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ROTARY STEPPING SWITCHES

Original Filed March 15, 1946

2 Sheets-Sheet 1

FIG. 3

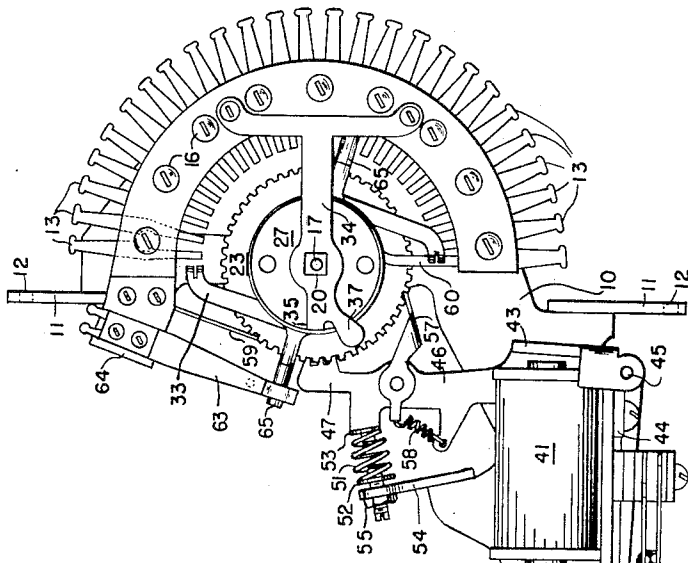


FIG. 1

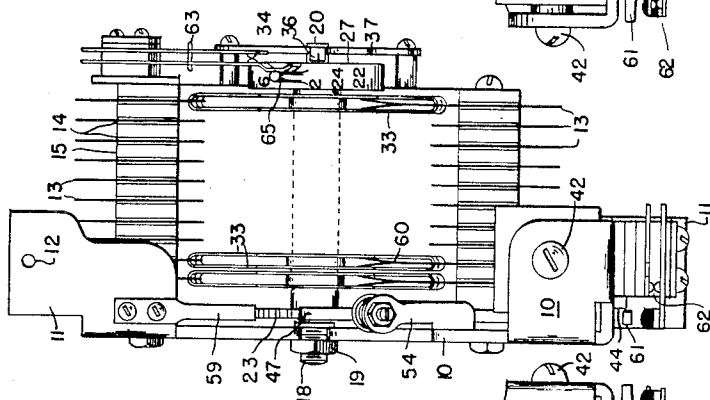


FIG. 2

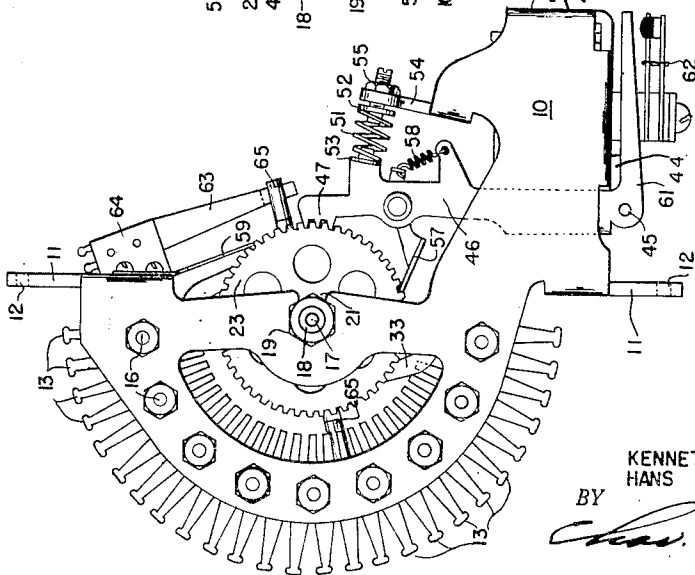
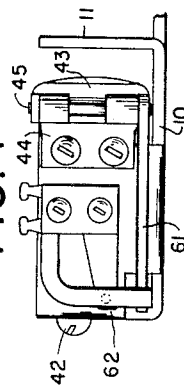


FIG. 4



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ROTARY STEPPING SWITCHES

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Original application March 15, 1946, Serial No. 654,556.
Divided and this application September 29, 1951, Serial No. 248,897

11 Claims. (Cl. 200--105)

The present invention relates to rotary switches of the step by step type and more particularly to such switches that are especially designed for use in automatic telephone systems. This application is a division of the pending application of Kenneth W. Graybill and Hans Sengebusch, Serial No. 654,556, filed March 15, 1946, now abandoned.

In conventional rotary switches of the type noted, the maximum stepping speed is about 55 steps per second employing a 100 ohm magnet coil and including four wipers in cooperating engagement with four rows or levels of contact sets in the associated contact bank. Modern switching practice in automatic telephone systems requires a greater speed of operation than that noted, without any reduction in the resistance of the magnet coil as it is desirable to preserve the self-protecting character thereof.

Accordingly, it is a general object of the present invention to provide a rotary switch of the character noted that is thoroughly reliable in operation at speeds considerably greater than heretofore possible.

Another object of the invention is to provide an improved rotary switch that is simple and economical to manufacture and that is of rugged construction so that it has a long operating life.

A further object of the invention is to provide a rotary switch of improved construction involving a simplified assembly of the elements thereof in order to effect a reduction in the amount of manual adjustment needed to bring the elements mentioned into their correct and final relationships.

In keeping with the last-mentioned object, it is one feature of the invention to mount all of the component parts of the switch upon a one-piece frame that is so constructed and arranged that the contact bank, the wipers, the electromagnet and the associated armature fall automatically in their correct and proper relationships incident to the assembly thereof upon the frame.

Another feature of the invention resides in the provision of a novel relationship between the drive spring and the electromagnet incorporated in the switch so that upon deenergization of the magnet coil of the electromagnet the drive spring possesses sufficient energy to deliver through an associated pawl and ratchet mechanism adequate energy to advance the switch wipers with respect to the associated bank contacts.

A further feature of the invention resides in the provision of an improved arrangement for positively stopping the ratchet drive at the conclusion of the forward stroke thereof and for positively centering the switch wipers in their advanced positions with respect to the contacts in the associated contact bank.

Further features of the invention pertain to the particular arrangement of the elements of the rotary switch, whereby the above-outlined and additional operating features thereof are attained.

In accordance with the present invention, a rotary switch of the step by step type has been provided that

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has a normal stepping speed in excess of 70 steps per second employing a 100 ohm magnet coil and including 10 wipers in cooperating engagement with 10 rows or levels of contact sets in the associated contact bank, whereby the speed of operation of the switch is substantially increased with respect to conventional rotary switches of this type, notwithstanding the greater load imposed upon the wiper set thereof.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which Figure 1 is a front elevational view of a rotary switch of the step by step type embodying the present invention; Figs. 2 and 3 are respective side elevational views of the opposite sides of the switch; Fig. 4 is a fragmentary bottom view of the switch; Fig. 5 is an enlarged side elevational view of the wiper assembly incorporated in the switch; Fig. 6 is an enlarged vertical sectional view, taken in the direction of the arrows along the line 6--6 in Fig. 5, of the wiper assembly; Fig. 6A is an enlarged fragmentary vertical sectional view, similar to Fig. 6, of a modified form of the wiper assembly; and Figs. 7, 7A and 7B are greatly enlarged fragmentary side elevational views of the pawl and ratchet mechanism incorporated in the switch, illustrating the successive positions thereof incident to forward stepping of the ratchet wheel.

Referring now to the drawings, there is illustrated a rotary switch of the step by step type embodying the features of the present invention that is especially designed for use in automatic telephone systems and that comprises a one-piece frame 10 upon which all of the parts of the switch are mounted, the frame 10 being formed from sheet steel or other suitable material by stamping or similar operations. A pair of oppositely disposed flanges 11 drilled and tapped as at 12 are provided on the frame 10 to facilitate mounting same on any desired support (not shown).

To the left of these flanges (Fig. 2) the frame is arcuate in shape and carries a bank of stationary contacts 13 which are arranged in levels or rows. There are twenty-five contacts in each level, and adjacent levels are separated from one another by insulators 14 and spacers 15. Ten levels are shown, but it will be understood that any desired number may be arranged as illustrated, these being secured to the frame by elongated screws 16 which pass through suitable holes in the frame and corresponding holes in the insulators 14 and spacers 15. As indicated by dotted lines in Fig. 3, the individual contacts are so shaped as to avoid being short-circuited by these screws. Each contact in the bank is provided at its outer end with a flared soldering lug and is disposed along a line radial to the axis of the wiper assembly now to be described.

This assembly includes a stationary spindle or shaft 17 one end of which is rigidly secured to the switch frame by means of a flanged stud 18 and a nut 19. As shown in Fig. 6, the stud is threaded on the inside to receive shaft 17 and is threaded on the outside to receive nut 19, the latter being tightened down after the stud has been inserted in a slot 21 in the switch frame and centered with respect to bank contacts 13. Mounted on the stationary spindle 17 is a rotatable hollow shaft or sleeve member 22 having integral therewith (or rigidly affixed thereto) a toothed ratchet wheel 23. A square nut 20 screwed on the end of spindle 17 prevents axial movement of the rotary member. Carried by sleeve 22 but insulated therefrom by a tubular insulator 24 are a series of disc-like wiper-carrying hubs 25, a spacer 26 and a drum 27; these are separated from one another by insulating washers 28 and are tightened down against the

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toothed wheel by means of a nut 29 so that they are rigid with respect to the rotary member.

A shallow internal recess 31 is provided in one face of each wiper-carrying hub so that the distance along the surface of the tubular insulator 24 from one hub to the adjacent hub is increased, with a corresponding increase in leakage resistance between the two. Each hub also has two oppositely disposed peripheral recesses 32 in which are seated a pair of double-ended wiper blades 33 shaped as illustrated in Fig. 5. These blades are rigidly secured to their associated hubs as by spot welding, and it will be noted that the recesses 32 in which they are seated are slightly deeper than the thickness of the blades themselves so that variations in the thickness of the blades due to ordinary manufacturing tolerances will not affect the spacing of the adjacent ones of the hubs. The importance of this mode of construction will be self-evident since the wipers must be spaced along the shaft with great exactness to coincide with the spacing of the different levels of bank contacts. In practice excellent results have been obtained by machining the hubs approximately to the desired thickness, welding the wiper blades thereto and then squeezing or compressing the hubs to exact thickness in a power press.

Returning again to the square nut 20 which prevents axial movement of the rotatable portion of the wiper assembly, this is locked in position on the stationary shaft 17 by means of a flat spring member 34 mounted on the contact bank as shown in Figs. 3 and 6. A suitable square opening near the free end of the spring member normally fits over the nut 20 preventing rotation thereof; this also serves to assist in keeping the spindle 17 properly centered with respect to the contacts 13. A bent-over lug 35 at the extreme end of the spring member is provided with an index line 36 which is adapted to register with numbered markings on the drum 27 in order to facilitate determining the rotary position occupied by the wipers at any time. Application of finger pressure to a second lug 37 on the spring member will deflect same as shown by dotted lines in Fig. 6, permitting the entire wiper assembly to be drawn away from the frame and the associated contact bank if nut 19 is loosened slightly.

An alternative mode of construction is shown in Fig. 6A. According to this, no nut is provided on the end of spindle 17 to prevent axial movement of the hollow shaft 22. Instead, spring 34' is provided with a bushing 20' which it is tensioned to press against the end of the hollow shaft to prevent endwise displacement thereof. As indicated, there is a circular recess in the bushing which is adapted to receive the end of spindle 17 and maintain same centered with respect to the bank contacts. The spring 34' may be deflected in the same way as that in Fig. 6, to free the end of the wiper assembly.

The wipers are moved in steps under control of an electromagnet 41 which is rigidly secured to the switch frame by means of a screw 42. As best seen in Fig. 3, a portion of the frame is bent over to form an L-shaped heel piece for this magnet. Associated with the magnet is pivotal magnetic armature 43 which is supported on the frame by means of a nonmagnetic yoke 44 and a bearing pin 45, said yoke being rigidly secured to the heel piece by means of two screws as shown. The armature is provided with an elongated lever arm 46 having at its extreme end a toothed portion 47 adapted to mesh with the teeth on wheel 23.

A heavy compression spring 51, the two ends of which are coiled about a pair of flanged centering studs 52 and 53, urges the lever arm toward wheel 23. The stud 52 is provided with a threaded shank which screws into a tapped hole in an arm 54 on the switch frame; this permits the stud to be advanced or retracted to change the spring tension on arm 46, it being understood that unintended changes in such spring tension are prevented by means of a lock-nut 55 which is tightened down after the tension has been properly adjusted.

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Pivotaly mounted on the lever arm 46 upon a pin 56 is a pawl 57 which is urged toward the toothed wheel 23 by a light coiled spring 58. When the electromagnet 41 is energized, it attracts armature 43 against the tension of spring 51, causing the pawl tip to move over one tooth of wheel 23 and lodge in the next notch, while at the same time the toothed portion 47 of the lever arm moves away from wheel 23. Due to the location of the pin 56, upon which the pawl 57 is mounted, well above the bearing pin 45, there is little pivoting of the pawl 57 about the pin 56 as the tip of the pawl 57 moves over the one tooth of the wheel 23, whereby little energy is wasted in straining the light spring 58 incident to this movement of the pawl 57. A flat spring 59 secured to the contact bank prevents retrograde movement of the wiper assembly during this operation. Upon the subsequent de-energization of the electromagnet, spring 51 quickly restores lever arm 46 to normal causing pawl 57 to advance the toothed wheel 23 and the associated wipers toward the next contact position in the contact bank. As the wheel 23 reaches its next position, the toothed portion or stop 47 of the lever arm 46 once more meshes with the teeth of the wheel 23 so that the wipers (which now are moving very rapidly) will not be carried beyond that position due to acquired momentum. Moreover, this arrangement eliminates the usual pawl stop that is normally incorporated in a rotary switch of this type and the consequent jamming or wedging of the pawl 57 under the pawl stop and the attendant loss of energy. Further, the cooperation between the toothed portion of stop 47 of the lever arm 46 and the teeth on the periphery of the wheel 23 positively insures final centering of the wiper blades 33 upon the selected contacts 13 in the associated levels of the contact bank.

In the arrangement, the spring 51 is located in the plane of the pawl 57 and slightly thereabove, so that when the electromagnet 41 is deenergized to release the armature 43 the spring 51 may deliver substantially all of its stored energy to the toothed wheel 23 through the pawl 57 with very little friction between the armature 43 and the bearing pin 45. Moreover, the electromagnet 41 attracts the armature 43 at a point disposed between the bearing pin 45 and the pin 56, upon which the pawl 57 is pivotaly mounted, so as further to reduce friction between the armature 43 and the bearing pin 56 as energy is being stored in the spring 51.

The manner in which the toothed portion of the lever arm re-engages the toothed wheel is illustrated quite clearly in Figs. 7, 7A, and 7B, which show these elements in three successive positions near the end of the lever arm's return stroke. A particular tooth on each element is identified by a dot in all three figures, making it easy to understand the relative movement of the two elements. In Fig. 7, the toothed portion 47 is just outside the path of the teeth on wheel 23 and both are moving in the direction indicated by their respective arrows. Fig. 7A shows how the two sets of teeth clear one another as they begin to mesh, while Fig. 7B illustrates their final position, wherein rotation of wheel 23 is halted by the toothed portion of the lever arm.

It will be realized that the pull of the electromagnet 41 upon its armature 43 is not constant throughout the movement of the armature toward the core of the electromagnet. Instead as the armature approaches the core, the attractive force between the two increases at an accelerated rate, the change in this force bearing a non-linear relationship to the space displacement of the armature from its starting position. To take the fullest advantage of the increased pull which thus occurs as the armature nears the end of its stroke, spring 51 is specially designed to have a non-linear force/displacement characteristic approximating the force/displacement characteristic of the electromagnet and its associated armature, whereby a greater amount of energy is stored in the spring for a given final displacement of the armature than otherwise would be the case. As a result, an in-

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creased amount of energy is available to drive the wipers upon deenergization of the electromagnet, and in practice this has been found to contribute very materially to the speed at which the wipers are stepped. This may be accomplished by forming the spring 51 of a general 5
frustro-conical configuration, the turns adjacent to the stud 53 being of a smaller diameter and consequently stiffer than the turns adjacent to the stud 52, as illustrated in Figs. 2 and 3. Thus this compound spring 51 is effective to store a greater amount of energy employ- 10
ing a 100 ohm electromagnet coil 41, without increasing the operating time of the armature 43, so that the wiper blades 33 are stepped more quickly incident to the release of the armature 43 than in conventional rotary switches of this type.

A pair of divergent brushes 60 is provided for each pair of wiper blades 33. These brushes 60 are mounted on the contact bank, as shown in Figs. 1 and 3, and make electrical contact with their associated wipers 33 in all positions thereof, engaging the same as shown in 20
Fig. 5. In the arrangement, the brushes 60 are disposed in the planes of the respective rows of contacts 13 and one step behind the first contact set 13 in the respective rows so that the wiper blades 33 pass over the brushes 60 and then the contacts 33 in the rows but do not engage simultaneously the brushes 60 and the 25th
contacts 13 in the rows as such would produce an undesirable non-uniform load or drag upon the toothed wheel 23 in this position of the wiper blades 33. Further the brushes 60 are arranged flat-wise and have a composite thickness that is the same as that of each contact 13 in order to insure a uniform load upon the wiper blades 33 at each step of the wheel 23. Of course it will be understood that in a given step of the wiper assembly when one of the wiper blades 33 disengages the 25th
contact 13 in one of the rows, the companion wiper blade 33 engages the brushes 60; and in the next step of the wiper assembly, the companion wiper blade 33 disengages the brushes 60 and engages the first contact 13 in the one row. This relationship is obtained by the arrangement of the angle between adjacent ones of the wiper blades 33 greater by one step of the shaft 22 than the angle of the arc of the bank assembly, as shown in Fig. 3.

More specifically, in the illustrated embodiment of the switch, the sleeve 22 carries a number of wiper blades (N) that are spaced apart by the same angle ($360^\circ/N$); and each row of contact sets 13 includes a brush pair 60 and a number (M) of individual contacts 13 that are arranged in an arc within the angle ($360^\circ/N$) ($M/M+1$) and individually spaced apart by the same angle ($360^\circ/N$) ($M/M+1$); wherein $N=2$, and $M=25$ in the illustrated embodiment; and the wheel 23 comprises a number of teeth $N(M+1)$.

The armature 43 is provided with a second lever arm 61 which operates a set of auxiliary contacts 62. In the drawings, this contact set is illustrated as a single pair of contacts which are separated upon the energization of the electromagnet, but it will be appreciated that any desired other set of contacts might be employed. A second auxiliary set of contacts 63 are mounted on the contact bank by means of a detachable mounting plate 64; these are operated by a pair of pins 65 rigidly affixed to the drum 27 at two diametrically opposite points thereon. Preferably, pins 65 are so located as to operate the associated contact set when the wipers occupy their home position, as shown in Fig. 3.

Having described the invention, what we believe to be new and desire to protect by Letters Patent is set forth in the following claims.

What is claimed is:

1. A rotary stepping switch comprising a frame, a shaft carried by said frame and mounted for rotary step-by-step movement in a given direction, a wiper assembly carried by said shaft and including a number of wipers arranged

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coplanar and disposed in equally angularly spaced-apart relation, an arcuate bank assembly carried by said frame and disposed about said shaft and including a brush member and a plurality of contact members arranged coplanar and engageable by said wipers and disposed in equally angularly spaced-apart relation, the angle between adjacent ones of said wipers being greater by the angle of one step of said shaft than the angle of the arc of said bank assembly so that one of said wipers is stepped out of said bank assembly disengaging the last member therein as another of said wipers is stepped into said bank assembly engaging the first member therein and the angle between adjacent ones of said members being equal to the angle of a step of said shaft so that one of said wipers 15
in said bank assembly is stepped to disengage one of said members and to engage the adjacent one of said members, whereby there is no simultaneous engagement of two of said members upon any step of said shaft in order to render substantially fixed the load upon said shaft at each step thereof, said brush member being electrically connected to said wiper assembly in each step of said shaft, a wheel carried by said shaft and provided with a number of teeth arranged in equally angularly spaced-apart relation corresponding to the steps of said shaft, a bearing pin carried by said frame and disposed remote from said wheel, a lever arm pivotally mounted adjacent to the inner end thereof upon said bearing pin and projecting toward said wheel, a stop carried by said lever arm adjacent to the outer end thereof, means including a spring disposed between said frame and said lever arm adjacent to the outer end thereof for biasing said lever arm toward said wheel to engage said stop and the teeth on said wheel, means including an electromagnet carried by said frame for moving said lever arm away from said wheel and then for releasing said lever arm, movement of said lever arm away from said wheel storing energy in said spring and disengaging said stop from the teeth on said wheel, said lever arm being returned back toward said wheel by said spring in response to the release of said lever arm, and means including a pawl carried by said lever arm and cooperating with the teeth on said wheel for driving said wheel one step in said given direction in response to return movement of said lever arm back toward said wheel, said stop re-engaging the teeth on said wheel at the conclusion of the step of said wheel in order to prevent override of said wheel beyond one step thereof in said given direction and to center one of said wipers in engagement with the selected one of said members.

2. The rotary stepping switch set forth in claim 1; wherein said wiper assembly includes N wipers, said angle between adjacent ones of said wipers is $360^\circ/N$, said bank assembly includes M contact members, said angle of the arc of said bank assembly is ($360^\circ/N$) ($M/M+1$), said angle between adjacent ones of said members is ($360^\circ/N$) ($M/M+1$), and the number of teeth on said wheel is $N(M+1)$.

3. In a rotary stepping switch including a frame, a shaft carried by said frame and mounted for rotary step by step movement in a given direction, a wiper carried by said shaft, and an arcuate contact bank carried by said frame and disposed about said shaft and provided with a plurality of individual contacts engageable by said wiper and disposed in angularly spaced-apart relation corresponding to the steps of said shaft; the combination comprising a wheel carried by said shaft and provided with a plurality of angularly spaced-apart teeth, a bearing pin carried by said frame and disposed remote from said wheel, a lever arm pivotally mounted adjacent to the inner end thereof upon said bearing pin and projecting toward said wheel, a stop carried by said lever arm adjacent to the outer end thereof, means including a compression spring disposed between said frame and said lever arm adjacent to the outer end thereof for biasing said lever arm toward said wheel to engage said stop and the teeth on said wheel, a pivot pin

carried by said lever arm adjacent to the outer end thereof, a pawl pivotally mounted adjacent to the inner end thereof upon said pivot pin and projecting toward said wheel, means biasing the outer end of said pawl into engagement with one of the teeth on said wheel, and means for moving said lever arm away from said wheel and then for releasing said lever arm, movement of said lever arm away from said wheel storing energy in said spring and disengaging said stop from the teeth on said wheel and causing said pawl to ride over the engaged tooth on said wheel, said lever arm being returned back toward said wheel by said spring in response to the release of said lever arm, return movement of said lever arm back toward said wheel causing said pawl to drive the engaged tooth on said wheel one step in said given direction and reengaging said stop and the teeth on said wheel, reengagement of said stop and the teeth on said wheel preventing over-ride of said wheel beyond one step thereof in said given direction and centering said wheel to insure accurate engagement between said wiper and the selected one of said contacts in said contact bank.

4. The rotary stepping switch combination set forth in claim 3, wherein said wheel and said lever arm and said spring and said pawl and said stop are disposed substantially in coplanar relationship normal to the axis of said shaft.

5. The rotary stepping switch combination set forth in claim 4, wherein said spring and said pawl are arranged in substantial alignment with each other.

6. The rotary stepping switch combination set forth in claim 3, wherein said stop is disposed substantially at the extreme outer end of said lever arm.

7. The rotary stepping switch combination set forth in claim 3, wherein said stop includes a plurality of teeth arranged to engage a plurality of the teeth on said wheel when said lever arm is moved toward said wheel.

8. In a rotary stepping switch including a frame, a shaft carried by said frame and mounted for rotary step by step movement in a given direction, a wiper carried by said shaft, and an arcuate contact bank carried by said frame and disposed about said shaft and provided with a plurality of individual contacts engageable by said wiper and disposed in angularly spaced-apart relation corresponding to the steps of said shaft; the combination comprising a wheel carried by said shaft and provided with a plurality of angularly spaced-apart teeth, a bearing pin carried by said frame and disposed remote from said wheel, a lever arm pivotally mounted adjacent to the inner end thereof upon said bearing pin and projecting toward said wheel, a stop carried by said lever arm adjacent to the outer end thereof, means including a compression spring disposed between said frame and said lever arm adjacent to the outer end thereof for biasing said lever arm toward said wheel to engage said stop and the teeth on said wheel, a pivot pin carried by said lever arm adjacent to the outer end thereof, a pawl pivotally mounted adjacent to the inner end thereof upon said pivot pin and projecting toward said wheel, means biasing the outer end of said pawl into engagement with one of the teeth on said wheel, a magnetic armature carried by said lever arm intermediate said pins, and an electromagnet carried by said frame and operatively associated with said armature and provided with a magnet coil, said armature being attracted in response to energization of said magnet coil to move said lever arm away from said wheel and being released in response to deenergization of said magnet coil to release said lever arm, movement of said lever arm away from said wheel storing energy in said spring and disengaging said stop from the teeth on said wheel and causing said pawl to ride over the engaged tooth on said wheel, said lever arm being returned back toward said wheel by said spring in response to the release of said

lever arm, return movement of said lever arm back toward said wheel causing said pawl to drive the engaged tooth on said wheel one step in said given direction and reengaging said stop and the teeth on said wheel, reengagement of said stop and the teeth on said wheel preventing override of said wheel beyond one step thereof in said given direction and centering said wheel to insure accurate engagement between said wiper and the selected one of said contacts in said contact bank.

9. The rotary stepping switch combination set forth in claim 8, wherein said contact bank is positioned in first and second adjacent quadrants disposed rearwardly of said shaft and said electromagnet is positioned in an adjacent third quadrant disposed forwardly of said shaft, and the axis of said magnet coil is disposed substantially normal to a plane passing through the opposite ends of said contact bank.

10. In a rotary stepping switch including a frame, a shaft carried by said frame and mounted for rotary step by step movement in a given direction, a wiper carried by said shaft, and an arcuate contact bank carried by said frame and disposed about said shaft and provided with a plurality of individual contacts engageable by said wiper and disposed in angularly spaced-apart relation corresponding to the steps of said shaft; the combination comprising a wheel carried by said shaft and provided with a plurality of angularly spaced-apart teeth, a pivotally mounted lever arm carried by said frame and movable toward and away from said wheel, a compound compression spring disposed between said frame and said lever arm and biasing said lever arm toward said wheel, a magnetic armature carried by said lever arm, an electromagnet carried by said frame and operatively associated with said armature and provided with a magnet coil, said armature being attracted toward said electromagnet in response to energization of said magnet coil to move said lever arm away from said wheel and being released in response to deenergization of said magnet coil to release said lever arm, said electromagnet having a nonuniform force of attraction-armature displacement characteristic so that an increasing force of attraction is exerted upon said armature as it is moved toward said electromagnet and as said lever arm is moved away from said wheel, movement of said lever arm away from said wheel storing energy in said compound spring, said compound spring having a nonuniform stress-strain characteristic so that increasing stress must be applied thereto as it is strained in order to obtain successive unit strains thereof, said characteristic of said electromagnet substantially matching said characteristic of said compound spring so that the acceleration of said armature in its movement toward said electromagnet is substantially constant over the stroke thereof, said lever arm being returned back toward said wheel by said compound spring in response to the release of said lever arm, and means responsive to the return movement of said lever arm back toward said wheel and cooperating with the teeth on said wheel for rotating said wheel one step in said given direction so as to drive said wiper from engagement with one of said contacts in said contact bank into engagement with the adjacent one of said contacts in said contact bank.

11. The rotary stepping switch combination set forth in claim 10, wherein said compound compression spring includes a substantially frusto-conical section, whereby the convolutions thereof of decreasing diameter possess an increasing compression strain modulus.

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