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MAGNETICALLY LATCHABLE RELAY

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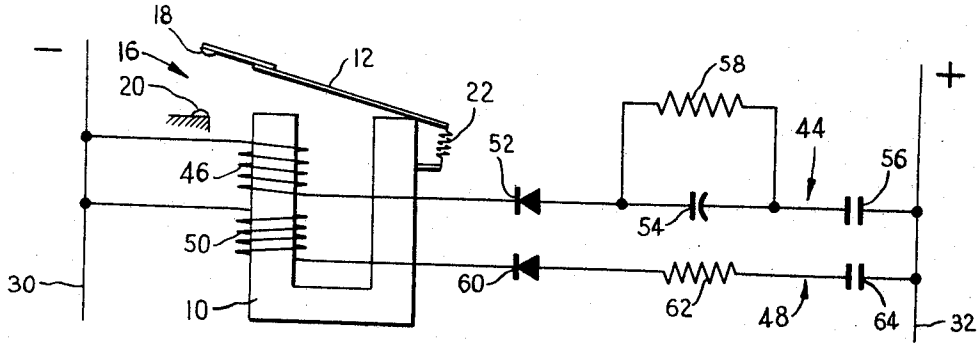

INVENTOR.
GEORGE M. EULER
BY David M. Schiller
ATTORNEY

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MAGNETICALLY LATCHABLE RELAY

George M. Euler, Normal, Ill., assignor to General Electric Company, a corporation of New York

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ABSTRACT OF THE DISCLOSURE

A magnetically latchable relay which is latched by energization of a circuit which provides a large inrush current to a latching coil and is unlatched by energization of an unlatching coil. The large inrush current is provided by connecting a capacitor in series with the latching coil and a diode for energization from an AC or a DC source.

This invention relates to electromagnetically operated relays and has particular relation to magnetically latchable relays.

Relays of the magnetically latchable type have been proposed heretofore and generally include a magnetic core and a movable magnetic armature with a coil surrounding the core, the core being formed of a special material which exhibits a very high magnetic retentivity and a high permeability. When the coil is energized, the armature is attracted to the core and sufficient residual flux is established so that when the coil is deenergized, the armature remains attracted to the core.

Previous designs of magnetically latchable relays have suffered from several disadvantages. Among these is the high cost of the special core material employed. Further, previous designs have included a latching coil with a large number of turns and have employed high currents to obtain the necessary magnetizing force to assure sufficient residual flux to maintain the armature in engagement with the core when the coil is deenergized. Such designs require that the coil be capable of dissipating large amounts of power especially in applications wherein the latching circuit is energized for relatively long periods of time. An example of a previous design of magnetically latchable relay is found in U.S. Patent 3,128,418.

It is therefore an object of the present invention to provide a novel and improved magnetically latchable relay having a latching coil with means for supplying a large inrush current to the coil which thereafter decreases to a relatively low steady state value.

It is another object of the invention to provide a novel and improved magnetically latchable relay of inexpensive design including a core formed of conventional electrical steel and an armature formed of material exhibiting both a moderately high residual flux density and a moderately high coercive force.

It is a further object of the invention to provide a novel and improved magnetically latchable relay of inexpensive and efficient design utilizing readily available and low cost components and magnetic materials.

In carrying out the invention in one form a magnetically latchable relay is provided including a core and an armature mounted for movement relative to the core. A switch is arranged for operation in response to movement of the armature, and restoring means is provided to urge the armature out of engagement with the core. Coil means surrounds the core and is connected to latching and unlatching circuits adapted for energization from a source of voltage. The core is formed of conventional high silicon electrical steel containing approximately 1½% silicon, whereas the armature is formed of a material exhibiting a moderately high residual flux density of from 5000 to 6000 gauss and a moderately high coercive force of from 50 to 60 oersteds. A material suitable for the armature is a readily available chrome magnet steel containing about 5% chromium. The armature is the high coercive force portion of the magnetic circuit. The latching circuit includes a device such as a capacitor which supplies a high inrush current to the coil means which quickly reduces to a low steady state value. Each of the latching and unlatching circuits includes switch means for controlling energization of the respective circuits.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing in which

The figure is a diagrammatic representation of a magnetically latchable relay constructed in accordance with the present invention.

Referring now to the drawing there is diagrammatically illustrated a magnetically latchable relay constructed in accord with the present invention. The relay shown is capable of energization from either a direct voltage or an alternating voltage source and includes a laminated generally U-shaped core **10** formed of a suitable magnetizable material such as conventional high silicon electrical steel. The relay also includes a magnetic armature **12** which is mounted for movement in any suitable manner relative to the core **10**. As illustrated, the armature **12** is mounted for pivotal movement at the upper end of the right-hand leg of the core **10**. The material of the armature is described hereinafter. The present invention is applicable to the relay disclosed in application S.N. 352,005, now Patent No. 3,236,969, filed Mar. 16, 1964, by G. M. Euler entitled "Electromagnetically Operated Relays" and assigned to the assignee of the present invention.

A suitable switch **16** is operated in accord with movements of the armature **12** and as diagrammatically shown, the armature supports a movable contact **18** for movement with respect to a fixed contact **20**. In the normal position of the armature **12** as illustrated, the armature is spaced from the core **10** whereas the contacts **18** and **20** are likewise spaced from each other. Suitable restoring means in the form of a spring **22** is associated with the armature **12** to maintain the armature in its normal position spaced from the core. In order to magnetize the core **10** to attract the armature **12** to the core **10**, there is provided coil means surrounding the core **10** and adapted for energization from a suitable source of voltage. In the embodiment illustrated the coil means is energized from a direct voltage source represented by the conductors **30** and **32** having the polarity shown by the associated plus and minus signs. The coil means preferably comprises a pair of separate coils **46** and **50** oppositely wound on the core **10**. In order to control energization of the coils **46** and **50** a pair of electrically separate latching and unlatching circuits **44** and **48** respectively include the coils **46** and **50** and are connected across the source of voltage represented by conductors **30** and **32**. The provision of separate latching and unlatching circuits avoids undesired sneak circuits therebetween.

As previously stated, the material of the core **10** is conventional high silicon electrical steel which typically contains .08% carbon, .5% manganese, .05% phosphorus, .045% sulphur, 1.5–2% silicon, .45–.55% aluminum and the remainder iron. The coercive force of this material is about one oersted. In accord with the invention the armature **12** is formed of a readily available comparatively low cost material which exhibits a moderately high residual flux density, a moderately high coercive force and a fairly high permeability. The material preferably employed for the armature **12** is a chrome magnet

steel known as Sparta steel AISI–A2. Such material typically contains 1.00% carbon, .65% manganese, 5.25% chromium, .30% silicon, .25% vanadium, 1.10% molybdenum with the remainder iron. Such steel has particularly advantageous magnetic properties for purposes of the invention when heated at 1700° F. for twenty minutes, quenched in oil, and tempered at 300° F. for two hours. Upon the application of a maximum magnetizing force of about 300 oersteds, a saturation induction of approximately 10,800 gauss is obtained. The maximum residual flux density realized when the magnetizing force is reduced to zero is of the order of 5,400 gauss. Also, this material exhibits a coercive force of about 57 oersteds and the permeability is approximately 80. The armature **12** is the high coercive force portion of the magnetic circuit and exhibits a coercive force which is about fifty times that of the core **10**.

The latching circuit **44** includes in series with the coil **46**, a diode **52**, a capacitor **54**, and a switch **56**. A resistor **58** is connected in parallel with capacitor **54**. The switch **56** may be controlled in any suitable manner and when the switch **56** is closed, a pulse of direct current traverses the coil **46** to effect magnetization of the core **10** to an extent sufficient to attract the armature **12** to the core against the bias of spring **22**. The capacitor **54** provides a high inrush current to the coil **46** to produce a strong magnetizing force with a small number of turns of the coil **46**. When the switch **56** is opened, a residual flux is established in the magnetic circuit which results from the fairly high coercive force of armature **12** and which is effective to hold the armature in engagement with the core. Resistor **58** operates to discharge the capacitor **54** when switch **56** is opened to permit repeated operation of the device. The high inrush current is quickly reduced to a low steady state value resulting in low power applied to the coil **46** if the switch **56** is kept closed for an extended period as required in certain applications.

The unlatching circuit **48** includes in series the coil **50**, a diode **60**, a resistor **62**, and a switch **64**. When switch **64** is closed, direct current flows through coil **50** to establish a magnetizing force effective to reduce the residual flux to a level below that sufficient to overcome the force of the spring **22** and maintain engagement of the armature with the core. As a result, the spring **22** returns the armature to its normal illustrated position. The coercive force of the magnetic circuit is less than that of the armature material and does not require excessive magnetizing force to unlatch the armature.

The diodes **52** and **60** are poled in the same direction and are effective to prevent undesired current flow in the associated circuit in response to voltage induced in the associated coil as a result of current flow in the other circuit. The diodes also permit energization of the device from an alternating voltage source rather than from a direct voltage source. If desired, the capacitor **54** can be replaced by a miniature incandescent lamp which also is capable of providing a high inrush current and low steady state current.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications are possible and it is intended to cover all modifications falling within the spirit and scope of the invention.

I claim:

1. A magnetically latchable relay comprising in combination, a magnetic circuit including a core formed of magnetizable material, and an armature formed of magnetizable material, means mounting said armature for movement into and out of engagement with said core, a switch operable in response to movement of said armature, restoring means urging said armature out of engagement with said core, coil means surrounding said core, a latching circuit adapted for energization from a source of voltage, said latching circuit including in series said coil means, a rectifier, and an inrush current producing device, means controlling energization of said latching circuit to effect energization of said coil means through said inrush current producing device and move said armature into engagement with said core, said magnetic circuit when said armature and core are engaged providing a residual flux having a value sufficient to maintain engagement of said armature and core when said latching circuit is deenergized, an unlatching circuit connected to said coil means for energization from a source of voltage, and means controlling energization of said unlatching circuit to effect energization of said coil means so as to reduce said residual flux to a value which permits said restoring means to move the armature out of engagement with said core.

2. A relay as defined in claim **1** wherein the armature is formed of a chrome magnet steel with at least five percent chromium, and the core is formed of high silicon electrical steel.

3. A magnetically latchable relay comprising in combination, a magnetic circuit including a core formed of magnetizable material, and an armature formed of a magnetizable material, means mounting said armature for movement into and out of engagement with said core, a switch operable in response to movement of said armature, restoring means urging said armature out of engagement with said core, coil means surrounding said core, a latching circuit adapted for energization from a source of voltage, said latching circuit including in series said coil means, a rectifier, and a capacitor, a resistor in parallel with said capacitor, means controlling energization of said latching circuit to effect energization of said coil means through said capacitor and move said armature into engagement with said core, said magnetic circuit when said armature and core are engaged providing a residual flux having a value sufficient to maintain engagement of said armature and core when said latching circuit is deenergized, an unlatching circuit connected to said coil means for energization from a source of voltage, and means controlling energization of said unlatching circuit to effect energization of said coil means so as to reduce said residual flux to a value which permits said restoring means to move the armature out of engagement with said core said capacitor being discharged through said resistor when said latching circuit is deenergized, such that subsequent reenergization of said latching circuit and said coil means will move said armature into engagement with said core.

4. A relay as defined in claim **3** wherein the armature is formed of a chrome magnet steel with at least five percent chromium and exhibiting a coercive force of from fifty to sixty oersteds.

5. A magnetically latchable relay comprising in combination, a magnetic circuit including a core formed of magnetizable material, and an armature formed of a magnetizable material, means mounting said armature for movement into and out of engagement with said core, a switch operable in response to movement of said armature, restoring means urging said armature out of engagement with said core, a latching circuit for energization from a source of voltage including a latching coil surrounding said core, a first rectifier in series with said latching coil, a capacitor in series with said first rectifier, and a resistor in parallel with said capacitor; means controlling energization of said latching circuit to effect energization of said latching coil and move said armature into engagement with said core, said magnetic circuit when said armature and core are engaged providing a residual flux having a value sufficient to maintain engagement of said armature and core when said latching circuit is deenerized, and unlatching circuit for energization from a source of voltage including an unlatching coil separate from said latching coil and wound on said core in opposition to said latching coil, and a second rectifier in series with said unlatching coil and poled in the same direction as said first rectifier; and means controlling energization of said unlatching circuit to effect energization of said unlatching

coil so as to reduce said residual flux to a value which permits said restoring means to move the armature out of engagement with said core.

6. A relay as defined in claim 5 wherein the armature is formed of a chrome magnet steel with at least five percent chromium and exhibiting a coercive force of from fifty to sixty oersteds, and the core is formed of high silicon electrical steel.

7. A magnetically latchable relay comprising in combination, a magnetic circuit including a core formed of a silicon steel with at least one and one-half percent silicon, an armature formed of a chrome magnet steel with at least five percent chromium, means mounting said armature for movement into and out of engagement with said core, a switch operable in response to movement of said armature, restoring means urging said armature out of engagement with said core, a latching circuit for energization from a source of direct current voltage including a latching coil surrounding said core, a first rectifier in series with said latching coil, and an inrush current producing device in series with said first rectifier, means controlling energization of said latching circuit to effect energization of said latching coil and move said armature into engagement with said core, said magnetic circuit when said armature and core are engaged providing a

residual flux having a value sufficient to maintain engagement of said armature and core when said latching circuit is deenergized, an unlatching circuit for energization from said source of direct current voltage including an unlatching coil separate from said latching coil and wound on said core in opposition to said latching coil, and a second rectifier in series with said unlatching coil and poled in the same direction as said first rectifier; and means controlling energization of said unlatching circuit to effect energization of said unlatching coil so as to reduce said residual flux to a value which permits said restoring means to move the armature out of engagement with said core, said armature material exhibiting a coercive force of from fifty to sixty oersteds and a residual flux density of from five thousand to six thousand gauss.

References Cited

UNITED STATES PATENTS

2,427,750	9/1947	Snyder	317—151
2,441,984	5/1948	Armstrong	317—155.5 X
2,928,027	3/1960	Dennison	317—154
3,010,053	11/1961	Schubert	317—155.5

LEE T. HIX, *Primary Examiner.*