arranged for 50-point operation (figure 34). The wiper for each level has only one wiping tip. The tips on succeeding levels are spaced 180° apart. The wipers of two levels are connected electrically. In one full revolution, the wipers will have traversed each bank contact of two levels once.

A four-level switch, operating at 48 volts d.c., has a maximum speed of 30 steps-per-second on remote control from an external pulsing device or 50 steps-per-second self-interruptedly. The minimum life of the switch is 5,000,000 half revolutions. The switch can be supplied with coils for any d-c operation up to 110 volts d.c. Standard coils are provided for 6, 12, 24, 48, 60, and 110 volts d.c. (see TABLE I).

### 8.2 Main Assemblies

The main assemblies of the type 13 and type 14 rotary switches are the bank assembly, the wiper assembly, and the driving mechanism (figure 33).

#### 8.2.1 Bank assembly.

This assembly is a semicircular structure of from one to six levels and is made up of alternate layers of phosphor bronze contacts and phenolic insulators. Each level has, besides its 25 bank contacts, a wiper brush spring which provides the electrical connection between the wiper and bank contact circuits. The wiper brush spring extends inward toward the

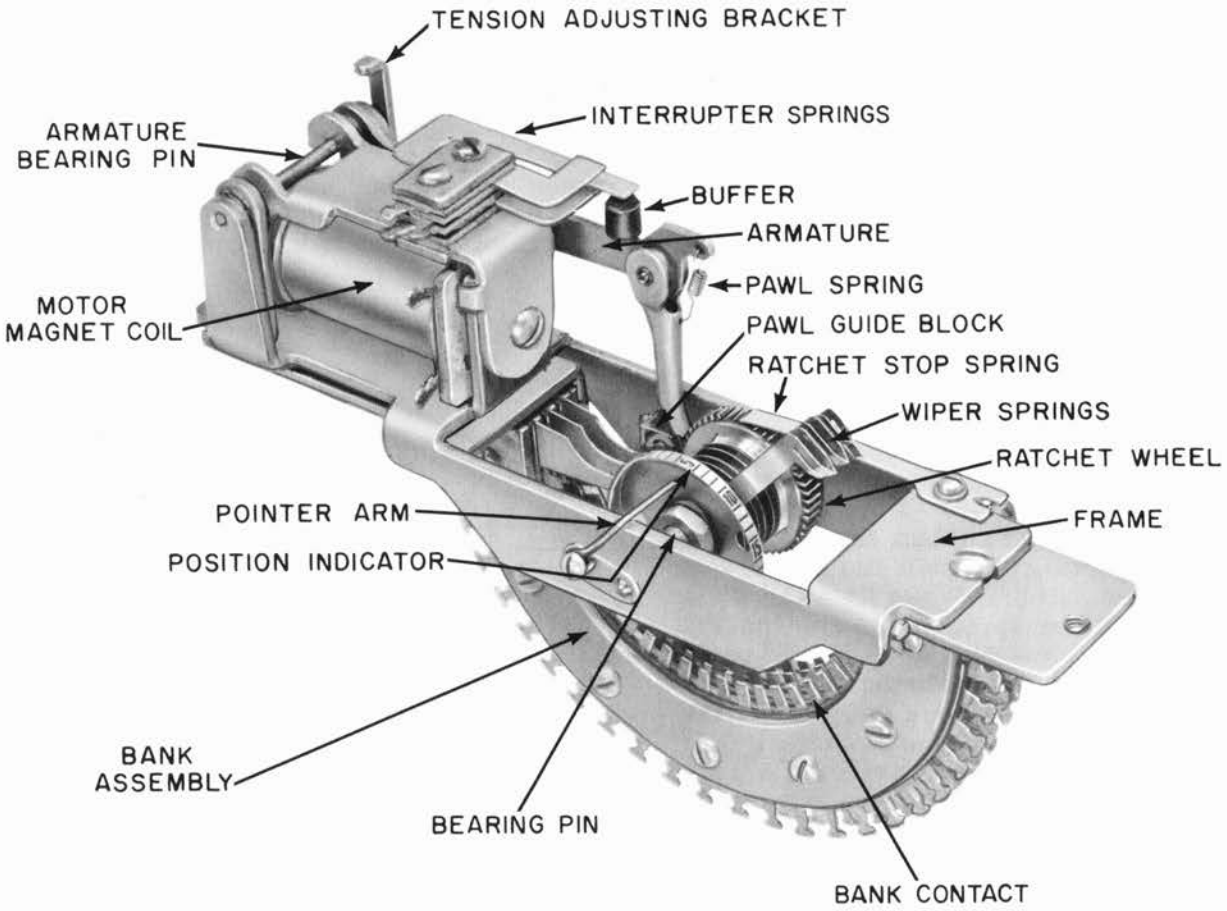



*Figure 33. Type 13 and type 14 rotary switch assembly details.*

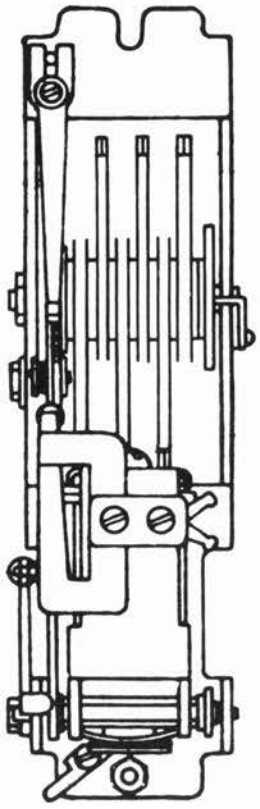


*Figure 34. Wiper arrangement for a 50-point switch.*

wiper bearing and is so positioned and tensioned that it makes frictional contact with its associated wiper. The brush contacts are located at the 26th position of the bank. The ratchet has 50 teeth, 25 for each half revolution of the switch. When the switch is normal, one end of the wipers is resting on contact 25 and the other end is resting on the brush contact springs.

8.2.2 Wiper assembly.

The wiper assembly consists of wiper blades, a ratchet, and a position indicator. These parts are assembled on a reamed shaft, one end of which is knurled, and the other threaded. A brass ratchet is force fitted over the knurled end. A hard rubber tube is placed over the shaft and on this is assembled the wiper springs, spacers, and insulators. The insulators extend to the end of the wipers to prevent accidental shorting of adjacent springs. The indicating wheel is held at the other end with a nut securely clamping the wiper springs in position.

The complete assembly rotates on a phosphor-bronze bearing pin. The undercut portion of this pin is filled with lubricating grease at the time of manufacture to provide a smooth

bearing surface for the life of the switch. The bearing plate, which is riveted to one end of the bearing pin, is secured to the frame with a screw. The wiper assembly may be disassembled from the frame by the removal of this plate.

The phosphor-bronze wiper blades are formed with wiping tips at both ends (180° apart). They are assembled in pairs and properly spaced on the shaft. A wiper pair touch both sides of a bank contact at the same time and can be either bridging or nonbridging.

8.2.3 Driving mechanism.

A ratchet, which is part of the wiper assembly, is engaged by a pawl riveted to the arm of the motor magnet armature. When the magnet is energized, the armature moves and withdraws the pawl from the ratchet. When the magnet is de-energized, a drive spring restores the armature to normal causing the pawl to engage the next ratchet tooth and thus stepping the wipers ahead to the next bank contact. At the end of the driving stroke, the armature strikes the armature stop, the wiper drives the pawl against the pawl stop to lock the wipers in place, and thus prevent overthrow. A stationary ratchet spring, which also engages the ratchet wheel, prevents backward movement of the wiper assembly, when the coil is energized.

8.3 Mounting

The type 13 and type 14 rotary switch frames are drilled and tapped for mounting with two 8-32 screws. When these switches are mounted on a panel or between two angle irons on a shelf, the banks and wiring project to the rear while the magnet and mechanism extend a maximum of 2-7/8 inches to the front. (Mounting dimensions are shown in figure 35.) Dimension "X" is 1-15/16 inches for type 13 rotary switches (25 point) 1 to 6 levels; for type 14 rotary switches (50 point) 1 to 3 levels, 2-15/32 inches; for type 14 rotary switches (50 point) 4 levels, dimension "Y" is 2-1/16 inches and 2-9/16 inches respectively.

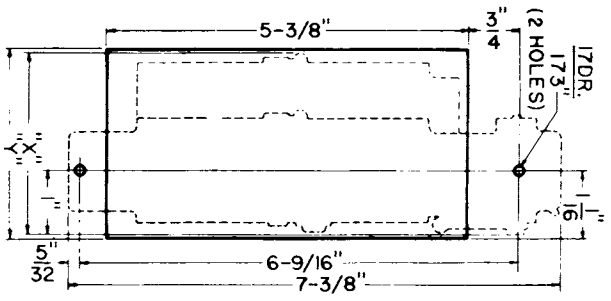



*Figure 35. Type 13 and type 14 rotary switch mounting dimensions.*

Brackets and studs are used to mount the switch away from a flat mounting surface such as a Strowger switch base (see figure 36). Sufficient space is provided for the bank wiring. Mounting brackets, similar as those used with the type 45 switch, may be used either with rubber cushions for noise damping or with metal spacers for rigid mounting. In this case, the switch projects 5-5/8 inches.

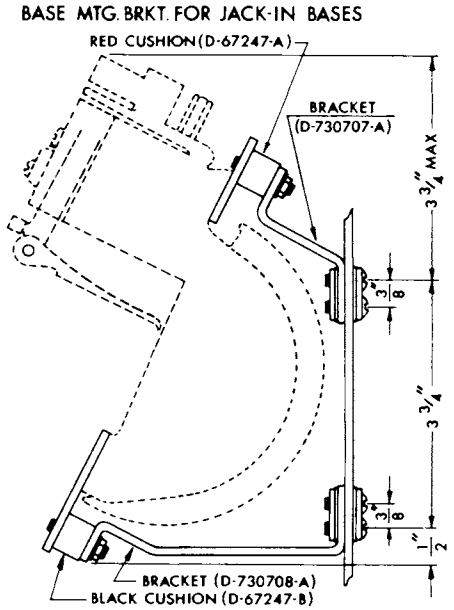



*Figure 36. Type 13 and type 14 rotary switch bracket mounting.*

8.4 Preventive Maintenance

Inspect and adjust the type 13 and type 14 rotary switches as follows:

8.4.1 Brush springs.

The brush springs, which are part of the bank assembly, should rest against the inner hub of the wipers with sufficient tension to insure good electrical contact as the wiper assembly rotates.

In general, the brush springs will not require readjustment during the life of the switch. If it does become necessary to readjust them, the bank must be removed by loosening the two mounting screws. Extreme care should be taken when reassembling the bank so as to avoid damage to the brushes and wipers. Check the brush spring tension as follows:

a. For general-purpose switches, the brush springs (wiper terminal springs) shall be tensioned and curved so that with all pressure relieved, the ends of the two springs in a pair shall be separated approximately 1/4 inches and when assembled in the wiper assembly the two springs will close to within approximately 1/4 inches of their ends.

b. When switches are used as finders or connectors on telephone switchboards, the brush springs (wiper terminal springs) shall be tensioned and curved so that with all pressure relieved, the ends of the two springs in a pair shall be separated approximately 3/8 inches and when assembled in the wiper assembly the two springs will close to within approximately 1/4 inches of their ends.

8.4.2 Wipers.

The wipers should have sufficient tension to insure good electrical contact with the bank contacts and should be aligned so as to pass onto the base of the brushes without excessive sidewise movement. Check the wiper spring alignment and tension.

For general-use switches:

a. The wiper assembly shall turn freely on its bearings.

b. The backs of all wipers shall be slightly flared.

c. The sets of wipers shall be aligned so that they pass onto the base of the brush terminals without excessive movement to one side or the other and the wiper springs of the first level should clear the pawl and pawl stop by a minimum of 1/64 inches during rotation.

d. Each spring of a wiper having a broad flat tip for contact surface shall be tensioned to follow approximately 3/32 inches, measured at the tip when its opposing spring is deflected.

e. Each spring of a wiper having a knife edge contact shall be tensioned to follow approximately 1/16 inches measured at the tip when its opposing spring is deflected.

NOTE: With the wipers off the bank, each of the two wiper tips shall make contact with and be approximately parallel to its mating wiper tip, the clearance should not exceed .004 inches at the point nearest the hub. The contacting surfaces of the two tips of a wiper shall be in line with a plane perpendicular to the hub.

This requirement shall be considered met if all four tips of each pair of wipers make contact with the brush as the wipers step onto the bank.

f. The indicator shall point to the number or line on the indicating wheel corresponding to the bank contacts on which the wipers are resting.

g. For switches used as finders or connectors, the wiper springs shall have a minimum tension of 25 grams and a maximum tension of 40 grams, as measured between the wipers and banks.

8.4.3 Bank.

The bank is attached to the switch frame by two mounting screws. One passes through an adjustable bushing and the other through a slot in the frame, which provides complete adjustment of the bank position relative to the frame. Check the position of the bank relative to the frame. This should be done in the following order:

a. Set the wipers on the 25th bank contact by moving the pawl stop.

b. Set the wipers on the first bank contact by turning the bank-adjusting bushing at the armature end of the switch.

c. Set the wipers on the 11th contact by loosening both mounting screws and shifting the bank as necessary.

d. The edge of the bridging or private wiper shall be approximately in alignment with the front edge of contacts No. 1 and No. 25, and the edge of the nonbridging or line wipers shall rest between 1/4 inches and 1/2 inches of the contact width ahead of the front edge of contacts No. 1 and No. 25.

e. With the wiper assembly in any normal position of rest, the bridging or private wipers shall not bridge adjacent contacts within 1/64 inches.

NOTE: The above requirements are adjustments of the pawl-stop and bank-adjusting screws.

8.4.4 Armature stop.

The pawl stop serves to position the wipers accurately on the bank contacts, but it is not intended to stop the full force of the armature driving stroke since such a condition would result in short life for both the pawl and the ratchet. An armature stop is therefore provided to arrest the driving blow of the armature just before the pawl engages its stop. Check adjustment of armature stop as follows:

a. The armature stop is most easily adjusted by turning it until it strikes the armature and then lightly tightening the mounting screw. By tapping the end of the stop, turn it until proper adjustment is obtained. Securely tighten the mounting screw.

b. The armature stop shall be set to relieve the pressure of the pawl against the pawl stop.

c. The armature stop shall allow play in the wiper assembly when the armature is against the stop and is engaging any ratchet tooth. This play shall be just perceptible on at least one tooth.

8.4.5 Ratchet spring.

The ratchet spring is provided to hold the wiper assembly in place while the armature pawl is being prepared for the next step. Check the ratchet spring tension and position as follows:

a. The tip of the ratchet spring shall clear the radial surface of each ratchet tooth with the armature against the armature stop. The clearance shall not exceed .004 inches.

b. The ratchet spring shall be tensioned to have a minimum pressure of 50 grams and a maximum pressure of 125 grams against the ratchet teeth, measured at the curve near the tip of the spring. NOTE: On five- or six-level switches, the minimum pressure may be 35 grams.

8.4.6 Armature.

a. The armature shall not bind on its bearing nor on the bearing pin locking spring.

b. The pawl shall not bind on its bearing nor on the switch frame.

c. The pawl spring shall cause the tip of the pawl to rest firmly against the ratchet when the armature is operated.

d. The contact spring operating bushing shall fit tightly on the armature and shall have a two-thirds minimum of its width opposite the associated springs.

e. The spring washer shall hold the armature stroke adjusting screw securely in place.

f. The stroke-adjusting screw shall be set so that the pawl just drops in on the next tooth without binding on the tip of the tooth when there is .002 inches between the screw and coil core and does not drop in without binding with .005 inches between the screw and coil core.

NOTE: The above condition shall be determined by operating the rotary magnet at its nominal voltage with the proper gauge inserted between the armature and the coil core and then depressing the pawl by hand to check its relationship to the ratchet teeth.

8.4.7 Motor magnet springs.

The motor magnet springs are actuated by a buffer attached to the armature of the switch. To secure long trouble-free life and correct operation of the switch, the contact pressures must be maintained and also the position of the armature in its stroke when the springs make or break contact. Check the tension and gauging of the motor magnet contact springs as follows:

a. Unless otherwise specified, when the gauging value for a make or break of the motor magnet springs given on the switch adjustment sheet is .003 inches, the variation allowed for inspection shall insure that the motor magnet springs make or break when there is a .002 inch gauge placed between the stroke adjusting screw and the coil core and do not make or break with a .005 inch gauge placed between the stroke adjusting screw and the coil core when the magnet is energized.

b. Unless otherwise specified, when the gauging values given in the switch adjustment sheet for a make or break of the motor magnet springs is .004 inches or more, the variation allowed for inspection shall insure that the springs make or break when a gauge .002 inches less than the specified value is placed between the stroke adjusting screw and the coil core, and shall not make or break when a gauge .002 inches greater than the specified value is placed between the stroke adjusting screw and the coil core when the magnet is energized.

NOTE: The break spring shall be adjusted after gauging to give maximum uniform speed on the voltage for which the switch is to be used.

If there are two sets of interrupter springs, when speed-testing the switch, adjust the outer set of interrupter springs to give maximum uniform speed on the voltage for which the switch is to be used.

8.4.8 Armature driving spring.

The proper tension required in the coiled spring on the heavy-duty type switch and the flat spring on the light-duty type switch are specified on the switch adjustment sheets. Check driving spring tension as follows:

a. When the first contact is a break contact, the tension of the armature driving spring shall be adjusted in accordance with the associated switch adjustment sheet. The total tension against the first back contact shall be 250 to 400 grams, unless otherwise specified on the switch adjustment

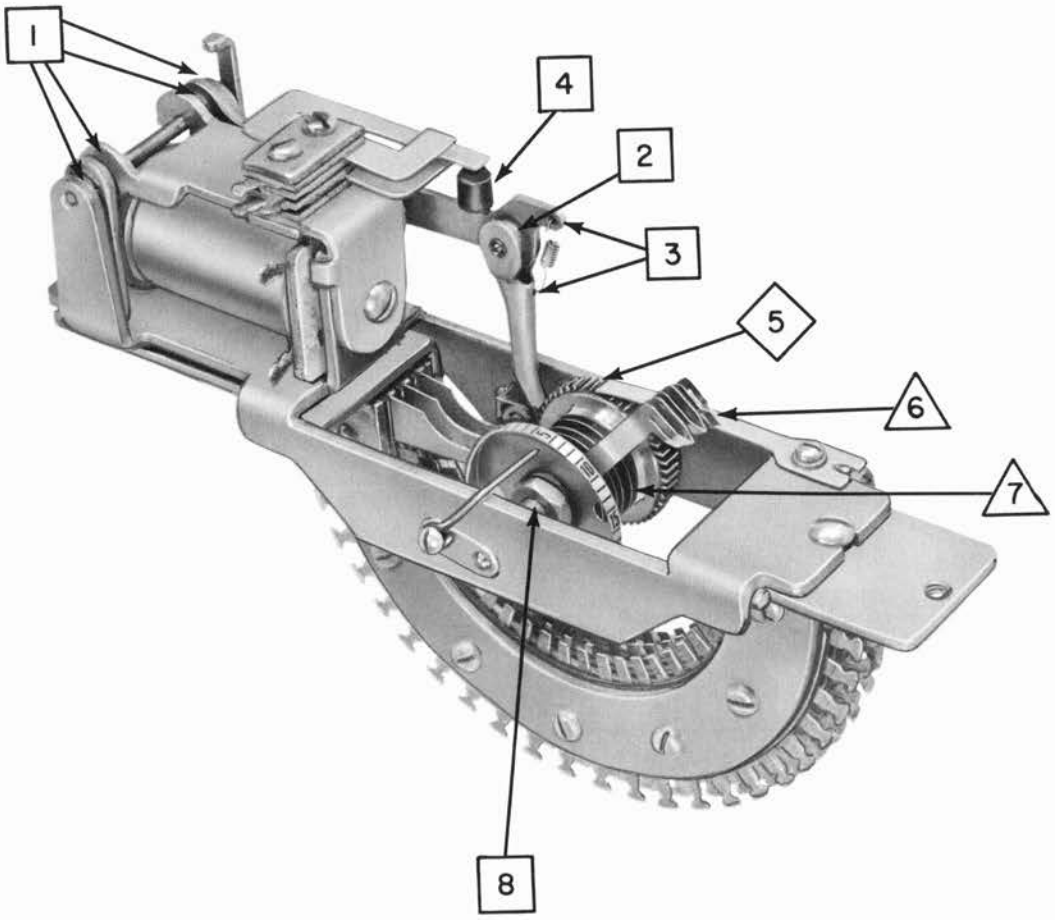



*Figure 37. Type 13 and type 14 rotary switch lubrication.*

sheet. If there is more than one armature spring, each individual armature spring shall have a minimum tension of 100 grams. When there are two sets of rotary-interrupter break springs, each set shall have a minimum tension of 150 grams and a maximum tension of 200 grams, measured at the end of the armature spring.

b. When the first contact is a make contact, the first armature spring shall be tensioned against the armature buffer with a pressure of 25 to 75 grams, measured at the end of the spring. The combined tension of the contact springs and the armature driving spring shall be adjusted in accordance with the associated switch adjustment sheet.

8.4.9 Self-interrupted speed test.

An over-all check on the adjustment of switches equipped with interrupter springs may be made by running the switch self-interruptedly.

8.4.10 Lubrication (figure 37).

The type 13 and type 14 rotary switches should be lubricated at 50,000; 100,000; and 250,000 half-revolutions, and every 500,000 half-revolutions thereafter. Clean the switch thoroughly and lubricate following steps a. through e. below:

a. Apply one dip of spindle oil (spec. 5231) to:

[1] Each of the four armature bearings (one dip to each bearing).

b. Distribute one dip of spindle oil (spec. 5231) among:

[2] The pawl bearing.

[3] The pawl spring mounting holes and coils.

[4] The interrupter spring buffers.

c. Apply two dips of graphite oil lubricant grade C (spec. 5232) evenly to:

◇5◇ The ratchet teeth. During lubrication, rotate the wiper assembly in order to distribute the lubricant over the ratchet teeth.

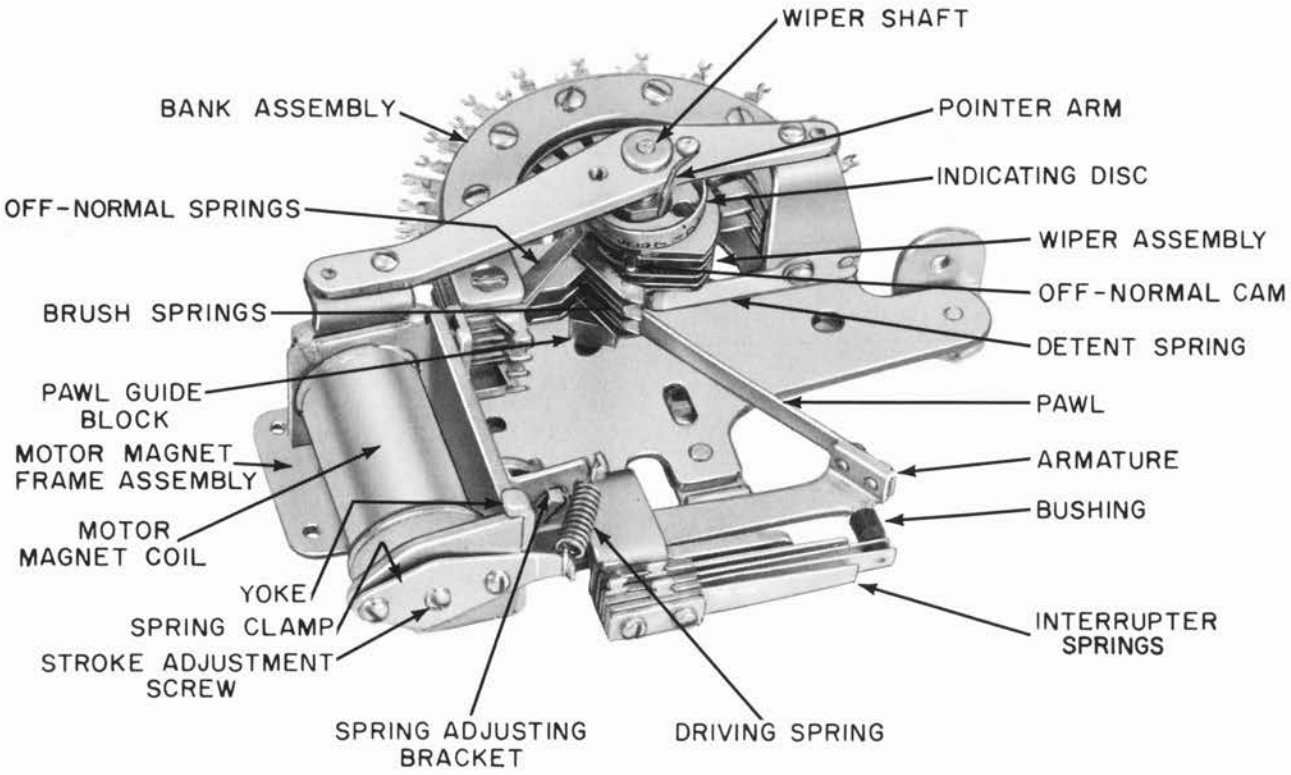



*Figure 38. Type 26 rotary switch assembly details.*

d. Distribute one dip of watch oil (spec. 5228) among:

△6 Three pairs of wiper tips. (Example: A three-level wiper assembly would require two dips of lubricant. A six-level wiper assembly would require four dips of lubricant.) NOTE: After lubrication rotate the wipers in order to distribute the oil on the banks.

△7 The insides of two wipers at a point near the hub; so that, when rotated, the lubricated part of the wipers will contact the brushes.

The lubrication of the bearing pin (wiper shaft) during manufacture is usually sufficient for the life of the switch. If excessive friction is noted:

e. Apply one dip of spindle oil (spec. 5231) between:

[8] The frame and the wiper assembly shaft at each end.

## 9. TYPE 26 ROTARY STEPPING SWITCH

### 9.1 General Description

The type 26 rotary switch (figure 38) is a relatively high-speed, heavy-duty, single-motion, magnet-driven, stepping device. The wiper assembly is indirectly driven. The wipers advance when the armature is restoring after the magnet has been de-energized. The switch can be operated self-interruptedly through its interrupter springs or by remote controlled pulses. This switch has off-normal springs. The wipers are formed with wiping tips at both ends (180° apart) and may be bridging or nonbridging.

The bank is a semicircular structure with either three or four levels of eleven contacts each. The brush springs, which are made up as a separate assembly, provide the electrical connection between the wiper and bank contact circuits.

The switch operates as follows: The magnet is energized, the armature operates against the tension of a coiled, drive spring, and the rotary pawl is positioned in the next tooth of the wiper assembly ratchet. When the magnet is de-energized, the coil-spring tension restores the armature and advances the wipers one step ahead. Thus the wipers are stepped (by pulses) to the magnet coil or automatically by interrupting its circuit at the magnet interrupter springs.

A four-level switch operating at 48-volts d.c. has a maximum speed of approximately 30 steps-per-second on remote control from external pulses and approximately 50 steps-per-second self-interruptedly. Minimum switch life is at least 5,000,000 half-revolutions.

This switch can be supplied with magnet coils for d-c operation up to 110 volts. Standard coils are provided for operation on 6, 12, 24, 48, 60, and 110 volts d.c. This switch is 5-3/4 inches over-all length, 2 inches in width, and 5 inches high. Its net weight is approximately 12 to 18 ounces.

9.2 Main Assemblies

The main assemblies of the type 26 rotary switch are the bank assembly, the wiper assembly, the driving mechanism, and the wiper brush assembly. The details of the assemblies are shown in figure 38.

9.2.1 Bank assembly.

a. This assembly is a semicircular structure, usually three for four levels, that is made up of alternate layers of phosphor-bronze contacts and phenolic insulators. Each level has eleven contacts.

b. The bank is attached to a "U" shaped mounting bracket, forming a complete bank assembly. This assembly is mounted on the switch frame with two hexagon-head screws. Slotted mounting holes permit adjustment of the bank position relative to the wipers.

9.2.2 Wiper assembly.

a. This is a precision made unit which is separately manufactured. This assembly consists of wiping springs, a ratchet, an indicating disc, and an off-normal cam for operating off-normal springs used with the homing type switch operation. The ratchet and shaft are machined from a single piece of phosphor bronze. The shaft rotates on bearings, one of which is staked to the frame and the other to the bearing plate. The plate is held to the frame with two machine screws. The wiper assembly can be removed by removing the plate.

b. Wipers consist of two phosphor-bronze springs with wiping tips formed on both ends (180° apart). The wipers touch both sides of a bank contact at the same time.

9.2.3 Driving mechanism.

a. The motor magnet heelpiece is staked to the switch frame. The armature seats against a yoke shaped bracket and the heelpiece and is held in position by the coil spring that drives the wiper assembly. Coil-spring tension is regulated by a hexagon head machine screw that is automatically clamped in place after adjustment.

b. The armature stroke adjusting screw is locked in place. One end of the coil spring is attached to the formed lug at the tip of this plate.

c. Two small machine screws hold the wiper assembly driving pawl to the end of the armature extension arm.

d. An adjustable pawl guide block, located on the frame adjacent to the ratchet wheel, prevents overthrow and locks the ratchet wheel in place after rotation. A flat detent spring holds the wiper assembly in position between rotary steps.

9.2.4 Wiper brush assembly.

a. The brush assembly permits the wipers to make the electrical connection between the bank contact and the brush contact circuits. A wiper brush is a thin phosphor-bronze spring formed and slotted at one end to make two wiping tips. These two tips are tensioned in opposite directions so as to make contact with the inner surfaces of a wiper pair.

b. The brushes are assembled as a separate spring pile-up and held to the switch frame with a machine screw. Off-normal springs are included in this assembly. They are open when the switch is in the home position and are part of the homing circuit.

9.3 Mounting

The type 26 rotary switch is mounted with two 8-32 screws. Brackets for mounting a single switch, parallel with and projecting 5-1/2 inches from a flat surface, are shown in figure 39.

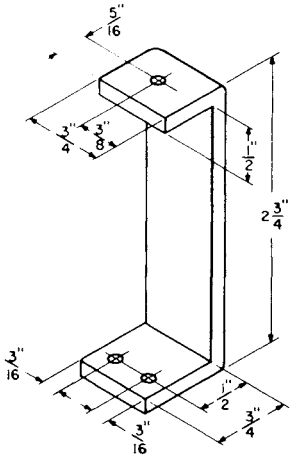



*Figure 39. Type 26 rotary switch mounting brackets.*

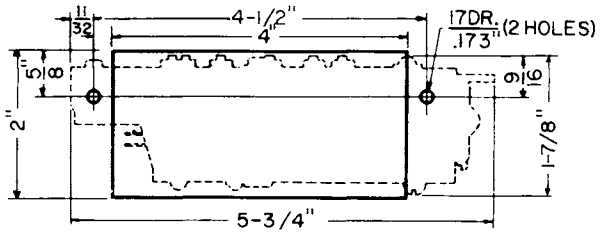



*Figure 40. Type 26 rotary switch mounting dimensions.*

Mounting and switch dimensions are shown in figure 40.

When these switches are mounted on a panel or between two angle irons on a shelf, the mechanism projects 2-3/4 inches to the front, and the banks and wiring 2-1/2 inches to the rear.

9.4 Preventive Maintenance

Inspect and adjust the type 26 rotary switch as follows:

9.4.1 Brush springs.

The brush springs should rest against the inner hub of the wipers with sufficient tension to insure good electrical contact as the wiper assembly rotates.

In general, the brush springs will not require readjustment during the life of the switch. If it does become necessary to re-tension them, the brush spring assembly must be removed. Extreme care should be taken when reassembling the brush springs so as to avoid damage to them or the wipers.

a. The brush springs (wiper terminal springs) shall be tensioned and curved so that with all pressure relieved, the ends of the two springs in a pair shall be separated approximately 1/8 inches and shall align with the wipers so as to have approximately equal pressure against the wiper springs of a pair.

b. The portion of the brush springs over which the tips of the wiper springs pass shall be aligned with the centers of the associated bank contacts within 1/64 inches. NOTE: Any forming of the brush springs to meet this requirement shall be limited to the portion within 3/16 inches of the insulating washers.

c. The ends of the brush spring shall clear the steel washers between the two wiper springs of a pair.

d. The ends of the brush spring shall clear the first bank contacts by minimum 1/32 inches.

9.4.2 Wipers.

a. The wipers should have sufficient tension to insure good electrical contact with the bank.

b. The wiper assembly shall turn freely on its bearings.

c. The sets of wipers shall be aligned so that they pass onto the base of the brush terminals without excessive movements to one side or the other.

d. Each spring of a wiper shall be tensioned to follow approximately 1/16 inches measured at the tip when its opposing spring is deflected.

e. The indicator shall point to the number or line on the indicating wheel corresponding to the bank contacts on which the wipers are resting.

9.4.3 Bank

The bank is attached to the switch frame by two hexagon-head screws which pass through slots in the switch bank to provide for adjustment of the bank. This should be done in the following order:

a. Assemble the bank and lightly tighten the mounting screw on the end of the frame opposite the armature.

b. Set the wipers on the 11th contact on type 26 switch by adjusting the pawl stop.

c. Set the wipers on the first contact by pivoting the bank about the mounting screw at the end of frame opposite the switch armature. Tighten both mounting screws.

When making switch bank adjustments, the armature stop and ratchet spring shall always be loosened.

d. The edge of the bridging or private wiper shall be approximately in alignment with the front edge of contacts No. 1 and No. 11, and the edge of the nonbridging or line wipers shall rest approximately on the center of contacts No. 1 and No. 11.

e. With the wiper assembly in any normal position of rest, the bridging or private wipers shall not bridge adjacent contacts within 1/64 inches.

9.4.4 Armature stop.

The pawl stop is only intended to position the wipers accurately on the bank contact, not to stop the full force of the armature driving

stroke since this would result in a short life for both the pawl and the ratchet teeth. An armature stop is therefore provided to arrest the driving blow of the armature just before the pawl engages its stop. Check adjustment of armature stop as follows:

a. The armature stop shall be set to relieve the pressure of the pawl against the pawl stop.

b. The armature stop shall allow play in the wiper assembly when the armature is against the stop and is engaging any ratchet tooth. This play shall be just perceptible on at least one tooth.

9.4.5 Ratchet spring.

The ratchet spring is provided to hold the wiper assembly in place while the armature pawl is being prepared for the next step. Check the ratchet-spring tension and position.

a. The tip of the ratchet spring shall clear the radial surface of each ratchet tooth with the armature against the armature stop. NOTE: The clearance shall not exceed .004 inches.

b. With the armature against the armature stop, the ratchet spring shall rest against the ratchet tooth with a minimum of 50 grams and a maximum of 125 grams pressure, measured 1/4 inches from the tip of the spring.

9.4.6 Armature.

The armature stroke, or travel is adjusted by turning the adjusting screw in the face of the armature. The two screws in the driving-spring bracket should be loosened when adjusting the armature stroke-adjusting screw, but they should be securely tightened afterwards. Check the armature as follows:

a. The armature shall not bind on the heel-piece.

b. The contact spring operating bushing shall fit tightly on the armature.

c. The driving-spring bracket shall hold the armature stroke-adjusting screw securely in place.

d. The stroke-adjusting screw shall be set so the pawl just drops in on the next tooth without binding on the tip of the tooth when there is .0015 inches between the screw and coil core and does not drop in without binding with .002 inches between the screw and coil core, on at least one tooth. NOTE: The above condition shall be determined by operating the rotary magnet on nominal voltage with the proper gauge between the armature and coil core and then depressing the pawl by hand to check its relationship to the ratchet teeth.

9.4.7 Pawl.

The pawl should not strike the switch frame but should rest securely against the ratchet teeth. Check the pawl as follows:

a. The pawl shall clear the switch frame.

b. The tip of the pawl shall rest against the ratchet when the armature is operated with a minimum of 50 grams and a maximum of 150 grams pressure.

c. The pawl stop shall have its diagonal surface resting squarely on the side of the pawl.

9.4.8 Interrupter springs.

The interrupter springs are actuated by a buffer attached to the armature of the switch. To secure proper operation the contact pressures must be maintained and the contacts must open and/or close with the armature at a specified point in its travel. Check the tension and gauging of the interrupter springs and the armature driving spring as follows:

a. Unless otherwise specified on the relay adjustment sheet, the interrupter springs shall open when there is a .006 inch gauge placed between the stroke-adjusting screw and the coil core and shall not open with a .007 inch gauge placed between the screw and the core when the magnet is energized.

b. When the first contact is a break contact, the tension of the armature driving spring shall be adjusted in accordance with the associated relay adjustment sheet. The armature spring or springs shall be tensioned with a pressure of 250 to 400 grams against the back contact spring, measured at the point where the armature bushing strikes the main spring, unless otherwise specified on the switch adjustment sheet.

c. When the first contact is a make contact, the combined tension of the contact springs and the armature driving spring shall be adjusted in accordance with the associated relay adjustment sheet. The armature spring shall rest against the armature bushing with a minimum pressure of 25 grams and a maximum pressure of 75 grams measured where the armature spring strikes the bushing.

9.4.9 Off-normal springs.

The off-normal springs, which are part of the brush spring assembly, should be adjusted to have sufficient contact pressure and so that they operate only on the proper step. Check the off-normal springs as follows:

a. The center of the off-normal spring operating arm bushing shall contact some portion of the flat form of the main contact spring.

b. With the wipers resting on the bank contacts on which the off-normal springs are to operate, break contacts shall open with approximately .015 inches contact separation.

c. With the wipers on the bank contact before or on the next contact after that on which the off-normal contact springs operate, the operating arm bushing shall clear the operating spring of break assemblies, and shall allow approximately .015 inches contact separation for make assemblies.

d. Contact pressure shall be a minimum of 30 grams.

9.4.10 Self-interrupted speed test.

An over-all check on the adjustment of switches equipped with break or break-make interrupter springs may be made by running the switch self-interruptedly. Recheck all adjustments if it does not operate smoothly.

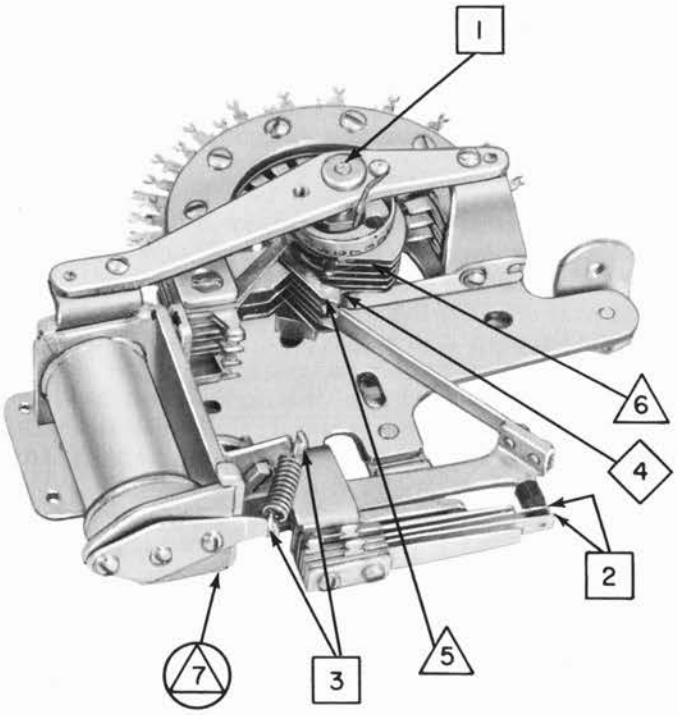



*Figure 41. Type 26 rotary switch lubrication.*

9.4.11 Lubrication (figure 41).

The type 26 rotary switch should be lubricated at 50,000; 100,000; and 250,000 half-revolutions and every 500,000 half-revolutions thereafter. Clean the switch thoroughly and lubricate following the steps below:

a. Distribute one dip of spindle oil (spec. 5231) among:

[1] Each of the wiper assembly bearings.

[2] The interrupter spring buffers and armature bushings.

[3] The driving spring mounts and coils.

b. Distribute one dip of graphite oil lubricant grade C (spec. 5232) to:

◇4 The ratchet teeth, while the wiper assembly is rotating.

c. Distribute one dip of watch oil (spec. 5228) between:

△5 Every three pairs of wiper tips. (Example: A three-level wiper assembly would require two dips of lubricant.) NOTE: After lubrication, rotate the wipers in order to distribute the oil on the banks.

d. Apply one dip of watch oil (spec. 5228) to:

△6 The insides of two wipers, at a point near the hub so that when rotated, the lubricated part of the wipers will contact the brushes.

e. Apply, sparingly, some plastic petroleum grease (spec. 5694) to:

(7) The entire length of the armature bearing surface. This should be done with a brush.

## 10. TYPE 40 AND TYPE 44 ROTARY SWITCHES

### 10.1 General Description

The type 40 and type 44 rotary switches (figure 42) are small, lightweight, and fast stepping. The type 40 rotary switch has 10 bank contacts per level, in one to five levels. The type 44 rotary switch has 11 bank contacts per level, in one to six levels. The switch driving magnet may be remote-pulse controlled, or may be operated self-interruptedly. The switches employ an indirect-driving mechanism. The wipers are stepped when the armature is restoring.

These switches, equipped with three levels and the maximum number of off-normal and interrupter springs, are small enough to permit mounting in the same panel space as a telephone-type relay. A typical three-level unit, operating at 48 volts, steps approximately 65 steps-per-second, self-interruptedly, and up to 35 steps-per-second when remote-pulse controlled. Life tests indicate an expected service life of 20 million one-third revolutions when run self-interruptedly. A three-arm wiper arrangement causes all bank contacts to be traversed in a one-third revolution of the wiper assembly.

Magnet coils may be supplied for any direct current up to 110 volts. Standard coils are furnished to allow operation at 6, 12, 24, 48, 60, and 110 volts d.c. (see TABLE I). The switches may be adapted for use with 115 volt, 60 cycle a.c. by using a suitable rectifier unit. Control switching must be done on the d-c side of the rectifier only.

10.2 Main Assemblies

The main assemblies of the type 40 and type 44 rotary switches are the bank assembly, the wiper assembly, and the driving mechanism. The details of the assemblies are shown in figure 42.

10.2.1 Bank assembly.

The switches may appear with either of two functionally identical bank assemblies, using either assembled or molded bank levels. The major difference appears in the design of the brush springs. The molded bank level uses a brush spring made of single-thickness contact material, and the assembled level uses a brush spring made of two-thicknesses of contact material. Each bank level has 10 (type 40) or 11 (type 44) bank contacts and the wiper brush spring. Since it is often necessary, from a circuit standpoint, to have the wiper rest on a bank contact in the 11th step, an extra contact is added in the first and second (control) levels and appears as the 12th contact on those levels on the type 44 switch only. In the normal or home position, no wipers rest on bank contacts (except on levels No. 1 and No. 2 of the type 44 switch). The individual bank levels (11-point banks) are fastened to a bank plate which mates with slots in the switch frame.

The slot arrangement allows removal of the switch frame from its mounting without disturbing the bank wiring, and allows adjustment of the bank with relation to the wipers. When specified, these switches may be fitted with bank terminals suitable for use with Series 78 A-MP Taper Tabs.

10.2.2 Wiper assembly.

The wiper assembly consists of a hub and ratchet, wheel, a set of wiper blades for each bank level, and an indicator wheel all permanently assembled. The assembly fits onto the wiper shaft and is held in position by a machine screw. Three off-normal spring cam lobes

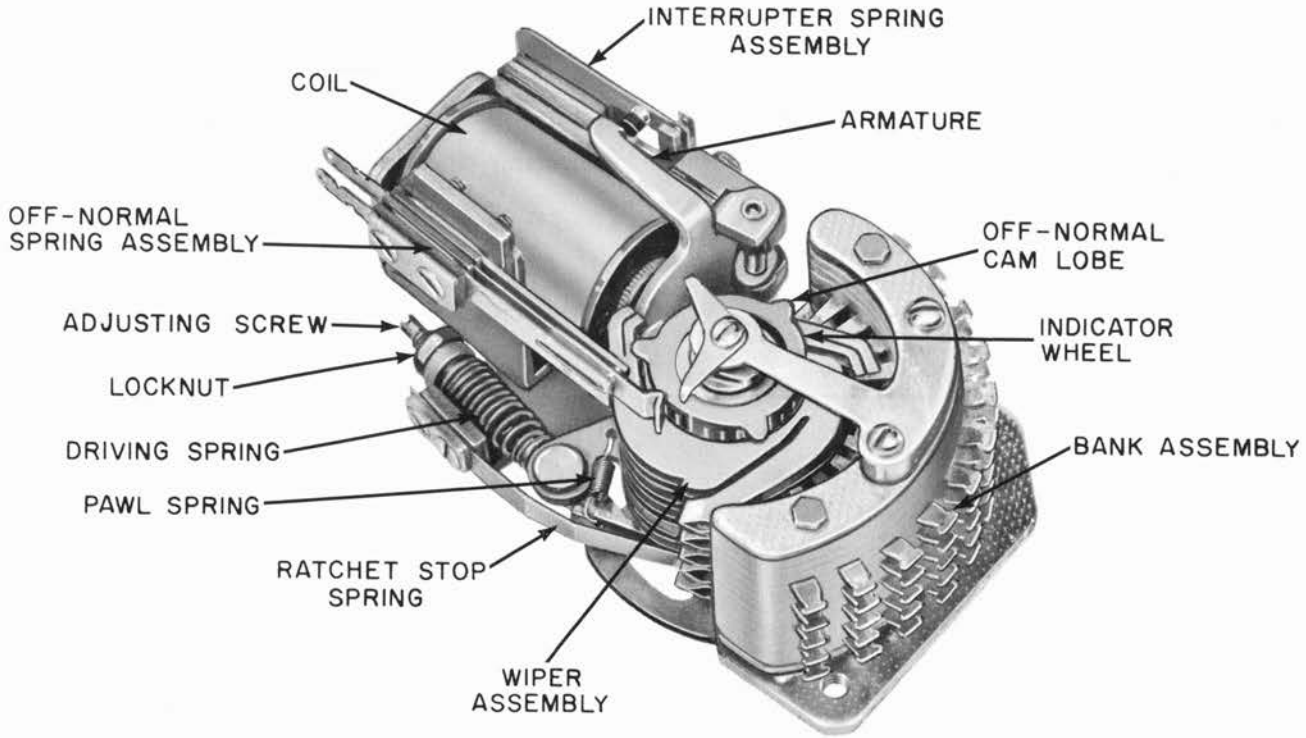



*Figure 42. Type 40 and type 44 rotary switch assembly details.*

are molded onto the indicator wheel. These cam lobes operate the off-normal springs when the wipers are in the normal or home position.

10.2.3 Driving mechanism.

The indirect-drive type driving mechanism, consists of the driving magnet coil and armature, stopping teeth (on the armature), the pawl and pawl spring, the driving spring, and detent stop spring all mounted on one side of a steel frame. Operation of the indirect-driving mechanism is described in section 2.3.1. The interrupter springs and the off-normal springs are also mounted on the switch frame. The interrupter springs are operated by the armature arm and the off-normal springs are operated by the wiper assembly indicator wheel cams.

10.3 Arrangement for 20- or 30-Point Operation (Type 40) or for 22- or 33-Point Operation (Type 44)

A 20- or 22-point switch for three contact levels (6 bank levels) and a 30- or 33-point switch for two contact levels (6 bank levels) may be obtained by using wipers having one, instead of three, wiping tips. These special wiper assemblies are arranged so that the first wiper rotates over the first level on the first 10 or 11 steps, the second wiper rotates over the second level on the next 10 or 11 steps; and for 30- or 33-point operation, the third wiper rotates over the third level on the following 10 or 11 steps (see figures 43 and 44). The wipers are electrically commoned by strapping the external terminals of their associated brush contacts. The lobes are removed from the periphery of the indicator wheel at the 10th or 11th and 20th or 22nd positions so that the off-normal springs are operated only in the home position or once during each revolution of the wipers.

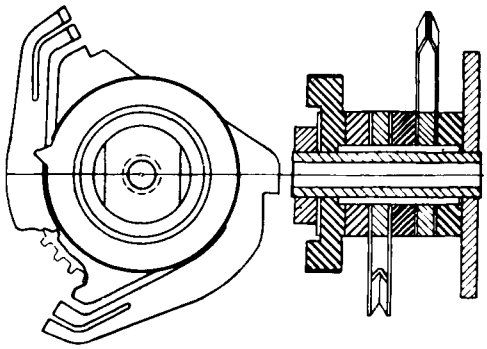


*Figure 43. Wiper arrangement for 20- or 22-point bank.*

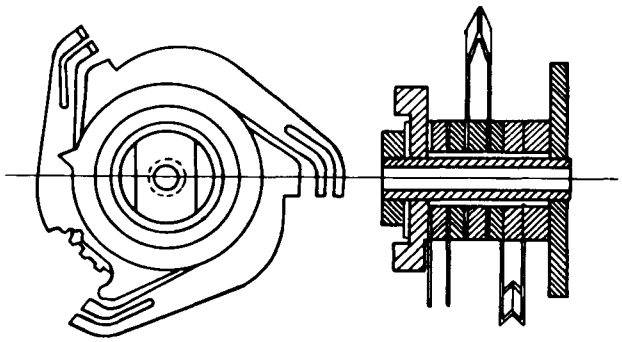


*Figure 44. Wiper arrangement for 30- or 33-point bank.*

10.4 Mounting

For greatest shock resistance, the type 40 and type 44 rotary switch should be mounted flat with the bank levels parallel to the mounting surface. The type 40 and type 44 rotary stepping switches may be furnished with a mounting bracket. Refer to figure 45 for overall dimensions of the switch. Two types of mounting brackets are available. The base mounting type mounts the switch at right angles to the mounting surface as illustrated in figure 46. This particular bracket is slotted to allow the switch to be swung away from the mounting panel to provide access to the bank terminals from the front and to adjustment points, when the switch is surrounded by other equipment.

The second bracket (for shelf mounting) mounts the unit parallel to the mounting surface as illustrated in figure 47. The bracket is drilled and tapped for mounting with 8-32 screws. Three screws are required for base mounting and two for shelf mounting.

When the switch is furnished with solderless terminals for use with A-MP Taper Tabs special base or shelf mounting, brackets are required (figures 46 and 47).

Mounting dimensions are shown in figure 48.

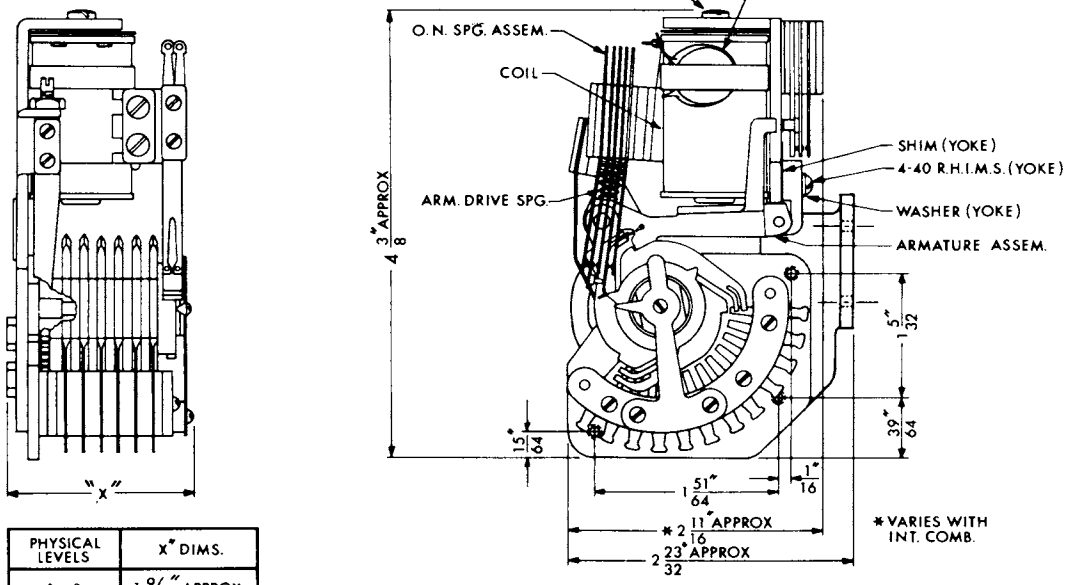
10.5 Preventive Maintenance

Type 40 and type 44 rotary switches should be inspected, tested, and adjusted if necessary, according to the following procedures:

10.5.1 Brush springs.

The brush springs, which are part of the bank assembly, should rest against the inner hub of the wipers with sufficient tension to insure good electrical contact as the wiper assembly rotates.

Check the brush spring tension. In general, the brush springs will not require readjustment during the life of the switch. If adjustment is necessary, the switch must be removed from its bank. Loosen the two hexagon-head machine screws to permit separation of bank




| PHYSICAL LEVELS | "X" DIMS. |
|---|---|
| 1 - 3 | 1 9/32" APPROX. |
| 4 SPCL. | 1 43/64" APPROX. |
| 4 - 6 | 1 57/64" APPROX. |
| 7 - 8 | 2 9/32" APPROX. |

*Figure 45. Type 40 and type 44 rotary switch over-all dimensions.*

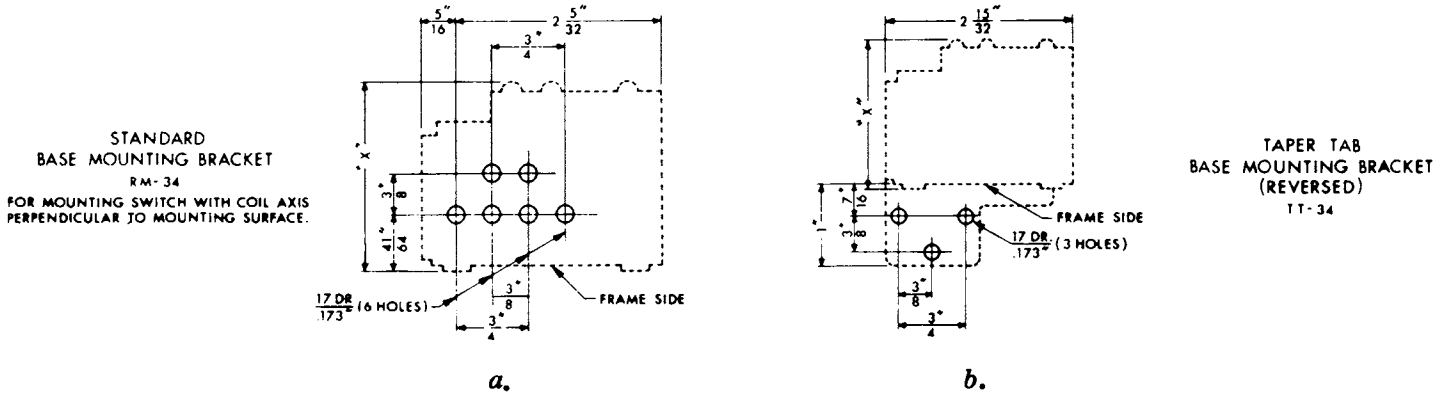



*Figure 46. Type 40 and type 44 rotary switch base mounting bracket.*

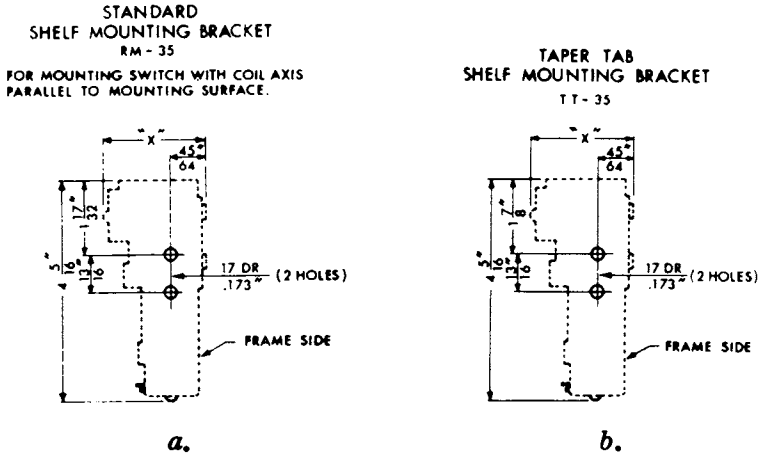



*Figure 47. Type 40 and type 44 rotary switch shelf mounting bracket.*

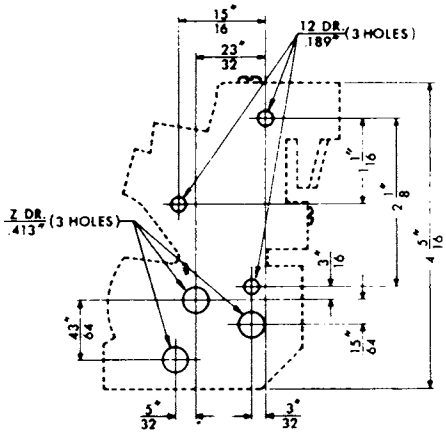



*Figure 48. Type 40 and type 44 rotary switch mounting dimensions.*

and wiper. Remove the two round-head machine screws which fasten the indicator pointer to the bank assembly. Extreme care should be taken when reassembling the switch to avoid damage to the brushes and wipers.

CAUTION: There are two types of brush springs: brush springs on molded bank levels and brush springs on assembled bank levels.

a. Molded bank levels. The two legs of the brush spring (wiper terminal spring) shall be tensioned and curved, so that with all pressure relieved, there shall be a separation of 3/64 inches minimum and 1/8 inches maximum between the tip of the short leg and the other leg in a line perpendicular to the bank mounting frame. When assembled in the switch assembly, the two legs of the spring shall be spaced equidistant from a line through the center of the contacts.

b. Assembled bank levels. The brush springs (wiper terminal springs) shall be tensioned and curved, so that with all pressure relieved, the ends shall be separated approximately 5/32 inches. When assembled in the wiper assembly, the two springs shall lie flat against each other along the length visible from the pawl side of the switch.

10.5.2 Wiper assembly.

The wipers should have sufficient tension to insure good electrical contact with the bank contacts. Check the wiper spring alignment and tension as follows:

a. The wiper assembly shall turn freely on its shaft. NOTE: On switches equipped with a shaft-support bracket, this requirement shall be met with the shaft-support bracket firmly tensioned against the shoulder of the shaft.

b. Each spring, of a bridging or nonbridging wiper pair shall be tensioned to follow a minimum of 1/8 inches and a maximum of 5/32 inches, measured at the tip when its opposing spring is deflected. This adjustment shall be met when one set of wipers is positioned on the fifth contact.

c. The wiper pairs shall be aligned so that they pass onto the base of the brush without excessive movement (1/64 inches) to one side or the other.

d. With the wipers resting on the bank contacts, there shall be a minimum clearance of 1/32 inches between the wiper springs of adjacent wiper pairs.

e. The indicator shall point to the line or raised portion on the indicator wheel corresponding to the bank contact on which the wipers are resting. NOTE: The triangle on the indicator wheel is the normal or home position.

10.5.3 Armature.

When the armature is operated, the pawl is positioned in the next tooth of the ratchet wheel. A coil-type spring restores the armature when the magnet is de-energized, rotating the wiper assembly one contact, after which the stopping teeth on the armature engage the ratchet wheel teeth. For proper operation, there must be no binds in the armature assembly.

a. Check the armature air line. The armature shall clear the heelpiece; and a .003 inch gauge shall be tight and a .0015 inch gauge shall be loose in the air line, with the armature electrically operated. The armature shall be parallel to the heelpiece as gauged visually.

b. Check the pawl-spring tension. The pawl tip shall rest against the ratchet wheel with a minimum pressure of 130 grams and a maximum pressure of 175 grams, with the armature in the unoperated position. The pawl shall not bind in its bearings. The edges of the pawl, along its length, shall be parallel to the sides of the ratchet wheel; and the tip of the pawl shall be parallel to the edge of the ratchet teeth as gauged by eye.

c. Check the stopping teeth engagement. The stopping teeth engagement is adjusted by placing the correct shim (.006 inches, .010 inches, or .014 inches) under the yoke. (Readjustment of engagement should not be required throughout the life of the switch unless the armature is replaced.)

   The armature stopping teeth shall not project beyond either edge of the ratchet teeth by more than .010 inches in any position allowed by play in the armature bearings, and the edge of the pawl shall project a minimum of 1/64 inches and a maximum of 3/64 inches beyond the wiper side of the ratchet teeth in any position allowed by play in the armature and pawl bearings.

d. The wiper springs shall clear the armature and pawl a minimum of 1/32 inches during rotation.

e. (When replacing the armature only.) With the ratchet stopping spring held away from the ratchet and the armature in the unoperated position:

(1) The pawl shall not bind, with the play between the ratchet wheel and the armature stopping teeth taken up in the direction of wiper rotation, and the pawl is lifted out of the ratchet teeth.

(2) There shall be a clearance (.008 inches maximum) between the normally engaged surface of the stopping teeth and ratchet, with the play taken up in the direction opposite to wiper rotation.

NOTE: The above requirement is met by selecting the correct shim (.006 inches, .010 inches, or .014 inches) and placing it between the yoke and heelpiece. The thinnest suitable shim should be used to avoid interference between the stopping teeth and the top surface of the ratchet teeth as the armature restores. These shims are not furnished with replacement armatures, but must be ordered separately.

10.5.4 Ratchet stopping spring.

The ratchet stopping spring is provided to hold the wiper assembly in place while the armature pawl is being prepared for the next step. Check the ratchet-spring tension and position as follows:

a. The ratchet stopping spring shall be tensioned to have a minimum pressure against the ratchet wheel of 75 grams and a maximum of 125 grams, measured at the tip of the spring.

b. With the armature in the unoperated position, the ratchet stopping spring shall clear the armature and pawl by a minimum of 1/32 inches.

c. With the play between the pawl and ratchet wheel taken up in the direction opposite to wiper rotation, and the armature in the unoperated position; there shall be a minimum of a perceptible clearance to a maximum of .003 inches between the spring tip and the radial surface of the ratchet tooth.

d. The tip of the ratchet stopping spring shall project a minimum of 1/64 inches beyond the wiper side of the ratchet wheel and shall be parallel to the edge of the ratchet teeth as gauged by eye.

e. The wiper springs shall clear the ratchet stopping spring a minimum of 1/32 inches during rotation.

10.5.5 Bank.

The bank is attached to the switch frame by two screws. The mounting holes in the frame are slotted, providing an adjustment of the bank position relative to the frame. Check the bank position relative to the frame.

The flat tips of the bridging wipers shall be approximately centered on the bank contacts and the edge of nonbridging wipers shall lie on the center third of the contact. NOTE: The above requirement is an adjustment of the bank position.

10.5.6 Armature driving spring.

A coil-type spring restores the armature when the magnet is de-energized, driving the wiper assembly. An adjustment screw and locknut are provided. The proper pressure required is specified on the switch adjustment sheets.

a. Check the restoring spring pressure. The armature driving spring pressure shall be adjusted in accordance with the associated switch adjustment sheet, which expresses pressure in terms of margining current.

b. The armature shall completely restore from the operated position when retarded by hand and allowed to restore slowly on any step.

10.5.7 Interrupter springs.

The interrupter springs are actuated by an arm on the armature of the switch. To secure long, trouble-free life and correct operation of the switch, the contact pressures and also the position of the armature in its stroke must be maintained when the springs make or break contact. Check the tension and gauging of the interrupter springs as follows:

a. With the armature electrically operated, the portion of the armature arm which actuates the spring bushing shall be parallel to the frame as gauged by eye and shall clear the frame a minimum of .010 inches. The spring buffer shall be perpendicular to the armature spring and shall not project more than .005 inches beyond the edge of the armature arm.

b. Contacts shall not be out of alignment (judged visually) by more than 40% of their base diameter.

c. The interrupter springs shall be gauged as specified in the associated switch adjustment sheet by inserting a gauge of the proper value between the armature and the coil core. Unless otherwise specified on the switch adjustment sheet, a variation from the values specified or plus or minus .001 inches shall be allowed for inspection.

NOTE: The break spring shall be adjusted after gauging to give maximum uniform speed on the voltage for which the switch is to be used. If there are two sets of interrupter springs, adjust the outer set of interrupter springs when speed testing the switch to give maximum uniform speed on the voltage for which the switch is to be used.

d. Break springs shall have a minimum contact pressure of 275 grams and a maximum of 400 grams. (When there are two sets of interrupter break springs, each set shall have 150 grams minimum, and 200 grams maximum contact pressure.)

e. There shall be a minimum of .002 inches difference between the break and make gauging of any break-make combination.

f. Both contacts of a pair shall make or break within .002 inches of each other as gauged visually.

g. The contact gap, on make or break springs, shall be .008 inches minimum.

10.5.8 Off-normal springs.

The off-normal springs are usually provided to open homing circuits when the wipers are on the 10th step (type 40) or 11th step (type 44). They may, however, perform other functions. Adjustment of the off-normal springs should insure good electrical contact on both make and break springs. Check the off-normal springs as follows:

a. The off-normal spring assembly shall be approximately parallel to the surface of the switch frame to which the wiper shaft is mounted.

b. The apex of the V-form of the main lever spring shall approximately line up with the center line of the off-normal actuating lobe of the indicator wheel on the 10th step (type 40) or 11th step (type 44) and the edge nearest the wiper springs shall not be closer than 1/32 inches to the edge of the lobe. The V-form shall clear the lobe on the 10th and 1st steps by a minimum of .010 inches in any position permitted by play in the wiper assembly.

c. The wiper springs shall clear the off-normal springs a minimum of 1/32 inches during rotation.

d. The apex of the V-form of the main lever shall be approximately parallel to the wiper shaft.

e. There shall be a perceptible clearance between the V-form of the main spring and the indicator wheel on steps 1 to 9 (type 40) or 1 to 10 (type 44).

f. Break springs shall have a total contact pressure of not less than 35 grams nor more than 50 grams, as measured between the form or buffer and the contact at a point nearest the form or buffer. On assemblies with more than one pair of break springs, each pair of contacts must have a minimum of 35 grams and a maximum of 50 grams contact pressure.

g. Make springs shall have a total contact pressure of not less than 30 grams; 15 grams for each contact of a pair, measured at the ends of the make spring.

h. Where a lever spring has a make contact only, it shall be tensioned against the preceding lever spring or stop spring with a minimum pressure of 25 grams and a maximum of 35 grams.

i. Make and break springs shall have a minimum contact separation of .008 inches.

j. Both contacts of a pair shall make or break within .002 inches of each other as gauged visually.

k. In combinations where the second pair of springs are break springs, the buffer of the second lever spring shall clear the first lever spring by a minimum of space that is perceptible and a maximum of .003 inches when the combination is not operated by the actuating arm.

10.5.9 Self-interrupted speed test.

An over-all check of the adjustment of switches equipped with interrupter springs may be made by running the switch self-interruptedly. If the switch does not operate properly, all adjustments should be rechecked.

10.5.10 Lubrication (figure 49).

Switches should be kept clean and well lubricated. It is recommended that the type 40 and type 44 rotary switches be lubricated at 50,000; 100,000; and 250,000 one-third revolutions and every 500,000 one-third revolutions thereafter.

NOTE: For low-temperature lubrication instructions, contact Automatic Electric Company, Northlake, Illinois.

When lubricating, clean the brush before using a different lubricating oil. Clean the switch thoroughly and lubricate following steps a. through g. below.

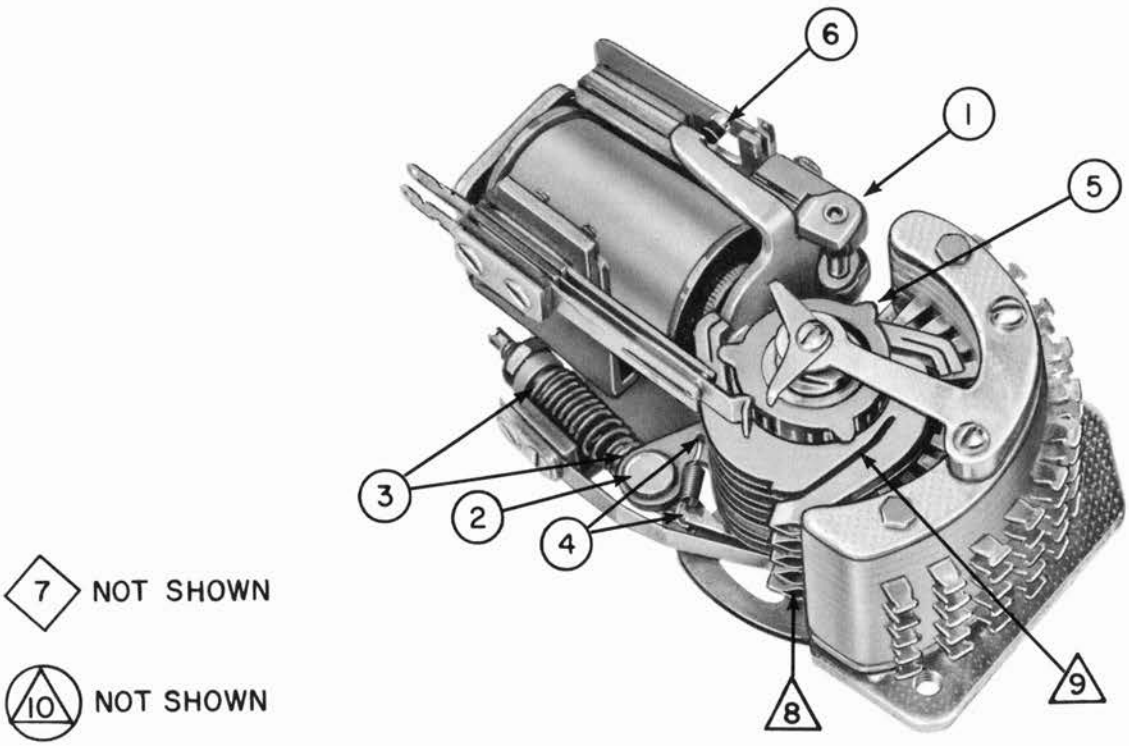



*Figure 49. Type 40 and type 44 rotary switch lubrication.*

a. Distribute one dip of blended lubricating oil (spec. 5684) to:

(1) Each of the yoke bearings.

b. Apply one dip of blended lubricating oil (spec. 5684) to:

(2) The pawl bearing, where the pawl and pawl bearing pin contacts the armature (on both sides of the armature).

c. Distribute, evenly, one dip of blended lubricating oil (spec. 5684) to the following points:

(3) The driving spring seats and coils.

(4) The pawl spring mounting holes and coils.

(5) The off-normal cam lobes of the indicator wheel.

(6) The interrupter spring buffers.

d. Apply two dips of graphite oil lubricant grade C (spec. 5232) to:

(7) The ratchet teeth, while the wiper assembly is rotating.

e. Distribute one dip of watch oil (spec. 5228) between:

(8) Every six pairs of wiper tips. (Example: A two-level wiper assembly would require one dip of lubricant. A four-level wiper assembly would require two dips of lubricant. A six-level wiper assembly would require three dips.) NOTE: After lubrication, rotate the wipers in order to distribute the oil on the banks.

f. To lubricate the brush springs, position the wipers on the first contact and lubricate as follows. Apply one dip of watch oil (spec. 5228) to:

(9) Every three pairs of wipers, at some point near the hub which will contact the brush spring. (Example: A two-level wiper assembly would require two dips of lubricant. A four-level wiper assembly would require four dips of lubricant. A six-level wiper assembly would require six dips of lubricant.)

g. For disassembled switch as follows:

(10) Fill the undercut portion of the wiper shaft with plastic petroleum grease (spec. 5694). Apply a small amount of grease to the end of the shaft opposite the mounting hub before the shaft is assembled into the hub. NOTE: Wiper shafts are lubricated

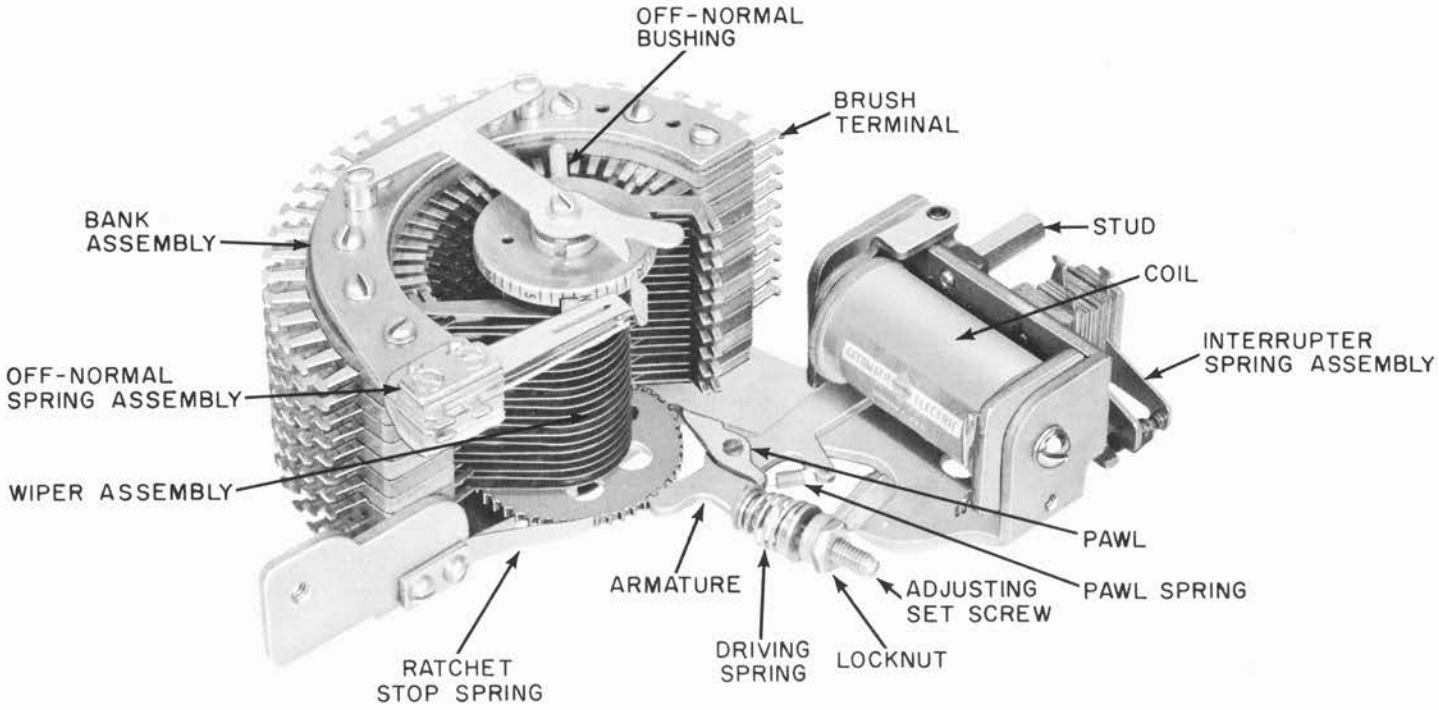



*Figure 50. Type 45 rotary switch assembly details.*

for the life of the wiper assembly. Relubricate the shaft only when replacing wiper assemblies.

## 11. TYPE 45 ROTARY SWITCH

### 11.1 General Description

The type 45 rotary switch (figure 50) is a high-speed, heavy-duty, single-motion, stepping switch with positive nonoverthrow stopping. It can be operated by remote-control pulses or self-interruptedly through its own interrupter springs. The wipers, with wiping tips formed at both ends (180° apart) are rotated in one direction over a semicircular contact bank.

The bank level has 25 contacts and one wiper brush terminal contact. The frame, bank, and wiper assembly design permits the addition of levels up to a maximum of 16, without altering the basic construction. If 16 wipers are used, at least 8 must have tips at only one end (see figure 51). No more than 12 wiper tips are to be on the bank contacts at any one time. Wipers may be bridging or nonbridging.

Off-normal springs, with make and break combinations and actuated on the 26th step by a wiper assembly arm, are provided as required. These springs may be used for homing or other external circuits.

The switch is fast stepping and requires only one field adjustment. The operating speed for a 48-volt, 10-level switch is approximately 50 steps-per-second self-interrupted. When operating from external pulses a maximum of approximately 35 steps-per-second can be obtained.

The type 45 switch has an expected life of 10,000,000 half-revolutions operated self-interruptedly. It has a special industrial application when the speedy searching and selection for one marked contact out of a group of maximum 25 or 50 terminals is required. The type 45 is an indirect-drive type switch and operates as previously described for the type 44 rotary stepping switch.

The switch may be supplied with magnet coils for operation at any d-c voltage up to 110 or any a-c voltage up to 115. Standard coils are provided for operation at 6, 12, 24, 48, 60, or 110 volts d.c. (see TABLE I).

### 11.2 Main Assemblies

The main assemblies of the type 45 rotary stepping switch are the bank assembly, the wiper assembly, and the driving mechanism.

The details of the assemblies are shown in figure 50.

#### 11.2.1 Bank assembly.

This assembly is a semicircular structure made up of alternate layers of contacts and phenolic insulators or may be assembled of molded bank levels. This provides a hard

moisture-proof bank which will withstand a voltage breakdown test of 1250 volts a.c. rms.

Each level has, besides its 25 bank contacts, a wiper brush spring at the 26th position of the switch. The wiper brush spring extends inward toward the wiper bearing and is so positioned and tensioned that it makes frictional contact with its associated wiper.

It is often necessary, from a circuit standpoint, to have the wipers rest on a bank contact at the 26th step. An extra contact, therefore, is provided to the control levels (1st and 2nd levels) that appear as the 27th bank terminal. There are 26 steps to each half revolution.

11.2.2 Wiper assembly.

This assembly consists of a hub bearing assembly, ratchet wheel, wipers, insulators, and a position indicator wheel.

The bearing hub is a hardened seamless, steel tube. The 52 tooth ratchet wheel, the desired number of wipers and their separation insulators are assembled to the hub. The wiper assembly hub fits over and rotates on a steel shaft. Before being placed on the shaft, the retaining cavity of the hub is partially filled with a low-temperature lubricating grease for the bearing surface. This will usually last for the life of the switch. A pair of wipers is made up of two wiping springs formed with wiping tips at both ends (180° apart). The split tips act like twin contacts and insure double contact on each side of a bank terminal. The control level wipers are formed with a much larger wiping area so that they will bridge adjacent contacts, as the switch is rotating. Bridging wipers are supplied as required.

The periphery of the indicator wheel is divided into two equal parts by two cam posts, 180° apart. These cam posts operate the off-normal springs when the wipers are stepped to the first bank position. The indicating pointer will now point to the first line on the indicating wheel. A projection, at the foot of the T-bracket serves as the indicating pointer.

11.2.3 Driving mechanism.

This assembly consists of the driving magnet coil, a combined armature and stop, a driving spring, a pawl and a pawl spring. The driving coil is usually 100 ohms for 48-volt d-c operation. Operation at other voltages is possible through the use of suitable coils (see TABLE I).

An open, one piece, single-sided switch frame is used. The bank is mounted on one side of this frame so that it may be built up from two to a possible maximum of 16 levels, without alteration to the frame itself.

The off-normal springs, which are mounted on the tip of the bank frame, are operated by the off-normal bushings on the number indicator wheel. The interrupter springs, which are mounted on the switch frame, are operated by the armature arm. The detent spring is also mounted on the switch frame and is tensioned to engage the teeth of the ratchet wheel holding the wipers in place, while the armature is operating.

11.3 50-Point Operation (Figure 51)

A 50-point switch for a maximum of five contact levels (10 bank levels) may be obtained by using two bank levels and two separate wipers. These wipers, spaced 180° apart, have wiping tips on only one end. One wiper rotates over one level for the first 25 steps and the other over the second level for the next 25 steps. Both sets of wipers are electrically connected by strapping the external terminals of their associated wiper brushes.

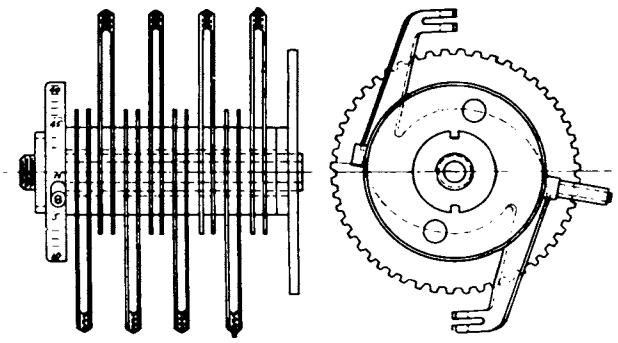


*Figure 51. Wiper arrangement for a 50-point switch.*

11.4 Mounting

The type 45 rotary stepping switch is drilled and tapped for mounting with two 8-32 screws. Mounting arrangements for this switch are as follows:

a. Surface mounting on a relay base is illustrated in figure 52. One switch, using these brackets, requires six vertical relay spaces. If the adjacent space is to be occupied, switch banks cannot exceed four levels. The frame is supported on 1/2 inch rubber cushions (black, soft rubber and red, firm rubber) for noise suppression. Two pairs of brackets are required for mounting a switch of 2-12 levels and

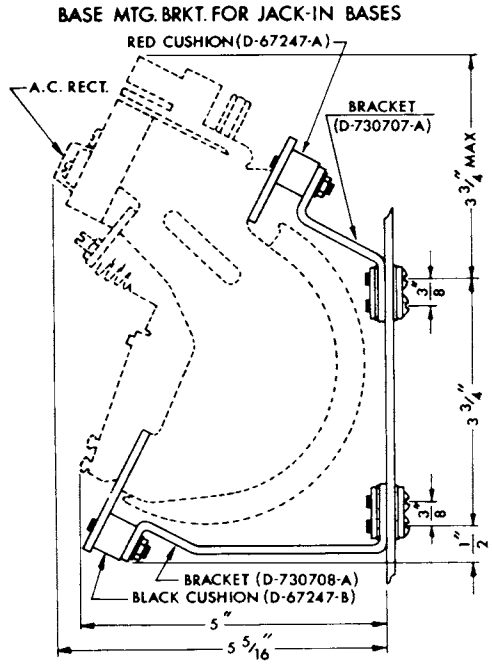



*Figure 52. Type 45 rotary switch bracket mounting.*

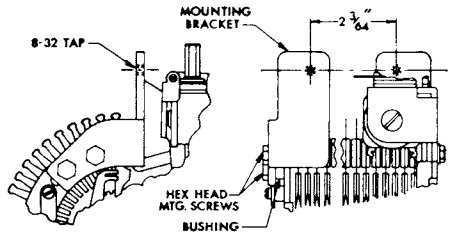



*Figure 53. Additional mounting bracket for 13-16 level switches.*

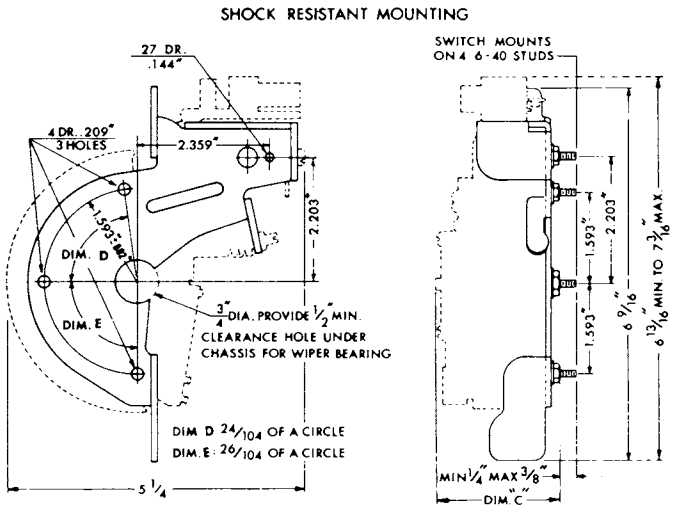



*Figure 54. Shock resistant mounting.*

an additional pair of brackets is required for mounting switches of 13-16 levels (see figure 53).

b. For recessed mounting between two horizontal shelf angles, the switch projects 2-11/16 inches above the mounting surface and 2-9/16 inches below. The switch may be rigidly fastened to the shelf angles or supported on rubber cushions for damping sound and vibrations.

c. For greatest shock resistance, the switch should be mounted flat with the bank levels parallel to the mounting surface. No brackets are required. Mounting dimensions are shown in figure 54.

## 11.5 A-c Operation

The type 45 rotary switch can be equipped in the factory with a half-wave rectifier and filter assembly for 115 volt 60 cycle a-c operation (see figure 55). A type 45 switch, having a d-c coil, can be modified in the field. Order a PA-98 rectifier and filter assembly from Automatic Electric Sales Corporation. Remove the rotary switch coil mounting screw. Hook the rectifier assembly over the switch frame and retighten the coil-mounting screw. If the control circuit is to move the switch wipers one step at a time, wire as shown in figure 56 to terminal screws 2 and 3. If the control circuit is to start and stop continual self-interrupted stepping, the control device is connected to terminals 2 and 4.

The electrical characteristics of the alternating current and a 48 volt d-c switch are very similar. The self-interrupted speed on 115 volts a.c. is approximately 50 steps-per-second. The speed, from an external pulsing circuit, is a maximum of 35 steps-per-second.

## 11.6 Preventive Maintenance

The type 45 rotary switch should be inspected, and adjusted if necessary, according to the following procedure:

### 11.6.1 Brush springs.

The brush springs, which are part of the bank assembly, should rest against the inner hub of the wipers with sufficient tension to insure good electrical contact as the wiper assembly rotates. In general, the brush springs will not require readjustment during the life of the switch. If it does become necessary to readjust them, the armature must first be removed by loosening the two yoke mounting screws and the wiper assembly must be taken out by loosening the shaft mounting hex nut and two shaft support bracket screws. Extreme care should

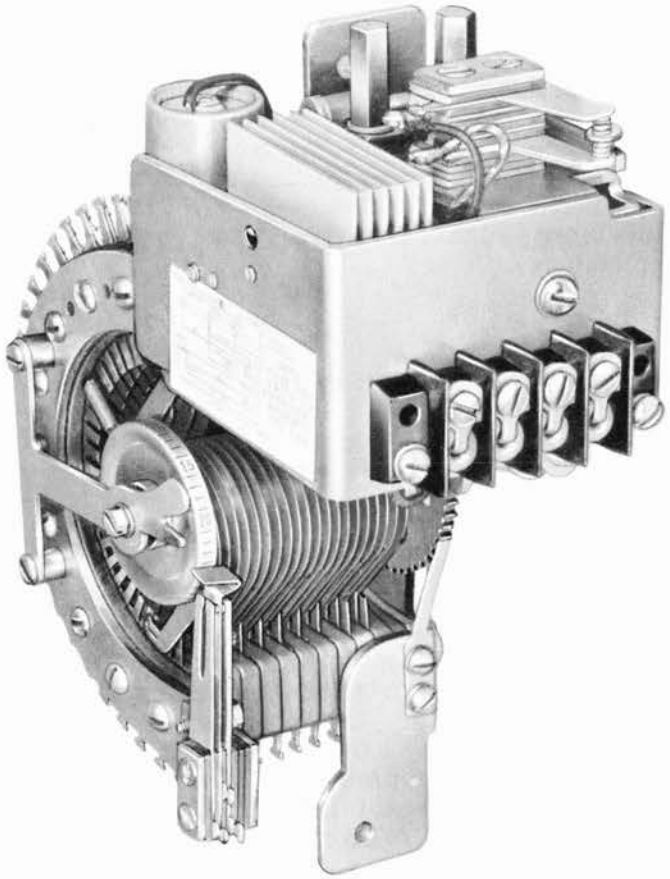


*Figure 55. Type 45 rotary switch with PA-98 rectifier unit.*

be taken when reassembling the switch to avoid damage to the brushes and wipers. Check the brush tension as follows:

a. The brush springs (wiper terminal springs) shall be tensioned and curved so that with all pressure relieved, the ends of the two springs in a pair shall be separated a minimum of 1/2 inches. A line passing through the points on the tip of a brush spring shall be approximately parallel, as gauged by eye, to the plane passing through the bank contacts of the same level.

b. When assembled in the wiper assembly, the two brush springs of a pair shall close and lie approximately flat against each other. In the area over which the wiper tips pass, the springs may start a slight separation. The springs shall not be separated more than .006 inches (as judged visually) at the angle in the springs.

NOTE: DO NOT insert any gauge between the brush springs; damage to the brush springs may result.

11.6.2 Wipers.

The wipers should have sufficient tension to insure good electrical contact with the bank

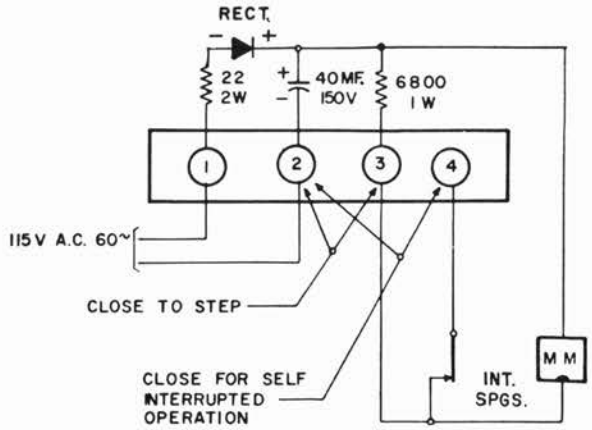



*Figure 56. Type 45 rotary switch – diagram for a-c operation using PA-98 rectifier unit.*

contacts. Check the wiper spring alignment and tension as follows:

a. The wiper assembly shall turn freely on its shaft with the shaft mounted in the frame and the shaft support bracket firmly tensioned against the shoulder of the shaft.

b. The wiper pairs shall be aligned so that they pass onto the base of the brushes and off the last bank contact without excessive movement (1/64 inches) to one side or the other.

c. There shall be a minimum of .015 inches clearance between the heel-end of the wiper tip of a nonbridging wiper and the nearest bank contact with the wiper tip positioned between two bank contacts. This requirement shall be checked between bank contacts No. 5 and No. 6 and between bank contacts No. 19 and No. 20.

NOTE: In positioning the wiper springs on the bank to meet the requirements described in paragraphs b. and c. above, the adjustments will be made at the base of the wiper spring arms. The arms of a wiper spring shall be relatively straight and parallel to each other. (Free from kinks or excessive bow.) A separation between the wiper blades of an individual pair of 5/64 inches, as measured at the heel-end of the tip with the wiper off the bank contacts, is necessary if requirements of paragraphs b. and c. are to be met.

d. Each spring of a bridging wiper pair shall be tensioned to follow approximately 1/8 inches measured at the tip when its opposing spring is deflected.

e. Each spring of a nonbridging wiper pair shall be tensioned to follow approximately

3/32 inches measured at the tip when its opposing spring is deflected.

f. With the wipers resting on the bank contacts, there shall be a minimum clearance of 1/16 inches between the wiper springs of adjacent wiper pairs.

g. On fifty-point rotary switches, with either wiper group resting on the twentieth (20th) bank contact, there shall be a minimum clearance of 1/64 inches between the wiper springs and their associated brush springs.

h. On fifty-point rotary switches, there shall be a minimum clearance of 1/64 inches between the wipers from which the tips have been removed and the brush springs.

i. The indicator shall point to the number or line on the indicator wheel corresponding to the bank contact on which the wipers are resting.

11.6.3 Armature.

When the armature is operated, its pawl is positioned in the next tooth of the ratchet wheel. A coil-type spring restores the armature when the magnet is de-energized, rotating the wiper assembly one contact, after which the stopping teeth on the armature engage the ratchet wheel teeth. For proper operation, there must be no binds in the armature assembly. Check the armature as follows:

a. The armature shall not bind on its bearing.

b. The armature shall clear the heelpiece, and a .003 inch gauge shall be tight and a .0015 inch gauge shall be loose in the air line with the armature electrically operated.

c. The pawl shall not bind in its bearings.

d. The pawl tip and armature stopping teeth shall be located centrally with respect to the ratchet wheel.

e. The pawl tip shall rest against the ratchet wheel with a minimum pressure of 130 grams and a maximum of 150 grams with armature in unoperated position.

f. (When the armature is replaced only.) With the armature in the unoperated position and the play between the ratchet wheel and armature stopping teeth taken up in the direction of wiper rotation, the pawl shall not bind when it is lifted out of the ratchet teeth. With the play taken up in the direction opposite to rotation, there shall be a clearance (maximum .008 inches) between the top stopping tooth and ratchet tooth.

NOTE: The above requirement is met by selecting the correct shim (.006 inches, .010 inches, or .014 inches) and placing it between yoke and heelpiece. The thinnest suitable shim should be used to avoid interference between the stopping teeth and the top surface of the ratchet teeth as the armature restores. These shims are NOT furnished as part of the replacement armature, but must be ordered separately.

11.6.4 Pawl.

The edges of the rotary pawl along its length shall be parallel to the sides of the ratchet wheel, and the tip of the pawl shall be parallel to the edge of the ratchet teeth as gauged by eye.

11.6.5 Ratchet stopping spring.

The ratchet stopping spring is provided to hold the wiper assembly in place while the armature pawl is being prepared for the next step. Check the ratchet spring tension and position.

a. The ratchet stopping spring shall be tensioned to have a minimum pressure of 75 grams and a maximum pressure of 125 grams against the ratchet wheel, as measured at the curve near the tip of the spring.

b. With the play between the pawl and ratchet wheel taken up in the direction opposite to wiper rotation and the armature in the unoperated position, there shall be a minimum clearance, which is perceptible and a maximum of .003 inches between the spring tip and the radial surface of the ratchet tooth.

11.6.6 Bank.

The bank is attached to the switch frame by nuts screwed onto three of the bank assembly screws which project through the frame. The mounting holes in the frame are slotted, providing circumferential adjustment only of the bank position relative to the frame. Check the bank position relative to the frame.

The edge of the bridging wipers shall be approximately in alignment with the front edge of the contacts and the edge of the nonbridging wipers shall lie on the center third of the contacts.

NOTE: The above requirement is an adjustment of the bank position.

11.6.7 Armature-driving spring.

A coil-type spring restores the armature when the magnet is de-energized, driving the wiper

assembly. An adjustment screw and locknut are provided. The proper pressure required is specified on the switch adjustment sheets. Check the driving spring pressure as follows:

a. The armature driving spring pressure shall be adjusted in accordance with the associated switch adjustment sheet.

b. The armature shall completely restore from operated position when retarded by hand and allowed to restore slowly.

11.6.8 Interrupter springs.

The interrupter springs are actuated by an arm on the armature of the switch. To secure long, trouble-free life and correct operation of the switch, the correct pressures must be maintained and also the position of the armature in its stroke when the springs make or break contact. Check the tension and gauging of the interrupter springs as follows:

a. The armature arm shall strike the lever spring bushing centrally.

b. Contacts shall not be out of alignment (judged visually) by more than 1/5 of their face diameter and shall make contact at approximately the center of their faces.

c. The interrupter springs shall be gauged by inserting a gauge of the proper value between the armature and the coil core.

d. Make-gauging shall be as specified on the associated switch adjustment sheet with a variation from the values specified, of plus .002 inches minus .001 inches allowed for inspection, unless otherwise specified on the switch adjustment sheet.

e. Break springs not used to "speed" the switch shall be adjusted as specified on the associated switch adjustment sheet with a variation from the values specified, of plus or minus .002 inches allowed for inspection, unless otherwise specified on the switch adjustment sheet.

f. For break springs used to speed test the switch, the values given on the associated switch adjustment sheet are only approximate and are marked with an asterisk. Adjust these break springs to give maximum uniform speed on the voltage for which the switch is to be used.

NOTE: Where there is only one break combination, it will be used for speed testing the switch. Where there is more than one break combination, the outer set will be used for speed testing the switch; the inner set need only be readjusted if required to prevent the outer set from breaking first.

g. Following the adjustment of the break springs to meet speeding requirements, check interrupter springs in accordance with paragraph i. below.

h. Break springs shall have a minimum contact pressure of 275 grams and a maximum of 400 grams. When there are two sets of rotary interrupter break springs, each set shall have 150 grams minimum and 200 grams maximum contact pressure.

i. There shall be a minimum of .001 inches difference between the break and make gauging of any break-make combination.

j. Contact gap on make or break springs shall be .008 inches minimum.

11.6.9 Off-normal springs.

The off-normal springs are usually provided to open homing circuits when the wipers are on the 26th step. They may however perform other functions. Adjustment of the off-normal springs should insure good electrical contact on both make and break springs. Check the off-normal springs as follows:

NOTE: Break combinations are defined as those combinations which are open when the switch is in the home position. Make combinations are defined as those combinations which are closed when the switch is in the home position.

a. The apex of the V-form of the main lever spring shall approximately line up with the center line of the off-normal bushing on the 26th step, and either edge shall not be closer than 1/32 inches to the edge of the bushing. The V-form shall clear the bushing on the 25th and 1st steps by a minimum of .010 inches with the wiper assembly play taken up in the direction of the spring form.

b. The armature spring of a break combination shall have a minimum contact pressure of 35 grams and a maximum of 50 grams against the break spring as measured between the form or buffer and the contact at a point nearest the form or buffer.

c. In combinations where the first pair of springs are break springs, the break spring shall clear the off-normal bushing by a minimum of 1/32 inches.

d. On assemblies where a second pair of springs are break springs, the buffer of the second lever spring shall clear the first lever spring by a minimum of space

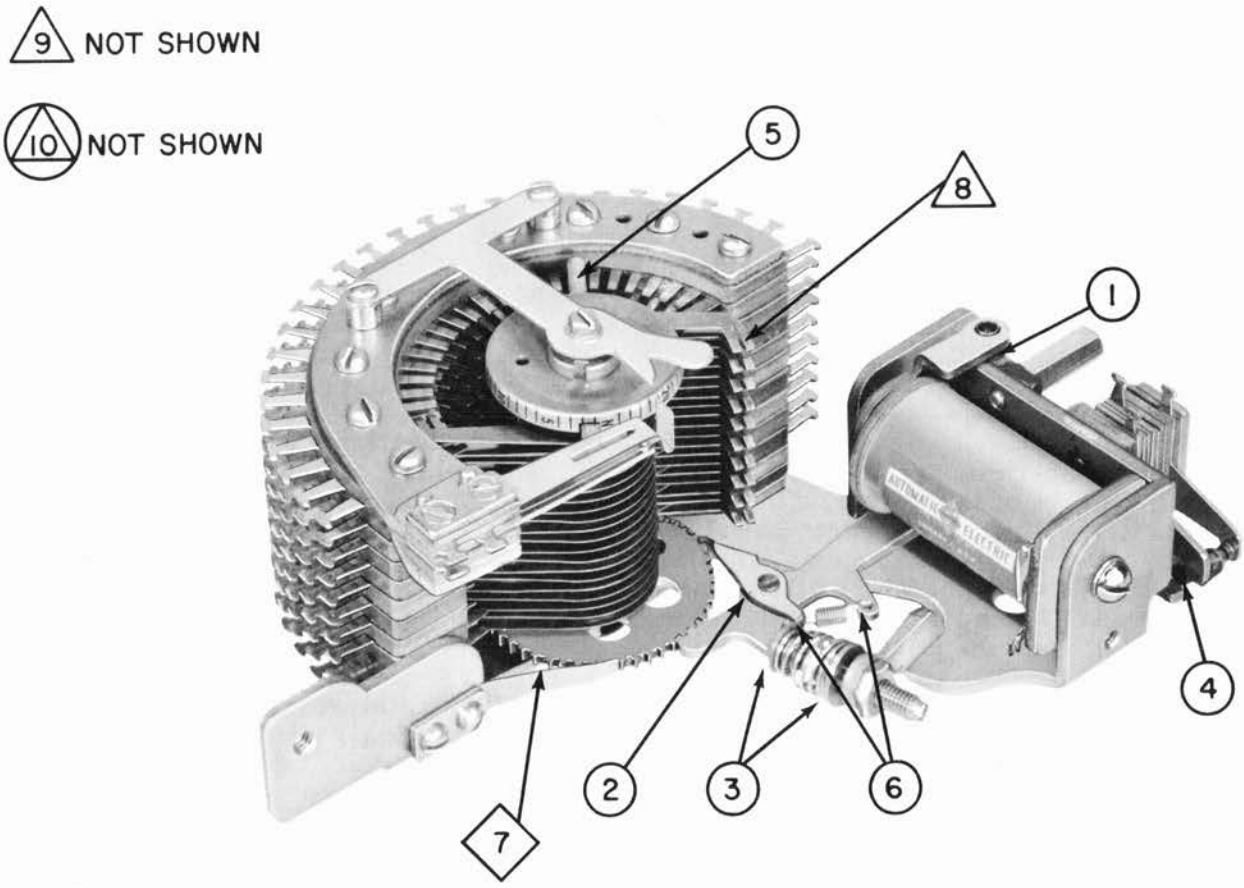



*Figure 57. Type 45 rotary switch lubrication.*

that is perceptible and a maximum of .003 inches when the springs are not operated by the actuating arm.

e. In combinations where an armature spring has make contacts only, it shall rest against the preceding armature spring with a minimum pressure of 25 grams and a maximum of 35 grams.

f. Make and break springs shall have a minimum contact separation of .008 inches.

g. Both contacts of a pair shall make or break within .002 inches of each other as gauged visually.

h. Break springs shall break contact before make springs make contact.

i. Make springs shall have a minimum total contact pressure of 30 grams (15 grams for each contact of a pair) measured at the ends of the make spring.

11.6.10 Self-interrupted speed test.

An over-all check on the adjustment of switches equipped with interrupter springs may be made by running the switch self-interruptedly. If it does not operate smoothly, all adjustments should be rechecked.

11.6.11 Lubrication (figure 57).

It is recommended that the type 45 rotary switch be lubricated at 50,000; 100,000; and 250,000 half-revolutions and after every 500,000 half-revolutions thereafter.

NOTE: For low-temperature lubrication instructions, contact Automatic Electric Company, Northlake, Illinois.

Clean the switch thoroughly and lubricate (TABLE IV), following steps a. through g. below:

a. Distribute one dip of blended lubricating oil (spec. 5684) between:

(1) Each end of the two yoke bearings.

b. Apply one dip of blended lubricating oil (spec. 5684) to:

(2) The pawl bearing pin, where the pawl and the pawl bearing pin contacts the armature.

c. Distribute one dip of blended lubricating oil (spec. 5684) among the following points.

(3) The driving-spring seats and coils.

④ The interrupter spring buffers.

⑤ The off-normal bushings. NOTE: Do not lubricate nylon bushings.

⑥ The pawl spring mounting holes and coils.

d. Apply two dips of graphite oil lubricant (spec. 5232-C) to:

◇⑦ The ratchet teeth (rotate the wiper assembly during lubrication in order to distribute the lubricant evenly over all of the ratchet teeth).

e. Distribute one dip of watch oil (spec. 5228) between:

△⑧ The wiper tips of three pairs of wiper springs. NOTE: Both ends of the wiper springs should be lubricated; therefore a three level wiper assembly would require two dips of oil, one for each end. Rotate the wipers after lubrication to distribute the oil over the entire bank.

f. To lubricate the brush springs (not shown), position the wiper assembly so that the wipers are resting on the 18th contact. Apply one dip of watch oil (spec. 5228) to:

△⑨ The insides of two wipers, at a point near the hub so that when rotated the lubricated portion of the wiper will contact the brushes. When all the wipers have been lubricated in this manner, rotate the wiper assembly 180° and repeat the process. (Example: A six-level switch will require six dips of lubricant.)

g. If the switch is disassembled, proceed as follows:

⑩ On switches of one to four levels, fill the undercut portion of the wiper shaft with plastic petroleum grease (spec. 5694). Apply a small amount of grease to the end of the shaft opposite the mounting hub before the shaft is assembled into the hub. On switches of more than 4 levels, fill the entire wiper hub with grease (spec. 5694).

NOTE: Wiper shafts are lubricated for the life of the wiper assembly. Relubricate the shaft only when replacing wiper assemblies.

TABLE IV. LUBRICANTS

| Symbol | Description | Order No. | Amount | Remarks |
|---|---|---|---|---|
| □ | Spindle oil (5231)<br>Spindle oil (5231) | H-78612-5<br>H-78612-6 | 2 oz.<br>4 oz. | For lubricating bearing and bank contacts. |
| ◇ | Graphite oil lubricant (5232-C) | H-78612-9 | 2 oz. | For lubricating rotary and minor switch ratchet wheels. |
| ⊡ | Low temperature oil-dag lubricant (5563) | H-78612-28 | 2 oz. | For lubricating minor switch in low temperature operation. |
| △ | Watch oil (5228) | H-78612-30 | 2 oz. | For lubricating rotary switch wiper tips and brushes. |
| ○ | Blended lubricating oil (5684) | H-78612-31 | 2 oz. | For lubricating type 44 and 45 rotary switches. |
| ⊜ | Plastic petroleum (5694) | H-78612-47 | 8 oz. | For lubricating rotary stepping switch bearings. |

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