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2,382,664

ELECTROMAGNETIC OPERATOR

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Fig. 1

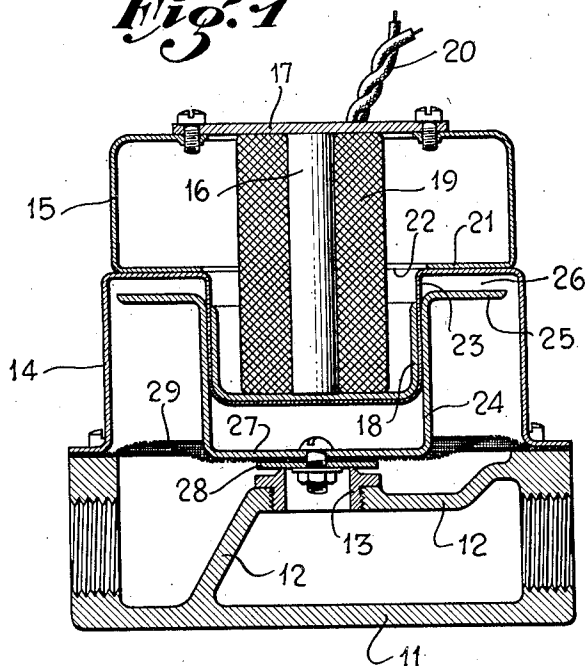


Fig. 2

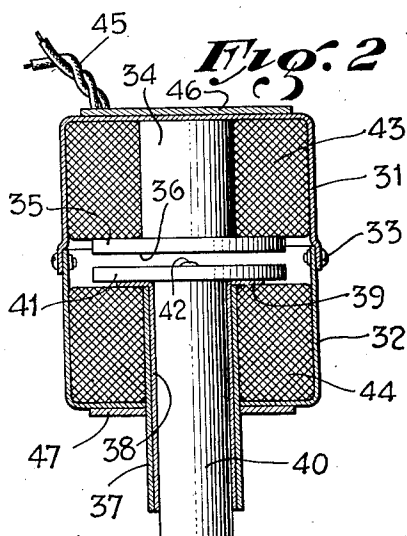
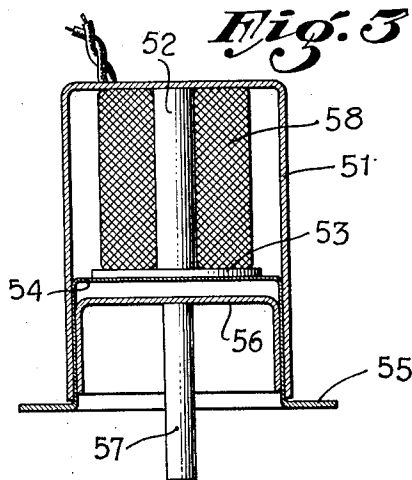


Fig. 3



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ELECTROMAGNETIC OPERATOR

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13 Claims. (Cl. 175—336)

My present invention relates to low energy-consumption electromagnetic operators, and particularly to those of the iron-clad single-working-gap type.

In my copending application, Serial No. 456,358, filed August 27, 1942, now Patent No. 2,358,828, granted September 26, 1944, I have disclosed an electromagnetic operator, of the series working-gap type, the energy consumption of which is very small in comparison with that of electromagnetic operators of conventional form and capable of performing equivalent work; the improvement residing mainly in the provision of a core having, at its ends, enlargements forming pole faces which are considerably greater in area than the cross-sectional area of the body of the core. The improved operation of that device is mainly due to the fact that, when the flux density in the core (produced by a weak magnetizing force) is at a point considerably below the knee of the magnetization curve for the core material, the flux density in the large-area pole face is substantially the same as that which could be produced by the weak magnetizing force if the cross-sectional area of the body of the core were not reduced; reduction of the body area making possible the use of a coil winding of small mean turn diameter and correspondingly small electrical resistance. It is a general object of the present invention to apply similar principles to provide a low energy-consumption electromagnetic operator of the single working-gap type. The device disclosed in the aforementioned copending application, while obviously not so limited, was designed for energization by a minute amount of electrical power, such as that available from a thermoelectric generating device heated by an ordinary small pilot-burner flame; the devices disclosed in the present application, however, are primarily intended for energization by a somewhat greater amount of power, of the order of 5 watts.

Another object of this invention is the provision of an iron-clad electromagnetic operator wherein the working-gap, instead of being located in the interior of the device, is defined in part by an outer portion of the core; a more specific object being the provision of an operator of that type which has an annular pole face formed by a flanged portion of its outer shell.

Another object is the provision, in an electromagnetic operator, of the general type described, of non-magnetic means for preventing direct engagement of the armature with the pole face, and for sealing the interior of the electromagnet; the

means also serving as a support for the electromagnet.

Another object is the provision of means for reducing the reluctance of the fixed air-gap of an iron-clad electromagnetic operator.

Other objects and advantages of the invention will be found in the description, the drawing, and in the claims; and for full understanding of the invention, reference may be had to the following detailed description and accompanying drawing, wherein:

Figure 1 is a sectional view of an electromagnetically operated fluid control valve embodying my invention; and

Figures 2 and 3 are sectional views of modified forms of electromagnetic operators embodying the invention.

Referring first to Fig. 1 of the drawing, the numeral 11 indicates a valve casing having a partition 12, in an opening through which partition is threaded a valve port and seat member 13. Secured to the open top end of the valve casing is a cylindrical housing 14, of non-magnetic material, which supports an electromagnet comprising a generally cup-shaped outer core portion 15 and a cylindrical inner core portion 16 which is intimately attached, as by welding, to an iron plate 17 which covers a central opening in the end wall of the outer core portion and is removably secured thereto by screws. Welded to the free, or bottom, end of the inner core portion 16 is a cup-shaped enlargement or head 18 of magnetic material; and surrounding the portion 18 is an energizing coil winding 19 having external leads 20. The opening in the outer core portion, covered by the plate 17, is of such size that the coil and inner core assembly can be withdrawn from the electromagnet for replacement by a similar unit. The open end of the cup-shaped outer core portion 15 is inwardly turned to form a flange 21, the underside of this flange providing an annular pole face 22. The flange 21 is secured, as by welding, to the top wall of the non-magnetic housing 14, which wall is of reduced thickness and has a central depression, formed by a cup-shaped portion 23, closely conforming to the entire outer surface of the cup-shaped inner core head 18. Slidable on this head, and magnetically separated therefrom by the portion 23, is a cup-shaped armature 24 having an annular flange 25 extending from its open end, which flange cooperates with the pole face 22 to define the single working-gap 26 of the electromagnet; the "fixed" air-gap being formed by the side wall of the non-magnetic portion 23. Attached to the end wall 27 of the arma-

ture is a closure member 28 cooperable with the seat member 13; and interposed between the armature and the closure member is a flexible perforate diaphragm 29, of finely woven wire, which is secured at its margin between the valve casing and the housing 14. This diaphragm, while permitting equalization of the fluid pressures on its opposite sides, serves to prevent entrance of foreign matter, carried by the controlled fluid, to the sliding surface of the armature.

The cup-shaped outer core portion 15 is constructed of material of such thickness that its effective cross-sectional area is substantially equal to that of the inner core portion 16; and the considerable space provided between the coil winding 19 and the side wall of the outer core portion minimizes flux leakage between these parts. The area of the annular pole face 22 is obviously many times that of the cross-section of the inner core portion 16, so that the flux density in the working-gap 26 is very low; the relative proportions shown in Fig. 1 being those preferred when the magnetizing force is of the order of that produced by a pilot-burner-heated thermoelectric device; it being borne in mind that, due to the relatively small diameter of the core portion 16, the mean turn diameter and electrical resistance of coil 19 are correspondingly small. In modified forms of the electromagnet shown in Fig. 1, the ratio between the areas of the pole face and inner core cross-section may be as low as 4:1 or 2:1 when the magnetizing force is relatively high, but still considerably below the knee of the magnetization curve for the particular material employed. By bending the flanges 21 and 25 so that they are at corresponding inclined angles, the area of the working-gap can be increased without increasing the external dimensions of the electromagnet; however, when the angle of inclination is large, the actual pull is not greatly increased, due to the unuseful transverse flux then produced in the gap. Due to the large area of the side surface of the inner core head 18, the flux density in the fixed air-gap between it and the armature is low, and the losses in this part of the magnetic circuit thus minimized. It will be observed that when the armature 24 is in attracted position with its flange 25 separated from the pole face 22 only by the non-magnetic top wall of housing 14, there is a considerable space between the end wall 27 of the armature and that of the head 18 so that that space therefore does not constitute a working-gap, and the end wall of the armature could be eliminated without materially affecting the operation of the electromagnet; however, the construction shown is preferred since it affords convenient means for connecting the armature to the device to be operated, and also aids to some degree in conduction of the flux. The "draw-formed" portion of housing 14 serves not only as a magnetic separator between the working-gap flanges 21 and 25 and between the armature and the inner core head, but also as a fluid seal for the electromagnet when it is employed in a valve structure.

Referring now to the modified form of electromagnetic operator shown in Fig. 2, the numerals 31 and 32 indicate a pair of cup-shaped core portions which are intimately joined together by tightly lapping the mouth of one over that of the other, screws 33 serving to secure the junction. Attached, as by welding, to the end wall of the upper core portion 31 is a cylindrical inner core portion 34 having at its free end a cylindrical stop or head 35, of the same material as the core por-

tion, the underside 36 of which forms the pole face of the electromagnet. Welded in a central opening through the end wall of the lower cup-shaped portion 32, and so arranged that it extends to a considerable distance from either side of the wall, is a sleeve 37 of magnetic material. A press-fit within this sleeve is another sleeve 38, of thin non-magnetic material, having at its inner or upper end, immediately above the corresponding end of the outer sleeve, a flange 39. A sliding fit within the inner sleeve is a magnetic plunger 40, the outer end of which is adapted to be connected to a device to be operated. The plunger has at its upper end a cylindrical head 41, also of magnetic material, the top surface of which defines with the pole face 36 the working-gap of the electromagnet. Direct engagement of the heads 35 and 41, when the electromagnet is energized, is prevented by a non-magnetic button 42 set in the lower head; and, when the plunger is in its unattracted position as shown, the underside of its head is separated from the magnetic sleeve 37 by the non-magnetic flange 39. The adjacent surface areas of the heads 35 and 41 are several times greater than the cross-sectional areas of the core portion 34 and plunger 40, respectively, but the heads are preferably of such diameter that the space between them and the outer core portions is large enough to prevent material lateral leakage of flux. For energizing the electromagnet, a pair of coil windings 43 and 44, connected in aiding relation and having external leads 45, are provided; one winding surrounding the core portion 34, and the other the magnetic sleeve 37. Due to the large surface area of the sleeve 37 adjacent the plunger 40, the reluctance of the fixed air-gap between these parts is relatively low. To increase the flux-conducting capacity of the end walls of the outer core portions 31 and 32, disks 46 and 47, of magnetic material, are welded to their outer surfaces.

Referring now to the still further modified form of electromagnetic operator shown in Fig. 3, the numeral 51 indicates an elongated cup-shaped outer core portion, to the end wall of which is welded an inner cylindrical core portion 52 having at its bottom end a disk-like head 53, the underside of which forms the pole face of the electromagnet. A press-fit in the open end of the core portion 51 is a cup-shaped member 54, of thin non-magnetic material, the end wall of which is forced into close engagement with the core head 53. The member 54 serves both as a magnetic separator and also as a seal for the interior of the electromagnet, and has at its open end a thickened flange 55 whereby the electromagnet can be mounted, as on a valve casing. Slidable within the member 54 is a cup-shaped armature 56, having a stem 57 for connection to a device to be operated, which armature is attracted toward the inner core head 53 when the electromagnet is energized by passage of current through its coil winding 58. It will be observed that this form of the invention also embodies the features of providing a large-area working-gap, and a low-reluctance fixed air-gap.

While I have herein shown and described specific embodiments of my invention, I wish it to be understood that modifications may be made without departing from the spirit of the invention, and that I intend therefore to be limited only by the scope of the appended claims.

I claim as my invention:

1. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner por-

tion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; an armature reciprocable with respect to said inner core portion and in good flux-transfer relation thereto, said armature having a surface defining with said pole face a working-gap; and a coil winding in said space.

2. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; said inner core portion being enlarged at its free end; an armature reciprocally mounted on said enlargement of the inner core portion and in good flux-transfer relation thereto, said armature having a surface defining with said pole face a working-gap; and a coil winding in said space.

3. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending inwardly from its open end to form a substantially plane pole face of substantial area; an armature having a substantially plane surface defining with said pole face a working gap, said armature being reciprocally mounted on said inner core portion for movement of said surface toward and away from said pole face; and a coil winding in said space.

4. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a substantially plane pole face of substantial area; said inner core portion being enlarged at its free end; an armature of generally cup-shaped form, and inverted with respect to said cup-shaped core portion, reciprocally mounted on said enlargement of the inner core portion and in good flux-transfer relation thereto, said armature having a flange extending from its open end providing a surface defining with said pole face a working-gap; and a coil winding in said space.

5. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; said inner core portion having at its free end a cup-shaped head, inverted in relation to said cup-shaped core portion; a member of thin non-magnetic material having a portion covering said pole face and secured thereto, another portion closely surrounding the side and end walls of said cup-shaped head, and a thickened marginal portion extending outwardly beyond said flange to form a support for said core member; an armature of cup-shaped form, corresponding to that of said

cup-shaped head, slidable on the portion of said non-magnetic member surrounding the side wall of said cup-shaped head, said armature having a flange extending from its open end which provides a surface defining with said pole face a working gap; and a coil winding in said space and surrounding the unenlarged part of said inner core portion.

6. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; said inner core portion having at its free end a cup-shaped head, inverted in relation to said cup-shaped core portion; a member of thin non-magnetic material having a portion covering said pole face and another portion closely surrounding the side and end walls of said cup-shaped head; an armature of cup-shaped form, corresponding to that of said cup-shaped head, slidable on the portion of said non-magnetic member surrounding the side wall of said cup-shaped head, said armature having a flange extending from its open end which provides a surface defining with said pole face a working gap; and a coil winding in said space and surrounding the unenlarged part of said inner core portion.

7. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; said inner core portion having at its free end a cup-shaped head, inverted in relation to said cup-shaped core portion; a member of thin non-magnetic material having a portion covering said pole face and another portion closely surrounding the side and end walls of said cup-shaped head; an armature slidable on the portion of said non-magnetic member surrounding the side wall of said cup-shaped head, said armature having a surface defining with said pole face a working gap; and a coil winding in said space and surrounding the unenlarged part of said inner core portion.

8. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; said inner core portion having an enlargement at its free end; a member of thin non-magnetic material having a portion covering said pole face and another portion closely surrounding said enlargement of the inner core portion; an armature slidable on said other portion of said non-magnetic member and having a surface defining with said pole face a working-gap; and a coil winding in said space and surrounding the unenlarged part of said inner core portion.

9. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith

a space for an energizing coil winding, said cup-shaped portion having a flange extending from its open end to form a pole face of substantial area; a member of non-magnetic material secured to and covering said pole face, and having an outwardly extending portion serving as a support for said core member; an armature reciprocable with respect to said inner core portion and in good flux-transfer relation thereto, said armature having a surface defining with said pole face a working-gap; and a coil winding in said space.

10. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding; said inner core portion being enlarged at its free end to form, within said cup-shaped portion, a pole face the area of which is at least several times greater than the cross-sectional area of the unenlarged part of the inner core portion; a generally cup-shaped member of thin non-magnetic material closely received in the open end of said cup-shaped core portion, and so arranged that the outer surface of its end wall is in engagement with said pole face, said cup-shaped member having at its open end a flange which serves as a support for said core member; an armature slidable in said cup-shaped member, the inner surface of said armature defining with said pole face a working-gap; and a coil winding in said space and surrounding said unenlarged part of the inner core portion.

11. In an electromagnetic operator of the single working-gap type: a core member having a generally cup-shaped outer portion and an inner portion extending substantially centrally from the end wall of the outer portion to define therewith a space for an energizing coil winding; said inner

core portion being enlarged at its free end to form, within said cup-shaped portion, a pole face the area of which is at least several times greater than the cross-sectional area of the unenlarged part of the inner core portion; a generally cup-shaped member of thin non-magnetic material closely received in the open end of said cup-shaped core portion, and so arranged that the outer surface of its end wall is in engagement with said pole face; an armature slidable in said cup-shaped member, the inner surface of said armature defining with said pole face a working-gap; and a coil winding in said space and surrounding said unenlarged part of the inner core portion.

12. In an electromagnetic operator: a fixed core member having an energizing coil winding and providing a pole face; an armature arranged for attraction toward said pole face when the core is energized; and means for supporting said core member and for preventing direct engagement of said armature with said pole face, comprising an integrally formed member of non-magnetic material having a medial portion closely covering said pole face and end portions forming a support for the core member, said medial portion being reduced in thickness.

13. In an electromagnetic operator: a fixed core member having an energizing coil winding and providing a pole face; an armature arranged for attraction toward said pole face when the core is energized; and means for supporting said core member and for preventing direct engagement of said armature with said pole face, comprising a member of non-magnetic material having a portion closely covering said pole face and extending therebeyond to form a support for the core member.

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