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SPRING PILE-UP ELECTROMAGNETIC RELAY

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2 Sheets-Sheet 2

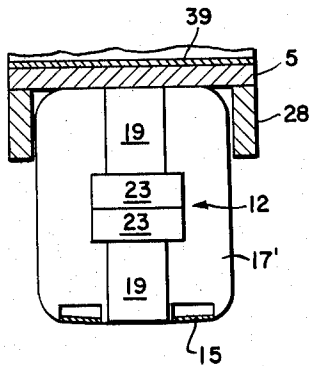


FIG. 7.

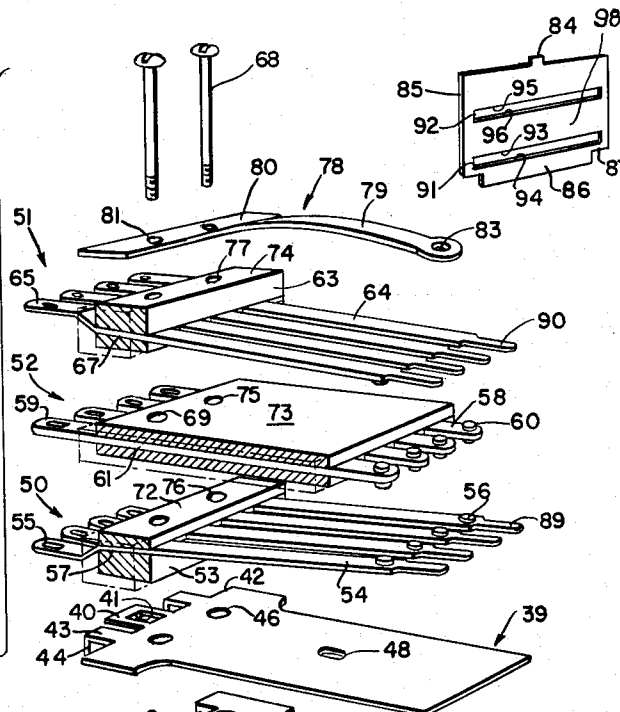
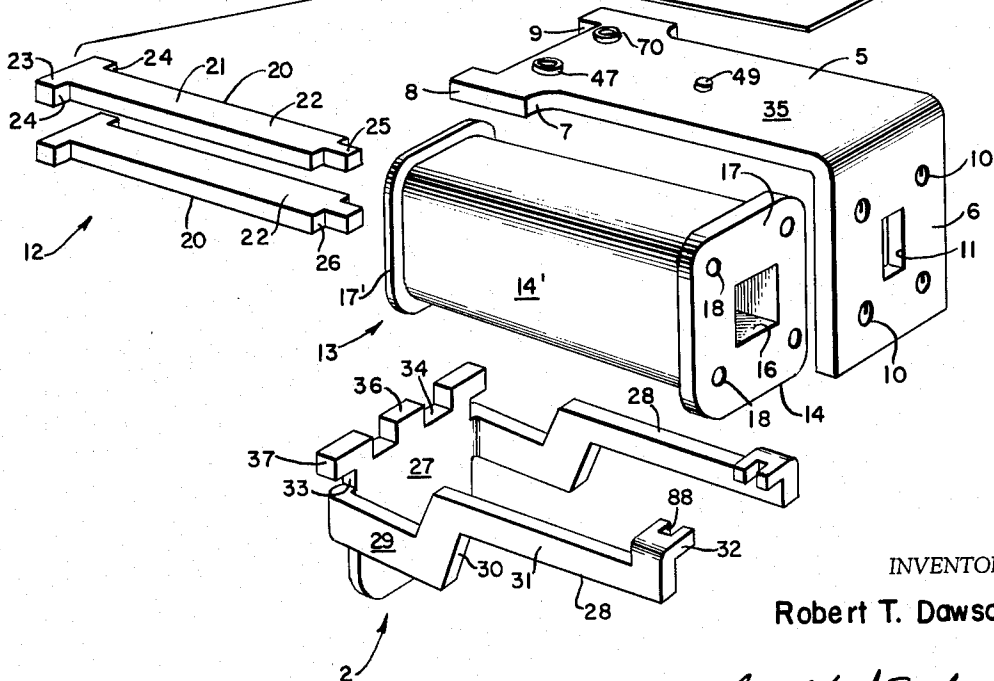


FIG. 8.



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SPRING PILE-UP ELECTROMAGNETIC RELAY
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This invention relates to electromagnetic relays and more particularly to an electromagnetic relay in which the contacts are mounted on the relay frame for actuation by the movement of an armature.

In bar relays and telephone type relays, it is known to mount the movable contacts on elongated leaf type contact springs, the contact springs being rigidly attached to a mounting block of insulating material. Where the contacts are closed by positive movement of an armature operated actuator, for example a card or bar, both the movable and stationary contacts are mounted in opposed relation, so that the movable contacts are moved against the bias of the contact springs into engagement with the stationary contacts when the relay is energized. In another well known construction, the contact springs are attached to a mounting block and the springs are bent or kinked between the mounting block and the contacts to normally bias the movable contacts into closing engagement with the stationary contacts, the contacts being open when the relay is energized and the contact operator is actuated. Where the contacts are closed solely by the bias of the contact spring, difficulties frequently arise as a result of bending the contact springs to provide the necessary contact closing pressures. The bending of the contact springs is frequently accomplished by mass production methods after the springs are molded or otherwise attached to the mounting block. Such bending may involve coining, or kinking of the spring, but in any event the spring is permanently deformed to provide the necessary bias for the movable contact. This procedure has not been found satisfactory in practice, since bending sometimes "work hardens" the spring with the result that the endurance of the spring is rendered unpredictable during the stress reversals occasioned by operation of the relay.

To avoid fatigue failure of the contact springs when the springs are bent, the springs are sometimes "over-designed," i.e., provided with a factor of safety to compensate for the unpredictable performance resulting from bending. Such over-design may be accomplished by increasing the thickness of the contact spring, or its width, and correspondingly the cost of the relay is increased, since the most economical material size is not used.

To avoid the effects of "work hardening" due to bending the contact springs, the springs are sometimes heat-treated after bending to restore the original material characteristics. Obviously, such heat treating is an expensive process which, unless special equipment is used, can only be performed prior to molding or otherwise permanently attaching the contact springs to the insulating mounting block. In any event, the problem is present and, in the past, has required additional manufacturing steps or uneconomical methods to provide the desired contact spring. In the present invention, the contact springs are pretensioned in a unique manner that eliminates the shortcomings of the methods used in the past. According to this invention, the contact springs of the movable contacts are attached to their supporting mounting members, preferably by molding, so that the springs are disposed at an angle to the stationary contact assemblies. The springs are substantially straight along their length and are not kinked or bent in any way. The predetermined angle at which the springs are inclined toward the stationary contacts provides the necessary pretensioning

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and, hence, closing pressures for the movable contacts at the ends of the springs to properly engage the stationary contacts.

Another problem frequently encountered is the assembly and positioning of the various parts of the relay, for example, the armature, and the contacts which are operated by the armature. For example, where the armature is pivoted to the frame, it must be mounted securely on its pivot to prevent any movement of the armature relative to the pivot to insure that the armature face will be properly positioned relative to the pole face of the electromagnet to provide the desired "pull in" characteristics. The proper positioning of the armature face in spaced relation to the pole face of the electromagnet is effected by providing a backstop engageable with an end portion of the armature to limit the movement of the armature face away from the electromagnet when the relay is unenergized. In the case of a telephone type relay, the proper space between the armature face and the electromagnet is effected by bending the portion of the armature end extending from the armature face. In the present invention, such adjustment is substantially eliminated, or at least minimized, since the dimensions of the armature and the supporting portion of the frame are closely controlled to reduce to a minimum any variations in the position of the armature on the relay and, hence, in the "pull in" characteristics of the relay. Since the resisting forces of the contact springs are also a consideration in determining the pull in characteristics of a relay, the means for pretensioning the contact springs as previously described is extremely important.

Another significant feature of the present relay which relates to the operation of the contact springs, and, hence, to the pull in characteristics, is that only one row of contacts of a double-throw type contact arrangement is moved by the armature during the initial travel of the armature. The magnetic forces attracting the armature to the pole face of the core are the smallest and hence the most critical when the armature is at its maximum distance from the core. It will thus be apparent that when the retarding spring forces are not effective until the armature has moved at least a short distance, the attractive forces need not be so great and efficiency is improved. It will also be readily apparent that the increased retarding forces of the contact spring do not begin to operate until the magnetic pull between the armature and the pole face of the core has substantially increased due to movement of the armature toward the pole face of the core.

Where the frame which forms part of the magnetic circuit of the relay functions as a backstop for the armature ends, the ends of the armature must be magnetically insulated from the frame to prevent sticking. In the past, this magnetic insulation is usually effected by positioning a stop member to space the ends of the relay from the frame, or by providing a nonmagnetic member between the armature ends and the frame.

In the present invention, the ends of the armature which extend over the frame are effectively insulated from the magnetic frame by a member of nonmagnetic material which extends the length of the relay frame and on which the ends of the armature rest when the relay is in its unenergized condition. This nonmagnetic member further functions to retain the armature on its pivot on the frame. The nonmagnetic member is held in position when the relay is properly adjusted, by the contact stack assembly. This arrangement, as one skilled in the art will recognize, is highly desirable, since both the armature and the contacts can be properly positioned and secured in coacting adjusted relationship in a single operation. If it is desired to obtain pull in characteristics of very close tolerances, an adjusting fixture could be used

to obtain the proper relative positioning of the associated parts. When such a fixture is used, the adjusting is effected in a single operation merely by properly placing the relay in the fixture and then tightening the stack mounting screws after the parts are properly positioned. It will also be apparent that the nonmagnetic member, which extends the length of the surface of the frame between the frame and the contacts, will reduce "frame to contact capacitance" in addition to insuring antistick operation of the relay.

Another problem arises when the electromagnet is secured to the frame of the relay. In prior constructions, the core is attached to the heel portion of the relay by mechanical means such as swaging or staking after the end of the core is passed through an opening in the heel portion of the frame. Such mechanical staking in this fashion has proved satisfactory except when it is desired to use the heel piece for mounting the relay on a supporting structure. Mounting is difficult, since the end portion of the core protrudes beyond the surface of the heel portion of the frame, in which instance it is necessary to grind away or otherwise remove the protruding portion of the core to provide a flat, flush mounting surface.

In the present invention, the mounting problem is obviated by so constructing the core and frame that, after attaching the core, the outside surface of the heel piece to which the core is attached will be smooth and flat. It will thus be unnecessary to grind or otherwise finish this mounting surface by a subsequent operation.

Another problem frequently encountered in the assembly of the contacts for telephone type relays is the proper adjusting of the contacts relative to each other and to the frame on which the contact stacks are mounted. In the present invention, the contacts are each pre-attached by cementing or preferably molding the contact supporting members in insulating mounting blocks which are subsequently placed in superposed relation and attached to the frame of the relay. The surfaces of the mounting blocks which contact each other are provided with interfitting projections and recesses to permit proper alignment of the movable contacts and stationary contacts merely by mounting the blocks one on the other. The portion of the relay frame on which the contact stack is mounted is also provided with recesses or projections which engage with corresponding members in the lowermost insulating member of the stack assembly. By the use of such an arrangement, the contacts are properly positioned relative to the frame, armature and to each other merely by placing the preassembled contact stack on the surface of the frame and then fastening the stack.

Accordingly, an object of the present invention is to provide an electromagnetic relay in which the movable contacts are mounted on contact springs which are accurately pretensioned to bias the movable contacts into engagement with the stationary contacts.

Another object of the present invention related to the first is to provide a relay having movable leaf type contact springs which are molded to a mounting block of insulating material along a portion of the springs remote from the contacts at an angle to the plane of the stationary contacts.

Another object of the present invention is to provide a relay in which leaf type contact springs which support the movable contacts are pre-tensioned by a new, unique construction which eliminates bending or otherwise deforming the contact springs to obtain proper contact engaging pressures.

A further object of the present invention is to provide a contact stack arrangement in which the mounting blocks for the movable and stationary contact assemblies are provided with interlocking projections and recesses to permit rapid aligned assembly of the contacts.

An additional object of the present invention is to provide a relay in which the armature retaining member

underlies the contact stack, is secured to the frame by the stack, and acts as a backstop to magnetically insulate the armature tails from the relay frame.

A further object of the present invention is to provide an armature and armature retaining element which cooperate with the contact stack to permit proper positioning of the armature and the contact stack in a single assembly operation.

A further object is to provide a unique core and frame assembly for an electromagnetic relay in which the core is fastened to the heel piece in a manner which provides a smooth outer surface on the portion of the heel piece by which the relay is supported.

A further object is to provide a multi-piece core comprised of a plurality of stamped core members of identical configuration held together solely by attaching the core members to the frame heel piece.

A still further object is to provide a relay construction which is particularly economical to manufacture, simple to assemble, and requires little, if any, adjustment.

In order that the manner in which these and other objects are attained in accordance with the invention can be understood in detail, reference is had to the accompanying drawings, which form a part of this specification, and wherein:

FIG. 1 is a side elevational view of an electromagnetic relay, including a contact spring construction in accordance with the present invention;

FIG. 2 is a top plan view of the relay of FIG. 1;

FIG. 3 is an end elevational view of the relay of FIG. 1, showing the armature end of the relay;

FIG. 4 is an end elevational view of the device of FIG. 1, showing the heel end of the relay;

FIG. 5 is a vertical sectional view taken on the line 5—5 of FIG. 1;

FIG. 6 is a horizontal sectional view taken on the line 6—6 of FIG. 1;

FIG. 7 is a partial vertical sectional view taken on the line 7—7 of FIG. 1; and

FIG. 8 is a view in exploded perspective of the relay including its associated parts.

Referring now to the drawings in detail, FIG. 1 shows a relay in accordance with the present invention. The relay includes a frame 1, an armature 2 pivoted to the frame, a contact stack designated generally as 3 mounted on the frame, and an electromagnet 4 attached to the frame.

As best seen in FIG. 8, the frame 1 is L-shaped and has a flat, generally rectangular main leg 5 projecting generally at right angles to a flat, rectangular heel piece 6; heel piece 6 and main leg 5 being formed of an integral strip of uniform thickness magnetic material. The end of leg 5 remote from heel piece 6 flares outwardly as at 7 to form an end of a larger transverse dimension than that of main leg 5, and terminates in an armature supporting portion comprising a pair of longitudinally extending projections 8 defining therebetween a generally U-shaped slot 9.

Rectangular heel piece 6 of frame 1 has a plurality of threaded bores 10 extending through the heel piece, into which threaded fasteners can be screwed to mount the relay to a supporting structure. Heel piece 6 is also provided with a rectangular opening 11 to enable securing the electromagnet to heel piece 6 of the frame. Threaded bores 10 are disposed in a generally rectangular arrangement in heel piece 6.

Electromagnet 4 is comprised of a core 12 surrounded by a coil assembly 13. Coil assembly 13 includes a bobbin 14 of molded resilient plastic material, which is preferably nylon, and a coil 14' of magnet wire wound on the bobbin, the ends of the coil being attached to terminals 15. Bobbin 14 comprises a thin walled rectangular body portion 15' which defines a rectangular core receiving opening 16. At the ends of rectangular body 15' are generally flat, rectangular end members 17 and

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17' which extend radially from rectangular body 15'. Flat end 17 of the bobbin which contacts heel piece 6 is provided with a plurality of circular depressions 18 in alignment with threaded bores 10 to provide clearance space to accommodate the ends of any of the threaded fasteners used to mount the relay which may protrude through the heel piece. The other end 17' of bobbin 14 has a pair of rectangular bars 19 protruding longitudinally from the face of end 17', one on each side of rectangular opening 16 of bobbin 14.

As best seen in FIG. 8, core 12 is comprised of two core members 20 of identical outline configuration and of substantially the same uniform thickness. Each core member 20 has a pair of flat planer surfaces 21 on opposite sides of the core member. Core member 20 has a rectangular body portion 22 with an integral rectangular pole end 23 at right angles to core body 22 which extends beyond the side edges of the body to provide a pair of abutment surfaces 24 which are generally parallel with and face heel piece 6. At its other end, body 22 has a projection 25 extending longitudinally from the body. The projection 25 is smaller in width than the body, thereby providing flat stop shoulders 26 at the end of body 20 which face in the same direction as the abutment surfaces 24. The rectangular opening 16 in bobbin 14 is dimensioned to receive core members 20 and closely embrace the exposed surfaces of body 22 when the core members are aligned with their planer surfaces 21 in contact. An important relationship between the core and the bobbin is that the length of body 22 of core member 20 is slightly less than the length of bobbin 14 from the surface of flat end 17 to the surface of flat end 17'. Due to the slight difference in length, the resilient plastic material of the bobbin will be deformed slightly in an axial direction when the core members 20 are inserted in the rectangular opening 16 of bobbin 14 and projections 25 are inserted in rectangular opening 11 in heel piece 6 with stop shoulders 26 in engagement with the surface of the heel piece adjacent the rectangular opening. This slight axial compression is effected by the engagement of abutment surfaces 24 of core members 20 with flat end 17' of the bobbin. Since bobbin 14 is axially compressed, the springiness due to the resiliency of the bobbin material will prevent any movement of the bobbin along the core, and hence the core will be rigidly attached.

Armature 2 of magnetic material comprises a flat, generally rectangular main body portion 27 having a pair of generally parallel arms 28 projecting from opposite edges of main body 27. Each arm 28 extends at right angles to the plane of main body 27 and has a forward portion 29, an angled step 30, and a straight portion 31 terminating in an end 32 which projects inwardly across the surface of frame leg 5. A pair of U-shaped notches 33 open outwardly in aligned relation from opposite edges of armature body 27. Notches 33 engage with projections 8 of main leg 5 to pivotally support the armature 2 on frame 1 with the portion of the armature main body between the notches disposed in the U-shaped slot 9.

An edge 34 of the armature main body 27 is coplanar with a surface 35 of main leg 5 remote from the electromagnet. A lug 36 extends beyond surface 35 from edge 34 of armature body 27. On each side of lug 36 and spaced therefrom are ears 37 extending from edge 34 beyond surface 35 of main leg 5. The ears 37 are parallel to each other and have outwardly projecting portions having surfaces 38 which provide a side wall for notches 33. The edge 34 and the surfaces 38 are coplanar so that the edge 34 will be coplanar with the surface 35 of frame 1 when the armature is in its pivotal position on the frame. When so positioned, the armature pivots with the surfaces 38 in bearing contact with the surface 35 of the projections 8, and the surface of body 27 in contact with the edge of main leg 5 between the projections 8.

Armature 2 is retained by a preformed, thin, resilient,

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generally rectangular nonmagnetic member 39 in contact with surface 35 of frame leg 5. Nonmagnetic member 39 has at one end a centrally located, longitudinally extending tongue 40 having a rectangular opening 41 therein. Rectangular opening 41 has one side in straight line relation with edge 42 of nonmagnetic member 39 from which the tongue projects. When the nonmagnetic member 39 is positioned on frame leg 5, lug 36 of armature 2 projects through rectangular opening 41. At each side of tongue 40 and spaced therefrom is a tab 43 extending longitudinally from edge 42 of nonmagnetic member 39. Tabs 43 contact edge 34 of armature body 27 with the ends 44 of tabs 43 extending at right angles to the tabs to engage the armature body 27 on the surface 45 of the armature body remote from the pole face of the core. It will thus be apparent that the tongue 40 and tabs 43 with ends 44 cooperate with edge 34, lug 36 and surface 45 to retain the armature 2 on its pivotal support on frame leg 5.

Nonmagnetic member 39 has a pair of transversely spaced openings 46 through which annular projections on frame leg 5 project when the nonmagnetic member is placed on the frame. An elongated opening 48 in approximately the middle of nonmagnetic member 39 receives locating half punch 49 extending from surface 35 of frame leg 5. Openings 46 are slightly larger in diameter than the diameter of annular projections 47 so that nonmagnetic member 39 can be moved slightly longitudinally of the frame to properly position nonmagnetic member 39 to retain the armature 2 on its pivot.

Contact stack 3 comprises a first movable contact assembly 50, a second movable contact assembly 51 and a stationary contact assembly 52 located between the first and second movable contact assemblies. The first movable contact assembly 50 includes a parallelepiped insulating mounting member 53 molded to a plurality of movable contact springs 54. Each spring 54 has a terminal portion 55 at one end of the spring and a contact 56 spaced slightly from the other end of the spring. Intermediate its ends at a point remote from the contacts 56, spring 54 has a supported portion 57 attached to insulating mounting member 53.

Stationary contact assembly 52 comprises a plurality of stationary contact arms 58 having a terminal end 59 and a stationary contact 60 mounted adjacent the other end. Stationary contact arm 58 has a supported portion 61 intermediate its ends attached to a parallelepiped insulating mounting member 62. Mounting member 62 extends along a substantial portion of the length of stationary contact arms 58 to support the arms and increase the rigidity of the assembly.

Second movable contact assembly 51 is identical to movable contact assembly 50, save that contact assembly 51 is inverted relative to contact assembly 50. Second movable contact assembly 51 comprises a parallelepiped insulating mounting member 63 molded to a plurality of movable contact springs 64. Each spring 64 has a terminal portion 65 and a movable contact 66 spaced slightly from the other end of the spring. Intermediate its ends, at a point remote from movable contacts 66, spring 64 has a supported portion 67 attached to insulating mounting member 63.

As best seen in FIG. 2 in broken lines, and in FIG. 5, the supported portions 57 and 67 of contact springs 54 and 64 are cut away as at 67' to permit the material of mounting members 53 and 63 to insulate threaded fasteners 68 from contact springs 57 and 67. Stationary contact arms 58 are similarly cut away for the same purpose.

Adjacent terminals 55 and 65, the ends of movable contact springs 54 and 64 are bent away from stationary contact terminals 59 to provide sufficient space to attach suitable wires for connecting the relay to the device to be operated. Supported portions 57 and 67 of contact springs 54 and 64 are disposed at an angle to the plane of stationary contact assembly 52. Springs 54 and 64, when relaxed, are substantially straight along their length from

and including supported portions 57 and 67 to contacts 56 and 66.

When the contact stack 3 is assembled and fastened to frame 5 with stationary contact assembly 52 superimposed on first movable contact assembly 50 and second movable contact assembly 51 superimposed on stationary contact assembly 52, movable contacts 56 engage stationary contacts 60. Contact spring 54 is effectively pre-tensioned by disposing the supported portion 57 at an angle to the plane of stationary contact assembly 52. The angle at which the supported portion is disposed relative to the plane of stationary contact assembly 52 will naturally depend on the required closing pressure for the contact as well as the distance that the supported portions are spaced from the plane of stationary contact assembly 52. It has been found, however, that under ordinary circumstances almost all desired closing pressures can be obtained by disposing the supported portion 57 of contact spring 54 at an angle ("A", FIG. 1) of between 2° and 15° to the plane of stationary contact assembly 52, when the supported portions 57 of contact springs 54 are between $\frac{1}{16}$ " and $\frac{3}{8}$ " from the supported portions 61 of stationary contact arms 58.

The contact stack 3 is attached to frame leg 5 adjacent armature 2 by threaded fasteners 68 which extend completely through aligned bores 69 in contact stack 3 and are screwed into threaded bores 70 in annular projections 47 of frame leg 5. Nonmagnetic plate 39 is interposed between the contact stack and surface 35 of frame leg 5. When the threaded fasteners 68 are tightened, the contact stack 3 is firmly pressed against nonmagnetic member 39 to secure the nonmagnetic member to frame leg 5 in its desired position. Since the nonmagnetic member 39 is very thin and flexible, the contact stack 3 is mounted closely adjacent the armature pivot to leave only a very short exposed portion 71 of nonmagnetic member 39 exposed between armature 2 and contact stack 3. As best seen in FIG. 6, exposed portion 71 of nonmagnetic member 39 from the edge of the contact stack 3 to the face of armature 2 is less than the thickness of armature body 27. It can also be seen from FIG. 6 that the exposed portion of nonmagnetic member 39 from end 44 of tab 43 to the edge of the contact stack is less than twice the thickness of armature body 27. Since only a very short exposed portion 71 of nonmagnetic member 39 extends from the edge of contact stack 3 to surface 45 of armature body 27, this exposed portion is relatively rigid and, even though the nonmagnetic member is resilient and of thin material, exerts sufficient spring force to maintain tabs 43 in contact with edge 34 of armature body 27. It will be apparent that when the armature is so retained it is free to pivot, but is securely held to its pivot by tabs 43, tab ends 44, and tongue 40 of nonmagnetic member 39.

As best seen in FIGS. 5 and 6, insulating mounting members 53, 62 and 63 each have a pair of mounting surfaces 72, 73 and 74, respectively, on opposite sides of the mounting members which surfaces are generally parallel to surface 35 of frame leg 5. Extending completely through each mounting member 53, 62 and 63 are bores 69 in which threaded fasteners 68 are inserted. To facilitate aligning stationary contact assembly 52 with movable contact assemblies 50 and 51, mounting surfaces 72, 73 and 74 of mounting members 53, 62 and 63 are provided with interengaging aligning means. The aligning means on mounting member 62 for the stationary contacts are annular projections 75 concentric with bores 69, annular projections 75 protruding beyond each mounting surface 73 of insulating mounting member 62. The mounting surfaces 72 and 74 of insulating mounting members 53 and 63 which engage with the surfaces 73 of mounting member 62 each have annular recesses 76 like counterbores, co-axial with each bore 69. When mounting members 53, 62 and 63 are placed in superimposed relation, annular projections 75 engage in recesses 76 to align the movable and stationary contacts in predeter-

mined relation. Surfaces 72 and 74 of insulating mounting members 53 and 63 remote from stationary contact assembly 52 each have a pair of annular recesses 77 which are essentially identical to recesses 76 and are co-axial with bores 69. The recesses 77 in mounting member 53 of first movable contact assembly 50 are engaged by annular projections 47 on frame leg 5 to position contact stack 3 in predetermined aligned relation relative to frame 1 and corresponding to armature 2.

A T-shaped armature return spring 78 has an elongate spring portion 79 corresponding to the stem of the T and a straight head portion 80 corresponding to the bar of the T which is mounted on surface 74 of insulating mounting member 63. Straight head portion 80 has a pair of circular openings 81 and protruding projections 82 co-axial with openings 81, the projections extending toward frame leg 5. Projections 82 engage with recesses 77 in insulating mounting member 63 to align aperture 83 at the end of spring portion 79 with projection 84 of operating card 85.

Movable contacts 56 and 66 are operated by card 85 having an elongated tab 86 extending from an edge 87 of card 85 opposite projection 84. At each side of tab 86, edge 87 forms a pair of stop shoulders which limit the distance that tab 86 can be inserted in slots 88 of armature ends 31 to maintain edge 87 of tab 86 essentially parallel with surface 35 of frame leg 5. Card 85 extends generally at right angles to surface 35 of frame leg 5 and hence is parallel with the contact stack 3. Ends 89 and 90 of movable contact springs 54 and 64 remote from mounting members 53 and 63 extend through slots 91 and 92 in card 85. Slots 91 and 92 are slightly longer than tab 86 and have edges 93, 94 and 95, 96, respectively, which are generally parallel to each other and to surface 35 of frame leg 5. The portion of card 85 between edge 94 and edge 96 is generally rectangular. This rectangle or bar 98 is the portion of the card which functions to push movable contacts 56 and 66 into and out of engagement with stationary contacts 60.

When electromagnet 4 is energized, body 27 of armature 2 is moved into engagement with pole end 23 of core 12. Ends 31 of armature 2 move card 85 generally at right angles to leg 5 with edge 87 of card 85 in engagement with the surfaces of ends 31 adjacent slots 88 of armature 2. Edge 96 of slot 92 engages the surface of ends 90 of movable contact springs 64 to move movable contact 66 away from stationary contacts 60. Simultaneously, edge 93 of slot 91 is moved away from relay frame leg 5 to permit ends 89 of contact springs 53 to move toward stationary contacts 60, so that movable contacts 56 engage contacts 60. When the relay is de-energized, return spring 78 moves card 85 toward frame leg 5, thereby moving ends 31 of armature 2 against the surface of nonmagnetic member 39 while body 27 pivots away from pole end 23 of core 12. In the unenergized position, as best seen in FIGS. 1 and 4, edge 93 of card 85 engages ends 89 of movable contact springs 54 to hold movable contacts 56 spaced from stationary contacts 60. Movable contacts 66 on movable contact springs 64 engage with stationary contacts 60, the engaging pressures being due solely to the spring action of contact springs 64. When the relay is unenergized, ends 90 of contact springs 64 are spaced between edges 95 and 96 of slot 92. When the relay is energized, ends 89 of movable contact springs 54 are spaced between edges 93 and 94 of slot 91 and again the sole engaging pressure between movable contacts 56 and stationary contacts 60 is due to the spring bias of movable contact springs 54. As previously explained in detail, the closing pressure of the springs is due solely to mounting the supported portions 57 of movable contact springs 54 and the supported portions 67 of movable contact springs 64 at an angle to stationary contact assembly 52. As shown in FIG. 1, this angle "A" is measured between supported portions 57 or 67 and stationary contact arms 58. Movable contact springs 54

and 64, although substantially straight in their relaxed condition, as best seen in FIG. 8, become bowed, as seen in FIG. 1, when the contact stack is assembled. As best seen in FIG. 1, in their bowed position indicated generally as 97, the movable contact springs 54 and 64 each have smooth, even curvatures and are not bent or kinked along their lengths. Since the terminals 55 and 59 do not flex or bend during operation of the relay, they can be bent in desired configuration without affecting the endurance of the movable portion of the spring.

When electromagnet 4 is energized, a magnetic flux is set up in the magnetic circuit of the relay comprising the magnetic core 12, magnetic frame 1 and magnetic body 27 of armature 2, the only break in the magnetic circuit being the air gap between armature body 27 and pole end 23 of core 12. Surfaces 38 of notches 33 are in intimate contact with surfaces 35 of projections 8 of frame leg 5, and body 27 adjacent edge 34 of armature 2 is in engagement with the edge of U-shaped slot 9 to complete the magnetic circuit at the armature pivot. Since the magnetic circuit is complete save for the armature air gap, the full energy of the magnetic field produced by electromagnet 4 will be utilized to attract the armature body 27 when the relay is energized.

When the armature is unenergized, ends 90 of movable contact springs 64 are spaced between edges 95 and 96 of card 85, and contacts 66 engage stationary contacts 60 (FIGS. 1 and 4). Also, edge 93 engages end 89 of contact springs 54, thereby spacing movable contacts 56 from stationary contacts 60. Hence, the card 85, with slots 91 and 92, provides suitable means for spacing at least one set of movable contacts from stationary contacts 60. Since ends 90 of movable contact springs 64 are spaced from edge 96 of card 85, the additional force due to movable contact springs 64 does not begin to act until after the armature body 27 has moved slightly toward core 12. In fact, movable contact springs 54 which (when the relay is unenergized) engage edge 93 of card 85 create a force in opposition to the force of armature return spring 78, the assisting force due to springs 54 being greatest when armature body 27 is farthest from core 12. Since the magnetic attraction between two members varies inversely as the square of the distance between the members, it will readily be appreciated that the slight freedom of movement of armature body 27 prior to the action of the retarding forces due to contact springs 64 is indeed an asset to reduce to a minimum the flux and hence the current required to pivot the armature. On the other hand, when the armature is energized and armature body 27 is in engagement with core 12, the forces due to movable contact springs 64 assist in returning the armature to its original unenergized position. This feature tends to prevent sticking of armature body 27 to the pole end 23 of core 12. Again, the forces due to contact springs 54 which would retard the armature from returning to its unenergized position do not come into play until after armature body 27 is out of contact with pole end 23 of core 12, at which time ends 89 engage with edge 93 of card 85.

Nonmagnetic member 39 extends the length of relay frame leg 5 and functions as a magnetic insulator to prevent ends 31 of armature 2 from sticking to surface 35 of frame leg 5 when the relay is energized. As previously described, nonmagnetic member 39 also functions to retain armature 2 on its pivot, the nonmagnetic member 39 being integral and extending from armature body 27 at one end of frame leg 5 to a point beyond ends 31 of armature 2 at the other end of frame leg 5.

To assemble the relay, core members 20 are aligned in superimposed relation and are inserted in rectangular opening 16 of bobbin 14 with abutment surfaces 24 in engagement with end 17 of bobbin 14 between bars 19. Rectangular pole ends 23 extend transversely of the armature to provide a rectangular pole face approximately twice as long as it is wide, with the long dimension gen-

erally parallel with edge 34 of armature body 27. The projections 25 are aligned with and inserted in rectangular opening 11 in heel piece 6 whereupon the projections are staked or otherwise fastened by mechanical means to heel piece 6. Since the longitudinal length of projections 25 is less than the thickness of the frame, the end portions of projections 25 do not protrude beyond the surface of heel piece 6. By this arrangement, it is unnecessary to finish the surface of the frame to provide a smooth mounting surface. Preferably, however, a cement is applied to the slightly recessed ends of the core after assembly to provide a flush smooth surface.

Armature 2 is then positioned on the frame with projections 8 in notches 33 and the portion of body 27 adjacent edge 34 in engagement with the edge of slot 9. Nonmagnetic member 39 is then placed on surface 35 of frame leg 5 with lug 36 of armature 2 projecting through rectangular opening 41 of tongue 40. Tabs 43 are engagement with top edge 34 of armature 2, whereas the end portions of tabs 43 are in contact with surface 45 of armature body 27. Contact stack 3 is assembled by superimposing stationary contact assembly 52 on movable contact assembly 50 and movable contact assembly 51 on stationary contact assembly 52 with projections 75 and recesses 76 in interfitting engagement. The contact stack 3 is mounted on frame 5 with annular projections 47 in engagement with recesses 76 of movable contact assembly 50. Armature return spring 78 is placed on surface 74 of mounting member 63 with projections 82 engaging in recesses 77. Threaded fasteners 68 are inserted in bores 69 and screwed into bores 70 of frame leg 5. Before threaded fasteners 68 are tightened, nonmagnetic member 39 is moved longitudinally of the frame to insure that ends 44 of tabs 43 contact surface 45 of armature body 27 to securely hold the armature to its pivot. Threaded fasteners 68 are then tightened to fixedly secure contact stack 3, armature 2 and nonmagnetic member 39 to the frame. Card 85 is then positioned with ends 89 and 90 of contact springs 54 and 64 in slots 91 and 92 and edge 87 in contact with ends 31 of armature 2, the tab 86 extending into slots 88 of armature ends 31. If it is desired to very closely control the pull-in characteristics of the relay, the assembled relay can be placed in an appropriate adjusting fixture (not shown) to precisely adjust the contacts and armature of the relay. In some instances, it may be necessary to bend the ends 31 or arms 28 of armature 2 to obtain the necessary air gap between armature body 27 and core 12.

It is to be understood that, while a preferred embodiment of this invention has been shown for illustrative purposes, many variations can be made which are within the scope of the invention. For example, in the preferred embodiment, the movable contact springs 54 and 64 are molded in insulating mounting members 53 and 63, but of course could be attached to mounting members 53 and 63 by other means, such as cementing or by disposing the springs between mating insulating mounting member surfaces which are properly angled.

While, for illustrative purposes, the invention has been shown by preferred embodiment thereof oriented in a particular position, it will be understood that the relay could be disposed in any operating position and that the novel features of the invention find more general application.

What is claimed is:

1. In an electromagnetic relay, the combination comprising
 - a magnetic frame,
 - a magnetic armature carried by said frame,
 - a contact stack including a stationary contact assembly and movable contact assemblies carried by said frame,
 - said stationary contact assembly comprising
 - an elongated stationary contact arm having a sup-

ported portion intermediate the ends of the arm,
 a stationary contact adjacent one end of said arm, said movable contact assemblies comprising
 a pair of movable contact springs each having a supported portion intermediate the ends of the springs,
 a pair of insulating mounting members each having at least one mounting surface,
 said supported portions of said movable contact springs being carried by said insulating mounting members, each of said movable contact springs having a movable contact on a portion of the spring remote from the mounting member,
 said movable contact springs each being substantially straight along its length from said movable contact to and including said portion supported by said mounting member;
 said mounting members being disposed in superposed relation with said elongated contact arm for said stationary contact disposed between the said pair of movable contact springs, the stationary and movable contacts being in alignment,
 said portions of each of said movable contact springs supported by said mounting members each being disposed at an angle to incline said movable contact toward the plane of said stationary contact arm to normally bias said movable contact into engagement with said stationary contact, and
 contact operating means in engagement with at least one of said springs to space one of said movable contacts from said stationary contact, said means being associated with said armature to operate said movable contacts when said relay is energized.

2. An electromagnetic relay in accordance with claim 1 in which
 the contact operating means are in engagement with said one of said movable contact springs only when the movable contact is spaced from the stationary contact, the closing pressure for said contacts being due only to the force resulting from the bias of said movable contact spring.

3. An electromagnetic relay in accordance with claim 1 in which
 the supported portion of said elongated arm for said stationary contact is embedded in an insulating mounting member having mounting surfaces on opposite sides of the member in contact with one mounting surface of each of said mounting members for said movable contact springs.

4. A relay in accordance with claim 1 in which the supported portion of said movable contact spring is disposed at an angle of between 2° and 15° to the plane of said stationary contact.

5. A contact stack for an electromagnetic relay having a frame, comprising
 a first movable contact assembly, a stationary contact assembly, and a second movable contact assembly carried by said frame in stacked superposed relation,
 said stationary contact assembly comprising
 a plurality of flat elongated stationary contact arms each having a stationary contact adjacent one end of the arm and a terminal adjacent the other end of the arm,
 an insulating mounting member supporting said stationary contact arms along a substantial length of each arm intermediate the stationary contact and the terminal,
 said first and second movable contact assemblies each comprising
 a plurality of flat elongated contact springs each having a movable contact adjacent one end and a terminal adjacent the other end,
 an insulating mounting member supporting said

contact springs along an intermediate length of said springs adjacent the terminal ends,
 each of said contact springs when relaxed being substantially straight along its length from the terminal to the movable contact end,
 said supported length of said stationary contact springs being substantially larger than the supported length of said movable contact springs,
 said insulating mounting member of said stationary contact assembly being disposed between said insulating mounting members of said first and second movable contact assemblies with said movable contacts in alignment with said stationary contacts,
 said supported lengths of said contact springs of said first and second movable contact assemblies being disposed at an acute angle to the plane of the stationary contact arm to normally bias said movable contacts into engagement with said stationary contacts, and
 spacing means in engagement with said contact springs of said first movable contact assembly to space said movable contacts from said stationary contacts, said spacing means being operatively interconnected with said armature to allow said movable contacts to engage said stationary contacts when said armature is operated by energizing said relay.

6. An electromagnetic relay comprising in combination
 a magnetic frame member including
 a heel portion and
 a flat leg projecting at right angles from said heel portion and having an armature supporting portion spaced from said heel portion, said armature supporting portion being provided with a pair of projections spaced apart transversely of said leg and extending longitudinally thereof;
 an electromagnet carried by said frame member and comprising
 a magnetic core having one end fixed to said heel portion, said core projecting beside said leg and having an exposed pole face located adjacent said armature supporting portion of said leg, and
 a coil surrounding said core;
 a magnetic armature comprising
 a flat main body portion,
 a pair of spaced, at least generally parallel arms projecting each from a different one of two opposite edges of said main body portion and integral therewith, and extending at least generally at right angles to the plane of said main body portion,
 means defining a pair of notches each opening outwardly from a different one of said opposite edges, said notches being aligned with each other across said main body portion and including bearing faces engageable with cooperating bearing faces formed on said pair of projections of said frame member leg said main body portion having a third edge extending between said opposite edges and said notches being located adjacent said third edge, said third edge being provided with an outwardly projecting lug,
 said armature being pivotally supported on said armature supporting portion of said leg with said transversely spaced projections of said leg engaged in said notches of said armature main body portion to provide an armature pivot, and said main body portion extending across said pole face of said core, said armature arms extending each beside a different one of the side edges of said leg toward said heel portion;
 means for retaining said armature on said armature supporting portion on said leg with at least a por-

- tion of said means for retaining said armature in contact with the surface of the leg opposite the surface which faces the electromagnet;
- a contact stack disposed on the side of said means for retaining said armature opposite the side of said means for retaining said armature which engages said leg, said contact stack including movable contact means;
- fastener means securing said contact stack to said frame, the contact stack thus secured being operative to fix said armature retaining means on said frame;
- said spaced, generally parallel arms of said armature terminating in a pair of integral inwardly facing ends each extending transversely across a portion of said main leg of the frame spaced from said armature supporting portion, and
- spacing means on said frame leg to space said inwardly facing ends of said armature from said leg; and
- means interconnecting said armature and said movable contacts to actuate said contacts when said electromagnet is energized to pivot the armature.
7. An electromagnetic relay in accordance with claim 6 in which
- said armature retaining means is a generally flat, thin, resilient nonmagnetic member comprising
- a tongue extending beyond said armature main body portion and having an opening into which the said outwardly projecting lug of the armature extends,
- a pair of generally parallel tabs, spaced one on each side of the tongue, engaging said third edge of said armature main body each on a different side of the said projecting lug, the end portions of said tabs extending generally at right angles to said nonmagnetic member to engage the side of said armature main body portion remote from said pole face of said core,
- said tabs and tongue cooperating to retain said armature pivotally supported on said armature supporting portion of said frame.
8. An electromagnetic relay in accordance with claim 6 in which
- said armature retaining means and said spacing means for said armature ends comprise a generally flat, thin, resilient member extending along said frame leg from said armature supporting portion of said leg to the portion of said leg adjacent the inwardly facing ends of said armature with at least the means for spacing said armature ends from said frame being nonmagnetic to magnetically insulate said inwardly facing ends from said frame.
9. An electromagnetic relay in accordance with claim 6 in which
- said armature retaining means and said spacing means for said armature ends comprise an integral, generally flat, thin, resilient, nonmagnetic member extending along said frame leg from said armature supporting portion of said leg to the portion of said leg adjacent the inwardly facing ends of said armature and is in contact therewith to retain said armature and to magnetically insulate said inwardly facing armature ends from said frame.
10. In a relay of the type described,
- a magnetic frame member including
- a heel portion, and
- a flat leg projecting from the heel portion;
- an armature pivotally mounted on said flat leg and comprising
- a main body portion,
- a pair of spaced, at least generally parallel integral arms projecting each from a different one of two opposite edges of said main body portion and extending generally parallel beside said

- flat leg, said arms terminating in a pair of integral inwardly facing ends each extending transversely across a portion of said leg and each having a transverse inwardly opening slot;
- a contact stack including fixed and movable contacts mounted on said frame leg and extending therealong;
- a generally rectangular member of insulating material having an edge portion disposed in and extending between said slots, said rectangular member extending generally above said leg and having apertures therein positioned to extend around said movable contacts of said stack; and
- an electromagnet secured to said frame and adjacent said main body portion of said armature to pivot same;
- said rectangular member being effective to operate said contacts in response to pivotal movement of said armature.
11. An electromagnetic relay comprising in combination:
- a magnetic frame member including
- a heel portion, and
- a flat leg portion projecting at an angle from said heel portion and having an armature-supporting portion;
- an electromagnet carried by said frame member and comprising
- a magnetic core fixed to said frame, said core having an exposed pole face, and
- a coil surrounding said core,
- a magnetic armature comprising
- a flat main body portion,
- a pair of spaced, at least generally parallel arms projecting integrally from said main body portion at an angle to the plane of said main body portion, and
- armature mounting means associated with said main body portion,
- said armature being pivotally supported on said armature-supporting portion of said frame by said armature mounting means of said main body with said main body portion extending across said pole face of said core,
- a thin, resilient, nonmagnetic member on said frame in contact with at least a portion of the surface of the frame opposite the surface which faces the electromagnet,
- said magnetic member comprising a tongue extending beyond said armature main body portion with a portion of said tongue extending over a part of said armature main body portion to retain said armature pivotally supported by said armature mounting means on said armature supporting position of said frame,
- a contact stack disposed on the side of said nonmagnetic member opposite the face of said nonmagnetic member which engages said leg, said contact stack including movable contact means;
- fastener means for securing said contact stack and said nonmagnetic member to said frame,
- said spaced, generally parallel arms of said armature terminating in a pair of integral inwardly facing ends each extending transversely across a portion of said main leg of the frame adjacent the heel portion of the frame,
- an integral portion of said nonmagnetic member extending longitudinally along said frame and between said frame leg and said inwardly facing ends to magnetically insulate said inwardly facing ends from said frame;
- said armature being operable to actuate said movable contacts when said electromagnet is energized to pivot the armature.
12. In a relay,

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a frame member including a flat leg of magnetic material;
 a contact stack mounted on one side of said leg and including sets of movable and stationary contacts;
 an electromagnet on the other side of said leg;
 an armature pivotally mounted on said leg;
 each set of said movable contacts being embedded in an insulating mounting block, and each set of said stationary contacts being embedded in an insulating mounting block;
 said mounting blocks having interengaging annular projections and depressions to align said contacts merely by stacking said mounting blocks;
 projections in the form of embossments on said side of said frame leg on which the contact stack is mounted to mount an assembly stack in alignment with said frame leg;
 elongated metal fasteners extending concentrically through said annular projections and depressions of said blocks and into said frame leg concentric with said embossments to align said contacts in predetermined relation relative to said armature and frame leg, and
 means integral with said mounting block for insulating each contact of each of said sets from said elongated metal fasteners.

13. A relay in accordance with claim 12 which further includes
 leaf spring means at the end of said stack remote from said frame leg,
 said spring means having mounting apertures therein and including concentric embossments to align said spring with said stack.

14. In an electromagnetic relay the combination comprising
 a magnetic frame member including
 a heel portion having a rectangular opening,
 a flat, generally rectangular leg portion projecting at an angle from said heel portion and having an armature supporting portion,
 an electromagnet including a coil assembly surrounding a magnetic core having one end fixed to said heel portion of said frame,
 said magnetic core projecting beside said leg of said frame, said core comprising:
 a rectangular body portion,
 a rectangular pole portion at one end of said body portion projecting transversely beyond the side edges of said body portion to provide abutment surfaces generally at right angles to said body portion,
 a rectangular projection extending longitudinally from the end of said body portion opposite said pole portion, said rectangular end projection having a width which is less than that of said body portion to define stop faces at the end of said body portion on each side of said projection,
 said core being disposed with its end projection fixed in said rectangular opening of said heel portion and the stop faces of said core in engagement with the surface of said heel portion adjacent said electromagnet,
 said rectangular end projection extending longitudinally from the body portion of said core having a length which is less than the thickness of the heel portion of said frame to provide a projection free smooth mounting surface on the face of said heel portion remote from said coil assembly,
 said coil assembly including a bobbin having a coil thereon with the ends of said bobbin retained between said heel portion of said frame and the abutment surfaces of said core, and
 an armature carried by the armature supporting portion of said leg with a main body portion of said

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armature extending across said pole portion of said core member.

15. A relay in accordance with claim 14 in which said magnetic core includes at least a pair of core members of identical outline configuration having plane surfaces thereof in contacting engagement.

16. In an electromagnetic relay the combination comprising
 a magnetic frame member including
 a heel portion having a rectangular opening,
 a flat, generally rectangular leg portion projecting at an angle from said heel portion and having an armature supporting portion,
 an electromagnet including a coil assembly surrounding a magnetic core having one end fixed to said heel portion of said frame,
 said magnetic core including at least a pair of core members having an identical configuration and being of similar uniform thickness projecting beside said leg of said frame, each of said core members comprising
 a rectangular body portion,
 a rectangular pole portion at one end of said body portion projecting transversely beyond the side edges of said body portion to provide a pair of abutment surfaces generally at right angles to said body portion,
 a rectangular projection extending longitudinally from the end of said body portion opposite said pole portion, said rectangular end projection having a width which is less than that of said body portion to define stop faces at the end of said body portion on each side of said projection,
 said core members being disposed one adjacent the other in aligned relation with the end projections fixed in said rectangular opening of said heel portion and the stop faces of said core members in engagement with the surface of said heel portion adjacent said electromagnet,
 said coil assembly including a bobbin having a coil thereon with the ends of said bobbin retained between said heel portion of said frame and the abutment surfaces of said core members, said bobbin having a rectangular opening extending the length thereof, the walls defining said opening being in embracing engagement with said body portions of said core members,
 said core members being retained in fixed aligned relation, one to the other, solely by said end projections fixed to said frame and said rectangular opening of said bobbin, and
 an armature carried by the armature supporting portion of said leg with a main body portion of said armature extending across said pole portion of said core members.

17. In an electromagnetic relay the combination comprising
 a magnetic frame member including
 a heel portion having a rectangular opening,
 a flat, generally rectangular leg portion projecting at an angle from said heel portion and having an armature supporting portion,
 an electromagnet including a coil assembly surrounding a magnetic core having one end fixed to said heel portion of said frame,
 said magnetic core including at least a pair of core members having an identical configuration and being of similar uniform thickness projecting beside said leg of said frame, each of said core members comprising
 a rectangular body portion,
 a rectangular pole portion at one end of said body portion projecting transversely beyond the side edges of said body portion to provide a pair of

abutment surfaces generally at right angles to said body portion,

- a rectangular projection extending longitudinally from the end of said body portion opposite said pole portion, said rectangular end projection having a width which is less than that of said body portion to define a pair of stop faces at the end of said body portion on each side of said projection,
- said core members being disposed one adjacent the other in aligned relation with the end projections fixed in said rectangular opening of said heel portion and the stop faces of said core members in engagement with the surface of said heel portion adjacent said electromagnet,
- said coil assembly including a bobbin having a coil thereon with the ends of said bobbin retained between said heel portion of said frame and the abutment surfaces of said core members,
- said bobbin comprising
- a hollow, thin-walled, rectangular body member of molded plastic material having a rectangular opening therethrough, and
- substantially flat ends extending generally radially outwardly from each end of said rectangular body member,
- said heel portion of said frame having a plurality of fastener receiving openings extending therethrough,
- a one of said substantially flat ends of said bobbin adjacent said heel portion having recesses extending partially through said flat end,
- said recesses being aligned with said fastener receiving openings of said heel portion to accommodate the

end portions of any fasteners which may project through said heel portion when said relay is mounted, and

an armature carried by the armature supporting portion of said leg with a main body portion of said armature extending across said pole portion of said core members.

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