March 29, 1966 L. O. WOODS 3,243,546

ELECTRICAL SWITCHING DEVICE HAVING MINIMAL CONTACT BOUNCE

Filed April 28, 1964 2 Sheets-Sheet 1

Fig. 1

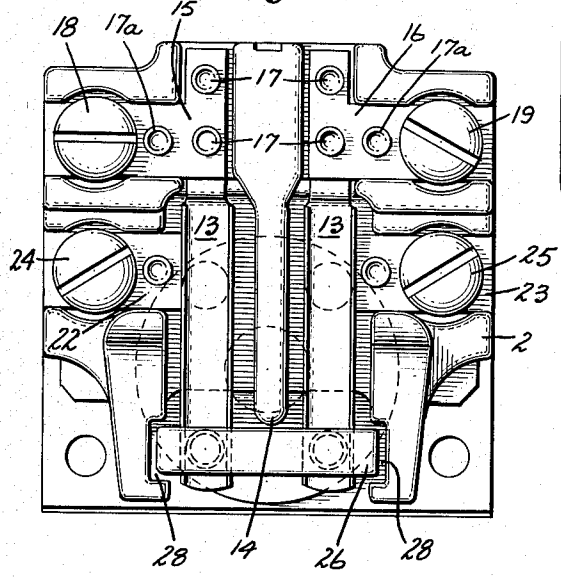


Fig. 2

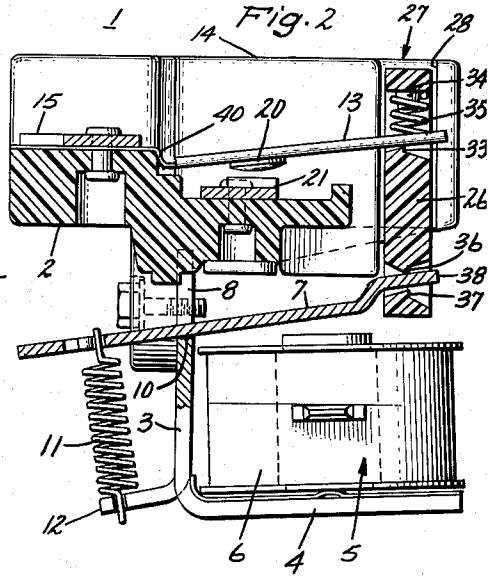


Fig. 3

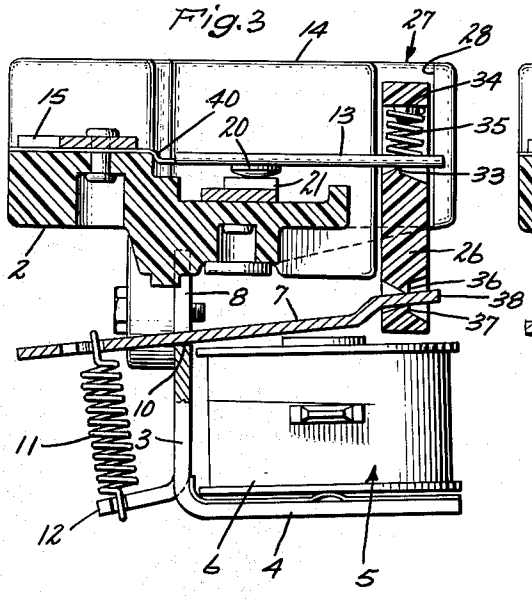
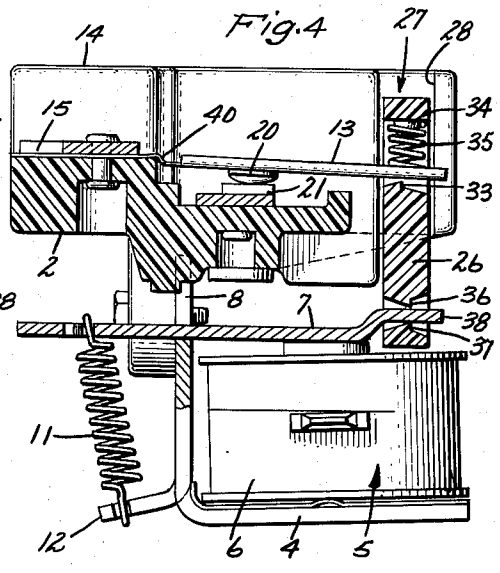


Fig. 4



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March 29, 1966 L. O. WOODS 3,243,546

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Filed April 28, 1964 2 Sheets-Sheet 2

Fig. 5

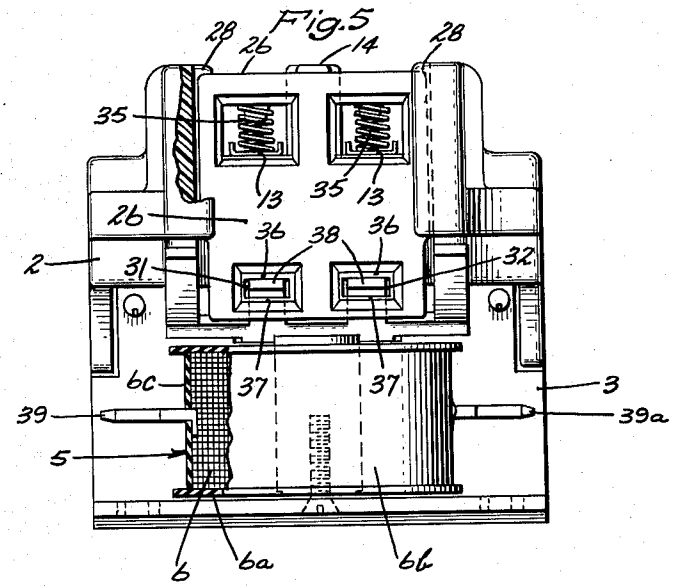
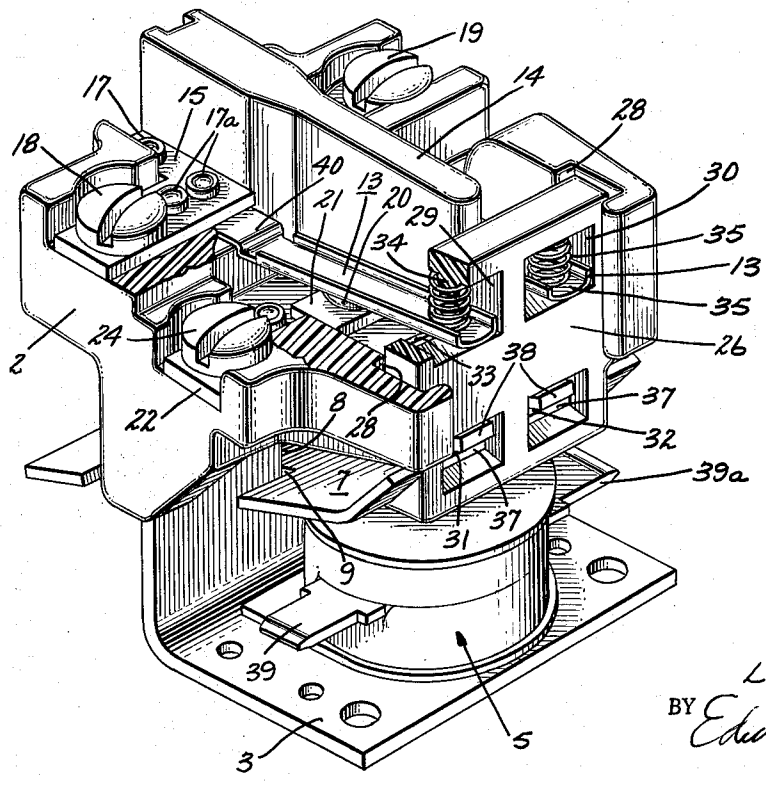


Fig. 6



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United States Patent Office 3,243,546
Patented Mar. 29, 1966

3,243,546

ELECTRICAL SWITCHING DEVICE HAVING MINIMAL CONTACT BOUNCE

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Filed Apr. 28, 1964, Ser. No. 363,219
5 Claims. (Cl. 200—87)

The present invention relates to electric switching devices and more particularly to electromagnetic switches or relays in which the contact operation is controlled by means of an electromagnet.

In conventional electromagnetic switches and relays there is a tendency for the contacts to bounce apart after their initial closure. The contacts are ordinarily engaged at relatively high velocity and under appreciable pressure, whereby they may bounce apart as much as several times before closing. This is particularly true if a lightweight simplified construction is used because with a reduction in weight there is a substantial loss in the effectiveness of the inertia of the parts of a switch. Contact bounce is very undesirable since it tends to cause arcing and even welding between the contacts. The tendency toward welding is particularly aggravated for relays which are used in circuits carrying substantial currents.

By reducing the contact bounce, the possibility of welding may be substantially reduced. Thus, a relay including means for eliminating contact bounce, may be rated for a higher load current than a similar relay without such means. The higher current rating is, of course, desirable since it greatly widens the field of application of the relay. For example, in the motor control field, a relay without substantial contact bounce could be used with motors over a much wider range of horsepower ratings than could a conventional relay with the customary contact arrangements.

Accordingly, it is a primary object of my invention to provide a new and improved electromagnetic relay in which the contact bounce is extremely small upon the closure of the contacts.

It is another object of my invention to provide such a relay which utilizes light weight parts of simplified construction that are inexpensive to make and easily fabricated.

A further object of my invention is to provide an improved electromagnetic switching device which is capable of safely controlling relatively high currents for its size and weight.

In carrying out my invention in one form thereof I have provided an electromagnetic relay including a base member having a channel formed therein. A carriage which includes a spring as one of its parts is slidably received in the channel of the base member for movement between two positions. A contact arm is mounted in the relay in cantilever fashion with its free end being engaged in the carriage by the carriage spring. The carriage spring continuously biases this cantilever arm in one direction. The cantilever arm carries a movable contact which is mounted on the arm intermediate the ends of the arm. This movable contact is engageable with another contact to close a circuit.

An actuating means moves the carriage between its two positions to open and close the contacts. As the carriage moves from one of its positions to its other position, the movable contact initially closes with the other contact intermediate the two positions of the carriage. The overtravel of the carriage to its final position compresses the spring against the arm, thereby pressing the contacts together and damping contact bounce. Because the spring is continuously stressed against the contact carrying arm it provides a strong force immediately upon the contact closure to inhibit bounce. As the overtravel of the carriage occurs the spring, due to its further compression,

supplies additional force to the movable contact through the arm to provide additional resistance to contact bounce.

By a further aspect of my invention I have formed my contact carrying arm out of resilient material and I have so constructed my switch that the overtravel of the carriage carries the free end of the arm further after the initial contact closure to flex the arm and rock the movable contact. This combination of actions limits the bounce very severely and even wipes the contacts together thereby substatnially increasing the current carrying capacity of the relay. This makes it practical to use a light weight single ply armature and a simplified relay construction.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. My invention, however, both as to organization and method of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a top view of an electromagnetic relay embodying my invention in one form thereof;

FIG. 2 is a side view partly broken away and partially in section, of the relay of FIG. 1, showing the relay in its contacts open position;

FIG. 3 is a view similar to FIG. 2 but showing the relay in an intermediate operating condition with the contacts in their initial closed position;

FIG. 4 is a view similar to FIG. 2 but showing the relay in its contact closed position with the carriage having completed its travel, the contact rocked forward and the resilient arm flexed;

FIG. 5 is a front view, partially broken away and partially in section, of the relay of FIG. 1; and

FIG. 6 is a perspective view of the relay of FIG. 1, partially broken away to show detail.

Referring now to FIGS. 1–6, I have showed therein an electromagnetic relay **1** embodying my invention in one form thereof. The relay **1** includes a base member **2** formed of insulating material. An L-shaped frame or yoke **3** formed of magnetic material is secured to the underside of the base **2**. Mounted on the foot portion **4** of the yoke **3** is an electromagnet **5** comprising a coil **6** wound on an insulating spool **6*a*** which is in turn positioned around the axial iron core **6*b*** shown in dotted lines (see FIG. 5). As shown, an insulating cover **6*c*** may also be included in the electromagnet assembly.

Looking now in particular at FIG. 6 it may be seen that an armature member **7** is positioned on the yoke **3** for actuation by the electromagnet **5**. The armature **7** is positioned above the electromagnet **5** and at its lefthand end (as shown in the drawings) extends through a recess **8** in the upper end of the yoke **3**. The armature includes grooves **9** in each of its sides and these grooves fit over the sides of the recess **8**. This prevents lateral shifting of the armature. The grooves are sufficiently wider than the thickness of the yoke so that the fitting of the grooves over the yoke does not prevent the armature from freely pivoting on the yoke when it is operating. As can be seen from a comparison of FIGS. 2, 3 and 4 the armature **7** pivots on the yoke **3** with the bottom surface **10** of the yoke recess **8** serving as the pivot point. Normally the armature **7** is spring biased away from the electromagnet **5** by means of a tension spring **11** connected between its lefthand and (as viewed in the drawings) and a tab **12** formed on the yoke **3**. The spring **11** by pulling downwardly on the lefthand end of the armature biases the righthand portion of the armature upwardly away from the electromagnet **5**.

A pair of identical contact carrying arms or resilient spring strips **13** are mounted on the upper side of the base

2 on opposite sides of the divider 14 which is formed integrally with the base. The resilient contact arms 13 are mounted cantilever fashion on the base by means of terminals 15 and 16 respectively. The inner ends of the arms 13 are secured to the terminals 15 and 16 by means of rivets 17, and, in particular, the lefthand arm (as viewed in FIG. 1) is secured to the terminal 15 and the righthand arm is secured to the terminal 16 with the arms extending from the terminals parallel to each other on opposite sides of the divider 14. The terminals 15 and 16 are, in turn, secured to the base 2 by the rivets 17*a*, and suitable hold-down screws 18 and 19 are provided on the terminals for attaching external leads.

A contact 20 is mounted on the lower side of each of the arms 13 intermediate its respective ends. The contacts 20 are positioned to move into and out of engagement with a pair of cooperating stationary contacts 21 upon the contact closing movement of the arms 13 in a manner which will be described hereinafter. The two contacts 20 of the relay are connected respectively to the terminals 15 and 16 through the arms 13. The stationary contacts 21 may be seen in FIG. 1 to be mounted respectively on terminals 22 and 23 which are provided with suitable screws 24 and 25 for the attachment of external leads. Thus, it will be seen that when the contacts 20 and 21 are closed, a circuit is completed from the terminal 15 to the terminal 22 and a second circuit is completed from the terminal 16 to the terminal 23. When the relay is in its normal position, both of the circuits are opened by the disengagement of the contacts 20 and 21.

Turning now to a consideration of the carriage 26 which is actuated by the armature 7 for opening and closing the contacts, it may be seen that the carriage 26 is received in a carriage guide channel 27 formed by the grooves 28 in the base member 2 for reciprocal movement. As best shown in FIG. 6 the carriage may be seen to be a plate-like member formed of insulating material, with two windows 29 and 30 being formed at its upper end and two windows 31 and 32 being formed in its lower end. The upper windows 29 and 30 each include a lower knife edge 33 and an upper stud 34. The resilient arms 13 project through respective ones of the upper windows as shown in FIG. 6 and coil springs 35 are engaged on the upper studs 34 and stressed against the resilient arms 13 biasing the arms away from the studs towards the knife edges 33. Suitable registration embossments or flanges (not shown) may be formed in the arms to hold the springs in position if desired.

Looking now at FIGS. 2–4 it may be seen that the lower windows 31 and 32 have upper and lower knife edges 36 and 37. The two tongues 38 of the armature 7 are positioned in respective ones of the lower windows 31 and 32 and engage the knife edges respectively to move the carriage downwardly and upwardly as the electromagnet 5 is energized and deenergized.

Turning now to the method of operation of the relay including the manner in which contact bounce is substantially eliminated and a contact rocking and wiping action is obtained, assume first that the relay is in a normally open position (FIG. 2). Now when current is applied to the electromagnet 5 through the terminals 39 and 39*a* provided on it, a magnetic field is set up tending to pull the armature downwardly. As shown in FIG. 3 the armature begins to pivot downwardly on the surface 10 which serves as a pivot point, the armature tongues 38 engaging the knife edge 37 of the lower carriage windows as the armature moves downwardly. The carriage 26 is pulled downwardly in its channel as the armature continues its downward travel. The carriage springs 35 which are engaged against the arms 13 move the free ends of the arms downwardly with the carriage.

This movement continues until such time as the movable contacts 20 engage the stationary contacts 21 (FIG. 3). The portions of the resilient arms adjacent to the base flex downwardly as the resilient arms are pivoted

downwardly by the carriage 26. The side edges of the resilient arms 13 may be seen to be turned upwardly intermediate their ends to add strength so that the resilient arms are less subject to flexing in their intermediate or middle regions. When the movable contacts engage against the stationary contacts the downward movement of the contacts 20 terminates; but as indicated by a comparison of FIG. 3 with FIG. 4 the armature 7 and the carriage 26 at that time have not finished their travel. Rather, after the initial contact engagement is made between the contacts 20 and 21 the armature 7 and the carriage 26 continue to move downwardly to their final or complete position as shown in FIG. 4.

As each of the contacts 20 engages its stationary contact 21, the associated carriage spring 35 immediately provides a strong force preventing bounce of the contact because of the compressive force continuously present in the springs 35. In other words, the biasing force applied to each of the resilient arms 13 by the associated spring 35 acts immediately as a closure force preventing bounce. As the armature 7 and the carriage 26 continue to move after this initial contact closure, the carriage 26 compresses the springs 35 still further which presses the contacts together firmly. Also, this action forces the free ends of the resilient arms 13 further downwardly causing a reverse flexing of the ends of are arms secured to the base and a rocking of the contacts 20 toward the free ends of the arms. This increasing in pressure together with the initial spring pressure on the contact closure, tends to prevent the contacts 20 from bouncing off the contacts 21. The rocking of the contacts serves to facilitate a good contact making action with some contact wiping also occurring enabling the making of higher currents.

It will be understood that the force on the free end of the resilient arms increases steadily after initial closing of the contacts until the carriage has reached the limit of its travel. The contact bounce is held to a very small value by this action and in fact it is substantially eliminated being helped by the rocking action which helps to absorb the initial impact.

Other features of my improved relay also tend to limit contact bounce. One of these features is the position of the contacts 20 on the resilient arms 13. The contacts 20 as shown are relatively close to the pivots or bends 40 around which the resilient arms flex. The contacts 21 being closer to the flexure points than the carriage 26, move much slower than the carriage and thereby the velocity of the contacts as they engage the stationary contacts 21 is relatively low. This reduced velocity, of course, helps to prevent contact bounce since it does not create momentum in the moving contacts. Further, due to this positioning close to the flexure points of the strips, the contact pressure at the initial closing is relatively high, which also helps to limit bounce. The supplying of the forces of the carriage at the far or free ends of the resilient arms gives a good leverage factor further increasing the effectiveness of the force supplied by the springs 35 of the carriage. All of these factors help to make possible a lightweight simplified construction while giving high effective forces.

In addition to providing a contact closing action with little or no contact bounce, the relay 1 also provides for reliable action over a relatively long life. Lightweight parts cause less damage to one another and their supporting structure as they close together than heavier parts having more inertia force. Of course, parts consuming less material in their construction reduce material cost. The mounting of the carriage 26 with its internal springs 35 for sliding movement in the channel 27 is particularly desirable from the standpoint of long life. The sliding action of the carriage in the channel, together with the knife edges 33, 36 and 37, provide an action whereby there is little if any binding and only a small amount of friction between the parts as they move and this substantially lessens wear.

The opening action of the relay is in general the reverse of the closing action. As power is removed from the electromagnet **5**, the armature **7** is, of course, free to pivot upwardly under the action of the biasing spring **11**. As the right-hand end of the armature pivots upwardly, the tongues **38** leave the lower knife edges **37** and engage the upper knife edges **36**, and the carriage **26** moves upwardly. As the motion of the carriage continues upward, the extra compression of the springs **35** is relieved. Then knife edges **33** come up to the bottoms of the resilient arms **13**, as shown in FIG. 3, and lift them upwardly. The contacts **20** are thereby disengaged from the stationary contacts **21**. This breaking of the contacts **20** and **21** occurs at a relatively low velocity for the same reasons explained in discussing the contact making operation, i.e., the movable contact being located in a mid region of an arm **13** moves more slowly than the carriage. The low velocity during breaking is particularly desirable where the relay is connected in an alternating current circuit because although arcing occurs at the low breaking velocity and the arc persists for the same length of time as at higher velocities, i.e., until the first current zero, the length of the arc path is reduced so there is less energy in the arc. The minimizing of the arcing during disengaging also aids in prolonging the life of the relay. The strips **13** continue to be moved upwardly until the armature **7** engages the underside of the base **2** as shown at **41**, in FIG. 2.

The incidence of arcing and contact welding is extremely low in the relay **1** for the reasons explained above. It will be noted though that strong contact opening forces are provided therein. Thus, even if an occasional weld should occur, strong forces on parts having momentum at the instant contact separation is initiated are available to break it. In particular, when the electromagnet **5** is deenergized the force of the large tension spring **11** works to propel the armature **7** against the carriage **26** and the carriage **26** against the resilient arms **13** to move the resilient arms which work with leverage to open the contacts. The contact opening operation in the relay **1** is thus equally as desirable as the non-bouncing contact closing operation.

While in accordance with the patent statutes, I have described what at present is considered to be the preferred embodiment of my invention, it will be obvious to those skilled in the art that numerous changes and modifications may be made therein without departing from the invention and it is therefore aimed in the appended claims to cover all such equivalent variations as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an electric switching device, a base member having guide means formed thereon, a carriage slidably received by said guide means, a single arm mounted in said device in cantilever fashion with the free end of said arm extending to said carriage, a spring entirely located within said carriage and being positioned between said carriage and said free end of said arm and being continuously stressed and biasing said arm in one direction, a movable contact carried by said arm intermediate its ends, another contact engageable by said movable contact, actuating means for moving said carriage between two positions to open and close said contacts, said carriage actuating said arm with said movable contact through said spring, said movable contact initially closing with said other contact intermediate the two positions of said carriage with the overtravel of said carriage to the completion of its movement further stressing the spring against said arm and flexing said arm, thereby pressing and wiping said contacts together and damping contact bounce.

2. In an electric switching device, a base member, a carriage reciprocally mounted on said base member, a single contact arm mounted cantilever fashion in said switching device with its free end projecting to said carriage, a movable contact carried by said arm, a second contact engageable by said movable contact, a spring carried between said free end of said contact arm and said carriage for actuating said arm and said movable contact from said carriage, and actuating means for moving said carriage from a first position to a second position for closing said contacts, said movable contact engaging said second contact before the travel of said carriage to said second position is completed, whereby said spring is stressed between said carriage and said arm for damping contact bounce.

3. In an electric switching device, a base member having a guide means formed thereon, a carriage reciprocably carried by said guide means, a contact arm mounted on said base, a free end of said contact arm arranged for actuation by said carriage, a compression spring entirely located within said carriage and being positioned between said carriage and said free end of said contact arm for biasing said contact arm in one direction, a movable contact carried by said arm intermediate the ends of said arm, a second contact engageable by said movable contact, actuating means for moving said carriage between two positions to open and close said contacts, said movable contact initially closing with said second contact intermediate the two positions of said carriage, with the overtravel of said carriage to the completion of its movement moving the free end of said arm through said compression spring further in the direction of movement of said carriage and pivoting said strip on said movable and said fixed contacts which act as a fulcrum, and rocking said movable contact, thereby pressing and wiping said contacts together and damping contact bounce.

4. An electromagnetic relay comprising a base member having a channel formed therein, a carriage slidably received by said channel, said carriage including a carriage spring having one end directly engaging said carriage, a leaf spring strip mounted cantilever fashion on said base with its free end extending into said carriage and being engaged at its free end by the other end of said carriage spring, a movable contact carried by said strip intermediate the ends of said strip, a second contact engageable by said movable contact, actuating means for moving said carriage between two positions to open and close said contacts, said carriage actuating said strip with said movable contact through said carriage spring, said movable contact initially closing with said second contact intermediate the two positions of said carriage, with the overtravel of said carriage to the completion of its movement compressing said carriage spring against said free end of said strip, to move said free end of said strip further in the direction of movement of said carriage and pivot said strip on said movable and said fixed contacts which act as a fulcrum, said mounted end of said strip adjacent said base flexing and moving in the opposite direction, whereby said movable contact is pressed and wiped into engagement with said second contact.

5. An electromagnetic relay comprising a base member having a channel formed therein, a carriage slidably received by said channel, said carriage including a pair of carriage springs entirely located within said carriage and having one end of each of said carriage springs directly engaging the carriage, a pair of leaf spring strips mounted cantilever fashion on said base in side-by-side relation and extending parallel to each other, the free ends of said spring strips being received in said carriage and engaged by the other ends of the respective carriage springs at said free ends, said carriage springs being continuously stressed to bias said strips in one direction continuously, at least one movable contact carried by each of said strips intermediate the ends of said strips, a fixed contact engageable by each of said movable contacts, a light weight single ply armature attracted upon energization of an electromagnet, a spring means for returning said armature to its unattracted position, linking means mechanically linking said carriage to said armature for actuation by said arma-

ture between two carriage positions, and said carriage moving said strips between a contact open and contact closed position, said movable contact initially closing with said fixed contact intermediate the two positions of said carriage, with the overtravel of said carriage to the completion of its position further stressing the carriage springs against the strips to flex said strips carrying said movable contacts, and rock said movable contacts, thereby wiping and pressing said contacts more firmly together and damping contact bounce.

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