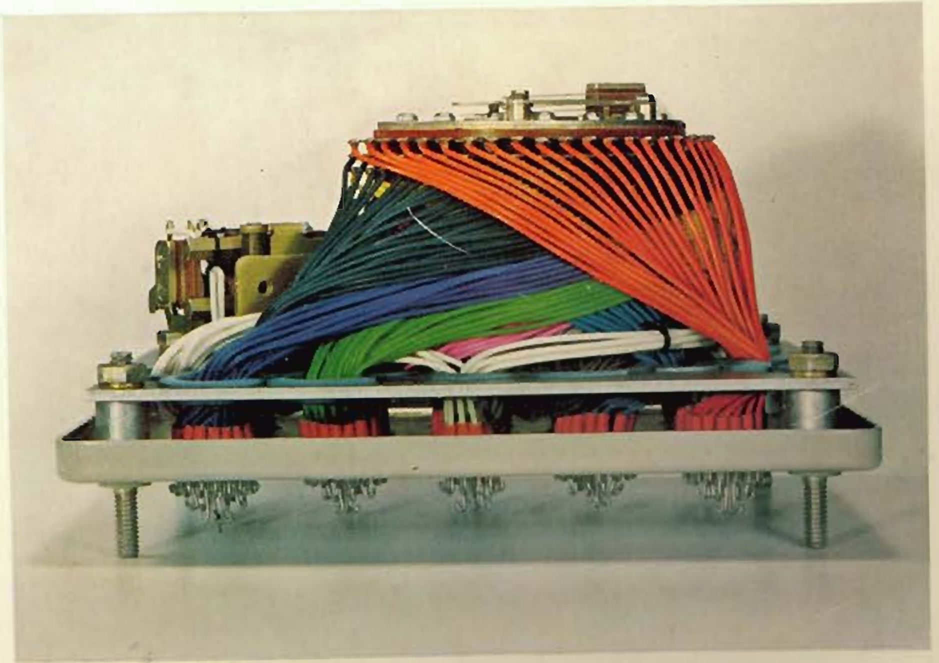


Photographs on the front and back cover are of AE's Type 45 Rotary Stepping Switch wired for hermetic sealing.

C-1057—40M —3-64— Merit

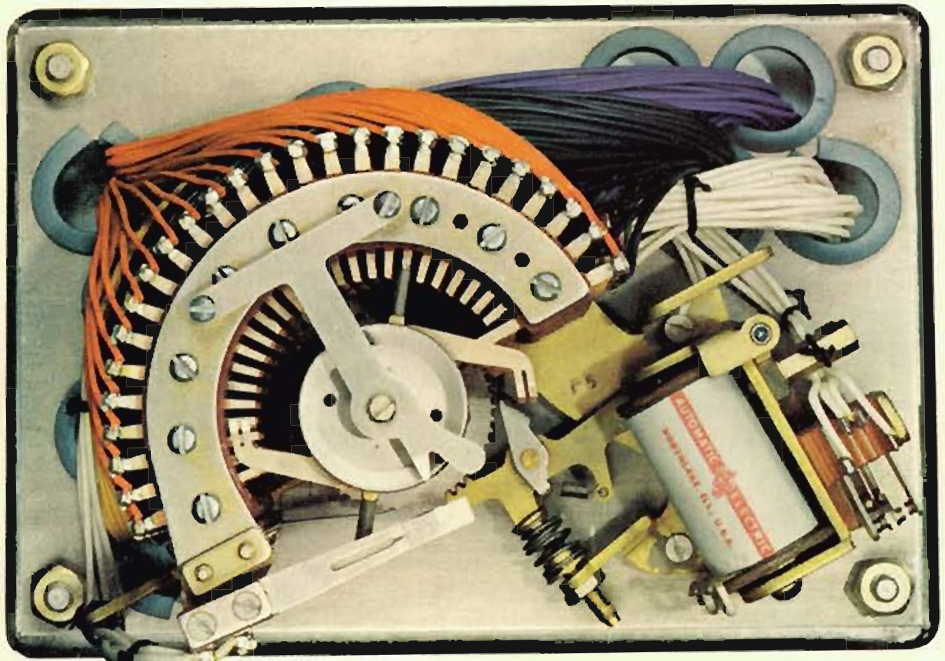
Printed in the U.S.A.

HOW TO USE ROTARY STEPPING SWITCHES

AUTOMATIC ELECTRIC

$1.45

HOW TO USE ROTARY STEPPING SWITCHES



Today's rotary stepping switches are the result of decades of service usage and experience. Here, in one book, are the major "DO's" and "DON'T's" of their successful application.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

HOW TO USE ROTARY STEPPING SWITCHES

V. E. JAMES, *Editor*

AUTOMATIC ELECTRIC COMPANY • Northlake, Illinois

TCI Library: www.telephonecollectors.info

Published by AUTOMATIC ELECTRIC COMPANY, Northlake, Illinois.

First Edition, March 30, 1964.

Printed in the United States of America.

Printed by MERIT PRINTING CORPORATION.

Library of Congress Catalog Card Number: 64-19348

TABLE OF CONTENTS

EDITOR'S PREFACE

The purpose of this small volume is to help the engineer become better informed about rotary stepping switches. Much of the information presented herein has appeared over the years in other places. This is an attempt to gather this information together, combine it with much that has never been previously published, and to present it in one easy-to-use format. We hope that it will serve as a "Primer" to those engineers whose formal education bypassed the study of electromechanical switching devices, and as a "Reference Book" to those who know the rotary stepping switch but who have been led to overlook (or have forgotten) its versatility, economy, longevity and simplicity.

If the rotary stepping switch in its present quite mature form didn't already exist, it would have to be invented and perfected out of economic necessity. This could only come about after the expenditure of much development time and expense, much burning of the "midnight oil", and considerable design refinement. Even then, the resulting product would be quite inferior to today's well "shaken down" and fully-developed product because today's rotary stepping switch profits from decades of service usage, application experience, and design refinement. The manufacturer of equipment

TCI Library: www.telephonecollectors.info

using these very modern components would then advertise, "This latest model of . . . . uses rotary stepping switches, with the resulting economy, simplicity, ruggedness, and reliability".

It is obvious that any circuit component can be misunderstood, misapplied, and mistreated. That's why, in addition to describing the proper and beneficial ways to use rotary stepping switches, this book offers many words of caution on improper usage.

I wish to express my appreciation to the staff engineers of the Industrial Products Division, Automatic Electric Company, who served as my "Editorial Board": J. D. Ashby, D. A. Dibbern, R. A. Gibson, H. P. Hohberger, G. L. McDermott, L. B. Mitchell, and H. E. Nelson.

We are grateful to our many fine customers whose products are shining examples of how to use rotary stepping switches wisely and well. Thanks are also due to Joe Kurnick, H. A. Bersted, L. E. Clayton, Howard Bourne, Stanley Kubicz, Jack Lacker and the many others who helped with the manuscript and with the task of transforming it into book form.

V. E. JAMES
La Grange Park, Ill.
February, 1964

I. THIS IS A ROTARY STEPPING SWITCH

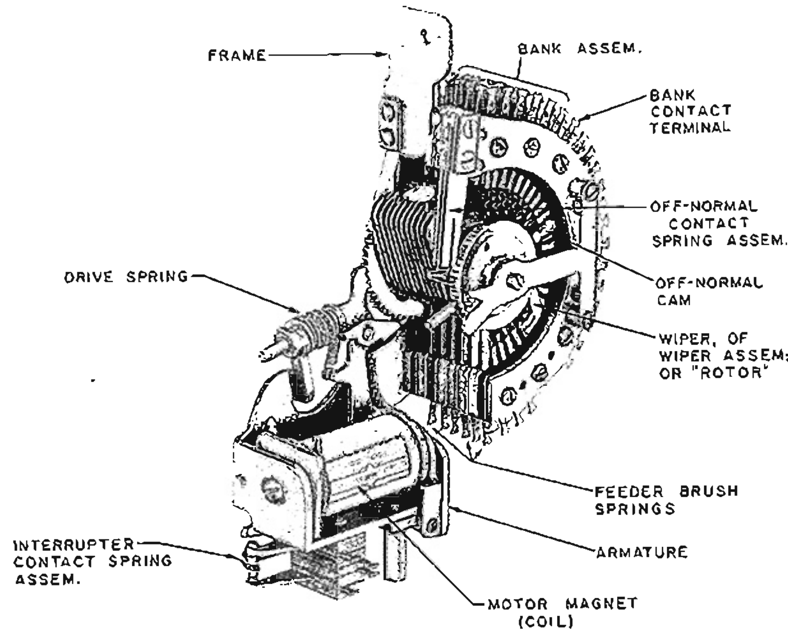


Fig. 1. Automatic Electric Company's Type 45 Rotary Stepping Switch.

This is a rotary stepping switch, as manufactured by Automatic Electric Company. It is a direct descendant of a famous telephone ancestor, the "rotary line switch", used to electrically connect one pair of wires in a dial telephone exchange to another particular pair of wires selected by the mechanical action of the unit from a large group of pairs. This function is accomplished by moving a pair of spring contacts or "wipers" in an arc and into contact with certain stationary "contacts" to which the *selected* pair of wires is connected. The stationary contacts are assembled in the form of a "bank" which may contain 10, 25, or 100 pairs (or sets) of contacts. Each of these stationary contacts in the bank is permanently connected to two wires that provide an electrical path to a particular group of telephone subscribers, or to a particular subscriber in a group, depending on the location of the rotary line switch in the system.

Today's rotary stepping switches are faster, stronger, and more versatile than any of their telephone ancestors. They *must* be so, because they have become one of the most widely-used components in industrial control, and, as such, must work harder, faster, longer and with closer-spaced consecutive operations than required in telephone exchanges.

They are used to switch, select, count, indicate, monitor, time, control, test and program in a wide variety of industrial products and applications. When properly engineered, specified and applied, they can handle situations with severe ambient temperatures, shock and vibration. They are not as sensitive to radiation effects as some other devices now in common use.

To understand some of the reasons for this popularity, we must first agree on common definitions. What *is* a rotary stepping switch?

It is more than just a "switch". A *switch* (electrically speaking) is something that causes a change in an electrical circuit. It may be used to turn a light or an appliance on or off, in one of its simplest forms, by closing a circuit ("make"), or by opening a circuit ("break"). In slightly less simple forms it may interrupt one circuit before establishing another ("break-before-make"), or it may establish a new circuit before disrupting the old one ("make-before-break").

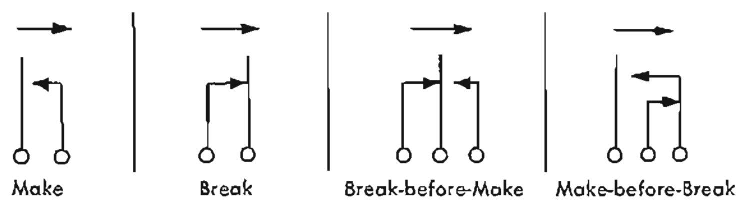


Fig. 2. Nomenclature for basic switch contact forms.

It is more than just a "rotary switch". A commonly accepted definition of a rotary switch is a circularly arranged grouping of individual contacts, to which a movable member successively connects as it is rotated. The most common understanding of this designation (outside of the telephone field) is that of a hand operated (rotated) switch such as the station-selection switch on your television set. Consequently, the term "rotary switch" is not generally satisfactory for use in designating an electromagnetically stepped device.

It is more than just a "stepping switch". By *mechanically* ratcheting a movable contact from one "permanent" contact position or "point" to another, under the actuating power derived from an electromagnet, a vertically-moving "stepping switch" results, as shown below.

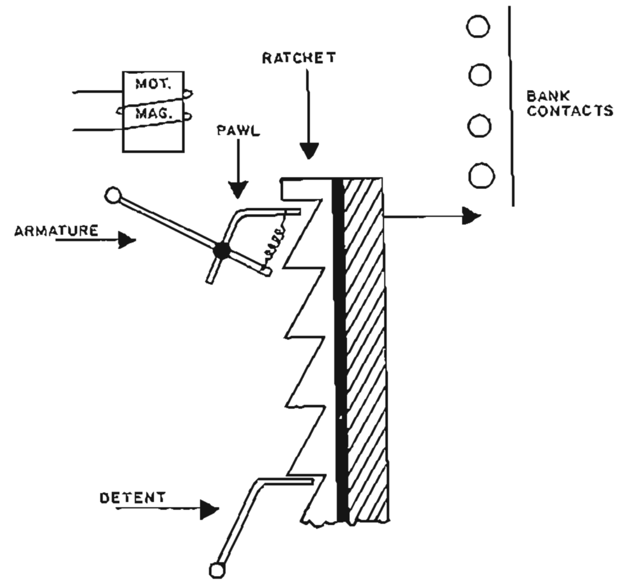
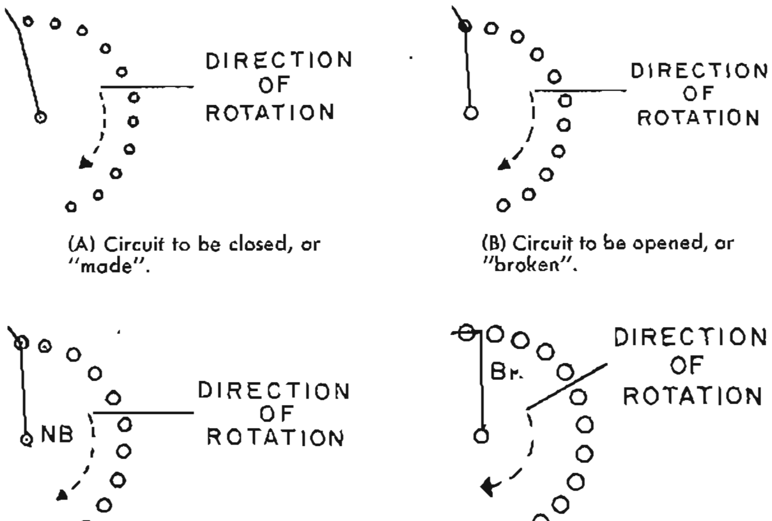


Fig. 3. Schematic of "stepping switch" with vertical (up-and-down) motion.

What IS a rotary stepping switch, then? It is precisely what its name implies: it rotates, it steps, it switches. More fully, a rotary stepping switch is a mechanism consisting essentially of one or more wiping springs fixed on a shaft moved by a pawl and ratchet which is actuated by an electromagnet in response to momentary pulses of current. At each pulse, the pawl engages the ratchet, moving the wipers (to which circuits are connected) one step forward into contact with stationary terminals to which a selected circuit is connected. (Look at Figure 1, page 1, again.) These stationary terminals are assembled in one unit in the form of a semi-circular (or arc) "bank", and may number up to 250 or more individual contacts. Bank levels, equal in number to pairs of wipers, are separated from each other by an insulating material.

TCI Library: www.telephonecollectors.info

A rotary stepping switch performs the same basic switching functions as a "switch" (see Figure 2, page 2). That is, it can "make" or "break" a circuit. It can transfer a circuit with a "break-before-make" action. In rotary stepping switch nomenclature, this is called "non-bridging" and designated "NB" (see Figure 4C, below). If the transfer action is "make-before-break", it is called "bridging", and designated "Br".



(A) Circuit to be closed, or "made".

(B) Circuit to be opened, or "broken".

(C) Circuit to be transferred, or "broken" and then "made" called "nonbridging" transfer. Designated "NB".

(D) Circuit to be transferred, of a "make-before-break" type, called "bridging". Designated "Br".

Fig. 4. Schematics of the four basic switching actions of rotary stepping switches.

Notice in the above make-before-break schematic (Figure 4D) that the tip of rotatable member (the wiper) is indicated as being of sufficient length to touch the contact moved to, before leaving the contact last rested upon. This additional length of wiper tip is the physical component that gives bridging, or make-before-break, action to rotary stepping switch operation. That is why care must be taken in preparing schematics of bridging levels. The additional designation of "Br." on the schematic is also a recommended practice.

II. ROTARY STEPPING SWITCH NOMENCLATURE

Mechanical Components

The descriptions used in designating rotary stepping switch parts, for re-ordering or for describing as part of a circuit function, are confusing to many. This is because they grew out of telephone practice, but do not represent uniformity even in that area. The rotated contacting member, or "finger tip", is called a *wiper*. The rotated group of wipers and supporting mechanism, including the *ratchet wheel*, is called a *wiper assembly*. (Some call it a "rotor".)

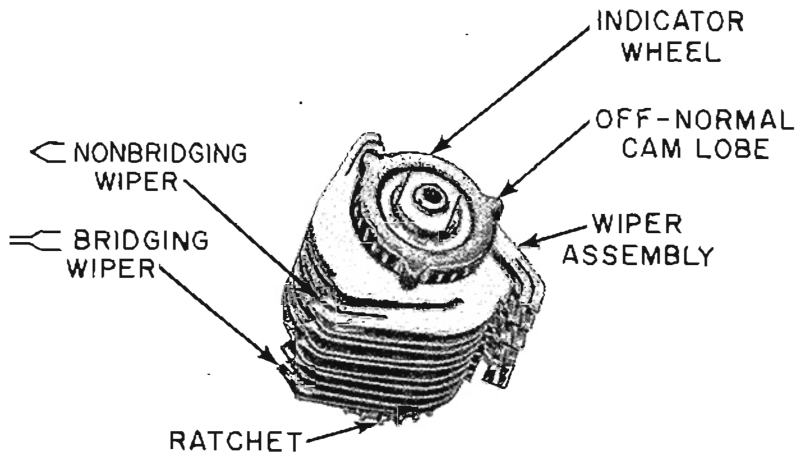


Fig. 5. Typical rotary stepping switch wiper assembly.

As discussed in the previous chapter, wipers are of two basic kinds, those which close ("make") the circuit, and those which open ("break") the circuit. The former is by far the most common.

There are two kinds of wiper tips: bridging and non-bridging, both of which are often supplied on the same wiper assembly (Figure 5). *Bridging wipers* have long flat tips which, during rota-

TCI Library: www.telephonecollectors.info

tion, 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. *Non-bridging wipers* have shorter tips that leave one bank contact before engaging the next, avoiding the electrical interconnection between circuits of adjoining bank contacts.

The arrangement of contacts in a single arc, each electrically insulated, to which the wiper will be sequentially connected as it rotates, is called a physical bank level, or more simply, a *level*. The total accumulation of levels into an assembly is called a *bank*.

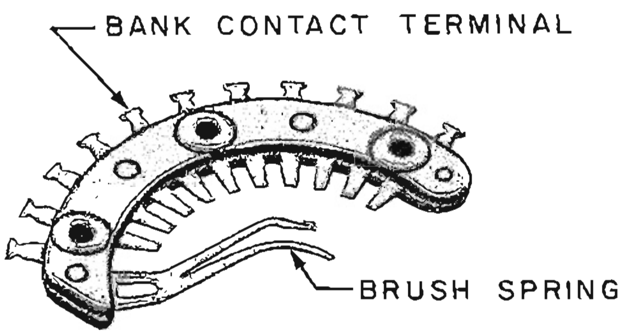


Fig. 6. A physical bank level (compact rotary stepping switch).

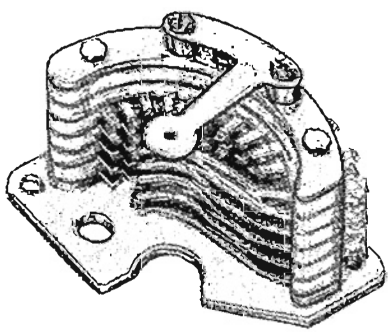


Fig. 7. Typical bank assembly of wiper and bank parts (compact rotary stepping switch).

It is customary at AE to designate the existence of even a single level of "break" contacts in the bank of a rotary stepping switch by adding the suffix "NC" to the rotary stepping switch Type. Thus "Type 45NC" designates a Type 45 Rotary Stepping Switch with one or more levels of normally-closed bank contacts, regardless of how many other levels of the more common "make" contacts (normally-open) are present on the same rotary stepping switch.

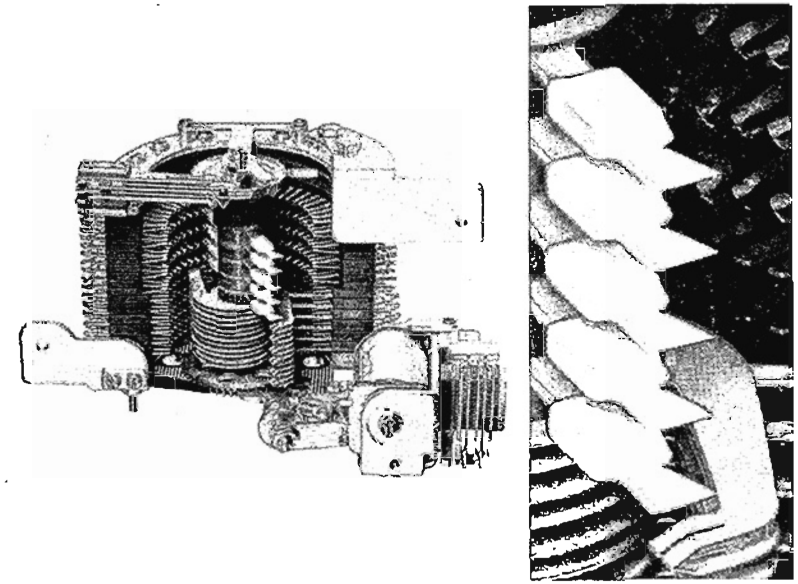


Fig. 8. A typical Type 45NC Rotary Stepping Switch.

A rotary stepping switch is composed of the following essentials: *frame* (the "platform" on which all parts are assembled and which is in turn fastened to the chassis of whatever equipment is using it), *coil* (the electromagnet commonly called the "Motor Magnet" or "MM"), *armature assembly* (which includes the pawl spring), *drive spring, wiper assembly, bank, interrupter contact springs,* and *off-normal contact springs.* The purpose of the interrupter contact springs and off-normal contact springs will be covered in detail later.

The *coil* or "motor magnet" consists of a coil of wire wound on a piece of cylindrical iron called a coil core. In the unoperated position, the magnetic circuit is completed through the frame, coil core, "armature air gap", and armature. As the armature is attracted (operates), the air gap is reduced to zero, until the armature seats against the end of the coil core. The rotary stepping switch is then said to be operated. The distance through which the armature was attracted from the unoperated position to the operated position is called the armature "stroke". Other details of the rotary stepping switch can be identified from the sketch below:

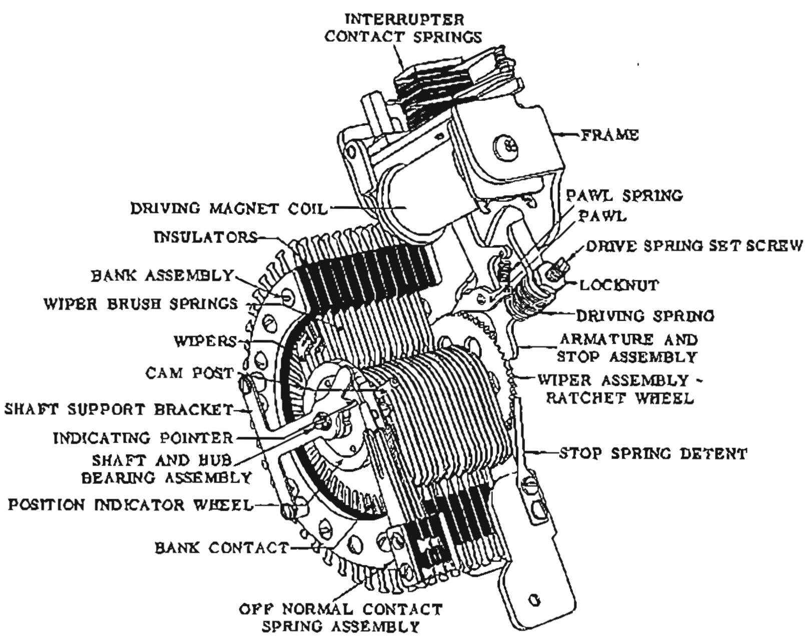


Fig. 9. Type 45 Rotary Stepping Switch—assembly details.

The Series OCS Relay is part switch and part relay. It is built on a ratcheting switch-type mechanism, but operates cams which move contacts to "on" and "off" positions, like the conventional relay. It is largely used to replace mechanical interlock relays. For method of "homing" the Series OCS Relay (that is, of restoring it to a normal position at the completion of a switching operation) see Figure 64, page 119. For other suggested uses, see subsequent Figures 65, 66, 67, 68 and 69.

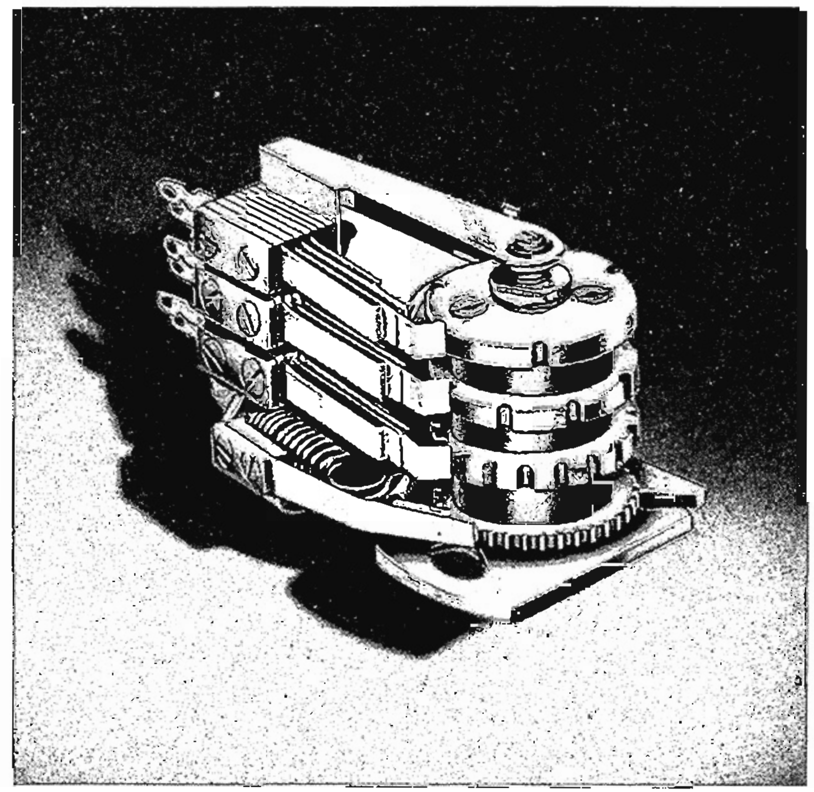


Fig. 10. Series OCS Relay with 3 cams.

TCI Library: www.telephonecollectors.info

Types of "Drive"

There are two types of driving mechanisms used in rotary stepping switches: indirect and direct. When the armature-pawl combination acts directly on the ratchet, under the magnetic attraction generated by the electromagnet, the rotary stepping switch is said to be *directly driven*.

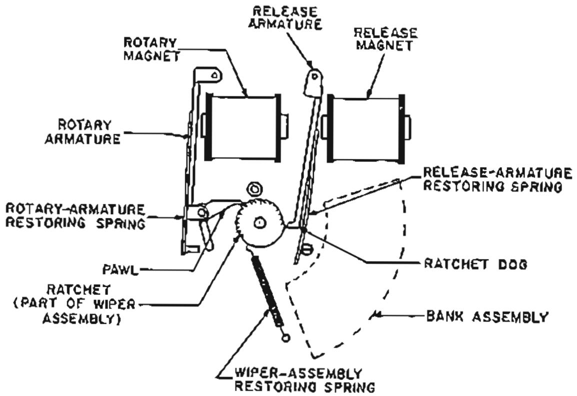


Fig. 11. Direct drive mechanism.

Such a switch is the AE "Minor Switch". (The "Strowger" two-motion switch is called a "Major Switch" in telephone parlance.)

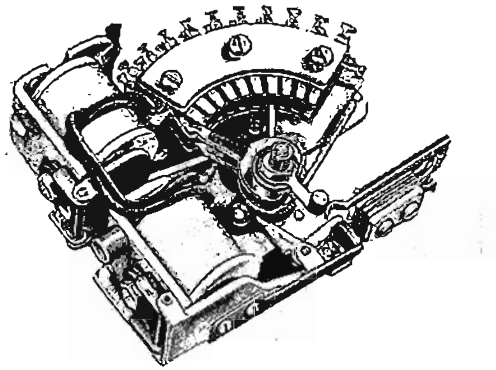


Fig. 12. The directly driven Minor Switch.

When the pawl is caused to act on the ratchet wheel from mechanical force resulting from potential energy stored mechanically in some form of a drive spring, the mechanism is said to be an *indirectly driven* rotary stepping switch.

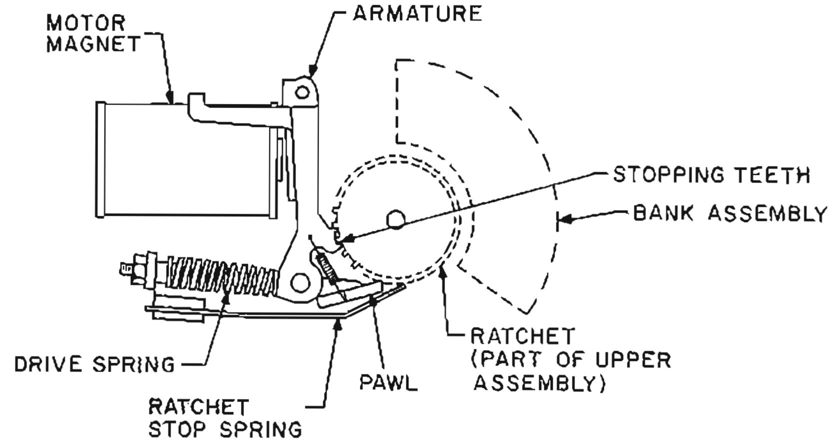


Fig. 13. Indirect drive mechanism.

Examples of indirectly driven rotary stepping switches are the Automatic Electric Company Types 45, 40, 44, 80 and 88. The Type 45 is known as a large switch, the Types 40, 44, 80 and 88 as "compact" switches, because of their relative size. The principal parts of a Type 44 rotary stepping switch are used as the basis for Figure 13 above.

It can be proven quite readily that the indirectly driven rotary stepping switch is more consistent in performance, has longer life, is more efficient and is capable of faster stepping than the directly driven rotary stepping switch. However, that is not the purpose of this book, and the subject is covered fully in AE Sales Circular 1641.

TCI Library: www.telephonecollectors.info

Direction of Stepping

Rotary stepping switches are classed either as *unidirectional* or *dual-directional*. Dual-directional is sometimes designated as "around-and-return" or as "bidirectional". Unidirectional rotary stepping switches step in one direction only. Wipers are so arranged that, when all bank contacts have been traversed, the mechanism is in its reset or "normal" position. Such a rotary stepping switch must be stepped to its normal position after each use. Dual-directional rotary stepping switches step in one direction to the selected contact. 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 original stepping took place.

AE rotary stepping switches of both the "full size" (Type 45) and the "compact size" (Types 40, 44, 80, and 88) are all *unidirectional*. The "Minor Switch", and some other AE rotary stepping switches, are of the *dual-directional* types. Dual-directional, two coil* spring-released types of switches have one large advantage over the other types: the release step is just one *large* step (release armature operation) from wherever the switch is positioned in a reverse direction back to the starting point. This action is very fast (about 80 milliseconds, maximum, for an eleven position Minor Switch) and provides a time advantage over any other method of resetting to the starting point.

The maximum attainable self-interrupted stepping rate of the unidirectional rotary stepping switches is somewhere around 60 steps per second under ideal conditions. This means that an 11 point switch (Type 44), equivalent in capacity to the Minor Switch in number of points or bank positions, would require about 11/60 of a second, or approximately .180 seconds (180 milliseconds) to restore

**One coil steps the switch forward. The other coil (when energized at a different time) removes a holding detent from the ratchet wheel, causing the switch rotor to "fly" back to the home, or normal position, from the force of the tensioned restoring spring.*

from the farthest point (by forward stepping) to the starting position. On the Type 45 (26 position) rotary stepping switch, this becomes about .430 seconds (430 milliseconds), and for a Type 45 (52 position) this becomes about .870 seconds (870 milliseconds). This is something to be kept in mind when designing circuits, and can be simply restated: No switch is as fast in restoring from a "farthest point" as a Minor Switch, with its single step "flyback" or release to the home position. In every other respect than this, the advantages are with the unidirectional, spring driven, indirect drive type of steppers.

Schematically, the dual-directional Minor Switch can be pictured as operating in this manner:

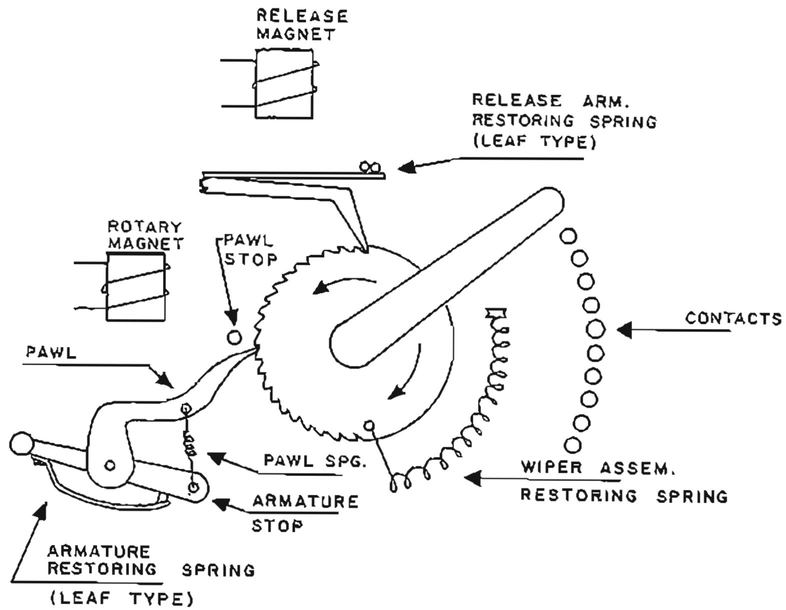


Fig. 14. Schematic of Minor Switch.

In Figure 14, the switch moves one tooth notch each time the *rotary* magnet is energized, and is held in this position by the detent of the *release* magnet armature when the rotary armature re-positions at the end of the energized period of the rotary armature. Successive steps take place in the same manner. When the *release* magnet is energized, the detent is removed from the holding position and the rotor returns to its home position (against the stop) from the force of the restoring spring.

The same kind of a picture presentation can be made for the unidirectional rotary stepping switch:

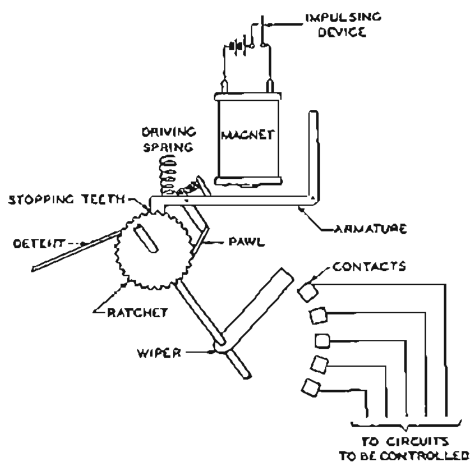


Fig. 15. Schematic diagram of pulse-controlled operation, unidirectional rotary stepping switch.

Each time the Motor Magnet is energized, the armature is attracted against the tension of the driving spring, and the pawl slips over the adjacent tooth. When the Motor Magnet is de-energized, the driving spring pushes the armature pawl against the ratchet tooth it rests upon and moves the wiper assembly the prescribed distance, carrying the wipers forward to the next bank contact. The detent prevents movement in the unwanted direction while the armature is being attracted to the "cocked" position. The wiper is always moved in the same rotary direction in successive steps.

III. BASIC OPERATING CIRCUITS FOR INDIRECTLY DRIVEN ROTARY STEPPING SWITCHES

There are basically two ways of stepping an indirectly driven rotary stepping switch: *pulsed* and *self-interrupted.*

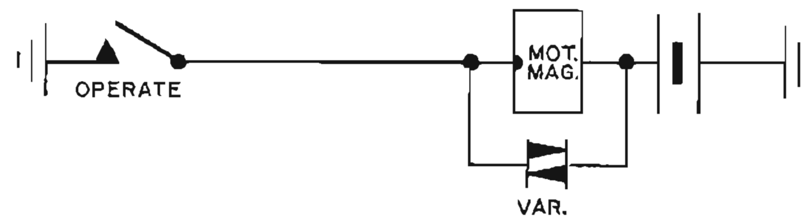


Fig. 16. Basic circuit for a rotary stepping switch.*

When a circuit of proper voltage and power capabilities is closed to the motor magnet coil of the indirectly driven rotary stepping switch, the armature is attracted and held in the "cocked" position. (See also Figure 15.) When the coil circuit is de-energized, the potential energy stored in the drive spring pushes the pawl against the associated ratchet wheel tooth, causing the wiper assembly to take a step. A set of stopping teeth engages the ratchet wheel about one-half the way down, securely preventing overthrow of the wiper assembly, and accurately positioning the wipers on the banks without strain on the pawl. The illustrations in Figure 17, page 16, show how the armature "stopping" teeth mesh with the ratchet wheel during one cycle of operation.

Repetitive pulses (circuit closures) will cause the switch to take as many steps as the number of discrete pulses received.

**A varistor is shown for contact protection in Figure 16. A capacitor-resistor net is equally effective, and will be indicated in most of the subsequent figures.*

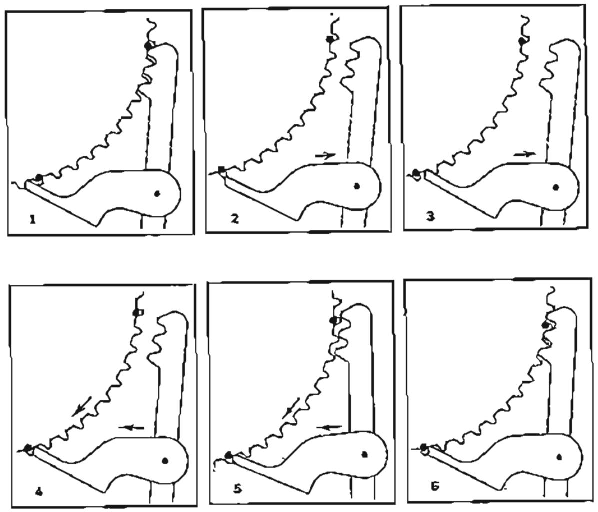


Fig. 17. Pawl and "stopping" teeth action.

Pulsed Stepping

The length of time the circuit is closed (and opened) in a series of fast pulses is very important. To be effective, a pulse to the switch must consist of an "on" time interval (coil current flowing) long enough to fully attract the armature into a "cocked" position, storing potential energy in the drive spring while doing so. The "off" time interval must be adequate for the drive spring to move the armature, and associated wiper assembly to the next bank contact position (Figure 18). For a series of nearly constant speed pulses this can be expressed as "per cent make" (closed circuit) and "per cent break" (open circuit) as related to the overall span of a single pulse. At ten pulses per second pulsing rate, a "per cent make" of 80% and a "per cent break" of 20% would represent a pulse "on" time of 80 milliseconds and a pulse "off" time of 20 milliseconds. At a pulsing speed twice as fast (20 pulses per second), the respective per cent make and break intervals would be 40 milliseconds and 10 milliseconds. From the following table and the average "per cent make" curves, it will be seen that the switch must neither be starved (given too short a pulse) nor kept energized too long (given too long a pulse), if the desired speed response is to be obtained.

It will also be noted that the pulse rate versus the per cent make relationships become more critical as the pulse speed increases. In other words, the per cent make latitude to which the rotary stepping switch can accommodate narrows with pulse rate increase.

Average Characteristic	Minor Switch	Type 44	Type 45
Motor magnet operate time	16 ms	16 ms	18 ms
Motor magnet release time	11 ms	3 ms	5 ms
Maximum theoretical impulse speed	35.5 pps	53 pps	43.5 pps

Fig. 18. Maximum theoretical impulse speeds.

If the switch is being pulsed from a cam or controllable pulse generator, the ideal per cent make is indicated in Figure 19 by the dashed line through the pulse envelope and should be held closer to the top line than the bottom. All of this applies to an "externally pulsed" switch and does not enter directly into the capabilities of a switch being driven "self-interruptedly".

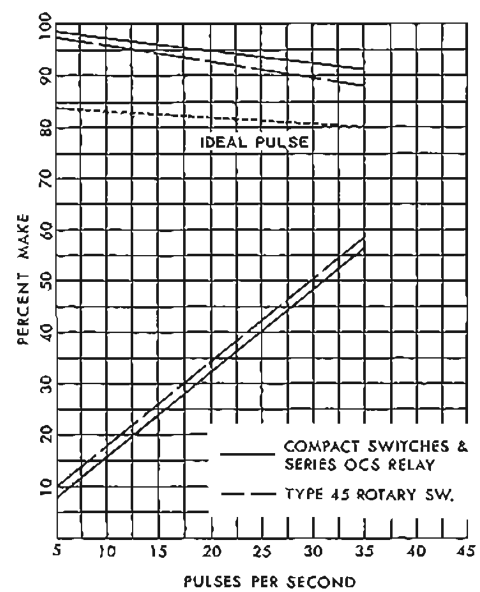


Fig. 19. Typical pulse range curves.

Self-Interrupted Stepping

Self-interrupted operation is used to step the switch rapidly from one point to another without use of discrete pulses from outside the switch. Under self-interrupted operation, a circuit is closed to the coil through its own interrupter contact springs. When the coil is energized, the armature is attracted in the usual way, but before fully seating on the coil core it is caused to open its own circuit, de-energizing itself. This causes the armature to fall away, driving the wiper assembly one step, but as it does so the interrupter contacts are caused to reclose. The armature is again attracted, re-cocking the switch and causing re-opening of the interrupter contacts. Thus the switch is made to run "self-interruptedly" until the circuit is opened permanently, by opening of the circuit at the off-normal springs, or at a bank level being used to furnish the self-interrupting potential. Examples of both kinds of circuits follow later on in this book.

Self-interrupted operation of the switch is sometimes referred to as "buzzing", or "door-bell" operation. For schematic representation, see Figure 20, below.

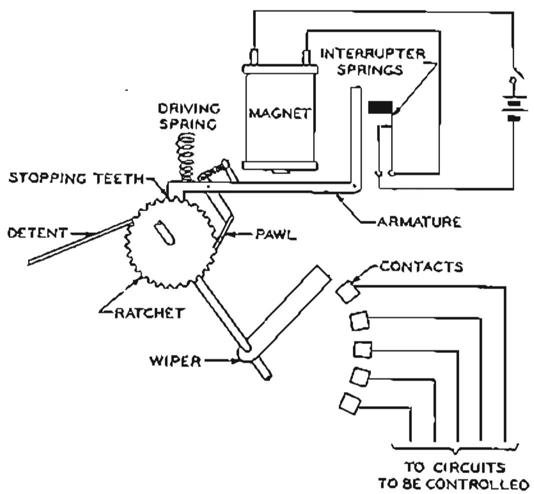


Fig. 20. Schematic diagram of self-interrupted operation, unidirectional rotary stepping switch.

Considerations of Maximum Circuit-Closure Time

Rotary stepping switch coils, operating at the voltage for which they were designed, will stand continuous pulsing indefinitely.

Use of a Limiting Resistor

When coils are to be held energized for long periods of time, a limiting resistance should be inserted in series with the coil.

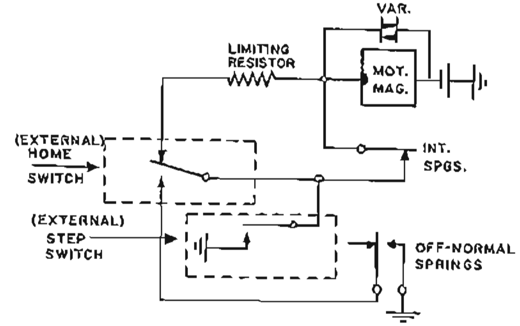


Fig. 21. Current-limiting resistor for long pulse duration, to avoid overheating coil. *Please note: Switches "dotted in" are external to the stepping switch and are controlled manually, or otherwise not associated with the switch mechanism.*

When the rotary stepping switch in Figure 21 is completely actuated, the current-limiting resistor is inserted in series with the rotary stepping switch coil (because a short is removed from the limiting resistor by operation of the interrupter springs—"INT. SPGS"). In this condition the power consumed is reduced to a point where the wattage dissipated by the switch coil is of a non-damaging value. Opening the "step" external control contacts will cause the switch to be de-energized and advance one step. The interrupter contacts, when they reclose on this release, again short the limiting resistor for the successive step, if any. As depicted, the current-limiting resistor is not in effect when the switch is stepping self-interruptedly.

The limiting resistor used in a circuit of this type must, of course, be of sufficient wattage (about 10 watts capability) to operate in a relatively cool condition and must not be of high enough resistance to reduce the total circuit (coil) current to less than one-third of the normal current which the rotary stepping switch would otherwise draw.

Explanation of "Homing" in Figure 21

It happens that Figure 21 can also be used to show the homing technique for indirectly driven stepping switches using interrupter and off-normal contact springs. In Figure 21, the contacts in the circuit identified as "home" are presumed to be on some remote relay or manually operated device, by means of which the circuit indicates whether the switch is to take individual steps (or self-interrupted steps) to drive the switch to the home or normal position. With the "home" contacts in the position depicted, closure of the "step" contacts provides a circuit to the rotary stepping switch motor magnet as described under "Use of a Limiting Resistor".

When the "home" contacts are in the position other than pictured in Figure 21, and the stepping switch is off-normal, a circuit is closed from the stepping switch off-normal contact springs through the "home" contact, and the interrupter contact springs of the stepping switch to the motor magnet of the stepping switch. The stepping switch will operate in a self-interrupted manner until such time as the off-normal contact springs transfer to the position shown in the sketch. At this point self-interrupted motion stops. The switch is "home", or at normal.

Pulse-Inversion Circuit for Direct Drive

In some cases it is a *must* that the stepping switch move to the next bank position on pulse *initiation*. To make an indirectly driven stepping switch do this (circuit-wise like a Minor Switch), a relay is introduced into the circuit, as shown in Figure 22.

Closure of the impulsing device's contacts provides the circuit to the motor magnet of the rotary stepping switch. The stepping switch energizes, and when its armature is completely operated, the interrupter springs will close the circuit to the coil of Relay A. Relay A operates and, by means of its make-before-break contacts, locks itself to the pulse and opens the circuit to the rotary stepping switch motor magnet. The rotary stepping switch is de-energized immediately and restores to the unoperated condition, advancing the wipers one step. When the rotary stepping switch is in the de-energized position, the interrupter springs open the operating circuit for Relay A. Relay A

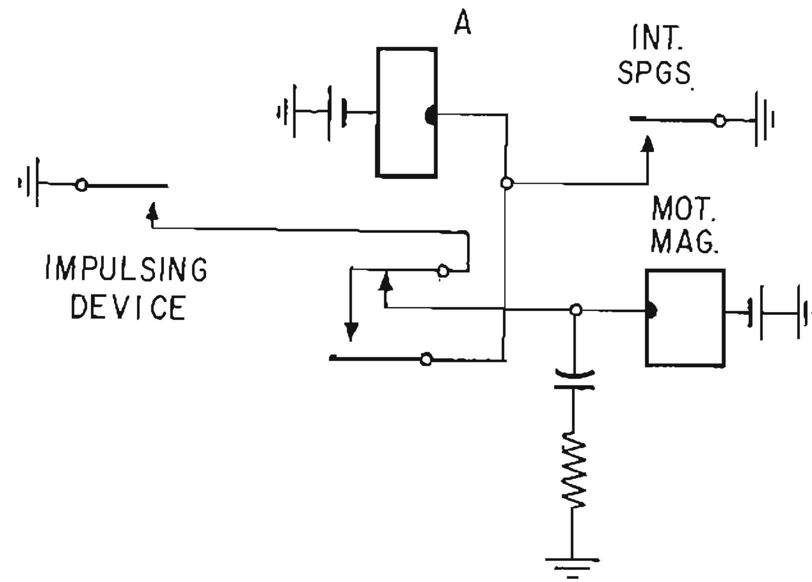


Fig. 22. Pulse-inversion circuit for rotary stepping switch "direct drive," to step switch on pulse closure.

remains operated until the contacts of the impulsing device open. When these contacts do open, Relay A restores and reconnects the rotary stepping switch motor magnet to the impulsing lead. The next closure of the contacts of the impulsing device will cause the circuit operation described above to be repeated.

IV. "HOMING" OF ROTARY STEPPING SWITCHES

Rotary stepping switches usually incorporate facilities which, through various arrangements, will cause the wipers to restore to a normal position at the completion of a switching operation. This is called *homing*, and may be done in two ways on indirectly driven rotary stepping switches, and by the integral design of directly driven rotary stepping switches.

Homing of the Directly Driven Minor Switch

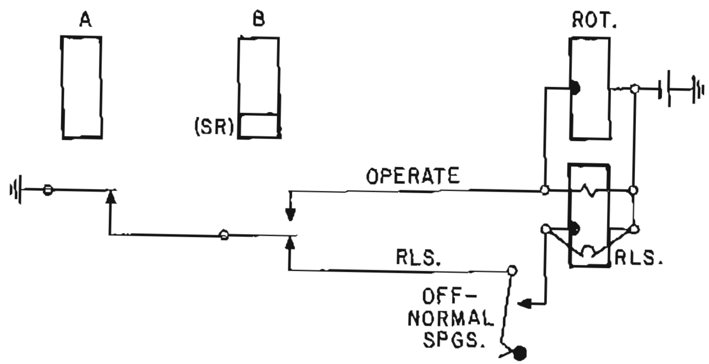


Fig. 23. Restoring Minor Switch to normal.

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 the homing spring; a detent on the ratchet dog holds them in position against this pull. When the switching circuit is released, Relays A and B restore, and ground, through the now-closed off-normal springs, 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.

Homing of the Indirectly Driven Rotary Stepping Switch

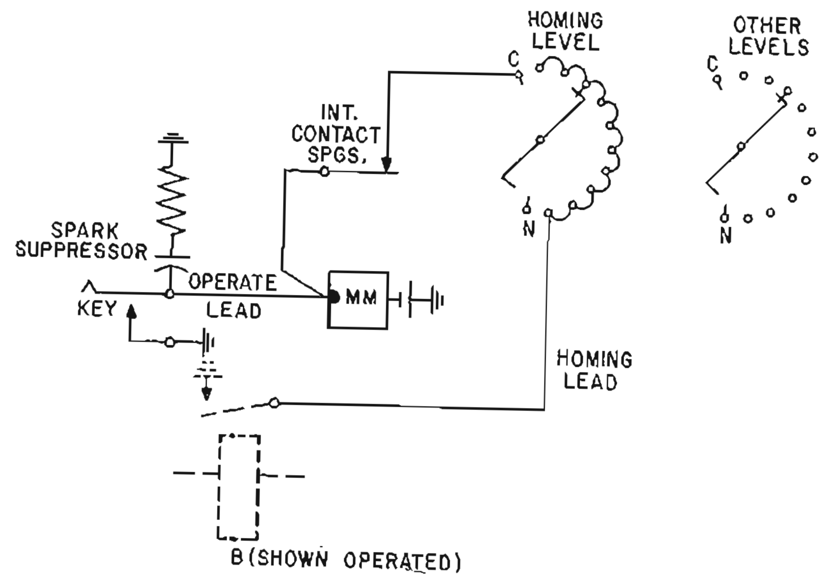


Fig. 24. Restoring an indirectly driven rotary stepping switch to normal by means of a wired switch level.

Figure 24 illustrates the method of restoring an indirectly driven rotary stepping switch to its home position by means of a wired bank level. 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 the 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 24).

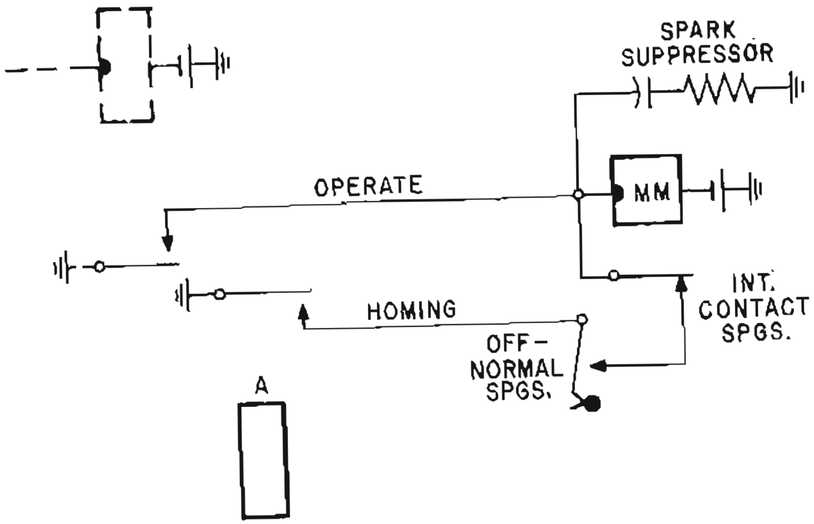


Fig. 25. Restoring an indirectly driven rotary stepping switch to normal by means of off-normal springs.

The motor magnet (MM) in Figure 25 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 motor 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.

Self-Interrupted Stepping and Homing of the Type 45NC Rotary Stepping Switch

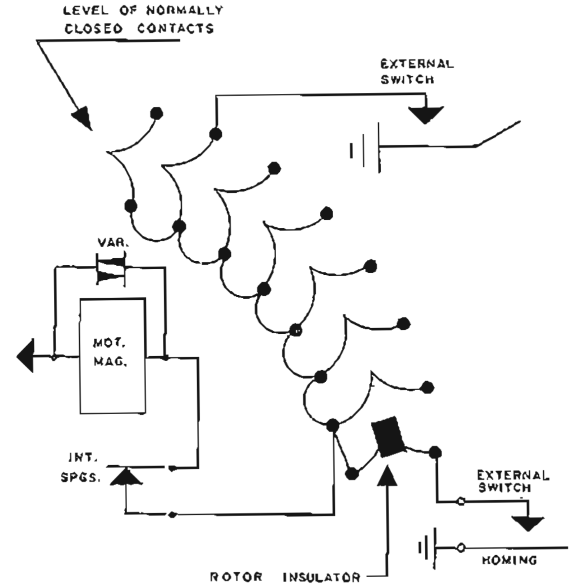


Fig. 26. Homing by means of a normally-closed level.

When equipped with at least one "normally-closed" level, the Type 45NC Rotary Stepping Switch can be stepped self-interruptedly to a desired contact, or homed, without the use of relays (thus eliminating the timing problems inherent in that method of homing). Figure 26 shows schematically how this is accomplished. Besides saving the cost of an associated relay, the wiring costs are reduced, since potentials need not be connected to unwanted positions (as is required for normally-open contact levels used for this kind of an application).

In Figure 26, the closure of switch "X" will cause the switch to run self-interruptedly to this point, then stop. Also, closure of the "homing" switch will cause the switch to run self-interruptedly to the home position, and then stop.

Homing of the Series OCS Relay

Homing of the cam-switching Series OCS Relay is discussed fully on page 119.

TCI Library: www.telephonecollectors.info

Courtesy of ELECTRONICS WORLD.

V. BASIC THINGS YOU CAN DO WITH ROTARY STEPPING SWITCHES

To make use of rotary stepping switches we must analyze what they can do for us. As its name indicates, the rotary stepping switch is used to close circuits, open circuits, and transfer circuits. Therefore, the broadest category of what it can do is *switch*. This can be pinned down to eight broad functions: *select, indicate, count, time intervals and pulses, control, monitor, test* and *program*.

A. Select

Since rotary stepping switches take one step for each incoming pulse, they can be used to select any specific contact point in the bank of contact points. This can be done under manual control, or automatically. If, for example, with the wipers standing in the "home" position, five impulses are sent to the motor magnet, the wipers will end up in bank contact position No. 5. In this position, as many functions can be performed through the wiper circuits as there are bank contact levels being contacted.

A typical circuit of this type, operating under control of a dial, is given on the next page.

TCI Library: www.telephonecollectors.info

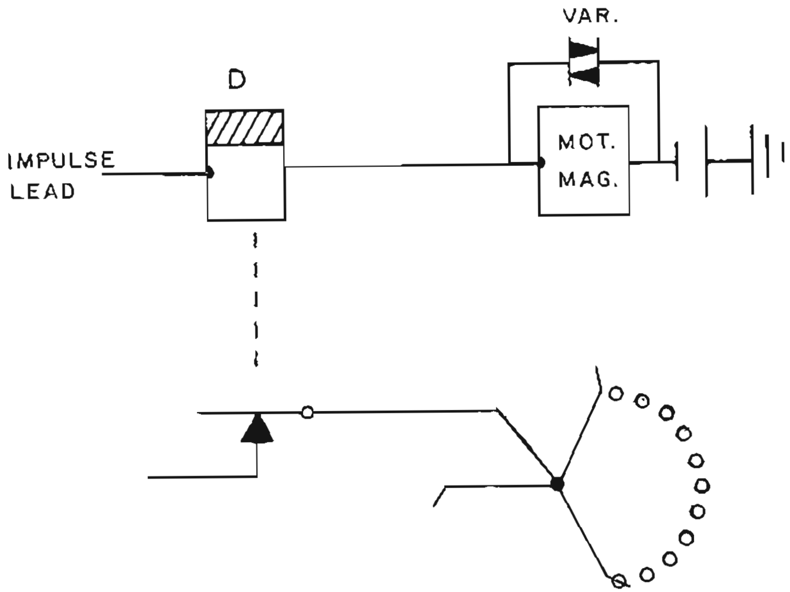


Fig. 27. Wiper disconnect circuit during stepping, to avoid energizing circuits wiped over. *NOTE: Relay D must have a vendor-chosen low-resistance coil.*

In this circuit the select lead is held open during the series of pulses (by slow-to-release Relay D) until the wiper has reached the desired contact, after which Relay D restores to establish the chosen circuit(s). The wiper circuit(s) is (are) held open during stepping to avoid making undesired connections.

Caution

Relay D must be engineered to have an operate time equal to or less than the operate time of the rotary stepping switch and must have a release time slightly longer than the release time of the rotary stepping switch. Using telephone-type relays such as AE's Class A and B relays, it is suggested that the Series ASR or BSR type of relay be used with an 11/16" long copper slug for impulse rates of approximately 10 pulses per second (telephone dial speed).

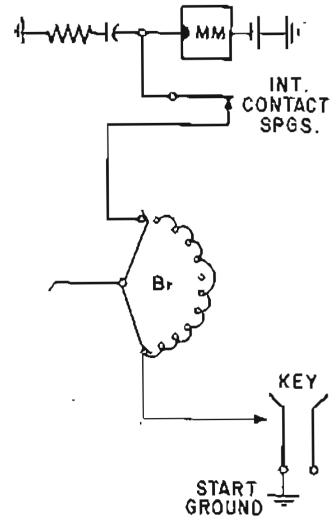


Fig. 28. Self-interrupted searching for absence-of-potential (ground).

The arrangement shown in Figure 28 searches for an absence-of-potential (shown as "ground" in the sketch). A bridging level must be used. A start ground from a control relay's contacts or from a key (via the normal contact, the wipers, and the rotary switch interrupter contact 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.

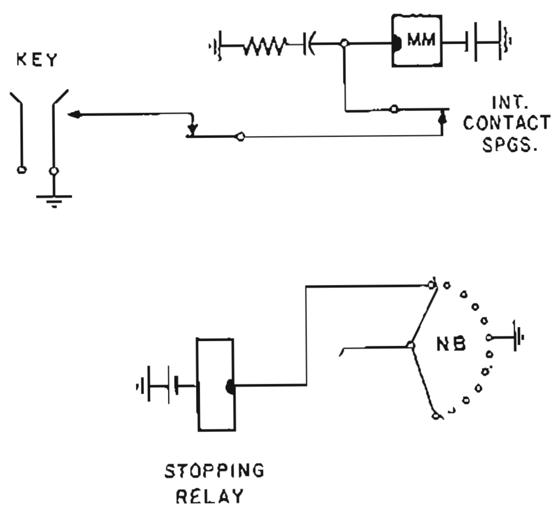


Fig. 29. Self-interrupted searching for presence-of-potential (ground).

The arrangement shown above 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 contact 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 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 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 MM and prevents further stepping. Caution: The stopping relay must be very fast to operate in order to open the motor magnet circuit before the switch is energized.

B. Indicate

Rotary stepping switches are ideally suited for visual indication of the number of pulses received and/or the number associated with the bank contact position reached. By the use of a circuit similar to Figure 29, a lamp (or other visual indicator) can be operated from the selected bank contact. The correctness of the indication can be accurately checked by observing the actual wiper location. This kind of visual checking is much more difficult, if not impossible, to achieve when using relays or solid-state devices unless very expensive associated equipment is also employed.

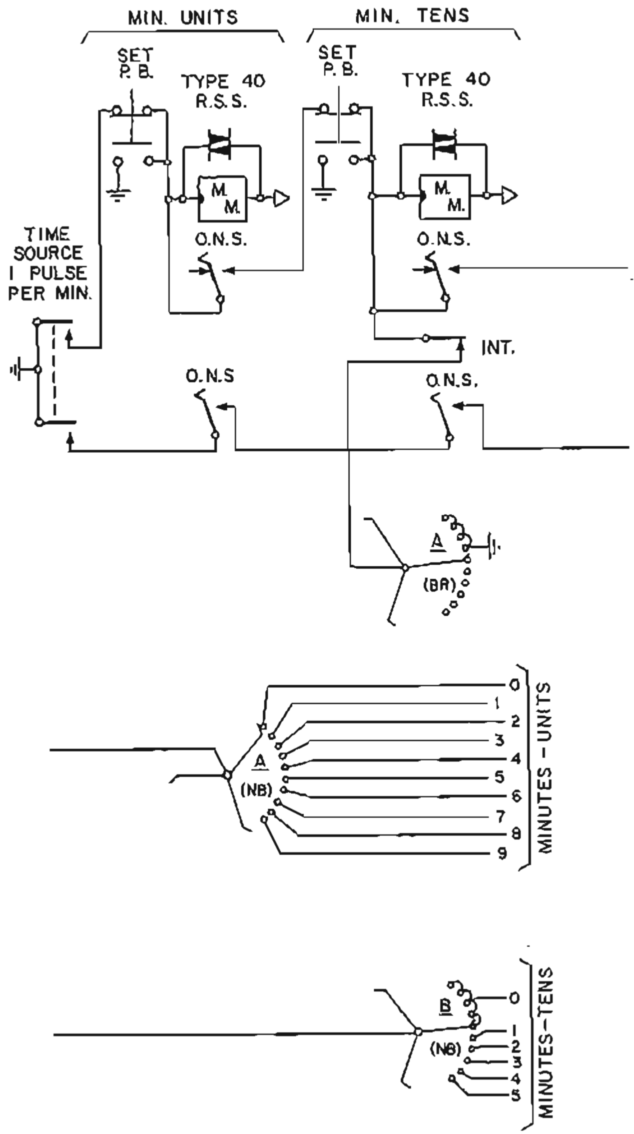
C. Count

Accumulating or totalizing pulse counts is a "natural" using rotary stepping switches. Incoming pulses are accumulated on the "units switch", until the accumulation has reached a pre-determined (spill over) value, after which a single pulse is passed on (spilled out) to the next switch. The count of units and groups of units can thus be accumulated and passed onto the next totalizing area until the entire count has been made. This can take the form of relatively simple accumulations of 10's, 100's, etc., or of relatively sophisticated groupings, as in the Digital Clock, Figure 30.

Digital Clock with 24-Hour Readout

Figure 30 shows how two Type 40 Rotary Stepping Switches and one Type 45 Rotary Stepping Switch can be used to make a full 24-hour clock. It requires a time source with one pulse per minute output to drive it, and it is equipped with push buttons for proper initial setting of the units and tens of minutes and hours.

TCI Library: www.telephonecollectors.info



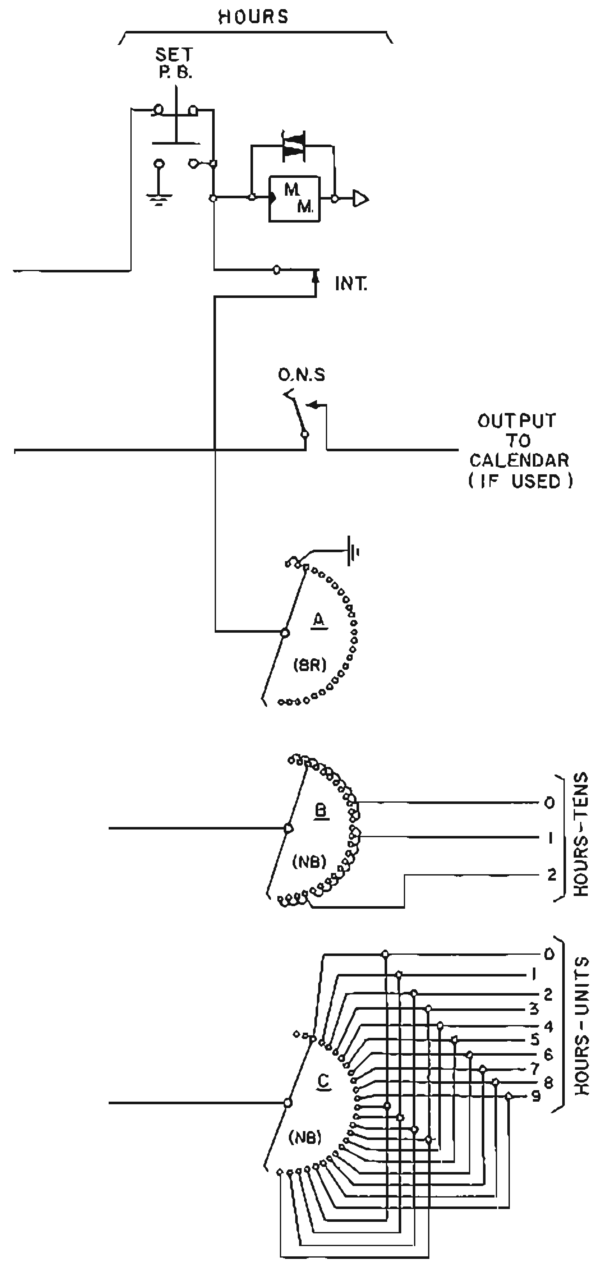


Fig. 30. Digital clock with 24-hour readout.

With the stepping switches as drawn, the decimal readout from the units of minutes switch, the tens of minutes switch, and hours switch is zero, zero, zero, zero (0000). This condition can only take place during the 60 second interval following 2359 immediately before midnight.

When the pulse contacts of the time source close, the motor magnet of the Minutes Units switch is energized. When these contacts open, the Minutes Units switch advances one step to its second bank contact, and the Minutes Units readout changes from zero to one. When nine minutes have been registered, the Minutes Units switch is on its tenth bank contact and the off-normal springs have transferred to the opposite contact. Thus, the next closure of the time source impulse contacts will, in addition to energizing the Minutes Units switch, also be extended to the coil of the Minutes Tens switch, energizing both in parallel.

When the time pulse goes off, the Minutes Units switch will be back to zero, and the Minutes Tens switch will have advanced to the sixth bank contact (with a decimal value of one). The first four bank contacts on the Minutes Tens switch are always skipped by strapping on level A.

When the Minutes Tens switch is on the tenth bank contact (with a decimal value of five) and the Minutes Units switch is on the tenth bank contact (with a decimal value of nine), the next closure of the pulsing contacts will energize the Minutes Units switch, the Minutes Tens switch, and the Hours switch. Following the pulse, all three switches will advance.

The circuit is wired so that the clock will count from zero, zero, zero, zero (0000) to 2359 every 24 hours. If a companion Digital Calendar (see Figure 63) is used, the pulse that changes 2359 to 0000 will also forward a single pulse through the off-normal chain to advance the Calendar one day.

The switches in the clock should always be set in this order: Minutes Units, Minutes Tens, and Hours.

D. Time Intervals and Pulses

A rotary stepping switch can be used with any time pulse source to generate time intervals. Figure 31 illustrates a circuit that can be used to generate actuating pulses and to develop a total time interval. It takes ten times the length of the initiating pulse interval for the switch to reach the last bank contact. This can, for example, represent a generated time delay that might be required for an alarm initiating interval.

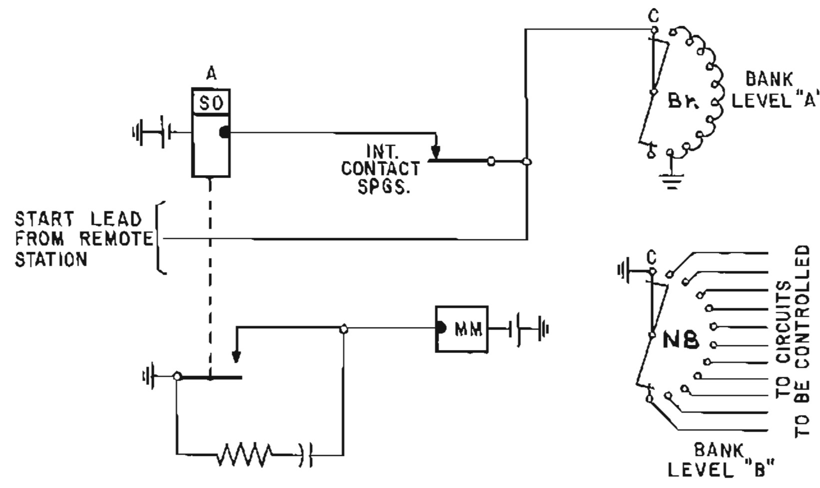


Fig. 31. Pulse producing.

The circuit shown in Figure 31 is used to generate pulses somewhat similarly to those produced by the circuit arrangement of Figure 32, on the following page. However, a definite number of pulses (or some multiple of that number) is produced each time the starting key is closed in Figure 31, while Figure 32 is shown wired so that pulses are sent only as long as the "start" circuit remains closed.

Operation of Figure 31

In Figure 31 on previous page, 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, thus 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.

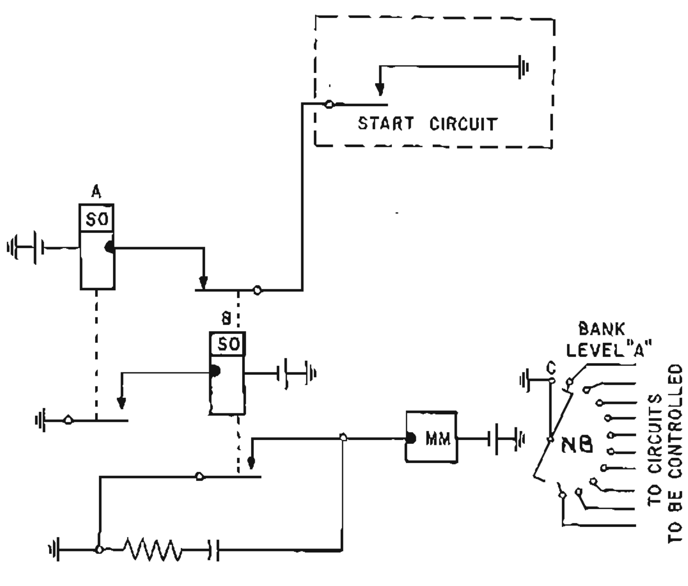


Fig. 32. Pulse sending.

Relay A is slow-to-operate and slow-to-release. This aids in the creation of a time interval between steps of the rotary stepping switch. The characteristics of Relay A can be chosen to produce the desired timing.

Operation of Figure 32

This 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 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. When 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 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.

E. Control

A rotary stepping switch can be used alone, from a simple pulse source, or under control of a more sophisticated pulse source. Hundreds of different circuit examples could be used for illustrating this feature. For this purpose, two have been chosen: one of a directly driven Minor Switch (Figure 33), the other of the more commonly employed indirectly driven switch (Figure 34). *Please note that the control methods used for rotary stepping switches in general are not applicable to the Minor Switch, and vice versa.*

TCI Library: www.telephonecollectors.info

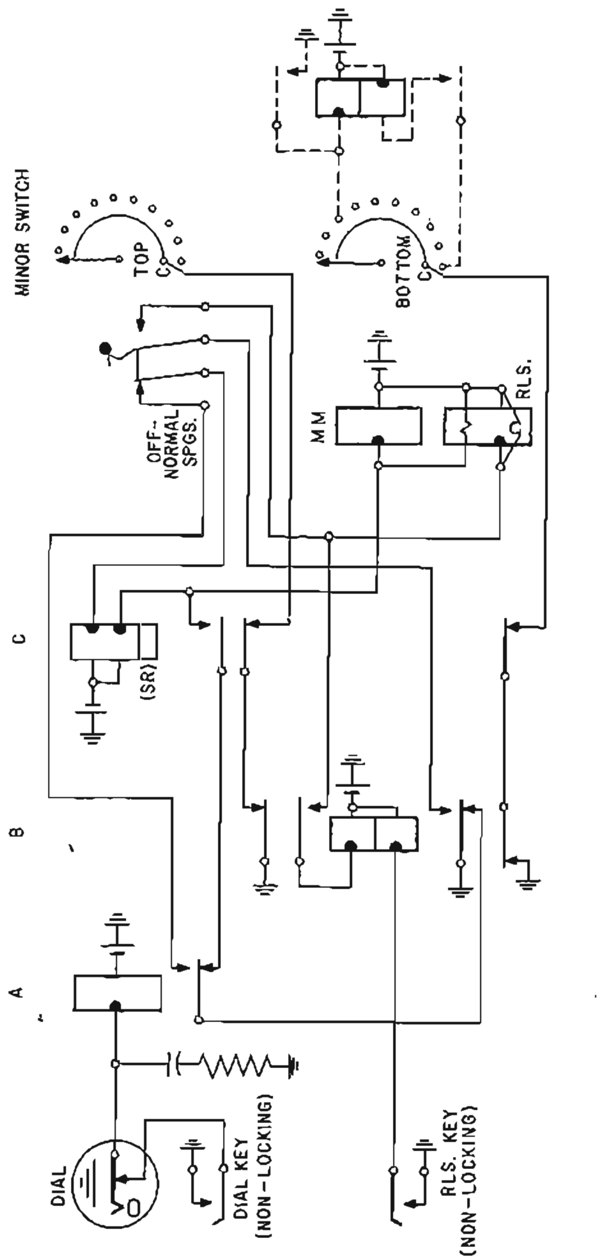


Fig. 33. Typical remote control circuit—directly driven Minor Switch.

Telephone Dial Remote Control of the Minor Switch

Operation of a non-locking dial key closes the circuit for Relay A. (The dial key must be manually 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 magnet (MM).

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 rotary magnet of the Minor Switch. The energization of the rotary magnet steps the wiper assembly to the first set of bank contacts. During the first step taken by the wiper assembly, the off-normal contacts change position. The pair of off-normal spring contacts (shown closed) open. The pair shown open closes. Opening the normally-closed pair of off-normal springs opens the operating circuit for Relay C. However, Relay C and the rotary magnet are still being pulsed through the make contacts of Relay C.

The closing of the dial impulse springs, at the end of the first pulse, will re-operate 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 re-energized to step the wipers ahead one step.

The dial comes to rest at the completion of the series of pulses corresponding to the digit dialed. Relay A re-operates but Relay C, after the expiration of its slow-release interval, releases. Release of the dial key restores Relay A. *Note: Figure 33 is repeated on the following page for easier reference.*

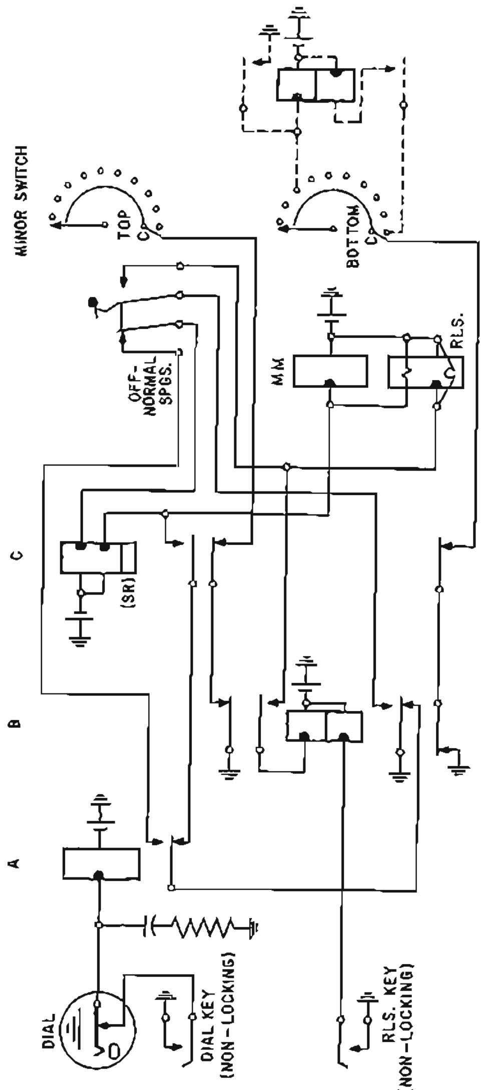


Fig. 33. Typical remote control circuit - Minor Switch. (Repeated for easier reference.)

External Control Circuit Selection

A control relay has been connected to the third contact of the bottom level of bank contacts in Figure 33. 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.

Circuit Release

Momentary operation of the release key (RLS.) in Figure 33 closes ground to Relay B. The operation of Relay B closes ground to the release magnet (RLS.) 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 (BOTTOM) bank preventing false operation of any control relays while the wipers are restoring. The off-normal springs re-operate, opening the release magnet and the Relay B locking circuits.

External Control Circuit Release

Digit "0" is dialed to discontinue the external control function (see Figure 33). 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 release key (RLS.) is operated, the circuit is restored to normal.

Safety Feature

The non-locking 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.

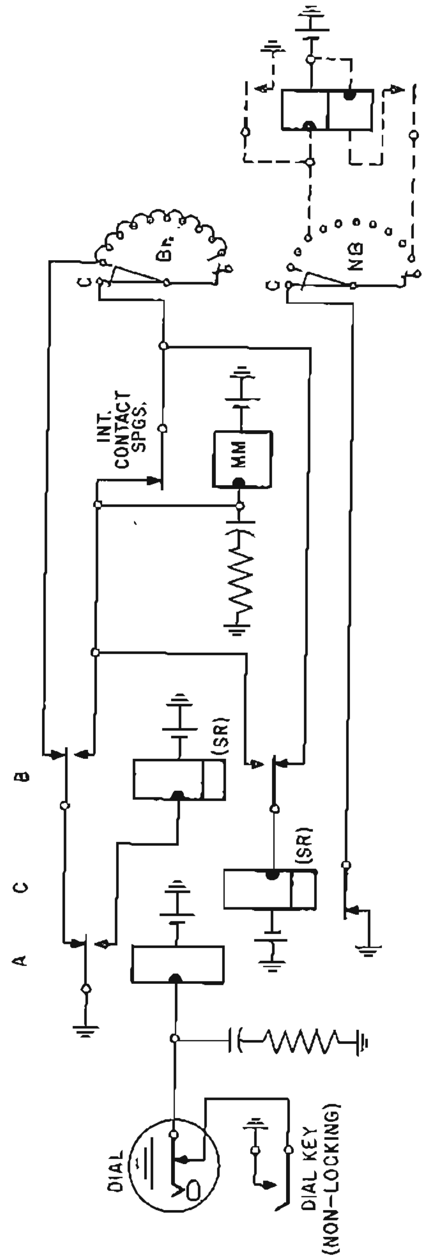


Fig. 34. Typical remote control circuit—indirectly driven rotary stepping switch.

Telephone Dial Control of the Indirectly Driven Rotary Stepping Switch

The most commonly used rotary stepping switch is of the indirect drive type. Figure 34 and the following explanations describe the techniques for using this rotary stepping switch for remote control by telephone dial.

Stepping the Switch

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 re-operates. 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 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 re-operation of Relay A and steps the wiper assembly one step until the dial has restored.

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 bank terminal on which the wipers rest. This control relay operates and locks to an external ground through its make contacts.

Circuit Release

The restoration of the dial key releases Relay A which releases Relay B, and the 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 (non-bridging) 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.

External Control Circuit Release

The digit "0" is dialed to release the external control circuit. This is similar to the arrangement described on page 41.

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.

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.

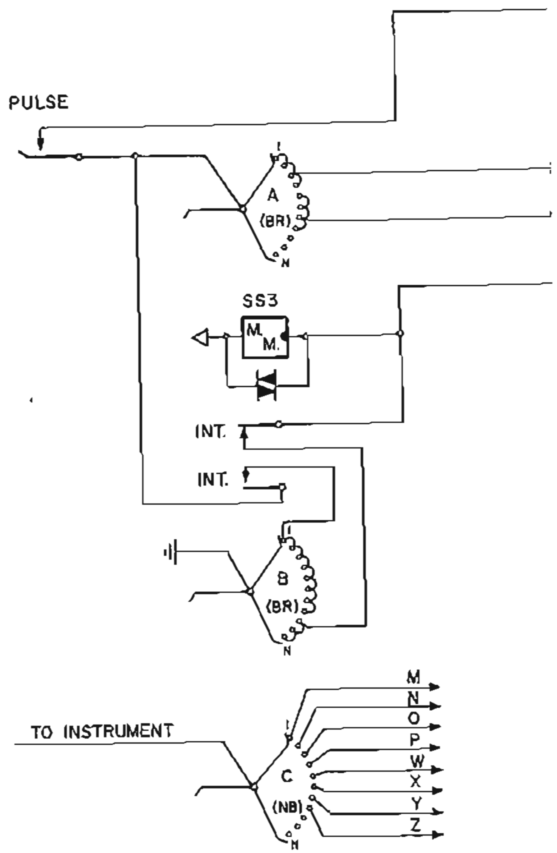
F. Monitor

One of the uses for which rotary stepping switches are frequently employed is that of successively scanning or monitoring devices connected to the bank contacts that are to be supervised or to give supervision. If conditions are found to be normal when bank contacts are successively tested, the switch is allowed to step to the next bank contact position, etc. Switches may be ganged to provide any number of monitoring positions. Such a circuit is discussed below and shown on pages 46 and 47.

Scanning Circuit

This circuit demonstrates the use of a small rotary stepping switch (Type 44) used to switch a signal lead between levels on one or more large rotary stepping switches (Type 45) to make it possible to connect one point at a time with a large number of total points. Position 26 on the Type 45 stepping switch is absorbed in each half rotation, so that 25 points are sequentially scanned for each half rotation. Starting with the switches in position 1 as shown, the circuit operates as follows.

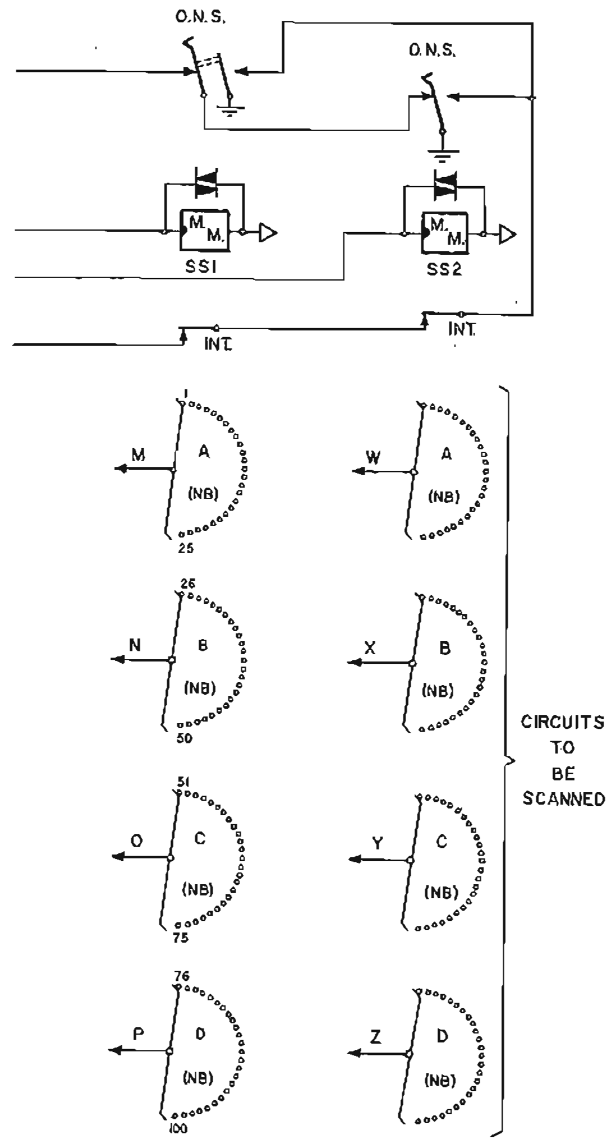
Ground from the off-normal contacts of the two Type 45 switches in series is closed by the pulse contacts through bank level A of SS3 to the stepping switch coil of SS1. SS1 is energized, and when the pulse contacts open it advances one step, connecting the scanning lead to point 2. The next pulse moves SS1 to point 3, etc. When SS1 receives the 25th pulse, its wipers advance to position 26 and the off-normal contacts are operated. Ground from the off-normal contact on SS1 is closed through the interrupter contacts of SS1 and SS2 to the motor magnet of SS3. SS3 cocks and closes the circuit from ground on the wiper of level B, through interrupter contacts on SS3, through level A of SS3 to the motor magnet of SS1. SS1 cocks and opens the circuit to SS3 by means of its interrupter springs. SS3 advances, switching its wipers to position 2 and in advancing, opens its interrupter contacts to release SS1 and permit it to advance to contact 26 (on level B of SS1). The next two cycles are similar. After SS1 has connected the scanning lead to the 100th point, it receives a pulse from the pulse contacts and steps to physical position 26, closing its off-normal contact springs to energize SS3. SS3 cocks, closing the circuit to SS1, which also cocks, opening the circuit to SS3. SS3 advances its wipers to position 5, and in advancing, opens the circuit to SS1. The next pulse from the pulsing contacts is taken through level A of SS3 to the motor magnet of SS2 and the next 4 cycles scan the points from 101 through 200 on the levels of SS2. After point 200 has been scanned, SS3 is advanced to position 9, and ground from the wiper on level B is closed through the inter-

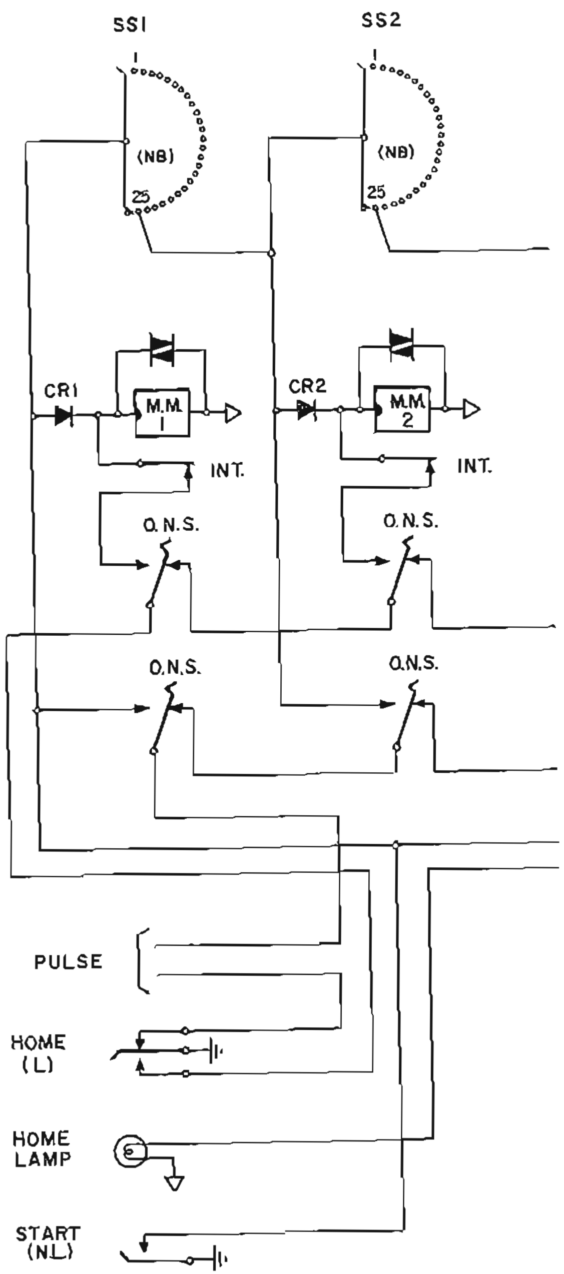


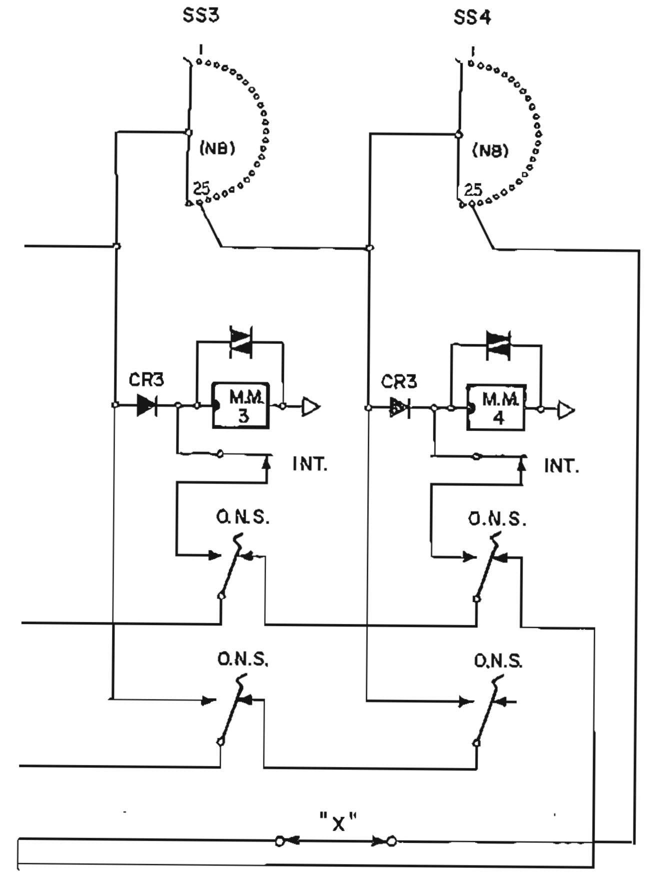
NOTE:
If circuit is to switch Low-Level signals, use gold contacts on signal levels.

Fig. 35. Scanning circuit. Switches between wipers to scan a large number of points.

rupter contacts on SS3 to the coil of SS3. SS3 takes 3 steps self-interruptedly and stops on position 1. The complete cycle will now start over.







NOTE:

If only one cycle is desired omit "X" wiring.

Fig. 36. Circuit to continuously cycle through a series of rotary stepping switches.

Circuit to Continuously Cycle Through a Series of Rotary Stepping Switches

The function of this circuit is to allow cycling through a series of rotary stepping switches. This circuit might be preferred to that shown in Figure 36 in situations where large numbers of contacts must be connected simultaneously.

The circuit is started by momentary operation of the "start" key which energizes, then releases the motor magnet of rotary stepping switch 1 (SS1). SS1 advances to position 1, restoring its off-normal contacts and completing the circuit from ground on the "home" lever key through external pulsing contacts, through the off-normal contacts of SS1, to the motor magnet of SS1. SS1 takes one step for each pulse provided by the external pulsing contacts, and when it reaches position 25, completes a circuit so that, on the 26th impulse, the motor magnets of both SS1 and SS2 are energized. At the end of the 26th pulse, SS1 returns to home position and SS2 advances to its position 1. At the end of the cycle through SS2, the pulse lead is switched to SS3, then to SS4. When SS4 reaches position 25, it closes a circuit so that, on the next impulse, SS1 will also be energized and the whole cycle will be repeated. (By elimination of X wiring, the circuit will stop after SS4 has been cycled.) To reset the circuit to the home position at any time, the locking "home" lever key is operated. The rotary stepping switches are then homed in sequence through their off-normal and interrupter contacts. When all rotary stepping switches have reached the home position, the home lamp (optional) is lighted. Diodes CR1, CR2, CR3 and CR4 are provided in the circuit so that, during homing, switches will not pass a pulse from one to the other.

G. Circuit Testing

In circuit analyzers, rotary stepping switches are used to switch circuits being tested in sequence for continuity, resistance, and insulation characteristics. The Type 45NC, particularly, lends itself to this kind of service without the necessity of using an auxiliary relay, as illustrated in Figure 37.

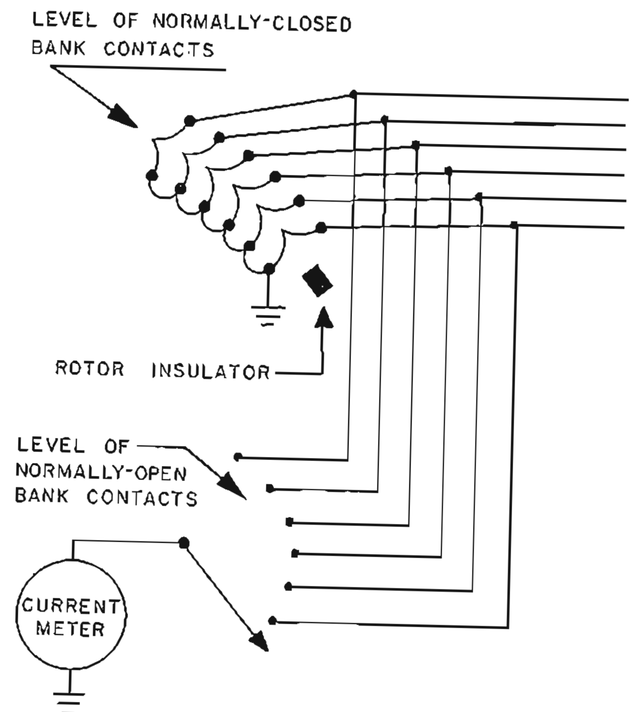


Fig. 37. Schematic of how a typical Type 45NC Rotary Stepping Switch is used for circuit testing.

H. Program

The Series OCS Relay (Figure 10, page 9) is a shock-resistant, cam-type, unidirectional rotary stepping switch. It can be supplied with from one to eight cams. Each cam can be divided into 30, 32, or 36 intervals; any combination of operated or unoperated intervals can be provided on each cam. If "off-normal" springs are required, however, one cam must be used to provide this feature. While primarily used for pre-planned programming, the versatility of the Series OCS is indicated by the six circuits presented later in this book as Figures 64, 65, 66, 67, 68 and 69. Descriptive literature on the Series OCS Relay is available from Automatic Electric Company on request.

I. Other

A commonly encountered problem in rotary stepping switch application is the need for more contacts per level, or for more levels per switch, than are available. These limitations can be overcome by appropriate circuitry and the use of a number of rotary stepping switches. Figures 38 and 39 are typical of circuits which can be utilized.

Arrangement to Provide Positive Interlock (Figure 38)

The incoming pulse operates Relay A. Relay A locks up through make springs to a multiple ground on break interrupter springs of all switches. Therefore, if any switch does not operate sufficiently to break the interrupter springs, Relay A remains operated and no further stepping occurs. When this condition exists long enough for Relay B to operate, the incoming pulse lead is opened and ground is provided to an alarm circuit.

If by some chance the switches did step together electrically, but did not mechanically due to a broken pawl pin, worn ratchet, etc., the circuit to Relay C would be incomplete. This relay would then release, opening the pulsing lead and completing ground to an alarm circuit.

If two switches are used, this method requires one bridging level of each switch. If more than two switches are used, the intermediate switches have to provide two bank levels each.

Arrangement to Provide Additional Switch Capacity (Figure 39)

This circuit is designed to permit the use of standard rotary stepping switches in circuits which require a rotary stepping switch having more than a standard number of contact points.

Characteristics

This circuit uses rotary stepping switches only; no relays are needed. The two relays shown on the circuit are merely impulse-repeating relays, and could be eliminated if a proper pulse source is available.

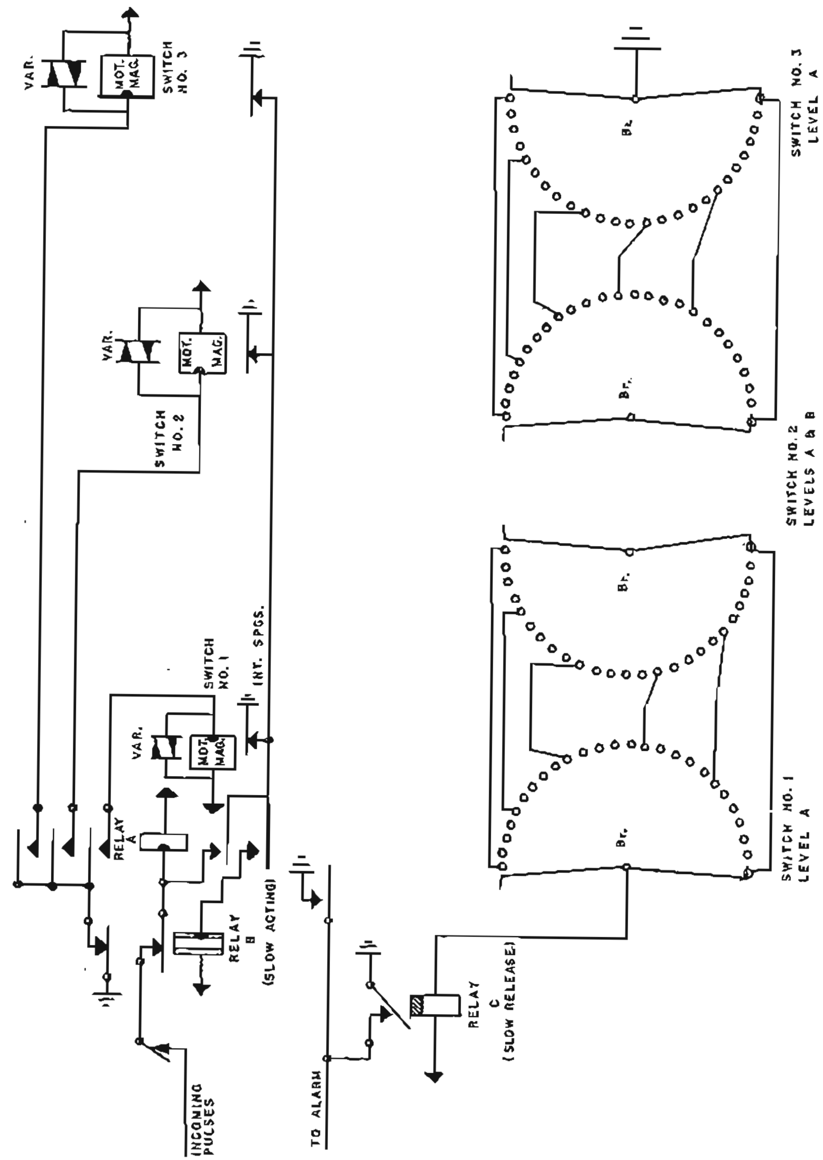


Fig. 38. Arrangement to provide positive interlock.

This circuit can be expanded to as many contact points as required merely by inserting additional rotary stepping switches, wired in the same manner as the center one.

This circuit is pulsed at a maximum of 11 steps per second (see Discussion, page 56).

Operation

With the various rotary stepping switch wipers in random positions (as in the case of examining the circuit or maintaining the equipment), Relay R2 is energized. This provides ground through levels A1, A2, and A3 to self-interrupt the rotary stepping switches to the home position. When this position is reached, ground is placed on the home position bank contact of rotary stepping switch No. 1 (SS1) from the off-normal springs (ON3) of SS3. This would cause SS1 to step to the first contact, which is electrically dead. At the same time, the closure of the off-normal springs of SS1 extends a similar ground to the home position contact of SS2. This repeats until all switches in the circuit are on the first contact. When SS3 steps onto its first contact, it closes the pulsing lead from Relay R1 through the off-normal springs to SS2, to the motor magnet (MM1) of SS1. As Relay R1 is pulsed, SS1 continues to step until the 25th pulse is received, and the switch is in its home position. The off-normal springs operate and ground is provided to bank terminal one of SS2. This will cause SS2 to take one step and land upon its second contact (contact No. 25 as far as the circuit is concerned). At the time the off-normal springs of SS1 cause SS2 to take this step, it also transfers the pulsing lead from SS1 to SS2. This repeats on each switch until the last switch is reached.

When less than all of the bank contacts on the last switch are required, the switch can be homed back to its starting contact by merely operating Relay R2. Relay R2 must be in an un-operated position before the circuit is pulsed.

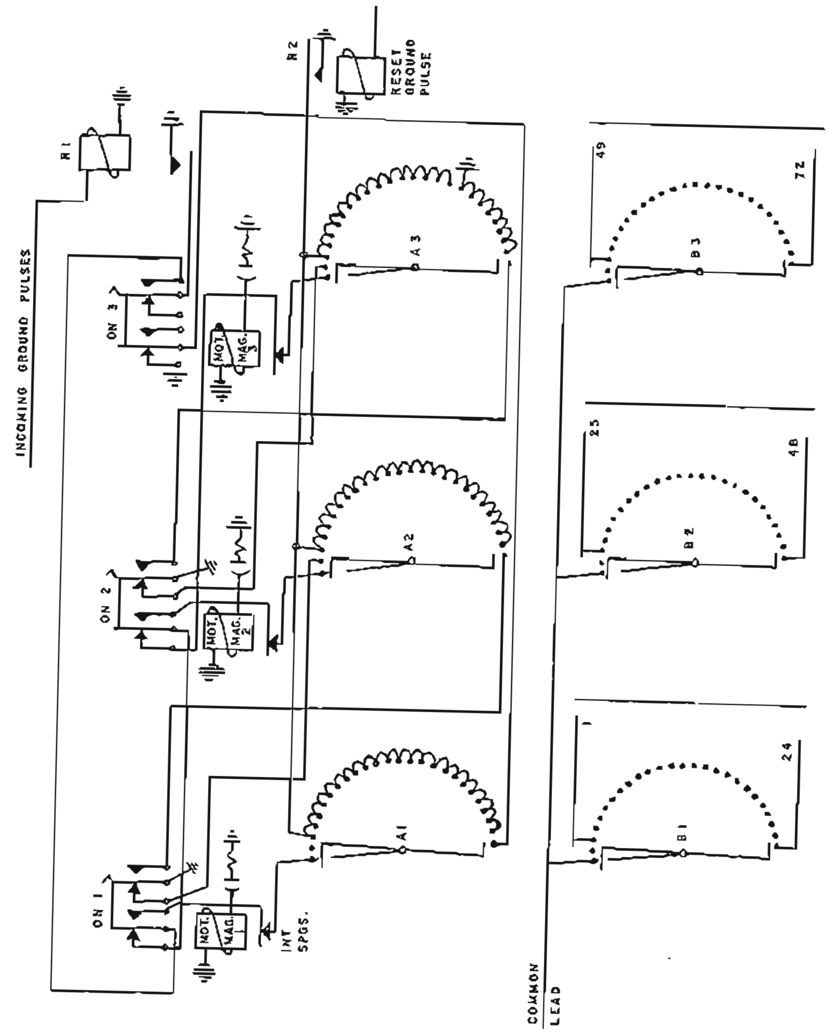


Fig. 39. Arrangement to provide additional switch capacity.

TCI Library: www.telephonecollectors.info

Discussion

This circuit does not have "races" or other critical timing. The minimum closed time of the incoming pulse is 40 milliseconds. This value includes a safety factor. The minimum open time required is 50 milliseconds which also includes a safety factor. These minimum open and closed times of the pulse are determined by the operate and release times of the individual switches.

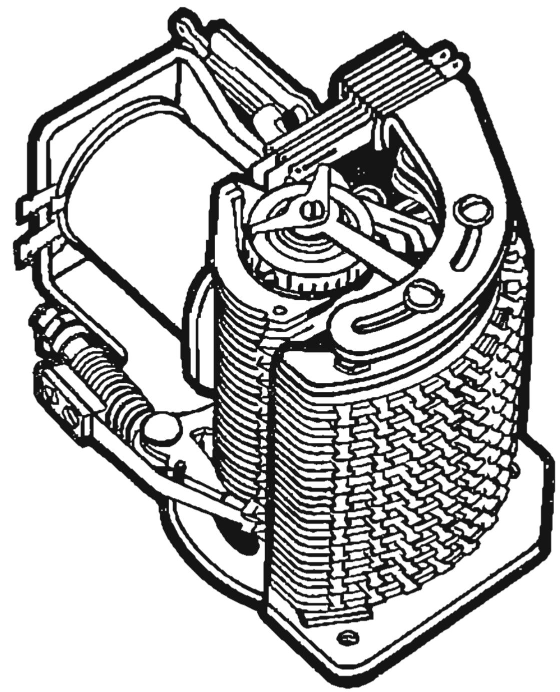
There are two shortcomings of this circuit which must be understood before incorporating it into a design

First: The required 2C off-normal spring assembly increases the mechanical load on the 26th step and should not be used on Type 45 Rotary Stepping Switches having more than eight levels.

Second: When examining the rotary stepping switches for maintenance purposes, they are often in random position. The reset contact on Relay R2 provides a circuit to restore the switches to the start position. However, should SS2 or SS3 reach their dormant position before SS1, they will continue to rotate automatically until SS1 reaches home, then SS2, and then SS3. Provisions should be made that a circuit to Relay R2 is provided until all switches have come to rest.

Unlimited Circuit Possibilities

It is beyond the scope of this publication to go into all of the details of how to use rotary stepping switches, because of the extensiveness of possibilities. Some of the customer usages reported to us are so ingenious that we hadn't thought of them ourselves. If you have need of an application for which there is no similar reference in any of our publications, this should not deter you from exploring the possibility of using a rotary stepping switch. Staff engineering assistance is readily available to help with specific problems not covered in this book or other referenced publications.



VI. POWER REQUIREMENTS OF ROTARY STEPPING SWITCHES

For acceptable operation, a rotary stepping switch coil must be supplied *direct current* of the proper *voltage stability*. The maximum acceptable variation from nominal is plus or minus 10 per cent. The power available for each rotary stepping switch should be at least 20 (preferably 30) watts. Nominal voltages considered standard are 6, 12, 24, 48, and 110. Coils can be wound for any reasonable voltage, but the current-handling capabilities of the controlling contacts makes the range of 24 to 110 volts the most practical, with 48 volts considered as ideal. When so indicated at the time of ordering (so that they will be supplied with proper adjustment), switches may be powered from commercial power AC by use of a small rectifier.

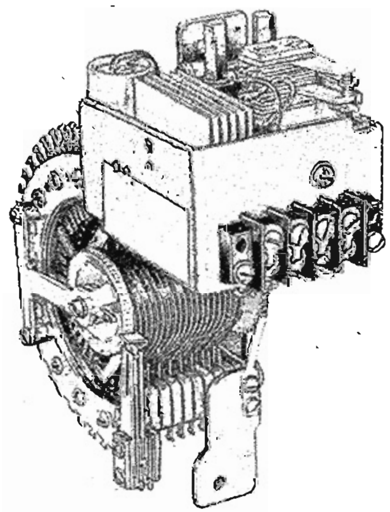


Fig. 40. Type 45 Rotary Stepping Switch with PA-98 rectifier unit.

Use of this power supply provides an inexpensive source of ideal voltage, and the matching adjustment of the switch provides the optimum of performance. Unless the rotary stepping switch is factory-adjusted to work with the rectifier that will be used, however, it may run raggedly, especially when being run self-interruptedly. It must also be remembered that all switching is to be done on the DC (output) side of the rectifier.

A PA-98 rectifier unit is used on the larger Type 45 rotary stepping switch:

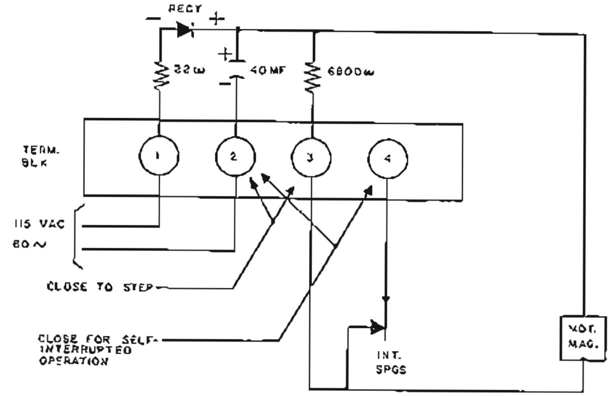


Fig. 41. Schematic diagram of the Type 45 Rotary Stepping Switch for AC operation using the PA-98 rectifier unit.

As shown in the following schematic diagram (Figure 42), Automatic Electric's "compact" rotary stepping switches use contact protection of different types from that used on the Type 45. The Types 40 and 80 rotary stepping switches (and the Series OCS relay) use a PA-97 rectifier unit with a capacitor-resistor net instead of the 6800 ohms resistor used on the Type 45. The Types 80 and 88 "compact" rotary stepping switches use an AP-88 rectifier unit with the capacitor-resistor values indicated.

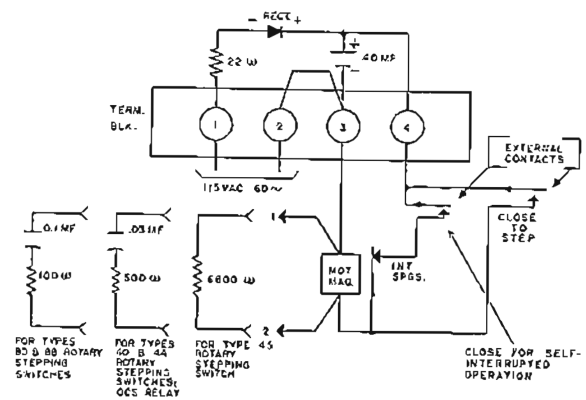


Fig. 42. AC rectifier—schematic diagram.

Because the rotary stepping switch coil is highly inductive, large (heavy-duty) contacts are recommended on controlling relays, and contact protection is required. All contact protection devices reduce the speed capability of a rotary stepping switch. Even the best of such devices represents a compromise between contact protection and speed reduction. Check with the manufacturer on kind and size of contacts required.

The ideal contact protection is something that hasn't yet been realized. A practical kind of contact protection is of the type called "varistor", placed directly across the coil of the switch, or a capacitor-resistor net in parallel with the coil. For best results with respect to avoiding adverse results to both the life of the controlling contacts and the speed and performance capabilities of the rotary stepping switch, follow the advice of the manufacturer. This is covered in detail in AE's Bulletin #961-473. Diodes, in general, are not successfully employed for this purpose. In fact, misapplication of diodes for this purpose, and for the elimination of electrical "noise", has been a big factor in the occasional misapplication and resulting poor performance of rotary stepping switches. This will be covered more fully in Chapter VIII.

The circuits discussed in this volume sometimes show varistors used across the coil (a relatively recent practice), but most often capacitor-resistor nets are shown. In most cases, varistors would be the first choice, and, if the circuits were being drawn for the first time, they would show varistors in place of the R-C nets.

VII. BASIC THINGS YOU SHOULD NOT ASK ROTARY STEPPING SWITCHES TO DO

Don't Ask Rotary Stepping Switches to Speed Precisely

Rotary stepping switches are adjusted to run self-interruptedly at a rate that represents the smoothest operation for the individual switch. The self-interrupted rate of a particular rotary stepping switch is influenced by the precise coil inductance of that unit, the armature stroke, driving-spring tension, wiper load characteristics, individual magnetic characteristics (reluctance of the magnetic circuit), and many other lesser factors. While rotary stepping switches of a like kind will have *similar* characteristics, they will *not* have *identical* characteristics, and thus will not run at identical self-interrupted speeds when individually tuned for best performance. It is, therefore, impossible to predict exactly the speed at which a rotary stepping switch will run, or to get an exactly "uniform batch" of them, as far as precise "speed" is concerned. The circuit designer must recognize that this situation exists, and not try to generate a specific time interval by use of self-interrupted rotary stepping switches alone, or expect to keep two or more rotary stepping switches synchronized when running in this fashion.

Don't Ask Rotary Stepping Switches to Respond to Fast Pulses at Low Ambient Temperatures Without Adequate Manufacturer's Knowledge of Precautions to be Taken.

Even though rotary stepping switches are modified during manufacture by the use of a low temperature lubricant and other safeguards to insure functioning at temperature extremes, the effect of temperature on timing is considerable. This may cause the response to the first pulse of a series to be critically long unless adequate precautions are taken. Be sure to check with the manufacturer before setting up critical timing values that rotary stepping switches have to meet under extremes of ambient temperature. These extremes can usually be handled, but only if the manufacturer has prior knowledge of all facets of the problem.

TCI Library: www.telephonecollectors.info

Don't Ask Rotary Stepping Switches to Operate Under Other Unfavorable Conditions Without Manufacturer's Knowledge of Precautions to be Taken.

When properly protected, rotary stepping switches can also withstand variations of dust, moisture, fungus, shock, vibration, and other unfavorable conditions, extremes of applied voltage, line surges, etc. However, give your manufacturer (and yourself) a break by spelling out these requirements in detail at the time you place your order.

Don't Ask Rotary Stepping Switches to Operate from Non-Bridging Wipers for Self-Interrupted Driving.

When the rotary stepping switch is to be operated from bank points, through its own interrupter springs, care must be taken that the wiper that provides the coil circuit is of the bridging type. Otherwise, the wiper tips will be burned off rapidly, and the rotary stepping switch will home erratically. To be safe, *always* use bridging wipers in a "homing" circuit.

Don't Ask Rotary Stepping Switches to Provide Critical Contacting on Base Metal Contacts.

For industrial usage, where initial cost is not as important as the accuracy and reliability of instrumentation readings taken through the wiper and bank circuits of rotary stepping switches, certain benefits may be derived from having the contacting parts of a precious metal. Gold plate is most successfully employed; silver plate also has long been recognized as a good material for such purposes, but migration of the silver through any phenolic-type insulator with which it is in contact has largely prevented such usage. Inlaid silver is free from this fault. However, use of inlaid silver has been generally discontinued in the industry for reasons of its tendency to tarnish, relatively high cost, etc.

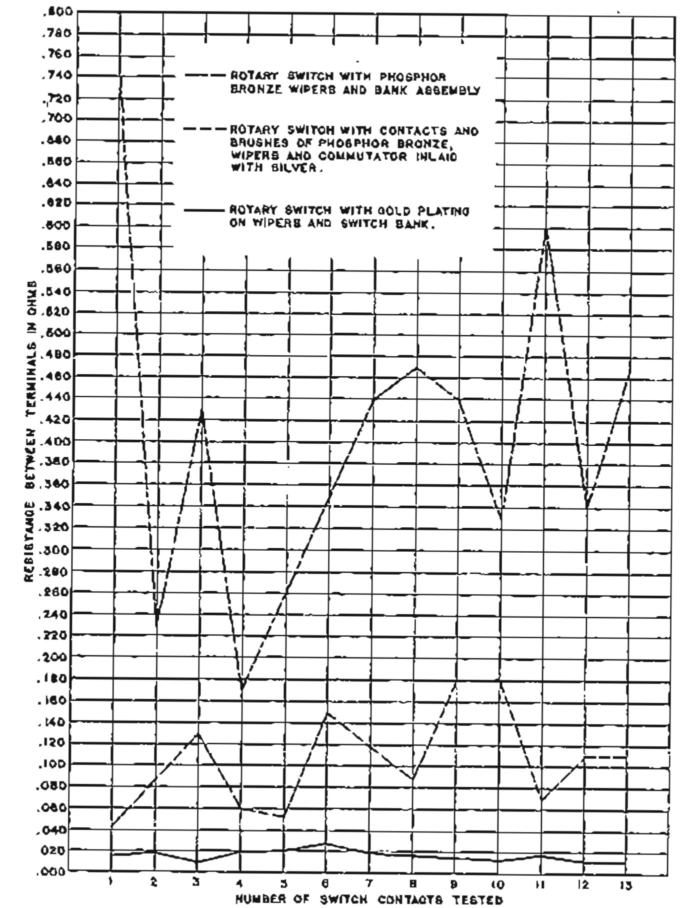


Fig. 43. Measurements made with 1000 cycles AC and 0.10 amp. DC flowing through the contact.

Gold plating insures the ability of the switch to provide a constant and low-value resistance path for measurement, indication, and supervisory purposes. Figures 43 and 44 are typical graphs comparing resistances between terminals for gold plated, inlaid silver, and standard phosphor-bronze contacts. Measurements for the graphs were made at the upper limits of heavy vibration and show the maximum variations in resistance between terminals for the three types of contacts.

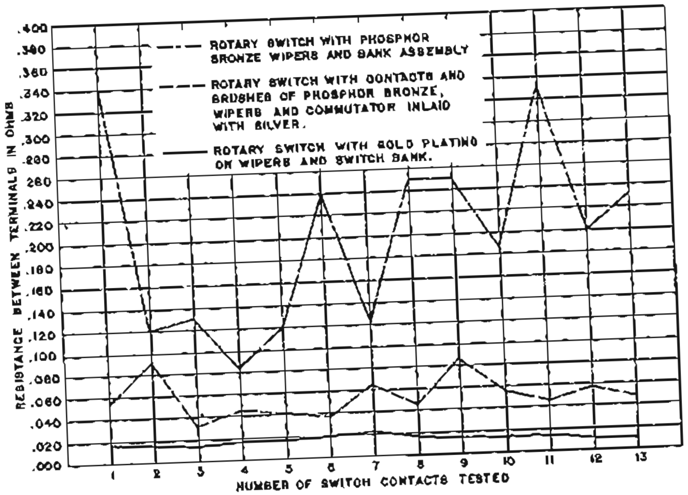


Fig. 44. Measurements made with 1000 cycles AC (no DC) flowing through contact.

Gold plated contacts are relatively expensive, and charges for custom building are made on a per-level basis. It is generally recommended that the use of precious metals be limited to the switching of circuits where the electrical potential is quite low, or where thermocouple monitoring requires low and constant contact resistance and freedom from such spurious potentials as regular base metal contacts might generate. The other less critical circuits can be handled with standard contacts.

Although the first few rotations of a gold plated wiper across a gold plated bank contact seem to remove all, or nearly all, of the gold at the point of contacting, the effect of the gold plating is permanent. A large percentage of the loosened gold is forced into the pores of the base metal parts. That amount of gold is adequate to stabilize the contact resistance for the mechanical life of the rotary stepping switch.

Other

Not all of the impossible-to-achieve, or undesirable things that a rotary stepping switch should not be asked to do can be described, or even anticipated. For some commonly-encountered undesirable situations, see "Circuit Traps" in Chapter VIII.

VIII. SOME COMMONLY ENCOUNTERED APPLICATION PROBLEMS (AND HOW TO AVOID THEM)

The problem most commonly encountered by engineers who are not familiar with rotary stepping switch techniques can be summarized by the complaint: "This rotary stepping switch doesn't run well self-interruptedly!"

Three Most Common Categories of Application Error

There are three broad categories of misapplication that result in unsatisfactory performance of a rotary stepping switch when running self-interruptedly:

A. Inadequate, unusual, incorrect or absence of contact protection. (This is probably the most common category of error.)

B. A poorly regulated power supply that may either over-power or starve the rotary stepping switch under varying circuit conditions.

C. A general tendency to hang other circuit components (other than suitable arc suppression) across the rotary stepping switch coil. Particular villains in this instance are lamps and diodes.

Why These Application Errors Cause Trouble

Rotary stepping switch adjustment is a "tuning" operation. In order for a rotary stepping switch to run well self-interruptedly, it must be "tuned" by adjustment of the interrupter contacts. These contacts must open late enough in the closing stroke of the armature so that the delay in decay of coil flux (plus the inertia of the armature) will permit the armature to complete its stroke to the coil core. However, the contacts must not re-close so early in the return (or release) stroke that the armature is not permitted to restore completely and the stopping comb not allowed to engage the ratchet teeth.

TCI Library: www.telephonecollectors.info

Essentially we have a mechanism that is "tuned" to a balance between coil inductance, mechanical load (wipers), drive spring tension, interrupter spring tension, circuit voltage, etc. *Anything* connected in parallel with a rotary stepping switch coil increases its release time by delaying the decay of the magnetic field because of shunting action.

Factory adjustment is a studied compromise. A rotary stepping switch is "tuned" in the factory with a standard line-test resistor and capacitor (as described in AE Bulletin No. 473) or a varistor (if specified) in the circuit, unless the customer asks that it be done in still another manner.

Both of these are compromises between complete suppression of the high back-EMF from the coil and serious speed reduction. The R-C network or varistor recommended *will do, and does,* a sufficiently good job of contact protection so that the interrupter contacts on the rotary stepping switch will provide satisfactory service for the rated mechanical life of the unit.

Some Specific Application Errors

Error No. 1: Even when recommended R-C net or varistor contact protection is employed, a moderate amount of sparking and arcing occurs at the controlling contacts. Serious problems arise if the customer attempts to drive rotary stepping switches with relay contacts that are too delicate to stand this.

Error No. 2: In an attempt to erase all evidence of arcing, the customer is tempted to use transistors or diodes, which cannot withstand the back-EMF that results even with standard R-C or varistor protection.

Solutions: To correct either of the two above errors, simply use controlling contacts that are rugged enough, bounce-free enough, to do the job with what the manufacturer considers standard contact protection.

In an attempt to find the solution to a rotary stepping switch application where the unit does not run well self-interruptedly, a customer may grope for an answer instead of asking the manufacturer for help.

Error No. 3: He may start by increasing the Capacitance in the R-C net. This *does* reduce the back-EMF in the circuit, but if the C is increased very much, the release time of the switch is increased, and it staggers or completely refuses to run self-interruptedly.

Error No. 4: He may attempt to use a large capacitor by itself. When this is done, the circuits look like a dead short when the contacts are closed to the coil, and the contacts will soon weld together. Again, release time is increased, and the switch may stagger or fail to run self-interruptedly.

Error No. 5: He decides that a non-inductive resistor may be employed. However, if the resistor is of low enough value to do a good job of shunting the spike from the inductance, it may impose too much drain as a load on the controlling circuit.

Error No. 6: A diode is then substituted in place of the resistor and capacitor in order to protect a transistor which is driving the rotary stepping switch. The diode has the advantage of drawing no current when the switch is energized, and clamping the voltage when the switch is energized, so that the back-EMF can only be a few volts above nominal. The diode, however, very seriously lengthens the switch release time. (The switch is effectively shunted down.) This can only be employed, if at all, with a power supply having a nearly perfect regulation. Even then the rotary stepping switch must be finely tuned in the circuit and will have greatly reduced speed capability.

Solutions: Good results from resistor-diode suppression. A compromise that is being used by nearly all of the manufacturers of transistor-driven digital voltmeters is the use of a diode in series with a resistor to clamp the voltage at about twice nominal (e.g., a 40 VDC pulse, approximately 12 ms long, to drive a 24 VDC

TCI Library: www.telephonecollectors.info

rotary stepping switch). Protection for the driving transistor is provided by a diode which clamps the voltage at 60 VDC. This protects the transistor without intolerable increase in release time.

The back-to-back diode. This refers to the back-to-back diode made as a contact protector. They are not so severe in their effect that they can't be considered as stable and predictable. They stand up well in service, but have no particular advantage over the manufacturer's recommended varistor, or over an R-C network.

Electromechanical Tuning Essential to Successful Usage

All the above-mentioned schemes consist of components placed in parallel with the coil. In every case the switch release time is affected. A switch, "tuned" to work with one network or component, will not necessarily work when a different one is used. For this reason, manufacturers would like to have the customer supply *complete* information regarding both the power supply and the contact protection at the time of ordering. Sometimes it is found necessary, and usually desirable, to make up a fixture embodying the customer's power and contact protection details, and adjust and final-speed the switch with these exact circuit elements in place. All manufacturers are glad to do this.

Error No. 7: Effect of a parallel-connected relay. In many circuits a rotary stepping switch motor magnet coil must, for circuit reasons, be shunted by a slow-to-release relay, with a resulting increase in release time. For instance, if we try to run a rotary stepping switch self-interruptedly without removing a parallel slow-to-release relay from the circuit, as in Figure 27, Page 28, the rotary stepping switch may stagger and stutter.

Error No. 8: Poor voltage regulation. Gross under and over voltage can also badly upset a stepping switch that was correctly "tuned" to run at maximum uniform speed at the factory. Unless specially ordered and adjusted, one should not expect rotary stepping switches to run well self-interruptedly at much more than 10% variation from nominal voltage.

Circuit Traps

Some seemingly logical circuit arrangements do not provide the necessary factors for good rotary stepping switch results. These have been published elsewhere as "Circuit Traps" (AE Circular No. 1012, *Relay Magic*) and are being repeated here for your convenience.

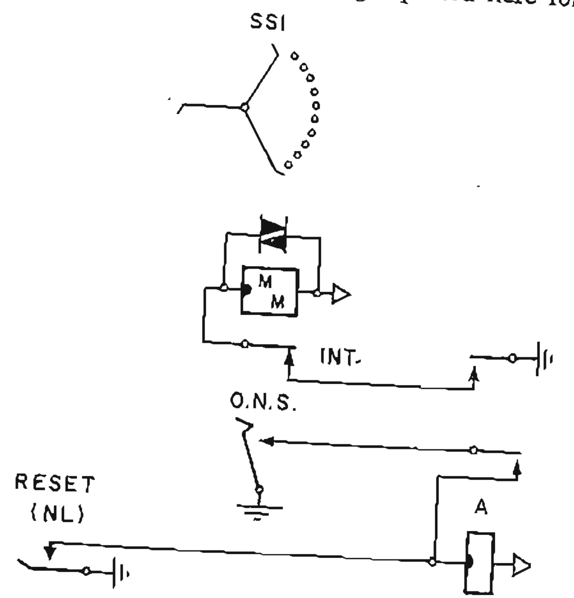


Fig. 45. Stopping a self-interrupted rotary stepping switch by releasing a relay.

Trap No. 1

This circuit demonstrates one of the most common errors made in application of rotary stepping switches. Theoretically, the circuit is supposed to work like this: When the reset switch is operated, Relay A is energized and locks to the off-normal contacts of the stepping switch. Relay A also closes a circuit through the stepping switch interrupter contacts so that the switch will run self-interruptedly to the home position. At the home position Relay A restores, stopping the stepping switch.

The trouble with this circuit (or circuits like it) is that Relay A invariably releases too slowly to stop the stepping switch (or if it happened to work when new, it doesn't with aging). Also a homing circuit should be arranged so that even continuous operation of the reset key will not cause the stepping switch to pass the desired position.

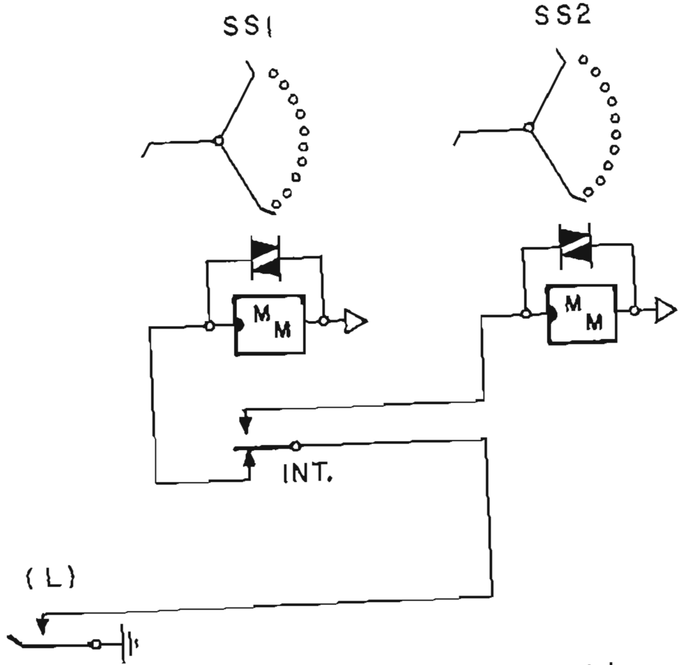


Fig. 46. Synchronizing self-interrupted rotary stepping switches.

Trap No. 2

This circuit answers a question that is often asked, and shows a configuration that absolutely will not work. It is not possible to synchronize two rotary stepping switches running *self-interruptedly*. In the circuit shown, rotary stepping switch 1 (SS1) will run self-interruptedly very satisfactorily, but SS2 will step intermittently (if at all) since the closure of the normally open contact on the interrupter springs of SS1 is of such short duration that it is not possible for SS2 to cock reliably.

IX. GUIDE TO PROPER PREVENTATIVE MAINTENANCE

Lubrication

In any mechanical device there is a limit to how much service life can be obtained without *any* preventative maintenance at all. So, like other mechanical devices, the trouble-free *service life* of rotary stepping switches *can be extended by preventative maintenance.* In the past, however, rotary stepping switches have suffered from an over-emphasis on maintenance, particularly over-lubrication. Lubrication is a mixed blessing, at best, and many rotary stepping switches would have run better and longer without any maintenance at all, instead of the "slopping" of lubricants they got.

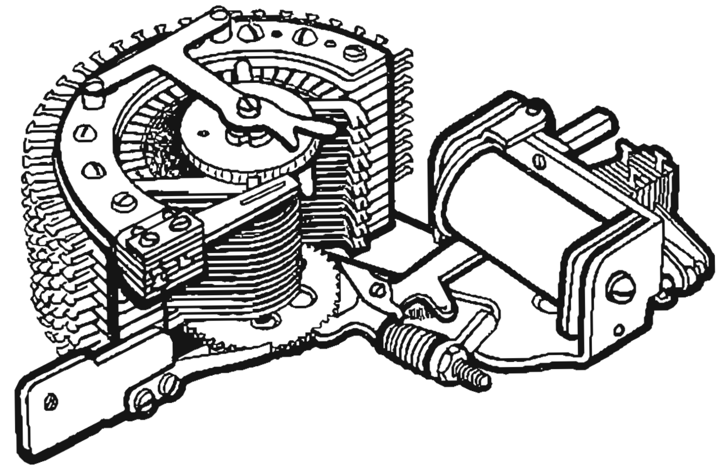
Standard lubrication charts (a part of Automatic Electric's regular telephone maintenance information) are usually included as a packing sheet in all rotary stepping switch shipments to original equipment manufacturers. This information is also available in AE's Bulletin No. 961-473, and is detailed and voluminous.

The following pages of this book contain "Modified Maintenance Instructions", in which previously available information is simplified and reduced in scope. These instructions associate the type of lubricant and the point of application with geometric figures painted on the bottles of the recommended lubrication kit (see Figure 47 on the following page). With these modified procedures, showing the correct application location and amount of lubrication to be used, rotary stepping switch lubrication is easily accomplished.

TCI Library: www.telephonecollectors.info

Fig. 47. Lubrication kit for AE rotary stepping switches.

Over-lubrication is to be avoided, particularly the use of too much graphite lubricant on the ratchet wheel and pawl. If this is splashed on insulating surfaces, the insulation characteristics suffer. If it is splashed on the wiper tips or bank contacts, the contact resistance becomes erratic.



Modified Standard Lubrication Instructions for the Type 45 Rotary Stepping Switch

(Service Lub — 11)

These switches are basically made up of a wiper assembly with wiping surfaces which rotate over a fixed bank of contacts. On a Type 45 this is either 25 or 26 contacts plus a brush position. It is recommended that the Type 45 Rotary Stepping Switch be lubricated at 50,000, 100,000, 250,000 half-revolutions, and every 6 months or every 500,000 half-revolutions thereafter, whichever occurs first.

There are three basic lubricants: 1. Blended Lubricating Oil, marked with Symbol "O". 2. Watch Oil, Symbol "△". 3. Graphite Oil Lubricant, Symbol "◇". These can be obtained by ordering PD-9100-1. This convenient lubrication kit contains three bottles with individual applicators, and each bottle is marked with the appropriate symbol. (See Figure 47, page 72.)

NOTE: These instructions are intended for switches using standard lubricants. For information regarding special low temperature applications, contact Automatic Electric Co., Industrial Products Division, Northlake, Illinois.

TCI Library: www.telephonecollectors.info

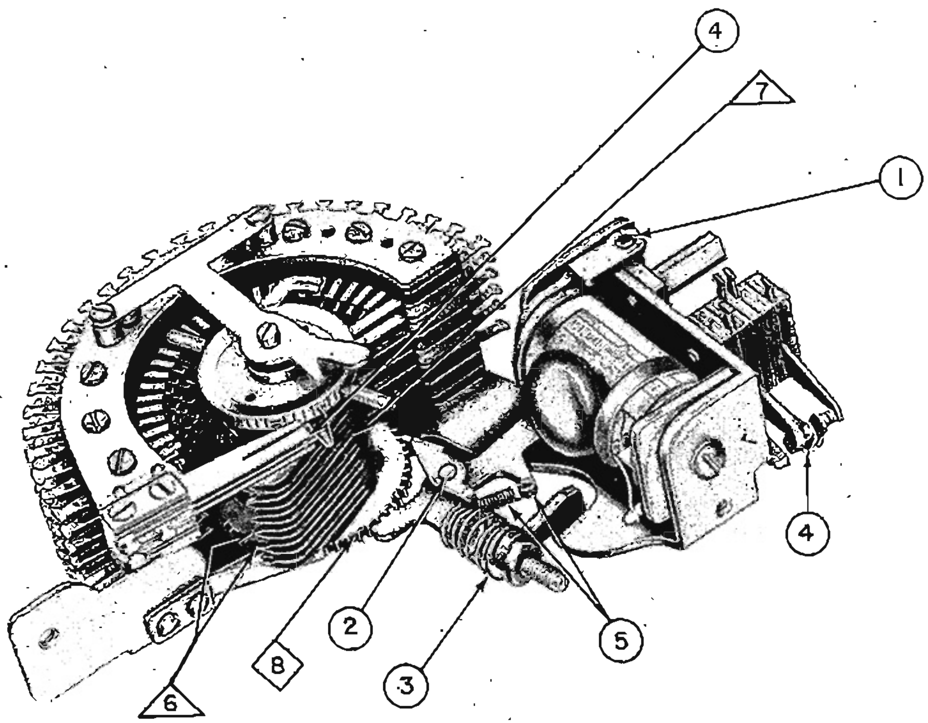


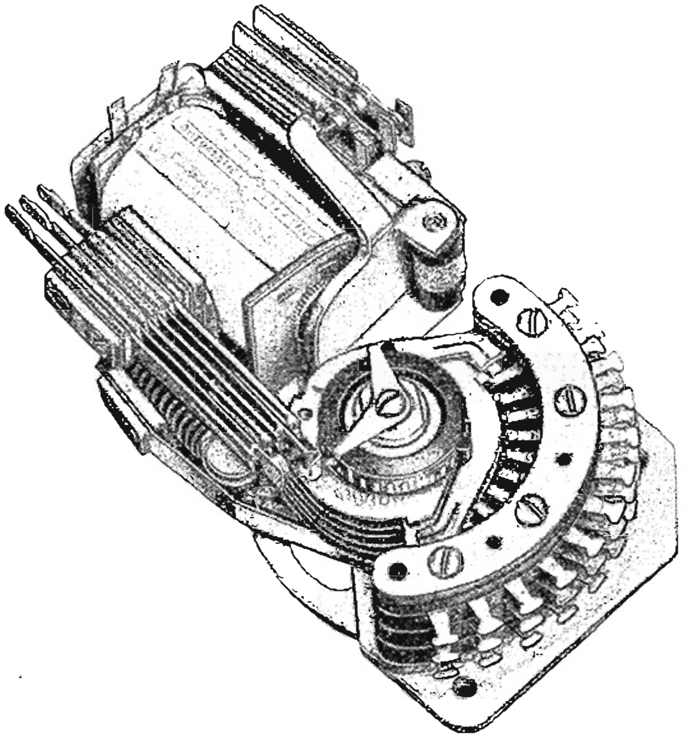
Fig. 48. Lubrication points for AE Type 45 Rotary Stepping Switch.

After cleaning the Type 45 Rotary Stepping Switch thoroughly, lubricate per the following procedure:

	Apply one "dip" lightly to:*
BLENDED OIL: "O"	Point 1. Yoke Bearing (both sides) Point 2. Pawl Bearing Pin (both sides) Point 3. Drive Spring (seats and coils) Point 4. Off-Normal and Interrupter Buffers (if any) Point 5. Pawl Spring (holes and coil)
	Apply one "dip" lightly to:*
WATCH OIL: "△"	Point 6. Each Wiper Tip Point 7. Insides of Wipers (to lubricate the brushes). *Note: Rotate wiper assembly after each operation to distribute lubricants.*
	Apply one "dip" lightly to:*
GRAPHITE OIL: "◇"	Point 8. Ratchet Teeth (while rotating)

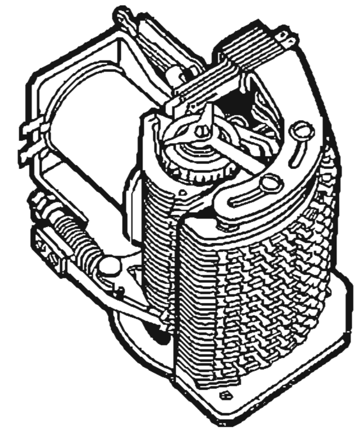
**NOTE: A "dip" is defined as the amount of lubricant adhering to the applicator located in the bottle stopper, after wiping off on the neck of the bottle.*

TCI Library: www.telephonecollectors.info



The Type 44 Rotary Stepping Switch.

One of the first "compacts", this switch is available with up to eight 10-point levels (with 11 points on all levels where specified). See pages 80, 144 and 150 for other "compact" rotary stepping switches.



Modified Standard Lubrication Instructions for Types 40, 44, 80 and 88 Rotary Stepping Switches

(Service Lub — 15)

These switches are basically made up of a wiper assembly with wiping surfaces which rotate over fixed banks of contacts containing either 10 or 11 contacts, plus brushes, depending on the exact type of switch. It is recommended that Type 40, 44, 80, and 88 Rotary Stepping Switches be lubricated at 50,000, 100,000, and 250,000 third-revolutions; and every 500,000 third-revolutions thereafter, or every 6 months, whichever occurs first.

There are three basic lubricants: 1. Blended Lubricating Oil, Symbol "O". 2. Watch Oil, Symbol "△", and 3. Graphite Oil Lubricant, "◇". These can be obtained by ordering PD-9100-1. This convenient lubrication kit contains three bottles with individual applicators, and each bottle is marked with the appropriate symbol. (See Figure 47, page 72.)

NOTE: These instructions are intended for switches using standard lubricants. For information regarding special low temperature applications, contact Automatic Electric Co., Industrial Products Division, Northlake, Illinois.

TCI Library: www.telephonecollectors.info

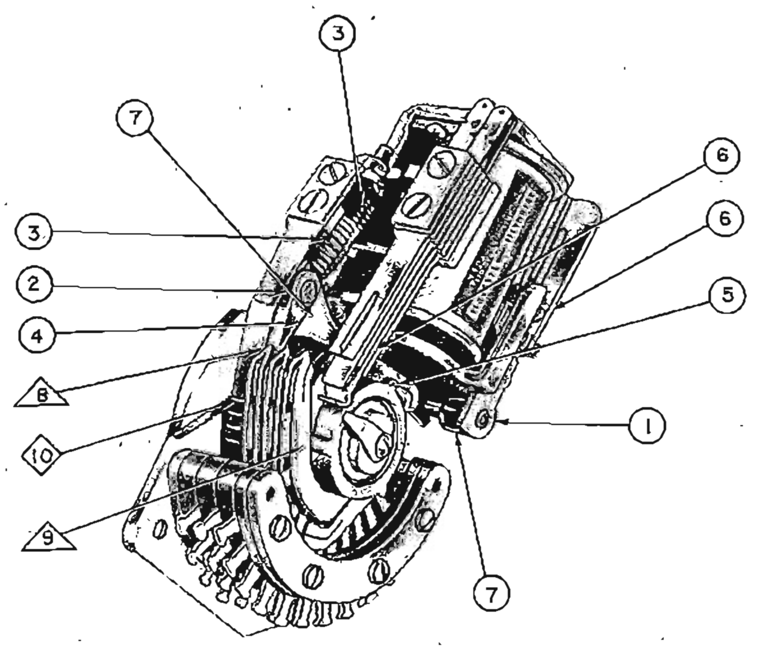
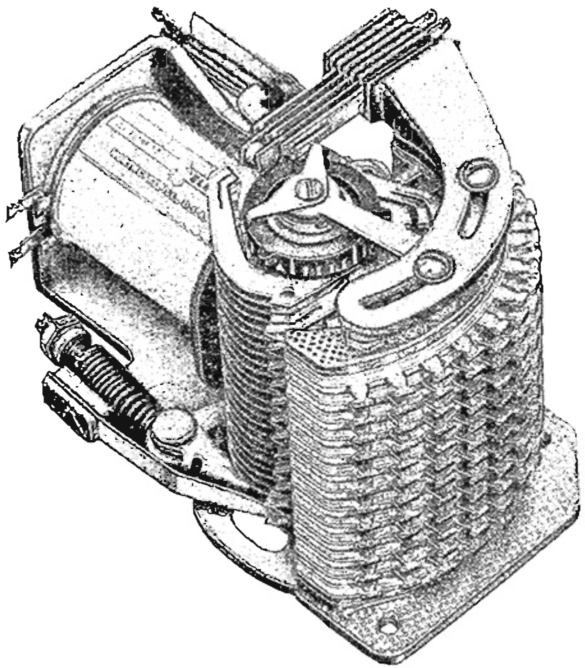


Fig. 49. Lubrication points for typical AE "compact" rotary stepping switch.

After cleaning the rotary stepping switch thoroughly, lubricate as per the following instructions:

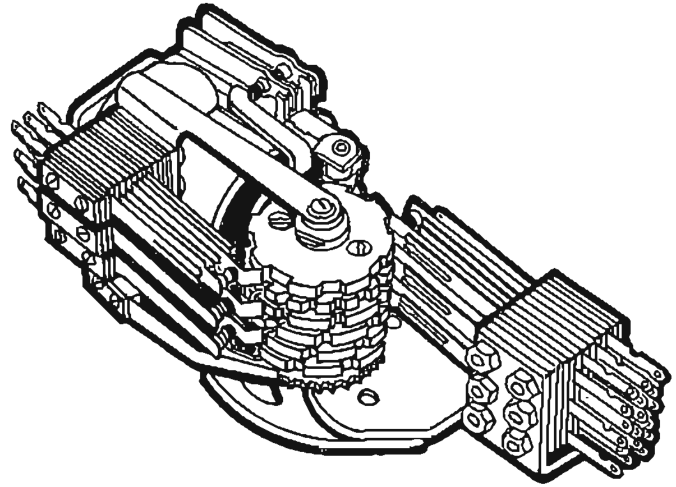
	Apply one "dip" lightly to:*
BLENDED OIL: "O"	Point 1. Yoke Bearing (both sides) Point 2. Pawl Bearing Pin (both sides) Point 3. Drive Spring (seats & coils) Point 4. Pawl Spring (holes & coils) Point 5. Off-Normal Cam Lobes Point 6. Off-Normal & Interrupter Buffers (if any) Point 7. Thoroughly saturate felt sleeve and wick.
	Apply one "dip" lightly to:*
WATCH OIL: "△"	Point 8. Each Wiper Tip Point 9. Insides of Wipers (to lubricate brushes) *Note: Rotate wiper assembly after each operation to distribute lubricants.*
	Apply one "dip" lightly to:*
GRAPHITE OIL: "◇"	Point 10. Ratchet Teeth (while rotating)

**NOTE: A "dip" is defined as the amount of lubricant adhering to the applicator located in the bottle stopper, after wiping off on the neck of the bottle.*



The Type 88 Rotary Stepping Switch

This is a larger-capacity version of the Type 44, shown on page 76. It has from six to twelve 10-point levels, with 11 points on all levels where specified.



Modified Standard Lubrication Instructions for the Series OCS Relay

(Service Lub — 17)

The OCS Relay is a cam-switching device using the same basic mechanism as a Type 44 Rotary Stepping Switch. The OCS Relay should be lubricated before putting into service, after 30,000 revolutions 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).

There are two basic lubricants used on the OCS Relay: 1. Blended Lubricating Oil, Symbol "O". 2. Graphite Oil Lubricant, Symbol "◇". These can be obtained by ordering PD-9100-1. This convenient kit contains the necessary lubricants supplied in bottles with individual applicators, and each bottle is marked with the appropriate symbol. (See Figure 47, page 72.)

NOTE: These instructions are intended for switches using standard lubricants. For information regarding special low temperature applications, contact Automatic Electric Co., Industrial Products Division, Northlake, Illinois.

TCI Library: www.telephonecollectors.info

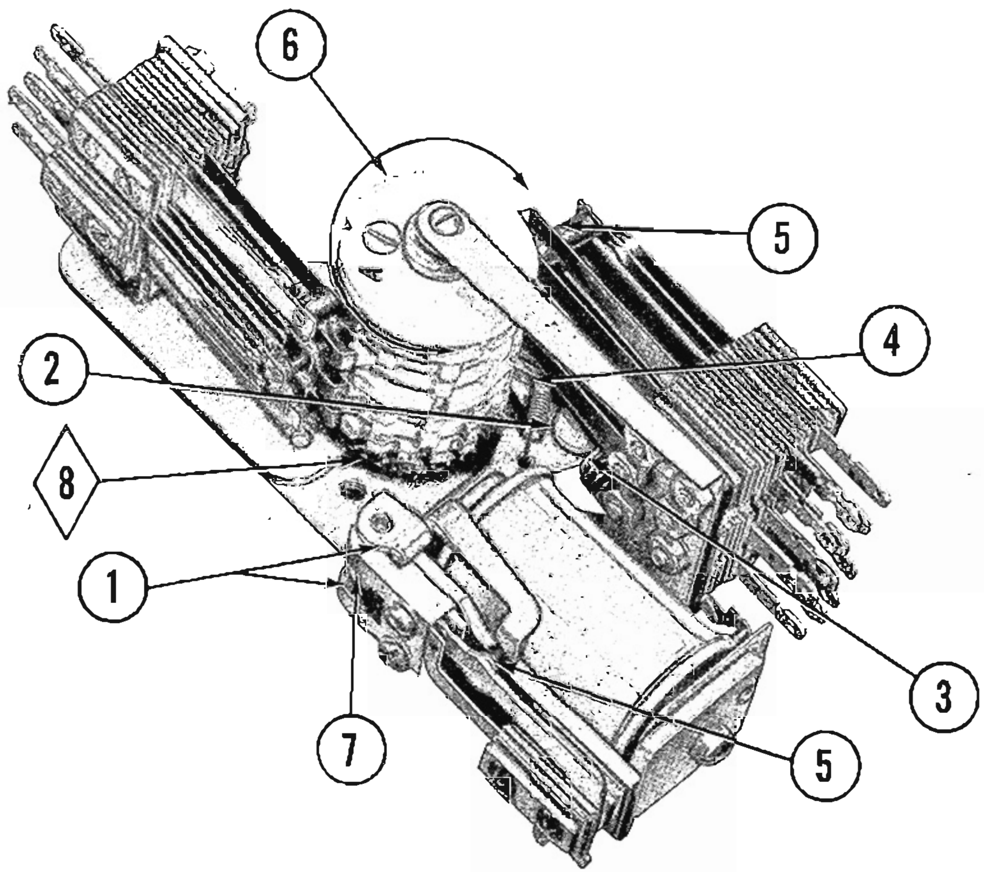


Fig. 50. Lubrication points for AE's Series OCS Relay.

After cleaning the Series OCS Relay thoroughly, lubricate as per the following procedure:

	Apply one "dip" lightly to points 1 through 5:*
	Point 1. Yoke Bearings (both sides)
	Point 2. Pawl Bearing Pin (both sides)
	Point 3. Drive Spring (seats and coil)
	Point 4. Pawl Spring (seats and coil)
BLENDED OIL: "O"	Point 5. Buffers on Interrupter Springs and Tips of Cam-Lever Springs
	Point 6. Apply a thin coat on two-thirds of the circumference of each fibre cam.
	Point 7. Thoroughly saturate felt sleeve and wick.
	Apply one "dip" lightly to:*
GRAPHITE OIL: "◇"	Point 8. Ratchet Teeth (while rotating)

**NOTE: A "dip" is defined as the amount of lubricant adhering to the applicator located in the bottle stopper, after wiping off on the neck of the bottle.*

TCI Library: www.telephonecollectors.info

Mechanical Maintenance

Users of rotary stepping switches sometimes express apprehension that their switches are not being maintained properly. AE Types 40, 44, 80, and 88 and 45 rotary stepping switches were especially designed to be as maintenance-free as anything mechanical can be, and are so simple that if maintenance is needed, or preventative maintenance is desired, the required procedure is simply and easily carried out.

Avoid Over-Maintenance

Rotary stepping switches, as shipped, are *adjusted to fit the power supply* on which they were finally adjusted and speeded. The drive spring tension, the interrupter contact spring tensions and break gauging are set to provide the ultimate in self-stepping speed and smoothness. This will last for a long, long time, without any preventative maintenance unless the switch is misused or abused in some way. More rotary stepping switches are ruined because the adjustment is tinkered with than for any other reason. Those who most successfully employ rotary stepping switches protect them from the effects of user curiosity and prying fingers by sealing them away from both. A gasketed enclosure with a lead seal is a very effective way of solving most of the tampering problems encountered.

Most telephone users of rotary stepping switches have factory-trained and highly skilled maintenance personnel. They can afford to follow the recommended "every 6 months or each . . . . . . sweeps of the bank" full maintenance procedure. Very few industrial users have such skilled maintenance personnel. Therefore, *the best maintenance is sometimes no maintenance.* However, assuming the user can provide even moderately skilled maintenance, the following of a *very limited* lubrication program will insure realization of full, and trouble-free, life of the rotary stepping switch. This consists of very *light* lubrication, at recommended or accessible periods, as outlined on the preceding pages.

Bank contacts that need light cleaning may be sprayed with one of the spray cleaners with normally good results, provided they are *lightly* re-lubricated with the watch oil lubricant as previously described.

Readjusting the Drive Spring

Before *any* mechanical readjustment of a rotary stepping switch is made, it is recommended that this chapter be read through to its conclusion.

The drive spring normally needs no attention during the life of a rotary stepping switch. However, if more drive spring tension seems to be required due to the drifting of the power supply, or for any other reason, some modification may be found necessary. Remember — this is not to be done extensively or capriciously. The original tensioning and the recommended readjustment are both best made by electrically "margining" the rotary stepping switch. Before attempting to adjust the drive spring tension to "go" or "no go" values, the recommended "margining" value of resistance (to be put in series with the magnet coil, on a prescribed voltage) should be obtained from the manufacturer's home office or his nearest staff engineer.

In case of emergency, the approximately-correct drive spring tension can be set in this manner: Loosen the hex nut that locks the screw that is used to compress (tension) the drive spring. With this nut loose, but held in place, slowly turn the screw clockwise, trying the switch for correct tension each quarter turn. The correct tension is approximately determined, non-electrically, by finding a minimum tension that will step the wipers positively, in *all* bank positions, when the armature action is retarded by hand. *Caution: Some of the more heavily-loaded switches may not step fully when "retarded by hand." This is acceptable only if they step fully when operated electrically.*

When the value of the tension has been put into the drive spring, give the screw an additional ⅛- to ¼-revolution clockwise, and hold it in this position as the clamping nut is turned down tight. This should result in a very effective drive spring setting, not very far away from the results of electrical margining.

Some users of rotary stepping switches glyptol this hex nut just before shipment of their equipment in order to discourage such capricious tampering. However, manufacturers of rotary stepping switches will not supply them with glyptol already on the locking screw, because this is a "field adjustment," meant to be changed slightly if conditions of application and service aging so warrant.

Readjusting the Interrupter Contact Springs

The interrupter contact springs are "monkeyed with" all too often. These have already been set for best performance by the manufacturer. Barring contact erosion due to inadequate contact protection, there is seldom need to readjust ("re-gap") in service, if the power supply is correct and if coil shunts are avoided. Assuming that there is some need for interrupter contact readjustment, it is most effectively made as follows: *(Caution: Use insulated tools.)* With the switch running self-interruptedly, on the *correct* applied voltage, bend the *heavy* back contact spring blank slightly forward and backward as close to the frame (point of attachment) as possible until the switch sounds smooth and fast. This is the ideal gauging and is the way that factory "timing" or final adjustment is done.

Ordinarily, barring damage from some kind of accident or inexpert handling, the only two things needed to get a rotary stepping switch back into nearly perfect performance state is the readjustment of the interrupter contact springs and of the armature drive spring tension, *in that order,* unless the drive spring tension is proven to be incorrect. In that instance, make this adjustment *before* adjusting the interrupter contact springs. However, the interrupter contact springs are so much more likely to need correction than the drive spring tension that it is recommended that they always be checked out first. It is usually then found unnecessary to change the drive spring tension.

It will be seen from the previous discussion that the two elements *sometimes* needing field attention are very accessible, easy to handle, and almost never in need of change. Placing these adjustments where they are easily accessible and easily changed has been a mixed blessing — they invite tinkering. After they've been tinkered with by someone who was just turning or bending, the switch can still easily be put back into good adjustment by anyone who can follow the above instructions, or who knows the procedure already. But, in the meantime, the switch may have been accused of faults it didn't have in the first place.

Customer Maintenance Courses

Some manufacturers of rotary stepping switches conduct customer courses in maintenance techniques at their factories. (Automatic Electric holds several such courses a year.) Various advantages can

be obtained from attendance of a key person or persons at such a course. The usual advantage of training someone to be an "authority" on the subject is obvious. This person can be instrumental in preparing maintenance routines for field use, in training field service personnel where such personnel are a part of regular customer service organization, in instructing those handling switches while manufacturing operations are in progress, during which switches may occasionally suffer from handling, etc.

In addition to the factory-conducted courses, it is often possible that "seminar" types of educational and maintenance sessions can be arranged for in the customer's area, to be conducted by a manufacturer's staff engineer(s).

TCI Library: www.telephonecollectors.info

X. SOME THINGS TO REMEMBER TO DO

DO employ gold plating on all rotary stepping switch levels where constantly low contact resistance is desired; where thermocouple or other relatively "dry" voltages are being encountered; where detrimental thermal "noise" may otherwise be generated; or, where galvanic voltages are to be avoided. Perhaps a good maxim regarding gold plating is, "when in doubt, specify gold." At least discuss your critical contact resistance problems with the manufacturer.

DO protect the rotary stepping switch by a gasket sealed enclosure (with a lead seal to prevent tampering) if the operating conditions are dirty, and inexpert maintenance personnel are likely to tinker with the switch. For example, an inadvertently introduced small magnetic particle between coil core and armature will stall the most robust switch. Inept service personnel will always attack the rotary stepping switch first, even though the trouble is consistently and eventually found to be elsewhere. Enclosures can be employed to discourage "tinkering," while permitting recommended maintenance.

DO protect the rotary stepping switch in a hermetically-sealed enclosure if conditions such as temperature extremes, humidity excesses,

etc. warrant. Immerse the switch in oil only after a thorough discussion with manufacturer. Oil immersion is successfully used only when all electrical arcing within the enclosure has been eliminated. It is then very effective.

DO install the rotary stepping switch in its own protective enclosure, *separate* from other components or devices that may suffer from a critical rise in temperature if cabinet doors are kept closed.

The sight of a rotary stepping switch exposed to cutting oil and flying metal chips from a nearby machine tool is all too common. This usually happens when they have been mounted in a cabinet with other devices, and the doors are left open continuously so that the other devices won't fail because of an ambient temperature too high for them to stand. This doesn't give the rotary stepping switch a "fair shake", and a fair shake is all that it requires for nearly perfect reliability and longevity.

DO discuss with the manufacturer all of your questions for which answers do not seem at hand.

XI. SOME THINGS TO REMEMBER TO AVOID

DON'T put opposite potentials on adjacent wipers or bank levels, and preferably not on adjacent bank contacts.

DON'T switch live circuits exceeding the 1/10 ampere non-inductance circuit load rating (or its inductive equivalent) on the wiper-to-bank contacts of non-bridging wipers, unless you are willing to accept some life reduction.

DON'T load the bank of a rotary stepping switch to the point where arcing or burning at the wiper tips and bank contacts occurs.

DON'T overpower the driving mechanism with excessively high voltage. No device has ever been as carelessly treated in this regard as the rotary stepping switch, and then as universally damned because it gave trouble after such mistreatment. For example, in some equipment the rotary stepping switches are "over-driven" (powered by 200% or more over-voltage) in order to get stepping speeds beyond those recommended by the manufacturer. This inevitably results in parts being broken from sheer impact. This would be acceptable if everyone, especially the user, was prepared for the reduced life which results, but such is not the usual expectation.

If you have a speed problem, discuss it with your manufacturer, rather than apply gross over-voltage for long periods of running.

DON'T put the power supply for a rotary stepping switch too far away from the switch. A rotary stepping switch is designed for remote control (as demonstrated by the circuits in Chapter VI), but the power supply itself must be adjacent to the switch for best results.

DON'T exceed the manufacturer's recommendations for mechanical loading. Life will suffer if you do. Mechanical overloading may consist of an excessive number of wipers specified to contact the bank at any one time, too many interrupter contact springs, too many off-normal contact springs to operate at a critical point in the wiper movement, or combinations of these factors which cause severe mechanical overload on one or more steps.

For other **DON'TS,** review the discussions in Chapters VII and VIII.

XII. HOW TO DETERMINE IF THE ROTARY STEPPING SWITCH IS THE ANSWER TO YOUR NEED

Usually there is the possibility of a multiple-choice situation in circuit design that might permit using either rotary stepping switches or some other kind of component for the job. Consideration of some of the following factors may help in coming to the correct engineering solution.

Economy

The cost-per-contact on the large switch bank of a rotary stepping switch is very low. A twelve level, 25-point rotary stepping switch represents a twelve pole, 25 position switching arrangement, for which the purchase price is about $45. This represents a figure of only 15c per contact.

While this is amazingly low, even greater economies can often be achieved by using rotary stepping switches because of their simplicity of design. No complicated control circuitry is involved. There is no added cost for the power that would otherwise be consumed between switching operations. The built-in "memory" costs nothing extra. There is no cost for providing sequential selection. There is a definite saving in cost of space and volume for the overall circuitry needed to do the job some other way. There is possibly even a savings in engineering costs because of the *simplicity* of the control circuitry.

Taken together, the combined cost-per-contact for both switching and control of the rotary stepping switch is very low indeed — practically always less than for any other technique.

Size

The charge is sometimes made that rotary stepping switches are too bulky, too heavy, or both. However, surprising as it may be, a complete analysis of the volume and weight required to do a moderately sizable switching job usually reveals that the use of stepping switches results in a saving in both volume and weight. Check costs, before jumping to any conclusion in this area. The results will probably favor the rotary stepping switch technique.

Simplicity

The simplicity and sequential operation of the rotary stepping switch favor doing the job that way. The switch takes one step per pulse, sequentially, and holds its position in spite of power failure. Anyone can see the state of the circuit at any time by visually examining the switch's position, hence no elaborate indicating or circuit status checking equipment is involved. This simplicity represents a great saving over the involved techniques necessary to provide the same information in other types of switching.

Ruggedness

There is little doubt that switches can hold their own in the face of destructive ambients, such as shock, vibration, radiation, temperature extremes, reflected line surge voltages, etc. It is necessary to advise the manufacturer of the conditions to be met, so that proper precautions can be taken to engineer for the exact job to be done.

Marriage of Components

Where information must be stored or accumulated at a rate that electromagnetic devices can't follow, it may still be desirable to use rotary stepping switches in the output side of the circuit, where their "muscles" make their use especially appropriate. Many such circuits save power and space, and represent the only satisfactory solution to the problem. Consider the use of rotary stepping switches for any function, whether there are other possibilities or not. The final decision should be based on the best engineering approach, rather than a decision to go to one way or the other merely because it is "policy", or "modern", or "indicated". Once it has been determined that best engineering decrees the use of rotary stepping switches, care must be taken that the possibility of field problems are avoided.

We will examine one of the possibilities for a field objection and the precautions to be taken to prevent it.

Audible Noise Reduction

Stepping switches can no more be made noiseless than other similar mechanisms such as typewriters, teleprinters, etc. Reduction of noise can be simply accomplished, in part, by mounting of the switch on rubber cushions, and still further by enclosure. Practically complete noise reduction, if found necessary and desirable, is accomplished by lining the enclosure with an easy-to-apply self-adhesive type of noise-absorbing material readily obtainable commercially in strip form. Even in small amounts, this sound-absorbing type of material is amazingly effective in the elimination of audible noise.

TCI Library: www.telephonecollectors.info

XIII. HOW TO GET WHAT YOU WANT WHEN YOU ORDER

Specify Gold Contacting When Needed

The most frequent oversight in ordering, and the most costly to rectify, is the failure to specify gold contacting for the critical circuits. This matter is fully discussed, where appropriate, in this booklet. A *re-reading* of Chapters VII and X should help to clarify this matter. If doubt persists, discuss fully with the vendor, but don't gamble. That is not to say we don't recommend experimentation and even field experience type of testing to determine whether the cost of gold is or is not justified, where it is possible to make such an investigation. Gold is costly and is to be avoided where it serves little or no purpose.

Specify an Adequate Number of Electrical Levels

The number of physical levels and the number of electrical levels can be different by a ratio of 2 to 1 or a ratio of 3 to 1. To avoid mistakes, tell the vendor how many of each is required if you recognize in advance how this is determined. If there is any doubt, describe your needs fully, as in the following: "Four circuits to 50 points", or "three circuits to 30 points", etc.

How to get 52-point Operation

You may obtain 52-point operation on a Type 45 Rotary Stepping Switch 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 26 steps and the other over the second level for the next 26 steps. Both sets of wipers are electrically commoned by strapping the external terminals of their associated brush springs. Since the maximum number of physical banks recommended on a Type 45 Rotary Stepping Switch is 16, the greatest number of 52-point electrical levels is 8.

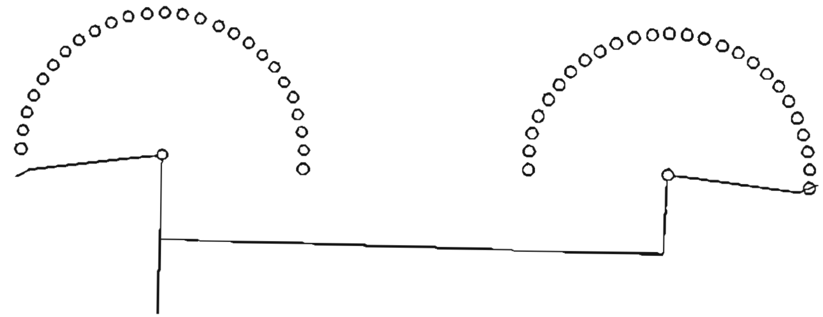


Fig. 51. Schematic of two physical 26-point levels connected to provide one 52-point electrical level on an AE Type 45 Rotary Stepping Switch.

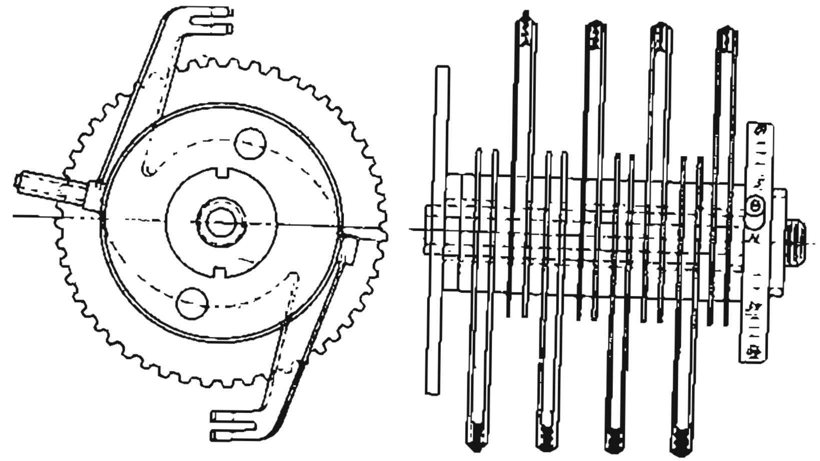


Fig. 52. Wiper arrangement for a 52-point rotary stepping switch.

How to get 50-point operation

Similarly to the above, 50-point operation on the Type 45 Rotary Stepping Switch is obtained by banks having 25 contacts per level, with an open space on step 26 and another open space on step 52.

TCI Library: www.telephonecollectors.info

How to get 20-point, 22-point, 30-point, or 33-point operation

The Types 40 and 80 Rotary Stepping Switches have 10 wiper positions on a 120° bank. The Types 44 and 88 Rotary Stepping Switches have 11 wiper positions on a similar 120° bank. By appropriate selection and specification, 20-point, 22-point, 30-point or 33-point electrical levels may be obtained. The following figures and explanations should clarify these options.

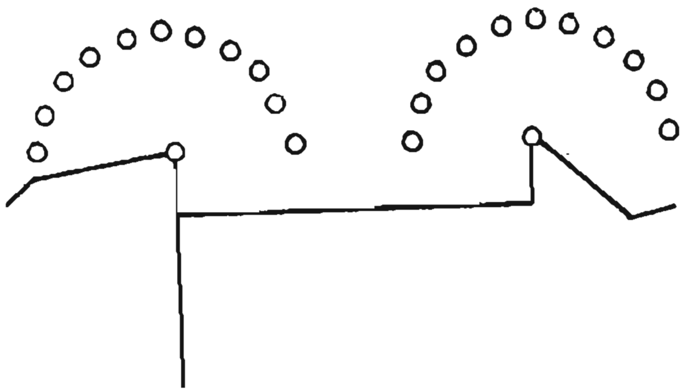


Fig. 53. Schematic of two physical 10-point (or 11-point) levels connected to provide one 20-point (or 22-point) electrical level.

How to get 20-point operation

You may obtain 20-point operation by using wipers having one wiping tip instead of three. These special wiper assemblies are arranged so that the first wiper rotates over the first level on the first 10 steps, and the second wiper rotates over the second level on the next 10 steps.

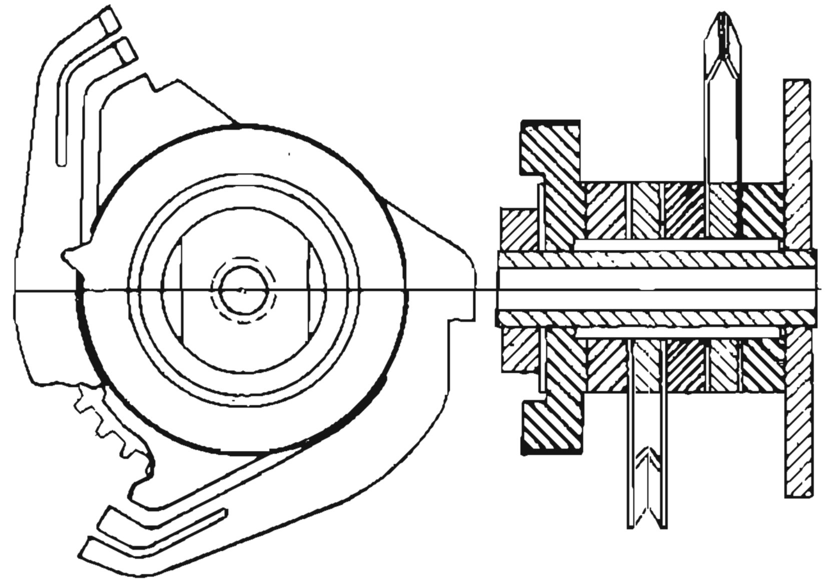


Fig. 54. Wiper arrangement for 20-point (or 22-point) bank. *Note: There are ten positions on a 20-position switch, and 11 positions on a 22-position switch on which no bank contacts are being contacted by the wipers. These can be skipped over self-interruptedly to the "home" position by appropriate circuitry.*

Two physical levels are connected together electrically, as in Figure 53, and mechanically arranged as in Figure 54, to make one 20-point electrical level. The decimal (10-point) physical banks are found on the Types 40 and 80 Rotary Stepping Switches. Since the maximum number of physical banks recommended on a Type 40 Rotary Stepping Switch is 6, the greatest number of 20-point electrical levels is 3. The maximum number of physical bank levels on the Type 80 Rotary Stepping Switch is 12, so the greatest number of 20-point electrical levels is 6.

The wipers are electrically commoned by strapping the external terminals of their associated brush springs.

How to get 22-point operation

You may obtain 22-point operation by using wipers having one wiping tip instead of three. These special wiper assemblies are arranged so that the first wiper rotates over the first level for the first 11 steps, and the second wiper rotates over the second level for the next 11 steps.

Two physical levels are connected together electrically, as in Figure 53, and mechanically arranged as in Figure 54, to make one 22-point electrical level. The 11-point physical banks are found on the Types 44 and 88 Rotary Stepping Switches. Since the maximum number of physical banks recommended on the Type 44 Rotary Stepping Switch is 6, the greatest number of 22-point electrical levels is 3. The maximum number of physical bank levels on the Type 88 is 12, so the greatest number of 22-point electrical levels is 6.

The wipers are electrically commoned by strapping the external terminals of their associated brush contacts.

How to get 30-point operation

You may obtain 30-point operation by using wipers having one wiping tip instead of three. These special wiper assemblies are so arranged that the first wiper rotates over the first level for the first 10 steps, the second wiper rotates over the second level for the next 10 steps, and the third wiper rotates over the third level for the following 10 steps.

Three physical levels are connected together electrically, as in Figure 55, and mechanically arranged as in Figure 56, to make one 30-point electrical level. The decimal (10-point) physical banks are found on the Types 40 and 80 Rotary Stepping Switches. Since the maximum number of physical banks recommended on a Type 40 Rotary Stepping Switch is 6, the greatest number of 30-point electrical levels is 2. The maximum number of physical bank levels on the Type 80 Rotary Stepping Switch is 12, so the greatest number of 30-point electrical levels is 4.

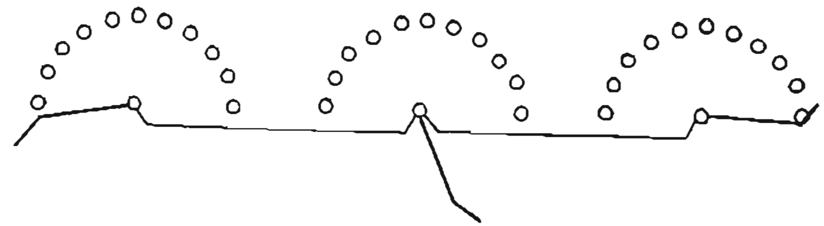


Fig. 55. Schematic of three physical 10-point (or 11-point) levels connected to provide one 30-point (or 33-point) electrical level.

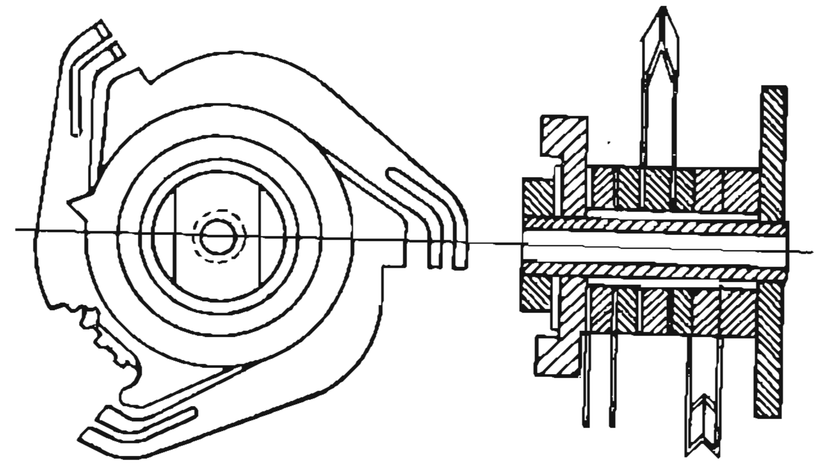


Fig. 56. Wiper arrangement for 30-point (or 33-point) bank.

The wipers are electrically commoned by strapping the external terminals of their associated brush springs. There are no lobes except in the 30th position (to stop the rotary stepping switch at the home position), so that the off-normal springs are operated only in the home position (once during each revolution of the wipers).

TCI Library: www.telephonecollectors.info

How to get 33-point operation

You may obtain 33-point operation by using wipers having one wiping tip instead of three. These special wiper assemblies are so arranged that the first wiper rotates over the first level for the first 11 steps, the second wiper rotates over the second level for the next 11 steps, and the third wiper rotates over the third level for the following 11 steps.

Three physical levels are connected together electrically, as in Figure 55, and mechanically arranged as in Figure 56, to make one 33-point electrical level. The 11-point physical banks are found on the Types 44 and 88 Rotary Stepping Switches. Since the maximum number of physical banks recommended on a Type 44 Rotary Stepping Switch is 6, the greatest number of 33-point electrical levels is 2. The maximum number of physical bank levels on the Type 88 Rotary Stepping Switch is 12, so the greatest number of 33-point electrical levels is 4.

The wipers are electrically commoned by strapping the external terminals of their associated brush springs. There are no lobes except in the 33rd position (to stop the rotary stepping switch at the home position), so that the off-normal springs are operated only in the home position (once during each revolution of the wipers).

Specify the Exact Number of Contacts Wanted on All Levels

Needless "double loading" has a tendency to reduce life and cause erratic speeding of rotary stepping switches. For this reason, Automatic Electric does NOT recommend a "full bank" on *all* levels of the Types 45, 44 and 88 Rotary Stepping Switches.

If 25-point bank contacts are specifed on an order for the Type 45, the bank will have 26 points only on the bridging levels used for control or homing through the wiper and bank, and 25 points on the rest of the levels. Some users plan to use the 26th point on *all* levels, and forget to so advise the manufacturer. Since it is virtually impossible to make this change in the field, "full banks" *must be ordered specifically* as required, thus: "5 non-bridging levels, *each* with 26 points."

On the 11-point-per-level Types 44 and 88 Rotary Stepping Switches, it is standard practice at Automatic Electric to place contacts in the 11th position *only* on those levels needing them (the bridging levels that may be used for control or homing the switch through wiper and bank). Therefore, if you plan to use the 11th position contacts on *all* levels (after considering the possible negative effects of "double loading"), be certain to specify this in your order, thus: "Full bank, 11th position contacts on all bank levels."

Specify "Bridging" and "Non-Bridging" Levels as Needed

A 10-level rotary stepping switch is normally constructed with 1 bridging level (for control purposes) and 9 non-bridging levels. If you want something different, you must tell the manufacturer exactly what you want, and the quantity desired, thus: "2 bridging and 8 non-bridging levels", etc.

Identify Your Power Supply

Unless the power supply is "solid", BE SPECIFIC. Inclusion of a sketch or detailed description of the power supply will enable the manufacturer to furnish you with properly adjusted switches. For example, "to operate on 110 volts DC" is totally inadequate if your power supply is rectified 115 VAC from a commercial source.

Order from Stock

Custom engineering and manufacturing takes time. If your need is more a matter of urgency than specifics, use a manufacturer's stock program. (See, for example, AE's "Stock Letter".) Refinement of the engineering details can often follow the prototype testing done with rotary stepping switches obtained directly and quickly from stock.

Re-Order by Manufacturer's Piece Number

Once you have established the details of the rotary stepping switch needed, have obtained one, used it and found it has everything you want, the easiest and quickest way to get additional quantities of that same identical unit is to *re-order by the manufacturer's piece number.* What does this do for you?

1. It makes sure that your order is handled speedily. (It will go right into production without awaiting its turn in engineering.)

2. It avoids the chance of an engineering oversight and resultant error. It doesn't happen frequently (but even once is too often). When it does happen, the customer's complaint letter always says, "Why didn't you give me what I had on my previous order?" Therefore, ordering by piece number with *reference to the past order* is an excellent idea. Typewriters don't spell too well, at times, and they can also skip digits. If piece number PW-94136-1 gave you the results you wanted on Order Number C-XXXX, tell the manufacturer and make certain of getting exactly the same thing again.

Other

The best reference source in initial ordering is the manufacturer's catalog. The most frequent errors in ordering usually can be put down to haste or failure to refer to the catalog. These deficiencies usually are failure to specify voltage (and whether AC or DC), number and kind of interrupter springs, number and kind of off-normal springs, kind of mounting and mounting materials (such as shock mounting with rubber cushions, etc.), and ambient temperatures or other unfavorable conditions to be met.

XIV. SOME ADDITIONAL CIRCUITS YOU'LL FIND USEFUL

For your convenience, this chapter contains several circuits previously presented in other publications, but not repeated in the preceding chapters of this book. These are by no means exhaustive; no book is large enough to hold all of them. If you don't find a circuit to meet your needs in some section of this book, consult with the manufacturer's home office or staff engineer.

The contents of this chapter are divided basically into three types of circuits: Those primarily concerned with rotary stepping switches; those utilizing the unique features of the Series OCS Relay, and those using AE's Codel Relay.

Circuits Concerned with Rotary Stepping Switches

Remote impulse control (Figure 57)

This circuit provides dial control of switching functions using only two relays at the remote control point. It provides impulse inversion, maintained supervision and reset signalling.

Operation of the key closes a circuit through the dial "D" to Relay A. Relay A operates and closes a circuit to Relay B. Relay B operates, closes its contacts (associated with leads designated "H") and prepares a circuit to the lead designated "P" such that when Relay A restores on dial impulses, the potential on the contacts of Relay A will be extended out on lead "P" each time Relay A restores. Relay B is equipped with a slow release heel-end slug. This slug causes Relay B to remain operated during a series of impulses received at normal dial speeds (8-12 PPS). Opening of the key opens the circuit to Relay A. Relay A will restore, opening Relay B, and closing a momentary circuit out on the lead "P". Relay B will restore, open the circuit to the leads designated "H" and will close a solid circuit to the lead designated "R".

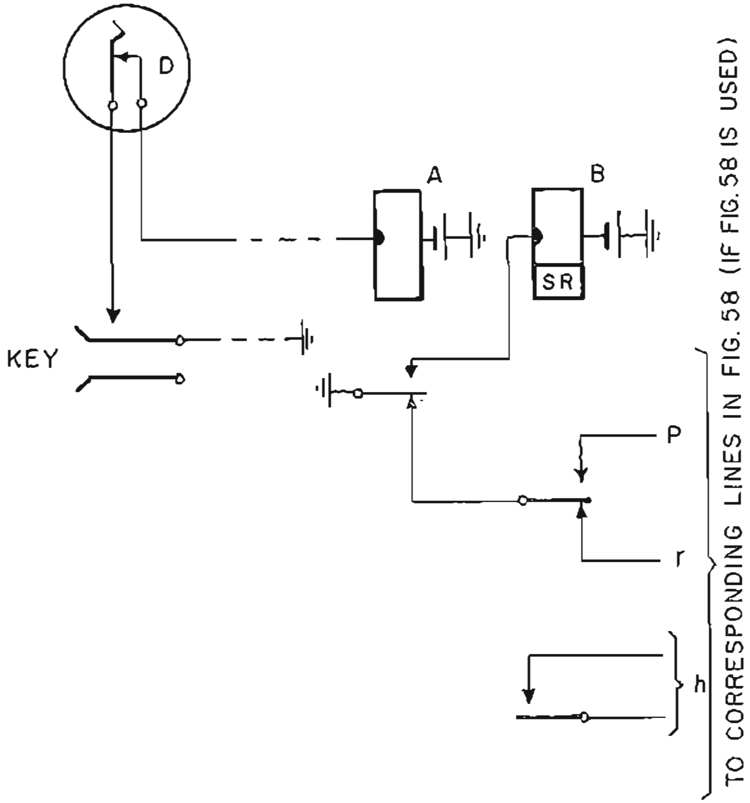


Fig. 57. Remote impulse control including reset over two wires (A B function).

The impulsing springs of the dial at the remote dialing point should be equipped with a resistor and condenser combination connected across the dial, and should consist of the maximum resistance in series with the minimum capacity which will adequately suppress sparking at the dial contacts. The values for the resistor and condenser will be dependent upon the voltage used, the relay voltage and coil characteristics, and the length and nature of the pair of wires which connects the dial to the circuit.

One word of caution — When a relay is ordered to function as an impulse-receiving relay from a telephone type dial, that fact should be noted in the ordering information for the relay. There is a vast difference between an ordinary 1C quick-acting relay and a 1C impulse-receiving relay for the same voltage.

Remote switching of groups of impulses

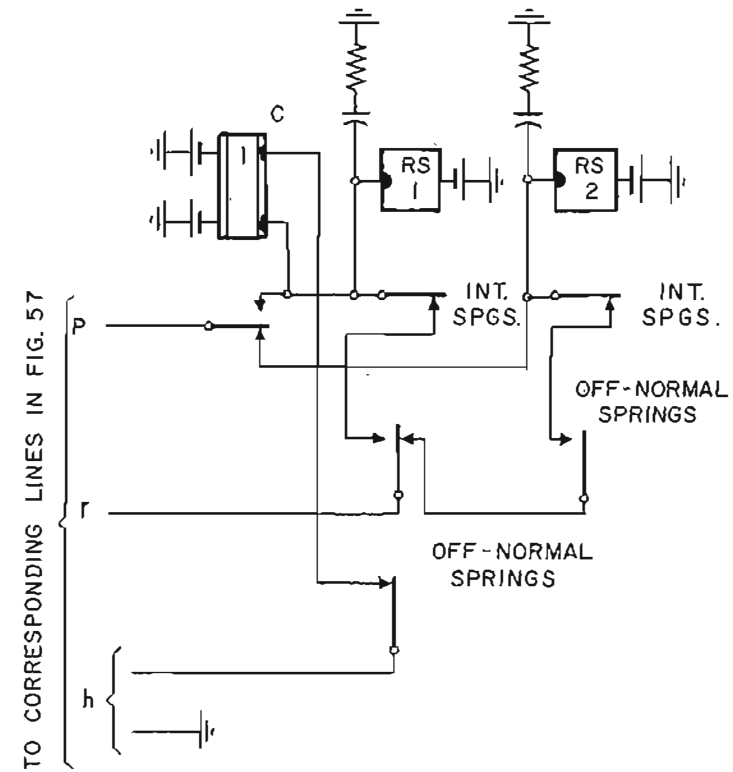


Fig. 58. Remote switching of groups of impulses (A B C function).

Operation of the equipment in Figure 58 requires that the equipment in Figure 57 also be provided. Figures 57 and 58 together provide means whereby successive series of dialed impulses from a remote point can be used to successively position electromagnetic switching devices. In this case, two rotary stepping switches are illustrated.

When Figure 58 (together with Figure 57) is used, operation of the key in Figure 57 causes Relay A to operate, and in operating closes circuitry to Relay B. Relay B operates, closing a circuit over the leads designated "H" through the off-normal springs of rotary stepping switch No. 1 (SS1) to the number 1 winding of Relay C. Relay C operates. Impulse trains generated by the dial cause Relay A to restore once for each generated impulse. Each time Relay A is normal, a circuit is closed over the lead designated "P" to the coil of SS1, and the number 2 winding of Relay C in parallel. Relay B remains operated on the impulse train because of its slow-release heel-end slug, and Relay C remains operated on the impulse train because of the copper sleeve on its core. As soon as SS1 has taken its first step, the circuit to the number 1 winding of Relay C is opened by the transfer of the off-normal spring.

When the first impulse train is complete, Relay A remains operated, Relay B remains operated, and Relay C restores. The second impulse train causes Relays A and B to function as previously described, and each time Relay A is in the normal position a circuit is closed over the lead designated "P" through the back contacts of Relay C to the coil of SS2. SS2 will follow the impulses generated by Relay A.

Following the dialing of the two digits, SS1 and SS2 have been positioned on the bank contacts selected by the digit values dialed.

The circuit is released by opening the key. Relay A restores, opening

Relay B. Relay B will restore following its normal slow-release time delay, closing a circuit over the lead designated "R" to SS1 through its off-normal springs and interrupter springs. SS1 will step in a self-interrupted manner until the home or normal position is reached. At this point, the off-normal springs will transfer to the position shown on the sketch and extend this circuit from lead "R" through the off-normal springs and interrupter springs of SS2 to the coil of SS2. This switch will step in a self-interrupted manner until it achieves the home or normal position, at which point its off-normal springs open and motion stops. At this time, the entire circuit in Figures 57 and 58 is released and idle.

This same circuit can be utilized for any number of successive digits by the addition and proper connection of additional relays similar to Relay C and the necessary additional rotary stepping switches. If, however, an appreciable number of digits are to be registered, a more desirable means of routing to the successive rotary stepping switches would be to provide one common rotary switch for routing impulse trains successively. If this approach is taken, the basic philosophy is similar to that illustrated in Figure 59 for rotary stepping switch "S". This sequence switch "picks" during a series of impulses, and advances one step when the series is complete. The sequence switch could be controlled from a single slow-release relay similar to Relay C, arranged with appropriate circuitry to operate each time an impulse train is received.

TCI Library: www.telephonecollectors.info

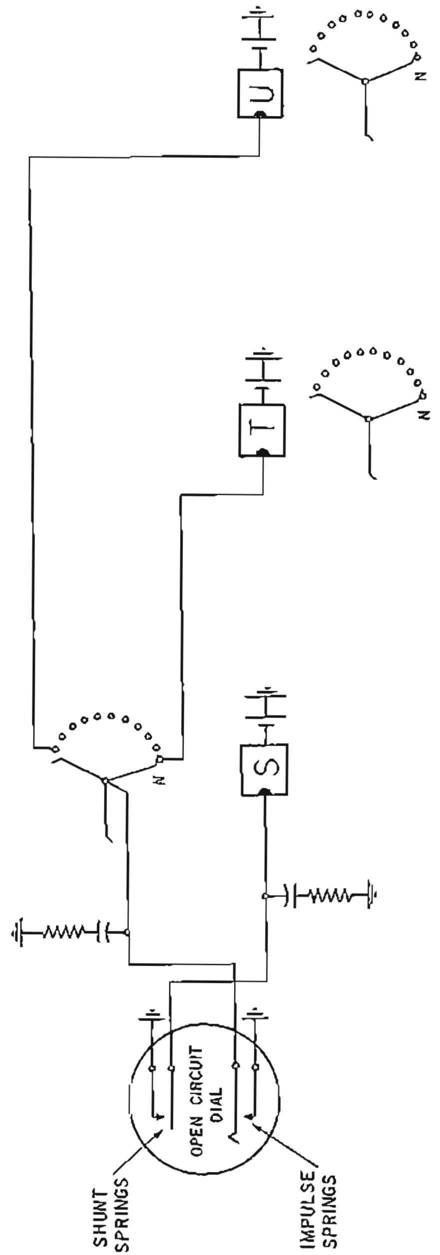


Fig. 59. Local sequential stepping switch control without relays. (See Figures 57 and 58 for remote operation.)

Local sequential stepping switch control without relays (Figure 59)

This is a very economical means for sequential switching of impulse trains. As shown, the first series of impulses will cause rotary stepping switch T (SST) to step while rotary stepping switch S (SSS) is held in the operated position during that period of time that the dial is off-normal. Following completion of the first digit, SSS will position itself on the next bank contact, and the next group of impulses will cause SSU to operate.

Each time the dial is drawn off-normal to dial a digit, the shunt springs close and energize the coil of SSS. SSS picks its armature but does not allow the wiper assembly to move until the dial returns to normal and the shunt springs open. As the dial returns to normal from the digit selected, the impulse springs will close one closure for each unit value of the digit dialed. Each time the impulse springs are closed during the first digit, SST will take one step. Following the positioning of SSS on the next bank contact, the next series of impulses will be routed to SSU, causing it to step.

Caution: While this circuit is convenient for local stepping switch control, it is not a normal technique. The majority of telephone dial devices available have normally-closed impulse springs, rather than normally-open. Further, the amount of current required by a rotary stepping switch precludes any possibility of the use of a circuit of this type from a dialing device located quite remote from the rotary stepping switches. Generally, it is much better practice to use the circuit shown in Figures 57 and 58.

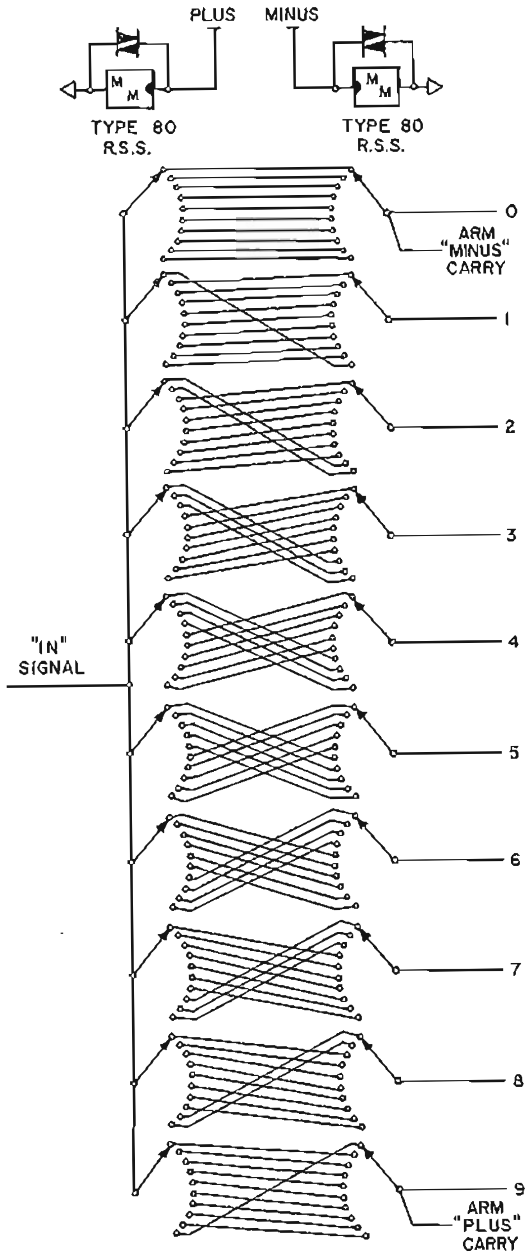


Fig. 60. Bi-directional decade.

Bi-directional decade (Figure 60)

With the advent of the Type 80 Rotary Stepping Switch, a full bi-directional counting network consisting of two rotary stepping switches became practical. The control circuit requires that each of the rotary stepping switches have ten levels of ten points each.

As can be seen from Figure 60, the output lead which will be connected to the "in" signal source at any given time will depend upon the phase relationship of the two switches. As drawn, both switches are on bank contact one, therefore are in phase, giving a resultant output of zero. Should the left hand Plus switch advance five steps and the right hand Minus switch make no movement, the "in" signal would then be connected to output lead number five. Similarly, following this, an advance of three steps on the Minus switch would cause output lead number two to be activated (5 minus 3 equals 2).

The two rotary stepping switches will function as a two-direction decimal network. However, should there be a requirement for bi-directional counting into a second decade, it becomes obvious that with this decade in the zero condition, receipt of a Minus impulse causes this decade to reduce to a nine output, and carries a Minus one forward into the tens decade. To provide for this, we suggest that the circuit arm a Minus-carry auxiliary circuit whenever it is in the zero condition.

Similarly, with this decade in the nine condition, the receipt of a Plus impulse drives this decade to zero and carries a Plus impulse into the tens decade. The drawing suggests that the Plus-carry be armed whenever this decade is in the nine condition.

Additional features can be incorporated utilizing additional bank levels or off-normal springs to prevent the movement of the bi-directional counting chain toward negative numbers. Thus, should both decades or all decades become zero, appropriate circuitry can be arranged to reject Minus impulses. However, for purposes of illustrating the cross connections necessary for a decimal bi-directional decade, these additional circuit items have been left out.

TCI Library: www.telephonecollectors.info

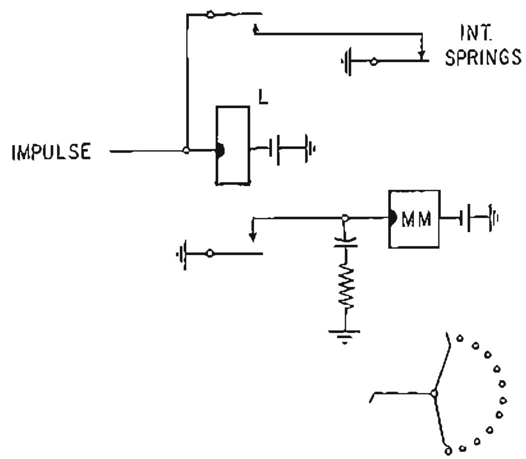


Fig. 61. Lock pulsing to insure stepping on inadequate or irregular-shaped pulse.

Lock pulsing

When a remotely generated impulse is of too short duration or is so irregularly shaped that a rotary stepping switch does not obtain adequate coil "on" time to assure proper operation, a relay can be added to provide "lock pulsing", as in Figure 61.

In order to insure that each step is properly taken, it is necessary that Relay L be engineered to have an operate time and operating characteristics that will enable the relay to follow the impulse. If this is done, Relay L will operate on each impulse and will not be released until the rotary stepping switch has had sufficient time to take a proper step and acknowledge the fact to the relay.

This circuit can only be used where the interval between successive impulses is adequate for the movement of the rotary stepping switch. The percentage of time that the impulse is "on" is extremely pertinent to this problem and its solution.

When the impulse is received by Relay L, Relay L will operate and lock itself to the normally-closed interrupter springs on the rotary stepping switch. Relay L closes a circuit to the coil of the rotary stepping switch. The rotary stepping switch will energize and "pick" its armature. When the rotary stepping switch is adequately operated, the interrupter springs break, opening the lock for Relay L. Relay L

will restore and open the circuit to the rotary stepping switch coil. The rotary stepping switch coil will restore the armature to normal, advancing the wipers one step and re-establishing the lock circuit as available for Relay L on the next impulse, when received.

Remote selection of 1 point out of 100

The circuit in Figure 62 illustrates how a selection of 1 point out of 100 can be made by using three Type 44 Rotary Stepping Switches. It also demonstrates a typical telephone dialing circuit.

Operation of the locking lever key energizes Relay A through the normally-closed telephone dial contacts. Relay A operates, closing a circuit to Relay B, which then closes a circuit to Relay C through the off-normal contacts of rotary stepping switch No. 1 (SS1) and winding 2 of Relay C. When the telephone dial is rotated and released, Relay A restores once for each dial pulse. In restoring, Relay A energizes Relay C (winding 1) and the motor magnet coil of SS1 through a contact on Relay B and Relay C. Both Relay B and Relay C are slow-to-release so that they will not restore between dial pulses. At the end of the first dialed digit, Relay C restores during the interval between digits. Since the off-normal contacts of SS1 are now open, Relay C cannot be re-operated until after the circuit has been returned to normal. The second dialed digit causes Relay A to pulse, and upon each restoration of Relay A, either SS2 or SS3 will be pulsed, depending on whether the first digit dialed was from one to five or from six to zero. Thus, with its bank level on the first dialed digit SS1 selects either SS2 or SS3. SS1 also selects 1 of 5 bank levels on one of the switches, so that the control lead is connected to a particular point out of 100 after the second digit has been dialed.

It is normal practice to hold the control lead open (through contacts on Relay C) during dialing, so that unwanted bank contacts will not be energized when they are passed over. The circuit is restored to normal by releasing the locking lever key. Relay A restores and, after a short delay, Relay B restores, energizing SS1 through its off-normal and interrupter contacts. SS1 runs self-interruptedly until it reaches the home position. Then it stops and transfers the homing circuit to SS3 or SS2. When all switches have reached the home position, the remote home lamp (optional) is lighted.

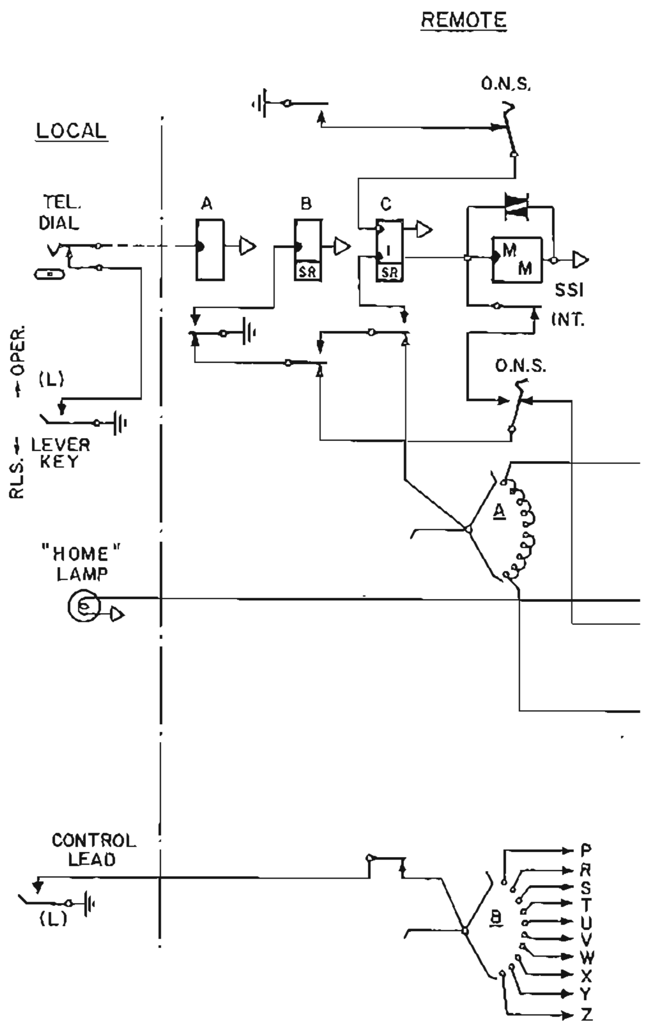
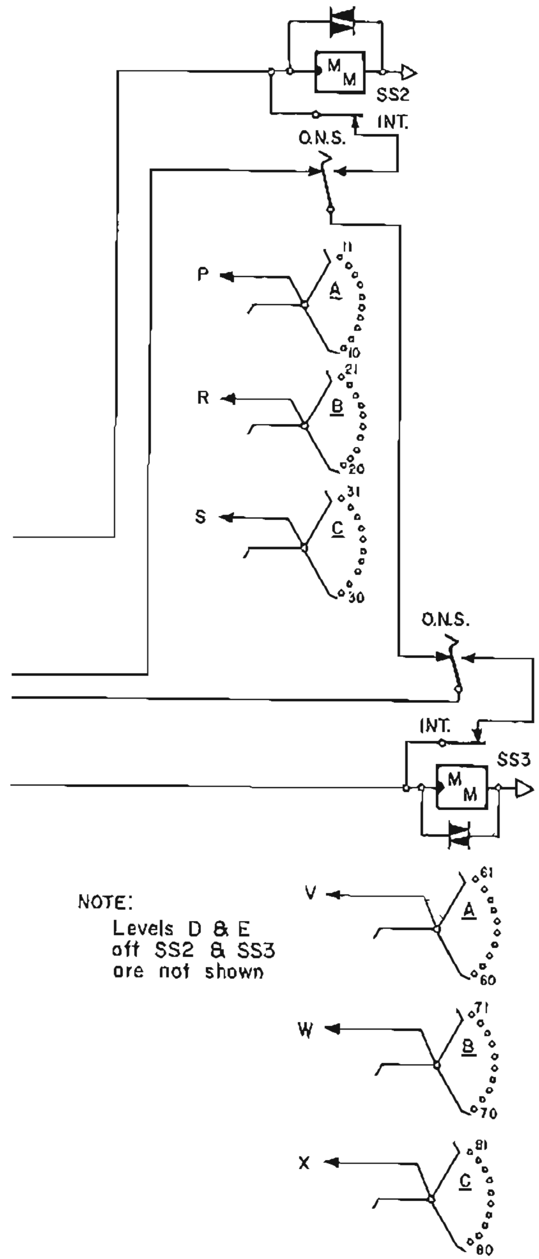


Fig. 62. Remote selection of 1 point out of 100. Illustrates typical telephone dialing circuit.



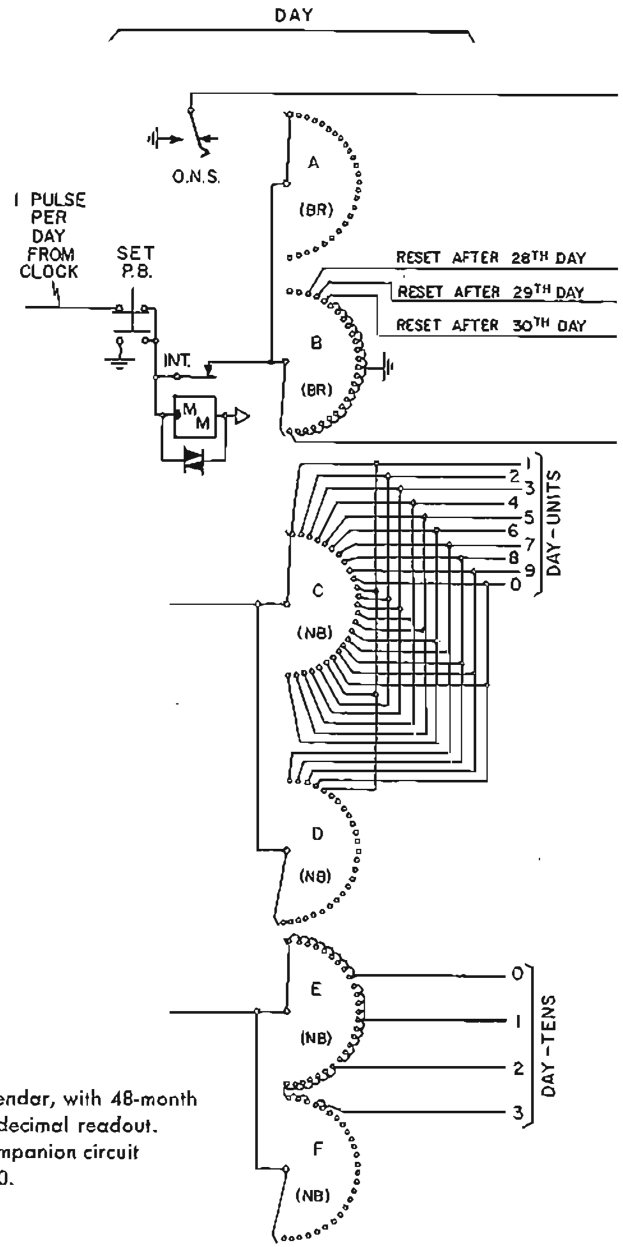
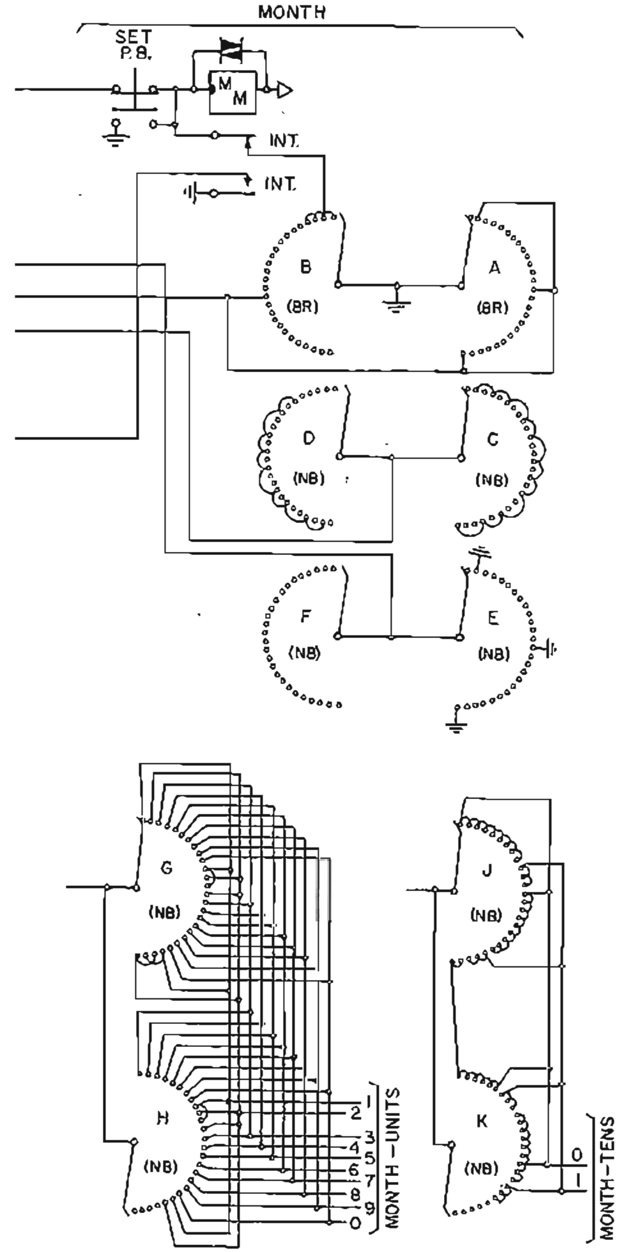


Fig. 63. Digital calendar, with 48-month cycle and decimal readout. This is a companion circuit to Figure 30.



Digital calendar (Figure 63)

This circuit is suggested for use with the digital clock of Figure 30 to provide decimal data pertaining to the time and date for a full four-year cycle.

The Day rotary stepping switch is drawn so that the decimal readout indicates the first day of a month. Similarly, the Month rotary stepping switch is shown in a position pecular to the first month (January) of a 48-month cycle.

The wiring of levels A, B, C, D, E, and F on the Month switch determines when the Day switch should reset itself to the first day of a new month, and as a result, advances the Month switch one month. The wiring on level E causes this reset after the 28th of February in the first three Februarys of the four-year cycle. The wiring of levels A and B provides that homing shall take place after the 29th day of the fourth February in a four-year cycle. In addition, it provides the necessary signal for movement following the 28th day on any month of February. Similarly, the wiring of levels C and D controls the resetting of the Day switch for months containing 30 and 31 days.

The resetting of the Day switch is interlocked with the advancing of the Month switch. When the Day switch encounters a homing signal on its B level, indicating the end of a current month, it will advance to the 52nd (or normal) position, at which point the off-normal springs energize the coil of the Month rotary stepping switch. The Month interrupter springs provide positive DC to the 52nd bank point of level B for the Day switch, causing the Day switch to take one self-interrupted step to position one, indicating the first day of a new month. The off-normal springs restore to the position shown, releasing the Month switch which advances one step to the succeeding month.

Obviously, when such a system is placed in service the proper date must be set on the Day switch by means of the set push button. The proper month (both in terms of decimal value and relationship to leap-year) must be set on the Month switch. This setting of Day and Month should be done in that order.

Circuits Using the Series OCS (cam-switching) Relay

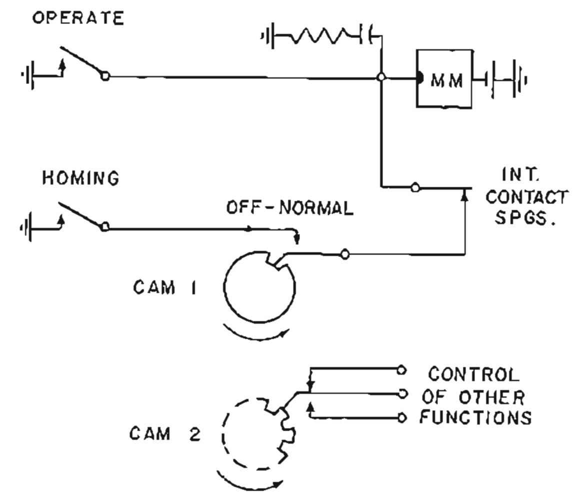


Fig. 64. Pulse-driven OCS with reset function.

Impulse operation of the Series OCS relay

The OCS relay in Figure 64 is arranged to operate on impulses over a single lead, and to reset when necessary by means of a homing signal over a separate lead.

As indicated, one of the cams on the OCS relay is used as an off-normal or homing cam. The other cams can be cut as required, OCS relays are equipped with either 30-, 32-, or 36-step ratchets.

Each time the operate contacts close, the OCS relay will "pick"; when the operate contacts open, the OCS relay will advance the cam assembly one step. This cycle follows each time the operate contacts are closed and opened.

Closing the homing contacts of the OCS at the same time the interrupter springs are closed completes a circuit through the interrupter springs to the relay coil. This is necessary when the program requires skipping of certain contacts, or when it is desirable to return the relay to home position. In this condition the relay will operate in a self-interrupted manner, opening its own circuit each time it is energized, and stepping forward until the off-normal springs open.

TCI Library: www.telephonecollectors.info

Mechanically latched on-off function

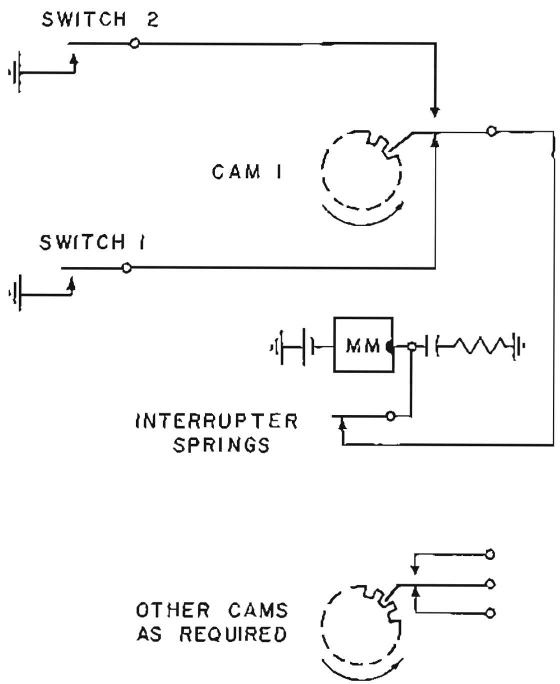


Fig. 65. Mechanically latched on-off function.

The OCS relay in Figure 65 is arranged to step in a self-interrupted manner, one step at a time, when the remote contacts associated with the present position of the relay are closed. Closure of the alternate set of contacts will not affect the status of the relay.

As drawn, closure of Switch 2 will not affect the status of the OCS relay. Closure of Switch 1 causes a self-interrupted circuit to be connected through the interrupter springs to the coil of the OCS relay. The OCS relay will take one self-interrupted step, and in so doing will cause the springs on Cam 1 to transfer to the Switch 2 side. Continued closure of Switch 1 (or repeated closures of Switch 1) with the OCS relay in this new position will not affect the status of the relay. Now the OCS relay will only recognize a signal from Switch 2.

When Switch 2 is closed, the OCS relay will take one self-interrupted step in the same manner as described previously, causing the Cam 1 springs to restore to the condition shown in the drawing.

A refinement of this circuit logic, the OCS relay can recognize a number of successive acknowledgment signals from some process. It can be used in this way to establish successive commands and to only recognize completion signals as a result of these commands. When the completion signal is received, the OCS relay is positioned on the next step, generating the new command and only recognizing the new acknowledgment. This technique is used very successfully in many machine tool and process control applications.

Pulse dividing

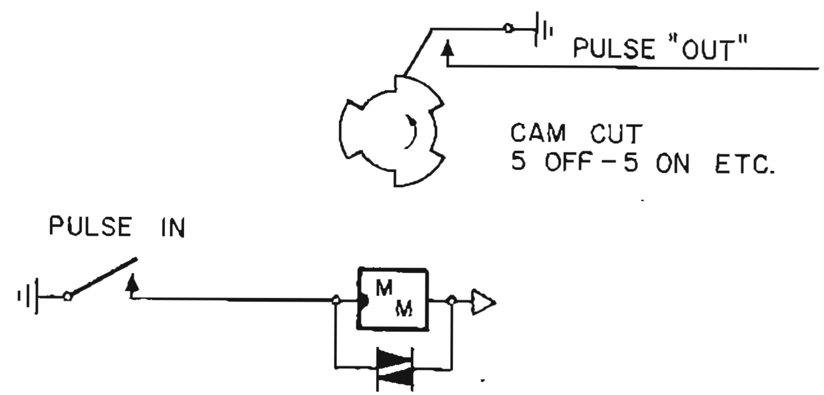


Fig. 66. 30-point OCS relay used as a 5-to-1 divider.

Figure 66 shows a 30-point OCS relay used as a 5-to-1 pulse divider. Simple and rugged pulse dividers, capable of pulsing at relatively high frequencies, can be obtained for nearly any pulse division requirements, since OCS relays are also available in 32- and 36-point configurations.

TCI Library: www.telephonecollectors.info

Binary readout (Figure 67)

Figure 67 demonstrates the use of a 32-point OCS cam-operated relay as a binary readout. With the cams cut as shown, their contacts can be used to give an output signal of from 1 to 32, in standard binary code. The schematic shows the readout in position 32. The exact "stacking" (sequential cam arrangement) shown is not the best for good distribution of loading on the mechanism, but is shown in this form for simplicity and better understanding of the Series OCS relay as a binary readout device. On an actual order, the cams would be arranged to provide best balanced loading.

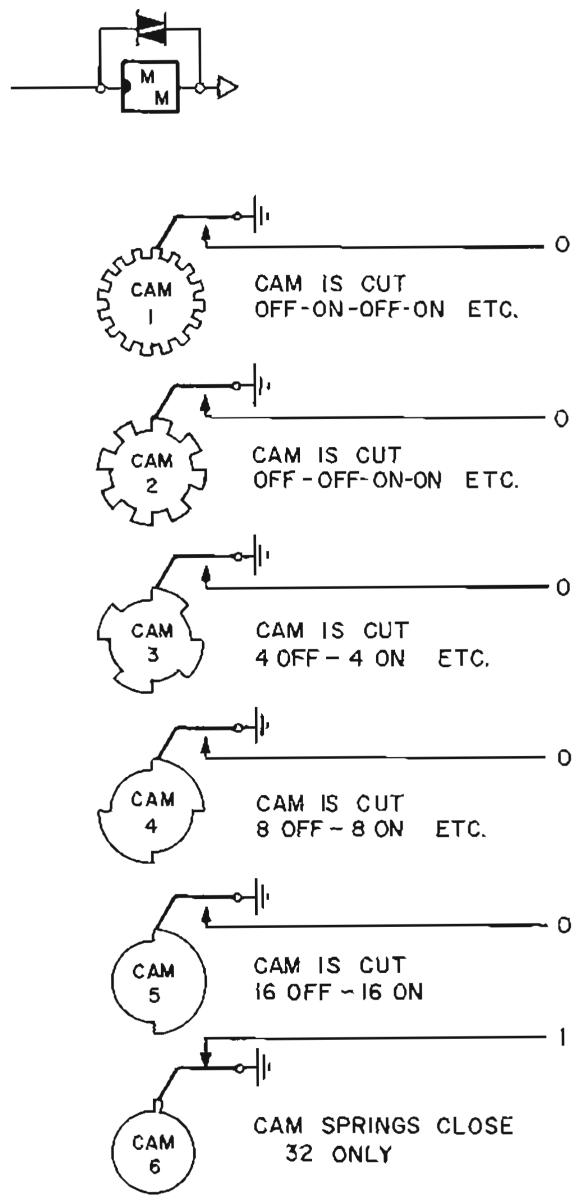


Fig. 67. AE's 32-point OCS relay used as a binary readout. (Shown in position 32.)

TCI Library: www.telephonecollectors.info

Decimal-to-binary conversion (Figure 68)

For a binary code (1-2-4-8), four levels are required on each of the rotary stepping switches indicated. The switches are drawn in the home (or normal) eleventh position. They will, under dial or some external control, be advanced a given number of steps as indicated by the decimal value of the positioning digit. The wiring of the four levels of the rotary stepping switch will determine the binary signals which will appear on the four output leads from each of the switches.

Such a circuit as is illustrated in Figure 68 can well be used as the upstream data source for Figure 70, which involves scanning transmission, storage, and use of such binary data.

The means for effecting movement of the rotary stepping switches indicated in Figure 68 are described in Figures 56 and 57.

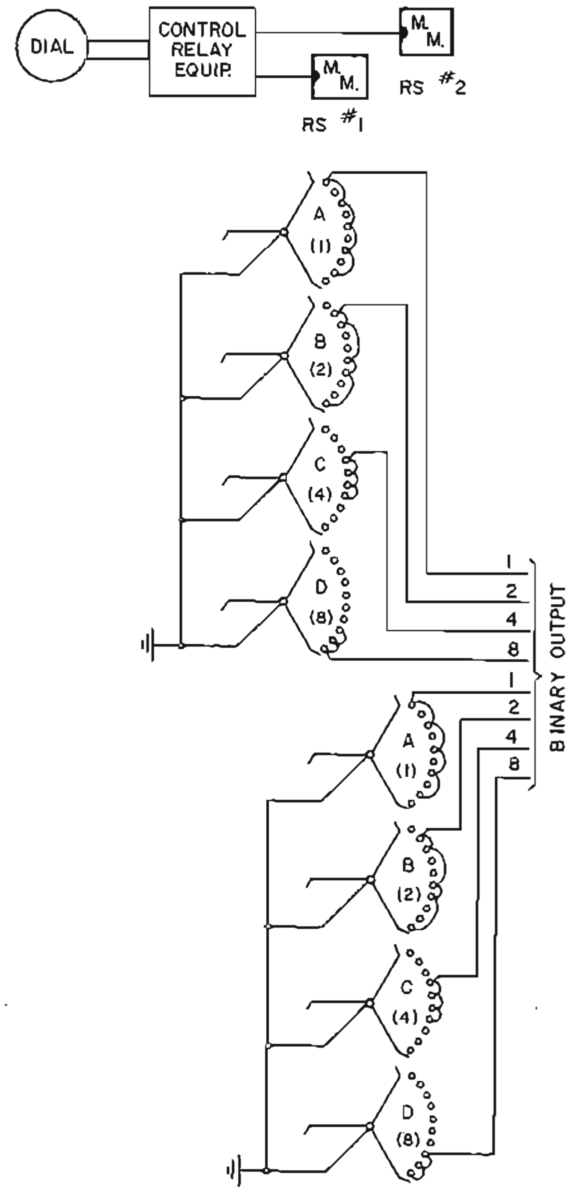


Fig. 68. Decimal-to-binary conversion.

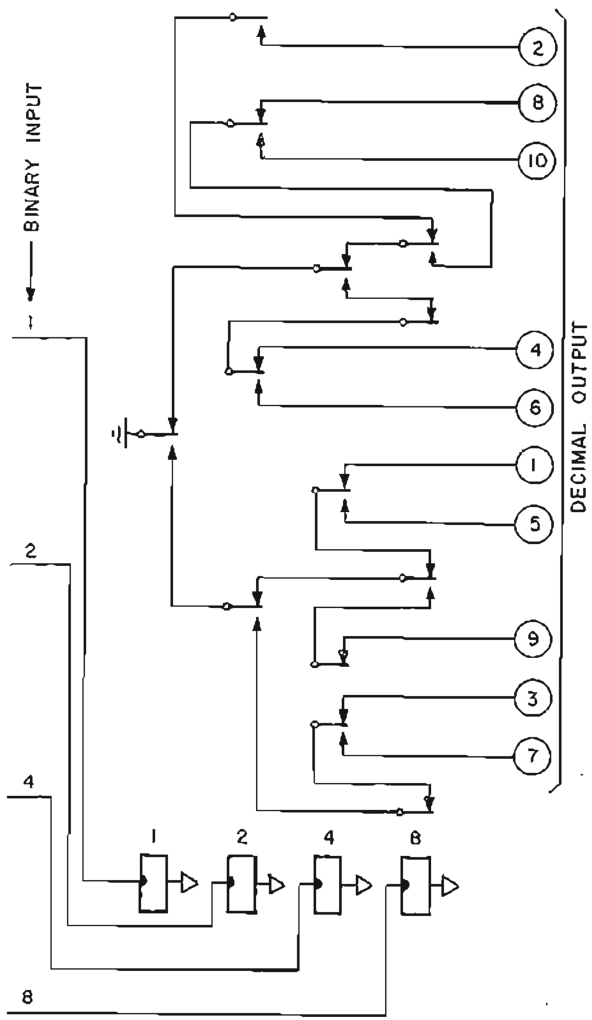


Fig. 69. Binary-to-decimal conversion.

Binary-to-decimal conversion (Figure 69)

Figure 69 is the converse of Figure 68. In the previous figure we converted decimal information into binary form. In this one we convert binary form data back into decimal form.

This circuit is a specialized form of a folded tree circuit.

Positive DC, appearing on one or more of the four binary input leads, will cause the associated relay to be operated, resulting in a decimal output equal to the arithmetic sum of the binary coded input.

Figure 69 might well be used as the output translation for Figure 70, which follows, relative to the scanning and handling of such coded data.

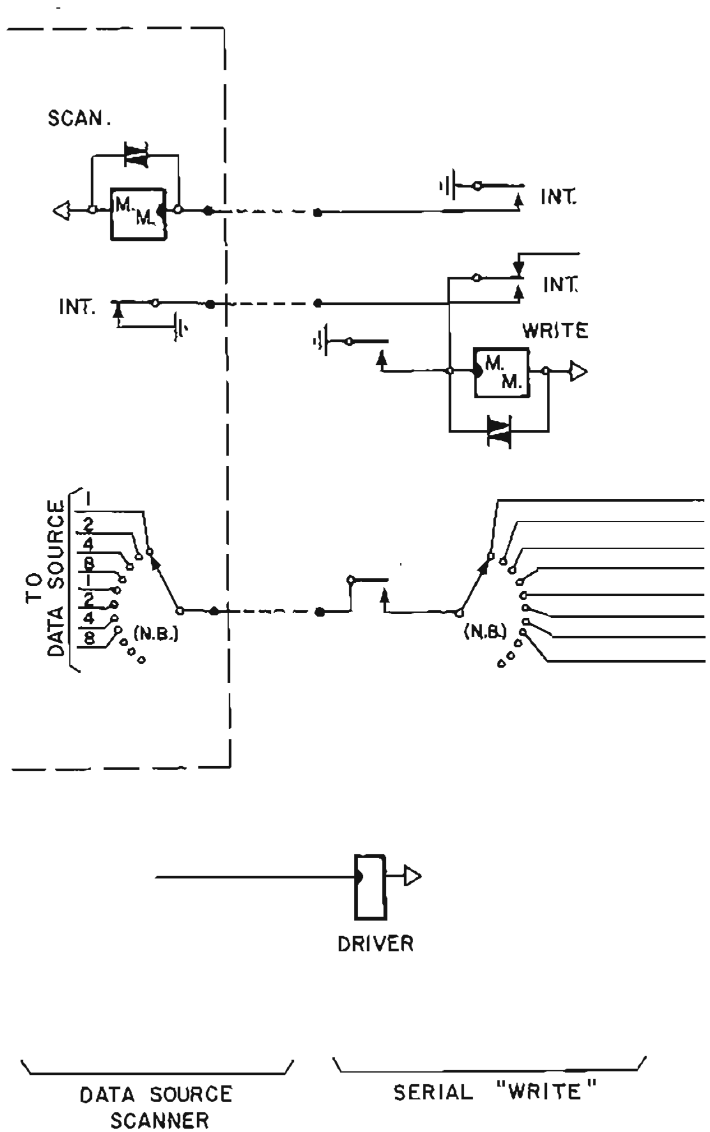
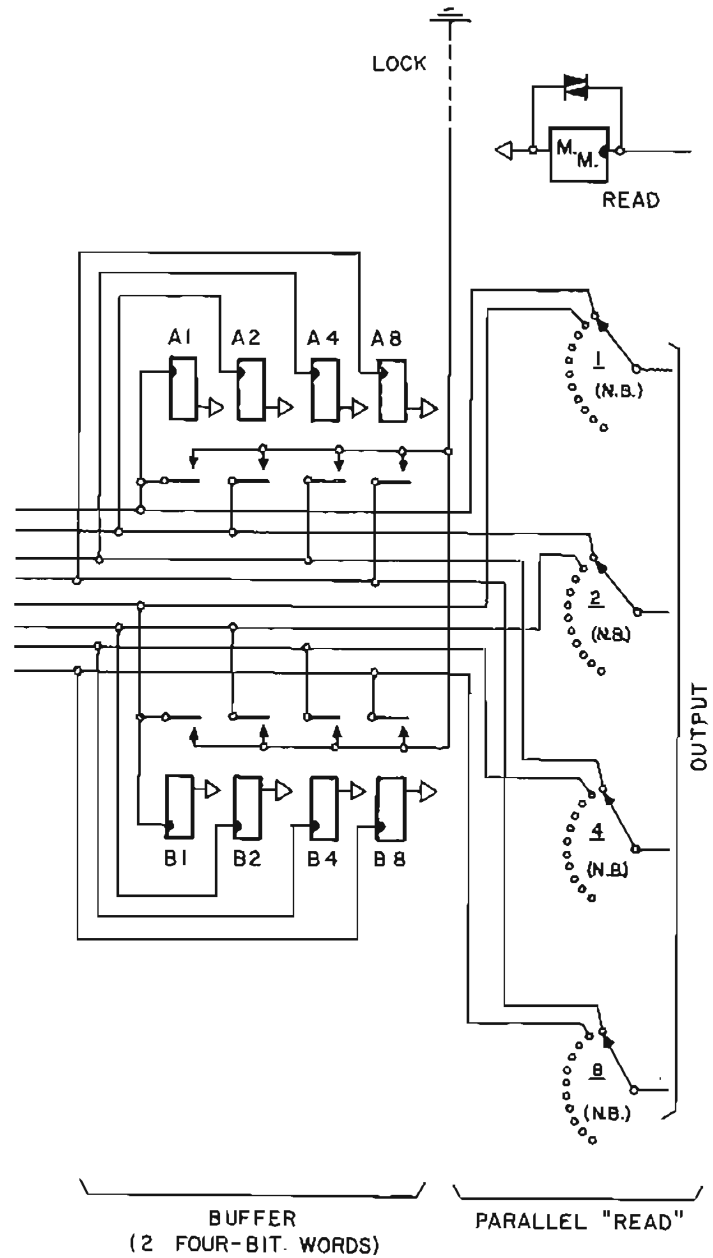


Fig. 70. Four-bit memory device. Typical use of AE's Type 59 Codel relay.



TCI Library: www.telephonecollectors.info

Circuits Using the Type 59 Codel Relay

The Type 59 Codel relay can be described as an inexpensive four-bit memory device. We do not mean that because it is a four-bit device it only costs 50¢. A "bit" in this instance can be defined as a single item of information however derived. The Type 59 Codel relay resembles four individual electro-magnetic relays, each having a 1A spring combination, but with each stationary contact electrically in common.

In industrial usages of rotary stepping switches and relays there can be many areas where similar storage is necessary. Figure 70 illustrates a digital application for two four-bit words. Figure 71 illustrates the use of the Codel relay in a shift-register application.

Four-bit memory device (Figure 70)

Assume that Figure 68 is connected to the left hand portion of Figure 70 and that Figure 69 is connected to the right hand portion of Figure 70. It is now possible by means of the dial in Figure 68 to dial two decimal digits on registers one and two and have the binary coded equivalent of these decimal values available to the bank contacts of the Scan rotary stepping switch of Figure 70.

The dotted lines connecting the Scan portion of Figure 70 to the Write portion indicate that scanning and writing can be remotely located from each other. The Driver relay is indicated, although the method of making the Driver relay pulse is not shown. This can be done by a pulse generator or some similar control device.

When it is desired to transfer the data appearing on the bank contacts of the Scan rotary stepping switch, the Driver relay is pulsed a total of 8 times. When the contacts of the Driver relay close, the coil of the Write switch is energized, actuating the armature. The Write switch then locks itself operated (through its own normally-open interrupter springs to the positive DC of the normally-closed interrupter springs of the Scan switch). The other contact on the Driver relay connects the wiper of the Scan switch to the wiper of the Write

switch. The normally-open interrupter spring of the Write switch closes a circuit to the coil of the Scan switch.

Should a positive DC "bit" appear on bank contact 1 of the Scan switch during this time (with the Driver relay energized), this potential will be extended through bank contact 1 of the Write switch to the coil of Relay A1. Relay A1 will operate and lock itself to the common lock circuit.

When the Scan switch has fully actuated its armature, its normally-closed interrupter springs open, and (presuming the Driver relay has now restored) the lock circuit for the Write switch is removed, permitting the Write switch to advance to the next bank contact. Opening of the interrupter springs on the Write switch permits release of the Scan switch. The Scan switch will advance to its next bank contact.

The inter-relationship of the two rotary stepping switches is such that they are synchronized on each pulse cycle generated by the Driver relay. Each time a positive potential appears on a bank contact of the Scan switch, this potential is extended through the contacts of the Driver relay and the bank of the Write switch to the Codel relay coil peculiar to that bit value. Whereupon that relay will operate and lock.

The buffer, consisting of two Type 59 Codel relays, can accommodate two four-bit words or the data-equivalent of two decimal digits.

Now the coded form of the two decimal digits, originally dialed into the buffer (Figure 68) has been stored. As drawn, the output from the "A" word appears as positive DC on the first bank contact of each of the four levels of the Read switch. If Figure 69 were connected to the wipers of the Read switch, the decimal translation of this coded information would be available at the correct output lead in Figure 69.

A remote pulse will cause the Read switch to advance to the second bank contact. In this position the data which is stored in the "B" word is extended to the translating relay of Figure 69. When the stored information is no longer needed, momentary opening of the lock circuit will release both buffers.

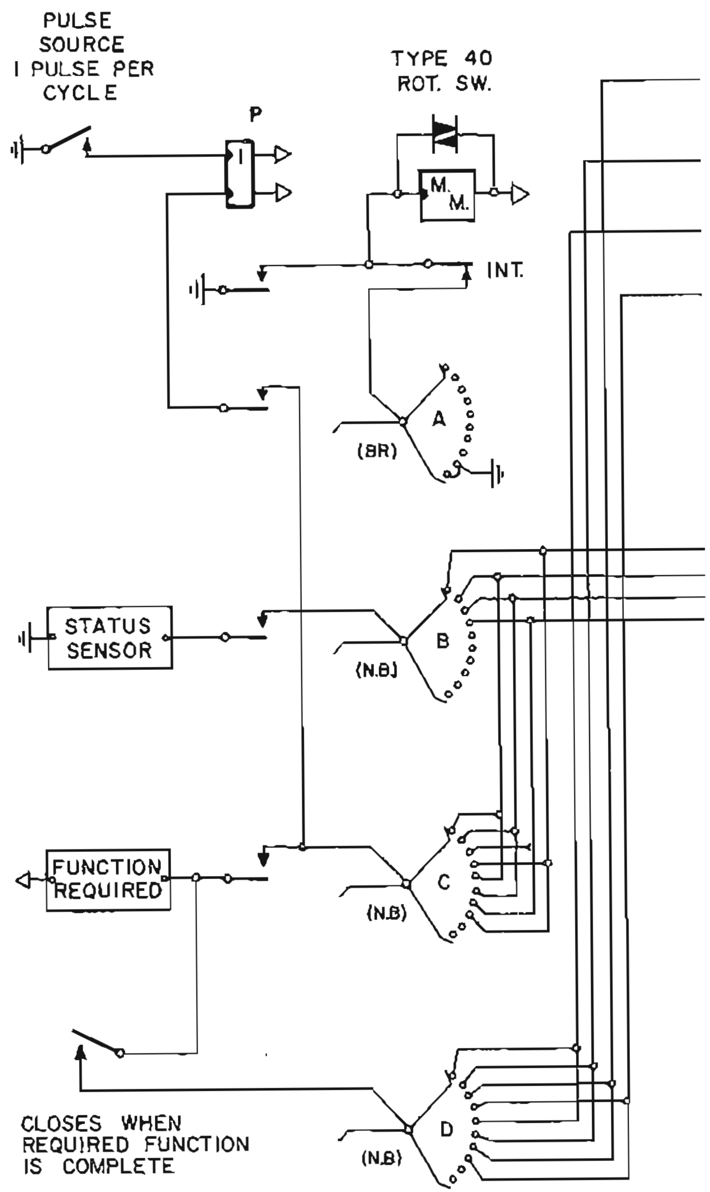
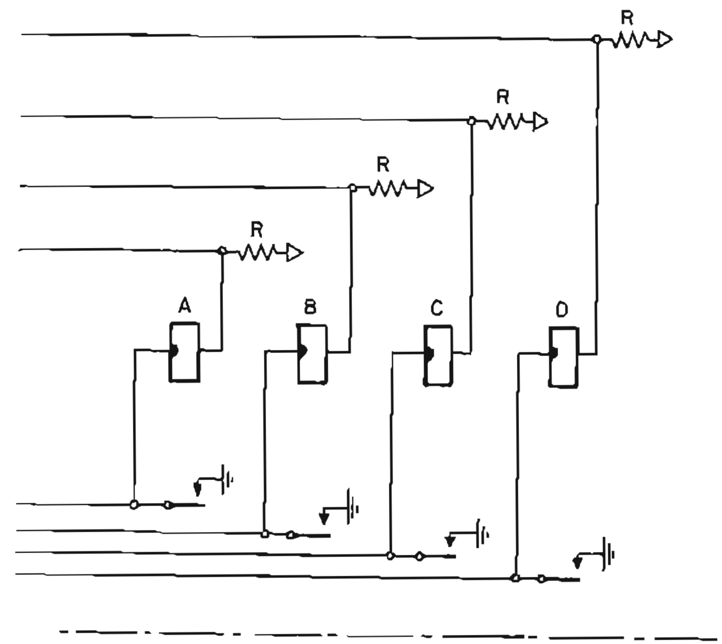


Fig. 71. Four-bit shift register using AE's Codel relay.



Four-bit shift register (Figure 71)

A shift register is a temporary memory device that stores information for use at the proper time, and in the proper sequence. The use of shift registers is common in the automation of indexing machines, conveyor belts, and similar arrangements where items follow one after another in line.

In order to understand Figure 71, visualize a manufacturing process with a conveyorized operation that indexes past work stations and inspection stations. The inspection stations sense that the manufactured product does not have a certain characteristic, or does not meet some requirement such as weight, shape or surface finish. The "Status Sensor" in Figure 71 is associated with this inspection station. A station three steps further down the indexing conveyor either modifies or rejects those items that have already been sensed as undesirable. The "Function Required" equipment in Figure 71 is associated with this modification or rejection station.

The pulse source is related to the drive mechanism of the indexing conveyor. It generates one impulse for each shift of the index to keep the rotary stepping switch in phase with the indexing conveyor.

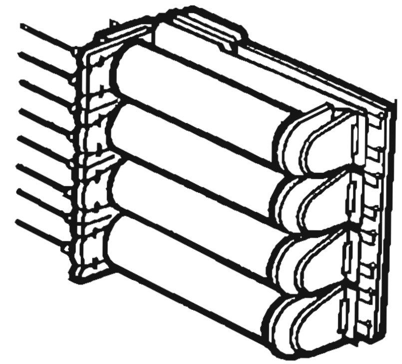
Each time the contacts of the pulse source close, Relay P is energized, closing a circuit to the coil of the Type 40 Rotary Stepping Switch and connecting the Function Required and Status Sensor equipment to the wipers of the rotary stepping switch. If the Status Sensor detects a substandard item, positive DC is forwarded through bank level B, contact one, to the coil of Relay A. Relay A will operate and lock. When the contacts of the pulse source open and Relay P restores, the coil of the Type 40 Rotary Stepping Switch is released and the wipers advance to the second position. A subsequent pulse resets the Status Sensor and forwards to Relay B an indication of the condition of the new item of merchandise in the inspection station.

This same cycle takes place for one more step with Relay C acting as the memory device.

Following this position, the rotary stepping switch is now on bank contact 4. Operation of Relay P permits the Status Sensor to mark substandard merchandise on Relay D. At the same time, the positive DC lock on the contacts of Relay A can be forwarded through bank level C to the Function Required section of the equipment, causing the substandard item to be modified or rejected. After the substandard item is modifed or ejected from the conveyor, the contacts controlling this function are closed through level B contacts to the resistor supply for Relay A. Relay A is shorted out and releases.

Because the modification or rejection taking place at the Function Required equipment might take longer than the duration of the pulse cycle that drives Relay P, a circuit is provided to a second winding on Relay P. This locks Relay P from the wiper of level C on the rotary stepping switch until the register relay has been released. Thus, the complete Function Required can take place, regardless of the duration of the pulse source cycle.

Figure 71 illustrated the use of an AE Type 59 Codel relay having four discrete coils and contact combinations. This is ideal when a



four-bit shift register is desired. However, as many relays can be used as are necessary to cover the distance between "inspection" and "function". Simply make sure that the bank contacts of the rotary stepping switch are arranged in multiples of sufficient width to accommodate the required number of relays. They do not necessarily have to be Type 59 relays.

"Carry" to second register (Figure 72)

In the use of rotary stepping switches for digital applications, it is often more economical to use several rotary stepping switches, one after the other, to accumulate digital information.

In order for successive ranks of switches to be stepped at the proper time, various "carry" techniques can be employed. Some of these cause the "carry" to take place simultaneously across all switches. On the other hand, it is sometimes desirable that the "carry" occur shortly after the completion of a particular impulse.

The circuit in Figure 72 depicts means for counting impulses on register switch number 1. Upon receipt of the tenth impulse, the circuit is arranged to cause register number 2 to count "one" and register number 1 to indicate "zero". This same technique can be extended from register 2 to register 3 in the same manner.

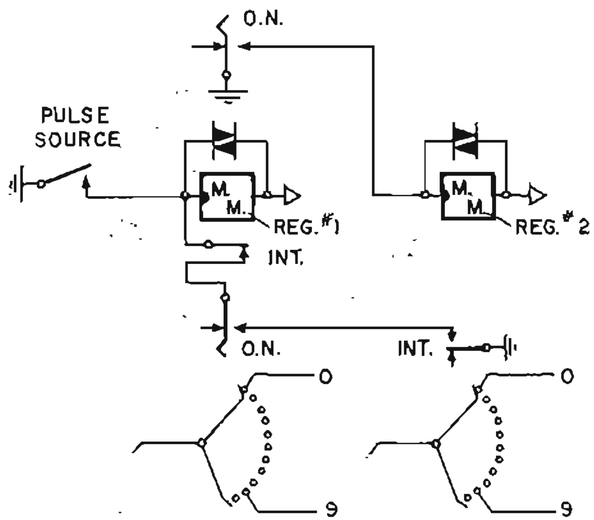


Fig. 72. "Carry" to second register.

Register number 1 will operate and release its armature following the upstream pulse source. Both registers are shown on the zero connection. This is step number 1 for both switches (one step beyond the normal or tenth position). When nine impulses have been received by register number 1, the switch will be on bank point nine. The tenth pulse causes the wipers to move to bank position ten, and simultaneously causes the off-normal springs to transfer.

The upper set of off-normal springs for register 1 will energize the coil of register switch number 2. When register 2 has actuated its armature, its interrupter springs provide a circuit through the lower off-normal springs of register 1, and through the interrupter springs on register 1 to the coil. Register 1 then steps self-interruptedly, causing the off-normal springs to transfer back to the condition shown in the drawing. Register 2 releases and its wipers advance one step.

Having received ten impulses, register 2 is on bank contact two and register 1 on bank contact one. To carry this to a third register, register 2, upon moving from the ninth to the tenth bank contact, closes a similar circuit to register number 3 and, similarly, steps self-interruptedly to bank contact one, etc.

XV. SOLID-STATE CONTROL OF STEPPING RATE OF THE ROTARY STEPPING SWITCH

The advantages of easy and convenient user control of the stepping speeds of rotary stepping switches are obvious. Figures 31 and 32 show circuits that can be used to vary stepping rate. However, once the components have been selected and applied to those circuits, only slight further variation in stepping speed is possible. Various other circuits have been published, using a rheostat type of speed control. One of the most versatile units of this type is a "Solid-State Driver", manufactured by Electro-Seal Corporation, Des Plaines, Illinois. This unit demonstrates one of the best examples of a "happy marriage" between solid-state devices and the rotary stepping switch.

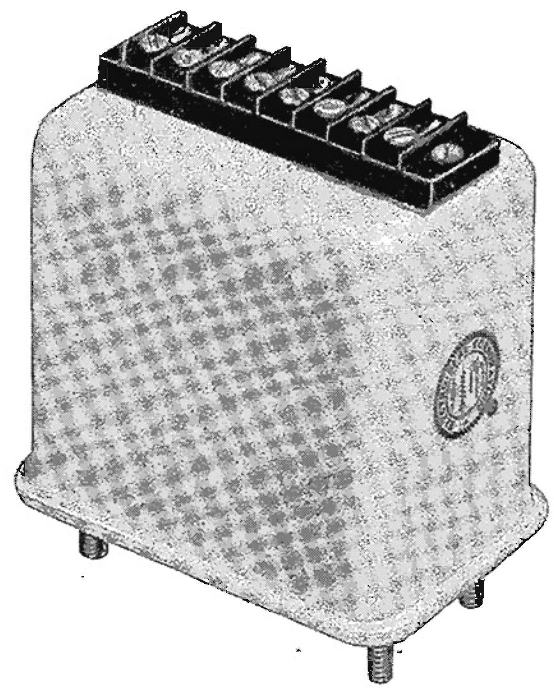


Fig. 73. Typical solid-state Driver. Courtesy of the Electro-Seal Corporation. See Figure 78 for dimensional drawing. Furnished as shown with either a dust protective enclosure or hermetically sealed.

TCI Library: www.telephonecollectors.info

Electro-Seal claims that the rheostat settings of their "Solid-State Driver" will provide adjustable control of stepping switch speeds ranging from 1 step in 5 seconds to 15 steps per second, at nominal input. By using one set of contacts on the rotary stepping switch to select external timing resistors, the stepping can be programmed to "dwell" on any particular position for a predetermined time. This permits a program of sequential control that gives the desired dwell on any or all individual contacts.

Exclusive of the control rheostat, the 100-130 VAC unit provides the source of DC required by the stepping switch and its control circuitry, in addition to providing stepping switch interrupter contact protection. Similar units are available for operation on 24, 48, and 110 VDC.

The manufacturer claims less than ±5% drift in stepping speed for nominal input voltage at 25°C ambient. Rates of controlled pulsing as high as 30 per second, and as low as 1 per minute, are claimed for specially designed Drivers.

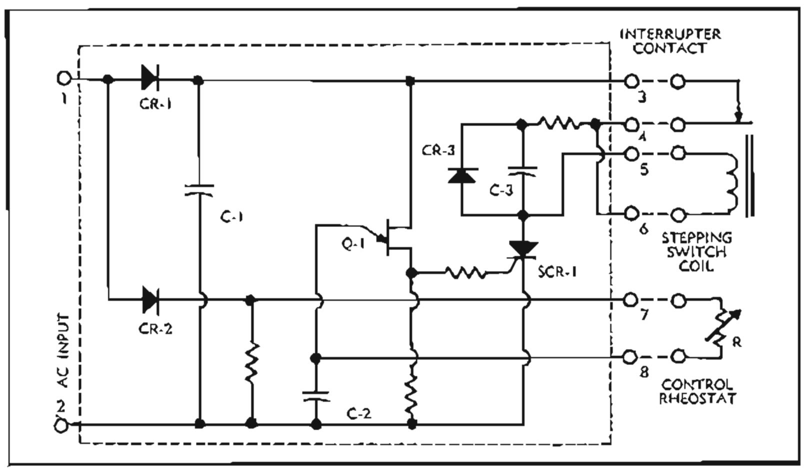


Fig. 74. Basic schematic of the solid-state Driver.

All illustrations used in this chapter are through the courtesy of Electro-Seal Corporation. The following discussions are taken, with permission, from their Bulletin 6311.

Theory of Operation

The basic schematic is shown in Figure 74. When 115 VAC is applied to input terminals 1 and 2, capacitor C-1 is charged through diode CR-1. This voltage appears across the stepping switch coil and controlled rectifier SCR-1 through the normally-closed interrupter contacts of the stepping switch. Since SCR-1 is off at this time, the coil is not energized.

Simultaneously, capacitor C-2 charges through diode CR-2 at a rate determined by the (external) control rheostat. When C-2 charges to the emitter peak point voltage of Unijunction transistor Q-1, the latter conducts, gating on SCR-1. Current flows through the switch coil, cocking the switch. This opens the interrupter contact, disconnecting the coil and turning off SCR-1. The switch then steps and the action repeats. The control rheostat changes the time required to charge C-2 to the firing point of Q-1 and changes the stepping rate accordingly. CR-3 and C-3 provide arc suppression for the interrupter contacts.

Stepping rate as a function of the rheostat resistance is given in Figure 75.

TCI Library: www.telephonecollectors.info

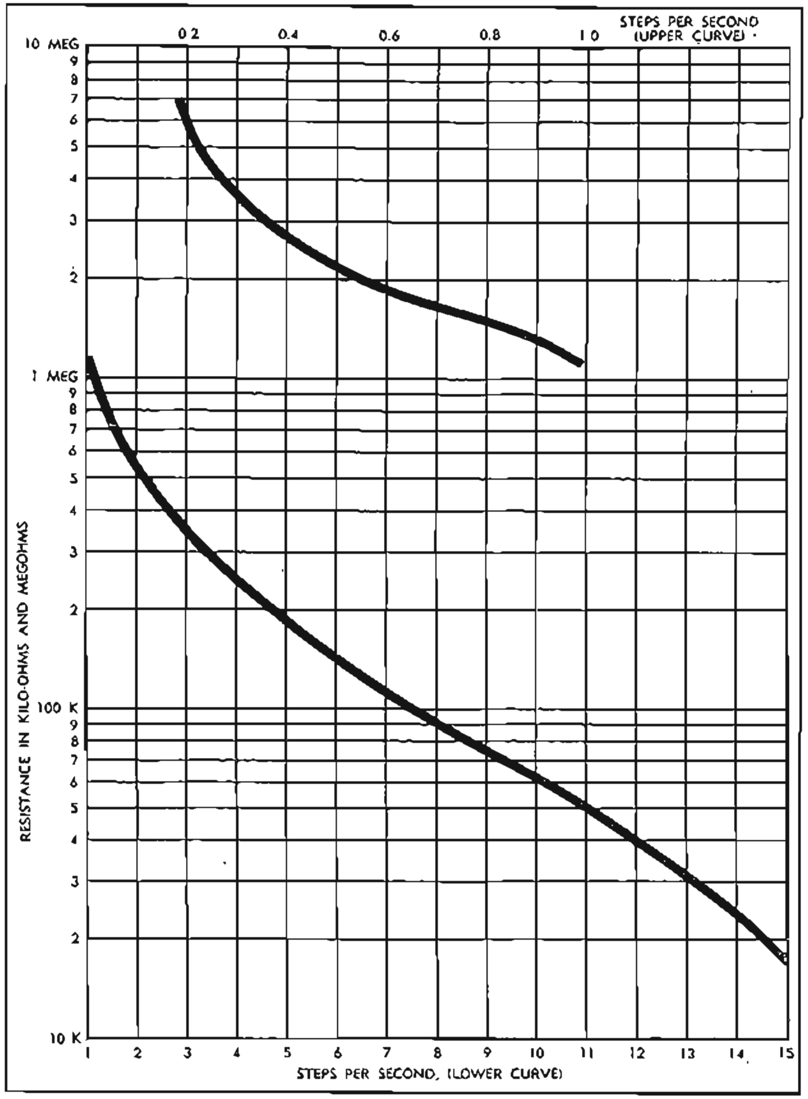


Fig. 75. Stepping rate as a function of rheostat resistance.

Application

The Stepping Switch Driver is designed to operate stepping devices at fixed rates sufficiently slow to permit the bank or wafer contacts to pull in and/or drop out relays and contactors. This may require 10 to 100 milliseconds of contact dwell before stepping to the next position.

The Driver offers the further advantage of programming such a device to stay in each position a different length of time. This circuit is illustrated in Figure 76. Terminal 7 is connected to the wiper of an extra bank of contacts on the stepping switch. As the switch steps, the value of resistance that will give the desired delay for the next step is automatically connected to terminal 8. Delay of as long as 5 seconds between steps may be obtained. An approximation of the value of resistance required for a given delay may be obtained from the curves in Figure 75. Resistors under 26,000 ohms must be capable of carrying 2 watts. Higher values may be rated 1 watt up to 0.25 megohms and ½ watt for delay time greater than ¼ second (4 steps per second).

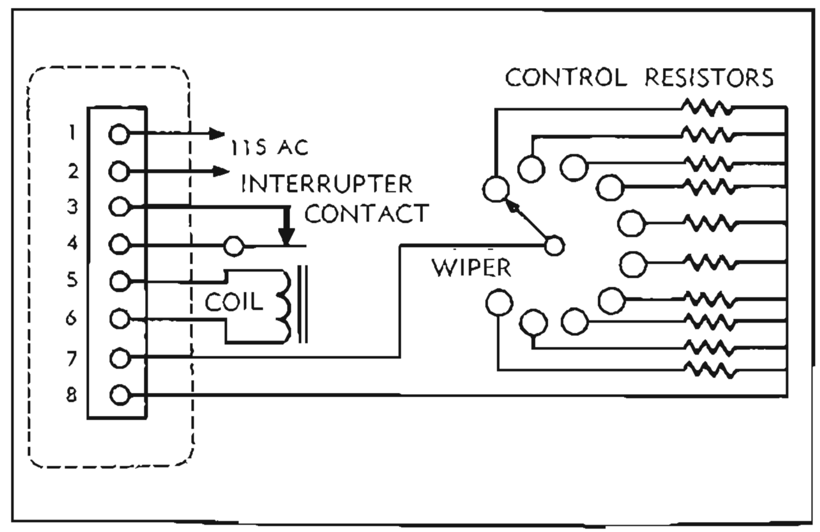


Fig. 76. Circuit illustrating use of solid-state Driver to program a rotary stepping switch.

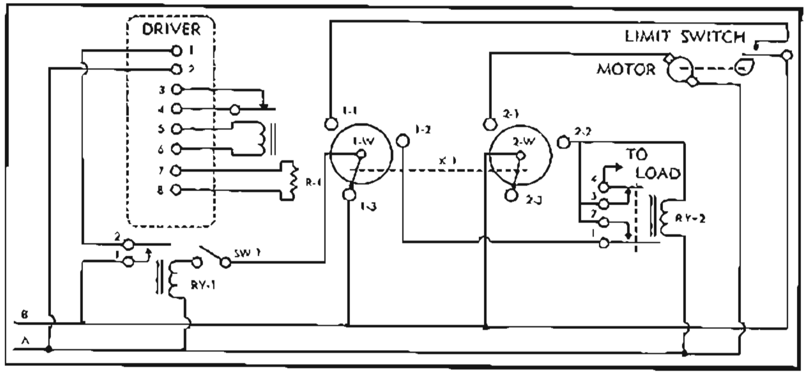


Fig. 77. Control circuit for an automatic process.

A closed loop control system used in an automated process control circuit is presented in Figure 77. Connection details for the stepping switch are the same as in Figure 76, except for the control resistor, R-1, which will probably be a value in excess of 60,000 ohms to allow approximately 100 milliseconds contact time per step. For simplicity only two sets of bank contacts with non-bridging wipers are shown.

Position 1-3 (and 2-3) is the starting point of the cycle. When SW-1 is closed, the control relay RY-1 is energized and pulls in, closing the input circuit to the Driver. This steps K-1 (clockwise) and opens the coil circuit of RY-1, which drops out, opening the input to the Driver. Assume that in this position it is desired to operate a motor (through a suitable relay not illustrated in the diagram) to move a piece into position; completion of the motor's function will be signaled by closure of a limit switch. This energizes RY-1 which steps K-1 to position 1-2, dropping out RY-1 and again opening the input to the Driver.

In this position it is desired to perform a function on the piece for one minute. This is done through time delay relay RY-2, whose normally closed contacts (3 and 4) furnish power to a load circuit. After one minute delay, RY-2 pulls in, disconnecting the load circuit and closing RY-1, which pulls in and causes the Driver to step K-1 back to the starting position. If SW-1 remains closed, the cycle will repeat indefinitely.

This system depends upon the stepping rate of K-1 being less than the drop out time of RY-1. If RY-1 is a conventional AC relay, it may have a release time as slow as 50 milliseconds. Hence, control resistor R-1 must delay the Driver circuit more than 50 milliseconds (100 milliseconds is recommended to allow an ample safety factor). See Figure 75 for resistance values which yield time delays of 10 steps per second or less.

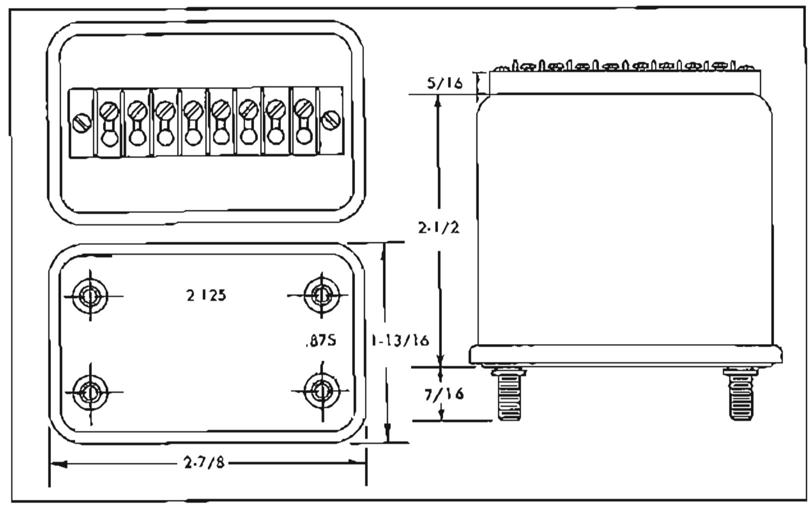
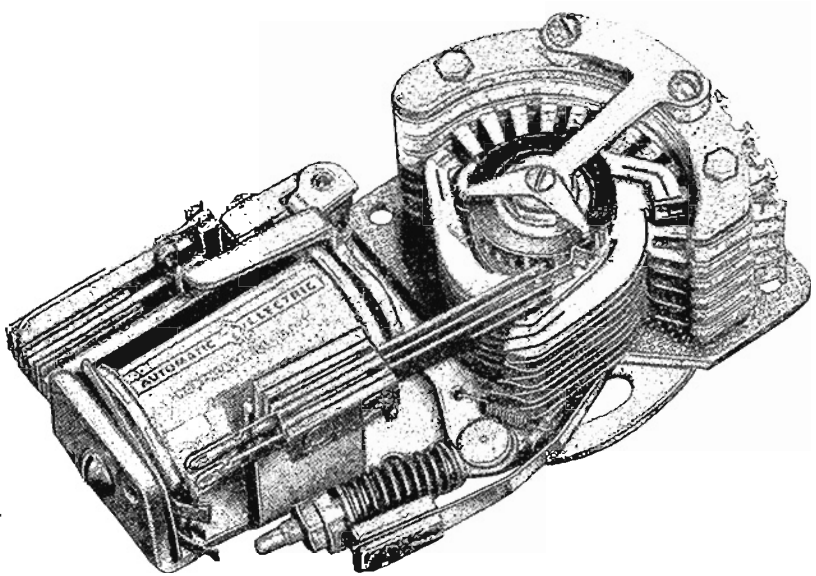


Fig. 78. Dimensional drawing of a typical solid-state Driver.

TCI Library: www.telephonecollectors.info



The Type 40 Rotary Stepping Switch.

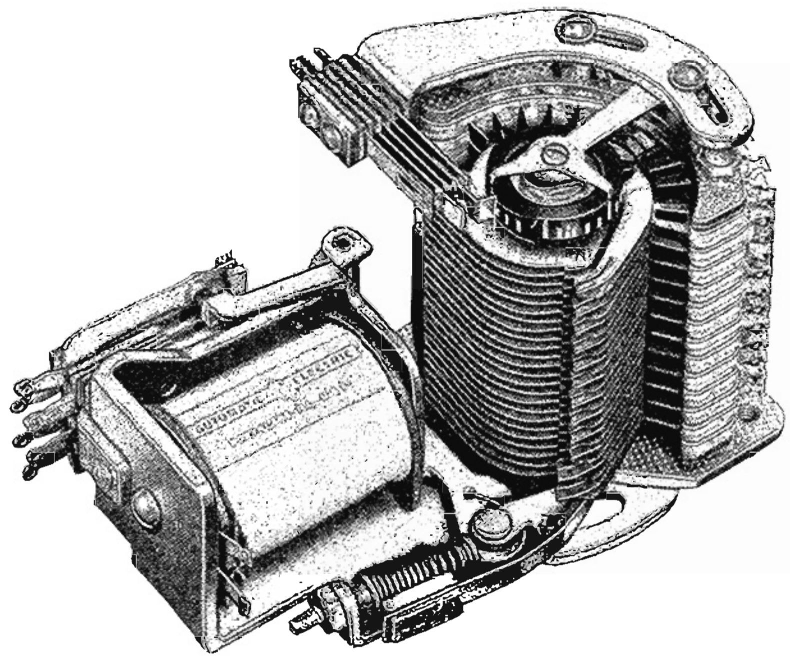
This is a new compact decimal switch with a capacity of 6 bank levels, but with only 10 points per level, so that no extra steps must be taken, nor off-normal points skipped when counting decimally. (See page 151 for a larger-capacity version.)

INDEX OF ILLUSTRATIONS AND CIRCUITS

TCI Library: www.telephonecollectors.info

TCI Library: www.telephonecollectors.info

TCI Library: www.telephonecollectors.info



The Type 80 Rotary Stepping Switch.

This is a larger-capacity version of the Type 40 (shown on page 144), with the same "compact" and "decimal" features. It has a capacity of six to twelve 10-point levels.

BIBLIOGRAPHY

"Characteristics of Strowger Switches", K. W. Graybill.

"The Type 45 Rotary Stepping Switch", R. L. Huffman.

"The Type 44 Rotary Stepping Switch", D. N. McDonald.
(The above articles originally appeared in various issues of *The Automatic Electric Technical Journal*. Reprinted as AE Circular 1641-D, *Characteristics of Strowger Switches*, April, 1960.)

Rotary Stepping Switches, Automatic Electric, Technical Bulletin #961-473, Issue 8, 1961.

"Telephone-Type Relays", a series of four articles, V. E. James, *Product Engineering*. (Reprinted as part of AE Circular 1866-A, *Automatic Electric Relay Characteristics*, November, 1961.)

"Stepping Switches for Use in Industry", E.S. Di Julio, *The Automatic Electric Technical Journal*, January, 1963.

"The Rotary Stepping Switch in Extremes of Environment", E. C. Coulombe. Paper given at the Third Annual Relay Symposium, Oklahoma State University, 1955.

"Stepping Switches", D. A. Dibbern and V. E. James, *Machine Design*, Electrical Controls Book, June 14, 1962.

"Stepping Switches", V. E. James, *Product Engineering*, Nov. 11, 1957.

"Versatile Machine Control", E. W. Smith, *Automation*, March, 1958.

"Selective Feeding Control", *Automation*, March, 1958.

"Reliable Stepping Switch Circuit Design", J. D. Ashby, *Electromechanical Design*, February, 1963.

Basic Circuits, AE Circular 1927, First Edition: October, 1959.

Relay Magic, AE Circular 1012, First Edition: March, 1962.

Relay Highlights, Automatic Electric:

No. 6. "Telephone-Type Stepping Switches for Data Reduction", October, 1958.

No. 7. "Telephone Relays and Switches in Circuit Analyzers", First Edition: March, 1955.

No. 10. "Precious Metal Contacting for Industrial Stepping Switch Applications", November, 1958.

No. 13. "Automatic Circuit Analyzer", December, 1958.

No. 15. "AE Relays and Switches Automate Gear Hobber", February, 1958.

No. 16. "Traffic Control Programming", November, 1958.

No. 18. "Eggs — Handled With Care", March, 1960.

No. 19. "Automatic Tactical Test Equipment", May, 1960.

No. 20. "Traffic Detection and Computing Devices", April, 1961.

No. 22. "1 Machine Plus 1 Typist Equal Automatic Billing", October, 1962.

No. 23. "Tool Control Features AE Components", July, 1963.

No. 24. "Gertsch Complex Ratio Bridge", July, 1963.

No. 25. "Automatic Tape Control, Inc. Automates Radio Station", November, 1963.

The Electro-Seal Stepping Switch Driver, Model 625-E12-2, Electro-Seal Corporation, Bulletin 6311, September, 1963.

TCI Library: www.telephonecollectors.info