April 15, 1958 H. F. MASON 2,831,082

SWITCH CONSTRUCTION

Filed Dec. 11, 1952 4 Sheets-Sheet 1

Fig. 1.

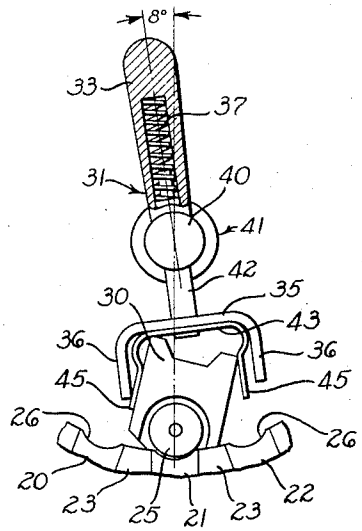


Fig. 2.

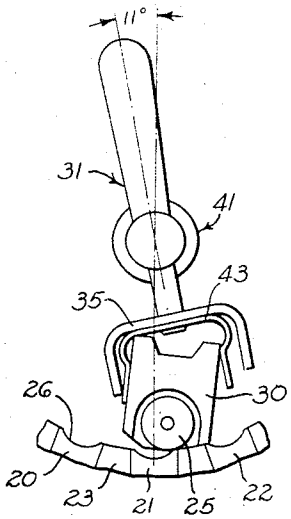


Fig. 3.

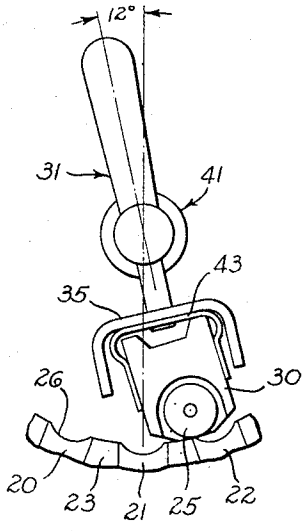
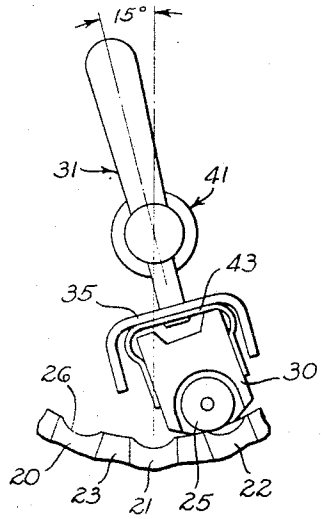


Fig. 4.



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BY

April 15, 1958 H. F. MASON 2,831,082

SWITCH CONSTRUCTION

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Fig. 5.

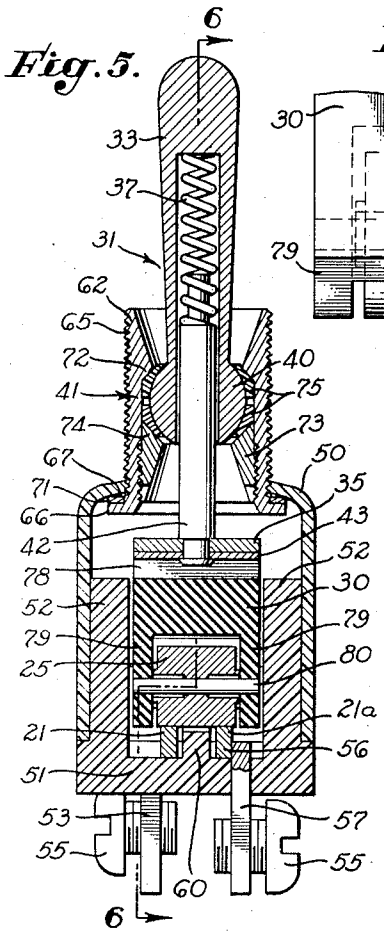


Fig. 7.

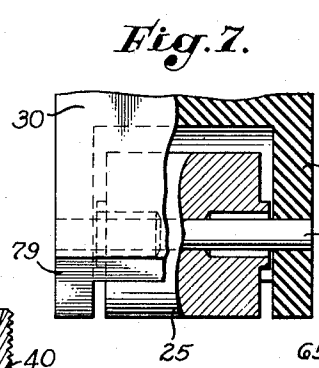


Fig. 6.

Fig. 8.

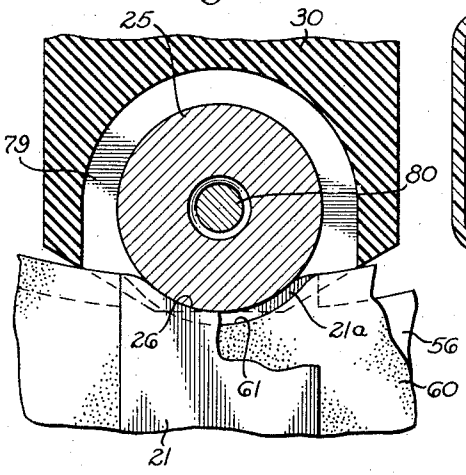
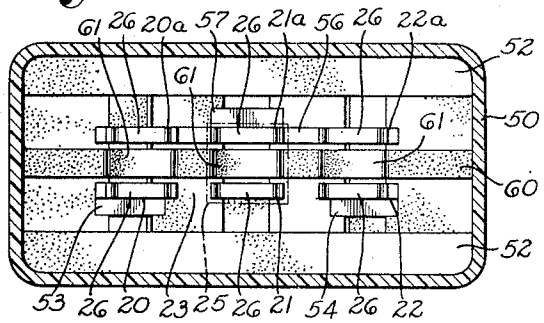


Fig. 9.



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SWITCH CONSTRUCTION

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Fig. 10.

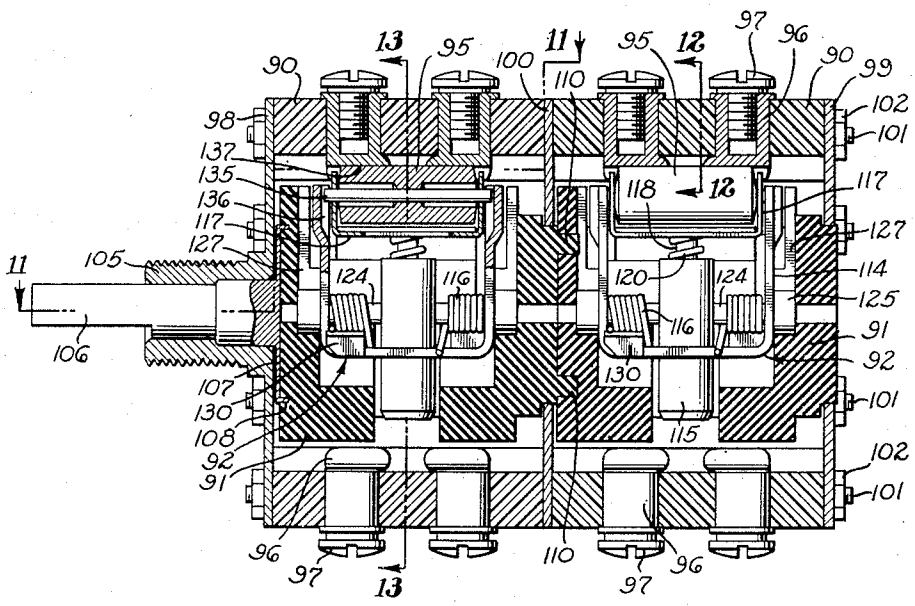


Fig. 11.

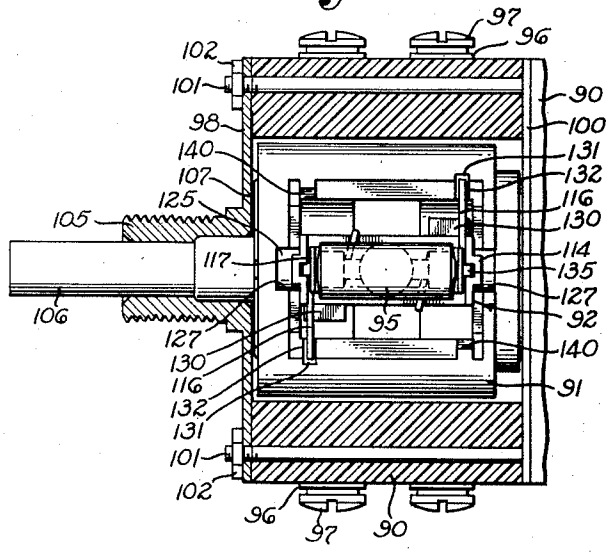
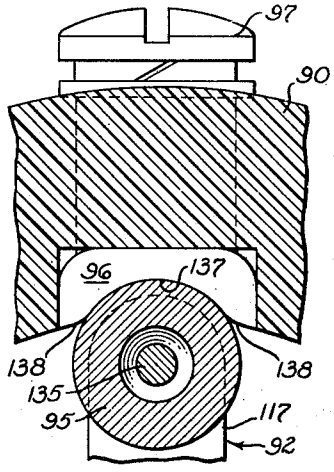


Fig. 12.



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SWITCH CONSTRUCTION

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Fig. 13.

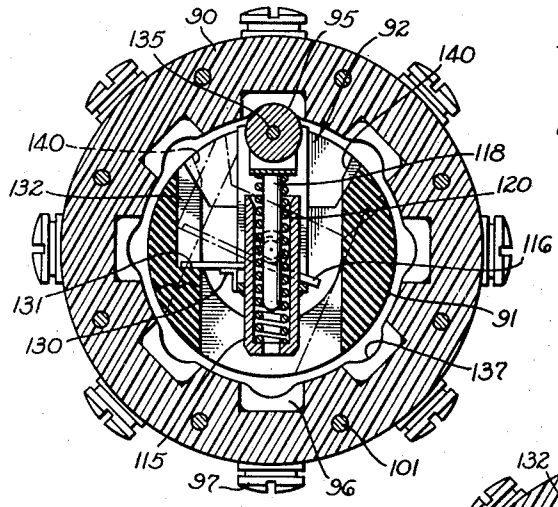


Fig. 15.

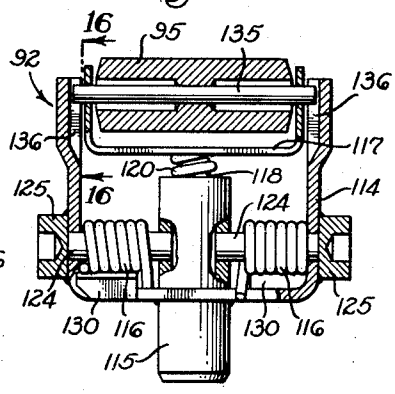


Fig. 14.

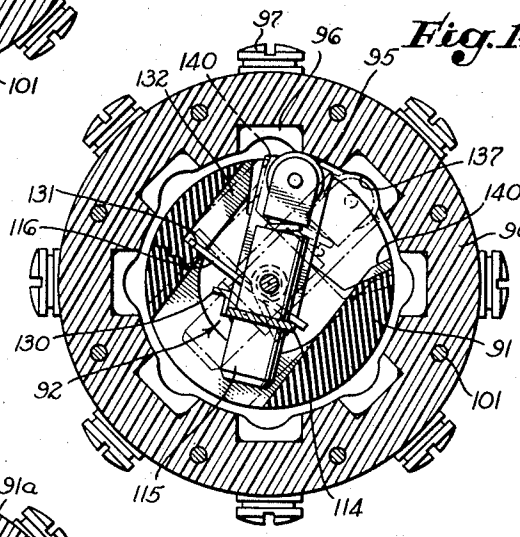


Fig. 16.

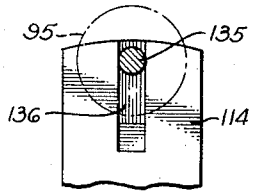


Fig. 18.

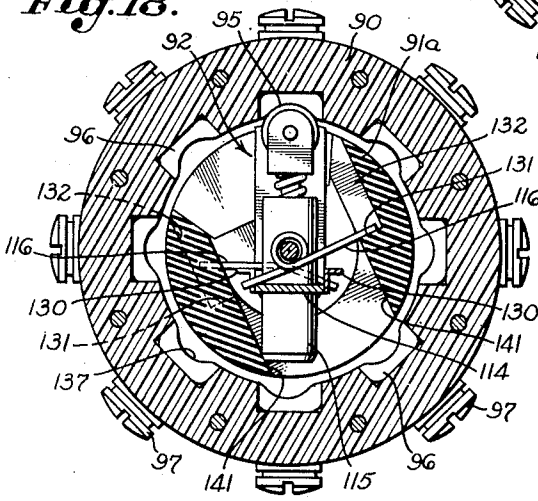
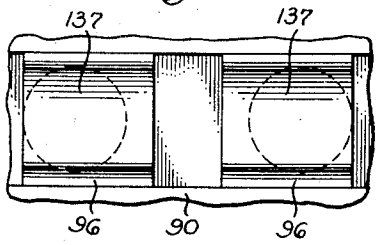


Fig. 17.



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United States Patent Office 2,831,082 Patented Apr. 15, 1958

2,831,082

SWITCH CONSTRUCTION

Howard F. Mason, Los Angeles, Calif., assignor to Mason Electric Corporation, a corporation of California

Application December 11, 1952, Serial No. 325,401

12 Claims. (Cl. 200—68)

This invention relates to snap action switches and one object of the invention is to provide a combination of elements operating with fast make and break that may be embodied in diverse types of switches including lever switches, rotary switches, push-type switches and various types of relays. It will be apparent that the invention is widely applicable to various specific uses. For the purpose of disclosure and to illustrate the principles involved, the invention will be described herein as embodied in two specific switches for aircraft use, one switch being of the lever type and the other switch being of the rotary type. These specific disclosures will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to the construction of other switches for other specific uses.

It is an important object of the invention to provide a snap action switch that operates in a positive manner in the sense that the circuit-controlling switch member of the switch snaps from one predetermined position to another for opening or closing a circuit without any possibility of pausing or stopping between the two predetermined positions. The desired snap action occurs regardless of how the switch is manually manipulated by the operator. In general, this object is attained by the combination of a carrier for the switch member and an actuating means to move the carrier with lost motion between the actuating means and the carrier, these elements being acted upon by cooperating yielding means. In a preferred form of the invention, a first yielding means provides a detent action tending to hold the switch member at predetermined positions along its path of movement, and a second yielding means provides the snap action to shift the switch member without pause from one predetermined position or station to another.

The path along which the switch member moves is provided with recesses at each of the predetermined stations for the switch member and the first yielding means continuously presses the switch member laterally toward this path to cause the switch member to releasably engage the recesses. Each of these detent recesses provides a pair of oppositely sloping cam surfaces at each station for cooperation with the switch member. Thus the path along which the switch member moves is divided into zones for cam action of the switch member at the predetermined stations and zones of free movement of the switch member between the predetermined stations. The first yielding means, which may be termed a detent yielding means, is effective in the cam zones to tend to center the switch member at each station and the second yielding means is effective in the zones of free movement between the stations to provide the required snap action from station to station. In the preferred embodiments of the invention the switch member is in the form of a rotary member rotatably carried by the carrier to roll along the described path from station to station. The use of such a rotary switch member not only improves the cam action at each station but also reduces friction to facilitate the snap action from station to station.

To carry out the purposes of the invention the range of lost motion between the actuating means and the contact carrier operated thereby is at least equal to the length of a zone of free movement between stations to permit the second yielding means to function over the length of a zone of free movement independently of the actuating means. Preferably, the second yielding means which produces the snap action is so constructed that it tends to maintain the carrier at a central position with respect to this range of lost motion. Thus with the switch member engaging a recess at a given station and the actuating means free to move, the second yielding means will tend to hold the actuating means at a position centralized with respect to the given position. On the other hand, if the actuating means is manually shifted progressively out of this centralized position the second yielding means will tend to cause the carrier to follow the movement of the actuating means. The detent yielding means, however, is strong enough to prevent the carrier from initially following the actuating means.

By virtue of this arrangement and the described relationships there are four stages of the operation of the switch to shift the switch member from a given station to the next station. These four stages occur in sequence as the actuating means is manually moved progressively from a position centralized at the given station toward a position centralized at the next station. In the first stage of switch operation the rotary switch member lingers in the contact recess to store energy in the second yielding means. In the second stage the actuating means forces the switch member to the brink of the recess. In the third stage the second actuating means snaps the rotary switch member to the brink of the recess at the next station. The last stage is the seating of the rotary switch member in the recess by cam action.

It is another object of the invention to meet certain problems involved in the construction of a heavy duty switch of this type, for example, a switch for frequent operation to control fifty or more amperes of current at 30 or more volts. Some of these problems are primarily electrical since they arise from arcing in the making and breaking of circuits. Other of the problems are more or less mechanical.

The snap action for fast make and fast break is, of course, part of the solution for modifying the undesirable effects of arcing at the contacts. If it is further contemplated that relatively large contact bodies will be employed which, by virtue of their massiveness, tend to remain relatively cool and therefore tend to quench arcs. A special feature of the invention in this regard, however, is the employment of a switch arrangement that divides the arcing effect between two arcs in series. At each circuit closing position of the switch member, the switch member shorts or bridges a pair of contacts thus dividing the arcing effect between the two contacts.

Some arcing is, of course, inevitable and a further object of the invention is to keep the effect of arcs on the material of the contacts from reducing the efficiency of the switch. This object is accomplished largely by extending the contacts into the zones of free movement of the switch member so that arcing occurs at points spaced away from the recesses in which the switch member is normally seated. This object is also attained in part by the use of a rotary switch member which tends to polish the contact surfaces and thus restore the effectiveness of any surfaces that may be damaged by arcing.

A further object of the invention is to provide for accurate positioning of the switch member at the pair of contacts at each station with adequate pressure against

each of the two contacts. A feature of the invention is that this object is attained by giving the switch member several degrees of freedom so that it may accommodate itself to the pairs of contacts regardless of structural inaccuracies and so that the switch member may equalize its pressure between the two contacts in each pair.

The various objects, features, and special uses of the invention may be understood from the detailed description to follow considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

Figs. 1 to 4 are simplified diagrammatic views showing four successive positions of a switch mechanism constructed in accord with the invention;

Fig. 5 is a longitudinal sectional view of a two-pole, double-throw switch of the lever type embodying the invention, the section being taken as indicated by the line 5—5 of Fig. 6;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 5;

Fig. 7 is an enlarged fragmentary detailed view of the structure shown in Fig. 5, the fragmentary view being partly in section and partly in elevation;

Fig. 8 is a greatly enlarged fragment of Fig. 6;

Fig. 9 is a section taken along the broken line 9—9 of Fig. 6 to disclose the pairs of contacts of the switch in plan view;

Fig. 10 is a longitudinal sectional view of a rotary gang switch embodying the invention;

Fig. 11 is a transverse section taken as indicated by the line 11—11 of Fig. 10;

Fig. 12 is an enlarged fragmentary section taken as indicated by the line 12—12 of Fig. 10;

Fig. 13 is a transverse section taken as indicated by the line 13—13 of Fig. 10;

Fig. 14 is a view similar to Fig. 13 showing the parts in a second position;

Fig. 15 is an enlarged detail of Fig. 10;

Fig. 16 is an enlarged fragmentary section taken as indicated by the line 16—16 of Fig. 15;

Fig. 17 is an enlarged fragmentary view of a pair of contacts of the switch as seen in plan; and

Fig. 18 is a view similar to Fig. 14 illustrating a modification of the structure.

In the diagrammatic Figures 1 to 4 illustrating the principles underlying the invention, a series of switch contacts **20**, **21**, **22** together with intervening portions of a body of non-conducting material **23** provides a path for a circuit-controlling switch member **25**. The switch member **25** is preferably in the form of a metal roller. A recess **26** is provided at each of the three stations represented by the three contacts **20**, **21** and **22** to form seats for releasable engagement by the switch member **25**. In this instance since the switch member **25** is in the form of a roller, preferably each of the recesses **26** has the same curvature as the periphery of the roller. In the construction shown, the recesses **26** are formed in the contacts and each contact is wider in the direction of the path than the recess.

The rotary switch member **25** is journalled in a suitable carrier **30** which, in this instance, is in the form of a block of rubber or other similar elastic material. A suitable actuating means generally designated **31** to shift the carrier **30** and the switch member **25** from station to station is operatively connected with the carrier in a suitable manner to provide a range of lost motion between the actuating means and the carrier. In the construction shown, the actuating means **31** is in the form of a lever and one arm of the lever is in the form of an actuating handle **33**. To provide the desired lost motion between the actuating means and the carrier the second arm of the lever may be in the form of a yoke **35** having two arms **36** straddling the carrier.

It is contemplated that suitable yielding means will be provided to press the rotary switch member **25** laterally towards the path along the contacts thereby to cause the rotary switch member to releasably engage the recesses **26** at the various stations. Such yielding means may be incorporated in the carrier **30** or in the actuating means **31** or may act between the actuating means and the carrier or between the carrier and the rotary switch member. In the present example of the invention the desired yielding means is incorporated in the construction of the actuating means **31**.

The actuating means **31** is made in two sections that are slidingly telescoped together and are continuously urged apart by a coil spring **37**. One of the two sections comprises the handle **33** and a ball enlargement **40** integral therewith by means of which the actuating means is pivotally mounted in a suitable bearing assembly **41**. The other section of the actuating means comprises the yoke **35** which has a shank **42** slidingly extending into the handle section against the coil spring **37**.

In addition to the coil spring **37** the switch mechanism has a second yielding means effective between the actuating means **31** and the carrier **30** to tend to position the carrier centrally in its range of movement relative to the actuating means. In the combination shown in Figs. 1 to 4 this second yielding means is in the form of a leaf spring **43** mounted on the yoke **35** to provide two leaf spring arms **45** between the two yoke arms **36**. These two leaf spring arms **45** tend to hold the carrier **30** and the yoke **35** centralized with respect to each other with the axis of the rotary switch member **25** in line with the axis of the actuating means.

As may be seen in Fig. 1 the carrier **30** moves through its range of relative movement with a rocking action which is resisted by the leaf spring arms **45** and is limited in a positive manner by the yoke arms **36**. It is also to be noted that when the carrier **30** is rocked out of its normal central position it is placed under diagonal compression between the base of the yoke **35** and the rotary switch member **25**. The compression of the elastic carrier body cooperates with the coil spring **37** in urging the rotary switch member into engagement with the recesses **26**.

The path for the rotary switch member **25** provided by the contacts **20**, **21** and **22** together with the intervening non-conducting material is concentric to the pivot axis of the lever actuating means **31**. Since the rotary switch member **25** is yieldingly pressed toward this arcuate path, each of the recesses **26** in effect constitutes a pair of oppositely inclined cam shoulders for the rotary switch member. Thus the arcuate path is divided into cam zones represented by the recesses **26** and intervening zones where the rotary switch member **25** may move freely, the intervening zones of free movement being arcuate raceways for the rotary switch member. Since the contacts **20**, **21** and **22** are wider than the corresponding recesses **26** formed therein each of the arcuate raceways for free movement of the rotary switch member includes portions of the contacts.

The mode of operation of the switch mechanism shown in Figs. 1 to 4 may be readily understood when it is considered that when the actuating means is shifted out of its normal central position relative to the carrier and switch member, the yielding tendency of the switch member **25** to remain seated in a recess **26** is sufficient to resist the yielding tendency of the leaf spring **43** to dislodge the switch member, and when it is further considered that the range of movement of the carrier **30** relative to the yoke **35** and the ability of the leaf spring **43** to store energy for actuation of the carrier **30** are sufficient to permit the carrier to move by spring power across a zone of free movement from one recess to another. By virtue of the relationships involved the operation of the switch in shifting the switch member **25** from one recess or switch station to another is divided into

the four stages which will now be described in more detail.

In the normal position of the switch mechanism with the switch member **25** in a recess **26** at one of the contact stations, say at the contact **21**, and with the handle **33** of the lever actuating means free from manual restraint, the first yielding means **37** in the handle **33** exerts pressure to hold the switch member **25** seated in the recess of the contact **21**. The two leaf spring arms **45** yieldingly engaging opposite sides of the carrier **30** hold the handle **33** centralized with respect to the contact **21** with the axis of the handle in line with the axis of the rotary switch member **25**. When the handle **33** is manually rocked progressively counterclockwise, as viewed in the drawings, toward a position centralized with respect to the next contact **22**, initially the rotary switch member **25** remains snugly seated in the recess of the contact **21**. As a result the carrier **30** rocks relative to the moving actuating means **31** with consequent storing of energy by stressing of the left leaf spring arm **45**. This first stage terminates at the end of the range of relative movement between the carrier and the actuating lever when the left arm **36** of the yoke **35** abuts the left leaf spring arm **45**.

The second stage of the operation of the switch consists in the positive or direct action of the actuating means on the carrier **30** as the left yoke arm **36** forces the carrier to move and cause the rotary switch member **25** to climb up the slope of the recess of the contact **21**. In Fig. 1 illustrating this second stage, the handle **33** has been swung 8° from its starting position. As the rotary switch member **25** climbs up the right cam shoulder provided by the recess it causes energy to be stored not only by compression of the spring **37** in the handle **33** but also by diagonal compression of the elastic body of the carrier **30**. When the arm **33** has been moved 11° from its starting position, as shown in Fig. 2, the rotary switch member **25** nearly reaches the right brink of the recess in the contact **21**. Only slight additional movement will place the rotary switch member at the edge of the arcuate raceway or zone of free movement.

The third stage of the operation then takes place automatically and independently of the actuating means **31**, this third stage consisting in the snap action of the carrier **30** across the zone of free movement into the cam zone at the next contact **22**. In this snap action the left leaf spring arm **45** releases its stored energy to the carrier **33** and there is a certain further release of stored energy as the carrier swings out of its diagonally compressed position. The momentum of the carrier and the rotary switch member is sufficient to throw the carrier past the center of its range of relative movement in opposition to the right leaf spring arm **45** as well as in opposition to the compression of the carrier as it assumes a second diagonal position. In all instances of compression of the carrier **30** whether diagonally or centrally there is, of course, also accompanying compression of the spring **37** in the handle **33**.

The fact that the throw of the carrier **30** is sufficient to stress the right leaf spring arm **45** does not result in return movement of the carrier, however, because the throw is sufficient to cause the rotary switch member **25** to cross the left brink of the recess in the next contact **22** where cam action again becomes effective. In comparing Figs. 2 and 3 it will be noted that the handle **33** has been advanced counterclockwise from an 11° position to a 12° position and the carrier has been snapped across the arcuate raceway into the cam zone at the next contact **22**.

If at this time the handle **33** were released, the cam action provided by the pressure of the rotary switch member **25** against the left cam surface of the contact **22** would be sufficient for carrying out the fourth stage of the switch operation which consists of the switch member **25** rolling down the cam shoulder to seat firmly in the bottom of the recess at the contact **22**. The released actuating means would follow this camming movement of the rotary switch member **25** and the leaf spring **43** acting between the actuating means and the carrier would centralize the position of the actuating means relative to the contact **22**. In the normal operation of the switch, however, the handle is not released at the position shown in Fig. 3, the normal follow-through by the operator's hand continuing through the final cam operation at the contact **22**.

Certain important features of the invention may be appreciated by further analysis of the switch operation. In the first place there is a unique cycle of storing and releasing energy. The first stage of the described switch operation stores energy in the left spring arm **45**, the second stage in which the switch member climbs up the cam surface at the contact **21** results in further storage of energy in the coil spring **37** as well as in the elastic material of the carrier **30**, the third stage results in the release of a major quantity of energy from the left leaf spring arm **45** and the storage of a lesser quantity in the right leaf spring arm **45**, and the fourth stage results in final release of the energy stored in the coil spring **37**, in the right leaf spring arm **45**, and in the resilient body of the carrier **30**.

A second feature is the manner in which the current-carrying efficiency of the switch is maintained by increase of pressure between the switch member **25** and the contact **21** as the switch member rolls from its normal seated position to the brink of the contact recess. In its normal seated position the switch member has a maximum area of mutual contact with the contact **21**. This mutual area is reduced as the switch member is dislodged from its seat, but the resulting cam action increases the pressure between the switch member and the contact, the increase being along a steep pressure gradient because of the diagonal compression of the carrier in combination with the compression of the coil spring **37**. Thus the increase in pressure between the switch member and the contact as the switch member climbs a recess slope compensates for reduction of the area involved, and such pressure compensation maintains the current-carrying ability of the cooperating parts.

A third feature is that each of the contacts is wider than the corresponding recess **26** in the contact so that arcing in making and breaking circuits occurs at edge portions of the contact spaced away from the recess. Thus the arcing is remote from the normal contact seat of the switch member. It is to be further noted that any effect of arcing on an edge portion of a contact is offset by the tendency of the rolling switch member to restore damaged surfaces of the contacts, especially since the rolling action occurs under substantial pressure.

A further feature of the invention with regard to arcing is the fact that the edge portion of each contact lies in a zone of free movement of the switch member. In the snap action of the carrier the rotary switch member attains substantial velocity before it leaves one contact member and, of course, the switch member approaches the edge portion of the next contact member at even higher velocity. Such rapid make and break minimize the arcing effect and, as heretofore stated, each of the contacts **20**, **21** and **22** will tend to stay cool and therefore tend to quench any arcs that occur.

Figs. 5 to 9 show how the basic switch mechanism of Figs. 1 to 4 may be embodied in a lever-type switch to serve the purpose of a conventional toggle switch. The parts of the switch previously described in Figs. 1 to 4 are indicated by corresponding numerals. In this instance the mechanism is adapted to serve the purpose of a single-pole, double-throw switch.

The switch construction shown in Figs. 5 to 9 includes a box-like housing **50**, preferably of plastic non-conducting material, which is closed on its lower side by a thick arcuate wall **51** concentric to the pivot axis of the acuat-

ing means 31. The thick wall 51 is unitary with a pair of parallel side walls 52 which, as shown in Fig. 5, telescope into the housing 50 and are suitably bonded thereto.

The previously mentioned contacts 20, 21 and 22 are embedded in the arcuate wall 51 but in this instance there is a second row of three contacts 20*a*, 21*a* and 22*a* (Fig. 9) to provide a pair of contacts at each station to be bridged by the rotary switch member 25. The contacts 20 and 22 in the first row are connected, respectively, with external terminals 53 and 54 and the external terminals are provided with the usual terminal screws 55. The intermediate contact 21 in the first row is a dummy or dead-end terminal. The three terminals 20*a*, 21*a* and 22*a* of the second row are all integral parts of a single conductor 56 which is united with a third terminal 57 having a terminal screw 55.

The arcuate wall 51 and the two side walls 52 form an arcuate channel of non-conducting material to confine the yoke 35 and the carrier 30 for guidance of the rotary switch member 25. This channel is formed with a central non-conducting arcuate rib 60 that extends between the two rows of contacts, the rib being of the same height as the six contacts but being formed with recesses 61 at each of the three switch stations, these recesses being deeper than the corresponding contact recesses 26. By virtue of this arrangement the rotary switch member 25 rides and seats on the pair of contacts at each station, but rides on the central arcuate rib 60 between stations. The arcuate raceway for free movement of the switch member between stations is formed in part by the arcuate rib 60 and in part by edge portions of the contacts adjacent the contact recesses 26.

Preferably the switch is of fluid-tight construction with the arcuate wall 51 bonded to the housing 50 in a fluid-tight manner and with the actuating means 31 also sealed off in the region of the pivotal mounting of the ball enlargement 40. In the construction shown a tubular member 62 mounted on the switch housing 50 has the usual external threads 65 to receive the usual retaining nut (not shown) for permanently mounting the switch. The tubular member 62 is in threaded engagement with the wall of the housing 50 and is provided with a radial flange 66 on its inner end for cooperation with an inner sealing gasket 67 of suitable material. This particular switch has what may be termed a momentary return spring 70 to cooperate with the yoke 35, as will be explained later, which spring is a leaf spring having a base portion 71 apertured for engagement between the flange 66 and the sealing gasket 67.

The tubular member 62 may be adapted in any suitable manner to serve as a fluid-tight bearing for the ball enlargement 40. For example, the tubular member 62 may be formed with an internal tapered shoulder 72 and may be threaded to receive a bushing 73 having a similar tapered shoulder 74, the two tapered shoulders serving to confine a pair of bearing rings 75. The two bearing rings 75 have spherically curved surfaces to embrace the ball enlargement 40 and are made of suitable material to permit universal movement of the ball enlargement and at the same time to form an effective seal around the ball member. A feature of the invention is the use of rings for this purpose made of a plastic having the trade name Teflon which offers exceptionally low resistance to rotary movement of the ball enlargement 40.

The elastic body of rubber-like material that comprises the carrier 30 is yieldingly embraced by the leaf spring arms 45 which tend to maintain the carrier and actuating means centralized relative to each other. Preferably the elastic body is cut away centrally to form a pair of upwardly extending corner portions 78 for contact with the base portion of the yoke 35, which corner portions are stressed in compression diagonally when the carrier rocks relative to the yoke as heretofore described.

In the construction shown in the drawings, the carrier body 30 is hollowed out to receive the rotary switch member 25 and to form parallel side walls 79 to support the opposite ends of an axle pin 80 for the rotary switch member. As best shown in Figs. 5 and 7 the rotary switch member 25 is preferably in the form of a metal roller with its interior counterbored so that only the central portion of the roller embraces the axle pin 80. This arrangement gives the rotary switch member freedom to rock to a limited extent relative to the axle pin 80 as well as to rotate about the axis of the axle pin. Preferably the axle pin 80 is sufficiently flexible to add to this freedom of the rotary switch member and for this purpose the axle pin may be made of piano wire.

It is apparent that the rotary switch member 25 has several degrees of freedom for movement. It is movable along the arcuate path of contacts concentric to the pivot axis of the lever or actuating means 31; it is movable radially of that axis by virtue of the telescoped construction of the lever actuating means; it is rotatable about the axis of the lever, i. e., about an axis radially of the pivot axis of the lever; and it has freedom to rock about an axis perpendicular to the radial axis, i. e., about the normal axis of the axle pin 80. It will be apparent that the elasticity of the carriage 30 contributes to all of these various degrees of freedom.

The momentary return spring 70, which may be omitted, has an effective range of elastic movement sufficient to cause the rotary switch member 25 to be shifted from the station at the contacts 22—22*a* to the station at the intermediate pair of contacts 21—21*a*. Thus, if the lever 33 is manually shifted to carry the switch member to the pair of contacts 22—22*a* from the contacts 21—21*a*, the switch will stay in the new position only so long as manual force is applied to the handle 33 and when the handle is released the switch will return automatically to the middle position shown in Fig. 6. In this middle position no circuits are closed by the rotary switch member 25 but in the left position as viewed in Fig. 6, the switch terminal 57 is connected to the switch terminal 53 and in the right position the switch terminal 57 is connected to the switch terminal 54.

Figs. 10 to 17 illustrate how the principles of the invention may be incorporated in a rotary switch having eight positions and sixteen switch contacts. Preferably the rotary switch is of a construction that facilitates the uniting of any desired number of switch units to form a gang switch operated by a single actuating shaft. Fig. 10, by way of example, shows two such switch units united to provide a rotary gang switch having eight positions with two separate rotary switch members electrically interconnecting corresponding pairs of switch terminals at each of the eight positions.

Each of the two switch units shown in Fig. 10 comprises the basic combination of a stator 90 in the form of a thick-walled cylinder of a suitable plastic non-conducting material, an actuating means 91 in the form of a rotor also made of non-conducting plastic material, and a carrier, generally designated 92, which carries a rotary switch member 95. Each of the two stator cylinders 90 has embedded therein eight pairs of contacts 96 which extend to the exterior of the switch and are provided with external terminal screws 97.

The housing for the two-unit gang switch comprises the two cylindrical stators 90, an end plate 98, a second end plate 99 and an intermediate transverse plate 100, this assembly being united by a series of longitudinal tie rods 101 and nuts 102.

The end plate 98 is formed with an externally threaded boss or tubular extension 105 in which is journalled an actuating shaft 106 that is operatively connected to the rotor 91 of the left-hand switch unit as viewed in Fig. 10. In the construction shown the actuating shaft 106 is unitary with a thin disc 107 at its inner end, which disc has a flanged rim portion 108 embedded in the material of the left-hand rotor. Thus one end of the rotor is

supported by the actuating shaft **106**, the other end being journalled in the intermediate transverse plate **100**.

The left-hand rotor **91** is formed with a circular series of lugs or longitudinal projections **110** which mate with corresponding recesses in the right-hand rotor **91** to operatively interconnect the two rotors and to rotatably support one end of the second rotor. The other end of the second rotor is journalled in the second end plate **99**. Each of the rotors **91** is suitably hollowed out diametrically to house a carrier **92** and to permit the required freedom for the carrier to move relative to the rotor through a range of sufficient extent for the snap action heretofore described.

As best shown in Fig. 15, the principal parts of the carrier **92** are: a U-shaped frame **114** pivotally mounted in the rotor **91** for rotation coaxially of the rotor; a diametrical tubular member **115** mounted on the U-shaped frame; a pair of opposed torsion springs **116** which tend to hold the U-shaped frame in a central position with respect to its range of movement relative to the rotor; a yoke **117** which journals the rotary switch member **95** and has a shank **118** extending into the tubular member **115**; and a coil spring **120** in the tubular member **115** which surrounds the shank **118** and urges the yoke **117** radially outward.

A tubular member **115** extends through the base portion of the U-shaped frame **114**, being welded thereto, and is additionally supported by two axial pins **124**. Each of the axial pins **124** is mounted in one of the legs of the U-shaped frame **114** and has an enlarged head **125** welded to the outside of the frame to serve as a trunnion for pivotally mounting the frame in the rotor **91**. As indicated in Fig. 10, the rotor **91** is formed with a pair of radial slots **127** the inner ends of which serve as bearings for the trunnions with the trunnions positioned on the same axis as the rotor.

Each of the two torsion springs **116** is wrapped around an axial pin **124** with one leg of the torsion spring resting on the base of the U-shaped frame **114** and with the other leg normally resting on an angular support **130** carried by the U-shaped frame and also normally resting on a corresponding shoulder **131** at the end of a corresponding slot **132** in the rotor **91**. Normally the two torsion springs **116** are in balanced opposition to maintain the carrier **92** in a normal position centralized with respect to the rotor **91**. This normal position is shown in full lines in Figs. 10, 11, 13 and 15.

Preferably the rotary switch member **95** is mounted on an axle pin **135** in the manner heretofore described to give the rotary member a certain freedom to rock relative to the normal axis of the axle pin. The axle pin **135** is mounted in the two legs of the yoke **117** with end portions of the axle pin extending beyond the yoke. The extended end portions of the axle pin **135** are guided by radial grooves **136** formed in the legs of the U-shaped frame **114**.

It is apparent that the rotary switch member **95** has the various degrees of freedom heretofore described and that the coil spring **120** continually urges the rotary switch member outward against the surrounding stator **90**. The stator **90** in combination with the two circular rows of contacts **96** provides a continuous circular path for the switch member **95** and the individual contacts **96** are formed with recesses **137** that serve the same function as the recesses in the contacts of the first form of the invention.

Preferably the brinks of the recesses **137** are slightly chamfered or rounded off as shown at **138** in Fig. 12. It has been found that forming the contact recesses with the rounded shoulders **138** eliminates a certain troublesome tendency for the metal of the contacts to be upset by impact of the switch member against the walls of the contact recesses. By virtue of the rounded shoulders **138** the switch member **95** moves into a recess **137** in a smooth manner without damaging impact and the polishing action of the switch member on the metal of the contact eliminates any minor damage to the contact that may tend to occur at the two shoulders **138**.

The operation of the rotary switch may be readily understood since it is fundamentally the same switch operation as heretofore described. When a rotor **91** is rotated progressively by the actuating shaft **106** away from the normal centralized position of the rotor with respect to the carrier **92** at a given switch station, the pressure exerted by the coil spring **120** is sufficient to maintain the switch member **95** initially in the recess **137** at the switch station. Consequently initial rotation of the rotor **91** out of its normal position causes one of the torsion springs **116** to be stressed. Fig. 14 shows in full lines how continued progressive rotation of the rotor **91** eventually brings inclined wall surfaces **140** of the rotor against the two legs of the U-shaped frame **114** whereupon the rotor acts in a positive manner to dislodge the switch member **95** from the recess **137**.

With continued rotation of the rotor **91** the switch member **95** is carried to the brink of the recess **137** whereupon the stressed torsion spring **116** snaps the carriage **92** toward the next switch station where the switch member enters the next cam region as heretofore described. The cam action powered by the coil spring **120** tends to center the switch member and carrier at the new station and the two torsion springs **116** cooperate to tend to centralize the position of the rotor **91** relative to the new station.

The modified rotary switch shown in Fig. 18 is largely identical to the structure heretofore described as indicated by the use of corresponding numerals to indicate corresponding parts. The modification consists in changing the internal configuration of the rotor **91***a* so that the rotary movement of the carrier **92** relative to the rotor is limited by abutment of a wall surface **141** against the end of the tubular member **115**.

In all forms of the invention the actuating means that cooperates with the carrier has what may be termed a "kicker" portion for impact against the carrier at the end of the range of relative movement of the carrier. The purpose is to kick the switch member out of engagement with the recess at the station so that the snap action can occur to carry the switch member towards the next switch station. It is desirable, of course, that the arcuate path for free movement of the rotary switch member **95** be provided by smooth and accurately concentric surfaces. To this end it is contemplated that the two rows of contacts **96** will be embedded in the stator **90** when the stator is molded or cast and that subsequently the stator together with the embedded contacts will be machined and processed to achieve the desired accurate concentricity.

The specific embodiments described in detail for the purpose of illustration will suggest to those skilled in the art various changes, substitutions and other departures from my disclosure that properly lie within the spirit and scope of the appended claims.

I claim as my invention:

1. In a switch, the combination of: an arcuate, concave contact path having a center of curvature and having circumferentially spaced, radially inwardly directed, recesses therein and having thereon at least one stationary contact in which one of said recesses is formed; a freely rotatable roller contact engaging and movable along said contact path and receivable in each of said recesses; a contact carrier for said roller contact located radially inwardly of and movable adjacent and parallel to said contact path; an axle carrying said roller contact and mounted on said contact carrier and providing free rotation of said roller contact relative to said contact carrier; actuating means movable about said center of curvature of said contact path for moving said contact carrier adjacent and parallel to said contact path; means providing a lost-motion connection between said actuating means and

said contact carrier; kicking means carried by said actuating means and engageable with said contact carrier for limiting the range of lost motion between said actuating means and said contact carrier so as to kick said roller contact out of each of said recesses; and resilient means for biasing said roller contact into engagement with said contact path.

2. A switch as defined in claim 1 including another resilient means connecting said actuating means and said contact carrier for centering said contact carrier in said range of lost motion between said actuating means and said contact carrier.

3. A switch as defined in claim 1 wherein said resilient means comprises means for progressively increasing the force biasing said roller contact into engagement with said contact path in response to movement of said roller contact toward the center of said contact path.

4. A switch as defined in claim 1 wherein said means providing said lost-motion connection comprises a rockable connection between said actuating means and said contact carrier, whereby said contact carrier may rock relative to said actuating means within said range of lost motion provided by said limiting means.

5. A switch as set forth in claim 4 wherein said contact carrier is engageable with said actuating means at either of two circumferentially spaced points between said contact path and the center of said contact path to provide said rockable connection between said contact carrier and said actuating means.

6. A switch as defined in claim 1 wherein said recesses have substantially the same curvature in cross section as said roller contact.

7. A switch as defined in claim 1 wherein said contact path defines part of a cylinder.

8. A switch according to claim 1 wherein said contact path defines a full cylinder.

9. A switch as set forth in claim 1 wherein said stationary contact is circumferentially wider than said recess therein.

10. A switch according to claim 1 wherein said range of lost motion is at least equal to the distance between said recesses.

11. A switch according to claim 1 wherein said axle is flexible and resilient and wherein said roller contact engages said axle throughout a central portion thereof only with clearance on either end of said central portion to permit said roller contact to rock relative to said axle.

12. A switch including a roller contact and a flexible and resilient axle carrying said roller contact, said roller contact engaging said axle throughout a central portion thereof only with clearance on either end of said central portion to permit said roller contact to rock relative to said axle.

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