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[54] **ELECTRICAL SWITCH COMPONENTS AND SWITCHES FORMED THEREBY**
20 Claims, 27 Drawing Figs.

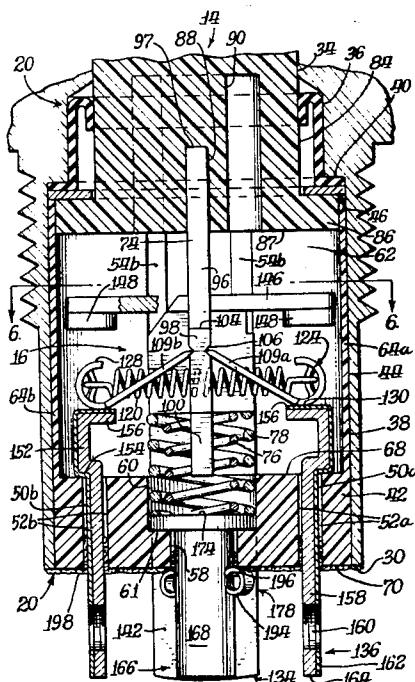
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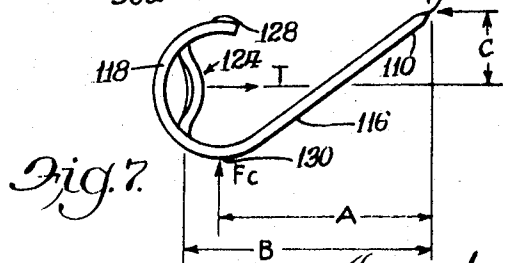
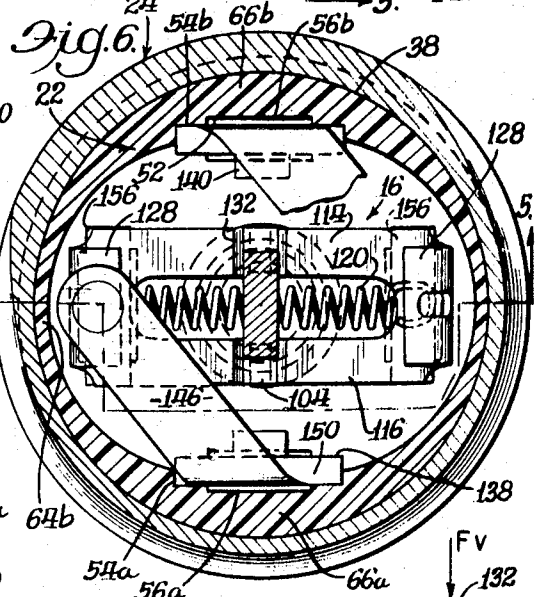
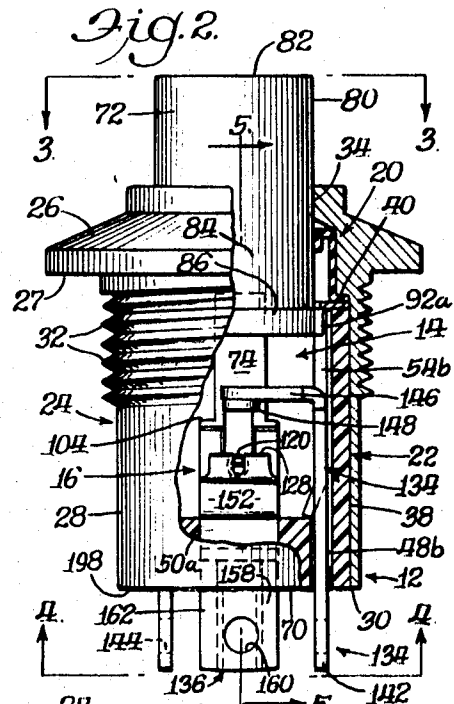
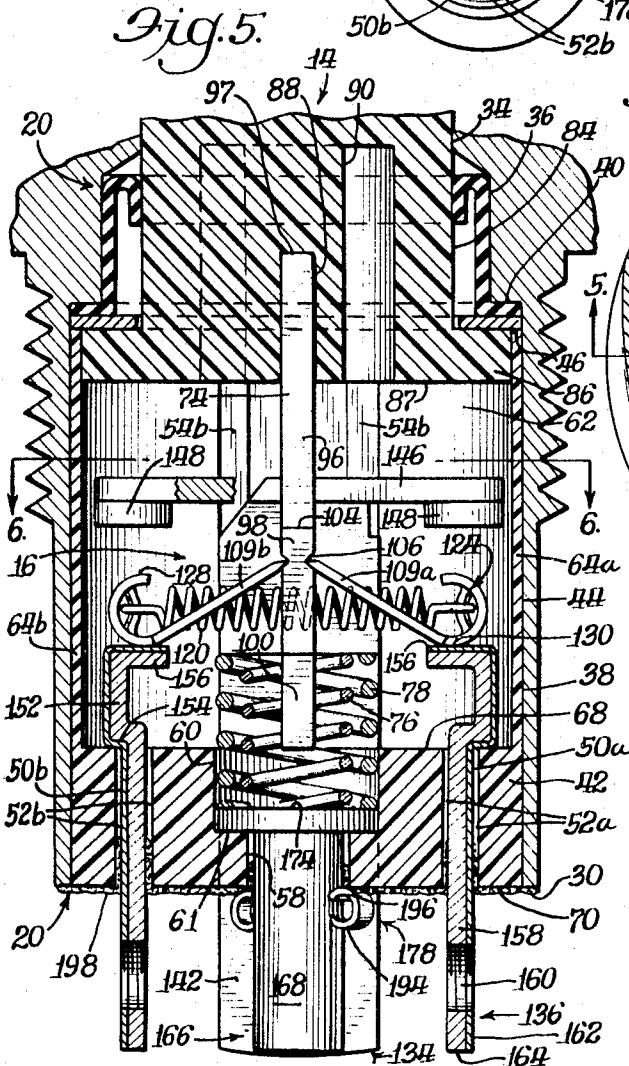
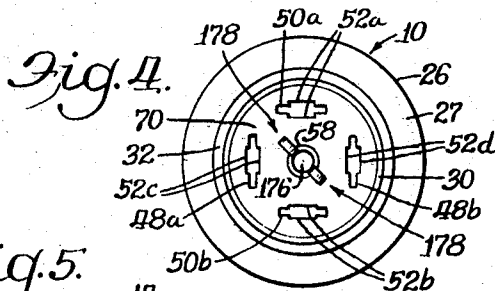
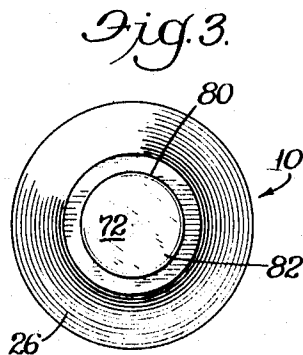
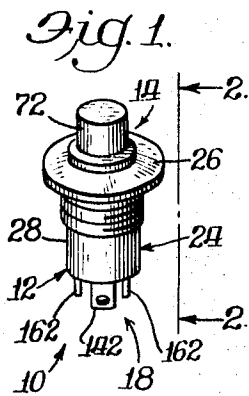
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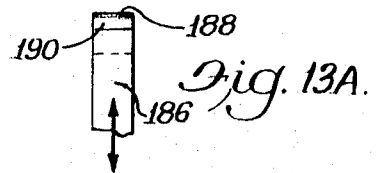
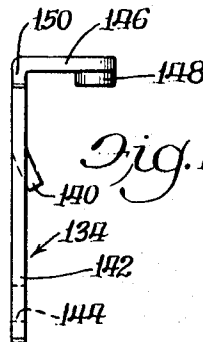
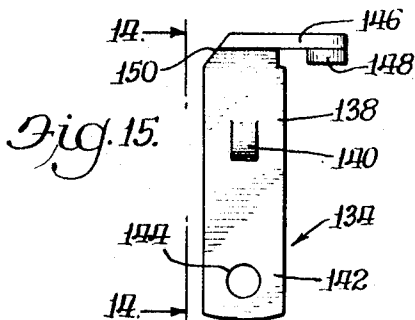
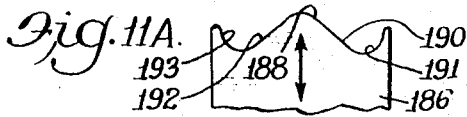
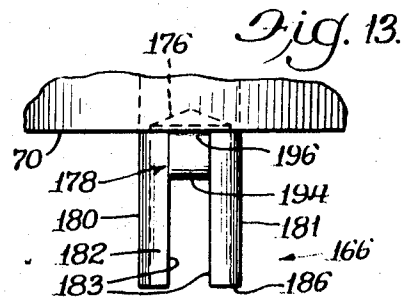
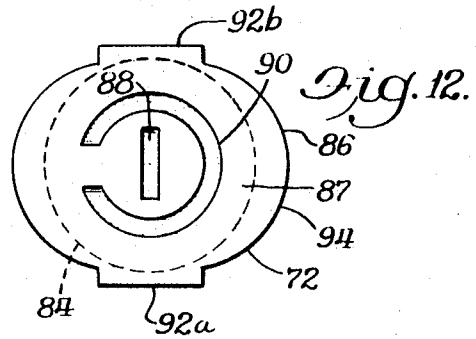
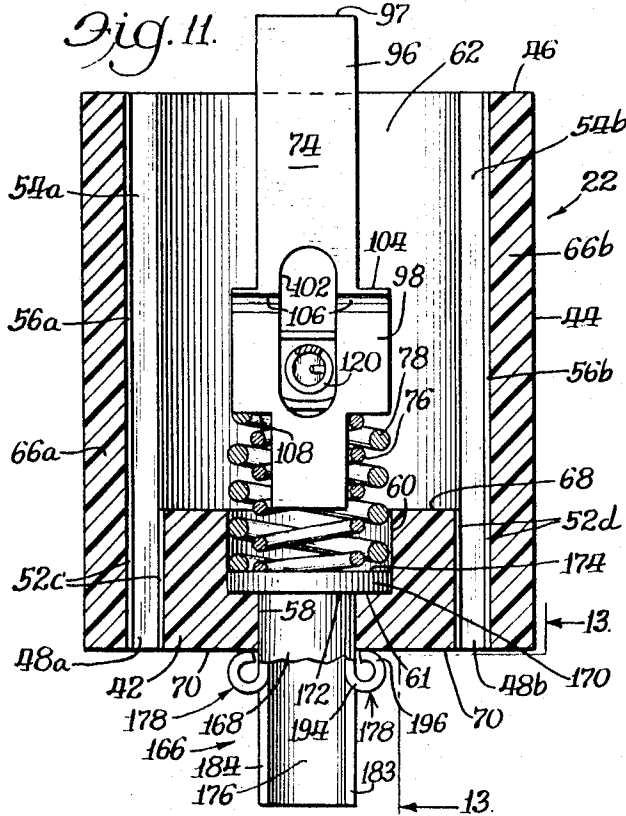
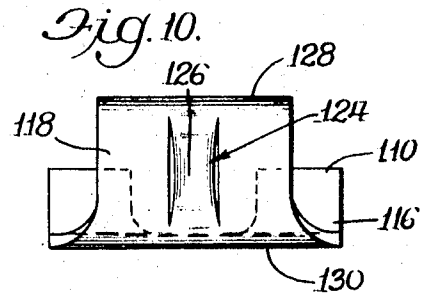
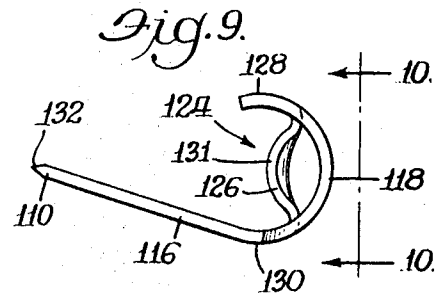
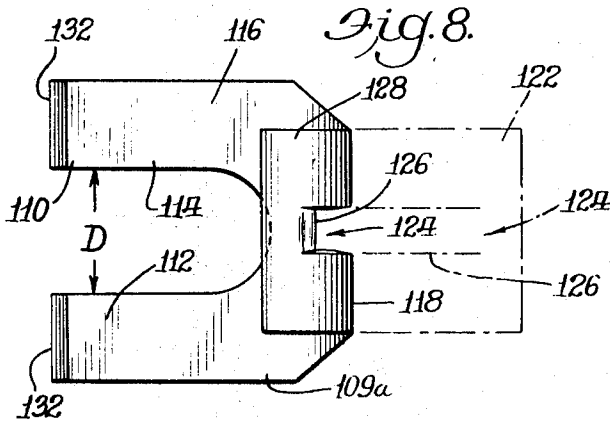
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ABSTRACT: This invention relates to electrical switch components for snap action mechanisms particularly of the butterfly type and utilizes a second class lever system wherein the tension spring is attached outboard of the contact portions to an integral shear formed attachment strut to afford large movement differential, high leverage contact forces and stability. The integral attachment strut means for the one piece switchblade and contact member is reversely curved for mechanical wear properties in attachment of the end of the tension spring and is proportioned and located for maintenance of dimensional stability to the curved spaced contact portions. There is use of the space intermediate the contacts for location and attachment of the tension member, the contacts being spaced portions of the end of the switchblade which is of a generally cylindrical form. The switches also have a "rolling sleeve" sealing means, dual use of the terminal slot for mounting and as a rotation preventing keyway and also a common terminal means is resiliently mounted in situ in a manner to form an open sided solder pot. The two pole four circuit version of the mechanism has an energy storing resilient donut mechanism for assuring simultaneity of both sets of bridging contacts.

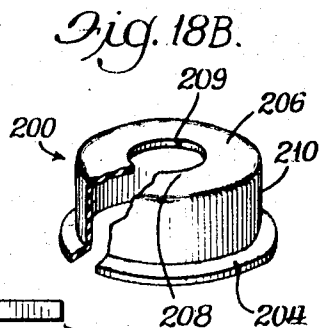
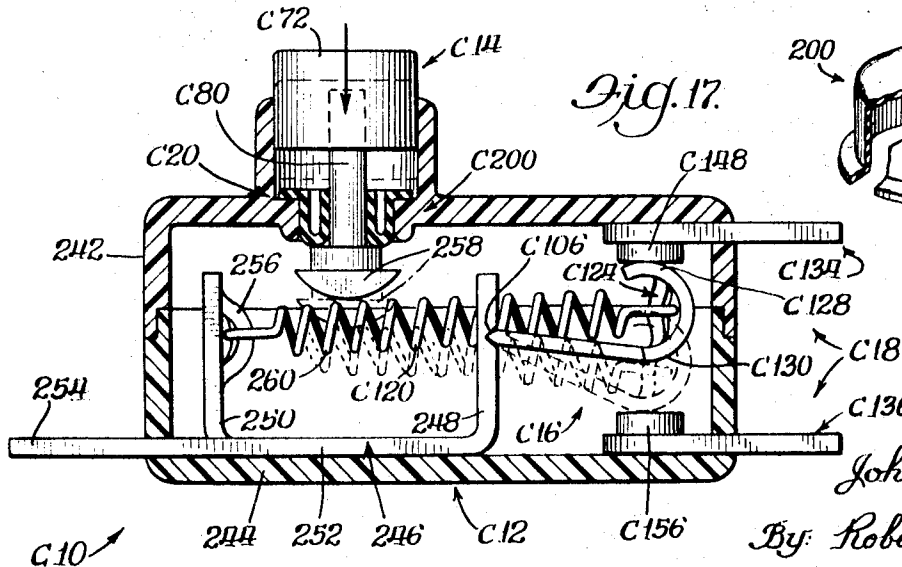
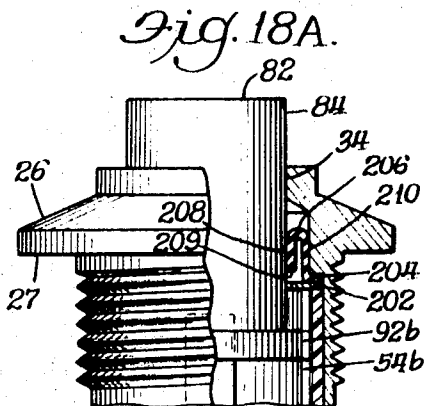
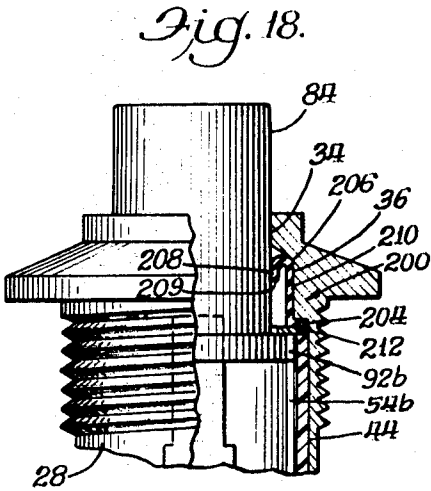
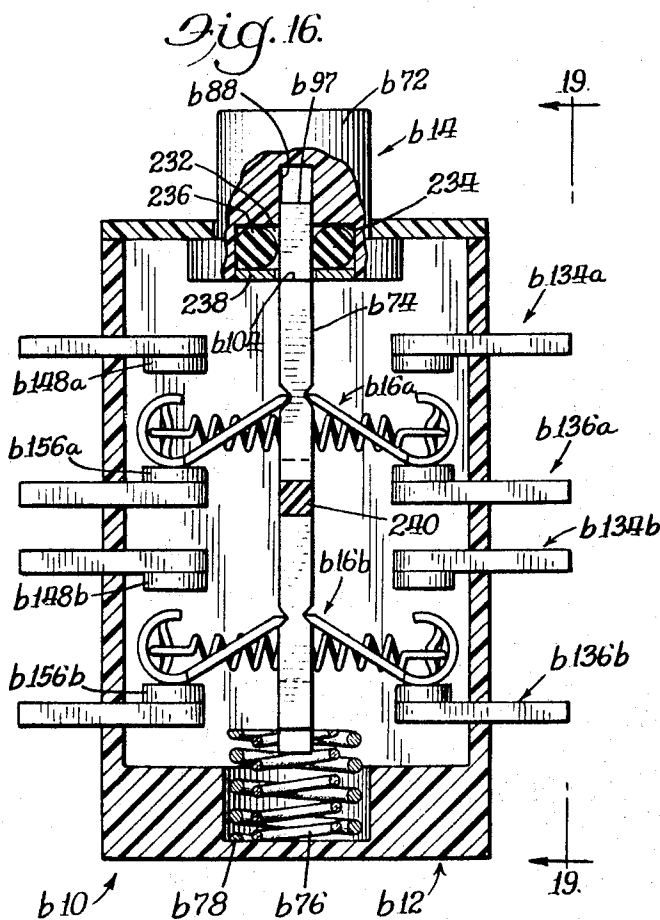




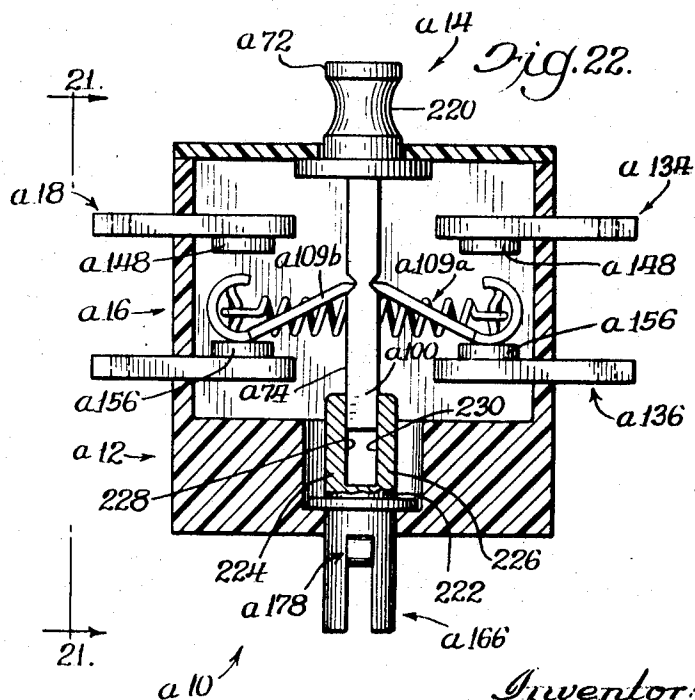
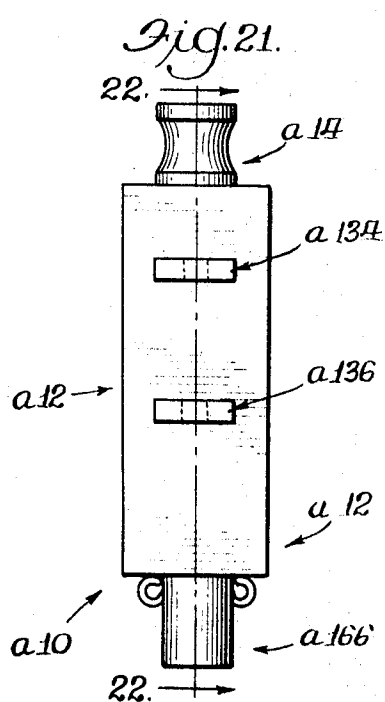
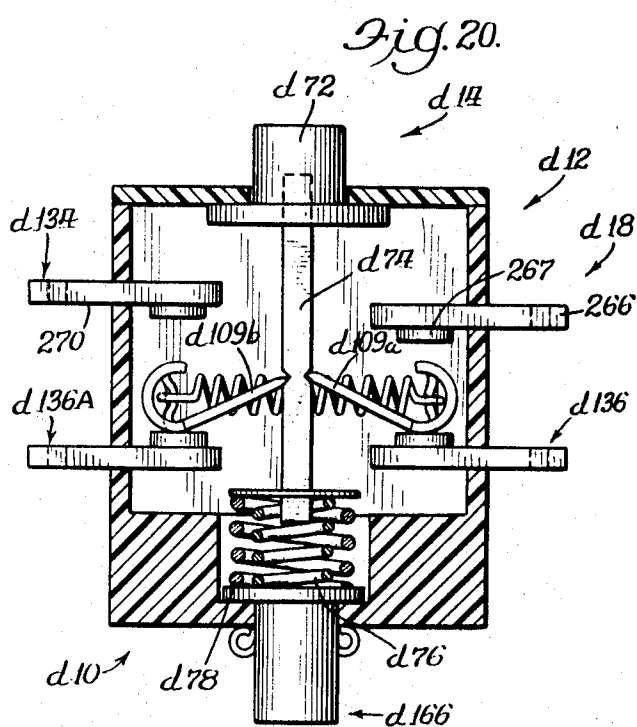
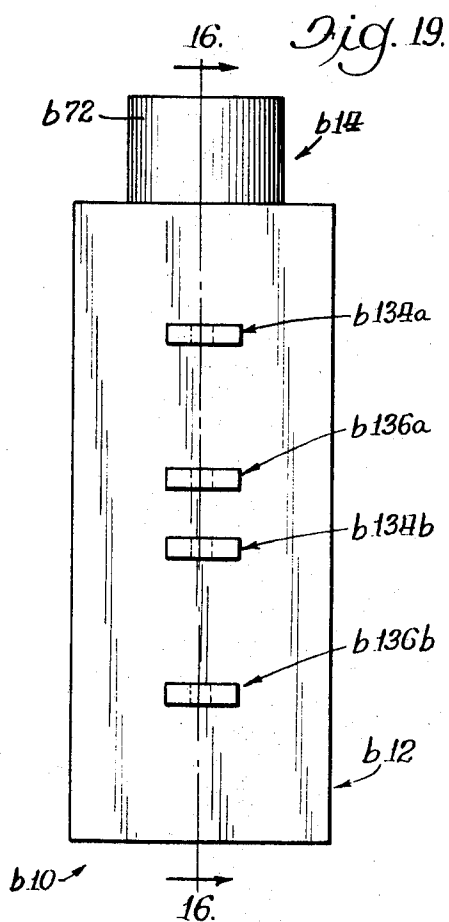
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ELECTRICAL SWITCH COMPONENTS AND SWITCHES FORMED THEREBY

BACKGROUND

This invention is concerned with the electrical switch art and more particularly with components in snap action mechanisms and the mechanisms formed thereby.

More specifically, this invention relates to a compact elegant combination switchblade and contact means which is exceedingly useful in snap switch mechanisms, certain other novel components, and when all are combined with other components, rugged precision snap switches are provided. One primary use of the combination switchblade and contact member is in a single-pole double-throw switch of the type often called a two circuit switch. It differs from the ordinary single pole switches in that it is provided with four terminals and a movable bridging contact mechanism is adapted to selectively contact either of two pairs of terminals to complete a circuit. This general type of switch mechanism is sometimes referred to as a butterfly mechanism, the bridging contact mechanism being analogous to the movable "wings."

Butterfly type prior art snap switches of extremely limited scope were proposed at least 40 years ago but apparently did not enjoy extensive commercial success due at least in part to lack of any suggestion of any of the necessary precisional qualities required by modern industry (see U.S. Pat. No. 1,645,528). Prior art precision snap switches of the butterfly type, as for example, the two circuit snap switch shown in my prior U.S. Pat. No. 2,840,657 offered a major improvement over the flexible blade type switches more commonly used prior to the invention thereof. However, the instant switch, while having some similarity to the "butterfly" action of each of the above patents, represents dramatic improvement and sharply differentiates from each of the mechanisms of those patents as shall become apparent hereinafter.

The prior art mechanism shown in my U.S. Pat. No. 2,840,657 provides a third class leveraging system which is severely restricted in design in a longitudinal direction (between outboard edges of the butterfly mechanism) because of the many elements to be disposed serially. Starting at the centerline of the butterfly actuator and movable contact mechanism of my previous patent, there are required: Stock on the actuator for carrying the precision pivot points, legs on the flat switchblades of sufficient length to provide good action, stock for the attachment means in the bight of the U-shaped legs to couple the compression and tension portions of the mechanism, and stock on the flat switchblades to attachably mount the top and bottom contacts on the end of the flat switchblade.

In a truly small switch of my previously patented type, the top and bottom contacts take so much space at the end of the flat blade, that there is not sufficient room for the mechanism (actuator, legs, attachment means, and tension spring). Stated in another way, the contacts required by the electrical parameters so dominate the mechanism that in a very real sense, it is the limiting factor. There are two different facets to this lack of longitudinal room for the mechanism in my previously patented switch, namely:

- (1) Insufficient length for necessary mechanism geometry to perform the function, and
- (2) Insufficient space for adequately strong and long-lived tension spring members.

It is the overcentering of the line of action of the tension spring member in butterfly-type mechanisms that provides a snap action to the contacts. It is desirable to have the distance of movement of the line of action of the spring be as large as possible in extremely small mechanisms. In my previously patented mechanisms this overcentering distance is typically one-half of the contact throw or gap. The smaller the switch the smaller the ratio of the overcentering movement to contact gap. As my aforementioned patent mechanisms get smaller and smaller, the small overcentering movement produces two practical evils, namely:

- (1) Low decisiveness at the trip point, known as "dead break," and
- (2) Lack of simultaneity in operation of the two switchblades. Simply put, this is poor snap action.

The earlier mechanisms, such as shown in U.S. Pat. No. 1,645,528, were essentially concerned with single circuit mechanisms (on or off), are lacking in symmetry, have only a single contact surface on the bridging mechanism, lack precision characteristics of pivot, have poor attachment techniques for the spring, etc. such that the teachings of this patent have little relevance to modern compact precision snap switch construction.

SUMMARY

The new switch mechanism described in detail hereinafter not only overcomes the aforementioned problems, but additionally provides other advantages.

Two circuit snap switches of my new invention find wide use in aircraft, ships, and control usages in industry, and is particularly well adapted for usage where precision snap action push button switches are desired for panel boards, control sticks, pressure switches, or any hand or machine operated use. The precision qualities of the below identified switch qualifies it as a limit switch with unique size, rating, sealing and economy features.

With the foregoing in mind, it will be noted that there is provided a combination switchblade and contact means wherein the contact means is integral with the switchblade—the member is one-piece unitary stamping—and due to the construction thereof forms a second class leveraging system as distinct from a third class leveraging system to afford a far more effective powering of the snap mechanism.

The second class lever operation with the tension spring provides a greater leverage and a longer throw or moment on the contacts in my new mechanism. The length of the lever associated with the overcentering force compared to the length of the lever to the contact force is favorable in my new mechanism. The ratio of the moments of these two forces (overcentering force-contact force) is greater than unity in my new mechanism whereas in my previous patent it was less than unity.

Thus this invention teaches a mechanism which is very effective in producing contact force.

This same second class lever system provides advantages in that it affords a configuration of mechanism such that the tension spring member throws the bridging mechanism overcenter with a significant increase in throw over prior art capabilities. With this greatly increased "throw" it is now possible to have good definite snap action in very small mechanisms. There is sufficient movement in a butterfly mechanism so that the first side (left for example) to start in motion helps the other (right side for example) overcenter with resultant good simultaneity and no "double" clicking.

It is a further advantage of this invention to provide a second class lever system in a butterfly snap action mechanism which is economical without sacrifice of high precision and compactness. Another advantage is the provision of a two circuit snap switch wherein physically small compact mechanisms may be provided through the elegant use of the space intermediate spaced contacts.

The new mechanism has a configuration providing a tension spring member of greatly increased length which in turn provides increased leverage and better switching geometry, the increased length allowing for a stronger spring which gives a truly remarkable force in even extremely small mechanisms. In one practical instance of a switch mechanism having a "butterfly wingspread" of less than one-half inch, there is produced a measured contact force of 120 grams. This increased force confers a good snap action feel and also gives a very low value of contact resistance. Testing has revealed consistent contact resistance capabilities below 4 milliohms in the aforementioned small switches which are of the construction

shown and described herein. Heretofore, in similar size switches, 20 milliohms has been considered good. This major reduction of the contact resistance is significant in the problem of "flicker" in switches, but with the high force produced by this new mechanism, contact flicker is now essentially eliminated and there is a 100 percent reliability on contact make.

This invention provides a leveraging system and construction features for a snap mechanism which affords low contact bounce, an extremely useful feature whenever solid state circuits are used. The leveraging mechanism also provides a compact switch mechanism having extremely desirable characteristics of "low flicker," and low contact resistance which are maintained under extreme conditions of vibration, shock, and acceleration. Other useful advantages of the below-described switch construction are the economic aspects in that the parts are formed from simple stampings, the parts are easily to assemble, few parts are necessary, and there is an exceedingly effective use of the small "space" available interiorly of the switch. Still further advantages are a switch mechanism which is exceedingly reliable in that it obviates dead centering in a mechanism where there is a positive snap action, which is well adapted to handle electrical overloads, and where a mechanism is provided which is mechanically and electrically of great strength.

More particular advantage of this invention are to provide a switch wherein the mechanical actuation of the movable switch parts can reliably withstand a quarter of a million mechanical cycles, to provide a mechanism which has a trip point repeatability of great definitiveness, to provide a mechanism which is sealed against environment and flux and to provide a mechanism where the casing thereof is well adapted to a variety of mounting styles.

Another advantage of this invention is the provision of a sealed switch mechanism wherein the movable push button is sealed to the casing by a limp flexible boot of impermeable material using a rolling sleeve principle as distinct from a bellows mechanism, the rolling sleeve providing a uniform negligibly low resistance to movement over a large temperature range.

The snap action mechanism is also well adapted to reliably meet mid-porxion, and difficult military specification standards, for example, military standards MIL-S-8805/3 and MS 25089, as well as United States Navy high shock tests, all of the above specification standards including extraordinary ranges of vibrational, acceleration and shock tests in wet environments over an extreme temperature range.

An improved common terminal means which is easy to assembly and mount while affording an economical solder pot is another feature of the invention. Prior art common terminals often have not been well adapted to satisfactory mounting to normally encountered production variances in the plastic case and subsequently providing a solder pot after installation. Herein there is taught a common terminal means which is mounted in situ by deforming the sidewalls thereof in a manner to provide a resilient strut attachment means to afford good mounting characteristics over a wide variety of tolerances of case structures and simultaneously providing openings in the sidewalls of the terminal to afford a good solder pot which allows escape of gas and other contaminants. It will also be noted that the method of attaching a common terminal means to afford the foregoing characteristics requires only simple tooling and economical reciprocation motion.

It is an advantage of this invention to provide a basic mechanism which is well adapted for usage in a wide variety of switch types including a low travel type, a sequential type, two pole four circuit snap switch type, and the like.

In the two pole four circuit snap switch mechanism there is a mechanism provided which stores energy during the operation of the switch so as to positively insure simultaneous actuation operation or snap movement of all of the moving contacts to thereby insure against improper switch operation, the means to so provide being simple and economic. More par-

ticularly, the two pole four circuit mechanism provides an energy storing means for storing the initial energy of actuation so that when the switch mechanism resistance of one pair of movable contacts approaches zero, the stored energy in the energy storing means will aid in tripping and insuring positive overcentering of the centering of the second pair of movable contacts to thereby assure simultaneity of action.

It should be noted that the switchblade contact member has an end portion which is deliberately cylindrical, whereby the end portion always presents the same amount of contact gap, no matter what angle the legs portion of the switchblade assumes during its action to thus afford good arc interrupting ability and ability to withstand dielectric breakdown voltage of significant values. An improved method of attaching the ends of the tension spring is provided in the new mechanism by forming a shear form strut structure in the cylindrical end of the formed blade which, in addition to the attachment function performs a strengthening strut action to maintain dimensional stability of the spaced contact surfaces.

The attachment strut means aforesaid takes a minimum of space and is so arranged and proportioned that the spring attaches immediately adjacent to the end of the blade. The strut is deliberately formed with a radius which mates with the rounded cross section of the tension spring to provide good wear characteristics through extreme cycling of the switch without a sawing effect.

Additional advantages of the present invention will be apparent from the following descriptions when taken in connection with the accompanying drawings.

DRAWINGS

FIG. 1 is a top perspective view of a single-pole, double-throw switch utilizing the aforesaid snap action mechanism and common terminal means, said view being approximately actual size of one commercial embodiment;

FIG. 2 is a partial sectional view of the mechanism shown in FIG. 1;

FIG. 3 is a top view along lines 3—3 of FIG. 2;

FIG. 4 is a bottom view along lines 4—4 of FIG. 2 with the terminal extensions removed for clarity;

FIG. 5 is a greatly enlarged internal elevational view partially in section similar in many respects to FIG. 2, but rotated approximately 90° and taken along lines 5—5 of FIG. 6;

FIG. 6 is a sectional view taken along lines 6—6 of FIG. 5;

FIG. 7 is a semidiagrammatic view of a force diagram indicating the geometry of the combination switchblade contact mechanism shown in the foregoing figures;

FIG. 8 is a plan view of the switchblade contact structure in greatly enlarged size, the dotted midportion, portion showing the configuration prior to formation of the curvilinear contact end structure thereon;

FIG. 9 is a side view of the structure shown in FIG. 8 subsequent to the formation of the contact structure;

FIG. 10 is an end view of the contact structure shown in FIG. 9 along lines 10—10 of FIG. 9;

FIG. 11 is a partial elevation and sectional view of the mechanism shown in FIG. 2 with some of the parts removed and with the bottom common terminal means being rotated 45° to give a clear indication of the formation of the common terminal means by the tool shown in FIG. 11A;

FIG. 11A indicates the tool which reciprocally moves to form the resilient strut attachment means on the common terminal means immediately thereabove in FIG. 11;

FIG. 12 is a bottom view of the button shown in FIGS. 2, 3 and 5 for sliding association with the bore in the casing means shown in FIG. 11;

FIG. 13 is a view along lines 13—13 of FIG. 11 indicating the formation of the common terminal means, said common terminal means being rotated approximately 45° from that shown in FIG. 4 for pictorial reasons only;

FIG. 13A is a side view of the tool shown in FIG. 11A;

FIG. 14 is a side elevational view of the upper terminal member along lines 14—14 of FIG. 15 and also shown in FIG. 5;

FIG. 15 is a plan view of the terminal member of FIG. 14;

FIG. 16 is an elevational view, partially in section of an alternate embodiment switch, namely a two pole four circuit switch using the general snap switch mechanism shown in the preceding figures;

FIG. 16A is an isolated plan view of the energy storing rubber donut shaped member usable in mechanisms of the type shown in FIG. 16;

FIG. 17 is an elevational view partially in section of another alternate embodiment of switch mechanism that may be classified as a "low travel" switch mechanism using the combination switchblade and contact means of other mechanisms shown in the earlier figures;

FIG. 18 is a partial sectional view of the flexible, button sealing mechanism, on greatly enlarged scale, utilizing the rolling sleeve principle;

FIG. 18A is a partial sectional view similar to FIG. 18 showing the relationship of the parts in actuated position;

FIG. 18B is a perspective view of the sealing means shown in FIGS. 18 and 18A;

FIG. 19 is a side view along lines 19—19 of FIG. 16;

FIG. 20 is a partial sectional and elevational view of an alternate mechanism which assures positive sequential switching;

FIG. 21 is a side elevational view along lines 21—21 of an alternate embodiment of a push-pull type snap switch mechanism shown in FIG. 22; and

FIG. 22 is a front elevational partial sectional view along lines 22—22 of FIG. 21 showing a push-pull mechanism using the snap mechanism of preceding figures.

Referring now with greater particularity to the drawings, and specifically to FIGS. 1 through 14, 18, 18A and 18B, there is shown a compact precision two circuit snap switch mechanism 10 which broadly comprises a support means 12, movable actuator means 14, combination switchblade and contact means 16, terminal means 18 and sealing means 20.

More particularly, the support means 12 comprises an inner dielectric casing means 22 and an outer protective casing means 24. The inner dielectric casing means is preferably formed of a sturdy plastic such as Bakelite and the like, which has good dielectric strength properties as well as desired mechanical properties of structural strength. The outer protective casing means 24 is preferably formed of metal such as for example aluminum and has an enlarged collar 26 adjacent to the top thereof to provide a shoulder 27 for engagement with a suitable panel, control stick, or other mounting surface.

As can be observed in FIGS. 1, 2 and 5, the switch mechanism 10 has a generally cylindrical shape and the other casing means 24 is generally barrel shaped with sidewalls 28 depending from the collar portion 26 to encase the moving portions of the switch. The bottom of the outer protective casing 24 terminates in an open end portion 30 and the inner dielectric casing means 22 is snugly telescopically disposed therewithin as shall be discussed. On the sidewalls 28, adjacent the collar 26 and shoulder 27 are threads 32 for mounting washers and nuts (not shown) to in turn mount the switch in conventional manner.

The interior of the outer casing means 24 is formed with three concentric bores, namely, the upper smallest bore 34 which mounts the switch actuator means 14, slightly larger counter bore 36 of relatively short axial height which contains the upper sealing means 20 and the large cylindrical bore 38 which forms the main portion of the switch housing per se. A transverse shoulder 40 connects the bores 36 and 38 and provide one surface for mounting the sealing means 20 as shall be described.

The inner dielectric casing means 22 is shown in isolated view in FIG. 11 and is also shown in assembled relation to the outer casing in the various sectional views of FIGS. 2, 5 and 6

and comprises a base portion 42 having upwardly extending cylindrical outer sidewalls 44 which snugly fit in bore 38 and terminate at an open top end portion 46. The base portion 42 has a pair of oppositely disposed through aperture means 48a and 48b for receipt of upper terminals to be further described in detail. The apertures 48a and 48b are generally rectilinear in shape and are symmetrically disposed on opposite sides of the axis of the outer cylindrical walls 44 and quite closely adjacent thereto for maximum mechanical spacing of the terminal members to be inserted therewithin. Another pair of similarly rectilinearly formed lower terminal through apertures 50a and 50b are shown in FIG. 4. (It should be noted that in FIG. 4 the apertures are shown with the upper and lower terminals removed therefrom for purposes of pictorial clarity.) Apertures 50a and 50b are symmetrically oppositely disposed relative to the axis of the walls 44 at maximum spacing to each other and to apertures 48a and 48b. It will be noted that each of the apertures 48a and 48b, 50a and 50b have expanded mid portions 52a, 52b, 52c and 52d for purposes hereinafter described.

As can best be seen in FIG. 11, through upper terminal apertures 48a and 48b become open slots in the side walls 44 of casing means 22 and each respectively have upper portions 54a and 54b which extend from base portion 42 to the open end 46. The radially outwardly portion expanded mid portions 52c and 52d also become open slots 56a and 56b which are coextensive with open slots 54a and 54b as shown.

The base portion 42 is also formed with a small central bore 58 and an enlarged counter bore 60 defining a shoulder 61 therebetween. The operative functions of the bores 58 and 60 and the shoulder 61 shall be described during the description of the common terminal means.

As can best be perceived in FIG. 6, the walls 44 of the internal casing means are not of uniform thickness, the bore 62 forming the main housing being generally ellipsoidal in shape when viewed in cross section. Since the exterior walls 44 are cylindrical, the ellipsoidal bore 62 forming the interior wall of the casing means 22 have thinned down portions 64a and 64b on the major axis of the ellipsoidal interior bore and thickened portions 66a and 66b on the minor axis of the ellipsoidal bore. The thin portions 64a and 64b of the housing, on the major axis of the bore, provide maximum operating space for the combination switchblade and contact means 16. The thickened portions 66a and 66b of the sidewalls, on the minor axis of the bore, provide mechanical strength for mounting the upper terminal means in slots 54a and 54b, the strength in the stock for slots 54a and 54b also being needed in their additional functions as rotation preventing keyways and precision slides for the actuator means 14 as will become apparent. The base portion 42 is formed with a transverse wall surface 68 which becomes the interior bottom wall of the switch mechanism and an outer transverse wall 70. After assembly, the wall 70 and the apertures therein are covered with a thin layer of sealing material or "potted" with suitable epoxy potting compound 198, to provide a sealing of the bottom of the switch.

The actuator means 14 comprises a bottom member 72 formed of a molded dielectric material (preferably Nylon, Delrin or the like) and an elongated metal member 74 in force transmitting relationship thereto. The actuator means also includes a pair of return springs 76 and 78 for returning member 74 and button 72 to their at rest positions shown in FIGS. 2 and 5. The return springs also serve an electrical function as will be described.

The button member 72 may be best perceived by a close examination of FIGS. 2, 5 and 11 and essentially comprises an upper cylindrical exterior portion 80 having a top 82 which is adapted to be manually engaged, cylindrical depending sidewalls having a portion 80 exterior of the housing a portion 84 located interior of casing 24, and an enlarged bottom flange portion 86. A bottom surface 87 of the bottom member is formed with a rectilinear central aperture 88 for receipt of the member 74. There is a C-shaped sink 90 for mold cooling

purposes which may be formed in the bottom surface 87 of the button for effective molding of the button 72. The bottom flange 86 is preferably formed with a shape complimentary to the interior bore 62 of the dielectric internal casing means 22 and, as will be perceived by comparing FIGS. 11 and 6, these shapes are substantially identical. The bottom flange 86 if formed with a pair of oppositely disposed rectilinear key lugs or wings 92a and 92b which are adapted to slide in open casing slots 54a and 54b of the inner casing means 22. It will be noted that the lugs 92a and 92b do not fit into the extensions of the shallow enlarged mid portions, slots 56a and 56b. Thus, a slight space is provided between the outer edges of the wings or lugs 92a and 92b and the radially outwardly walls of the enlarged mid portions 56a and 56b to afford free movement of air or gas within the interior of the sealed switch casing upon actuation of the switch button to thereby prevent any compression or pistonlike action during actuation. The remaining curvilinear portions 94 of the flange 86 closely mate with the sidewalls forming the bore 62 of the casing means 22.

The metal actuating member 74 is generally rectangular in cross section and disposed along the vertical axis of the switch 10 with the long cross-sectional dimension thereof disposed on the minor axis of bore 62. The member 74 has an upper reduced width portion 96 having a top 97 which engages the bottom of the central aperture 88 in the button 72. The actuator 74 has an enlarged mid portion 98 connected to upper portion 96 by a shoulder 104, and a reduced width short bottom portion 100 which fits within the inner and outer concentric springs 76 and 78 as shown in FIGS. 5 and 11. A central, oval-shaped, elongated, transverse aperture 102 is centrally formed in the midportion 98 and extends from the bottom portion 100 upwardly into the narrow upper portion 96. Two pairs of opposed V-shaped notch portions 106 are formed on opposite sides of the aperture 102 and on opposite faces of the mid portion 98 as may be seen in FIGS. 5 and 11. The V-shaped notches 106 serve as pivotal points and as precision locations for the combination switchblade and contact means 16. It will be noted that the shoulder 104 formed between the mid portion 98 and the necked down portion 96 of member 74 is located immediately adjacent to the notches 106, there being only sufficient backup stock above the notches as necessary to prevent distortion of the notches for purposes hereinafter appearing. A lower transverse shoulder 108 if formed on member 74 between bottom portion 100 and midportion 98 and engages the return springs 76 and 78 which bias member 74 and button 72 in an upwardly direction.

The metal actuator member 74 mounts the combination switchblade and contact means 16 and initiates the snap action thereof to afford electrical switching. The combination switchblade and contact means 16 comprises a pair of identical members 109a and 109b and each is preferably formed in a unitary integral manner from relatively sturdy sheet stock in a stamping type of forming operation. The members are preferably formed of distinctly major parts of silver and minor amounts of nickel and magnesium added for purposes of hardness, the preferred proportions being 98 percent silver and the remaining 2 percent being nickel and magnesium added for hardness, such material being available under the trade name Consil of the Handy and Harmon Company in the U.S.A.

As shown in detached view FIGS. 8, 9 and 10, and in assembled view in FIGS. 2, 5 and 6, the combination switchblade and contact means 16 individual members 109a and 109b each have a first end portion 110 comprising a pair of spaced legs 112 and 114, a midportion 116 and a curvilinear second end portion 118. The legs 112 and 114 are spaced apart a dimension D greater than the diameter of a tension spring 120 which passes therebetween as will be perceived in FIGS. 5 and 6. The tension spring 120 is conventionally formed of stainless steel. The combination switchblade and contact means 16 is initially blanked out of strip stock and as shown in FIG. 8, the second end portion 118 is initially flat as shown by dotted lines indicated by the number 122.

A combination strut and attachment means 124 is shear formed in the second end portion 118 as indicated by the dotted parallel lines in the flat end 122. As may be seen in FIG. 8, the shear form strut and attachment portion 126 is deformed from the plane of portion 122 while it is flat prior to the curling of the end to the curvilinear cylindrical shape 118 as shown. Strut attachment 124 is relatively short and stubby and an integral part 126 of the contact means 16 centrally formed in the end 118. As shown, it is formed with a reverse curve portion 131. Portion 131 mates with the end of coil spring 120 for a low wear connection. The attachment strut means 124 has a width dimension at least as great or greater than the cross sectional thickness of the material. For extra long life connection, the portion 131 may be formed in a saddle shaped configuration as shown most clearly in FIG. 9. It will be noted that the deformed portion 126 forms a sturdy separating strut separating upper contact portion 128 and lower contact portion 130 so as to resist any deformation and or flexure of the connecting portion therebetween to maintain dimensional stability and integrity throughout the life of the mechanism. The lower contact surface 130 is located in the same plane as the first portion 110 and the mid portion 116, while contact surface 128 is offset from that plane.

As viewed in top view (see FIGS. 6 and 8), it will be noted that the second end portion 118, particularly at the portion 128 from which forms the upper movable contact, is narrower in width than the outboard edges of the spaced legs 112 and 114. This narrowed end portion 118 allows the entire combination switchblade and contact means 16 to pivot in notches 106 around sharpened edges 132 and have the necessary mechanical clearance to the thin portions 64a of the inner dielectric casing means 22. Stated another way, maximum utilization of space along the major axis of the oval interior of the casing 22 is provided by necking down or narrowing of the width of the second portion 118 of the combination contact and switchblade member. The sharp edges 132 in notches 106 provide precision pivot points.

As aforementioned, the strut means 124 is preferably formed with a reverse curve shape which extends toward said first end portion 110 as viewed in side view in FIG. 9. The center 131 of the strut reverse curve is adjacent the axis of the cylindrical end portion 118 so that the line of action of spring 120 and the point of attachment of spring 120 is substantially in a plane which bisects the area intermediate the spaced contact portions 128 and 130. It will also be noted that the strut attachment means 124 is located in a plane that bisects the area intermediate the spaced legs 112 and 114 for symmetrical balancing of forces caused by tension spring 120.

Due to the relatively short length of strut means 124 (as viewed in side view), the curvilinear contact portions 130 and 128 are provided with a sturdy strut action to maintain dimensional stability therebetween. This maintenance of dimensional stability is important in switching mechanisms where fairly high current loads may be encountered. (When it is remembered that military standard testing referred to in the early portion of this specification requires that a switch of the size approximately shown in FIG. 1 must maintain five overloads of 600 amps, the maintenance of dimensional stability and prevention of arcing upon actuation of the switch is of importance.)

Also of note is that the end portion 118 is deliberately of a generally cylindrical shape as viewed in side view. The axis of the cylindrical end portion 118 is in a plane parallel to the plane of the flat first portion 110 and midportion 116. This is advantageous in tooling and in forming of the part and provided electrical advantages as will be explained hereinafter. The curvilinear strut means 124 is located outwardly or away from pivotal sharpened edge 132 a greater dimension than the upper and lower contact portions 128 and 130 are spaced from said pivotal edge. The force diagrams involved and the advantages of this configuration which provides a second class leveraging system will be set forth in more detail in the description of the operation of the mechanism.

It will be noted that in the instant embodiment of switch, the tension spring 120 passes through aperture 120 in member 74 so as to mount the pair of opposed combination switchblade and contact members 109a and 109b in the opposing V-shaped notches 106. It will be further noted that the individual combination switchblade and contact members 109a and 109b are rather stubby and ruggedly formed so as to be rigid and without flexure to any measurable degree.

The opposed members 109a and 109b forming the combination switchblade and contact means 16 are adapted to have the contact portions thereon be snapped between opposed fixed contact portions on upper terminal members 134 and lower terminal members 136. It will be noted that each of the oppositely disposed symmetrical upper terminal members 134 are identical in configuration and they are respectively disposed in casing slots 54a and 54b and through apertures 50a, 50b of the casing means 22. The upper terminal members 134 are shown in detached relation in FIGS. 14 and 15 and in assembled relation in FIGS. 1, 2, 5 and 6 with each having a main portion 138 which terminates in outer exterior portion 142. The terminal members 136 are inserted in the through apertures 50a and 50b until stop mounting lugs 140 engage base casing surface 68 to correctly position the terminal members in the vertical position in the slots as shown. Adjacent the outer exterior ends of the terminal members 134 are through transverse apertures 144 which preferably are threaded for mounting there circuitry. Since there are minute burrs that occur in a threading operation, the slots and apertures 50a, 50b, 54a, and 54b are formed with the aforementioned expanded mid portions 56a, 56b, 52c and 52d so that any slight burrs formed in the threading operation on the terminals do not skive the plastic casing or break off so as to cause contaminating small particles interiorly of the switch during assembly, further the expanded mid portions afford a good flow of potting compound for positive sealing of the terminals and the case 22.

The upper portions of the terminal members 134 are formed with an offset transverse portion 146 having a depending fixed contact 148 thereon. The contact 148 is preferably made of electrical grade silver for its good contact and conducting properties, the remaining portion of member 146 being composed of silver coated brass or the like (to form the entire terminal member of the same composition as the combination contact and switchblade members 109a and 109b of FIGS. 8, 9 and 10 is uneconomic). It will be noted that the junction between upper transverse portion 146 and the depending portion 138 is necked down at 150 and, as may be seen in FIG. 6, as a lesser cross-sectional dimension. This reduced dimension of transverse portion 146 affords necessary electrical clearance between upper portion 96 of actuation member 74 within the restricted requirements on space interiorly of the switch as may be best perceived in FIG. 6. It will also be observed that shoulder 104 on actuation member 74 is located immediately adjacent to the notches 106 so as to preserve vertical electrical clearance from the underside of transverse portions 146 of the upper terminal means when movable switch blade members are in their at rest position in engagement with the lower terminal members 136 and actuation member 74 is in its uppermost position.

A pair of substantially identical lower terminal members 136 are assembled to provide the lower fixed contacts of the switch. Each of the lower terminal members 136 (see FIG. 5) are formed with a C-shaped upper portion having a midvertical portion 152, a lower shoulder transverse portion 154 on an upper transverse portion 156. As shown, transverse portion 156 is generally parallel with portion 154 and forms the lower fixed contact portion for electrical contact engagement with contact portion 130 of the movable contact members 109a and 109b. Lower shoulder 154 engages casing surface 68 to provide vertical stability in mounting the lower terminal means. An exterior depending portion 162 of the lower terminal means is essentially similar in length and configuration with portion 142 of the upper terminal members and also

formed with a through threaded aperture 160 similar to threaded aperture 144. The opposed lower terminal members 136 are each respectively disposed in slots 52a and 52b as shown in FIG. 5 and fixed contact portions 156 are vertically below and in direct opposition to upper depending contact portions 148 of the upper terminal members. It will be noted that each of the lower terminal members 136, as best shown in FIG. 5, are preferably formed of a bimetal, approximately one-third portion 162 being silver, the other two-thirds of the bimetal being identified with a numeral 164 preferably being of good electrical grade brass which may be coated with a nontarnishing silver-type coating if desired. It will be observed that the fixed contact surface 156, is deliberately composed of the one-third portion 162 of the bimetal of the lower terminal means which is comprised of silver.

The base portion 42 of the interior casing means 22 centrally mounts a common terminal means 166 (see FIGS. 4, 5, 11, 11A, 13 and 13A). The common terminal means 166 is generally cylindrical in configuration having a top surface 174, an enlarged head 170, and side walls 168 depending from the enlarged head 170. The head 170 and the side walls 168 define a transverse shoulder 172 for engagement with counterbore shoulder 61 in the casing base 42. A central bore 176 is formed in the common terminal means 166 from the end 180 which is remote from the headed portion 170. The bore 176 does not extend all the way through member 166 and thus the bottom and the inner walls thereof forms a central depression or "pot." A pair of combination attachment and resilient strut means 178 are formed from the material of the sidewalls 168. It will be noted that the strut means 178 are symmetrically disposed on opposite sides of the axis of the bore 176 and while this is preferred for simple tooling it is possible in some applications to have three or four struts formed. However, when more than two struts are formed, the struts, and the slots so formed would preferably be of lesser width to preserve the integrity and stability of the remaining upstanding portions 180 and 181. The movement of material from the side walls to form the attachment and strut means 178 performs the dual function of in situ mounting of the common terminal means 166 to the casing 22 and also the movement of the material from the sidewalls forms the openings 183 and 184 in an open sided solder "pot." The "pot" is defined by bore 176 and the remaining upstanding curvilinear portions 180 and 181 of the side walls 168. As will be seen, opposed openings 183 and 184 are axially aligned, relatively narrow, and of lesser length than bore 176. The openings 183 and 184 allow the escape of gas and contaminants from the "pot" during the later soldering of a lead wire to the common terminal means while the walls or extension 180 and 181 confine the solder to the relatively small space immediately adjacent to the terminal means to afford good electrical clearance to other parts of the switch.

As shown, the resilient strut attachment means 178 are integral deformed portions of the sidewalls 168 which have one end remaining attached thereto after formation thereof. The strut means 178 are formed by the reciprocal movement of tool 186. (It will be perceived that the mounting occurs after placement of a nondeformed common terminal means in bore 58 of the internal casing means 22, fixing the head 170 against movement and then relatively moving the tool 186 and the common terminal means.)

The tool 186 shown in FIGS. 11A and 13A has a central locating portion 188 which extends beyond the wall cutting and deforming portions 190 and 192. As the tool 186 and terminal means 166 are moved toward each other, the engagement of sharp edges of portions 190 and 192 upon the end walls 186 defined by bore 176 of the terminal member sidewalls 168 form the oppositely disposed strut means 178. The engagement of the end walls 186 with portions 190 and 192 causes outward deformation of the sidewalls which continue to move and assume the curvilinear shape shown. It will be noted that each of the strut means 178 is formed so that it extends radially outwardly away from the sidewalls at 194 and then back inwardly toward the sidewalls as shown at 196. De-

pending on the length of stroke of tool 186, the strut in formation thereof, will spirally curl within itself while maintaining a mounting engagement to the mounting surface. Reflection will show that the length of slots 183 and 184 will always have a dimension, as measured from end 186, which is greater than one-half of the distance from end 186 to the mounting surface (such as switch casing bottom surface 70.) The dimension which the strut extends outwardly from the sidewalls is a function of the slope of surfaces 190 and reverse surface 191 and the complimentary surfaces 192 and 193 which determine the diameter of the curl or spiral formed. Some resiliency is imparted to the construction of the strut means 178 since it is not "squashed flat" against the surface 70 and the free end of the strut member is predisposed to further curling. This slight resiliency is advantageous in preventing cracking or extreme stressing of the plastic cases to which it may be mounted, such as inner casing 22. As will be apparent, this structure of common terminal means and the method of mounting same affords an accommodation to a wide variance in thickness between counterbore surface 61 and end surface 70 of the base portion 42.

It will be noted that it is possible to have one size of common terminal member usable for a variety of different switch constructions wherein the mounting thickness varies from switch to switch. By merely having a fixture which causes head portion 172 to be firmly supported, the common terminal means is easily mounted in situs.

The configuration of the end of the forming tool 186 as aforesaid, causes the deformed material of the sidewalls to roll back within itself, a particularly useful feature for small mechanisms where electrical clearance with other terminals is a problem. As will be observed in FIG. 4, the resilient wing or strut means 178 for the common terminal means 166 are so disposed and located on surface 70 so as to bisect the area intermediate the external extensions 142 and 158 of the upper and lower terminal members 134 and 136. The curling within themselves of the individual struts, as shown at 196, uses a minimum amount of space and maintenance of dielectric spacing to the other terminals is obtained.

As seen in the drawings, the top 174 of the head portion 170 of the common terminal means 166 mechanically and electrically engages each of springs 76 and 78, each of said springs in turn mechanically and electrically engage transverse shoulder 108 on actuator member 74. Since metal member 74 mounts the movable contact and switchblade means 16, electrical contact to the upper and lower contact terminals is provided through members 109a and 109b. The springs 76 and 78 have different "hands" to prevent interlocking between the two springs. The inner spring 76 is preferably made of stainless steel to provide the mechanical strength needed for return action and mechanical resistance to shock and vibration. The outer spring 78 is preferably made of a silver, magnesium and nickel alloy of the type aforesaid relative to the movable contact members 109a and 109b. Spring 78 may be formed of beryllium copper in some applications. The primary function of the outer spring 78 is electrical current carrying capacity and it is larger than the inner spring 76 not only in diameter of the coil but in diameter of wire size.

The upper end of the switch casing is sealed by a rubber boot 200 which has an initial shape somewhat similar to a hat as shown in FIG. 18B. The hat-shaped boot 200 is sealingly trapped between shoulder 40 and the top 46 of internal casing member 22, there being a washer 212 between, as shall be described.

More particularly, the hat shaped member 200 is formed with a laterally extending flange portion 204, upstanding walls 210, a laterally inwardly extending top portion 206 terminating in a central aperture 209. The nonstretched diameter of aperture 209 is less than the outer diameter of the button 72. The margin of the boot immediately surrounding the aperture 210 is designated with the numeral 208. The hat shaped member 200 is assembled to the button 72 by forcing the latter through the aperture 209. Circumferential pressure thus

created provides a seal between the boot member or sleeve member 200 and the button 72 preventing ingress and egress of moisture and other contaminants. After initial assembly, the end portion 209 and the margin 208 immediately surrounding same are placed at the inverted relationship to the button shown in FIGS. 5, 18 and 18A, this inversion being accomplished by moving a small tube of approximately the same ID as the OD of the button walls 84 into engagement with walls or margin 208 surrounding the aperture 209 of the boot causing the end portion to turn downwardly towards the button flange 86 as shown. The subassembly thus created is then assembled into the bores 36 and 44 of the outer casing as shown in FIGS. 5 and 18. Sealing compression on flange 204 is provided by the top 46 of the inner casing 22 through the washer 212.

The sleeve or boot member is preferably made of silicone rubber material having low structural integrity (almost limp). As shown in FIGS. 18 and 18A, the movement of the button downwardly causes a rolling sleeve action wherein portion 208 moves with the button walls 84 causing more and more of portion 206 of the boot to move therewith. This rolling sleeve action requires very minute force and thus very low actuating pressures to overcome the very low resistance involved. The silicone rubber maintains its limpsness over large ambient temperature ranges and this, together with the rolling sleeve principle affords constant and repeatable trip point values.

When all of the aforesaid and described parts are placed in assembled position as shown in FIGS. 2 and 5, the bottom portion of the casing is preferably covered with an epoxy potting compound for sealing of the lower end of the switch. It is preferred that the electrical grade epoxies of the thermo setting variety be used.

Attention is now invited to the free body force diagram shown in FIG. 7. In particular, attention is invited to the illustrated dimensions A, B and C. Dimension A is the distance between the end 132 and the contact surface, said dimension being the same for both the lower contact surface 130 and the upper contact surface 128 when either of said contact surface 130 and the upper contact surface 128 when either of said contact surfaces are in contact with the lower and upper respective fixed contacts 156 and 148. Dimension B is the dimension between the end 132 of the point of attachment of the ends of spring 120 to the attachment strut means 124. Dimension C is the amount of overcenter movement from the dead center position to the at rest position for the particular geometry of parts shown. T is the line of action of the tension force of spring 120, and Fv is the line of force of the actuation means 14. Fc is the force on the contacts portions 128 and 130.

As aforesaid, in prior art switches, particularly of the butterfly type, the prior art contact means generally so dominates the mechanism that it has become a limiting factor in small models. This lack of room for efficient contact means in truly small prior art mechanisms gives rise to insufficient length for necessary mechanism geometry to perform the snap action function; and insufficient space for adequately strong and long lived tension spring members such as spring 120. The particular geometry of the mechanism of the combination switchblade and contact means 16 shown in FIG. 7 provides a second class leveraging system since dimension B is greater than dimension A. Stated another way, the contact force Fc is subject to the mechanical advantage provided by the tension spring 120 with force T working through the lever arm B. The contact force Fc on both members 109a and 109b is greater than the vertical force component provided by spring 120.

It will be observed that the tension T provided by spring 12 provides a very effective powering of the snap mechanism and also provides the contact force when the parts are at rest. The tension provided by spring 120 provides a long throw or moment to the movable members 109a and 109b. The ratio of B to A as shown in FIG. 7, compares the length of the lever arm B associated with the overcentering force, to the length of the lever arm A of the contact force and thus it is the ratio of the

moments of these two forces. It will be noted that B is greater than A and thus is greater than unity and as aforesaid it is this ratio as applied to the tension T of spring 120 which produces contact force.

The ration B/A also has application to the distance that the tension spring 120 throws the movable snap switch contact members over center on actuation of the switch. It provides a large "throw" so as to provide good definite snap action. In this regard it will be noted that the distance C is the distance the pivot point at 106 moves under force Fv so as to provide overcentering. In small mechanisms, it is desirable to have the overcentering movement C of the line of action of the tension force T be as large as possible since due to the large movement C, you get a good definite snap action. Since the construction described provides good sufficient movement in the vertical plane (the dimension C), thereby it assures no double clicking and good simultaneity. (Simultaneity in small switches is that aspect of assuring that when one side of the switch mechanism 109a for example goes over center, the other side 109b will also go over center. There is a large movement differential involved in this mechanism which is a function of dimension C and thereby dead centering is eliminated.)

In the instant mechanism 10, due the greatly increased leverage, the space to have a meaningful sized tension spring, and better switch geometry above referred to, an amazing amount of contact force between contact surfaces such as 156 and 130 is possible for the at rest positions of the movable contact members 109a and 109b. This increased contact force confers good snap cation manual "feed" and also gives a very low value of contact resistance. In many applications of manually actuated switches, it is important to the operator to "know" form a tactile sense, that the switch has snapped over-center. It will be appreciated that contact force initially resists the snapping over center upon actuation of the switch button 72, thus, the change from high values in contact pressure during reversal is dramatic and confers the requisite "feel."

In small switches of the size shown in FIG. 1 (i.e., casing 24 having a length of approximately 0.90 inches and an OD of 0.562 inches), consistent contact resistance capabilities below 4 milliohms in switches which meet the above referred to military specs have been obtained. In prior devices 20 milliohms resistance has been considered good, and this reduction is a very significant 80 percent reduction over all known prior art devices. This reduction of contact resistance to the low values is significant in problems of "flicker" in switches. Heretofore, a fairly high percentage of switches would "flicker" when subjected to vibration, acceleration, etc., but with the high force produced by this mechanism, contact flicker is no longer a problem and there is great reliability on contact make.

It has been previously referred to that as viewed from the side, the end portion 118 of the movable contact means 16 is a portion of a cylinder. This portion 118 thus presents, due to its configuration the same amount of contact gap to fixed contacts 148 and 156 no matter what angle the legs 112 and 114 assume during the movement of member 74. With the usual oval faced contacts of the prior art devices, there is an angular bridging action which reduces the effective contact gap or electrical clearance which has disadvantage in both arc interrupting ability and on the dielectric breakdown voltage which may be sustained by the mechanism.

Further, it has been found that the cylindrical contact surface apparently helps in obtaining reliability of contact closure in switches of the type hereinabove described. It is thought that the curvilinear upper and lower contact surfaces 128 and 130 each make line contact with the respective flat fixed upper and lower contacts 148 and 156, at least in theory. In practice, it is believed that due to extremely minute surface irregularities, contact is made at two points on the line. This gives the effect of bifurcated contacts providing parallel current paths with greatly increased probability of contact closure despite the presence of extremely minute contamination. The radius of the contact surface is much smaller for the cylinder on the end 118 than is typical with oval contacts used

heretofore. Typically, for switches of the size described, the radius for the cylinder end 118 is on the order of 0.050 inches compared to 0.125 inches for the conventional oval contact face. This sharper radius on the contact surfaces 128 and 130 increases unit contact pressure and decreases the probability of a contaminant blocking contact closure. This obtains because a particle of a given size—say for example 0.001 inches—is effective over only a small area where it can provide intervention. The probability of closure is thus greatly increased by each of these mechanisms. Taking together the result is extremely good contact reliability.

The butterfly operation of the switch 10 is relatively simple and straight forward. Movement downwardly of the actuator means button 72 causes member 74 to move downwardly against the bias of springs 76 and 78. The movable bridging contact and attachment means 16, being restrained by fixed lower contact surfaces 156, remain in contact therewith until pivot points 106 pass the line of action (center line) of spring 120. The movable contact members then snap overcenter and upper contact surfaces 130 engage upper contacts 148 until such time as release of finger or other mechanical pressure on the top of button 72 causes springs 76 and 78 to return the parts to the position shown in FIG. 5. As the member returns past the center line of spring 120, the movable switchblade members 109a and 109b snap over center again in reverse.

From the foregoing description, it is apparent that a switch mechanism above-described is spring return switch. That is to say that the springs 76 and 78 return the parts to the at rest position shown in FIG. 5 so that a circuit is completed between the two lower contacts (and also through the common terminal means if so desired). This general type of switch is sometimes called a "momentary" switch. Also, it will be noted that the upper pair of contacts 148 are bridged only when the button 72 is held down.

If the springs 76 and 78 are omitted, a push-pull type of switch may be formed as is shown somewhat semidiagrammatically in FIGS. 21 and 22 where similar parts are identified with similar numerals with the addition of the prefix a and with new parts being identified without a prefix. The essential distinctions in this mechanism a10 are no return springs, the switch casing or support means a12 is rectilinear with the terminals a134 and a136 shown coming out of the casing generally transverse of line of actuation movement of the button and a sliding contact means is provided for maintaining contact between the common terminal means and the actuator a74. Movement of the button a72 to a downwardly position will cause members a109a and a109b to retain reversed position until button a72 is moved upwardly. As shown, the button 172 is formed with a narrowed waist 220 to facilitate the "pull" in reversing the switch. The common terminal means a166 has a modified head structure to accommodate to a sliding contact to the end a100 of member a74. More particularly, a cylindrical upstanding portion 222 is bifurcated to form upstand portions 224 and 226 having sliding contact surfaces 228 and 230 which maintain constant contact with member a74. The switch a10 of the type shown in FIG. 22, when manually operated in either direction, will remain actuated until a succeeding actuation in the opposite direction. Also, the restoring force may be supplied by a return button (not shown) of insulating material in place of common terminal a166. Also, a conducting spring of low force (not shown) may be used to give good continuity during sliding of a100 against 228 and 230 if desired.

The particular embodiments of this invention heretofore and hereafter shown and described will be understood as being illustrative only. Various changes in structure will occur to those skilled in the art and are to be understood as forming a part of my invention insofar as they fall within the spirit and scope of the claims. As has been generally alluded to heretofore, the principles of this invention may be applied equally well to a two pole four circuit switch. Such a switch b10 is shown in FIGS. 16 and 19 wherein similar parts are identified with similar reference numerals with the addition of the prefix

b and where only new parts are identified with reference numbers without a prefix. It will be appreciated that FIG. 16 is semidiagrammatic representation and in principles of operation, there is a general similarity to aforesaid switches *a10* and *10*. The construction shown in FIG. 16 is not shown with a common terminal means, however, if it is so desired, a common terminal means may be connected so as to be electrically connected to only the lower set of bridging contact means *b16b* without modification of other structure. Also, a restoring button (not shown) similar to *a72* may be used instead of return springs *b78* and *b76* if a push-pull type is desired.

The actuator *b74* is formed with an insulating section *240* which prevents electrical interconnection between the upper bridging contact means *b16a* and lower bridging contact means *b16b*. Of particular interest in the construction shown in FIG. 16 is the unique energy storing means *236* which stores energy during the early part of actuation and releases this energy to assure simultaneously of both sets of movable contact means *b16a* and *b16b*. More particularly, the energy storing means comprises a rubber donut shaped member *236* which is trapped in a counterbore *234* in the underside of the button means *b72* by a washer *238* said washer in turn engaging a shoulder *b104* on actuator member *b74*. It will be noted that there is clearance intermediate the top *b97* of the metal actuator member *b74* and the bottom of guide bore *b88* in the button whereby the force transmission from the button to the actuator member *74* is only through compression of the energy storing rubber donut member *236*. As the donut *236* is further and further compressed, it reaches a point where force from the button is transmitted to the actuator member *74* moving same downwardly against the springs *b76* and *b78*. As one of the two sets of bridging contact members has the line of action of the springs *b120* come to dead center, the other spring member and bridging contact member is, due to the construction, also very close to the dead center position. As the first bridging contact means goes over center, the energy stored by the compression in the energy storing donut *236*, aids in assuring that the second bridging contacts also reverse since the stored energy plus the sudden loss in resistance causes a sudden downward movement of the actuator member *b74* in turn causing the other member to quickly pass over-center. This assures good simultaneity and impossibility of double clicking. It is possible to have a suitable helical coil spring substituted for donut *236*.

A low travel switch mechanism *c10* is shown in FIG. 17 in somewhat semidiagrammatical form. Similar parts are identified with similar reference numbers with the addition of the prefix *c* and different parts have new reference numbers without the addition of a prefix.

The switch *c10* essentially comprises a support means *c12* actuator means *c14*, combination contact and switchable means *c16*, for movement between contacts on terminal means *c18*, there being sealing means *c20* for keeping contaminants from the interior of the casing formed by upper and lower portions *242* and *244*, respectively. Casing portions *242* and *244* mounting support bracket means *246* having a base portion *252* interconnecting spaced upstanding portions *248* and *250* and having an external common terminal *254*. Portion *248* is formed with a mid aperture (not shown) and the top thereof on opposite sides of the mid aperture is formed with V-notches *c106* to mount the combination contact and switchblade means *c16*. Portion *250* adjacent the top thereof is formed with a shear form attachment means *256* in opposition to the attachment means *c124*.

One end of spring *c120* is attached to attachment *256* and the other to strut attachment means *c124*. The bottom *258* of button *c72* is located relative to the casing so as to impinge upon spring *c120* at *260* which is a point intermediate attachment part *256* and the pivot point *c106*. It will be noted that a plane connecting point *256* and notches *c106* is below a plane connecting points *256* and *c124* and thus, the at rest position of the parts puts contact surface *c128* in engagement with upper terminal means *c134* fixed contact *c148*.

The switch mechanism *c10* is different in certain respects from the earlier described switches and in a sense it is a one-half butterfly switch since only one "wing" moves. It will be noted that switch *c10* does not involve a movable metal actuator member having a pair of bridging members pivoting thereon. Rather, the button member *c72* is disposed so that its end portion *258* engages portion *260* of the tension spring which causes the line of action of the spring *c120* to move past the plane connecting pivot point *106a* and attachment point *256*. This causes the movable contact means *c16* to snap over center. One advantage of this "low travel" mechanism being that the aforesaid second class lever is provided for the movable contact means *c16* which affords good stability, high contact pressure and precision actuation even though very small movements for actuation are involved. The movement differential for the button is very slight in mechanisms of the type shown in FIG. 17 and in this sense it differs dramatically from the other figures. The amount of actuation movement required, is a function of where the button end *258* and engagement point *260* on spring *c120* is located. The further point *260* is spaced from fixed pivot point *256* the greater the movement differential or more "travel" required by button *c72* and of course the converse obtains.

A sequential mechanism is shown in FIG. 20, said figure being in a semidiagrammatic form. The disposition of the parts is similar to that shown in switches *10* and *a10*, and similar parts will be identified with the same reference numerals using the prefix *d*. The essential difference between the mechanisms shown is that the upper and lower terminal means are in offset relationship in the vertical plane. Note that terminal *266* and contact *267* thereon are closer to lower terminal *d136* as compared to upper terminal *d134*. This method of construction insures that switching occurs between circuits involved with the common terminal means *d166* and the movable contact on member *109a* and fixed upper contact *216* on the right side of FIG. 20, prior to switching occurring on the left side, i.e., with movable member *d109b* making contact with the fixed contact on terminal *270*. Also, terminal *d136A* (on the left) may be disposed lower than *d136* (on the right) so as to accentuate the time delay between halves of the butterfly. Consistent sequencing times (depending on spacing) of 0.0005 to 0.002 seconds have been obtained. Thus, positive sequentially is obtained without denegrating the other advantages of the aforesaid switches.

It has also been found that the combination contact and switchable means shown in all of the embodiments may be formed from a bimetal composed of a silver layer and a brass or phosphor bronze layer, although it is preferred that care should be exercised to see that the contact portions such as *128* and *130* are of the silver portion of the bimetal.

I claim:

1. A unitary combination switchblade and contact means for compact snap switch mechanisms comprising a member characterized as being

- a. of one-piece and being formed solely from a single piece of material,
- b. being electrically conductive,
- c. formed with first and second spaced end portions interconnected by a mid-portion,
- d. said first end portion being characterized as
 - i. having spaced leg portions,
 - ii. each said spaced leg portion having a low friction pivotal edge portion,
- e. said second end portion being formed in a predetermined shape
 - i. generally curvilinear as viewed in a direction transverse to a plane including a portion of said first end portion and said second end portion,
 - ii. said predetermined shape on said second end portion having upper and lower curvilinear contact portions located in spaced relation to each other on said curvilinear shape and spaced from each other,

- iii. said predetermined shape second end portion having an attachment means portion formed from said curvilinear shape in alignment with said plane including a portion of said first end portion and said second end portion, said plane extending between said upper and lower spaced contact portions,
- f. said attachment means portion being spaced from said edge portions a distance at least as great as each of said upper and lower curvilinear contact means portions are spaced from said edge portions, whereby said contact means when pivoted about said edge portions by a biasing force associated with said attachment means and extending intermediate said spaced leg portions and along said plane provides a second class lever for pivotal movement around said edge portions.
2. The switchblade and contact means set forth in claim 1 composed of distinctly major portions of silver with minor portions of magnesium and nickel added for hardness wherein said first end portion and said midportion are located in a plane which angularly intersects a second plane interconnecting said attachment means and said edge portion.
3. The switchblade and contact means set forth in claim 1 wherein said curvilinear second end portion is of generally cylindrical shape to provide contact portions on the periphery thereof, the axis of said cylindrical shape being in a plane generally parallel to a plane connecting said first end portion and midportion, said attachment means being a deformed portion of said cylindrical shape and being disposed generally transversally to said axis of said cylindrical shape.
4. The switchblade contact means of claim 3 wherein said member is stampingly formed from flat strip stock to provide a flat first and midportion, said second portion being curved back toward said midportion, said deformed portion of said cylindrical shape forming said attachment means also providing a strut action to maintain dimensional stability between said spaced contact portions.
5. The switchblade contact means of claim 4 wherein said deformed portion of said cylindrical-shaped second end portion forming said attachment means and providing said strut action is further characterized as being:
- located in a plane that substantially bisects the area intermediate said spaced leg portions, and
 - is of a curvilinear shape reversely curved from the cylindrical shape of said second end portion and toward said first end portion, whereby the pivotal attachment of an end of a biasing coil spring to said attachment means will withstand a great number of mechanical actuations of said switchblade with precision and without damage to the spring or the attachment means.
6. A compact switch mechanism comprising support means, actuator means movable mounted relative to said support means for movement in a first plane from a first position to a second position, spring means, and combination switchblade and contact means pivotally mounted generally transversally of said first plane for movement between A and B positions, said combination switchblade and contact means comprising a combination switchblade and contact member characterized as:
- a unitary one-piece formed metal member having first and second spaced end portions connected by a midportion,
 - said first end portion comprising spaced leg means having means for affording pivotal movement relative to said support means,
 - said spring means being a tension coil spring of a diameter less than the space between said spaced leg means extending between said spaced leg means,
 - said second end portion comprising,
 - curvilinear spaced upper and lower contact portions, and
 - attachment means for said spring means, said attachment means being located in a plane which extends from said means affording pivotal movement relative to

said support means and an area intermediate said upper and lower spaced contact portions, said attachment means being located outwardly of said means affording pivotal movement relative to said support means a distance greater than the distance between said means affording pivotal movement relative to said support means and said spaced contact portions, said attachment means affording a pivotal connection to said spring means, whereby movement of said actuator means in said first plane from said first to said second position causes said combination switchblade and contact means to pivotally move from said A position to said B position with a snap action, to provide low bounce of said curvilinear contact portions upon attainment of said B position, and to provide a tendency of maintenance of said curvilinear contact portions in said B position with high vibrational, shock, and acceleration stability until said actuator means returns to said first position.

7. The compact snap switch mechanism of claim 6 wherein said support means comprises a generally cylindrical shaped casing means having a central actuator means receiving bore, said actuator means comprises an elongated metal member movable along the axis of the bore of said cylindrical casing means, and button means, said button means having an exterior portion and an interior portion located within said bore of said casing means, said button means being in rotation preventing relationship with said bore in said casing and being in force transmitting, rotation preventing, relationship to said elongated metal member, said elongated metal member having notch means and a through aperture located intermediate the ends thereof, bias spring means associated with the end of said actuator means opposite from said button means for returning said actuator means from its second to its first position, upper and lower terminal means respectively having fixed contact portions located adjacent to said B and A positions of said combination switchblade and contact means, said terminal means having exterior portions extending beyond said casing means for connection to electrical circuitry, whereby movement of said button means causes said actuator member to move said combination switchblade and contact member from engagement with lower terminal contact portion to engagement with said upper terminal member contact portion.

8. The mechanism set forth in claim 7 wherein said cylindrical casting means comprises an inner dielectric casing member and an outer protective member, said inner casing member having generally cylindrical outer sidewalls and a closed end of said inner casing member having four equally spaced through apertures located closely adjacent the plane of said sidewall and a central through internally counter-bored aperture, a pair of each of said upper and lower terminal members being disposed in said four spaced apertures, electrically conductive common terminal means disposed in said central counterbored aperture, said common terminal means having a closed, enlarged, head portion engaging the margin surrounding said counter bore and an exterior end portion, said exterior end portion having bore means and resilient attachment strut means deformed outwardly from said exterior end portion, said attachment strut means being disposed in a plane substantially bisecting the area between the exterior portions of said upper and lower terminal means disposed in said four spaced apertures, said coil spring biasing means having first and second ends, said first end being disposed in biasing force transmitting and in electrical current transmitting engagement with said closed head portion of said common terminal means and said second end being disposed in force transmitting and electrical current transmitting engagement with said elongated metal actuating member, said coil spring biasing means comprising inner and outer concentric springs of similar length and different diameters, said inner and outer springs each having a different hand which prevents interlocking along the inner surface of the outer spring and the outer sur-

face of the inner spring, whereby an electrical circuit may be switched from said common terminal means and said pair of lower terminals to said pair of upper terminals through said biasing coil spring means, elongated metal actuator and combination switchblade and contact means.

9. The switch mechanism of claim 7 wherein said casing means is formed with an internal shoulder means adjacent said actuator means receiving bore, and low force rolling sleeve sealing means is disposed intermediate said casing means and said button means, said rolling sleeve sealing means comprising a flexible hat shaped member having a cylindrical sidewall portion, an axially outwardly radially enlarged margin adjacent the bottom of the sidewall portion sealingly, fixed disposed adjacent to said casing means internal shoulder means, and a top portion being centrally apertured and extending initially toward the axis of the sidewalls, said sidewalls being substantially uniform, flexible and sealingly connecting said top portion and said enlarged margin, the margin surrounding said central aperture in said top portion being radially stretched and resiliently sealingly engaging said button means for movement therewith, said top portion moving toward said enlarged margin with actuation of said button causing said thin flexible sidewalls to rollingly fold within themselves at a uniform constant low resistance while maintaining a seal between said casing means and said button.

10. The mechanism set forth in claim 7 wherein said cylindrically shaped casing means is formed of dielectric material and said central bore is generally ellipsoidal in cross section having a major and minor axis, said casing bore having axially aligned oppositely disposed slot means formed in the margins of said casing means bore, said slot means being located on the minor axis of said ellipsoidal casing bore, said upper terminal means for said mechanism comprising an elongated portion and an angularly offset portion having a fixed contact portion, said elongated portion of said terminal means being disposed in said slot means with the fixed contact portion being disposed on said major axis of said ellipsoidal casing bore, said button means of said mechanism having a radially enlarged margin portion with a shape complimentary to the shape of said casing bore means, said enlarged margin portion being formed with radially extending portions slidably fitting into said slot means, whereby said slot means serves as a keyway preventing rotation of said button and said actuator means and mounts said upper terminal means.

11. The mechanism set forth in claim 8 wherein said four equal spaced terminal receiving through apertures in said casing means are each generally of a cross-sectional shape complimentary to the shape of the individual said upper and lower terminal means, each of said through apertures having oppositely disposed enlarged midportions, at least one individual terminal member of said upper and lower terminal members having a transverse threaded bore, said threaded bore of said terminal member being aligned with said casing aperture enlarged midportion, whereby any burrs on said terminal members associated with or formed in the threading of said threaded bores may pass freely through said enlarged midportions without skiving of the margins of said dielectric casing material, the said lower terminal means of said mechanism being disposed in an oppositely disposed pair of said through apertures, each of said lower contact members having a fixed contact portion for electrical contact with said combination switchblade and contact means, said lower terminal means being generally bimetallic first and second members throughout the length thereof, said first member being substantially one-third of the lower terminal means, an extremely good electrical conductor, and forming the fixed contact portion of the lower terminal means.

12. The mechanism set forth in claim 6 which assures sequential switching wherein a pair of combination switchblade and contact means are disposed in pivotally mounted opposed relation on said actuator means for simultaneous movement between said A and B positions, said mechanism having a pair of upper terminal means, a common

terminal means electrically connected to said actuator means, and a pair of lower terminal means, each of said lower terminal means having a fixed contact portion located generally transverse to said actuator means and adjacent said A position of said combination switchblade and contact means, said upper terminal means having fixed contact portions in staggered transverse relationship vertically above individual contact portions of said lower terminal means, on of said upper terminal means fixed contact portions being disposed closer to said lower terminal means fixed contact portions than the other of said upper fixed contact portions, whereby movement of said actuator means from its first to its second position causes one of said pair of combination switchblade and contact means to make mechanical and electrical contact with said one fixed contact portion of said upper terminal means before the other of said pair of combination switchblade and contact means makes mechanical and electrical contact with said other fixed contact portion of said upper terminal means whereby a sequential switching action is assured.

13. The switch mechanism set forth in claim 6 characterized as a low travel mechanism wherein said tension coil spring has first and second spaced ends, said actuator means comprises button means having an exterior portion and a spring means engaging portion, said spring means engaging portion engaging said tension coil spring at a point along the length thereof intermediate said spaced first and second ends, said support means comprises bracket means having first and second spaced upstanding portions and a terminal portion, said first portion being formed with through aperture means and notch means adjacent said aperture means, said aperture means receiving said tension coil spring and said notch means pivotally receiving said spaced leg means of said combination switchblade and contact member, said second upstanding portion being formed with a bracket spring attachment pivot point means for pivotal connecting receipt of said second end of said tension coil spring, said first end of said tension coil spring being attached to said attachment strut means of said combination switchblade and contact member for movement with and for pivotal movement to said combination switchblade and contact member, whereby deformation of said tension coil spring by said spring means engaging portion of said actuator means causes snap action movement of said combination switchblade and contact means.

14. The switch mechanism set forth in claim 13 wherein said tension coil spring is the sole biasing force in biasing said combination switchblade contact means to said A position, exterior pressure on said exterior portion of said button means causes deformation of said tension coil spring which in turn causes movement of said combination switchblade and contact means from said A to said B position and release of pressure on said exterior portion of said button means causes said combination switchblade and contact member to return to said A position solely under the bias of said tension coil spring.

15. The switch mechanism set forth in claim 14 wherein the amount of required travel of said button means necessary to cause said combination switchblade and contact member to move from said A position to said B position is a function of the location of the point of engagement of said spring engagement means portion of said button means upon said tension coil spring means along the length thereof, the closer the said point of engagement is located to said second end of said tension coil spring the greater the required travel of said button means necessary to cause movement of said combination switchblade and contact member from said A position to said B position.

16. The switch mechanism set forth in claim 6 characterized as a push-pull mechanism wherein said actuator means when placed in said A position remains in said A position and when placed in said B position tends to remain in said B position.

17. In a compact snap switch mechanism having support means, actuator means movably mounted relative to said support means for movement from a first position to a second position, means for moving said actuator means relative to

said support means, and means to return said actuator means from said second position to its first position, the improvements comprising a pair of discrete combination switchblade and contact means pivotally mounted on opposite sides of said actuator means for movement between A and B positions, said combination switchblade and contact means extending generally transversally of said actuator means, and spring means connecting said combination switchblade and contact means, each of said combination switchblade and contact means being characterized as being:

- a. unitary one-piece formed metal members having first and second spaced end portions connected by a midportion,
- b. said first end portion comprising spaced leg means having means for pivotally engaging said actuator means, said spring means extending between said spaced leg means,
- c. said second end portion comprising,
 - i. a pair of curvilinear spaced contact portions, one of said spaced contact portions being located in the plane of said first end and mid portions, the other of said spaced contact portions being offset from the plane of said first end and mid portions, and
 - ii. attachment means for said spring means, said attachment means being located in a plane which extends from said means for pivotally engaging said actuator and an area intermediate said spaced contact portions, said attachment means being located outwardly of said actuator means a distance at least as great as the distance between said actuator means and said spaced contact portions, said attachment means affording a pivotal connection to said spring means, whereby movement of said actuator means from said first to said second position causes each of said combination switchblade and contact means to move from said A position to said B position with a snap action and low bounce of said curvilinear contact portions and upon attainment of said B position, to tend to maintain said curvilinear contact portions in said B position with high vibrational, shock, and acceleration stability until said actuator means returns to said first position.

18. The switch mechanism set forth in claim 6 characterized as a two pole four circuit mechanism wherein said actuator means comprises an elongated member having a pair of sets of vertically spaced notch means and a pair of through apertures respectively located adjacent to each of said sets of notch means intermediate the ends of said member said elongated metal member being further characterized as having an insulating portion intermediate said spaced sets of notch means and through apertures to prevent transmission of electrical current between spaced portions of said elongated metal member, said elongated metal member having a first shoulder means adjacent the top thereof and a second shoulder means adjacent the bottom thereof, two pairs of combination switchblade and contact means, each respective pair having spaced leg means located in one set of said notch means, bias spring means associated with said second shoulder means for biasing said actuator means towards its first position and each of said pairs of combination switchblade and contact means

toward said A position.

19. The switch mechanism as set forth in claim 18 wherein said actuator means includes energy storing means located intermediate said first shoulder of said elongated member and said button means, said energy storing means comprising a resilient compressible member proportioned and located in the line of force transmission of actuation energy pressure on the button means for snap actuation of the combination contact and switchblade member, said energy storing means absorbing and storing part of the energy pressure of actuation for later release, said energy storing means releasing the stored energy when one of said pairs of combination switchblade and contact members moves from said A to said B position, the release of the stored energy assuring that the other of said pairs of combination switchblade and contact means moves from said A to said B position to thereby assure simultaneity of actuation of both pairs of combination switchblade and contact means.

20. In a compact butterfly snap switch mechanism having support means, actuator means movably mounted relative to said support means for movement from a first position to a second position, button means for moving said actuator means relative to said support means, return bias means having a bias force of a predetermined magnitude to return said actuator means from said second position to its first position, said actuator means comprising an elongated member formed with a pair of sets of vertically spaced notch means and a pair of through apertures located adjacent to each of said sets of notch means, said elongated member being formed of metal and with an insulating portion intermediate said spaced sets of notch means to prevent transmission of electrical current between spaced portions thereof, two vertically spaced pairs of switchblade means pivotally mounted on opposite sides of said actuator means for movement between A and B positions, said switchblade means extending generally transversally of said actuator means, first and second spring means respectively extending through said aperture means and respectively connecting said individual pairs of switchblade means in said notch means on said elongated member, and energy storing means located in the line of force transmission of actuation energy pressure on the button means for snap actuation of the switchblade means, said energy storing means being a resilient compressible rubber doughnut shaped member having a compressed and an uncompressed state, the force required to compress said energy storing member from said uncompressed to said compressed state being less than said predetermined bias force of said means to return said actuator means from said second position to said first position, said energy storing means absorbing and storing part of the energy pressure of actuation for later release, said energy storing means releasing the stored energy when one of said pairs of switchblade means moves from said A to said B positions during movement of said actuator means from said first to said second position, the release of the stored energy assuring that the other of said pairs of switchblade means moves from said A to said B position to thereby assure simultaneity of actuation of both pairs of switchblade means.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,612,793 Dated October 12, 1971

Inventor(s) John O. Roeser

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 3, line 42 change "mid-porxion," to
--extreme--.

In column 9, line 27 change "there" to --other--.

In column 10, line 21 change "heat" to --head--.

In column 11, line 6 change "form" to --from--.

In column 12, line 67 change "ans" to --and--.

In column 13, line 29 change "cation" to --action--
and change "feed" to --feel--; in line 32 change "form" to
--from--.

In column 16, line 42 change "sequentially" to
--sequentiality--.

In claim 8, column 18, line 49 before "closed"
insert --closed bottom end at an end remote from said button
means, said--.

In claim 9, column 19, line 13 change "fixed" to
--fixedly--.

Signed and sealed this 9th day of May 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents