

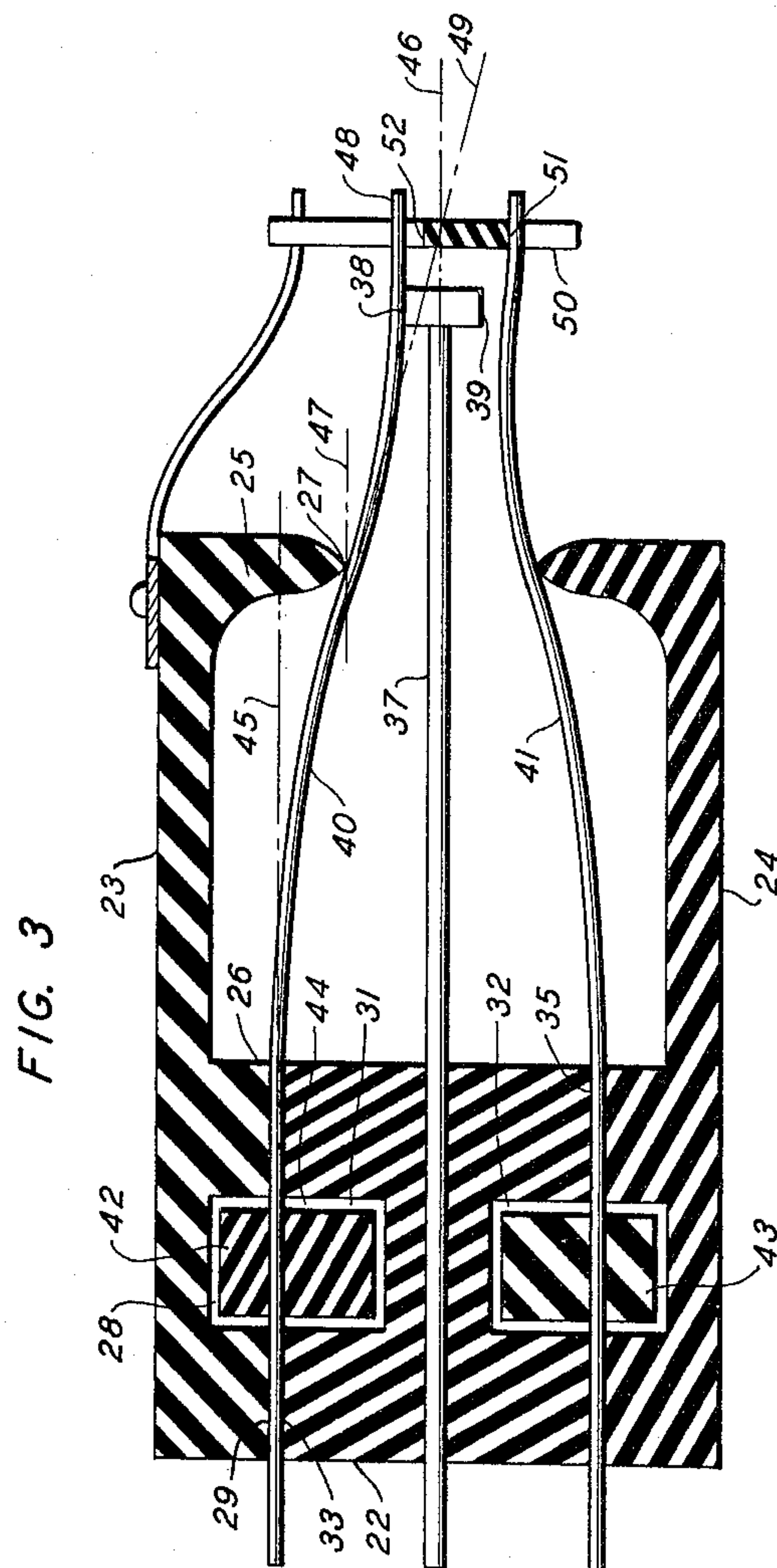
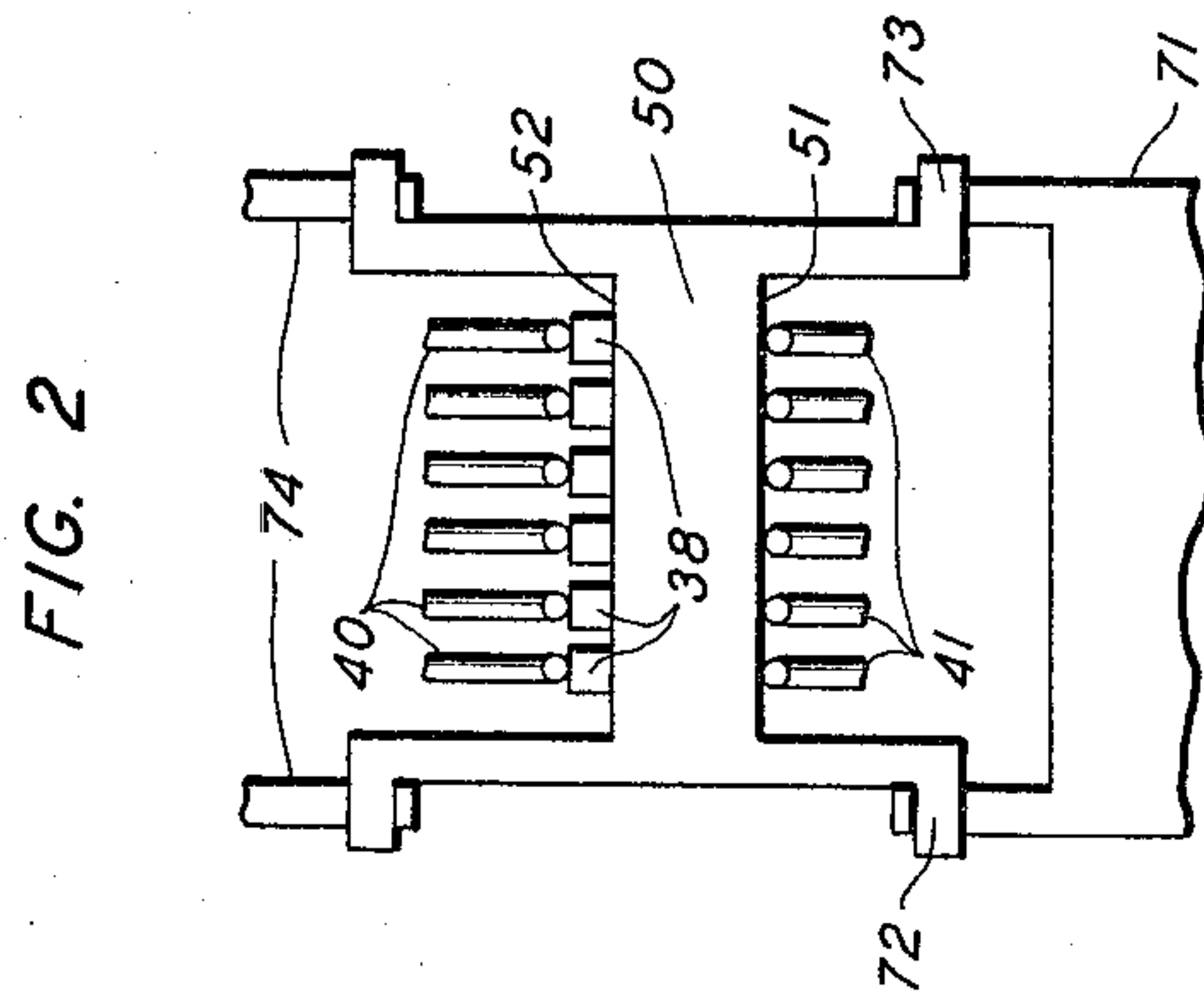
Dec. 6, 1966

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WIRE SPRING RELAY WITH IMPROVED MEANS
FOR DETERMINING CONTACT FORCE

3,290,629

3 Sheets-Sheet 2



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FIG. 6

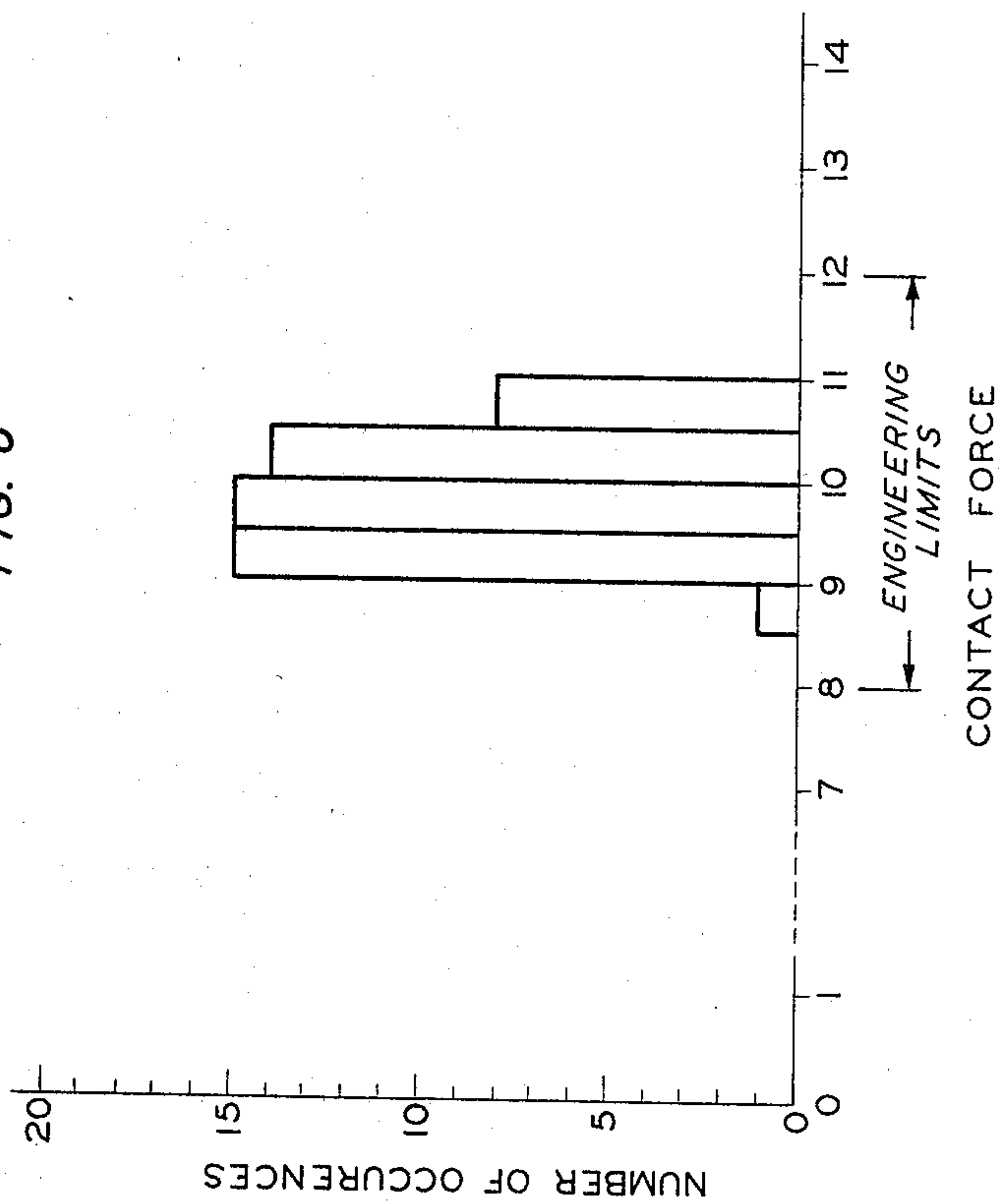
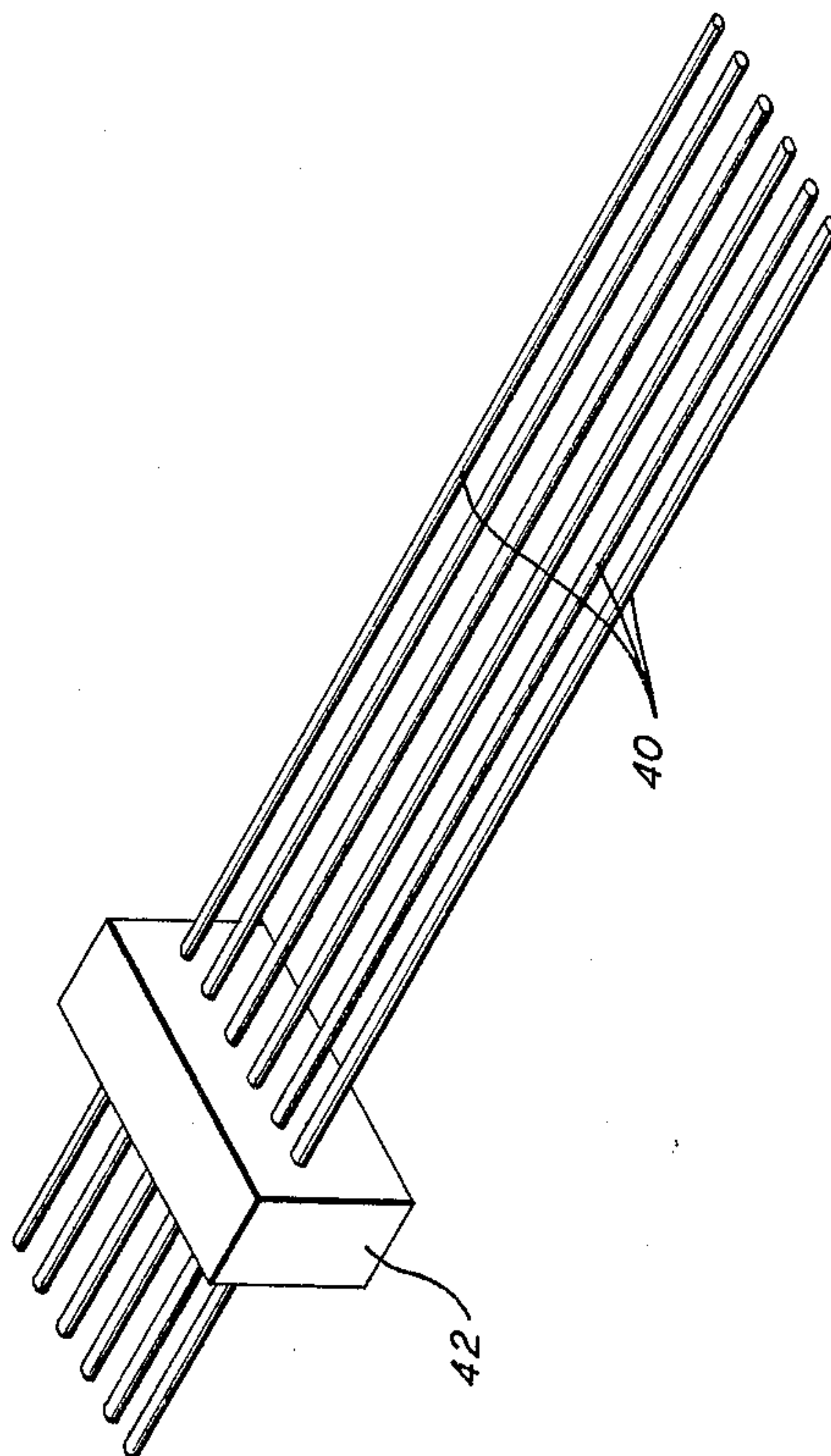


FIG. 4



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WIRE SPRING RELAY WITH IMPROVED MEANS FOR DETERMINING CONTACT FORCE

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This invention relates to electromagnetic switching devices and in particular to miniature devices wherein wires are used as the contact members.

Electromagnetic relays utilizing wires as contacts are well known. See, for example, those disclosed in Patent 2,608,630 issued to H. C. Harrison on Aug. 26, 1952, and Patent 2,682,584 issued to H. M. Knapp on June 29, 1954. Relays of this type are commonly called wire spring relays.

In a wire spring relay, a plurality of parallel wires or wire springs are embedded in a common base to form a comb-like structure. When assembled in an operative arrangement, the comb-like structure containing the embedded wire springs is positioned so that each wire spring can engage and disengage a mating contact. While such arrangements are theoretically satisfactory, many difficulties arise when theory is put into practice.

For example, a contact force within predetermined limits must be maintained between a wire spring and its mating contact. Generally, the required contact force is obtained by angling the wire spring from a position above to a position below its mating contact; when bowing or deflecting the free end of the wire spring back over the mating contact and finally, resting the free end of the deflected wire spring on the mating contact. With this arrangement, the two contacts are pressed together with the required amount of force.

Heretofore, the desired interaction between contact members has been achieved by molding the wire springs and mating contacts in a common base in such a manner that the mating contacts are aligned in a first plane and the wire springs are aligned in a second plane. The planes are disposed with respect to each other so that the second passes through the first at an acute angle. As a result, the free ends of the wire springs can be bowed or deflected back from below the first plane and tensioned against the top of the mating contacts.

This arrangement, however, requires special molding treatment. In molding a plastic material about a metal rod, it is important that the molding die separate along the axis of the rod. Therefore, where the wire springs are molded at an angle to the major planes of the base, the faces of the dies must be designed to separate on a bias. Making dies that will separate on a bias, however, is costly. Therefore, it is advantageous to eliminate this expense by molding the wire springs parallel to the major planes of the base.

In one known arrangement, wherein the wire springs are molded without an angle, the wire springs are aligned in one level or reference plane while the mating contacts are aligned in another, but lower, level plane. The wire springs are then placed in a jig and bent or kinked with a tool until the free ends thereof are deformed to a position beneath the plane of the mating contacts. By virtue of the kinking operation, the deformed wire springs lie in a plane intersecting the plane of the mating contacts at an acute angle. As before, the free ends of the wire springs are bowed back to rest against the top of the mating contacts. While this method eliminates the molding difficulties, the additional operation of kinking the wire springs is required.

While the foregoing methods of acquiring contact force having disadvantages, they are generally satisfactory in

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large wire spring relays. Neither, however, is satisfactory where the relays are miniaturized. In the first method, molding difficulties are intensified due to the small size. In the second method, uniformity of contact force is lost.

Uniform contact force means that any force variations between wire springs will be restricted to within a tolerable range as for example, between 8 and 12 grams in miniature relays and 8 to 18 grams in large relays. Force variations are caused by unequal deflecting of the wire springs.

Large relays obtain uniform contact force without maintaining equal deflections. Instead, the effect of unequal deflection is overcome by using long, wire springs having a low stiffness.

Long, low stiffness wire springs develop a low force per unit deflection. As a result, relatively large variations in deflection can be tolerated before contact force is significantly affected.

Where, however, the relay is miniaturized a short, stiff wire spring is used and the force per unit deflection is high. Accordingly, the effect of unequal deflections is magnified in that small variations in deflection produce large variations in contact force. Therefore, close control of deflection must be maintained in miniaturized wire spring relays.

The procedure of kinking the wires that so conveniently tensions wire springs in large wire spring relays is unsuitable in miniature relays because close control of the kinking cannot be maintained. In the course of kinking, some wire springs are bent more than others. As a result, the wire spring protrude from the point of kinking at odd angles. In other words, the wire springs become dispersed.

As a result of dispersion, the point of beginning deflection is not the same for every kinked wire spring. As a consequence, deflection of the wire springs will be unequal and the amount of force induced therein will vary from wire spring to wire spring. Moreover, as a result of the magnified effect of unequal deflections, intolerable variations in contact force will occur. Consequently, the procedure of kinking the wires is unsuitable in miniature wire spring relays.

Dispersion is also a problem where kinking is not used. Because wire spring relays use fine wires for contacts, handling during assembly invariably causes wire spring misalignments. As before, such misalignment or dispersion is magnified into tolerable variations in contact force.

It is, therefore, broadly an object of this invention to control the variation of contact force in electromagnetic switching devices.

It is specifically an object of this invention to control the variation of contact force in wire spring relays, particularly of the miniature type.

According to one feature of this invention, a plurality of mating contacts lying in a first plane are combined with a support block for holding mating contacts, a plurality of wire springs each having a long axis, clamping surfaces movably disposed in the support block for aligning and clamping one end of each wire spring in a second plane, and a ridge disposed between the first and second planes in a position orthogonal to the long axis of the wire springs. Each wire spring is bowed around the ridge and has one end gripped between the clamping surfaces and the other end resting on a mating contact.

Other objects, advantages, and novel aspects of this invention are apparent from a consideration of the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is an elevation view of a wire spring relay constructed in accordance with the present invention;

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FIG. 2 is an end view with parts broken away of the embodiment shown in FIG. 1;

FIG. 3 is a section view of the switching portion in the operated state of the relay shown in FIG. 1;

FIG. 4 is a perspective view of a comb structure assembled from wire springs embedded in a base;

FIG. 5 is part of a section view taken along line 5—5 passing through the embodiment illustrated in FIG. 1; and

FIG. 6 is a graphical representation of contact force variations observed in relays constructed in accordance with this invention.

The embodiment illustrated in FIG. 1 comprises a support block 20 mounted on a motor assembly 21. The support block 20 comprises an inner member 22 and two outer members 23 and 24. The inner member 22 and the outer members 23 and 24 may be conveniently molded from any dielectric material. Both outer members 23 and 24 are identical. Therefore, a description of one will suffice for the other.

As shown in FIG. 3, the outer member 23 is elongated and, on the same side but at opposite ends thereof, includes two projections 25 and 26. The projection 25 includes a ridge 27 while the projection 26 includes a pocket 28 in a clamping surface 29. The ridge 27 is arranged to protrude beyond the outer member 23 a greater distance than does the clamping surface 29.

The inner member 22 includes two pockets 31 and 32 disposed on opposite sides thereof. The pocket 31 is in a clamping surface 33, and the pocket 32 is in a clamping surface 35.

The inner member 22, as illustrated in FIG. 3, includes a mating contact 37 molded therein. The mating contact mates with a wire spring. Advantageously, portions of the mating contact 37 protrude out of two sides of the inner member 22. The mating contact 37 can be conveniently made of any electrically conducting material such as a copper-nickel alloy. One end thereof terminates in a pair of contacting surfaces 38 and 39 which can be conveniently made of any noble metal.

A pair of flexible contacts or wire springs 40 and 41, as illustrated in FIG. 3, are associated with the mating contact 37 in electrically contacting relationship. As shown in FIG. 4, the wire spring 40 is one of a plurality of wires embedded in a base 42 to form a comb-like structure. Similarly, the wire spring 41 is one of a plurality of wires embedded in a base 43 shown in FIG. 3. The wire springs can be conveniently made of any electrically conducting material but a precious metal alloy is preferred.

Both wire springs 40 and 41 are clamped in the support block 20 between the inner member 22 and the outer members 23 and 24. Each is clamped in a similar manner. Therefore, a description of one will suffice for the other.

As shown in FIG. 3, the base 42 including the wire spring 40 is centered in a cavity 44. The cavity 44 is formed in the support block 20 when the pocket 28 in the outer member 23 is aligned with the pocket 31 in the inner member 22.

When the cavity 44 contains the base 42 therein, the clamping surface 29 on the outer member 23 presses portions of the wire spring 40 and the other wire springs embedded in the base 42 against the clamping surface 33 on the inner member 22 as shown in FIG. 5. As a result, all of the wire springs are secured in the support block 20. Moreover, any dispersion of the wire springs as they emerge from the base 42 is corrected and all are aligned in a common plane 45.

The plane 45 is one of three planes shown as lines in FIG. 3. The plane 45 is disposed in parallel with another plane 46 that passes through the long axis of the mating contact 37. Between the planes 45 and 46, and parallel thereto, is a plane 47. As shown in FIG. 3, the plane 47 is tangent to the ridge 27.

As shown in FIG. 3, a free end 48 of the wire spring

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40 has been deflected out of the plane 45 and around the ridge 27 to a position of rest against the contacting surface 38. Accordingly, the wire spring 40 corresponds to a deflected beam supported at each end with a load applied at an intermediate point therebetween.

When the free end 48 is removed from the contacting surface 38 and allowed to assume a static state, the deflection produced by the ridge 27 compels the free end 48 to take a position along a line 49 shown in FIG. 3. Moreover, when the free ends of the remaining wire springs embedded in the base 42 are unsupported, they are deflected by the ridge 27 in a similar manner. Furthermore, since the clamping surfaces 29 and 33 cooperate to compel all of the wire springs to lie in the plane 45, the amount of deflection produced by the ridge 27 will be essentially the same for each of the wire springs embedded in the base 42. As a result, all of the wire springs are compelled to lie in a common plane containing the line 49 when their free ends are not supported. Therefore, the physical point of beginning deflection for each wire spring will lie in a common plane when each is deflected about the ridge 27 and into engagement with a mating contact. Consequently, the same amount of energy is stored in each wire spring as it is deflected from its position along the line 49 to a position against a mating contact. As a result, variation in contact force is maintained within an acceptable range.

Tests have shown that with this arrangement, variation in contact force can easily be kept within the range of 8 to 12 grams. FIG. 7 illustrates contact force distributions based on a number of observations of relays built in accordance with this invention.

All of the wire springs are operatively associated with the motor assembly 21 by a card 50 having two edges 51 and 52. The edge 51, as shown in FIG. 2, engages the wire spring 41 and the other wire springs common to the base 43, while the edge 52 is engageable with the wire spring 40 and the other wire springs common to the base 42. As shown in FIG. 1, the card 50 alternately engages the wire springs 40 and 41 in response to movement of the motor assembly 21.

The motor assembly 21, as shown in FIG. 1, comprises a core 60, an armature 61, and a coil 62.

The core 60 is substantially U-shaped, made of a magnetic material, and comprises two legs 63 and 64. The leg 63 is substantially shorter than the leg 64. Moreover, the ends of the legs 63 and 64 terminate in chamfered surfaces. The chamfered surfaces are disposed to lie in a common plane shown as a line 65 in FIG. 1.

The armature 61 is substantially L-shaped, made of a magnetic material, and includes a long leg 66 and a short leg 67. The coil 62 is wound on a bobbin 68 disposed around the long leg 64. Both legs 66 and 67 end in chamfers and as in the core 60, both chamfers lie in a common plane shown as a line 69 in FIG. 1.

The armature 61 is connected to the core 60 by a hinge 70. One end of the hinge 70 is connected to the short leg 63 on the core 60 while the other end is connected to the long leg 66 on the armature 61.

When the relay is operated, all of the chamfers are superimposed along the line 65. As a result, the armature 61 and the core 60 abut each other to form thereby a closed path of magnetic material around and through the coil 62.

Attached to the long leg 66 on the armature 61 is a bracket 71. As shown in FIG. 2, the bracket 71 includes two ears 72 and 73 for engaging the card 50. Engaging the card 50 at the opposite end thereof is a spring 74. The spring 74 is arranged to oppose movement of the armature 61 and can be attached to the outer member 23 in any convenient manner.

With the motor assembly 21 operated, the card 50 is pulled down by the bracket 71. As shown in FIG. 3, the wire spring 41 protruding over the edge 51 is deflected away from the contacting surface 39 by the downward

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movement of the card 50. On the other hand, the wire spring 40 now passes over the edge 52 without touching and engages the contacting surface 38. As a consequence, an electrically conducting path between the mating contact 37 and the wire spring 40 has been established and an electrically conducting path between the wire spring 41 and the mating contact 37 has been disrupted.

When the motor assembly 21 is de-energized, the spring 74 lifts the card 50 and the bracket 71 thereby causing the armature 61 to pivot on the hinge 70. When this occurs, the edge 52 lifts the wire spring 40 from the contacting surface 38 while the edge 51 permits the wire spring 41 to engage the contacting surface 39 as shown in FIG. 1. As a result, the electrically conducting path between the mating contact 37 and the wire spring 40 will be disrupted and an electrically conducting path between the wire spring 41 and the mating contact 37 will be established.

By repeating the foregoing cycle, electrical currents passing through the mating contact 37 can be switched between the wire spring contacts 40 and 41. Accordingly, there has been disclosed herein a miniature relay that is ideally suited for switching electrical currents wherein the contact force between the contacting members does not vary beyond predetermined limits.

From the foregoing, it is readily apparent that various arrangements can be advantageously used to exploit this invention. Therefore, while one specific embodiment has been selected for detailed disclosure, the invention is not limited in its application to the embodiment disclosed. As a result, the embodiment which has been described should be taken as illustrative of the invention and its application rather than restrictive thereof.

What is claimed is:

1. In an electromagnetic switching device, the combination comprising:
 - a pair of outer members each including deflecting means and an outer clamping means;
 - an inner member including inner clamping means, said inner member disposed between said outer members with said inner clamping means adjacent to said outer clamping means on each of said outer members;
 - a plurality of contacts mounted on said inner member; and
 - a pair of wire spring combs each comprising a plurality of two-ended wire springs, each of said combs disposed between an outer member and said inner member with each wire spring therein bowed around the deflecting means on said outer member with one end thereof urged toward one of said contacts and the other end thereof clamped between adjacent inner and outer clamping means.
2. A switching device in accordance with claim 1 including moving means for moving the free ends of said wire springs out of engagement with said contact.
3. In an electromagnetic switching device, the combination comprising:
 - a pair of outer members each having a first clamping means and an outer pocket at one end and deflecting means at the other end thereof;
 - an inner member having an inner pocket and a second clamping means on two sides thereof, said inner member disposed between said outer members with said second clamping means adjacent to a first clamping means and each outer pocket superimposed over an inner pocket to form a cavity;
 - a plurality of contacts mounted in said inner member;
 - a pair of wire spring combs each comprising a base and a plurality of wire springs, each comb disposed with the base thereof in one of the cavities formed between said inner and outer pockets and with each wire spring therein bowed around the deflecting means on one of said outer members with a first por-

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- tion thereof urged toward one of said contacts, a second portion thereof in said one cavity, and a third portion thereof clamped between adjacent first and second clamping means; and
 - means for moving said first portion of each wire spring out of engagement with a contact.
4. In an electromagnetic switching device, the combination comprising:
 - an outer member including deflecting means and a first clamping means;
 - an inner member including a second clamping means, said inner member disposed with said second clamping means adjacent to said first clamping means;
 - a plurality of mating contacts mounted in said inner member;
 - a plurality of flexible contacts wherein each flexible contact is bowed around said deflecting means and has a fixed end and a free end, said fixed end being disposed between said first and second clamping means and said free end being urged toward one of said mating contacts; and
 - means for disengaging said flexible contacts from said mating contacts.
 5. In an electromagnetic switching device, the combination comprising:
 - an outer member including a deflecting ridge and a first clamping means;
 - an inner member including a second clamping means, said inner member disposed with said second clamping means adjacent to said first clamping means;
 - a contact mounted in said inner member;
 - a two-ended wire spring bowed around said deflecting ridge with one end engaging said contact and the other end disposed between said first and second clamping means;
 - motor means; and
 - a card adjacent to said wire spring and responsive to energization of said motor means for disengaging said one end from said contact.
 6. In an electromagnetic switching device, the combination comprising:
 - a unitary molded outer member including a deflecting ridge and a first clamping means;
 - a molded inner member including a second clamping means, said inner member disposed with said second clamping means adjacent to said first clamping means;
 - a contact molded in said inner member;
 - a two-ended wire spring bowed around said deflecting ridge with one end engaging said contact and the other end disposed between said first and second clamping means;
 - motor means; and
 - a molded card adjacent to said wire spring and responsive to energization of said motor means for disengaging said one end from said contact.
 7. In an electromagnetic switching device, the combination comprising:
 - a plurality of contacts lying in a first plane;
 - a support for holding said contacts;
 - a plurality of wire springs each having a long axis and two ends;
 - clamping surfaces movably disposed on said support for aligning and gripping one end of each wire spring in a second plane, said second plane spaced from and parallel to said first plane;
 - a ridge disposed orthogonally to said long axis and in a third plane located parallel to and between said first and second planes, each of said wire springs deflected around said ridge with one end against a contact and the other end gripped between said clamping surfaces; and
 - means for moving said one end away from said contact.

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8. In an electromagnetic switching device the combination comprising:

a pair of outer members each including deflecting means and an outer clamping means;

an inner member including inner clamping means, 5
said inner member being disposed between said outer members with said inner clamping means adjacent to said outer clamping means on each of said outer members;

a plurality of mating contacts mounted on said inner 10
member; and

a plurality of elongated movable contacts arranged to 15
cooperate with said mating contacts to perform a switching function, said movable contacts being divided into two sets wherein each set comprises a plurality of said movable contacts disposed side by side, each of said movable contacts in a set having a fixed end and a free end and each of said movable contacts being bowed around the deflecting means 20
on one of said outer members with said free end

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urged toward said mating contacts and said fixed end clamped between said inner and outer clamping means.

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