July 17, 1923.

1,462,251

F. M. SLOUGH

SEQUENCE SWITCH

Filed May 8, 1918

2 Sheets-Sheet 1

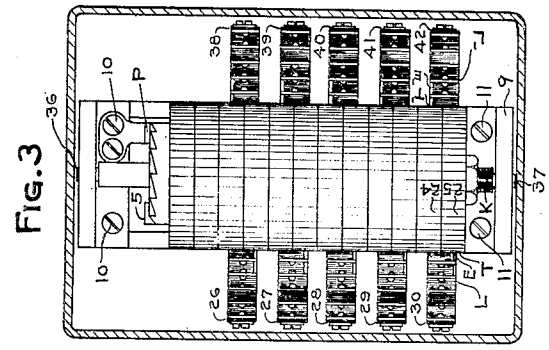


FIG. 3

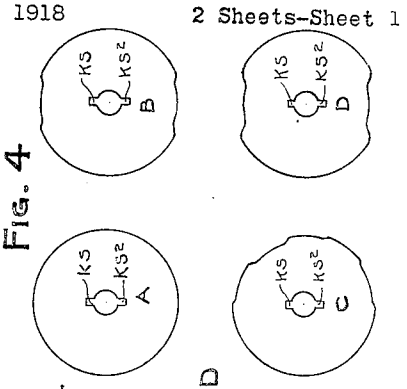


FIG. 4

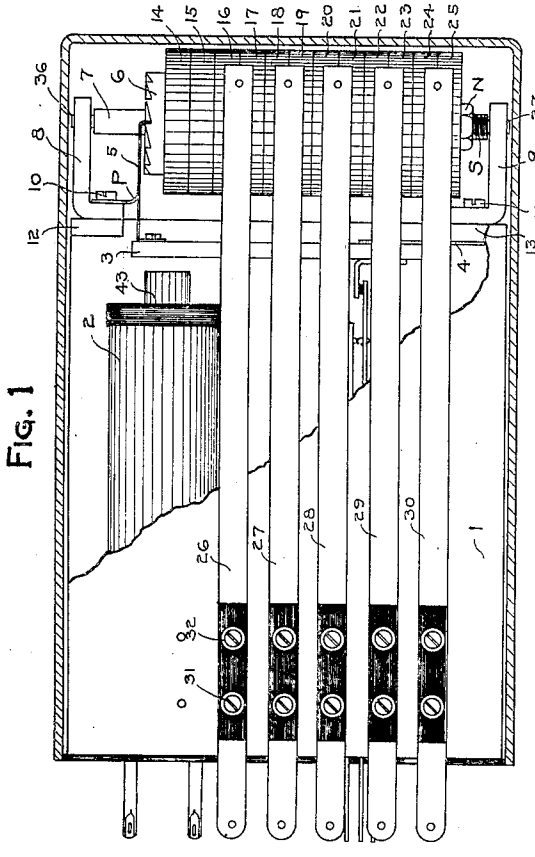


FIG. 1

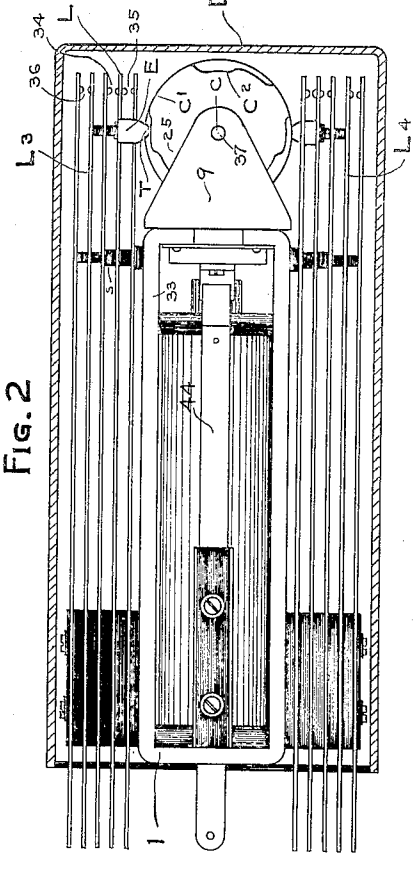


FIG. 2

INVENTOR

Franklin M. Slough

July 17, 1923. 1,462,251

F. M. SLOUGH

SEQUENCE SWITCH

Filed May 8, 1918 2 Sheets-Sheet 2

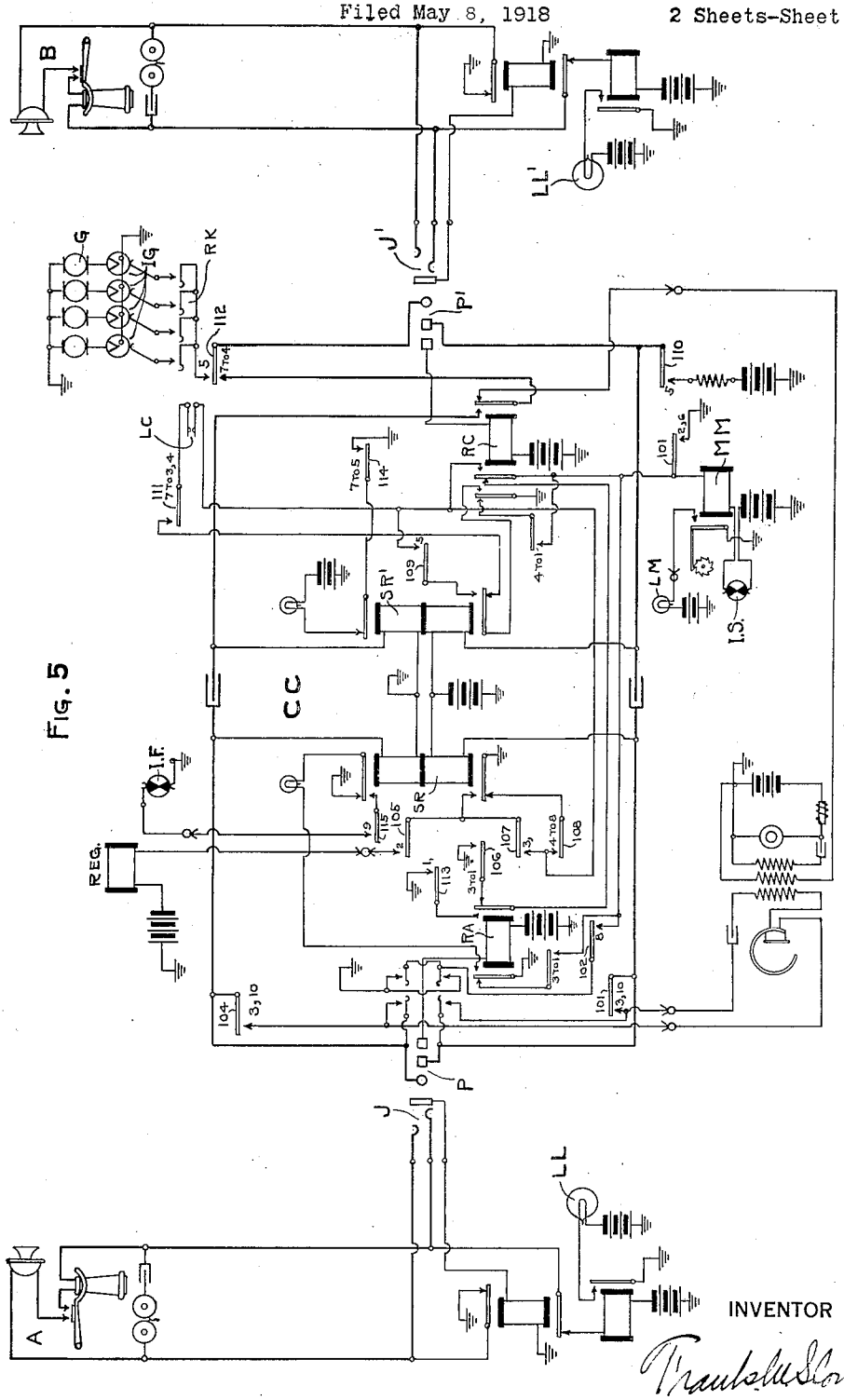


Fig. 5

INVENTOR

Frank M. Slough

Patented July 17, 1923. 1,462,251

UNITED STATES PATENT OFFICE.

FRANK M. SLOUGH, OF ROCHESTER, NEW YORK, ASSIGNOR TO THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

SEQUENCE SWITCH.

Application filed May 8, 1918. Serial No. 233,202.

To all whom it may concern:

Be it known that I, FRANK M. SLOUGH, a citizen of the United States, and residing at Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Sequence Switches, of which the following is a full, clear, concise, and exact description.

This invention relates to circuit controlling apparatus commonly called sequence-switches, whereby means are provided for automatically controlling a series of circuit changes either of the same device or of different devices in a definite and predetermined sequence.

One of the objects of this invention is the provision of a device of this character which is light in weight, cheap of construction, certain in action, and occupying a minimum of space, and by which a large number of circuit changes may be effected with a minimum amount of apparatus.

Another object is the provision of a device of this character, having contacts which are readily accessible for examination and so arranged that they will require little or no adjustment or attention after once being set up.

Another object is to include in a unitary structure, propelling means for the contact operating members.

Another object is to provide a structure wherein the contact operating members may be removed and replaced by other contact operating members which may be adapted to operate the contacts in a different sequence than that of the removed contact operating member.

Further objects and advantages will appear as the description of the device progresses.

A device of this character may be used for controlling electrical apparatus of many kinds, but is particularly designed for use in telephone systems wherein certain circuit changes must be automatically effected in a definite way.

Briefly described, the device consists of a frame in which a shaft is rotatably mounted. A plurality of spring contact operating members, preferably of insulating material, are non-rotatably mounted on this shaft. These members are disk shaped and provided with suitable projections at the circumference to engage motor or lever springs of contact spring sets to move the same in one direction or the other, depending upon the position and contour of these disk members. The disk members may have any desired contour as will provide any desired operation of the spring contact levers.

A motor mechanism is provided for rotating the shaft through its successive step by step movements, this mechanism comprising a motor magnet longitudinally placed at the rear of the rotating shaft and between the contact spring sets. This motor magnet by virtue of a pawl and ratchet connection with the rotatable shaft, may by controlling the movement of its armature propel the rotatable shaft a step at a time whereby the switch shaft may be rotated. In practice the rotation of the switch shaft at certain points of its revolution will be interrupted, the pawl and ratchet propelling means being also adapted to properly condition the shaft at such times.

For a more complete description of this invention reference is now made to the accompanying drawings in which Fig. 1 shows a plan view of a switch structure embodying my invention.

Figure 2 shows a side elevation of th said switch structure.

Figure 3 shows an end view, and Fig. 4 shows four spring contact operating disks lettered A, B, C, and D respectively, having differing peripheral contours for the purposes above set forth and as will be later explained.

Figure 5 illustrates circuits of a telephone line interconnecting cord circuit involving the use of the apparatus illustrated in the before mentioned figures.

Referring now to the drawings in which the same reference characters are applied to like parts in the various figures, 1 represents a U-shaped frame member enclosing an electro-magnet 2 and an armature 3 for the said electromagnet, the armature being pivoted on a spring 4 so that when attracted by electromagnet 2 by means of a spring pawl member 5 engaging a toothed crown wheel member 6, a shaft 7 to which the toothed crown wheel is secured may be rotated a step at a time, each step comprising a fractional part of a revolution of the shaft. The shaft 7 is supported in the supporting members 8 and 9 being journaled therein, the members 8 and 9 being remov-

ably secured by machine screws 10 and 11 to the extensions 12 and 13 of the U shaped frame 1. Likewise carried on the shaft 7 and non-rotatably secured with reference thereto, are a plurality of contact spring operating disks 14 to 25 inclusive, there being in the embodiment illustrated twelve contact spring operating disks shown mounted on the shaft 7, and adapted to be rotated with the said shaft step by step a fractional revolution at a time whenever the armature 3 is attracted by the electromagnet 2.

A plurality of contact spring sets 26, 27, 28, 29 and 30, are shown as being secured by machine screws as 31 and 32 for the contact spring set 26 to the upper arm 33 of the U-shaped member 1, these spring sets comprising a plurality of contact springs. Each spring set includes a lever spring L which is provided with a depending extension E, the tip T of which rests upon the periphery of one of the contact spring operating disks as 25 which disk, made preferably of insulating material, has its peripheral cam face divided into sections or switch operating positions, the cam face at each section by its distance from the center C of the disk regulating the position of the lever spring L of the set of springs 30, and therefore determines the operative condition of the sets of switch contacts contained in the set of switch springs 30.

As shown in the drawing the cam face upon which the tip T of the lever spring extension E rests, causes the lever spring L to take such a position that its contacts 34 and 35 are opened, likewise so that the controlled contacts 36 are also opened. This is the mid-way position of the lever spring. It can easily be seen that when that portion of the cam face marked C′ is next advanced to the lever spring, it will be lifted to close the contacts 34 and 36. Likewise when that portion of the cam face marked C^2 attains the lever spring operating position, that the lever spring L which has a downward spring tension, will fall to such a position that the contacts 35, only, will be closed, the rest of the contacts of the spring set being opened. The other spring sets 29, 28, 27 and 26 before mentioned, are suitably controlled by the disks 23, 21, 19 and 17 respectively, during the different operative positions resulting from the step by step rotation of the shaft 7. The other disk members before mentioned may or may not have the same peripheral contour as the cam member 25. On the contrary they may have widely different contours one from the other and from the disk 25, depending upon the exigencies in the circuits in which the device of my invention is to be used.

Other contours which may be used in practice are shown at A, B, C and D of Fig. 4, illustrating different disk members which might be used in practice, and it is understood that many other forms of disk members having cam faces arranged for different operating results on a lever spring, such as L may be used. These disk members are removably secured to the shaft 7, by means of the clamping nut N, which is secured to the shaft by the threaded end thereof S. By removing the machine screws 10 and 11, the supporting members 8 and 9 can be detached from the U shaped frame 1, and may be removed from the structure, the removed portion including the shaft 7 and the disks and toothed wheel attached thereto. The members 8 and 9 may then be removed from the shaft, which merely has its ends 36 and 37 journaled therein, and the disk member may then be removed by removing the clamping nut N and pulling the disk members off the shaft to which they are keyed by a key extending into a key slot K on the shaft and key slots KS in the disks. Thus it is easy to withdraw the unit comprising the shaft and disks from the structure and replace disks as may be called for by circuit exigencies.

Now on the opposite and lower side of the structure from the spring sets 26 to 30 inclusive, are like spring sets 38, 39, 40, 41 and 42. It will be noted that the spring sets on either side are in the same vertical plane, the set 42 being placed just below the set 30. But by virtue of the tip T of the depending extension E of the lever spring L for the spring set 30 being positioned to contact with the associated cam wheel 25 at a point in line with one side of the spring set, it is obvious that the same kind of a spring set when reversed in position and placed on the other side of the structure, such as in the case of the spring set 42, that this depending extension shown at E′ for the spring set 42, will depend from the other side of the lever spring L′, and the tip T thereof will rest on the cam wheel 24 instead of the cam wheel 25. Therefore, although the two spring sets 30 and 42 are in the same vertical plane and the cam wheels 24 and 25 are in different vertical planes, though located side by side, that the cam wheel 25 in its rotation will operate the spring set 30, and the cam wheel 24 will operate the spring set 42. A rectangular dust-proof cover D is provided for the switch.

Referring to Fig. 4, it will be seen that I preferably have an additional key slot for the disks as, the key slot KS, this permitting a cam wheel to be placed on the shaft in either of two ways; each way producing for a point on its periphery a difference in position of 180°, so that if the cam wheel is adapted to control an upper set of springs in a given way, that by plac-

ing it on the shaft in the other way, it may be made to control a lower set of springs in the same way as it before controlled the upper set of springs. In this way I am enabled to reduce the number of kinds of disks required to something like half the number that would be otherwise required, and by a particular arrangement of depending members E and E', I am enabled to use the same spring sets on either side of the structure and enable spring sets on different sides of the structure to be controlled by different cam wheels. I am thus enabled to nearly double the number of spring sets to be controlled in a given mounting space.

The frame 1 supporting the spring sets, cam wheels, etc., as described, is preferably made of iron so that it may furnish a return for the magnetic circuit in which is included the core 43 of the electromagnet 2 and the armature 3 therefor. A retaining spring pawl P, is adapted to retain the rotated shaft carrying the cam wheels in any position to which it is propelled, the shaping of the teeth on the crown toothed wheel and the pressure of the spring pawl P centering the retained position of the cam wheels. The spring sets have insulating studs *s*, to properly support the springs of the spring sets in their normal positions. There is an additional set of springs 44 containing "make" and "break" contacts, but which may be made up containing any other preferred contact set combinations, the contacts of these springs being operated to make or break a circuit as required whenever the armature 3 is moved under the control of the electromagnet 2.

Referring now to Fig. 5 which shows a telephone system operating under the control of apparatus, such as is illustrated in Figs. 1 to 4 inclusive, at A I show a calling subscriber's telephone set, and at B a called subscriber's telephone set having the usual substation apparatus. At the central office the calling telephone line terminates in a multiple jack J having an associated line lamp LL, and the called line likewise terminates in a multiple jack J' having an associated line lamp LL'. At CC, I show a cord circuit terminating in an answering plug P and a call plug P', adapted to cooperate respectively with the calling line jack and the called line jack. Calling and called subscriber controlled relays SR and SR' are provided for the cord circuit for purposes which will be later described. Answering and called plug and jack switch controlled relays are shown at RA and RC. At 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, and 116 inclusive, are shown lever springs such as the lever spring L or L' of Figs. 1, 2 and 3, or as the subsidiary lever springs L^3 or L^4 by the movement of which spring contacts may be opened or closed. The sequence switch associated with the cord circuit of Fig. 5 has its motormagnet, such as indicated at 2 in Fig. 1 shown at MM in Fig. 5, and a circuit interrupter IS is shown in the circuit of the winding of the motormagnet to control the step by step action of the sequence switch. Numbers are placed adjacent the switch contacts operated by the sequence switch lever spring above mentioned, to denote the sequence switch positions in which these contacts are closed in the operation of the cord circuit in completing a connection and in the supervision of the same by the operator. A supervisory lamp flashing interrupter is shown at IG. At IF is shown a plurality of ringing generator interrupters of any of the well known type, and at G are shown a plurality of ringing generators for party line ringing, it being assumed that the cord circuit may be called upon to selectively signal stations on a party line, and the apparatus and the circuits is so arranged as to provide for such operation. At RK are shown a plurality of ringing keys to include the said ringing generator in circuit with the called line, which ringing keys have locking contacts, the depressal of only one ringing key serving to release the previously locked contacts. At LC I show local contacts common to the plurality of ringing keys RK and adapted to be closed only for as long as the operator manually depresses one of the said ringing keys. At LM is located a lamp connected to the local switch magnet contacts to indicate the operation thereof.

Sequence switch nomenclature.

For the sake of clearness, the sequence switch springs 101 to 115 inclusive are not shown in actual relative positions, but are arranged through the circuit as is most convenient for the sake of clearness. The operating cams are also omitted, the positions of the rotary elements by which the contacts are closed at times being indicated by the numbers placed adjacent to switch contacts. For example, lever spring 101 is closed in positions 2 and 6. Also lever spring 116 closes the upper set of contacts in all positions from position 7 to position 4 and throughout the intermediate positions, being opened again in positions 4 to 6 inclusive. The lower set of lever springs 116 are only closed in position 5. Lever spring 101 is for the purpose of closing a local circuit for the motormagnet MM between certain positions independent of the rest of the cord circuit apparatus, and the numbers 2 and 6 indicate that when the device leaves the first position it will be carried through to the third position without a stop, due to the continuous closure of the local circuit of its

motormagnet, this closure being continued through position 2 by the closure of contacts of the lever spring 101. The same thing again occurs for position 6.

The sequence switch being described as above and the circuits involved containing well known features and well known functions, a brief description will suffice for the operation of the circuits. This is for convenience given in such a form that the sequence switch position functions will be clearly shown.

Sequence switch positions with respect to cord circuit operations.

Position 1. Normal position.—Inserting of answering plug into calling line jack moves sequence switch to position 2.

Position 2. Registration position.—Operator's position register is energized while the sequence switch is in position 2. Local controlling switch spring remains closed during position 2, to cause the register to be immediately stepped to position 3.

Position 3. Automatic listening position.—Operator's circuit connected to talking conductors of cord circuit. Ringing condition establishing circuit is opened in this position. Operator tests line of called subscriber. If operator withdraws answering plug from calling subscriber's line jack, sequence switch is advanced to position 1 through intermediate positions. Otherwise operator inserts called plug in called like jack. Switch advances to position 4.

Position 4. Operator's set disconnected.—Ringing condition establishing circuit is closed. If operator withdraws called plug from jack, sequence switch will advance through intermediate positions to position 3. If when called plug is inserted as above related calling subscriber retires, sequence switch will advance to position 8. Operator rings by depressing proper ringing key, closing local ringing key contacts in ringing condition establishing circuit. This steps sequence switch to position 5.

Position 5. Automatic ringing position.—Response of called party will advance sequence switch to position 6, retiring the ringing function. Retiring by calling subscriber will advance sequence switch to position 8, retiring ringing function in and after position 6.

Position 6. No operative function in this position.—Sequence switch by its local switch contact passes from this position to position 7.

Position 7. Subscriber's conversational circuit establishing position.—Subscribers converse until they retire. Called subscriber retiring lights associated supervisory lamp. Calling subscriber retiring advances sequence switch to position 8.

Position 8. Calling subscriber's retiring position.—Calling subscriber's supervisory lamp lighted. Upon making a recall sequence switch advances to position 9.

Position 9. Automatic recall position.—Calling subscriber's supervisory lamp flashes. Operator responds by throwing recall key which extinguishes flashing lamp, and which advances sequence switch to position 10. If subscriber retires before operator throws recall key, the supervisory lamp will in position 9 resume steady light.

Position 10. Operator converses with recalling subscriber to learn cause of recall.—If a new connection is desired, withdrawal of called plug from first called line jack will advance sequence switch from position 10 to position 1, or normal position. If recalling subscriber desires another call to be sent over the same line as before, operator again depresses proper ringing key which advances sequence switch to position 5 or "ringing position."

Notes.

In any position from position 3 and through the intermediate positions, the switch will return to position 1 whenever the answering plug is withdrawn from calling subscriber's telephone line jack. In any position from position 4 and through the intermediate positions, the switch will advance to position 1 when the called plug is withdrawn from the jack. Whenever the ringing key is depressed, assuming that the calling subscriber is on the line and the called subscriber not on the line with the plug in the jack, the ringing function may be performed by depressing the ringing key, the sequence switch immediately advancing from whatever its position is to the ringing position 5.

It will be apparent that numerous and extensive departures may be made from the embodiments of my invention illustrated and described herein without departing from the spirit thereof.

What I claim is:

1. In a sequence switch, a shaft, a plurality of cam discs in substantially contiguous relation mounted thereon, a set of contact springs mounted adjacent each pair of the said cam disks and adapted to be operated thereby, means to rotate the said shaft to operate the said contact springs, a mechanical link member through which motion is communicated from a rotated cam disk to a motor spring of its associated set of springs, and means to mount a pair of the said sets of springs in the same vertical plane, the said communicating link having its cam contact making portion located on one side of the vertical plane extending through the centers of the said pair of contact spring sets, whereby one of the said contact spring sets will be operated by one of the said cam

disks, and the other of the said contact sets will be operated by an adjoining cam.

2. In a sequence switch, a shaft, a plurality of rotatable discs mounted on said shaft, said discs being provided with cam surfaces, a pair of sets of contact springs, the sets being oppositely mounted in a plane at right angles to the said shaft and being in operative relation to a pair of disks, means to rotate the said shaft, means to cause one of the said discs to operate the springs of one set, and means to cause another of the said discs to operate the springs of the other set when the said shaft is rotated.

3. In a sequence switch, a rotatable shaft therefor, a plurality of separate cams adapted to be removably secured to the said shaft in substantially contiguous relation, means to secure the said cams to the said shaft in either of two positions, one of the said positions producing an angular advance of 180° over the other position, a pair of sets of contact springs, means to rotate the said shaft, means to cause one of the said cams to operate the springs of one set, and means to cause another of the said cams to operate the springs of the other set, the said sets of springs being oppositely mounted in the switch frame in the same vertical plane, and means to secure the said springs to the said frame.

4. In a sequence switch, a plurality of separate disk cams removably keyed to a rotatable shaft, a plurality of sets of contact springs having cam engaging portions on the one side of the said cams, and a plurality of sets of contact springs having cam engaging portions on the other side of the said cams, alternate cams being adapted in their motion to operate the springs located on the same side of the said cams.

5. In a sequence switch, a rotatable cam shaft, a plurality of separate cams secured thereto, means to rotate the said shaft, and means to cause alternate cams in their motion to operate contact springs located on the same side of the said shaft, the other cams operating contact springs on the opposite side of the said shaft.

6. In a sequence switch, the combination with a U shaped frame member, an electromagnet located between the arms of the U shaped member and having its core parallel thereto, an armature for the said electromagnet flexibly secured to the said frame, the said armature, the said frame and the said core constituting the metallic portions of the magnetic circuit for the said electromagnet, sets of contact springs mounted on the outside of the arms of the U shaped member and arranged side by side in two groups, one group for each arm, the ends of the said springs extending beyond the said arm and beyond the said armature, a rotatable shaft removably secured to the said frame, and contact spring operating cams secured to the said shaft, pawl and ratchet means for the said armature and the said shaft to cause the said armature to rotate the said shaft a predetermined amount at each energization of the electromagnet to produce different spring operating positions for the different sections of the periphery of the said cams.

7. In a sequence switch, a frame therefor, a rotatable cam shaft journaled in the said frame, electromagnetically operated pawl and ratchet means to rotatably advance in steps the said shaft, a plurality of contact springs in two groups mounted on the said frame, one of the said groups being mounted on one side of the said shaft and the other group being mounted on the other side of the said shaft, a plurality of separate cam discs secured to the said shaft and adapted to rotate therewith, and means to cause alternate cam discs in their motion to operate contact springs located on the same side of the said shaft, the remaining cam discs operating contact springs on the opposite side of the said shaft.

8. In a sequence switch, a rotatable cam shaft, a plurality of independent cam disks secured thereto, means to rotate the said shaft, contact springs adapted to cooperate with the said cam discs, one of the said contact springs of each set being a motor spring, and an angularly depending member for each of the said motor springs having its cam engaging surface in a plane to the one side of the plane in which is placed the contacts of the associated set of springs, the associated cam disc being fixed to the said shaft to center with the engaged depending member.

9. In a sequence switch, a rotatable cam shaft, a plurality of independent cam members of insulating material secured thereto, means to rotate the said shaft, means to cause alternate cam members in the rotation of the said cam shaft to operate contact springs having their cam engaging portions located on the same side of the said shaft, the other cam members operating contact springs having cam engaging portions on the opposite side of the said shaft.

10. In a sequence switch, a rotatable cam shaft, a plurality of independent cams secured thereto, an electromagnet and armature therefor, pawl and ratchet means associated therewith whereby the said electromagnet may cause the rotation of the said shaft, means to cause alternate cams in their motion to operate contact springs located on the same side of the said shaft, and means to cause the remaining cams in their motion to operate contact springs located on the other side of the said shaft.

11. In a sequence switch, a rotatable cam shaft, a U shaped frame therefor into which the cam shaft is journaled, a switch propel-

ling mechanism located between the arms of the said frame to rotate the said cam shaft, a plurality of cams mounted on the said cam shaft, two groups of spring sets, each group mounted on one of the said frame arms, the said cams being located between the ends of the said springs, and adapted to operate the said springs, and means associated with each set of springs to communicate motion from an associated cam to a motor spring of the set, the said last-named means being placed so as to cause successive cams in their motion to operate contact springs of alternate groups.

12. In a sequence switch, a rotatable shaft therefor, a plurality of switch operating members therefor placed in substantially contiguous relation, means to cause all of the said members to be simultaneously stepped from one operative position and to stop at another operative position, the said switch operating members thus having a number of operative positions, and means to adjust some of the switch operating members on the rotatable shaft so that a given operative position of some of the members may be located 180° in advance of some operating position of another member.

In witness whereof, I hereunto subscribe my name this 6th day of May, A. D. 1918.

FRANK M. SLOUGH.