Dec. 16, 1941. A. G. STIMSON 2,266,618

ELECTROMAGNET

Filed Feb. 18, 1941

Fig. 1.

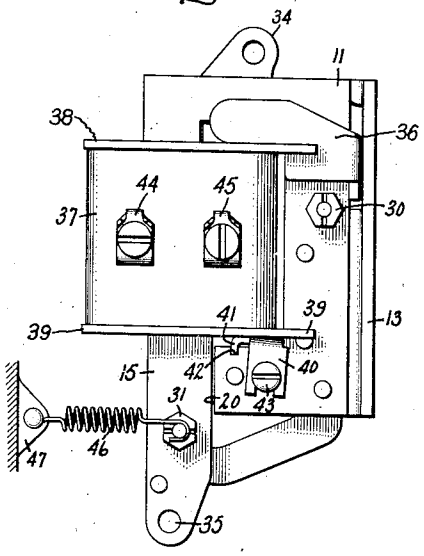


Fig. 3.

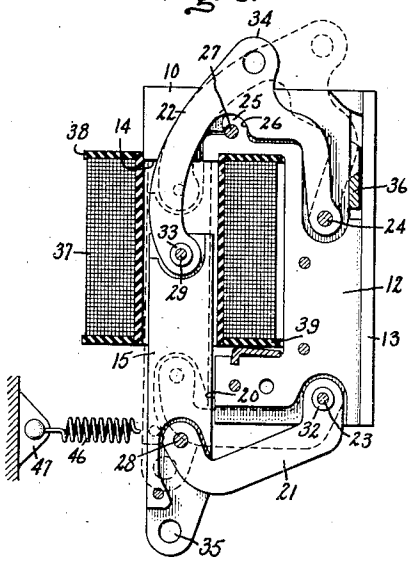


Fig. 2.

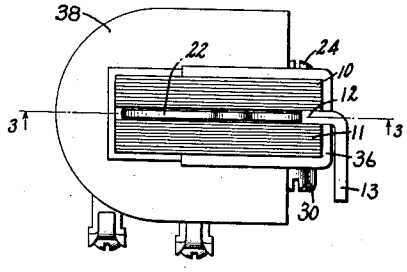
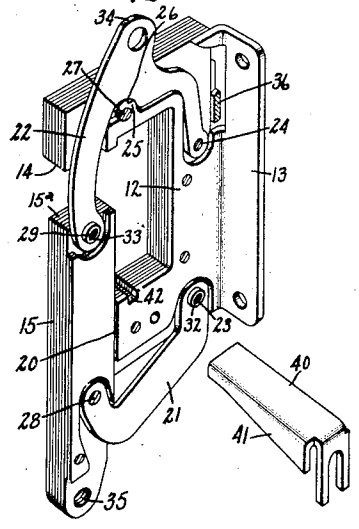


Fig. 4.



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2,266,618

UNITED STATES PATENT OFFICE

2,266,618

ELECTROMAGNET

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Application February 18, 1941, Serial No. 379,513

8 Claims. (Cl. 175—341)

My invention relates to electromagnets and particularly to the plunger type of electromagnets having provision for exerting a pushing force as well as a pulling force.

Heretofore three types of electromagnets have been well known. The plunger type, shown by way of example in Patent 1,696,615 to Trombetta, issued December 25, 1928, has a relatively long stroke and a reasonably constant pull as the air gap decreases. The clapper type of magnet, shown by way of example in Patent 1,761,772 to C. F. Carpenter et al., issued June 3, 1930, is characterized by relatively small magnetic leakage area, a short stroke, and simplicity and cheapness of construction. The E-shaped type of magnet, shown by way of example in Patent 1,964,464 issued on June 26, 1934, to R. W. Goff tends to combine the characteristics of the clapper and plunger types of magnet. The long stroke of the plunger type of magnet is not, however, characteristic of the E-shaped magnet. In many applications, where a small inexpensive magnet is required to exert a relatively long operating stroke, it is desirable to combine the most desirable characteristics of the clapper and plunger magnets. Such a combined construction should provide the long stroke and relatively constant pull characteristics of the plunger as well as the small leakage area and the reliable and inexpensive construction of the clapper type magnet.

It is, therefore, an object of my invention to provide a highly efficient plunger type of electromagnet of simple, reliable and inexpensive construction having a relatively long stroke.

It is a further object of my invention to provide a plunger type magnet having provision for exerting a pushing as well as a pulling force.

A still further object of my invention is the provision of a clapper type of plunger magnet, the pull characteristics of which may be varied substantially without appreciably altering its construction.

According to my invention, a longitudinally movable plunger is supported for substantially straight line movement upon a pair of pivotally mounted links, and is so arranged that in its closed position it cooperates with a stationary core structure to complete a substantially rectangular magnetic frame. The stationary core and movable plunger are provided with cooperating pole faces in a plane substantially perpendicular to the direction of movement of the plunger. The plunger is positioned for movement within the central aperture of an energizing solenoid.

For a more complete understanding of my invention and a further appreciation of its many objects and advantages reference should now be had to the following detailed specification and the accompanying drawing in which Fig. 1 is a side elevation of an electromagnet embodying my invention; Fig. 2 is a plan view of the electromagnet shown in Fig. 1; Fig. 3 is a cross-sectional view taken along the line 3—3 of Fig. 2; and Fig. 4 is a perspective view of the plunger and core structure of the electromagnet shown in Figs. 1, 2 and 3.

Referring now to the drawing, a divided stationary core of my electromagnet comprises two sets of stacked laminations 10 and 11 of magnetizable material spaced apart by the relatively thick plate 12 of magnetic material to define a pair of central slots. The plate 12 is provided with a mounting flange 13 for attachment to a suitable support. The magnetic core 10, 11 is approximately C-shaped and has an upper horizontal portion which overhangs the lower horizontal portion to form a pole face 14.

A movable plunger 15, formed of a solid stack of laminations of magnetizable material, is movably mounted beneath the pole face 14 for substantially straight line longitudinal movement toward and away from the pole face 14 and laterally with respect to a second pole face 20 of the core. The pole face 20 is on the lower horizontal leg of the core and is disposed at right angles to the pole face 14. The cross sectional dimensions of the plunger 15 are slightly less than the dimensions of the pole face 14 for reasons which will appear hereinafter. The plunger 15 is pivotally supported upon a pair of swingable links 21 and 22 which lie within the slotted core 10, 11 and are pivotally mounted upon a rivet 23 and a bolt 24, respectively, passing through the core 10, 11. The links 21 and 22 are U-shaped to follow in general the contour of the core 10, 11, as is best shown at Figs. 3 and 4, and are preferably formed of non-magnetic steel. To accommodate the pivoted ends and the body portions of the links 21 and 22, the plate 12 is recessed as shown in Figs. 3 and 4, and the central laminations of the plunger 15 are likewise recessed as shown. The recessed central laminations of the plunger form at its ends a second pair of slots for receiving the ends of the links 21, 22. To form a lower limit stop for the plunger 15, a protruding abutment 25 formed on the plate 12 is disposed to engage a

shoulder 26 on the link 22. A copper rivet 27 passes through the abutment 25 to assist in supporting the plate 12 with respect to the core 10, 11 and to act as an electric conductor as will be more fully described below. The plunger 15 is pivotally supported upon the links 21 and 22 by a bolt 28 and a rivet 29, respectively.

It will now be observed that the link 21 is pivotally mounted upon a fixed rivet 23 and the link 22 is pivotally mounted upon a removable bolt 24, while the movable plunger 15 is supported upon the links 21 and 22 by means of a removable bolt 28 and a fixed rivet 29 respectively. The bolts 24 and 28 are provided with nuts 30 and 31 respectively and are removable. The rivets 23 and 29 are provided at their central portions with sleeves 32 and 33 respectively. The sleeves 32 and 33 are of a length equal to the thickness of the plate 12 so that they assist in spacing apart the core portions 10 and 11 and the laminations of the plunger 15. The sleeves also serve as bearings for the links 21 and 22, which are thinner than the plate 12 so that they may move freely in the slots formed between the core portions 10, 11 and by the recessed central laminations of the plunger 15. To provide for the exertion of either a horizontal or a vertical pushing force by the plunger 15, the link 22 is formed with an apertured ear 34 extending beyond the periphery of the core member 10, 11. In operation the ear 34 rotates about the bolt 24 and may be attached to any desired mechanical load. Likewise, to provide for the attachment of the armature 15 to a mechanical load in pulling relationship, the armature 15 is apertured at 35.

Since my electromagnet is particularly designed for operation in connection with alternating current, it is desirable to provide a shading coil to minimize the effect of variation in current in the alternating current line. My shading coil comprises a U-shaped copper member 36 embracing the core 10, 11 and having its ends connected together by the copper rivet 27. It will be recalled that the copper rivet 27 also serves the purpose of supporting the central lamination 12. With this construction the shading coil in effect shades about three-fourths of the area of the pole face 14.

An energizing winding or solenoid 37 is disposed to enclose the upper portion of the armature 15 and the air gap between the pole faces 14 and 15a. The solenoid 37 fills substantially the entire space between the upper and lower horizontal legs of the core 10, 11 and is provided at each end with bifurcated insulating collars 38 and 39. The solenoid is positioned by the pole face 14, which extends a small distance into the solenoid, and by the bifurcated collars which embrace the core 10, 11. The solenoid 37 is held firmly in position by an L-shaped wedge 40 having a wedge-shaped flange 41 engaging a notch 42 in the core 10, 11. The wedge 40 is drawn and held in position by a bolt 43 which passes through a hole in the core 10, 11 and is threaded into the plate 12. For connection to a source of energy the solenoid 37 is provided with terminals 44 and 45. The function of the removable bolts 24 and 28 will now be apparent. By removing the bolts the plunger 15 may be swung away from the pole face 20 to permit removal of the solenoid 37. It will now be evident that the difference in sectional dimensions of the pole face 14 and the plunger 15 permits the solenoid 37 to be positioned by the pole face while insuring clearance between the solenoid and plunger.

The lower end of the armature 15 is biased away from the pole face 20 of the core by a tension spring 46 secured at one end to a fixed support 47 which may be the same support upon which the flange 13 is mounted.

In operation, when the armature 15 picks up it moves in an arcuate path of relatively large radius defined by the movement of the bolt 28 and the rivet 29 in arcs about the rivet 23 and the bolt 24, respectively, as centers. The pole face 14 and the abutment 25 are so positioned that the armature moves over center with respect to the rivet 23 and the bolt 24; that is, at about the midpoint of the path of movement the armature 15 lies tangent to the arcs defined by the bolt 28 and the rivet 29. Since the radius of these arcs is large with respect to their lengths, it will be seen that the armature 15 moves in substantially a straight line toward the pole face 14. It will be observed that when the core and armature are energized an attractive force will be exerted between the pole face 20 of the stationary core and the side of the armature 15. Whenever the bolt 28 is below dead center with respect to the rivet 23 this horizontal force will have a downwardly directed vertical component opposing the pick-up force exerted upon the armature from the pole face 14, and whenever the bolt 28 is above dead center an upwardly directed vertical component of force will assist the pick-up force from the pole face 14. It is for the purpose of neutralizing the attraction between the pole face 20 and the side of the armature that the tension spring 46 is arranged to exert an oppositely directed force upon the armature. Furthermore, since the spring 46 is disposed for overcenter operation, it has the effect of assisting the electromagnetic pull on the lower half of the stroke and opposing the electromagnetic pull on the upper half of the stroke. Thus the vertical components of force exerted by the pole face 20 in directions tending to exaggerate the increased pull as the armature approaches the pole face 14 are neutralized by the spring 46; and the spring also introduces vertical components of force in opposite directions to make the pull curve more constant.

If desired, of course, my electromagnet may be used without the spring 46. The effect of the spring 46, however, is such that by its use an adjustment of the pull of the solenoid is possible without altering its construction substantially. The magnetic pull may be adjusted by changing the tension of the spring 46, since the spring exerts a vertical component of force upon the plunger.

It will now be apparent that my electromagnet has a long stroke, reliable and inexpensive construction, and high efficiency. The concentration of all the core iron in a single C-shaped core section has the effect of increasing the efficiency of the magnet over that of a double-cored plunger magnet. Since the cross-sectional area of the core increases as the square of the sectional dimensions, while the surface area of iron increases directly with the dimensions, a single core section of large cross section will have less leakage area than two core sections having the same total cross section. Tests of the instant electromagnet have proven that it can exert substantially twice the pull of a double-cored magnet of the same size.

While I have described but one preferred em-

bodiment of my invention, it will be understood, of course, by those skilled in the art that many modifications thereof may be made, and I, therefore, wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electromagnet comprising a divided stationary core of magnetic material defining a first central slot, a movable plunger of magnetic material centrally recessed to define a second slot, means for supporting said plunger from said core to define therebetween an air gap and to provide for substantially straight line longitudinal movement of said plunger to close and open said air gap, said means comprising a swingable link movable within said slots and pivoted to said core and to said plunger, and an energizing winding disposed in magnetizing relation to said core and plunger.

2. An electromagnet comprising a divided stationary core of magnetizable material mounted upon opposite sides of a recessed central plate of magnetic material to define a first pair of slots, a movable plunger centrally recessed to define a second pair of slots, means for supporting said plunger from said core to define therebetween an air gap and to provide for substantially straight line longitudinal movement of said plunger to close and open said air gap, said means comprising a plurality of swingable links movable within said pairs of slots and pivoted to said core and to said plunger, and an energizing solenoid disposed in the region of said air gap to magnetize said core and plunger.

3. An electromagnet comprising a divided stationary core of magnetizable material of substantially C-shape having an overhanging upper horizontal leg forming a pole face, a recessed plate disposed between the halves of said core to space said halves apart and thereby to define a first pair of slots, a movable plunger disposed in a position beneath said pole face to define therewith an air gap, the opposite ends of said plunger being centrally recessed to form a second pair of slots, a pair of swingable links pivotally attached to said core within said first pair of slots and pivotally attached to said plunger within said second pair of slots for supporting said plunger in said position and for substantially straight line longitudinal movement to close and open said air gap, and an energizing winding enclosing said air gap and a portion of said movable plunger.

4. An electromagnet comprising a divided stationary core of magnetizable material of substantially C shape having an overhanging upper horizontal leg forming a pole face, a recessed plate of magnetic material disposed between the halves of said core to space said halves apart and thereby to define a first pair of slots, said plate being provided with a mounting flange extending beyond said core and being also provided with a protruding abutment lying within one of said slots, a movable plunger of magnetizable material disposed in a position beneath said pole face to define therewith an air gap, the opposite ends of said plunger being recessed to form a second pair of slots, a pair of swingable links movable within said first and second pairs of slots for supporting said plunger in said position and for substantially straight line longitudinally movement to close and open said air gap, said plunger and said core forming a substantially rectangular magnetic frame structure when said air gap is closed, one of said links having a shoulder disposed to engage said abutment to provide a lower limit stop for said plunger, means for pivotally attaching said links to said plunger within said second pair of slots, means for pivotally attaching said links to said core within said first pair of slots, and an energizing winding arranged beneath said pole face to enclose said air gap and a portion of said plunger.

5. An electromagnet comprising a divided stationary core of magnetizable material of substantially C shape having an overhanging upper horizontal leg forming a pole face, a recessed plate of magnetic material disposed between the halves of said core to space said halves apart and thereby to define a first pair of slots, said plate being provided with a mounting flange extending beyond said core and being also provided with a protruding abutment lying at the base of one of said slots, a shading coil of electric conducting material embracing a section of said core and passing through said core and said abutment, a movable plunger of magnetizable material disposed in a position beneath said pole face to define therewith an air gap, the opposite ends of said plunger being centrally recessed to form a second pair of slots, a pair of swingable links movable within said first and second pairs of slots for supporting said plunger in said position and for substantially straight line longitudinal movement to close and open said air gap, said plunger and said core forming a substantially rectangular magnetic frame structure when said air gap is closed, one of said links having a shoulder disposed to engage said abutment to provide a lower limit stop for said plunger and being also provided with an apertured ear extending beyond said core for connection to an external load in pushing relation, means disposed within said first pair of slots for pivotally and detachably mounting said one link upon said core and for pivotally mounting the other of said links permanently upon said core, and means disposed within said second pair of slots for pivotally connecting said one link permanently to said plunger and pivotally and detachably connecting said other link to said plunger, an energizing winding arranged beneath said pole face to enclose said air gap and a portion of said plunger, and a wedge removably positioned between said energizing winding and the lower horizontal leg of said C-shaped core for firmly holding said energizing winding in position.

6. An electromagnet comprising a stationary core of magnetizable material of substantially C shape having an overhanging upper horizontal leg forming a pole face, a movable plunger of magnetizable material disposed in a position beneath said pole face to define therewith an air gap, means for supporting said plunger in said position and for substantially straight line movement to close and open said air gap, said means comprising a plurality of links pivotally mounted upon said core and pivotally attached to said plunger, a spring attached to said plunger and arranged to bias the lower end of said plunger away from the lower horizontal leg of said C-shaped core in a direction substantially at right angles to the direction of movement of said plunger, and an energizing winding disposed in magnetizing relation to said core and plunger.

7. An electromagnet comprising a divided sta-

tionary core of magnetizable material of substantially C shape having an overhanging upper horizontal leg forming a pole face, a recessed plate of magnetic material disposed between the halves of said core to space said halves apart and thereby to define a first pair of slots, said plate being provided with a mounting flange extending beyond said core and being also provided with a protruding abutment lying in the base of one of said slots, a shading coil of electric conducting material comprising a U-shaped portion embracing a section of said core and a rivet passing through said laminated core and said abutment and electrically connecting the ends of said U-shaped portion, a movable plunger of magnetizable material disposed in a position beneath said pole face to define therewith an air gap, the opposite ends of said plunger being centrally recessed to form a second pair of slots, a pair of swingable links movable within said first and second pair of slots for supporting said plunger in said position and for substantially straight line longitudinal motion to close and open said air gap, said plunger and said core forming a substantially rectangular magnetic frame structure when said air gap is closed, one of said links having a shoulder disposed to engage said abutment to provide a lower limit stop for said plunger and being also provided with an apertured ear extending beyond said core for connection to an external load in pushing relation, means disposed within said first pair of slots for pivotally and detachably mounting said one link upon said core and for pivotally mounting the other of said links permanently upon said core, and means disposed within said second pair of slots for pivotally connecting said one link permanently to said plunger and pivotally and detachably connecting said other link to said plunger, a spring attached to said plunger and arranged to bias the lower end of said plunger away from the lower horizontal leg of said core in a direction substantially at right angles to the direction of movement of said plunger, an energizing winding arranged beneath said pole face to enclose said air gap and a portion of said plunger, and a wedge removably positioned between said energizing winding and the lower horizontal leg of said C-shaped core for firmly holding said energizing winding in position.

8. An electromagnet comprising a divided stationary core of magnetizable material defining a first central slot, said core being of substantially C shape to provide a pair of substantially parallel extending legs, the ends of said legs being arranged to provide pole faces lying in substantially perpendicular planes, a movable plunger of magnetizable material centrally recessed to define a second slot and disposed to complete a magnetic flux path between said pole faces, one end of said plunger defining with a first of said pole faces a variable air gap and the other end of said plunger being disposed adjacent the second of said pole faces to define therewith a substantially fixed air gap, means for supporting said plunger from said core for substantially straight line movement toward and away from said first pole face and laterally with respect to said second face, said means comprising a swingable link movable within said slots and mounted upon pivots on said core and plunger, resilient means for biasing said other end of said plunger away from said second pole face thereby to oppose the magnetic attractive force exerted by said second pole face upon said other end of said plunger in a direction transverse to the direction of motion of said plunger and to minimize the retarding frictional forces at said pivot, and an energizing winding disposed in magnetizing relation to said core and plunger.

ALLEN G. STIMSON.