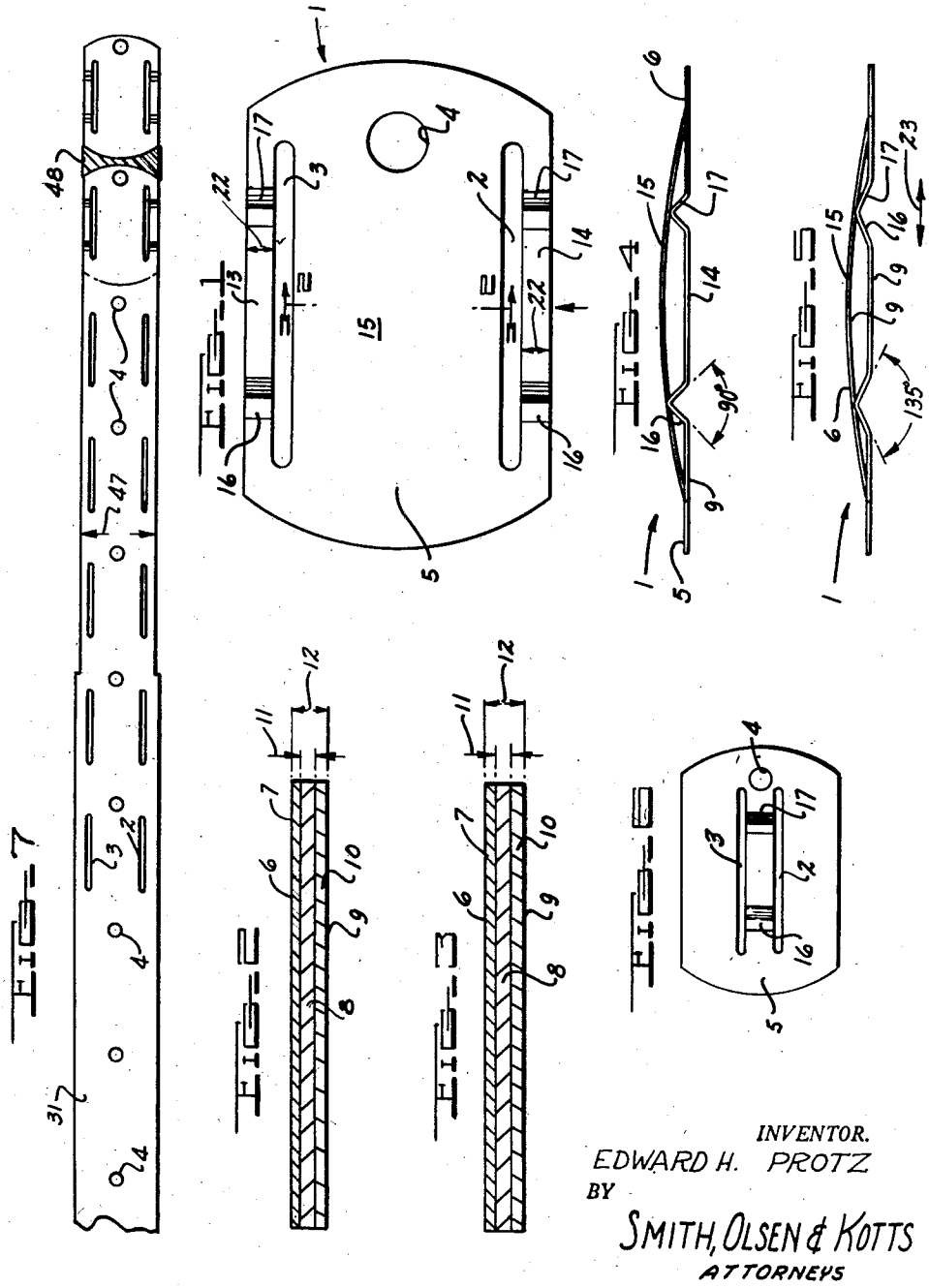
March 11, 1958 E. H. PROTZ 2,825,960

SNAP-ACTING ELEMENT AND METHOD OF MAKING SAME

Filed July 14, 1955 2 Sheets-Sheet 1



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FIG. 8

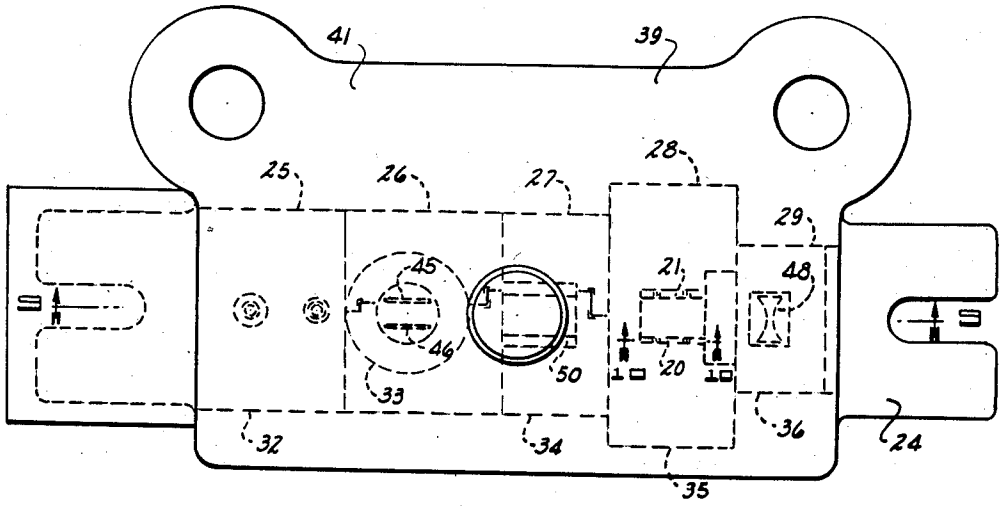


FIG. 9

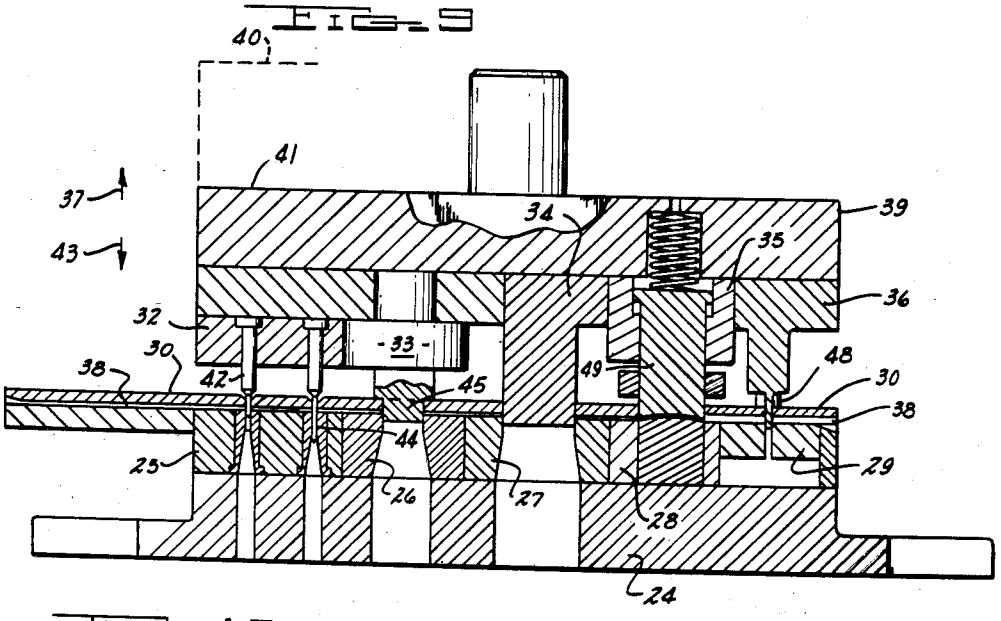
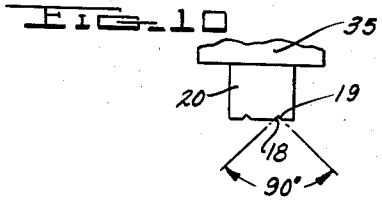


FIG. 10



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2,825,960

Patented Mar. 11, 1958

2,825,960

SNAP-ACTING ELEMENT AND METHOD OF MAKING SAME

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Application July 14, 1955, Serial No. 522,103

5 Claims. (Cl. 29—155.55)

This invention relates to switch blades and methods of manufacturing them.

One form of switch blade includes a blade body formed of laminations of metals and/or metal alloys having different coefficients of thermal expansion. The blade body is initially formed with a bowed portion, and with the concave face of the bowed portion formed of a material having a higher coefficient of expansion than the material which forms the convex surface. In utilizing the switch blade in a switch, one end of the blade is put into electrical communication with one switch terminal and the other end of the blade is provided with a contact element for making and breaking contact with at least one other terminal. Passage of electric current between the terminals takes place through the switch blade.

Passage of current through the blade causes it to heat up, and if the current flow becomes higher than a predetermined value the material which forms the concave surface of the blade will expand sufficiently to remove the bow and thereby cause the blade contact element to break contact with its terminal.

The blade may be of such design that the cooling action which takes place after circuit breakage causes the blade to automatically return into contact with its terminal and thereby remake the circuit through the switch. Heating of the blade may snap it slightly over center so that the blade bowing force acts (during the subsequent cooling period) against the blade returning force. The rate at which the blade returns to the terminal is therefore inversely proportional to the bowing force existing in the blade (assuming other factors remain constant). If this bowing force is small the blade will return to the terminal fairly quickly (possibly in four seconds or less) and if the bowing force is large, the blade will return to the terminal in a much slower time (possibly eighteen seconds or more).

The nature of the blade material also influences the blade return rate. Thus, some materials experience greater expansive-contractive movements and inherently produce greater "blade returning forces" than other materials. As a result, the return rates will vary with different materials. The nature of the blade materials determines the current flow at which the blade will expand, and since different installations require different current flows, a complete line of blades can be provided by merely varying the blade materials. It is desirable that the "blade return rates" for all of the different blades be held within certain limits, and since the nature of the blade material determines the blade returning force, it is necessary that some means be provided for varying the bowing force in accordance with the nature of the blade material.

It is an object of the present invention to provide means and methods for controlling the bowing force, thereby controlling the blade return rate.

It is necessary that the blade return rate for any given blade remain the same over the life of the blade, and

this can only be possible if the blade bowing force remains the same over the entire blade life.

It is another object of the present invention to provide a blade construction wherein the blade bowing force remains constant over the entire blade life.

As stated previously the nature of the blade materials will determine the current flow at which the blade will expand. The blade-expanding current flow can be varied by varying the component materials used and/or varying the relative thicknesses of the component materials. It is desirable that the same machinery be employed for the production of all blades and it is therefore necessary to so choose the blade materials and relative thicknesses thereof as to maintain the total blade thickness constant for all blades.

It is the usual practice to construct the blades of two sheets having different coefficients of expansion. These sheets are rolled and secured together to form a laminated construction. The relative thicknesses of the two sheets and the sheet materials determine the current flow which the blade can carry. It has been found that when only two sheets are employed the current-carrying characteristics of the blade cannot be very precisely controlled, but that when three sheets are employed the current-carrying characteristics of the blade can be very precisely controlled.

An object of the invention is to provide a method of forming blades wherein the same machinery can be employed to construct a plurality of different blades.

Another object is to provide a blade construction wherein the current-carrying characteristics of the blade can be changed and very precisely controlled.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

Fig. 1 is a plan view of a blade constructed in accordance with the invention.

Fig. 2 is a sectional view on line 2—2 in Fig. 1.

Fig. 3 is a sectional view on the same line as Fig. 2 but of a blade construction wherein the component materials are of different relative thicknesses than those shown in Fig. 2,

Fig. 4 is an edge view of the Fig. 1 blade taken in the direction of arrow 4,

Fig. 5 is a view taken in the same direction as Fig. 4 but taken at a later stage in the production of the blade.

Fig. 6 is a view taken in the same direction as Fig. 1 but of a modified blade constructed in accordance with the invention,

Fig. 7 is a plan view of a blade material showing it at various stages during its passage through the Fig. 8 apparatus.

Fig. 8 is a plan view of one apparatus which may be employed to manufacture the Fig. 1 blade,

Fig. 9 is a sectional view taken on line 9—9 in Fig. 8, and

Fig. 10 is a sectional view taken on line 10—10 in Fig. 8.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

In the drawings there is shown a switch blade 1 having two parallel closed ended slits 2, 3 and a hole 4. Hole 4 accommodates blade 1 for fixed securement on a switch terminal (not shown), and the blade construction is such that end portion 5 of the blade is free for "circuit making" and "circuit breaking" movement toward and away from another switch terminal (not shown). A contact element (not shown) may be provided on portion 5 for making and breaking the contact.

Blade 1 is of multi-metal construction, and preferably three metal sheets are employed instead of the usual two. One surface 6 of the blade is formed of a material 7 having a low coefficient of expansion. Material 7 may be invar having a composition of about 36 parts by weight of nickel to about 64 parts by weight of iron. The central sheet 8 may be formed of pure nickel. The surface 9 of the blade is formed of a material 10 having a higher coefficient of expansion than material 7. Material 10 may be a nickel, chrome, iron alloy having 22 parts by weight of nickel to about 3 parts by weight of chromium and 75 parts by weight of iron.

In order to vary the current flow at which the blade expands, the relative thicknesses of materials 7 and 10 are varied. However, the thickness 11 of material 8 and the total blade thickness 12 are preferably the same for all blades. Material 10 is a relatively high resistance alloy, and the thickness of material 10 will therefore determine the current flow at which the blade expands. Thus, when material 10 is relatively thick the blade will expand at a low current flow, and when material 10 is relatively thin the blade will expand at a higher current flow. Material 10 is thinner in the Fig. 3 blade than in the Fig. 2 blade, and accordingly the Fig. 3 blade will expand at a higher current flow than the Fig. 2 blade.

It is necessary that each blade be stressed or bowed prior to its installation in its switch, and in one form of the invention this stressing or bowing action is accomplished by crimping side blade areas 13 and 14. This crimping action causes central blade area 15 to take a bowed position as shown in Fig. 4. There may be one or more crimps in each of areas 13 and 14, depending on the bow which it is desired to put into area 15. Each crimp is of V-shape cross section and includes two walls 16 and 17. These walls initially take an angle of 90° relative to each other. This angle corresponds to that of the crimp-forming surfaces 18 and 19 on crimping elements 20 and 21 (shown in Figs. 8 and 10). The bowing of area 15 puts a stress on the crimps such that immediately after the blade is removed from crimping elements 20 and 21 walls 16 and 17 spread apart or diverge to an angle of about 130°. After a series of "heat-cool" cycle movements in a testing apparatus (not shown) walls 16 and 17 spread still further apart to an angle of about 135° (shown in Fig. 5). Thereafter, walls 16 and 17 maintain their 135° angular relationship.

Operation of the blade in a switch is such that when current flow is below a predetermined value the circuit is completed through the blade. However, when the current flow rises above the predetermined value blade 1 heats up and material 10 expands longitudinally so as to remove the bow in area 15. Removal of this bow is accompanied by a movement of blade portion 5 away from its terminal and breakage of the circuit through the blade.

Expansive movement of material 10 continues until a very slight reverse bow is put in area 15, i. e. until the portion of surface 6 in area 15 becomes very slightly concave.

After the circuit through blade 1 is broken the blade begins to cool, and this cooling causes material 10 to contract so as to urge area 15 back to its illustrated position. However, the crimps in areas 13 and 14 resist this movement of area 15 (due to the fact that area 15 is at this time reversely bowed). Therefore, the

rate at which the blade returns to a circuit closing position will be inversely proportional to the stressing force of the crimps, i. e. if the stressing force of the crimps is large, the blade will return very slowly (or possibly not at all, in which case a manually operated push button will be required to return it), while if the crimp force is small, the blade will return rapidly.

It is desirable to vary and/or control the "return rate" of the blade and accordingly it is desirable to be able to vary and control the stress force of the crimps. In the present invention the stress force is controlled by controlling the widths of areas 13 and 14 in the directions of arrows 22. It will be appreciated that if areas 13 and 14 are made relatively wide the crimped areas can be correspondingly widened, and the force of the crimps can be correspondingly increased. Thus, an actual blade construction wherein the arrow 22 dimension was .050 inch resulted in such a crimp force that cooling of the blade failed to return area 15 to its illustrated position, while another blade construction wherein the arrow 22 dimension was .040 inch resulted in the blade 15 area returning to its illustrated position in four and one-half seconds.

If the blade return rate for each blade is to remain the same throughout the blade life, it is necessary that the force of the crimps remain the same throughout the blade life, i. e. that the crimp walls 16 and 17 do not diverge apart more than their Fig. 5 stressed positions after extended periods of use. In this respect the 135° angle taken by walls 16 and 17 is found advantageous over other lesser angles in that when the crimp walls diverge at about 135° they do not increase their divergencies after extensive operational periods. When the crimp walls diverge at lesser angles they tend to diverge further apart after extensive periods of use and thereby destroy the "return rate" calibration of the blades. The reason for this tendency of the crimp walls to "further" diverge is believed to derive from the fact that when two walls diverge at a small angle, say 50°, only a relatively small force in the direction of arrows 23 (see Fig. 5) is required to cause a further divergence of the walls, while when two walls diverge at a larger angle, say 125°, a comparatively large force in the arrow 23 direction is required to cause a further divergence. This is due to the fact that in the first case a comparatively large component of the arrow 22 force acts against the crimp wall to bend it, while in the second case only a small component of the arrow 22 force acts to bend the crimp wall. Experience to date indicates that angular divergencies of walls 16 and 17 between 125° and 150° give sufficient bowing action without decrease in the crimp force after extended operational periods.

There is shown a blade in Fig. 6 which is similar to the Fig. 1 blade except that the central blade area is crimped instead of the side blade areas. The slits 2 and 3 are spaced apart a lesser distance than in the Fig. 1 blade in order to provide only the necessary crimp forces. The arrow 22 dimension in the Fig. 6 construction may be varied to vary the crimp force.

Formation of the Fig. 1 blade may be effected by the mechanism shown in Figs. 8 through 10. This mechanism includes a base 24 on which are fixedly secured a plurality of die members or blocks 25, 26, 27, 28 and 29. A plate 30 fixedly extends over blocks 25 through 29 so as to form a slot 38 for accommodating the travel of a blade-forming strip 31 (shown in Fig. 7) through the mechanism. Positioned above plate 30 and mounted on a die member 39 for movement in the directions of arrows 37 and 43 are a plurality of punch members 32, 33, 34, 35 and 36.

Strip 31 is initially fed into the left side of the mechanism until it registers with a circular punch element 42 extending from member 32. During the feeding of strip 31 the upper face 41 of die member 39 takes the dotted

line position 40. When strip 31 is in registry with punch 42 member 39 is moved in the arrow 43 direction so as to cause punch 42 to form hole 4 in strip 31. Member 39 is then raised in the arrow 37 direction, and strip 31 fed to the right until hole 4 registers with a locating pin 44. Pin 44 positions or "locates" strip 31 relative to punch elements 45 and 46 which form slots 2 and 3 in strip 31. The width of strip 31 must be closely controlled so it is necessary to provide two cutting elements 50 for shaving the strip to the correct width 47.

Crimps are formed in strip 31 by means of crimping tools 20 and 21 which are fixedly secured to member 35. During the crimping operation area 15 of strip 31 becomes bowed, and a spring urged die member 49 is provided for insuring and maintaining the desired bow shape. The actual bowing force is, however, provided by downward movement of tools 20 and 21. Cutting of strip 31 to form the individual blades is effected by a cutting element 48 projecting from member 36.

It will be understood that after strip 31 has been moved to the right for the fifth time each downward movement of member 39 will cause the simultaneous formation of a hole 4, a pair of slits 2 and 3, the shaving of strip 31 to the 47 dimension, the crimping of side areas 13 and 14, and the separation of one blade from the right end of strip 31.

Due to the fact that total thickness 12 of the blade is the same for different blades, a complete line of blades can be manufactured from the mechanism illustrated in Figs. 8 through 10. The width of slits 2 and 3 (and the arrow 22 dimension of side portions 13 and 14) can be controlled by suitable replacement of members 45 and 46. The Fig. 6 blade can be formed by suitable replacement of members 33 and 35.

I claim:

1. The method of forming a switch blade comprising the steps of providing a blade body with a double ended slit whereby to form two spaced blade areas, crimping a portion of one of said areas to provide two crimp-forming walls arranged at about 90 radial degrees to each other, and removing the crimping force to allow the crimp-forming walls to diverge to about 135 radial degrees.

2. In connection with the construction of heat actuated multi-metal switch blades of the type wherein the blade comprises a blade body having a closed ended slit therein whereby to form two spaced blade areas, one of said areas being crimped so as to bow the other area into a position wherein heat will remove the bow; the invention comprising a method of controlling the blade operating characteristics by the steps of crimping one of the blade areas to provide two crimp-forming walls arranged at about 90 radial degrees to each other, removing the crimping force to allow the crimp-forming walls to diverge to about 135 radial degrees, decreasing the width of said one area to increase the bow return rate, increasing the width of said one area to decrease the bow return rate, and varying the relative thicknesses of the blade component sheets while maintaining the total blade thickness constant whereby to vary the blade-actuating current.

3. The method of forming one of a plurality of thermally responsive switch blades having uniform long-life characteristics and substantially the same external dimensions but different time rates of response to the same temperature change, comprising the steps of providing a blade body with an internal slit therein to form two spaced blade areas wherein the location of the slit is preselected to give a desired ratio of said areas, crimping a portion of one of said areas to provide two crimp-forming walls arranged at about 90 radial degrees to each other, and removing the crimping force to allow the crimp forming walls to diverge to about 135 radial degrees.

4. The method of forming one of a plurality of trimetallic thermally responsive switch blades of uniform long-life characteristics and substantially the same external dimensions, but having different electrical resistances by varying the relative thicknesses of the layers of metal, said method comprising the steps of providing a blade body with an internal slit therein to form two spaced blade areas therein and wherein the blade body has layers of metal of the prescribed thicknesses, crimping a portion of one of said areas to provide two crimp-forming walls arranged at about 90 radial degrees to each other, and removing the crimping force to allow the crimp-forming walls to diverge to about 135 radial degrees.

5. The method of forming a plurality of thermally responsive switch blades having uniform long-life characteristics comprising the steps of advancing a strip of thermally responsive metal, inserting lengthwise slits in said strip at longitudinally spaced intervals to form a series of parallel spaced blade areas, crimping a portion of one of said areas of each of said series of blade areas to provide in each two crimp-forming walls arranged at about 90 radial degrees to one another, and removing the crimping force to allow the crimp-forming walls to diverge to about 135 radial degrees, and thereafter cutting said strip between each of said series of blade areas to provide individual switch blades.

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