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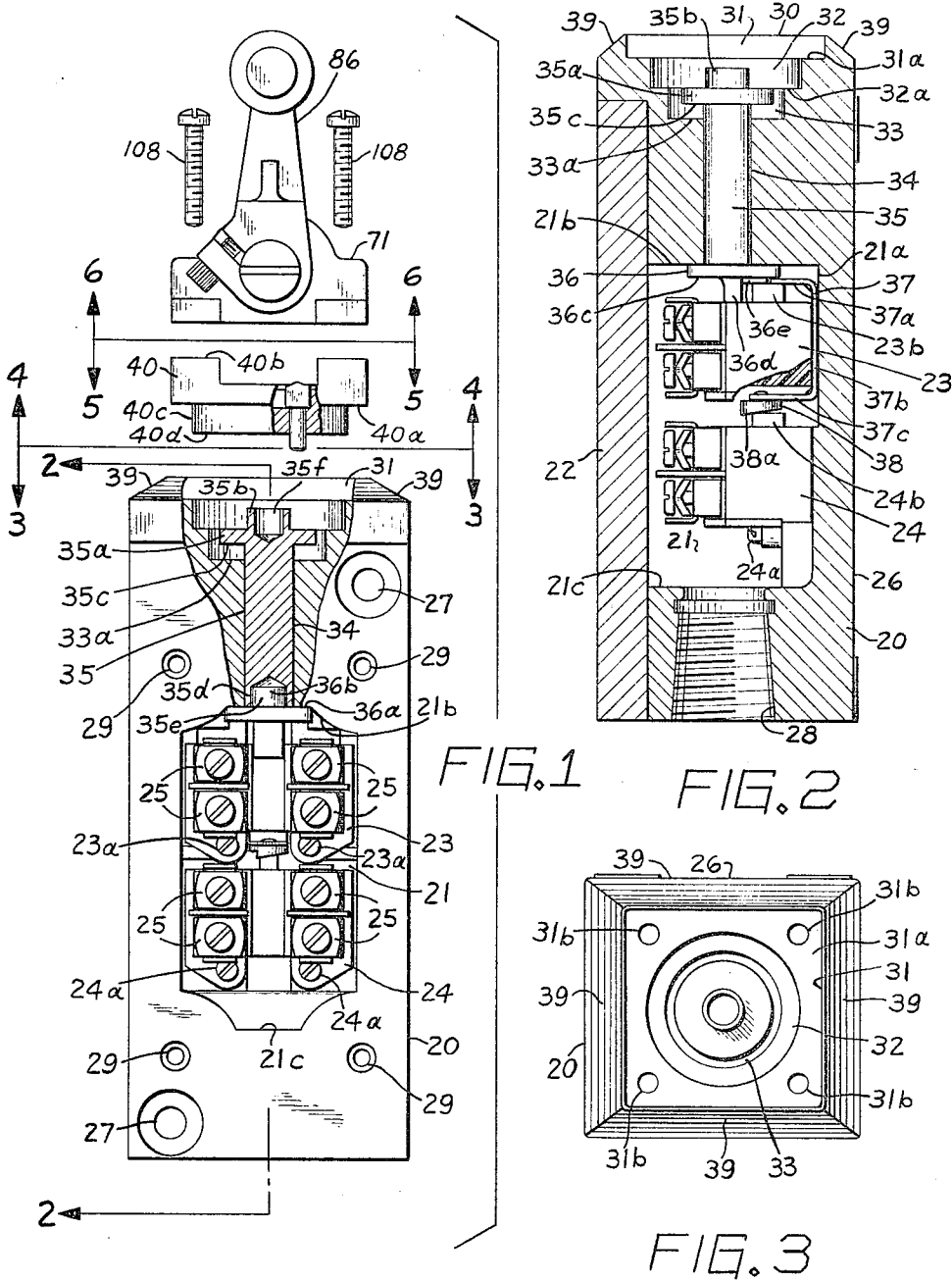
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3,287,516

EXPLOSION RESISTANT LIMIT SWITCH

Filed Aug. 21, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

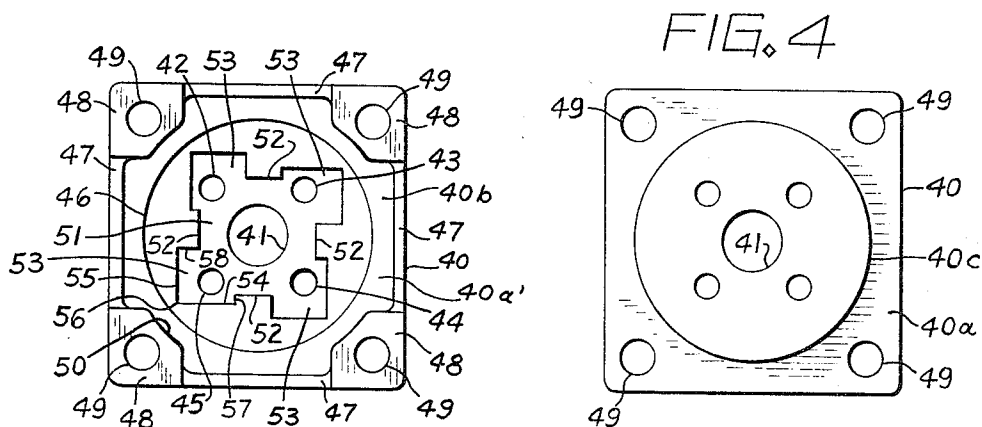
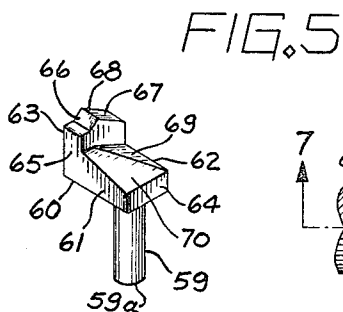


FIG. 9

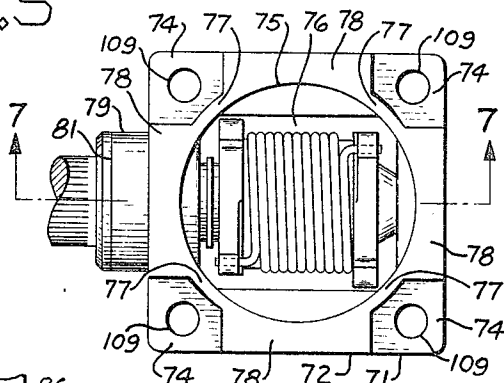


FIG. 6

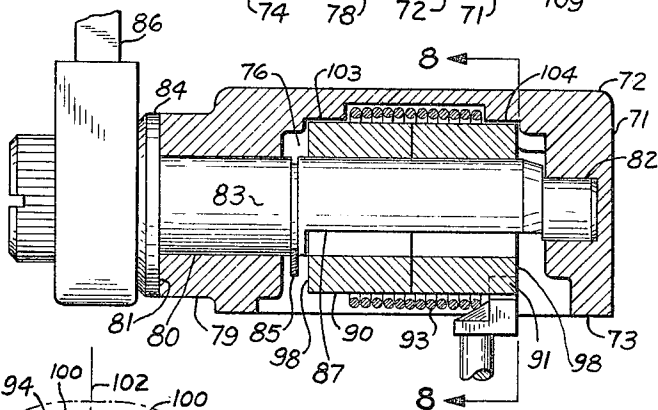


FIG. 7

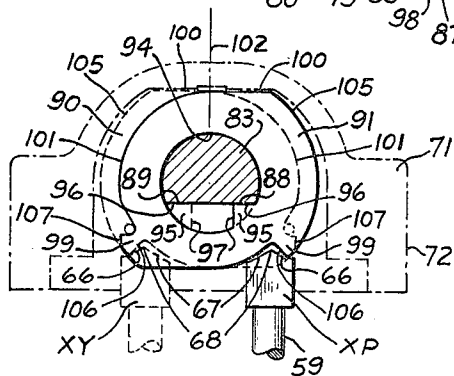


FIG. 8

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3,287,516

EXPLOSION RESISTANT LIMIT SWITCH

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10 Claims. (Cl. 200—47)

The present invention relates to electric switches and more particularly, to an electric limit switch of the explosion resistant type which includes a novel enclosure and operating mechanism which are arranged so the switch may be readily serviced and assembled to provide a large variety of different combinations of switching operations using a minimum of interchangeable parts.

The explosion resistant limit switch structure to which the present invention relates is particularly suited for operation in atmospheres where hazardous combustible dust or gases are present, such as may be found in refineries, distilleries, mines, grain elevators, flour mills, etc. To qualify for use in these applications the device must not only be able to withstand the forces caused by expansion of the gases within the closed internal cavity of the device wherein the circuit making and breaking units are located when the gases are ignited by electric arcs resulting from the operation of the circuit making and breaking units, but also must prevent passage of the hot ignited gases and flames to the exterior of the device which would otherwise ignite the gases of the surrounding atmosphere.

To achieve a structure which will provide the desired protection, the housing of the device which encloses the circuit making and breaking units is usually formed of cast metal with the walls of considerable thickness. All of the openings in the housing which permit entry into the cavity for service and wiring purposes are also closed by metal covers of substantial thickness which are secured to the housing by closely spaced members which have a threaded connection with the housing. To prevent passage of flames and hot gases from the interior cavity to the exterior of the limit housing, all joints between the covers and body of the housing are machined to provide closely mating surfaces of considerable extent. All points of entry for stationary members, such as wire conductors, are provided with threads to assure a path of considerable length for the passage of flames and hot gases.

A limit switch is a device which has an external operator which in response to an externally applied force causes switch units within the housing for the limit switch to operate. Thus it will be seen that an explosion resistant limit switch is required to be provided with a means which will transmit motion from a movable actuator located exterior of the housing to switch units within the cavity of the limit switch housing. This arrangement requires that an explosion resistant limit switch have a member which is movable in an opening in the housing which extends from the cavity within the housing to the exterior of the housing and that clearance between the member and housing be provided to permit the member to move to accomplish its function. Further, good engineering practices dictate that an explosion resistant limit switch include an arrangement for relieving the pressures generated within the cavity upon combustion without defeating the objectives of cooling the flames generated within the cavity sufficiently to prevent exit of the flames to the exterior of the housing. Therefore the plunger as used in the explosion resistant limit switch according to the present invention is movable in a bore which has a considerable diameter and length and a close tolerance fit is provided between the walls of the plunger and bore so that the limit switch will function as intended.

It is an object of the present invention to provide an improved, compact, rugged, snap action type explosion resistant limit switch which can be readily installed and

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serviced and converted to provide a large variety of different switching operations so it can be used in a large number of different kinds of installations and positions.

Another object of the present invention is to provide an explosion resistant limit switch with a housing having walls of considerable thickness which enclose an internal cavity wherein one or more snap switches may be installed and to position a removable member and a plunger on one end of the housing so a large variety of different type external operators may be attached to the housing to operate the switches within the cavity.

A further object of the present invention is to provide an explosion resistant limit switch with a housing which encloses the switching units for the limit switch and an adapter which is nonrotatably mountable on one end of the housing so any one of a plurality of different type external operators may be mounted in different angular positions on the end of the housing to operate a plunger which is carried by the housing to operate the switching units in response to movements of the external operator.

A still further object of the present invention is to provide an explosion resistant limit switch with a housing which has walls of considerable thickness enclosing an internal cavity containing the switching units of the limit switch, and to actuate the switches through a plunger which has a considerable diameter and length so any one of a plurality of different type detachable external operators may be used to impart movement through the plunger to the switching units within the cavity when the external operator is nonrotatably positioned in any one of a plurality of angular positions by an adapter which is positioned between the operator and housing.

In carrying out the foregoing object it is another object of the present invention to use the adapter as a means for positioning members for transmitting movements of the external operator to the plunger and to position the adapter in a square shaped recess in one end of the housing.

Another object of the present invention is to provide an end of an explosion resistant limit switch with a square shaped recess wherein an adapter may be positioned so any one of a plurality of different type external operators may be positioned in any one of a plurality of angular positions through a connection which includes cooperating bosses and recesses on the adapter and operator and to use the adapter as a guide for positioning a number of plungers which are actuated by the external operator to impart movement through a plunger carried by the end of the housing to the switching units carried in a cavity within the housing.

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

FIG. 1 is an exploded front elevational view of an explosion resistant limit switch according to the present invention with the cover removed and portions of the housing and adapter broken away to illustrate the location of plungers carried by the housing and the adapter which will impart movements of an external operator to the switches within a cavity enclosed by the housing for the limit switch.

FIG. 2 is a cross sectional view taken along line 2—2 in FIG. 1 in the direction of the indicating arrows 2—2 and showing in cross section the cover which was omitted in FIG. 1.

FIG. 3 is a top plan view of the housing taken along line 3—3 in FIG. 1 in the direction of the indicating arrows 3—3.

FIG. 4 is a bottom plan view of the adapter taken along line 4—4 in FIG. 1 in the direction of the indicating arrows 4—4.

FIG. 5 is a top plan view of the adapter taken along line 5—5 in FIG. 1 in the direction of the arrows 5—5.

FIG. 6 is a bottom plan view of one form of an external operator which may be used with the housing and adapter according to the present invention, which view is taken along line 6—6 in FIG. 1 in the direction of the indicating arrows 6—6 with the external operating arm for the operator removed.

FIG. 7 is an enlarged cross-sectional view taken along line 7—7 in FIG. 6 including a portion of external operating arm.

FIG. 8 is a cross sectional view taken along line 8—8 in FIG. 7.

FIG. 9 is a perspective view of a plunger as used by the operator mechanism shown in FIG. 8.

Referring to FIGS. 1—3 of the drawings, a housing 20 for an explosion resistant limit switch is shown. The housing 20 is preferably formed of cast metal to have walls of considerable thickness surrounding an internal cavity 21 which is closed by a cover 22. Positioned in tandem within the cavity 21 are a pair of snap acting switches 23 and 24.

The switches 23 and 24, which per se do not constitute a feature of the present invention, are preferably identical and are respectively secured to a bottom wall 21a of the cavity 21 by screws 23a and 24a. The switches 23 and 24 each have an actuator 23b and 24b which faces a top or end wall 21b of the cavity 21. The actuators 23b and 24b, as is conventional with the type of switches herein used, are each preferably biased toward the end wall 21b by suitable spring means within the switch casing and are arranged to move internal switching contacts in response to movements of the actuators 23b and 24b for making and breaking circuits between a plurality of terminals which are designated as 25.

The housing 20, which acts as a base, has a rear wall 26 which is arranged to secure the housing 20 to a support, not shown, by a pair of screws which pass through bores 27 located at opposite diagonal corners of the housing 20. Preferably portions of the housing 20 wherein the bores 27 are located are counterbored to provide clearance for the heads of the screws when the housing 20 is secured to the support.

The cavity 21 has a bottom wall 21c wherein a threaded opening 28 is formed to extend from the exterior of the housing 20 to the cavity 21. The threaded opening 28 is provided to secure a conventional threaded coupling, not shown, which secures an electrical conduit through which electrical conductors are passed from the exterior of the housing 20 into the cavity 21 where they are connected to terminals 25.

The cavity 21 is closed by the cover 22 which is secured to the housing 20 by screws, not shown, which are threaded into threaded bores 29 which are located at the four corners of the cavity 21, as in FIG. 1.

An outer top and exterior wall 30 of the housing 20 has a square shaped recess 31 preferably centered therein. Centered within the square shaped recess 31 is a circular recess 32 which is sized to expose a portion of a bottom wall 31a of recess 31 around its entire circumference. Centered within the circular recess 32 is a second circular recess 33 which is sized to expose a portion of a bottom wall 32a of recess 32 around its entire circumference. Centered within the recess 33 and extending through the material of housing 20 into the cavity 21 is a bore 34. The bore 34 has a diameter sized to expose a portion of a bottom wall 33a of the recess 33 around its entire circumference. The bore 34 is provided with a smooth ground surface so a plunger 35 may be axially moved therein with a minimum tolerance fit. Preferably, the diameter and length of the bore 34 are considerable and selected to comply with the accepted standards set down by the Underwriters Laboratories for enclosures which are to be used in hazardous environments. The bore herein shown has a diameter of $\frac{3}{8}$ inch and a length

of one inch and the clearance between the outer surface of the plunger 35 and the inner walls of bore 34 is 0.003 inch.

The plunger 35, which is received in bore 34, has a circular flange 35a formed adjacent an end 35b of the plunger 35 which is disposed at the end wall 30 of the housing 20. The flange 35a has a diameter smaller than the diameter of recess 33 and has a bottom surface 35c arranged to engage the surface 33a to thereby limit the movement of the plunger 35 toward the cavity 21. The end 35b of plunger 35 has a socket 35f formed therein. Similarly, the opposite end 35d of plunger 35 which extends into cavity 21 when the surfaces 35c and 33a engage each other has a socket 35e formed therein. A slider mechanism comprising parts 36 and 37 is positioned within cavity 21. The part 36 has a flat front face 36a which engages the end wall 21b of the cavity 21. Projecting outwardly of the front face 36a is a projection 36b which is received in the socket 35e for maintaining the plunger 35 and part 36 in alignment. Projecting from a rear face 36c of part 36 is a projection 36d which is received in a groove in the switch 23 for guiding the part 36 when the part 36 is moved by the plunger 35. Projecting downwardly from projection 36d on the rear face 36c of the part 36 is a raised boss 36e which is located to engage the actuator 23b of switch 23.

The part 37 has a portion 37a arranged to engage the rear face 36c and a portion 37b passing below the switch 23 with clearance. The portion 37b extends to a portion 37c which is formed to extend upwardly so as to have an end aligned with the actuator 24b of the switch 24.

It will be seen from the foregoing that movement of the plunger 35 in a direction toward the cavity 21 will cause the parts 36 and 37 to move toward switches 23 and 24. The boss 36e of part 36 which engages the actuator 23b thus moves the actuator 23b to actuate the switch 23. Similarly, the portion 37c causes movement of actuator 24b to actuate the switch 24.

It is well known that variations in manufacturing tolerances and the characteristics of snap switches may prevent the switches 23 and 24 from being simultaneously actuated in response to the movement of the parts 36 and 37. Alternately, under other conditions, it may be desirable to have the switches 23 and 24 operate sequentially in response to the movement of the parts 36 and 37. To accomplish the foregoing, the portion 37c is provided with an adjustment means which includes a cam 38 which is rotatable on the portion 37c. The cam 38 is generally cylindrical and has a central opening located to pass a rivet for securing a flat rear face to the portion 37c in a position so only a portion of a front face 38a of the cam 38 engages the actuator 24b. The front face 38a is shaped to provide a circular inclined ramp which faces actuator and is arranged so only a portion engages the actuator 24b. The rivet which secures the cam 38 to the portion 37c is arranged to normally maintain the cam 38 against rotation on the portion 37c but to permit the cam to be manually rotated. Thus, as the cam 38 is rotated the area of engagement between the inclined ramp on the front face 38a and the actuator 24b may be varied to change the effective operating length of the part 37 so the switches 23 and 24 can be made to operate either simultaneously or sequentially in response to movements of the plunger 35.

As seen in FIGS. 1—3, each of the sides at the end wall 30 are bevelled as indicated by the numeral 39 which bevels 39 extend from the periphery of the square recess 31 to the external side walls of the housing 20. The bevels 39 provide a transition between the side walls and an adapter 40 which has portions positioned in the recesses 31 and 32. The adapter 40 has a bottom wall or surface 40a shown in FIG. 4 and a top wall or surface 40b, shown in FIG. 5.

The outline of the bottom surface 40a is square shaped and sized to be received in the square shaped recess 31.

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Centrally located on the bottom surface 40a and projecting downwardly therefrom is a circular boss 40c which has a diameter sized so the boss 40c is receivable in a circular recess 32. Preferably, the surfaces are arranged so the surface 40a engages the bottom wall 31a of recess 31 when the adapter 40 is positioned on the wall 30 while a surface 40d on the boss 40c is spaced with a minimum clearance from the bottom wall 32a of the recess 32.

As shown in FIG. 5, the top wall 40b, which is square shaped, is provided with a central opening 41 and four quadrately located openings 42, 43, 44 and 45, all of which extend between the top wall 40b and the bottom surface 40d. The openings 42-45 are located equidistantly from the center of the opening 41 at the corners of an imaginary square which has its diagonals passing through the center of the opening 41.

Centrally located on the top wall 40b is a raised circular boss 46 which is centered at the center of the opening 41 and has a diameter sufficient to expose a flat surface 40a' of the top wall 40b between the periphery of the boss 46 and raised ribs 47 which extend upwardly from the four side edges of the top wall 40b.

Extending upwardly from each of the four corners of the top wall 40b and projecting beyond the top surface of the ribs 47 is a raised boss-like portion 48. Each of the bosses 48 are identical and are generally square-shaped, having a bore 49 downwardly extending from the center of its top surface in alignment with threaded bores 31b in the top surface of housing 20. Each of the bosses 48 are provided with an arcuate side wall 50 having a curvature defined by an arc centered in the center of the opening 41 to expose the surface 40a' of the top wall 40b between each of the bosses 48 and the periphery of the circular boss 46.

Extending downwardly from the top surface of the circular boss 46 is an irregularly shaped recess 51 which is generally square in shape. For purposes of description, as shown in FIG. 5, the recess 51 will be said to have vertical wall portions 52 which constitute the remaining portions of an imaginary square recess which has its diagonals intersecting at the center of the opening 41 and its sides tangent to the portions of the openings 42-45 remote from the center of the opening 41. For further purposes of description, the recess 51 may be described as having a rectangular recess 53 at each of its four corners. As each of the recesses 53 are identical and face in opposite directions at the opposite diagonal corners of the recess 51, only the recess 53 in the lower left corner of FIG. 5 will be supplied with identification numerals. The recess 53 has walls 54 and 55 intersecting at right angles to provide corners 56. Each of the corners 56 of all of the recesses 53 are equidistantly spaced from the periphery of the boss 46. The recesses also have portions of walls 57 and 58 which are arranged so the center of an imaginary diagonal of the recess 53 does not coincide with the center of the openings 42-45. To accomplish the foregoing, the walls 54 and 58 are equidistantly spaced on opposite sides of the horizontal axis through the opening 45 while the walls 55 and 57 are arranged so the wall 55 is at a greater distance from the vertical axis through the opening 45 than wall 57.

The openings 42-45 each are arranged to receive a shank of a headed plunger which will be designated by a numeral 42-45 and a suffix p to indicate the particular opening 42-45 wherein the plunger is installed. The designation 42p indicates the plunger in the opening 42 43p indicates the plunger in the opening 43, etc.

Each of the plungers has a shank portion 59 and a head portion 60. The shank portion 59 is received in the openings 42-45 which act as guides for reciprocal movement of the plungers 42p-45p. The head portions 60 of the respective plungers are received in the recesses 53 which are arranged so the plungers 42p-45p are oriented in a predetermined manner and are movable in the recesses

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53. This is accomplished by locating the head portion 60 on the shank portion 59 so the side walls 61 and 62 on the head portion will be juxtaposed to the walls 54 and 58 of the recess 53 and the end walls 63 and 64 will be respectively juxtaposed to the end walls 55 and 57. Each of the head portions have an upper or top surface which is shaped to provide an upstanding wall 65 which has an inclined camming surface 66 and an inclined clearance surface 67, which are joined at an apex 68. The shape of the camming surface 66, the clearance surface 67 and the position of the apex 68 may be slightly varied to change the responsive operation of the plungers 42p-45p to an external operator which will be later described. The surfaces 66 and 67 and the apex 68 are arranged on the wall 65 so the camming surface extends from the wall 54 toward the wall 58 and the clearance surface extends from the apex 68 toward the wall 58 in each of the recesses 53. Additionally, the top surface of each head portion 60 is provided with portions 69 and 70 provided as inclined surfaces which extend downwardly from the wall 65 to provide clearance for an operator when the plungers are in an inactive position, as will be hereinafter described.

While the adapter 40 will accept a variety of forms of external operator mechanisms 71, one form shown in detail in FIGS. 6-8 is disclosed and claimed in an application for United States Patent, Serial No. 372,854, assigned to the assignee of the present invention, filed June 5, 1964 which has been assigned by the inventors Rudolf H. Kiessling and Carl A. Schaefer to the assignee of the present invention. In the preferred form, each of the external operator mechanisms which is used with the adapter 40 and housing 20 is provided with an external housing 72 which has a square-shaped bottom surface 73 complementary in shape and size to the top surface 40b of the adapter 40. The complementary shape of the surface 73 is accomplished by providing a recess 74 in each of the corners of the surface 73 which are complementary in size and shape with the bosses 48.

Further, the bottom surface is provided with a central circular opening 75. The opening 75 is centered in the square-shaped bottom surface 73 and extends into an internal cavity 76 within the housing 72. The opening 75 has a diameter slightly larger than the diameter of the circular boss 46 and thus together with the recesses 74 effectively provides a raised rib 77 adjacent each of the corners and a raised boss 78 between the adjacent recesses 74. If required, the ribs 77 and the bosses 78 may be used to compress a sealing gasket, not shown, into sealing engagement with the surfaces 40a' of the top surface 40b of adapter 40 when the operator mechanism 71 is secured to the top surface 40b.

The housing 72 has an externally projecting hub 79 projecting from one side. The hub 79 has a bore 80 extending from a flat end 81 of the hub 79 into the cavity 76. The bore 80 is axially aligned with a bore 82 which extends from the cavity 76 partly into the side wall of the housing 72 opposite to the wall wherein the bore 80 is formed. The bores 80 and 82 provide bearing supports for a shaft 83 which has one end journaled in the bore 82 and its other end extending through the bore 80 external of the housing 72. If desired, the shaft 83 may be provided with a flange 84 which engages the end wall 81 and a groove to receive a snap ring 85 which flange 84 and ring 85 serve to maintain the shaft 83 and the housing 72 assembled. Further if desired, the external end of the shaft 83 may be knurled to provide a means for nonrotatably securing an external operator, such as an arm 86.

The portion of the shaft 83 within the cavity 76 is cut away to provide a flat surface 87 having edges 88 and 89. Rotatably carried on the portion of the shaft 83 within the cavity 76 are two identical cam members 90 and 91 which face in opposite directions and are interconnected by a

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torsion spring 93. The members 90 and 91 each have a bore 94 to provide a bearing support for the members 90 and 91 on shaft 83. For identification purposes, in FIG. 8 the parts of the member 91 are shown in full lines and the portions of the member 90 in broken lines. Extending inwardly in each bore 94 is a rib-like lug 95 which has surfaces 96 and 97 at right angles to each other. The lugs 95 and the flattened surface 87 are arranged so the surfaces 96 and 97 will engage the edges 88 and 89 to limit rotation of the members to 90° on the shaft 83. Extending outwardly from an end 98 of the members 90 and 91 is a lug 99 which provides a seat for an end of the torsion spring 93. The torsion spring 93 has its intermediate portion surrounding the body portion of the members 90 and 91 and its opposite ends in engagement with the lugs 99 and is arranged to constantly urge the members 90 and 91 in opposite directions of rotation on the shaft 83 to a position wherein the surface 96 on the member 91 engages the edge 88 and the surface 96 on the member 90 engages the edge 89. Extending outwardly from the ends 98 on the members 90 and 91 are stop surfaces 100. The surfaces 100 on the respective members 90 and 91 are preferably parallel to the surfaces 96 on the respective members 90 and 91 and extend tangentially outwardly of the cylindrical surface portion 101 in a direction as shown in FIG. 8 with the ribs for the surfaces 96 on the members 90 and 91 located on the same side of a center line 102 as the stop surfaces 100. Projecting from the bottom wall of the cavity 76 at opposite ends of the cavity 76 are stops 103 and 104. The stops 103 and 104 on the housing 72 and the stop surfaces on the members 90 and 91 are arranged so that the stop surface 100 on the member 90 is in engagement with the stop 103 and the stop surface 100 on the member 91 is in engagement with the stop 104 when the shaft 83 and the members 90 and 91 are positioned as shown in FIG. 8.

The stop surfaces 100 extend outwardly of the center line 102 and terminate at a junction with a cam surface 105 formed by a portion of a cylindrical surface having a radius centered at the center of the bores 94. The cam surfaces 105 terminate at a cam edge 106 located approximately along a radius passing from the center of the bore 94 through the apex of the rib-like lug 95. In this connection it should be noted that the leading edge 107 of the lugs 99 are located at a radial angle slightly greater than 90° from the cam edge 106.

The operation of the parts of the external operator mechanism 71 will now be set forth, reference being had to FIG. 8 of the drawing. When the parts of the mechanism are at rest, the torsion spring 93 urges the cam member 91, shown in full lines in FIG. 8, in a counterclockwise direction to a position wherein the stop surface 100 on the member 91 engages the stop 104 and the cam member 90, shown in broken lines, clockwise to a position wherein the stop surface 100 on the member 90 engages the stop 103. When the members 90 and 91 are thus positioned, the surfaces 96 on the members 90 and 91 will respectively engage the edges 88 and 89 thereby maintaining the shaft 83 in its centered position.

Also in FIG. 8, the plungers 42p-45p which are actuated by the cam members 90 and 91 in response to the direction of rotation of shaft 83 are shown. The plungers will be designated as XP and YP with the XP plunger shown in full lines as positioned for actuation by the cam member 91 and the plunger YP shown in broken lines as positioned for actuation by the cam member 90. The plungers XP and YP each have their respective inclined cam surfaces 66, inclined clearance surfaces 67, apexes 68 and shank portions 59 designated as previously described.

When an external force is applied to cause rotation of shaft 83 in a clockwise direction in FIG. 8, the edge 88 on the shaft 83 will press against the surface 96 on the member 91 and thereby cause the member 91 to rotate in

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a clockwise direction. As the member 91 initially rotates clockwise, the camming edge 106 on the member 91 will slide on the inclined cam surface 66 on the plunger XP to thereby cause the plunger XP to move downwardly. After the member 91 has rotated clockwise a few degrees of rotation, the apex 68 on the plunger XP passes into engagement with the cylindrical cam surface 105 on the member 91 and the downward movement of the plunger XP ceases and the inclined clearance surface 67 on the plunger XP engages the surface 105 on the member 91. The shaft 83 is prevented from rotating further than 90° in a clockwise direction from its initial position by a pair of stop means. One of the stop means is provided by the lug 99 on the member 91 which is located to engage the stop 104 at 90° of rotation of the member 91. The other stop means is provided when the edge 88 on the shaft 83 moves into engagement with the surface 97 on the member 90, as will now be explained. It will be seen that as the shaft 83 rotates clockwise, the edge 89 of the shaft 83 will move from its engagement with the surface 96 on the member 90 so that while the shaft 83 is rotated clockwise, the member 90 will not be caused to rotate and the stop surface 100 on the member 90 will remain in engagement with the stop 103 because of the force exerted by the torsion spring 93. However, when the shaft 83 is rotated 90° clockwise from its initial position, the edge 88 on the shaft 83 will be rotated to engage the surface 97 on the member 90 which is held against clockwise rotation by the engagement of its stop surface 100 with the stop 103. Thus the member 90 will prevent clockwise rotation of the shaft beyond 90° from the initial at-rest position of the parts of the operation mechanism 71.

When the force causing a clockwise rotation of the shaft 83 is released, the shaft 83 and the member 91 will be returned to the neutral or initial position by the torsion spring 93. This result is accomplished because the member 90 was prevented from rotating clockwise and the torsion spring 93 was tightened during the clockwise rotation of the member 91. Thus as the end of the torsion spring 93 which is attached to the member 90 was relatively fixed during the clockwise rotation of the member 91, release of the force causing a clockwise rotation of the member 91 will permit the torsion spring 93 to rotate the member 91 in a counterclockwise direction to the neutral position wherein the stop 100 on the member 91 engages the stop 104 on the housing 72.

When an external force is applied to cause rotation of the shaft 83 in a counterclockwise direction in FIG. 8, the edge 89 on the shaft 83 will press against the surface 96 on the member 90 and thereby cause the member 90 to rotate in a counterclockwise direction. As the member 90 initially rotates counterclockwise, the camming edge 106 on the member 90 will slide on the inclined cam surface 66 on the plunger YP to thereby cause the plunger YP to move downwardly. After the member 90 has rotated counterclockwise a few degrees, the apex 68 on the plunger YP passes into engagement with the cylindrical cam surface 105 of the member 90 and the downward movement of the plunger XP ceases and the inclined clearance surface 67 on the plunger YP engages the surface 105 on the member 90. The shaft 83 is prevented from rotating further than 90° in a counterclockwise direction from its initial position by a pair of stop means. One of the stop means is provided by the lug 99 on the member 90 which is located to engage the stop 103 at 90° of rotation of the member 90. The other stop means is provided when the edge 89 on the shaft 83 moves into engagement with the surface 97 on the member 91, as will now be explained. It will be seen that as the shaft 83 rotates counterclockwise, the edge 88 of the shaft 83 will move from its engagement with the surface 96 on the member 91 so that while the shaft 83 is rotated counterclockwise, the member 91 will not be caused to rotate and the stop surface 100 on the member 91 will remain in engagement with the stop 104 because of the force

exerted by the torsion spring 93. However, when the shaft 83 is rotated 90° counterclockwise from its initial position, the edge 89 on the shaft 83 will be rotated to engage the surface 97 on the member 91 which is held against counterclockwise rotation by the engagement of its stop surface 100 with the stop 104. Thus the member 91 will prevent counterclockwise rotation of the shaft 83 beyond 90° from the initial at-rest position of the parts of the operation mechanism, 71.

When the force causing a counterclockwise rotation of the shaft 83 is released, the shaft 83 and the member 90 will be returned to the neutral or initial position by the torsion spring 93. This result is accomplished because the member 91 was prevented from rotating counterclockwise and the torsion spring 93 was tightened during the counterclockwise rotation of the member 90. Thus as the end of the torsion spring 93 which is attached to the member 91 was relatively fixed during the counterclockwise rotation of the member 90, release of the force causing the counterclockwise rotation of the member 90 will permit the torsion spring 93 to rotate the member 90 in a clockwise direction to the neutral position wherein the stop 100 on the member 90 engages the stop 103 on the housing 72.

The external operator 71 and the adapter 40 are secured to the top wall 30 of the housing 20 by screws 108 which are passed through openings 109 in the respective corners of the housing 72 and bores 49 in the adapter into threaded bores 31b in the housing 20. The opening 109, bore 49 and bores 31b are aligned with one another when the operator 71 is positioned in any one of four positions on the adapter 40 and the adapter 40 is positioned in the recess 31.

When the operator 71 and adapter 40 are thus positioned on the housing 20, a secure nonrotatable connection is established between the secured parts. This connection is achieved by the square shape of the adapter which fits within the square shaped recess 31 and the bosses 48 and recess 74 at each of the corners of the adapter 40 and housing 72. The nonrotatable connection is thus achieved independently of any aid from the screws 108 which merely maintain the operator 71, adapter 40 and housing 20 assembled.

When the housing 71 and the adapter 40 are secured in position on the housing 20, the end portions 59a of the shanks portions 59 of the plungers 42p-45p are positioned to engage the flange 35a of the plunger 35 because of the location of openings 42-45 which act as guides for the plungers 42p-45p and the diameter of the flange 35a which is greater than the distance of the center of openings 42-45 from the center of opening 41. As previously stated, the bias on actuators 23b and 24b of switches 23 and 24 continuously urges the sliders 36 and 37 toward the wall 21b of cavity 21. The sliders 36 and 37 thus continuously urge the plunger 35 outwardly of the cavity 21 so that the flange 35a continuously urges the plungers 42p-45p toward the parts of external operator 71. Further, when the adapter 40 is positioned on housing 20, the opening 41 receives the end 35b of plunger 35 to further guide the plunger in its movements when the plunger 35 is moved by plungers 42p-45p, as will now be described.

Two or more of the plungers 42p-45p are installed in the openings 42-45 to provide different operations of the switching mechanism in response to movements of the operator mechanism 71. As was previously explained, a force on the operator arm 86 will cause the shaft 83 of the external operator mechanism 71 to rotate in either a clockwise or counterclockwise direction to actuate either of the cam member 90 or 91 which in turn will actuate one of the plungers 42p-45p. The limit switch according to the present invention can be made to operate in response to a clockwise movement, a counterclockwise movement or respond to both clockwise and counterclockwise movements of the arm 86 by properly locating the plungers 42p-45p for the various rotative positions of the oper-

ator mechanism 71 on the top wall of the housing 20. When the operator mechanism 71 is positioned as respectively having the shaft 83 extending from the front wall, the left side wall, the rear wall and the right side wall and wherein clockwise and counterclockwise refers to operation obtained when viewing the end of the shaft 83. Further it will be seen that when the limit switch is to be responsive to rotation of the shaft 83 in only one direction at least one plunger must be removed and when the limit switch is to be responsive to two directions of rotation of the shaft, all of the plungers 42p-45p, may be included in all of the openings 42-45, although only two of the plungers at the opposite corners of one diagonal will be active and the other two plungers at the opposite corners of the other diagonal will act as spares. This result is obtained because the camming edge 106 passes with clearance over the surfaces 69 and 70 of the plungers which act as spares. It is believed the following tabulations will illustrate the foregoing, wherein CW refers to clockwise rotation of shaft 83 and CCW refers to counterclockwise rotation for the indicated positions of the operating mechanism 71 on housing 20.

	Operation	Plunger in Opening	
		Active	Omitted
Front-----	CW-----	42	44
	CCW-----	44	42
	CW & CCW-----	42, 44	
Left-----	CW-----	43	45
	CCW-----	45	43
	CW & CCW-----	43, 45	
Rear-----	CW-----	44	42
	CCW-----	42	44
	CW & CCW-----	42, 44	
Right-----	CW-----	45	43
	CCW-----	43	45
	CW & CCW-----	43, 45	

Another modification contemplated by the switch structure shown and described is the use of an external operator mechanism similar to the external operator mechanism 71 described which will not depend upon the operation of the plungers 42p-45p, but which will impart movement to the plunger 35 by engaging the end 35b of the plunger 35 to move the sliders 36 and 37 with the cavity 21. An operator mechanism for accomplishing this result is disclosed in United States application Serial No. 381,737, filed July 10, 1964, which has been assigned by the inventor Thomas Parris, Jr., to the assignee of the present invention. In this connection an additional operator mechanism which may be used to actuate the plungers 42p-45p in a manner clearly apparent is disclosed in an application for United States patent Serial No. 381,738, filed July 10, 1964, which has also been assigned by the inventor Thomas Parris, Jr. to the assignee of the present invention.

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 the broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. An explosion resistant limit switch comprising: a housing having an internal cavity, a switch mounted in the cavity, said switch having an actuator extending toward one end of the housing, a recess in said end, a bore extending from said recess into the cavity, a plunger slidably received in the bore, said plunger having first end portion engaging the actuator and a second end portion within the recess, an adapter having a portion received in the recess and an opening exposing at least a portion of said second end of the plunger, an external operator for the limit switch nonrotatably mounted in any one of a plurality of selected positions on the adapter and having a movable external operating member and means in-

cluding a pin movable in the opening in the adapter having a portion engaging the second end of the plunger for moving the plunger in response to movements of the operating member.

2. An explosion resistant limit switch comprising: a housing having an internal cavity, a switch mounted in the cavity, said switch having an actuator extending toward one end of the housing, a square shaped recess in said end, a circular recess centrally located in the square shaped recess, a bore extending centrally from said circular recess to the cavity, a plunger slideably received in the bore, said plunger having a first end portion engaging the actuator and a flanged end portion within the circular recess, an adapter having portions received in the circular and square shaped recesses and an opening for exposing at least a portion of the flanged end of the plunger, an external operator for the limit switch nonrotatably mounted in any one of a plurality of selected positions on the adapter and having an external operating member and means including a pin movable in the opening in the adapter engaging the flanged end of the plunger for moving the plunger in response to movements of the operating member.

3. An explosion resistant limit switch comprising: a housing having an internal cavity, a switch mounted in the cavity, said switch having an actuator extending toward one end of the housing, a recess having a square shaped portion in said end, a bore extending from said recess into the cavity, a plunger slideably received in the bore, said plunger having a first end portion engaging the actuator and a second end portion within the recess, a square shaped adapter having a portion on one side received in the recess, a raised boss on each corner of a square shaped side opposite said one side, and an opening extending between said one and said opposite sides exposing at least a portion of said second end of the plunger, an external operator for the limit switch mounted on the adapter, said operator having a square shaped face with recesses at each corner receiving the bosses on the adapter for nonrotatably mounting the operator in any one of a plurality of positions on the adapter when the operator is mounted on the adapter and an externally operated member and means operating in the opening in the adapter engaging the flanged end portion of the plunger for moving the plunger in response to movements of the externally operated member.

4. In an explosion resistant limit switch, the combination comprising: a housing having an internal cavity containing switching units for the limit switch, an adapter non-rotatably mounted on an end of the housing, a selected one of a plurality of different type external operators nonrotatably mounted on the adapter in any one of a plurality of angular positions relative to said end of the housing, each of said operators having an externally operated member, and means including a plurality of spaced bores in the adapter and a plunger carried by the housing and having a flanged end aligned with the bores for transmitting movement of the member to the switching units in the cavity.

5. In an explosion resistant limit switch, the combination comprising: a housing having an internal cavity containing switching units for the limit switch, an adapter non-rotatably mounted on an end of the housing, a selected one of a plurality of different type external operators nonrotatably mounted on the adapter in any one of a plurality of angular positions relative to said end of the housing, each of said operators having a movable member and means including a plurality of spaced bores in the adapter, a plunger carried by the housing and

having a flanged end aligned with the bores and at least one plunger member movable in the bores for transmitting movement of the movable member to the switching units in the cavity.

6. In an explosion resistant limit switch, the combination comprising: a housing having an internal cavity, a switching unit mounted in the cavity having an actuator extending toward one end of the housing, an external recess in said end of the housing, a counterbore centered in the recess and extending toward the cavity, a bore centered in the counterbore and extending to the cavity, a movable plunger slideable in the bore having a pair of opposite ends with one of said ends being exposed to the cavity and the other of said ends being exposed to the recess, said other end of the plunger having a flange thereon positioned in the counterbore, means including a slider in the cavity having portions engaging the exposed said one end of the plunger and the actuator of the switch for actuating the switch in response to movement of the plunger, an external operator including a housing having a bottom face and a member extending externally of the operator housing, an adapter having a top surface and a bottom surface respectively engaged by the bottom face of the operator and the end of the housing providing a nonrotatable connection between the operator and housing, said bottom surface being sized to be received in the recess and having a circular boss centrally formed thereon sized to be received in the counterbore, a generally square shaped recess in the top surface, an opening centrally located in the square shaped recess and an opening located adjacent each of the corners of the square shaped recess with the centrally located opening and the openings at the corners extending between the top and bottom surfaces in alignment with portions of the plunger including the flange on the plunger, cooperating bosses and recesses at each of the corners of the top surface of the adapter and the bottom face of the operator providing the nonrotatable connection when the operator is in any one of a plurality of positions relative to the end of the housing and means including a member having a portion extending through at least one of the openings in the adapter for transmitting movement of the operator member to the plunger.

7. The combination as recited in claim 6 wherein the recess in the end of the housing is square shaped and the top and the bottom surfaces of the adapter are square shaped.

8. The combination as recited in claim 6 wherein a pair of switching units are mounted in tandem in the cavity and each switching unit has an actuator extending toward the said one end.

9. The combination as recited in claim 8 wherein the slider means has portions engaging the actuators of both switches for actuating the switches in response to movement of the plunger.

10. The combination as recited in claim 6 wherein the means for transmitting movement of the operator member to the plunger includes a pair of plungers each having a portion extending through one of the openings at the corners in the adapter.

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