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MULTIPLE CONTACT ELECTROMAGNETICALLY ACTUATED SWITCH AND ACCESSORIES THEREFOR

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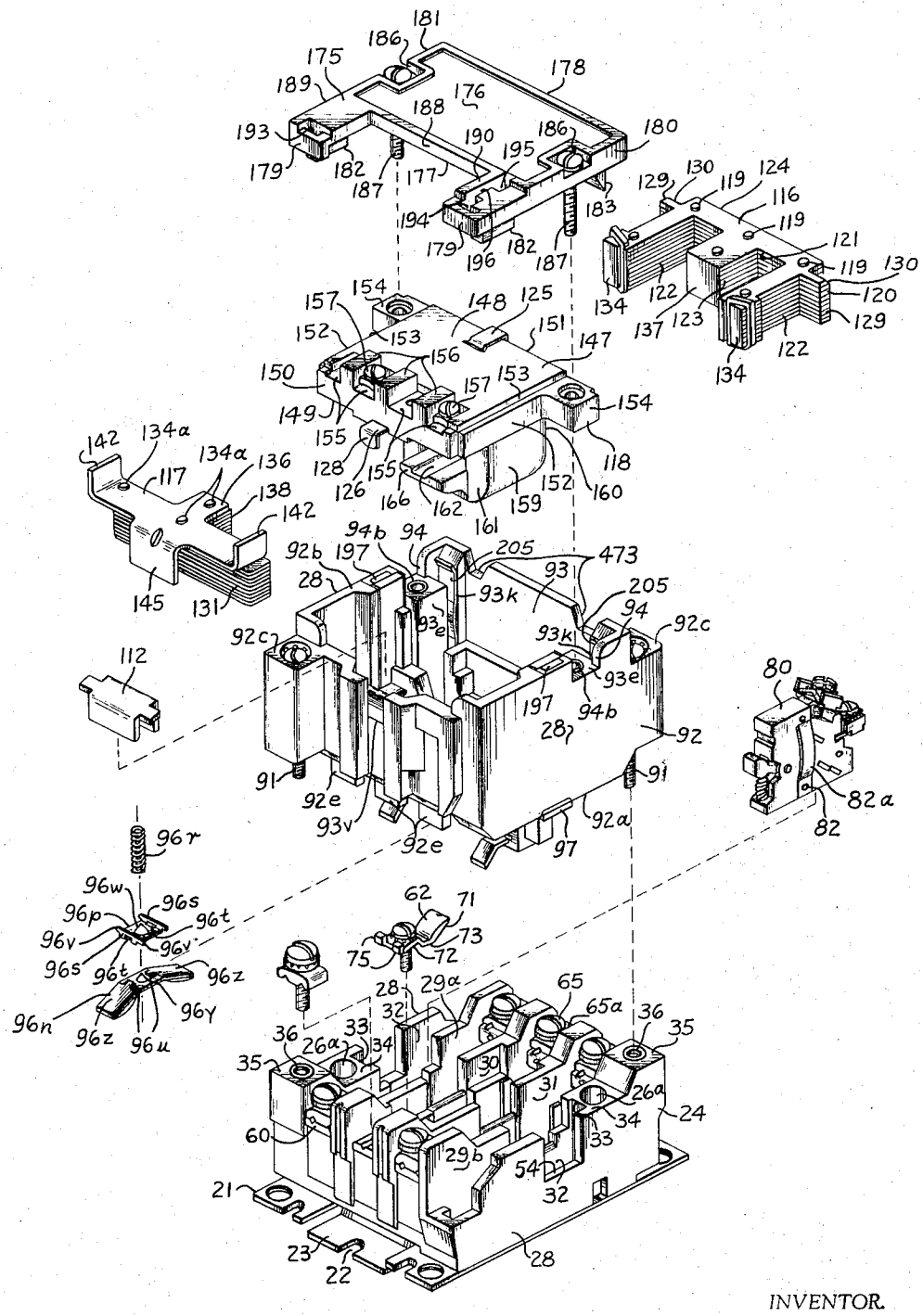

FIG. 1

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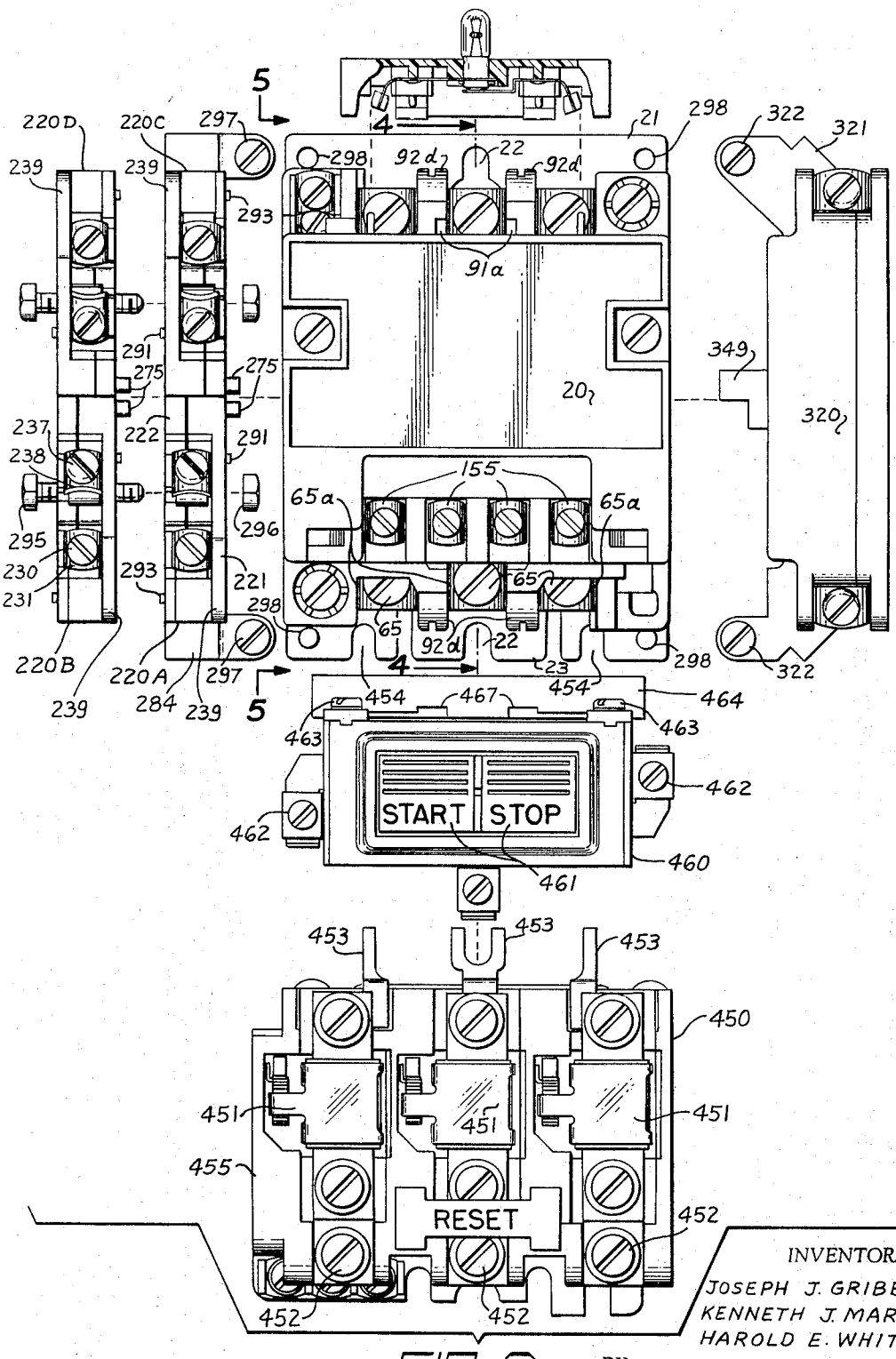

FIG. 2

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MULTIPLE CONTACT ELECTROMAGNETICALLY ACTUATED SWITCH AND ACCESSORIES THEREFOR

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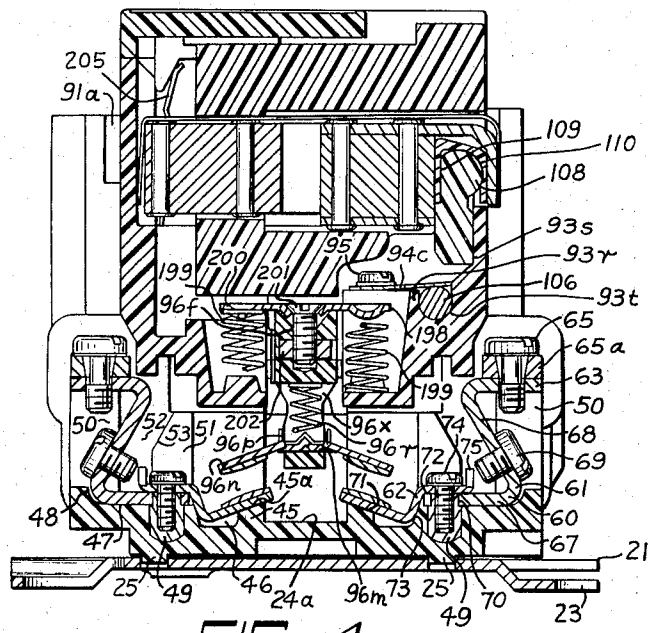

FIG. 4

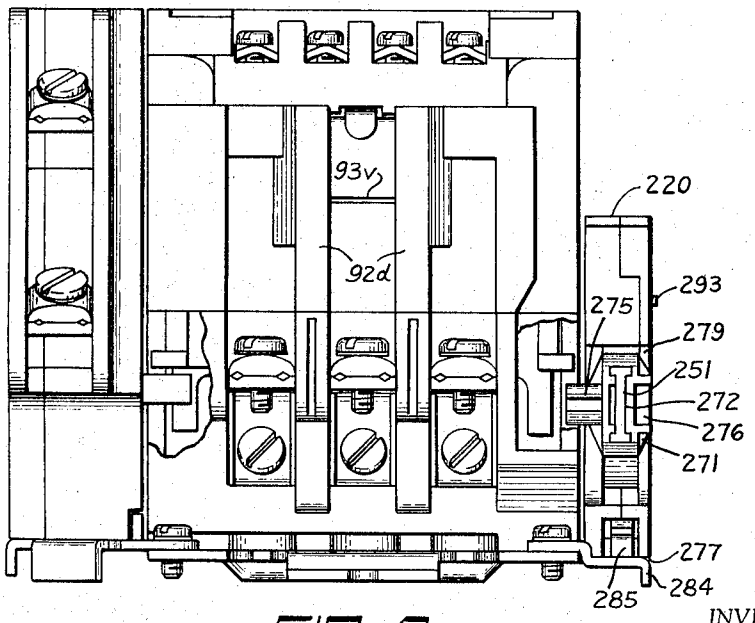

FIG. 3

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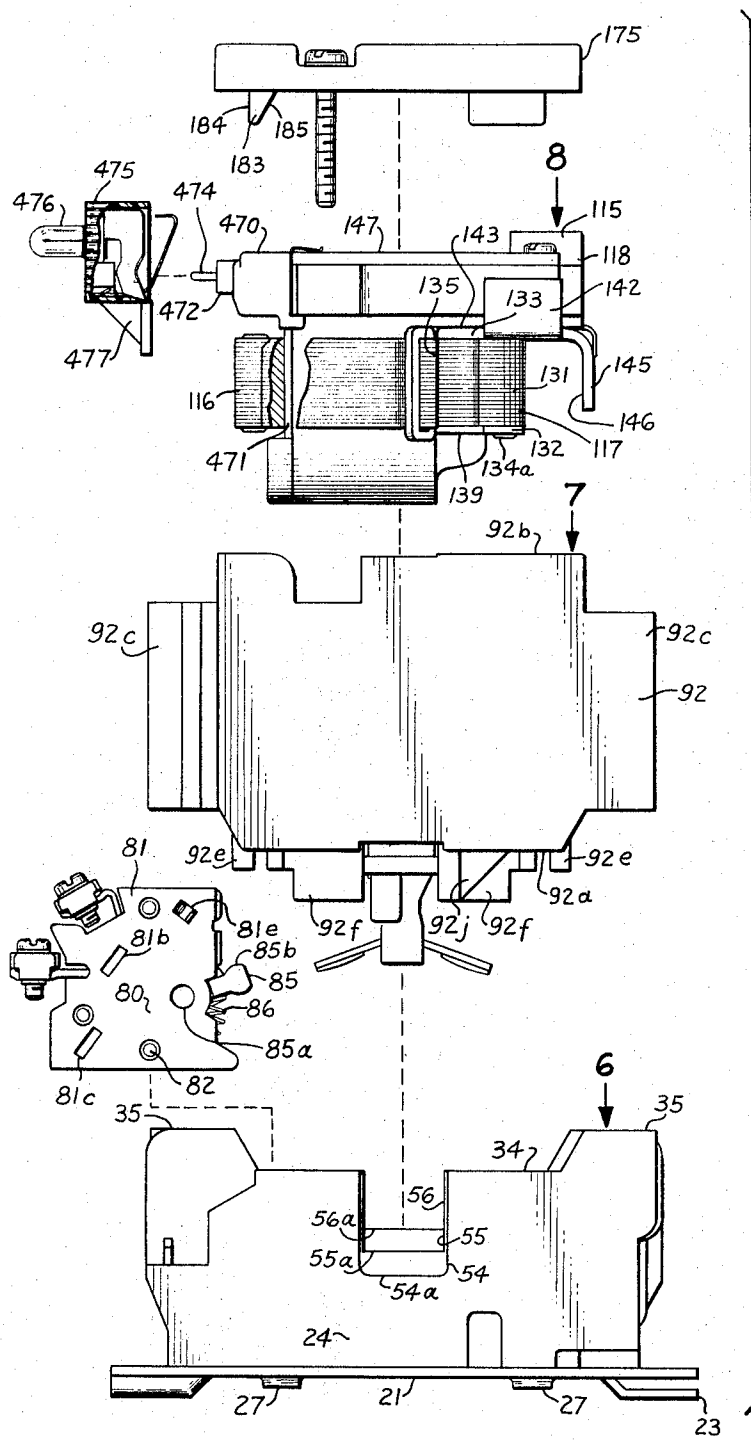

FIG. 5

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MULTIPLE CONTACT ELECTROMAGNETICALLY ACTUATED SWITCH AND ACCESSORIES THEREFOR

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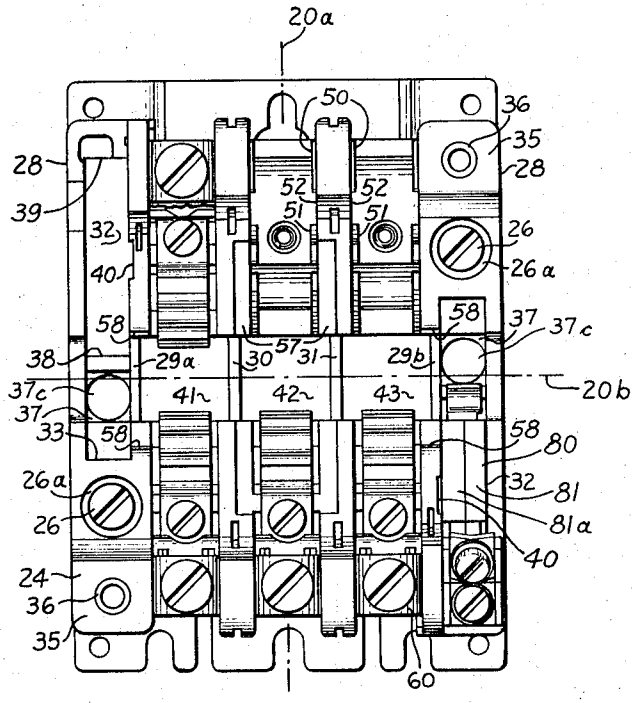

FIG. 6

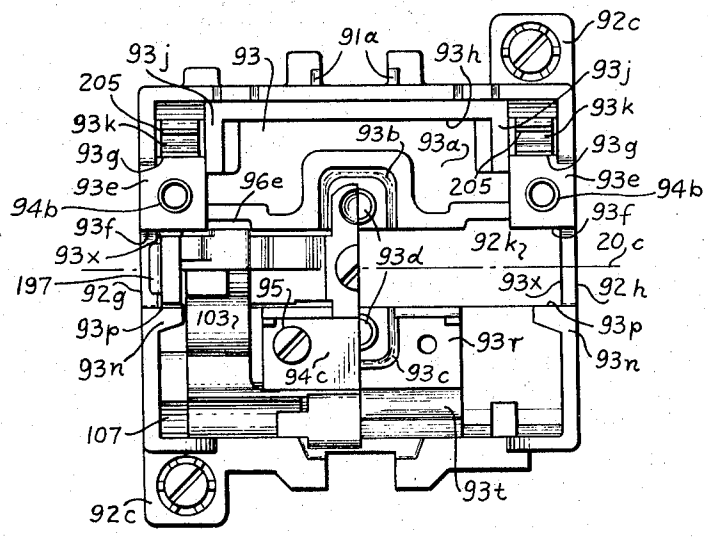

FIG. 7

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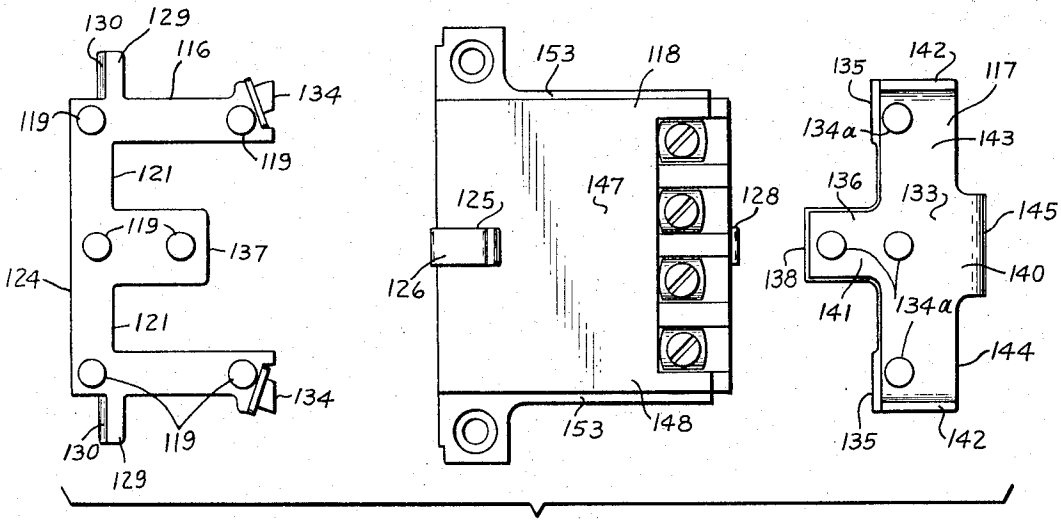

FIG. 8

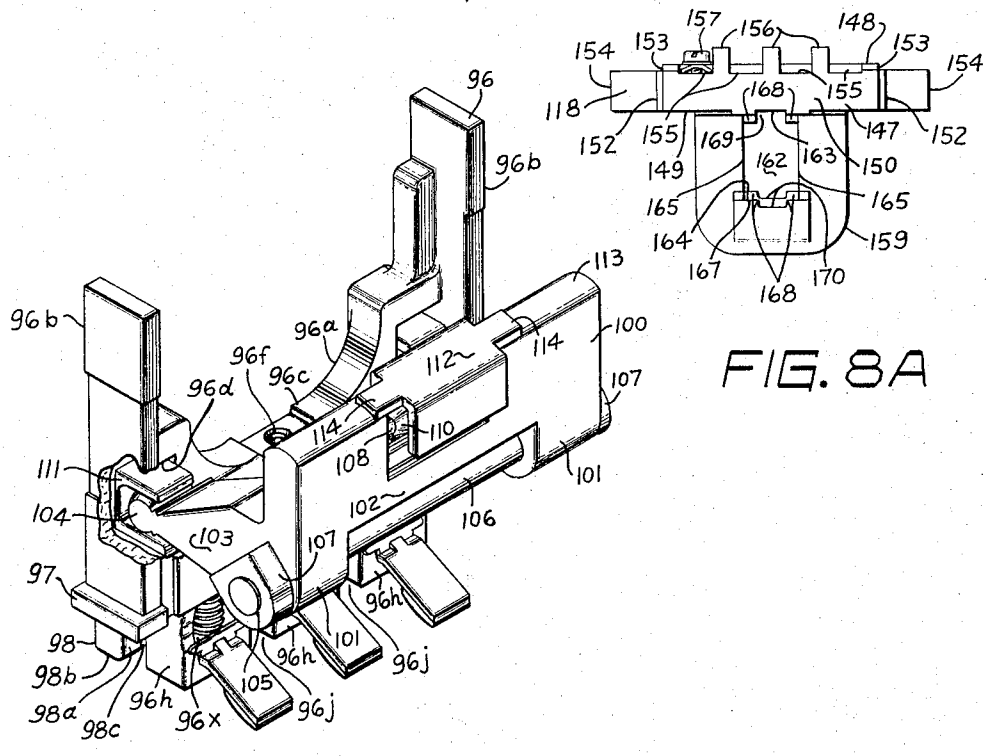

FIG. 9

FIG. 8A

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MULTIPLE CONTACT ELECTROMAGNETICALLY ACTUATED SWITCH AND ACCESSORIES THEREFOR

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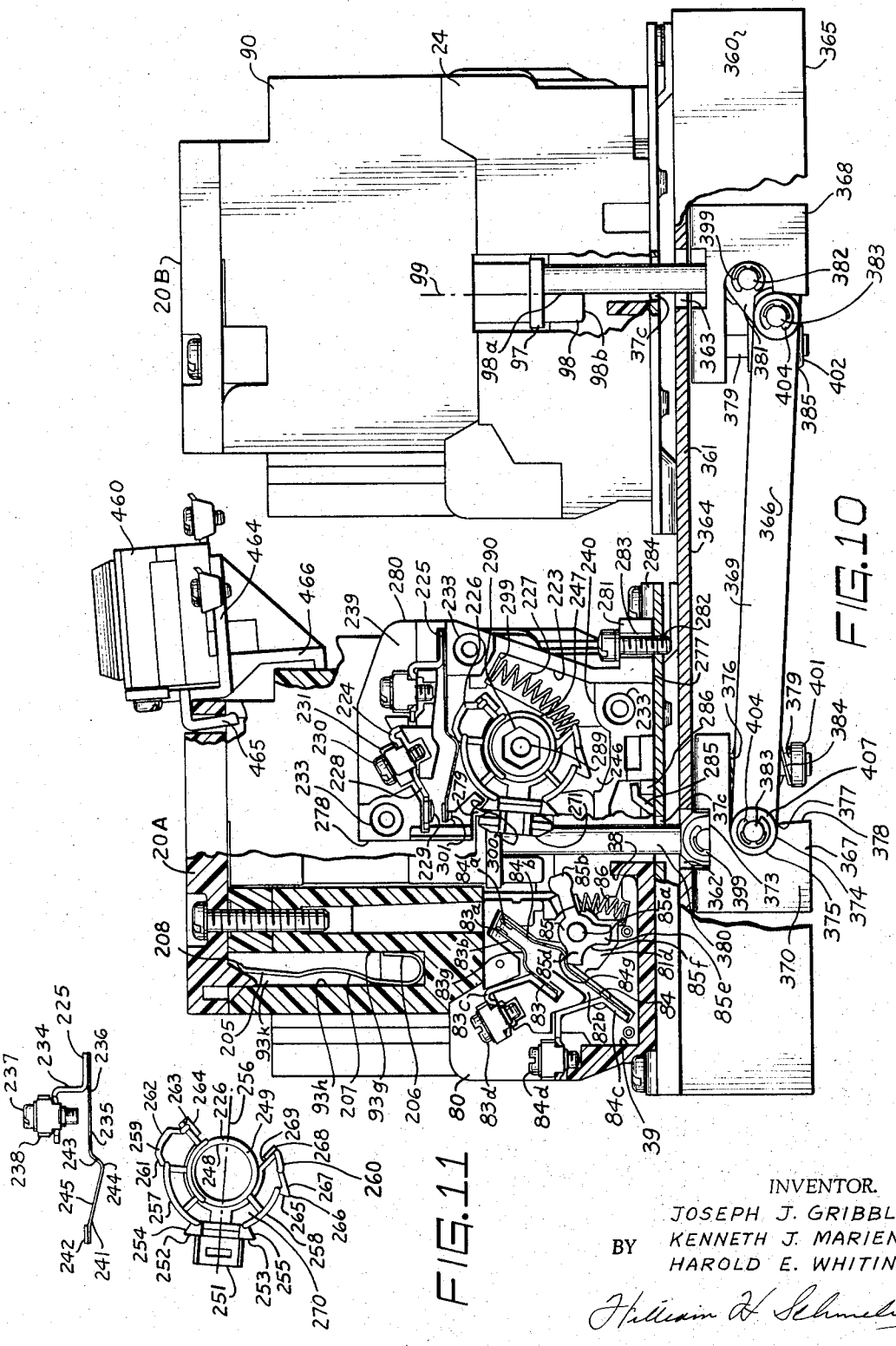

FIG. 10

FIG. 11

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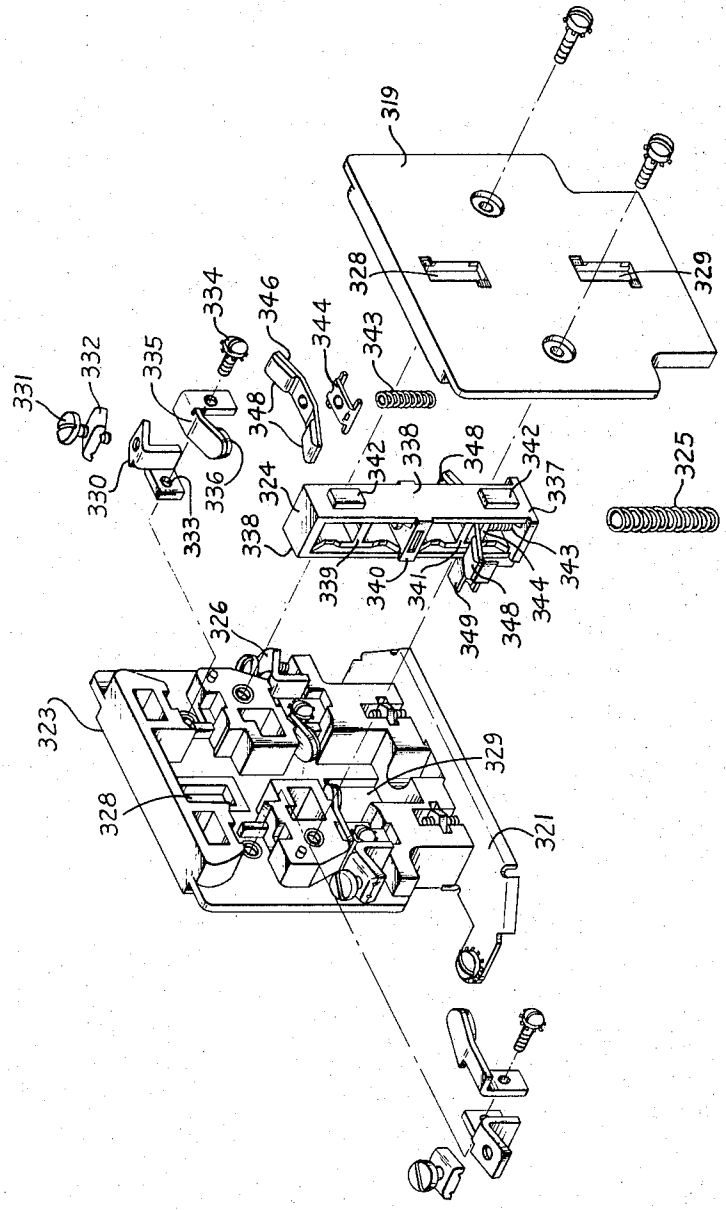

FIG. 12

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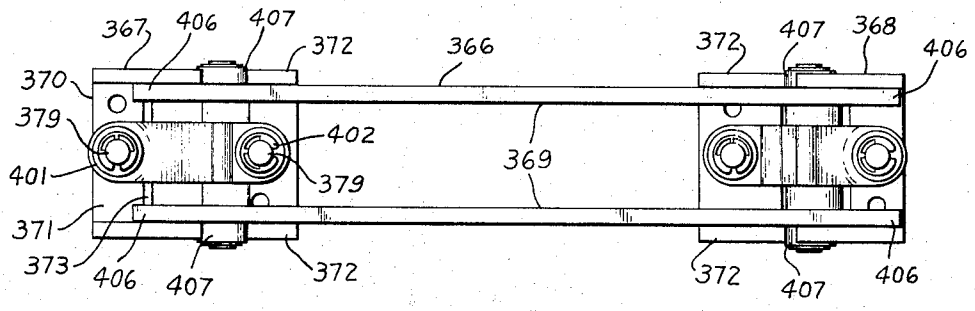

FIG. 13

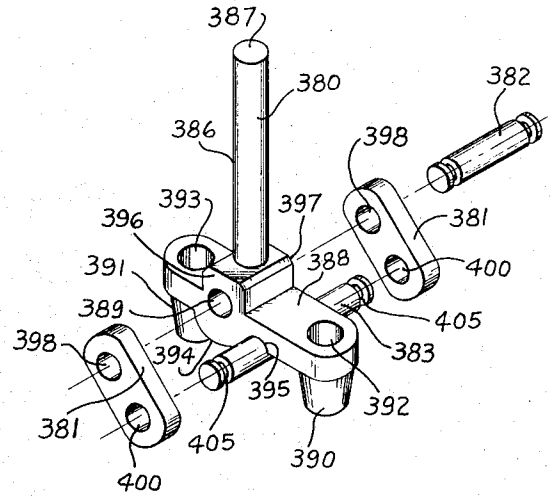

FIG. 14

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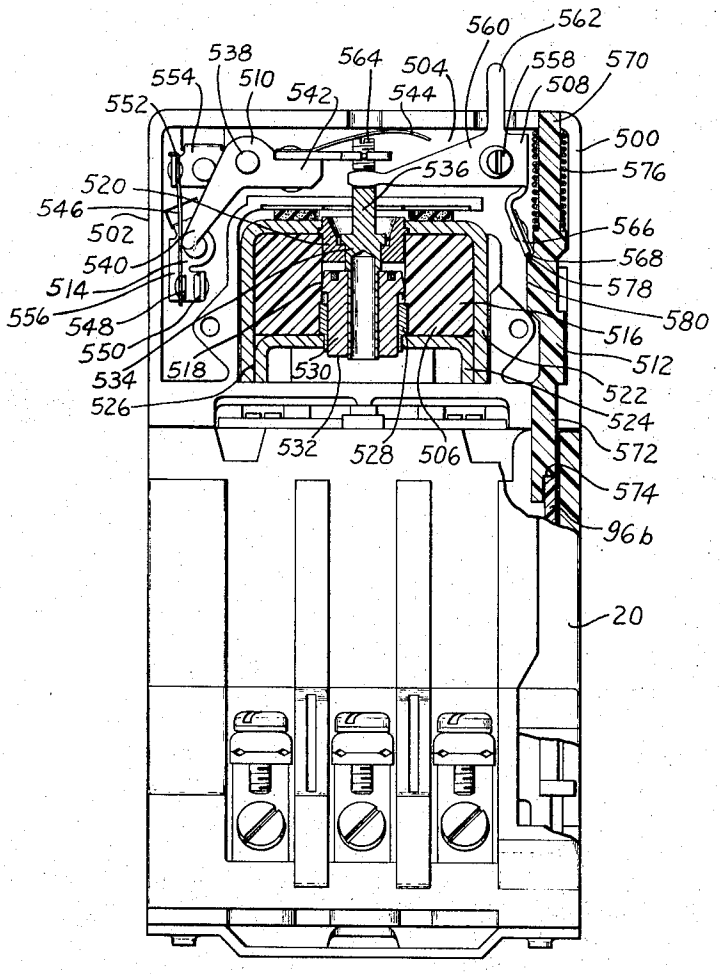

FIG. 15

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United States Patent Office 3,354,415 Patented Nov. 21, 1967

3,354,415

MULTIPLE CONTACT ELECTROMAGNETICALLY ACTUATED SWITCH AND ACCESSORIES THEREFOR

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Filed July 20, 1965, Ser. No. 473,299
23 Claims. (Cl. 335—131)

ABSTRACT OF THE DISCLOSURE

A multiple contact electromagnetically actuated contactor having a bell crank connection between a magnet armature and a movable contact carrier so the armature moves in a path of travel parallel to a mounting panel and the movable contacts in a path perpendicular to the panel to minimize contact bounce and an arrangement whereby the magnet coil and contacts each are enclosed in separate detachable housings to permit servicing and replacement without disturbing the wire connections to the stationary contacts and an arrangement whereby a pair of contactors may be mounted side by side on a support which positions a mechanical interlock between the contactors and the mounting panel to minimize the mounting area required by the interlocked contactors and to provide the contactors with openings in their bottom and side walls to actuate the mechanical interlocks and externally operated switches which may have rotary or linearly movable actuators when the switches are mounted on either side of the contactors.

The present invention relates to electromagnetic switching devices and more particularly to electromagnetic contactors and to switching assemblies which may be combined therewith.

Electromagnetic switching devices of the type with which the present invention is concerned are commonly known as contactors, which, in industrial control environments, may be used individually or in combination with other switching units and may be mounted as exposed on a control panel or within an enclosure. From the standpoint of application, contactors may be regarded as basic switching units as they are frequently combined with other switching units and mechanical interlocking mechanisms to perform a great variety of circuit control functions. Among the prime considerations which an industrial type contactor is required to satisfy is that the contactor must occupy a minimum space on a panel and have a minimum weight for a given voltage and ampere rating. It is one of the objects of the present invention to satisfy this requirement.

Additionally, another requirement which an industrial type contactor must satisfy is that it must provide dependable operation throughout a long life when operating at its rated capacity and it must be arranged so it can be easily mounted on a panel and electrical connections can be easily made to both the terminals of the switching assembly and to the terminals of its energizing coil. It is an object of our invention to satisfy all of these requirements.

Other desirable features which are required to be present in an industrial type contactor are that the contactor must be easy to assemble, inspect and replace the various components such as the circuit controlling contacts and coil and be combined with to actuate and support auxiliary switching devices, mechanical interlock devices and an indicating device, such as a pilot light, as well as support auxiliary electrical devices such as overload relays, and manually actuated switches. It is

an object of our invention to satisfy all of these requirements.

Heretofore, in attempting to satisfy the foregoing requirements, contactors known as vertical acting contactors have been furnished which included an arrangement wherein the movable elements of the electromagnet and the movable contacts of the contactor moved along axes in parallel vertical planes so that the shock which occurred when the moving heavy magnetic metal parts of the electromagnet are stopped in their fully energized position caused an undesirable vibration of the movable contacts of the contactor. This undesirable result is known as contact bounce.

This arrangement was objectionable in that it required the incoming and outgoing conductor wires to be attached at the top of the contactor providing an undesirable wire arrangement which was further complicated when an overload relay was positioned at the bottom side of the basic contactor to form a device commonly known as a starter.

In an effort to solve the wiring difficulties, contactors known as horizontal acting contactors have been furnished which were arranged so the movable contacts and movable electromagnet parts moved in a plane perpendicular to the panel on which the contactor is mounted. While this arrangement provided a solution to the wiring problem in that it permitted the incoming conductors to be connected at one side of the contactor, e.g., the top of the contactor, and the outgoing conductors to be connected at the other, or bottom side of the contactor, it did not diminish the contact bounce problem.

Recognizing the deficiencies as above described in contactors, wherein the movable electromagnet parts and the movable contacts moved along the same axis, contactors have been provided which included an arrangement wherein the movable contacts moved along an axis perpendicular to the panel on which the contactor is mounted while the movable parts of the electromagnet moved along an axis parallel to the panel on which the contactor is mounted. While the contactors, which were arranged so the movable contacts and the movable electromagnet parts moved along axes which were mutually perpendicular, did minimize the problem of contact bounce and simplified the problem of connecting the incoming and outgoing conductors to the device, the arrangements which were heretofore tried increased the difficulties of combining the basic contactor with auxiliary switches and mechanical interlock structures without imposing unbalancing forces on the movable contact structure or the electromagnet structure which greatly decreased the durability and reliability of the contactor.

Accordingly, it is another object of our invention to provide an electromagnetic switching device, commonly known as a contactor, which is arranged so the movable contacts of the contactor move along an axis perpendicular to a mounting panel while the movable parts of the electromagnet move along an axis which is parallel to the panel and to transmit the movement of the movable parts of the electromagnet to the movable contacts through a unitary lever which is pivotally mounted on two widely spaced bearings and pivotally connected to a support for the movable contacts through two widely spaced bearings.

A still further object is to provide a contactor in which both the movable and stationary contact portions of the switching contacts are substantially total enclosed but may be easily inspected and replaced by a simple disassembly operation of one portion of the contactor apparatus from another portion without disturbing the connections of any of the wires connected to and from the contactor.

Another object is to provide a contactor in which both the movable and stationary contact portions of the switching contacts are substantially totally enclosed but may be easily inspected and replaced by a simple disassembly operation of one portion of the contactor from another and in which the electromagnet which is also substantially totally enclosed may be easily inspected and replaced by a simple disassembly operation of a cover for the contactor from the said another portion without disturbing the connections of any of the wires connected in circuit with the switching contacts.

A further object is to provide a contactor with a base which has a pair of spaced stationary contacts in each of a plurality of compartments, a housing mountable on the base enclosing an electromagnet and providing a guide for a carrier which is arranged to position a plurality of movable contacts so the movable contacts engage the stationary contacts when the carrier is moved by the electromagnet toward the base and to resiliently position an electrical switch in either of two additional compartments in the base which are located adjacent the outer walls of the base so an actuator for the switch is moved by the carrier upon movement of the carrier by the electromagnet.

A further object is to provide a contactor with a base which has a pair of spaced stationary contacts in each of a plurality of compartments, a housing mountable on the base enclosing an electromagnet which provides a guide for a carrier which is arranged to position a plurality of movable contacts so the movable contacts will engage the stationary contacts when the carrier is moved by the electromagnet toward the base, to include an electrical switch in either of two compartments in the base which are located adjacent the outer walls of the base so an actuator for the switch is moved by the carrier upon movement of the carrier by the electromagnet and to provide the actuator with a stepped cam portion for actuating a movable contact of the switch which cam is arranged so vibrations of the carrier are isolated from the movable contact.

A further object is to provide a contactor with a base which has a pair of spaced stationary contacts in each of a plurality of compartments, a housing mountable on the base enclosing an electromagnet which provides a guide for a carrier which is arranged to position a plurality of movable contacts so the movable contacts engage the stationary contacts when the carrier is moved by the electromagnet toward the base to include an electrical switch in either of two compartments in the base which are located adjacent the outer walls of the base so an actuator for the switch is moved by the carrier upon movement of the carrier by the electromagnet and to provide the actuator with a stepped cam portion for actuating a movable contact of the switch which cam is arranged so vibrations of the carrier are isolated from the movable contact.

An additional object is to position a pair of contactors in spaced relation on a common U-shaped channel member and to provide a mechanical interlock mechanism for preventing simultaneous movement of the parts of both contactors to an energized position which is received between the arms of the channel member and has a pair of spaced plungers each of which extends through an opening in the base for one of the contactors so as to be movable by a carrier for the movable contacts and to provide an electrical switch in either of two compartments in the base which are located adjacent the outer walls of the base to have an actuator in alignment with the openings in the base so an actuator for the switch is moved by the carrier upon movement of the plunger of the interlock mechanism.

A further object is to provide a contactor with a base which supports a plurality of pairs of stationary contacts and an assembly including a housing, which is detachably carried on the base, which housing is formed to have an

internal caivty and a rectangular opening in the bottom wall of the cavity so the U-shaped carrier which has a bight portion carrying movable contacts external to the bottom external surface of the housing and arm portions guided for movement on opposite side walls of the cavity will cause the movable contacts to engage the stationary contacts when the carrier is moved in one direction, resilient means interposed between the bottom wall and the bight portion of the carrier for urging the carrier in a direction opposite said one direction, stop means on the carrier engageable with the bottom external surface of the housing for limiting movement of the carrier in the said opposite direction, a unitary bell crank journalled on bearings at its opposite ends and having a pair of spaced arms pivotally mounted in the arm portions of the carrier and arm pivotally connected with an armature of a magnet motor which is positioned in the cavity and a cover for the housing which encloses the cavity and supplies a stressing force on a spring mount for a stationary magnet part of the electromagnet when the cover is secured to the housing.

An additional object is to provide an electromagnetic switching device with a removable movable contact assembly which is engageable with contact portions of a pair of spaced stationary contact assemblies which movable contact assembly includes a spring, a contact unit which is removable from the assembly and a retainer for the contact unit and which assembly is positioned in an opening in a support so the retainer which has a portion received in the opening arranged to be guided by extending ears which engage portion of the support external of the opening is constantly biased by the spring toward a bottom wall of the opening and to provide cooperating lugs and detents on the retainer and contact unit for maintaining the contact unit in said opening between the retainer and the bottom wall of the opening.

An additional object is to provide an electromagnetic switching device with a removable movable contact assembly which is engageable with contact portions of a pair of spaced stationary contact assemblies which movable contact assembly includes a spring, a contact unit which is removable from the assembly and a retainer for the contact unit and which assembly is positioned in an opening in a support so the retainer which has a portion received in the opening arranged to be guided by extending ears which engage portion of the support external of the opening is constantly biased by the spring toward a bottom wall of the opening and to provide cooperating lugs and detents on the retainer and contact unit for maintaining the contact unit in said opening between the retainer and the bottom wall of the opening and to provide the contact portions of the stationary contacts with suitable ears which are arranged to engage portions of the side walls of a compartment wherein the contact assemblies are positioned for guiding the contact portions into a proper position relative to a terminal portion of the stationary contact assembly when the contact portion is secured to the terminal portion.

A further object is to provide a contactor with a rectangular shape to have a power unit containing the electromagnet parts of the contactor mounted in front of a base carrying a plurality of pairs of current carrying parts of the contactor and to transmit a vertical movement of the parts of the electromagnet to a horizontal movement of a carrier carrying the movable contacts of the current carrying parts by a single bell crank lever which is pivoted on horizontally aligned widely spaced bearings and to arrange the parts of the contactor to permit: (1) a pair of contactors when mounted on a U-shaped channel member to be mechanically interlocked by levers carried by the channel; (2) a switching unit which is responsive to an excess current flow in any one of the current carrying parts and connected in circuit with the coil of the electromagnet to be mounted adjacent the bottom wall of the contactor; (3) a plurality of switches having rotatable ac-

tuators to be mounted adjacent either side wall of the contactor which switches may be positioned either side by side or end to end adjacent either or both of the sidewalls; (4) a switch having a horizontally movable actuator to be mounted adjacent either side wall of the contactor; (5) a pilot light assembly to be mounted adjacent the top and front wall edge of the contactor which pilot light assembly includes a wafer-thin coil which is positioned by the coil and stationary magnet parts of the electromagnet and a detachable bulb carrying base which is positioned by a dovetail slot connection on the top wall of the contactor; and (6) a manual switch to be positioned adjacent the bottom and front wall by a resilient bracket which is held in position by openings in the cover for the contactor.

A further object is to provide a contactor with a rectangular shape to have a power unit containing the electromagnet parts of the contactor mounted in front of a base carrying a plurality of pairs of current carrying parts of the contactor and to transmit a vertical movement of the parts of the electromagnet to a horizontal movement of a carrier carrying the movable contacts of the current carrying parts by a single bell crank lever which is pivoted on horizontally aligned, widely spaced bearings, and to arrange the parts of the contactor to permit: (1) a pair of contactors when mounted on a U-shaped channel member to be mechanically interlocked by levers carried by the channel; (2) a switching unit which is responsive to an excess current flow in any one of the pairs of current carrying parts and connected in circuit with the coil of the electromagnet to be mounted adjacent the bottom wall of the contactor; (3) a plurality of switches having rotatable actuators to be mounted adjacent either side wall of the contactor which switches may be positioned either side by side or end to end adjacent either or both of the sidewalls; (4) a switch having a horizontally movable actuator to be mounted adjacent either side wall of the contactor; (5) a pilot light assembly to be mounted adjacent the top and front wall edge of the contactor which pilot light assembly includes a wafer-thin coil which is positioned by the coil and stationary magnet parts of the electromagnet coil and a detachable bulb carrying base which is positioned by a dovetail slot connection on the top wall of the contactor; (6) a manual switch to be positioned adjacent the bottom and front wall by a resilient bracket which is held in position by openings in the cover for the contactor; (7) a switch having a rotatable actuator to be positioned in either or both of a pair of compartments in the base and to move all of the actuators of the switches and the levers interlocking the two contactors by portions of the yoke which carries the movable contacts.

Further objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

FIG. 1 is an exploded view showing in perspective the components of a switching assembly embodying the features of the present invention.

FIG. 2 is a front elevational view of the switching assembly shown in FIG. 1 with broken lines showing as detached, certain of the accessories which may be combined therewith.

FIG. 3 is a view showing in elevation a side of the switching assembly with certain of the accessories assembled and with certain portions of the housing for the switching assembly broken away to illustrate the operative connections between the switching assembly and accessories.

FIG. 4 is a cross-sectional view taken along line 4—4 in FIG. 2 in the direction of the indicating arrows.

FIG. 5 is an exploded view of the switching assembly taken in the direction of the arrows 5—5 in FIG. 2.

FIG. 6 is a view of a stationary contact assembly taken in the direction of arrow 6 in FIG. 5, with a portion broken away to illustrate constructional details of a stationary contact and with some of the stationary contacts removed from the stationary contact support.

FIG. 7 is a view of a movable contact actuating portion of the device taken in the direction of arrow 7 in FIG. 5, with portions of the actuating mechanism for the device omitted to the right of a vertical centerline.

FIG. 8 is an exploded plan view of the magnet assembly taken in the direction of arrow 8 in FIG. 5.

FIG. 8A is an end plan view of the coil shown in FIG. 8.

FIG. 9 is a perspective view of a mechanism for actuating the movable contacts of the switching mechanism which view includes a broken-away portion to illustrate details of a bearing structure used in the mechanism.

FIG. 10 is a side elevational view of a pair of switching assemblies mounted on a common support with a portion of the support broken away to illustrate details of a mechanical interlock which operates between the pair of switching assemblies and with one of the devices having portions thereof removed to illustrate constructional details of an electrical interlock switching mechanism which may be used with the switching assembly as well as an arrangement for supporting a manually operable switching mechanism and the details of the engagement between portions of a cover and other components of the switching mechanism according to the present invention.

FIG. 11 shows, as detached, the operating mechanism for an interlock switch mechanism in FIG. 10 so the portions thereof may be more readily identified.

FIG. 12 is an exploded view showing in perspective the components of a switch mechanism which is shown as detached from the right side of the switch mechanism in FIG. 2.

FIG. 13 is a bottom plan view of a mechanical interlock employed in FIG. 10.

FIG. 14 is an exploded view showing in perspective certain components of the mechanical interlock mechanism in FIG. 13.

FIG. 15 is an elevational view taken in the direction of arrow 15 in FIG. 2 showing the switching assembly with a locking attachment replacing a cover for the switching assembly and the connection between the locking attachment and switching assembly.

Referring to the drawings, and particularly to FIG. 2, there is shown an electromagnetic switch assembly 20. The switch 20 as shown in FIGS. 1, 2, and 5 has a mounting plate 21 with a pair of openings 22 which are formed in downwardly indented portions 23 formed in opposite edges of the plate 21 for securing the switch assembly 20 to a panel and the like. The plate 21 also includes a plurality of additional openings which will be hereinafter described. A stationary contact base or support 24, shown in FIG. 1, which is preferably formed of a molded material having arc suppressant capabilities, is positioned on the plate 21, as shown in FIG. 4, by a pair of bosses 25, which extend into suitably located openings in the plate 21. The support 24 is secured to the plate 21 by a pair of screws 26, as in FIG. 6, which are located at diametrically opposite corners of the support 24, and extend through suitable passages 26*a* in the support 24 into openings which are threaded into a pair of bosses 27 in the plate 21, as shown in FIG. 5.

As shown in FIG. 6, the construction of the portion of the support 24 to the left of a vertical centerline 20*a* and above a horizontal centerline 20*b* is identical and a reverse image of the construction of a portion of the support 24 to the right of centerline 20*a* and below the centerline 20*b*. Similarly, the construction of the portion of the support 24 to the right of the centerline 20*a* and above the centerline 20*b* is identical and the reverse image of the portion of the support 24 to the left of the centerline 20*a* and below the centerline 20*b*. Therefore a description of the parts of the support 24 to the right of

the centerline 20*a* will fully describe the constructional details of the entire support 24.

As shown in FIGS. 1 and 6, the support 24 is provided with a pair of outer walls 28 and partitions 29*a*, 29*b*, 30 and 31, which are spaced between and extend parallel to the walls 28 and upwardly from a base or bottom wall 24*a* of the support 24, as shown in FIG. 4. The walls 28 and the partitions 29*a* and 29*b* provide a pair of compartments 32 each of which are closed at an end 33 to provide material for a counterbore around the passages 26*a* for one of the screws 26. The counterbores of the passages for the screws 26 are sized so the head of the screw 26 is below the upper surface of the support 24 when the support 24 is secured to the plate 21. The material of the support 24 which provides the closed ends 33 of the compartments 32 is formed to extend upwardly above a surface 34, wherein the counterbore for the passages for the screws 26 are formed, as in FIG. 5, to provide a pair of raised bosses 35, as in FIGS. 1, 5 and 6, wherein threaded inserts 36 are embedded. Extending upwardly, as in FIG. 6, through the bottom wall 24*a* of the support 24 into the compartments 32, are rectangular openings 37 which are centered on opposite sides of the centerline 20*b* as shown in FIG. 6, and are aligned with circular openings 37*c* in the mounting plate 21. The end of the compartments 32 adjacent the opening 37 is provided with an upstanding wall 38 and the end remote from the opening 37 is provided with an upstanding wall 39. As most clearly shown in FIG. 6, the side wall of the partitions 29*a* and 29*b* facing each of the compartments 32 has a vertically extending recess 40 which extends from the top surface of the partitions to the bottom wall 24*a* of the support 24.

The partitions 30 and 31 are spaced between the walls 29*a* and 29*b* to provide three compartments 41, 42 and 43, which are of equal width and which extend transversely across the entire width of the support 24. As the shape of the bottom wall of each of the compartments 41–43 is identical, only the details of the compartment 42, as shown in FIG. 4, will be specifically described. Further, because the shape of the bottom wall of the compartment 42 above and below the centerline 20*b* of the support 24 are identical, only the shape of the bottom wall of compartment 42 above the centerline 20*b* will be specifically described, reference being had to FIGS. 4 and 6. Spaced above the centerline 20*b* is an upwardly extending boss 45 which has a top surface 45*a* inclined toward a recess 46. The reces 46 is formed betwen the boss 45 and a ledge 47 which is terminated by an upwardly curved wall 48. Secured in the material which forms the ledge 47 is a threaded insert 49 which has a portion extending above the upper surface of the ledge 47.

A description of the configuration of the walls which form compartments 41–43 will now be set forth. The shape of the walls of the partitions 29*a* and 29*b* which face the compartments 41 and 43 are identical. Similarly, the shape of the walls of partitions 30 and 31 which face compartment 42 are identical. Also the shape of the walls of the partitions 30 and 31 which respectively face the compartments 41 and 43 are identical and, with minor exceptions, the shape of the walls of the partitions 29*b* and 31 which face compartment 43 are identical. Thus a description of the opposite side walls which form the partition 31 will provide a description of the shape of the walls which form each of the compartments 41–43. Further, as the portions of the partition 31 above and below the horizontal centerline 20*b* in FIG. 6 are identical in shape, a description of the shape of the wall portion of the partition 31 above the centerline 20*b* will adequately describe the shape of the walls of the partitions 29*a*, 29*b*, 30 and 31 of the support 24.

Extending on opposite sides of the partition 31 are portions 50 and 51 which are spaced to provide a groove 52 which is most clearly seen in FIGS. 4 and 6. The portions 50 have a width as shown in FIG. 6 and as shown in FIG. 4, the portions 51 have an inclined edge 53 forming an entry into groove 52.

As shown in FIG. 1, each of the partitions 29*a*, 29*b*, 30 and 31, as well as the end walls 28, are provided with a notch, each of which is of equal width and centered on the centerline 20*b*. The base 54*a* of a notch 54 in the walls 28 is shown in FIG. 5. Similarly, the base 55*a* of a notch 55 in the partitions 29*a* and 29*b* is shown in FIG. 5 and the base 56*a* of the notch 56 in the partitions 30 and 31 is also shown in FIG. 5. As shown in FIG. 6, the walls of the partitions 30 and 31 facing the compartment 42 are provided with a recess 57 which extends on opposite sides of the centerline 20*b*. The recesses 57 each have a bottom surface substantially planar with the base 56*a* of the notches 56. The notches 55 are provided with stepped portions to provide a vertical wall 58 shown in FIG. 6 which stepped portions have a horizontal bottom wall planar with the bases 56*a* of the notches 56.

The foregoing constitutes a description of the molded insulating support 24.

Securable in each of the compartments 41, 42 and 43 are cooperating pairs of terminal and stationary contact assemblies 60 which are most clearly seen in FIGS. 1, 4 and 6. As each of the assemblies are identical and each are identically positioned in the opposite ends of the compartments 41–43, only the assembly shown to the right in FIG. 4 will be specifically described, it being understood that each of the compartments 41–43 has a stationary contact assembly positioned in opposite directions from its opposite ends at equal distances from the centerline 20*b*.

As shown in FIG. 4, the stationary contact assembly 60 includes a Z-shaped terminal connector 61 and a removable stationary contact 62. The terminal connector has an upper horizontal portion 63 which rests upon the raised portions 50 and has a threaded opening to receive a screw 65 for tightening a clamp 65*a* upon a bared end of a wire lead which is not shown. The upper horizontal portion 63 is connected to a lower horizontal portion 67 by an inclined center portion 68. The inclined portion 68 is provided with a threaded opening to receive a screw 69 which may also be used to electrically connect the bared end of a wire conductor, not shown. The lower horizontal portion 67 is provided with an opening 70 to receive the projection of insert 49, while the portion 67 rests upon the ledge 47 and a pair of extending ears, not shown, which are arranged to be received in recesses 52.

The removable stationary contact 62 has an inclined portion 71 having a bottom surface which rests upon the inclined surface 45*a* of the boss 45. The upper surface of the inclined portion 71 preferably is provided with a contact material, such as a noble metal or alloy thereof, which has a high current conducting and arc extinguishing capability. The inclined portion 71 is connected to a securing portion 72 by an intermediate portion 73. The intermediate portion 73 is arranged to be received in the recess 46 when the inclined portion 71 is supported on the boss 45. The securing portion 72 has an opening thereon which is arranged to hold captive a screw 74. Extending upwardly and outwardly from the end of the securing portion 72 are a pair of oppositely extending ears 75, which are most clearly shown in FIG. 1. The stationary contact assemblies 60 are installed in each of the ends of the compartments 41–43, as follows. Initially, the Z-shaped terminal connector 61 is inserted into an end of one of the compartments 41–43 so that the underside surface of the upper horizontal portion 63 rests upon the upper surface of the raised portions 50, and the underside surface of the lower horizontal portion 67 rests upon the ledge 47 with the opening 70 receiving the extending portion of the insert 49. The extending ears on the lower horizontal portion 67 additionally aid in maintaining the connector 61 in its inserted position. The removable stationary contact 62 is then installed in position by insert-

ing the same at an angle toward the base 24*a* with the ears 75 in contact with the inclined surface 53. The inclined surface 53 directs the contact 62 into position so that the screw 74 is aligned with the opening 70 and the insert 49 while the inclined portion 71 rests upon the boss 45. The removable stationary contact 62 is secured in position when the screw 74 is tightened in insert 49. It will be seen that the foregoing construction provides an arrangement whereby the contact making and breaking portion, which includes the contact material on the portion 71, may be replaced without disturbing the wire connections which may be secured by the screws 65 and 69 when the device 20 is wired in a control circuit. All that is required to remove the stationary contact portion 62 is to loosen the screw 74 and remove the stationary contact assembly 62 so that a replacement contact assembly 62 may be readily installed as described above.

If desired, an additional switch 80 may be installed in either or both of the compartments 32. In FIG. 6, only one switch 80 is shown as installed in the lower right-hand compartment 32, it being understood that an additional switch 80, not shown, may be installed in the upper left-hand compartment 32, as in FIG. 6. The external configuration of switch 80 is most clearly shown in FIGS. 1 and 5 and the position of the switch 80 within the compartments 32 is most clearly shown in FIGS. 6 and 10. As shown in FIG. 6, the compartments 32 are located on opposite corners of the support 24 and are identical in configuration and extend in opposite directions from the centerline 20*b*. Thus the compartments 32 each will receive an identical switch 80 which, when positioned therein, will extend in opposite directions of the centerline 20*b*.

The switch 80, as shown in FIG. 6, includes two mating housing parts 81 and 81*a* which are basically mirror images of each other. The housing parts 81 and 81*a* are sized so that when the switch 80 is positioned in either of the compartments 32, a front nose portion of the housing parts 81 and 81*a* will engage the upstanding wall 38 while the rear portions thereof are positioned by the wall 39. The housing parts 81 and 81*a* are secured together by means of a fastening means, such as rivets 82, which extend through aligned openings in the housing parts 81 and 81*a*, and when secured together provide an internal cavity 82*b*, shown in FIG. 10, wherein a stationary contact assembly 83, a movable contact assembly 84, and a rotatable actuator 85 are received.

The stationary contact assembly 83 includes a contact button 83*a* which is secured to one end of a resilient metal support 83*b*. The other end of the support 83*b* is secured to a rigid metal member 83*c* which is provided with a threaded opening to receive a terminal screw 83*d* which, when tightened, will force a clamp into tight engagement with the bared end of a conductor wire, not shown. The movable contact assembly 84 includes a contact button 84*a* which is secured to one end of a resilient metal support 84*b*. The other end of the support 84*b* is secured to a rigid member 84*c* which is provided with a threaded opening to receive a terminal screw 84*d* which, when tightened, will force a clamp into tight engagement with the bared end of a conductor wire, not shown. The rigid members 83*c* and 84*c* are shaped as shown to have a portion extending from the cavity 82*b* through openings in the housing parts 81 and 81*a* to the exterior of the switch 80 so the screws 83*d* and 84*d* are externally accessible. The areas of securement between the supports 83*b* and 84*b* and the respective rigid members 83*c* and 84*c* are positioned within recesses which are provided as extensions of cavity 82*b* and which are sized to tightly receive the areas of securement between the supports 83*b* and 84*b* and the rigid members 83*c* and 84*c*. Additionally, the rigid members 83*c* and 84*c* are provided with suitably located ears which extend outwardly to be respectively received in openings indicated as 81*b* and 81*c* in FIG. 5, which are formed in the housing parts 81 and 81*a* to further position the contact assemblies 83 and 84 in the switch 80. As shown in FIG. 10, the resilient support 83*b* has a downwardly curved portion 83*g* which is arranged to position the contact button 83*a* in spaced relation to the walls which form the cavity 82*b*. Similarly, the resilient support 84*b* has a curved portion 84*g* located intermediate the contact button 84*a* and the end portion which is secured to the rigid member 84*c*. The curved portion 84*g* is downwardly curved as shown and extends toward an opening 81*d* in the housing parts 81 and 81*a*. Each of the housing parts 81 and 81*a* are provided with an opening, which openings are aligned when the housing parts 81 and 81*a* are secured together to provide pivot bearings for journals 85*a* which extend in opposite directions on the rotatable actuator 85. The actuator 85 has an actuating arm 85*b* extending outwardly through the opening 81*d* to the exterior of the housing parts 81 and 81*a*. The arm 85*b* has oppositely facing rounded surfaces on the top and bottom surfaces of the end which extends exterior to the housing parts 81 and 81*a*. Located intermediate the journals 85*a* and the rounded surfaces on the arm 85*b* are raised portions which position one end of a compression spring 86 which has its other end seated on the bottom surface of the cavity 82*b* so as to constantly urge the actuator 85 counterclockwise. As shown in FIG. 10, extending outwardly from the journals 85*a* generally in the opposite direction from the arm 85*b* is a lever portion 85*d* which has a substantially flat surface at its free end. Also extending outwardly from the journals 85*a* generally at right angles to the lever 85*d* is a lever 85*e*. Extending between the levers 85*d* and 85*e* is a recess 85*f*.

When the actuator 85 is positioned in the switch 80, as shown in FIG. 10, the contact buttons 83*a* and 84*a* of the switch 80 will be in the normally open position; that is, the spring 86 causes the actuator 85 to normally be rotated counterclockwise to a position where the lever 85*d* is positioned below the curved portion 84*g*. When the actuator 85 is caused to be rotated clockwise by an outside force which is impressed on the rounded surface of the actuating arm 85*b*, as will be hereinafter described, it will be seen that the flat surface on the free end of the lever 85*d* will ride upon the curved portion 84*g* to a position where the flat surface of the lever 85*d* is substantially centered on the apex of the curved portion 84*g*, causing the contact buttons 84*a* to move into contact making position with the button 83*a*. The flattened surface on the lever 85*d* is arranged so that the vibrations which may be imparted to the actuator 85 will not cause separation of the buttons 83*a* and 84*a*.

It will be seen that if the actuator 85 is inverted in the switch housing parts 81 and 81*a* to a position wherein the lever 85*e* extends upwardly, in a view not shown, then the force exerted by the spring 86 which urges the actuator 85 in a counterclockwise direction will cause the lever 85*e* to move into engagement with the curved portion 84*g* to cause the contact buttons 83*a* and 84*a* to normally engage one another. When the actuator 85 is rotated clockwise to its actuated position, the recess 85*f* will be in alignment with the curved portion 84*g* so the contacts will separate under the action of their resilient supports 83*b* and 84*b*. Thus it will be seen that a reversal of the position of the actuator 85 will cause the contact buttons 83*a* and 84*a* of the switch 80 to be either in a normally closed or in a normally open position. Further, when the actuator 85 is arranged so the contact buttons 83*a* and 84*a* are in the normally open position, when the actuator 85 is rotated, vibration will not cause separation of the contact buttons 83*a* and 84*a* to thereby prevent the arcing which normally otherwise would occur because of vibrations imparted to the device.

The housing parts 81 and 81*a* are substantially identical with the exception that, as shown in FIG. 5, the housing part 81 is provided with an opening 81*e* which is located so as to be in alignment with the contact buttons

83a and 84a. This opening 81e permits visual observation of the contact buttons 83a and 84a to determine if they are operative. Additionally, the housing part 81a is provided with a recess at its lower surface which is aligned with the openings which receive the rivets 82. This recess is utilized to provide a seat for a leaf spring member 82a, shown in FIG. 1, which is secured to the housing part 81a by one of the rivets 82 and which is arranged to be received in the vertically extending recess 40 in one of the partitions 29a or 29b facing one of the compartments 32 when the switch 80 is inserted into the compartments 32. The spring 82a resiliently positions the switch 80 in the compartments 32.

As shown in FIG. 10, removably detached and supported by the stationary contact assembly, which includes the support 24, is a magnet and movable contact assembly 90. The movable contact assembly is secured to the support 24 by a pair of screws 91, shown in FIG. 1, which are threaded into the inserts 36 in the support 24. The movable contact assembly 90 includes a housing 92 formed of molded material to provide an internal cavity, which will be later described. The housing 92 is generally rectangular in shape and has bottom and top walls, indicated respectively as 92a and 92b in FIG. 5. Extending from the opposite corners of the housing 92, as in FIGS. 1 and 7, are bosses 92c. The top and bottom surfaces of the bosses 92c are spaced below and above the top and the bottom walls 92b and 92a, as in FIG. 5, with the spacing between the bottom wall of the bosses 92c arranged so the bottom wall 92a engages the top walls 34 of the support 24 as the bottom wall of the boss 92c rests upon the top surface of the bosses 35. The bosses 92c are each provided with a bore to permit passage of the securing screws 91 which are threaded into the inserts 36 in the support 24. As shown in FIGS. 2 and 3, the side walls of the housing 92 are provided with strengthening ribs, indicated by 92d, with the central ribs at the top of the device, as in FIGS. 2 and 4, being provided with vertical slots 91a for securement of a pilot light to be later described.

As shown in FIGS. 1 and 5, extending downwardly from the bottom wall 92a and spaced to be received in the compartments 41–43 when the housing 92 is positioned on the support 24 in a position to be behind the terminal screws 65 and the clamps 65a are bosses 92e which acts as wire stops to limit the depth of penetration of the wire leads beneath the clamps 65a which are tightened by the screws 65. Also, as shown in FIG. 5, extending downwardly from the bottom wall 92a is a rectangular boss 92f which is sized to extend into the recesses 57 in the partitions 30 and 31 for positioning the housing 92 on the support 24. The bottom wall 92a has a rectangular opening 92k, as in FIG. 7, extending between the side walls 92g and 92h which also extends through the boss 92f to effectively divide the boss 92f into a pair of bosses. The centerline 20c of the housing 92 is coplanar with the centerline 20b of the support 24 when the housing 92 is positioned on the support 24. If desired, a pair of spaced downwardly extending guides 92j, one of which is shown in FIG. 5, may be formed to extend downwardly from the bottom wall 92a to present a vertical wall vertically aligned with an edge of the opening 92k. The guides are received in the stepped portions which provide vertical walls 58 when the housing is positioned on the support 24.

As shown in FIG. 1, the housing 92 has an internal cavity 93 which is rectangular in shape. The cavity is centered on the centerline 20c, shown in FIG. 7, which also provides a centerline for the opening 92k in the bottom wall 92a of the housing 92. A bottom wall 93a of the cavity 93 extends generally parallel to the bottom wall 92a. Extending downwardly from the bottom wall 93a into the bosses 92f on either side of the opening 92k are recesses 93b and 93c which, as shown in FIG. 7, are identical in shape and extend in opposite directions of the opening 92k. Each of the recesses 93b and 93c have a spring seat 93d on their bottom surfaces. Extending upwardly from the bottom wall 93a and projecting inwardly into the cavity 93 from the opposite side walls of the cavity, as in FIG. 7, are a pair of bosses 93e. As shown in FIG. 1, the bosses 93e have a top surface which is coplanar with a bottom edge of a notch 94 in the side walls 92g and 92h wherein a threaded insert 94b is embedded. As shown in FIG. 7, the bosses 93e are preferably rectangular in shape and have a side wall 93f vertically aligned with an edge of the opening 92k and a wall 93g parallel to the wall 93f spaced from an end wall 93h of the cavity 93. A partition 93j extending from the bottom wall 93a between walls 93g and end wall 93h provides a recess 93k. A rib extends along opening 92k and around the recesses 93b to add strength to the bottom wall 93a. Extending inwardly from the opposite side walls of the cavity 93 are vertical ribs which extend upwardly from the bottom wall 93a to the top surface 92b and have a side wall 93p in vertical alignment with an edge of the opening 92k. The side walls 93f and 93p are thus parallel and spaced on opposite sides of the opening 92k and form slots or guideways 93x at opposite ends of the opening 92k, which are perpendicular to the bottom wall 92a of the cavity 93 and centered on centerline 20c. The material of the housing 92 surrounding the recess 93c is raised to provide a rectangular boss 93r which has a length at least equal to the length of a metal plate 94c, shown in FIGS. 4 and 7, and a width extending from the opening 92k to a side wall 93s of the cavity 93. The height of the boss 93r is shown in FIG. 4. The boss 93r is provided with a pair of spaced bores which are located to receive screws 95, shown in FIG. 7. Downwardly extending in the boss 93r, as shown in FIGS. 4 and 7, is a horizontal recess 93t which extends over the entire length of the boss 93r and is spaced parallel to the wall 93s. The recess 93t is U-shaped, having a depth equal to its diameter and extends along an axis parallel to the centerline 20c. The wall 93s of the housing 92 is also provided with an opening 93v as shown in FIGS. 1 and 3 which exposes the interior of the cavity 93 to the exterior of housing 92.

The foregoing constitutes a description of the location and shape of both the exterior and interior of the molded housing part 92 of the movable magnet and housing assembly 90.

A movable contact and guide assembly 96 for the device which is carried by the housing part 92 and is most clearly shown in FIG. 9, includes a U-shaped support 96a which is preferably formed of a molded insulating material to have a pair of spaced upwardly extending arms 96b which are interconnected by a bight portion 96c. The support 96a is sized to be inserted upwardly through the opening 92k in the bottom wall 92a of the housing 92 with the arms 96b received in the slots 93x which guide the support 96a along a vertical reciprocal path of movement relative to the bottom wall 92a of the housing 92. Extending forwardly at the junction of each of the arms 96b and the bight portion 96c are rectangular sockets 96d which extend outwardly of the bight portion 96c. The sockets 96d each have appreciable depth and face in the same direction which, for descriptive purposes, will be indicated as facing the front of the support 96a, as shown in FIG. 9. If desired, the rear face of the support 96a, as shown in FIG. 7, may be provided with ribs 96e which are received in suitably located slots in the material of the housing 92 which surrounds the opening 92k.

Centrally located in the bight portion 96c is a bore 96f which extends downwardly to a rectangular opening in the rear face of the bight portion 96c. As shown in FIG. 4, the bore 96f has its upper end countersunk. The rectangular opening is arranged to receive a nut 202 which threadedly receives a screw 201 which extends through bore 96f.

As shown in FIG. 9, extending downwardly of the bight portion 96c are three U-shaped movable contact supports 96h which are spaced from each other by grooves 96j. The grooves 96j and the supports 96h are arranged so that when the assembly 96 is positioned in the housing 92 and the housing 92 is positioned on the support 24, the bight portion 96c will be positioned in the notches 54–56 in a manner so that the supports 96h will extend downwardly into the compartments 41–43 while the grooves 96j straddle the portions of the partions 30 and 31 below the notches 56. The supports 96h are identical and each includes a substantially rectangular opening 96x. As shown in FIG. 4, the openings 96x have a spring seat on one end and a substantially flat wall 96m on its opposite end. A movable contact 96n, a contact retainer 96p and a spring 96r are positioned in each of the openings 96x with the contact 96n held against the flat wall 96m by the retainer 96p which is urged into engagement with the contact 96n by the spring 96r. The spring 96r is of the compression type and has one end positioned by the spring seat in the openings 96x and its other end positioned between a pair of spaced bent-up portions 96s extending along opposite edges on the retainer 96p. As shown in FIG. 1, the bent-up portions 96s are provided with centrally located notches 96t and oppositely extending ears 96v, which ears 96v are arranged to engage the front and rear faces of the arms of the U-shaped supports 96h surrounding the opening 96x so as to maintain the retainer 96p in the opening 96x. Spaced between the bent-up portions 96s, the retainer 96p has a raised conical boss 96w which acts as a seat for the spring 96r. The movable contact 96n has a central portion 96y and portions 96z which extend in opposite directions from the central portion 96y at an inclined angle which is identical to the angle of incline of the portions 71 of the stationary contacts 62. Each of the portions 96z are provided with a surface of contact material which has a high current carrying and arc suppressant capability which is engageable with the contact material of the removable stationary contact 62 when the assembly 96 is positioned relative to the support 24, as in FIG. 4. The central portion 96y is provided with a raised, centrally located, conical boss similar to boss 96w, which is received within the conical recess formed in the material of the retainer 96p opposite the conical boss 96w. The conical recess in the retainer 96p and conical boss on the portion 96y serve to maintain the central portion 96y in engagement with the flat wall 96m. Located as shown in FIG. 1, along opposite edges of the central portion 96y, are bent-up ears 96u which are spaced and formed to extend upwardly from the central portion 96w and arranged to be received in the notches 96t on opposite sides of the retainer 96p to prevent movement of the movable contacts 96n in a direction transverse to the supports 96h.

During assembly, a movable contact 96n is inserted in position beneath the contact retainer 96p by merely manually raising the retainer 96p against the force of the spring 96r and inserting the movable contact 96n into a position wherein the central portion 96y is aligned with the flat wall 96m of the opening 96x. The retainer 96p when released is urged by the spring 96r into tight engagement with the movable contact 96n so that the conical recess of the retainer engages the conical boss on the central portion 96y of the movable contact 96n and the ears 96u are received in the notches 96t of the retainer 96p to thus maintain the movable contact 96n in position. It is to be appreciated that the foregoing arrangement will permit the movable contact 96n to move vertically upwardly in the opening 96x but will prevent a transverse separation of the movable contact 96n and retainer 96p because of the ears 96u which are received in the notches 96t act as a ratchet when the movable contacts 96n are inserted into position beneath the retainers 96p.

As shown in FIGS. 1, 5, and 9, extending outwardly on the lower ends of each of the arms 96b are ledges 97. The ledges 97 extending over the entire width of arms 96b are arranged to be received in the notches 54 of the support 24, so as to provide portions which extend in opposite directions of the centerline 20b. As shown in FIG. 10, extending downwardly below each of the ledges 97 are projections 98 which are respectively formed on opposite sides of a centerline 99 of the support 96a. The projections 98 have a side wall 98a located on the centerline 99 and have a flat bottom surface 98b. As shown in FIG. 9, the projections 98 are each spaced from the support 96h adjacent thereto by a groove 98c which is adapted to straddle the portion of walls 29a and 29b below the bases 55a of the notches 55. The foregoing completes a description of the movable contact and guide assembly 96.

A bell crank type actuator assembly, which is most clearly shown in FIG. 9 and is rotatably positioned in the housing 92, is formed of molded insulating material to have a pair of spaced pivot portions 101 which extend downward from a solid lever portion 102. Extending outwardly from each of the pivot portions 101 on opposite ends of the lever portion 102 are a pair of spaced levers 103 each of which has a ball 104 integrally formed on its free end. The pivot portions 101 each are provided with a bore 105 which are in axial alignment with one another and which act as a bearing for a metallic rod 106. Extending outwardly of the bores 105 on the pivot portions 101 are bosses 107 which are sized to engage the internal walls of the cavity 93 and axially position the actuator 100 in the cavity 93 in the housing 92, as in FIG. 7. Also, it will be seen in FIG. 7, that when the actuator is positioned in the cavity 93, a clearance is provided between the levers 103 and the ribs 93n. As shown in FIG. 9, spaced between the pivot portions 101 of the lever portion 102 along an end 113 which is remote from the pivot portions 101, is a modified ball portion 108 of a ball and socket combination. As shown in FIG. 4, the ball portion 108 includes a vertical planar surface facing in the same direction as the levers 103 and define one side of a recess 109. The ball portion further includes a raised elongated lentil-shaped portion 110 which is substantially plano-convex in cross section along both a transverse and longitudinal axis.

Positioned on each of the balls 104 and on the ball portion 108 is an insert which is preferably formed of a relatively resilient molded plastic material. As shown in FIG. 9, the inserts which are positioned on balls 104 are U-shaped channel-like members 111 having a rectangular outer shape sized to be loosely received in the sockets 96d and a spherical indentation formed on the inner surfaces of each of the arms of the channel-like inserts 111 which indentation is sized to correspond to the outer curvature of the balls 104.

The insert member 112 which is positioned on the ball portion 108 consists of a U-shaped channel-like member having appreciable length. One arm of the member 112 is sized to be received in recess 109 and the other arm has a recess formed on its inner surface which is complementary in shape to the shape of the plano-convex shape of the lentil-shaped portion 110. The inner surface of the bight of the member 112 is curved to correspond with the curvature of the free end 113 of lever 102, and a pair of ears 114 are provided on the free ends of the bight portion of member 112 which rest upon the upper surface of the free end 113 to further position the member 112 on lever 102. It will be seen that while the members 111 and 112 provide a ball and socket connection to each of the levers 103 and 102, the relatively large outer surfaces of the channel-like members 111 and 112 provide an appreciable surface area for a sliding contact with other moving members.

The components of the electromagnet assembly 115 for the device 20, which are most clearly shown in FIGS. 5 and 8, include an E-shaped stationary magnet core as-

sembly **116**, a movable T-shaped armature assembly **117** and a magnet coil assembly **118**. As shown in FIGS. 1 and 8, the magnet core assembly **116** comprises a stack of laminated magnetic metal parts which are secured together by rivets **119** to provide a magnet core **120**. The magnet core **120** has a base portion **121** from which extends a pair of spaced parallel arms **122** and a leg **123** spaced intermediate the arms **122**. The arms **122** each have a pole surface **134** on a free end which is located beyond a surface **137** of the leg **123**. The surfaces **134** each have a groove formed therein to position a closed conductor loop which acts as a shading coil for the magnet structure. Each of the arms **122** have an outwardly extending lug **129** formed thereon which lugs **129** provide a surface **130** which is spaced from a surface **124** of the base portion **121**.

As shown in FIGS. 5 and 8, the armature assembly **117** comprises a stack of laminated magnetic metal parts **131** which are secured between a pair of metal plate-like members **132** and **133** by rivets **134***a*. The laminated parts **131** have portions which extend beyond the boundary of the metal parts **132** and **133** to provide pole faces **135** for the armature assembly **117** which are aligned with the pole surfaces **134** of the magnet core assembly **116**. Extending between the surfaces **135** on the parts **131** and the members **132** and **133** is a central leg portion **136**. The leg portion **136** on parts **131** extends beyond the boundaries of the members **132** and **133** to provide a face **138** which is arranged to be slightly spaced from the surface **137** on leg **123**, when the faces **135** engage the surfaces **134**. The member **132** is generally T-shaped to correspond to the T-shape of the parts **131** and has an exposed flat surface **139**, shown in FIG. 5. As shown in FIG. 8, the member **133** has a rectangular central portion **140** secured to parts **131** and a portion **141** secured to the leg portion **136**. Extending upwardly on the portion **140**, as shown in FIGS. 1 and 5, are portions **142** which are formed to extend perpendicular to an exterior surface **143** of the member **133** at the opposite ends of the portion **140**.

Extending downwardly along an edge **144** of the portion **140** and opposite to the portions **142** is a lever **145**. As shown in FIG. 5, the lever portion **145** extends perpendicular to the surface **143** in a direction opposite to portions **142** and is arranged to provide a surface **146**, which is spaced from the parts **131**.

The magnet coil assembly **118**, which is most clearly shown in FIG. 1, comprises a molded plastic housing or case, which is formed to have a rectangular base **147**. The base **147** has a top surface **148**, a bottom surface **149**, a front wall **150**, a rear wall **151** and a pair of spaced side walls **152**. Extending along the edges between each of the side walls **152** and the top surface **148** is a rectangular groove **153** having a bottom surface coplanar with a top surface of a rectangular ear **154**, each of which extends outwardly of one of the side walls **152** and has a surface forming an extension of the rear wall **151**. The ears **154** have a depth and width equal to the depth and width of the notches **94** in the housing **92** and are received therein when the magnet assembly is positioned in the cavity **93**. The base **147** is sized so a portion of the bottom wall **149** rests upon a top edge of the housing **92** adjacent the opening **93***v* when the ears **154** are positioned in the notches **94**. A plurality of recesses **155** which are separated by upstanding ribs **156** are formed in the top surface **148** along the edge between the top surface **148** and the front wall **150**. Embedded in the bottom surfaces of each of the recesses **155** is a threaded conductor, not shown, which threadedly receives a screw **157** which is arranged to tighten a wire clamp against a bared end of a wire conductor, not shown. Extending downwardly from the bottom surface **149** is a U-shaped housing **159** for the windings of a magnet coil which is embedded in the molded material of the housing **159** and extends into a portion of the base **147**. The wire winding of the coil is connected by suitable leads embedded in the molded material of the base **147** and which extend to the embedded inserts which receive screws **157**. The housing **159** has an end **160** coplanar with the rear wall **151** and an end **161** spaced rearwardly of the front wall **150** so as to expose a considerable portion of the bottom surface **149** between end **161** and the front wall **150**. As shown in FIG. 8A, the housing **159** has a rectangular opening **162** extending between the ends **160** and **161** which has a top wall **163**, a bottom wall **164** and a pair of side walls **165**. Extending outwardly from the end **161** is a boss **166**, most clearly seen in FIG. 1, which has a surface **167** coplanar with the bottom wall **164**. Extending downwardly from the top wall **163** and upwardly from the bottom wall **164** from the end **160** approximately half the distance to the end **161** are raised portions **168**. These raised portions **168** are arranged to loosely center the leg **123** of the magnet core **120** in the opening **162**.

A member **126**, formed of resilient metal, has an end **125** in clamping engagement with the top surface **148** and a portion extending between raised portions **168** in engagement with the center leg **123** to resiliently position the magnet core **120** on the base **147**. Extending outwardly of the end **125** is an arm which extends along the bottom surface **149** to a curved end **128**. The end **128** extends perpendicular to the surface **149** in spaced relation to the front wall **150**. Extending between the rear wall **151** and the front wall **150** in the bottom surface **149** of the base **147** is a groove **169** which is arranged to receive the arm portion of the metal member **126**. Also formed in the bottom wall **164** and the surface **167** and the top wall **163** are grooves **170** which provide clearance for the rivets **134***a*, when the core assembly **116** and the armature assembly **117** are assembled with the magnet coil assembly **118**, as will now be explained.

The assembly of the components of the electromagnet assembly **115** is readily accomplished by positioning the member **126** on the base **147**, as above described, and inserting the leg **123** of the magnet core **120** into the opening **162** into a position wherein the base portion **121** rests against the end **160** of the housing **159**. When the magnet core **120** is thus positioned, the arms **122** will extend exterior of the housing **159** so that the free end surfaces **134** will be positioned forwardly of the end surface **161**, and the leg portion **123** will be positioned by the raised portions **168** which terminate to the rear of the free end surface **137** of the leg portion **123**. The free end surface **137** will be positioned in the opening **162** to the rear of the surface **161**. When the magnet core **120** is thus positioned it will be seen in FIG. 1 that the curved end portion **128** of the metal member **126** is positioned forwardly of the front surface **150**. The T-shaped armature assembly **117** is installed in position by inserting the leg portion **136** into the opening **162** with the portions **142** extending alongside the side walls **152**. The armature assembly **117** is moved to its final assembled position when a slight force is exerted to cause the curved end **128** to be forced out of a position to permit the lever **145** to pass the curved end **128**.

When the armature assembly **117** is thus positioned, its movement relative to the coil assembly **118** will be guided by the portions **142** which are engageable with the side walls **152**, and the hard surfaces of the members **132** and **133** which engage the surface **149** of the base **147** and the surface **167** of the boss **166**. The extent of the movement of the armature assembly **117** in one direction will be limited by the inside wall of the housing **92**. Movement of the armature assembly **117** in the other direction is limited by the engagement between the surfaces of the faces **135** and **134** on the core **120** and the armature assembly **117**.

A cover **175** for the housing **92**, which is most clearly seen in FIGS. 1 and 5, is formed as a molded plastic part to have a top surface **176**, a bottom surface **177**, a rear

wall 178, a front wall 179 and side walls 180 and 181. The walls 178, 179, 180 and 181 are sized so the cover 175 forms a continuation of the outer walls of the housing 92. The bottom surface 177 is provided with a recess, not shown, which receives the top surface 148 of the coil assembly 118 while portions of the cover 175 adjacent the recess rest in grooves 153. Extending downwardly from the bottom surface 177 are a pair of rectangular lugs 182 which are located adjacent the corners of the front wall 179 and the side walls 180 and 181. The lugs 182 are arranged to engage portions of the inner walls of the housing 92 for positioning the front wall 179 portion of the cover 175 on the housing 92 in a direction of movement along an axis perpendicular to the walls 180 and 181. Also extending downwardly from the bottom surface 177 are a pair of lugs 183 which are disposed proximate the corners defined by the rear wall 178 and the side walls 180 and 181. As shown in FIG. 5, the lugs 183 each have a vertical wall 184 which is arranged to engage an inner wall portion of the housing 92 so as to position the cover 175 on the housing 92 along an axis perpendicular to the rear wall 178. The lugs 183 also have an inclined wall 185 which faces downwardly of the bottom surface 177 and toward the front wall 179. The inclined surface 185 is arranged to be received in the recesses 93*k* in the housing 92, for a purpose to be later explained.

Again referring to FIG. 1, the top surface 176 is provided with a pair of recesses 186 which extend into the side walls 180 and 181. The recesses 186 are each provided with an opening aligned with openings in the ears 154 of the magnet coil assembly 118 and the inserts 94*b* in the housing 92 so that screws 187, when threaded into inserts 94*b*, will secure the cover 175, the magnet assembly 118 and the housing 92 together. The front wall 179 of the cover 175 is provided with a central recess which has a wall 188 spaced to the rear of the recesses 155 and the ribs 156. This arrangement will provide a suitable protected area whereon information of the coil characteristics of the device may be marked and an indication of the markings for the terminals which include the screws 157 may be applied. It will be seen that the recess which provides the wall 188 effectively causes the cover 175 to have a pair of ears indicated by numerals 189 and 190 which respectively have one edge formed by the side walls 181 and 180 and another edge formed by the front wall 179. The ears 189 and 190 are respectively provided with openings 193 and 194 which extend parallel to the front wall 179 for positioning a start-stop push button switch, as will be later explained. The opening 194 is formed in cover 175 to be in alignment with the portions 142 on the armature assembly 117, so as to visually expose a portion of the portions 142 when the armature assembly 117 is in a deenergized position. The ear 190 is provided with an additional opening 195 which extends through the ear 190 so as to visually expose the portion 142 when the armature assembly 117 is in its energized position. Thus the openings 194 and 195 provide an arrangement which will permit observation of the device to determine if the device 20 is in an energized or de-energized condition. If desired, the wall portions which form openings 194 and 195 may be inclined so suitable markings, such as OFF and ON, may be included thereon. Further, if desired, the openings 194 and 195 may be interconnected by an opening 196, which may be used to permit passage of a suitable instrument, not shown, which may be inserted between the surfaces 134 on the magnet core assembly 116 and surfaces 135 on the armature assembly 117 to maintain the armature assembly 117 against movement during shipment of the device 20. Additionally, the opening 196 may be used to permit passage of an instrument to a position between the armature assembly 117 and an inner wall portion of the housing 92 to maintain the armature assembly 117 in an energized position when it is desirable to check the circuits wherein the device 20 may be wired without energizing the magnet coil assembly 118 of the device.

It is believed a description of the assembly of the switch assembly will aid to the further understanding of the features thereof. As previously set forth, the stationary contact support 24 is initially secured to the mounting plate 21 by the screws 26 and the assemblies 60 are installed at the opposite ends of compartments 41–43. As shown in FIG. 4, the installation of assemblies 60, shown in FIG. 6, in the compartments 41–43 of the support 24 is accomplished by first installing the terminal connectors 61 in position and then positioning the removable contacts 62 of the contact assemblies 60 so the screws 74 may be threaded into the inserts 49.

If desired, as shown in FIG. 1, one or two electrical switches 80 may be included in compartment 32. The foregoing completes the assembly of the stationary contact assembly which is carried by the stationary contact support 24.

The assembly of the movable contact assembly 96, which is carried by the housing 92, is preferably initiated by positioning the movable contacts 96*n* beneath the contact retainers 96*p* which are biased by springs 96*r* in each of the openings 96*x* of the support 96*a*, so as to complete the assembly of the movable contact and guide assembly 96, which is most clearly shown in FIG. 4. If desired, a metal liner 197, shown in FIG. 1, may be inserted in each of the guideways 93*x*. The movable contact and guide assembly 96 is then positioned in the housing 92 by inserting the arm portions 96*b* upwardly through the opening 92*k* so the arm portions 96*b* are slideably received by the liners 197 in the guideways 93*x*. The liners 197 are included to minimize wear of the parts as the movable contact and guide assembly 96 reciprocates in the housing 92. Proper orientation of the movable contact and guide assembly 96 in the housing 92 is achieved by the ribs 96*e* which permit the movable contact and guide assembly 96 to be inserted through the opening 92*k* only when the ribs 96*e* are properly aligned with the openings in the side wall of the opening 92*k*. After the movable contact and guide assembly 96 is thus positioned in the housing 92, a return spring assembly 198, shown in FIG. 4, consisting of a pair of springs 199, a spring seat 200, the screw 201 and the nut 202, as shown in FIG. 4, is installed in the housing 92. The installation of the return spring assembly is accomplished by positioning the nut 202 in a recess in the bight position 96*c*, which is aligned with the bore 96*f*, and positioning the springs 199 in the recesses 93*b* and 93*c*. The spring seat 200 has a pair of raised bosses which act as seats for springs 199 at its opposite ends and an opening centrally located therein which is arranged to permit the screw 201 to pass therethrough and through the bore 96*f* into threaded engagement with nut 202. The return spring assembly 198 constantly biases the bight portion 96*c* toward the bottom wall 92*a* of housing 92.

The bell crank actuator assembly 100, which includes the metallic rod 106, the inserts 111 on balls 104, and the insert 112 on the lentil-shaped portion 110, is then positioned in the cavity 93 of housing 92. The insertion of the actuator assembly 100 is accomplished by positioning the inserts 111 in the sockets 96*d* and permitting the pivot portions 101 to move to a position so the rod 106 is positioned in the horizontal recess 93*t*. The bell crank actuator assembly 100 is maintained in position in the cavity 93 of the housing 92 by the metal plate 94*c* and the pair of screws 95. The metal plate 94*c* has a portion resting on the rod 106, as shown in FIG. 4, and is secured in position on the boss 93*r* by the screws 95 which pass through suitable openings in the plate 94*c* and the bosses 93*r* to the outer bottom wall 92*a* where they threadedly receive nuts, not shown. The assembly of the movable contact portion of the magnet and movable contact assembly 90 is completed when a pair of leaf-like spring members 205, shown in FIGS. 1, 4, 7, and 10, are installed in

the cavities 93*k*. The spring members 205, as shown in FIG. 10, have a U-shaped bottom portion arranged so an arm portion 206 is pressed into engagement with the wall 93*g* and another arm portion 207 is pressed into engagement with the wall 93*h* and extends from the bottom of cavity 93*k* to the top edge wall of the wall 93*h*. The free end 208 of the arm portion 207 is curved away from the wall 93*h*, as shown in FIG. 10.

The assembly of the components of the electromagnet assembly 115 has been previously set forth so that, as shown in FIG. 5, the components comprising the stationary contact support 24, the movable contact assembly and parts associated with housing 92, the electromagnet assembly 115 and the cover 175 are conditioned for assembly with one another.

If desired, the assembly which includes the housing 92 may be first positioned on the stationary contact support 24 and secured thereto by the screws 91 which are threaded into the inserts 36. The assembly of the housing 92 and the support 24 will align the movable contacts 96*n* in a position relative to the stationary contact assemblies 60 so the portions 96*z* of the movable contacts 96*n* will engage the portions 71 of the stationary contacts when the movable contact and guide assembly 96 is moved toward the base 24*a* against the force of the springs 199.

After the foregoing assembly has been completed, the previously assembled electromagnet assembly 115 is installed in position in housing 92. This is accomplished by inserting the elecrtomagnet assembly 115 in a position wherein the lever portion 145 hooks over the channel-like insert 112 and the ears 154 are received in the notches 94. When the electromagnet assembly 115 is thus positioned, the lugs 129 will be positioned in the cavities 93*k* with the surfaces 130 facing the arm portions 207 of the springs 205 and the terminal portion of the coil which includes the screws 157 will be exposed at the upper surface of the assembly thus far completed.

The assembly of the basic switch assembly 20 is completed when the cover 175 is applied to the top surface of the housing 92. The cover 175 is positioned to have recesses 186 in alignment with the openings in ears 154 of the electromagnetic assembly 115 and the threaded inserts 94*b*. The screws 87 are then threaded into the inserts 94*b*. During the tightening of the screws 187 into the inserts 94*b*, the inclined wall 185 on the lugs 183, see FIG. 5, engages the curved free end portion 208 of the springs members 205 to thereby force the arms portions 207 to the right, see FIG. 10. As shown in FIG. 1, when the arm portions 207 move to the right they engage the surfaces 130 on the lugs 129 of the stationary magnet assembly 116 to resiliently position the electromagnet assembly 115 in the housing 92, and provide a media for absorbing shock when the coil assembly 118 is energized to cause the armature assembly 117 to move into engagement with the stationary magnet assembly 116.

From the foregoing it is apparent that the switching assembly 20 can be readily serviced without disturbing the wire connections to the terminal screws 65. If the coil is believed to be faulty, all that is required is that the leads to coil terminals be removed by loosening the screws 157, and the cover 175 and electromagnet assembly 115 may be removed from the housing 92 by loosening the screws 187. When this operation has been performed, an entirely new replacement electromagnet assembly 115 may be installed in a manner previously described or the coil assembly 118 may be removed from its cooperating position with the stationary magnet assembly 116 and the armature assembly 117. This later operation is performed by manually pulling the armature assembly 117 and the stationary magnet assembly 116 in opposite directions to force the curved end portion 128 of the spring metal member 126 to an out-of-the-way position whereby the armature assembly 117 and magnet assembly 116 may be readily disassociated from the coil assembly 18. The reassembly of the armature assembly 117, the stationary magnet assembly 116 and the replacement coil assembly 118 is accomplished in the manner previously described. Thus the coil assembly 118, the armature assembly 117 and the stationary magnet assembly 116 may be serviced and inspected without disturbing the stationary and movable contact assembly portions of the switching assembly 20.

If it is desired to inspect or replace the movable contacts 96*n* or the stationary contacts 62, all that is required is that screws 91 be loosened, so the housing 92, the electromagnet assembly 115 and the cover 175 may be removed as an assembled unit from the stationary contact support 24. It is apparent that this operation can also be performed without disturbing the connections of the wires which are secured by the screws 65. When the housing 92 is detached from the support 24, the movable contacts 96*n* and the stationary contacts 62 may be readily inspected and replaced, as precedingly described.

In view of the foregoing, the operation of the switching assembly 20 is as follows. When the coil assembly 118 is deenergized, the springs 199 will constantly urge the movable contact and guide assembly 96 upwardly from the base 24*a* so the contacts 96*n* are separated from the stationary contacts 62. The upward movement of the guide assembly 96 causes the bell crank actuator 100 to rotate about its pivot portions 101 to a position shown in FIG. 4, wherein the insert 112 which is carried by the lentil-shaped portion 110 causes the armature assembly 117 to be moved by its hooked lever portion 145, so as to move the armature assembly 117 to a position wherein the pole faces 135 are separated from the pole faces 134 on the stationary magnet assembly 116. The position of the armature assembly 117 may be readily observed through the openings 194 and 195 in the cover 175 and through the opening 93*v* in the housing 92. The movement of the armature assembly 117 and the movable contact and guide assembly 96 to their deenergized positions is limited by the hooked lever portion 145 which engages the walls of the cavity 93 surrounding the opening 93*v*.

When the magnet coil assembly 118 is energized from a suitable source of current, not shown, the magnetic flux induced by the coil assembly 118 in the stationary magnet assembly 116 and the armature assembly 117 causes the armature assembly 117 to move in a direction parallel to the plate 21 to a position wherein the surfaces 135 engage the surfaces 134. The shock attending the engagement of the armature assembly 117 and the stationary magnet core assembly 116 is absorbed by the springs 205. The movement of the armature assembly 117 to its energized position is guided by portions of the molded coil assembly 118, as for example, the ears 142 engage the side walls 152, and the portions of the metal plate members 132 and 133 engage the top wall 163 and the bottom wall 164 of the opening 162 while the grooves in the molded coil assembly 118 provide clearance for the rivets 134*a* which secure the assembly of the parts forming the armature assembly 117.

The molded insert 112 is received between the lever 145 and the laminated magnetic metal plates 131 of the armature assembly 117. Therefore, as the armature assembly 117 moves to its energized position, the insert 112 is similarly moved. The insert 112 has a generally rectangular outer surface so a nonrotatable connection exists between the insert 112 and the armature assembly 117. The insert 112 is centrally positioned on the free end 113 of lever 102 on a lentil-shaped portion 110 by a similarly shaped socket on the inner faces of the channel-like inset 112. Thus a connection which will be capable of a limited universal type movement exists between the insert 112 and the lever 102 so the movement of the insert 112 is imparted with a minimum of friction to the lever portion 102 of the bell crank actuator 100. The bell crank actuator 100 is pivoted at its opposite ends on the metallic rod 106 which, as shown in the drawings, extends the entire length of the solid lever portion 102 along an

axis parallel to the plate **21**. The solid rod **106**, which is of a considerable diameter to resist bending, is supported at its central portion at two spaced locations in the spaced U-shaped recesses **93***t* located in the boss **93***r*. The rod **106** is held in position by the plate **94***c*. The foregoing arrangement will provide the bell crank actuator **100** with a pivot which will have a minimum of twisting forces imposed thereon when the bell crank actuator **100** is rotated about its pivot portions **101**. The rotational movement of the lever portion **102** causes the spaced lever portions **103** on the bell crank actautor **100** to move downwardly toward the base **24***a*.

The lever portions **103** at their free ends have ball portions **104** formed thereon which are received in the cooperating sockets formed in the interior surfaces of the channel-like inserts **111**. Thus a connection capable of universal movement is presented between the lever portions **103** and the inserts **111**. The inserts **111** have a configuration on their external surface which is generally rectanglar and are received in sockets **96***d* which are also rectanglar in shape so a non-rotative connection is established between the inserts **111** and the movable contact and guide assembly **96**. Thus as the levers **103** move downwardly, the movable contact and guide assembly **96** will move downwardly, being guided in its movement by the metal liners **197** which are positioned within the guideways **93***x*.

The downward movement of the movable contact and guide assembly **96** causes the springs **199** to be compressed and the movable contacts **96***n* to be moved into bridging engagement with the stationary contact assemblies **60** on opposite ends of the compartments **41–43**. The shock attending the engagement between the movable contact assemblies **96***n* and the stationary contact assemblies **60** is absorbed by the springs **96***r* which are compressed upon the engagement between the contact assemblies **96***n* and **60** to firmly press the movable contact assemblies **96***n* into engagement with the stationary contact assemblies **60**. The downward movement of the movable contact and guide assemblies **96** also causes the projections **98** and the ledges **97** to move downwardly toward the mounting plate **21**. As most clearly shown in FIG. 10, the projections **98** and the ledges **97** are exposed to the exterior of the stationary contact support **24** by the notches **54** in the walls **28**. It will be seen from FIG. 9 that the ledges **97** extend outwardly of the arms **96***b* while the projections **98** extend in vertical alignment with the arms **96***b*. The ledges **97** and projections **98** are thus arranged so the ledges **97** move vertically in the notches **54** while the projections move vertically in the compartments **32**. The bottom wall portions of the ledges **97** adjacent the projection **98** are arranged to engage and move the actuating arm **85***b* of the switches **80** so the contacts of the switches **80** in the respective compartments **32** move from a circuit opening to a circuit closing position and vice versa prior to the engagement of the movable contact assemblies **96***n* with the stationary contact assemblies **60**. The switches **80** are commonly known as electrical interlock switches to those skilled in the art and are usually installed in control circuits. The contacts of the contact assemblies **96***n* and **60** are usually connected to power circuits. Thus the device **20** will operate to control the condition of the control circuits prior to the energization of the power circuits to assure a safe, reliable operation of a system wherein the device **20** may be included.

If desired, a plurality of additional switch assemblies, indicated by numerals **220A**, **220B**, **220C** and **220D** may be attached along the outer walls **28** of the basic switch assembly **20**, as illustrated in FIG. 2. As each of the switch assemblies are identical, only one of the same will be described, reference being had to FIGS. 2, 3, 10 and 11 of the drawings. While in FIG. 2 of the drawings the switch assemblies **220A–D** are shown as being mounted adjacent the left side of the switch assembly **20**, it is to be appreciated that identical switch assemblies may be mounted adjacent the right side of the switch assembly **20** without departing from the scope of the present invention.

Each of the switch assemblies **220A–D** includes a housing which is formed of a pair of mating housing parts **221** and **222** which preferably are formed of a suitable molded insulating material. The housing parts **221** and **222** are formed to provide an internal cavity **223** which, as shown in FIG. 10, encloses at least portions of a stationary contact assembly **224**, a movable contact assembly **225**, a rotatable contact actuator **226** and a spring **227**.

The stationary contact assembly **224** includes a metal part **228** which has a contact portion **229** on one end and a threaded opening on the other end which receives a screw **230**. When tightened, the screw **230** urges a clamp **231** into clamping engagement with a bared end of an electrical conductor, not shown. The stationary contact assembly **224** is immovably positioned between the housing parts **221** and **222** by suitably located ears which are received in suitably located and sized cavities in the housing parts **221** and **222** when the housing parts **221** and **222** are secured together by screws which are passed through bores **233** in the housing part **221** into threaded engagement with suitable threaded inserts, not shown, which are embedded in the molded material forming the housing part **222**.

As most clearly seen in FIG. 11, the movable contact assembly **225** includes a rigid metal part **234** and a flexible blade-type metal part **235**. The parts **234** and **235** are secured to each other as by welding at a junction **236** which is located at one end of each of the metal parts **234** and **235**. The junction **236** is tightly received in a suitably located and sized recess formed in the molded material of the housing part **221** to maintain the portions of movable contact assembly **225** at the junction **236** in an immovable position. The rigid metal part **234** has a threaded opening at an end remote from the junctions **236** which is arranged to receive a screw **237** for the purpose of urging a clamp **238** into tight engagement with a bared end of an electrical conductor, not shown.

In this connection it should be noted the screws **230** and **237** as well as the clamps **231** and **238** are both externally accessible for the purpose of making the connection with the electrical conductors. Further, for the purpose of providing the necessary electrical clearances without increasing the size of the switch assemblies **220A–D**, only the housing part **221** is provided with a barrier portion **239**. Thus when two switch assemblies, such as switch assemblies **220A** and **220B**, are interconnected side by side as shown in FIG. 2, in a manner which will be later described, the conductors as well as the clamps **231** and **238** and the screws **230** and **237** on the respective adjacent switches **220** will be separated by surfaces of the barrier portion **239** to provide adequate electrical clearances in accordance with code requirements which are known to those familiar with the art.

The flexible metal part **235** is preferably formed of a spring material to have the portion extending from the junction **236** oriented generaly beneath the stationary contact assembly **224** and parallel to a base **240** of the cavity **223** in the housing part **221**. A portion **241** of the metal part **235** remote from the junction **236** is bifurcated, in a manner not specifically shown, to provide a pair of portions whereon a pair of contact portions, indicated by the numerals **242**, are secured.

The junction **236** is positioned and the part **235** is formed so the contact portions **242** are normally separated from the contact portion **229** and the portion **241** engages a stop **301** formed on the housing part **221**. The part **235** has a portion intermediate the junction **236** and the portion **241** whereon the contact portions **242** are carried which is downwardly bent to provide an inclined wall portion **243** which terminates in a rounded apex **244**. The apex **244** separates the inclined wall portion **243** from a substantially straight extending arm portion **245** which

includes the portion 241 on which the contact portions 242 are secured.

Extending outwardly of a rear wall 246 of the housing part 221 into the cavity 223 is a cylindrical boss 247 which is located centrally in the cavity 223 and is formed to have a considerable diameter. The boss 247 provides a bearing journal for the rotatable actuator 226 which may be positioned in either of two positions on the boss 247. The rotatable actuator 226, which is most clearly shown in FIG. 11, is preferably formed of molded insulating material which has a low coefficient of friction to reduce wear as a central bore 248 in a hub portion 249 of the rotatable actuator 226 rotates on the cylindrical boss 247. Extending outwardly of the hub portion 249 into an opening which is formed in the housing parts 221 and 222 to expose the cavity 223 to the exterior of the switch assembly 220, is an actuating arm 251 having an I-shaped free end portion as shown in FIG. 3. Referring again to FIG. 11, positioned on opposite sides of the actuating arm are a pair of stops 252 and 253, each of which have a surface respectively designed as 254 and 255 which extend in a plane defined by a radius of the bore 248 equidistantly on opposite sides of a center line 256 defined by a diameter of the bore 248 and the center of the actuating arm 251. The rotatable actuator 226 also is provided with a pair of cylindrical surfaces 257 and 258 which are concentric to the hub portion 249 and extend from the stops 252 and 253 in opposite directions from the centerline 256 to cam portions 259 and 260. The cam portion 259 generally protrudes from the cylindrical surface 257 and is provided with a cam surface 261 and a dwell surface 262. The cam surface 261 provides an incline which extends outwardly from the cylindrical surface 257 and is located so the cam surface 261 is at least 90° clockwise of the centerline 256 in FIG. 10. The dwell surface 262 extends from the cam surface 261 in a clockwise direction to a radial wall 263 which is provided with a projection 264 which serves as a seat for one end of the spring 227 when the rotatable actuator 226 is in one of its two positions on the cylindrical boss 247. The cam portion 260 similarly protrudes from the cylindrical surface 258 and is provided with a wall 265 which is defined by a radius of the bore 248 along an axis which is at an angle less than 90° counterclockwise from the centerline 256 in FIG. 10. The wall 265 extends outwardly of the cylindrical surface 258 and terminates in a sharp apex 266. The apex 266 is formed between the wall 265 and an inclined wall 267 which extends to a continuing portion of the cylindrical surface 258. The cylindrical surface 258 at a location remote from the stop 253 terminates in radial wall 269 which is provided with a projection 268 which serves as a seat for one end of the spring 227 when the rotatable actuator is in another of its two positions on the cylindrical boss 247. The rotatable actuator is provided with a plurality of openings 270 which are included merely to reduce the cross-sectional mass of the actuator to conserve materials and shorten molding cycle times, as is well known to those skilled in the art.

As shown in FIG. 3, the free end of the actuating arm 251 is provided with an actuating lever 271 which may be mounted in either of two positions on the arm 251. The lever 271 also is preferably formed of a molded insulating material to have an I-shaped opening 272 which acts as a socket to receive the I-shaped free end of the actuating arm 251. Preferably the rotatable actuator 226 and the actuating lever 271 are molded of a slightly resilient plastic material and the free end of the actuator arm 251 and the opening 272 are formed so the lever 271 is held in position on the lever 251 with a snap-on connection. Extending outwardly of the actuating lever 271 along an axis parallel to the axis of the bore 248 when the lever 271 is positioned on the actuating arm 251 is a projection 275 which is provided with a cylindrical outer configuration and arranged to extend beyond the confines of the switch assembly 220. Similarly, extending within the confines of the switch assembly 220 as in FIG. 3, the actuating lever 271 is provided with a socket 276 which is axially aligned with the projection 275.

The housing parts 221 and 222 are each provided with a bottom wall 277 and a front wall 278 which extends vertical to the bottom wall 277. A portion of the front wall 278 is removed to provide a recess 279. The recess 279 is arranged so the actuating lever 271 is continuously positioned in the recess 279. This is accomplished by arranging the parts of the switch assembly 220 so the actuating lever 271 does not have any portions thereof projecting beyond a plane defined by the vertical front wall 278. A portion of the exterior of a rear wall 280 of the housing parts 221 and 222 is inclined to provide a mounting foot portion 281 which, as shown in FIG. 10, is provided with a base to permit the passage of a mounting screw 283 into a threaded opening in a metal mounting plate 284. The mounting plate 284, as shown in FIG. 3, has a tang or finger 285 extending upwardly from its upper surface toward the opening for screw 283. The tang or finger 285 is located to be received in a notch which extends from the front wall 278 and which notch is arranged so a portion 286 adjacent the bottom wall 277 of the housing parts 221 and 222 is received beneath the tang 285 to maintain the front wall portion of the switch assembly 220 assembled on the mounting plate 284 while the rear wall portion is maintained by the screw 283 which extends through the bore 282.

The housing part 222 is provided with a cylindrical opening which is aligned with the cylindrical boss 247 when the housing parts 221 and 222 are secured together. The cylindrical boss 247, which has a top surface arranged to be flush with the outer surface of the housing part 222 of the assembled housing parts 221 and 222, also has a bore 289 extending therethrough which at each end is provided with a hexagonally shaped counter bore 290.

As shown in FIG. 2, the external surface of the housing part 221 is provided with a projection 291 which extends on the opposite side of the switch assembly 220 from a recess in the housing part 222. Similarly, the housing part 222 has a projection 293 which extends on the opposite side wall of the switch assembly 220 from a recess in the housing part 221.

When two identical switch assemblies 220, indicated by letters A and B, are assembled side by side, as shown in FIG. 2, the projection 293 on the housing part 222 will be received in the recess in the housing part 221. Similarly, the projection 291 on the housing part 221 will be received in the recess in the housing part 222 to prevent relative rotation between the switch assemblies 220A and 220B. The side by side assembly of the switch assemblies 220A and 220B is maintained by a screw 295 and a nut 296 which threadedly receives the screw 295. When the parts are assembled, the head of the screw 295 is received in the counterbore 290 on the housing part 222 side of the switch assembly 220B while the nut 296 is received in the counterbore 290 on the housing part 221 side of the switch assembly 220A. It is obvious that the screw 295 has a length which will cause the head of the screw 295 and the nut 296 to be received entirely within the respective counterbores 290 when the switch assemblies 220A and 220B are thus assembled.

Further, when the switch assemblies 220A and 220B are positioned as above described, and the actuating levers 271 of the switch assemblies 220A and 220B are properly positioned on the rotatable actuators 226 of the switch assemblies 220A and 220B, the projection 275 associated with both of the switch assemblies 220A and 220B will extend to the right, as in FIG. 2. Further, when the switch assemblies 220A and 220B are thus positioned, the projection 275 of the switch assembly 220B will be received in the socket 276 of the switch assembly 220A to provide a driving connection between the actuating levers 271 of both of the switch assemblies 220A and 220B.

If desired, the mounting plate 284 may be provided with an additional tang or finger and opening which are located at the opposite end of the mounting plate 284 from the tang 285 and opening for screw 283 which were used to mount the switch assembly 220A. Further it will be observed the additional tang faces in the opposite direction from the tang 285. This arrangement will permit a switch assembly, designated as 220C in FIG. 2, to be mounted on the mounting plate 284 in addition to the switch assembly 220A. When the switch assemblies 220A and 220C are both mounted on the same mounting plate, the front walls 278 of the respective switch assemblies 220A and 220C will be juxtaposed to each other. If the actuating levers 271 of the respective switch assemblies 220A and 220C are properly positioned on the rotary actuators 226 of the respective switch assemblies 220A and 220C, then the projection 275 of the switch assemblies 220A and 220C will extend in the same direction, e.g., to the right in FIG. 2. Further, when the switch assemblies 220A and 220C are thus mounted on the mounting plate 284, the projections 275 will be slightly spaced on opposite sides of a centerline defined by the juxtaposed front walls 278 of the switch assemblies 220A and 220C. It is also apparent that an additional switch, designated in FIG. 2 as 220D, may be mounted on switch 220C in the same manner as switch assembly 220B is mounted on the switch assembly 220A.

The mounting plate 284 is securable to the mounting plate 21 by a pair of screws 297 which are tightened into a pair of openings 298 in the plate 21. Thus as the switch assemblies 220B and 220D are respectively mounted on the switch assemblies 220A and 220C and as the switch assemblies 220A and 220C are individually mounted on the mounting plate 284, all that is required to mount the four enumerated switch assemblies on the left side of the switch assembly 20 is to tighten the two screws 297 in the pair of openings 298.

The arrangement of the parts previously described will cause the centerline defined by the front walls 278 to be aligned with the centerline of the support 96*a* of the movable contact and guide assembly 96 and the projections 275 of the switch assemblies to extend into notches 54 to engage the bottom surface of the ledge 97.

When the switch assembly 20 is de-energized, the ledges 97 will be positioned adjacent the bottom wall 92*a* of the housing 92. That is, at the upper portions of the notches 54. When the switch assembly 20 is energized, the ledges 97 will move downwardly in the notches 54 toward the mounting plate 21. The projections 275 of the switches 220A and 220C extend to be in the path of travel of the ledge 97 as the ledges are moved downwardly in response to the energization of the switching assembly 20. Thus as the ledge 97 moves downwardly, the projections 275 will be moved downwardly to actuate the switching assemblies 220A, 220B, 220C and 220D in a manner to be now explained.

The rotatable actuator 226 may be mounted in either of two positions on the cylindrical boss 247. Referring now to FIGS. 10 and 11, when the rotatable actuator 226 is positioned as shown in FIG. 10, the spring 227, which has one end resting on the wall 268 and the other end resting on a spring seat 299 provided by a wall portion within the cavity 223 by the housing part 221, constantly urges the rotatable actuator 226 in a clockwise direction to a position wherein the stop surface 254 engages a stop surface 300. The stop surface is provided by a portion of the housing part 221. When the switching assembly 20 is de-energized, the stop surface 254 will engage the stop surface 300 and the rotatable actuator 226 will be positioned by the spring 227 so the cam surface 261 is out of engagement with the inclined wall 243 of the flexible metal part 235, thus permitting the contact portions 242 to be separated from the contact portion 229.

When the switching assembly 20 is energized so as to move the ledge 97 downwardly, the actuating lever 271 moves in a downward direction thereby causing the rotatable actuator 226 to rotate counterclockwise about the cylindrical boss 247 against the force exerted by the spring 227. The rotation thus imparted to the rotatable actuator 226 causes the cam surface 261 to move into engagement with the inclined wall 243. A continued counterclockwise rotation of the rotatable actuator 226 causes the cam surface 261 to move the apex 244 and contact portions 242 upwardly to a position wherein the contact portions 242 engage the contact portion 229. A further continued rotation in a counterclockwise direction of the rotatable actuator 226, after the contact portions 242 initially engage the contact portion 229, causes the cam surface to move the apex 244 upwardly while the junction 236 and the contact portions 242 are held against upward movement. This continued upward movement of the apex 244 causes the contact portions 242 to move across the surface of the contact portion 229 with a contact wiping action so the surface of the engaging contacts are in effect scrubbed to provide an improved electrical engagement therebetween. A further continued rotation of the rotatable actuator in a counterclockwise direction causes the dwell surface 262 to move into engagement with the apex 244 so that for practical purposes, the upward movement of the apex 244 ceases and a constant engagement pressure is maintained between contact portions 242 and the contact portion 229. The parts of the switch assembly 220 and the linear movement of the ledge 97 are arranged so the counterclockwise movement of the rotatable actuator 226 ceases when the apex 244 is positioned centrally of the dwell surface 262. Thus as the apex 244 is positioned on a surface which has a substantially constant radius, as provided by the dwell surface 262, and as the contact portions 242 were previously pressed into tight engagement with the contact portion 229, slight movements of the rotatable actuator 226 as may be caused by vibrations of the movable contact and guide assembly 96 after it has moved to its energized position will not disturb the engagement between the contact portions 242 and the contact portion 229. Further, it will be seen that the dwell surface 262 extends an appreciable distance over the circumference of the rotatable actuator 226. This arrangement will cause the contact portions 242 to engage the contact portion 229 of the switch assemblies 220 prior to the engagement of the contacts of the movable contact 96*n* with the stationary contacts 60 of the switch assembly 20 so that the circuits associated with the switching assemblies 220 will be energized prior to the energization of the circuits which are controlled by the switch assembly 20.

When the switch assembly 20 is de-energized, the ledge 97 moves upwardly and the contacts 96*n* of the switch assembly 20 separate from the stationary contacts 60 to interrupt the circuits which are controlled by the switch assembly 20. Again, because of the extent of the dwell surface 262, the contact portions 242 do not move to a separated position from the contact portion 229 until the contacts of the switch assembly 20 are separated. Thus the circuits controlled by the switch assemblies 220 will not be interrupted until the circuits controlled by the switch assembly 20 are interrupted.

When the ledge 97 moves upwardly, as the switch assembly 20 is de-energized, the spring 227 causes the rotatable actuator 226 to move in a clockwise direction to the position shown in FIG. 10, wherein the parts of the switch assembly 220 are positioned as previously described. In connection with the configuration of the dwell surface 262, preferably the portion of the dwell surface 262 adjacent the cam surface 261 is at a lesser distance from the center of the hub portion 249 than the portion of the dwell surface 262 which is adjacent the radial wall 263. This construction is included to minimize the friction between the apex 244 and the dwell surface 262 as the rotatable actuator 226 moves toward the de-energized position shown in FIG. 10.

When the rotatable actuator 226 is positioned in its second position, not shown, the spring 227 has one end resting on the wall 263 and the other end resting on the spring seat 299 so that the spring 227 constantly urges the rotatable actuator 226 in a clockwise direction to a position wherein the stop surface 255 engages the stop surface 300. When the rotatable actuator 226 is thus positioned, the apex 266 engages the portion 245 of the flexible metal part 235 to press the contact portions 242 into firm engagement with the contact portion 229.

When the switching assembly 20 is energized so as to move the ledge 97 downwardly, the actuating lever 271 moves in a downward direction thereby causing the rotatable actuator 226 to rotate counterclockwise about the cylindrical boss 247 against the force exerted by the spring 227. The rotation thus imparted to the rotatable actuator 226 moves the apex 266 out of engagement with the portion 245 of the flexible metal part 235 and the contact portions 242 separate from the contact portion 229.

The separation of the contact portion 242 occurs prior to the engagement between the movable contacts and stationary contacts of the switch 20 so that the circuits controlled by the switch assembly 220 will be interrupted prior to the energization of the circuits controlled by the switch assembly 20.

When the ledge 97 moves upwardly as the switch assembly is de-energized, the spring 227 causes the rotatable actuator 226 to move in a clockwise direction wherein the parts of the switch assembly are positioned as previously described. During the initial clockwise movement of the rotatable actuator 226, the inclined wall 267 engages the portion 245 of the flexible metal part 235 to thereby cause the contact portions 242 to move into engagement with the contact portion 229 prior to the engagement of the apex 266 with the portion 245. A further continued rotation of the rotatable actuator 226 causes apex 266 to engage the portion 245 and move the apex 244 of the flexible metal part upwardly while the junction 236 and the contact portions 242 are held against upward movement. This continued upward movement of the apex 244 causes the contact portions 242 to move across the surface of the contact portion 229 with a contact wiping action for the purpose previously set forth.

If desired, a switch assembly 320 having a linearly movable actuator may also be attached to either the right or left side of the switch assembly 20, so as to be actuated thereby. The switch assembly 320, which is shown in FIG. 2 as mountable on the right side of the switch assembly 20, is provided with a mounting plate 321. The mounting plate 321 is provided with a pair of openings for holding captive a pair of screws 322 which are threaded into the openings 298 in the mounting plate 21 for mounting the switch assembly 320 adjacent the right wall 28 of the switch assembly 20.

The switch assembly 320, as shown in FIG. 12, includes a housing 323, which is mounted on the mounting plate 321, a cover 319, a movable contact guide and support assembly 324, a return spring 325, and one or more pairs of stationary contact assemblies 326.

The housing 323 and the cover 319 are each provided with a pair of rectangular openings 328 and 329 which are aligned along the vertical centerline of the switch assembly 320. The housing 323, which is preferably formed of a suitable molded insulating material, is arranged to provide a support for one or two pairs of the stationary contact assemblies 326. Each of the stationary contact assemblies includes a member 330 which is formed as shown to have a threaded opening for receiving a screw 331 for tightening a clamp 332 to a bared end of an electrical conductor, not shown, and an opening 333 for receiving a screw 334 for securing a removable contact portion 335 of the stationary contact assembly 326. The removable contact portions 335 each have a portion arranged to be secured by the screw 334 to the member 330 and a portion having a contact 336 thereon. The terminal members 330 and the removable stationary contact assemblies 326 are positioned in the housing 323 so the contacts 336 of each pair may selectively face toward or away from the mounting plate 321 on opposite sides of the centerline through the openings 328 and 329. The housing 323 is arranged to support two pairs of stationary contacts 326 so as to form what is commonly known as a two pole switch.

The movable contact guide and support assembly 324 includes a member 337 which is preferably formed of molded insulating material to have a pair of side walls 338 between which extend cross bars 339, 340, and 341. The side walls 338 each have a pair of spaced rectangular projections 342 thereon which are received in the openings 328 and 329 when the cover 319 is assembled to the housing 323. The openings 328 and 329 and the projections 342 are arranged to guide the movable contact guide and support assembly during its movements. The cross bars 339–341 are arranged to provide seats for springs 343. The springs provide resilient supports for the contact retainers 344 and the movable contacts 346. The movable contacts 346 each have a central portion in engagement with the contact retainers 344 and a portion extending in opposite directions of the guide member 324 which have a contact 348 thereon. The contacts 348 are arranged to engage the contacts 336 so as to complete a circuit between the contacts of each pair of stationary contacts. The movable contacts 346 may be positioned relative to the cross bars 339–341 so that the contacts 348 may face either toward or away from the mounting plate 321.

Thus the contacts 348 on the movable contacts 346 can be arranged to engage the contacts 336 of the stationary contact assembly 326 when the stationary contacts 336 are in either of their two positions.

The return spring 325, which is positioned between the housing 323 and the guide member 337, constantly urges the movable contact guide and support assembly 324 upwardly in the housing 323. The projection on the side wall 338 which extends through the lower opening 329 in the housing 323 is provided with a fixed extending lug 349 which extends exterior to the housing 323. The lug 349 is arranged to engage the lower surface of the ledge 97 when the switch assembly 320 is mounted adjacent the side wall 28 of the switch assembly 20 in a manner described.

The openings 328 and 329, the projections 342 on the guide member 337, the stationary contact assemblies 326 and the position of the movable contacts 346 on the guide member 337 are arranged so that normally the movable contacts 346 will be separated from the contacts 336 when the contacts 336 face away from the mounting plate 321 and will normally engage the contacts 336 when the contacts 336 face the mounting plate 321. Thus the switch assembly 320, which may be a two pole device, may have all normally open, all normally closed, or a normally open and a normally closed contacts.

In view of the foregoing description it is apparent that as the ledge 97 moves downwardly in response to the energization of the switch assembly 20, the lug 349 will cause the movable contact and guide assembly 324 to move downwardly in opposition to the force exerted by the return spring 325. The downward movement of the movable contact guide and support assembly 324 will cause the normally closed contacts 348 to separate from the contacts 336 and the normally open contacts 348 to engage the contacts 336. When the switch assembly 20 is deenergized, the contacts 348 will return to their original positions.

The contact structures of the switch assembly 320 preferably are formed to have the same current conducting capability as the contact structures of the switch assembly 20. The switch assembly 20, previously described, is basically a three pole device. Thus the simple addition

of the switch assembly 320 to one side of the switch assembly 20 will convert the switch assembly 20 to a four or five pole device which may also include one or two switches 80 and a selected number of the switches 220.

Certain circuit applications, such as reversing circuits for electric motors, frequently include a pair of separate switch assemblies which are required to be energized independently of each other but must be prevented from being simultaneously energized. The combination of switch assemblies heretofore described can be used to electrically prevent the simultaneous energization of a pair of switch assemblies. For example, a pair of switch assemblies, indicated as 20A and 20B in FIG. 10, may be mounted on a common support 360 and the simultaneous energization thereof may be electrically prevented by providing each of the switch assemblies 20A and 20B with a separate switch 80 or a switch assembly 220, as previously described. This is accomplished by connecting the coil windings of the switch assemblies 20A and 20B in a series circuit with the normally closed contacts of the switch assemblies 80 or 220 which are operated by the switches 20B and 20A. Thus if one of the switch assemblies 20A or 20B is energized, the energization of the other will be prevented by the open contacts of the switch assemblies 80 or 220 which are moved to a circuit opening position by the energized switch assembly 20B or 20A. This arrangement of preventing the simultaneous energization of the switch assemblies 2OA and 20B is commonly known as electrical interlocking and when the switches 80 and 220 operate as described, they are called electrical interlock switches.

Frequently conditions are encountered when it is desirable to not only use electrical interlock switches for preventing the simultaneous operation of the switch assemblies 20A and 20B but also to prevent their simultaneous operation by a mechanical means. Also under other conditions, it may be desirable not to include an electrical interlock arrangement in the system and to rely exclusively on a mechanical arrangement for preventing the simultaneous operation of the switch assemblies 20A and 20B.

In FIG. 10 the pair of switch assemblies 20A and 20B each have their respective mounting plates secured to the support 360. The support 360 is formed as a U-shaped channel member having a web portion 361 and a pair of spaced arms 365 downwardly extending from the web portion 361. The web portion 361 is sized to permit the mounting of the switches 20A and 20B in a side by side position and is provided with openings 362 and 363 which are aligned with the openings 37*c* in the bases 24 and similarly located openings in the mounting plates 21 so the bottom surfaces of the ledges 97 of the switches 20A and 20B are exposed to a bottom surface 364 of the web 361. The spaced arms 365, which are formed to extend along the marginal edges of the web portion 361, are provided with a means, not shown, for attaching the entire assembly, including the switch assemblies 20A and 20B, as well as the support 360 to a panel, not shown. The arms 365 are formed to extend downwardly sufficiently to provide space for a mechanical interlock assembly 366 which is carried by the bottom surface 364, which will now be described.

As shown in FIGS, 10, 13 and 14, the interlock mechanism 366 includes a pair of actuators 367 and 368 which are interconnected by a pair of lever bars 369. As each of the actuators 367 and 368 are identical and are arranged to face on opposite directions on the bottom surface 364, only the actuator 367 will be specifically described. The actuator 367 includes a channel member 370 which has a web portion 371 and a pair of spaced arms 372 which extend parallel to the spaced arms 372 of the actuator 368. The web portion 371 is provided with an opening 373 centered between the arms 372 and aligned with the opening 362 when the web portion 371 is secured to the bottom surface, 364. Each of the arms 372 is provided with a notch 374. The notch 374 is shaped to provide a semicircular notch 375 having a radial center located in a plane which is perpendicular to the common centerline of the openings 362 and 363 which passes through the centers of the openings 362 and 363. The notches 374 further are shaped to provide a horizontal edge 376 which extends tangentially of the portion of the semicircular notch 375 adjacent the web 371 and a curved surface 377 which extends tangentially of the portion of the semi-circular notch 375 remote from the web 371. The curved surface 377 has a relatively small radius compared to the radius of the semicircular notch 375 and extends to an edge 378 which is slightly inclined toward the horizontal edge 376. Secured to the web 371 on opposite sides of the opening 362 along a centerline passing through the openings 362 and 363 are a pair of guide members 379, each of which extend perpendicular to the web 371 and parallel to the spaced arms 372.

As most clearly shown in FIG. 14, the actuator 367 also includes a plunger 380, a pair of levers 381, a pair of pivot pins 382 and 383 and a pair of return springs 384 and 385. The plunger 380 is provided with a shank portion 386 which extends upwardly in alignment with the vertical axis of movement of the movable contact and guide assembly 96*n* to an upper free end 387 which is positioned to engage the bottom wall of the ledge 97 adjacent the side wall 98*a*. Formed on the lower end of the shank portion 386 is a portion 388 which has a bore 389. The bore 389 extends through the portion 388 perpendicular to the axis of the shank portion 386 and provides a bearing journal for the pivot pin 382. Spaced on the portion 388 on opposite sides of the bore 389 are guide portions 390 and 391 which project downwardly from the portion 388 and each have bores 392 and 393 which are slideable on the guide members 379.

The guide members 379 are located on the web 371 so the guide portion 390 and the bore 392 are spaced at a greater distance from the shank 386 than the guide portions 391 and the bore 393. A round bottom surface 394 is formed on the portion 388. The surface 394 is defined by a portion of a cylindrical surface having its radial center located at the axial center of the bore 389. The portion of the surface 394 adjacent the guide portions 390 is provided with a clearance notch 395. The portion 388 is also provided with straight flat surfaces 396 and 397 which lie in planes parallel to a plane extending through the axis of the bores 392 and 393.

The levers 381 each have a bore 398 on one end which is received by an end of the pivot pin 382 and is maintained assembled on the ends of the pivot pin 382 by retainers 399 which may be received in suitable grooves at the ends of the pivot pin 382. When the levers 381 are thus assembled on the pivot pin 382, the flat surfaces 396 and 397 will guide the levers 381 in a straight line path of pivotal movement. The other end of each of the levers 381 is provided with a bore 400 which receives the pivot pin 383. The bores 398 and 400 are spaced on the levers 381 so the pivot pin 383 will roll on the curved bottom surface 394 when the levers rotate about the pivot pin 382.

The return springs 384 and 385, which are positioned between spring seats 401 and 402 on the free end of the guide members 379 and the portion 388, normally urge the plunger 380 upwardly to a position wherein the portion 388 engages the web 371. The guide portions 390 and 391, which are received within the convolutions of the springs 384 and 385, guide the springs during compression.

The lever bars 369 each have an opening at its opposite end which is received by an end of the pivot pin 383 which projects beyond the outer surface of the levers 381. The lever bars 369, levers 381 and the pivot pin 383, are maintained assembled by retainers 404 which are received in suitable grooves 405 formed on the free ends of the pivot pins 383. The openings in each lever bar 369 which receive the pivot pins 383 are spaced from each other so

that when the levers 369 and 381 are thus assembled, the levers 381 will be inclined from a vertical centerline passing through axis of the shank 386 of the plunger 380. The incline of the levers 381 is arranged so the portions of the levers 381 of the actuators 367 and 368 attached to the pivot pins 383 are spaced a lesser distance than the portions of the levers 381 of the actuators 367 and 368 which are attached to the pivot pins 382.

Each of the lever bars 369 has guide portions 406 thereon. The guide portions 406 are formed as projections which extend beyond the notches 375 and are arranged to slidingly engage the inner surfaces of the spaced arms 372. Additionally positioned between the retainers 404 and the outer surfaces of the lever bars 369 on the pivot pins 383 are rollers 407. The rollers 407 have the same diameter as the semicircular notches 375 and are arranged to engage and roll upon the horizontal edge 376 when the assembly of the foregoing parts is completed.

In view of the foregoing description, the operation and advantages of the mechanical interlock assembly is as follows.

When switch assemblies 20A and 20B are both de-energized, the return springs 384 and 385 urge both plungers 380 upwardly thereby maintaining an engagement between the free end 387 and the ledge 97. Also the levers 381 will be inclined at substantially equal angles toward each other thereby positioning the rollers 407 of the actuators 367 and 368 equidistantly from the bottoms of the semicircular notches 375. When the rollers 407 are thus positioned, a vertical line of centers through the axis of the pivot pins 383 will lie forwardly of the inclined edge 378 while a portion of the rollers 407 will be vertically aligned with the curved surfaces 377.

When either of the switch assemblies 20A or 20B is energized, e.g., the switch assembly 20B in FIG. 10, the ledge 97 is moved vertically downwardly. The vertical downward movement of the ledge 97 of the switch assembly 20B, moves the plunger 380 of the actuator 368 downwardly against the forces exerted by the springs 384 and 385.

The initial downward movement of the plunger 380 causes the pivot levers 381 of the actuator 368 to move clockwise to a more inclined position while the pivot lever 381 of the actuator 367 moves clockwise toward a more vertical position relative to a centerline passing through the axis of the shank 380. The clockwise movement of the levers 381 of the actuators 367 and 368 is accompanied by a horizontal movement to the left of the lever bars 369 to a limiting position wherein the rollers 407 seat within the notches 375 of the actuator 367. When the lever bars 369 are thus positioned, the rollers 407 of the actuator 368 will be external of the notches 375 of the actuator 368. During the foregoing movements, the rollers 407 will roll upon the horizontal edges 376 and the pivot pin 383 will roll on the curved bottom surface 394.

A continued downward movement of the plunger 380 of the actuator 368, after the rollers 407 of the actuator 367 are seated in the notches 375, causes the rollers 407 of the actuator 368 to move in a generally vertical path as the lever bars 369 pivot about the pivot provided by the seated rollers 407 in the notches 375 of the actuator 367. When the switch assembly is fully energized, the ledge 97 will be at its lowest downward position and the rollers 407 of the actuator 368 will be moved to their final interlocking position wherein they are horizontally aligned with the inclined surface 378 of the actuator 368.

During the movement of the rollers 407 to their final position, the guide portions 406 will guide the movement of the lever bars 369 and the curved surfaces 377 will prevent any interference to movements of the rollers 407 to the interlocking position.

If the switch 20A should be energized while the rollers 407 of the actuator 368 are in an interlocking position, the downward movement of the plunger 380 of the actuator 367 will be prevented because the lever bars 369 are prevented from movements to the right by an engagement of the rollers 407 with the inclined surface 378 of the actuator 368. This arrangement will maintain the seating engagement of the rollers 407 in the notches 375 of the actuator 367 and prevent downward movement of the plunger 380 of the actuator 367 to thereby prevent movement of the contact guide and support assembly 96 of the switch assembly 20A to its energized position.

In view of the foregoing description it is obvious that energization of the switch assembly 20A will prevent movement of the contact guide and support assembly 96 of the switch assembly 20B to an energized position should the switch assembly 20B be energized subsequent to the energization of the switch assembly 20A.

In the event both switch assemblies 20A and 20B are energized for simultaneous movement to their energized positions, the movable contact guide and support assemblies 96 of both of the switch assemblies 20A and 20B will be prevented from moving to their energized position as follows. When the switches 20A and 20B are simultaneously energized, the plungers 380 of both of the actuators 367 and 368 will move downwardly an insignificant distance to a position wherein the rollers 407 of the actuators 367 and 368 move into engagement with the curved surfaces 377 and thereby prevent a continued downward movement of the plungers 380 of the actuators 367 and 368. When the switch assemblies 20A and 20B are simultaneously de-energized, the interlock assembly, including the rollers 407 of actuators 367 and 368, will return to their at-rest position previously described. Alternately, if one of the switch assemblies is de-energized and the other switch assembly remains energized, e.g., switch assembly 20A is de-energized while the switch assembly 20B remains energized, the interlock mechanism, including the rollers 407, will move to the position previously described wherein the rollers 407 of the actuator 367 are seated in the notches 375 while the rollers 407 of the actuator 368 are positioned adjacent the inclined surface 378.

The movements to the proper positions of the interlock mechanism upon simultaneous energization of both of the switches 20A and 20B and then a subsequent de-energization of one of the switches 20A or 20B is accomplished without frictional interference between any of the moving parts of the entire interlock mechanism which would normally prevent such movements.

It is to be noted that when both switch assemblies 20A and 20B are simultaneously energized, the parts of the interlock assembly are essentially moved to a "jammed" condition. Frequently, in other types of mechanical interlocks, when this condition is encountered, a subsequent de-energization of either one or both of the switch assemblies 20A and/or 20B will not restore the operative condition of the interlock mechanism. Rather, the interlock mechanism can be returned to an operative condition only if tools are used to force the interlock mechanism from its jammed state.

In contrast, the interlock mechanism according to the present invention will not only relieve itself of its jammed condition but will instantly move to its proper interlocking position.

As previously stated, the levers 381 of the actuators 367 and 368 are positioned by the lever bars 369 so the levers 381 of the actuators 367 and 368 are inclined toward each other. Thus when both of the switches 20A and 20B are simultaneously energized, the levers 381 of both of the actuators 367 and 368 will move vertically downwardly without rotational movement about the pivot pins 382 and 383 to a position wherein the rollers 407 of the actuators 367 and 368 engage the curved surfaces 377. When the rollers 407 are thus positioned, a circumferential portion of the roller 407 of the actuator 367 to the left of a vertical centerline through the pivot pin 383 will engage the curved surface 377 of the actuator 367

while a circumferential portion of the roller 407 of the actuator 368 to the right of a vertical centerline through the pivot pin 383 will engage the curved surface 377 of the actuator 368. Thus any further movements of the rollers 407 of both of the actuators 367 and 368 is prevented as the rollers 407 and inclined levers 381 of the actuators 367 and 368 constantly apply forces in opposite directions.

When one of the switch assemblies 20A or 20B is de-energized while the other switch assembly, e.g., switch assembly 20B remains energized, the interlock mechanism will move without assistance to prevent re-energization of the switch assembly 20A as long as the switch assembly 20B remains energized. When the switch assembly 20A is de-energized, the downward vertical force causing an engagement of the rollers 407 of the actuator 367 with the curved surfaces 377 is removed, while the downward vertical force which causes the rollers 407 to engage the curved surface 377 of the actuator 368 continues. The continued force on the actuator 368 causes two phenomena to occur for moving the lever bar 369 to the proper interlocking position. The incline of lever 381 of the actuator 368 to the left causes the lever 381 to move downwardly and to the left to an interlocking position with the inclined edge 378 as the rollers 407 of the actuator 368 roll over the curved surface 377. Similarly, the rounded surface 377 permits the rollers 407 of the actuator 367 to rotate and move upwardly without frictional binding into a seating position in the notch 375 where the rollers 407 thus prevent switch assembly 20A from being energized.

In the foregoing description the switch assemblies 20A and 20B are indicated as energized and de-energized. These terms are used to indicate the operational movements of the contact guide and support assembly 96 and without consideration of the electrical condition of the operating coil.

As shown in FIG. 2, a switch mechanism 450 may be mounted adjacent the lower side wall of the electromagnetic switch assembly 20. The switch mechanism 450 is of the type which will respond to an excess current condition in any one of a plurality of circuits and may be of the type disclosed in an application for United States patent Ser. No. 327,952, filed Dec. 4, 1963, entitled, "Switch Mechanism," which has been assigned by the inventors, Don J. Arneberg, Harold E. Whiting and Merlin Y. Turnbull to the assignee of the present invention. The switch mechanism 450, as disclosed in the Arneberg et al. application, includes a plurality of current responsive elements of the melting alloy type, which are each designated by a numeral 451 in FIG. 2. Each of the current responsive elements 451 in response to an excess current flow between a terminal screw 452 and a connector prong 453 permits a pair of normally closed contacts, not shown, in a switch housing 455, to move to a circuit interrupting position. The switch mechanism 450 has a base, not shown, which is securable by fastening screws in notches 454 in the plate 21 and when the switch mechanism 450 is thus secured, the connector prongs 453 will be secured by the terminal clamps 65*a* when screws 65 are tightened. The contacts of the switch 450 are preferably included in series circuit with one of the terminals of the coil which are secured by screws 157. Thus when any of the current responsive elements 451 is subjected to an excess current flow, the coil winding of the electromagnetic switch 20 will be de-energized, and the contacts thereof will move to a circuit opening position.

Likewise, it may be desirable to support a push button switch assemblage adjacent the lower top portion of the electromagnetic switch assembly 20. In such a case, a push button switch assemblage, such as illustrated in FIGS. 2 and 10 and disclosed in United States Patent No. 2,902,534, which issued on Sept. 1, 1959 to Joseph J. Gribble, may be provided. This assemblage comprises a casing 460 in which suitable push button switches 461 are mounted and wires which lead from connecting terminals 462 to the terminals of the coil which include the screws 157. Suitable screws 463 are used to secure the casing 460 to a snap fastening element 464 which fastens the casing 460 to the electromagnetic switch 20.

For this purpose, the openings 193 and 194 in the cover 175 are provided, which are arranged to receive suitable prongs 465 on the element 464. The element 464 is in the form of a bracket which is arranged so the prongs 465 overlie a portion of the cover 175 while a pair of spaced arms 466 integrally formed on the element 464 are firmly pressed against the front wall of the electromagnetic switch 20. The element 464 also includes a pair of resilient arms 467 which are used to secure the casing 460 to the element 464 so the casing 460 may have a limited movement relative to the switch 20. This arrangement will permit the structures heretofore described to be mounted without difficulty within an enclosure, not shown, with the actuating buttons of the switches 461 exposed through an opening in the cover for the enclosure in spite of discrepancies in manufacturing tolerances of the enclosure.

Additionally, if desired, a pilot light assemblage having a mode of operation as disclosed in the United States Patent No. 3,146,325, issued Aug. 25, 1964 to Joseph J. Gribble, may be mounted on the electromagnetic switch 20, in a manner shown in FIGS. 2 and 5. In executing the concepts incorporated in the Gribble patent, the pilot light assemblage as used with the switch assembly 20 includes a molded portion 470, shown in FIG. 5, which encloses a wafer-thin portion 471 having a coil winding embedded therein which is mounted to surround the leg 123 of the magnet core 116. Integrally formed with the portion 470 is a pair of spaced projections 472 which extend through the notches 473 which are illustrated in FIG. 1. The projections 472 provide supports for the prongs 474 which extend external to the exterior of the switch mechanism 20. The prongs are electrically connected to the coil winding within the portion 471.

A separate hollow support 475 for a bulb 476 of the pilot light assemblage is formed of a molded insulating material to enclose suitable means for releasably gripping the prongs 474 and electrically connecting the prongs 474 to a socket for the bulb 476. The support 475 includes a portion 477 which is received in the vertical slots 91*a*, as shown in FIG. 2, to form a dove-tail connection therewith, so that a pilot light will be positioned at the upper top corner of the electromagnetic switch 20 without the use of other fastening means.

The means for electrically connecting the prongs 474 include a pair of conductors formed of resilient material which have ends respectively connected to engage the base and central terminal of the incandescent bulb 476 and extending ends which are suitably curved to be deflected as the support 475 is moved into position on the switch 20. Additionally, the support 475 has a pair of spaced resilient members spaced on opposite sides of the portion 477 arranged to engage the outer walls of the switch 20 for the purpose of absorbing shocks and maintaining the support 475 in position on the switch 20.

The electromagnetic switch may also be provided with a latch attachment 500 as shown in FIG. 15 of the drawings. The latch attachment 500, when used, replaces the cover 175 of the switch 20. The attachment 500 has an outer housing 502 and a bottom surface corresponding in shape to the bottom surface 177 of the cover 175. The housing 502 encloses a cavity 504 wherein a magnet motor 506, a latch lever 508, a bell crank 510, a slider 512 and a switch 514 are positioned.

The magnet motor 506 includes a magnet coil 516 having terminals, not shown, extending externally on opposite sides of the housing 502 which are connectible in an energizing circuit for the coil 516. The coil 516 has a central bore 518 which receives a pole piece 520. The pole piece 520 is positioned in the bore 518 by a U-shaped

yoke 522 which is secured to a U-shaped clamping member 524. The coil 516, the yoke 522 and member 524 when positioned as shown in FIG. 15 are maintained assembled when the yoke 522 and member 524 are welded together at the areas indicated by the numeral 526. Slidably positioned in the bore 518 and guided therein by a part 528, carried by the member 524, is a plunger assembly 530 which includes an armature 532, which is attracted to engage the pole piece 520 when the coil 516 is energized and a plunger 534 which extends through a bore in the pole piece 520 to present a stem 536 which extends externally of the remainder of the magnet motor 506.

The bell crank lever 510 is rotatable about a pivot 538 which is positioned by the housing 502 and has an arm 540 extending in one direction from the pivot 538 and an arm 542 extending in another direction from the pivot as shown in FIG. 15. A spring 544 reacting between a housing 502 and the arm 542 normally urges the lever 510 clockwise as in FIG. 15 to a position wherein an end of the arm engages and moves a resilient leaf-like part 564 of the switch 514 to the left, as in FIG. 15. The switch 514 has a movable contact 548 carried on a free end of the leaf-like part 546 which is arranged to engage a stationary contact 550. The leaf-like part has a fixed end 552 secured to a terminal member 554 which extends through an opening in the housing 502. The stationary contact 550 is carried on a metal terminal member 556 which similarly extends through an opening in the housing 502 so as to be externally accessible.

The latch lever 508 is rotatable about an adjustable pivot 558 which is carried by the housing 502. The lever 508 has an arm portion 560 extending to engage the end of the stem 536 and an arm 562 which extends through an opening in the housing 502. The end of the arm 560 is also engaged by a suitable adjustment screw 564 which is carried on the end of the arm 542. Extending generally generally at right angles to the arm 560 is a portion 566 which has a free edge 568. As the adjustment screw 564 on the arm 542 engages the arm 560 of the latch member 508, the spring 544 normally urges the latch member 508 in a counterclockwise direction.

The slider 512 has one end 570 extending through and guided by a suitable opening in the top wall of the housing 502 and its opposite end 572 extending through and guided by a suitable opening formed in the bottom wall of the housing 502. The end 572 is arranged to rest upon the free end 574 of one of the arms 96*b* of the movable contact and guide assembly 96. The slider 512 is normally biased by spring 576, which has one end resting on a portion of an inner wall of the housing 502 surrounding the cavity 504, downwardly so the free end 572 is pressed into engagement with the end 574 of the arm 96*b*. The slider has a ledge 578 facing toward and disposed to be engaged by the edge 568 on the latch member 508 when the movable contact and guide assembly 96 is positioned so that the movable contacts of the switch 20 are pressed into tight engagement with the stationary contacts. Extending downwardly below the ledge 578 is a vertical surface 580 which is engaged by the free edge 568 when the arm 96*b* is moved upwardly so that the movable contacts of the switch 20 are disengaged from the stationary contacts.

In FIG. 15, the switch 20 has its parts positioned so the movable contacts are in engagement with the stationary contacts when the arm 96*b* is moved downwardly to the position shown. The downward movement of the arm 96*b* permits the spring 576 to urge the slider 512 downwardly to a position wherein the edge 568 of the latch lever 508 rests upon the ledge 578. As also shown in FIG. 15, the coil 516 of the magnet motor 506 is de-energized, permitting the armature 532 and the plunger 534, including the stem 536, to be moved downwardly by the spring 544. When the parts of the latch attachment 500 are thus arranged, the edge 568 will prevent upward movement of the slider 512 so that the arm 96*b* is maintained in position whereby the movable contacts of the switch 20 are maintained in engagement with the stationary contacts even though the electromagnet of the switch 20 should be de-energized. Also, when the plunger assembly 530 is in the position shown in FIG. 15, the spring 544 will cause the bell crank lever 510 to be rotated in a clockwise direction to a position wherein the arm 540 causes the leaf-like part to be moved to the left and cause the separation of the movable contact 548 from the stationary contact 550. As the terminals 554 and 556 are connected in series with the actuating coil of the switch 20, the coil of the switch 20 is de-energized and the movable contacts of the switch 20 are maintained in engagement with the stationary contacts.

When the coil 516 is energized, the plunger assembly 530 will move upwardly to a position wherein the stem 536 causes the latch lever 508 to rotate in a clockwise direction and the bell crank lever 510 to rotate in a counterclockwise direction about their respective pivots. When the bell crank lever 510 rotates in a counterclockwise direction the arm 540 is retracted to a position which permits the movable contact 548 to engage a stationary contact 550 to complete the circuit to the operating coil of the switch 20. Similarly, when the latch lever 508 rotates clockwise, the edge 568 will move from its engagement with the latch 578 so that the return springs in the switch assembly 20 will cause the arm 96*b* to move upwardly and force the slider 512 upwardly while compressing the spring 576 to a position wherein the free end 570 is visible from the exterior of the housing 502. After the parts of the latch attachment are thus positioned, the coil 516 may be de-energized and the parts of the device will remain as described wherein the movable contacts 548 are in engagement with the stationary contacts 550 so as to complete the circuit to the operating coil of the switch 20. Also it is to be noted that if it is desired to cause the release of the parts of the device, the arm 562 may be used to rotate the latch 508 in a clockwise direction to effect release of the latch mechanism in the same manner as when the magnet coil 516 was energized.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partition extending from the bottom wall in the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom

wall and a portion exposed through an opening in a side wall of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and to engage and bridge the contact portions of the stationary contacts and complete an electric circuit therebetween when the carrier is in a second of said two positions and means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, and a mechanical interlock carried by the bottom surface of the support having a pair of plungers each of which extends through one of the openings in the support to engage one of the carriers and prevent simultaneous movement of the carriers of both switch units to their second position of movement.

2. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through an opening in a side wall of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the barrier is in a first of the said two positions and to engage and bridge the contact portions of the stationary contacts when the carrier is in a second of said two positions and means including a bell crank lever and an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, and a mechanical interlock having a plurality of levers carried by the bottom surface of the support and a pair of plungers engaging the carriers of the switch units preventing simultaneous movement of the carriers of both switch units to their second position of movement.

3. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through an opening in a side wall of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and to engage and bridge the contact portions of the stationary contacts when the carrier is in a second of said two positions, means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a separate switch positioned in the cavity and having an actuator engageable with the carrier and a pair of contacts in a circuit with the magnet coil of the other of said pair of similar switch units which is mounted on the support electrically preventing simultaneous energization of the magnet coil of both switch units, and a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement.

4. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through an opening in a side wall of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and to engage and bridge the contact portions of the stationary contacts when the carrier is in a second of said two positions, means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a separate switch mounted adjacent one of the side walls of each one of the switch units, each of said separate switches having an actuator engageable with the portion of the carrier through the opening in the side wall of the switch unit on which the separate switch is mounted, and a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement.

5. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces

and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through an opening in a side wall of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and engage and bridge the contact portions when the carrier is in a second of said two positions and means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement, a separately enclosed electric switch mounted adjacent one side of one of the switch units and a second separately enclosed switch mounted adjacent the other side of the said one switch unit, said separately enclosed switch respectively having a rotatable actuator and a linearly movable actuator with each of the actuators extending through the openings in the side walls engaged by the portions of the carrier exposed by the openings and moved by the carrier when the carrier moves to the second position.

6. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through openings in opposite side walls of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and engage and bridge the contact portions when the carrier is in a second of said two positions and means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement, a plurality of first separately enclosed switches mounted adjacent one side of one of the switch units, each of said first separately enclosed switches having a rotatable actuator extending toward the opening in the said one side wall actuated by the portion of the carrier exposed to the opening in the said one side wall, and a single separately enclosed switch mounted adjacent the side wall opposite the said one side wall of the housing, said single switch having a linearly movable actuator engaged by the portion of the carrier exposed through the opening in the side wall adjacent the single switch.

7. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments to have a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having an exposed portion vertically aligned with the opening in the bottom wall and a portion exposed through openings in opposite side walls of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two positions and engage and bridge the contact portions when the carrier is in a second of said two positions, means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a pair of separately enclosed identical switches each positioned in an opposite corner of the cavity between one of the compartments and one of the sidewalls and having a rotatable actuator engaged by one of the exposed portions of the carrier and actuated thereby as the carrier moves between its two positions, a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement, and a second pair of separately enclosed identical switches mounted adjacent one external side wall of one of the switch units, said second pair of identical switch units when mounted having identical walls facing one another positioned on the centerline of the adjacent switch unit and having rotatable actuators extending into the opening in the adjacent one side wall and moved by the carrier of the adjacent switch unit.

8. In an electric switching assembly, the combination comprising: a support provided with a plate-like mounting portion presenting a top and a bottom surface with a pair of spaced openings extending between the surfaces and a pair of spaced mounting members extending from

the mounting portion for mounting the support on a panel with the bottom surface spaced and parallel to the panel; a pair of electromagnetically operated switch units, each of said switch units having: a generally rectangularly shaped external housing enclosing an internal cavity with a bottom wall of said housing secured to the top surface of the support so an opening in the bottom wall is aligned with one of the pair of openings in the support, a plurality of parallel partitions extending from the bottom wall into the cavity parallel to a pair of side walls of the housing providing a plurality of compartments, a pair of stationary contacts positioned in each of the compartments having a contact portion on each side of a centerline which is perpendicular to the bottom wall and spaced equidistantly between a front and a rear wall of the housing, said pairs of stationary contacts also having wire connecting terminal portions extending from the contact portions externally of the front and rear walls; a movable contact carrier linearly movable between two positions in the cavity in a path along the centerline, said carrier having a portion vertically aligned with and exposed through the opening in the bottom wall and a portion exposed through openings in opposite side walls of the housing, a plurality of movable contacts carried by the contact carrier to be separated from the stationary contacts when the carrier is in a first of the said two position and engage and bridge the contact portions when the carrier is in a second of said two positions, means including an electromagnet having a magnet coil for moving the carrier from the first position to the second position upon energization of the magnet coil by a control circuit, a pair of separately enclosed identical switches each positioned in an opposite corner of the cavity between one of the compartments and one of the sidewalls and having a rotatable actuator engaged by one of the exposed portions of the carrier and actuated as the carrier moves between its two positions, a mechanical interlock carried by the bottom surface of the support preventing simultaneous movement of the carriers of both switch units to their second position of movement, a second pair of separately enclosed identical switches externally mounted adjacent a first of the opposite side walls of one of the switch units, said second pair of identical switch units when mounted having identical walls facing one another positioned on the centerline of the adjacent switch unit, each of said second pair of switch units having a rotatable actuator extending into the opening in the adjacent first side wall moved by the carrier of the adjacent switch unit, and a single separately enclosed switch mounted adjacent and externally of a second of said opposite side walls of the said one switch unit, said single separately enclosed switch having a linearly movable actuator extending through the opening in the side wall adjacent thereto engaged by the portion of the carrier exposed to the second side wall opening moved by the carrier as the carrier moves between the two positions.

9. A switch assembly comprising: a base having a plurality of spaced compartments each having a pair of spaced stationary contacts mounted thereon, a housing detachably mounted on the base; a movable U-shaped contact guide and support having a pair of spaced arms engaging a pair of spaced side walls of the housing for guiding the movement of the U-shaped contact guide and support along an axis perpendicular to the base and having a portion integrally formed with the spaced arms carrying a plurality of spaced movable contacts each of which is positioned to bridge one of the pairs of stationary contacts; a magnet assembly having an armature movable in a linear path along an axis parallel to the base; and a bell crank lever having: an actuating portion movable by the armature, a pair of spaced arms integrally formed at opposite ends of the actuating portion engaging the arms of the U-shaped contact guide and support and portions integrally formed at opposite ends of the actuating portion pivotally mounting the bell crank on the housing.

10. The combination as recited in claim 9 wherein the actuating portion of the bell crank lever is moved by the armature through a ball and socket type connection and the spaced arms of the bell crank are connected to the arms of the U-shaped contact guide and support by ball and socket connections.

11. The combination as recited in claim 9 wherein the ball and socket connections with the spaced arms are established by U-shaped channel inserts which have a rectangular outer configuration formed by a pair of spaced arms extending from a connecting web portion and a rounded interior configuration formed by rounded surfaces on surfaces of the spaced arms which face one another.

12. A switch assembly comprising: a base having a plurality of spaced compartments each having a pair of spaced stationary contacts mounted therein, a housing having: a bottom wall detachably mounted on the base, an open sided internal cavity extending between a pair of spaced side walls, and an opening in the bottom wall extending between the side walls exposing the internal cavity, a movable U-shaped contact guide and support having a pair of spaced arms engaging the side walls within the cavity guiding the movement of the U-shaped contact guide and support along an axis perpendicular to the base and a contact support portion integrally formed with the arms and extending through the opening supporting a plurality of spaced movable contacts externally of the bottom wall in positions so each of the movable contacts is engageable with both of the contacts of one of the pairs of stationary contacts, a bell crank lever pivotally mounted within the cavity, said lever having: an actuating portion, a pair of spaced arms integrally formed at opposite ends of the actuating portion engaging the arms of the U-shaped support, and portions integrally formed at the opposite ends of the actuating portion pivotally mounting the lever in the cavity, a magnet assembly removably supported in the cavity having an armature movable in a linear path along an axis parallel to the base and a portion on the armature engaging the actuating portion of the bell crank lever for moving the actuating portion of the bell crank lever, a cover closing the open side of the cavity, said cover having portions engaging portions of the magnet assembly for maintaining the magnet assembly in the cavity, and separate removable fastening means securing the housing to the base and the cover to the housing whereby the contacts and the magnet assembly may be individually and independently inspected.

13. A switch assembly comprising: a base having a plurality of spaced compartments each having a pair of spaced stationary contacts mounted therein, a housing having: a bottom wall detachably mounted on the base, an open sided internal cavity extending between a pair of spaced side walls, and an opening in the bottom wall extending between the side walls exposing the internal cavity, a movable U-shaped contact guide and support having a pair of spaced arms engaging the side walls within the cavity for guiding the movement of the U-shaped contact guide and support along an axis perpendicular to the base and a contact support portion integrally formed with the arms extending through the opening supporting a plurality of spaced movable contacts externally of the bottom wall in positions so each of the movable contacts is engageable with both of the contacts of one of the pairs of stationary contacts, a bell crank lever pivotally mounted within the cavity, said lever having: an actuating portion, a pair of spaced arms integrally formed at opposite ends of the actuating portion, a ball and socket connection between the arms of the lever and the arms of the U-shaped support, and portions on the lever integrally formed at the opposite ends of the actuating portion pivotally mounting the lever in the cavity, a magnet assembly removably supported in the cavity, said magnet assembly having an armature movable in a linear path along an axis parallel to the base and a

portion on the armature engaging the actuating portion of the bell crank lever for moving the actuating portion of the bell crank lever, a cover closing the open side of the cavity, said cover having portions engaging portions of the magnet assembly for maintaining the magnet assembly in the cavity, and separate fastening means securing the housing to the base and the cover to the housing whereby the contacts and the magnet assembly may be individually and independently inspected.

14. A switch assembly comprising: a base having a plurality of spaced compartments each having a pair of spaced stationary contacts mounted therein; a removable housing mounted on the base; a movable U-shaped contact guide and support having a pair of spaced arms engaging a pair of spaced side walls of the housing and guided for movement along an axis perpendicular to the base by the pair of spaced side walls, said U-shaped contact guide and support having a portion integrally formed with the spaced arms carrying a plurality of spaced movable contacts each of which is positioned to bridge the contacts of one of the pairs of stationary contacts; a magnet assembly having an armature movable in a linear path along an axis parallel to the base; and a bell crank lever having an actuating portion movable by the armature, a pair of spaced arms integrally formed at opposite ends of the actuating portion engaging the arms of the U-shaped contact guide and support and portions integrally formed at opposite ends of the actuating portion pivotally mounting the bell crank on the housing.

15. A switch assembly comprising: a base having a plurality of spaced compartments each having a pair of spaced stationary contacts mounted therein; a removable housing mounted on the base supporting: a movable U-shaped contact guide and support having a pair of spaced arms engaging a pair of spaced side walls of the housing guided for movement along an axis perpendicular to the base by the pair of spaced side walls, said U-shaped contact guide and support having a portion integrally formed with the spaced arms carrying a plurality of spaced movable contacts each of which is positioned to engage both of the contacts of one of the pairs of stationary contacts, a magnet assembly having an armature movable in a linear path along an axis parallel to the base, a bell crank lever having: an actuating portion movable by the armature, a pair of spaced arms integrally formed at opposite ends of the actuating portion engaging the arms of the U-shaped contact guide and support, and portions integrally formed at opposite ends of the actuating portion pivotally mounting the bell crank on the housing, and a removable cover for the housing, and means engaging the cover and magnet assembly for resiliently positioning the magnet assembly in the housing.

16. The combination as recited in claim 14 wherein a pair of separately enclosed identical switches are positioned at opposite corners of the base between one of the compartments and one of the side walls of the base which switches each have a rotatable actuator engaging the contact carrying portion of the U-shaped contact guide and support.

17. The combination as recited in claim 16 wherein the rotatable actuator of each of the switches has a flattened portion arranged to engage a resilient contact finger for moving a movable contact into engagement with a stationary contact.

18. The combination as recited in claim 17 wherein the flattened portion of the actuator engages the resilient contact finger and causes the contacts of the separately enclosed switch to engage prior to the engagement of the contacts carried by the U-shaped support with the pair of stationary contacts.

19. The combination as recited in claim 17 wherein the flattened portion of the actuator is arranged to move out of engagement with the resilient contact finger and causes the contacts of the separately enclosed switch to separate subsequent to a separation of the contacts carried by the U-shaped support and the pair of stationary contacts.

20. In an electric switch assembly, the combination comprising: a base of insulating material having a front wall, a rear wall and a bottom wall, a plurality of parallel partitions extending between the front and rear walls from said bottom wall to provide a plurality of spaced compartments with each of said compartments having open opposite ends at the front and rear walls of the base, a plurality of grooves formed in each of the partitions to provide a pair of oppositely facing grooves near each end of each compartment, a stationary contact assembly positioned at each end of each of the compartments, each of said stationary contact assemblies including a wire connecting member having oppositely extending ears positioned by the grooves and closing an end of the compartment and a contact carrying member positioned by the bottom wall and said grooves, said contact carrying member being secured to the wire connecting member by a screw which extends through openings in the contact carrying member and the wire connecting member into a threaded insert which is embedded in the bottom wall of the base.

21. The combination as recited in claim 20 wherein each groove has an edge inclined which is engaged by ears which are formed on opposite edges of the contact carrying member and the wire connecting member of the stationary contact assemblies for guiding and positioning both of the members so the openings in both members are aligned with the insert embedded in the base.

22. In an electric switch assembly, the combination comprising: a base of insulating material having a front wall, a rear wall and a bottom wall, a plurality of parallel partitions extending between the front and rear walls from said bottom wall to provide a plurality of spaced compartments with each of said compartments having open opposite ends at the front and rear walls of the base, a plurality of grooves formed in each of the partitions to provide a pair of oppositely facing grooves near each end of each compartment, a stationary contact assembly positioned at each end of each of the compartments, each of said stationary contact assemblies including a wire connecting member having oppositely extending ears positioned by the grooves and closing an end of the compartment and a member carrying a contact portion, oppositely extending ears on the contact carrying member extending into the grooves positioning a portion of the member on the bottom wall, said contact member having a portion secured to the wire connecting member by a screw which extends through openings in the contact carrying member and the wire connecting member into a threaded insert which is embedded in the bottom wall of the base, a member of insulating material movable between two positions in a plane perpendicular to the bottom wall and parallel and equidistant to the front and rear walls of the base, said member having a plurality of portions with openings therein which portions are spaced so each compartment has a portion therein, a movable contact assembly positioned in each of said openings to be separated from the stationary contacts when the member is in a first of said two positions and to engage and bridge the contact portions of the contact carrying members at opposite ends of the compartments for completing an electric circuit therebetween when the member is in a second of the two positions, each of said movable contact assemblies including: a movable contact element having: an intermediate portion positioned in the opening in the member and a pair of contact portions extending from opposite sides of the member which are arranged to engage the contact portions of the stationary contact assemblies, a retainer having a central portion in engagement with the intermediate portion and extending ears engageable with the material of the member adjacent the opening, said intermediate portion and retainer having cooperating tangs

and detents for positioning the contact element in the opening, and a compression spring having one end in engagement with the retainer and a second end engaging a wall portion of the member within the opening for constantly urging the retainer and contact element toward the bottom wall of the base.

23. An electromagnetic operated control mechanism comprising: a housing providing an internal cavity which is closed by a cover, an electromagent assembly positioned within the cavity and removable as a unit when the cover is detached from the housing, said assembly having: a molded member enclosing a magnet coil and providing a support for terminals for the magnet coil, a stationary magnet part positioned by the molded member and having a portion extending into a passage in the magnet coil and arm portions disposed external to the magnet coil, and a movable armature guided during its movements by portions of the molded member and having a portion extending into the passage and other portions arranged to engage the arm portions of the stationary magnet part, and a spring clip positioned by the molded member and having a

portion extending through the passage engaging the armature maintaining the armature and molded member assembled when the assembly is removed from the cavity.

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