Nov. 7, 1939. P. W. SWENSON 2,178,656

ELECTROMAGNETIC SWITCHING DEVICE

Original Filed Dec. 11, 1935 2 Sheets-Sheet 1

FIG. 1

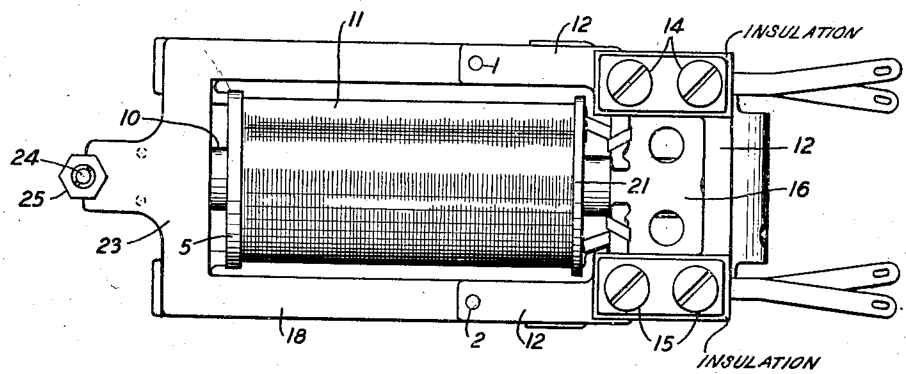

FIG. 2

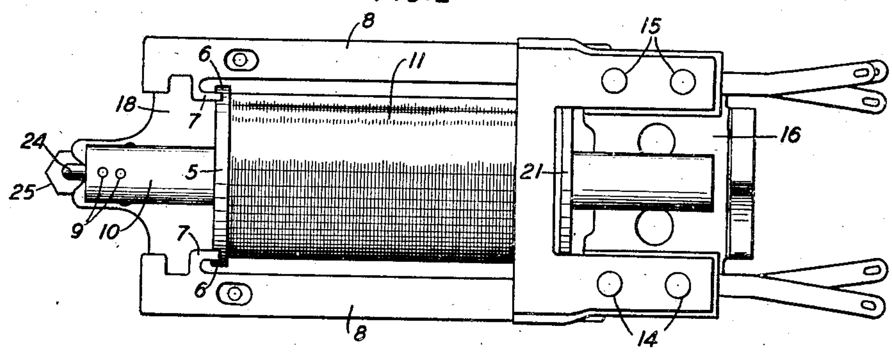

FIG. 3

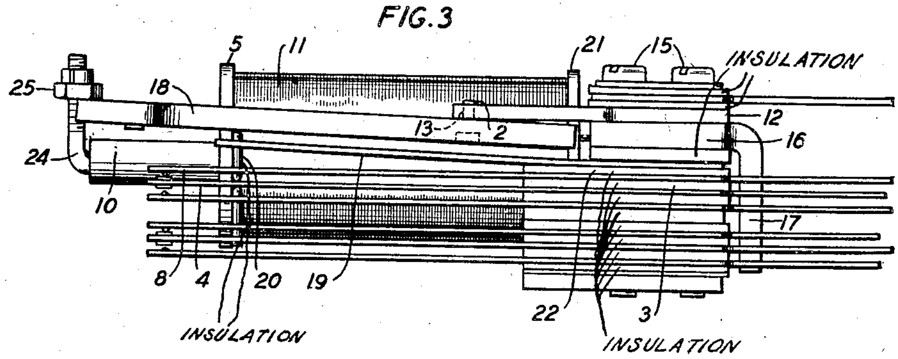

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FIG. 4

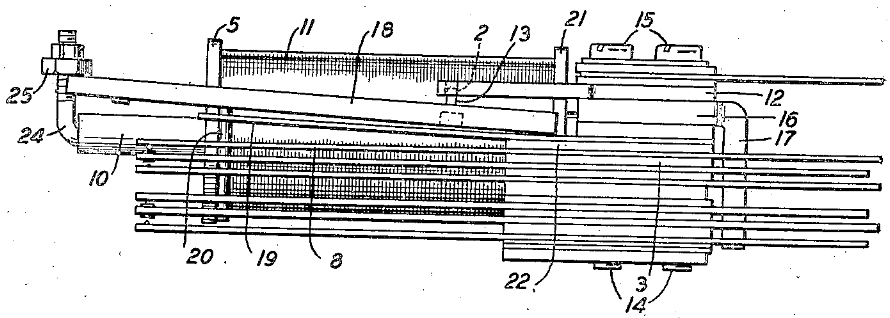


FIG. 5A

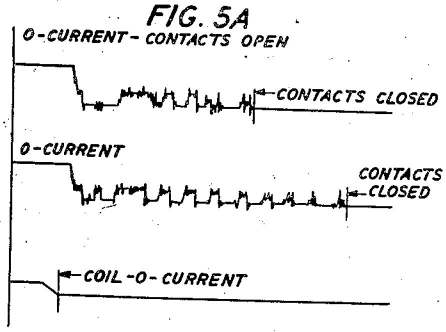


FIG. 6A

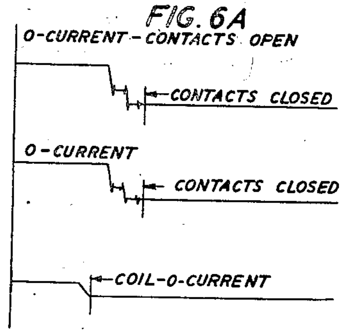


FIG. 5B

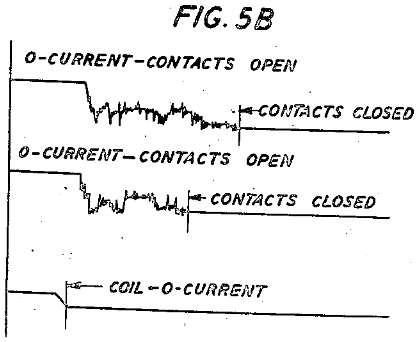


FIG. 6B

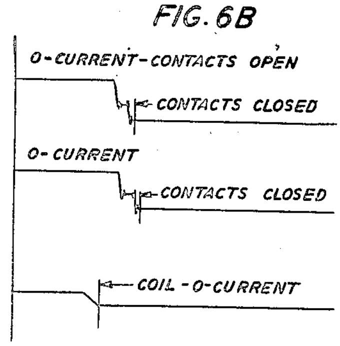
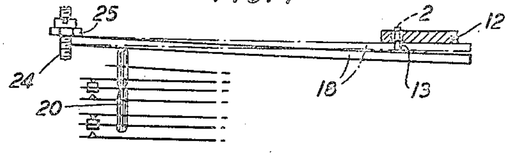


FIG. 7



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UNITED STATES PATENT OFFICE

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ELECTROMAGNETIC SWITCHING DEVICE

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Original application December 11, 1935, Serial No. 53,982. Divided and this application February 21, 1939, Serial No. 257,568

8 Claims. (Cl. 200—104)

This invention relates to electric switching devices and particularly to electromagnetic relays, and is a division of my copending application Serial No. 53,982 filed December 11, 1935.

In electrical systems, generally, and in telephone systems particularly, an electromagnetic relay plays an important part and is one of the most extensively employed switching devices.

To insure satisfactory functioning of the circuits of a telephone system and to guard against interruption of service, it is necessary that the relays employed in such systems be so designed as to function at maximum efficiency at all times and be so constructed as to operate and release without "chatter" or vibration of its contacts, which condition frequently results from too severe an impact of the armature against the pole face of the core when the armature operates and from armature rebound from the back-stop when the armature releases.

It is well known, of course, that the pull of an armature is of minimum value when the armature is in its open position and the air-gap which separates the core from the armature is of maximum width. The pull increases rapidly as the armature moves toward the core and the width of the air-gap is diminished. The result is to cause the armature to engage the core with which it coacts with considerable impact since the force exerted upon it is a maximum at the instant of engagement. Under these circumstances, the contact springs which are closed together by the operation of the armature, are subject to considerable contact "chatter" due to the rebound of the armature during the period in which it dissipates the momentum acquired in its travel from the unoperated to the operated position. Furthermore, and particularly with relays carrying heavy contact spring loads, the release of the armature by the pushing power of the contact springs gives the armature a considerable speed of release during which it acquires a quantity of momentum that must be dissipated before the armature comes to rest. When the mass of the armature is considerable and the armature is hinged on the rear of the core structure, this momentum is dissipated by the rebound of the armature at its front end, which rebound is transmitted to the contact springs and causes them to falsely open or close until the amplitude of the rebound swings of the armature is reduced to the point when it can no longer affect the contacts.

Both of these conditions make it difficult to design fast operating circuits through the contacts of such a relay since it may be a relatively long period after the operation or the release of the relay that reliable closure can be assured through the contacts.

It is the object of this invention to provide electromagnetic relays in which the condition of contact chatter, both on the operation and the release of the relay, is materially improved. This object is attained, according to one feature of the invention, by the provision of a relay structure having its armature freely suspended on an armature bracket magnetically yoked to the rear of the core structure. The points of suspension are not at the ends of the armature but intermediate the front and rear thereof so as to provide said armature with an axis of rotation in a line through the points of suspension without, at the same time, restricting the movement of the armature about any other point or points within its mass. With this construction, contact chatter and armature rebound is reduced to a minimum, first, because the armature acquires less momentum during the operation and releasing travel and, therefore, acquires less energy which has to be dissipated by rebounding, secondly, because when the armature operates there is a magnetic pull at both ends of the armature which tends to reduce the amplitude of rebound, and, thirdly, because on the release of the armature and due to the free suspension thereof and the fact that the spring loads push the front end of the armature against the back-stop, the momentum of release can be dissipated by the armature freely swinging away from its front end and, therefore, away from where such swings can affect the contacts.

These and other features of the invention which contribute to the over-all efficiency of the relay will be readily understood from the following detailed description made with reference to the accompanying drawings, in which:

Figs. 1, 2 and 3 show, respectively, a top plan view, a bottom plan view and a side elevation of a relay embodying the features of the invention, Fig. 3 particularly representing the position of the armature when the relay is in the unoperated position prior to energization;

Fig. 4 is the same view as Fig. 3 except that it illustrates the position of the armature upon releasing subsequent to energization;

Figs. 5 and 6 show, respectively, the result of oscillographic studies on a conventionally hinged relay and those on a relay whose armature is suspended according to the principles of this invention; while

Fig. 7 illustrates a schematic presentation of the principle involved in the invention.

The relay core 10 is substantially cylindrical throughout its length and on an intermediate portion thereof supports the relay coil 11. The front portion of the core 10, or that portion immediately below the cross-reach 23 of the armature is flattened to provide a pole face of suitable area. The back-stop for the armature utilized in this construction comprises an L-shaped pin 24 having one end thereof protruding from the front end of core 10 and the other portion extending at right angles thereto and threaded to accommodate the nut 25. The front edge of the armature 18 is slightly concave to permit the pin 24 to pass the armature and to provide the necessary armature bearing surface for the nut. This type of construction permits the front edges of the core 10 and the armature 18 to be in substantial alignment, thereby reducing the leakage paths which are common to arrangements heretofore employed in which the core, to provide mounting space for the back-stop, extends beyond the front edge of the armature. This arrangement further reduces leakage flux to a minimum and permits substantially all of the core flux to cross the armature air-gap and therefore to be utilized for producing traction. The front end of the core 10 may be bored to permit the insertion of the pin 24 which may then be staked into position as generally indicated by the holes 9 (Fig. 2).

An L-shaped bracket comprising arms 16 and 17 is welded to the rear portion of the core 10. The hanging portion 17 of the bracket (as seen in Figs. 3 and 4) serves as a means for mounting the relay on a relay rack, the portion 16 extending the entire width of the relay and constituting a support for the spring assemblies which are located on either side of the relay and secured to the bracket portion 16 by means of screws 14 and 15.

Interposed between the upper and lower spring assemblies and the bracket portion 16 is secured, also by means of screws 14 and 15, a U-shaped armature bracket 12 having its two legs extending in a direction parallel to the longitudinal axis of the core 10 and provided with apertures 1 and 2 at the extremities thereof, which form a line perpendicular to the longitudinal axis of the core. These apertures are for the purpose of receiving cylindrical projections 13 which are embossed on the legs of the armature as explained hereinafter. A longitudinal adjustment of the armature bracket 12 may be made by loosening screws 14, 15, moving the bracket 12 forward or backward in accordance with the required adjustment, and then tightening the screws 14, 15, the bracket 12 being provided with oblong holes (not shown) to permit it to be shifted without necessitating the removal of the spring assemblies or in any other way disturbing the relay structure as a whole.

The spring assemblies comprise the usual contact spring combinations. The passive or stationary contact spring, such as 8, for instance, is relatively thick and may carry one or more contact elements disposed, preferably, at right angles to the longitudinal axis of the spring. A lateral projection 7 abuts against a projection, such as 6, on the front spoolhead 5 which is further provided interiorly with spaced projections (not shown) for other stationary contacts which are normally tensioned against the spoolhead projections. The companion active or movable spring, such as 4, is a relatively thin spring carrying the required number of contact points and disposed in accordance with the contact elements on the stationary spring. The various springs in the spring assemblies on each side of the relay are separated from each other by insulating spacers, such as 3, which extend forward along the springs from the bracket 16 to provide the springs with considerable stiffness. When the contact spring assemblies contain normally made "back" or unoperated contacts as, for instance, springs 8 and 4, a balancing spring 19 is interposed on each side of the relay between the armature 18 and the innermost spring of each spring assembly. This balancing spring, acting through the contact stud 20 which is inserted into the armature and abuts against the balancing spring at the tip thereof, tensions the armature against the back-stop nut 25 and thereby avoids any vibratory movement of the armature which would tend to push spring 4 away from spring 5. Other contact studs, such as 20, extend between moving springs and pass through the stationary springs so that the motion of the armature is transmitted to the moving springs.

The armature 18 comprises a substantially U-shaped structure having an elongated projection intermediate its cross-reach member 23 with an end surface notched to allow the armature, when in position, to move freely with respect to the pin 25 and having a width slightly greater than the width of the pole face of the core structure 10. The leg members of the armature are substantially rectangular and extend in length from the cross-reach member 23 to the rear spoolhead 21. On each leg and at a distance away from the end thereof a cylindrical projection 13 is provided (only one being shown in Fig. 3) which is adapted to be received into the aperture 2 of armature bracket 12, it being understood that a similar projection 13 is provided on the other leg and received into aperture 1 of the corresponding leg of the bracket 12.

While in the preferred construction I have shown the supporting projections upon the armature legs and the receiving apertures in the bracket legs, it is just as easy to reverse the relationship and have the projections upon the bracket legs and the apertures in the armature legs without departing from the scope and purpose of this invention.

The armature, when in place on the core structure, is freely suspended with its projections 13 in the apertures 1 and 2 and free to rotate about a virtual axis which is perpendicular to the longitudinal axis of the core in the arc limited by the adjustment of nut 25 and the space between the lower surface of the armature bracket legs and the upper surface of balancing springs 19 or, if no balancing springs are provided, then the upper surface of the first spring insulator, such as 22. The armature is further capable of an angular movement about its front end as fulcrum, which end is held stationary against the surface of nut 25 by the spring assemblies pushing against the armature through the series of contact studs 20. This movement permits the projections 13 to slide in and out of the apertures 1 and 2.

Having thus described those elements of the relay which are material to an understanding of my invention and the manner in which they are assembled to form a preferred embodiment of said relay, I will now describe how the free suspension of the armature as above described tends to eliminate contact chatter or vibration both on the operation and the release of the armature.

Considering Figs. 3, 4 and 7, the first-mentioned figure shows the position of the armature when the relay is in an unoperated position. The front end of the armature is resting beneath the surface of nut 25, it being firmly held in this position by the back pressure of the spring assemblies transmitted to each leg of the armature by the contact studs 20. Inasmuch as these contact studs are located toward the front end of the armature but behind the contact points of the various contact springs, said armature occupies a downwardly sloping position with its two projections 13 partially within the apertures 1 and 2, but with its back end resting or not resting upon the surface of balancing springs 19 or spring separator 22 depending upon the quantity of tension with which the springs push against the armature at the forward end.

When the relay is magnetized by the excitation of coil 11, the magnetic flux produced in the core extends through the legs of the armature bracket 12, inasmuch as this bracket is magnetically yoked to the core 10 by means of the L-bracket 16 to which the core is welded. As a result, the core exerts a force of attraction at two places; the first at the pole face and the second at the two armature bracket legs. This double force is exerted upon the two ends of the armature 18 which thereby acquires a counter-clockwise turning movement about its projections 13 which brings the armature face flush up against the core pole face and the armature legs extending beyond the points of suspension flush up against the underside of the armature bracket legs.

The armature, in moving to its operated position, acquires a certain quantity of momentum which, of course, must be dissipated before it settles to a position of rest. If the armature had been hinged to the bracket 16 by the ends of its legs, which is the more usual mode of attachment, this momentum would have to be dissipated by the oscillatory movement of the armature about the hinge, and since this produces the greatest amount of armature displacement at the front end thereof where contact movement is effected, this oscillatory motion would cause the contacts to be falsely opened or closed in varying degrees until the amplitude of the oscillations communicated to the springs would be insufficient to close or open the contacts. However, with my preferred mode of suspension, while the momentum acquired by the armature must still be dissipated through oscillatory motion, yet the deleterious effect upon the contacts is considerably diminished since the quantity of momentum to be dissipated at the front end of the armature is much smaller due to the intermediate suspension which allows a part of the momentum to be dissipated at the rear of the armature, the angle of motion is also shorter because of this mode of suspension and the magnetizing force which tends to hold the legs of the armature to the legs of the bracket further reduces the angle of motion when the armature oscillates. The result is that the movement of the armature at its front end takes place through a small arc which is barely sufficient to effect the closure of the contacts carried by the springs, thereby shortening the interval after the operation of the armature, in which case reliable contact closures can be assured.

When coil 11 is deenergized, the armature drops back against the back-stop nut 25 (as shown in Fig. 4) by virtue of the force exerted against it by the tensioned spring assemblies opposite each of its legs. As in the case of operation so in the case of release, the armature acquires momentum in returning to its normal position, which momentum must be dissipated before the armature assumes a position of rest. If the armature were hinged by the end of its legs to the bracket 16, this momentum would have to be dissipated through an oscillatory movement of the armature which would be greatest at the forward end where the energy of the oscillations, if the amplitude were great enough, would be transmitted to the contact springs through studs 20 and cause a breaking of back contacts and the consequent release of circuits established therethrough. How serious this "contact chatter" may be in some cases and how long it may last, is made clear by an inspection of Figs. 5A and 5B which are reproductions of two oscillographic studies made upon relays carrying large spring assemblies with their respective armatures hinged at the rear. The two upper lines in Figs. 5A and 5B represent the current condition through two separate pairs of back contacts on the relays, while the lower line represents the current through the respective coils of the relays. It is evident from an inspection of these two figures that while each contact pair closes some little time after the current in the coil has reached zero value, there is no reliable contact closure until a considerable period thereafter, thus making it impossible to establish circuits through these contacts until a relatively long time after the current through the relay coil has reached zero value.

With my preferred mode of armature suspension, however, rebound effects on the release of the armature are practically eliminated. Considering Fig. 4, which shows the position of the armature at the instant its forward end strikes the nut 25 on the release, the armature has acquired, during its releasing movement, a quantity of momentum which has to be dissipated before it comes to rest against the back-stop nut 25. If, as said before, the armature were hinged on the rear, the energy would have to be dissipated by the oscillatory movement of its forward end, with a consequent transmission of this movement to the springs. But inasmuch as the armature is freely suspended by projections 13, and since the contact spring assemblies exert a pressure to keep the forward end of the armature against the nut 25, said armature is free to move angularly in the opposite direction to the way it would move if it had been hinged at the rear. That is, the movement which will take place to dissipate the acquired momentum will be that which would take place if the armature were hinged at the nut 25 rather than at the end of its legs. And since the points of suspension 13 are slidable within the apertures 1 and 2, the energy is dissipated by oscillatory rebounds of the armature as a whole, its amplitude of oscillation being greatest, of course, at its legs and practically inappreciable at the point where it engages studs 20 as illustrated in Fig. 7. In this way, the effect of armature rebound on the contacts is practically removed since the only rebound motion which can now be communicated to the spring assemblies is the unappreciable movement which takes place at the head of the relay, thus providing reliable contact closure on the back contacts almost immediately after said contacts are closed.

Figs. 6A and 6B illustrate the marked improvement in back contact performance which is brought about by my method of armature suspension. Both figures represent oscillographic studies made upon relays equipped with the same spring assemblies as the relays whose back contact performance is illustrated by the oscillographic studies shown in Figs. 5A and 5B, but with armatures freely suspended as above described. It will be observed that both for the relay which gave the results shown in Fig. 6A as well as for the one which gave the results shown in Fig. 6B, reliable back contact closure takes place but a small interval after the current in the coil becomes zero and that the amount of contact chatter prior to that time is almost nil.

What is claimed is:

1. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for causing the closing and opening of said contacts, and means for loosely and freely supporting said armature at a point intermediate its forward and rear ends, said supporting means permitting the armature to pivot about said point of support on its forward movement and to pivot about its forward end when it reaches its operated position to prevent said forward end from rebounding and disturbing the condition of said contacts.

2. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for causing the closing and opening of said contacts, and means for loosely and freely supporting said armature at a point intermediate its forward and rear ends, said supporting means permitting the armature to pivot about said point of support on its release movement and to pivot about its forward end when it reaches its released position to prevent said forward end from rebounding and disturbing the condition of said contacts.

3. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for causing the closing and opening of said contacts, and means for loosely and freely supporting said armature at a point intermediate its forward and rear ends, said supporting means permitting the armature to pivot about said point of support on its forward and release movements and to pivot about its forward end when it reaches either its operated position or its released position to prevent said forward end from rebounding and disturbing the condition of said contacts.

4. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for causing the closing and opening of said contacts, an armature bracket magnetically yoked to the rear of said core and having apertures therein, and projections on said armature disposed intermediate its forward and rear ends loosely fitting into said apertures whereby the armature may pivot about said projections on its operating and release movements and may pivot about its forward end when it reaches its released position to prevent the disturbance of said contacts by a rebound movement of said armature.

5. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for closing and opening said contacts, two projections on said armature disposed intermediate its forward and rear ends for supporting said armature, and a U-shaped armature bracket magnetically yoked by its cross-member to the rear of said core and having an aperture in each of its legs equidistant from said cross-member for loosely receiving the projections of said armature whereby the armature is supported thereby to pivot about said projections on its operating and release movements and when it completes said operating and release movements to pivot about its forward end due to said projections sliding freely in and out of said apertures to prevent a rebound movement from disturbing the condition of said contacts.

6. An electromagnetic relay comprising a core, a winding for energizing the same, a U-shaped armature having the cross-member of its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward end of said armature between said positions for closing and opening said contacts, a supporting projection on each leg of said armature disposed intermediate its forward and rear ends and perpendicularly aligned with respect to the longitudinal axis of said armature, a U-shaped armature bracket magnetically yoked to the rear of said core with its legs extending forwardly parallel to the axis of said core and having an aperture in each leg thereof, said apertures being perpendicularly aligned with respect to the longitudinal axis of said core and adapted to receive said armature projections whereby said armature will pivot freely about said projections in its operating and release movements and will pivot about its forward end to prevent said armature from rebounding and disturbing the condition of said contacts.

7. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, an L-shaped ad-

justable back-stop at the forward end of said core for varying and limiting the movement of the forward end of said armature between its operated and released positions, a set of contacts, means associated with and responsive to the movement of the forward movement of said armature between said positions for the closing and opening of said contacts, an armature bracket magnetically yoked to the rear of said core and having apertures therein, and projections in said armature disposed intermediate its forward and rear ends loosely fitting into said apertures whereby the armature is free to pivot about said projections in its operating and release movements and to pivot about said adjustable back-stop on release to prevent the armature from rebounding and changing the condition of said contacts.

8. An electromagnetic relay comprising a core, a winding for energizing the same, an armature having its forward end disposed in proximity to said core for attraction thereby, stop means associated with the forward end of said armature for limiting the movement of said armature between its operated and released positions, a set of springs having contacts thereon, means for supporting said springs on the rear portion of said core, an armature bracket magnetically yoked to the rear of said core and having apertures therein, a pivotal support for said armature comprising projections on said armature disposed intermediate its forward and rear ends loosely fitting into said apertures, and spring supported studs disposed between the contacts of said springs and the pivotal support of said armature for transmitting the operating movement of said armature to certain of said springs to close said contacts, said armature being free to pivot about said projections on its operating movement and free to pivot about its forward end at the completion of its operating movement to prevent a rebound movement from disturbing the condition of said contacts, said studs acting upon said armature to oppose said last-mentioned pivotal movement.

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