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T. G. GRAU ET AL
MAGNETICALLY LATCHING TYPE RELAY CONTAINING
A FLUX LIMITING CONstriction
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3,401,367

FIG. 1

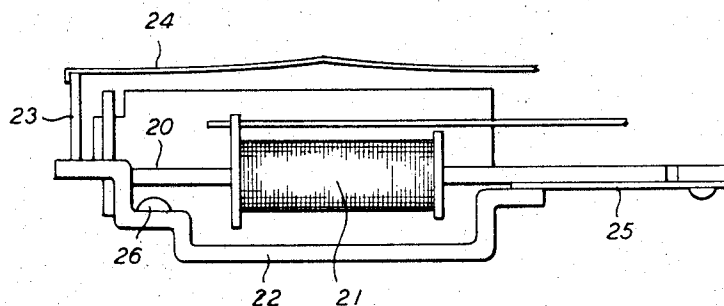


FIG. 2

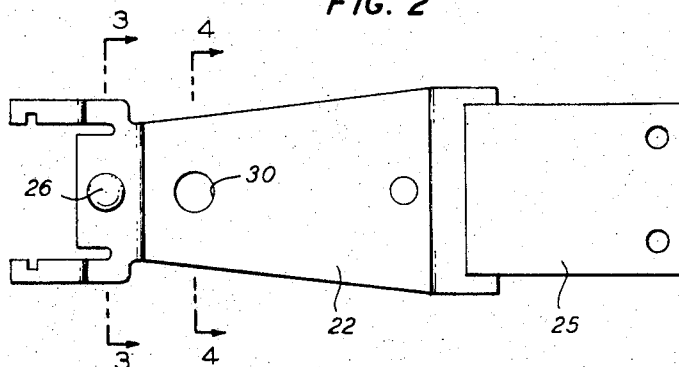


FIG. 3

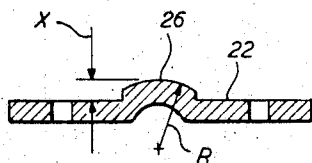
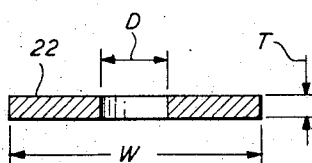
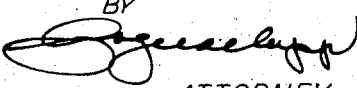


FIG. 4



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MAGNETICALLY LATCHING TYPE RELAY CONTAINING A FLUX LIMITING CONstriction

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ABSTRACT OF THE DISCLOSURE

A magnetic latching wire spring relay is disclosed wherein the armature includes a serial section of flux conducting cross-sectional area which is reduced with respect to its remaining flux conducting cross-sectional area.

This invention relates to relays and more particularly pertains to the type in which the armature latches magnetically.

Broadly, the object of this invention is to achieve operating stability in latching type relays.

For its latching function, a magnetically latching relay depends on a remanent material disposed somewhere in its magnetic circuit. Typically, the core is the component which contains the remanent material.

The usual operating cycle of a magnetically latching relay begins with the armature open. The cycle starts when a magnetic flux pulse is applied to the relay's magnetic circuit in order to move the armature to a closed position against the core. Once moved to the closed position, the armature is held there by the remanent flux which remains in the magnetic circuit after the initial flux pulse is gone.

The cycle is complete when a second flux pulse restores the armature to its open position. The second flux pulse has a polarity opposite to the first flux pulse. Hence, it opposes the remanent holding flux retained by the core. When these opposing fluxes interact, and the resultant drops below a predetermined value, a biasing arrangement acting on the armature compels it to return to its open position thereby completing the operating cycle.

Latching force and release time are particularly significant characteristics of magnetically latching relays. Latching force is the force which holds the armature in the closed position and its magnitude is a function of the amount of remanent flux remaining in the magnetic circuit after the initial flux pulse has been removed. Since latching force should be as large as reasonably possible, the larger the remanent flux, the better.

Release time, on the other hand, is the time required for the armature to move from its closed position to its open position. It, too, depends upon the magnitude of remanent flux remaining in the magnetic circuit after the initial flux pulse has been removed; viz, the greater the remanent flux which must be overcome, the longer it takes before the armature can start to move toward its open position. For fast release time, therefore, the smaller the remanent flux, the better.

Clearly these two requirements oppose each other. Hence, the best relay designs have heretofore been compromises. For example, in the AM relay, which is used extensively in the Bell Telephone System, the latching force is limited to about 175 grams in order to achieve release times in the range of 5 to 8 milliseconds.

In relays of the AM type, the remanent flux in the magnetic circuit concentrates in a flux path linking a dome projecting from the end of the armature and a portion of the core which the dome contacts when the armature is in the closed position. In the AM relay itself, the dome

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projects above the armature .006 inch and has a radius of 1.5 inches, the remanent flux has a value of 3300 maxwells, and the biasing force acting on the armature does not exceed a maximum of 270 grams. With these characteristics, the AM relay exhibits the release time range and latching force specified.

While the release time range and latching force presently available in AM relays are generally satisfactory, the latching force is very close to the minimum level tolerable. In fact, minor manufacturing variations in the armature, such as dome radius, core hardness, material, or the like, cause the latching force to drop below a useful level.

It is, therefore, a specific object of this invention to increase latching force without increasing release time.

Latching force is directly proportional to the square of the remanent flux passing from the dome to the core when the dome and core are engaged. Heretofore, the flux saturation level of the flux path between the dome and the core has been the limiting factor in determining the amount of remanent flux available to establish latching force. In short, the permeability of the flux path is such that it saturates before any other portion of the magnetic circuit. In the AM and similar type telephone relays, reluctance, and hence the saturation level, of the flux path is adjusted by carefully fabricating the dome; viz, in the AM relay, a radius of 1.5 inches and a height above the armature surface of .006 inch.

As indicated above, however, the latching force obtained from flux delivered from a dome having a radius of 1.5 inches and a height of .006 inch is close to the minimum level tolerable and minor manufacturing deviations regularly produce latching forces which are too low. As a result, an unduly large number of relays must be rejected during manufacture.

Sensitivity to manufacturing deviations is basically a function of the dome's ability to use remanent flux effectively. In general, the smaller the dome's radius, the less efficiently it uses the flux. Moreover, in the case of a small radius dome, small changes in characteristics such as radius produce large changes in flux usage.

Large domes, on the other hand, are more efficient flux users and function with comparative insensitivity to minor changes. In other words, manufacturing deviations produce much smaller flux variations and commensurate latching force variations where large radius domes are used than where small radius domes are used.

It is, therefore, another specific object of this invention to increase the size of domes which can be used on latching type relay armatures.

According to a preferred embodiment of this invention, the magnitude of the remanent flux available in the magnetic circuit is limited to a value below the saturation value of the effective flux path which conducts flux between the armature and the core. As a consequence, a large dome can be used. When a large dome is used with a small remanent flux, its greater flux using ability produces the same latching force as does an inherently inefficient small dome using a large remanent flux. Thus, while both arrangements produce the same latching force, the one using a large dome does so with relative insensitivity to manufacturing variations.

Furthermore, the large dome arrangement, in conjunction with a flux restriction in the magnetic circuit, not only reduces manufacturing sensitivity, but it also shortens release time. As explained before, the release time interval is shortened when the magnitude of the remanent flux is reduced. Thus, since a smaller remanent flux is used, this invention produces a double advantage.

A more complete understanding of this invention will be aided by the following detailed description when taken in conjunction with the drawing in which:

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FIG. 1 is an elevation view of a motor assembly made in accordance with this invention and adapted for use in a magnetically latching relay;

FIG. 2 is a plan view of the armature and hinge used in the motor assembly shown in FIG. 1;

FIG. 3 is a section view taken along the line 3—3 of the armature shown in FIG. 2;

FIG. 4 is a section view taken along the line 4—4 of the armature shown in FIG. 2.

A preferred embodiment of a motor assembly 10 for use in a magnetically latching relay is shown in FIG. 1. An entire magnetically latching relay would also include a contact assembly but this invention applies solely to the motor assembly 10. Therefore, a contact assembly is not shown. Any suitable contact assembly, however, can be used and, for a typical example, see Patent 2,682,584 issued to H. M. Knapp on June 29, 1954. While the contact assembly shown in the Knapp patent is typical, some modification would be required to match it to the motor assembly 10 disclosed herein. Such modification, however, would easily be within the abilities of one skilled in the art.

The motor assembly 10 comprises a core 20, a coil 21, an armature 22, a card 23 and a return spring 24. In the embodiment shown in FIG. 1, the coil 21 is the filled type and fits around the core 20. While a filled type coil is disclosed, others such as the bobbin type are equally suitable.

The armature 22 is made of a magnetic material such as soft magnet iron and extends around the coil 21. One end engages the core 20 through a hinge 25, while the other end engages the core 20 through a dome 26. The armature 22 and the core 20 interact with each other in response to magnetic flux flowing through the dome 26. Specifically, when flux flows through the dome 26, the armature 22 is attracted toward the core 20.

The dome 26, as shown in FIG. 3, is pressed into the body of the armature 22. In the embodiment being described, the dimension X is the height it projects above the surface of the armature 22 while the dimension R is a radius. For satisfactory results X is .006 inch while R ranges from 2 to 5 inches. While the X dimension need not be exactly .006 inch, .006 inch has been found to work quite well.

The card 23 and the return spring 24 cooperate to transmit armature movement to a suitable contact assembly (not shown). Furthermore, the return spring 24 interacts with the contact assembly to produce a biasing force which urges the armature 22 away from the core 20. The card 23 is conveniently made of a plastic material and directly attached to the armature 22. The return spring 24, on the other hand, is attached to the card 23 at one end and to a support assembly (not shown) at the other end. In the embodiment being described, the return spring 24 is arranged so that the maximum force exerted on the armature 22 by the card 23 will not exceed 270 grams. The magnitude of the return spring force, and, hence, the card force exerted on the armature, is readily adjusted to accommodate various contact assemblies merely by modifying the bend in the return spring 24.

The purpose of the core 20 is to transmit flux generated by the coil 21. Moreover, it is made from a remanent material and thus also stores and transmits remanent flux. In both cases, it transmits the flux to and from the armature 22. In the embodiment being described, the core 20 has a coercive force in the range of 12 to 14 oersteds. In order to provide this level of remanent flux, the core 20 is conveniently made from C-1045 steel hardened to 35 to 40 on the Rockwell C scale.

In operating the motor assembly 10, a suitable voltage pulse is applied to the coil 21. In the particular embodiment being described, the pulse is negative and has a magnitude in the order of 43 to 53 volts. As a result, a first flux pulse is generated. The first flux pulse flows through the magnetic circuit of the motor assembly 10,

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viz, through the core 20, the armature 22, and the air gaps located at the hinge spring 25 and the dome 26.

The first flux pulse sets up a force which attracts the armature 22 until the dome 26 makes contact with the core 20. In addition, the first flux pulse establishes a predetermined magnitude of remanent flux in the core 20, viz, approximately 2800 maxwells. As a result, when the first flux pulse disappears, the force established by the remanent flux holds the dome 26 against the core 20.

As the armature 22 moves under the influence of the first flux pulse toward the core 20, the card 23 also moves. This card movement is available for application to open or close contacts in a suitable contact assembly.

The operating cycle of the motor assembly 10 is complete when a second voltage pulse of positive potential and a magnitude in the order of 20 to 26 volts is applied to the coil 21. The second voltage pulse establishes a second flux pulse in the core 20 which has an opposite magnetic polarity to the first flux pulse. As a result the remanent flux stored in the core 20 by the first flux pulse is opposed. When the net or resultant flux in the core 20 drops low enough, the force between the dome 26 and the core 20 becomes insufficient to overcome the biasing force exerted by the return spring 24 and the armature 22 moves away from the core 20.

As the armature 22 moves away from the core 20, the card 23 again moves but this time in a reverse direction. Hence, any switching states established by the card's initial movement will be reversed. Thus, the operating cycle has been returned to its starting condition and is ready to begin again.

In the embodiment being described, a portion of the magnetic circuit is arranged to magnetically saturate before the flux path linking the dome 26 and the core 20; viz, a portion of the armature 22. As can be seen from FIGS. 1, 2 and 4, the cross section of the armature 22 coinciding with the diameter of the hole 30 is reduced with respect to the rest of the armature and, hence, functions as a flux limiting restriction. In short, it acts as a sort of flux bottleneck.

In the cross section illustrated in FIG. 4, the dimension D is the diameter of the hole 30 while the dimensions T and W are the thickness and width of the armature 22, respectively. In the embodiment being described, D is .296 inch, T is .064 inch, and W is .709 inch. When the armature 22 is fabricated with these dimensions and operated under the conditions specified, the flux limiting cross section of the armature in the vicinity of the hole 30 magnetically saturates before any other portion of the magnetic circuit and thereby limits the amount of flux in the magnetic circuit of the motor assembly 10; specifically, to a magnitude of about 2800 maxwells. As a result, the motor assembly 10 exhibits a shorter release time than similar motor assemblies in other latching type relays. Furthermore, where the radius of the dome 26 falls within the range specified, e.g. 2 to 5 inches, a substantial latching force is also obtained.

When the modified version made in accordance with this invention is compared with an unmodified AM type relay, the modified version shows a marked improvement. For example, in the unmodified AM type relay having a 1.5 inch dome radius, the net latching force is typically 170 to 180 grams and the return time is about 8 milliseconds. In relays made in accordance with this invention and having a dome radius of 2.5 inches and an armature having its cross section reduced by a .296 inch diameter hole, the net latching force measures 250 grams and the maximum release time 8.00 milliseconds. Moreover, when the dome radius is increased to 5 inches, the net latching force measured in the modified relay increases to 283 grams without significantly changing the release time. Similar results are achieved when the dimension D ranges from .281 to .344 inch.

In summary, therefore, a preferred embodiment of a motor assembly has been described and disclosed in

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which the latching force of a magnetic latching relay is increased without a concurrent increase in release time. Furthermore, the increase in latching force has been achieved with armatures having dome radii ranging from 2 to 5 inches. For the purpose of illustration, only one embodiment has been described. It will be understood, however, that this embodiment is merely one of many which will occur readily to those skilled in the art and which will fall within the scope of this invention.

What is claimed is:

1. In a magnetically latching relay, the combination comprising:

a magnetic core;

an armature including a raised dome magnetically linked to said core by a flux path, said armature being arranged to move said dome toward said core in response to a first flux pulse, to hold said dome and said core together in response to a remanent flux, and to separate said dome and said core in response to a second flux pulse, said first and second flux pulses having opposite magnetic polarities; magnetic means including said core for supplying said first flux pulse to said armature in response to a first electrical potential, for supplying said second flux pulse to said armature in response to a second electrical potential, for establishing said remanent flux in response to said first flux pulse, and for reducing the magnitude of said remanent flux in response to said second flux pulse, said remanent flux having a magnitude sufficient to hold said dome and core together after they are joined but insufficient to join said dome and core when they are apart;

biasing means for urging said armature away from said core; and

flux restricting means for limiting the magnitude of said remanent flux to a value less than the lowest saturation value of said flux path.

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2. A combination in accordance with claim 1 wherein said dome has a radius in the range of 2 to 5 inches and a height above the armature surface of approximately .006 inch.

3. A combination in accordance with claim 2 wherein said biasing means comprises a return spring arranged to exert a force on said armature in the order of 270 grams, said first electrical potential is negative and has a value ranging from 43 to 53 volts, and said second electrical potential is positive and has a value ranging from 20 to 26 volts.

4. A combination in accordance with claim 3 wherein said flux restricting means comprises a reduced cross section of said armature.

5. A combination in accordance with claim 1 wherein said dome has a radius in the range of 2 to 5 inches and a height above the armature surface of approximately .006 inch, said armature at its narrowest portion is .064 inch thick, .702 inch wide and contains a hole having a diameter of .296 inch, said biasing means comprises a return spring arranged to exert a force of approximately 270 grams on said armature, said first potential ranges from 43 to 53 volts, said second potential is opposite to said first potential and ranges from 20 to 26 volts, and said core is made of a magnetically remanent material having a coercive force in the range of 12 to 14 oersteds.

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