Aug. 6, 1957 H. F. MARTIN 2,802,078

MAGNETIC LATCH BI-STABLE RELAY

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FIG_1

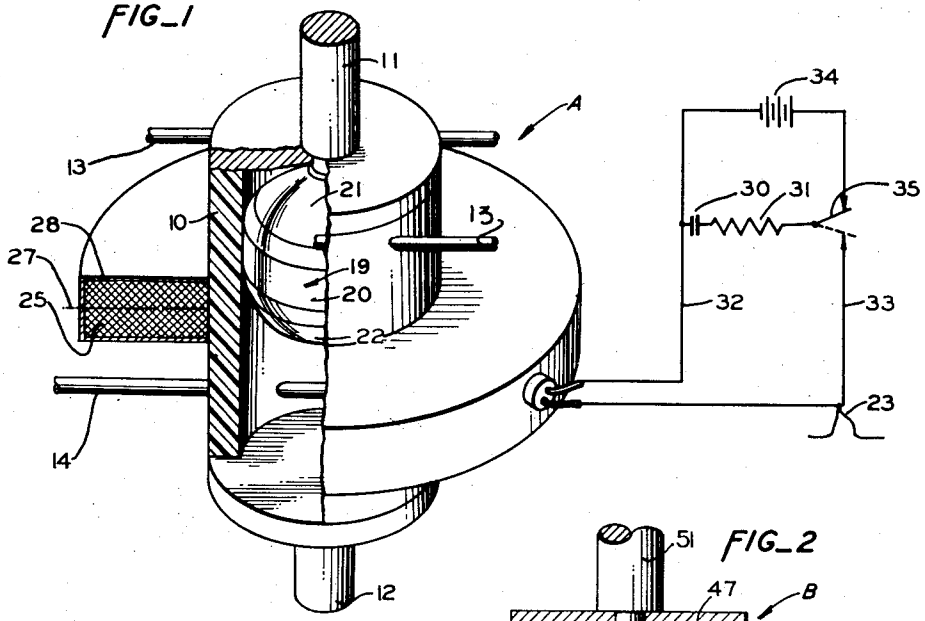


FIG_2

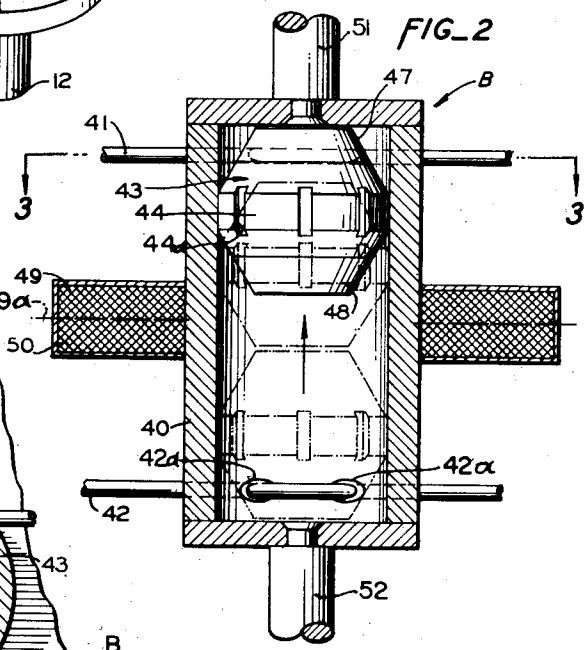
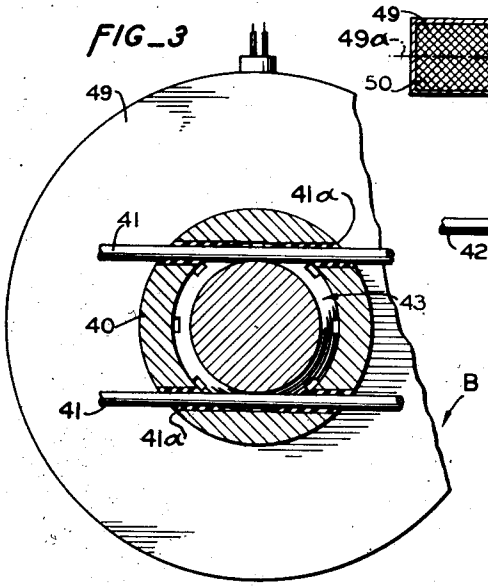


FIG_3



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MAGNETIC LATCH BI-STABLE RELAY

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10 Claims. (Cl. 200—87)

This invention relates to relays, and pertains more particularly to a high-speed, magnetic latch bi-stable relay for actuation in either of two directions by a short-duration pulse of electrical current.

In recent years there has existed a growing need for a small, high-speed relay for use in controlling vacuum tubes, and at times to replace them. It is not essential that such relays be of high current-carrying capacity, but it is important that they have an operating time of approximately one millisecond or less, and that they have a normal life of several million cycles of operation.

I have now devised a simple relay of this type, and one which can be actuated from either of its two operated conditions to the other by a single, short pulse of electrical current through a single actuating coil of the relay, and with no shift of polarity.

An object of the present invention is to provide a simple, improved, bi-stable relay.

Another object is to provide a relay having a pair of magnetized pole-pieces mounted in spaced apart relation, and to drive a magnetically permeable armature along a predetermined path from one pole piece to the other by a short duration pulse through a coil, the mid-plane of which is located intermediately of the pole pieces.

A further object of the invention is to provide a magnetic-latch relay having magnetized pole-pieces and a magnetically permeable armature, a single coil being provided to drive a guided, shuttle-type armature from either pole piece toward the other, and to free the armature while it is still in motion so that its momentum will carry it to the other pole piece.

A further object is to provide a high-speed, pulse-actuated, bi-stable relay with a low-mass, magnetically permeable armature arranged to contact conductors mounted adjacent each of a pair of magnetic pole pieces.

A still further object is to provide a bi-stable relay employing a solenoid type coil centered substantially midway between the two poles of a magnet to effect the transfer of a shuttle type armature from either of said poles to the other.

These and other objects and advantages of the invention will be apparent from the following description, taken in conjunction with the accompanying drawings, consisting of one sheet, wherein:

Fig. 1 is a perspective view of a relay embodying the present invention, portions being broken away and an actuating circuit therefor being indicated diagrammatically.

Fig. 2 is a longitudinal sectional view through a relay of the same general type as that shown in Fig. 1, but embodying a modified form of armature, the armature being shown in solid lines in one actuated position thereof, in dash-one-dot lines during transition, and in dash-two-dot lines in its other actuated position.

Fig. 3 is a sectional view taken along line 3—3 of Fig. 2.

Referring to the drawings, the present invention, as exemplified in Fig. 1, comprises a high speed, bi-stable

relay A having armature guide means such as a tubular housing **10** which may be of non-magnetic material such as plastic. A pair of magnetized pole pieces **11** and **12** are mounted one in each end of the housing **10**. The pole pieces **11** and **12** may be either permanent magnets, or the poles of one or more electro-magnets. In either event, they preferably are of substantially equal magnetic strength, and both preferably are magnetized at all times during operation of the relay.

A pair of electrical contact means, comprising conductors **13** are mounted in one end of the housing **10** and a second pair of conductors **14** are similarly mounted in the other end of the housing for alternate contact by a shuttle type armature **19** mounted for free movement axially within the housing **10**.

The armature **19** is of magnetically permeable material, such as soft iron, and is of generally spherical shape. It may have a cylindrical band **20** formed centrally therearound to maintain the armature against endwise turning within the housing guide means **10**. The armature **19** preferably has a pair of non-tarnishing end contact portions **21** and **22** of high electrical conductivity formed integrally thereon. These end contact portions may be of silver, either plated or soldered in place, to provide an electrically conductive path between the pair of contact conductors **13** or **14** with which it may be in contact.

The armature **19** is moved from one pole piece to the other by a short-duration electrical pulse, indicated by the graph **23** in Fig. 1, through a thin, flat, actuating coil **25** which surrounds a medial portion of the tubular housing **10**. The transverse mid-plane of the coil **25**, indicated by the broken line **27** (Fig. 1) is centered between the pole pieces **11** and **12**. The coil **25** preferably is housed in a shell **28** of magnetically permeable material of low magnetic retentivity.

The actuating current pulse applied to the coil **25** must, of course, be of sufficient strength to generate a magnetic flux field of sufficient magnitude to overcome the magnetic attraction of the pole piece **11** or **12** toward which the armature is at the time attracted, thereby drawing the armature **25** toward an intermediate, dash-one-dot line position of Fig. 2.

The actuating current pulse must also be of sufficiently short duration that the flux field of the coil **25** will collapse while the armature **19** is still in motion from one pole-piece toward the other, and while the armature still retains sufficient momentum to carry it beyond the midpoint between the two pole pieces. As it passes this midpoint, the armature will be more strongly attracted by the magnetic field of the other pole piece than the one from which it has been withdrawn, and thus will be drawn into contact with the conductors of the other pole piece. The armature will be retained in the latter position by the magnetic attraction of the other pole piece until again withdrawn therefrom and hurled toward the first pole piece by a similar re-energization of the coil **25**.

Any tendency of the armature **19** to bounce back from the pole pieces may be reduced or eliminated by causing its spherically curved end portions **21** and **22** to engage the contact wires **13** or **14** instead of the pole pieces **11** and **12**. Reducing the pressure within the housing **10** so that the armature moves in a partial vacuum would also affect the actuating characteristics of the armature.

In a test model of the invention with the interior of the housing filled with air at atmospheric pressure, using a coil **25** of 300 turns of .007 inch diameter magnet wire, an armature **19** of soft iron weighing .015 gram with a length of travel of .040 inch from one pole piece to the other, and energizing the coil with a pulse of 25 volts with a pulse time of 250 microseconds timed by a capacitor-resistance circuit, actual transfer time of the armature **19** was just over one millisecond. By reducing

the length of armature travel, the duration of the pulse, the mass of the armature and the mass effect of the shell **28**, it is anticipated that even faster operation may be attained.

For supplying the coil **25** with a short duration pulse of electrical current, indicated by the graph **23** (Fig. 1) a capacitor **30** and a resistor **31** are shown connected in series by conductors **32** and **33** to a battery **34** for charging the capacitor **30** when a switch **35** is in its solid line position of Fig. 1. When moved to its broken line position of Fig. 1, the switch **35** disconnects the battery **34** from the circuit, and connects the capacitor **30** and resistor **31** in series with the coil **25**, thereby discharging the capacitor through the coil to supply the short duration current pulse indicated by the graph **23**.

For a coil having an inductance of 30 mhy., connected as indicated in Fig. 1, to a one microfarad capacitor and a resistance of 100 ohm, a supply of direct current of 25 volts has been found satisfactory. This provides a pulse of approximately 750 microseconds' duration, peaking at approximately 250 micro-seconds with sufficient intensity to cause transfer of the armature **19** from one pole piece to the other.

In the modified form of the invention shown in Figs. 2 and 3, a relay B has a tubular housing **40** of conductive, but magnetically non-permeable material, such as, for example, aluminum. In such case the contact conductors **41** and **42** are insulated from each other and from the housing **40** by being mounted in insulative bushings **41***a* and **42***a*, respectively, mounted in the tubular housing **40**.

Also, in Fig. 2, the armature **43** is illustrated as having a generally cylindrical central portion **44** with integral truncated, conical, non-tarnishing end portions **47** and **48** of high electrical conductivity. The contact conductors **41** and **42** at opposite ends of the housings are so located that the tapered end portions **47** and **48** will enter between the respective pairs of these contact conductors so as to arrest the movement of the armature just short of contact with the pole pieces. The wedging effect thus produced tends to eliminate bounce. Longitudinal slots **44***a* may be provided in the mid-portion of the armature to avoid air compression by the armature as it is moved from one actuated position to the other.

An actuating coil **49** surrounds the tubular body portion similarly to the coil **25** of Fig. 1, and may be enclosed in a magnetically permeable shell **50** of low magnetic retentivity similar to the shell **28** of Fig. 1. Magnetized pole pieces **51** and **52** similar to the pole pieces **11** and **12** of Fig. 1 are mounted at the ends of the tubular housing **40**. The medial plane of the coil **49**, indicated by the broken line **49***a* is located between the pole pieces **51** and **52**.

The relay B shown in Fig. 2 may be operated by the same circuit as that shown in Fig. 1 and of course either relay may be actuated by any circuit capable of generating a current pulse of sufficient intensity to withdraw the armature from the pole piece toward which it is attracted at the time, and of sufficiently short duration to free the armature in time so that its inertia will carry it within the field of major attraction of the other pole piece. Since many such circuits are well known to those familiar with the art, and since they form no part of the present invention, they will not be described herein.

While I have illustrated a preferred form of the invention, and one modification thereof, it will be understood however, that various changes and modifications may be made in the details thereof without departing from the scope of the invention as set forth in the appended claims.

Having thus described the invention, what I claim as new and desire to protect by Letters Patent is defined in the following claims.

I claim:

1. A magnetic latch, bi-stable relay comprising a straight tubular non-magnetic housing, a pair of magnetized pole pieces mounted one in each end of said housing in spaced apart relation, a magnetically permeable armature formed with a cylindrical mid-portion fitted slidably within the housing for guided movement of the armature between the pole pieces, a convergent face formed on an end of the armature, a contact member mounted at one end of the housing for wiping, armature arresting, contact with the convergent face of the armature, and a coil surrounding a medial portion of the housing for driving the armature along a straight path from one pole piece toward the other within the housing upon energization of the coil by a short pulse of electrical current.

2. In a magnetic latch bi-stable relay, a housing, a pair of magnetized pole pieces mounted in spaced apart relation in said housing, a magnetically permeable armature mounted within said housing for straight line shuttle movement between said pole pieces, armature arresting means mounted within each end of the housing for arresting the armature in slightly spaced relation to the pole pieces, and a coil mounted with its transverse mid-plane located intermediately of said pole pieces for magnetization by a short duration pulse of electrical current of sufficient magnitude to withdraw the armature from either of said pole pieces and to hurl it toward the other of said pole pieces for release by the coil while the armature still retains sufficient momentum to carry it into the magnetic field of the other pole piece.

3. In a magnetic latch bi-stable relay a pair of magnetized pole pieces mounted in spaced apart relation, a magnetically permeable armature mounted for shuttle movement between said pole pieces, and a coil mounted with its transverse mid-plane located intermediately of said pole pieces for magnetization by a short duration pulse of electrical current of sufficient magnitude to withdraw the armature from either of said pole pieces and to hurl it toward the other of said pole pieces, and circuit means operatively connected to the coil for generating an electrical pulse of sufficiently short duration to allow the coil magnetic field to collapse and free the armature while the latter still has sufficient momentum to carry it into the magnetic field of the other pole piece.

4. A magnetic latch bi-stable relay comprising a pair of magnetized pole pieces mounted in spaced apart relation, armature guide means defining a straight path extending between said pole pieces, a magnetically permeable armature mounted for straight line movement along said guide means between said pole pieces, said armature being of a size for magnetic latching to either of said pole pieces, a flat coil surrounding said guide means, the mid-plane of the coil being located substantially midway between said pole pieces, whereby when said coil is energized by a short duration pulse of electrical current of predetermined minimum magnitude and shortness of duration, the armature will be withdrawn from either of said pole pieces to which it is magnetically latched, and will be hurled toward the other of said pole pieces for release by collapse of the coil magnetic field while the armature still has sufficient momentum to carry it into magnetically latched engagement with the other pole piece.

5. A magnetic latch bi-stable relay comprising a housing, a pair of magnetized pole pieces mounted in spaced apart relation in said housing, a pair of contact members exposed within an end of said housing, a magnetically permeable armature fitted slidably within said housing for guided, straight line, shuttle movement between said pole pieces, said armature being of a size for magnetic latching to either of said pole pieces, a tapered contact portion of high electrical conductivity integral with an end of said armature for wedging between said pair of contact members when magnetically latched to one of the pole pieces, a coil surrounding said housing, the mid-plane of the coil being located substantially midway between said pole pieces, whereby when said coil is energized by

a short duration pulse of electrical current of predetermined minimum magnitude and shortness of duration, the armature will be withdrawn from either of said pole pieces with which it is magnetically latched, and will be hurled toward the other of said pole pieces for release by collapse of the coil magnetic field while the armature still retains sufficient momentum to carry it into magnetically latched engagement with the other pole piece.

6. A magnetic latch, bi-stable relay comprising a pair of magnetized pole pieces mounted in spaced apart relation, an armature of magnetically permeable material mounted between said pole pieces for travel along a predetermined path therebetween, a non-tarnishing element applied to an end of the armature and having a contact surface thereon disposed at an acute angle to the path of armature travel, contact means adjacent an end of the path of armature travel positioned for engagement by the contact surface of said non-tarnishing element in a position to arrest the armature just short of engagement with the pole piece, thereby to provide a wiping, arresting action on the armature, and a solenoid type coil surrounding the path of armature travel at a medial point thereof for energization by a short duration pulse of electrical current to drive the armature from magnetically latched condition adjacent one pole piece to magnetically latched condition adjacent the other pole piece.

7. A magnetic latch, bi-stable relay comprising a pair of magnetized pole pieces mounted in spaced apart relation, a straight tubular housing sealed co-axially to said pole pieces and enclosing the space therebetween, an armature of magnetically permeable material mounted between said pole pieces and fitted for axial slidable movement within said housing for travel between said pole pieces, electrical contact means mounted in an end portion of said housing for engagement by the armature at its limit of travel toward a pole piece, and a solenoid type coil surrounding the path of armature travel at a medial point thereof for energization by a short duration pulse of electrical current to drive the armature from magnetically latched condition adjacent one pole piece to magnetically latched condition adjacent the other pole piece.

8. In a magnetic latch relay wherein a magnetically permeable armature is mounted for movement along a predetermined straight path between a pair of spaced-apart magnetized pole pieces either of which pole pieces is of sufficient strength to retain the armature magnetically latched thereto; a solenoid coil medially surrounding the path of armature movement and means for energizing the coil by a pulse of electrical current of sufficient magnitude to create a magnetic flux field of sufficient strength to overcome the magnetic attraction of the

armature toward a pole piece to which it is latched and to draw the armature toward a medial point in its path, the pulse being of sufficiently short duration to cause the flux field of the coil to collapse and free the armature while the latter retains sufficient momentum to carry it into latched relation with the other pole piece.

9. In a bi-stable magnetic latch relay, a pair of magnetized pole pieces mounted in spaced-apart relation, armature guide means defining a straight path between the pole pieces, an armature of magnetically permeable material mounted for shuttle movement along the straight path defined by said guide means back and forth between said pole pieces, said armature being of a size for magnetic latching to either of said pole pieces when adjacent thereto; shuttle actuating means comprising a coil surrounding the path of armature movement at a medial point thereof for energization by a pulse of electrical current of sufficient magnitude and shortness of duration to alternately hurl the shuttle back and forth along its path from latched condition adjacent one pole piece to latched condition adjacent the other pole piece.

10. A bi-stable, magnetic-latch relay comprising a pair of aligned magnetized pole pieces spaced apart in their direction of alignment, a straight tubular housing of magnetically non-permeable material enclosing the space between the pole pieces, an armature of magnetically permeable material fitted slidably within the housing for movement lengthwise of the housing between the pole pieces, said armature being of a size to latch magnetically to either of said pole pieces when adjacent thereto, a flat, solenoid-type coil surrounding the housing medially of the path of armature travel therein, a shell of low-retentivity, magnetically permeable material on the coil, and means for energizing the coil by a short duration pulse of electrical current of predetermined minimum magnitude, whereby the magnetic attraction of the armature toward the pole piece to which it is latched is overcome by the magnetic flux field of the coil to draw the armature toward a medial position in the housing, and the flux field of the coil is collapsed in time to free the armature while the latter retains sufficient momentum to carry it into latched relation with the other pole piece.

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