Nov. 2, 1937. A. G. STIMSON 2,098,070

ELECTROMAGNETIC RELAY

Filed May 29, 1935

Fig. 1.

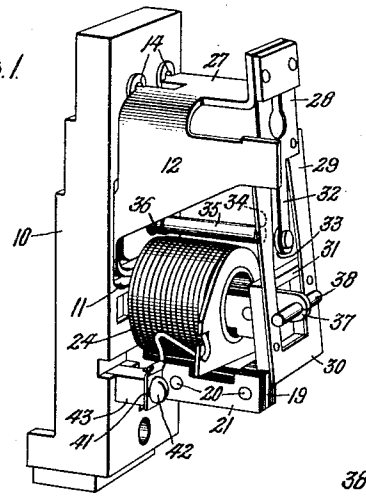


Fig. 3.

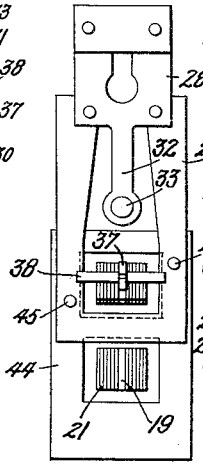


Fig. 4.

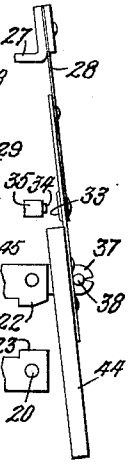
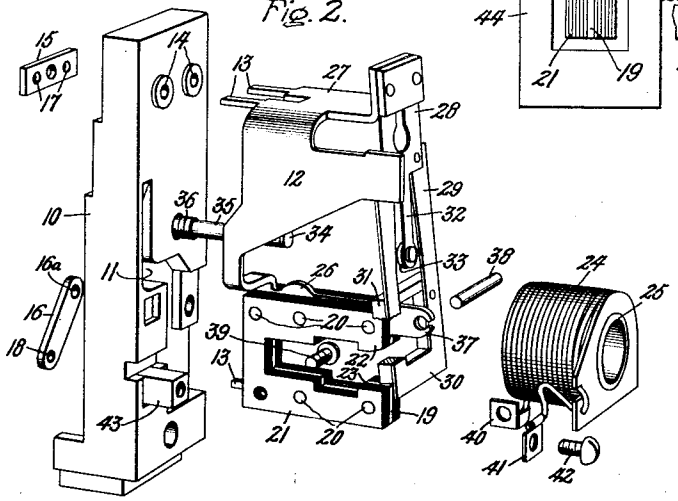


Fig. 2.



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2,098,070

ELECTROMAGNETIC RELAY

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3 Claims. (Cl. 175—338)

My invention relates to electroresponsive devices, more particularly to electromagnetic relays for controlling the starting circuit of a split-phase induction motor, and has for an object the provision of a simple, reliable and inexpensive relay of this character.

It is well understood, of course, that in starting motors of the split-phase type, it is necessary to provide means for insuring that the starting winding of the motor shall be energized only during the starting period. Various relays have heretofore been proposed for controlling the starting circuit of such motors but much is yet to be desired in providing an inexpensive, noiseless relay which will satisfactorily perform the proper switching operation in response to the current of the motor. Accordingly, it is a further object of my invention to provide a single coil, electromagnetic relay which is noiseless in operation, which is economical to manufacture and which controls with great reliability the starting and running connections of the motor.

In carrying out my invention in one form, I provide a laminated, magnetizable frame having an air gap and a resiliently supported, magnetizable armature movable into and out of the air gap to control a pair of contacts in accordance with the value of the magnetic forces produced upon energization of an operating winding associated with the magnetizable frame. The armature, which is of relatively light construction, has a tendency to vibrate in the air gap in accordance with the fluctuations of the alternating-current supplied to the operating winding, and in order effectively to damp these vibrations, I provide a short-circuited winding carried by the movable armature, the repulsion force exerted on the short-circuited winding opposing the magnetic force exerted upon the armature. More specifically, I provide a supporting bracket formed of magnetizable material to which a plurality of magnetizable plates are secured in face-to-face relation in order to form the magnetizable frame, the plates and the bracket being formed to provide an air gap in the frame. Secured to another portion of the bracket, is a cantilever spring which resiliently supports the armature in a given position adjacent the magnetizable frame. Resiliently supported for movement with the armature, is a contact arranged to engage a fixed contact when the armature is attracted into the air gap. Due to the construction of the armature and the spring, the armature is susceptible not only to forced vibration within the air gap in accordance with the fluctuation of the magnetic field produced by the alternating-current, but the armature and the spring are also susceptible to free vibration about their normal position when the armature is suddenly released from the air gap. This free vibration may be of sufficient amplitude to cause the contacts to be re-engaged after the armature is released and accordingly, I provide stop means positioned to absorb the kinetic energy accumulated in the armature and thus prevent free vibration of the armature and the spring about the normal position.

For a more complete understanding of my invention, reference should now be had to the drawing in which Fig. 1 is a perspective view of a relay embodying my invention; Fig. 2 is a view in exploded perspective of the relay shown in Fig. 1; Fig. 3 is a partial plan view of a modified form of relay embodying my invention; and Fig. 4 is a fragmentary, elevational view of the relay shown in Fig. 3.

Referring now to Figs. 1 and 2 of the drawing, I have shown my invention in one form as applied to a relay comprising a base 10 of insulating material provided with an irregularly shaped groove 11 in which rests a supporting bracket 12 of steel or other suitable magnetizable material. In order to provide for easy assembly of the bracket 12 on the base, the bracket is provided with a plurality of fingers or prongs 13 arranged to extend through suitable apertures 14 in the base, only two of the apertures 14 being shown. The fingers 13 are of sufficient length to extend outwardly on the opposite side of the base 10 when the bracket is assembled in the groove 11, and two straps 15 and 16 on the opposite side of the base are respectively provided with apertures 17 and 18 alignable with the extending ends of the fingers 13. When the bracket and the straps have been assembled on the base, the extending ends of the fingers 13 may be overturned or otherwise suitably secured to the straps 15 and 16 in order to secure the bracket 12 rigidly to the base 10. The strap 16 also serves as an electrical conductor as will be more fully explained hereinafter.

As shown best in Fig. 2, the bracket 12 is provided with a substantially U-shaped portion 19 on the opposite sides of which are secured, as for example by the rivets 20, a plurality of similarly shaped plates of magnetizable material so as to form a laminated, magnetizable frame 21 having opposed pole faces 22 and 23 forming an air gap at the open end thereof. Mounted on one leg of the magnetizable frame 21 is an operating coil 24 comprising an insulating spool 25

on which the turns of the coil are wound. Extending outwardly from the leg of the magnetizable frame on which the coil 24 is mounted, is a lug or ear 26 formed on the portion 19 of the bracket 12 and arranged to cooperate with the spool 25 to support the coil 24 on the magnetizable frame. The dimensions of the spool are such that when the coil 24 is placed over the leg of the frame 21 and pressed downwardly thereon, the spool is forced into intimate engagement with the lug 26 and with the corners of the opposite side of the frame leg. Thus a rigid three-point support for the winding 24 is obtained, the spool preferably being formed of fiber so that the lug 26 cuts a groove therein as the coil is forced downwardly on the frame, thereby preventing turning of the coil or vibratory movement thereof.

Formed on the other end of the bracket 12, is a supporting portion 27 to which is secured one end of a cantilever spring 28, the other end of which is secured to the legs of a U-shaped armature 29 formed of steel or other suitable magnetizable material. As shown, the spring 28 normally supports the armature 29 in spaced relation with the magnetizable frame 21 so as to form an air gap between the armature and the frame, and the yoke portion 30 of the armature is in alignment with the air gap between the pole faces 22 and 23. Secured to the armature 29 in the air gap between the armature and the frame, I provide a short-circuited winding 31 comprising a single-turn coil of highly conductive material, such as copper, the purpose of which will be more fully described later.

Extending outwardly from the cantilever spring 28 between the legs of the armature 29, is a spring finger 32 which supports a movable contact 33 in cooperating relation with a fixed contact 34 carried on a supporting post 35 threadedly mounted, as indicated by the reference numeral 36, on the base 10. This threaded mounting of the contact post 35 provides for easy adjustment of the relay contacts 33 and 34.

Extending outwardly from the magnetizable frame 21 between the legs of the armature 29, is a supporting finger 37 on which is loosely mounted a stop bar 38 preferably formed of rawhide or other suitable flexible material. As shown, the stop bar 38 is loosely supported intermediate its ends and is thus rendered self-alignable with the armature 29.

In order to describe the operation of the relay, it will be assumed that the relay is connected in the starting and running circuits of a motor in the well-known manner, with the operating coil 24 in series with the running winding and the contacts 33 and 34 in series with the starting winding. The external circuit connections will be apparent upon reference to Fig. 4 of Patent No. 1,996,599 issued April 2, 1935 to Louis W. Thompson, and the internal circuits of the relay will now be traced. The starting winding circuit may be traced from a common terminal of the relay (not shown) which preferably threadedly engages an aperture (16a) in the strap 16, through the strap 16, the finger 13 secured thereto, the bracket 12, the cantilever spring 28, the spring finger 32, the contacts 33 and 34 and the supporting post 35 which is electrically connected to the starting winding of the motor. Likewise, the running winding circuit may be traced from the common terminal through the strap 16 and the finger 13 to a terminal screw 39 which secures one terminal 40 of the coil 24 to the frame 21. From the terminal 40 the circuit may be traced through the coil 24 to the terminal 41 secured by a terminal screw 42 to a terminal post 43 which is electrically connected to the running winding of the motor.

It will be apparent now that when the motor (not shown) is connected to a suitable source of alternating-current through the relay, there will be a rush of current through the operating coil 24 which is connected in the running winding circuit of the motor. The magnetic flux produced by energization of the coil 24 will cause the armature to move toward the frame 21 and close the contacts 33 and 34 in the starting winding circuit of the motor. It will be seen that this magnetic flux will flow through two parallel paths, the main portion of the flux flowing through the U-shaped magnetizable frame 21 and the air gap between the pole faces 22 and 23, thereby creating a high intensity magnetic field between the pole faces, and the remainder of the magnetic flux passing through the bracket 12, the cantilever spring 28, the magnetizable armature 29 and the air gap between the armature and the frame 21. Accordingly, the armature 29 will be attracted toward the magnetic frame not only by the flux flowing through the gap between the armature and the frame but also by the leakage flux between the pole faces 22 and 23.

As the armature 29 approaches the high intensity magnetic field between the pole faces 22 and 23, the magnetic attractive force on the armature greatly increases, this force varying substantially inversely as the square of the distance between the high intensity region and the armature. Accordingly the armature moves with a quick action to close the contacts 33 and 34, and it will be observed that by reason of the resilient mounting of the armature 29 and the contact 33, and by reason of the fact that the armature in its attracted position does not rigidly engage the magnetizable frame 21 or any other stationary member, the relay is substantially noiseless.

As shown, the pole faces 22 and 23 provide a relatively wide region of high intensity magnetic flux within which the armature may come to rest, and the pole face 22 is preferably beveled in order to provide a component of flux at an angle to the main flux between the poles. It will be understood that since the main flux between the poles is substantialy parallel with the armature when the armature is in its attracted position a state of comparative instability may exist between the retractive force exerted by the spring 28 and the magnetic force exerted on the armature. However, the component of flux produced by the beveled face of the pole 22 exerts a steadying pull on the armature, which tends to maintain the armature in a position of equilibrium within the air gap.

As hereinbefore mentioned, the armature 29 and the spring 28 are of relatively light construction and consequently, the armature has a tendency to vibrate in the gap between the pole faces 22 and 23 as the alternating-current excitation varies from a zero to a maximum value during each half-cycle. The short-circuited winding 31, however, which is secured to the armature and arranged to encircle one leg of the frame 21 when the armature is in its attracted position, serves to damp this forced vibration. The damping effect of the short-circuited winding 31 is due

in part to the repulsion force exerted thereon by the magnetic field, which force is in a direction to oppose the magnetic pull on the armature, and in part to the out-of-phase flux produced by the circulating current which is induced in the short-circuited winding. A substantial portion of this out-of-phase flux, which is substantially 90° out of phase with the main flux, passes through the magnetizable frame 21 and through the armature 29 between the pole faces 22 and 23, and since this flux will obtain a maximum value when the main flux is passing through its minimum value, the magnetic pull exerted on the armature by this out-of-phase flux tends to stabilize the armature.

As soon as the contacts 33 and 34 are closed, the motor begins to accelerate and as the motor comes up to speed, the current through the running winding and through the coil 24 decreases. In order that the motor may reach the desired speed before the starting winding is deenergized, the relay is arranged to retain its armature in the attracted position until the energizing current has decreased to a value substantially lower than the value of current necessary initially to attract the armature. The manner in which the relay accomplishes this differential operation may best be understood by observing that the armature initially moves from a field of minimum intensity into a field of maximum intensity whereby the magnetic force on the armature increases, and by observing that in moving to its attracted position, the armature substantially closes both the air gap between the frame 21 and the armature and the air gap between the pole faces 22 and 23. Although the opposing repulsion force on the short-circuited winding 31 also increases as the armature moves into the high intensity field, this increase is of much less magnitude than the increase in the magnetic force.

When the energization of the winding 24 has decreased sufficiently to permit the spring 28 to operate the armature out of the air gap and away from the frame 21, it will be observed that the armature moves from a high intensity field into a field of minimum intensity and accordingly, the armature moves quickly to open the contacts 33 and 34. Movement of the armature away from the frame 21 is arrested by engagement of the armature with the resilient stop 38.

In order more clearly to explain the function of the stop 38, the operation of the armature 29 when released from the air gap will be considered with the stop 38 omitted. It will be apparent that if the coil 24 is deenergized and the armature 29 is suddenly released for operation out of the air gap by the spring 28, the kinetic energy stored in the armature as it is moved will be effective to carry the armature beyond its normal position, and the kinetic energy will then be stored in the spring 28. When sufficient energy has been stored in the spring to bring the armature to rest, the spring will be effective to return the armature towards the normal position and again the armature will move through the normal position and will store energy in the spring. Thus it will be seen that the armature and the spring when once released from the air gap, will vibrate freely about the normal position with a natural periodicity and amplitude of vibration which is dependent upon the moment of inertia of the armature and the strength of the spring.

This free vibration of the armature is not only objectionable from the standpoint of noise but the amplitude of vibration may be sufficient to cause the contacts 33 and 34 to be reclosed each time that the armature vibrates.

Accordingly, I have provided the stop bar 38 arranged to engage the armature 29 as it moves out of the air gap and absorb the kinetic energy of the armature. Preferably the stop 38 is arranged slightly beyond the normal position of the armature in order to minimize the load on the spring when the relay is deenergized. However, it will be apparent that the stop must be arranged closely enough to the normal position of the armature to prevent an appreciable amount of energy being stored in the spring. Likewise I have found that if the stop is located too close to the magnetizable frame 21, the armature 29 will have a tendency to vibrate each time that the energizing current in the coil 24 passes through the maximum value during each cycle. It will of course be understood that in some cases the free vibration of the armature may not be of sufficient magnitude to reclose the contacts and in such cases the stop bar may be omitted, if desired.

It will be apparent now that the operation of the relay is to a large degree dependent upon the frequency of the alternating-current supplied to the relay. While the relay shown in Figs. 1 and 2, which is designed for operation on the usual 60-cycle commercial frequency, will operate satisfactorily over a rather wide band of frequencies, it has been found necessary to modify the relay somewhat as shown in Figs. 3 and 4, in order to prevent excessive vibration of the armature on relatively low frequencies, for example, in the neighborhood of 25 cycles.

Referring to Figs. 3 and 4, it will be observed that the relay here shown is identical with the relay shown in Figs. 1 and 2, except for the construction of the short-circuited winding. In this modification of the relay, the single-turn, short-circuited winding 31 has been replaced by a large double-turn, short-circuited winding 44 secured to the armature 29 by the rivets 45. It will be seen that in this form of the relay, the short-circuited winding 44 encircles both legs of the magnetizable frame 21 when the armature is in its attracted position and accordingly, a greater repulsion force is exerted on the winding 44 than would be exerted on a single-turn winding. In addition to the greater repulsion force exerted, the increased mass of the winding 44 assists in damping the tendency of the armature to vibrate within the air gap, and the relay when so damped is suitable for operation on low frequency currents.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. An alternating-current relay comprising a magnetizable frame having an air gap, a magnetizable armature, a cantilever spring secured to said armature for normally supporting said armature in a position adjacent said frame, said armature and said cantilever spring having a natural amplitude of vibration about said normal position when said armature is moved from said position to stress said spring and then released, means including an operating winding for producing a magnetic flux in said frame to attract said armature from said normal position to a

position within said air gap, means including a short-circuited winding carried by said armature for damping forced vibration of said armature within said air gap, and a stop for preventing free vibration of said armature about said normal position when said armature is released from said air gap, said stop being positioned beyond said normal position but within the natural vibration range of said armature.

2. An alternating-current relay comprising a magnetizable frame having an air gap, a magnetizable armature, a cantilever spring secured to said armature for normally supporting said armature in a position adjacent said frame, said armature and said cantilever spring having a natural amplitude of vibration about said normal position when said armature is moved from said position to stress said spring and then released, means including an operating winding for producing a magnetic flux in said frame to attract said armature from said normal position to a position within said air gap, means including a short-circuited winding carried by said armature for damping forced vibration of said armature within said air gap, and a stop for absorbing the kinetic energy of said armature to prevent free vibration about said normal position when said armature is released from said air gap, said stop being formed of resilient material and being positioned within the natural vibration range of said armature.

3. An alternating-current relay comprising a magnetizable frame having an air gap, an operating winding associated with said frame energizable to provide a high intensity magnetic field in said air gap, a magnetizable armature normally resiliently positioned adjacent said air gap and movable into said air gap in response to the magnetic force exerted due to a predetermined degree of energization of said winding, said armature having a natural amplitude of vibration about its normal position when released from said air gap, means including a short-circuited winding carried by said armature for damping forced vibration of said armature within said air gap, the repulsion force exerted on said short-circuited winding opposing the magnetic force on said armature, said armature substantially closing said air gap when in its attracted position whereby an increased force is exerted on said armature to maintain said armature in said air gap until the energization of said operating winding is reduced below said predetermined value, and stop means for preventing free vibration of said armature upon release of said armature from said air gap.

4. An alternating-current relay comprising a magnetizable frame having an air gap, an operating winding associated with said frame and energizable to provide a magnetic field of high intensity in said air gap, a magnetizable armature, a cantilever spring for normally supporting said armature in a position adjacent said air gap, said armature being arranged to be attracted into said high intensity magnetic field upon a predetermined degree of energization of said winding against the bias exerted by said cantilever spring, the force on said armature increasing as said armature enters said air gap whereby said armature is maintained in said high intensity field until the energization of said operating winding is reduced below the value required for initial operation of said armature, means including a short-circuited winding for damping forced vibration of said armature within said air gap, said cantilever spring operating said armature and said short-circuited winding out of said air gap upon said reduction of energization of said winding, and a stop for absorbing the kinetic energy of said armature to prevent free vibration about said normal position when said armature is moved out of said air gap by said cantilever spring.

5. An alternating-current relay comprising a magnetizable supporting bracket having a U-shaped portion, a plurality of U-shaped magnetizable plates secured to said U-shaped portion of said bracket in face-to-face relation to form a laminated frame having an open end, a U-shaped magnetizable armature, a cantilever spring, means securing one end of said spring to another portion of said bracket and the other end of said spring to the legs of said U-shaped armature, the yoke portion of said armature being normally positioned adjacent the open end of said laminated frame, means including an operating winding on said frame for operating said armature from said normal position to a position in which the yoke portion of said armature nests between the legs of said laminated frame, a finger extending outwardly from one leg of said frame between the legs of said armature, and stop means carried by said finger for limiting the movement of said armature away from said frame under the influence of said cantilever spring upon a decrease in the energization of said operating winding.

6. A relay comprising a U-shaped magnetizable frame, a U-shaped magnetizable armature, means for resiliently supporting said armature substantially at right angles to said frame with the yoke portion of said armature in alignment with the gap between the legs of said U-shaped frame, said yoke portion being normally positioned outwardly from the ends of said frame legs, means including an operating winding associated with said frame energizable to operate said armature to a position in which said yoke nests between the legs of said frame, one of said frame legs nesting within said armature, said resilient supporting means being effective to move said armature away from said frame upon a decrease in the energization of said operating winding, a finger extending outwardly from said one frame leg between the legs of said U-shaped armature, and stop means comprising a bar supported intermediate its ends on said finger for limiting the movement of said armature by said resilient means, the ends of said bar extending into the path of movement of the legs of said armature.

7. An alternating-current relay comprising a laminated magnetic frame having a plurality of substantially rectangular poles, an inner lamination of said frame having a portion extending outwardly from a side of one of said poles, an operating coil for said relay comprising a spool of insulating material surrounding said one pole, the dimensions of said extending portion being such that when said coil is pressed onto said pole, said spool is forced into intimate engagement with said extending portion and with the remote corners of said rectangular pole whereby a rigid three-point support for said coil is provided.

8. An alternating-current relay comprising a magnetizable supporting bracket having a U-shaped portion, a plurality of U-shaped magnitizable plates secured on opposite sides of said U-shaped bracket portion in face-to-face relation to form a laminated magnetizable frame having substantially rectangular poles, said

bracket portion forming a lamination of said frame and having an ear extending outwardly from one of said poles adjacent the base of said pole, an operating coil for said relay comprising a spool of insulating material surrounding said pole, said spool being arranged to engage said ear when said coil is pressed onto said pole, whereby said spool is forced into intimate engagement with said ear and with the remote corners of said pole to provide a rigid three-point support for said coil.

ALLEN G. STIMSON.