April 30, 1957 G. O. WAGNER 2,790,876

RELAY

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FIG. 1.

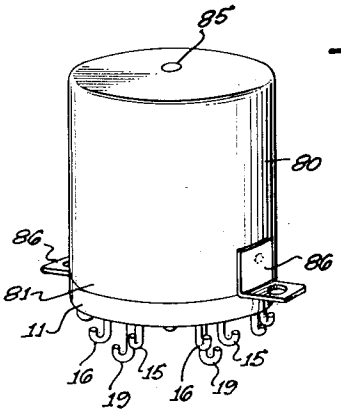


FIG. 2.

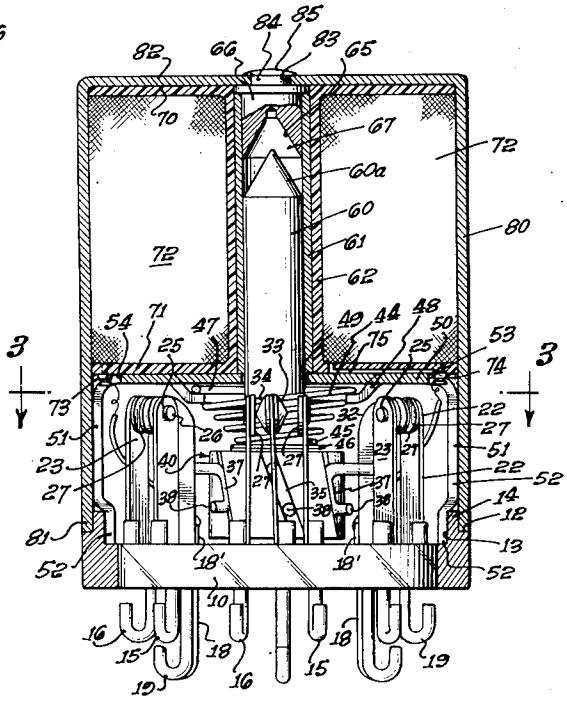
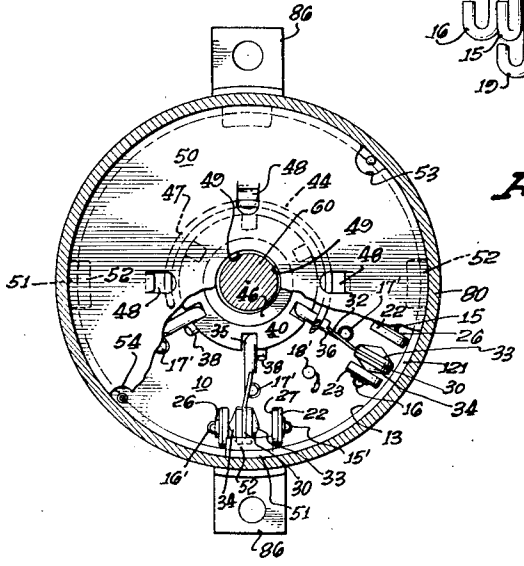


FIG. 3.



GEORGE O. WAGNER,
INVENTOR.

BY Reed & Lawlor
ATTORNEY.

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FIG. 4

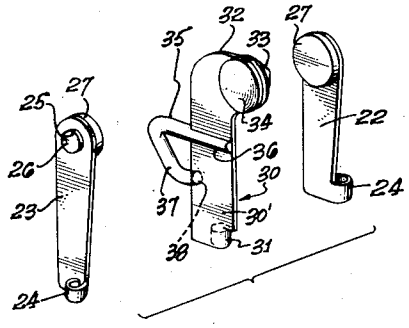


FIG. 5.

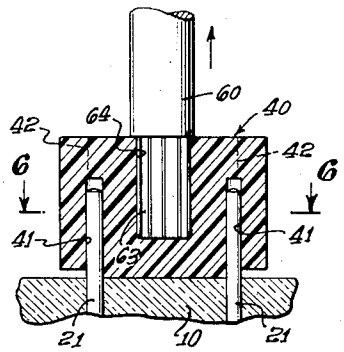


FIG. 6.

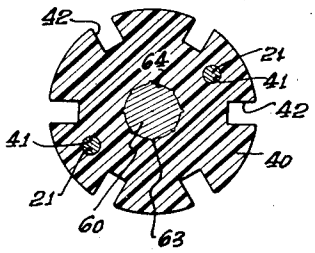


FIG. 7.

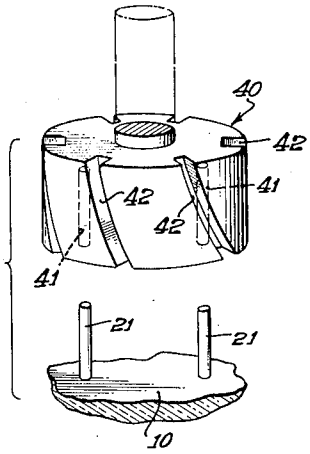
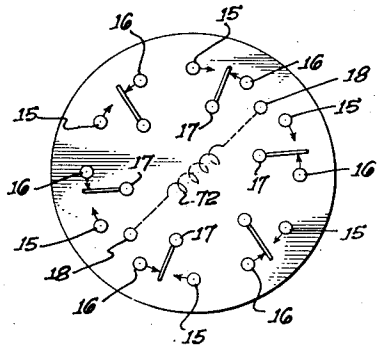


FIG. 8.



INVENTOR.
GEORGE O. WAGNER,
BY Reed & Lawlor
ATTORNEY.

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2,790,876

RELAY

George O. Wagner, Burbank, Calif., assignor, by mesne assignments, to Elgin Instrument Company, Elgin, Ill., a corporation of Illinois

Application March 22, 1954, Serial No. 417,715

10 Claims. (Cl. 200—104)

This invention relates generally to switches, and is particularly concerned with remotely controlled relays by means of which electrical circuits may be opened and closed through power actuated devices such as solenoids energized from a remote point.

In an increasingly large field of application, as particularly exemplified in aviation, there is a demand for small, light, and shock-proof relays having incorporated therein power means for faithfully responsive, positive actuation, under the control of an operator located at a remote control station.

In the design and construction of relays of this type it is very important that dimensions and weight be restricted without sacrifice of effectiveness and durability and without undue increase in costs. Of no less importance is the stability of such device when subjected to vibration and shock. The incorporation of positively responsive actuation and unyielding retention of parts both in their operated and restored positions is also essential to successful relays in this field. It is further required that strong and uniformly responsive power means be included to insure such positive actuation to operated position and unyielding retention in restored position. The compact unification of the parts of these relays within sealed containers is also desirable.

With these and similar problems in view, it is among the general objects of the invention to provide a novel, effective, and efficient device of the character set forth, particularly designed to meet the increasingly rigid requirements of Air Force specifications.

More specifically, it is among the objects of the invention to provide an improved electromagnetic relay of miniature size but incorporating therein features of strength, durability, power actuation and faithful performance heretofore generally found only in relays of more substantial size.

A further object is to provide a compact relay of low weight without sacrifice of reliability and durability.

It is also an object of the invention to provide a relay that is vibration resistant and shock resistant, even though of light weight and small size.

The invention also includes as an object the provision of a compact and light relay guarded from ambient conditions by hermetic sealing within a rigid magnetic housing that forms part of the flux path of the actuating solenoid.

It is also an object of the invention to provide a powerful and mechanically efficient actuating means for a relay of the type under consideration and to achieve this objective with economy of space and weight.

In addition to the other objects hereinabove specifically enumerated, as well as those which will be recognized from a consideration of the following specification taken in conjunction with the accompanying drawings, are those relating to structural details insuring uniform operation under adverse conditions of shock and vibration, longevity of service without repair or adjustment, and economy of both manufacture and operation.

The invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of a relay that embodies the invention. Though only one form of relay constructed in accordance with the principles of this invention is described below and illustrated in the accompanying drawing, it is to be understood that the invention is not limited to the details of construction of this form of relay but that the invention may be embodied in other forms that fall within the scope of the appended claims.

In the drawings wherein like reference characters indicate like elements throughout the several views:

Fig. 1 is a side elevational view of a relay embodying the features of this invention;

Fig. 2 is an enlarged vertical sectional view through the relay shown in Fig. 1;

Fig. 3 is a transverse sectional view, with some parts broken away, taken on the line 3—3 of Fig. 2 looking in the direction of the arrows thereof;

Fig. 4 is an exploded perspective view of one set of the contacts of the relay;

Fig. 5 is a detailed vertical section through the contact actuator of the device;

Fig. 6 is a transverse section through the contact actuator, taken in line 6—6 of Fig. 5, looking in the direction of the arrows thereof;

Fig. 7 is an exploded view showing the contact actuator and its guide pins, and,

Fig. 8 is a schematic wiring diagram of the relay as viewed from the top.

In general terms, the embodiment of the invention here presented is characterized by a novel arrangement of a rigid member supporting both fixed contacts and movable contacts, actuating means for moving the latter relatively to the former, power means for controlling the actuating means, and an enclosing housing. More specifically, this form of the invention comprises a base mounting a circular multi-fold series of contact sets, each set including a pair of juxtaposed fixed contacts on an interposed movable contact. The contacts are located at the inner ends of contact terminals that extend through the base. A longitudinally reciprocable, spring urged actuator is disposed centrally of the circular series. The actuator includes peripheral, longitudinally inclined actuating slots equal in number to the movable contacts.

A longitudinally movable actuator pin is carried by each of the movable contacts. Each of these pins engages a corresponding slot of the actuator. Thus, upon longitudinal reciprocation of the actuator, a turning moment is applied to each movable contact arm to move its contact from one to the other of its companion fixed contacts. Controlled reciprocation of the actuator against the force of the spring is provided by an integrally included, remotely controlled power means. In the form of the relay described herein, the power means is a solenoid and an armature which constitutes an operating shaft for the actuator. While the invention is not limited thereto, it contemplates the use of an enclosing housing that is composed of magnetic material, thus forming a return path for the magnetic flux of the solenoid coil as well as a seal for the internal parts.

Referring now more particularly to the drawings, the structure comprises an insulating base **10**, preferably circular in form and conveniently manufactured of glass, thermo-setting plastic or some similar non-conducting or dielectric material. The base **10** is mounted within and is supported and protected by a peripheral metallic base ring **11**. The ring **11** extends upwardly beyond the upper inner surface of the base **10**, its outer surface being rabbeted as at **12** to receive the lower edge of the enclosing housing **80**. The inner surface of the upward

extension of ring 11 is counter-bored as at 13 to receive the lower end of the finger of a spacer and spring retaining-spider 50. This construction thus provides an intermediate upwardly extending flange 14 between the rabbet 12 and the counter-bore 13.

Extending through and moulded in the base 10 are two concentric circular series of terminal connectors, preferably formed of tinned chrome steel wire. The outer circular series is composed of equally spaced pairs of right and left hand fixed-contact terminals 15 and 16, respectively. In the simplest design the spacing between the fixed-contact terminal of one pair and the next adjacent fixed-contact terminal of another pair is equal to the spacing between the terminals of each pair and thus a uniform circular spacing between the successive contacts 15 and 16 results. As shown here, six pairs, each comprising a right and left hand fixed-contact terminal, are provided, and thus the pairs, being uniformly spaced, are disposed on either side of intermediate 60° divergent radii.

The inner concentric circular series of terminals comprises six uniformly spaced movable contact terminals 17 disposed in the plane of the intermediate 60° divergent radii referred to above and are thus each angularly intermediate a corresponding pair of the fixed contact terminals and are inwardly spaced therefrom. Two additional diametrically opposite coil terminals 18 are also included in the inner concentric circular series as shown in Fig. 8. Terminals 18 are preferably located equidistantly intermediate opposed pairs of movable contact terminals, thereby uniformly balancing the circular disposition of the inner circular series of movable contact terminals. Thus, the entire arrangement possesses a two-fold symmetry about the coil terminals and the sets of contacts themselves possess a six-fold symmetry.

The outer ends of all the terminals are illustrated as formed with J-shaped extremities 19 for convenience in making electrical connections to associated circuits. Such outer ends of the inner circular series preferably extend beyond those of the outer circular series to further facilitate making such connections. The inner ends 15', 16', and 17' of all contact terminals are straight and extend beyond the inner surface of the base 10 to provide mounting portions for the contact arms, while like straight extensions 18' of the coil terminals 18 provide for electrical connection with coil leads.

Inwardly protruding from the base 10, there is also provided a pair of diametrically opposite straight actuator guide pins 21. The inward extension of guide pins 21 exceeds that of the inward extension of the inner ends 15', 16', 17' and 18' of the terminals. Pins 21 are arranged at equal radial distances from the center of base 10 but within the circle of the inner series of terminals thereby constituting an inner separate and distinct two-pin series.

Mounted on the inner ends 15' and 16' of the outer circular series of right and left hand fixed-contact terminals 15 and 16 are a circular series of corresponding opposed right and left hand fixed contacts 22 and 23. Each fixed contact comprises a relatively stiff blade, preferably of Phosphor bronze and formed at its lower end with a cylindrical sleeve 24. Sleeves 24 receive the ends 15' and 16' of the fixed contact terminals and are secured thereto adjacent the inner surface of base 10 by welding or other suitable means. The upper opposite end of each contact is apertured as at 25 and receives through such aperture the stud end 26 of a headed, flat faced, silver contact button 27. It will, of course, be understood that the contact buttons 27 of each pair face inwardly in confronting relation to form oppositely disposed right and left hand fixed contact faces.

For alternative selective closure of the right and left hand fixed contacts, there is provided a circular series of movable contacts 30. Each movable contact blade 30' is formed with a cylindrical pin-encompassing sleeve 31

similar to sleeves 24 of the blades 22 and 23 for similar rigid attachment, as by welding, to the inwardly extending ends 17' of the movable contact terminals 17. The opposite upper or outer ends of the contacts 30 include wings 32 that extend radially outward of the blades 31 and thus between the contact buttons 27 of the blades 22 and 23. Each wing 32 is apertured to receive therethrough the shank of a silver contact button formed with right and left hand conical contact heads 33 and 34, respectively.

The blades 30' upon which the movable contacts are mounted are of lighter gauge material than the blades 22 and 23 in order to render such blades more flexible and also to provide differences in the free periods of oscillation of the fixed and movable blades. By employing cooperating contact arms having different periods of oscillation, the danger of excessive contact bounce, or chatter, is minimized when contact is established either upon actuation to operated condition or deactuation to restored condition.

Movement of the movable contact members 30 by which they are flexed from the normal straight plane of the blade, with little torsion, is imparted thereto by actuator pins 35. Each pin 35 includes a straight half-round blade engaging end 36, the flat face of which is welded to one face of the blade at approximately the longitudinal center of the blade. The pins 35 extend radially inward from the blades in the same normal plane for a short distance and then turn to form a downwardly extending and inclined slot follower bight 37 terminating in a return bent terminal end 38. The pins 35 are more rigid than the flat blades 30 and hence lateral motion imparted to the slot follower bights 37 are translated by bodily movement of the pins to produce transverse flexing of the blades. Such flexing results in making and breaking contact between right and left hand contact heads 33 and 34 and right and left hand fixed contact buttons 27.

Lateral motion of the pins 35 is produced by reciprocating movement of a circular cylindrical centrally disposed actuator 40 composed of nylon or other suitable insulating material. The actuator 40 is slidably mounted upon the guide pins 21 received within spaced apertures 41 of the actuator so that rotation of the actuator within the structure is precluded, while free longitudinal reciprocation on the pins is permitted. Extending inwardly of the side walls of the actuator 40 are six inclined slots 42, each of which receives one of the follower bights 37 of one actuating pin 35. The slots 42 and bights 37 are of similar inclination and both may be either straight or helical. Since the pins 35 and their slot-follower bights 37 are fixed against longitudinal motion, it will be readily understood that longitudinal motion of the actuator relative to the base, cams the pins laterally to flex the blades 30 transversely for movement of their contact heads 33 and 34 to and from engagement with the right and left hand fixed-contact heads 27 respectively.

As here shown, the normal or restored position of the actuator is a downward position closely adjacent the base 10 and with the follower bights 37 toward the upper ends of the slots 42. In this position, each of the movable contacts 17 is closed with one of the stationary contacts 15, but contacts 17 and 16 are open.

Positive closure of contacts 15 and 17 and positive opening of the contacts 17 and 16 are maintained while the relay is in the restored position, even in the presence of shock or vibration by a strong spiral compression coil spring 44, preferably formed of heavy music wire. The smaller end terminal turn 45 of the spring 44 exerts downward pressure on the actuator 40 through the medium of intermediate shim rings 46 which may be readily added or removed to adjust the force applied by the spring. The opposite upper and larger terminal turn 47 of the spring 44 is secured by clips 48 struck out from the body of a magnetic steel spacer plate 50, the central

aperture 49 of which is concentric with the actuator 40. Spaced depending arms 51 extend from the outer peripheral edge of the plate 50 toward the base ring 11 where inwardly turned ends 52 engage within the counterbore 13 and abut the base 10. By this construction it will be seen that the spring is confined in operative pressure relation, suitably adjusted by shims 46, with the actuator 40 to bias the actuator towards the restored position shown. The peripheral edges of plate 50 are also provided with diametrically opposite recesses 53 and 54 through which the coil leads may pass to the ends 20 of the solenoid.

Power actuation of the actuator to an upward, operated position is, in this form of the invention, provided by electromechanical means comprising a magnetic steel plunger 60 operating within a stationary brass coil sleeve 61 fitted within the central cylinder 62 of a molded nylon coil bobbin. The lower end 63 of the solenoid plunger 60 may be serrated as shown in Fig. 5 and pressed within the central receiving bore 64 of the actuator to provide a positive rigid connection between actuator and plunger. The opposite upper end 60*a* of the plunger 60 is conical, thus adapting it to be received within and guided by the conforming conical walls 65 of a stationary, electrical steel core member 66. As will be noted, an air gap 67 is formed between conical plunger end 64 and conical core walls 65. The air gap 67 constitutes a dash-pot which cushions the movement of the plunger and actuator when the solenoid becomes energized or deenergized.

The nylon coil bobbin is formed with top and bottom end-flanges 70 and 71 respectively formed integral with the ends of the central cylinder 62. The coil 72 is preferably loosely wound about the cylinder 62 within the confines of the end flanges 70 and 71 with a minimum of stretch, and the outer surface of the coil is inwardly spaced from the peripheral edges of the flanges 70 and 71, to accommodate expansion at high temperatures. The lower flange 71 is formed at one peripheral edge with a tapped boss 73 to receive therethrough the terminal end of the outer coil winding. A companion tapped boss 74 is located diametrically opposite the boss 73 and each is provided with grooves 75 to receive the edges of the recesses 53 of plate 50. The companion boss 74 communicates with a radial groove 76 in the inner face of the flange and in which the terminal end of the inner coil winding is laid.

The relay construction is completed by the provision of a magnetic steel housing shell 80 of cylindrical cup-shaped design. The lower open end 81 of the housing 80 is preferably rigidly, permanently, and hermetically sealed, as by welding, to the steel base ring 11, being seated within the rabbet 12 of the latter. The side walls of the steel housing extend downwardly and around the spacer plate 50 and around the coil 72 and in snug engagement with the peripheral edges of flanges 70 and 71. The closed outer end 82 of the housing bears against the outer face of upper flange 70 and is centrally apertured as at 83 to receive therethrough the shank 84 of the outer end of steel core member 66. Externally of the end 82, the shank 84 is headed over as at 85 to rigidly secure the housing and core member together and in flux conducting relationship. For mounting the relay in desired location, apertured flanges 86 may be welded on opposite sides of the housing, as shown.

The operation of the device, being quite simple, is believed to be clear from the forgoing discussion of the structure, arrangement, and function of the parts. Suffice it therefore to say that as and when the coil is energized, the solenoid lifts the actuator which is constrained by the actuator pins to move in a longitudinal direction, forcing the follower bights to move laterally to an extent depending on the inclination of the actuator slots and such movement imparts bending motion to the movable contacts to force them to break contact with one corresponding stationary contact and to make contact with the other corresponding contact. Since the magnetic force produced by the coil is more than sufficient to overcome the spring force, insufficient movement of the actuator when current is applied is precluded. Conversely, when the coil is de-energized the movable contacts are flexed in the opposite direction forcing them to break with the corresponding latter contact and to make with the corresponding former contact. The spring is relatively powerful compared to the work required to return the parts to their restored position so that upon de-energization of the coil a prompt and permanent return of the contacts to their restored position is insured.

Thus, provision is made for positive closure of each movable contact 17 with a corresponding stationary contact 16 and positive opening of the contacts 17 and 15 in the operated position by employing a solenoid that exerts a large force compared with that of the spring. Thus, positive reliable action is attained in the relay, both when actuated to operative position and when deactuated to restored position.

From the foregoing, it will be seen that the invention provides a rugged, durable, compact and hermetically sealed relay. The parts are so designed, assembled, interrelated and secured as to provide shock resistance and to withstand excessive vibration for long periods.

One important feature of the invention resides in the use of the steel protective housing as a path of low magnetic reluctance. This feature provides an arrangement in which weight is restricted while still providing efficient operation of the solenoid with a minimum supply of electrical energy.

Though only one embodiment of the invention has been described herein in detail, it will be understood that various changes which will now suggest themselves to those skilled in the art may be made in the material, form, details of construction, and arrangement of the elements and number of contacts of the relay without departing from the concepts of the invention. It will be noted, for example, that relays embodying some of the concepts of my invention may be constructed which employ other power actuating means than those specifically disclosed herein. Reference is therefore made to the appended claims for a definition of the limits of the invention.

I claim:

1. In a relay, a base, a first and second circular series of stationary contacts mounted on said base, a concentric third circular series of cooperating contacts mounted on said base and normally making contacts respectively with the first series of said contacts, said third series being laterally movable spring contacts, an actuator mounted for reciprocating movement along the axis of said circular series, and motion translating means between said actuator and said third movable contacts for laterally moving said third movable contacts from said first series to said second series of contacts in response to reciprocation of said actuator, said motion translating means including a slotted drum connected to said actuator, the slots in said drum being angularly disposed relative to said movable contacts, and means including rigid actuator pins connected to said third series of contacts, and slidingly driven by said slots to effect the lateral movement of said first and second series of contacts.

2. In a relay, a base, a circular series of stationary contacts mounted on said base, a concentric circular series of cooperating laterally flexible contacts mounted on said base, an actuator having inclined peripheral slots mounted for reciprocation along the axis of said series, and motion translating pin means engaging the slots of said actuator, said pin means directly engaging said flexible contacts for laterally flexing said flexible contacts in response to reciprocation of said actuator along said axis.

3. In a relay, a base, first and second circular series

of stationary contacts rigidly mounted on said base, a third circular series of cooperating laterally flexible contacts rigidly mounted on said base, an actuator having axially extending inclined surface slots mounted for axial reciprocation within said series and along the axis thereof, and slot followers rigidly secured to said flexible contacts and slidable within said slots, laterally flexing said laterally flexible contacts in response to reciprocation of said actuator.

4. In a relay, a rigid circular base, a circular series of stationary contacts having right and left hand pairs of contact surfaces rigidly mounted on said base, a concentric radially spaced circular series of cooperating laterally flexible contacts rigidly mounted on said base having movable contact surfaces disposed between the right and left hand pairs of stationary contact surfaces, an actuator mounted for reciprocating movement within said circular series and along the axis thereof and having longitudinally extending inclined cam slots formed therein, and motion translating means comprising rigid pins carried by said flexible contacts rigidly secured to said movable contact surfaces and slot followers mounted within said slots for laterally flexing said flexible contacts from contact with one of said pairs to contact with the other of said pairs in response to reciprocation of said actuator.

5. In a relay, a rigid, circular base, a circular series of stationary contacts having right and left hand pairs of contact surfaces rigidly mounted on said base, a concentric radially spaced circular series of cooperating laterally flexible contacts rigidly mounted on said base having movable contact surfaces disposed between the right and left hand pairs of stationary contact surfaces, an actuator mounted for reciprocating movement within said circular series and along the axis thereof, longitudinally extending inclined cam slots in said actuator, motion translating means comprising rigid pins rigidly secured to said flexible contacts and slot followers mounted within said slots for laterally flexing said flexible contacts from contact with one of said pairs to contact with the other of said pairs in response to reciprocation of said actuator, a solenoid plunger coaxially mounted on said actuator, and a solenoid coil coaxially surrounding said plunger to reciprocate said actuator upon energization thereof.

6. In a relay, a rigid circular base, a circular series of stationary contacts having right and left hand pairs of contact surfaces rigidly mounted on said base, a concentric radially spaced circular series of cooperating laterally flexible contacts rigidly mounted on said base having movable contact surfaces disposed between the right and left hand pairs of stationary contact surfaces, a contact actuator mounted for reciprocating movement within said circular series and along the axis thereof, longitudinally extending inclined cam slots in said actuator, rigid motion translating pins rigidly secured to said flexible contacts including followers mounted within said slots for lateral movement in response to reciprocation of said actuator, a coil spring engaging said actuator to bias the same in one direction, a solenoid plunger carried by said actuator, and a solenoid coil surrounding said plunger operable upon energization thereof to move said actuator in the opposite direction against the force of said coil spring.

7. In a device of the character described, a base, a circular series of right and left hand stationary contact connectors extending through said base, an inner circular series of movable contact connectors extending through said base, a pair of guide pins extending inwardly of said base within the inner circular series of movable contact connectors, right and left hand stationary contacts mounted on said stationary contact connectors, laterally flexible movable contact members mounted on said movable contact connectors, a cylindrical actuator having inclined surface slots mounted on said pins for reciprocation with respect thereto, rigid actuator pins carried by said movable contact members, slot follower bights formed in said actuator pins and fitted within said slots, a solenoid plunger on said actuator, a solenoid coil surrounding said plunger, and a magnetic casing hermetically sealed with said base and enclosing said contacts, actuator, plunger and coil.

8. In a device of the character described, a base, a circular series of right and left hand stationary contact connectors extending through said base each including an inner straight stationary contact mounting portion, an inner circular series of movable contact connectors extending through said base each including an inner straight movable contact mounting portion, a pair of guide pins extending inwardly of said base within the inner circular series of movable contact connectors, right and left hand stationary contacts mounted on said stationary contact mounting portions, laterally flexible movable contact members mounted on said movable contact mounting portions, pairs of right and left hand juxtaposed contact surfaces carried by said right and left hand stationary contacts, movable contact surfaces interposed between said right and left hand contact surfaces carried by said laterally flexible movable contact members, a cylindrical actuator having inclined surface slots mounted on said pins for reciprocation with respect thereto, rigid actuator pins carried by said movable contact members, slot follower bights formed in said actuator pins and fitted within said slots, a solenoid plunger on said actuator, a solenoid coil surrounding said plunger, and a magnetic casing hermetically sealed with said base and enclosing said contacts, actuator, plunger and coil.

9. In a device of the character described, a base, a circular series of right and left hand stationary contact connectors extending through said base each including an inner straight stationary contact mounting portion, an inner circular series of movable contact connectors extending through said base, each including an inner straight movable contact mounting portion, a pair of guide pins extending inwardly of said base within the inner circular series of movable contact connectors, right and left hand stationary contacts mounted on said stationary contact mounting portions, laterally flexible movable contact members mounted on said movable contact mounting portions, pairs of right and left hand juxtaposed contact surfaces carried by said right and left hand stationary contacts, movable contact surfaces interposed between said right and left hand contact surfaces carried by said laterally flexible movable contact members, a cylindrical actuator having inclined surface slots mounted on said pins for reciprocation with respect thereto, spring means for urging said actuator towards said base, means for adjusting the tension of said spring means, rigid actuator pins carried by said movable contact members, slot follower bights formed in said actuator pins and fitted within said slots, a solenoid plunger on said actuator, a solenoid coil surrounding said plunger, and a magnetic casing hermetically sealed with said base and enclosing said contacts, actuator, plunger and coil.

10. In a device of the character described, a circular dielectric base, a circular series of right and left hand stationary contact connectors extending through said base each including an outer return bent conductor receiving portion and an inner straight stationary contact mounting portion, an inner circular series of movable contact connectors extending through said base each including an outer return bent conductor receiving portion and an inner straight movable contact mounting portion, a pair of coil terminal connectors extending through said base, each having outer return bent conductor receiving portions and inner straight coil terminal receiving portions, a pair of guide pins extending inwardly of said base within the inner circular series of movable contact connectors, right and left hand stationary contacts mounted on said stationary contact mounting portions, laterally flexible movable contact members mounted on said movable contact mounting portions, pairs of right and left hand juxtaposed contact surfaces carried by said right and left hand stationary contacts, movable contact sur-

faces interposed between said right and left hand contact surfaces carried by said movable laterally flexible movable contact members, a cylindrical actuator having inclined surface slots mounted on said pins for reciprocation with respect thereto, spring means for urging said actuator towards said base, means for adjusting the tension of said spring means, rigid actuator pins carried by said movable contact members, slot follower bights formed in said actuator pins and fitted within said slots, a solenoid plunger on said actuator, a solenoid coil surrounding said plunger, and a magnetic casing hermetically sealed with said base and enclosing said contacts, actuator, plunger and coil.

References Cited in the file of this patent

UNITED STATES PATENTS

746,095	Kaisling	Dec. 8, 1903
946,489	Clement	Jan. 11, 1910
1,038,776	McLarn	Sept. 17, 1912
1,839,034	Johnson	Dec. 29, 1931
2,122,643	Colemb	July 5, 1938
2,279,395	Gardiner	Apr. 14, 1942
2,484,358	Stapleton	Oct. 11, 1949

FOREIGN PATENTS

217,006	Germany	June 3, 1909