

Dec. 20, 1932.

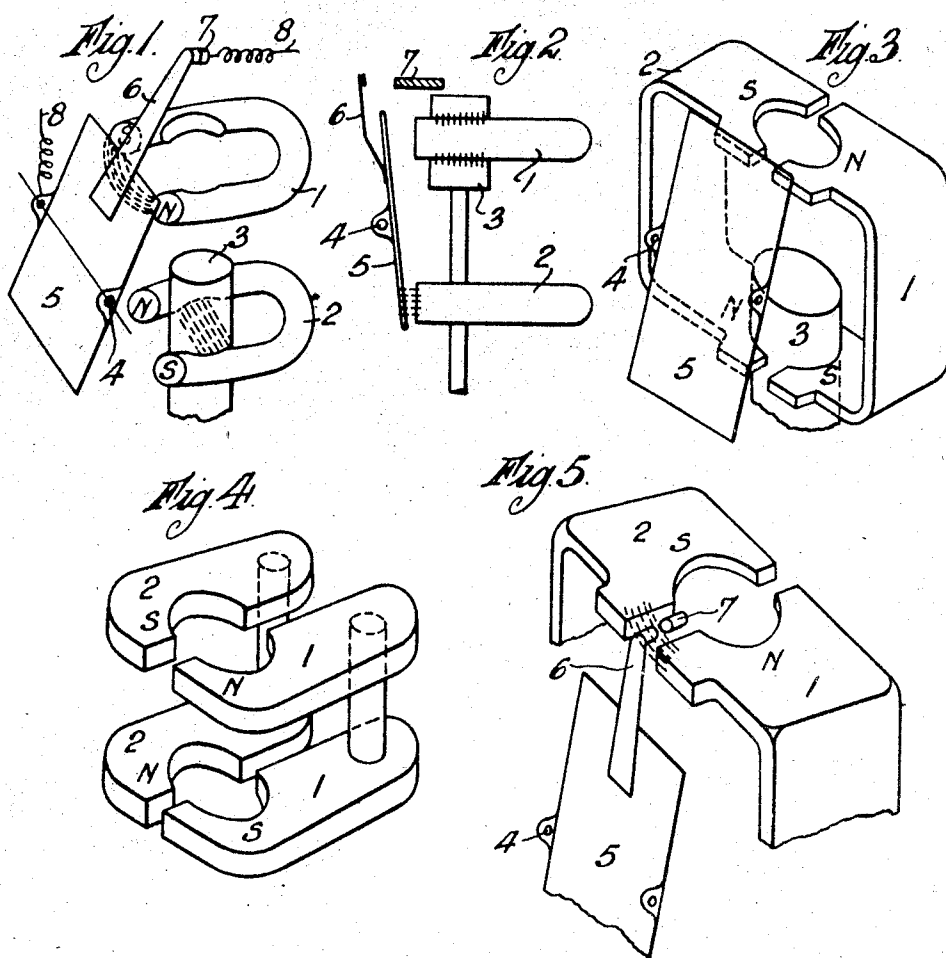
J. N. MORRIS ET AL

1,891,568

MAGNETICALLY OPERATED APPARATUS

Filed March 27, 1930

4 Sheets-Sheet 1



Inventors:
J. N. Morris
M. D. Scott,
By their Attorneys
P. A. W. Wright

Dec. 20, 1932.

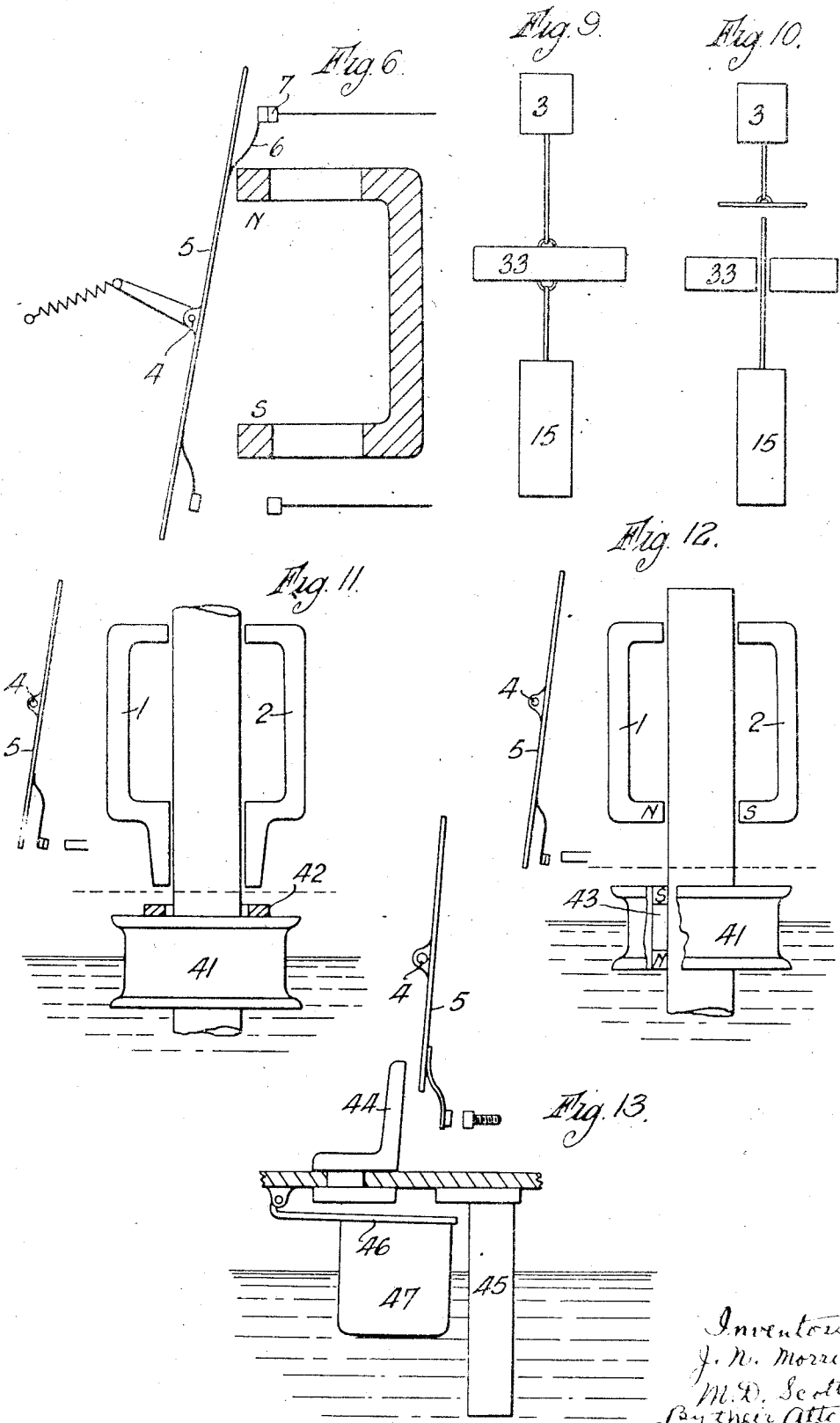
J. N. MORRIS ET AL

1,891,568

MAGNETICALLY OPERATED APPARATUS

Filed March 27, 1930

4 Sheets-Sheet 2



Inventors:
J. N. Morris
M. D. Scott.
By their Attorneys,
Baldwin & Wright.

Dec. 20, 1932.

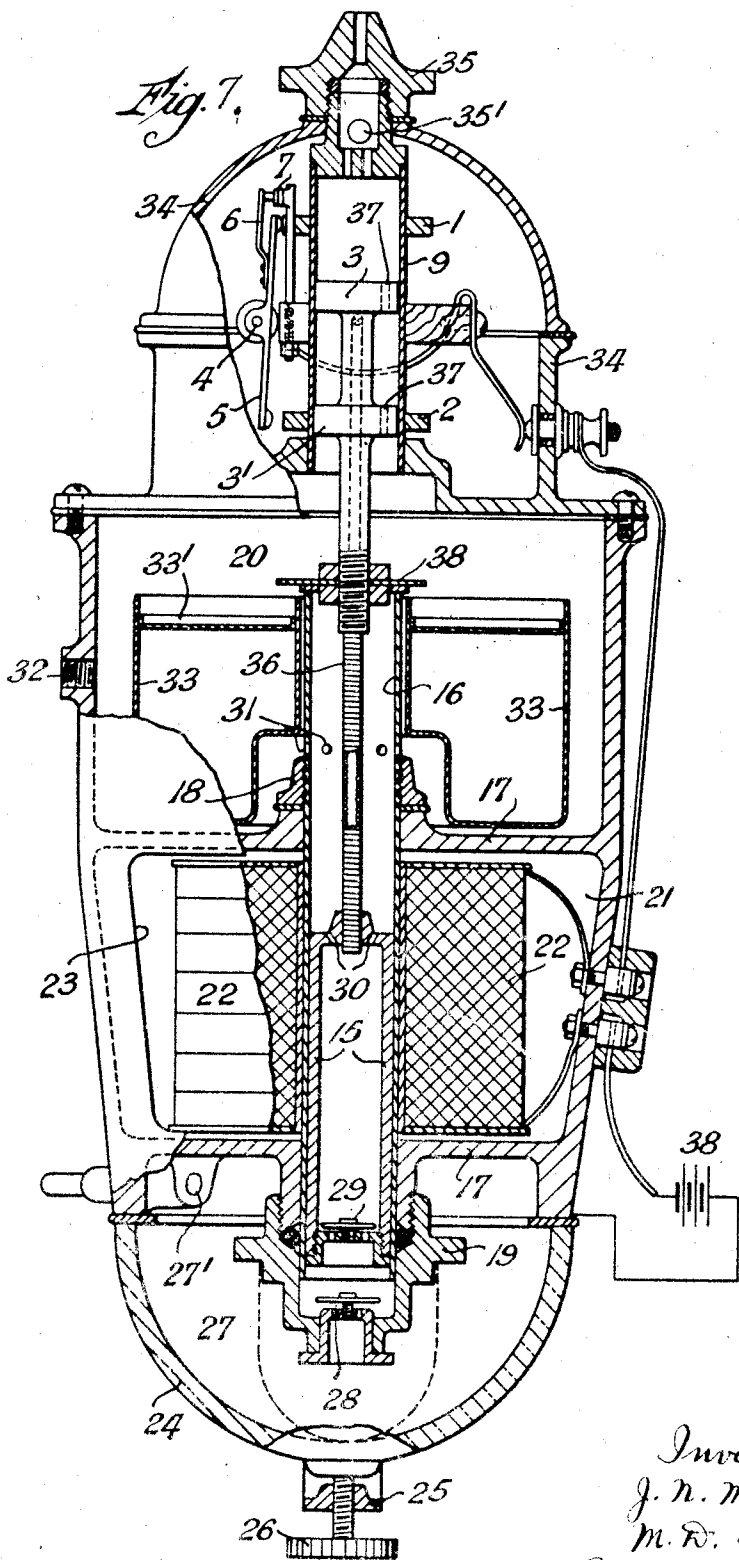
J. N. MORRIS ET AL

1,891,568

MAGNETICALLY OPERATED APPARATUS.

Filed March 27, 1930

4 Sheets-Sheet 3



Inventors.
J. N. Morris.
M. D. Scott.
By their Attorneys,
Baldwin Wright

Dec. 20, 1932.

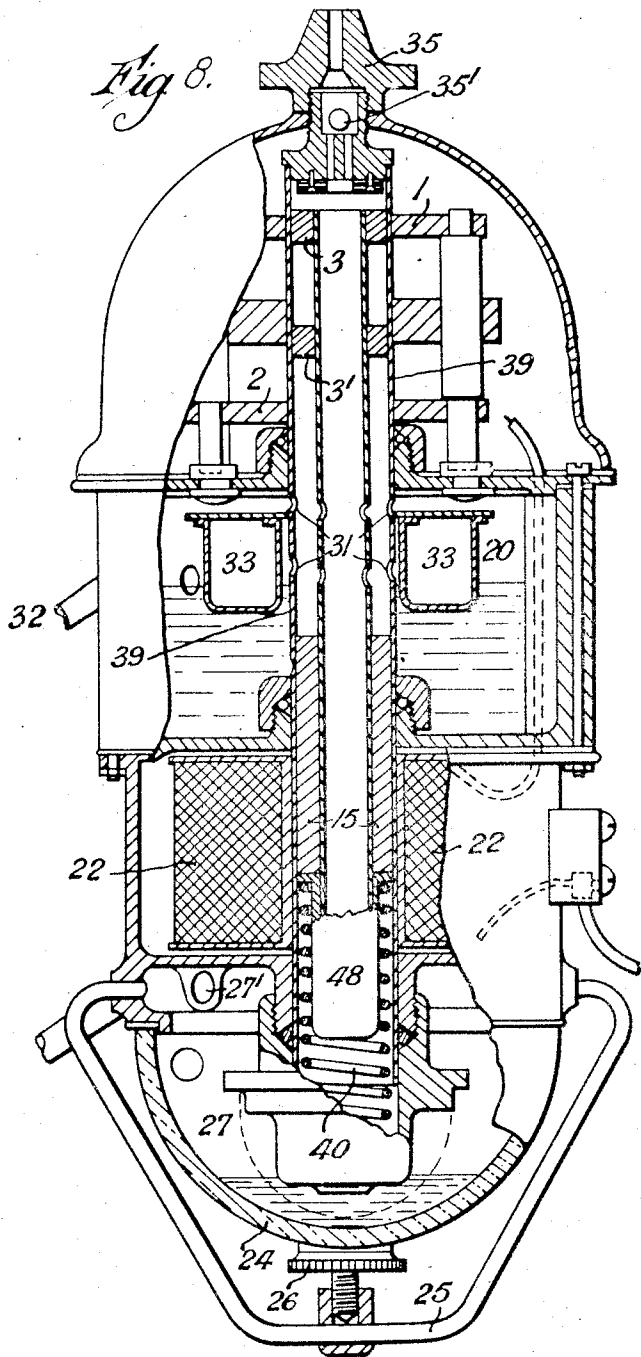
J. N. MORRIS ET AL

1,891,568

MAGNETICALLY OPERATED APPARATUS

Filed March 27, 1930.

4 Sheets-Sheet 4



Inventors,
J. N. Morris.
M. D. Scott.
By their attorneys,
Baldwin Wright

UNITED STATES PATENT OFFICE

JOHN NEVILLE MORRIS, OF LONDON, AND MURRAY DUNCAN SCOTT, OF ENFIELD,
ENGLAND

MAGNETICALLY OPERATED APPARATUS

Application filed March 27, 1930, Serial No. 439,425, and in Great Britain July 25, 1929.

This invention relates to improvements in magnetically operated control mechanism.

More especially the invention is concerned with electrically operated reciprocating apparatus such as a hammer or pump in which the reciprocating member is carried or operated by the movable core of a solenoid, the winding of which is connected with electric contacts which are made and broken by the movement of the core.

The main object of this invention is to obtain a positive control of the solenoid circuit, and thereby a defined movement of its core, by so arranging or mounting the electric contacts that they are open or closed by a common armature.

According to the present invention a magnetic control mechanism comprises a moving part, movement of which part is utilized to bring a body of permeable material into one or other of two magnetic circuits, separate or associated, thereby exposing different parts of an armature alternately to predominating magnetic attraction and causing the armature to move accordingly.

In the preferred embodiment of the invention two similar permanent magnets are employed arranged so as to constitute in effect a ring magnet having diametrically opposite air gaps, across which the flux is alternately short circuited by means of the body of magnetic material whereby the leakage fields of the magnets are alternately decreased with respect to each other so as to actuate the armature.

Alternatively the magnets, instead of being arranged in series so as to provide air gaps between their opposite poles, may be employed in parallel when the magnetic fields across the air gaps of each magnet are alternately short circuited.

It is obvious that in place of permanent magnets, permanently magnetized electromagnets may be employed and the use of the term "permanent magnets" throughout the specification and claims is intended to include such. In order to prevent the permanent magnets from becoming demagnetized a few turns of wire may be wound on to the magnets, and which turns may be connected in

series or in parallel with the circuit of the solenoid.

In the application of this invention to electrically operated reciprocating apparatus, such for example as an electrically operated pump whose piston is actuated by or constitutes the core of a solenoid, the circuit of the solenoid is controlled by the armature of the control mechanism and the reciprocating or other moving part of the magnetic control mechanism is actuated by the piston (or solenoid core). A soft iron block or plunger, which is actuated by or connected to the piston (or alternatively the core of the solenoid), may conveniently be employed for short circuiting and/or varying the flux intensity of the magnetic fields of the magnets.

The magnets are arranged with the opposite poles of different magnets, or of the same magnet located in such a position that they respectively correspond with those of the plunger at the beginning and end of its stroke.

It will thus be seen that each time the plunger moves between one pair of opposite poles of the magnets it causes a short circuit of flux, and therefore there will be a relative increase of flux of one pair of poles with respect to the other pair. An electric make and break in the circuit of the solenoid may thus be positively operated by the armature of the magnets, the ends of which armature are alternately attracted by each pair of poles as the soft iron plunger together with the piston reciprocates. In an arrangement having a single permanent magnet, this is so located that the plunger at the ends of its stroke moves into a position to form a conductive path between one of the poles of the magnet and the armature. It will thus be seen that there is a variation in or redistribution of the flux at each pole causing each end of the armature to be alternately attracted by each pole.

While the invention has been mainly described and is hereinafter illustrated with reference to pumping apparatus it is to be understood that it is applicable for other

purposes such for example as liquid level or pressure indicating apparatus.

The invention is illustrated in the accompanying drawings in which:—

5 Figures 1 and 2 are respectively a perspective view and elevation of switch gear according to the invention.

Figures 3 and 4 illustrate modifications.

Figure 5 is a detail view.

10 Figure 6 is a detail view of a magnet controlling two circuits.

Figures 7 and 8 are sectional elevations of two forms of pumping apparatus fitted with the switch gear illustrated in Figures 1-5.

15 Figures 9-13 are detail views of various modifications of mechanisms for suspending the operation of the pump.

Referring to Figures 1 and 2, 1 and 2 are permanent magnets between which is mounted to reciprocate an iron block or disc 3. The movement of the disc 3, it will be understood is operatively controlled by the reciprocating part of the apparatus whose reciprocatory movement the switch gear is employed to control. Mounted to rock about an axis 4 is an armature 5 which carries a contact finger 6 adapted to contact with a point 7 and make or break a circuit 8. It will be obvious that when the disc 3 moves between the poles of either one of the magnets 1 and 2 it will provide a short circuit or path for the flux of the magnet, decreasing the external field of the magnet. Thus in Figure 1 the magnet 2 has been short circuited, and the magnetic attraction of the magnet 1 will be stronger, thus attracting the armature 5 and completing the circuit 8. The circuit 8 may as hereinafter described constitute the circuit of a solenoid operating a pump piston, which piston will therefore be operated, imparting movement to the disc 3 (which may be in the form of an iron plunger), raising it to the Figure 2 position, when the magnet 1 is short circuited. The magnetic attraction of the magnet 2 will now be stronger and attract the armature 5 breaking the circuit 8. Each time therefore there is a reciprocating movement of the plunger 3 there will be a relative increase in the external magnetic field of one of the magnets 1 and 2 sufficient to rock the armature 5 and either make or break the circuit 8.

In place of permanent magnets, electro-magnets may be employed in which case the windings will be continuously excited. Or the strength of the permanent magnets may be maintained for example by a few turns of wire passed around the magnets 1 and 2, and connected into the circuit 8.

Figures 3 and 4 show an alternative arrangement of magnets in which the flux of both magnets 1 and 2 is used to attract the armature, the effect being virtually to employ a ring magnet in which a gap is caused

to appear alternately at two diametrically opposite points.

This arrangement of magnets in series will be found preferable to that of Figures 1 and 2, where the magnets are in parallel since the out of balance forces acting on each end of the armature remain constant when the iron plunger or disc 3 is moving from one air gap to another. Assuming that the plunger 3 has moved out of one air gap, a reluctance proportional to one air gap is inserted in the magnetic system, which decreases the pull on each end of the armature by an equal amount so that until the plunger has moved into a position to short circuit the magnetic field across the other air gap there is no movement of the armature. When the magnets are in parallel, that is the arrangement comprises two separate coaxial circular magnetic systems, the pull on the armature ends does not remain constant with the result that should one of the magnets lose strength, the balance of the system may be upset.

As illustrated in Figure 5 the contact points 6-7 may be so mounted that a field of force lies across the path of rupture, so that a rapid disruption of any arc, that may form occurs.

Although not shown in Figures 1-5 for the sake of clearness it is desirable that the polar faces of the magnets abut against a tube 9 (see Figures 5, 7 and 8) of non-magnetic material within which tube the plunger 3 is free to slide.

In the foregoing constructions it has been assumed that the pump piston or other reciprocating member operated by the solenoid is returned to its initial position by gravity or spring means. In some cases however, it may be desirable to construct the switch gear to operate two solenoids, one pulling in the opposite direction to the other, as for example in a pump pumping against pressure, or in a pump constructed to operate in any position with respect to gravity. For this purpose the armature 5 may be arranged so as normally to return to a mid position equidistant from the magnet poles by a spring, the spring being normally overcome by the magnetic attraction at either end of the armature, but in the event of the attraction being nullified by two short-circuiting paths, such as iron discs, the armature will fly to "off" position, leaving both contact points open. Such an arrangement is illustrated in Figure 6.

Referring now to Figures 7 and 8, the soft iron plunger is connected to a pump piston 15 slidably mounted in a tube 16 which constitutes the pump cylinder. The tube 16 is mounted in a casting indicated generally at 17 and is secured in position by screwed locking members 18 and 19. The casting 17 is divided into an upper float chamber or reservoir 20, and a compartment 21 for a solenoid 130

22, which is mounted upon the exterior of the tube 16, a window 23 being provided in the wall of the casting to enable this to be inserted in position.

5 The lower end of the casting 17 has attached to it a cup 24 by means of a stirrup piece 25 provided with a set screw 26, in order that the cup, which is preferably made of glass, may readily be detachable for cleaning purposes. The cup 24 forms a lower chamber 27 and 27' is the inlet thereto. The lower end of the pump cylinder is closed by the locking member 19, but has one way access to the chamber 27 through the one way valve 28, which allows passage of liquid from chamber 27 to the pump cylinder. Any suitable form of non-return valve may be used.

15 The pump piston 15 consists of a hollow piece of soft iron and constitutes the core of the solenoid 22. In the foot of the piston is another one way valve 29, holes 30 being provided in the top end to allow the passage of liquid past the piston and thence into the reservoir 20. 31 are leakage holes for a purpose hereinafter described.

25 32 is the delivery from the reservoir, in which is provided a float 33.

30 The float chamber or reservoir 20 is closed by a two-part casting 34 which forms a housing for the switch gear illustrated in the preceding Figures 1-5.

35 The tube 9 of non-magnetic material, within which the switch plunger 3 slides, is secured at each end in the casting 34 in such a manner that the switch gear is mounted within a flash tight casing, and at its upper end is closed by a cap piece 35 forming a vent between the reservoir chamber and the atmosphere. To ensure that this vent is sealed should the action of the pump not cease due to the float 33 becoming perforated or from any other cause, there is mounted in this container a cork or other buoyant ball 35' which is raised should the liquid reach this point, and seals the aperture. To make it unnecessary to ensure the correct alignment between the upper tube 9 and the lower tube 16, carrying the pump piston, the plunger or discs 3-3' are connected to the pump piston 15 by means of a flexible metallic tube 36. This form of connection being tubular also serves the purpose of lubricating the plunger 3, since some of the liquid rises up the tube 36 as the pump plunger descends, and passes through apertures 37 in the plunger 3. On the plunger 3 or tube 36 is a ring 38 adapted to be engaged by the float 33 when the float chamber is full. The chamber 27 also serves as a trap for dirt and sediment, and as a chamber into which fluid from the reservoir 20 above can sink, due to leakage through the valves when the pump is idle, thus ensuring that the valves 28 and 29 are below the liquid level and therefore primed.

The action of the pump is as follows:—

When the terminals are connected to a battery or direct current electricity supply indicated at 38, the current will flow through the solenoid coil 22 through the contacts 6-7 70 and armature 5. The excitation of the coil 22 attracts and raises its core forming the pump piston 15 closing the valve 29, and opening the valve 28, thus drawing liquid into the pump cylinder 16. As the piston 75 15 rises, it carries with it the plunger or discs 3, and when this disc enters the polar field of the permanent magnet 1, this short-circuits the flux across its poles and causes a relative increase of magnetic attraction at the poles 80 of the lower magnet 2. This variation in flux causes the armature 5 to move over, open the contacts 6-7 and thus break the circuit of the coil 22. The piston 15 will now descend by gravity, the fluid (after a sufficient 85 number of strokes) passing through the apertures 30 bored in the upper end of the piston 15 whence it flows over the top of the tube walls 16 into the float chamber. When the piston 15 and hence the plunger 3 descends to the bottom of its stroke, the polar flux path of the magnet 2 is short-circuited, the attraction at the polar area 1 is increased, the armature 5 is rocked over, the contacts 6-7 made, the coil 22 excited, and the piston 15 is again 95 drawn within the solenoid, drawing in liquid as before described, switching itself off, descending by gravity and delivering a further pumpful in the float chamber. Provided there is no output or a curtailed output from the delivery pipe 32, the level will rise until the float 33 is submerged or about to be submerged, when the float will rise, and the plunger 15 will be prevented from falling by the washer 38 coming in contact with the 105 upper surface of the float. This will prevent the plunger 3 from short-circuiting the flux at the polar area of the magnet 2, and will prevent the contacts 6-7 from being closed. When a delivery demand is made, the liquid will flow out through the delivery pipe, the float 33 will sink, allowing the washer to fall with it, until the plunger 3 short-circuits the flux about the polar area 2, the contacts 6-7 are closed, and pumping recommences. 115

In some cases it may be necessary to make the distance between the magnet poles longer than the stroke of the pump piston in which case two iron discs 3 and 3' (see Figures 7 and 8) are used connected either by a magnetic 120 or non-magnetic rod, tube, or link, the upper disc being used to short-circuit the flux about the upper magnet pole faces, and the lower of the two discs to short-circuit the flux about the lower magnet pole faces. Alternatively, 125 when it is desired to provide for variation in the length of stroke of the pump piston, the distance between these two discs is made adjustable, by screw-threading one disc upon the other, or sliding one upon a sleeve, or by 130

any other means so that if the distance between the two discs is reduced, the pump piston stroke is increased, and vice versa.

In order to ensure that the pump piston causes the excitation and de-excitation of the coil 22, to occur at the times most convenient for effective valve operation and silence, the position of the pump piston is adjustable in relation to the plunger 3 or a spring may be placed between these members.

It is well-known that in plunger pumps of this type, it is necessary to "prime" the pump before starting, and in order that the pump should, under all circumstances, be so primed, notwithstanding the tank on which the pump draws becoming dry, or a fracture or leakage on the suction or inlet pipe, the volumetric content of that portion of the float chamber below the delivery outlet is equal to or greater than the volume of the chamber 27 less that portion below the valve 28. Liquid will thus descend into this trap from the float chamber when the pump is left standing for any time, owing to the leak occurring through the holes 31 and the valves 28 and 29. When therefore, the pump comes to rest, a volume of liquid is contained either in the float chamber and in the pump piston and cylinder or within the lower chamber 27 and up to a level such as will ensure that the two valves and the lower portion of the piston are immersed. It will be seen that the inlet pipe is arranged at a point above the end of the piston at the bottom of its stroke.

Referring now to Figure 8, the tubes 9 and 16 are joined into a single tube 39 passing through the switch gear, float and lower chambers. The pump operation is also modified, and the plunger is raised by the action of a spring 40 and drawn downwardly by the solenoid 22, the piston 15 and the plunger 3 being connected to one another by a tube of non-magnetic substance. Apertures are provided in that portion of the tube 39 which passes through the float chamber. An extension is provided upon the lower end of the piston 15, passing through the centre of the spring 40 and carried down to a point sufficiently low to ensure submergence of the valve 29 which is carried in this extension. Apertures are provided for inlet and outlet as previously described. Any of the alternative methods for suspending the action of the pump, hereinafter described may be employed, but it will be seen that this form of construction allows of a more compact unit. If a float is employed to sustain the weight of the piston 15 and plunger 3 then a slot is cut in the tube 39, through which a projection from the float extends.

It is obvious that alternatively the float 33 instead of being free to move with respect to the piston 15, may be directly connected to both the piston and plunger 3 as shown in Figure 9. In Figure 10 only the plunger 3

is operated by the float 33, and the piston 15 is separate so that it is always free to return to its initial position.

The upper surface of the float 33 is preferably as shown in Figure 7 constructed with a tank or gallery 33' into which the liquid is delivered by the pump piston. The delivery of liquid into this gallery virtually increases the weight of the float, which is restrained from rising until the level in the container is higher than would otherwise be the case. A small aperture is provided in the container or gallery, through which the liquid can leak. When the flow from the container is less than the delivery capacity of the pump, the float will become submerged, when the buoyancy of the float will be equal to its natural buoyancy without the head of liquid carried in the gallery. The float will now rise, as the level in the container rises and trip or stop the action of the pump by means before described. This gallery thus gives rise to an increase in the period both of pumping, and non-pumping on a curtailed delivery.

In place of employing a mechanical form of float operated cut off to suspend the action when the pump has filled the float chamber or a container such as may be carried in the pump itself, or when the liquid has risen to a definite head or height, such as would be required to maintain the level in a vapourizing jet or carburetter; (refer now to Figure 11) the magnets may be constructed with extensions to their lower polar surfaces, and a float 41 suspended in the liquid may be used to raise an iron ring 42 into magnetic contact with the magnet poles 1 and 2, preventing the lower extremity of the magnets drawing over the armature 5 and so closing the contact points 6—7 irrespective of the position of plunger 3.

In an alternative arrangement shown in Figure 12, a permanent magnet 43 is carried in the float itself, so that the closing movement of the armature is again prevented irrespective of the position of the plunger 3. In this construction, the strength of the magnet 43 may be maintained by arranging its polarity and position in juxtaposition with and to the solenoid plunger.

Alternatively, the float 41 may be constructed to raise a soft iron sleeve carried up within the non-magnetic tube 39 to short-circuit the flux on the lower polar extremities of the magnets 1—2.

Alternatively, as shown in Figure 13 a soft iron core 44 may be mounted in a position adjacent to the outer surface of the lower extremity of the armature 5, and which core becomes magnetized from a permanent magnet 45 by bringing the soft iron core into magnetic contact with the permanent magnet through the medium of a lever 46 of soft iron actuated by a float 47 in the liquid container. Where a pump constructed as above described

is required to deliver liquid at atmospheric pressure, an aperture is provided between the float chamber or pump container and the atmosphere, as shown for example, in Figures 5 7 and 8. Where however, this pump is required to deliver at a pressure above atmosphere, no aperture is provided, and to ensure cutting out the action of the pump when the pressure has reached some pre-determined maximum, a closed diaphragm or chamber is provided within the pump container, the contraction of which under pressure, will serve to decrease its buoyancy, and this reduction in buoyancy, may be used to operate short-circuiting magnets or to suspend the action of the pump in the same way as the buoyant float method previously described.

Alternatively, the diaphragm can be mounted on any portion of the pressure pipe delivery line so that the expansion of the diaphragm breaks the circuit of the solenoid operations of the pump.

Alternatively, the action of this diaphragm may be used to press or abut upon the moving armature 5 of the switch gear.

It is to be understood that when a pair of magnets are employed, they may be arranged either in series or in parallel and in the accompanying claims the expression "a pair of magnets each having an air gap" is to be read as applying also to apparatus where the magnets are arranged in series in the magnetic circuit, as for example shown in Figures 3, 4 and 5.

What we claim is:—

1. In a magnetically operated relay the combination of two permanent magnets spaced apart from one another and each having an air gap, a magnetically attractive armature mounted to respond to variations in the leakage fields across the said air gaps, and a body of magnetic material which is movable for alternately shunting the magnetic fields across the said air gaps of said magnets, whereby the leakage fields of said magnets are alternately decreased with respect to each other to effect actuation of the armature.

2. In magnetic control mechanism the combination of a moving part, a pair of associated magnetic circuits, an armature mounted to respond to relative variations in flux intensity in the leakage fields of the said magnetic circuits, and a body of magnetic material movable by the moving part into one or the other of said magnetic circuits, thereby exposing different parts of the armature alternately to predominating magnetic attraction which causes it to move accordingly.

3. In a magnetic control mechanism the combination of a magnetic circuit having two air gaps arranged in series in the circuit, an armature of highly permeable material pivotally mounted to respond to variation in

the magnetic fields across said air gaps, and a body of magnetic material movable into and out of a position for short circuiting one or other of said magnetic fields and causing the armature to move accordingly.

4. In a magnetic control mechanism the combination of a substantially circular magnetic circuit having two air gaps arranged in series at substantially diametrically opposite points therein, an armature of highly permeable material pivotally mounted to respond to variation in the magnetic fields across said air gaps, and a body of magnetic material movable into and out of a position for short circuiting one or other of said magnetic fields and causing the armature to move accordingly.

5. In a magnetic control mechanism, the combination of a moving part, two permanent magnets spaced apart from one another and each having an air gap, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a body of magnetic material movable by the moving part so as alternately to shunt the magnetic fields across the air gaps of said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature.

6. In magnetic control mechanism, the combination of a moving part, two permanent magnets arranged in series in a magnetic circuit so as to provide air gaps, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a body of magnetic material movable by the moving part so as alternately to shunt the magnetic fields between said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature.

7. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising, a pair of magnetic circuits, an armature mounted to respond to relative variations in flux intensity in the leakage fields of the said magnetic circuits and a body of magnetic material movable by the reciprocating member into one or the other of said magnetic circuits thereby exposing different parts of the armature alternately to predominating magnetic attraction which causes it to move accordingly to make and break the circuit of the solenoid.

8. In a magnetically controlled switch, the combination of a moving part, a pair of magnetic circuits, an armature mounted to respond to relative variations in flux intensity in the leakage fields of the said magnetic circuits, a body of magnetic material

movable by the moving part into one or other of said magnetic circuits, thereby exposing different parts of the armature alternately to predominating magnetic attraction which causes it to move accordingly, and make and break contacts one of which is carried by the armature.

9. In a magnetically controlled switch, the combination of a magnetic circuit having two air gaps arranged in series in the circuit, an armature of highly permeable material pivotally mounted to respond to variation in the magnetic fields across said air gaps, a body of magnetic material movable into and out of a position for short circuiting one or other of said magnetic fields and causing the armature to move accordingly, and make and break contacts one of which is carried by the armature.

10. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising a magnetic circuit having two air gaps arranged in series in the circuit, an armature of highly permeable material pivotally mounted to respond to variation in the magnetic fields across said air gaps, and a body of magnetic material carried by and movable with the reciprocating member and movable into and out of a position for short circuiting one or other of said magnetic fields and causing the armature to move accordingly.

11. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising two permanent magnets spaced apart from one another and each having an air gap, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a body of magnetic material carried by and movable with the reciprocating member so as alternately to shunt the magnetic fields across the air gaps of said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature.

12. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising two permanent magnets arranged in series in a magnetic circuit so as to provide air gaps, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a body of magnetic material carried by and movable with the reciprocating member so as alternately to shunt the magnetic fields

between said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature.

13. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising a pair of magnetic circuits, an armature mounted to respond to relative variations in flux intensity in the leakage fields of the said magnetic circuits, and a pair of discs of magnetic material connected in spaced relation and adapted to be moved by the reciprocating member to cause one or the other of said discs to come into one or the other of said circuits and thereby expose different parts of the armature alternately to predominating magnetic attraction which causes it to move accordingly to make and break the circuit of the solenoid.

14. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising a pair of magnetic circuits, and armature mounted to respond to relative variations in flux intensity in the leakage fields of the said magnetic circuits, and a pair of discs of magnetic material connected in spaced relation and adapted to be moved by the reciprocating member to cause one or the other of said discs to come into one or the other of said circuits and thereby expose different parts of the armature alternately to predominating magnetic attraction which causes it to move accordingly to make and break the circuit of the solenoid, and means whereby the spaced relation of the discs may be varied.

15. In electrically operated reciprocating apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising two magnets spaced apart from one another and each having an air gap, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a pair of discs of magnetic material connected in spaced relation and adapted to be moved by the reciprocating member to cause each thereof to alternately move into and out of the air gap of an associated one of the magnets so as alternately to shunt the magnetic fields across the air gaps of said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature, and making or breaking of the circuit of the solenoid.

16. In electrically operated reciprocating

apparatus the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising two magnets spaced apart from one another and each having an air gap, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a pair of discs of magnetic material connected in spaced relation and adapted to be moved by the reciprocating member to cause each thereof to alternately move into and out of the air gap of an associated one of the magnets so as alternately to shunt the magnetic fields across the air gaps of said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature, and making or breaking of the circuit of the solenoid, and means whereby the spaced relation of the discs may be varied.

17. In electrically operated reciprocating apparatus, the combination of a reciprocating member, a solenoid for actuating the reciprocating member, and magnetic control mechanism for controlling the circuit of the solenoid comprising two permanent magnets spaced apart from one another and each having an air gap, an armature mounted to respond to relative variations in flux intensity in the leakage fields of said magnets, and a body of magnetic material carried by and movable with the reciprocating member so as alternately to shunt the magnetic fields across the air gaps of said magnets whereby the leakage fields of the magnets are alternately decreased with respect to each other to effect actuation of the armature, and re-energizing windings for the magnets connected with the solenoid circuit.

In testimony that we claim the foregoing as our invention, we have signed our names this 14th day of March, 1930.

JOHN NEVILLE MORRIS.
MURRAY DUNCAN SCOTT.