Feb. 20, 1968 C. P. VINOT 3,370,138

THREE POSITION LIMIT SWITCH

Filed Oct. 13, 1965 3 Sheets-Sheet 1

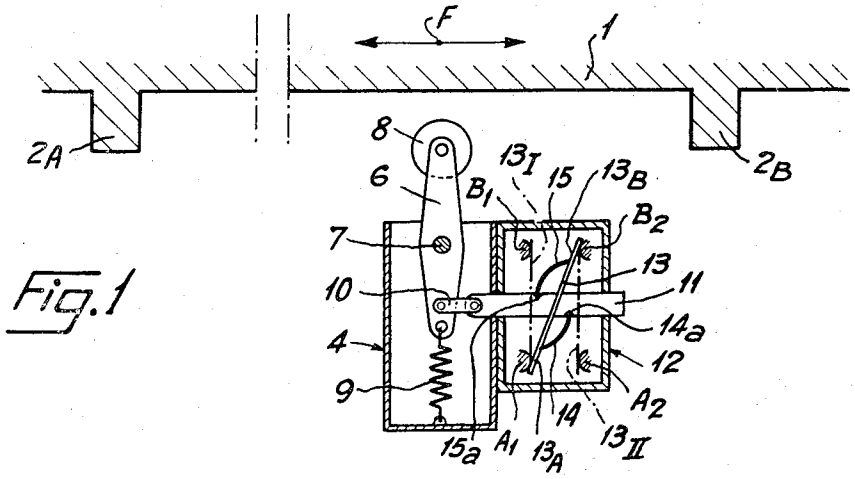

Fig. 1

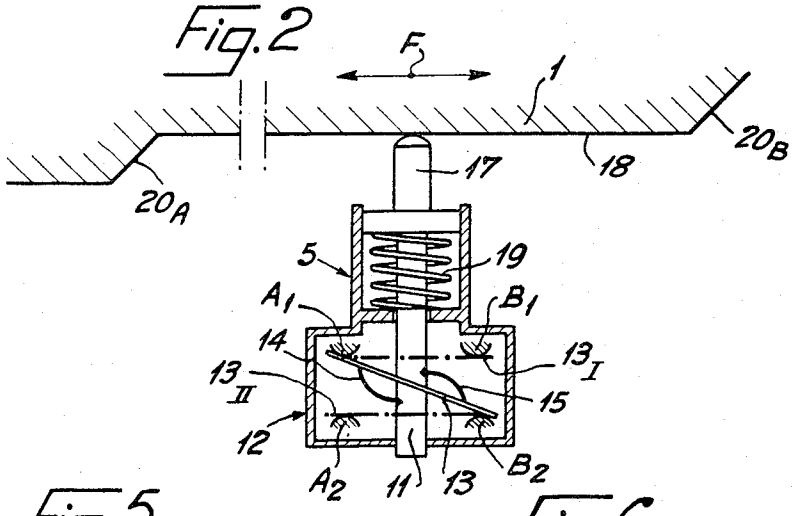

Fig. 2

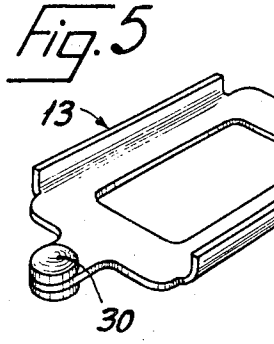

Fig. 5

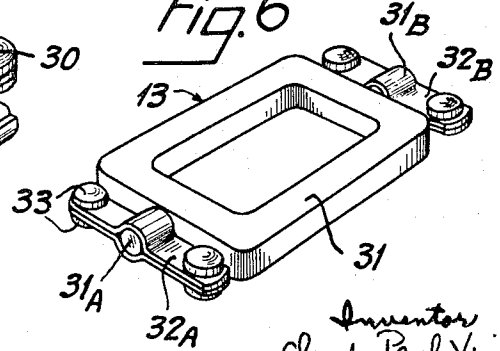

Fig. 6

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Feb. 20, 1968 C. P. VINOT 3,370,138

THREE POSITION LIMIT SWITCH

Filed Oct. 13, 1965 3 Sheets-Sheet 2

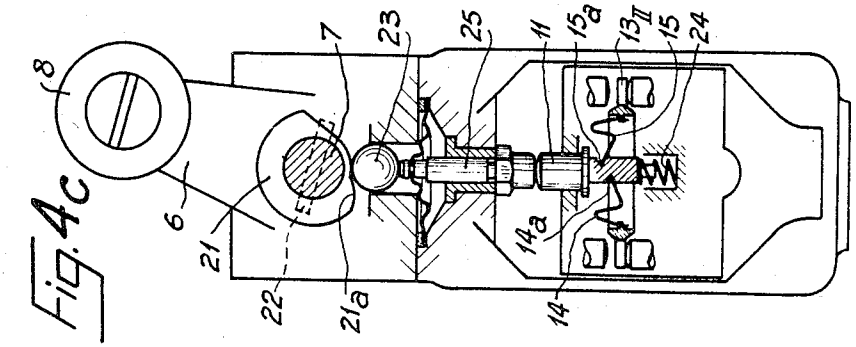

Fig. 4c

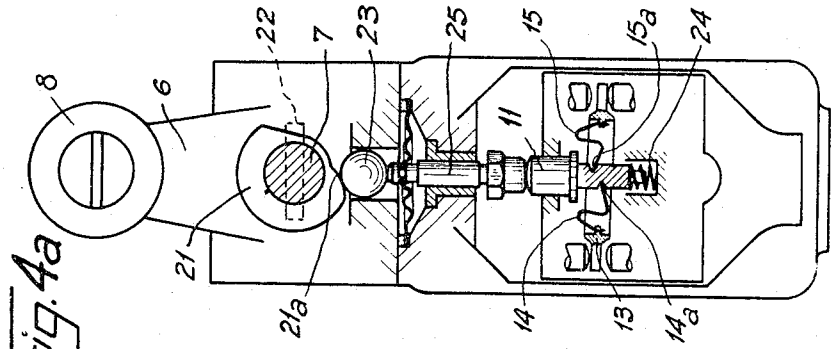

Fig. 4a

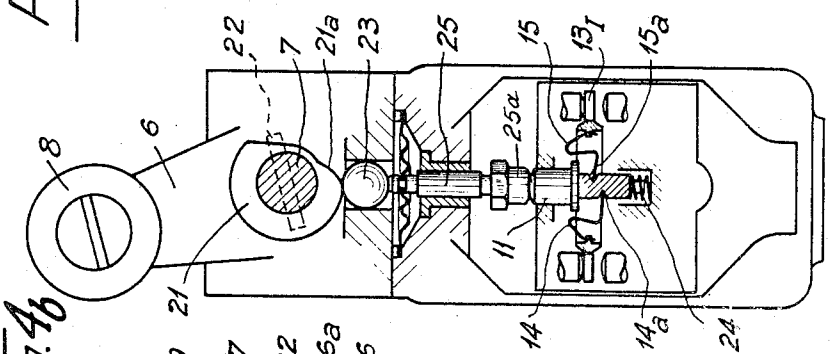

Fig. 4b

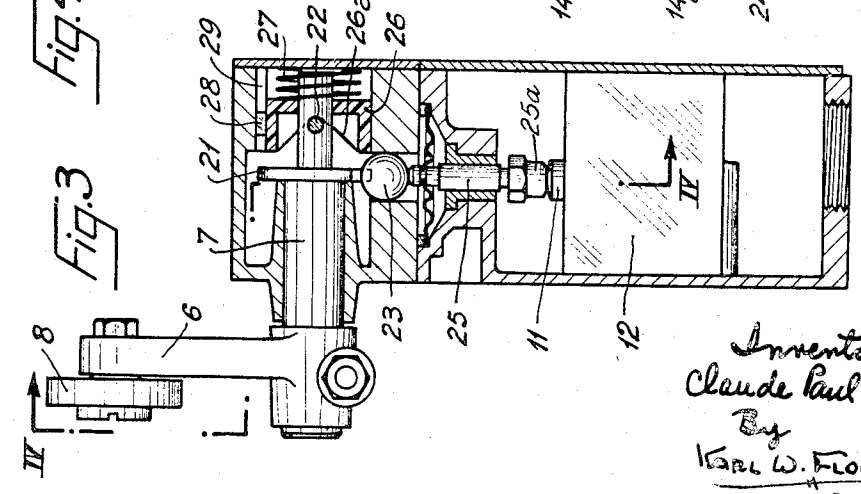

Fig. 3

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THREE POSITION LIMIT SWITCH

Filed Oct. 13, 1965 3 Sheets-Sheet 3

Fig. 7b

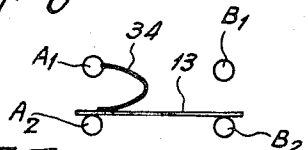


Fig. 7a

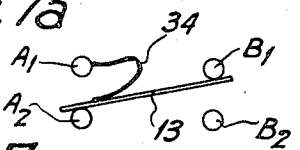


Fig. 7c

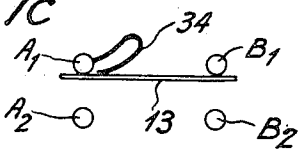


Fig. 8

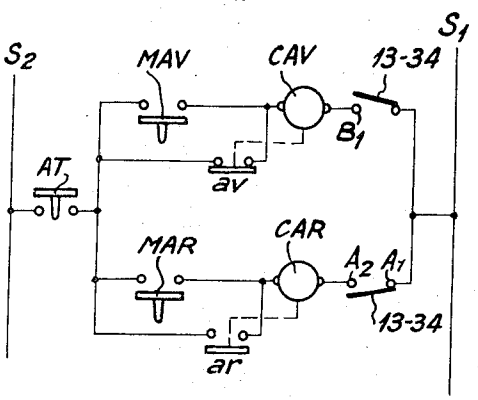


Fig. 9b

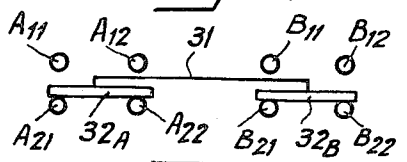


Fig. 9a

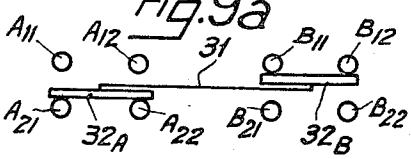


Fig. 9c

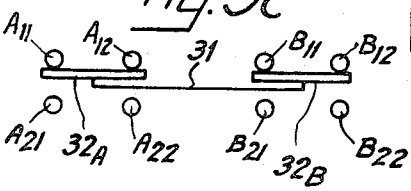
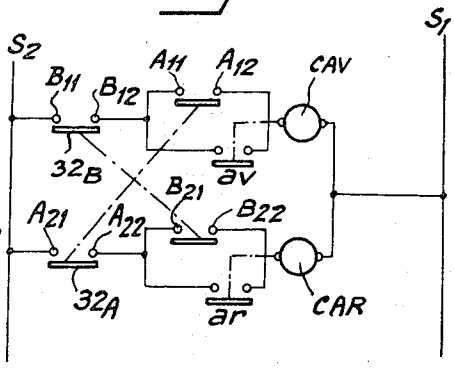


Fig. 10



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3,370,138

THREE POSITION LIMIT SWITCH

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Filed Oct. 13, 1965, Ser. No. 495,593
Claims priority, application France, Nov. 6, 1964, 994,228
2 Claims. (Cl. 200—47)

ABSTRACT OF THE DISCLOSURE

A three position limit switch with a snap-acting type of contact carrying member disymmetrically solicited by its springs so that the contact carrying member may occupy a stable diagonal position between its end contacts. The contact carrying member is kept in a stable diagonal position owing to accurate centering of its spring urged actuator, so that said member rocks in one direction towards one of the end positions for a displacement of the actuator in one direction, and conversely, rocks in the other directions towards the other end position for reverse displacement of the actuator.

This invention relates to electromechanical arrangements embodying relatively movable parts and electric switch contacts interposed in the path of relative motion of said parts so as to be actuated from one to another switching position as said parts assume predetermined relative positions along said path of motion.

Arrangements of this kind are widely used in various fields of engineering, especially for automatic and semi-automatic control purposes. One important type of application of such an arrangement has to do with the reciprocation of a mechanical part, for instance a machine-tool slide, which is to reverse its direction of displacement at each end of its path of travel. A limit switch assembly can then be provided at a stationary position alongside the path of reciprocation of the part, for actuation by limit stops or cams projecting from the part. In other types of application, one or more such switch assemblies may be associated in a similar manner with a moving part for actuation by stops or camming means projecting from the part at one or more points of its path of travel as for synchronizing the motion of said part with various control functions in a complex automatic or semi-automatic electromechanical control system.

It is an object of this invention to provide improved electromechanical switching arrangements of this general type, which will operate more simply, efficiently and reliably than conventional such arrangements.

In French Patent No. 1,328,440 granted the assignees of the present application, there was disclosed a quick-acting switch or microswitch device which is three-positional in character. The device includes a movable contact-carrying member in the form of a generally rectangular recessed, conductive frame member carrying electric contacts at its ends. Two pairs of stationary contacts are further provided in the device, disposed in a quadrangular arrangement on opposite sides of the frame whereby the frame can assume either of two end positions in which the movable contacts carried on a related side of the frame and at both ends thereof are simultaneously engaging respective stationary contacts of a related one of said pairs, as well as assuming an intermediate position in which the frame is disposed obliquely, with a contact on one of its sides at one of its ends engaging a stationary contact of one pair and a contact on its other side at its other end engaging a stationary contact of the other pair.

For displacing the frame between its three positions there is provided an axially displaceable actuator rod extending through the recess in the frame, and a pair of arcuate toggle springs having outer ends attached to the ends of the frame and inner ends attached to axially spaced points of the actuator rod. As a result of this arrangement, a continuous axial displacement of the actuator rod will cause a discontinuous, snap-action displacement of the frame from one end position to its intermediate position then to its other end position.

In U.S. application Ser. No. 483,264, filed Aug. 27, 1965, by A. G. Faffart, now abandoned, and assigned the assignees of the present application, a modification of the above three-positional switch is disclosed, wherein the frame member is insulating rather than conductive and carries conductive bridge-like contact members at its ends adapted to cooperate with four pairs of stationary contacts rather than with two pairs of contacts as in the basic device disclosed in the said French patent.

The present invention is based on the realization that three-positional switch devices of the general character disclosed in the aforementioned French patent and copending U.S. application are capable of extremely desirable performance as limit switches and/or synchronizing switches in electromechanical arrangements of the kind referred to at the beginning of this specification, in that the intermediate position of the movable contact-carrying frame member makes available an increased variety of switching combinations unachievable with the two-positional switches heretofore generally used. It is, therefore, an object of this invention to provide electromechanical switching arrangements of the class referred to, embodying three-positional switch devices. Another object is to provide modified three-positional switches adapted for actuation between the three switching conditions thereof by camming means projecting from a mechanical part in relative motion with respect to the switch. Other objects relate to the provision of improved circuitry associated with such three-positional switch devices. Other objects will appear.

In modifying the three-positional switch assemblies of the above-identified French patent and U.S. application for the purposes of the present invention, an unexpected difficulty that had to be overcome has arisen from the need to stabilize the movable frame member in its intermediate position during the relative motion between the switch and the part actuating it. Important aspects of the invention relate to the means used for such stabilizing or centering action.

Exemplary embodiments of the invention will now be described for purposes of illustration but not of limitation with reference to the accompanying drawings, wherein:

FIGURE 1 is a simplified view, mostly in section, illustrating the operating principle of the invention in one form of embodiment;

FIGURE 2 is a similar view illustrating the inventive principle in another embodiment;

FIGURE 3 is a sectional view of a practical construction of improved three-positional limit switch according to this invention;

FIGURE 4*a* is a view on line IV—IV of FIGURE 3, with the movable switch assembly being shown in its intermediate position; and

FIGURES 4*b* and 4*c* are similar views with the movable switch assembly in its respective end positions;

FIGURE 5 is a perspective view, on an enlarged scale, of one form of construction of the movable contact-carrying frame;

FIGURE 6 similarly shows another form of frame construction;

FIGURES 7*a*, *b* and *c* are schematic views of the three switching positions obtained when using a frame according to FIGURE 5;

FIGURE 8 shows a circuit diagram of a typical motor control circuit utilizing a three-positional switch according to the invention embodying a movable frame according to FIGURE 5;

FIGURES 9*a*, *b* and *c* are schematic views of the three switching positions obtained with the use of a frame according to FIGURE 6; and

FIGURE 10 is a circuit diagram of a typical motor control circuit utilizing a three-positional switch according to the invention embodying a movable frame according to FIGURE 6.

The principle of the invention will first be disclosed with reference to the schematic views of FIGURES 1 and 2.

Referring first to FIG. 1, a machine part **1**, such as a slide of a machine-tool, is reciprocable in the directions indicated by the arrows F. A limit switch assembly according to the invention, generally designated **4**, is supported from stationary structure not shown so as to be actuated by the movable part **1** as the latter approaches or reaches either end of its reciprocatory stroke. For this purpose the movable part **1** is shown as having a pair of projecting stops **2A** and **2B** and limit switch assembly **4** has an actuator roller **8** positioned for engagement by said stops.

Roller **8** is journalled at the outer end of a two-armed lever **6** forming a follower pivoted on a pivot **7** mounted in the frame of switch assembly **4**. The inner end of lever **6** is attached to one end of a tension spring **9** having its other end anchored to the frame of assembly **4** so as to bias the lever to the intermediate position shown.

The lever **6** has one end of a small link **10** pivoted to it near the inner end of the lever, and the opposite end of link **10** is attached to one end of a slider rod **11**. Rod **11** is axially slidable through holes formed in the opposite sides of a casing **12** attached to one side of the structure of switch assembly **4**. It will thus be seen that engagement of roller **8** by either one of the limit stops **2A**, **2B** of the machine part **1** will cause lever **6** to rock in one or the other direction about its pivot **7** in opposition to the centering spring **9**, and such rocking of the lever will displace the slider rod **11** in a corresponding axial direction.

The slider rod **11** extends through the inner recess of a generally rectangular frame member **13** (two practical forms of construction of which are respectively shown in FIGS. 5 and 6 to be later described). Frame member **13** is connected to slider rod by way of a pair of arcuate leaf springs **14** and **15** which together constitute a spring toggle linkage whose action will be presently disclosed in detail. As will be apparent from FIG. 1, each leaf spring **14**, **15** has its outer end suitably attached to a related end cross member of the rectangular frame **13**, and its inner end pivoted to a point of slider rod **11**. The points **14***a* and **15***a* of pivotal attachment of the leaf springs **14**, **15** with rod **11** are longitudinally displaced a substantial distance along the length of the rod.

With the slider rod **11** in the intermediate position assumed under the action of centering spring **9** when roller **8** is out of engagement with either of the limit stops **2A**, **2B**, as shown in FIG. 1, the toggle springs **14**, **15** act to hold the frame member **13** in an oblique or diagonal position, as shown in full lines, wherein the lower end **13A** of movable contact frame **13** engages a stationary contact element **A1** and the upper end **13B** of the contact frame engages a contact element **B2**, said contact element **A1** and **B2** being part of a set of four stationary contact elements **A1**, **A2**, **B1**, **B2** suitably supported in stationary position within the microswitch casing **12**. This diagonal position of the contact frame **13** is stably retained so long as the points of spring attachment **14***a*, **15***a* are positioned on opposite sides from the mid-plane of contact frame member **13**.

If slider rod **11** is axially displaced a sufficient amount leftward from its intermediate position, as will occur when stop **2A** acts on roller **8** towards the endmost point of the rightward displacement stroke of movable part **1**, so that the point **14***a* of rod **11** is forced past the mid-plane of frame **13** in the leftward direction, the corresponding leaf spring **14** is rocked suddenly about its inner end **14***a* and carries with it the lower end **13A** of frame **13** in the rightward direction while the upper spring **15** and the upper end **13B** of the frame remain substantially unmoved. The frame **13** thus assumes the position 13_{II} indicated in chain lines, in which the frame **13** is positioned in a plane normal to the rod **11** and its ends engage the fixed contact elements **A2** and **B2**.

Conversely, if rod **11** is displaced rightward from the intermediate position shown as by action of stop **2B** on roller **8** at the end of the leftward stroke of part **1**, point **15***a* on moving past the mid-plane of the frame **13** causes a similar but reverse toggle action, spring **15** now rocking leftward about its inner end at **15***a* and carrying the upper end **13B** of frame **13** into engagement with contact element **B1** while the lower spring **14** and lower end of the frame are substantially unmoved. The frame **13** is thereby brought to its alternative end position 13_I.

The above-described displacements of frame member **13** and the consequent switching operations are extremely fast-acting, their rate of occurrence being independent of the rate of displacement of the slider rod **11** and hence of the rate of displacement of the movable part **1**.

A more detailed description of a fast-acting three-positional microswitch of this type may be found in French Patent 1,328,440.

FIGURE 2 illustrates a similar operating principle embodied with a different geometry of the moving parts. The limit switch assembly is here generally designated **5**, and parts thereof similar to parts of the assembly **4** of FIG. 1 are similarly designated. The slider rod **11** in this case extends in a direction normal to the direction of movement of the machine part **1**, such as a machine-tool slide. Rod **11** is provided with an outward actuator extension or follower **17** which is biassed by a compression spring **19** into engagement with a flat side surface **18** of the moving part **1**, which surface **18** continues at one end as a ramp **20A** directed toward the switch assembly **5** and at its other end as a ramp **20B** away from the switch assembly. The relative dimensioning and positioning of the parts is such that with actuator **17** engaging the flat side surface **18** under the biassing action of spring **19**, which is the position shown and which obtains throughout the major extent of the path of travel of part **1** in either direction, the contact frame member **13** in switch casing **12** is held in its oblique intermediate position by the toggle springs **14**, **15**, because the points of attachment of the inner ends of these springs to slider rod **11** are then positioned on different sides of the mid-plane of frame **13**. In this intermediate position the contact frame **13** engages the diagonally-related contacts **A1** and **B2** as shown. As part **1** approaches or reaches the end of its rightward stroke, ramp **20A** pushes actuator finger **17** inward, the inner end of toggle spring **15** moves past the mid-plane of frame **13** and the frame snaps to the end position indicated as 13_I where it engages the contacts **A1** and **B1**. When on the other hand part **1** reaches the end of its leftward stroke ramp **20B** allows finger **17** to be pushed outward of the switch assembly by spring **19**, the inner end of toggle spring **14** moves past the mid-plane of frame **13** and said frame snaps to its other end position 13_{II} where it engages the contacts **A2** and **B2**.

A practical form of construction of a limit switch arrangement according to the invention, which operates on the general lines described with reference to FIG. 1,

will now be described with reference to the detailed views of FIGURES 3 and 4.

The assembly shown includes the actuator roller 8 carried at the outer end of a lever arm 6 as by means of the bolt and nut shown. Lever arm 6 is secured, as by means of a set screw or the like, at the outer end of pivot shaft 7 which is journalled in a sleeve bearing of the fixed casing of the switch assembly. The pivot shaft 7 has a cam disk 21, later described in detail, secured thereon and has a coaxial extension of reduced diameter projecting beyond the cam, with a crosspin 22 extending through a diametric hole formed through said extension. A generally cup-shaped plunger member 26 is slidable in the switch casing in a direction parallel to the axis of shaft 7 and has a hole in its end wall through which the pivot extension is freely slidable. Plunger member 26 is prevented from rotating in the casing by means of a keying projection 28 thereof extending laterally into a longitudinal groove or keyway 29 of the switch casing. The plunger member 26 has a pair of V-shaped camming depressions 26*a* formed in diametrically opposite relation in its sidewalls, said depressions receiving the ends of the crosspin 22 therein. A compression coil spring 27 acting between the bottom surface of plunger 26 and the adjacent wall of the switch casing urges the plunger 26 in the outward direction, i.e. toward lever 6.

It will be understood that the arrangement just described as including crosspin 22, non-rotatable plunger 26 with its V-notches receiving the crosspin, and spring 27, serves as a resilient centering arrangement which acts to hold the rocker lever 6 yieldingly in its intermediate, upright position (as indicated in FIG. 4*a*) in the absence of a deflecting force acting on roller 8. Thus said centering arrangement is equivalent in function to the simple centering tension spring 9 of FIG. 1, and it will be understood that various other spring-centering arrangements might be used instead of the one shown.

Whereas in the schematic showing of FIG. 1 lever 6 was shown as acting on the slider rod 11 by way of a link, in the practical embodiment being described lever arm 6 acts on slider rod 11 by way of the cam 21, a follower ball 23 engaging the cam periphery and guided in a suitable tunnel formed in the switch casing, and an intermediate pushrod member 25 the operative length of which may be varied owing to the blind nut 25*a* and having its ends respectively engaging ball 23 and a part-spherical end surface of sliding rod 11, the pushrod 25 being likewise guided for axial displacement in a suitable cylindrical bearing or guide member mounted in the switch casing. A flexible accordion-pleated sealing disk is shown as surrounding the upper end of pushrod 25 and tightly engaging a neck portion thereof for protecting the delicate internal parts of the microswitch against entry of foreign materials while allowing for the reciprocation of the pushrod.

A compression spring 24 acting between the inner end of sliding rod 11 and a surface of the switch casing 12 axially biasses the moving parts including rod 11, pushrod 25 and ball 23 in the outward direction wherein ball 23 engages the cam 21.

The contact frame 13 will be later described in detail and it is sufficient for the present to indicate that it is a generally rectangular recessed frame member having the outer ends of the toggle springs 14 and 15 attached to inwardly-located points of its shorter, terminal sides, as schematically indicated in FIGURES 4*a–c*. The toggle springs 14 and 15 preferably are S-shaped, as shown in those figures, this shape increasing the flexibility of the springs and thereby facilitating the smooth movement of the springs past their most highly flexed condition, as the inner point of attachment of each spring with the sliding rod 11 moves past the mid-plane of the frame 13, as earlier explained.

The cam 21 includes an active peripheral portion 21*a* which is ideally in the form of a spiral arc. The angular setting of cam 21 on shaft 7 relative to the lever arm 6 is such that in the intermediate upright position of the lever (FIG. 4*a*) a central point of the spiral arc 21*a* engages the ball 23. In this condition the cam acts through ball 23 and pushrod 25 upon sliding rod 11 so as to maintain it in an intermediate axial position, with the spring 24 being partly compressed, and the axially offset points of attachment 14*a* and 15*a* of the inner ends of toggle springs 14 and 15 with rod 11 then being positioned on different sides of the mid-plane of frame 13. Under these conditions, as earlier explained, the frame 13 assumes a diagonal position, as shown in FIG. 4*a*, with the electrical contact members supported at the ends of the frame being in engagement with diagonally related stationary contacts (in a manner more fully discussed later).

When lever arm 6 is deflected to one side from its intermediate position, as by a stop of a movable machine part (not here shown) acting on roller 8, say when lever arm 6 is deflected leftward as shown in FIG. 4*b*, cam 21 rotates so as to engage ball 23 with an outer, larger-radius portion of the spiral arc 21*a*, and sliding rod 11 is depressed inward, further compressing spring 24. Spring end 15*a* is thus forced past the mid-plane of frame 13 and the frame is caused to snap to one of its end positions as shown at 13_I in FIG. 4*b*. When on the other hand lever arm 6 is deflected to the opposite side from its intermediate position, as in FIG. 4*c*, cam 21 is rotated so as to engage ball 23 with an inner, shorter-radius end portion of spiral arc 21*a*, and rod 11 is allowed to shift axially outward by the force of spring 24. Spring end 14*a* is thus forced past the mid-plane of frame 13 and the frame snaps to its opposite end position 13_{II}.

The limit switch apparatus so far disclosed is susceptible of a variety of applications in automatic and semi-automatic control. By way of illustration, two exemplary circuit arrangements with which said apparatus may be associated will be described in detail because of their potential importance in many fields of engineering.

The two circuit arrangements are shown in FIG. 8 and FIG. 10 respectively, and involve the use of different types of contact frame member 13 (as respectively shown in FIG. 5 and FIG. 6), and associated stationary contact elements.

Reference is first made to FIG. 5 which illustrates a single-acting contact frame member 13 usable according to a simpler form of the invention. The frame member 13 of FIG. 5 is wholly conductive and can be very simply produced as a generally rectangular element stamped out of conductive metal sheet with a rectangular recess, flanged longitudinal sides, and opposite lugs projecting from the shorter terminal sides of the rectangle, all as clearly shown in the drawing. The said end lugs are provided with contacts 30 e.g. in the form of two-headed rivets or disks soldered to the opposite faces of the lugs. It will be understood that when a frame member 13 of this form (FIG. 5) is used in the embodiments of the invention heretofore described, the associated stationary contacts in the switch casing 12 would simply include four contacts positioned at the apices of a rectangle in the manner indicated in FIGS. 1 and 2 as at A1, A2, B1, B2, and that in each of the three positions of the frame member 13 one of the "A" contacts would be electrically connected by way of said conductive frame member with one of the "B" contacts.

An alternative, double-acting, type of contact frame member 13 is shown in FIG. 6. In this case the body 31 of the frame member is insulating, being in the form of a recessed rectangle e.g. molded from suitable insulating plastic material, with cylindrical trunnions 31A and 31B projecting oppositely from its shorter terminal sides. Supported for limited angular displacement on each of the end trunnions is a conductive bridging member 32A, 32B respectively, which may conveniently be formed

from a pair of metallic strips suitably shaped, as clearly shown, and having contacts such as 33 attached to opposite side faces at each end of each of the bridging members 32A and 32B, i.e. eight movable contacts 33 in all. In this case, it will be understood that the stationary contacts of the switch assembly would likewise be eight in number, being disposed in four pairs. There would be one pair of stationary contacts A11 and A12, corresponding in position to that indicated at A1 e.g. in FIG. 1, both of which would be simultaneously engageable by the movable contacts 33 positioned on one (e.g. the upper) side of bridging member 32A; a second pair of stationary contacts A21 and A22, corresponding in position to that indicated at A2, both of which would be simultaneously engageable by the movable contacts 33 positioned on the opposite (e.g. under) side of the same bridging member 32A; a third pair of stationary contacts B11 and B12, corresponding in position to that indicated at B1, both engageable by the movable contacts 33 positioned on the first (upper) side of the other bridging member 32B; and a fourth pair of stationary contacts B21 and B22, corresponding in position with B2, and both engageable by the movable contacts 33 on the other (under) side of said bridging member 32B. The limited freedom of pivotal displacement of which the bridging members 32A and 32B are capable about their trunnions 31A and 31B ensures that in each contact-making position of the frame, the movable contacts 33 on each of the bridging members 32 exert balanced contact pressures on the stationary contacts engaged by them.

Referring now to the circuit diagram of FIG. 8, this as already indicated illustrates one aspect or application of the invention involving the use of the single-acting contact frame 13 of the type first described with reference to FIG. 5.

The circuit of FIG. 8 shows the pair of power lines or busses S1 and S2, and two parallel and generally similar circuit branches connected across said lines, by way of a manually actuated general cutoff switch AT interposed between one common junction of said circuit branches and the related power line, S2.

One of said circuit branches includes connected in series therein a manual switch MAV, a contactor CAV and the stationary contacts B1 and A1 (see for example FIG. 1) of the limit switch assembly. The other circuit branch similarly includes a manual switch MAR, a contactor CAR and the stationary contacts A1 and A2 of said assembly. The contactors CAV and CAR may be any conventional electromagnetic relay type devices adapted, when energized, to close relay contacts (not shown) for completing a supply circuit for a suitable electric motor (not shown). It is here assumed that such motor is a reversible motor adapted to drive a movable machine part, such as the part 1 shown in FIG. 1 or in FIG. 2, for example a machine-tool slide, in either direction. Energization of contactor CAV completes a supply circuit for said motor to rotate it in one direction, say for displacing the part 1 leftward, e.g. for a cutting stroke of a machine-tool of which slide 1 forms part, while energization of contactor CAR (with CAV deenergized) completes a different supply circuit for said motor to rotate it in the opposite direction for displacing the part 1 rightward, as for the return stroke of said machine-tool. It will be clear that a generally similar type of operation may be obtained in other ways, as with the contactors CAV and CAR controlling the supply circuits of different motors.

Energization of each of the contactors CAV and CAR simultaneously closes an associated pair of holding contacts *av* and *ar* respectively, whereby the energized contactor will remain energized after release of the manual switch MAV or MAR.

In the arrangement being described the conductive contact frame member 13 is connected by way of a flexible braid conductor 34 (see FIGS. 7*a–c*) to the stationary contact A1. Moreover the terminals corresponding to the contacts A1, A2, B1 are connected to the circuit while the contact B2 acts only as an abutment.

In describing the operation of this system, it may first be assumed that the movable part 1, such as a machine-tool slide, is positioned stationarily at any point along its path of travel other than the extreme forward or leftward end of its stroke. Since the part is stationary its motor is not operating, i.e. both contactors CAV and CAR are deenergized. If part 1 has stopped along an intermediate point of its path of travel the slider rod 11 is in its centered position and the contact frame 13 is at its intermediate, oblique, position wherein it electrically interconnects A1 with two diagonally related stationary contacts, such as the contacts A2 and B1 as indicated in FIG. 7*a*. If however part 1 at the time considered has stopped at the extreme rear or rightward end of its stroke, slider rod 11 is shifted to a corresponding one of its end positions, such as the position shown in FIG. 7*c* wherein frame 13 interconnects only the stationary contacts A1 and B1. In position shown in FIG. 7*b*, frame 13 and braid 34 inter connect only contacts A1, A2 because contact B2 without any conductor acts only as an abutment. It will be noted that the above assumptions are consistent with the conditions illustrated in FIG. 2, but it will be evident that minor changes in the assumptions made would render the present description of operation consistent with the arrangement of parts shown in FIG. 1.

Hence when the movable part is stationary at any point of its stroke, contactor CAV or CAR may be energized by depressing the switch MAV or MAR respectively. When reaching the end of its forward stroke (CAV energized), the slider 11 is displaced and shifts the frame in the position shown in FIG. 7*b*, so that conductive path between A1 and B1 is cut off but the path A1, A2 remains conductive. The movable part stops but owing to a manual depression on switch MAR reverse contact CAR may be energized causing movable part 1 to return back towards the other end of its stroke. When reaching said other end, conductive path A1, A2 is cut off (FIG. 7*c*), the movable part is stopped and can only start again in forward direction (path A1, B1 conductive).

As well known in the art, contactors CAV and CAR are provided with a mutual interlock of electrical and/or mechanical types, so that one only of said contactors may be actuated at once.

The circuit diagram of FIG. 10 illustrates another aspect or application of the invention, in which the movable contact frame 13 used is of the double-acting type shown in FIG. 6.

There are again in this case provided two parallel and similar circuit branches connected across the power lines S1 and S2. The upper or "forward" circuit branch comprises, in serial arrangement, a forward contactor CAV, the stationary contact elements A11 and A12 earlier referred to, and the statonary contact elements B11 and B12. Hold contacts *av* closed on energization of contactor CAV are shunted across the contacts A11 and A12. The lower or "reverse" circuit branch similar comprises the reverse contactor CAR, the stationary contacts B21 and B22 (shunted by the hold contacts *ar*) and stationary contacts A21 and A22.

Assuming an intermediate position of the machine part 1 along its path of travel, movable contact frame 13 is in its oblique intermediate position wherein its bridge member 32A interconnects the contacts A21 and A22 and its opposite bridge member 32B interconnects the contacts B11 and B12, as schematically indicated in FIG. 9*a*. Assuming that at such time one of the contactors, say forward contactor CAV, has been previously energized by means not shown and is being maintained in its energized condition through the hold contacts *av*, then the part 1 is traveling in the forward direction. On reaching the end of

its forward stroke the contact frame member is shifted to a corresponding one of its end positions, specifically the position shown in FIG. 9*b* wherein bridge 32A interconnects contacts A21 and A22 and bridge 32B interconnects B21 and B22, simultaneously disconnecting the contacts B11 and B12. This last disconnecting action deenergizes the forward contactor CAV while the connecting of B21 and B22 simultaneously energizes reverse contactor CAR. The motor is therefore deenergized and immediately reenergized to rotate in reverse, driving part 1 on its reverse stroke. Throughout this reverse displacement of part 1, the contact frame 13 again assumes its intermediate oblique position of FIG. 9*a*. As the part reaches the rearmost end of its travel, frame 13 shifts to its opposite end position, FIG. 9*c*, wherein contacts A11 and A12 are interconnected and contacts B11 and B12 are interconnected while previously connected contacts A21 and A22 are disconnected. The motor is thus again deenergized and immediately reenergized to drive the part on its forward displacement once again. Cyclic reciprocation of the part 1 thus proceeds in a fully automatic manner. It will be understood that any suitable manual switch means, not shown, may be provided in the circuit of FIG. 10 to initiate and stop the automatic sequence of the operations described.

It will be apparent from the foregoing disclosure that the three-positional limit switch assembly of the invention is able, in a simple and efficient manner, to perform useful switching actions during the displacement of a movable mechanical part, which actions were heretofore only possible with the use of two separate switches. Construction and adjustments are thereby substantially simplified and the operation is made safer and more reliable. Clearly, the circuit arrangements illustrated in FIGS. 8 and 10 are merely exemplary and do not exhaust the possibilities of the invention. While the switch assembly of the invention is here shown as a "limit switch" adapted for actuation at the opposite ends of the range of displacement of a moving part, it is obvious that depending on the particular application of the invention, such switch assembly may be positioned anywhere along the path of travel of a moving part, and more than one such switch assemblies can be positioned for sequential actuation by the moving part at different points of its path of travel, as for the synchronization of various operating steps in a complex control system. It is equally apparent that equivalent results may be obtained by mounting the switch assembly of the invention on a moving part for operation by stationary camming stops or ramps. The construction of the various mechanical components of the assembly may, moreover, depart considerably from what has been disclosed e.g. in FIGS. 3 and 4. While in the exemplary circuits of FIGS. 8 and 10 the contacts of the limit switch assembly are shown as being connected so as to energize a reversible motor through the intermediate agency of relay contactor means, it is to be understood that in case of small-sized motors, as used e.g. in self-synchronous remote control and/or remote indicating equipment, said contacts may be directly connected in the motor energizing circuits without the intermediacy of any relays or contactor means.

What I claim is:

1. Apparatus for switching circuitry dependent on the motion of two relatively movable parts comprising

two parts relatively movable in relation to each other;

a switch assembly supported from one of said parts including

a movable frame member having movable contact means carried on opposite ends of said frame member and on opposite sides thereof and having an opening therethrough,

at least two pairs of stationary contact means located for engagement with said movable contact means and positioned for engagement with movable contact means on opposite ends of said frame member in each of three positions of said frame member including

a stable intermediate position in which said movable contact means on one side at one end of said frame member engages one of said pairs of stationary contact means and said movable contact means on the other side at the other end of said frame member engages a diagonally-related stationary contact means of the other of said pairs of stationary contact means,

a first end position in which said movable contact means at both ends on one side of said frame member engage respective stationary contact means of one of said pairs,

and a second end position in which said movable contact means at both ends on the other side of said frame member engage respective stationary contact means of the other of said pairs,

an actuator rod extending through the opening in said frame member and displaceable in an axial direction over a continuous range of positions,

toggle spring means having outer ends connected to said frame member adjacent said opposite ends thereof and having inner ends connected to axially spaced points on said actuator rod whereby displacement of said rod over its range of positions will incrementally shift said frame member from one end position through said intermediate position to its other end position;

camming means on the other of said parts;

actuating means carried by said switch assembly and connected with said rod and contacting said camming means during relative motion of said parts;

circuit means connected to said contact means and adapted to be selectively switched between different circuit conditions during relative motion of said parts;

said actuating means comprising an actuating follower connected with said rod and projecting towards said other part,

said other part having a surface parallel to said direction of relative motion and followed by said follower in said intermediate position of said rod,

spring means to maintain said frame member in the stable intermediate position,

and said camming means including spaced camming ramps connected with said surface at spaced points thereof and extending towards and away from said one part for movement of said finger and rod away from said intermediate position and towards a related end position of said rod.

2. Apparatus for switching circuitry dependent on the motion of two relatively movable parts comprising

two parts relatively movable in relation to each other;

a switch assembly supported from one of said parts including

a movable frame member having movable contact means carried on opposite ends of said frame member and on opposite sides thereof and having an opening therethrough,

at least two pairs of stationary contact means located for engagement with said movable contact means and positioned for engagement with movable contact means on opposite ends of said frame member in each of three positions of said frame member including

a stable intermediate position in which said movable contact means on one side at one end of said frame member engages one of said pairs of stationary contact means and said movable contact means on the other side at the other end of said frame member engages a diagonally-related stationary contact means of the other of said pairs of stationary contact means,

a first end position in which said movable contact means at both ends on one side of said frame

member engage respective stationary contact means of one of said pairs, and a second end position in which said movable contact means at both ends on the other side of said frame member engage respective stationary contact means of the other of said pairs,

an actuator rod extending through the opening in said frame member and displaceable in an axial direction over a continuous range of positions,

toggle spring means having outer ends connected to said frame member adjacent said opposite ends thereof and having inner ends connected to axially spaced points on said actuator rod whereby displacement of said rod over its range of positions will incrementally shift said frame member from one end position through said intermediate position to its other end position;

camming means on the other of said parts;

actuating means carried by said switch assembly and connected with said rod and engageable with said camming means during relative motion of said parts;

circuit means connected to said contact means and adapted to be selectively switched between different circuit conditions during relative motion of said parts;

said circuit means including

reversible electric motor means,

two parallel circuit branches connected with said motor means and selectively energizable to rotate said motor means in a related one of two opposite directions,

each circuit means including two related pairs of said stationary contact means in each circuit

branch, hold contacts connected in shunt with a first one of said two pairs of stationary contact means in each circuit branch,

means for closing said hold contacts on energization of the related circuit branch,

and said movable contact means being arranged to interconnect the stationary contact means of each of the related pairs in each circuit branch in a related one of the end positions of said frame member, and interconnect said stationary contact means of the second one of said pairs in each circuit branch in said intermediate position of the frame member

whereby said reversible motor means will have the rotation thereof sequentially reversed as said actuating means engages said camming means during relative motion of said parts.

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