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R. RUSSO

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ELECTRIC SWITCH APPARATUS

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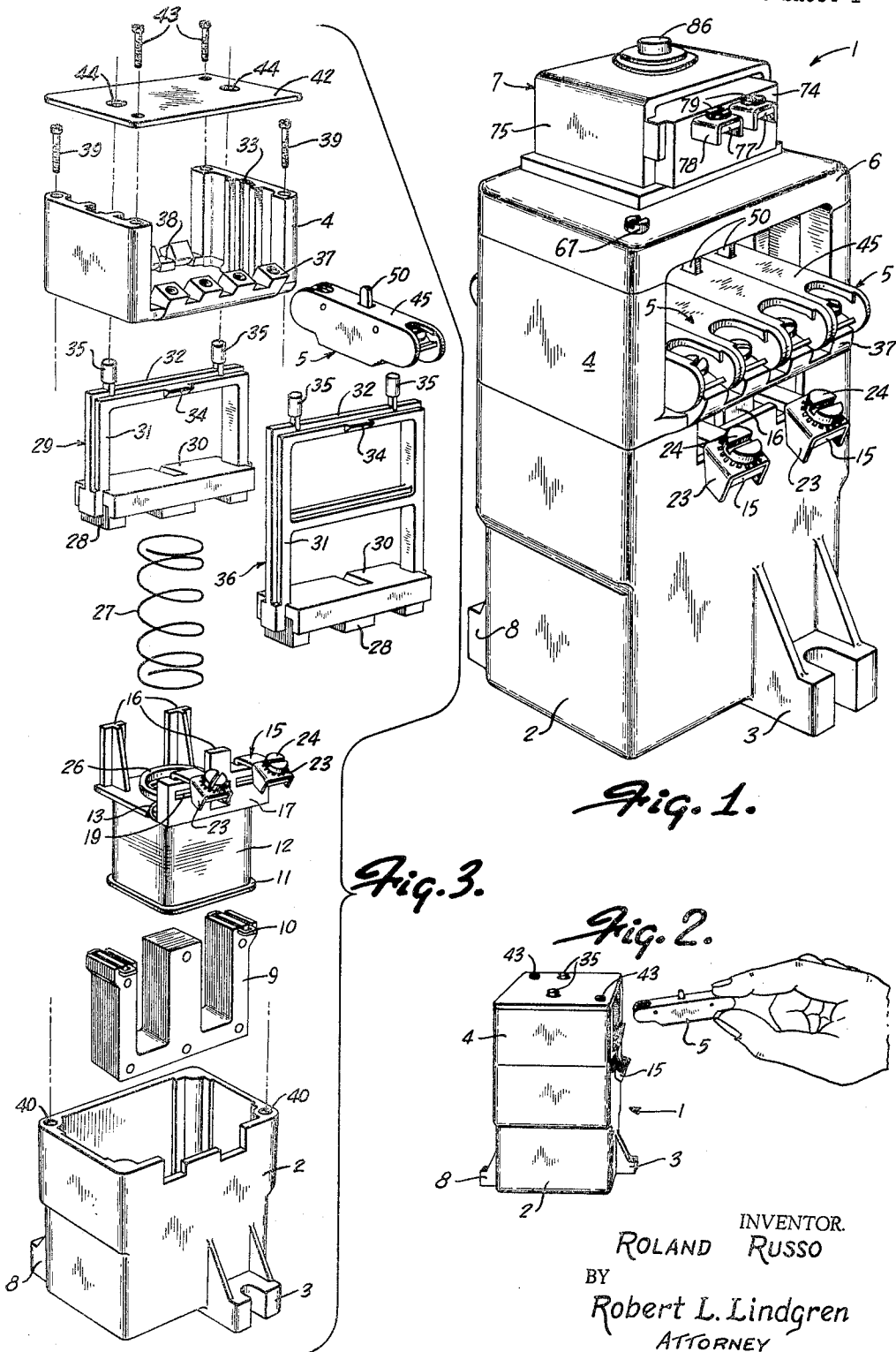


Fig. 1.

Fig. 3.

Fig. 2.

INVENTOR.  
ROLAND RUSSO  
BY  
Robert L. Lindgren  
ATTORNEY

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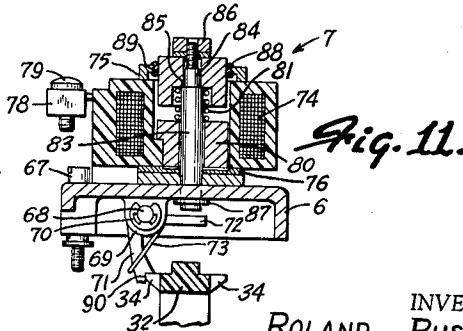
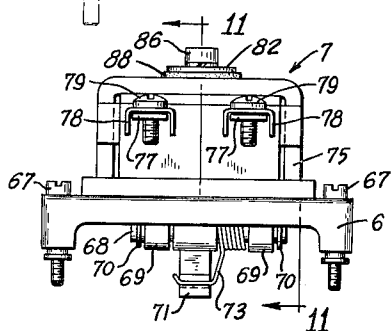
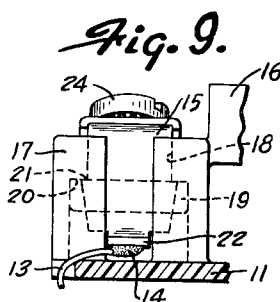
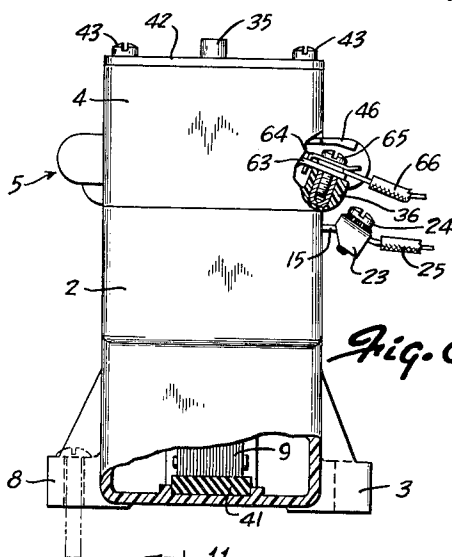
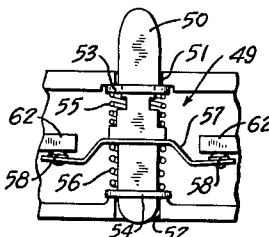
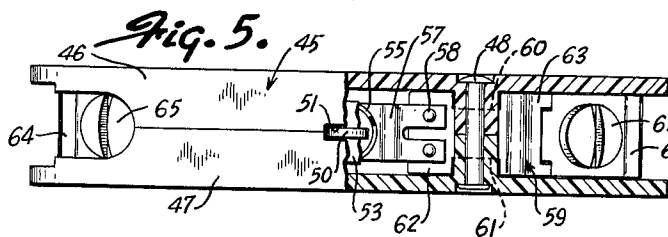
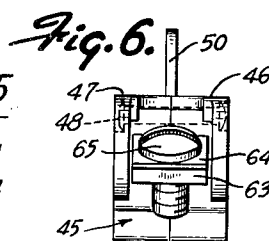
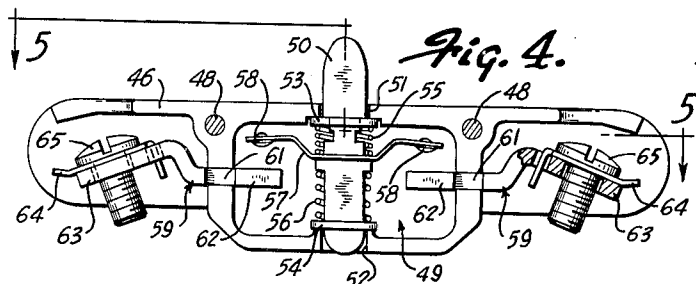
R. RUSSO

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2 Sheets-Sheet 2



INVENTOR.  
ROLAND RUSSO  
BY  
Robert L. Lindgren  
ATTORNEY

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## ELECTRIC SWITCH APPARATUS

Roland Russo, South Euclid, Ohio, assignor to The Clark  
Controller Company, Cleveland, Ohio, a corporation  
of Ohio

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14 Claims. (Cl. 200—104)

This invention relates to an apparatus for controlling the opening and closing of electrical circuits and, more particularly, to an electromagnetically actuated device for repeatedly establishing and interrupting an electric circuit.

Industries requiring complex machine tools and transfer lines, and thereby elaborate control systems, have established a need for industrial controls, and particularly relays, for use at the now commonly employed reduced control potential levels. Previously, relays designed for operation at potential levels up to 600 volts were in common use in these industries. Presently, many industries have established standards, such as the Machine Tool Standards, which require that all control potential levels be no greater than 120 volts.

With the growing complexity of machine tools and transfer lines, control systems requiring larger numbers of relays with lower voltage requirements are becoming predominant. Control panel space has become a prime concern in control system design. In view of the increased usage of reduced control potential levels in industry, the relatively large space required for the installation of control devices rated at the 600 volt level has aggravated the space problem.

The control device or relay of the invention has been designed primarily for use at control potential levels up to 300 volts, although somewhat higher levels may be employed under industrial conditions with a simple adjustment of pole spacing. The relay provides a substantial space saving economy over relays rated at 600 volts and a saving over other relays rated at lower control potential levels.

In addition to the advantages resulting from the compactness of the device, the number of parts required has been reduced to permit the manufacture and sale of the relay at an appreciably lower cost.

One of the most significant features of the control device of the invention lies in the unit construction and the easy changeability of the normally open and normally closed poles. Each pole is a unit completely separate from and readily removable from the relay base. The pole unit is attached to the base with a simultaneous connection of the pole leads. This is accomplished by merely turning a pair of screws located at opposite ends of the pole unit.

The pole unit comprises a plastic housing which encloses and protects both the stationary and movable contacts from contamination. The movable contacts enclosed within the housing arc of a bifurcated construction to provide multiple current flow paths through the pole unit and to thereby assure contact continuity and reliability. Various types of contacts and contact material are usable with the pole unit of the invention. The terminal ends of the stationary contacts project from opposite ends of the housing. A screw and wire clamp connected to each terminal end provide a means for attaching the electrical leads to the unit and a means for securing the unit to the relay base.

When a circuit change requires a change in a pole of the relay from normally open to normally closed, the two screws securing the pole and the leads are loosened, the pole is removed, and a normally closed pole is substituted therefor. In the event a pole unit wears out, burns out, or mechanically breaks down, it may be easily and quickly

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replaced by unskilled labor by a new inexpensive pole unit. In presently available relays, repair, conversion and replacement changes require the expenditure of considerable amounts of time by skilled personnel; and, in many instances, these changes require the costly and time consuming replacement of the entire relay apparatus. The instant relay affords a reduction in conversion and repair cost to the barest minimum.

The control device of the invention offers versatility not found in any known relays. The relay is freely usable in circuits requiring any number of poles from one to eight. Any combination of normally open or normally closed poles may be utilized. The standard four pole relay may be readily converted to an eight pole relay without removing the relay base from a control panel upon which it may be mounted.

The armature of the relay carries a thermoplastic operating yoke which may be a single yoke in four pole applications or a double yoke in eight pole applications. When the relay coil is energized and the armature is actuated, the yoke carried by the armature simultaneously engages the plungers connected to the movable contacts of all the pole units of the relay. Due to the particular construction of the yoke, the poles may be operated electrically, manually or by a mechanical latch arrangement.

An additional reduction in manufacturing cost is realized with the relay of the invention in the mode of connecting the coil terminals of the relay's electromagnet to the coil supporting plastic bobbin. Each of the terminal pieces is formed with an enlarged portion which may be permanently snapped into a slot in the molded plastic coil supporting bobbin. By providing a terminal which can be installed subsequent to the molding of the bobbin instead of molding the terminal integrally into the bobbin, this avoids an expensive and much less reliable soldering operation which would otherwise be required to connect the coil ends to the terminals. Due to the permanency of the snapped-in installation of the terminals of the control device of the instant invention, costly riveting of the terminal to the bobbin, which is the commonly employed alternative to integrally molding-in of terminals, is also eliminated.

To assure the positive engagement of the bobbin with the frame of the pole housing, the bobbin is formed with three vertically projecting fingers which engage pads formed on the bottom of the frame when the frame is secured to the relay case. The pads are provided on the base in a manner such that pole housing frame can be secured to the case in either of two positions. Only two screws are required to securely connect the pole housing frame to the relay case and, simultaneously therewith, to secure to bobbin, coil and magnetic core element in the case.

The bottom of the magnetic core element upon which the bobbin is supported is provided with a resilient mounting to reduce electromagnetic vibration and chatter to the barest minimum under operating conditions.

A combination of slotted and unslotted mounting feet which are formed at diagonally opposite ends of the base are provided to facilitate installation on crowded control panels.

The relay and all of its components have been designed to reduce the number of parts required to simplify and make possible the replacement of any and all parts of the relay under conditions requiring a minimum of skill and time. To facilitate the conversion of parts to accommodate a variety of control potential levels and relay usages, the coil, the pole housing and the movable contact actuating plunger of the relay may be made in colors distinguishing them for their particular application.

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The relay of the invention may include a latching lever mechanism at the option of the user, which acts in response to a torsion means to maintain the pole operating yoke in operative contact with the movable contact actuating plungers of the pole unit. The latch magnet is energized to move a shaft downwardly into engagement with an arm of the latch lever which results in the disengagement of the latch lever from the yoke and permits the yoke to rise when the relay coil is de-energized.

The invention therefore provides a smaller relay for use at reduced control potential levels. The relay utilizes readily replaceable and convertible pole units, the movable contact of which are enclosed in a protective housing. A four pole relay may be readily converted to an eight pole relay, and any number and combination (from one to eight) of normally open and normally closed poles may be employed with the latter. The coil supporting bobbin is constructed in a manner such that the coil terminals can be attached without being riveted to the bobbin or molded integrally thereto, and the finger projections thereof insure that the coil can be positively secured within the case. The latching device is a simple means for maintaining the operative condition of the relay without the expenditure of an appreciable amount of power.

Various other objects and advantages of the invention will become more fully apparent from the following drawings illustrating presently preferred embodiments thereof and wherein:

FIGURE 1 is a perspective view of the relay of the invention;

FIG. 2 is a perspective view of the relay of the invention illustrating the manual installation therein of a pole unit;

FIG. 3 is an exploded view of the relay showing the elements thereof;

FIG. 4 is a longitudinal sectional view of the pole unit of the invention with normally open contacts;

FIG. 5 is a plan view of the pole unit taken along line 5—5 of FIG. 4;

FIG. 6 is an end view of the pole unit;

FIG. 7 is a fragmentary view of a pole unit of the invention having normally closed contacts;

FIG. 8 is a side elevation of the relay of the invention with parts broken away to illustrate the resilient mounting of the electromagnet and the simultaneous connection of the pole unit to a lead and to the relay case;

FIG. 9 is a fragmentary end view of the bobbin of the invention illustrating the snap-in terminal connection thereto;

FIG. 10 is a front elevation of the latching device of the invention; and

FIG. 11 is a sectional view of the latching device taken along line 11—11 of FIG. 10.

The control device or relay 1 of the invention is shown in FIGURE 1 of the drawings as it would appear just prior to installation on a control panel. The relay 1 comprises a case 2 which is molded from a phenolic resin material. A slotted mounting foot 3 is molded integrally into the case 2. The pole housing frame 4 is shown in combination with four readily installed and removed pole units 5. A latch assembly support member 6 which serves in a dual capacity as a latching device support and as a relay cover is attached to the pole housing frame 4. An electro-mechanical latching device 7 is secured to the latch assembly support 6.

The simple and quick manual installation of a pole unit 5 into the pole housing frame 4 is shown in FIG. 2. A second panel mounting foot 8, which is also molded as an integral portion of case 2, is bored on its axis to receive a captive mounting screw. Mounting foot 8 is located diagonally opposite the slotted mounting foot 3 as is shown in FIGS. 2 and 3. The captive mounting screw supplied with non-slotted mounting foot 8 simplifies the control panel mounting of the relay. When the panel has been properly drilled to receive mounting screws,

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one screw may be partially threaded into the panel. Slotted foot 3 is hooked over the screw, and the captive mounting screw of foot 8 is threaded into the panel. The mounting procedure is completed when the screws of both mounting feet 3 and 8 are made fast to the panel.

A number of relays 1 can be mounted side by side in parallel horizontal rows. The small space between such rows can be utilized as a wire trough. Due to the compactness and design of the relay, only a minimum spacing is required between adjacent relays and relay rows greatly simplifying the maintenance thereof.

The individual elements of the relay are shown in FIG. 3 in an exploded view of the relay of the invention. A generally E-shaped magnet 9 consisting of a plurality of stacked magnetically permeable laminations of silicon-steel riveted together is designed to be inserted into case 2 and to be resiliently, but securely, supported within the case by mounting means provided in the bottom thereof. The E-shaped magnet 9 serves as the stationary magnet portion of the electromagnet of relay 1. A pair of shading coils 10 are positioned within slots machined into the tops of the outermost arms of magnet 9 and are resiliently bonded thereto. The shading coils are employed to reduce chatter present in the A.C. operation of an electro-magnet.

A bobbin 11, made of a strong non-conducting thermoplastic material such as nylon, is designed to be inserted over the central leg or arm of magnet 9. A coil winding 12 is wound upon bobbin 11 and is covered with a moisture-resistant tape.

While the instant relay is designed primarily for use in control applications requiring control potential levels of 300 volts and below, coils are usually supplied for the particular voltage level required in a specific circuit. Therefore, coils are generally available for use at voltage levels of 115—120 at frequencies of 50 and 60 cycles and 208—230 at frequencies of 50 or 60 cycles. However, a variety of coils at less commonly employed voltage and frequency levels up to 440 volts may be supplied for use in the relay of the invention. Each coil is provided with a color coded means to distinguish it from others rated for use at different control potential levels.

As is best viewed in FIG. 9, the ends 13 of the coil are soldered at 14 to coal terminals 15 which protrude out of case 2 on the same side as the slotted mounting foot 3. Bobbin 11 is molded with a series of projections 16 and a flange 17 extending from the top thereof. A portion of the projection 15 which protrudes from flange 17, as may be seen in FIGURE 1, is visible from the exterior of case 2. This portion may be colored or provided with other readily recognizable means to identify the various voltage levels attainable with the coil 12 being employed. The flange portion 17 includes a pair of spaced vertically extending channels 18 which open at the top of the flange. Horizontal slots 19, which cut across each of the vertical channels 18 and act to enlarge the channels at these points, are provided in flange 17. The slots 19 further act to produce terminal engaging shoulders 20 within the channels 18. The terminal 15 comprises a metal strip formed in a generally L-shaped configuration. The lower end of the L-shaped strip is formed with laterally projecting shoulder engaging extensions 21 which taper inwardly and downwardly to a constricted neck portion 22 and to which coil end 13 is soldered at 14.

To install terminal 15 on bobbin 11, the terminal end 13 of coil 12 is first soldered to the bottom portion of the terminal 15. The portion of the strip formed with extension 21 is forced into channel 18. The material forming the channel walls is designed to resiliently respond to extending stress exerted thereupon by extensions 21. When the extended portions of terminal 15 pass into horizontal slot 19, the channel walls resiliently respond to the reduction in stress previously exerted thereupon by the extensions 21 and return to their normal cross-sectional dimension. This acts to securely and rigidly retain

the end of terminal 15 to which the coil end 13 is soldered in channel 18 of bobbin flange 17.

This snapping-in method of attaching the terminal to the bobbin permits the realization of substantial manufacturing economics. Normally, such terminals would be molded into the bobbin when the bobbin was formed. To attach the coil lead to such a molded-in terminal, a difficult and costly soldering operation is required. An alternative method of attaching terminals which is in common use, requires the riveting of the terminal to the bobbin. This riveting operation has been found to be expensive and the results are often not reliable as the terminal tends to gradually work loose under conditions of continuous or excessive vibration. The snap-in method of the invention, however, provides a means whereby the coil ends 13 may be soldered to the terminal 15 prior to installation of the terminal in channel 18 of bobbin flange 17. After the soldering operation has been completed, the terminal may then be easily and securely snapped into the flange.

A wire clamp 23 and locking screw 24 are provided at the ends of coil terminals 15. As is shown in FIG. 8, the clamp and screw act to connect the coil 12 to the leads 25 of a power circuit (not shown).

The series of bobbin projections 16 are designed to be engaged by the bottom portion of housing 4 when the housing is secured to the case. The projections 16 cooperate with the housing 4 to force magnet 9 securely against its resilient mounting and to minimize the undesirable effects of electromagnetic vibration on the relay elements. The top of the bobbin 11 is also provided with an annular raised portion 26. This serves to retain an end of a non-magnetic compression spring 27 which is positioned between the bobbin and generally I-shaped armature 28 or movable element of the electromagnet of the relay which is generally fabricated from laminations of silicon steel. Spring 27 acts to maintain the separation of the armature 28 and the magnet 9 when coil 12 is in a de-energized condition.

As is best illustrated in FIG. 3, a pole unit actuating yoke 29, fabricated from a thermoplastic material, such as nylon, is molded to the top portion of the armature 28. Yoke 29 comprises a generally flat base portion 30 which is molded over armature 29 and the rivets thereof which secure the laminations and protrude laterally from the body of the armature. A yoke portion 31 extends upwardly from base 30 and produces the complete yoke enclosure 29. A ridge 32 is molded into the exterior surface of the yoke portion 31 of yoke 29. The vertically extending portions of ridge 32 complement guide channels 33 molded into pole housing 4 and act to control the vertical movement of the armature actuated yoke 29 with respect to the pole housing. The horizontally extending portion of ridge 32 is formed with a pad section 34 which acts in co-operation with a latching device 7, as is shown in FIG. 11, to maintain the relay in an operative condition though coil 12 is de-energized or, otherwise, inoperative. Projections 35 molded into yoke 29 act as means for manually actuating the relay. A double yoke 36 is shown in FIG. 3. This yoke 36 is employed in relays utilizing a pair of vertically stacked pole housing frames 4 in combination with two groups of pole units 5. Up to four pole units may be secured in each housing whereby up to a total of eight pole units may be employed with each relay and all of which pole units are operable through a single electromagnet and a yoke 36.

Pole housing frame 4 is shown in FIG. 3 to be formed with a series of spaced pole unit mounting blocks 37, each of which is provided with threaded apertures to receive screws from pole unit 5. The underside of pole housing frame 4 is provided with a series of spaced pads 38 which are adapted to engage the projections 16 of the bobbin 11 when the housing is secured to the case. The pads 38 on each side of the housing frame are symmetri-

cally aligned to permit the attachment of the housing frame to the case 2 in either of two positions.

A pair of screws 39 located at diagonally opposite corners of the housing frame 4 are threaded into openings 40 in case 2. Screws 39 act to secure the housing frames 4 to case 2 and, simultaneously therewith, through projections 16 and pads 38, to resiliently secure the bobbin 11 and the magnet 9 in position.

The resilient mounting of the stationary E-shaped magnet 9 may be best viewed in FIG. 8. A rubber-type or resilient plastic pad 41 is shown mounted on the base of case 2. When the two housing screws 39 are threaded into the case, the pads 38 of the pole housing frame 4 engage the top portion of projections 16 and resiliently bias bobbin 11 and magnet 9 against resilient pad 41 on the bottom of case 2.

A cover plate 42 is secured to the housing 4 by a pair of screws 43. Cover plate 42 is formed from a vinyl plastic or similar material, which can be marked by pencil or pen for purposes of identification, and with a pair of openings 44 through which yoke projections 35 extend for manual operation of yoke 29.

As may best be observed in FIGS. 4 and 5, each pole unit 5 consists of a generally elongated contact housing 45 which is formed into a pair of symmetrical pieces 46 and 47. The symmetrical housing halves or pieces are secured together by rivets 48. When the halves 46 and 47 of the contact housing 45 are riveted together, they produce a central enclosure 49 which contains and protects the movable and stationary contacts of pole unit 5. The top portions of the outer ends of contacts housing 45, when riveted together, serve as shields for the terminal ends of the pole unit. The material generally used in molding the contact housing pieces is a non-conducting plastic, such as melamine.

A contact actuating and yoke actuated plunger 50 made of thermoplastic material is positioned within the central enclosure 49 of contact housing 45 and projects through openings 51 and 52 in the top and bottom thereof respectively. The extent of vertical movement of the plunger 50 within enclosure 49 is controlled by a retaining ring 53 located near the uppermost portion of the plunger within enclosure 49. Plunger 50 is notched on its axis to permit insertion and positioning of retaining ring 53. A second retaining ring 54 may be mounted adjacent bottom opening 52 of enclosure 49.

A pair of compression springs 55 and 56 are positioned around the central portion of plunger 50 and on opposite sides of a movable bifurcated contact element 57. The contact element is restrained from vertical movement in one direction by a shoulder on plunger 50. Spring 55 is retained at one end of the plunger by retaining ring 53 and contact element 57, while spring 56 is retained at the other end by element 57 and retaining ring 54.

The bifurcated construction of movable contact element 57 may be best viewed in FIG. 5. As is illustrated in FIGS. 4 and 7, the outer ends of bifurcated contact element 57 are slightly bowed. This bow forms about a 2° angle with the horizontal plane of the element with a permissible tolerance of about plus or minus a degree. The combination of the thin material from which element 57 is made and the bowing of the ends thereof acts to produce a small, but effective, degree of contact wipe when the movable contact element 57 is flattened out against a stationary contact. This wiping action increases the effectiveness and reliability of the electrical contact obtainable from the pole unit 5.

Element 57 is provided with four contact tips 58, each of which is riveted to the bowed end of a leg of the bifurcated contact element. The bifurcated contact element 57 acts to provide multiple current flow paths through the pole unit which thereby produce substantially improved contact reliability.

The bifurcated contact element itself is made of a silver plated beryllium-copper alloy, and the contact tips 58

are generally made of gold bonded silver. The gold bonding of the contact tips 58 acts to prevent the formation of non-conducting oxides or sulfides on the silver tips during periods of storage thereby assuring initial contact continuity even after long periods of shelf life. Contact tips may be supplied in silver, silver alloy, or noble metal depending on particular usage. To eliminate any confusion which may develop with respect to the different types of contact tips, plunger 50 is made in various colors to permit immediate identification of the type of contact tips employed in the unit.

Contact members 59 of pole unit 5 are fabricated from a phosphor-bronze material to which is affixed, through edge-lay construction, silver or silver alloy. The complete surface of contact member 59 is then gold bonded. As is best viewed in FIG. 5, each of the contact members 59 is formed with notched out portions 60 and 61 between the ends thereof. These notched out portions are engaged by surfaces of the housing pieces 46 and 47 when the contact housing 45 is assembled. The portion of contact member 59 positioned in contacting relation with the contact tips 58 of bifurcated contact element 57 comprises stationary contact 62 of pole unit 5 while the opposite end thereof comprises the terminal or circuit connecting end 63 of contact member 59.

The terminal end 63 of the stationary contact is provided with a captive wire clamp 64 which is formed with a tongue which projects through a slot in terminal end 63. A dual purpose screw 65 maintaining clamp 64 captive with respect to terminal end 63 of contact member 59 is, in turn, held captive therein by the partially enclosed ends of the assembled halves 46 and 47 of housing 45. When the pole unit 5 is inserted into the pole housing frame of the relay, as is shown in FIG. 2, the captive screws 65 are threaded into the openings of the pole housing blocks 37. As is shown in FIG. 8, the leads 66 to a circuit (not shown) to be controlled by the pole unit may be simultaneously connected to the terminal end 63 of contact member 59 as the dual purpose screw is threaded into block 37 and wire clamp 64 forces lead 66 into firm electrical contact with terminal end 63.

The pole unit shown in FIG. 4 illustrates a normally open contact. The fragmentary view of the pole unit in FIG. 7 is illustrative of a unit having normally closed contacts. In the manufacturing operation, normally open and normally closed contacts can be provided by merely reversing the position of the bifurcated contact element 57 on plunger 50. This permits the realization of appreciable manufacturing economies in the assembly of pole units. Pole units with normally open contacts can be made to be readily distinguished from pole units having normally closed contacts by appropriately coloring the housing of the respective units for easy identification.

The relay of the invention is operated by energizing coil 12 through lead 25. The current in the coil acts to magnetize the E-shaped stationary magnet 9. The magnetic field produced by magnet 9 exerts an attracting force on armature 28 which overcomes the resistance of non-magnetic spring 27 causing the armature to move vertically downwardly and into contact with magnet 9. Yoke 29, which is secured to the armature and which is disposed for reciprocating movement in the guide channels 33 of pole housing 4, moves vertically downwardly with the armature. The yoke portion 31 of yoke 29 engages the portion of plunger 50 which projects from the top opening 51 of the central enclosure 49 of the pole unit during its downward movement. When the armature and yoke have reached the extent of their descent, the plunger 50 engaged by yoke portion 31 is fully depressed, the contact 57 in FIG. 4, which is normally open in its inoperative condition, is closed and flattened against contact 62 in operation by plunger 50; and conversely, the normally closed contacts of FIG. 7 are opened by the depression of plunger 50. The electromagnet and yoke of the standard unit shown in FIG. 3 can operate any

combination of one, two, three or four pole units of either the normally open or normally closed variety irrespective of the type of contacts employed. By manually depressing yoke projections 35, the pole units controlled by the yoke 29 can be operated irrespective of the energization of the coil 12.

By stacking a pair of pole housing frames 4 upon case 2, securing through both to the case and by utilizing a double yoke 36, shown in FIG. 3, the standard four pole relay can be readily converted into an eight pole relay. This would produce a relay capable of utilizing a group of up to four pole units at one level and a second group of up to four pole units at a level spaced thereabove. The conversion of a standard four pole relay to an eight pole relay can be accomplished while the relay is mounted upon a control panel; it can be accomplished quickly; and the conversion requires only a minimum of skill. In utilizing stacked pole housing frames and double yokes, any combination of normally open and normally closed pole units, from one to eight, may be employed.

When taking into consideration: that coil 12 may be changed according to the voltage requirement of the control system by merely removing the pole housing frame 4 and spring 27 and replacing the bobbin-coil assembly with one rated at a higher or lower voltage; that single pole units of one type may be readily replaced by pole units of another type, by removing only the dual purpose screws 65 from blocks 37 of the pole housing; and that the standard four pole relay may be converted to a relay which can utilize from one to eight poles merely by substituting yoke 36 for yoke 29 and adding a pole housing to the original assembly; it becomes readily apparent that the relay of the invention offers nearly unlimited flexibility and adaptability to a wide variety of control uses. In addition to the inherent flexibility of the relay, any changes required after the relay has been installed on a control panel can be made in a minimum amount of time and with a minimum amount of skill thereby substantially reducing changeover and repair costs of users. By employing distinguishing colors on interchangeable elements, the numbers of combinations of these elements usable can be increased without danger of confusion.

While the relay is designed primarily for use at control potential levels up to 300 volts, provision can be made in the relay of the invention to accommodate potential levels up to 440 volts. This can be accomplished by mounting pole units in every other mounting position in the pole housing 4, leaving alternate positions vacant.

The latching device 7, as is shown in FIGS. 10 and 11, is designed to mechanically maintain the yoke of the relay in an operative relation with the pole units regardless of the condition of coil 12 and to be electromagnetically or manually disengaged therefrom. The latching device comprises a latch support 6 which is mounted upon the pole housing 4 of the relay and is secured thereto by a pair of screws 67 located on diagonally opposite corners of the latch support 6.

On the underside of latch support 6, a pivot rod 68 is journaled in a pair of supporting blocks 69. A pair of retaining rings 70 are attached to the outer ends of pivot rod 68 and act to maintain the rod in its normal horizontal operating position. A latch 71 is connected to the pivot rod and is provided with a lever arm extension 72 extending at approximately right angles thereto.

A torsion spring 73, which is inserted over the pivot rod, is connected to an edge of the latch 71. The spring acts to maintain the latch under substantially constant operative tension.

The top of the latch support 6 carries a coil of wire windings 74 which is secured to the support by a magnet frame 75 and spring washer 76. The coil of the latch is encased in a non-conducting plastic material. A pair of terminals 77, equipped with wire clamps 78 and captive

screw 79 threaded therethrough, are connected to the leads of coil 74 and are adapted to be connected into a power supply circuit (not shown).

As may be best seen in FIG. 11, a stationary magnet 80 is mounted within coil 74. A compression spring 81 is mounted above the stationary magnet core 80 and acts to bias an armature 82 from contact with the stationary magnet core 80 when coil 74 is in a de-energized condition. A latch actuating shaft 83, having an upwardly projecting constricted shank 84 and a shoulder 85, is suspended from armature 82 by nut 86 threaded onto shank 84. Nut 86 acts to secure the shoulder 85 of the shaft in engagement with the lower end of the armature. The lower end of shaft 83 projects through latch support 6 and is restrained from upward movement with respect thereto by a retaining ring 87. A plastic bushing 88, generally made of nylon, is inserted into an opening 89 in magnet frame 75 and serves to permit the smooth, non-frictional movement of armature 82 with respect to stationary magnet 80.

The leading edge of latch 71 is formed with a notch 90 and is adapted to engage, in operation, the pad section 34 on yoke 29. When the relay coil 12 is energized and yoke 29 carried by armature 28 is drawn downwardly by the electromagnetic force of the energized coil, the spring biased latch 71 is drawn into contact with the pad 34 of the yoke 29 and the notched portion 90 of latch 71 engages and maintains yoke 29 in its depressed operative position.

When it is desired to release the latch, the latch coil 74 may be energized by a current pulse through terminals 77. This magnetizes magnet 80 causing armature 82 to overcome the force of compression spring 81. Actuating shaft 83 is forced downwardly and into engagement with the lever arm extension 72 of latch 71. When actuating shaft 83 engages latch 71, the notched portion 90 of the latch is deflected from engagement with the pad 34 of the yoke thereby permitting the yoke to rise and to assume its fully elevated and inoperative position. Through the action of spring 27, the armature 28 and yoke 29 are moved upwardly to their normal inoperative positions, and pole unit plungers 50 previously depressed by the yoke are released and return the contacts 57 carried thereby to their normal inoperative positions. The release of yoke 29 from latching engagement with latch 71 can also be readily accomplished by manually depressing the nut 86 which secures actuating shaft 83 to the armature 82. This can be done without the utilization of any power.

The latching device 7 produces a considerable saving in the electrical power required for the long term operation of the relay of the invention. This results from the mechanical latching of yoke 29 when it is depressed by the energization of relay coil 12. Once the coil is energized and the yoke is latched into its depressed operating position, no further power need be supplied to the coil or to the latch to maintain the poles of the relay in an operative position. Therefore, only a current pulse of a magnitude and duration sufficient to draw the armature 28, and yoke 29 secured thereto, into contact with the stationary E-shaped magnet 9 is required to operate up to eight pole units. A continuous current supply is unnecessary.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. A circuit controlling apparatus, comprising a case, an electro-magnet positioned in the case, the electromagnet having a coil of windings supported upon a nonmagnetic bobbin and a core of magnetically permeable material, the core having a generally stationary element biased against the case and a movable element disposed

opposite the stationary element and movably responsive to energization of the coil, the bobbin and coil being positioned in magnetizable relation with the core, the bobbin being formed with a plurality of terminal connector receiving receptacles, one portion of each receptacle having walls defining an enlarged portion, terminal connector members inserted into the receptacles, the terminal connector members having enlarged body portions disposed in fixed engagement with the walls of the receptacles defining the enlarged portion thereof, means for connecting the ends of the coil windings to the terminal connector members, means for connecting the terminal connector members in a circuit, the bobbin having a plurality of spaced projections extending therefrom and engageable with a portion of a pole housing, a pole housing secured to the case and having means thereon disposed in compressive engagement with the projections on the bobbin, a non-conducting yoke secured to the movable core element and movably mounted in the pole housing, a non-conducting compression means provided between the stationary core element and the movable core element to prevent contact thereby when the coil is inoperative, a pole unit secured to the housing, the pole unit having an enclosed movable contact and means for actuating the movable contact, means for simultaneously securing the unit to the housing and connecting the unit in an electrical circuit, a portion of the yoke being in operative proximity to the actuating means of the pole unit, the pole unit being actuable in response to the movement of the yoke, and a latching device disposed in latching relation to a portion of the yoke, the latching device having a resiliently biased arm engageable with the yoke to maintain the yoke in an operative condition and having electromagnetically and manually actuable means for disengaging the arm from contact with the yoke whereby upon energization of the coil of the electromagnet, the movable magnet and yoke are moved relative to the coil thereby actuating the pole unit and whereby the arm of the latching device engages and maintains the operative condition of the yoke until the arm engaging means of the latching device is disengaged therefrom.

2. A circuit controlling apparatus, comprising a frame, an electromagnet positioned on the frame, the electromagnet having a coil of windings supported upon a bobbin and a core of magnetically permeable material, the core having a generally stationary element and a movable element disposed opposite the stationary element and movably responsive to energization of the coil, the coil being positioned in magnetizable relation with one of the elements of the core, means for energizing the coil, a yoke secured to the movable core element and movable therewith on the frame in response to the energization of the coil, means provided between the stationary core element and the movable core element to prevent contact thereof when the coil is inoperative, a pole unit separably secured to the frame, the pole unit being separable from and connectable to the frame without the necessity of disassembling or interfering with any of the other elements of the circuit controlling apparatus; the pole unit comprising a generally stationary contact, a movable contact and means for actuating the movable contact, a portion of the yoke being engageable with the actuating means of the movable contact of the separable pole unit, the movable contact of the pole unit being actuable in response to the movement of the yoke to assume a position with respect to the stationary contact, and means for connecting the pole unit in a circuit whereby the circuit may be completed and broken through the pole unit by actuation of the yoke.

3. The circuit controlling apparatus of claim 2 wherein the bobbin is provided with a plurality of terminal connector receiving receptacles, one portion of each receptacle having walls defining an enlarged portion, and wherein terminal connector members are inserted into the recep-

tacles, the terminal connector members having enlarged body portions disposed in fixed engagement with the walls of the receptacles defining the enlarged portion thereof.

4. A circuit controlling apparatus, comprising a frame, an electromagnet having an electromagnetically responsive movable element positioned on the frame, means for energizing the electromagnet connected thereto, a yoke secured to the movable element of the electromagnet and movable therewith on the frame in response to the energization of the electromagnet, a pole unit separably connected to the frame as a unitary element, the pole unit being separable from and connectable to the frame without the necessity of disassembling or interfering with the other elements of the circuit controlling apparatus, the pole unit including a generally stationary contact, a movable contact and means for making and breaking the contacts, a portion of the yoke being engageable with the making and breaking means of the pole unit, the movable contact of the pole unit being actuable in response to the movement of the yoke to assume a position with respect to the stationary contact, and means for separably connecting the pole unit in a circuit whereby the circuit may be completed or broken through the pole unit by actuation of the yoke.

5. The circuit controlling apparatus of claim 4 wherein the movable contact and at least a portion of the stationary contact of the pole unit are enclosed by a housing.

6. The circuit controlling apparatus of claim 4 including a housing and means for simultaneously and removably securing the separable pole unit to the housing and connecting the unit in a circuit to facilitate the replacement, exchanging and interchanging of the pole units.

7. The circuit controlling apparatus of claim 4 including a latching device disposed in latching relation to a portion of the yoke, the device having an arm biased to engage and maintain the yoke in an operative condition and having electromagnetically and manually actuable means for disengaging the arm from contact with the yoke whereby upon energization of the coil of the electromagnet, the movable magnet and yoke are moved relative to the coil thereby actuating the pole unit and whereby the arm of the latching device engages and maintains the operative condition of the yoke until the arm engaging means of the latching device is disengaged therefrom.

8. A circuit controlling device, comprising a case, an electromagnet having an electromagnetically responsive movable portion positioned in the case, means for energizing the electromagnet, a group of separately actuable and individually removable unitary pole elements secured to the case, the pole elements being individually separable from and connectable to the case without disturbing or disassembling adjacent pole elements or other elements of the circuit controlling device, the unitary pole elements including stationary contacts, movable contacts and means for connecting and separating the contacts, a non-conducting yoke connected to the movable portion of the electromagnet and reciprocable in the case in response to the movement of the movable portion, the yoke having means for actuating the contact connecting and separating means in response to the electromagnetically induced movement of the yoke to position the movable contacts of the unitary pole elements with respect to the stationary contacts, and means for separably connecting the pole units in circuits whereby the circuits may be completed and broken through the pole unit by actuation of the yoke.

9. The circuit controlling device of claim 8 wherein means are provided on the case to receive a plurality of groups of unitary and individually separable pole elements and the yoke includes means for actuating a plurality of groups of pole units.

10. The circuit controlling device of claim 8 including latching means positioned to actuate the yoke for simultaneously actuating the movable contacts of the unitary

pole elements whereby some circuits may be broken and others may be completed.

11. A circuit controlling device, comprising a case, an electromagnet positioned at an end of the case and supported therein upon a resilient member, the electromagnet having a coil of windings supported upon a non-magnetic bobbin, the electromagnet having a generally stationary element having an E-shaped configuration and supported in the case by the resilient member, a movable element having a generally I-shaped configuration disposed opposite the stationary element and movably responsive to the energization of the coil being positioned around and in magnetizable relation with one of the legs of the stationary element of the electromagnet, terminal connector means connected to the bobbin, means for connecting the ends of the coil windings to the terminal connector means, means for connecting the terminal connector means in a circuit, the bobbin having a plurality of spaced projections extending upwardly therefrom, a pole housing mounted upon the end of the case opposite the electromagnet, the pole housing having means thereon for establishing compressive engagement with the projections on the bobbin, means for securing the housing to the case to thereby establish the compressive engagement of the bobbin projections with the housing and to simultaneously bias the stationary element against the resilient member, a non-conducting yoke secured to the movable element and disposed for reciprocation in the case and the pole housing, a non-conducting means provided between the stationary element and the movable element of the magnet to prevent contact thereof when the coil is inoperative, a pole unit mounted upon the housing, the pole unit having a movable contact and a means for actuating the movable contact, means for connecting the pole unit in an electrical circuit, a portion of the yoke being engageable in operation with the movable contact actuating means of the pole unit, the movable contact being thereby actuable in response to the movement of the yoke to assume a position with respect to the stationary contact whereby the circuit through the pole unit may be completed and broken in response to the energization and de-energization of the electromagnet.

12. The circuit controlling device of claim 11 including a latching device disposed in latching relation to a portion of the yoke, the latching device having a resiliently biased arm engageable with the yoke to maintain the yoke in operative condition and having electromagnetically and manually operable means for disengaging the arm from contact with the yoke whereby upon energization of the electromagnet, the movable element thereof and yoke are moved relative to the pole unit thereby actuating the pole unit and whereby the arm of the latching device engages and maintains the operative condition of the yoke until the arm engaging means of the latching device is disengaged therefrom.

13. A pole unit comprising an elongate nonconducting housing, the housing having an opening provided between the elongate ends thereof, a plunger disposed within the opening and reciprocable therein in response to an actuating means, a contact member within the housing, the contact member being responsive to the reciprocating movement of the plunger, resilient biasing means positioned between the plunger and the contact member for maintaining the contact member in an initial operative position, terminal elements mounted at opposite ends of the elongate housing, a portion of the terminal elements protruding from opposite ends of the housing and at an angle to the longitudinal axis of the unit to permit access thereto from an angle less than normal to the axis thereof, the protruding elements being exposed for connection to and horizontal extension of electric circuit means, horizontally accessible connecting means co-operable with and disposed adjacent to the protruding terminal portions for simultaneously connecting the pole unit in an electrical circuit and for securing the pole unit to a non-conducting base

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member having non-conducting mounting means disposed to complement, support and engage the angularly disposed terminal elements of the pole unit, a portion of the terminal elements projecting into the housing and into contacting proximity with respect to the contact member whereby an electrical circuit may be completed through the terminal elements and the contact member when contact between the elements and the member is established, and means for connecting the pole unit and the terminal elements in an electrical circuit.

14. The pole unit of claim 13, including means on the housing for partially enclosing the connecting means to maintain the connecting means in a captive condition with respect to the end portions of the housing.

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BERNARD A. GILHEANY, *Primary Examiner*.

ROBERT K. SCHAEFER, *Examiner*.