June 11, 1957 L. C. PERKINS ET AL 2,795,773

REPEATING MULTIPOLE SELECTOR RELAYS

Filed May 16, 1952

Fig. 1.

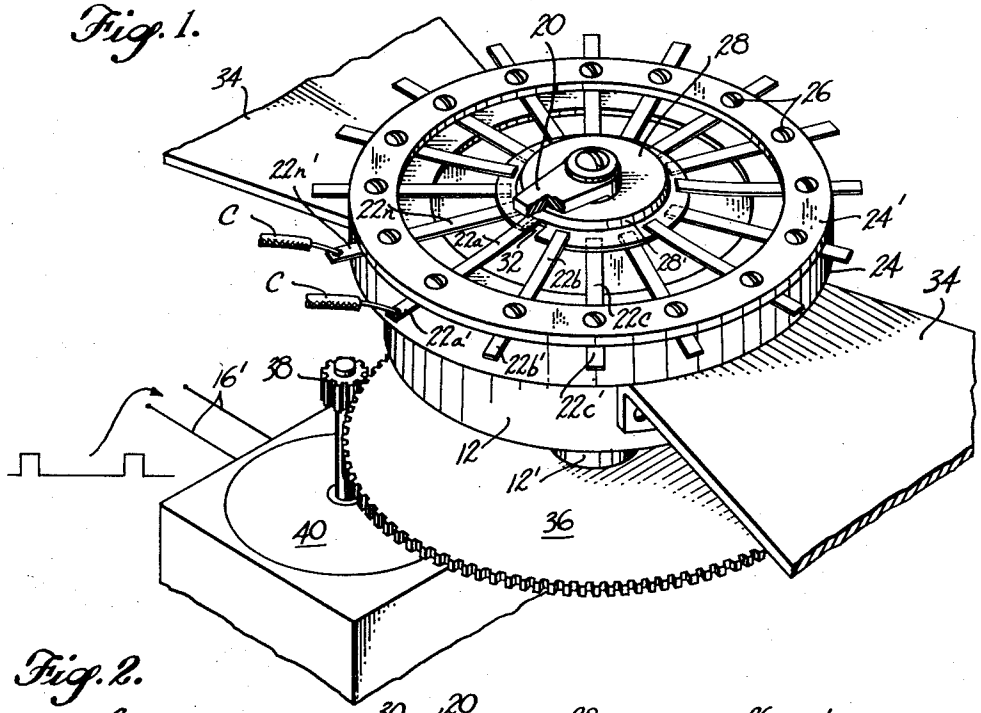


Fig. 2.

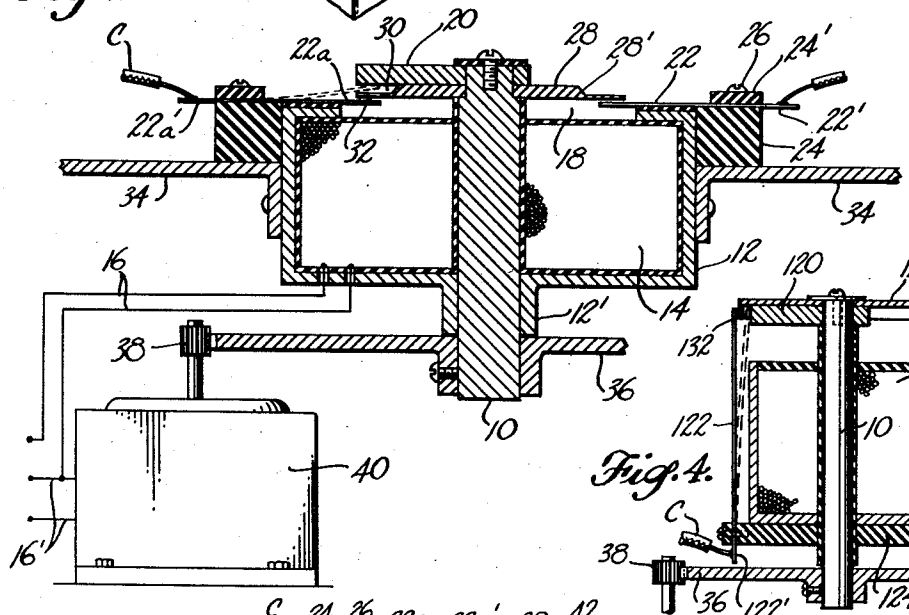
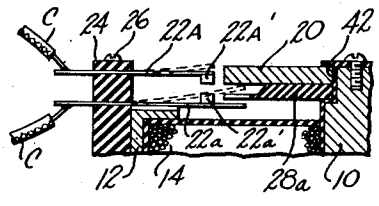


Fig. 4.

Fig. 3.



INVENTOR.
LEROY C. PERKINS
FRANCIS D. REYNOLDS

BY
Reynolds, Beach & Christman

ATTORNEYS

United States Patent Office 2,795,773 Patented June 11, 1957

2,795,773

REPEATING MULTIPOLE SELECTOR RELAYS

Leroy C. Perkins and Francis D. Reynolds, Seattle, Wash., assignors to Boeing Airplane Company, Seattle, Wash., a corporation of Delaware

Application May 16, 1952, Serial No. 288,254

9 Claims. (Cl. 340—147)

This invention relates to sequentially selective switching devices for remote control or automatic relay applications and more particularly concerns a device permitting rapid independent control of a plurality of circuits or elements through a common communication channel, such as a radio-frequency carrier channel or a single set of electrical conductors. The invention is herein illustratively described by reference to the preferred form thereof, which was devised for the remote control of a plurality of electrically operated units in toy vehicles, such as boats, trains, airplanes, etc. It will be understood, however, that the invention has various diverse applications and that a number of modifications and variations as to details of construction and operation may be made without departing from the underlying principles involved to which the appended claims are directed.

A typical remote relaying system for incorporation of the present selector relay includes a receiving station having a plurality of circuits or elements requiring independent selective control, a remote transmitting station incorporating a suitable primary control apparatus for generating selective control impulses in a form by which the individual impulses may be identified from each other, and a communication link for transmitting the selective control impulses to the receiving station, wherein the selector relay device is installed for operating the individual circuits or elements on the basis of the control impulses received. For present purposes the nature of the communication link, i. e., whether it be a single set of electrical conductors, a radio carrier channel or other medium of communication is immaterial. The number or nature of the plurality of circuits or elements controlled by the selector relay at the receiving station in accordance with the transmitted impulses, are likewise factors of secondary import. The same is true with respect to the choice of apparatus as the transmitting station for generating the desired control impulses, and the particular means by which such impulses are made distinguishable. For each of these purposes or functions conventional techniques or devices may be employed as will hereinafter more fully appear, which require no particular description in this specification. In its presently illustrated and preferred form, the improved selector relay device operates on the principle of rotary timing members in the two stations which members are driven and maintained in synchronism by suitable synchronizing signals transmitted over a communication link. Preferably one of these rotary timing members is driven by a progressive stepping motor, or the like, which is energized by a recurring train of electrical impulses generated and transmitted by progressive rotary movement of the rotary timing member in the other station so as to maintain the two members in step at all times. It is immaterial which of the two stations generates and transmits the synchronizing impulses and also as to the manner in which phasing or co-indexing of the two rotary timing members is initially established or is subsequently

restored if lost during operation of the system. In this connection there exist a variety of automatic self-synchronizing devices including selsyn systems and various forms of stepping mechanisms common to telemetering, telephony and other allied arts which could be used for synchronizing the timing members. These and other aspects of a system of that type are or may be conventional hence require no particular description herein.

The improved selector relay device includes a plurality of independently operated switch elements or the like which control different respective circuits or devices in the receiving station of such a system. These switch elements are operated (actuated or deactuated) in predetermined sequential order, by the presence or absence of transmitted control impulses during different portions of the timing member's rotation cycle. In other words, the total rotation cycle is divided in to a plurality of parts each corresponding to an individual switch element in the relay device. If, as the timing member rotates through each such portion of its cycle, a control impulse is received by the device the associated switch element will be actuated, whereas if no such impulse is then received, the switch element will either remain unactuated or will be deactuated, depending upon its immediately preceding condition. Moreover, each such switch element is caused to remain in its position of actuation or deactuation during the ensuing cycle of the rotative timing member. By employing synchronized timing members which rotate rapidly, the minimum duration of the period in which any particular switch element is required to remain in a given position may be made very short, whereas the maximum duration of the period during which a particular position may be maintained is unlimited assuming the condition of the system with respect to the presence or absence of the corresponding control impulse remains unchanged during continued rotation of the timing members.

An object of the invention is a selector relay device of the nature indicated which may be made in very simple, compact and inexpensive form for the purposes indicated, as well as others.

Another object is such a device capable of rapid selective control of a plurality of independent circuits or devices in accordance with electric signal impulses applied in recurring sequential manner to such device.

Still another object is such a relay device having a positive holding action which insures maintenance of the actuated or unactuated position of each switch element therein during the periods between opportunity for change of position of such element.

A further and related object is a selector relay device of the type indicated which is readily constructed with any desired number of individual switch elements so as to enable controlling any desired number of independent circuits or devices thereby.

In broad terms the multipole selector relay means comprises a plurality of switch elements arranged in series relationship, an electrically energizable actuating device movable along the series of switch elements for actuating any such element past which the device is moving at the instant of energization thereof, means holding the actuated switch elements in actuated positions against the force of resilient means or the like tending to urge such elements into their unactuated positions, and release means associated with the holding means and movable with the actuating means. The release means permits release from such holding means of any switch element in actuated position at the instant such element is being passed by the moving actuating means provided the latter is unenergized at the time, so as not to require continued actuation of the particular element.

In the first preferred form as herein described, the

switch actuating means comprising a magnetic flux concentrator which rotates with a circular plate having an opening or notch in its edge adjacent the concentrator, and the switch elements comprise resilient arms located at intervals about the periphery of the circular plate and disposed to project radially inwardly thereof along one side of such plate in the unactuated positions of the switch arms. A magnetic induction coil in the device provides magnetic flux through the flux concentrator at selected times during rotation of the concentrator and notched plate to deflect the instantaneously adjacent switch arm through the notch to the opposite side of the plate where it remains and slides during the remaining portion of the total rotation cycle. If upon completion of such rotation cycle the magnetic induction coil is again energized, the same switch arm is compelled to remain in its actuated position, whereas it is permitted to drop back freely through the notch to its unactuated position if no such energization occurs at that time. Thus the circular plate functions as a positive barrier or holding device functioning to maintain each switch arm in its position of actuation or deactuation at all times except when the flux concentrator and plate notch are passing the switch arm, when its position may be changed in accordance with the presence or absence of an energizing impulse applied to the magnetic induction coil.

In the second preferred general form herein described the switch arms, mounted in circular series arrangement, are disposed in parallel relationship, and the notched annular plate is of cylindrical form rather than flat circular form.

These and other features, objects and advantages of the invention will become more fully evident from the following detailed description thereof by reference to the accompanying drawings.

Figure 1 is a perspective view of the selector relay device.

Figure 2 is a vertical sectional view taken through the axis of the device.

Figure 3 is a similar sectional view illustrating certain details of a modified form.

Figure 4 is a vertical view taken through the axis of a second modified form of the invention.

With reference to Figures 1 and 2 a rotary shaft **10** of ferromagnetic material is journaled in a lower hub portion **12'** of the ferromagnetic cylindrical casing **12**. The casing contains an induction coil **14** surrounding the shaft **10** and electrically energizable through conductors **16** to set up an axial component of magnetic flux in the shaft. The ferromagnetic casing **12** provides a toroidal path for the magnetic flux entering one end of the shaft and leaving the opposite end thereof. However, the upper side or end of the cylindrical casing **12** has a large central opening **18** therein constituting an annular air gap interposed in the toroidal flux path.

A radial ferromagnetic arm **20** fixed upon the upper end of the shaft **10** at a location somewhat above the air gap **18** acts as a flux concentrator bridging over this air gap. Preferably, however, the radial length of the arm **20** is somewhat less than the radial width of the air gap **18**.

A plurality of switch arms **22***a*, **22***b*, **22***c*, etc., are mounted upon an insulating support **24** surrounding the upper end portion of the casing **12**. Of ferromagnetic material and tempered for resilience, these flat and elongated switch arms, located in angularly spaced relationship about the annular member **24**, project radially inwardly over the air gap **18** to lie beneath the path of rotation of the flux concentrator arm **20** as the latter turns with the shaft **10**. The switch arms are held firmly in place by an insulating clamping ring **24'** and machine screws **26** threaded through the ring and the individual switch arms, and down into the insulating block **24** which in turn is rigidly secured by suitable means to the housing **12**. The outer ends of the switch arms **22***a*, **22***b*, **22***c*, etc., designated **22***a'*, **22***b'*, **22***c'*, etc., respectively, serve as electric terminals or soldering lugs by which the electrical conductors C may be connected to the respective arms.

A conductive circular plate **28** is fixedly mounted upon the upper end of the shaft **10** immediately beneath the flux concentrator arm **20**. The radius of this plate is approximately equal to the radial length of the arm **20**, although its exact dimension is not particularly critical. The important factor is that the inner or projecting ends of the switch arms lap slightly under the circular plate **28** in the relaxed or undeflected positions of the switch arms (Figure 2). The thickness of the circular plate is reduced by a step in its upper face occurring at a radius slightly less than the radius to the inner ends of the switch arms. This step **28'** leaves a space **30** between the lower side of the concentrator arm **20** and the stepped upper side of the plate **28**.

When the ferromagnetic arm **20** is located immediately above or adjacent a particular switch arm, such as the arm **22***a* in Figures 1 and 2, and voltage is applied to the induction coil **14**, the resultant concentration of magnetic flux in the arm **20** attacts the switch arm **22***a* into the space **30** above the circular plate **28**. A notch **32** in the edge of the plate permits upward deflection of the switch arm to the flux concentrator arm **20** as shown by dotted lines in Figure 2. If the switch arm is magnetically held in this deflected position for a moment as the shaft **10** rotates the notched portion of the plate **28** out of registry with the switch arm, then removal of energization from the induction coil **14** will not be effective to return the arm by its own resilience back into its unactuated or relaxed position shown by solid lines in the same figure. Instead the arm will come to rest upon the upper face of the circular plate **28** and will slide thereon as the plate continues to rotate.

If the magnetic induction coil **14** remains unenergized as the flux concentrator arm **20** and the notch **32** pass over a different switch arm, **22***n* for example (Figure 1), the latter will remain in its unactuated or relaxed position beneath the plate **28**.

If, on the other hand, the magnetic flux concentrator arm **20** and the notch **32** advance into registry with a switch element riding on top of the plate **28** and the magnetic induction coil **14** is then unenegized, that particular switch element will snap resiliently down through the notch **32** into its normal or unactuated position.

Still again, if the magnetic induction coil **14** happens to be energized by a voltage impulse when the latter position of registry is reached it will be obvious that the actuated position of the particular switch arm will be continued for another complete cycle of rotation of the shaft **10**.

The conductive plate **28** constitutes a common ground terminal for all of the switch arms **22***a*, **22***b*, **22***c*, etc. The individual switch arms are out of contact with the plate **28** as long as they remain in their unactuated or relaxed positions. However, they are held steadily in contact with the plate during a full cycle of rotation thereof when actuated by the electrically energizable magnetic means comprising the coil **14** and the flux concentrator **20**. In order to expedite actuation and deactuation of the individual switch elements, the reduced portion of the circular disk **28** is made as thin as possible so as to minimize the total deflection of the switch arms necessary in moving between extreme positions. Ground contact of an individual switch arm is further expedited by its engagement with the underside of the magnetic flux concentrator **20** which is contacted before the switch arm drops down upon the upper side of the conductor plate **28**. For this reason it is preferred to copper plate or silver plate the flux concentrator arm **20** in order to form a good early contact upon switch actuation.

The casing **12** is provided with suitable mounting flanges **34**. The lower end of shaft **10** carries a large gear **36** which

meshes with a small pinion **38** driven by a stepping motor device **40**. The latter device may be energized by electrical impulses applied through electrical conductors **16'** in order to cause the shaft **10**, hence the flux concentrator arm **20** and the notched plate to rotate progressively by angular increments each equal to or a submultiple of the spacing between successive switch arms **22***a*, **22***b*, **22***c*, etc. Thus the shaft **10** constitutes a rotary timing member which may be synchronized with a similar timing member in a remote station through a communication channel including the conductors **16'**. The channel conductors **16** then afford a means of receiving selective control impulses applicable to the induction coil **14** in the different stopping points or points of registry of the flux concentrator **20** and the barrier plate opening **32** with the respective switch arms. Electric circuits or other devices may then be independently controlled by their respective switch elements **22***a*, **22***b*, **22***c*, etc., of which there may be any desired number provided.

In Figure 3 a fragmentary portion of a modified device is illustrated in order to show an alternative type of switch element. The switch arm **22***a*, similar in other respects to the arm **22***a*, in Figure 2, for example, carries on its upper side a switch contact **22***a'*. Another resilient switch arm **22A** mounted above the arms **22***a* carries a similar contact **22A'** beneath its projecting end overlying the contact **22***a'*. When the arm **22***a* is magnetically actuated into its dotted line position, the two contacts come into engagement, producing a slight upward deflection of the arm **22A**. Such engagement persists even though the arm **22***a* drops down slightly to rest upon the upper side of the circular insulating plate **28***a*, due to the resilient return of the arm **22A**. Preferably the arm **22A** is of nonferromagnetic material. There is thereby provided a type of switch device in which both contact elements may be insulated from ground so as to enable use of the selector relay device for controlling a plurality of circuits which may have differing reference potentials. For that type of application the plate **28** and arm **20** are insulated by the spacer **42** from shaft **10**.

In the second modified form appearing in Figure 4 a contact flange **128'** of cylindrical form on the periphery of plate **128** is employed in lieu of the flat circular flange **28'** on plate **28** in Figures 1 and 2. The resilient ferromagnetic switch arms **122** having ends overlapping the flange **128'** are disposed parallel to each other in circular series arrangement extending around the ferromagnetic jacket **112** of magnetic induction coil **114**. A stationary insulating disk **124** centrally apertured for journalling of ferromagnetic shaft **10** therein serves as an insulating support for arms **122** spaced apart around its periphery, the arms being held in place by insulating clamp rings **124'**. The lower end portions **122'** of arms **122** project below the plate **124** to provide external circuit connecting lugs as in the preceding forms.

As in the preceding forms the flux concentrator arm **120** is rotatively connected to the plate **128** and shaft **10**. A notch **132** in flange **128'** adjacent the outer end of arm **120** permits the selective actuating and deactuating movement of the individual switch arms in successive order as the shaft rotates and coil **114** is either energized or deenergized at the respective positions of registry during the rotation cycle.

The cylindrical form illustrated in Figure 4 has certain advantages over the flat circular plate form shown in Figure 1, for example, in its potentially smaller diameter and volume of space required, the inherently smaller magnetizing force necessary for actuating the switch arms as a result of the more efficient flux utilization, and the somewhat greater ease of servicing the device involving cleaning the switch contact faces which are more easily accessible in the cylindrical form than they are in the other form in the absence of special provisions for quick disassembly.

It will, of course, be obvious that the invention includes

still other possible forms of moving notched barrier plates between the sides of which control elements such as switch arms are actuated and deactuated, so that a detailed description of all of these should be unnecessary.

It will likewise be obvious that the uses to which the invention may be put, including remote control, automatic relaying and similar applications, also extend to the storage of information in binary digital form for indefinite periods of time. For instance, a relay with twenty-one contacts could store binary numbers equivalent to over one million in the decimal system. Thus a number would be "read" into relay as a storage device by cycling the slotted disk (i. e. one revolution) meantime pulsing the contact actuator in such a manner as to actuate certain contacts to represent the number "one" or to fail to actuate certain other contacts to represent the number "zero." The order of the "ones" and "zeroes" then represent the desired number to be recorded. The number will remain stored until the slotted disk is again cycled. Recapitulation or "reading back" of the stored information by the device is then accomplished by cycling the slotted disk and taking note ((automatically or otherwise) of the contacts which were actuated during the previous storage cycle of rotation, by their resilient return movement.

We claim as our invention:

1. Multipole selector relay means comprising a rotatable annular member, a plurality of magnetically actuatable switch elements comprising ferromagnetic material, means supporting said switch elements individually at locations spaced apart about the periphery of said rotatable member, and disposing such switch elements to lap one side of said member in the unactuated positions of such elements, yieldable return force-producing means normally maintaining said switch arms in unactuated position and yieldably resisting deflection thereof individually into respective actuated positions thereof lapping the opposite side of said rotatable member with such yieldable return force-producing means stressed thereby, and magnetic switch-element actuating means electrically energizable during such rotation of said member to pass magnetic flux through an individual switch element and thereby deflect such element then instantaneously adjacent such magnetic actuating means into actuated position of such element, said rotatable annular member having a restricted opening extending between opposite sides thereof permitting switch element deflection therethrough to entrap the element in actuated position on the opposite side of said annular member during continued rotation thereof until reregistry of such opening with such actuated element whereupon the return force-producing means instantly returns such element to its unactuated position through such opening.

2. Multipole selector relay means defined in claim 1, wherein the individual switch elements comprise resiliently flexible switch arms the resilience of which provides the return force acting on such arms.

3. Multipole selector relay means comprising a plurality of flexibly resilient ferromagnetic switch element strips, stationary means mounting said strips by corresponding ends thereof to project bodily therefrom into normal positions of the projecting ends of said strips lying in circular series relationship in the undeflected condition of said strips, said projecting strips being deflectable individually against the inherent resilient force thereof into actuated positions of their projecting ends displaced in like senses from the normal positions thereof, electromagnet means operable to scan said series of strips sequentially, and selectively energizable when in registry with any such strip for application of magnetic flux directly to said strip of an intensity producing deflection thereof into actuated position without similarly deflecting adjacent strips, and strip detaining means controlled in accordance with scanning position of said electromagnet means relative to said strips, continuously holding any

deflected strip in its actuated position while said electromagnet means registers with any other strip and constructed and arranged to permit resilient return of a deflected strip to its normal position by reregistry of said electromagnet means therewith.

4. Multipole selector relay means comprising a rotatable annular member, a plurality of magnetically actuatable switch elements, means supporting said switch elements individually at locations spaced apart about the periphery of said rotatable member, and disposing such switch elements to lap one side of said member in the unactuated positions of such elements, said switch elements comprising resilient ferromagnetic metal strips and said rotatable annular member comprising a circular plate lapped by such resilient strips projecting generally radially and inwardly of such plate, said strips being resiliently deflectable into respective actuated positions thereof lapping the opposite side of said rotatable circular plate, and magnetic switch-element actuating means electrically energizable during such rotation of said circular plate to deflect the individual switch element then instantaneously adjacent such magnetic actuating means into actuated position of such element, said rotatable circular plate having a notch in the edge thereof permitting deflection of a switch element therethrough to entrap the element in actuated position on the opposite side of said circular plate during continued rotation thereof until reregistry of such notch with such actuated element, said magnetic actuating means comprising a magnetic flux concentrator element maintained in registry with the notch in the rotary plate for directing magnetic flux into the adjacent switch element for deflecting such element through said notch.

5. Multipole selector relay means defined in claim 4, wherein the magnetic actuating means additionally comprises a ferromagnetic shaft concentric with the rotational axis of the rotary plate, a magnetic induction coil encircling said shaft, a toroidal ferromagnetic casing encircling said coil and having a centrally open end adjacent the rotary plate, the flux concentrator comprising a substantially radial ferromagnetic arm extending from the shaft to substantially the inner adjacent edge of the toroidal casing to overlie the radially-inner ends of the magnetically actuatable switch arms.

6. Multipole selector relay means defined in claim 5, and drive means operatively connected to the rotary plate and flux concentrator for rotating the same progressively through repeating cycles of rotation thereof, thereby permitting selective actuation of the individual switch arms in recurring sequential manner.

7. Multipole selector relay means comprising a rotatable annular member, a plurality of resiliently flexible, ferromagnetic, magnetically actuatable switch arms, means supporting said switch arms individually at locations spaced apart about the periphery of said rotatable member, and disposing such switch arms to lap one side of said rotatable member in the inactuated positions of such switch arms, said arms being resiliently deflectable into respective actuated positions thereof lapping the opposite side of said rotatable annular member, and magnetic switch-element actuating means electrically energizable during such rotation of said annular member to deflect the individual switch element then instantaneously adjacent such magnetic actuating means into actuated position of such element, said rotatable annular member having a restricted opening therein permitting deflection of a switch arm therethrough to entrap the arm in actuated position on the opposite side of said annular member during continued rotation thereof until reregistry of such opening with such actuated arm, said magnetic actuating means comprising a magnetic flux concentrator element maintained in registry with the opening in the rotary annular member for directing magnetic flux into the adjacent switch arm for deflecting such arm through said opening.

8. Multipole selector relay means defined in claim 7, wherein the magnetic actuating means additionally comprises a ferromagnetic shaft concentric with the rotational axis of the rotary annular member, a magnetic induction coil encircling said shaft, a toroidal ferromagnetic casing encircling said coil and having an open end adjacent the rotary annular member, the flux concentrator comprising a substantially radial ferromagnetic arm extending from the shaft to substantially a location overlying but spaced appreciably from the open end edge of said casing, the switch arms lying slightly outside the rotary path of the end of the flux concentrator arm.

9. Multipole selector relay means defined in claim 8, and drive means operatively connected to the rotary annular member and flux concentrator for rotating the same progressively through repeating cycles of rotation thereof, thereby permitting selective actuation of the individual switch arms in recurring sequential manner.

References Cited in the file of this patent

UNITED STATES PATENTS

1,156,043	Shephard	Oct. 5, 1915
1,689,294	Potts	Oct. 30, 1928
1,898,762	Clokey	Feb. 21, 1933
2,399,720	Brand	May 7, 1946
2,612,555	Kinsman	Sept. 30, 1952

FOREIGN PATENTS

554,096	Germany	July 6, 1932