March 18, 1958 H. SAUER 2,827,530

ROTARY RELAY

Filed Feb. 9, 1955 3 Sheets-Sheet 1

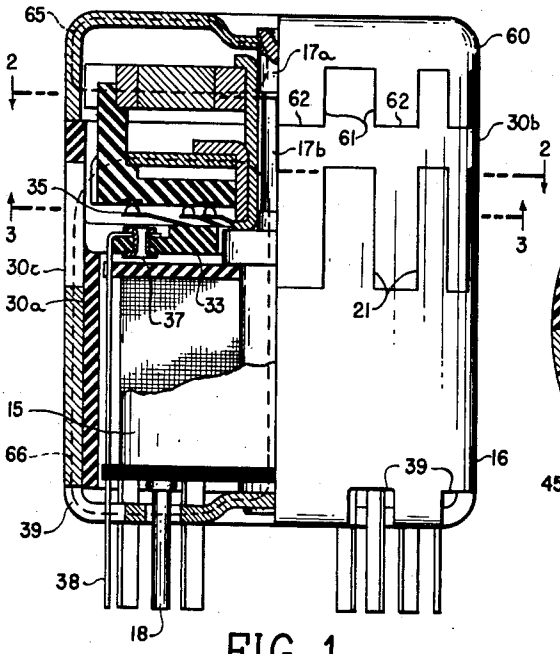


FIG. 1

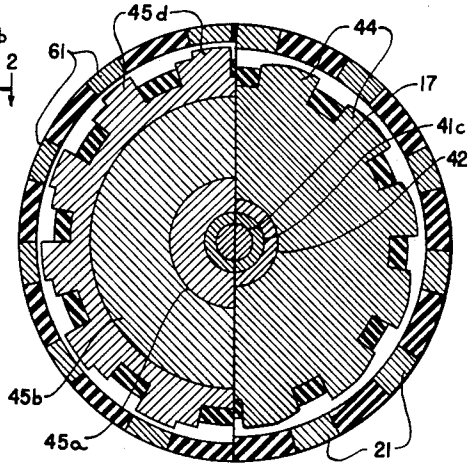


FIG. 2

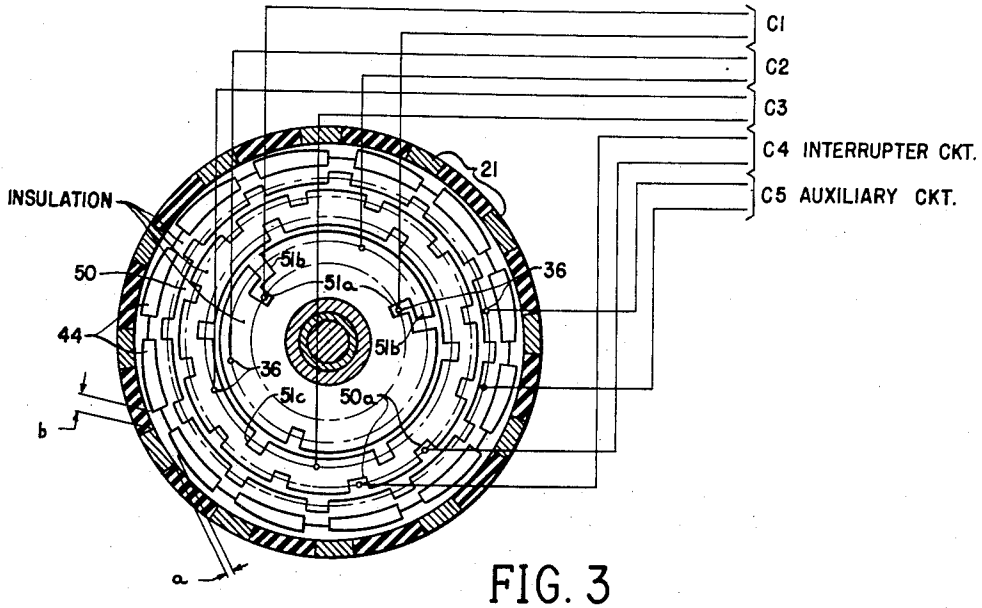


FIG. 3

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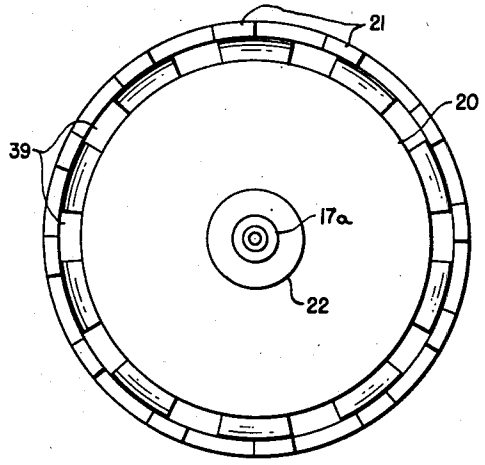


FIG. 5

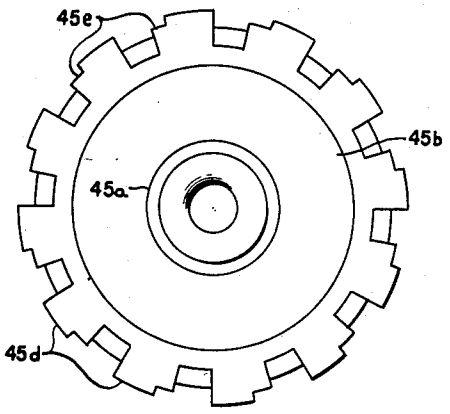


FIG. 10

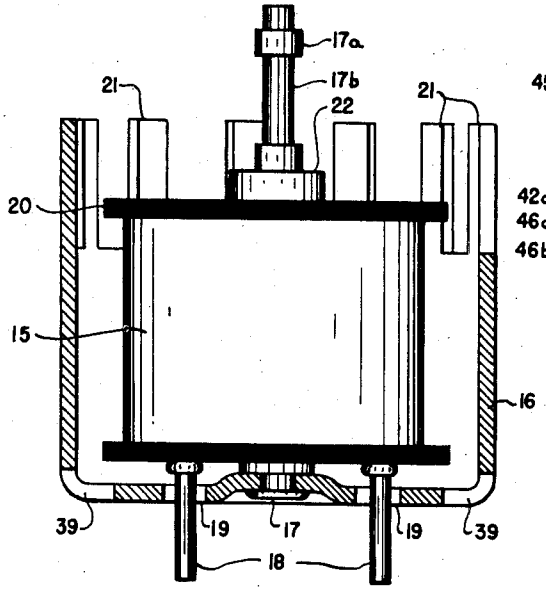


FIG. 4

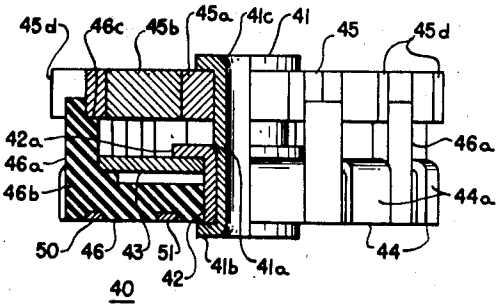


FIG. 9

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ROTARY RELAY

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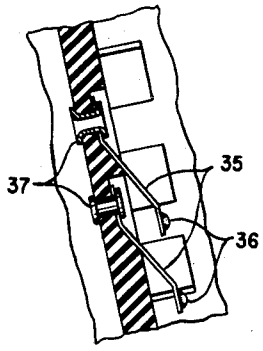


FIG. 8

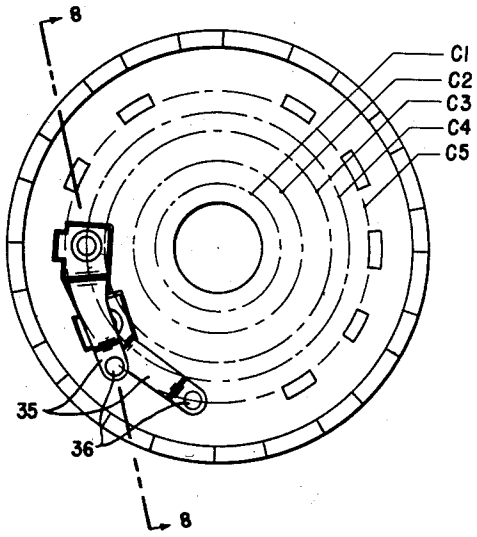


FIG. 7

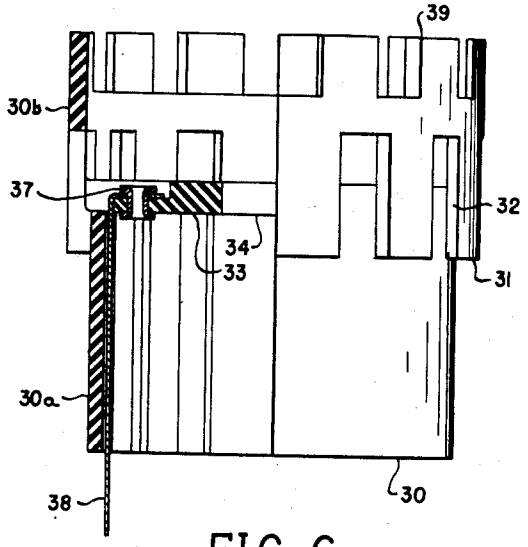


FIG. 6

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United States Patent Office 2,827,530
Patented Mar. 18, 1958

2,827,530

ROTARY RELAY

Hans Sauer, Chicago, Ill., assignor to General Telephone Laboratories, Incorporated, a corporation of Delaware

Application February 9, 1955, Serial No. 487,128

19 Claims. (Cl. 200—104)

This invention relates to electromagnetic relays of the rotary type and, more particularly, to improvements in rotary electromagnetic relays in which electrical contacts are operated by a continuous rotation of the mechanism. In a relay of the character contemplated by the present invention a single coil is inclosed in a cup, the core of the coil being rigidly secured at one extremity to the base of the cup and having at the opposite end a projecting shaft. The cup, of a magnetic metal, comprises a first heelpiece for the coil and is provided at its lip with a series of evenly spaced teeth disposed parallel with the axis of the coil core. A rotary armature having a series of radial poles corresponding in number to the series of heelpiece teeth is rotatably mounted on the coil core shaft such that if the coil is energized each of the armature poles will be magnetized and, should the poles at the moment of energization not be in alignment with the heel-piece teeth, the armature will be rotated until such alignment is completed.

A second cup also of a magnetic metal and also having a series of evenly spaced teeth disposed on its lip is provided to be rigidly secured to the other extremity of the coil core. The series of teeth of this second cup are identical in number with the teeth of the first cup and are similarly disposed parallel with the axis of the coil core. The second cup is arranged, however, so that its teeth alternate in their angular disposition with those of the first cup. A second rotary armature having a series of radial permanent magnet poles corresponding in number to the series of second cup teeth is also rotatably mounted on the coil or core shaft rotatable with the first rotary armature. The poles of the second rotary armature, which are suitably insulated from the first armature, when moved out of alignment with the teeth of the second cup, will tend to be drawn back into alignment by the action of the permanent magnet. This rotary position, with the poles of permanent magnet in alignment with the teeth of the second cup, may be considered the normal position of the mechanism. However, in this position, due to the alternate disposition of the series of teeth of the two cups, the poles of the first or electromagnetic armature will be out of alignment with the teeth of the first cup. Energization of the coil then, as previously described, will move these last-mentioned poles and teeth into alignment and the mechanism out of its normal position. Upon deenergization of the coil the second or permanent magnetic armature will cause its now misaligned poles and teeth of the second cup to restore to a succeeding normal position. It is evident that the mechanism will have a number of normal positions equal to the number of teeth in the series of teeth of each of the cups. If the coil is now periodically energized and deenergized and assuming a proper timing of the energization, the armatures can be continuously caused to rotate about the coil core shaft in the manner broadly described.

In the present embodiment of this invention the first

and second cups are suitably insulated from each other as by dove-tailing the insulator into the intervals formed by the alternating teeth. Also rotatably mounted on the core shaft and rotatable with the two rotary armatures are a pair of commutator rings each having successive contacting lobes thereon. Rigidly associated with the first cup are a series of tensioned contacting springs adapted to engage the contacting lobes of the commutator rings as the armatures are rotated. Thus two of the springs may be associated with one of the rings to control the periodic energization and deenergization of the coil, the springs closing a coil energizing circuit as they meet appropriate contacting lobes on the ring and opening the circuit as the lobes pass from contact as the armatures rotate. Other pairs of contacting springs may be associated with the other commutator ring to periodically close and open circuits associated with the said springs in accordance with the disposition of contacting lobes of the commutator ring all of which will be more specifically described hereinafter. The device according to this invention is broadly described in the foregoing may be used in any application requiring cam switching, alternate on-off operation or as a stepping switch, and the contacting sequence of any of the contact spring pairs can be altered by changing the positions of the commutator contacting lobes. The fundamental simplicity of such a relay having only a single moving part and that motion only continuously rotary obviously results in a relay which requires no attendance and the minimum amount of adjustment.

It is, accordingly, the principal object of my invention to provide a multi-contact electromagnet relay of the rotary type in which electrical circuits are periodically closed and opened by means of continuously rotating commutator rings associated with pairs of contacting springs with which the said circuits are associated, the commutator rings being associated with the sole moving element of the relay.

Another object of my invention is to provide a rotary relay of the character of the preceding paragraph in which a rotary armature with which the commutator rings are associated is provided with poles which may be periodically electromagnetized to thereby cause the poles to be successively attracted in a rotary direction to fixed circularly disposed poles of opposite polarity.

It is a further object of my invention to provide in a rotary relay of the character described in the preceding paragraph, a permanent magnet armature having a plurality of poles which by successively attracting the armature in a rotary direction to fixed circularly disposed poles of opposite polarity will cause the electromagnetic armature to be rotated away from its said fixed poles during the periods when it is not electromagnetized.

It is yet another object of my invention to provide an electromagnetic relay in which a normal position is maintained by a permanent magnetic attractive force and movement from the said normal position is accomplished by a momentarily superior electromagnetic attractive force, restoration to a normal position being accomplished by the said permanent magnetic attractive force on removal of the electromagnetic attractive force.

Still another object of my invention is to provide an electromagnetic rotary relay of the character described in the preceding paragraph which will comprise a minimum number of parts and because of its simplicity of operation will insure durability and economy of operation.

A still further object of my invention is the provision of an electromagnetic rotary relay which because of its construction insures a flexibility making it adaptable for a wide range of applications. The relay may, for ex-

ample, be readily hermetically sealed and readily adapted for plug-in use.

A novel feature of my invention is the use of two cup-shaped heelpieces associated with separate operating armatures, which heelpieces together with a magnetic insulator also constitute the enclosing envelope for the relay.

Another feature of my invention is a novel armature arrangement in which the armature is adapted to rotate continuously about an extension of the coil core.

Further objects and features of my invention will become apparent to those versed in the art from a perusal of the detailed description of my invention which follows. Illustrating the various components of the invention and referred to in the description are the accompanying drawings in which:

Fig. 1 is a partial section view of the preferred embodiment of my invention in which is shown the relationship of the component elements and the manner in which the insulating element may be interposed between the cup heelpieces,

Fig. 2 is a section view of the assembly taken along the line 2—2 of Fig. 1 in which is shown the relative positions with respect to the pole elements of the armatures when the operating coil is not energized,

Fig. 3 is a section view of the assembly taken along the line 3—3 of Fig. 1 in which are shown the commutator rings and their position with respect to the electromagnetic armature. Here also the relative positions of the contacting springs are symbolized together with associated circuits,

Fig. 4 is an elevational section view showing the first cup heelpiece inclosing the operating coil,

Fig. 5 is a top view of the elevation of Fig. 4 in which are shown the circularly disposed teeth forming the poles on the lip of the first cup heelpiece,

Fig. 6 is an elevational partial sectional view of the insulating element showing the manner of mounting the contacting springs and spring terminals,

Fig. 7 is a top view of the elevation of Fig. 6 in which are shown the positions of one pair of the concentrically disposed contacting springs,

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 7 showing the details of the contacting spring mounting,

Fig. 9 is an elevational partial sectional view of the armature assembly showing an insulating element holding in a fixed relative position the permanent magnetic and electromagnetic armatures, and

Fig. 10 is a top view of the armature assembly showing the circularly disposed permanent magnetic poles.

Referring particularly to Figs. 1, 4 and 5 of the drawings the preferred embodiment of my invention will now be described in detail. An operating coil 15 for the relay is enclosed in a cylindrical cup 16 made of a magnetic metal. The coil 15 is provided with a core 17 by means of one terminus of which it is rigidly secured to the base of the cup 16 in any convenient manner as by riveting. A pair of terminals 18 for the coil 15 extend through apertures 19 in the cup 16 provided therefor. The core 17 at the opposite terminus takes the form of a shaft 17*a* extending a substantial distance beyond the spool-head 20 of the coil 15. The shaft 17*a* may be undercut as at 17*b* to decrease the bearing surface and hence the friction of any element ultimately to be rotated on said shaft. On the lip of the cup 16 are provided a series of evenly spaced teeth 21 extending substantially parallel with the axis of the core 17 and shaft 17*a*. These teeth 21, in the preferred embodiment twelve in number, may conveniently be formed by cutting out at intervals portions of the lip of the cup 16. The shaft 17*a* is provided at the spool-head 20 with a bushing or shoulder 22 upon which an assembly to be described may be freely rotated. The cup 16, as is evident from Fig. 1, forms the base and lower half of the relay assembly.

In Fig. 6 is shown a cylindrical insulator element 30 having a lower portion 30*a* the outside diameter of which is such that it may be readily fitted inside the cup 16 thus forming an insulating wall between the coil 15 and the cup 16. The insulator element 30 further has an upper portion the outside diameter of which is such that when the element 30 is inserted into the cup 16 the cylindrical surface 30*b* will be flush with the outer surface of the cup 16 as is clearly shown in Fig. 1. A shoulder 31 is provided on the element 30 dividing the upper and lower portions 30*b* and 30*a* and insuring a positive fitting on the lip of the cup 16. The upper portion 30*b* of the cylindrical element 30 has a series of substantially rectangular cutouts 32 facing on the shoulder 31 and substantially parallel to the axis of the element 30. The cutouts 32 are so spaced and dimensioned as to correspond precisely with the teeth 21, the latter teeth being adapted to dove-tail with the cutouts 32 as the element 30 is inserted into the cup 16. The cutouts 32 and the teeth 21 may be slightly tapered to facilitate the introduction of the teeth into the cutouts.

Integral with the element 30 and in a plane perpendicular with the axis thereof is a partition 33 having a concentric aperture 34 adapted to admit the shoulder 22 of the shaft 17*a* as the element 30 is inserted in the cup 16. On this partition 33 are mounted, in the preferred embodiment, five pairs of contacting springs 35, one pair of which are shown in Fig. 7. As shown in Fig. 7 the contacts 36 of each pair of the spring 35 lie on five circles concentric with each other and with the axis of the cylindrical element 30 and, when the element 30 is inserted in the cup 16, with the shaft 17*a*. The angular disposition of the contacts 36 of the springs 35 will be described in connection with the description of the commutator rings hereinafter. The contacting springs 35 may be affixed to the partition 33 in any suitable manner such as by means of the sleeve rivets 37. Electrically connected to or forming a part of the contacting springs 35 are the spring terminals 38 which pass through the partition 33 through suitable apertures provided therefore and lie along the inner wall of the lower portion 30*a* of the cylindrical element 30. When the element 30 is inserted in the cup 16 the terminals 38 will extend through the apertures 39 provided therefor in the base of the cup 16 and provide means for connecting the contacting springs 35 with associated circuits, not shown. As indicated in the sectional view of Fig. 8 the mounting of the springs 35 is preferably recessed to preclude the possibility of any spring mounting interfering with the contacting circuit of any other pairs of springs.

Rotatably mounted on the shaft 17*a* and supported on the shoulder 22 is a rotor assembly 40 as shown in Fig. 9. A bushing 41 of a magnetic metal adapted to freely rotate about the shaft 17*a* forms a hub about which the other components of the rotor assembly 40 are arranged. Around one end of the bushing 41 (around the lower portion as viewed in Fig. 9) is press fitted a sleeve 42 having a flange 42*a* flaring outwardly from and perpendicularly to the axis of the sleeve 42 and the bushing 41. The lower portion of the bushing 41 may be of a slightly reduced outside diameter to form a shoulder 41*a* against which the sleeve 42 may be snugly fitted. A flat disk 43 of a magnetic metal constitutes the electromagnetic armature. The armature 43 is provided with a concentric aperture whereby it may be passed over the sleeve 42 and seated rigidly against the flange 42*a* in a position perpendicular to the axis of the bushing 41. At its periphery the disk 43 has a series of evenly spaced radial cutouts, twelve in number, leaving, as a result, twelve radially extending fingers 44. Each of the fingers 44 which constitute a plurality of poles for the armature 43 are turned downward at right angles to the plane of the armature disk 43 such that as said armature disk 43 is rotated about the axis of the bushing 41 and the shaft 17*a* the faces 44*a* of the poles 44 will be successively pre-

sented opposite the teeth **21** which constitute the poles of the heelpiece. Upon the armature disk **43** being electromagnetized along a circuit as will be more particularly described hereinafter the poles **21** and the poles **44** will become oppositely polarized and thereby will tend to remain in or be induced into the said opposing relationship.

Also rigidly mounted on the bushing **41** but at its upper extremity, as viewed in Fig. 9, is a three sectional permanent magnet armature **45**. A central hub **45***a* is rigidly affixed to the bushing **41** about which hub is rigidly fitted an annular permanent magnet **45***b*. The magnet **45***b* may conveniently be formed of a powdered metal and is encircled by a magnetic ring **45***c*. The three component sections of the permanent magnet armature **45** may be brought into one integral unit by any convenient process, such as by sintering. On the periphery of the ring **45***c* are a series of evenly spaced fingers **45***d* identical in number and angular disposition with the fingers **44** of the armature disk **43**. Through the influence of the permanent magnet **45***b* the fingers **45***d* which constitute a plurality of poles for the permanent magnetic armature **45** will be severally polarized oppositely to the polarization of the central hub **45***a*. As is evident in Fig. 10 each of the fingers **45***d* is notched at one corner of its outer face is at **45***e* for reasons that will become apparent hereinafter. Separating the permanent magnet armature **45** and the electromagnetic armature **43** and maintaining these elements in a fixed rotary and axial relationship is a circular insulating plate **46**. This plate is adapted by means of a suitable aperture to be fitted about the sleeve **42** in a plane perpendicular with the axis of the bushing **41**. Encircling the periphery of the insulator plate **46** is a series of evenly spaced insulating supports **46***a*, identical in number and angular disposition with the cutouts of the armature disk **43** and the intervals between the fingers **45***d* of the ring **45***c*. The insulating plate **46** is adapted to be fitted firmly against the lower surface of the armature disk **43**, the supports **46***a*, extending parallel to the axis of the bushing **41**, passing between the teeth **44**. The surface of the plate **46** facing the armature disk **43** may be undercut as indicated at **46***b* to insure a positive contact between the two elements. Each of the supports **46***a* has at its extremity an abutment **46***c* upon each of which the main body of the three-sectional permanent magnet armature **45** is supported. The remaining portion of each of the supports **46***c* is fitted into the intervals between the fingers **45***d*. Upon the arrangement of the component elements of the rotor assembly **40** upon the bushing **41** as described the elements are permanently secured in the described relationship in any convenient manner such as by riveting the ends of the bushing **41** back upon the adjacent element. The portion **41***c* thus will hold the armature **45** firmly against the supports **46***a* and the portion **41***b* will firmly hold in place the sleeve **42** and the insulator plate **46**. The riveted surface **41***b* may at the same time provide a bearing surface to ride on the shoulder **22**.

In the underside of the insulator plate **46** as viewed in Fig. 9 are imbedded two commutator rings **50** and **51** more clearly shown in the section view of Fig. 3. Each of the commutator rings **50** and **51** are provided with regularly spaced lobes **50***a* and **50***b*, and **51***a*, **51***b* and **51***c*, so arranged as to be successively associated with the contacts **36** of the springs **35** as the armature **40** is rotated in a manner to be more particularly described hereinafter.

A second cylindrical cup **60** also of a magnetic metal having an outside diameter preferably similar to that of the first cup **16** is provided enclosing the rotor assembly **40** and constitutes a heelpiece for the permanent magnetic armature **45**. On the lip of the cup **60** in a manner identical to that of the cup **16** are provided a series of evenly spaced teeth **61** which constitute the poles of the heelpiece. A central aperture in the base of the cup **60** is provided through which the end of the shaft **17***a* may be inserted when the cup is inverted and positioned as shown in Fig. 1. The cylindrical insulator element **30** at its upper rim also has a series of substantially rectangular cutouts **39** similar to the cutouts **32** and adapted to receive the teeth **61** and may be similarly slightly tapered to facilitate the positioning of the cup **60**. The teeth **61** and the cutouts **62** although substantially similar in size and identical in number with the teeth **21** and the cutouts **32** are arranged so that when the inverted cup **60** is positioned as shown in Fig. 1 the teeth **61** will be shifted in a rotary direction to alternate with the teeth **21** of the cup **16**. The cup **60** may be secured to the shaft **17***a* in any convenient manner such as by riveting the projecting stub of the shaft **17***a*. As the rotor assembly **40** is rotated about the shaft **17***a* the fingers **44** of the electromagnetic armature disk **43** will be successively rotated past the teeth **21** of the enclosing cup **16** while simultaneously the fingers **45***d* of the permanent magnet armature **45** will be successively rotated past the teeth **61** of the enclosing cup **60**. A slightly greater moment may be obtained for the permanent magnetic force by extending the distance of the face of each of the fingers **45***d* from the axis slightly beyond that of the fingers **44**. For this reason a slight cut-back **30***c* is necessitated in the inner rim of the element **30**. As is evident from Fig. 1 a compact, unitary assembly is formed by the three enclosing elements **16**, **30** and **60** and obviously such a unit is readily adapted to be hermetically sealed should this be desirable.

Turning now to a consideration of the operation of my invention, it will be assumed that the coil **15** is connected by means of the terminals to a suitable source of power not shown in the drawings. On the view of Fig. 3 is superimposed for illustration only the symbolized circuits associated with the relay. The circuits are designated C_1 to C_5, respectively, which designations are also used to identify the concentric disposition of the pairs of contacting springs **35** of Fig. 7. Also shown in Fig. 3, by means of points representing the contacts **36** of the contacting springs **35**, is the relative angular disposition of the contacting springs **35** of the preferred embodiment of the invention. Assuming the normal position of the rotor **40**, i. e., with the coil **15** not energized, it is seen that the contacts **36** of the circuit C_4 rest squarely on two adjacent lobes **50***a* of the commutator ring **50**. These lobes **50***a*, of which in this embodiment there are twelve, complete, through the commutator ring **50** proper, the circuit C_4 which may be connected between the coil terminals **18** and the source of power, not shown, the circuit C_4 therefore comprising an interrupter circuit for the relay. As the coil **15** is energized through the aforesaid completed circuit a magnetic circuit is established as indicated in Fig. 1 by the broken line **66**. At this point a second function of the sleeve **42** of the rotor assembly **40** becomes apparent. By increasing the cross-section of the disk armature **43** at its surface of contact with the bushing **41** and therefore with the core shaft **17***a* the reluctance at this transfer surface will be decreased thereby making available a greater flux density at the periphery, that is, at the poles **44**. With rotor **40** in its normal position, before the coil **15** is energized, the only force acting upon the rotor **40** will be the permanent magnetic force exerted through the circuit shown by the broken line **65**. Thus at this time the poles **45***d* will each be held opposite one of the poles **61** of the inverted second cup **60**. This position of the armature **45** is clearly shown in Fig. 2. The electromagnetic armature **43** will at this time be in the position also shown in Fig. 2 and in Fig. 3, that is, with the poles **44** substantially opposite the intervals between the teeth **21** of the heel-piece cup **16**. When the coil **15** is now energized an electromagnetic force greater than that exerted by the permanent magnet and overcoming the latter

force causes each of the poles 44 to be attracted to the pole 21 nearest—the nearest, as illustrated in Fig. 3, because of the comparative distances *a* and *b*—causing the electromagnetic armature 43 and therefore the rotor assembly 40 to be rotated in a clockwise direction. The faces 44*a* of the poles 44 may be slightly curved in the direction indicated so that the gap distance *a* may be gradually decreased thereby resulting in a progressively greater magnetic attraction as the electromagnetic armature 43 rotates and while the coil 15 is energized. During this rotation the poles 45*d* of the permanent magnetic armature 45 have moved off normal and the lobes 50*a* have moved from contact with the contacts 36 associated with the interrupter circuit C_4. The energizing circuit for the coil 15 is thereupon broken and the coil 15 is deenergized. The circuit 66 no longer exerts any attractive force between the faces 44*a* of the electromagnetic armature 43 and the poles 21 and the rotor assembly 40 is returned to the control ot the permanent magnet circuit 65. At this time due to the cutout notches 45*e* of the poles 45*d* the distances between the poles 45*d* and the poles 61 just passed will be greater than the distances between the said poles and next succeeding poles 61. The permanent magnet force exerted between the last-mentioned poles will therefore cause the permanent magnet armature 45 and therefore the rotor assembly 40 to continue the rotation initiated by the operation of the electromagnetic armature 43. This reaction will continue until the armature assembly 40 has returned to its normal position whereupon the contacts 36 of the interrupter circuit C_4 will again rest upon a pair of lobes 50*a* of the commutator ring 50 and the cycle just described will be repeated. Thus step-by-step the rotor assembly 40 will continue to rotate until the coil 15 energizing circuit is externally broken. In the preferred embodiment because of the number of the poles 21 and 61, i. e., twelve, each one of the cycles above described will accomplish one complete rotary step and, therefore, 1/12 of a revolution, however by increasing or decreasing the number of heelpiece poles 21 and 61 and armature poles 44 and 45*d* rotation in any number of steps may be accomplished.

The circuit C_5 associated by means of contacts 36 with the lobes 50*b* is closed at the half step rotary position of the armature assembly 40 when the circuit C_4 is open. The circuit C_5, the associated lobes 50*b* which also number twelve and alternate with the lobes 50*a* is therefore closed every twelfth half step alternating with the twelve complete steps during which the interrupter circuit C_4 is closed. This circuit C_5 may therefore be used in any application in which impulses alternating with the relay coil energizing impulses are required. It should be clear that the duration of the impulses is dependent upon two factors: the speed of rotation of the rotor assembly 40 which in turn is dependent largely upon the effectiveness of the magnetic fields, and the angular width of the lobes 50*a* and 50*b*. This latter dimension may be most easily adjusted according to the needs of the particular relay application. The use of only a single commutator ring 50 to effect the closing of both the circuits C_4 and C_5 is, of course, made possible by the alternate operation of the circuits. This alternation of operation makes possible with regard to the commutator ring 51 the association therewith of three operating circuits, circuits C_1, C_2 and C_3. The two lobes 51*a* and the contacts 36 associated with the circuit C_1 are shown separated by four complete rotary steps as may be necessary as dictated by the position of the associated pair of contacting springs 35 of Fig. 7. Since only two lobes 51*a* are provided the circuit C_1 will be closed only once for every complete rotation of the rotor assembly 40, that is, every twelfth complete rotary step of the rotor 40. The lobes 51*a* are formed as extensions of two of the lobes 51*b*, three in all of which are provided, each of which is also separated, but necessarily, by four complete rotary steps of the rotor 40. Since only two contacts 36 are associated with the three lobes 51*b* it is evident that the circuit C_2 will be closed once for every four complete rotary steps of the rotor 40. The lobes 51*c* are each separated by two complete rotary steps of the rotor 40, and since the lobes 51*c*, six in number, are also associated with only two contacts 36 the circuit C_3 associated therewith will be closed once every second complete rotary step of the rotor 40. The contacts 36 may obviously be angularly positioned in a manner other than as shown in Fig. 3, however to achieve the sequence of operation of the circuits C_1, C_2 and C_3 as above described it is required, assuming the closing of the circuit C_1 at the 0° angular rotation of the rotor assembly 40, that the circuit C_2 be closed at each 60°, 180°, and 300° angular rotational position and that the circuit C_3 be closed at each 30°, 90°, 150°, 210°, 270°, and 330° angular rotational position of the rotor assembly 40.

It is to be understood that, although the sequence of the contacting springs 35 has been based only on the utilization of the twelve complete rotary steps of the rotor 40 as described, other sequences of operation are available. Since every complete rotary step of the rotor 40 involves a partial step from the normal position and a partial step in return to a next succeeding normal position the half steps so resulting in actuality make available 24 rotary positions within which additional sequential arrangements may be developed. In that case proper and perhaps additional lobes will be required on the commutator ring 51.

What has been described is considered to be the preferred embodiment of my invention and it is to be further understood that other modifications in addition to those suggested in the preceding paragraph, both in structure and manner of operation, may be made without departing from the scope of my invention as defined in the claims which follow.

What is claimed is:

1. In a switching device having more than one normal position, a permanent magnetic armature associated with a first heelpiece and completing a magnetic circuit therewith, an electromagnetic armature associated with a second heelpiece, switching means associated with said armatures and operated jointly thereby, the flux flowing in said magnetic circuit holding said permanent magnetic armature and thereby said switching means in a first normal position, and an operating coil for said electromagnetic armature, said coil when energized completing an electromagnetic circuit through said second heelpiece and said electromagnetic armature whereby said electromagnetic armature is operated to thereby operate said switching means from said first normal position, the flux flowing in said magnetic circuit moving said permanent magnetic armature and thereby said switching means to a second normal position when said electromagnetic circuit is broken.

2. In a magnetic switching device having more than one normal position, a first armature and heelpiece, a permanent magnet associated with said first armature to complete a magnetic circuit through said first armature and heelpiece, a second armature and heelpiece, an electromagnet associated with said second armature, said electromagnet when energized completing an electromagnetic circuit through said second armature and heelpiece, said second armature cooperating with said first armature, switching means associated with said first and said second armatures and operated jointly thereby said switching means including a plurality of contacts closed in the different successive positions thereof, the flux flowing in said magnetic circuit holding said first armature and thereby said switching means in a first normal position, the flux produced in said electromagnetic circuit causing operation of said second armature and thereby moving said switching means from said first normal position

when said electromagnet is energized to thereby close one of said contacts.

3. In a magnetic switching device having more than one normal position as claimed in claim 2, in which the operation of said second armature also moves said first armature from said first normal position, and in which the flux flowing in said magnetic circuit moves said first armature and thereby said switching means to a second normal position when said electromagnet is deenergized.

4. In a magnetic switching device having more than one normal position, a shaft, a first rotary armature having a plurality of poles rotatably mounted on said shaft, a first fixed heelpiece having a plurality of poles adjacent to said poles of said first armature, a permanent magnet associated with said first armature and arranged to complete a plurality of magnetic circuits through said poles of said first armature and said first heelpiece, a second rotary armature mounted on said shaft and corotatable with said first armature, a second fixed heelpiece having a plurality of poles, said second armature having a plurality of poles adjacent to said poles of said second heelpiece, an electromagnet associated with said second armature, said electromagnet energized at times to complete a plurality of electromagnetic circuits through said poles of said second armature and said second heelpiece, the flux flowing in said magnetic circuits holding said first armature in a first normal rotary position whereby said poles of said first armature will be aligned with said poles of said first fixed heelpiece and the poles of said second armature will be out of alignment with said poles of said second fixed heelpiece, the flux flowing in said electromagnetic circuits when said electromagnetic is energized operative to move said poles of said second armature into alignment with said poles of said second fixed heelpiece thereby rotating said first armature from said first normal rotary position, and switching means associated with said first and said second armatures and operated jointly thereby, said switching means being in a first normal position when said first armature is in a first normal position and operated when said first armature is rotated from said first normal position, the said flux in said magnetic circuits operative to move said first armature to another normal position when said electromagnet is deenergized to thereby move said switching means to another normal position.

5. In a magnetic switching device having more than one normal position, an operating coil having a core, a rotor assembly rotatably mounted on an extension of said core, said rotor assembly comprising a permanent ring magnet having a plurality of poles on the periphery thereof, and a rotary armature also having a plurality of poles on the periphery thereof, a first fixed heelpiece having a plurality of poles adjacent to the poles of said ring magnet, a second fixed heelpiece having a plurality of poles adjacent to the poles of said rotary armature, said poles of said first heelpiece alternately spaced relative to said poles of said second heelpiece, said permanent magnet completing a plurality of magnetic circuits through said poles of said permanent magnet and said poles of said first heelpiece causing a flux to flow therein to hold said rotor in a first normal rotary position, said operating coil energized to complete a plurality of electromagnetic circuits through said core, and said poles of said rotary armature and said poles of said second fixed heelpiece causing a flux to flow therein to rotate said rotor from said first normal position, deenergization of said coil permitting said permanent magnet to move said rotor to a second normal position, and switching means associated with said rotor and operated thereby, said switching means being in a first normal position when said rotor is in said first normal position and in an operated position when said rotor is rotated from said first normal position, said switching means moved to a second normal position when said rotor is so moved.

6. In a magnetic switching device having more than one normal position, an operating coil having a core, a rotor rotatably mounted on an extension of said core, said rotor comprising a permanent ring magnet having a predetermined number of poles peripherally associated therewith, and a rotary armature having a number of poles similar in number and angular disposition to said poles of said permanent magnet peripherally associated therewith, a first fixed heelpiece encompassing said permanent ring magnet, said first heelpiece having a number of poles similar in number to said poles of said permanent magnet, a second fixed heelpiece encompassing said rotary armature, said second heelpiece having a number of poles similar in number to said poles of said rotary armature, said poles of said second heelpiece alternating in angular disposition with said poles of said first heelpiece, said permanent magnet completing a plurality of magnetic circuits through said poles of said permanent ring magnet—and said poles of said first heelpiece causing a flux to flow therein to hold said magnet poles and said first heelpiece poles in alignment to thereby hold said rotor in a first normal rotary position, said poles of said rotary armature and said second heelpiece poles thereby held out of alignment, said operating coil energized to complete a plurality of electromagnetic circuits through said core and said armature poles and said second heelpiece poles to cause a flux to flow therein to draw said armature poles and said second heelpiece poles into alignment and said permanent magnet poles and said first heelpiece poles out of alignment to thereby rotate said rotor from said first normal rotary position, said operating coil deenergized to permit the said flux in said permanent magnetic circuit to again draw said permanent magnet poles and said first heelpiece poles into alignment to thereby rotate said rotor into a next succeeding normal rotary position, and switching means associated with said rotor and operated thereby, said switching means being in a first normal position when said rotor is in a first normal position and in an operated position when said rotor is rotated from said first normal position, said switching means rotated to the next succeeding normal position when said rotor is moved to the next succeeding normal position.

7. In a magnetic switching device having more than one normal position as claimed in claim 6, said switching means comprising a commutator ring associated with said rotor and corotatable therewith and a plurality of pairs of contact springs associated with said commutator ring, said commutator ring electrically connecting a first pair of said contact springs and electrically disconnecting a second pair of said contact springs as said rotor is rotated from said first normal rotary position and electrically disconnecting said first pair of said contact springs and electrically connecting said second pair of said contact springs as said rotor is rotated into a said next succeeding normal rotary position.

8. In a magnetic switching device having more than one normal position as claimed in claim 6, said switching means comprising a plurality of commutator rings, said rings associated with said rotor and corrotatable therewith, each of said rings being provided with a plurality of sets of lobes, each of said sets of lobes being integral with said respective commutator rings, and a plurality of pairs of contact springs, each of said pairs of springs being individually associated with one of said sets of commutator lobes, said lobes electrically connecting and disconnecting said springs of each of said contact spring pairs through said commutator rings as said rotor and said commutator rings are rotated, said lobes and said contact spring pairs being so related that only one pair of said contact springs on each of said commutator rings will be electrically connected in any rotary position of said rotor.

9. In a magnetic switching device having more than one normal position, a shaft, a rotor rotatably mounted on said shaft, said rotor comprising a permanent ring

magnet and a rotary armature, each of said last-named elements having a predetermined like number of poles on the periphery thereof, said poles of each of said last-named elements being in substantial rotary alignment, and a first and a second commutator ring, said rings each being provided with a plurality of sets of lobes thereon, said sets of lobes of said first ring alternating on said ring and said sets of lobes of said second ring spaced in a predetermined relationship, a first circular heelpiece having a like predetermined number of poles adjacent to said poles of said permanent ring magnet, said poles of said permanent magnet adapted to rotate opposite said poles of said first heelpiece as said rotor is rotated on said shaft, a second circular heelpiece having a like predetermined number of poles adjacent to said poles of said rotary armature, said poles of said second heelpiece alternating about said shaft with said poles of said first heelpiece such that when said poles of said magnet are in rotary alignment with said poles of said first heelpiece the poles of said rotary armature will be out of alignment with said poles of said second heelpiece, said poles of said armature adapted to rotate opposite said poles of said second heelpiece as said rotor is rotated on said shaft, a coil, a core for said coil, an energizing circuit for said coil, and a plurality of pairs of contact springs associated respectively with said sets of commutator lobes, said lobes electrically connecting the individual springs of each of said contact spring pairs in sequence through said commutator rings as said pairs of springs contact said lobes, the pair of said plurality of pairs of contact springs associated with one of said sets of lobes of said first commutator ring controlling said coil energizing circuit, said permanent magnet completing a plurality of magnetic circuits through said permanent magnet poles and said first heelpiece poles, said magnetic circuits effective to bring said poles of said permanent magnet into alignment with said poles of said first heelpiece to thereby bring said rotor to a first normal rotary position, the said pair of said contact springs controlling said coil energizing circuit being electrically connected through the said one of said sets of lobes of said first commutator ring when said rotor is in said first normal position to thereby close said coil energizing circuit, said coil thereby energized to complete a plurality of electromagnetic circuits through said poles of said rotary armature and said poles of said second heelpiece, said electromagnetic circuits effective to rotate said armature poles into alignment with said poles of said second heelpiece to thereby rotate said rotor from said first normal rotary position whereby the said pair of contact springs controlling said coil energizing circuit is electrically disconnected to open said coil energizing circuit whereby said coil is deenergized, said permanent magnet circuit effective to rotate said poles of said permanent ring magnet into alignment with the next succeeding poles of said first heelpiece to thereby rotate said rotor into a next succeeding normal rotary position.

10. In a magnetic switching device having more than one normal position as claimed in claim 9, in which said rotor includes an insulator element for maintaining said permanent ring magnet, said rotary armature, and said first and said second commutator ring in a predetermined fixed relationship.

11. In a magnetic switching device having more than one normal position as claimed in claim 10, in which said core for said coil comprises an extension of said shaft, said plurality of electromagnetic circuits completed through said core and said shaft, and the rotation of said rotor into a next succeeding normal rotary position again electrically connecting the said pair of said contact springs controlling the said coil energizing circuit through the said one of said sets of lobes of said first commutator ring to thereby again close said coil energizing circuit whereby said rotor is again rotated from said next succeeding normal rotary position, said rotor being thereby caused to rotate continuously about said shaft.

12. In a magnetic switching device having more than one normal position as claimed in claim 11, in which said pairs of contact springs of said plurality of contact springs are so arranged with respect to the said sets of lobes of said commutator rings that only one of the pairs of contacting springs will be electrically connected by each of the commutator rings for any rotary position of said rotor, and said sets of lobes and said pairs of contact springs being so arranged and related that said springs of said pairs of contact springs will be electrically connected and disconnected in various sequences as said rotor is continuously rotated.

13. In a magnetic switching device having more than one normal position as claimed in claim 12, in which an insulator element separates said first and said second circular heelpieces, said first heelpiece enclosing said permanent ring magnet, said second heelpiece enclosing said coil and said rotary armature, said first heelpiece, said last-named insulator element and said second heelpiece constituting an integral envelope for said switching device.

14. A magnetic switching device having more than one normal rotary position comprising commutator means having contacting means cooperative therewith, a plurality of circuits individually operated by said contacting means, said circuits sequentially opened and closed as said commutator is rotated, and means for rotating said commutator comprising a first rotary armature and heelpiece means, a second rotary armature and heelpiece means, a first magnetic circuit through said first rotary armature and heelpiece means, a first means for energizing said first magnetic circuit, a second magnetic circuit through said second rotary armature and heelpiece means, and a second means for energizing said second magnetic circuit, said first magnetic circuit effective through said first armature and heelpiece means to move said commutator means to a first normal rotary position and said second magnetic circuit effective through said second armature and heelpiece means to move said commutator means to a next succeeding rotary position, said first and said second magnetic circuits effective alternately to continuously rotate said commutator means through successive normal rotary positions.

15. A magnetic switching device having more than one normal rotary position as claimed in claim 14, in which said first means for energizing said first magnetic circuit comprises a permanent magnet, said first magnetic circuit permanently energized thereby, said second means for energizing said second magnetic circuit comprises an electromagnet energized periodically to periodically energize said second magnetic circuit, and in which said second magnetic circuit exerts a substantially greater influence than said first magnetic circuit.

16. A magnetic switching device having more than one normal rotary position as claimed in claim 15, a first plurality of magnetic circuits through said first rotary armature and heelpiece means, said first energizing means energizing said first plurality of magnetic circuits, a second plurality of magnetic circuits through said second rotary armature and heelpiece means, said second energizing means energizing said second plurality of magnetic circuits, said second plurality of magnetic circuits exerting a substantially greater influence than said first plurality of magnetic circuits, said first and said second plurality of magnetic circuits effective alternately to continuously rotate said commutator means through successive normal rotary positions.

17. A magnetic switching device comprising a shaft, a rotor rotatably mounted on said shaft, a coil mounted on said shaft, said shaft constituting a core for said coil, said rotor comprising a first armature including a permanent magnet, said first armature having a plurality of

radial poles, a second armature having a plurality of radial poles, commutator means, and an insulating element maintaining said first armature, said second armature and said commutator means in isolated fixed relation, a first fixed heelpiece rigidly mounted on one extremity of said shaft and encompassing said first armature, said first heelpiece having a plurality of poles adjacent to said poles of said first armature, a second fixed heelpiece rigidly mounted on the other extremity of said shaft and encompassing said coil and said second armature, said second heelpiece having a plurality of poles adjacent to said poles of said second armature, said poles of said second heelpiece alternating with said poles of said first heelpiece such that the poles of one only of said armatures are aligned with corresponding heelpieces at one time, a second insulating element isolating and maintaining said first and said second heelpieces in a fixed relation, said first heelpiece, said second insulating element and said second heelpiece forming an integral envelope for said switching device, a plurality of contacting means cooperative with said commutator means, said plurality of contacting means having a plurality of circuits respectively associated therewith, said coil periodically energized to periodically magnetize said second armature, said magnetized first armature and said periodically magnetized second armature cooperating with said alternating poles of said first and said second heelpiece respectively to rotate said rotor on said shaft, said commutator means cooperating with said contacting means to sequentially open and close said circuits as said rotor is rotated.

18. In a magnetic switching device as claimed in claim 17, said contacting means comprising pairs of contact springs mounted within said envelope in connection with said second insulating element and so arranged to sequentially cooperate with said commutator means as said rotor is rotated, said springs having terminals extending outside of said envelope.

19. In a magnetic switching device having more than one normal position, a first armature and a heelpiece, a permanent magnet associated with said first armature to complete a plurality of magnetic circuits through said first armature and heelpiece, a second armature and a heelpiece, an electromagnet associated with said second armature, said electromagnet when energized completing a plurality of electromagnetic circuits through said second armature and heelpiece, said second armature cooperating with said first armature, switching means associated with said first and second armatures and operated jointly thereby, the flux flowing in said magnetic circuits holding said first armature and thereby said switching means in a first normal position, the flux produced in said electromagnetic circuits causing operation of said second armature and thereby moving said switching means from said first normal position when said electromagnet is energized, the flux produced in the first armature effective to move said switching means to the next successive normal position when said electromagnet is deenergized, the flux produced in the electromagnetic circuits effective to again move said switching means from said successive normal position when the electromagnet is reenergized, said switching means thereby caused to move to successive normal positions.

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