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R. L. PEEK, JR

2,800,535

CONTACT SPRINGS

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FIG. 1

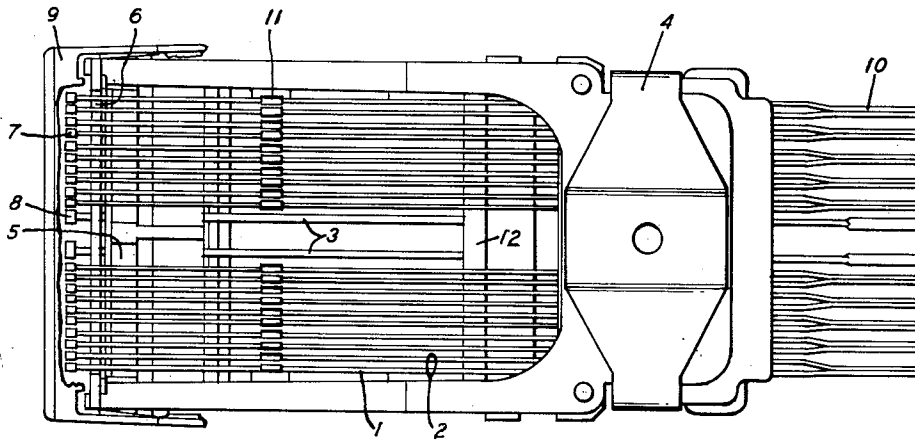


FIG. 2

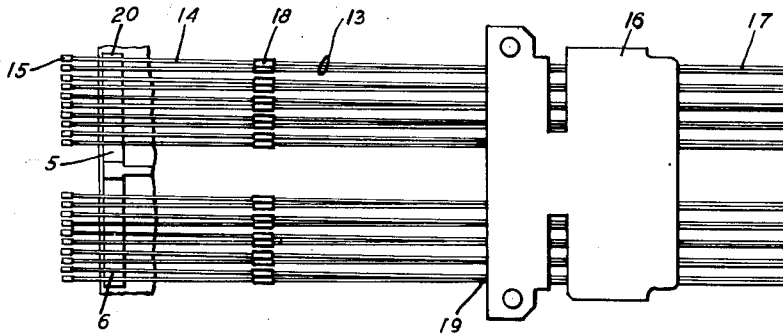


FIG. 3

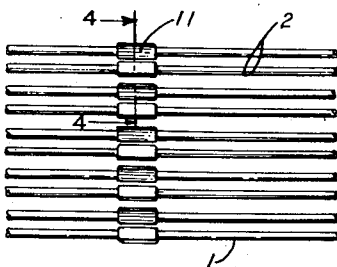
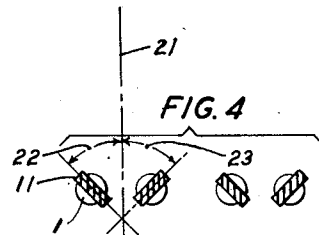


FIG. 4



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CONTACT SPRINGS

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12 Claims. (Cl. 200—1)

This invention relates to relay construction and more particularly to means whereby contact spring vibration resulting from the operation of relays is reduced in severity.

An object of the invention is to improve the operation of relays by largely eliminating recurrent vibratory reopenings caused by impact and other vibration heretofore present when such relays were operated or released.

A further object of the invention is to reduce contact chatter associated with the operation and release of relays.

Still another object of the invention is to increase the life wear characteristics of relay contacts by reducing the vibratory propensity of the movable springs to reopen said contacts after closure whereby arcing pits and erodes their surfaces.

More particularly, an object of the invention is to decrease the initial or impact vibrations of a relay's springs when the relay is operated or released, the initial vibrations being less amenable to conventional damping means than are later induced vibrations.

Another more particular object of the invention is to maximize the interference dissipation between the wires of a cooperating pair of springs such as are employed on conventional wire spring relays in order to damp the spring vibrations subsequent to the initial or impact vibrations.

Yet another specific object of the invention is to minimize the wear of the cards or studs associated with the movable springs of an electromagnetic device in order to maintain proper adjustments of the device for longer periods of time.

A feature of the invention pertains to spring vibration dissipative means in a relay so arranged that such means is not dependent upon such things as wear of an actuation card, contact surfaces, spring guide combs, or the like, or structure which may be used to fixedly retain springs, or the like, in proper spatial relationship with other functioning components of the relay.

Another feature of the invention resides in the arrangement whereby the axes of minimum section moduli for contact springs lie in planes which form acute angles with the normal operational plane of the springs.

A more specific feature of the invention involves coined flats on the movable springs of a wire spring relay such that said flats lie in planes which intersect the normal operational plane of the springs at acute angles.

Still another specific feature involves a coined flat on each of a cooperating pair of physically coupled movable wire springs in a wire spring relay such that said flats are at angles acute to the normal operational plane of movement of the springs and are substantially perpendicular to one another.

Yet another more specific feature of the invention involves molding the movable wire springs in assembly configurations similar to those disclosed in Patent 2,682,585, issued June 29, 1954, to H. M. Knapp et al. but wherein the terminal ends of the wire springs, which form a pair cooperating with a given fixed contact, are held in con-

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tact with one another along a tangential plane and wherein flats are coined on each one of each cooperating pair of said springs such that the flats are substantially perpendicular to each other and are at acute angles to the normal plane of movement of said springs.

Other objects and features of the present invention may be more readily understood from the following explanation and description when read with reference to the drawings in which:

Fig. 1 is a plan view of an electromagnetic relay including an embodiment of the invention;

Fig. 2 is a plan view of a molded wire spring assembly and a portion of a front molded block including a second embodiment of the invention;

Fig. 3 is an enlarged cutaway view of the coined flats illustrated in Fig. 1 and looking in the same direction as Fig. 1; and

Fig. 4 is an enlarged front end view of the coined flats taken along line 4—4 in Fig. 3.

After a description of the exemplary details of construction is set forth, an analysis and discussion of the merit of such details will be provided.

Looking at the figures in detail, Fig. 1 is a plan view of a wire spring relay wherein a plurality of movable wire springs 1 which are grouped as pairs 2 cooperate with fixed springs 3. The pairs of movable wire springs 2 which would cooperate with illustrated fixed springs 3 have been omitted in Fig. 1 to more clearly show the fixed spring construction, but they are similar to those pairs 2 depicted. The relay utilizes a plurality of molded wire spring assemblies, two of which are similar to the one depicted in Fig. 2. The plurality of molded spring assemblies are held in proper spatial relationship to one another, to the relay core (not shown), to the fixed spring assembly (partially shown), etc. by spring clip 4. The contact carrying ends of the molded spring assemblies are held in proper spatial relationship to one another by a front molded support 5 which fixedly retains the contact carrying ends of the fixed wire springs 3 in proper spatial relationship with the core plate of the relay (not shown).

On the upper and lower surfaces of the front molded support 5, as identified when the relay in Fig. 1 is viewed from the front end (left side of the drawing), are a series of teeth-like protrusions 6 which properly space and act as guides for the movable wire springs 1. The movable wire spring contact elements 7 which are affixed to the two wire springs 2 which form a pair cooperate with their respective fixed contact element 8.

A partial cutaway of the conventional dust-cover 9 is also shown in Fig. 1, as well as contact terminals 10.

A series of coined flats 11 formed along the intermediate portion of the movable springs 1 is shown. Damping bumpers 12 may be disposed between the assemblies of movable wire springs 1 and the assembly of fixed wire springs 3.

Fig. 2 discloses a molded wire spring assembly comprising a plurality of pairs 13 of movable contact springs 14 and the contacts 15 associated therewith. A cutaway portion of a front molded support 5 and associated teeth 6 is depicted holding the wire springs 14 apart at their forward or contact carrying ends. It is to be noted in this figure that the cooperating pair 13 of wire springs 14 are molded in the block assembly 16 with their rearward ends 17 physically coupled tangent to one another. Coined flats 18 are depicted intermediate to the cantilever retention points 19 and prop points 20 of the molded wires 14, said propped points 20 occurring at front molded support 5.

Fig. 3 is an enlarged cutaway section of pairs 2 of cooperating springs 1 and the coined flats 11 associated therewith as depicted in Fig. 1. The surfaces of the

coined flats 11, formed on a pair of cooperating movable springs 2, are at right angles to one another as depicted in Fig. 4. It will further be noted that the planes in which the surfaces of the coined flats 11 lie intersect the normal plane of operational motion 21 of the wire springs at acute angles 22 and 23, which, although shown to be about forty-five degrees each, need not be equal.

A prototype wire spring relay, of which the instant disclosure is an improvement, is disclosed and claimed in Patent 2,682,585, supra. The instant relay differs from the prototype primarily in the employment of coined flats and in the construction of the molded wire spring assembly depicted in Fig. 2.

Relay spring vibration and its resultant contact chatter always have been a serious problem in relay operation and in circuits embodying relays. Spring vibration is due to a multiplicity of causes randomly connected with the operational pattern of a given relay; e. g. the initial impact of the contacts when the relay is operated or released, the transmitting of external vibrational forces through the mounting bracket of the relay of the springs and their contacts, the vibrations transferred to the movable springs and their contacts as a result of armature impact, both against the core plate upon operation and the armature's back stop upon release, etc.

The magnitude of contact chatter resulting from some or all of the aforementioned diverse causes of spring vibrations is dependent in a large part upon the relative strength of the dynamic force or force modulation developed by the armature as it propels the contacts associated with the movable springs into intimate contact with those associated with the fixed springs, and the static force tending to hold the respective contact surfaces separated.

In most relay configurations, the static force is supplied by biasing springs. It is desirable from the standpoint of contact chatter to keep the static force as large as possible because it reduces armature rebound and movable spring vibration. However, as a result of a large static force, the relay's work load is increased, which in turn decreases relay sensitivity or requires that a larger coil be employed.

Instead of using exorbitantly large restraining forces to mitigate spring vibration and contact chatter, thereby to impede movement of the armature or at least seriously to reduce the relay's speed of operation, other means have generally been employed.

Some of the more common methods used to reduce spring vibrations and the contact chatter caused thereby are damping and shock cushioning means. Unfortunately, the common ways of damping and cushioning shocks are exercised at the expense of a reduction in the life of the relay contacts, relay structure, etc. or they are, in some instances, sufficiently expensive not to be economically justified. Further, it may well be that, apart from their cost, such damping means will be structurally objectionable, either initially or due to deterioration over a period of time. In this latter connection, the damping means may come to seriously interfere with proper relay operation.

In the general purpose wire spring relay as exemplified in the disclosure of Patent 2,682,585, supra, damping occurs to some extent at the contact surfaces, the movable spring guide comb, the cantilever retention points of the wire springs (where the springs enter the molded spring assemblies), and within the springs themselves (internal absorption). All of the above dissipative means decrease objectionable contact chatter, but they also decrease the life of the relay due to wear. Hence, these particular dissipative means should be minimized, and other means employed to reduce objectionable spring vibrations.

One way to minimize wear at such points in the relay structure and still reduce spring vibration is to place loose sleeves on each of the wire springs such as is done on open wire telephone lines where high frequency "singing" occurs. Another method, which is used on the wire spring

relay referred to, supra, resides in placing a bumper of soft dissipative material between the movable and fixed springs to absorb the vibratory energy stored in the springs during the relay's operation. While the sleeves will effectively dissipate most vibrations induced in the springs, their use entails substantial cost. On the other hand, the cost of bumpers can more readily be justified, but they are less efficient in reducing vibrations and may become structurally objectionable.

The invention disclosed herein is a generally better method of reducing vibratory motions in relay springs. Springs constructed in accordance with the instant invention do not possess the economical, structural, or wear disadvantages inherent in most other methods which are used or might be used to reduce spring vibration and the deleterious effects thereof.

It has been determined that the principal vibration of a wire spring occurs in a simple or normal plane coinciding with the direction of movement of the armature when the relay operates. The instant invention utilizes this fact, as particularly noted in relays employing wire springs, in conjunction with the fact that a circular member is capable of movement in any radial direction, to transfer part of the vibratory motion that normally occurs in the normal or operational plane to a relatively harmless plane perpendicular to the normal one.

This transfer to a relatively harmless plane can be produced if the axis of the minimum section modulus of the spring is arranged to lie in a plane which intersects the operational plane at an acute angle. The section modulus is the factor

$$\frac{I}{c}$$

in the flexure formula

$$M = \frac{SI}{c}$$

where:

M = bending moment in lbs.-in.

S = unit stress on any fiber in the beam in lbs. per square in.

I = rectangular moment of inertia of the beam with respect to its neutral axis in in.

c = the distance from the neutral axis to the outermost fiber of the cross section under consideration in in.

The factor

$$\frac{I}{c}$$

or section modulus is the conventional measure of the capacity of a section of a beam to resist a bending moment. A description and discussion of the flexure formula and the section modulus can be found in nearly any standard text on structural design or in any handbook, e. g., see Kent's Mechanical Engineer's Handbook, Design and Shop Practice, 11th ed. (1947), 7-17 et seq. Generally, such handbooks list values for section moduli of different cross sections including structural members such as I-beams, channels, etc.

It has been discovered that a minimum section modulus, to transfer part of this objectionable vibratory motion to a relatively harmless perpendicular plane of motion, can be obtained by coining a flat on the wire spring. As long as the flat lies in a plane which forms an acute angle with the plane of operational motion, transfer of some of the vibratory motion causing contact chatter will be effected. With this arrangement, the vibration is not confined to motion in the plane of actuation, but is described by the vector sum of a component lying in the plane of operational motion and a second component lying in a plane perpendicular thereto.

Investigations have indicated that this method of transferring part of the vibratory motion of a wire spring to a relatively harmless direction reduces by a substantial amount the energy content of the normal component.

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These investigations were conducted with round wires and a coined flat in length equal to substantially 5 percent of the free length of the wire springs. The flat was placed at the approximate mid-point of the free length and at an approximate 45-degree angle to the normal plane of motion.

Wire springs in the general purpose wire spring relay act effectively as propped cantilevers fixedly retained at a point corresponding to 19 on Fig. 2. Hence, results were obtained with a flat 11 (Fig. 3) coined at an essentially 45-degree angle (22 or 23 of Fig. 4) to the normal plane of motion 21 (Fig. 4); said flat equal in length to approximately 5 percent of the distance between cantilever retention point 19 and prop point 20 (Fig. 2), and placed substantially midway between points 19 and 20.

It is to be noted that less improvement can be obtained in reducing other than the impact or initial vibrations when the flat is at the mid-point of the propped cantilever spring. This is because the mid-point is at or near a node for some of the higher modes of vibration, and hence, such modes are not broken up as effectively as are the lower modes. Of course, it may well be that there are better positions along the length of the wire spring where the flat should be placed (e. g. the quarter point).

An improvement in the dissipation of impact energy greater than 50 percent was obtained in the case of the first mode of a single wire spring when it had a flat coined on it. In the case of the third mode, whose energy content in the absence of a coined flat was equal to approximately one-half that of the fundamental mode with no flat, the energy content was reduced to effectively zero.

In the case of twin wire springs (as used on the wire spring relay), when both springs had flats coined on them the order of improvement over twin wire springs without such flats was found to be in the order of 50 percent in the first and second modes and 30 percent in the case of the third mode. It is to be noted that in the case of twin wire springs with flats coined thereon, second mode dissipation occurred. This happens because the twin wires vibrate out of phase with one another and hence dissipate part of the energy found in the second mode; whereas, in the case of a single wire spring with a flat coined thereon, no cooperating wire spring is present to help reduce the energy content of the second mode.

These improvements in the degeneration of vibrational energy in the normal plane of the relay's operation are more pronounced when the wire springs which form a cooperating pair are physically coupled, such as being molded in actual contact with one another as depicted in Fig. 2. When the wires are in actual contact, their out-of-phase vibrations most effectively interfere with one another and hence damping is most efficient. When two wires of a pair are otherwise physically coupled to one another, as for example, through the media of a molded assembly rather than in actual contact with one another, the wires do not damp one another as efficiently. This results from the fact that the molding compound is not able to dissipate energy internally as expeditiously as do springs in contact nor is it able to transfer out-of-phase vibrations from one wire to the other as efficiently.

The reduction in energy content attributable to coining flats on wire springs as heretofore described is such that it substantially reduces spring vibrations, contact chatter, wear of the relay's components and minimizes continuing adjustments. The diversion of part of the impact energy of the wire springs to a perpendicular, and consequently, relatively harmless direction, reduces initial and early shock vibration at once, thereby improving the operating standard of relays. Ordinarily this initial vibratory motion is more difficult to eliminate by conventional methods of damping, hence, such an effective reduction in the initial energy content improves to a great extent the performance of the relay. The diversion of energy to a harmless direction of motion working in

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conjunction with the interference damping means substantially impedes the later spring vibrations.

The length of the flat and its position along the propped length of the wire spring also affect the degree of energy reduction, and further, will certainly influence the particular modes of vibration which are to be partially dissipated in the relatively harmless perpendicular direction. If the flats are not placed at any point along a propped cantilever spring which forms a node for one of the lower order harmonics more effective damping in all the lower order modes will be obtained. It has been established that the magnitude of the impact energy remaining in the higher modes is generally too small for them to contribute substantially to contact chatter and other adverse effects of spring vibrations. Then too, these higher harmonic vibrations are more effectively damped by such means as the bumper 12 depicted in Fig. 1 than are the lower harmonics.

The length of the flat, the width thereof, nor the angle formed with the normal plane of motion need be as heretofore specified. Also, the flats need not protrude past the diameter of their associated wire springs, it would be just as well if their width were limited to the diameter of the wire spring in order to preclude the necessity of wider spacing, etc. The results obtained would not vary materially because of this change.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. While the instant invention is described and depicted utilizing round springs as embodied in a wire spring relay, this is merely for exemplary purposes and should in no way be construed as limiting the invention to round or wire springs or for that matter to wire spring relays. 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. A contact spring fixed at one end and having its other end movable in a normal plane and having the axis of its minimum section modulus lying in a plane intersecting said normal plane at an acute angle.

2. A contact spring fixed at one end and having its other end movable in a normal plane and including a segment located between said ends having a section modulus less than that of any other section of said spring, the axis of said section modulus lying in a plane intersecting said normal plane at an acute angle.

3. A filamentary contact spring fixed at one end and having its other end movable in a normal plane and including a flattened portion located intermediate said ends, said portion lying in a plane intersecting said normal plane at an acute angle.

4. A filamentary contact spring fixed at one end and having its other end movable in a normal plane and including a flattened portion located substantially midway between said ends, said portion lying in a plane intersecting said normal plane at an acute angle.

5. A filamentary contact spring fixed at one end and having its other end movable in a normal plane and including a flattened portion located substantially midway between said ends, said portion lying in a plane intersecting said normal plane at an angle of approximately 45 degrees.

6. A propped cantilever round contact spring fixed at one end and propped at its other end and having said other end movable in a normal plane and including a flattened portion of length equal to approximately 5 percent of the free length of said spring and located substantially midway between said ends, said portion lying in a plane intersecting said normal plane at an angle of approximately 45 degrees.

7. A pair of substantially parallel contact springs, means for fixedly retaining one end of each so that said one ends are physically coupled, means for moving the other

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ends of said pair in substantially parallel normal planes, said springs having the axes of their minimum section moduli lying in planes which are substantially perpendicular to one another and which intersect said normal plane at acute angles.

8. A pair of substantially parallel contact springs, means for fixedly retaining one end of each so that said one ends are physically coupled, means for moving the other ends of said pair in substantially parallel normal planes, and including a segment on each of said springs located between said means having a minimum section modulus, the axes of said section moduli lying in planes which are substantially perpendicular to one another and which intersect said normal plane at acute angles.

9. A pair of substantially parallel filamentary contact springs, means for fixing one end of each so that said one ends are physically coupled, means for moving the other ends of said pair in substantially parallel normal planes, and including flattened portions on each of said springs located intermediate said means, said portions lying in planes which intersect said normal plane at acute angles.

10. A pair of substantially parallel filamentary contact springs, means for fixing one end of each so that said one ends are physically coupled, means for moving the other ends of said pair in substantially parallel normal planes, and including flattened portions on each of said springs located intermediate said means, said portions lying in planes which are substantially perpendicular to one another and which intersect said normal plane at acute angles.

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11. A pair of substantially parallel physically coupled filamentary contact springs disposed as propped cantilevers, means for moving the propped ends of said pair in substantially parallel normal planes, and including flattened portions on each of said springs located substantially midway along the free length of said cantilevers, said portions lying in planes which are substantially perpendicular to one another and which intersect said normal plane at acute angles.

12. A pair of substantially parallel filamentary contact springs, means for fixedly retaining one end of each of said springs whereby said one ends are in contact with one another, means for supporting the other ends of said springs separate from one another, means for moving said other ends in substantially parallel normal planes, and including flattened portions on each of said springs located substantially midway between said fixed and movable ends thereof, said portions lying in planes which are substantially perpendicular to one another and intersect said normal plane at acute angles.

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