Dec. 23, 1958 H. J. WIRTH, JR 2,866,030

RELAY

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FIG. 1

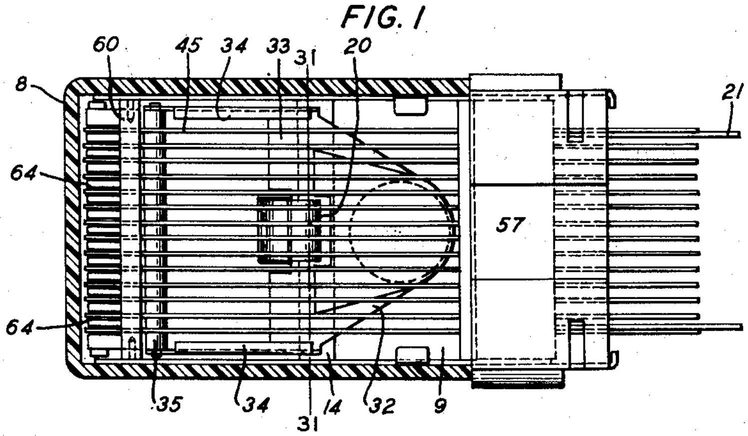

FIG. 2

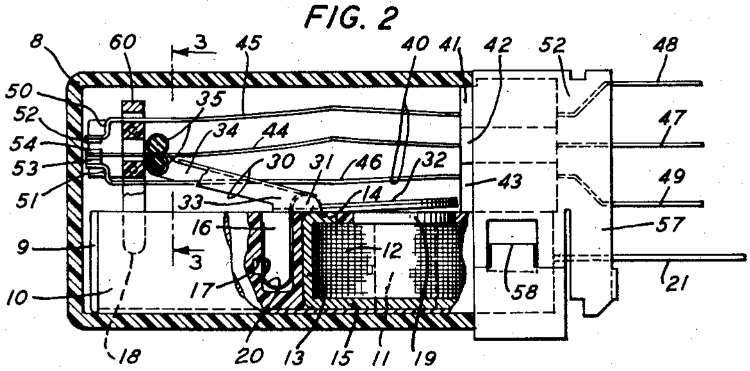

FIG. 3

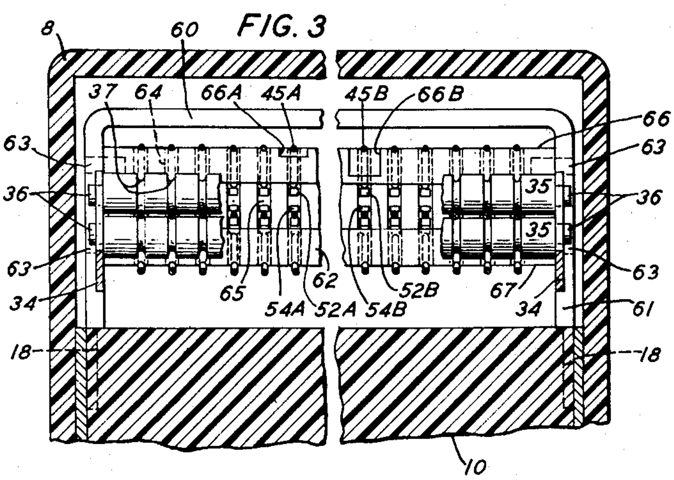

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FIG. 4

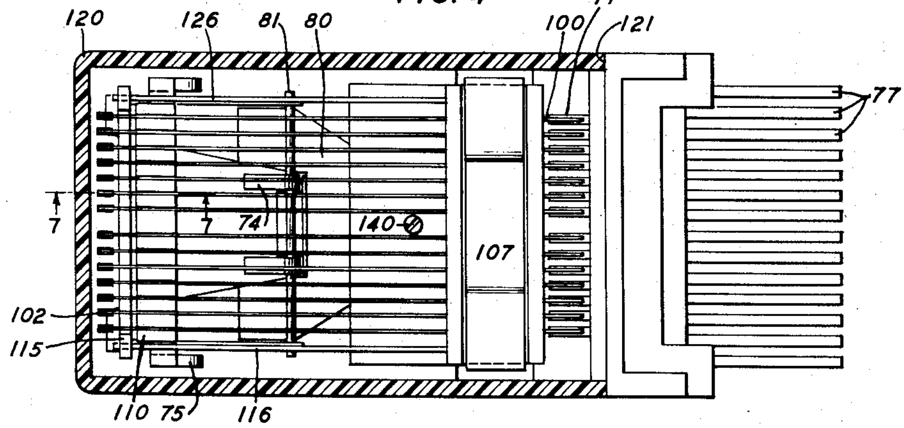

FIG. 5

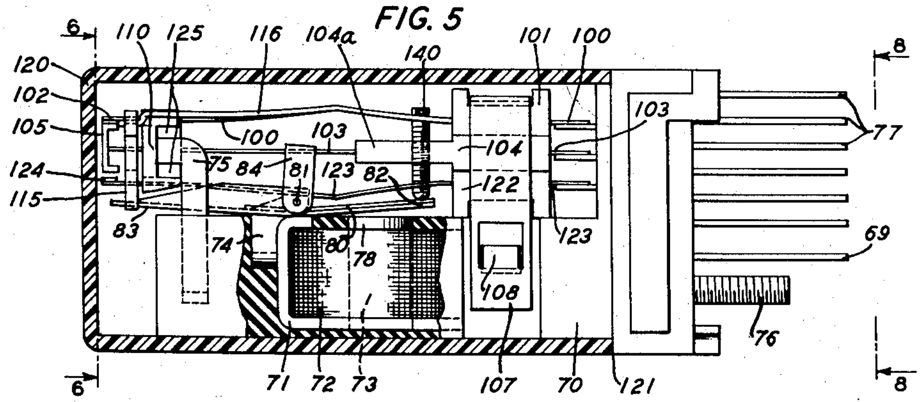

FIG. 6

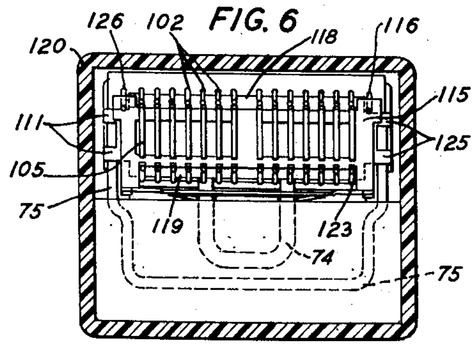

FIG. 7

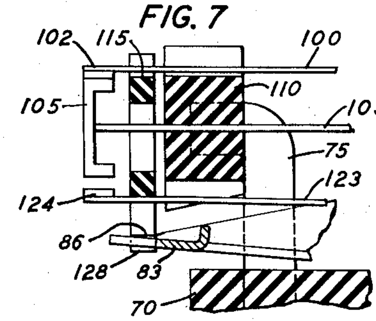

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FIG. 8

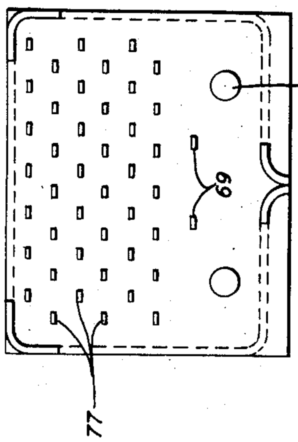


FIG. 10

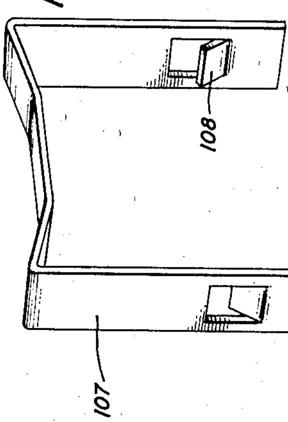
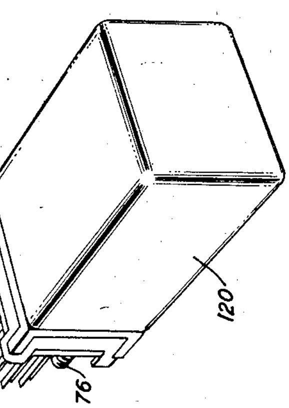
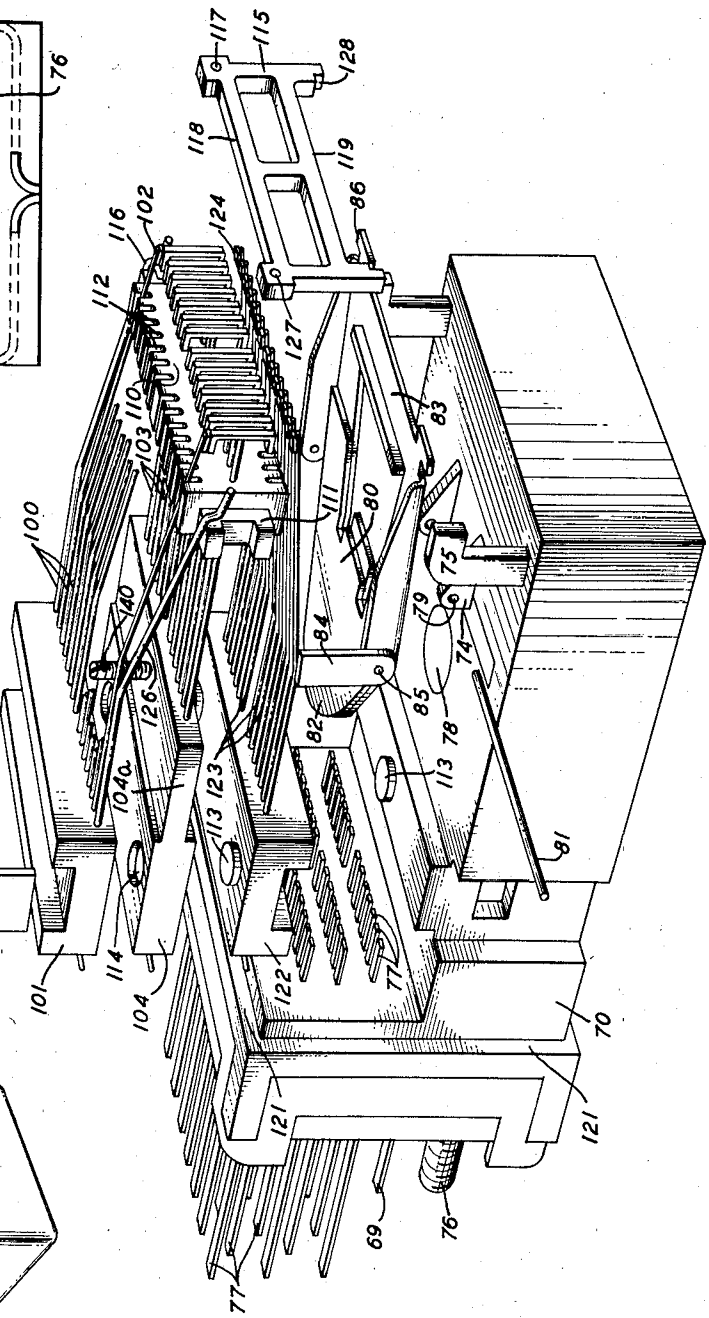


FIG. 9





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2,866,030
Patented Dec. 23, 1958

2,866,030

RELAY

Henry J. Wirth, Jr., Millington, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 24, 1955, Serial No. 542,244
9 Claims. (Cl. 200—104)

This invention relates to switching devices and more particularly to electromagnetic switching devices for controlling a multiplicity of electrical circuits.

An object of the invention is to improve the efficiency, compactness and economy of manufacture of electromagnetic relays and to facilitate their maintenance.

Particularly, it is an object of the invention to increase the capability of miniaturized relays which are employed in situations requiring high operating efficiencies.

Yet another object is to provide a small compact relay which may be freely orientated in any sense or direction with respect to its supporting means without interfering with the performance of its switching functions.

Still another object of the ivention is to provide a relay which may be utilized in a multiplicity of varied environments without adverse affect upon contacts, springs and the like.

A general feature of the invention is the combination in a relay of a unitary molded assembly comprising the principal non-moving parts of a relay, a simple contact spring assembly, an armature, contact operating means, means for cooperatively arranging these elements to function as a relay, and enclosing means.

A particular feature of the invention is the provision in a single unitary molded assembly of the principal non-moving parts of a relay.

Another particular feature of the invention is utilization of a hermetically sealed enclosure for the principal parts of the relay.

Yet another particular feature of the invention is the arrangement whereby a molded contact spring assembly, an armature, and an armature controlled spring actuating member may be replaceably mounted on a unitary molded assembly encasing the principal non-moving parts of a relay so as to form a relay whose moving parts are readily interchangeable to vary the relay's functions.

Other features may also be noted. Conventional electromagnetic relays require, in the aggregate, substantial amounts of power for their operation. Ordinarily, if small power consumption is of prime importance in connection with such relays, the relay operate and release times may need to be sacrificed or the relay's switching capacity may need to be curtailed in order to obtain operation on minimal power. In relays embodying the instant invention, however, neither the operate or release time of the relay nor its switching capacity need be reduced, and yet substantially lower power requirements can be realized. By constructions embodying the instant invention, satisfactory operation, from a sensitivity standpoint, has been realized on less than one-half watt per operation. Operate times less than 2 milliseconds and release times less than 1 millisecond are exemplary of contact actuation times obtained by virtue of the instant invention. With such a low power requirement per operation, substantial savings of power are possible. The lower power requirement is even more impressive when it is noted that it occurs even with a large complement of 14 sets of transfers provided for switching circuits. The instant invention not only enables the foregoing savings in power consumption without loss of contact actuation times or switching capacity, but it does so even when embodied in an over-all relay structure less than half the size of conventional wire spring relays.

These and other objects and features of the invention may be more fully understood when the following detailed description is read with reference to the drawings in which:

Fig. 1 is a plan view of one embodiment of the present invention with the top part of the cover removed;

Fig. 2 is a left side view of the embodiment depicted in Fig. 1 and is partially cut away to more clearly show the inter-relationships of the various parts;

Fig. 3 is a view taken along line 3—3 of Fig. 2;

Fig. 4 is a plan view of a second embodiment of the present invention with the top part of the cover removed;

Fig. 5 is a left side view of the embodiment depicted in Fig. 4 and is partially cut away to more clearly show the inter-relationships of the various parts;

Fig. 6 is a front view taken along line 6—6 of Fig. 5;

Fig. 7 is a partial left side view taken along line 7—7 of Fig. 4 and somewhat magnified to illustrate the disposition of the fixed and movable contacts;

Fig. 8 is a rear view of the relay depicted in Fig. 4;

Fig. 9 is a perspective drawing of the second embodiment of Figs. 4 through 8 illustrating the nature of the cover and depicting the approximate size of the relay; and

Fig. 10 is an exploded perspective view of the relay depicted in Figs. 4 through 9 which shows more clearly the inter-relationships and assembly details of the second embodiment.

Looking in detail at Figs. 1 through 3, which disclose a first embodiment of the instant invention, it can be seen that the basic components of the relay include a motor assembly **10**, an armature **30**, a contact spring assembly **40**, a spring clip **57** and a cover **8**. The armature **30** is mounted upon the motor assembly **10** in its proper position, and the contact spring assembly is fixedly retained in its proper position by spring clip **57** through the agency of inwardly extending tabs **58** which engage cooperating indentations on the rearward (to the right in Fig. 2) part of the metal case **9**. The cover **8** slides over the motor assembly **10** and contact spring assembly **40** to form a tight seal against a rearward flat surface made up of a portion of the contact spring assembly **40** and the motor assembly **10**.

The motor unit **10** is a unitary molded assembly which includes the principal non-moving parts of the relay. The external configuration of the motor assembly **10** is defined by the essentially rectangular, open-top, metal box **9**. A cylindrical core **11**, having an enlarged cylindrical pole face **19** fixedly attached to its upper surface, is connected at its lower end to a magnetic return path member **13**. The return path member **13** is constructed of a flat magnetic material formed in the shape of a J, the legs **14** and **15** of which are disposed parallel to the lower surface of the case **9**. The shorter leg **14** of the J, which is, in effect, a rearwardly extending flange on the upper face of the motor assembly **10**, acts as the transverse bearing surface for the hinge line **31** of the armature **30**. The lower surface of a cylindrical coil **12**, which surrounds core **11**, also rests on the inner flat surface of the longer leg **15** of the J-shaped return member **13**. With such an arrangement, the bridging of the pole face **19** and the return path member **13** by the armature **30** completes the magnetic circuit of the relay.

The magnetic circuit components, excluding the armature **30**, are mounted within the rectangular box **9** and are molded therein with any suitable plastic resin, for example, one of the epoxy resin compounds.

When the motor unit 10 is encapsulated in the resin, apertures (16, 17 and 18) are provided at proper locations to allow the armature 30 to be hinged external to the motor assembly 10 and also to receive a front fixed support 60, the function of which will be hereinafter described. Apertures 16 and 17 are provided to secure the lower portion of S-shaped flat spring 20, whose upper portion retains armature 30 in its proper position with respect to the previously described motor unit 10. The aperture 16 is essentially rectangular in cross section and extends vertically downward into the molded assembly unit 10. Within the aperture 16, but forward of it and below the upper surface of the motor unit 10, is a small rectangular aperture 17 which accommodates a hooked portion on the lowermost end of the armature retaining spring 20 to hold the spring in its proper position with respect to the encapsulated motor unit 10. Apertures 18 located on both sides of the motor unit 10 and extending vertically into the unit from the upper surface thereof receive the fixed spring support 60.

Coil lead-out terminals 21 extend from the rear of the motor unit 10 and form a part thereof. Hence, to form the motor unit or motor assembly 10, the core 11, the pole face 19, the coil 12, the lead-out terminals 21, and the return member 13 are all properly positioned in the confining structure 9 and suitable molding cores are provided to form apertures 16, 17, and 18. With these parts properly positioned, a unitary structure is formed by the use of any suitable molding compound.

The wire spring assembly 40 comprises a plurality of molded blocks 41, 42 and 43. Molded within the block 42 is a plurality of movable wire springs 44, whereas, adjacent blocks 41 and 43, on respective sides of the block 42, have molded therein a plurality of fixed springs 45 and 46, respectively. This arrangement provides three layers of wire springs, each of unitary construction. The rearward portions of the springs 44, 45, and 46 extend beyond their respective molded supports to provide lead-out terminals 47, 48, and 49, respectively. The upper and lower layers of fixed springs 45 and 46 extend forwardly in approximate parallelism to the sides of metal case 9 (when in position supporting motor unit 10) and to the movable springs 44, and have downwardly and upwardly extending offset portions 50 and 51, respectively, at their forwardmost ends. Precious metal contacts 52 and 53 are affixed to the lower and upper surfaces of the forwardmost ends of the upper and lower layers of the fixed springs 45 and 46, respectively. These contacts cooperate with precious metal contacts 54 which are affixed to both the upper and lower surfaces of the tip ends of the movable springs 44. As may best be seen in Figs. 2 and 3 of the drawing, a single upper spring 45 (with its contact 52) and a single lower spring 46 (with its contact 53) are provided for each contact element 54 of each movable spring 44.

The molded blocks 41, 42 and 43 have cooperating indentations and projections (not shown) in order that they may be properly stacked in operative relationship to one another. In turn, the lowermost molded assembly 43 and motor unit 10 have cooperating projections and indentations (not shown) so that they may be positively positioned quickly and easily with respect to each other. As was pointed out supra, U-shaped spring 57, which has inwardly extending lips 58 on both legs which lips engage recesses on the metal case 9, holds the wire spring assembly 40 in its proper position with respect to the motor unit 10.

The fixed spring front support 60 comprises a flat U-shaped metallic member 61 and a guide bracket 62. The ends of the U-shaped member 61 fit into apertures 18 in the motor unit 10 or, in the alternative, the ends of the member 61 may be molded in the motor unit 10 to allow the fixed spring support 60 to be an integral part of the motor unit 10. The bracket 62 is a U-shaped channel of insulating material supported between the legs of the member 61 by projections 63 which engage appropriate apertures in the legs of U-shaped member 61. The legs of U-shaped bracket 62 lie in planes substantially parallel to the upper surface of the motor unit 10 and the bight of the U extends in a forwardly direction (towards the left of Fig. 2). A plurality of vertically disposed grooves 64, equal to the number of contact elements utilized, are provided in the forwardmost portion (bight of the U) of the channel bracket 62. The grooves 64 are sufficiently deep to provide a rectangularly shaped aperture 65 in the bight of the U through which the individual movable springs 44 extend. These grooves 64 act as vertical guides for the fixed springs 45 and 46 by virtue of the downwardly and upwardly extending forwardmost portions of the springs 50 and 51. The meshing of the fixed springs 45 and 46 with the proper ones of the grooves 64 prevents the fixed springs 45 and 46 and their associated contact elements 52 and 53 from being displaced in a transverse direction.

The uppermost layer of springs 45 is bent so as to be pretensioned in a downward direction, and, in a similar manner, the lowermost layer of springs 46 is bent so as to be pretensioned in an upward direction. Under this arrangement, the uppermost layer of springs 45 continuously exerts a downward pressure on the upper surface 66 of U-shaped bracket 62 associated with the fixed spring support 60, and contrariwise, the lowermost layer of springs 46 continuously exerts an upward pressure on the lowermost surface 67 of the bracket 62.

The armature 30 is of a rocker-type construction (see Figs. 1 and 2) pivotally mounted along the line 31 by means of the spring 20. The pivot line 31 of the armature 30 is transverse to the sense of the wire springs (44, 45, and 46) and, as previously pointed out, lies along the shorter leg 14 of the J-shaped return path member 13. The semicircular upper end of the armature retaining spring 20 defines a fulcrum and supports the armature 30 in its proper position with respect to the motor unit 10. The portion 32 of the armature 30 to the rear of the fulcrum is formed in the shape of a triangle pivoted along its base and with its apex rounded on an even radius. The rearmost portion 32 bridges the pole face 19 to the return member 13 when the coil is energized. The forward part 33 of the armature 30 lies in a plane which intersects the plane of the rearward portion 32 at an obtuse angle. The forward part 33 comprises two forwardly extending L-shaped angle arms 34 which are secured at right angles to the fulcrum line 31. Two essentially cylindrical parallel guide bars 35 constructed of an insulating material are disposed between the forwardmost ends of the L-shaped angle arms 34 in planes parallel to the pivot line 31. The bars 35 are secured to arms 34 by means of laterally extending projections 36 housed in suitable apertures in the ends of the arms 34. The movable springs 44 are positioned intermediate these two guide bars 35 in a plurality of sections 37 of decreased radius which are disposed along each guide bar 35 to prevent lateral or transverse displacement of the movable wire springs 44. To facilitate this, each of the guide bars 35, though essentially cylindrical, has a flat surface along one side (Fig. 2) which flat surfaces engage each other. Thus, the middle layer of wire springs 44 cannot move in a transverse direction, their movement being restricted to vertical planes whenever the relay is operated or released.

The configuration of the armature 30 coupled with its mounting arrangement with respect to the motor unit 10 and to the movable springs 44 makes it apparent that, upon the energization of the coil 12, the springs 44 are moved in an upward direction by the forward part 33 of the armature 30 as a result of the rearward portion 32 moving in a downward direction to bridge the return path member 13 to the pole face 19.

It will be noted in the first embodiment of the instant invention, depicted in Figs. 1 to 3, that there are fourteen groups of contact elements, each group consisting of single over and under fixed contact elements and an interposed movable contact element. By referring to the previous description, it will be apaprent that in the normal unoperated position of the relay the contact elements **52** associated with fixed springs **45** are normally separated from the upper contact elements **54** associated with movable springs **44** with which they cooperate. Upon the operation of the relay however, the movable springs **44** are displaced in an upward direction by virtue of parallel bars **35** moving the upper movable contact elements **54** associated therewith into contact with the contact elements **52** associated with fixed spring layer **45**; i. e., the upper movable contact elements **54** and the fixed contact elements **52** form so-called "make" combinations. It can be appreciated that if the upper surface **66** of bracket **62**, against which the uppermost layer of springs **45** is pretensioned downwardly, is straight and parallel with respect to a line through the contact elements **54** of the movable springs **44**, then all of the contact elements **52** associated with fixed springs **45** will be contacted by their cooperating movable upper contact elements **54** at the same approximate time.

In some cases, however, it may be desirable that certain ones of the "make" combinations close at different points with respect to armature travel when the relay is operated. For example, if a slight depression such as that indicated at **66A** (Fig. 3) is formed on the upper surface **66** of bracket **62**, the fixed spring **45A** would obviously allow its associated contact element **52A** to be contacted by movable upper contact element **54A** at an earlier point in the path of the upward movement of movable wire springs **44** than would be the case if there were no depression. Cooperating contact elements such as these may be labeled "early make" contacts. If an even deeper depression were made in the upper surface **66** of the bracket **62**, for example, as illustrated in Fig. 3 as **66B**, the fixed spring **45B** due to its pretensioning would hold contact **52B** even closer to its corresponding movable upper contact element **54B** and, as a consequence, the contacts would close at an even earlier point in the course of upward movement springs **44**. These types of springs are ordinarily labeled "preliminary make" contacts. It is apparent that many other such gradations of "early" to "preliminary make" arrangements may be obtained by varying the depth of depression on the upper surface **66** of the bracket **62**.

It will also be perceived by observing the operation of the relay that the lower layer of fixed springs **46** cooperate with the movable springs **44** through their cooperating contact elements **53** and **54**, respectively, to form a plurality of "break" contacts. Ordinarily when the relay is in a released condition, the contact elements **53** associated with the fixed springs **46** are in contact with the lowermost contact elements **54** associated with movable springs **44**. Provided that the lower surface **67** of bracket **62** lies in a simple plane which is approximately parallel to a line through the contact elements **54**, associated with movable springs **44**, it is apparent that the operation of the relay will separate the lower movable spring contact elements **54** from their corresponding fixed spring contact elements **53** at about the same point in the operation of the armature. Here again, a gradation of depressions can be selectively formed upon the lower surface **67** of bracket **62** in order to provide a plurality of "early break" and "preliminary-break" combinations. Other combinations are possible, but ordinarily no more than three such gradations appear necessary to handle most combinational requirements for modern switching relays.

These diverse combinations of "early make," "preliminary make" and "normal make" with other combinations of "early break," "preliminary break" and "normal break" may be obtained primarily by coding the upper and lower surfaces, **66** and **67**, respectively, of the U-shaped bracket **62**. Hence, one of the advantages of this type of construction is that the bracket **62** may be coded for various design requirements and may be substituted at will to obtain a different coded combination when desired without greatly effecting any of the other components of the relay. In addition to the diverse combinations possible within the limits stated above, further complex combinations can be obtained by strapping if need be. Under such circumstances complex "make-before-break-before-make" combinations as well as many others can easily be perceived.

Another embodiment of the instant invention is depicted in Figs. 4 through 10. In many ways this second embodiment is quite similar to that previously described and depicted in Figs. 1 through 3. Hence, in describing the second embodiment, less detail will be needed except where the two embodiments differ.

Looking in detail at Figs. 4 through 10, it can be seen that the basic components of the relay, as in the case of the first embodiment, comprise essentially a motor assembly **70**, an armature **80**, a contact spring assembly comprising molded blocks **101** and **122** retaining movable springs **100** and **123** and a single layer of fixed springs **103** retained in a molded block **104**, a spring clip **107** and a cover **120**. Similar to the first embodiment of Figs. 1, 2 and 3, the armature **80** is mounted upon the motor assembly **70** in its proper position and the three layers of wire springs comprising the contact spring assembly are retained in their proper position with respect to the motor assembly **70** and to the armature **80** by a spring clip **107**. The inwardly extending tabs **108** on spring clip **107** engage cooperating indentations (see Fig. 10) molded into the motor assembly **70**.

Before describing these subassemblies in detail, it might be well to note that the principal functional difference between the second and first embodiments lies primarily in the way in which the armature moves the wire spring. In the first embodiment, a layer of movable springs is provided intermediate two layers of fixed springs and is moved directly by one end of the armature as the other end of the armature completed the magnetic circuit between the core and the return leg. In the second embodiment, the armature moves a movable card **115**, which in turn dislaces overlying or underlying movable springs with respect to an intermediate fixed spring layer. In this respect, the second embodiment utilizes a type of contact spring actuation quite similar to that disclosed in 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 et al.

Looking in detail at the motor unit assembly **70**, it can be seen that it includes the principal non-moving parts of the relay, as are shown in the motor unit assembly **10** of the first embodiment; but, the motor unit assembly **70** also includes fixed contact terminals **77** which are molded as an integral part thereof. The motor assembly **70** is defined by an essentially rectangular shape of an appropriately configurated mold and does not use a metal box to contain the various motor unit assembly parts prior to their molding. A cylindrical core **73**, whose upper end (Fig. 5) has attached thereto an integral pole face **78** and whose other end contacts the longer leg of a flat J-shaped return path member **71**, is disposed in a perpendicular relationship to the upper surface of the motor unit **70**, as was the case with the similar magnetic parts in the first embodiment. Integral with the shorter leg of the J-shaped return member **71**, which lies along the upper surface of the motor unit assembly **70**, is a U-shaped member **74** (Fig. 6). The upward two ends of member **74** extend above the surface of the motor unit assembly **70** and have apertures **79** (Fig. 10) therein in a direction transverse to the longitudinal axis of the relay springs in order to pivotally hold the armature **80** by a pin **81**.

The rocker-type armature **80** is pivotally mounted along an axis defined by pin **81** engaging apertures **85** in the armature **80** and apertures **79** in the U-shaped support member 74. When so mounted transversely to the sense of the wire springs 100, 123 and 103, the middle portion of the armature bears against the upper edge of the shorter leg of the J-shaped return member 71. In a manner similar to the case of the first embodiment, when the coil 72 is energized, the armature 80 bridges the return path member 71 and the core face pole 78 to complete a magnetic circuit.

Prior to the molding of the motor assembly unit 70 as a unitary structure, the core 73, pole face 78, coil 72 and J-shaped return member 71 are properly positioned as depicted particularly in Fig. 5. The U-shaped member 74, whose two ends are to provide a pivotal mounting for the armature 80, is likewise properly positioned integral with the shorter leg of the J-shaped return member 71. Another U-shaped member 75 (Fig. 6) is mounted transverse to the sense of the wire springs at the forward part of the mold and has two forwardly extending right-angle projections thereon (see Fig. 5 or 7). The purpose of this U-shaped member 75 is to support a fixed card 110 whose use and purpose will be described hereinafter.

Also properly mounted with respect to the magnetic circuit members, as well as with respect to the position to be occupied by the wire spring assembly upon completion of the relay, is a plurality of fixed contact terminals 77, one properly positioned for every wire spring, both fixed and movable. These are disposed at the rear of the motor assembly and are held in proper place prior to molding. Also extending from the motor assembly unit are the terminals 69, to allow connection to the coil 72, and threaded members 76, which act as supports for the relay upon final assembly and installation. The shape of the mold used to form a unitary structure out of the motor unit assembly 70, particularly as seen in Fig. 10, properly provides for the indentations which are to be engaged by the inwardly extending tabs 108 of the spring clip 107 and provides for extruded projections 113 which are to properly position the pluralities of molded blocks which contain the wire springs. Once all these various parts are properly positioned with respect to each other and to the final disposition of the wire spring assemblies, the unit is converted into a solid structure by the use of any suitable plastic resin.

The wire spring assembly comprises a plurality of contact springs 100, 123 and 103 retained in molded blocks 101, 122 and 104, respectively. Molded within the block 104 are a plurality of fixed wire springs 103; whereas, blocks 101 and 122 disposed on either side of fixed spring block 104 have molded therein a plurality of movable springs designated 100 and 123. Molded block 104 has a forwardly extending projection 104*a* which has a dual purpose. First, it is vertically apertured to receive backstop screw 140 which bears against the upper surface of rearward portion 82 of armature 80. Backstop screw 140 is adjustable to control the working air gap between the forward part 83 of armature 80 and pole piece 78. Second, the presence of forwardly projecting member 104*a* provides convenient means for supporting well known types of dampers (not shown) to reduce vibrations of movable springs 100 and 123 during the relay's operation, if needed.

The arrangement of molded blocks 101, 122 and 104 in stacked relation provides three layers of wire springs, each of unitary construction and whose rearward portions (Fig. 5) extend beyond the molded supports and, when properly positioned with respect to the motor unit assembly 70, bear against the previously disposed contact terminals 77 to provide continuity from some terminals through the appropriate wire springs and their cooperating contacts back to other terminals. As in the case of the first embodiment, the wire springs 100, 123 and 103 extend in a parallel sense with respect to the upper surface of the motor unit assembly 70 when in proper position with respect thereto. The forwardmost end of the movable springs 100 and 123 have affixed to their

proper sides contacts 102 and 124 which cooperate with appropriate upper and lower contact surfaces of fixed contacts 105 which are attached to the forwardmost end of fixed springs 103. Similar to the case of the first embodiment, a single upper spring 100, with its associated contact 102, cooperates with the upper surface of precious metal contact element 105, while a single lower spring designated 123, through the agency of its precious metal contact 124, cooperates with the lowermost surface of the precious metal contact 105. It can best be seen in Fig. 10 that the three molded blocks 101, 122 and 104 have a number of cooperating indentations 114 and projections 113 disposed with respect to one another such that they form an integral unit when mounted in their proper positions with respect to the motor unit assembly 70. It also can be seen that the uppermost molded block 101 has a channel formed in a transverse direction on its uppermost surface to fixedly retain spring clip 107 in its proper position when the relay is assembled.

In addition to the rear molded support 104 for fixed springs 103, there is provided a front fixed support 110 which molds the plurality of fixed springs 103 along a simple plane which, when in proper position, is essentially parallel to the upper surface of the motor unit assembly 70. This essentially rectangularly-shaped fixed spring support 110 has molded thereon U-shaped projections 111 and 125 on its outward ends. The vertical heights between these U-shaped legs is such as to be engageable by the forwardly extending projections on member 75 which were previously described. Hence, when the spring assembly is in its proper position the ends of the U-shaped member 75, whose ends extend in a vertical plane out of the surface of the motor unit assembly 70, engage the bights of the U-shaped members 111 and 125 on the outward ends of the fixed spring support 110 to properly position the fixed springs 103 with respect to the motor unit assembly 70. A plurality of grooves 112 are excised in longitudinal directions to the sense of the wire springs along the upper and lower surfaces of the transversely disposed fixed spring support 110. The grooves are so disposed to contain the movable springs 100 and 123 in a lateral direction so that during operation no substantial displacement is possible transverse to the longitudinal axis of the motor unit assembly 70. This assures that the contacts associated with the movable springs will properly engage their cooperating fixed contacts during operation.

In the uppermost layer of springs 100, each one is bent so as to be pretensioned in a downwardly direction and, therefore, to bear in a positive manner against the innermost portions of the corresponding groove 112 disposed along the upper edge of the fixed molded spring support 110. In a similar manner, each lowermost spring 123 is bent so as to be pretensioned in an upward direction. With this type of arrangement, the uppermost layer of springs 100 continuously exerts a downward pressure on the upper surface of the front molded support bracket 110; whereas the lowermost layer of springs 123 continuously exerts an upward pressure on the lowermost surface of the front molded support 110.

The armature 80, similar to the armature of the first embodiment, is of a rocker-type construction (Fig. 10) and is pivotally mounted along the line of the pin 81 by the cooperation of this pin 81 with the upstanding supports identified generally as 74. The pivot line of the armature 80 is transverse to the sense of the wire springs (100, 123 and 103) and, as previously pointed out, lies along the upper surface of the shorter leg of the J-shaped return path member 71. The rear portion 82 of the armature 80 is quite similar to the shape of its counterpart in the first embodiment, i. e., a triangle pivoted along its base with its apex rounded on an even radius. This rearmost portion 82 bridges the pole face 78 and the J-shaped return member 71 to complete the magnetic circuit whenever the coil 72 is energized. The principal portion of the forward part **83** of the armature **80** lies in a plane which intersects the plane of the rearward portion **82** at an obtuse angle (similarly to the first embodiment). The forward portion **83** of the armature **80** comprises two forwardly extending angle-shaped members connected at their forwardmost ends by a transverse plane member whose forwardmost outer ends form projections **86**, the function of which will be explained hereinafter. The forward portion of the armature **80** may be described as an essentially plane rectangular shaped member with a rectangular cut-out which is reinforced along its longitudinally extending sides by angle brackets.

A movable card **115** is provided for translating the motion of the armature to the movable springs and thereby properly opening and closing the contacts thereof when the relay is operated. The movable card **115** has an essentially rectangular shape with a pair of rectangular apertures cut therein. It is supported in a transverse direction adjacent the forward end of the motor unit assembly **70** by a pair of downwardly biased spring members **116** and **126** which are molded in the upper molded block **101**. The forwardmost ends of these downwardly biased heavy springs **116** and **126** engage apertures **117** and **127**, respectively, in the outer upper ends of movable card **115** and thereby keep a constant downward pressure upon movable card **115** when it is in its proper position with respect to the other components of the relay. The forwardmost ends of fixed springs **103**, and their fixed contacts **105**, project through the rectangular apertures in the card **115**; whereas, the upper layer of movable springs **100** bear against the upper surface **118** of the movable card **115** and the lower movable springs **123** bear against the lower surface **119**. When properly positioned the movable card **115** is held in its transverse position at the forwardmost portion of the motor unit **70** and armature **80**, by projections **128** on its lower surfaces, which surfaces cooperate with projections **86** on the forwardmost outer ends of armature **80**.

With the upper and lower portions **118** and **119** of the movable card **115** so disposed and with the heavy downwardly biased springs **116** and **126** properly engaging the cooperating apertures **117** and **127**, movement of the armature **80** allows the movable card **115** to displace the upper or lower layers of movable springs **100** or **123** by virtue of the surfaces **118** and **119** along its upper or lower portions **118** and **119** whenever the armature is operated. The upper layer of movable springs **100** cooperate with fixed springs **103** and are considered break contacts and the lower layer of movable springs **123** are make contacts.

Similarly to the first embodiment, it can be seen that when the coil **72** is energized, the rearmost portion **82** of the armature bridges the **J**-shaped return path member **71** to the core pole face **78**, thereby completing the magnetic circuit. The displacement of the rearmost portion of armature **80** in a downward direction pushes the forwardmost portion **83** in an upward direction, thereby displacing the movable card **115** upwardly. The displacement of the movable card in an upward direction separates the contacts **102** associated with the upper layer of movable springs **100** from their associated fixed contacts **105** and allows the lower layer of movable springs **123** to move in an upward direction to enable the contacts **124** to engage the contacts **105** on the fixed springs **103**.

Just as in the first embodiment, it will be noted that there are fourteen groups of contact elements. Each group in this second embodiment, however, consists of a single centrally disposed fixed contact element and an over and under movable contact element. Also, as in the case of the first embodiment, if the upper and lower surfaces **118** and **119**, respectively, of movable card **115** lie in simple planes which are parallel to the surfaces of the fixed contact **105**, then all of the "make" contacts (pairs **102—105**) will come together at the same point in time insofar as the operation of the armature **80** is concerned and all of the "break" contacts (pairs **123—105**) will separate at the same point in the travel of armature **80**.

The surfaces **118** and **119** can, however, be changed and so constructed as to give diverse combinations of "make" and "break" combinations. Just as was previously explained in connection with the first embodiment, if one of the particular contacts bearing against upper surface **118** is allowed to lie in an indentation along that surface, it will make contact with its associate fixed contact earlier in point of time as will be the case with the others. Hence, to get an early "make," a small depression can be appropriately formed in the upper surface **118**. If an even earlier "make" contact is desired, an even deeper depression may be so formed. In a similar manner, if a small depression is formed in the lower surface **119** of movable card **115**, the particular movable contact associated therewith will separate from its appropriate fixed contact at a later point in time, hence forming a late "break." Appropriate differences in these indentations can give a plurality of various combinations just as was previously described with the first embodiment. This allows a single relay structure to be utilized wherein a diverse number of coded combinations may be obtained merely by changing the configuration of the movable card **115**.

It is to be understood that the above-described arrangements are but illustrative of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electromagnetic relay comprising a unitary stationary structure including a magnetic core having pole pieces, an energizing winding for said core, and a rigid insulating body in which said core and winding are embedded; a contact spring assembly including a plurality of cooperating contact springs; insulating members for mounting said spring assembly and means for securing said members to said body; an armature; means for supporting said armature on said body in juxtaposition to said pole pieces; an operating card movable by said armature for selectively controlling certain ones of said cooperating contact springs; and means for energizing said coil to cause said armature to bridge said pole pieces and to move said operating card to control selected ones of said contact springs.

2. An electromagnetic relay comprising a unitary stationary structure including a magnetic core having pole pieces, an energizing winding linked magnetically to said core, an armature support bracket, and a rigid insulating body in which said core and armature support bracket and winding are embedded; a contact spring assembly including a plurality of cooperating contact springs; insulating members for mounting said spring assembly and means for securing said members to said body; an armature mounted upon said armature support bracket and operable upon the energization of said coil to bridge said pole pieces; an operating card disposed adjacent said armature, said card having surfaces engageable by selected ones of said contact springs; means to urge said operating card against said armature; and, means for energizing said coil whereby said armature causes said operating card to control selected ones of said wire springs.

3. An electromagnetic relay comprising a unitary stationary structure having forward and rearward ends and including a magnetic core having pole pieces, an energizing winding linked magnetically to said core, an armature support bracket, a molded support bracket, and a rigid insulating body in which said core and pole pieces and armature support bracket and molded support bracket and winding are embedded; a contact spring assembly including an insulating frame supported on said molded

support bracket and including a plurality of cooperating contact springs; a rocker-type armature pivotally mounted upon said armature support bracket and including a first portion movable to bridge said pole pieces when said coil is energized and including a second portion having a forward end adjacent the forward end of said unitary structure; an operating card disposed adjacent the forward end of said armature, said card having separate surfaces selectively engaging separate ones of said contact springs; means for urging said card against said armature; and, means for energizing said coil to cause said armature to bridge said pole pieces and thereby to move said card to control selected ones of said cooperating wire springs.

4. An electromagnetic relay comprising a unitary stationary structure having forward and rearward ends and including a magnetic core having pole pieces, an energizing winding linked magnetically to said core, an armature support bracket adjacent one of said pole pieces, a fixed spring support bracket, and a rigid insulating body in which said core and pole pieces and winding and support brackets are embedded; a contact spring assembly including three insulating members, said members having cooperating projections and indentations whereby they may be properly positioned in stacked relation to each other and to said unitary molded structure; a spring clip to hold said insulating members in stacked relation; a molded support engageable by said fixed spring support bracket to position said molded support with respect to said unitary structure; a plurality of fixed wire springs molded in one of said insulating members and in said molded support; pluralities of movable wire springs molded in individual ones of said other insulating members and extending forwardly in spaced proximity to said first plurality of wire springs and on opposite sides thereof; a rocker-type armature pivotally mounted upon said armature support bracket and including a first portion movable to bridge said pole pieces when said coil is energized and including a second portion having a forward end adjacent the forward end of said unitary structure; an operating card disposed adjacent the forward end of said armature, said card having a first surface engageable by certain ones of said springs of said contact spring assembly and having a second surface engageable by certain other ones of said springs of said wire spring assembly; means for urging said operating card against the forward end of said armature; means for energizing said coil to cause said armature to bridge said pole pieces and thereby to move said operating card to control selected ones of said movable springs; and, a sealed enclosure for said armature and said contact spring assembly, which enclosure abuts said unitary molded structure.

5. An electromagnetic relay comprising a unitary stationary structure including a magnetic core having pole pieces, an energizing winding linked magnetically to said core, an upstanding portion containing a plurality of fixed terminals, and a rigid insulating body in which said core and pole pieces and winding and fixed terminals are embedded; an armature mounted on said body in such relationship to said pole pieces as to be actuated magnetically when said winding is energized; a contact spring assembly including an insulating frame supporting a plurality of cooperating contact springs, said contact springs adapted to engage said fixed terminals to provide lead-outs for electrical circuits; a spring actuating card movable by said armature and engaging certain movable ones of said springs; clamping means for holding said wire spring assembly to said body; and, enclosure means for said armature and said contact spring assembly, which enclosure abuts said upstanding portion of said unitary stationary structure.

6. An electromagnetic relay comprising a unitary stationary structure including a magnetic core having pole pieces, an energizing winding linked magnetically to said core, an armature support bracket, a molded support bracket, and a rigid insulating body in which said core and pole pieces and said armature support bracket and said molded support bracket and said winding are embedded; an armature pivotally mounted on said support bracket in such relationship to said pole pieces as to be actuated magnetically when said winding is energized; a contact spring assembly comprising a plurality of insulating spring support members and an insulating frame supporting a plurality of contact springs, a spring actuating card movable by said armature and engaging certain movable ones of said springs; clamping means for holding said assembly to said body so that said armature when actuated moves said card; and, means for enclosing the armature and contact spring assembly, which enclosing means abuts against said plurality of insulating members to form an air-tight seal.

7. An electromagnetic relay comprising a unitary stationary structure having forward and rearward ends and a longitudinal axis and including a magnetic core having a pole portion which lies in a first plane, a magnetic return member attached to said core, a coil magnetically linked to said core, an armature support bracket disposed adjacent said return member, a fixed spring support bracket disposed adjacent the forward end of said unitary structure, a plurality of fixed terminals positioned rearwardly of said magnetic members, means for externally supporting said unitary structure, exposed terminals connected at one end to the leads of said coil, and a rigid insulating body in which the components of said unitary structure are embedded; a contact spring assembly including an insulating frame supporting a plurality of cooperating contact springs; a rocker-type armature pivotally mounted upon said armature support bracket and including a first portion movable to bridge said pole piece to said return member when said coil is energized and including a second portion having a forward end adjacent the forward end of said unitary structure, said forward end lying in a plane parallel to said first plane and transverse to said longitudinal axis; a movable operating card disposed adjacent the forward end of said armature and having first and second surfaces which engage different selected ones of said wires of said wire spring assembly; means to urge said operating card against the forward end of said armature; means for energizing said coil to cause said armature to bridge said return member and said pole piece and thereby to move said operating card to control selected ones of said cooperating wire springs; and, a sealed enclosure for said armature and said contact spring assembly which enclosure abuts that portion of the said unitary molded structure which surrounds said fixed terminals.

8. An electromagnetic relay comprising operating means including a core, pole pieces, an energizing winding, and an armature; said core, pole pieces, and winding embedded in a rigid body of insulating material and said armature hinged to said body, ranks of fixed and movable contact springs, each rank anchored adjacent the inner ends of its springs in an insulating block, the blocks superposed on said body, means for securing the blocks and the body together, a fixed contact spring support secured to said body, and a movable contact spring operator secured to said armature, whereby the spatial relations of the relay parts are determined by their attachment to said body.

9. An electromagnetic relay comprising operating means including a core, pole pieces, an energizing winding, and an armature; said core, pole pieces, and winding embedded in a rigid body of insulating material and said armature hinged to said body adjacent a pole piece, ranks of contact springs, said springs having contacts at their outer ends, each rank anchored adjacent the inner ends of its springs in an insulating block, the blocks superposed with one block resting on said body, means for securing the blocks to the body, a fixed contact spring support secured to said body, and a movable contact

spring operator secured to said armature, whereby the spatial relations of the relay parts are fixed by their attachment to said body.

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