March 8, 1966 F. A. ZUPA 3,239,727

ELECTROMAGNETIC SWITCHING DEVICE

Filed Aug. 12, 1963 2 Sheets-Sheet 1

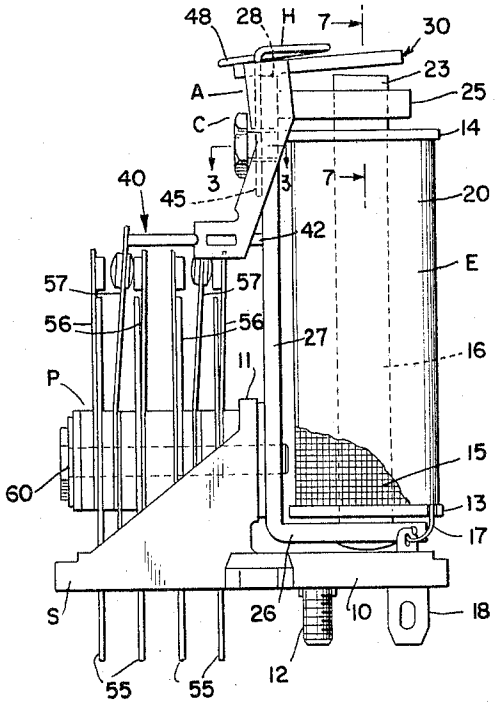

FIG. 1

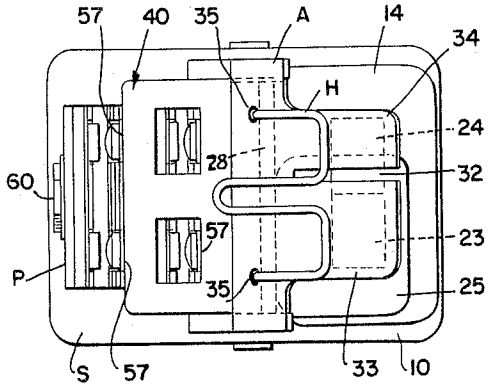

FIG. 2

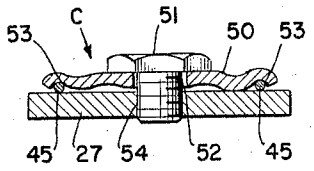

FIG. 3

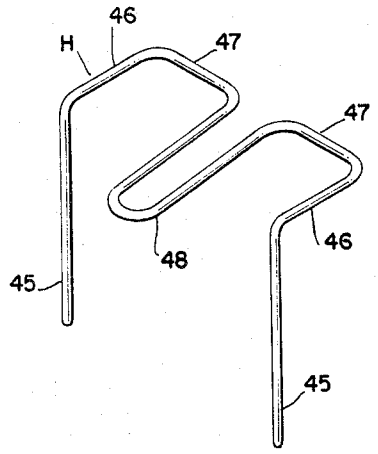

FIG. 4

INVENTOR.
FRANK A. ZUPA

BY F. J. Pisarra

ATTORNEY

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ELECTROMAGNETIC SWITCHING DEVICE

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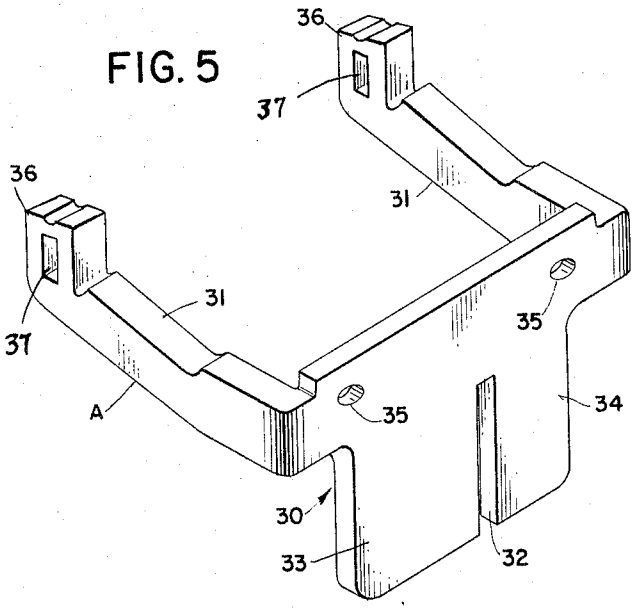
FIG. 5



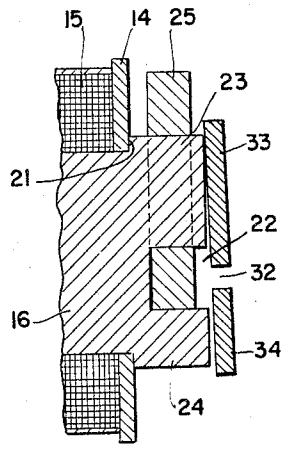


FIG. 7

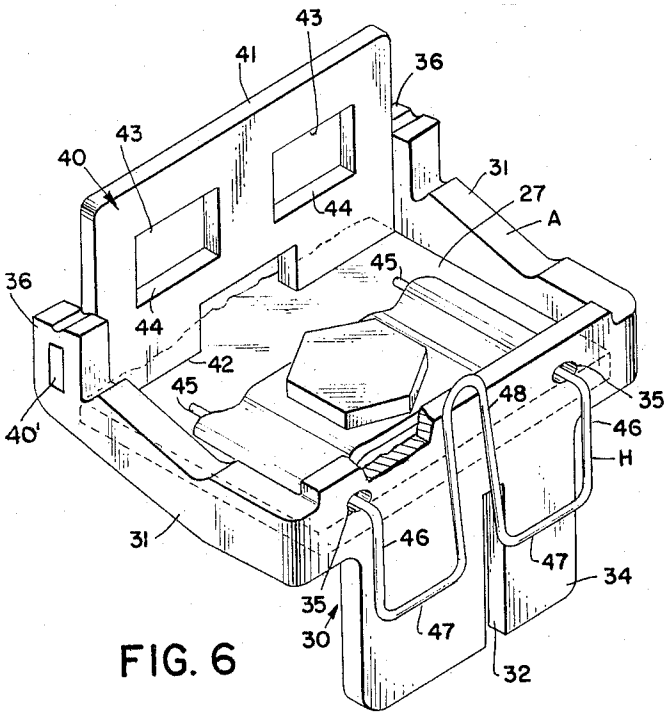


FIG. 6

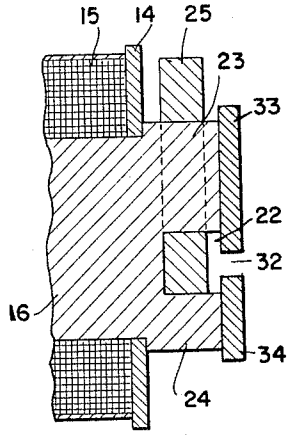


FIG. 8

INVENTOR.
FRANK A. ZUPA

BY J. J. Fisarra

ATTORNEY

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3,239,727

ELECTROMAGNETIC SWITCHING DEVICE

Frank A. Zupa, New York, N.Y., assignor to Allied Control Company, Inc., New York, N.Y., a corporation of New York

Filed Aug. 12, 1963, Ser. No. 301,378
17 Claims. (Cl. 317—165)

This invention relates to the art of electromagnetic devices and, more particularly, to an electromagnetic relay having improved features of design and construction. The invention pertains, in one of its more specific aspects, to an electromagnetic relay that is adapted to be readily made in small and miniature sizes and that is capable of rendering satisfactory service over extended periods of time.

The relay of this invention has wide application in the electronics field. It is especially useful as a component in electronic computers, telephone systems and the like.

The present relay may be advantageously employed with a wide variety of switch arrangements, i.e., various forms of single pole or multi-pole switches which may be either single throw or double throw. The detailed description herein and the accompanying drawings are directed, by way of example, to a relay embodying the invention and having a 4-pole double throw switch arrangement incorporated therein.

It should be borne in mind that the present relay may be advantageously employed to operate devices other than switch arrangements. For example, the relay of this invention may be utilized to operate valves, toggle switches or other mechanical or electro-mechanical devices.

The relay of this invention is applicable for operation with an alternating current power supply or a direct current power supply, depending on the inclusion or omission of a shading coil in association with a pole member. The embodiment of the invention herein illustrated and described contemplates the utilization of a shading coil for operation with an alternating current power supply.

The primary object of this invention is to provide an electromagnetic device having improved features of design and construction.

Another object of the invention is to provide a relay including a resilient hinge unit which is so constructed and arranged with respect to a rockable armature unit and other parts as to support and yieldingly maintain the armature unit in open position, when the relay is in unenergized condition, and permit pivotal movement of the armature to closed position, when the relay is in energized condition, the parts of the hinge unit being adapted to be adjusted to vary the force normally exerted on the armature unit as required by particular operating conditions.

The invention has, for another object, the provision of an improved armature that is especially useful in relays that are operated by alternating currents.

A further object of the invention is to provide a relay in which certain parts may be readily and conveniently united to form independent units or sub-assemblies that are subsequently brought together and interconnected to obtain the complete relay.

A still further object of the invention is to provide an electromagnetic device of the character indicated that is small, compact and lightweight in design; that is sturdy and durable in construction; that is reasonable in manufacturing cost; that may be readily adjusted, as required by particular operating conditions; and that is capable of affording efficient, dependable and trouble-free service over extended periods of time.

The resilient hinge unit and the armature unit, which are referred to above, constitute the two principal or outstanding features of this invention. The advantages and

benefits obtainable by utilization of these units will be discussed in detail further along in this description.

The enumerated objects and other objects, together with the advantages of this invention, will be readily understood by persons trained in the art from the following detailed description and the annexed drawings which respectively describe and illustrate a recommended form of the invention.

In the drawings, wherein like reference characters denote corresponding parts throughout the several views:

FIG. 1 is a view in side elevation of a relay constructed in accordance with this invention and utilizing a 4-pole double throw switch arrangement, the cover of the relay being omitted for better illustration of the operating parts;

FIG. 2 is a top plan view of FIG. 1;

FIG. 3 is a fragmentary view in enlargement taken along line 3—3 of FIG. 1;

FIG. 4 is an isometric view in enlargement of the resilient hinge unit of the relay which is shown in other views;

FIG. 5 is an isometric view in enlargement of the armature unit of the relay which is shown in other views;

FIG. 6 is a view similar to FIG. 5 and illustrates the armature cooperatively associated with several other parts of the relay;

FIG. 7 is a view in enlargement taken along line 7—7 of FIG. 1 and illustrates the position of portions of the armature relative to the poles when the relay is in energized condition and prior to adjustment of said portions of the armature to compensate for misalignment; and

FIG. 8 is a view corresponding to FIG. 7 and shows the relative position of the parts after the illustrated portions of the armature have been adjusted to compensate for misalignment.

The illustrated form of the invention is made up of six principal units or assemblies, namely a support unit S, an electromagnet unit E, an armature unit A, a resilient hinge unit H, a clamp unit C and a contact pile-up assembly P. These units are assembled and cooperatively arranged to obtain the complete relay which is shown in FIGS. 1 and 2 and which, in normal use, is generally provided with a protective cover or casing (not shown).

Support unit S, which is best shown in FIGS. 1 and 2, is preferably molded from a suitable electric insulating material, such as a phenol formaldehyde resinous composition that is available under the trade-name Bakelite. This unit is the same as or similar to the corresponding unit disclosed in pending application of James Diciolla, Ser. No. 81,772, for Electromagnetic Device, to which reference may be had for details of construction. Unit S includes a base **10** and a transverse partition **11**. Base **10** is equipped with a mounting bolt **12**.

Reference is now had to FIG. 1 for an understanding of the construction of electromagnet unit E. This unit includes an upstanding bobbin having a lower end flange **13** and an upper end flange **14**, a magnetizing coil **15** which is wound around the bobbin, and a polepiece or core member **16** which extends through the opening defined by the bobbin. Coil **15** has a pair of electric leads, only one of which is shown and identified by numeral **17**. This coil lead is connected to an electric terminal **18**, preferably by soldering. The other coil lead is connected to a corresponding electric terminal (not shown) in like manner. The coil terminals extend through and below corresponding slots in base **10** and are anchored to the base in any desired manner known to the art. These terminals are adapted to be connected to a suitable source of electric energy supply (not shown). Coil **15** is ensheathed in a protective outer wrap **20**.

The upper end portion of the polepiece is enlarged and is formed with a continuous shoulder **21** (FIG. 7) which bears against bobbin flange **14**. Also, the upper

end portion of the polepiece is bifurcated or slotted, as indicated at 22, whereby to obtain a pair of poles 23 and 24. Pole 23 is provided with a shading coil or ring 25 which is made of a highly conductive non-magnetic metal, such as copper. As is shown in FIGS. 7 and 8, a portion of the shading coil registers with slot 22. The illustrated electromagnet unit, including shading coil 25, is applicable for operation with an alternating current power supply.

The electromagnet unit also includes an L-shaped frame or bracket consisting of a horizontal bottom arm 26 and a vertical side arm 27 that is substantially parallel to polepiece 16. Side arm 27 extends above the bobbin and terminates in a rectilinear top edge 28 which is normal to the longitudinal axis of the polepiece. The lower end portion of the polepiece extends through an opening (not shown) in frame arm 26 and is peened over or otherwise formed to obtain a rigid connection between the polepiece and the frame.

Armature unit A is mounted on electromagnet unit E and cooperates therewith in a manner that will be described further along herein. The armature unit includes a plate-type armature 30 having a pair of spaced, parallel arms 31. Armature 30 is generally planar and is bifurcated, i.e. formed with a slot 32 that extends inwardly from its edge that is remote from arms 31, as shown in FIG. 2, to obtain armature portions 33 and 34 which overlie poles 23 and 24, respectively. Armature portions 33 and 34 are relatively deformable by bending to permit of ready adjustment, as may be required, at the time of assembly. The armature is provided with a pair of through openings 35. Each arm 31 terminates in an extension 36 having a rectangular opening 37.

A planar actuator 40 is anchored to armature unit A through the medium of extension 40' (FIG. 6) which register with openings 37. The actuator is made of Bakelite or other suitable electric insulating material and is preferably parallel to armature 30. The actuator has a forward edge 41 and a rearward edge 42 and is provided with a pair of openings 43 that are defined in part by corresponding edges 44.

Armature unit A is maintained against and rockable relative to frame edge 28 through a predetermined operating angle by resilient hinge unit H which will now be described. This unit, as is best shown in FIG. 4, is of one-piece construction and is made of a suitable resilient metallic wire that is preferably circular in transverse cross section. Unit H consists of a pair of parallel leg portions 45; a pair of parallel intermediate portions or arms 46, each of which is generally normal to a corresponding leg portion; a pair of coaxial intermediate portions or arms 47, each of which is generally normal to a corresponding portion 46; and a generally U-shaped loop portion 48 which is positioned substantially midway between portions 46. Loop portion 48 is offset from the common plane of portions 46 and projects toward leg portions 45 and beyond a plane which is common to the leg portions.

As is shown in FIGS. 1, 2 and 6, leg portions 45 extend through armature openings 35 and bear against the outer surface of frame arm 27. Openings 35 are slightly larger than the diameter of the leg portions to permit of limited lateral movement of the armature unit relative to the frame edge, consistent with design purposes. The leg portions are affixed to the frame by clamp unit C, which will be described further along herein. When the parts are assembled, as illustrated in FIG. 1, loop portion 48 of the hinge unit bears against the rear edge portion of armature 30 and biases the armature unit in a counterclockwise direction about frame edge 28. This biasing action is limited by engagement of rearward edge 42 of the actuator with the outer surface of frame arm 27.

Clamp unit C consists of a plate member 50 and a screw 51. The plate member has a central through opening 52 and is formed with a pair of parallel grooves 53 for reception of corresponding leg portions 45 of the hinge unit (FIG. 3). Screw 51 engages a through tap 54 in frame arm 27 whereby to effect firm gripping of the leg portions between the plate member and the frame arm.

Contact pile-up assembly P is essentially the same as the pile-up assembly which is disclosed in said application Serial No. 81,772. It is deemed sufficient for the purposes of this application to point out that the illustrated pile-up assembly includes a plurality of electric terminals 55, which extend through corresponding slots (not shown) in base 10; a plurality of flexible stationary contact arms 56; and a plurality of flexible movable contact arms 57 which are engaged by actuator 40. Assembly P is positioned to the left of partition 11, as viewed in FIG. 1, while electromagnet Unit E is positioned to the right of the partition. A screw connector 60 extends through aligned openings (not shown) in assembly P and partition 11 and engages a tap in frame arm 27, thereby joining and maintaining these parts in the illustrated relationship.

For the purpose of describing the operation of the herein described form of the invention, it is first assumed that the relay is assembled and that magnetizing coil 15 is in deenergized condition. As a consequence, the parts are in the relative position shown in FIGS. 1 and 2, armature unit A being biased in a counter-clockwise direction about frame edge 28 by hinge unit H to the extent allowed by engagement of rearward edge 42 of actuator 40 with the outer surface of frame arm 27. Thus, armature 30 is yieldingly maintained in its normal position away from poles 23 and 24 and movable contact arms 57 are in the relative positions shown in FIGS. 1 and 2.

When terminals 18 are connected to a suitable source of alternating current supply, magnetizing coil 15 is energized and poles 23 and 24 exert sufficient attracting force on armature portions 33 and 34, respectively, to impart clockwise rocking movement to the armature unit, as viewed in FIG. 1, against the action of loop portion 48 of the hinge unit. The poles limit clockwise pivotal movement of the armature unit. This movement of the armature unit imparts corresponding movement to actuator 40, thereby flexing movable contact arms 57 to the left. This causes these contact arms to break contact with certain of the stationary contact arms and make contact with certain other stationary contact arms, as will be evident from an examination of FIGS. 1 and 2. When the magnetizing coil is again deenergized, the parts automatically return to the relative position shown in FIGS. 1 and 2.

As was stated earlier herein, the resilient hinge unit constitutes one of the principal features of this invention. It will be evident from the description and the drawings that, with any selected stiffness of the spring wire of unit H and any given overhang of armature 30, the pressure exerted by the armature against frame edge 28 and the associated armature restoring force can be readily varied between predetermined limits by simply sliding legs 45 of the hinge unit under clamp plate 50 to proper position before locking the legs in place by means of clamp screw 51. The hinge unit therefore provides a number of advantages and benefits, which contribute to the utility of the relay, including the following:

(1) A resilient hinge unit of the character illustrated and described, and preferably made by forming a length of spring wire which is circular or rectangular in cross section, can be readily positioned on or removed from the relay without disturbing any of the parts other than the armature unit.

(2) While the hinge unit is not rigidly secured to the armature, it effectively restricts the hinged position of the armature within predetermined limits along edge 28 of the frame.

(3) The value of the spring pressure in holding the armature against edge 28 of the frame may be easily adjusted, i.e., varied, by shifting the clamped position of legs 45 relative to the frame.

(4) The resilient hinge unit is so constructed and arranged that the value of the spring pressure in holding the

armature against hinging edge **28** of the frame may be easily adjusted by bending its arms **46** while its legs **45** remain clamped in place on the frame.

(5) The resilient spring unit, by virtue of its loop portion **48** engaging the overhang on the armature **30** to the rear of hinging edge **28** of the frame, serves as a means for adjusting the armature back pressure, which pressure is especially useful to minimize the effects of shock to the relay contacts and/or to control the relay non-operate value of current or voltage.

In the design and construction of the motor element of an alternating current relay, the division of an end of the polepiece into two holes, one which is encircled by a shading coil and the other not, and the alignment of their poleface surfaces with a common poleface surface on the armature, constitute a critical part of the motor element design. The relative size of the areas of the shaded and unshaded pole surfaces on the polepiece, the inductive and resistive properties of the shading coil, and the magnetic reluctance resulting by the unavoidable length of the closed gap between the armature poleface and the polefaces of each pole, are all interrelated so that the magnitude of the closed gap affects the electromagnetic properties of the shaded and unshaded poles to the extent that it becomes difficult or costly to meet the required relay operate or pull-in value and the required maximum acceptable level of chattering noise common to alternating current relays. These common deficiencies in alternating current relay design are minimized by providing the armature with a simple slot, such as slot **32** in armature **30**. This constitutes the other principal feature of the invention, which is mentioned earlier herein, and results in a number of advantages or benefits, including the following:

(1) The provision of slot **32** in the armature, when located approximately centrally with respect to the space **22** between the two poles of the polepiece, provides in effect, two separate poleface surfaces, each of which is adapted to mate with the associated poleface surface of the corresponding pole when the armature portions **33** and **34** are properly aligned with poles **23** and **24**, as shown in FIG. 8.

(2) Either of armature portions **33** and **34** may be displaced or deformed relative to the other, as required: (1) To minimize or control the closed pole gap reluctance on the relay and (2) to minimize or control the audible noise common to improperly aligned armature and polepiece surfaces. FIG. 7 illustrates an armature which is misaligned at the time of assembly. It will be apparent that either or both of armature portions **33** and **34** may be bent to compensate for such misalignment, whereby the parts will be properly aligned, as shown in FIG. 8, when the relay is in energized condition.

(3) The slotted armature, by virtue of the airgap between the two resulting polefaces, reduces the fringing of the flux from the mating polefaces on the polepiece and thereby improves the perpendicularity of the direction of the flux at each poleface. This improvement in direction of the magnetic flux results in an increase in the numerical value of the flux density at the mating poleface surfaces. Since the magnetic tractive force varies directly as the square of the flux density normal to the effective poleface area, the slotted armature results in an appreciable increase in tractive force.

The enumerate advantages and beneficial effects of the bifurcated armature of an alternating current relay are amply supported by operating test data on a relay of the invention using an armature unit before and after forming the slot **32** in armature **30**. The test data established that when the alignment of the unsoltted armature is such as to have a closed gap length of 0.001 to 0.0015 inch at one of the poles of the polepiece, by cutting the slot and displacing one of the poleface surfaces of the armature in the direction to reduce the closed gap length so as to make a point or line contact at both pole surfaces, the overall tractive force for the same applied operating voltage value was considerably improved and the former audible chattering noise was eliminated insofar as the normal ear could detect.

From the foregoing, it is believed that the objects, advantages, construction and operation of my present invention will be readily comprehended by persons skilled in the art without further description. Although the invention has been herein shown and described in a simple and practicable form, it is recognized that certain parts thereof are representative of other parts which may be used in substantially the same manner to accomplish substantially the same results. Therefore, it is to be understood that the invention is not to be limited to the exact details described herein, but is to be accorded the full scope and protection of the appended claims.

I claim:

1. In an electromagnetic device, an electromagnet unit comprising a frame, an electromagnet coil carried by the frame, a polepiece extending through the coil and at least one pole at one end of the polepiece; an armature unit comprising an armature adjacent the pole, said armature engaging the frame and having a pair of spaced through openings formed therein; and a resilient hinge unit made of a single piece of spring metal and comprising a pair of end legs, each of which extends through a corresponding one of said openings and is secured to the frame, a pair of first arms connected to the legs, each arm being angularly disposed relative to a corresponding leg, and a loop member connected to the ends of the arms which are remote from the legs, said loop member being offset from the arms and projecting toward the legs; the frame, polepiece, armature and hinge unit being so constructed and arranged that the loop member normally and yieldingly imparts pivotal movement to the armature unit in one direction relative to the frame whereby the armature is positioned away from the pole, said armature unit, upon energization of the coil, being pivoted in a reverse direction against the action of the loop member due to the armature being attracted to the pole.

2. An electromagnetic device according to claim **1** wherein the hinge unit is made of a spring wire and further comprises a pair of second arms, each of which is secured to the end of a first arm that is remote from a corresponding leg, the loop member being connected to the ends of the second arms that are remote from the corresponding first arms and being positioned intermediate the first arms.

3. An electromagnetic device according to claim **2** wherein the first arms are substantially parallel, wherein the second arms are substantially coaxial and wherein the first and second arms are substantially entirely in a common plane.

4. An electromagnetic device according to claim **3** wherein the legs of the hinge unit are generally parallel, wherein each first arm of the hinge unit is generally normal to a corresponding leg, and wherein each second arm of the hinge unit is generally normal to a corresponding first arm.

5. An electromagnetic device according to claim **1** including means for securing the leg portions of the hinge unit to the frame and for varying the force exerted by the intermediate portion of the hinge unit on the armature.

6. An electromagnetic device according to claim **5** wherein said means comprises a clamp unit secured to the frame and engaging the leg portions of the hinge unit.

7. In an electromagnetic device, an electromagnet unit comprising a frame, an electromagnet coil carried by the frame, a polepiece extending through the coil and a pair of spaced poles at one end of the polepiece; an armature unit comprising an armature adjacent the poles, said armature including a pair of relatively deformable spaced portions, each of which is at least coextensive and aligned with a corresponding pole; and means including a resilient unit for securing the armature unit to the frame and for

normally and yieldingly imparting pivotal movement to the armature unit in one direction relative to the frame whereby said armature portions are positioned away from the poles, said armature unit, upon energization of the coil, being pivoted in a reverse direction against the action of the resilient unit due to the armature being attracted to the poles.

8. An electromagnetic device according to claim 7 including a shading coil circumscribing one of the poles, a portion of the shading coil being positioned in the space between the poles.

9. An electromagnetic device according to claim 7 wherein the armature comprises a bifurcated plate.

10. An electromagnetic device according to claim 7 wherein the armature unit includes a pair of spaced arms connected to the armature and an actuator secured to the ends of the arms that are remote from the armature.

11. An electromagnetic device according to claim 10 wherein the actuator is adapted to engage the frame and limit pivotal movement of the armature unit relative to the frame in said one direction.

12. In an electromagnetic device, an electromagnet unit comprising a frame, an electromagnet coil carried by the frame, a polepiece extending through the coil and a pair of spaced poles at one end of the polepiece; an armature unit comprising an armature adjacent the poles, said armature including a pair of relatively deformable spaced portions, each of which is at least coextensive and aligned with a corresponding pole, said armature having a pair of spaced through openings formed therein; and means including a resilient unit for securing the armature unit to the frame and for normally and yieldingly imparting pivotal movement to the armature unit in one direction relative to the frame whereby said armature portions are positioned away from the poles, said armature unit, upon energization of the coil, being pivoted in a reverse direction against the action of the resilient unit due to the armature being attracted to the poles, said resilient unit comprising a pair of leg portions, each of which extends through a corresponding one of said openings and is secured to the frame, and an intermediate portion connected to the leg portions and bearing against the armature whereby to effect such pivotal movement of the armature relative to the frame in said one direction.

13. An electromagnetic device according to claim 12 wherein the resilient unit is made of a single piece of spring wire that is configured to form a pair of end legs, a pair of first arms, each first arm being connected to

and defining an angle with a corresponding leg, a pair of second arms, each second arm being connected to the end of a first arm that is remote from a corresponding leg, and a loop member connected to the ends of the second arms that are remote from corresponding first arms, said loop member being positioned intermediate the first arms, being offset from the first arms and projecting toward the legs.

14. An electromagnetic device according to claim 12 wherein the resilient unit is made of a single piece of spring wire that is configured to form a pair of end legs, a pair of generally parallel first arms, each first arm being connected to and defining an angle with a corresponding leg, a pair of substantially coaxial second arms, each second arm being connected to the end of a first arm that is remote from a corresponding leg, and a loop member connected to the ends of the second arms which are remote from corresponding first arms, said first and second arms being substantially entirely in a common plane, said loop member being offset from said common plane and projecting toward the legs.

15. An electromagnetic device according to claim 14 wherein the legs of the resilient unit are generally parallel, wherein each first arm of the resilient unit is generally normal to a corresponding leg, and wherein each second arm of the resilient unit is generally normal to a corresponding first arm.

16. An electromagnetic unit according to claim 12 wherein said means also includes a clamp unit secured to the frame and engaging the leg portions of the resilient unit.

17. An electromagnetic device according to claim 12 wherein the armature unit includes a pair of spaced arms connected to the armature and an actuator secured to the ends of the arms that are remote from the armature, said actuator being adapted to engage the frame and limit pivotal movement of the armature unit relative to the frame in said one direction.

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BERNARD A. GILHEANY, *Primary Examiner.*

JOHN F. BURNS, *Examiner.*