This invention relates to electrical relay devices and more particularly to relaying devices of the so-called hot wire type.

Hot wire relays normally include a spring contact arm carrying one of a pair of movable electrical contacts and exerting a force tending to move the contacts into a pre-selected relationship. A wire, secured between a spaced anvil and the spring arm acts in tension when at a normal temperature, to restrain movement of the spring arm, opposing the internal force of the spring. The wire, which has a finite resistance and a substantial coefficient of thermal expansion, is connected as an element of an input signalling circuit. Current through the wire produces thermal-current heating or self-heating of the wire which in turn produces a physical elongation of the wire. Thus, for purposes of this description, the wire will be referred to as a "hot" wire or "sag" wire. When the magnitude of the input circuit current is adequate, the hot wire will elongate sufficiently to permit the contact arm to move to its operated position making or breaking the output circuit-controlling electrical contacts.

In general, for any given pair of contacts as the magnitude of the controlled current increases, the magnitude of the electrical contact pressure must increase if the voltage drop across the contacts and the heating of those contacts is not to become excessive. However, the magnitude of the contact closing force which can be exerted by or through the contact spring arm cannot exceed the restraining force which the hot wire is capable of exerting. Furthermore, during operation a given pair of contacts may be welded together. The restraining force of the hot wire must be of sufficient magnitude to break such a weld in order to prevent the relay from becoming inoperative. Yet the material and size of the hot wire is determined not only by these tensile strength and force transmitting requirements, but also and importantly, by the electrical resistance and thermal expansion characteristics of that wire.

In accordance with the principles of the present invention, a hot wire of appropriate electrical thermal characteristics, but of limited diameter and tensile strength, is utilized in a unique force multiplying mechanical system to permit the development of forces adequate for the control of heavy current electrical contacts. Furthermore, the prestressed or pre-tensioned contact spring arm is arranged to cause a slight wiping action to occur between the pair of contacts when the contact arm is moved to its operated position. The wiping action normally prevents operational freezing or welding of the contacts but novel means are additionally provided, representative as an element of the aforesaid mechanical system, for flexing the contact arm and rocking the contacts to separate them in cases where welding does occur therebetween.

In the disclosed embodiment the hot wire or sag wire portion of the relay has a plurality of independent reaches so that the relay will fail safely if the hot wire breaks during operation. Means are additionally provided, as an element of the force multiplying mechanical system, for enabling the magnitude of the forces to be readily adjusted.

In accordance with still other principles of the present invention, the effect of ambient temperature change on the operation of the relay is minimized by maintaining a preselected ratio of coefficients of linear expansion between various portions of the relay.

Therefore, an important object of this invention is to increase the current carrying capabilities of hot wire type relays and to facilitate adjustment of relays of that type.

Another object of this invention is to automatically separate heavy-current carrying contacts in relays of the aforesaid type which may become welded during operation.

Yet another object of this invention is an improved hot wire relay which will fail safe and will operate effectively over a wide range of ambient temperatures.

The manner of accomplishing the foregoing objects, and other objects and features of the invention, will become apparent from the following detailed description of an embodiment of the invention when read with reference to the accompanying drawings in which:

FIGURE 1 is a top plan view of a hot wire relay embodying the principles of the present invention;
FIGURE 2 is a bottom plan view of the hot wire relay illustrated in FIGURE 1;
FIGURE 3 is an enlarged sectional view taken along the line 3-3 of FIGURE 2; and
FIGURE 4 is a fragmentary, enlarged sectional view taken substantially along the line 4-4 of FIGURE 2.

Referring now to the drawing, the relay comprises a generally rectangular ceramic base 10, which carries at one end a set of three fixed terminals 12 and 14, which are held in place by rivets 16. The terminals 12 carry fixed contacts 18 which mate with corresponding movable contacts 20, and the terminal 14 carries a fixed contact 22 which mates with a moving contact 24.

Secured to the base 10 are two elongated resilient contact arms 26 which are fixed thereto and to terminals 30 by rivets 34. The contact arms 26 are cantilevered to the base 10 at one end thereof, thereby providing the free ends of the contact arms 26 with a spring-like degree of freedom in the direction of opening and closing the contacts 20. In a like manner, elongated contact arm 28 is secured at one end to the base 10 and to a terminal 32 by a rivet 34.

While three contact arms 26, 28 are representatively shown, it will be appreciated that a relay having one or more contact arms will be within the scope of the present invention. Electrical connections are made to terminals 12, 30 to establish the output, load or controlled circuit of the relay.

Contact arms 26 and 28 are prestressed and tend to occupy positions in which the contact pairs 18, 20 are closed and the contact pair 22, 24 is open. The opposite relationship is shown in the drawing since a hot wire or sag wire portion 40 of the relay is in a cold contracted condition which imposes a restraining force on contact arms 26 and 28 in a unique manner to be described.

Sag wire 40 which may be formed of any suitable conducting material, having relatively high electrical resistance, good strength and a high coefficient of thermal expansion, extends from a fixed anchor or rivet 42 around a fixed post 44, around an adjustable cam 46, around a fixed post 48 and back to a fixed anchor 50, all of which are suitably fastened to the base 10. The anchors or rivets 42 and 50 also serve to hold terminals 52 and 54 of an input signalling circuit in place. Cam 46 around which the sag wire 40 passes is eccentrically mounted on an anchor post 56 which secures cam 46 to the base 10. Consequently, rotation of the cam 46 serves to increase or decrease the tension of the wire 40.

Between the posts 48, 44 and anchors 42, 46, 50, the sag wire 40 passes over a ceramic actuator 60 which is slidably received in a slot 62 provided in the base 10. It will be appreciated that by virtue of the large number of reaches of wire 40 which contact the actuator 60 the
prestressing force of contact arms 26, 28 may be proportionally larger over an arrangement whereby only a single reach of wire was acting on the actuator 60. Therefore, forces adequate for the control of heavy-current conductors may exist in contact arms 26, 28 without sacrificing appropriate electrical thermal characteristics in the wire 40. It should be appreciated, of course, that the four reaches of wire illustrated are only one representative arrangement which satisfies the objects of the invention.

Each reach of the sag wire 40 rides in one of a plurality of shallow grooves 58 in the outer edge of the actuator 60. The tension in sag wire 40 causes the inner edge 9 of the actuator 60 to bear against the inner face 63 of a pusher plate 64 of a suitable fibrous electrical insulating material which rigidly underlies the contact arms 26 and 28.

The lower end portion 64c of the pusher plate 64 is in juxtaposition with the inner faces 66 of the lower portions of the contact arms 26. An upper tab portion 64b of the pusher plate 64 is secured to the central contact arm 28 by a rivet 79; the rivet also forming the moving contact 24. In FIGURE 4 it can be seen that the contact arms 26 are bent so that the pusher plate 64 is disposed away from contact arms 26 between the lower end portion 64a and an upper end portion 64c which is in juxtaposition with the inner faces of the contact arms 26 adjacent the contacts 20.

As a result of the opening 74 formed in the body of the pusher plate 64 receives a boss 76 on the base 10 which prevents transverse movement of the pusher plate 64. The rivet 79 and a shoulder 78 formed in the base 10 prevent longitudinal movement of the pusher plate 64. Therefore, contact arm 26 engages the pusher plate 64 only at the inner faces 66 which form an axis for pivotal movement of the pusher plate 64 and at the upper end portion 64c near but spaced from the contacts 20.

The actuator 60 bears against the pusher plate 64 at two laterally spaced points constituted by two leg portions adjacent the opening 74 of the pusher plate 64 which are produced when the central opening 74 is formed. Thus, even though the inner edge 59 of the actuator 60 may be slightly crowned, the pusher plate 64 does not have a tendency to rock about the axis defined by the section line 3—3 in FIGURE 2 of the drawing.

As to operation, the parts are shown in the cold or contracted condition of the sag wire 40 (no current through the input signalling circuit) in which position the actuator 60 bears against the inner face 63 of the pusher plate 64 causing its lower end 64a to bear against the inner faces 66 of the lower end portions of the contact arms 26 which point of engagement constitutes a pivot point for the pusher plate 64. Under this condition the upper end 64c of the pusher plate bears against the inner face of the upper end portions of the contact arms 26 to hold contacts 20 in an open position. At the same time the tab portion 64b of pusher plate 64 holds contact 24 in a closed position. As was indicated above, contact arms 26 are prestressed in order to move the contacts 20 into forceful engagement with the contacts 18. With no current passing through wire 40, the length of the wire 40 is selected and the cam 46 is positioned so that contact arms 26 are deflected to move contacts 20 away from contacts 18, with the wire 40 being under a pre-selected tension.

When current is supplied to the sag wire 40 it becomes heated and elongates. As the wire elongates, the contact arms 26, 28 are free to flex throughout their full length to move contact 24 away from contact 22 and contacts 28. The contacts 18. Thus a maximum 64c—64a closing 70 force occurs since the full spring force of the arms 26 is imposed on the contacts 18, 20.

When the heavier contacts 20 engage the contacts 18, the arms 26 are still in a biased condition which causes the body portions of contacts 20 to continue flexing across the contacts 18. This tendency causes a slight wiping action to occur between contacts 18-20 during the closing action.

In normal operation discontinuance of the supply of current to the sag wire 40 causes the wire to cool and to contract rapidly and, through pusher plate 64, to quickly and freely push the moving contacts 20, 24 to open and closed positions, respectively.

Absent any welding between contacts 18, 20 each arm 26 will effectively act as a rigid bar during the opening of contacts 18, 20. The force of the pusher plate 64 on the spring arm 26 permits only the small portion of the spring arm 26 between the point of contact with the upper end portion 64c and the contact 20 to flex toward the contact 18. Thus, less movement of the wire 40 is required to overcome the spring bias in arms 26 to initially open the contacts 18, 20 than would be the case if upper end portion 64c were located further away from contacts 20. It should further be noted that the arrangement of the actuator 60 and the pusher plate 64 with respect to the contacts 18, 20 causes a predetermined spacing therebetween which is a multiple of the movement of the actuator 60 or the wire 40 required to fully open the contacts.

In the event contacts 18, 20 are welded the spring arms 26 will act as long flexible spring arms during the opening of the contacts 18, 20. The cooling and contraction of the wire 40 causes the upper end portion 64c of the pusher plate 64 to exert a force against the undersides of the arms 26 at points fairly near but spaced from the contacts 20. The force causes the spring arms 26 to flex or bow about the upper end portion 64c between the lower portions 66 and the welded contacts 18, 20 so that the full length of each arm 26 is acting against the welded contacts 18, 20 to create a rocking action which breaks the weld therebetween.

A suitable material cements the sag wire 40 to the anchors 44, 45, 49 and 50. The two central strands of sag wire 40 may not be cemented to the cam 46 so as to enable final touchup of the adjustment therein. Thus, a plurality of independent reaches of wire, representatively shown as three, extend across the actuator 60. Therefore, assuming one reach of the sag wire 40 fails during operation, the remaining independent reaches of wire will cool exerting a force on the actuator 60 which will cause the contacts 18, 20 to be retained in their open or fail-safe position.

Yet another feature of the aforesaid unique relay arrangement is found in the relationship of the coefficients of linear expansion of the base 10 and of the wire 40. Normally, if a relay is subject to wide variations in ambient temperatures, the physical relationship between the base 10 and the sag wire 40 disposed thereon will vary. When the output circuit contacts are closed this problem can adversely affect the relay's operation. For instance, if the wire 40 was operated at a temperature of 70° F. and the ambient conditions changed 100° (as from 70° to 170° F.) the base temperature will rise 100° F., but the wire temperature will rise less than the 100° F. change due to the difference in radiation of a body which is at a higher temperature as compared to a body at a lower temperature. If, for example, the rise of temperature of the wire is but 60° F., the wire 40 will expand to a lesser degree than the base and could conceivably be placed in tension against the actuator 60 causing the output circuit contacts 18, 20 to open. Normally, when the input signalling circuit is energized the contacts 18, 20 should be closed. The physical relationship between the base 10 and the sag wire 40 required to keep contacts 18, 20 closed when the wire 40 is at a temperature 100° higher than that just described above may be maintained by selecting a base material having a coefficient of linear expansion which is 60% of the wire. The use of a ceramic material such as steatite has been found especially suitable to maintain equivalent expansion in the base 10 and in a sag wire 40 of suitable
conducting material. Other materials such as electrical porcelain and steel are also substantially close to that of steellike may be obtained in the present relay even though they are not perfectly adapted thereto.

While it will be apparent that the embodiment of the invention herein disclosed is well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the appended claims.

What is claimed is:

1. A relay mechanism comprising a base plate, a wire having a high coefficient of thermal expansion supported on and in substantial parallelism with one face of said base plate and adapted to elongate in response to electrical energization thereof, a resilient cantilever spring arm having one end fixed with respect to said base plate and having an opposite freely movable end supporting said second contact and exerting a force tending to move said second electrical contact in one direction relative to said first electrical contact, and means for applying a force on said cantilever spring arm in a direction opposite to said one direction when said wire is deenergized including an actuator plate slidably mounted in said base plate for mechanically coupling said wire with said arm and means engaging said cantilever spring arm operative in response to welding of said contacts for reducing the effective stiffness of said spring arm thereby permitting the rocking motion of said contacts.

2. A relay mechanism comprising a base plate, a wire having a high coefficient of thermal expansion supported on and in substantial parallelism with one face of said base plate and adapted to elongate in response to electrical energization thereof, a first electrical contact, means supporting said first electrical contact adjacent the opposite face of said base plate and means for applying a force on said cantilever spring arm in a direction opposite to said one direction when said wire is deenergized including an actuator plate slidably mounted in said base plate for mechanically coupling said wire with said arm and means engaging said cantilever spring arm operative in response to welding of said contacts for reducing the effective stiffness of said spring arm thereby permitting the rocking motion of said contacts.

3. A relay mechanism comprising a base, a pair of movable electrical contacts, resilient cantilever spring means having one end fixed with respect to said base and supporting at its free end one of said contacts and exerting a force tending to move said one of said contacts in one direction relative to the other of said contacts, an elongated pusher plate of rigid material having one end engaging the underside of said resilient cantilever spring means and an opposite end pivotally mounted with respect to said base, said pusher plate operable to reduce the effective stiffness of the cantilever spring arm on the welding of said contacts, a wire having a high coefficient of thermal expansion supported on said base and having a portion adapted to move a preselected amount in response to a preselected change of the electrical energization thereof, and said pivotally mounted end of said pusher plate to transmit forces from said wire to said resilient cantilever spring means for moving said one of said contacts in a direction opposite to said one direction.

4. A relay mechanism comprising a base, a pair of movable electrical contacts, resilient cantilever spring means having one end fixed with respect to said base and supporting at its free end one of said contacts and exerting a force tending to move said one of said contacts in one direction relative to the other of said contacts, an elongated pusher plate of rigid material having one end engaging the underside of said resilient cantilever spring means at a point near to but spaced from said free end of said cantilever spring means and having its opposite end pivotally mounted adjacent said base for pivotal movement about an axis spaced from said free end of said cantilever spring means, a wire having a high coefficient of thermal expansion supported on said base and having a portion adapted to move a preselected amount in response to a preselected change of the electrical energization thereof, and an actuator plate slidingly mounted in said base engageable with said portion of said wire and engaging said pusher plate on an area spaced both from said free end of said cantilever spring and from said axis to transmit forces from said wire to said cantilever spring means for moving said one of said contacts in a direction opposite to said one direction.

5. A relay mechanism comprising a base, a pair of movable electrical contacts, resilient cantilever spring means having one end fixed with respect to said base and supporting at its free end one of said contacts and exerting a force tending to move said one of said contacts in one direction relative to the other of said contacts, a pusher plate effective in response to a force applied thereto to exert a force on said cantilever spring means near but spaced from said free end for moving one of said contacts in the opposite direction relative to said other contact, a spring mounted on said base movably supporting said pusher plate with respect to said base, a portion of said cantilever spring means supporting said pusher plate adjacent said base for pivotal movement about an axis spaced from said free end of said cantilever spring means, a wire having a high coefficient of thermal expansion supported on said base and having a portion adapted to move a preselected amount in response to a preselected change of the electrical energization thereof, and an actuator plate slidingly mounted in said base engageable with said portion of said wire and engaging said pusher plate at an area between said free end of said cantilever spring and said axis for transmitting forces from said wire to said actuator means.

6. A relay mechanism comprising a base, a pair of movable electrical contacts, resilient cantilever spring means having a lower end portion fixed with respect to said base, a central body portion and a free end portion supporting one of said contacts and exerting a force tending to move said one of said contacts in one direction relative to the other of said contacts, a pusher plate effective in response to a force applied thereto to exert a force on said cantilever spring means near but spaced from said free end for moving said one of said contacts in the opposite direction relative to said other contact, means defining a central opening in said pusher plate, a spring mounted on said base movably supporting said pusher plate with respect to said base, said lower end portion of said cantilever spring means supporting said pusher plate adjacent said base for pivotal movement about an axis spaced from said free end portion of said cantilever spring means, said pusher plate being spaced from said central body portion of said cantilever spring means, a wire having a high coefficient of thermal expansion supported on said base and having a portion adapted to move a preselected amount in response to a preselected change of the electrical energization thereof, and an actuator plate slidingly mounted in said base engageable with said portion of said wire and engaging said pusher plate on either side of said central opening at an area between said free end portion of said cantilever spring and said
axis for transmitting forces from said wire to said actuator means.

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BERNARD A. GILHEANY, Primary Examiner.

RICHARD M. WOOD, Examiner.