United States Patent

Davies et al.

[15] **3,648,204**

[45] **Mar. 7, 1972**

[54] **SWITCH HAVING MAGNETIC LATCHING MEANS**

[72] Inventors: **Norman Davies**, Trafford; **Robert D. Binz**, West View, both of Pa.

[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

[22] Filed: **Jan. 29, 1971**

[21] Appl. No.: **110,871**

[52] **U.S. Cl.** **335/170**, 335/191

[51] **Int. Cl.** **H01h 9/20**

[58] **Field of Search** ....335/191, 170, 114, 174, 253, 335/254, 136, 125, 77, 150; 200/11, 11 A

[56] **References Cited**

UNITED STATES PATENTS

2,549,441	4/1951	Favre	335/191
2,556,054	6/1951	Allan et al.	335/191
3,585,544	6/1971	Cleaveland et al.	335/170

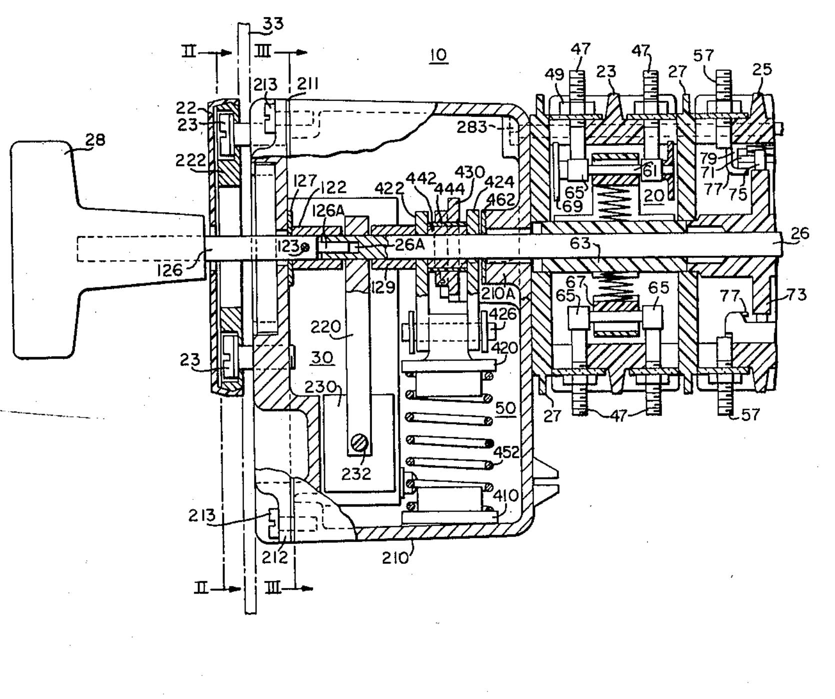
Primary Examiner—Harold Broome

Attorney—A. T. Stratton and Clement L. McHale

[57] **ABSTRACT**

A rotary switch having separable stationary and movable contacts and a shaft which is rotatable to actuate the movable contacts between two operating positions. A spring biasing means is operatively connected to the shaft to bias the shaft toward a first position corresponding to one of the operating positions of the associated contacts. A lever is mounted on the shaft and carries a magnetic armature which is disposed to engage a stationary magnetic structure having a permanent magnet member in a second position of the shaft which corresponds to the other operating position of the associated contacts to magnetically latch the switch contacts in the latter operating position. An electromagnetic coil is disposed on the stationary magnetic structure and is energizable to release the magnetic armature and the shaft which then actuates the associated contacts under the influence of the spring biasing means to the first-mentioned operating position of said contacts.

6 Claims, 7 Drawing Figures



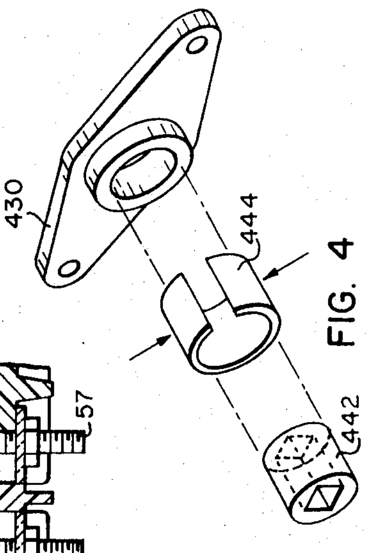


FIG. 4

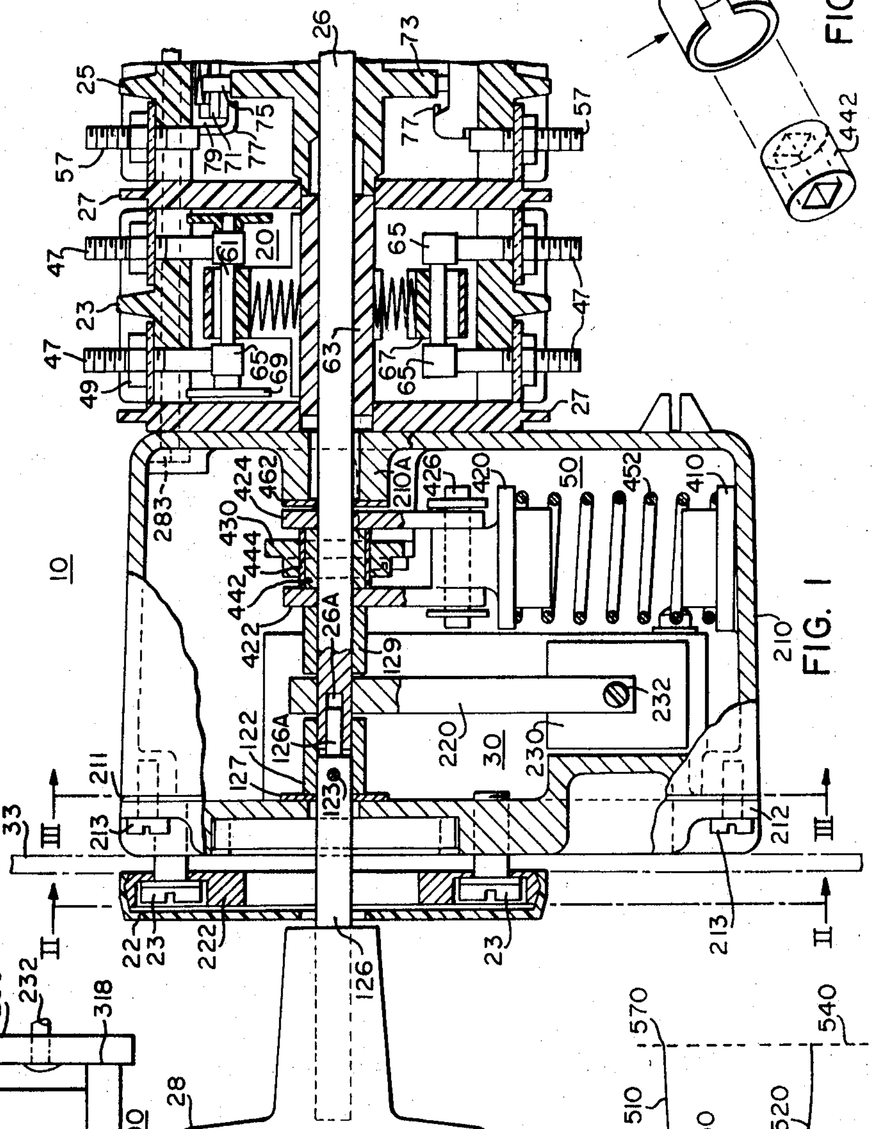


FIG. 1

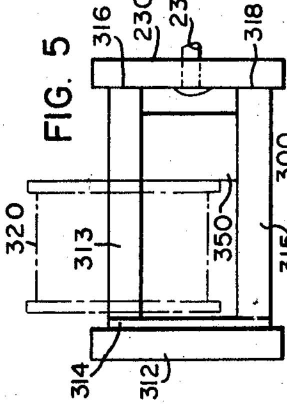


FIG. 5

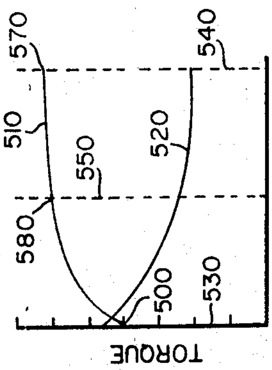


FIG. 6

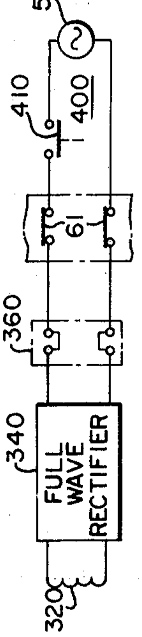


FIG. 7

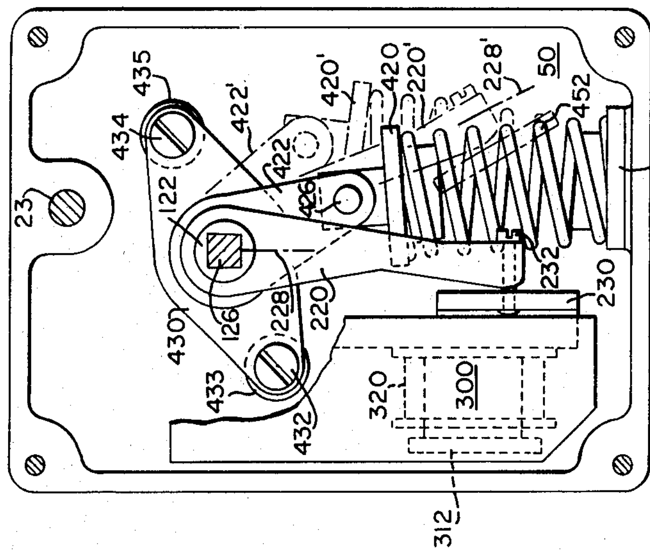


FIG. 3

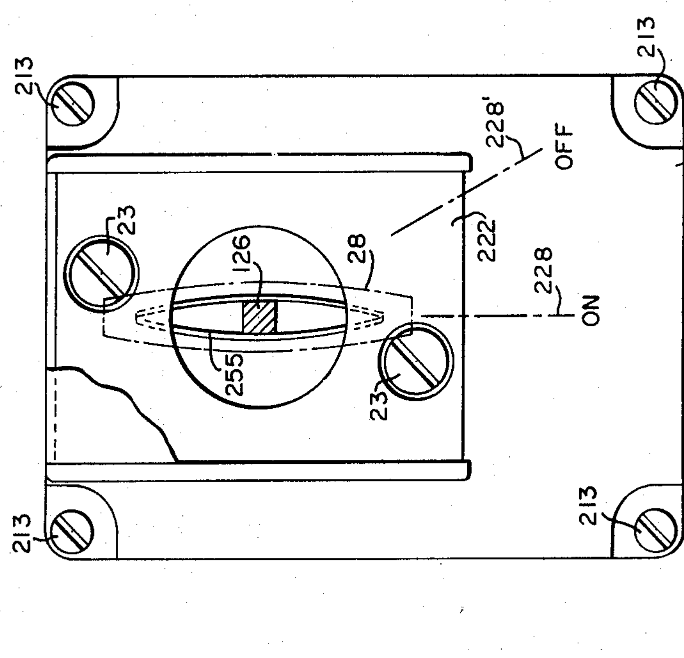


FIG. 2

SWITCH HAVING MAGNETIC LATCHING MEANS

BACKGROUND OF THE INVENTION

This invention relates to rotary switches and more particularly to means for remotely operating such switches.

In the application of rotary switches of the type disclosed in U.S. Pat. Nos. 3,206,564, 3,229,051 and 3,229,052, which are all assigned to the same assignee as the present application, it is sometimes necessary to provide for the operation of such switches from a location which is remote from the switches. One means which has been employed for this purpose in the past is to mechanically latch the switch in one operating position and to provide an electrical solenoid which is energizable to release the mechanical latch. Another means employed for this purpose which offers certain advantages over known mechanical latching means magnetically latches the shaft of the switch in one operating position by the use of magnetic flux from a permanent magnet and provides an electromagnetic coil or means which is energizable to release the shaft of the switch which is then actuated between operating positions by a torsion-spring biasing means. A means of the latter type is disclosed in copending application Ser. No. 862,427 filed Sept. 30, 1969 now U.S. Pat. No. 3,585,544 by C. M. Cleaveland and W. L. McKeithan, Jr. which is assigned to the same assignee as the present application. In the latter construction, the magnetic latching forces which must be provided by the magnetic latching means are determined primarily by the spring biasing forces which must be overcome when the shaft of the switch is in the magnetically latched operating condition. It has been found in the latter construction that the number of stages or sets of separable contacts in a particular switch which can be reliably operated by the spring biasing means is limited or determined by the available torque provided by the spring biasing means when the shaft of the switch rotates to an operating position away from the magnetically latched operating position.

It is therefore desirable to provide an improved switch construction of the type described in which the torque available to operate an increased number of switch stages is provided while limiting the biasing torque or forces which must be opposed or overcome by the associated magnetic latching means in the magnetically latched operating condition of the overall switch.

SUMMARY OF THE INVENTION

In accordance with the invention, a switch comprises separable stationary and movable contacts whose operation between two operating positions is actuated by the rotation of a shaft between first and second angular positions which correspond to the two positions of said contacts. A biasing means is provided to bias the shaft toward the second angular position of the shaft.

In order to magnetically and releasably latch the shaft in the first angular position of the shaft, a first lever arm having a magnetic armature disposed thereon is mounted on the shaft for rotation therewith. A stationary magnetic structure is disposed adjacent to the shaft and includes a permanent magnet member. When the shaft is manually actuated to the first angular position by suitable means, such as an associated handle, the armature on the first lever arm engages the stationary magnetic structure and the magnetic flux on the permanent member passes through the armature to magnetically latch or hold the shaft in the first angular position against the influence or torque exerted on the shaft by the associated biasing means.

The biasing means includes a second lever arm which is mounted on the shaft for rotation therewith and a biasing spring which may be of the compression type and which is operatively connected or disposed between the second lever arm and a relatively stationary support member or means. The second lever arm and the associated biasing spring together comprise a toggle means which is actuable between a first operating position corresponding to the first angular position of the shaft and a second operating position corresponding to the second angular position of the shaft with both operating positions of the toggle means being located on the same side of a line extending between the ends of the toggle means. The second lever arm and the biasing spring are disposed to apply a torque to the associated shaft in the second angular position of the shaft which is relatively greater than the torque applied to the shaft in the first angular position of the shaft.

In order to release the armature and the shaft when the shaft is magnetically latched in the first angular position, an electromagnetic means, such as an energizable winding or coil, is disposed on the stationary magnetic structure to provide a magnetic flux which opposes the magnetic flux from the permanent magnet member which passes through the armature thereby reducing the holding or latching torque or force exerted by the stationary magnetic structure on the shaft. When the armature and the shaft are released, the shaft is actuated to its second angular position by the associated biasing means.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be had to the preferred embodiment exemplary of the invention shown in the accompanying drawings in which:

FIG. 1 is a view, partly in side elevation and partly in section, of a rotary switch structure embodying the invention;

FIG. 2 is a view in section, taken along the line II—II of FIG. 1;

FIG. 3 is a view in section, taken along the line III—III of FIG. 1;

FIG. 4 is an enlarged detail view, illustrating the assembly of certain parts which form part of the rotary switch shown in FIG. 1;

FIG. 5 is an enlarged diagrammatic view of a magnetic structure which forms part of the switch structure shown in FIG. 1;

FIG. 6 is a graphical representation illustrating the operation of the rotary switch shown in FIG. 1; and

FIG. 7 is a schematic diagram illustrating the electrical connections of certain portions of the rotary switch shown in FIG. 1 in a particular application.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and FIG. 1 in particular, the switch structure **10** shown therein comprises a dial plate assembly **222**, a housing **210** for a magnetic latching means **30** and a spring return assembly or mechanism **50**, a first stage stator housing **23**, a second stage stator housing **25** and the spacing members **27** which are disposed at the opposite ends of the stator housings **23** and **25** and which may be disposed between successive stator housings where a plurality of stator housings are provided as disclosed in greater detail in U.S. Pat. No. 3,206,564 and the other patents previously mentioned for a switch structure of the same general type as the switch structure **10** shown in FIG. **1**. The switch structure **10** includes a first or main operating shaft **26** which extends axially through most of said switch structure and which is rotatably disposed in bearings (not shown) which may be provided at one end of said switch structure and at a location near the other end of said switch structure. The switch structure **10** also includes a second shaft **126** which projects axially to the left of the dial plate assembly **222**, as viewed in FIG. **1**, and which extends axially into the housing **210** with the second shaft **126** being coupled to the first shaft **26** by a coupling means which includes the bushing **122** for rotation with the first shaft **26** during certain operating conditions, as will be described hereinafter. A handle **28** is removably attached or secured to the left end of the second shaft **126** by suitable means such as a screw (not shown) and an end cover (not shown) may be removably attached at the other end of the switch structure **10** opposite the handle **28**. A rotor assembly **20** and a cam **73** may be carried or mounted on the first shaft **26** and where provided are rotatable with the shaft **26**.

The switch structure shown in FIG. 1 may be mounted on a switchboard panel 33 or other supporting structure by means of the screws or bolts 23 which extend through openings provided in the dial plate assembly 222 and the panel 33 into threaded openings provided in the cover 212 which is disposed at the front of the housing 210 and which is disposed on the opposite side of the panel 33 from the dial plate assembly 222. The heads of the screws 23 are covered by the dial plate cover 22 which may be snapped over the dial plate assembly 222, as shown in FIG. 1.

The stator housings 23 and 25 may be retained in axial alignment on the switch structure 10 by means of the bolts 283 which extend axially from the housing 210 through the stator housings 23 and 25 and any additional stator housings, where provided, as explained in detail in the patents previously mentioned. The stator housings 23 and 25, the spacing members 27, the rotor 63 of the rotor assembly 20 and the cam 73 are preferably molded from an electrically insulating material having excellent nontracking arc and wear resistance characteristics such as a glass-polyester material with an aluminum trihydrate filler. Thus, each of the parts of the switch structure 10 which are subject to wear has a relatively long life.

As shown in FIG. 1, a plurality of pairs of stationary contact members 47 may be disposed in two rows around the periphery of the first stator housing or contact support member 23. Respective pairs of contact members are angularly spaced at predetermined angles around the periphery of the switch structure 10. The two contact members 47 of each pair are spaced axially with respect to the stator housing 23. Each contact member 47 may function as a terminal member and as a contact member. Each contact member 47 is formed from a suitable electrically conducting material and may have a head which is enlarged in one plane to engage the walls of a recess in a stator housing 23, as described in detail in the patents previously mentioned. The head of each contact member 47 may be engaged by a contact roller carried by the rotor assembly 20. Each contact member 47 is retained in the stator housing 23 by means of a nut 49 which is threaded onto the contact member 47 to engage a washer as shown in FIG. 1. The number of pairs of contact members 47 and their relative positions may be varied as required in a particular application, as disclosed in detail in the patents previously mentioned.

The rotor assembly 20 may have one or more contact rollers 61 disposed at predetermined angular positions around the periphery of the rotor assembly 20 as required in a particular application. The rotor assembly 20 may be of a one-piece construction and comprises a hub 63 and a plurality of arms which are formed integrally with the hub 63, as described in detail in the patents previously mentioned. Each contact roller 61 is composed of a suitable electrically conducting material and is provided with two spaced integrally formed enlarged contact portions 65. Each contact roller 61 is disposed in a slot provided in one of the arms of the rotor assembly 20 and is biased radially outwardly in said rotor assembly by an associated spring with a spring seat 67 being disposed between one end of each of the contact rollers 61 and the associated spring. In order to reduce the friction between the contact portion 65 of each contact roller 61 and the heads of the stationary contact members 47, each contact roller 61 is rotatably mounted in one of the arms of the rotor assembly 20 and in order to further reduce such friction, a wheel 69 which is composed of electrically insulating material may be rotatably mounted on each end of each of the contact rollers 61 outside of the adjacent enlarged contact portion 69, as described in detail in the patents previously mentioned. In order that the rotor assembly 20 rotate with the shaft 26, the hub 63 of the rotor assembly 20 has a substantially square opening for receiving the shaft 26 and the portion of the shaft 26 on which the rotor assembly 20 is carried has a similar cross section.

In certain applications, it is desirable to provide a switch structure having normally closed contact members. The second stator housing 25 shown in FIG. 1 has such normally closed contact members mounted thereon. As shown in FIG.

1, a plurality of pairs of axially spaced contact members 57 may be angularly spaced around the periphery of the stator housing 25 with the inner ends 77 of each pair of contact members extending axially toward each other. A bridging contact member 71 is biased into engagement with the ends 77 of the associated contact members 57 by an associated spring, as described in detail in the patents previously mentioned. The bridging contact member 71 is disengaged from the ends 77 of the contact members 57 when a roller 75 on the bridging contact member 71 is engaged by the cam 73 with the movement of the contact-bridging member 71 being guided by a contact guide 79 which is disposed between the contact members 57 of each pair of said contact members. The cam 73 also includes a hub portion having a square opening for receiving the shaft 26 with the portion of the shaft 26 which carries the cam 73 having a similar cross section in order that the cam 73 rotate with the shaft 26.

In order to magnetically latch the shaft 26 in a first angular operating position or "on" position which corresponds to a first operating position of the movable contact rollers 61 and the bridging contact members 71, where provided, a releasable magnetic latching means or mechanism 30 is disposed in the housing 210 as shown in FIG. 1. It is to be noted that a gasket 211 may be provided between the back portion of the housing 210 and the front cover plate 212 to prevent the entrance of dust or other contaminating materials into the housing 210.

More specifically, the magnetic latching means 30 as shown in FIGS. 1 and 3 includes a lever arm 220 which is mounted on the shaft 26 for rotation therewith. The upper end of the lever arm 220 has a substantially square opening which is adapted to receive a portion of the shaft 26 having a similar cross section or shape. In order to axially position the lever arm 220 on the shaft 26, the generally tubular spacer member or bushing 129 is disposed on the shaft 26 between the lever arm 220 and the lever arm 422 which forms part of the spring return assembly 50 which will be described hereinafter. A magnetic armature or movable keeper member 230 is loosely mounted or supported at the outer end of the lever arm 220 by suitable means such as the screw 232.

The magnetic latching means 30 also includes a stationary magnetic structure 300 as shown in FIGS. 3 and 5. As shown in FIG. 5, the stationary magnetic structure 300 comprises a pair of spaced upper and lower plates 313 and 315, respectively, which are formed from a suitable soft magnetic material, such as steel or iron. It is to be noted that the right ends of the plates 313 and 315 form the pole faces 316 and 318, respectively, against which the armature 230 seats or engages when the lever arm 220 is magnetically latched by the magnetic latching means 30. In order to provide the magnetic flux which passes through the armature 230 and magnetically latches the armature 230 against the stationary magnetic structure 300 as shown in FIG. 5, a permanent magnet member 350 is provided which, as illustrated, extends tranversely between the plates 313 and 315 as shown in FIG. 5. In order to provide an alternate path having a relatively low magnetic reluctance for the magnetic flux from the permanent magnet member 350 to thereby prevent demagnetization of the permanent magnet member 350 and to reduce the amount of magnetic flux provided by the coil 320 which is required to release the armature 230, the stationary magnetic structure 300 also includes a magnetic plate member or fixed keeper 312 which is disposed adjacent to the left ends of the plates 313 and 315 and which is also formed from a suitable soft magnetic material, such as steel or iron. It is to be noted that the fixed keeper 312 is spaced from the adjacent ends of the plates 313 and 315 by a spacer member 314 which is formed from a substantially nonmagnetic material and which establishes a predetermined nonmagnetic gap in the alternate low-reluctance path which includes the fixed keeper 312.

In order to actuate the release of the armature 230 and, in turn, the shaft 26 when the armature 230 is magnetically latched to the stationary magnetic structure 300 as shown in

FIG. 5, the energizing or operating coil or winding 320 is inductively disposed on one of the magnetic plates 313 or 315. The operating winding 320 may include a plurality of conductor turns which are disposed to surround the upper magnetic plate 313, as illustrated. When a voltage is applied to the operating winding 320 and current flows in the conducting turns of the operating winding 320, a magnetic flux which is produced will be in such a direction as to pass through the armature 230 and to oppose the magnetic flux from the permanent magnet member 350 which also passes through the armature 230. The effective reluctance of the magnetic path which includes the armature 230 will be thus increased and the magnetic flux from the permanent magnet member 350 will then shift or transfer to the relatively lower reluctance magnetic path which includes the fixed keeper 312 to thereby release the armature 230 and the shaft 26. It is to be noted that the various parts which form the stationary magnetic structure 300 may be encapsulated in a suitably thermosetting material or a thermoplastic resin and that the stationary magnetic structure may be secured to the front cover 212 of the housing 210 by suitable means, such as a plurality of rivets (not shown).

In order to return or bias the shaft 26 to a tripped or "off" angular operating position which is angular spaced from the position of the shaft 126 shown in FIG. 3 in a counterclockwise direction by a predetermined angle, such as approximately 30°, and which corresponds to a second operating position of the lever arm 220, as indicated in phantom at 220' in FIG. 3, when the shaft 26 is released from the influence of the magnetic latching means 30, as will be described more fully hereinafter, a spring return assembly or mechanism 50 is disposed in the housing 210, as best shown in FIGS. 1 and 3. The normal or "off" angular position of the shaft 26 and the second operating position of the lever arm 220 also correspond to a second operating position of the movable contact rollers 65 and the bridging contact member 71, where provided.

More specifically, the spring return assembly 50 as shown in FIGS. 1 and 3 includes a pair of axially spaced lever arms 422 and 424 which are mounted on the shaft 26 for rotation therewith. The upper ends of each of the lever arms 422 and 424, as viewed in FIG. 1, has a square opening which is adapted to receive a portion of the shaft 26 having a similar cross section or shape. As previously mentioned, the bushing 129 is disposed on the shaft 26 between the lever arm 220 and the lever arm 422 in order to axially position the lever arm 422 with respect to the lever arm 220. In order to axially position the lever arm 424 with respect to the rear wall of the housing 210, the housing 210 includes an inwardly projecting portion 210A which includes an opening through which the shaft 26 passes. A washer 462 may be mounted on the shaft 26 between the lever arm 424 and the inwardly projecting portion 210A of the housing 210, as shown in FIG. 1.

The spring return assembly 50 also includes a biasing spring 452, as shown in FIGS. 1 and 3, which, as illustrated, is of the helically coiled compression type. In order to operatively connect the lever rms 422 and 424 to the spring 452, the outer ends of said lever arms are pivotally connected to a clevis member or upper spring seat member 420 by a pivot pin 426 which passes through substantially aligned openings provided in said lever arms and clevis member. As shown in FIG. 1, the upper end of the spring 50 bears against the clevis member 420 which includes a downwardly projecting portion which projects axially into the upper end of the spring 50. In order to retain the spring 50 in the assembled position shown in FIGS. 1 and 3, a spring anchor member or lower spring seat member 410 is disposed at the lower end of the spring 50 and includes a portion which projects axially upwardly into the lower end of the spring 50. The spring anchor member 410, in turn, is supported by the lower wall of the housing 210 and, where desired, the spring anchor member 410 may include a downwardly projecting portion which is adapted to project into a suitable recess (not shown) provided in the lower wall of the housing 210. It is to be noted that when the biasing spring 452 is assembled as shown in FIG. 3 and held in a charged or compressed condition, the spring 452 together with the lever arms 422 and 424 forms a toggle means which is operatively connected between the shaft 26 and the relatively stationary housing 210. It is also to be noted that the biasing spring 452 is disposed to bias the lever arms 422 and 424, along with shaft 26, on which said lever arms are mounted in a counterclockwise direction about the axis of the shaft 26, as viewed in FIG. 3.

In order to prevent any deflection of the shaft 26 under the influence of the forces exerted on the shaft 26 by the spring 452 through the lever arms 422 and 424 and to assist in rotatably supporting the shaft 26, the spring return assembly 50 includes a shaft-supporting means which, in turn, includes a relatively stationary bearing support member 430, as best shown in FIGS. 1 and 3. As best shown in FIG. 1, the bearing support member 430 is disposed between the lever arms 422 and 424 and includes a central opening through which the shaft 26 passes. The bearing support member 430, in turn, is supported by a pair of inwardly projecting portions 433 and 435 which may be provided as part of the rear wall of the housing 210 and which may be disposed on opposite sides of the shaft 26 to permit the required angular travel of the arms 422 and 424. The opposite ends of the bearing support member 430 may be secured to the inwardly projecting portions of the housing 210 by suitable means, such as a pair of bolts 432 and 434, as best shown in FIG. 3. As best shown in FIGS. 1 and 4, a generally tubular bearing member or sleeve bearing 442 may be disposed on the shaft 26 to extend axially between the lever arms 422 and 424 and to pass through the central opening provided in the bearing support member 430. The bearing member or bushing 442 may include a square opening which is adapted to receive a portion of the shaft 26 having a similar cross section or shape. In order to reduce the friction between the bushing 442 and the bearing support member 430, a bearing sleeve 444 may be disposed between the bushing 442 and the central opening of the bearing support member 430 with the bearing sleeve 444 being formed from a material having a relatively low coefficient of friction, such as polytetrafluoroethylene which is sold under the trademark "Teflon." It is also to be noted that the bushing 442 acts as an axial spacer between the lever arms 422 and 424.

As previously mentioned, the shaft 126 on which the handle 128 is mounted is operatively connected or coupled to the shaft 26 during certain operating conditions by a coupling means which comprises the generally tubular bushing member 122 as shown in FIG. 1. More specifically, the bushing 122 is secured to the shaft 126 for rotation therewith by a cross pin 123 which passes through aligned openings provided in the bushing 122 and the shaft 126. The bushing 122 also includes a portion of reduced size which projects through an opening in the front cover 212 of the housing 210 to assist in rotatably supporting the shaft 126. As illustrated, a washer 127 may be mounted on the shaft 126 between the bushing 122 and the front cover 212 of the housing 210. The bushing 122 also assists in axially positioning the lever arm 220 on the shaft 26 since the right end of the bushing 122 as viewed in FIG. 1 projects over the adjacent end of the shaft 126 with the lever arm 220 being disposed between the bushing 122 and the spacer member or bushing 129. The shaft 126 also includes a portion 126A of reduced cross section which projects axially into a recess 26A which is provided at the left end of the shaft 26 as viewed in FIG. 1 to assist in rotatably supporting the shaft 126.

In order to provide a predetermined amount of rotary lost motion between the shafts 126 and 26 when the handle 28 and the shaft 126 are rotated in a direction that would rotate the shaft 26 and the associated lever arm 220 in a counterclockwise direction, as viewed in FIG. 3, and that would otherwise move the armature 230 away from the magnetically latched position shown in FIG. 3, the bushing 122 may include a plurality of generally arcuate internal recesses (not shown), as described in detail in copending application, Ser. No.

862,427, now U.S. Pat. No. 3,585,544 previously mentioned. In other words, due to the internal configuration of the bushing 122 and the shape of the shaft 26, a predetermined amount of rotary lost motion may be provided between the shafts 126 and 26 when the shaft 126 is rotated in a counterclockwise direction from the position shown in FIG. 3 which corresponds to the magnetically latched position of the shaft 26 to thereby prevent the manual release of the lever arm 220 under the influence of any force exerted on the handle 28 and the associated shaft 126. In order to prevent the shaft 126 from being rotated in a counterclockwise direction beyond the limits of the predetermined amount of rotary lost motion which may be provided, the cross pin 123 may be extended radially and disposed to engage a stop member (not shown) which may be provided on the housing cover 212 to thereby prevent manual overriding of the magnetic latching means 30 and also prevent the shaft 26 from being manually turned to the "off" position of the associated contacts.

On the other hand, if the shaft 126 is rotated manually by means of a handle 28 in a clockwise direction when the shaft 26 is in the angular position which corresponds to the "off" position of the associated contacts, the internal configuration or shape of the bushing 122 may be such as to cause the shaft 26 to rotate with the shaft 126 in a clockwise direction as viewed in FIG. 3 to actuate the lever arm 220 and the armature 230 toward the magnetically latched position shown in FIG. 3, as described in detail in the last-mentioned copending application.

In order to apply a unidirectional voltage to the operating winding 320 of the stationary magnetic structure 300, as shown schematically in FIG. 7, a source of alternating current voltage as indicated at S1 may be electrically connected to the operating winding 320 through the contact 410 of a relay 400 which actuates the remote operation of the switch structure 10 shown in FIG. 1, the closed contact rollers 61 previously mentioned, the terminals of a terminal block indicated diagrammatically at 360 in FIG. 7 and through a full-wave rectifier circuit 340 which is indicated in block form in FIG. 7. The rectifier circuit 340 may be omitted with an alternating current supply if maximum speed of the switching operation is not necessary. In other words, the winding 320 will function properly when energized with either direct current or alternating current power. Minimum operating time is assured by direct current since alternating current may produce magnetic flux during a half cycle which is in a direction to temporarily aid the flux in the permanent magnet member rather than to oppose it.

In order that the position of the handle 28 reflect the actual operating condition of the switch structure 10 shown in FIG. 1, a pair of biasing leaf springs 255 are disposed to engage the shaft 126, as best shown in FIG. 2. The ends of the leaf springs 255 may be disposed in suitable recesses provided in the dial plate 222, as described in greater detail in copending application, Ser. No. 862,427 previously mentioned. When the handle 28 and the associated shaft 126 are rotated in a counterclockwise direction from the position of the shaft 126 shown in FIG. 3, while the switch structure 10 is magnetically latched by the magnetic latching means 30, the handle 28 and the shaft 126 along with the bushing 122 may rotate in a counterclockwise direction without unlatching the armature 230 and the shaft 26, as just explained. When the handle 28 is then released, the leaf springs 255 will actuate the handle 28 and the shaft 126 back to the position which corresponds to the position of the shaft 126 shown in FIG. 3 in order that the handle 28 reflect the actual operating condition or position of the switch structure 10 shown in FIG. 1. When the shaft 26 is released by the energization of the operating winding 320, the bushing 122 and the shaft 26 will be actuated from the positions indicated in FIG. 3 which correspond to the magnetically latched condition of the switch structure 10 in a counterclockwise direction due to the internal configuration of the bushing 122, and the handle 28 along with the shaft 126 will also be actuated in a counterclockwise direction against the influence exerted on the shaft 126 by the biasing springs 255 since the spring return assembly 50 which includes the spring 452 is relatively stronger than the leaf springs 255.

In the overall operation of the switch structure 10 shown in FIG. 1, it will be assumed first that the switch structure 10 is in the "off" or tripped operating condition which corresponds to a first angular position of the shaft 26 which is indicated by the dot-dash line 228′ in FIGS. 2 and 3. In this operating condition, the armature 230 and the lever arm 220 are spaced away from the associated stationary magnetic structure 300, as indicated by the dot-dash line 228′ and the position of the lever arm 220 indicated in phantom at 220′ in FIG. 3. In order to actuate the armature 230 to the magnetically latched position shown in FIG. 3, the handle 28 and the associated shaft 126 along with the bushing 122 are rotated in a clockwise direction and due to the internal configuration of the bushing 122, the shaft 26 will rotate with the shaft 126 until the shaft 26 reaches a second angular position as indicated by the dot-dash line 228 in FIGS. 2 and 3 and the armature 230, as well as the lever arm 220, reach the operating positions shown in FIG. 3 with the magnetic flux from the permanent magnet member 350 passing through the armature 230 which engages the pole faces 316 and 318 of the stationary magnetic structure, as shown in FIG. 5. It is to be noted that in this operating condition of the switch structure 10, the reluctance of the magnetic path which includes the armature 230 is relatively lower than that of the magnetic path which includes the fixed keeper 312 due to the presence of the nonmagnetic spacer member 314 and that most of the magnetic flux from the permanent magnet member 350 will therefore pass through the armature 230 to magnetically latch the armature 230 to the stationary magnetic structure 300 as shown in FIG. 3.

It is also to be noted that when the armature 230 is in the magnetically latched position and the shaft 26 is in the "on" operating position indicated at 228 in FIGS. 2 and 3, if the handle 28 and the shaft 126, as well as the bushing 122, are rotated in a counterclockwise direction from the operating positions indicated in FIGS. 2 and 3, the predetermined amount of rotary lost motion provided between the shafts 126 and 26 will permit the bushing 122 to rotate to a position which is angularly displaced in a counterclockwise direction from that shown in FIG. 3 without unlatching the armature 230. This is due to the predetermined amount of rotary lost motion which may be provided for one direction of rotary movement between the shafts 126 and 26, as previously described.

Assuming that the switch structure 10 shown in FIG. 1 is in the magnetically latched operating condition and that the shaft 26 is in the angular position indicated at 228 in FIG. 3, the switch structure 10 may be remotely operated by energizing the operating winding 320 of the stationary magnetic structure 300 shown in FIG. 5 by energizing said operating winding from a source of alternating current, as indicated at S1 in FIG. 7, through the full-wave rectifier circuit 340 by the closing of a contact 410 of a suitable control relay as indicated at 400 in FIG. 7 or from a source of direct current where provided. It is to be noted that prior to the energization of the operating winding 320, the torque exerted on the shaft 26 by the magnetic latching means 30 through the lever arm 220 is relatively greater than the torque exerted on the shaft 26 by the spring return assembly or mechanism 50, preferably by a ratio of approximately two to one. When the operating winding of the stationary magnetic structure 300 is energized, the magnetic flux from the operating winding 320 will pass through the armature 230 in such a direction as to oppose the magnetic flux from the permanent magnet member 350 to thereby release the armature 230 and the shaft 26 which will then move in a counterclockwise direction from the position indicated at 228 in FIG. 2 which corresponds to a first operating position of the switch structure 10 to the position indicated at 228′ in FIGS. 2 and 3 which corresponds to a second operating position of the switch structure 10 shown in FIG. 1. When the shaft 26 is actuated from the position indicated at

228 to the position indicated at 228′ in FIG. 2 under the influence of the spring return assembly 50 which includes the spring 452, the contacts 61 indicated diagrammatically in FIG. 7 will be actuated to the open position to thereby deenergize the operating winding 320 of the stationary magnetic structure 300 so that it is not necessary to have a continuous current flowing in the winding 320.

It is important to note in the overall operation of the switch structure 10, as just described, the effective torque exerted on the shaft 26 by the spring return assembly 50 varies as indicated by the curve 510 in FIG. 6 from a minimum value, as indicated at 560 in FIG. 6, when the shaft 26 is in the magnetically latched operating position, as indicated at 530 in FIG. 6, to a maximum value as indicated at 570 in FIG. 6 when the shaft 26 is in a tripped operating position, as indicated at 540 in FIG. 6. This is because the effective turning arm through which the force exerted by the spring 452 acts on the shaft 26, as indicated in FIG. 3, increases from a relatively smaller value when the shaft 26 is in a magnetically latched operating position to a maximum value when the shaft 26 moves or travels to the tripped position indicated at 228′ in FIG. 3. This is a desirable arrangement since the torque which is applied to the shaft 26 by the spring return assembly 50 which must be overcome by the magnetic latching means 30 when the shaft 26 is in the magnetically latched operating position is at a minimum value, while the torque applied to the shaft 26 to actuate a plurality of stages of the switch structure 10 when the shaft 26 is released from the magnetic latching means 30 is relatively greater and at a maximum value to increase the number of stages which can be actuated to the second operating position by the spring return assembly 50. It is to be noted that the torque characteristic provided by the spring return assembly 50 as indicated by the curve 510 is substantially the reverse of the torque characteristic provided by the spring return assembly disclosed in copending application, Ser. No. 862,427, now U.S. Pat. No. 3,585,544 previously mentioned as indicated by the curve 520 in FIG. 6. In other words, the torque applied to the corresponding shaft in the switch structure disclosed in the last-mentioned copending application decreases from a maximum value when the corresponding shaft is in the magnetically latched operating position to a minimum value when the corresponding shaft rotates to the tripped operating position, as indicated at 540 in FIG. 6.

It is also important to note in FIG. 6 that if the shaft 26 is manually actuated from the tripped operating position indicated at 540 to an intermediate operating position as indicated by the dotted line 550 in FIG. 6 and then released without being actuated to the magnetically latched position, indicated at 530 in FIG. 6, the spring return assembly 50 provides an available torque which is exerted on the shaft 26 as indicated at 580 which is relatively greater than the available torque from the spring return assembly disclosed in the last-mentioned copending application in order to insure that the contacts of the switch structure 10 are returned to the operating position which corresponds to the tripped operating position indicated at 540 in FIG. 6. The torque thus provided by the spring return assembly 50 as disclosed insures that a switch structure having a relatively large plurality of stages cannot be actuated to an intermediate operating position without the spring return assembly 50 actuating the shaft 26 to properly reflect the operating condition of the overall switch structure 10.

Considering the operation of the spring return assembly 50 and more specifically the lever arms 422 and 424 and the associated compression spring 452 as a toggle means, it is to be noted that the toggle means which includes said lever arms and the compression spring 452 is actuated from a first operating position which is disposed on one side of a line extending between the ends of the toggle means so defined to a second operating position which is also disposed on the same side of a line extending between the ends of said toggle means when the shaft 26 and the associated lever arms 422 and 424 move from the operating position indicated at 422 in FIG. 3 for one of said lever arms to the position indicated in phantom at 422′ for the same lever arm in FIG. 3.

It is to be understood that in certain applications a switch structure as disclosed may include a spring return assembly in which the biasing spring is held in tension rather than in compression as disclosed.

The switch apparatus embodying the teachings of this invention has several advantages. For example, a switch structure is disclosed including a spring return assembly having a torque-movement operating characteristic, as shown in FIG. 6, provides a relatively lower torque at the magnetically latched position of the associated shaft thus reducing the torque which must be opposed or overcome by the associated magnetic latching means 30 and a maximum torque at the tripped operating position which increases the number of stages which may be actuated by the spring return assembly in a particular application. In addition, a spring return assembly in a switch structure as disclosed eliminates or prevents teasing of a switch structure by actuating the switch structure to an intermediate position, as indicated at 550 in FIG. 6 without the switch structure being returned to the operating position which is reflected by the position of the associated parts of the switch structure, such as the handle.

I claim as my invention:

1. A switch comprising separable stationary and movable contacts, a rotatable shaft for actuating the movement of said movable contacts between two operating positions corresponding to first and second angular positions of said shaft, a first lever arm mounted on said shaft for rotation therewith, a magnetic armature mounted on said lever arm for movement therewith, a stationary magnetic structure including a permanent magnet disposed adjacent to said shaft, said armature being disposed to engage said stationary magnetic structure in the first angular position with said permanent magnet member providing magnetic flux which passes through said armature to magnetically latch said shaft in the first angular position, a second lever arm mounted on said shaft for movement therewith, a biasing spring operatively disposed between said second lever arm and a stationary support member for biasing said shaft toward said second angular position, the torque exerted on said shaft by said spring through said second lever arm being relatively greater when said shaft is in said second angular position than when said shaft is in said first angular position, and an electromagnetic means disposed on said stationary magnetic structure and energizable to provide magnetic flux which opposes the magnetic flux from said permanent magnet member which passes through said armature to thereby release said armature and shaft and to permit said shaft to be actuated to said second angular position by said biasing spring.

2. The combination as claim in claim 1 wherein said second lever arm and said biasing spring comprise a toggle means actuable between a first operating position corresponding to said first angular position of said shaft and a second operating position corresponding to said second angular position of said shaft, both operating positions of said toggle means being on the same side of a line extending between the ends of said toggle means.

3. The combination as claimed in claim 1 wherein an additional lever arm is mounted on said shaft adjacent to and spaced from said second lever arm, said additional lever arm being operatively connected to said biasing spring, and bearing means supported by said stationary support member is disposed to rotatably support said shaft between said second lever arm and said additional lever arm.

4. The combination as claimed in claim 1 wherein said biasing spring is a compression spring.

5. The combination as claimed in claim 2 wherein said biasing spring is a compression spring.

6. The combination as claimed in claim 3 wherein a clevis member is pivotally connected to both said second lever arm and said additional lever arm, said biasing spring being held in compression between said clevis member and said stationary support member.