Oct. 14, 1952 W. H. KITTO 2,614,195

ELECTRICAL CONTACT ASSEMBLY

Filed Oct. 27, 1949

Fig. 3.

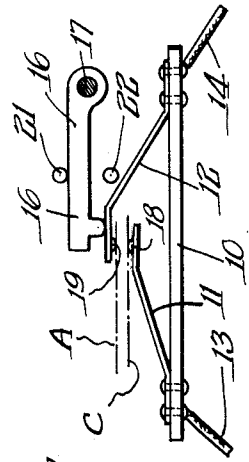


Fig. 2.

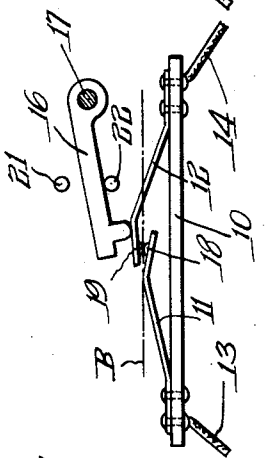


Fig. 1.

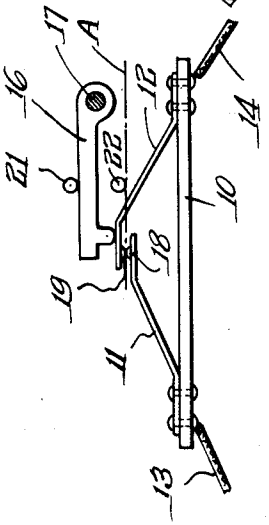


Fig. 6.

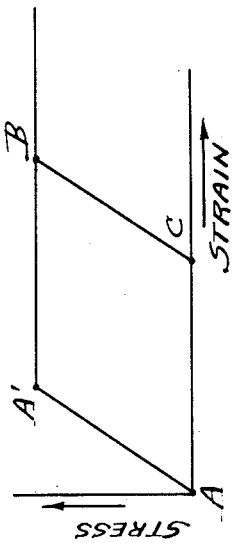


Fig. 4.

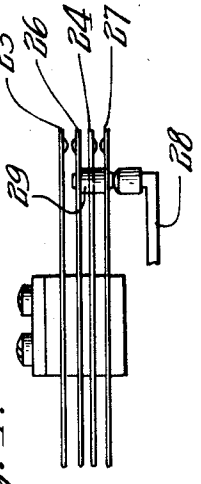
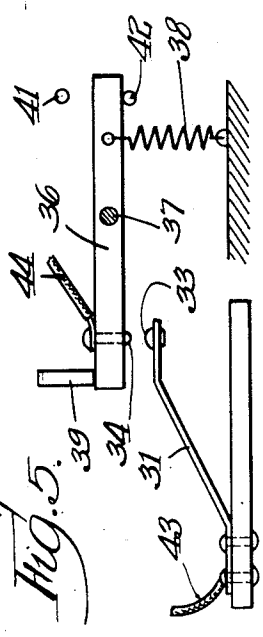


Fig. 5.



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ELECTRICAL CONTACT ASSEMBLY

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Application October 27, 1949, Serial No. 123,849

3 Claims. (Cl. 200—166)

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My invention relates to an improved electrical contact combination and method of producing the same. My invention is particularly concerned with a combination construction in which the adjustment of the contacts for arc gap and overtravel occurs automatically as an incident to the first operation of the combination.

In electric switch combinations in which contact is made by mechanically engaging one contact member against another (as contrasted with installations in which contact is made through wiping action, as in knife switches and the like), it is customary to provide a bottom contact blade of spring material such as Phosphor bronze or the like. Such a bottom contact blade (the term "bottom" is used for convenience and identified the contact carrying member ordinarily thought of as the "stationary contact") must be adjusted to provide proper arc gap and overtravel in order to have a properly functioning switch device. It is already known in this art that the length of the arc gap determines the electrical rating of the device and generally it must be accurately controlled, and that the overtravel affects the life expectancy of the device. There must be enough overtravel after the contacts come together to assure adequate contact pressure and some wiping action. Overtravel beyond that required markedly decreases life expectancy and is a factor to be considered in the design and adjustment of contact members.

While adjustment of contact carrying blades is a costly and tedious operation even when they are fully exposed after complete assembly, there are many installations, of which that shown in my copending application Serial No. 36,044, filed June 30, 1948, is an example, in which final assembly of the switch combination places the contact blades in a position where they can no longer be adjusted and the position which they finally assume cannot be determined. In the knife sharpener combination of the copending application described, the exact relative positions of the insulating plate 38, the switch actuator, and the upper resilient contact blade 34 are not established until the housing is secured to the bottom plate 22. The result is that the exact arc gap is difficult to determine and, of course, the amount of overtravel also is unknown. Even though careful installation control and inspection methods are utilized, it is still extremely difficult to avoid occasional failures due to faulty installation of switch contacts. There are many other installations in which this same general problem is encountered.

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In accordance with the main features of my invention, I employ a bottom or stationary contact member formed of relatively soft material having certain precise characteristics, as will be explained hereinbelow, preliminarily mount the said bottom contact member in a position to provide substantially no arc gap or much less arc gap than will normally be required in a given installation, and operate the switch combination in the intended manner to stress the bottom contact member beyond its elastic limit and automatically establish the most desired length of arc gap and distance of overtravel in the particular type of installation in which the switch is used.

The principal object of my invention is the provision of an improved contact blade combination of the type described and specific features and additional specific objects of the invention will appear from the following detailed description, taken with the accompanying drawings, wherein:

Fig. 1 is an elevational view partly schematic, showing a contact blade combination in accordance with my invention with the parts in the positions at which they are originally installed;

Fig. 2 shows the same combination as Fig. 1, with the parts in the position which they assume on first operation of the switch actuator;

Fig. 3 shows the combination of Fig. 1, with the parts in the positions which they assume after initial operation;

Fig. 4 is an elevational view showing another form of contact blade combination in the production of which my invention may be employed;

Fig. 5 shows a further modification of the invention; and

Fig. 6 is a diagrammatic view illustrating characteristics of the bottom contact blade.

Referring now first to Figs. 1 to 3, inclusive, I show a switch combination substantially of the type employed in the knife sharpener of my previously referred to copending application, comprising an insulating mounting plate 10, contact blades 11 and 12 secured thereto, conductors 13 and 14 suitably electrically connected to the contact blades and an actuator 16 pivoted at 17 and normally held upwardly by the spring action of contact blade 12. The contact blades 11 and 12 carry suitable contacts 18 and 19 through which electrical contact is adapted to be established between the conductors 13 and 14 when the switch combination is in actuated position.

The actuator 16 is limited in its movement by upper and lower stops 21 and 22.

While the characteristics of the contact blades 11 and 12 may vary considerably within the scope of my invention as determined by the particular characteristics required in a given installation, I wish initially to point out that in general the blade 12 is formed of a hard spring-like material having a high yield point (using the term in a metallurgical sense), such a material being, for example, Phosphor bronze, beryllium copper, or like material. The contact blade 11, on the other hand, is preferably formed of a relatively softer material having a lower yield point or lower elastic limit and having the property in the combination of becoming permanently stressed when it is moved beyond its elastic limit, thereby to assume a new position with respect to the contact blade 12 after the initial operation. While the materials employed for the lower contact blade are many, a suitable example is substantially pure cold rolled copper.

Referring now further to Figs. 2 and 3, it will be noted that the stroke of the actuator is determined by the positions of the stops 21 and 22, and if we consider a line representing the point of contact between the contact members 18 and 19, the total travel may be considered as representing the space between the dotted lines A of Fig. 1 and B of Fig. 2. Since the relatively soft contact blade 11 always retains some resiliency, it will spring back when released to a point indicated by the dotted line C of Fig. 3. For convenience, Figs. 1 to 3, showing the three positions of the parts described hereinabove, are in horizontal alignment, and the distance between the dotted lines A and C represent the final arc gap between the contact points 18 and 19, and the distance between the dotted lines B and C represents the overtravel and comprises that portion of the total movement of the contact blade 12 in which the contacts are in engagement both on closing and opening of such contacts. As previously pointed out, in other words, the distance between the dotted lines A and B represents total travel of the contact blade 12; the distance between the lines A and C represents the arc gap; and in the particular arrangement shown, the total amount by which the contact blade 11 becomes permanently deformed; and the distance between the dotted lines B and C represents the overtravel and determines the contact pressure and wiping action.

Those skilled in the art will understand that in a given installation the parts must be engineered to secure the results desired and in the engineering, several characteristics, dimensions, and the like must be taken into consideration. Disregarding elements of the design of the switch itself and considering only the relative characteristics of the contact blades 11 and 12, to secure my improved result it is necessary to consider the material itself of which the blades are made, the hardness of the material, the thickness of the blade, the width of the blade, and the length of the blade. If we assume identical dimensions of blades, that it is to say, same cross sectional area and same length, then it follows that the characteristics required to bring out my improved result may be obtained merely by proper selection of material and its metallurgical characteristics. Under certain circumstances also, I may employ exactly the same material in both contacts but vary characteristics thereof, including such factors as the amount of cold work on the material, the cross sectional area of the material, its length, etc.

To provide a guide for the selection of material and design of parts, I have determined mathematically the conditions which must be found in each blade to obtain the desired results. The deformable bottom blade or blade of softer material, however it may be referred to, should satisfy the formula

$$\frac{2L^2}{3Eh}S_E = D$$

where L is the effective free length of the blade in inches, E is the modulus of elasticity of the material employed, h is the thickness of the blade in inches, S_E is the stress at the elastic limit of the material in pounds per square inch, and D is the overtravel as determined in the manner indicated by comparison of Figs. 2 and 3. It is further important that the blade material retain some elasticity when stressed beyond its elastic limit and preferably that it have at least in general the stress-strain characteristics brought out by reference to Fig. 6 hereinbelow.

The top blade, that is to say, the blade formed of spring material, should be so engineered that the following relation will hold:

$$F < \frac{2L^2}{3Eh}S_E$$

where the symbols are employed in the same manner as in the previous equation and in which F is the total stroke of the blade in inches, that is to say, in which F represents in inches the distance between the dotted lines A and B as explained in connection with Figs. 1 to 3, inclusive. The symbol $<$ is used in a conventional manner to indicate that the quantity at the left should be smaller than that on the right.

Hereinabove I referred to the stress-strain characteristics of the relatively softer material, and in Fig. 6 a stress-strain diagram is reproduced to show generally what this relationship should be. The position of the bottom blade in Fig. 1 with its contact 18 generally along the line A of Fig. 1 is represented by the point A in Fig. 6. A downward motion of the blade corresponds to a motion to the right in the stress-strain diagram, and it will be noted that the stress increases at first until it reaches a maximum value at a point A' beyond which the stress remains constant. With the blade fully deflected as shown at its lowermost position in Fig. 2, the point B on this stress-strain curve is reached. When the actuator is released, there is a corresponding relaxing of the bottom blade to the point C on the stress-strain curve. Releasing the actuator corresponds to relaxing of the bottom blade, which occurs on a line B—C parallel to the line A—A'. When the force on the bottom blade becomes zero, the bottom blade reaches the position C in Fig. 6 and this corresponds to the dotted line position C of Fig. 3. Further operation of the bottom blade corresponds to a motion along the line C—B in the stress-strain diagram. No further permanent set of the bottom blade will occur.

Fig. 4 shows the manner in which the invention may be applied to the contacts of an ordinary telephone type relay. In this type of relay, relatively soft, "stationary" contact blades 23 and 24 carry contacts adapted to be engaged by contacts on relatively stiffer blades 26 and 27. An actuator 28 engages a button on the contact blade 27, and an insulating button 29 bridges contact

member 24 to engage contact member 26, so that contact members 26 and 27 move substantially as a unit to comprise the movable contact members. In this form of the invention, the stationary contacts 23 and 24 formed of relatively softer material preliminarily are adjusted to a lower position, as they appear in Fig. 4, so that on initial operation of the actuator 28, they will take a permanent set and automatically be adjusted in the same manner as described in connection with Figs. 1, 2 and 3 and by reference to the stress-strain diagram of Fig. 6.

Fig. 5 shows a still further modification of the invention in which a contact blade 31 is mounted on an insulating support 32 and has a contact 33 engaging a contact 34 on a contact carrying member 36. The contact carrying member 36 is pivoted at 37 and has a tension spring 38 which normally holds the contact carrying member 36 in a position to separate the contacts 33 and 34. An actuator 39 of suitable type is adapted to rotate the member 36 in the opposite direction about the pivot point 37 to engage the contacts 33 and 34. Stops 41 and 42 limit the movement of the movable contact member 36 in either direction. Conductors 43 and 44 are suitably provided for connecting the contacts 33 and 34 into a circuit which the switch is adapted to control.

In the form of the invention shown in Fig. 5, the movable contact carrying member 36 is substantially nonresilient as contrasted with the form of the invention shown in the preceding figures in which the movable contact member is a spring type of blade. The contact blade 31, however, is formed of material and so engineered as to satisfy the formula

$$\frac{2L^2}{3Eh}S_E=D$$

as explained hereinabove.

Many modifications of the invention are obvious. In general, it is preferred that the combination in which the invention is used be one in which the stroke of the actuator is of constant length and in which it does not change appreciably during the useful life of the device. In any event, if there should be a change, it should be of such character as to cause greater stressing of the relatively soft contact blade because under such circumstances it is possible for the blade to take a further permanent set and still maintain the characteristics explained in connection with Fig. 6. In all instances it will be understood that it is never necessary to make any adjustment of the contact blades, and in the case of only a single contact blade, as exemplified in the embodiment of Fig. 5, it is not necessary to make any adjustment of the relatively soft contact blade. All that is necessary is that the design of the relatively soft contact blade be such that it will always project above a position corresponding to the line C in Fig. 3, that is to say, that it will always be stressed beyond its elastic limit and take some permanent set, no matter how small, on the first complete movement of the actuator. Looking at the form of invention shown in Figs. 1 to 3, for example, the initial position of the contact blade 11 could be such as to cause its contact 18 to light any place between the lines A and C or above the line A for that matter, the result being that the said contact member 11 is carried past its elastic limit and moves through a flat line area corresponding to A', B, of any practicable length, and in which the said contact blade 11 is then free to move in normal operation along the line B—C, all as previously discussed.

It is apparent from the above considerations that my invention connotes a relationship between the parts which may be controlled either entirely by selection of material, or entirely by control of structure, the material being the same in each blade. In the design of a particular blade combination, any or all factors may be controlled at will to obtain the desired relationship of parts.

An illustrative example of operation under my invention may be had by reference to the combination described in connection with Figs. 1 to 3, inclusive. In such a combination I have used for the upper contact blade 12 a Phosphor bronze strip 8 numbers hard, .250 inch wide, .031 inch thick, and having an effective length of 1⅛ inches. In such combination the lower contact blade is formed of hot rolled copper of soft temper, with an effective length and width the same as the upper contact blade, but with a thickness of .043 inch. Such blades are initially mounted in such a manner that the lower or bottom contact blade projects up into contact with the upper contact blade. On the first stroke of the latter, the proper arc gap is automatically established by stress of the lower blade beyond its elastic limit in the manner described.

In the claims I have used the terms upper and lower to define the two contact blades, but it should be remembered that such terms are not used in a limiting sense, it being obvious that reversal in several respects is possible without departing from the spirit and meaning of the claims.

I claim:

1. A contact combination comprising a movable upper contact member movable between an upper position and a lower position, a free and normally stationary resilient lower contact member engaged by the upper contact member at an intermediate position in the movement of the latter from the upper position to the lower position, said lower contact member originally engaging the upper contact member at its upper position and initially stressed beyond its elastic limit upon initial movement of the upper contact member from its upper position to its lower position for thereafter assuming a free intermediate position out of engagement with the upper contact member when the latter is in its upper position.

2. A contact combination comprising a movable resilient upper contact member having a resilient arm and movable between an upper position and lower position and at all times biased to the upper position, means for moving the upper contact member from its upper position to its lower position and allowing return to its upper position, a free and normally stationary resilient lower contact member having a resilient arm and engaged by the upper contact member at an intermediate position in the movement of the latter from the upper position to the lower position, said upper resilient contact member having a higher elastic limit than said lower resilient contact member, said lower resilient contact member originally engaging the upper resilient contact member at its upper position and initially stressed beyond its elastic limit upon initial movement of the resilient upper contact member from its upper position to its lower position for thereafter assuming a free intermediate position out of engagement with the upper resilient contact member when the latter is in its upper posi-

tion, and said resilient upper contact member not being stressed beyond its elastic limit when it is moved from its upper position to its lower position so that it will always return to its upper position.

3. A contact combination comprising a substantially rigid movable upper contact member movable between an upper position and a lower position, means for biasing the movable upper contact member to its upper position but allowing movement thereof to its lower position, a free and normally stationary resilient lower contact member having a resilient arm and engaged by the upper contact member at an intermediate position in the movement of the latter from the upper position to the lower position, said lower contact member originally engaging the upper

contact member at its upper position and initially stressed beyond its elastic limit upon initial movement of the upper contact member from its upper position to its lower position for thereafter assuming a free intermediate position out of engagement with the upper contact member when the latter is in its upper position.

WILLIAM H. KITTO.

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