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H. M. KNAPP ET AL

2,807,868

METHOD OF MANUFACTURE OF CONTACT SPRINGS

Filed June 26, 1953

2 Sheets-Sheet 1

FIG. 1

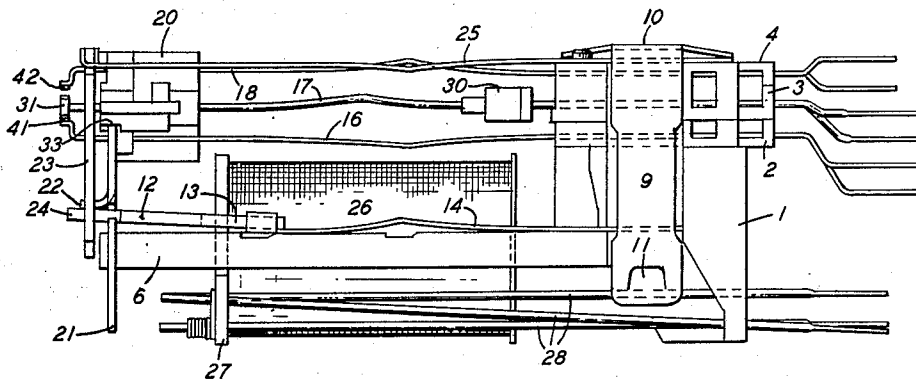


FIG. 2

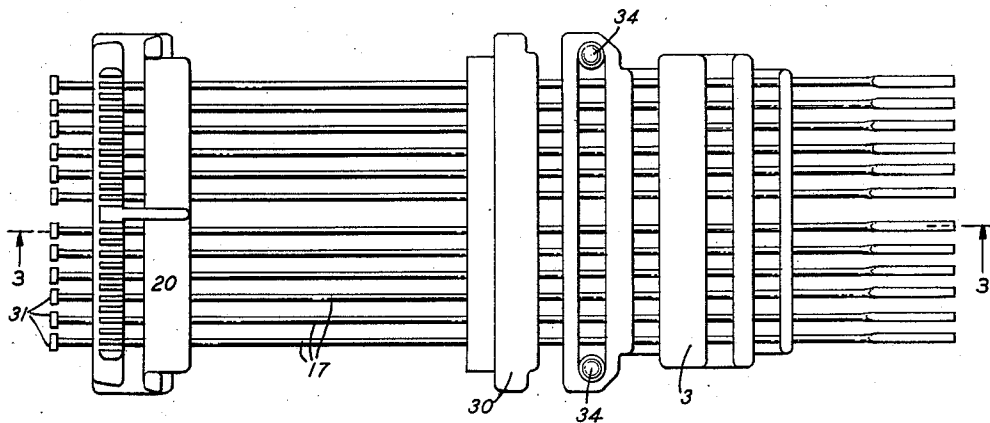
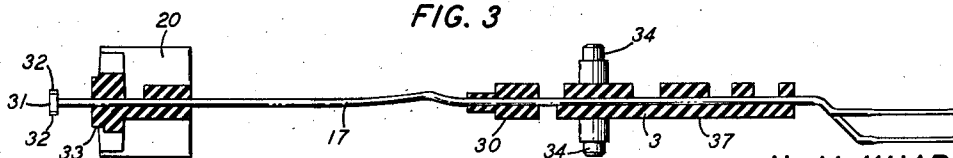


FIG. 3



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FIG. 4

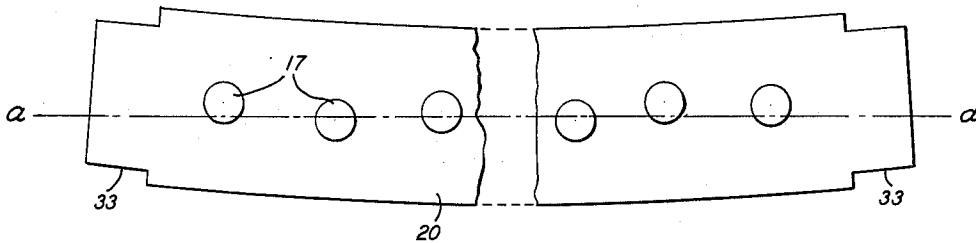


FIG. 5

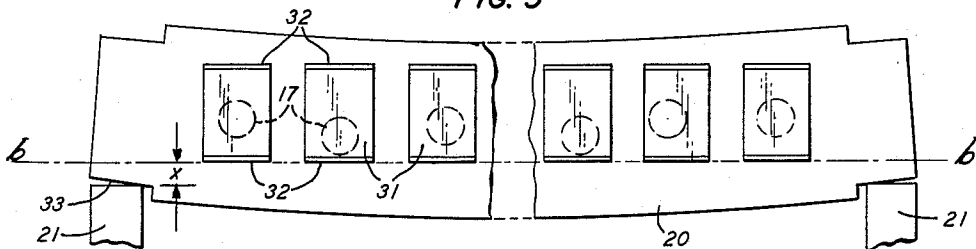
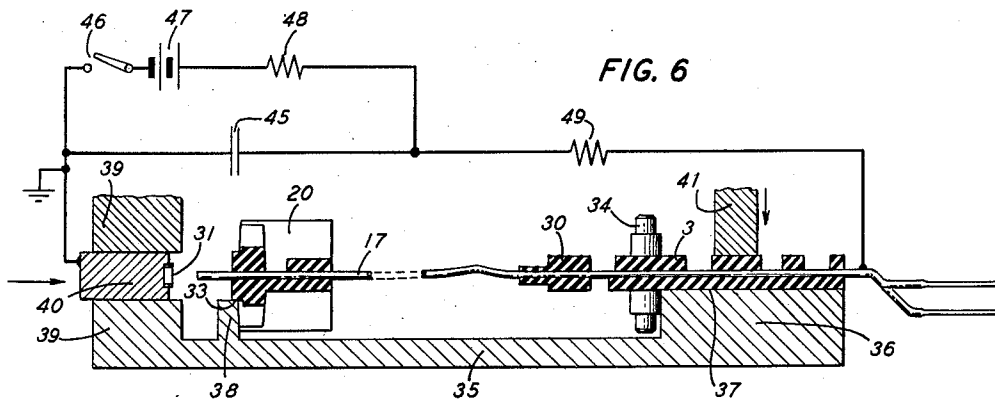


FIG. 6



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METHOD OF MANUFACTURE OF CONTACT SPRINGS

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1 Claim. (Cl. 29—155.55)

This invention relates to a method of manufacturing contact-carrying springs.

The object of this invention is to reduce the cost of precision manufacture of contact-carrying elements.

In the manufacture of contact-carrying springs for electrical devices, it is usually desirable and frequently imperative that the contacts carried by these springs be critically located relative to other structure, e. g., relative to a mating contact or contacts. Normally, however, contacts are supported by springs which in turn are supported by other structure so that the precise position of the contacts may vary substantially from specified positions due to variations in the size or shape of the plurality of component parts which cooperate to position the contacts. It has been customary to manufacture all of those contact-position determining parts to exceedingly close tolerances in order to insure that the contacts will be properly located, because the variations of the several parts from their nominal dimensions and shapes may be cumulative. Under the disclosed method of manufacture, the necessity of constructing a plurality of parts to close tolerances is avoided by holding contacts in their ultimate critical positions relative to a reference surface and then attaching them to the tip ends of their respective carrying springs, without regard to the positional relationship between the tip ends of the carrying springs and the critical positions.

The precise nature of the herein disclosed method of manufacture may be more completely understood from the following detailed description thereof when read with reference to the accompanying drawings in which:

Fig. 1 is a representation of an electromagnetic relay, to the manufacture of which the principles of this invention may be applied;

Fig. 2 is a plan view of one of the major elements of the relay shown in Fig. 1;

Fig. 3 is a view through 3—3 of Fig. 2;

Fig. 4 is an exaggerated representation of an end view of a distorted element of the type shown in Fig. 2, with the contacts omitted;

Fig. 5 is a view of the structure shown in Fig. 4 with the contacts positioned in accordance with the principles of the invention; and

Fig. 6 is a generalized representation of a machine which may be employed in the application of the method of manufacture.

The method of manufacture herein disclosed may be applied to the manufacture of contact-carrying springs employed in any type of electrical structure. The principles will be exemplarily applied, however, to a wire-spring relay, shown in Fig. 1 of the drawings, which is disclosed and claimed in the United States Patent 2,682,584 issued June 29, 1954, to H. M. Knapp and Patent 2,682,585 issued June 29, 1954, to H. M. Knapp and C. F. Spahn, Jr. The disclosures of these patents are incorporated herein by reference.

In general, a basic relay structure to the manufacture of which this method may be applied comprises a plurality

of molded blocks of insulating material 1, 2, 3 and 4 (Fig. 1) lying in stacked relationship. A substantially E-shaped core 6 having three coplanar legs engages the underside of the lowermost insulating block 1. The insulating blocks 1 to 4 and the core 6 are firmly held in stacked relationship by means of a clamp 9 which has an upper portion 10 springedly engaging the top of the stack and a pair of projections 11 engaging opposite sides of the core 6.

Upon the center leg of the core 6 is a coil 26 which is provided with a front spoolhead 27. The winding terminals of the coil 26 are connected to springs 28 which extend rearwardly of the relay through the lower molded insulating block 1.

The armature 12 is a substantially U-shaped member having a pair of relatively short legs 13 overlying and pivoting upon the outermost legs of the core 6. The armature 12 is maintained in position by means of an armature-return spring 14 which is generally U-shaped in appearance, the two legs of the U overlying the outer legs of the core 6 and being firmly attached to the rear of the armature legs 13, and the bight of the spring being firmly clamped between the core 6 and the underside of the lowermost molded insulating block 1.

Molded or otherwise affixed in the insulating blocks 2, 3 and 4, are a lower set of movable twin-wire contact springs 16, a center set of single-wire fixed contact springs 17 and an upper set of movable twin-wire springs 18, respectively. Each of the movable springs 16 and 18 is provided with a contact element 41 or 42, respectively, and each of the fixed springs 17 with a contact element 31. The fixed contact springs 17 are molded or otherwise affixed in a front molded block 20 of insulating material which is held in fixed relationship to the core 6 by means of a flat metal core plate 21 which is integral with the core 6. The core plate 21 is also provided with a projection 22 which serves as a back-stop for the armature. The moving springs 16 and 18 are actuated by means of an operating card 23 which engages projections 24 on the foremost edge of the armature 12. The load affecting the motion of the armature 12 is controlled in part by a balance spring 25 which engages the operating card 23 and which is fixed as a cantilever by being firmly held against the upper molded block 4 by the upper portion 10 of clamp 9.

Viewing the contacts and the contact-controlling elements more closely, it will be seen that due to the sharp bends in the movable spring members 16 and 18, all of the moving contact springs are pretensioned so as to tend to urge their contact elements 41 and 42 into engagement with the corresponding fixed contact elements 31. Since when the relay is unoperated the upper set of moving contact springs 18 is held away from the set of fixed contact springs 17 by the operating card 23, the contact sets 42 and 31 constitute "make" contacts. Upon the operation of the relay and the consequent downward movement of the operating card 23, the upper set of springs 18 is permitted to move downwardly so that the elements 42 engage their mating elements 31. Upon the release of the relay, the upper set of springs 18 is forced by the operating card 23 into the position shown in Fig. 1.

The operating card 23, when the relay is unoperated, does not engage the springs 16, and consequently the elements 41 are normally in contact with their corresponding elements 31. Upon the operation of the relay and the consequent downward movement of the operating card 23, the contacts 41 are forcibly separated from their mating contacts 31 so that these pairs of contacts constitute "break" contacts. Upon the release of the relay, and the consequent upward movement of operating card 23, the contact elements 41 are permitted to reengage their corresponding fixed contacts 31.

Because the operating card 23 is a relatively thin member of insulating material and because the core plate 21 is a relatively thin member of metal, both the operating card 23 and the core plate 21 can be manufactured to close tolerances by inexpensive methods. Therefore, with reference to the upper surface of the core 6, the unoperated position of the armature 12 can be precisely controlled by virtue of the preciseness of the location of the back-stop 22 on core plate 21, the operating card 23 may be precisely located due to the preciseness of the unoperated position of armature 12, the unoperated position of the springs 18 may be precisely located due to the preciseness of the location of the operating card 23, and the edge of the operating card 23 which engages the lower set of movable contact springs 16 during operation of the relay may be precisely located due to the preciseness of location of the operating card 23. If, then, the fixed contact elements 31 are precisely located, the point in the downward motion of the armature 12, upon the operation of the relay, at which the contacts 42 on the upper set of movable springs 18 will engage the fixed contact elements 31, and the point at which the contact elements 41 on the lower set of movable springs 16 will disengage the fixed contact elements 31 may be precisely controlled.

However, without benefit of this invention, it is difficult to locate accurately the fixed contact elements 31. The position of the contact surfaces of the contact elements 31 depends upon a plurality of factors including:

- (a) The overall height of the contact elements 31,
- (b) The exactness with which the contact elements 31 are centered on the tip ends of the springs 17,
- (c) The straightness and fabrication accuracy of the portion of the springs 17 lying forwardly of the front molded block 20,
- (d) The preciseness with which the springs 17 are molded or otherwise affixed in the front molded block 20,
- (e) The dimensional preciseness of the front molded block 20,
- (f) The accuracy with which the surfaces 33 of the front molded block 20 are positioned with relation to the upper surface of the core 6 by the upstanding portions of the core plate 21,
- (g) The accuracy with which the major unsupported length of the springs 17 adheres to its nominal shape,
- (h) The accuracy with which the springs 17 are molded or otherwise affixed in the rear molded block 3,
- (i) The height of the rear molded block 1, and
- (j) The planarity of the core.

It will readily be seen that if reasonable manufacturing tolerances are specified for each of these several elements, it is probable that the fixed contacts 31 will vary from their normal positions by an intolerable amount. Items (a), (f), (i) and (j), supra, can be readily controlled. The contact elements 31 can be precisely coined to height economically; the surfaces 33 may be precisely located due to the preciseness of the core plate 21; the rear block can be molded to precise height; and the core can be made plane by a flattening operation during manufacture and by means of a core plate such as 21, which holds the three core legs in alignment. By practicing the method of manufacture described herein, the variations (b), (c), (d), (e), (g) and (h), supra, need cause little or no concern, and the several elements there referred to may be manufactured to relatively loose tolerances.

The fixed contact-carrying springs 17 and the elements in which they are molded are shown in greater detail in Figs. 2 and 3 of the drawings. The element shown in these figures may be labeled a "comb." As may be seen in these views, the springs 17 are molded or otherwise affixed in a rear molded block 3 which has a lower surface 37 and a pair of projections 34 which serve as locating pins for maintaining the block 3 in accurate lateral relationship with blocks 2 and 4. The springs 17 are molded or otherwise affixed, near their front ends, in a front molded block 20 which has a lower reference surface 33 at either side thereof. These reference surfaces 33

engage upstanding portions of the core plate 21 and therefore may be accurately located relative to the upper surface of the core 6. Affixed by welding or otherwise to the tip end of each of the springs 17 is a contact element 31 which may be either all base metal or all precious metal or, preferably, a base metal slug surfaced on its upper and lower faces with precious metal caps 32.

Variations in the position of the tip ends of the springs 17 may arise in part, due to all or some of the variations above enumerated, including the effects of warping or other deformation of the front molded block 20 and of failure of the individual springs 17 to be precisely positioned within the front molded block 20. Thus, as is shown exaggeratedly in Fig. 4 of the drawings, the wires 17 may fail to lie in the plane, denoted by line $a-a$, in which they were intended to lie. It may be seen that if the contact elements 31 be centered on the individual wires 17, the contact surfaces 32 of those contact elements 31 will similarly lie in diverse positions other than their nominal positions, so that even though the moving contact elements 41 and 42 be precisely located and even though the surfaces 33 of the front molded block 20 be precisely located due to the preciseness of location of the upstanding portions of the core plate 21, the point in the travel of the armature at which the movable contact elements 42 will engage the surfaces 32 of their mating fixed contact elements 31 will not be accurately controlled nor will it be uniform among the several sets of mating contacts. Similarly, the point at which the movable contact elements 41 will be separated from the surfaces 32 of their mating fixed contact elements 31 will neither be accurately controlled nor of the same value for the several sets of contacts.

The contact surfaces 32, however, can be accurately and precisely located relative to any selected reference surface, such as to the upper surface of the core 6 or the upper surfaces of the core plate 21, and then affixed to the tip ends of the springs 17 without regard to the relationship between those tip ends and the surface of the core 6. Thus, as may be seen in Fig. 5 of the drawings, the lower surfaces of the precious metal faces 32 of the contact elements 31 may all be aligned along a reference line $b-b$, an imaginary line ideally selected a distance " x " above the reference surface defined by the upper surfaces of the core plate 21. If the contact elements 31 then be welded or otherwise affixed to the tip ends of the springs 17, the contact surfaces 32 will lie in exactly their correct positions so long as the free ends of the springs 17 are not distorted from their normal operational positions during the affixing operation. Though reference line $b-b$ in Fig. 5 is depicted as parallel to a plane in which the upper surfaces of the upstanding portions of core plate 21 lie, this is not necessary to satisfactorily attain the objects of the instant invention. Line $b-b$ need only be linear because the parallel disposition of contact surfaces 32 with respect to the surface of the core plate 6 can be accomplished by a simple adjustment after the relay is assembled. This is, provided the contact element surfaces follow a linear reference line such as $b-b$, and further, lie in a plane which intersects the plane defining the surface of core 6 along a line essentially parallel to the normal operating position of the springs.

In general, then, it is proposed that in the manufacture of a contact-carrying spring assembly, the rear of the springs be positioned accurately relative to a first reference plane without regard to the positions of the tip ends of the springs, that the contact elements then be positioned in proximity to the tip ends of the springs in a second reference plane which is critically located relative to the first reference plane, and that the contact elements then be affixed to the tip ends of the springs without regard to the positional relationship between the tip ends of the springs and the reference planes. It is imperative that the tip ends of the springs not be forced to assume any positions other than their normal operating positions;

they should be free to assume a non-externally stressed condition.

It is necessary in the particular case in which the springs 17 are deformed so as to be pretensioned, or in any case in which the springs are supported other than as true cantilevers (as in the illustrated embodiment), to provide an ancillary support at the point at which the front molded block 20 is attached to the spring or springs 17 in order to assure that the springs assume their normal operational positions.

While it is apparent that these operations may be performed by hand, with the assistance only of a reference surface or surfaces and an adhesive, a machine which will facilitate the practice of this method of manufacture is depicted generally in Fig. 6 of the drawings. The machine shown in Fig. 6 is particularly adapted to affix contact elements 31 to the comb shown in Figs. 2 and 3 of the drawings, i. e., to a plurality of springs 17 molded or otherwise affixed in a rear insulating block 3 and a front insulating block 20. The lower surface 37 of the rear molded block 3 is placed upon a reference surface comprising the upper face of the portion 36 of the jig 35. This placement may be considered to constitute a simulation of the position of the rear molded block 3 in its ultimate dimensional relationship to the upper surface of the core 6. The rear molded block 3 may be firmly clamped in this position by means of a member 41 pressing downwardly upon the upper face of the block 3. The surfaces 33 of the front molded block 20 are, in the particular embodiment of the invention disclosed in Fig. 6, placed in contact with the upper surface of a portion 38 of the jig 35. This upper surface of portion 38 serves the same function during the manufacture of the part that the upstanding portions of the core plate 21 serves in the assembly relay. The upper surface of the portion 38 is critically located relative to the upper surface of the element 36 of jig 35. The tip ends of the springs 17 are permitted to assume their normal operational positions. The contact elements 31, either with or without the contact surfaces 32 applied thereto, are affixed in a jaw 40 which is guided by the portions 39 of jig 35. The portions 39 and 40 are designed so that the contact elements 31, when in position in the jaw 40, are critically positioned relative to the upper surfaces of the upstanding portions 36 and 38 of the jig 35. The contacts 31 are thereby critically located relative to a reference surface which is assimilable to the upper surface of the core of the assembled relay so that the contacts 31 are functionally located, i. e., they are located in the position in which they should ultimately lie relative to a reference surface, and it is immaterial if the tip ends of the springs 17 fail to be centered on their respective contact elements.

While any suitable method of affixing the contacts 31 to the tip ends of the springs 17 may be employed, this affixation is preferably accomplished by welding, and in the preferred machine shown in Fig. 6, a system for percussively welding the contacts to their respective springs is disclosed. Though it is shown being utilized on a single contact and carrying spring, it is obvious that a plurality of such circuits could be provided. The jaw 40 is grounded, as is one side of capacitor 45. Upon the closure of switch 46, capacitor 45 is charged over a path from ground, switch 46, battery 47, current-limiting resistor 48, capacitor 45, to ground. The non-grounded side of capacitor 45 is connected through resistor 49 to one of the springs 17 so that a discharge path for capacitor 45 is completed through resistor 49 and through spring 17 except for the gap between the contact 31 and the tip end of the spring 17. When the contact element and spring are properly positioned, a force is exerted to propel jaw 40 to the right at a substantial rate. At a critical point in the travel of the contact 31 toward the tip end of the spring 17, that point being just slightly before the engagement of these elements, an arc will occur and capacitor 45 will be discharged through the above-traced circuit. The high cur-

rent at the junction of contact 31 and the tip end of the spring 17 is adequate to weld these elements together. Percussive welding possesses the merit that there is but limited possibility of the tip end of a spring 17 being displaced from its normal operational position during the welding operation.

Therefore, in the affixing of each of the contacts 31 to the tip ends of the springs 17, which are mounted in a rear insulating block 3 and in a front insulating block 20, the rear molded block 3 is first positioned on a first reference surface which lies in a first reference plane, and the rear molded block then is or may be clamped in this position either manually or by means of an element such as 41. If the springs 17 are not pretensioned, and if in their normal positions in the relay they are not supported at any other point in their length, i. e., if they are true cantilevers, no further positioning of the springs 17 need be done. If, however, the springs 17 are pretensioned, or if they are normally supported at a point intermediate their ends, as by a front molded block 20, then that supporting element or front molded block 20 should be supported by a surface lying in a reference plane which is critically located relative to the first reference plane. The contacts 31 are then accurately positioned in proximity to the tip ends of the springs 17 and in precise relationship to the reference planes, either by being held manually or with the assistance of a holding device such as jaw 40. The contacts 31 are then affixed to the tip ends of the springs 17 by any suitable means, such as by welding, care being taken not to displace the tip ends of the springs 17 from their operational positions. The affixing is done without regard to the point upon the contact elements 31 which are engaged by the respective tip ends of the springs 17.

While round-wire contact-carrying springs have been disclosed, it is to be understood that the method may be employed with equal facility with springs of other configurations. While the method, heretofore described, has been applied to the manufacture of contact-carrying springs supported in a unique fashion and utilized in a unique relay, it is to be understood that it is contemplated that any contact-carrying spring, regardless of the nature of its support and regardless of the instrumentality in which that spring is employed, may be manufactured by this method.

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:

The method of forming a contact-spring assembly by attaching a plurality of contact elements of predetermined size to respective tips of a plurality of contact springs that are held in fixed insulated relation to each other which comprises the steps of supporting the spring assembly such that said spring tips assume unrestrained positions with respect to a reference plane, supporting contact elements adjacent their respective tip ends in pre-selected positions with respect to said reference plane, which positions are independent of the positions assumed by said spring tips, moving said elements substantially simultaneously toward said respective tips, and affixing said contact elements to said tips without regard to the part of the joining surfaces of said elements which are contacted by their associated tips, said predetermined size being sufficient to assure contact between each of said elements and its associated tip.

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