Jan. 5, 1954 P. DUFFING 2,664,826

ELECTRICALLY OPERATED FLUID PUMP

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Fig. 1

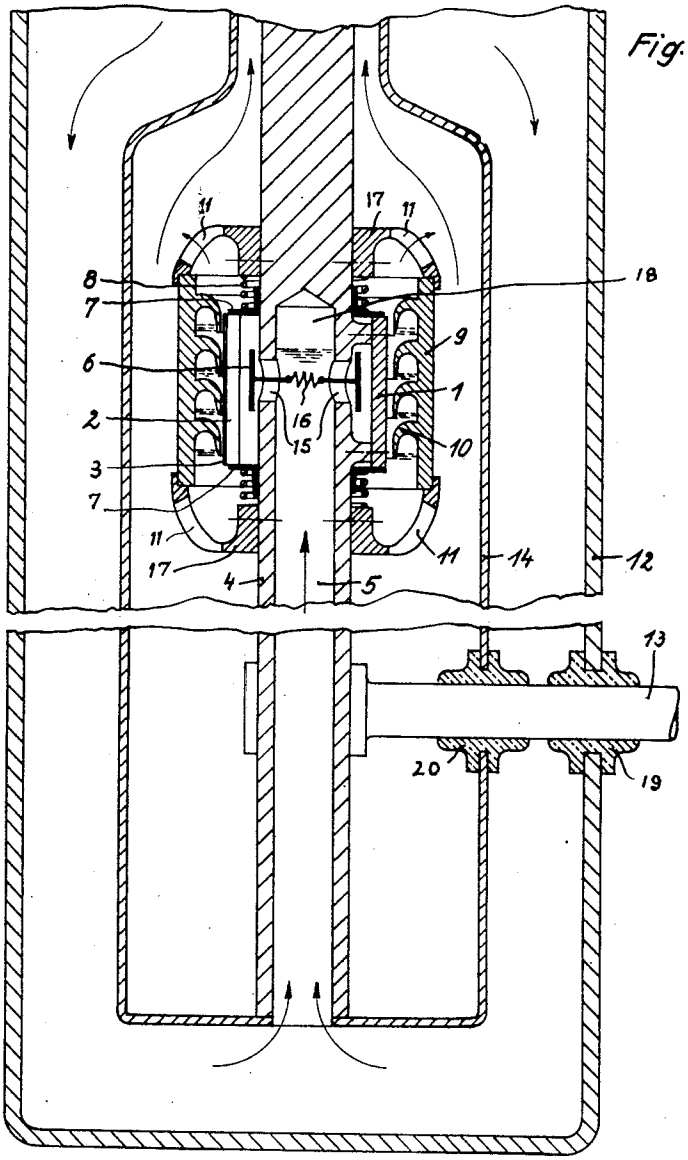


Fig. 2

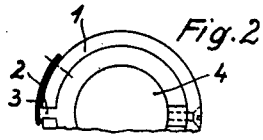
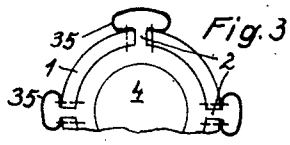


Fig. 3



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Fig. 4

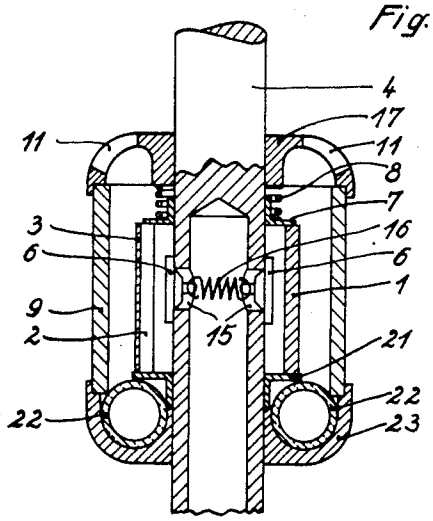
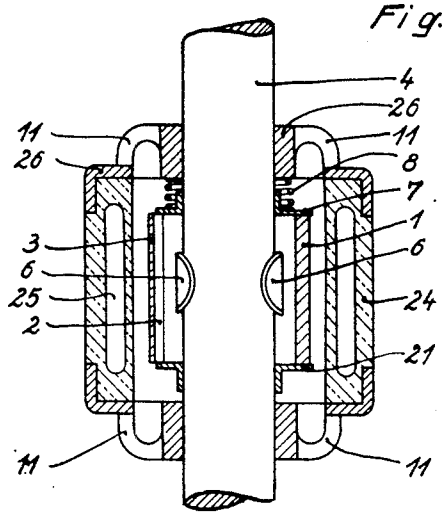


Fig. 5



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ELECTRICALLY OPERATED FLUID PUMP

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Application May 14, 1952, Serial No. 287,671

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11 Claims. (Cl. 103—152)

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My invention relates to electrically-operated pumps, such as oil pumps, and has for its general object to provide a pump of a particularly simple and space-saving design especially as regards the electric pump drive means.

A more specific object of my invention is to devise an electrically driven pump of the variable-volume chamber type in which the electric drive motor is so simplified and to such an extent integrated with the hydraulically active portion of the pump that it forms also the main structure of the variable-volume chamber.

Another object of my invention is to provide an electric pump, especially suitable for circulating liquid in electrical apparatus and machines, whose delivery varies automatically in dependence upon the electric current energizing the pump drive so that the pump output increases with an increase in current.

According to my invention, the pump comprises a slitted hollow cylinder of magnetizable material, such as iron or a ferromagnetic alloy, which is excited to contracting oscillations by means of an alternating magnet field that extends through the cylinder and is closed through the slit or slits.

When the field is produced by current of the customary line frequency (50 or 60 C. P. S.), the magnetic force in the slit alternates at twice that frequency (100 or 120 C. P. S.). The cylinder then oscillates in the same rhythm and accordingly contracts and expands the slit. The periodic variation in cylinder periphery causes a corresponding variation in cylinder volume. During each reduction in volume due to an increase in magnetic field strength, the fluid is forced out of the cylinder, for instance, through the slit. During each following increase in cylinder volume due to reduction in field strength, the fluid is inducted into the cylinder. Hence by providing suitable check-valve means, the oscillating cylinder is made to operate as a pump. The cylinder is preferably so dimensioned that its natural frequency is higher than double the frequency of the exciting alternating current.

According to another more specific feature of my invention, the cylinder slit is covered by a lid which provides check valve action and permits a flow of fluid substantially only from within the cylinder through the slit. Another check valve is preferably provided at a suction inlet of the cylinder chamber to permit at that place a flow substantially only in the inward direction.

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According to another feature of my invention, the magnetic field for the cylinder is produced by means of an electric conductor that passes axially through the cylinder. This conductor may be given a hollow design so that it serves also as an inlet conduit for the pump. The communication between the hollow of the conductor and the interior of the cylinder is then controlled by the above-mentioned check valve means.

According to another feature of my invention, the expulsion of liquid from the interior of the pump cylinder is controlled by spring-biased covers which close the two axial ends of the cylinder and thus operate as check valves. It is then not necessary to also use the slit of the cylinder as an exit for the oil or other liquid.

If it is desired to secure a highly uniform flow of liquid, the induction space and the space surrounding the cylinder are preferably provided with air chambers. In pumps whose centrally located conductor has a bore to form a conduit for the liquid to be pumped, this bore, according to another feature of my invention, is also designed as an equalizing air chamber. To this end, the bore is extended upwardly beyond the point where it communicates through a lateral opening with the interior of the cylinder. Air chambers in the space surrounding the pump cylinder may be formed by means of skirt members comparable to a diver's bell. Instead, however, air-filled bodies of highly elastic material, such as oil-resistant rubber, may be placed into the pump space adjacent to the cylinder.

The foregoing and more specific features of my invention are embodied in the example illustrated in the drawing, in which:

Fig. 1 shows an axial section through a pump according to the invention in conjunction with a fluid-circulating conduit system;

Fig. 2 shows a partial axial view of the pump proper;

Fig. 3 shows a similar axial view of a modified pump; and

Figs. 4 and 5 show respective sectional axial views of two other modifications.

The pump illustrated in Fig. 1 has a variable-volume chamber formed substantially by a hollow cylinder 1 which is slitted parallel to its axis. The slit 2 is covered by a lid 3 of flexible material. The lid is fastened to the outside of the cylinder 1 along one side of the slit so that it forms a check valve which opens the slit when the interior of the cylinder is under pressure and which closes the slit when the pressure outside of the cylinder is preponderant.

The cylinder 1 is centrally traversed by a rod-shaped conductor 4 with an axial bore 5. The bore 5 communicates with the interior of the cylinder 1 through lateral port openings 15 covered by respective check valves 6. The valves 6 are located at the outside of the conductor rod 4 and biased to closed position by a spring 16 which interconnects the two valve discs. The upper and lower axial sides of the cylinder 1 are closed by annular light-weight covers 7, each of which is slidable on the rod 4 and biased to closed position by a spring 8. The pump cylinder 1 is surrounded by a housing 9, also of hollow cylindrical shape. The housing 9 has several skirt-like projections 10 peripherally along its interior surface. These projections form annular air chambers much in the manner of a diver's bell. The housing 9 has its two axial sides covered by respective cap structures 17, each having a number of openings 11. The bore 5 of rod 4 is extended upwardly beyond the port openings 15 so that it forms also an air chamber at 18. The rod 4 with the cylinder 1 and the housing 9 is disposed within a vessel 14 which is surrounded by another vessel 12. The two vessels 14 and 12 communicate with each other at a place above the illustration. Electric current is suppiled to the rod 4 by means of a lead 13 insulated from the vessels 12 and 14 at 19 and 20 respectively. The upper end (not illustrated) of the rod 4 is also connected to a terminal or lead for the electric current.

When an alternating current passes through the conductor rod 4, it produces a magnetic alternating field in the magnetizable pump cylinder 1 which alternately contracts and expands the slit, thus varying the volume enclosed by the cylinder. The variation in volume has a frequency twice that of the energizing current. During contracting intervals of the cylinder, the liquid is forced through the check-valve covers 7 into the housing 9 from which it reaches the interior of the vessel 14 and flows, as indicated by arrows, through a desired circulatory path into the space between vessels 14 and 12. During expansion of the cylinder, the liquid is inducted from the vessel 12 through bore 5, ports 15 and check valves 6 into the interior of the pump cylinder 1. Consequently, a continuous circulation of the liquid is maintained by the pump.

As mentioned, the slit of the cylinder may be covered by a lid 3 to operate as a check valve. However, the pump may also be designed so that the liquid is ejected from the cylinder only through the openings of one or two valve covers 7. In that case, a diaphragm member covering the slit 2 is tightly secured along both sides of the slit as is shown, for instance, for each of the flexible diaphragms 35 pertaining to the modification illustrated in Fig. 3.

The pump cylinder may also be equipped with a plurality of longitudinal slits, the individual parts of the cylinder being then interconnected by resilient diaphragm connections 35, also as shown in Fig. 3. The cylinder and connecting diaphragm members are preferably so dimensioned that the natural frequency of the entire cylinder and diaphragm assembly is higher than twice the frequency of the alternating current.

Instead of providing the pump housing 9 with skirt members 10, the housing may be given a substantially straight inner surface, and the air chambers desired for better uniformity of the flow of liquid may then be provided by placing hollow elastic and air-filled bodies into the housing.

Such a design is preferable in cases where it is desired to prevent the liquid from being charged with air. Another modification securing the same result consists in making the housing 9 of rubber or similar resilient material, and giving it a double wall so that the air enclosed between the two walls acts as an air chamber.

Embodiments of the kind just-mentioned are shown in Figs. 4 and 5 wherein the same reference numerals are used as in Fig. 1 for corresponding respective elements. According to Fig. 4, the outer housing 9 of the pump is straight cylindrical. The lower axial side of the pump cylinder is covered by a lid 21 which serves as an abutment for one or several hollow air-filled bodies 22 of rubber or the like material placed into the lower cap 23.

In the embodiment of Fig. 5, the outer housing 24 of the pump consists of a double-walled structure of rubber or similarly elastic material whose hollow 25 is filled with air. The end caps 26 overlap the structure 24 sufficiently to hold it in place while permitting it to somewhat expand during the compression interval. In all other respects the embodiments of Figs. 4 and 5 are designed and operative as described above with reference to Figs. 1 and 2.

While pumps according to my invention are applicable for general purposes, they are especially advantageous in cases where space is at a premium and where alternating current for operating the pump is readily available. For instance, a favorable application of such pumps is in connection with circuit breakers and other electric apparatus that require a circulation insulating or arc-quenching liquid. In such cases, the field-producing conductor of the pump may form part of the electric conductor means that supply the current to the electric apparatus, as is the case in the illustrated embodiments.

It will be obvious to those skilled in the art upon a study of this disclosure that pumps according to the invention may be modified in various respects as regards structural details and the manner in which they are incorporated into a fluid system, without requiring a departure from the essential features of the invention and within the scope of the claims annexed hereto.

I claim:

1. An electric pump, comprising an alternating-current conductor for providing an alternating field, a slitted hollow cylinder of magnetizable material surrounding said conductor in said field to be periodically contracted due to said field, two annular cover members surrounding said conductor and having respective springs biasing said cover members against said cylinder at opposite axial sides respectively, and inlet valve means communicating with the interior of said cylinder.

2. An electric pump, comprising an alternating-current conductor for providing an alternating field, a slitted hollow cylinder of magnetizable material surrounding said conductor in said field to be periodically contracted due to said field, said conductor having a longitudinal bore and having a lateral port joining said bore with the interior of said cylinder, said bore having a closed end space axially beyond said port to form an air chamber, liquid conduit means including said bore and said port as well as said cylinder interior and having inlet valve means at said port, and outlet valve means communicating with the interior of said cylinder.

3. An electric pump, comprising an alternat-

ing-current conductor having a magnetic field, a hollow cylinder of magnetizable material having a longitudinal slit and being disposed around said conductor to be periodically contracted due to said field, a movable lid member covering said slit at the outside of said cylinder to form a check valve opposed to inward flow of liquid, cover means closing said cylinder at opposite axial sides respectively and comprising a cover member and a spring resiliently holding said cover member against said cylinder to form another check valve opposed to inward flow of liquid, said conductor having a longitudinal hollow and having a lateral port opening joining said hollow with the interior of said cylinder, and check valve means disposed at said port opening and opposed to outward flow of liquid from said cylinder.

4. An electric pump, comprising alternating-current means having a magnetic field when in operation, a slitted hollow cylinder of magnetizable material forming a variable-volume chamber and being positioned adjacent to said means to be periodically contracted by said field, and check valve means communicating with said chamber and forming a fluid path together therewith.

5. An electric pump, comprising an alternating-current conductor for providing an alternating field, a slitted hollow cylinder of magnetizable material forming a variable-volume chamber and surrounding said conductor to be periodically contracted due to said field, and check valve means communicating with said chamber and forming a fluid path together therewith.

6. An electric pump, comprising alternating-current means having a magnetic field, a hollow cylinder of magnetizable material having a longitudinal slit and forming a variable-volume chamber, said cylinder being disposed adjacent to said means to be periodically contracted by said field, a movable lid member covering said slit to form an outlet valve, and inlet valve means connected with said chamber.

7. An electric pump, comprising an alternating-current conductor for providing an alternating field, a slitted hollow cylinder of magnetizable material surrounding said conductor in said field to be periodically contracted due to said field, said conductor having a tubular portion and having a bore through which the interior of said tubular portion communicates with the interior of said cylinder so as to form a liquid flow path through said tubular portion and said bore and said cylinder, an inlet valve means at said bore to permit liquid flow substantially only in the direction from said tubular portion to said cylinder interior, and outlet valve means communicating with said interior of said cylinder.

8. An electric pump, comprising alternating-current means having a magnetic field, a slitted hollow cylinder of magnetizable material disposed adjacent to said means to be periodically contracted due to said field, said cylinder having respective axial openings, cover means closing said openings and comprising a cover member and a spring resiliently holding said cover member against said cylinder to form an outlet valve, and inlet valve means communicating with the interior of said cylinder.

9. An electric pump, comprising alternating-current conductor means having a magnetic field, a slitted hollow cylinder of magnetizable material surrounding said conductor means to be periodically contracted due to said field, said conductor means and said cylinder having a substantially vertical axis, a housing structure for liquid having a wall concentrically surrounding said cylinder in spaced relation thereto, said structure having annular skirt means extending from said wall inwardly and downwardly so as to form air pockets around said cylinder, and liquid conduit means forming a fluid path through said cylinder and having check valve means in said path.

10. An electric pump, comprising alternating-current means having a magnetic field, a slitted hollow cylinder of magnetizable material surrounding said means and being disposed in said field to be periodically contracted thereby, said cylinder having a natural frequency higher than twice the frequency of said alternating-current means, and inlet valve means and outlet valve means hydraulically joined with said cylinder.

11. An electric pump, comprising alternating-current means having a magnetic field, a slitted hollow cylinder of magnetizable material disposed in said field to be periodically contracted due to said field, a housing structure for liquid having a wall concentrically surrounding said cylinder in spaced relation thereto, a hollow gas-filled and elastically compressible body disposed within said housing structure, and check valve means communicating with the interior of said cylinder and forming a unidirectional fluid-flow path together therewith with said cylinder and with said housing structure.

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No references cited.