

Feb. 28, 1967

W. W. CAMP

3,307,130

ELECTROMAGNETIC DEVICE HAVING A SHUNT PLATE

Filed Jan. 13, 1965

2 Sheets-Sheet 1

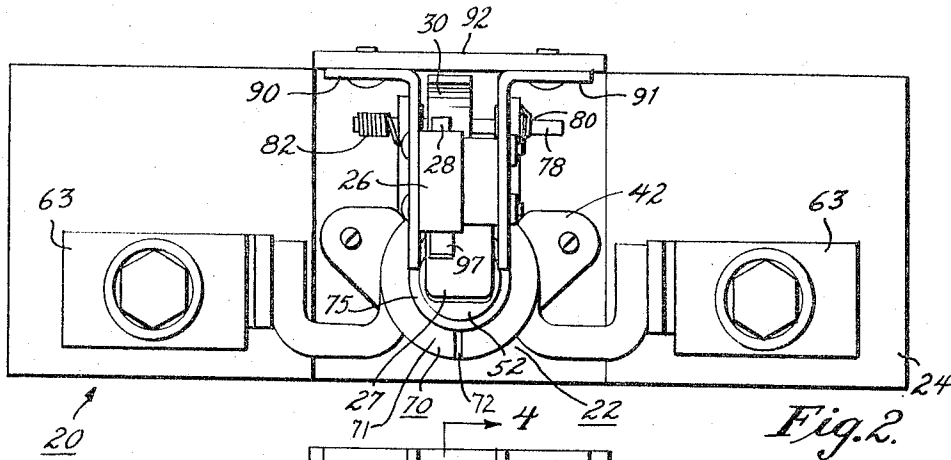


Fig. 1.

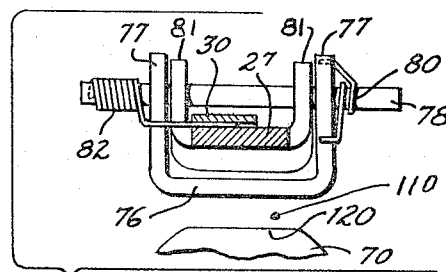
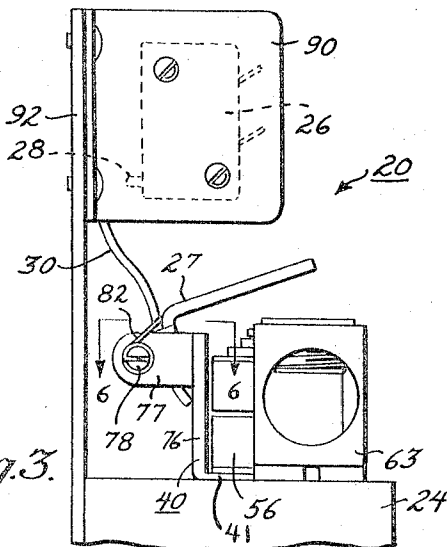
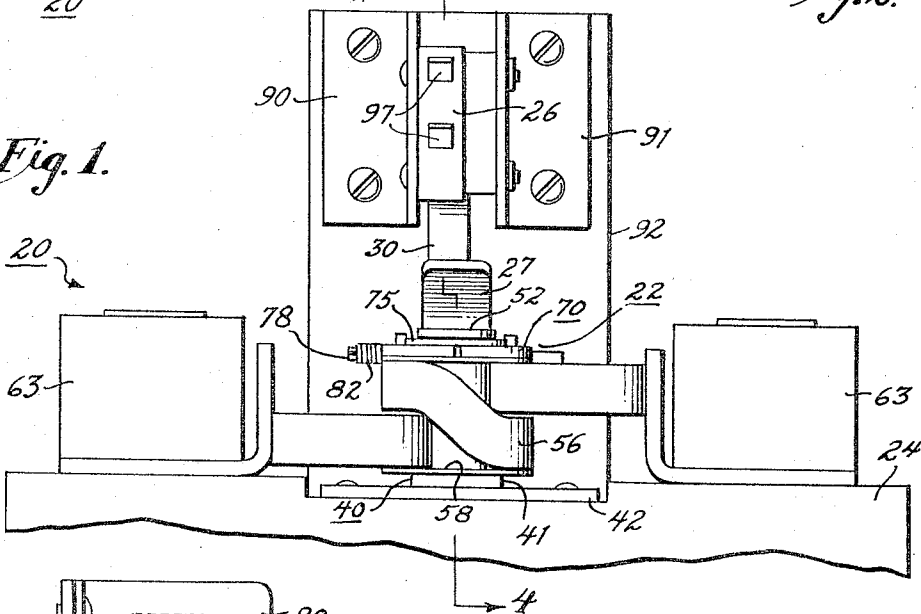


Fig. 6.

INVENTOR.
WILLIAM W. CAMP

BY

Joseph W. Camp
HIS ATTORNEY.

Feb. 28, 1967

W. W. CAMP

3,307,130

ELECTROMAGNETIC DEVICE HAVING A SHUNT PLATE

Filed Jan. 13, 1965

2 Sheets-Sheet 2

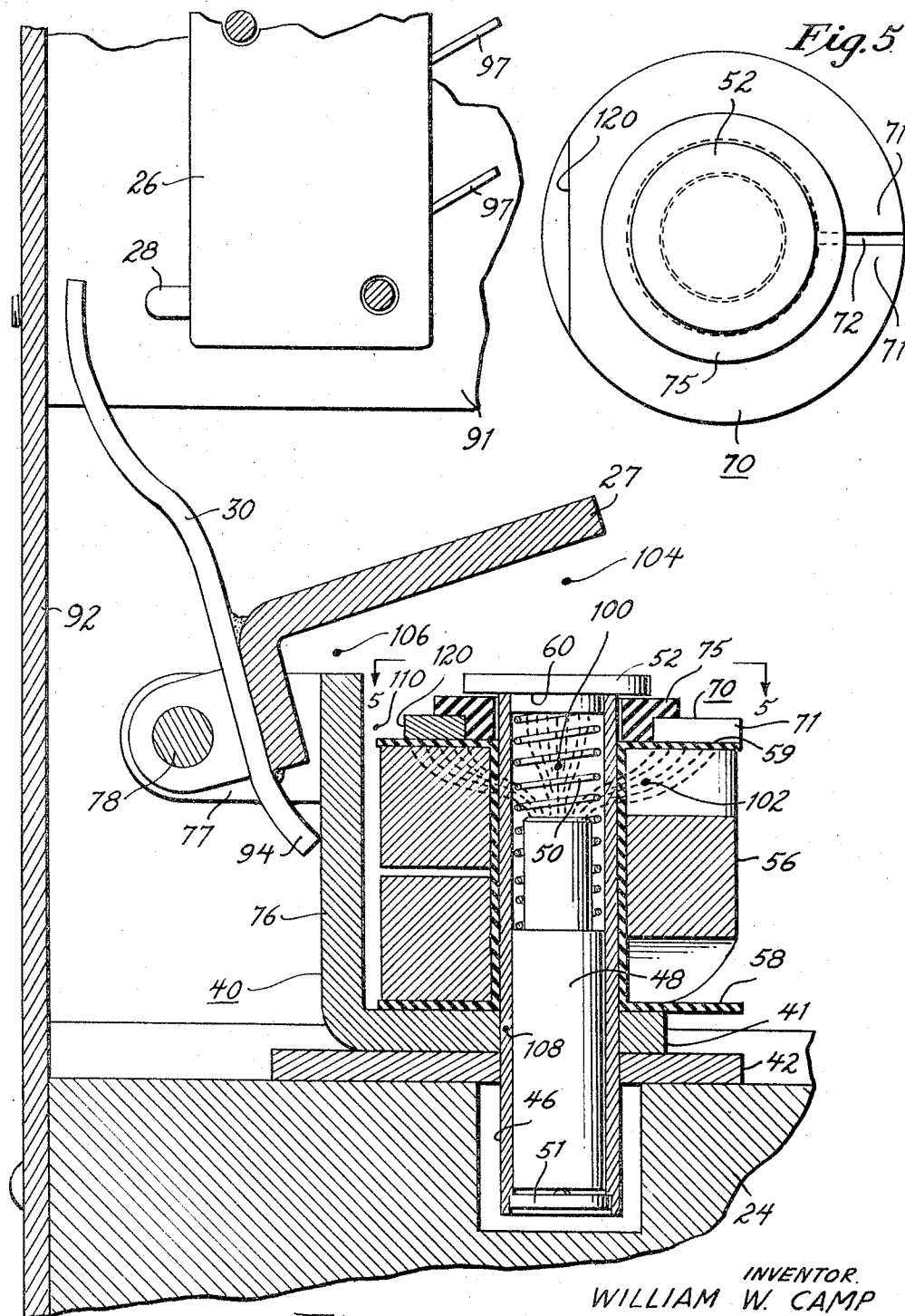


Fig. 4.

INVENTOR.
WILLIAM W. CAMP

BY

Joseph H. Donnan
ATTORNEY.

1

3,307,130

ELECTROMAGNETIC DEVICE HAVING A SHUNT PLATE

William W. Camp, Lawrenceville, N.J., assignor to Heine-
mann Electric Company, Trenton, N.J., a corporation
of New Jersey

Filed Jan. 13, 1965, Ser. No. 425,324

13 Claims. (Cl. 335-236)

This invention relates to electromagnetic devices and more particularly to circuit breakers and relays in which overload sensing is accomplished electromagnetically. It is an object of this invention to modify a known type of electromagnetic device to permit the flow through the circuit breaker or relay of higher inrush currents, of short durations, without tripping the circuit breakers or the relays.

An electromagnetic circuit breaker of the type to which this invention pertains is disclosed in United States Patent No. 2,360,922, issued to Kurt W. Wilckens, in which an electromagnetic sensing device including a solenoid coil, a time delay tube housing a movable magnetic core and a pivotal, spring biased, armature is used for the purpose of providing a time delay upon the occurrence of an overload which, if below a certain value and if it does not persist for a predetermined time, will not cause the tripping by the armature of the circuit breaker's operating mechanism and opening of the circuit breaker contacts, thereby avoiding nuisance tripping. In this type of circuit breaker, if the overload current is sufficiently high, the high overload current will substantially instantaneously attract the pivotal armature to trip the circuit breaker operating mechanism and open the circuit breaker contacts, thereby providing instantaneous tripping at high overloads.

However, electrical motors and other electrical loads are being constructed to safely accept increasingly higher, but substantially momentary, inrush currents. It is, therefore, another object of this invention to economically modify the prior known electromagnetic devices to permit them to accept the increasingly higher momentary inrush currents without instantaneous tripping of the circuit or relay at such higher inrush currents.

This invention is embodied in an electrical relay having separable contacts actuatable into and out of engagement by a reciprocal plunger. The plunger is engageable by an operating finger carried by a pivotal armature. The armature forms part of the electromagnetic device which further comprises a frame and a solenoid coil. The solenoid coil surrounds a tube housing a core of magnetizable material which is biased toward one end, the rear end, of the tube. The other or forward end of the tube includes a magnetizable pole piece toward which the core moves upon sufficient energization of the coil and the armature is biased away from the pole piece. Surrounding the forward end portion of the tube is a shunt plate of magnetizable material, but the shunt plate is separated from the pole piece by an air gap and the shunt plate forms another air gap with the movable core.

Thus, when the movable core has moved toward the pole piece its maximum amount, i.e., to its most forward position, in which position it may contact the pole piece, the magnetic reluctance of the magnetic circuit is only slightly less, and for practical purposes substantially the same with the shunt plate being used as it would be if

2

the shunt plate were omitted, but when the magnetic core has moved away from the pole piece its maximum amount, i.e., to its most rearward position, the magnetic reluctance of the device increases substantially.

Since the bias on the armature is adjusted so that the armature will be tripped, with the core fully in, at a given current, for a given device and a given number of turns, more electrical current will be required to produce a sufficient flux (in the gap between the pole piece and the armature) to attract the armature, i.e., the current level at which the armature will be actuated substantially instantaneously, has been raised, relative to a similar device without the shunt plate, permitting larger inrush currents of short duration to flow through the coil without causing tripping of the relay. Further, the ratio of the current required to produce a sufficient flux (in the gap between the pole piece and the armature) to attract the armature when the core is in its most rearward position, i.e., the current level at which the armature will be actuated instantaneously, compared to the current required to produce a sufficient flux to attract the armature when the core is in its most forward position has been increased compared to the same device without the shunt plate.

The foregoing and other objects of the invention, the principles of the invention, and the best mode in which I have contemplated applying such principles will more fully appear from the following description and accompanying drawings in illustration thereof.

In the drawings,

FIG. 1 is a front elevation illustrating an electromagnetic relay incorporating the present invention, the relay being shown in the unattracted position of the armature;

FIG. 2 is a plan view of the relay illustrated in FIG. 1;

FIG. 3 is a side elevation of the relay illustrated in FIG. 1, as viewed from the left in FIG. 1;

FIG. 4 is a partial, enlarged sectional view of the relay illustrated in FIG. 1 taken along the line 4-4 in FIG. 1;

FIG. 5 is a partial view taken along the line 5-5 in FIG. 4; and

FIG. 6 is a partial view taken along the line 6-6 in FIG. 3.

Referring to the drawings, FIG. 1 illustrates a relay 20 comprising an electromagnetic device 22 carried by an insulator base 24. Positioned above the electromagnetic device 22 is a switch 26 having separable contacts (not illustrated) actuatable by a reciprocal plunger 28 engageable by an operating finger 30 secured to an armature 27, the latter being of magnetizable material.

The electromagnetic device 22 further comprises an L-shaped frame 40 of magnetizable material. The leg or base 41 of the L-shaped frame 40 is secured to a support plate 42 and the latter is secured to the insulator base 24 by suitable screws inserted through the base 24 and into the plate 42. The leg 41 may be soldered to the support plate 42 and the latter is preferably of nonmagnetic material. A tube 46 extends through a hole in the leg 41 of the L-shaped frame 40 and through the support plate 42, the tube 46 being preferably of nonmagnetizable material and housing a movable core 48 of magnetizable material biased toward the lower end, as viewed in FIG. 4, of the tube by a spring 50, the lower end of the tube 46 being closed by an end cap 51 and the upper end of the tube being closed by a stepped pole piece 52, as shown in FIG. 4, the pole piece being of magnetizable

material. Preferably the tube 46 is soldered, or otherwise secured, to the leg 41, and its lower end extends into a recess in the base 24. Surrounding a part of the length of the tube, as also illustrated in FIG. 4, is an electrical, elongated solenoid coil 56 which is electrically separated from the other elements by an insulating spool 58 which may rest on the leg 41, the opposite end portions of the coil being connected to terminals 63 carried by the base 24.

As illustrated in FIG. 4, the tube 46 and the pole piece 52 extend out beyond the coil 56, i.e., the upper surface 59 of the spool 58 is spaced axially from the lower surface 60 of the pole piece 52. A ring or shunt plate 70 of magnetizable material, such as cold rolled steel, is positioned between the surface 59 and the surface 60. The shunt plate 70 may have opposed ends 71 (FIG. 5) forming a slit or air gap 72 giving the plate a general C-shape. The inner diameter of the shunt plate is preferably larger than the outer diameter of the tube 46, but about equal to the outer diameter of the pole piece 52, and the shunt plate 70 is preferably thinner than the space between the surfaces 59 and 60, as illustrated. To maintain the shunt plate 70 out of contact with the pole piece 52, a stepped ring 75 is placed between them, as illustrated, preferably of electrical insulating material.

The vertical frame leg 76 is formed with bent, spaced ears 77 having aligned holes forming bearings to receive spaced portions of a pintle 78. The armature 27 also has bent, spaced ears 81 through which the pintle 78 extends. The pintle 78 is restrainably held in one position by a spring 80 tightly wrapped about on one end portion of the pintle 78 and having end portions crossed and held apart by the width of one of the ears 77. Another spring 82 is mounted on the other end portion of the pintle 78, the spring 82 having an end portion received in a slot formed in the pintle 78 and the other end portion engaging the finger 30 to bias the armature 27 away from the pole piece 52. Thus, by rotating the pintle 78 in its bearings against the restraint of the spring 80, the bias on the armature provided by the spring 82 may be varied.

To support the switch 26 above the armature and in position for the finger 30 to actuate the plunger 28, the switch is secured, by suitable screws, to L-shaped plates 90, 91 as illustrated, and the plates 90, 91 are in turn connected to an upstanding element 92 secured at its lower end to the base 24.

The switch 26 is provided with terminals 97 to connect it to the circuit to be controlled.

When the coil 56 is energized below a predetermined current level, the armature 27 (due to its spring bias) assumes the position illustrated and the finger 30, hence, is out of engagement with the plunger 28, FIG. 4. Movement of the armature 27 and finger 30 at such time is limited by abutment of an extension 94 of the finger 30 with the vertical frame leg 76.

FIG. 4 illustrates the core 48 in its most rearward position, biased against the end cap 51, with the air gap between the pole piece 52 and the core 48 being at the maximum amount, preferably the core 48 being long enough so that when in this position the core 48 extends into the coil 56 for about three-quarters of the coil. When the coil 56 is energized at a predetermined current level, the core 48 moves upwardly against the spring bias of spring 50 and the retarding action of a liquid in the tube, to thereby reduce the air gap between the pole piece and the core, as is well known in the art, until the core moves to a position in which this gap is small enough to produce a sufficient magnetic force on the armature 27 to rotate the latter against the bias of the spring 82, whereupon the finger 30 engages the plunger 28 and actuates the switch 26, after a time delay due to the retarding action of the liquid.

At a second predetermined current level and above, 75

this second current level being substantially higher than the first mentioned current level, movement of the armature toward the pole piece, and, hence, actuation of the plunger 28 by the finger 30, takes place virtually instantaneously and without the time delay due to the retarding action of the liquid described heretofore. This second predetermined current level is substantially higher than it would be if the shunt plate 70 were omitted.

More specifically, the core 48 now forms a part of two air gaps, a first circular air gap 100 with the pole piece and a second annular air gap 102 with the shunt ring. The flux in the first air gap 100, it appears, is necked-down or constricted, as diagrammatically illustrated in FIG. 4, by the annular flux in the air gap 102.

Thus, two magnetic circuits are defined. A first magnetic circuit comprising the core 48, the first air gap 100, the pole piece 52, a third air gap 104 between the pole piece 52 and the armature 27, the armature 27, a fourth air gap 106 between the armature 27 and the frame 40, the frame 40, and a fifth gap 108 between the frame and the core 48.

A second, or a shunting circuit, is comprised by the core 48, the second air gap 102, the shunt plate 70, a sixth air gap 110 between the shunt plate and the frame 40, the frame 40, and the gap 108. As noted in FIGS. 4 and 5, the air gap 110 is increased by removing a segment of the shunt plate 70 adjacent the vertical frame leg 76 to define a straight surface 120 generally opposed and parallel to the facing surface of the leg 76.

Referring to the drawings, it is seen that the gaps 108 and 110 are small relative to the gaps 100 and 102 when the core 48 is biased to its rearwardmost position against the end cap 51. When the core 48 has been raised by the magnetic flux its maximum amount, a position not illustrated, in which position the forward surface of the core 48 may contact the lowermost surface of the pole piece 52, the gap 100 is reduced to its minimum or substantially eliminated and the gap 102 is also reduced to its minimum.

The bias of the spring 82 on the armature 27 is adjusted, with the core 48 at its forwardmost position (in which it may contact the pole piece 52), so that the armature 27 trips, i.e., is rotated sufficiently toward the pole piece 52 to engage the plunger 28 and actuate it sufficiently to operate the switch 26, at a first current level. Assuming thereafter that the core 48 and the armature 27 are in the position illustrated in FIG. 4, at current levels above the first mentioned current level but below a second current level, the armature will be tripped after a time delay period dependent on the magnitude of the current. With currents at or above the second mentioned current level, the magnetic flux created by the coil 56 in the air gap 104 is high enough to substantially instantaneously trip the armature 27 with virtually no prior movement of the core 48 toward the pole piece 52. It has been found that the second current level is significantly higher with use of the shunt plate 70 as compared to the same or similar device without the shunt plate 70. Thus, the relay 20 permits the flow through the coil 56 of higher, momentary currents, without tripping the armature 27 and the non-magnetic finger 30, due to the shunt plate 70 and the arrangement thereof relative to the other parts of the relay, than would be permitted if the shunt plate 70 were not used.

Stated differently, for a given coil, the ratio of the current required to overcome the bias of the spring 82 on the armature 27 when the air gap 100 is a maximum to the current required to overcome the same spring bias when the air gap 100 is at a minimum or nonexistent is substantially higher than the corresponding ratio for the same or a similar device which omits the shunt plate 70.

Thus, it is seen from the foregoing that the current level at which the armature will be tripped instantaneously has been appreciably raised.

5

Having described the invention, I claim:

1. An electromagnetic device comprising a solenoid coil, a magnetizable frame in the magnetic field of said coil and carrying said coil, an armature pivotally carried by said frame, a tube extending through a portion of said frame and being fixed relative to said frame, a movable core of magnetizable material within said tube and spring biased away from one end portion of said tube toward the other end portion, a magnetizable pole piece secured to one end portion of said tube and toward which said core is movable upon sufficient energization of said coil, said pole piece defining with said core a first magnetic air gap, a magnetic flux shunting plate disposed intermediate said coil and said pole piece and defining with said core a second magnetic air gap, said shunting plate having opposed end portions, an adjustable spring for biasing said armature, said armature and pole piece defining a third air gap, said shunting plate being spaced from said pole piece to define a fourth air gap, said frame being spaced from said shunting plate to define a fifth air gap, said frame defining with said core a sixth air gap, whereby for a given number of coil turns, the ratio of the current required to overcome the armature spring bias when the second air gap is a maximum to the current required to overcome the same armature spring bias when the second air gap is a minimum is substantially higher than the corresponding ratio for a similar device which omits the shunting plate.

2. An electromagnetic device for operating a pair of separable contacts controlled by a linkage mechanism comprising an electrical solenoid coil, a tube surrounded, at least in part, by said coil, a magnetizable core movable within said tube, means for retarding the movement of said core within said tube, an armature attractable by said coil, spring means biasing said armature away from said coil, a magnetizable pole piece secured to said tube between said core and said armature, a magnetizable frame in the magnetic field of said coil, said frame pivotally carrying said armature, a shunting plate of magnetizable material disposed intermediate said coil and said pole piece, and a spring within said tube to bias said core away from said pole piece and define a first air gap, said frame extending about said coil, said shunting plate and said core defining a second air gap between said armature and pole piece, a second spring biasing said armature away from said pole piece to define a third air gap, said shunting plate being axially spaced from said pole piece to define a fourth air gap, said frame being separated from said shunting plate by a fifth air gap, said frame being separated from said core by a sixth air gap, and, said fifth and sixth air gaps being small relative to said first and second air gaps.

3. An electromagnetic device comprising an armature, a solenoid coil, a magnetizable frame carrying said armature and coil, a magnetizable core movable by the magnetic field of said coil, a tube housing said core and surrounded in part by said coil, said tube being of nonmagnetizable material, a magnetizable pole piece mounted at one end of said tube and toward which said core is attractable, said pole piece defining with said core a first magnetic gap, a magnetic shunting ring of magnetizable material placed intermediate said pole piece and said core and surrounding said first magnetic gap to define with said core a second magnetic gap, said shunting ring defining with said frame a third gap, and an insulating ring spacing said shunting ring from said pole piece along the longitudinal axis of said tube and spacing said shunting ring radially from said tube.

4. An electromagnetic device comprising a solenoid coil, a magnetizable frame adjacent said coil and about at least two sides of said coil, an armature pivotally mounted on said frame, a magnetizable core movable by the magnetic field of said coil along the longitudinal axis of said coil, a magnetizable pole piece mounted at one end of said coil and toward which said core is attractable, said

6

pole piece defining with said core a first magnetic gap, a magnetizable shunting piece adjacent said frame and axially positioned intermediate said pole piece and said core so as to surround said first magnetic gap when said core is spaced away from said pole piece to define with said core a second magnetic gap in parallel with said first magnetic gap and a third magnetic gap with said pole piece, said pole piece and armature defining a fourth magnetic gap, whereby a first magnetic circuit is defined when the core is in its rearwardmost position comprising the gap between the core and the pole piece, the gap between the pole piece and the armature, and the frame, and a second magnetic circuit is defined when the core is in its forwardmost position comprising the gap between the pole piece and the armature, the armature, and the frame at which time substantially less flux is shunted as compared to the flux which is shunted in said first magnetic circuit.

5. The structure recited in claim 4 wherein a tube extends through a portion of said frame and is fixed relative thereto, said core is disposed within said tube and is biased toward the end of said tube opposite to said pole piece, and said armature is biased away from said pole piece.

6. The structure recited in claim 5 and further including a pintle supporting said armature and carried by said frame, said tube being fixed to said frame, a spring within said tube biasing said core away from said pole piece, said shunting piece is of ring-like shape, and a second spring biasing said armature away from said pole piece.

7. The structure recited in claim 4 wherein said shunting piece is flat and has a slit, said shunting piece defining between its own end portions and with said frame further flux gaps.

8. The structure recited in claim 4 wherein said shunting piece is of ring-like shape and with said frame defines a further flux gap.

9. The structure recited in claim 8 and further including a first spring biasing said core away from said pole piece, and a second spring biasing said armature from said pole piece.

10. In an electromagnetic device, the combination comprising a solenoid coil having a magnetizable pole piece at one end, a magnetizable frame on which said coil is mounted, an armature pivotally mounted on said frame, and a core movable toward and away from said pole piece and defining therewith a working gap, said armature, said core, said working gap, and said frame comprising a first magnetic circuit, a flux shunting piece carried by said coil and axially spaced from said pole piece to define with said frame and said core a second gap in parallel with said working gap, said flux shunting piece shunting a minor part of the flux of said coil when said core has moved toward said pole piece the maximum amount and a substantial part of the flux when said core has moved away from the pole piece the maximum amount.

11. An electromagnetic device comprising a solenoid coil, a magnetizable frame adjacent said coil and about two sides of said coil, an armature pivotally mounted on said frame, a magnetizable core movable by the magnetic field of said coil along the longitudinal axis of said coil, a magnetizable pole piece mounted at one end of said coil and toward which said core is attractable, said pole piece defining with said core a first magnetic gap, a magnetizable shunting piece adjacent said frame but axially spaced from said pole piece and defining with said core a second magnetic gap in parallel with said first gap, whereby a first magnetic circuit is defined when the core is in its most rearwardmost position comprising the gap between the core and the pole piece, the gap between the pole piece and the armature, and the frame, and a second magnetic circuit is defined when the core is in its most forwardmost position comprising the gap between the pole piece and the armature, the armature and the frame at which time substantially less flux is shunted as compared to the flux which is shunted in said first magnetic circuit.

7

12. The structure set forth in claim 11 wherein said shunting piece has a radial slit.

13. An electromagnetic device comprising an armature, a solenoid coil, a magnetizable frame carrying said armature and coil, a magnetizable core movable by the magnetic field of said coil, a tube housing said core and surrounded in part by said coil, said tube being of nonmagnetizable material, a magnetizable pole piece mounted at one end of said tube and toward which said core is attractable, said pole piece defining with said core a first magnetic gap, a magnetic shunting ring of magnetizable material placed intermediate said pole piece and said core and surrounding said first magnetic gap to define with

8

said core a second magnetic gap, said shunting ring being in magnetic circuit arrangement with said frame and being mounted spaced from said pole piece and spaced from said core.

References Cited by the Examiner

UNITED STATES PATENTS

3,081,387	3/1963	Smith	200—103
3,193,739	5/1965	Hollyday	317—177

BERNARD A. GILHEANY, *Primary Examiner*.

H. A. LEWITTER, *Examiner*.