

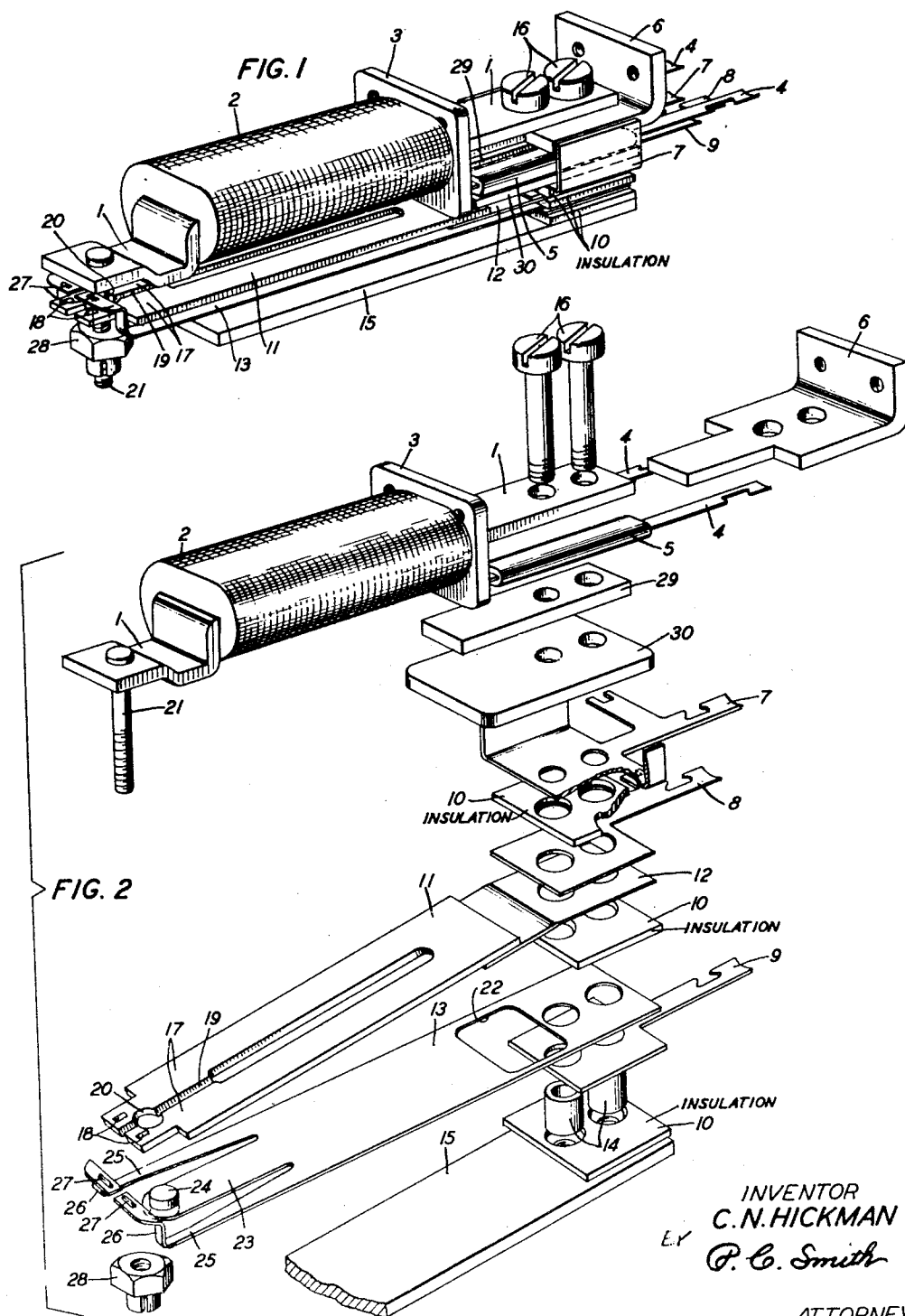
**April 4, 1950**

**C. N. HICKMAN**  
**ELECTROMAGNETIC RELAY**

**2,502,842**

Filed March 6, 1947

2 Sheets-Sheet 1



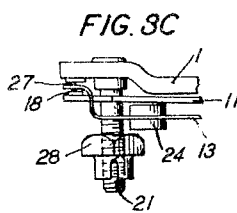
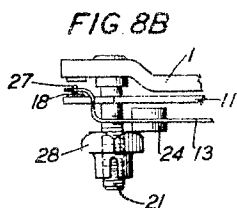
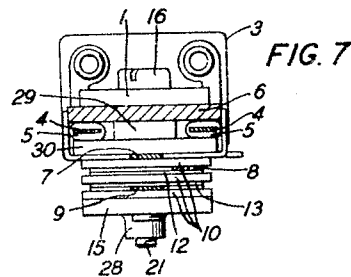
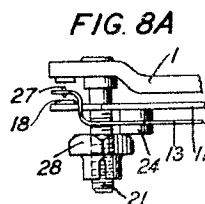
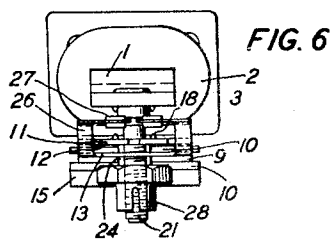
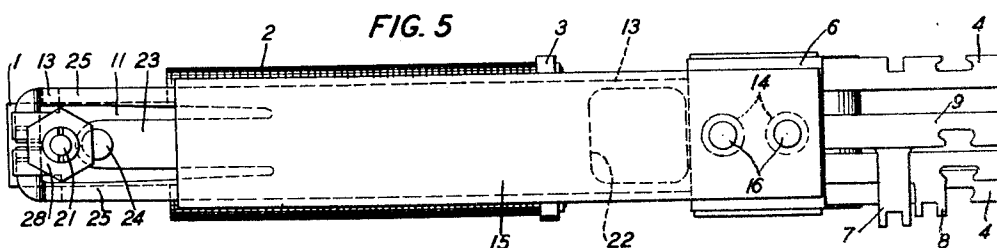
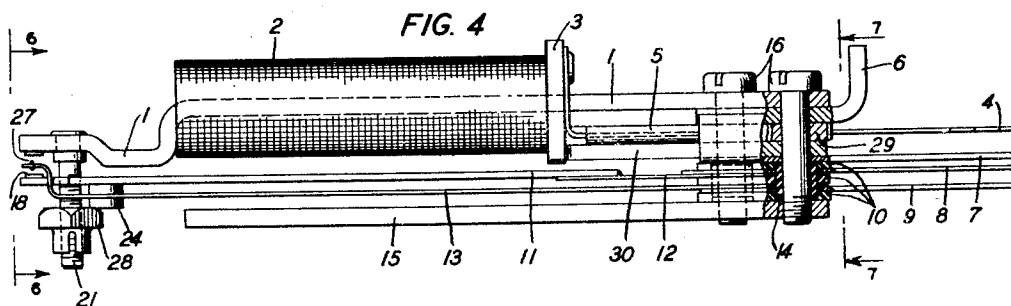
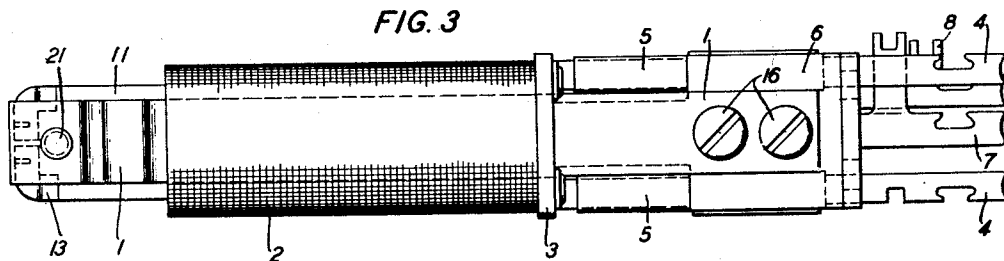
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

2,502,842

## ELECTROMAGNETIC RELAY

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10 Claims. (Cl. 200—37)

<sup>1</sup> This invention relates generally to electromagnetic relays and in particular to improvement of and concerning those electromagnetic relays in which the armature and core are used as electrical paths as well as elements of the magnetic circuits of the relay structure.

Relays used as line relays in telephone systems of the cross-bar type are customarily mounted in groups of ten or twenty, each relay adapted when operated to connect the grounded terminal of the central office battery with each of two circuits, one a circuit individual to the line with which the relay is associated and the other a circuit common to ten lines. This facility has been provided previously by two general types of relay construction. One type of relay has been provided with two pairs of contact springs, one spring of each pair being connected to ground while the other springs of the pairs are connected respectively to the line circuit and to the common circuit mentioned above. This type of relay necessitates thirty soldered connections for multiplying relays in the group of ten mounted together. Another type has been provided with a divided core and an armature cooperating therewith, both the armature and each of the core divisions, which are insulated from each other and from the armature, comprising electrical paths as well as elements of the magnetic circuit. The latter type of construction, as disclosed in Patent 2,312,902 to C. N. Hickman and E. Lakatos of March 2, 1943, simplified the wiring necessary for such relays as well as the assembling and installation of such relay groups.

The constant vigilance for ways and means of reducing space requirements of such relays and for improving the performance characteristics thereof has led to the type of relay embodying the present invention. The invention affords reduction as to space requirement by means of a rearrangement and addition of parts in a novel combination which in turn affords improved operating characteristics for such relays.

In accordance with the present invention as embodied in a relay, a single core leg is provided having an energizing winding thereon; an armature is provided for magnetic cooperation with said core in a similar manner as that disclosed in the above referenced patent to Hickman and Lakatos in that the core and armature are electrical paths as well as magnetic paths; a non-magnetic contact spring is provided for cooperating mechanically and electrically with the core and armature and for providing a third electrical path; the armature and spring are mechanically

<sup>2</sup> cooperable such that when the core winding is energized the initial movement of the armature is unloaded, then picks up mechanically by electrical contact therewith the non-magnetic spring and carries both to mechanical and electrical contact with the core and such that when the core winding is deenergized both armature and spring release together until the spring engages a back stop whereupon the armature continues its travel to normal biased position breaking electrical contact with said spring, the normal position of said armature being such as to engage mechanically without electrical contact therewith the said spring to bias same to its respective normal position; the armature is hinged to its support in the rear of the relay by means of a substantially coplanar cantilever leaf spring hinge arrangement such that the armature may be pretensioned over a long distance; the non-magnetic spring is a neutral spring representing substantially no load to the armature by virtue of being thin and very flexible or by virtue of having a window cut therefrom adjacent its support on the rear of the relay to reduce considerably its resistance to deformation in this area; the foregoing core, armature and non-magnetic spring, in addition to various other well-known parts of relays such as those parts which comprise a spring pile-up clamping assembly of insulators, bushings and screws, etc., are all assembled easily into a compact relay of less width and less height than such a relay as disclosed in the Hickman-Lakatos relay, patent above.

A line relay comprising substantially the above features and particularly the combination of a magnetic armature pretensioned through a long distance and a non-magnetic contact spring of neutral pile-up force characteristics mechanically interacting therewith in accordance with the invention will exhibit a more positive and more easily controlled action as regards the ability of the armature to snap through from non-operated to operated condition. The latter ability to "snap through," as is used to describe the pull curve ability of the relay to overcome the load curve of same at a definite point on both curves, is enhanced by the invention in that the load curve crosses the pull curve at a large angle by reason of its small slope, the subsequent discussion of the exemplary disclosure showing how the novel combination and arrangement of preceding described elements effects this advantage.

The following description of a preferred embodiment of the invention is set forth in connection with the drawings which form a part

thereof and of which the following are general descriptions of the various figures:

Fig. 1 is a perspective view of a relay constructed and assembled in accordance with the invention;

Fig. 2 is an exploded perspective of the relay of Fig. 1 showing the configuration of various parts of the relay and the manner in which same are assembled to form a completely assembled relay;

Figs. 3, 4 and 5 are respectively top view, side elevation partly in section and bottom view of the relay of Fig. 1;

Figs. 6 and 7 are respectively front and rear elevation views of the relay of Fig. 4 taken along lines 6—6 and 7—7 of Fig. 4; and,

Figs. 8A, 8B and 8C are views of the contact end of the relay of Fig. 4 showing three positions or steps in the operation and release of the relay.

The relay shown by various views in Figs. 1 through 7 and particularly as shown in Fig. 2 comprises a core 1 upon which is mounted a winding assembly consisting of winding 2, spoolhead 3 and winding lead terminals 4 encased in protective sleeves of plastic or similar material 5 and attached to spoolhead 3. Mounting bracket 6, spacers 29 and 30, terminals 7 through 9, insulator strips 10, armature 11 with its reed type cantilever spring hinge 12, contact spring 13, insulator bushings 14 and guard plate 15 are assembled as shown and clamped in a rigid assembly by means of machine screws 16 which are adapted to engage threaded holes in guard plate 15. The small holes through which screws 16 are adapted to pass are arranged to provide a snug but non-clamping fit for screws 16. The insulator bushings 14 are adapted to line the inner surfaces of all of the larger clearance holes shown and are also adapted to accommodate screws 16 in a snug but non-clamping fit, the bushings of course being axially confined between the guard plate 15 and the terminal 7.

The armature 11 is spot welded or otherwise suitably attached to its spring hinge 12 and said hinge 12 is provided with a preset deformation as shown in Fig. 2 to provide the armature-hinge assembly with spring bias downward as viewed in Figs. 1, and 4. The armature 11 is bifurcated to provide two essentially mechanically independent contact carrying bifurcations 17, each of which has welded thereon a contact 18. The bifurcating slot 19 is enlarged near the free end of the armature 11 to provide a clearance hole 20 through which the backstop stud 21 is assembled in the completed relay, as shown in Figs. 1 and 4.

The contact spring 13 is provided with a cut-out portion near its support to form a window 22, the purpose of which is to render the spring 13 in effect neutral in that spring 13 will represent substantially no load to the armature when moved thereby. The free end of spring 13, as shown most clearly in Fig. 2, is longitudinally slotted to provide a central portion 23 lying in the plane of the main body of spring 13 and carrying an insulator stud 24 staked thereto, as more clearly shown by such as Fig. 4, and two outer longitudinal portions 25, each of which is bent vertically for a short distance and then horizontally again in the forward direction. The vertical portions 26 of the upturned ends of the spring 13 are separated longitudinally of spring 13 from stud 24 such that the backstop stud 21 may pass freely therebetween as shown in such as Fig. 4. In addition the upturned nature of the free end of spring 13 permits the free end of

armature 11 to pass beneath the ends of spring 13 carrying contacts 27 and above the insulator stud 24 as shown in Fig. 4. The adjusting nut 28 is provided for backstop stud 21 to adjust the normal position of spring 13 as biased by armature 11 acting against stud 24 of spring 13, the stud 24 in turn engaging the backstop nut 28, which is threaded on the stud 21.

The types of materials which may be used for various parts of the above relay are discussed briefly at this point. Spoolhead 3 and insulator strips 10 may be made of such material as phenol fibre which provides properties of mechanical strength and electrical insulation. The terminals such as 4, 7, 8 and 9, the armature reed hinge 12 and the contact spring 13 may be made of such material as nickel-silver to provide in the case of the terminals a good electrical conductor, in the case of the reed hinge a resilient material and in the case of the contact spring a good electrical conductor of non-magnetic material. The bushings 14 and the insulator stud 24 may be of such material as hard rubber to provide a material of good mechanical strength and good electrical insulation properties. The guard plate 15 may be of cold rolled steel or similar material to provide a protective barrier for the relay from stray magnetic fields due perhaps to other structures which may be assembled near thereto, such as other relays of the character disclosed. The core 1, bracket 6 and spacers 29 and 30 may be of a material such as magnetic iron to provide an electrical path as well as a good magnetic path. The backstop stud 21 is preferably of brass or like material to prevent its interfering or interacting magnetically with the armature 11. The armature is preferably of silicon steel to embody good magnetic properties as well as electrical conductivity but may be made of other similar material. The sleeves 5 surrounding the winding lead terminals 4 may be made of plastic or other suitable insulating material. The above preferred types of materials of which the various specified parts of the relay may be made are not intended as limiting the invention to the use of the indicated materials for it is obvious that others can be used provided the indicated properties of such materials are present as will be appreciated by those skilled in similar uses of such component parts of similar relays.

The various electrical circuits available in the assembled relay are as follows: Terminals 4 are to be understood to be electrically connected to no part of the relay assembly other than the winding 2 which is, of course, insulated from core 1. Terminal 7 is electrically connected to core 1 by means of spacers 29 and 30 and bracket 6 and machine screws 16, and to guard plate 15 by means of screws 16. Terminal 8 is electrically connected to armature 11 by means of reed hinge 12 and these three are insulated from other parts of the assembly by means of bushings 14 and insulator plates 10. Likewise terminal 9 is electrically connected to contact spring 13 and both are insulated from the rest of the assembly by insulator plates 10.

Figs. 8A, 8B and 8C represent three positions assumed by the free ends of armature 11 and contact spring 13 upon energization of winding 2. Fig. 8A represents the normal position similar to that of Fig. 4. Fig. 8B represents the instant armature 11 has made electrical and mechanical contact with contact spring 13, thus indicating an amount of initial unloaded travel prior to engagement with spring 13. Fig. 8C represents the

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final position where armature 11 has carried spring 13 into mechanical as well as electrical contact with the core 1. Upon deenergization of winding 2 the armature 11 and spring 13 release together from contact with core 1 and at an instant during release appear similarly to Fig. 8B until the insulator stud 24 engages backstop nut 28. At this instant the armature 11 will break contact with spring 13 and continue releasing until it engages stud 24 to once again rest in normal position and thereby bias spring 13 to its normal position.

The window 22 cut-out of spring 13 near the supporting pile-up permits spring 13 to be deflected without building up any appreciable pile-up force and consequently presents no appreciable load to armature 11. The same or a comparable effect would result if spring 13 were made rather thin and not provided with the window. It is preferred to use the window arrangement or other reduction of cross-section area, however, since a thin spring generally represents poor mechanical strength. The means of supporting the armature 11, namely reed hinge 12, permits the armature to be pretensioned through a long distance resulting in a small rate of build up of pile-up force for such a structure. Both of these previous provisions coupled with the initial unloaded movement of the armature represents a load curve of small slope which will cross the pull curve of the magnetic structure at a large angle representing an unequivocal operating point of the relay which in turn will insure the "snapping-through" of the armature at a low value of pull by the magnetic circuit and at a predictable and reliable value of pull. The force applied by the armature to the contact spring in both normal and operated positions represents positive operation and prevents locking contacts by virtue of the impact available on release in case the spring contacts should stick to the core face or in case the armature contacts should stick to the spring contacts.

The terminal 7 will generally be connected to the grounded terminal of the central office battery and terminals 8 and 9 will be connected to the circuit common to the group of relays and to the circuit peculiar to the particular relay as previously outlined. As will be noticed from Figs. 3 and 5 in particular, all of the terminals of the relay are provided with different configurations at their wiring ends to facilitate the attachment thereto of suitable control wiring and circuit leads.

Numerous modifications and rearrangements of the structure employed for an exemplary disclosure of the invention will be suggested to those skilled in the art and since the scope of the invention is not intended to be limited to the specific disclosure suitable claims are appended which alone define the scope of the invention.

What is claimed is:

1. An electromagnetic relay comprising a core carrying an energizing winding and at least one electrical contact, a cantilever spring mounted armature normally biased to unactuated position and adapted to cooperate magnetically with said core under control of said winding, said armature carrying at least one electrical contact adapted to be connected electrically with said contact on said core when said armature is actuated, a contact spring controlled by said armature and carrying at least one electrical contact adapted to be connected electrically with each of the said contacts on said armature and said

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core when said armature is actuated, and means interacting between said core, said armature and said spring for enabling electrical disconnection of all of said electrical contacts in the unactuated position of said armature and for enabling electrical interconnection of all of said contacts in the actuated position of said armature, each of the said core, spring and armature being capable of carrying electrical current and being connectable when said armature is in unactuated position, to insulatedly separate electrical circuits.

2. An electromagnetic relay comprising a magnetic core, a magnetic armature, a non-magnetic contact spring, and a clamping arrangement for supporting said core having an energizing winding thereon and for supporting said contact spring having a reduced cross section adjacent the said support and for supporting said armature located between said core and said spring and hinged to said support by means of a cantilever hinge substantially coplanar with said armature, the said core, spring and armature being insulated from each other by said clamping arrangement and all adapted to conduct electric current, the free ends of said core, spring and armature being normally separated from each other and each carrying contacts adapted to make electrical contact with contacts of each of the others when said armature is actuated, the contacting end of said spring being positioned between the contacting ends of said core and said armature and mechanical means interacting between the contacting ends of said armature and said spring whereby the armature unequivocally determines the operated and non-operated positions of said spring.

3. An electromagnetic relay comprising in superimposed insulatedly supported relation in substantially parallel planes and superimposed in the order mentioned a core carrying an energizing winding and adapted to carry electric current, an armature adapted to carry electric current and supported by a resilient cantilever reed hinge substantially coplanar with said armature and a non-magnetic contact spring adapted to carry electric current and provided with a reduced cross section adjacent its support consisting of an opening in said spring between its longitudinal edges, the free ends of said core, spring and armature provided with contacts and normally separated from each other, said free ends being superimposed in space relation and in the latter order mentioned whereby upon actuation of said armature due to energization of the said winding the free end of said armature may engage mechanically with electrical contact closure the free end of said spring and may when fully actuated effect mechanical as well as electrical contact between the free ends of said core, said spring and said armature.

4. An electromagnetic relay structure comprising a core, an energizing winding on said core, a contact secured to the forward end of said core, an armature attractable toward the forward end of said core and having a contact secured thereto, a reed hinge secured to the rear end of said armature, a contact spring having a contact portion at its forward end interposed between the pole face of said core and the pole face of said armature, a back stop stud secured to the forward end of said core and having an adjustable back stop nut thereon against which said armature reed hinge normally biases said contact spring, and means for insulatedly clamp-

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ing the rear ends of said core and contact spring and the reed hinge of said armature together, said winding when energized being effective to first cause said armature to engage the contact end of said spring and to then move said spring into electrical engagement with said core contact.

5. An electromagnetic relay structure comprising a core, an energizing winding on said core, contacts secured to the forward end of said core, a bifurcated armature attractable toward the forward end of said core and having contacts secured to said bifurcations, a reed hinge secured to the rear end of said armature, a contact spring having its forward end longitudinally slotted to provide two contacting fingers, the said fingers carrying contacts and being interposed between the pole face of said core and the pole face of said armature, a back stop stud secured to the forward end of said core and having an adjustable back stop nut thereon against which said armature reed hinge normally biases said contact spring, and means for insulatedly clamping the rear ends of said core and contact spring and the reed hinge of said armature together, said winding when energized being effective to first cause said armature to engage the contact end of said spring and to then move the contacting fingers of said spring into electrical engagement with said core contacts.

6. An electromagnetic relay structure comprising a core, an energizing winding on said core, a contact secured to the forward end of said core, an armature attractable toward the forward end of said core and having a contact secured thereto, a reed hinge secured to the rear end of said armature and adapted to bias said armature away from said core, a contact spring having a contact portion at its forward end interposed between the pole face of said core and the pole face of said armature, a back stop stud secured to the forward end of said core and having an adjustable back stop nut thereon against which normally rests an insulator stud secured to the forward end of said contact spring, the said armature normally biasing said contact spring by engaging said insulator stud under the action of said reed hinge, and means for insulatedly clamping the rear ends of said core and contact spring and the reed hinge of said armature together, said winding when energized being effective to first cause said armature to engage the contact end of said spring and to then move said spring into electrical engagement with said core contact.

7. An electromagnetic relay structure comprising a core, an energizing winding on said core, contacts secured to the forward end of said core, a bifurcated armature attractable toward the forward end of said core and having contacts secured to said bifurcations, a reed hinge secured to the rear end of said armature, and adapted to bias said armature away from said core, a contact spring having its forward end longitudinally slotted to provide three fingers, one of said fingers having secured to the end thereof an insulator stud and the other two of said fingers carrying contacts and being interposed between the pole face of said core and the pole face of said armature, a back stop stud secured to the forward end of said core and having an adjustable back stop nut thereon against which normally rests said insulator stud secured to said contact spring, the said armature normally biasing said contact spring by engaging said insulator

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stud under the action of said reed hinge, and means for insulatedly clamping the rear ends of said core and contact spring and the reed hinge of said armature together, said winding when energized being effective to first cause said armature to engage the contact end of said spring and to then move the contact fingers of said spring into electrical engagement with said core contacts.

8. An electromagnetic relay structure comprising a core carrying an energizing winding between the ends of said core, one end carrying electrical contacts and the other end adapted to be supported, an armature provided at one end with electrical contacts adapted to cooperate with the contacts on said core and provided at the other end with a substantially coplanar cantilever reed hinge for supporting purposes, a contact spring adapted at one end to be supported and provided at the other end with a bent configuration resulting in a short length of the spring on the end thereof carrying contacts adapted to cooperate with the contacts on said core and said armature, the said short length lying in a plane substantially parallel to the main portion of said spring and connected thereto by a short section of said spring in a plane substantially perpendicular to the planes of the short length and the main body of said spring, the core, armature and spring being insulatedly supported by a clamping arrangement such that the said core, armature and spring are in substantially parallel planes and in superimposed mutually insulated relation wherein the armature is positioned between the said core and said spring, the free end of said armature being laterally confined by an opening in the short perpendicular portion of the free end of said spring such that the contact carrying free ends of said core, said spring and said armature are in substantially parallel planes and in a superimposed space relation wherein the spring is positioned between the said core and said armature.

9. An electromagnetic relay comprising securing means, an electrically conducting core having an energizing winding thereon, an electrically conducting armature magnetically attractable by said core when said core is energized by said winding, an electrically conducting contact spring movable under control of said armature, said core, armature and spring secured by said securing means substantially at one free end of each in mutually insulated superimposed relation in the order named, the other free ends of said core, armature and spring having thereon at least one electrical contact each and arranged in space relation such that the contact end of said spring is located between the contact ends of said core and said armature, said spring positively disconnected electrically from both when said armature is unoperated and positively connected electrically to both when said armature is operated.

10. An electromagnetic relay comprising securing means, an electrically conducting core having an energizing winding thereon, an electrically conducting armature magnetically attractable by said core when said core is energized by said winding, an electrically conducting contact spring movable under control of said armature, said core, armature and spring secured by said securing means substantially at one free end of each in mutually insulated superimposed relation in the order named, the other free ends of said core, armature and spring having thereon at least one electrical contact each and arranged in superimposed space relation such that the contact end

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of said spring is located between the contact ends of said core and said armature under all circumstances, and mechanical means interacting between said core, armature and spring to permit said armature when operated to positively interconnect said core, armature and spring electrically and to permit said armature when released to positively disconnect said core, armature and spring electrically.

CLARENCE N. HICKMAN.

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