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RELAY ARMATURE SPRING

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This invention relates to switching devices and, more particularly, to electromagnetically operated relays.

An object of this invention is the improvement of the operating characteristics and the extension of the life of electromagnetic relays.

Another object of this invention is the reduction of armature rebound and the minimizing of contact chatter in electromagnetic relays.

Another object of this invention is the absorption of the kinetic energy of a moving armature system.

A further object of this invention is the control of the force-displacement characteristics of a non-linear spring element.

A feature of this invention is a double-direction non-linear spring cooperating with a second spring conjointly to control the motional characteristics of a relay armature.

A further feature of this invention is a double-direction non-linear armature-control spring, and means for rendering this spring non-symmetrical and for controlling the degree of non-symmetry.

Conventional relays comprise a core, a coil, an armature, an armature back stop and at least one set of contact springs. Upon energization of the relay coil, the armature is attracted to the core whereby the contact set is either forced or permitted to open or close depending upon the design of the relay. The armature has a substantial mass and, as it approaches the core, a substantial velocity. Consequently, upon impact of the armature with the core an appreciable amount of kinetic energy must be dissipated. Normally, this energy is dissipated by imparting a portion of that energy to the core, and by single or multiple armature rebounds. The former results in vibration of the entire structure; the latter in false operations of the contacts. These effects are deleterious to the relay structure, they delay the full operation of the relay, they result in contact chatter and they cause undue wear of many critically dimensioned portions of the structure. A correlative condition exists upon the release of the relay: the armature forcibly strikes the backstop structure and rebounds, causing over-all vibration of the relay, wear, and plural false operations of the relay contacts.

Various attempts have been made to absorb the armature's excess kinetic energy through the use of plastic damping means interposed the armature and core and/or the armature and backstop. In general, these attempts have met with less than full success due to the unavailability of materials having a sufficiently low mechanical phase constant, due to lack of consistency of effect over a period of time resulting from displacement, wear or chemical change, and due to the failure of the damping means continuously to control the motion of the armature.

In accordance with the principles of this invention, means is provided which continuously controls the motion of the armature and which is substantially free of wear and of change of effectiveness with time. This means comprises a double-direction non-linear spring unit fixedly mounted with respect to the core and effective to con-

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trol the movement of the armature throughout the length of the armature's travel.

A more complete understanding of the nature of the invention may be obtained from the following detailed description of a preferred embodiment thereof, when read with reference to the accompanying drawings in which:

Fig. 1 is a top view of a structure embodying the principles of the invention, part of the structure being cut away to show certain details of the construction more clearly; and

Fig. 2 is a sectional view taken through 2—2 of Fig. 1. The relay in which the invention has been exemplarily embodied comprises a core having three legs 1, 2 and 3, the middle one of which is surrounded, over a portion of its length, by coil 4. The U-shaped armature 5 comprises a cross-piece extending across the front of the relay and adapted to bridge the three legs 1, 2 and 3 of the core, and two legs which extend rearwardly in proximity to the outside core legs 1 and 3, respectively, as may best be seen by reference to the cut-away portion of Fig. 1.

The bight of a U-shaped armature-return spring 7 is firmly held to the core by being clamped in the spring pile-up assembly 8. The legs of the armature-return spring 7 extend forwardly in proximity to the outer legs 1 and 3 of the core. Each of the legs of the armature-return spring 7 overlaps the end of the corresponding armature leg 6 and is affixed thereto by spot-welding or in any other suitable manner. Spring 7 is effective to hinge the extremes of the armature legs in pivotal relation with the core, to bias the armature to its unoperated position, and to restrain the movement of the armature in the operating direction.

A plurality of contact springs 9 is mounted in the spring pile-up assembly 8 and extends forwardly in approximate parallelism with the core. Certain of these springs are held in fixed relation to the core and certain others are so associated with the armature 5 as to be moved upon movement thereof. Any suitable spring-controlling means may be employed, such as the disclosed card system 10, for example.

Therefore, upon the energization of coil 4, armature 5 will pivot about the extremes of its legs and move downwardly (Fig. 2) toward the core legs 1, 2 and 3, operating the spring contacts in so doing. Upon deenergization of coil 1, armature 5 will return toward the position shown in the drawing, i. e., toward its released or unoperated position.

A spring-holding bracket of non-magnetic material is mounted near the forwardmost ends of the core legs 1, 2 and 3. This bracket, in one possible form, comprises two side members 11 and 12 (Fig. 1) extending in spaced parallelism one with the other, extending transversely of the core legs 1, 2 and 3, and engaging the side of those legs opposite the armature 5. Two essentially L-shaped blocks 13 are placed between the two side members 11 and 12 and at opposite ends thereof. Each of the blocks 13 is affixed to both of the side members 11 and 12 by soldering, welding, bolting, or by any other suitable means. Each of the blocks 13 is similarly affixed to the appropriate one of the outer core legs 1 and 3, this affixation being shown to be by screws 14 in the drawing. The operative armature-controlling member is a spring 15 which may be flat throughout its length, or may be provided with discontinuities 16 in its surface to increase the stiffness of the spring or otherwise to vary its characteristics. Spring 15 is firmly clamped at each end between one of the blocks 13 and one of the head pieces 17. Screws 18, passing through apertures in head pieces 17 and spring 15 and engaging tapped holes in blocks 13, serve as suitable attaching means. It has been found to be imperative that spring 15 be placed and maintained under tension if spring 15 is to have the requisite non-

linearity to fulfill its functions properly. Consequently, opposing outward forces of suitable magnitude should be exerted on the opposite ends of spring 15 while screws 18 are tightened.

The mid-portion of spring 15 is sandwiched between plates 19 and 20. Screws 21 engage apertures in spring 15 and in plate 20 and engage tapped apertures in plate 19 firmly to clamp that assembly together. By virtue of their engagement with tapped apertures in armature 5, screws 21 also serve as a mechanical linkage between the armature and the armature-controlling spring 15.

Upon energization of coil 4, armature 5 will be attracted to the core legs 1, 2 and 3, i. e., will move downwardly in Fig. 2. The movement of armature 5 will be communicated through screws 21 to plate 19 whereupon plate 19 will exert a downward force on spring 15. Since spring 15 is firmly clamped under tension between plates 19 and 20, spring 15 comprises in effect two tensioned cantilever springs, the effective length of each cantilever being controllable by varying the length of plate 19. The force-displacement characteristics of spring 15 in the operating direction of the armature may, therefore, be controlled by varying the length of plate 19, so that the forces exerted on the armature 5 by the coil 4 and core legs 1, 2 and 3, by the contact springs 9, by the armature-return spring 7 and by the armature-controlling spring 15 are in balance at any suitable point. Thus, the force-displacement characteristics of spring 15 may be selected so that the armature 5 will lightly strike the core, so that the armature will come to rest just at the core, or so that the armature will come to rest just before it contacts the core. It may be noted that the effective length of spring 15, in the direction of armature operation, may also be controlled by varying the width of head pieces 17, and that the force-displacement characteristics of the spring, in this direction of movement, may be controlled by varying the shape of the bearing surfaces 22 of the head pieces 17.

Upon deenergization of coil 4, armature 5 commences to return to its unoperated position, i. e., moves upwardly towards the position shown in Fig. 2 of the drawings. As armature 5 reaches the position shown in Fig. 2, however, it is moving at a substantial velocity, and therefore in the releasing of armature 5 as well as in the operating of armature 5, substantial kinetic energy must be in some fashion dissipated. Since no rigid backstop is provided, armature 5 can overtravel, i. e., it can continue to move upwardly after reaching the position shown in Fig. 2. In doing so, it again deflects spring 15 so that spring 15 again commences to oppose the motion of armature 5 and to absorb the excess kinetic energy of the armature. The effective force-displacement characteristics of spring 15, in the release direction of movement of the armature, can be controlled by varying the length of plate 20. The force-displacement characteristics of spring 15 can also be controlled, during the release period, by varying the length, the slope, and/or the shape of the bearing surfaces 23 of blocks 13. While surfaces 23 have been shown to be curved, it is to be understood that they may be straight or that they may approximate an arc of a circle, a portion of an ellipse, or have any other suitable geometry to impart the desired force-displacement characteristics to spring 15.

It will therefore be seen that armature 5 can be so conjointly controlled by springs 7 and 15 that the armature velocity, during operation of the relay, will reach zero at such time that there is but little or no impact of the armature and core and no rebounding of the armature. Similarly, upon release of the relay, the excess kinetic energy can be dissipated in the spring 15 rather than by forceful engagement of the armature with a backstop structure. Consequently, the armature can be operated and released without improper functioning of the relay contacts, and with minimum vibration and wear of the relay.

It is to be understood that the above-described arrangements are but illustrative of the application of the principles of the invention. Numerous other arrangements

may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a relay, a core, an armature, a spring hinge connecting said armature to said core, support means affixed to said core, a spring member supported at its ends under longitudinal tension by said support means, a first and a second plate on opposite sides and intermediate the ends of said spring member, and means for connecting said plates and said spring member to said armature.

2. In a relay, a flat core, an armature, a spring hinge connecting said armature to one side of said core, support means affixed to the other side of said core, a spring member supported at its ends under longitudinal tension by said support means, said spring member being spaced from said other side of said core, a first and a second plate on opposite sides and intermediate the ends of said spring member, and means for connecting said plates and said spring member to said armature.

3. In a relay, a flat core, a flat armature, a spring hinge connecting said armature to one side of said core and biasing said armature away from said core, a first and a second support block affixed to the other side of said core, a head piece individual to each of said blocks, a tensioned spring member, means for clamping one end of said member between said first support block and the head piece individual thereto, means for clamping the other end of said member between said second support block and the head piece individual thereto, a first and a second plate on opposite sides of said spring member, and means for connecting said plates and said spring member to said armature.

4. In a relay, a flat core having three legs, a flat armature bridgeable across the three legs of said core, a spring hinge connecting said armature to one side of said core and biasing said armature away from said core, a first support block affixed to the other side of one of the legs of said core, a second support block affixed to the other side of another one of the legs of said core, a head piece individual to each of said blocks, a tensioned spring member, means for clamping one end of said member between said first support block and the head piece individual thereto, means for clamping the other end of said member between said second support block and the head piece individual thereto, a first and a second plate on opposite sides of said spring member, and means for connecting said plates and said spring member to said armature.

5. In a relay, a flat core having two outer legs and one inner leg, a coil on the inner leg of said core, a flat armature bridgeable across one side of the legs of said core, a U-shaped spring hinge connecting said armature to said one side of said core and biasing said armature away from said core, a first support block affixed to the other side of one of the outer legs of said core, a second support block affixed to said other side of the other of the outer legs of said core, means rigidly interconnecting said blocks, a head piece individual to each of said blocks, a tensioned flat spring member having a transverse axis lying parallel to and a longitudinal axis lying perpendicular to the longitudinal axes of the legs of said core, said spring member being spaced from said other side of said core, means for clamping one end of said member between said first support block and the head piece individual thereto, means for clamping the other end of said member between said second support block and the head piece individual thereto, a first and a second plate on opposite sides of said spring member, and means for connecting said plates and said spring member to said armature.

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