

Nov. 4, 1952

D. C. KOEHLER
PRETENSIONED SPRING

2,616,993

Filed July 17, 1947

2 SHEETS—SHEET 1

FIG. 1

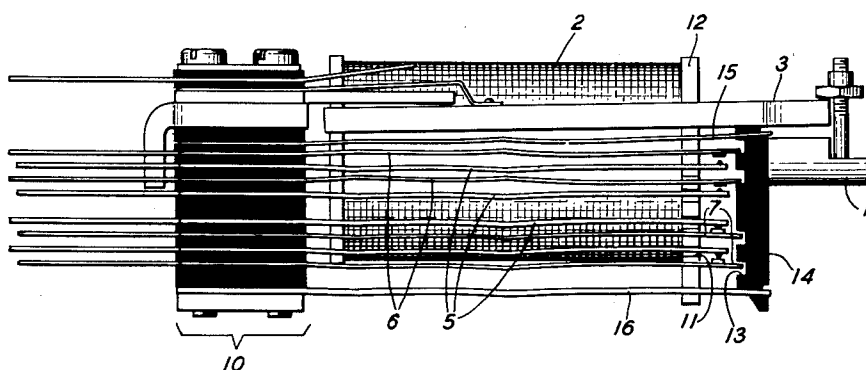


FIG. 2

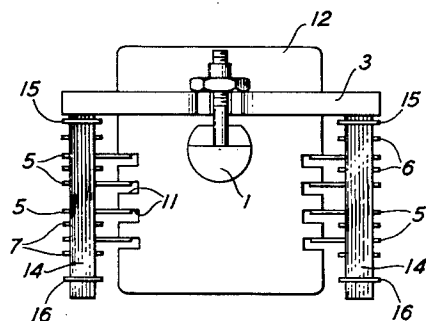


FIG. 3

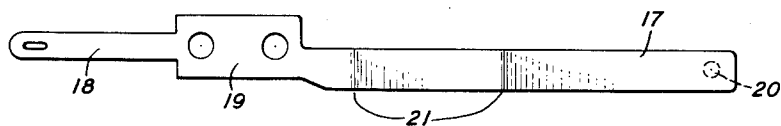
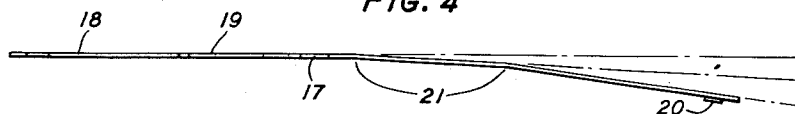


FIG. 4



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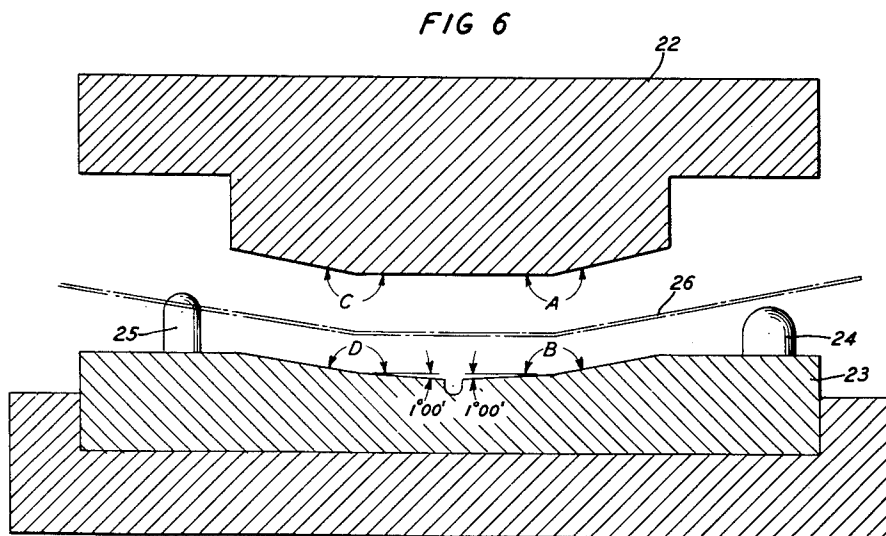
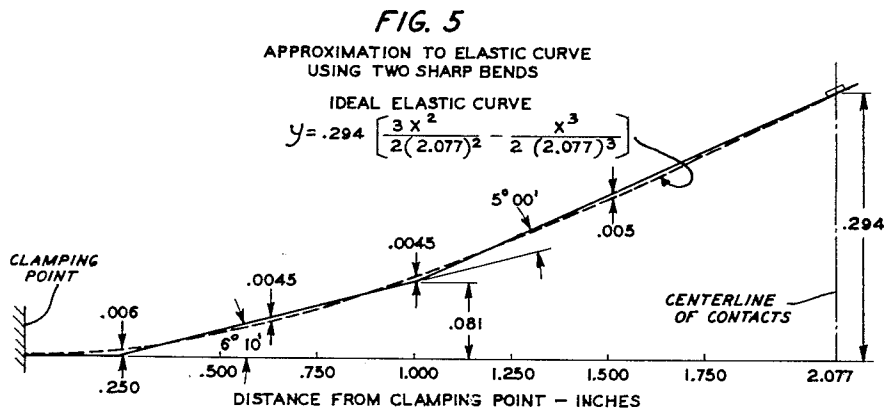
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2 SHEETS—SHEET 2



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UNITED STATES PATENT OFFICE

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PRETENSIONED SPRING

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10 Claims. (Cl. 200—1)

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This invention relates to elongated spring members and to methods for pretensioning said members, and more particularly to springs for electrical switching apparatus and new and improved methods for producing a predetermined tension in such springs.

In various utilizations of leaf or wire spring members, it is often a requirement that such springs be arranged to exert a certain amount of pressure at a given degree of flexure, i. e., that such springs shall be preformed so as to exert a certain pressure upon subsequent pretensioning. Such requirements are found in applications to electrical apparatus, and particularly in applications to electrical switching apparatus in which various electrical circuits are opened or closed under the control of electromagnetic devices or relays. It is frequently desirable or necessary that the contact springs employed in such relays be pretensioned so as to exert a given pressure when in position in the relay, or, in some instances, so as to exert a required contact pressure when operated by an armature which may, itself, be supported or biased by a pretensioned spring member.

A further requirement arising from the conventional arrangement of a plurality of contact springs mounted and arranged in parallelism is that when the contact end of an individual spring is offset from the plane of the clamping surface by an amount sufficient to give the proper spring tension, the shape of the curve must be controlled so that when the spring is mounted in a relay it will lie approximately straight so as to maintain necessary clearances between adjacent springs. Such requirement particularly exists where adjacent springs are tensioned in opposite directions.

The pretensioning of contact or similar springs has generally been accomplished by the hand-forming of the member in a smooth curve throughout its length. Attempts to preform such springs by a machine operation have generally proved unsatisfactory inasmuch as minor variations in spring thickness, hardness or elastic limit resulted in a non-uniform product which required further expensive and time-consuming manual adjustment after installation in the relay.

As far as the applicant is aware, previous attempts in the art to pretension springs have failed to meet all phases of the three-fold problem, i. e., if a uniform accurate preforming of the spring were obtained, the method either failed to obviate the necessity for an expensive hand operation, or else, by placing but a single

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bend in the spring, necessitated having all springs tensioned in the same direction to attain the required clearances between adjacent members while maintaining relay compactness.

An object of this invention, therefore, is to accurately, uniformly, and economically preform spring members to have a predetermined tension when in place.

Another object of this invention is to pretension resilient members so that when under the required degree of tension, they will lie in approximately a straight line.

A further object is to provide a simple and effective method for mechanically producing a predetermined tension in such spring members.

In accordance with the general features of the invention, elongated spring members are preformed to obtain a uniform predetermined degree of pretensioning by placing a series of sharp transverse bends in the spring at various points along its length. The bends are so located and of such degree that the resulting member is formed to closely approximate the shape of a desired curve to provide a given degree of subsequent pretensioning. Subsequent pretensioning shall hereinafter be understood to mean that when said spring is flexed into an approximately straight line it will exert a reactive pressure of a predetermined amount.

The invention may be more fully understood by reference to the accompanying drawings in which:

Fig. 1 is an elevational view of a relay equipped with contact springs embodying the features of the invention;

Fig. 2 is an end view of the relay disclosed in Fig. 1;

Fig. 3 is a top view of a contact spring preformed in accordance with the invention;

Fig. 4 is a side view of the contact spring shown in Fig. 3;

Fig. 5 represents a contact spring preformed to approximate a desired curve; and

Fig. 6 is an elevational view of a punch and die member which may be used to preform springs in accordance with the invention.

In order to demonstrate the employment of contact or support springs preformed in accordance with the present invention, an electromagnetic device or relay has been depicted in Figs. 1 and 2 which is more completely described in Patent 2,472,709, granted June 7, 1949, to H. M. Knapp. The relay comprises a core 1 having an actuating coil 2, and an armature 3. A plurality of contact springs 5, 6 and 7 are mounted in a

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spring pileup assembly 10 and extend in approximate parallelism to each other and to the core 1. The fixed or passive contact springs 5 are engaged by notches 11 in fixed card 12, and are so preformed that when installed in the relay they tend to bend upwardly at the contact end and thus exert a predeterminable pressure against the upper edges of the notches 11 in spoolhead 12. The advantage of such pretensioning of the fixed springs 5 and the employment of wide notches 11 is that the difficulty is thereby obviated of cutting notches of the exact width in a fixed card to firmly and accurately hold non-pretensioned springs of slightly varying thickness. The active or movable springs 6 and 7 are engaged by notches 13 in a movable card 14, actuable by armature 3. Each of these movable contact springs 6 and 7 is bent or preformed so as to be pretensioned to a desired degree when installed in the relay. The springs 6 which are arranged to make contact with their mating springs 5 upon actuation of the relay, are bent so as to exert a downward pressure against their respective notches 13 in card 14, and are normally held out of contact with their mating springs by the reactive pressure of said card 14. Springs 7, which are arranged to break contact with their mating springs 5 upon actuation of the relay, are bent so as to normally exert an upward pressure against their respective mating springs 5.

Upon actuation of the relay and the resulting downward movement of card 14, the upward pressure of the notches 13 against the springs 6 is released and said springs 6 move downwardly solely as a result of their resilient tension to engage their mating springs 5, and springs 7 are forced downwardly by card 14 so as to break contact with their respective mating springs 5. When the relay is not operated, the armature 3 is held in its released position as shown in Figs. 1 and 2 by the upwardly exerted resultant pressure of the downwardly tensioned contact springs 6, the downwardly tensioned balancing springs 15 and the upwardly tensioned balancing springs 16.

In accordance with the invention, the contact springs 5, 6 and 7 and the balancing springs 15 and 16 are each bent transversely at two points in their length (see Figs. 3 and 4) to a proper degree to provide the desired amount of pretensioning when they are installed in the relay. When the individual springs are clamped in the spring pile-up assembly 10 and placed in their normal tensioned position under the action of spoolhead 12, card 14, or their mating springs as previously described, each of the individual springs lies in approximately a straight line. In other words, when the relay is unoperated and thus the individual spring is in its normal tensioned position, the individual spring deviates but slightly from a plane surface. As may be seen in Fig. 1, in which the resultant shape of the spring has been greatly exaggerated for purposes of clarity, each segment of each spring assumes a slightly curved shape.

The necessity of preforming the individual springs so that upon subsequent pretensioning they will lie approximately straight arises from the requirement for clearance between adjacent springs to obviate the danger of undesirable interspring electrical contact. Such danger particularly exists where adjacent springs are tensioned in opposite directions as is the case of the upper two pairs of mating contact springs in Fig. 1. The applicant has found that if but a

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single sharp bend is placed in each spring it is difficult to reconcile the opposing factors of interspring clearance, relay compactness, spring thickness, and required amount of spring tensioning. Further, when mating springs are pretensioned in opposite directions, the contacting ends of springs having but a single bend are not sufficiently parallel one to the other to secure full use of the contacting surfaces.

In Figs. 3 and 4 a contact spring 17 comprising a terminal portion 18, a clamping surface 19 and a contact means 20 is bent transversely beyond the elastic limit of the material at two points 21 along its length. It is to be understood that additional bends may be placed at other points throughout the length either to position the operating length of the spring in relation to other parts for purposes other than pretensioning, or to more closely approximate a desired curve for purposes of pretensioning.

In order to meet the several requirements for springs to be used in approximate parallelism with other springs and formed to provide a desired degree of force, and particularly to meet the requirement for contact springs to be used in electromagnetic devices in which such springs must be mounted in parallel proximity for reasons of relay compactness and yet must have a certain minimum clearance between adjacent springs to prevent the completion of undesirable circuits, the springs should be curved in such a manner that when flexed to their normal pretensioned position, they will lie approximately in a straight line, as was briefly mentioned above in several instances.

In the embodiment of the invention presented herein, the spring has been bent to closely approximate the curve of a cantilever beam loaded at one end, the equation of such an elastic curve being representable by:

$$Y = \Delta \left(\frac{3X^2}{2L^2} - \frac{X^3}{2L^3} \right)$$

in which

Y = the ordinate as measured from a horizontal plane through the clamping surface,
 Δ = the maximum deflection of the spring as determined to provide a given contact force,
 X = the abscissa as measured from a vertical plane through the clamping point, and
 L = the length of the spring as measured from the clamping point to the center line of contacts.

In the example of Fig. 5 the dotted line represents such an elastic curve in which the length of the spring from clamping point to contact has been selected as 2.077 inches and in which the characteristics of the metal and the amount of pretensioning required have necessitated that the maximum deflection Δ be 0.294 inch. If the spring were conformed to the shape of the ideal elastic curve shown, it would form a straight line when the contact end was returned to the position of zero deflection.

The heavy line in the graph of Fig. 5 represents a contact spring shaped to closely approximate the theoretical curve of a cantilever beam loaded at one end by the placing of a 6-degree 10-minute transverse bend 0.250 inch from the clamping point, and an additional 5-degree transverse bend at a point 1.000 inch from the clamping point. As is evident in the graph of Fig. 5, the maximum departure from the ideal curve is 0.006 inch at the first bend. If the re-

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sultant pressure required is greater than can be obtained without undue departure from the theoretical curve, three or more bends per spring may be used.

In order to preform a spring having two bends as shown in Figs. 3 and 4, a punch and die assembly as depicted in Fig. 6 may be used. The tool comprises a male portion 22 and a female portion 23 between which the springs are pressed. Locating pins 24 and 25 may be provided to position the springs 26 relative to the die 23. In order to concentrate the pressure on the springs in the region where the bending takes place to provide greater uniformity in the amount of bend retained by the springs, the angles on the male or punch portion are made slightly sharper than the corresponding angles on the female or die portion. In the embodiment of the invention presented, for example, the angle A is one degree sharper than the angle B, and the angle C is one degree sharper than its mating angle D. The applicant has found through extensive study of the bent springs formed through the employment of this punch and die that there is no appreciable grain distortion, reduction in spring thickness, or reduction in the strength of the material in the area adjacent the bend.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore disclosed or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense. Specifically, the applicant has considered the employment of armature support or balancing springs of a material other than metal, the preforming of round wire springs in accordance with the invention, the bending of the spring to approximate a curve other than that disclosed herein, and the application of the invention to the preforming of springs for use in apparatus or mechanisms other than electromagnetic devices.

What is claimed is:

1. In a switch, a first and a second contact spring mounted in spaced proximity one to the other, each of said springs being shaped to approximate a desired elastic curve to provide a desired degree of subsequent pretensioning, each of said springs comprising an elongated metallic cantilever fixed at one end only, a finite number greater than one of permanent, transverse bends in the same direction in said cantilever, and electrical contact means at the free end of said cantilever, and means for causing movement of said first spring relative to said second spring to move said first spring into operative position relative to said second spring.

2. A cantilever spring comprising an elongated metallic member, and a plurality of spaced apart permanent transverse bends in the same direction in said member, the portion of said spring intermediate an adjacent pair of said bends being straight, and single unitary support means fixing one end only of said spring and adapted to prevent movement of any part of said fixed end responsive to the application of an unbalanced force at any other point along said spring, the shape of said spring approximating when not under load the shape it would assume if it were under load but had no permanent transverse bends.

3. In a switch, a first and a second contact spring mounted in spaced proximity one to the other, each of said springs being shaped to approximate the elastic curve of a cantilever beam

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loaded at one end to provide a desired degree of subsequent pretensioning, each of said springs comprising an elongated metallic cantilever fixed at one end only, a finite number greater than one of permanent transverse bends in the same direction in said cantilever, and electrical contact means on the free end of said cantilever, and means for causing movement of said first spring relative to said second spring to move said first spring into operative position relative to said second spring.

4. In a switch, a first and a second contact spring mounted in spaced proximity one to the other, each of said springs being shaped to approximate the elastic curve of a cantilever beam loaded at one end to provide a desired degree of subsequent pretensioning, each of said springs comprising an elongated metallic cantilever fixed at one end only, only two permanent transverse bends in the same direction in said cantilever, and electrical contact means adjacent the free end of said cantilever, and means for causing movement of said first spring relative to said second spring to move said first spring into operative position relative to said second spring.

5. In a switch, a first and a second contact spring mounted in spaced proximity one to the other, each of said springs being fixed at one end only and shaped to approximate the elastic curve of a cantilever beam loaded at one end in order to provide a desired degree of subsequent pretensioning, each of said springs comprising an elongated metallic member, two permanent transverse bends in the same direction in said member, and electrical contact means adjacent the free end of said member, said elastic curve being representable by the equation

$$Y = \Delta \left(\frac{3X^2}{2L^2} - \frac{X^3}{2L^3} \right)$$

in which Y is the ordinate as measured from a horizontal plane through one end of the spring, Δ is the maximum deflection of the spring as determined to give a given contact force, X is the abscissa as measured from a vertical plane through one end of the spring, and L is the length of the spring.

6. A cantilever spring comprising an elongated metallic member, and only two permanent transverse bends in the same direction in said member and single unitary support means fixing one end only of said spring and adapted to prevent movement of any part of said fixed end responsive to the application of an unbalanced force at any other point along said spring, the portion of said spring intermediate said two bends being straight, the shape of said spring approximating when not under load the shape it would assume if it were under load but had no permanent transverse bends.

7. A spring shaped to approximate a certain elastic curve in order to provide a desired degree of subsequent pretensioning comprising an elongated metallic member and a finite number greater than one permanent transverse bend in the same direction in said member, said certain elastic curve being representable by the equation

$$Y = \Delta \left(\frac{3X^2}{2L^2} - \frac{X^3}{2L^3} \right)$$

in which the ordinate Y is a distance measured from a horizontal plane through one end of the spring, Δ is the maximum deflection of the spring as determined to give a given reactive force, the abscissa X is a distance measured from a vertical

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plane through one end of the spring, and L is the length of the spring.

8. A cantilever contact spring comprising an elongated metallic member and a plurality of spaced apart permanent transverse bends in the same direction in said member, the portion of said spring intermediate an adjacent pair of said bends being straight, said bends being so located and of such degree that said spring is approximately straight when under a preselected load, and single unitary support means fixing one end only of said spring and adapted to prevent movement of any part of said fixed end responsive to the application of an unbalanced force at any other point along said spring.

9. A cantilever contact spring approximating a straight line when under a preselected load comprising an elongated metallic member and a plurality of spaced apart permanent transverse bends in the same direction in said member, the portion of said spring intermediate an adjacent pair of said bends being straight, and single unitary support means fixing one end only of said spring and adapted to prevent movement of any part of said fixed end responsive to the application of an unbalanced force at any other point along said spring.

10. A cantilever contact spring approximating a straight line when under a preselected load comprising an elongated metallic member and a plurality of spaced apart permanent transverse bends in the same direction in said member, the

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portion of said spring intermediate an adjacent pair of said bends being straight, said bends being of such degree that the shape of said spring approximates when not under load the shape it would assume if it were under said preselected load but had no permanent transverse bends, and single unitary support means fixing one end only of said spring and adapted to prevent movement of any part of said fixed end responsive to the application of an unbalanced force at any other point along said spring.

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