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2,177,795

COMPRESSOR AND ELECTRODYNAMIC ACTUATING MECHANISM THEREFOR

Filed May 27, 1938

3 Sheets-Sheet 1

Fig. 1.

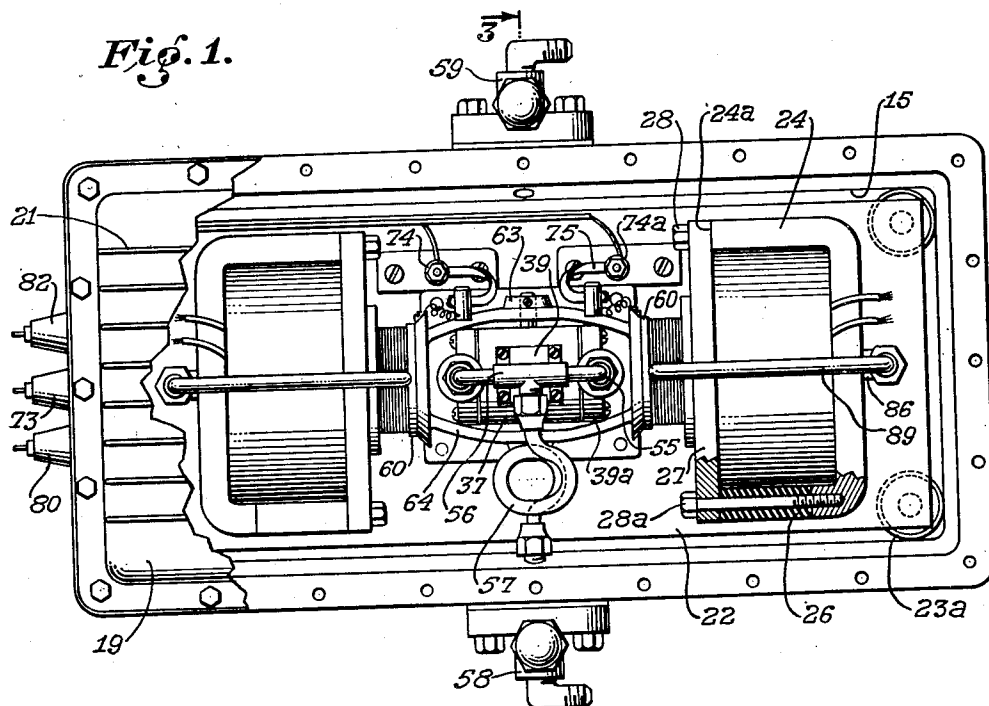
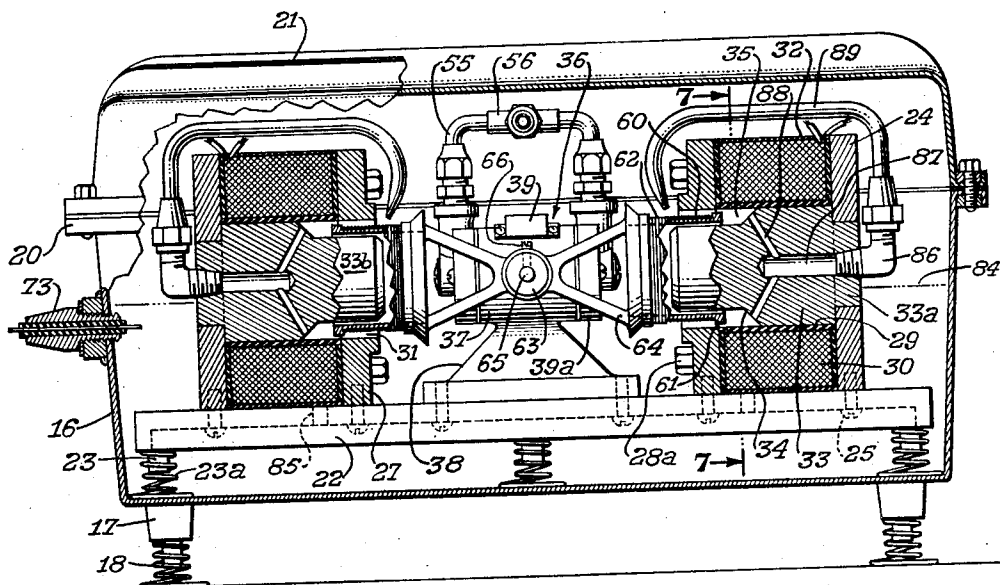


Fig. 2.



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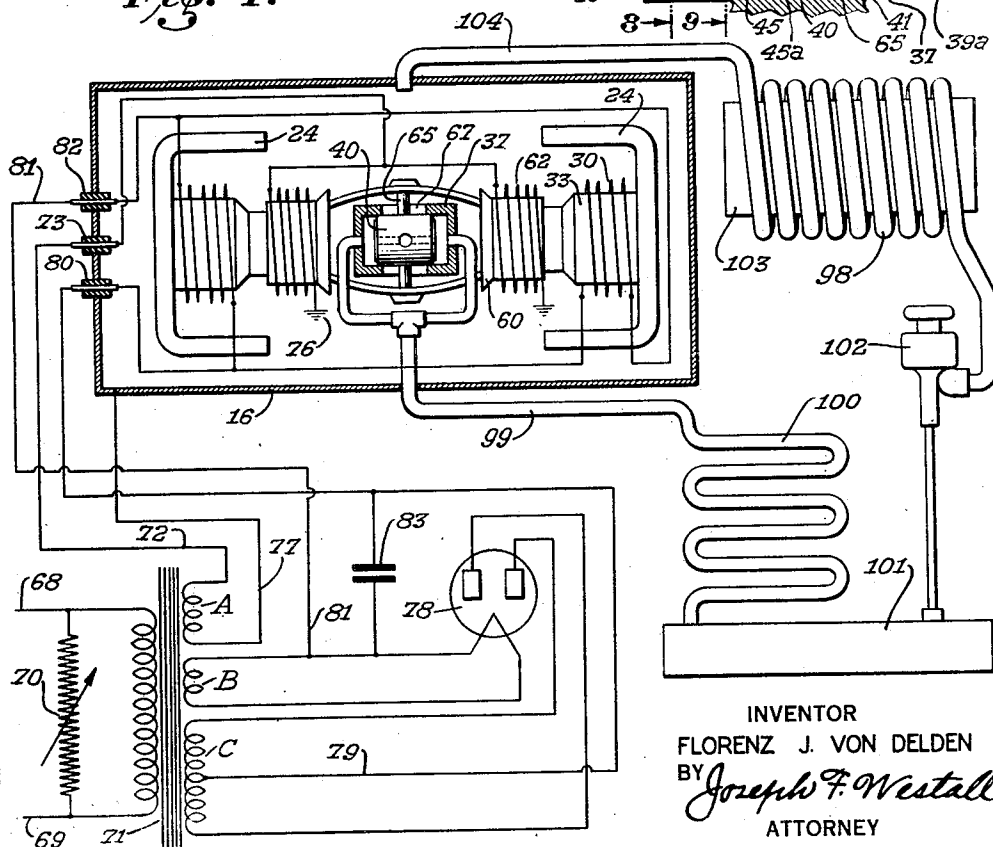
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Fig. 4.



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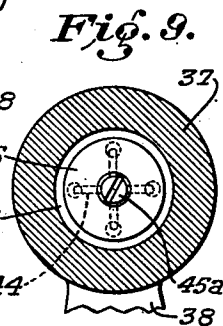
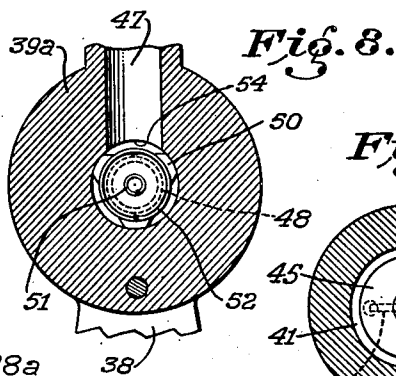
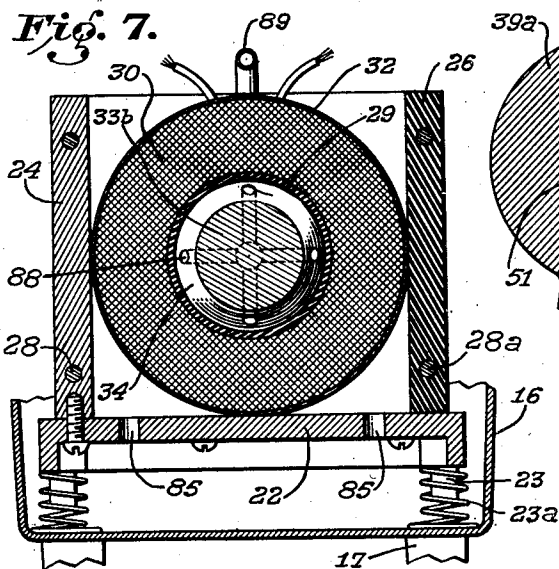
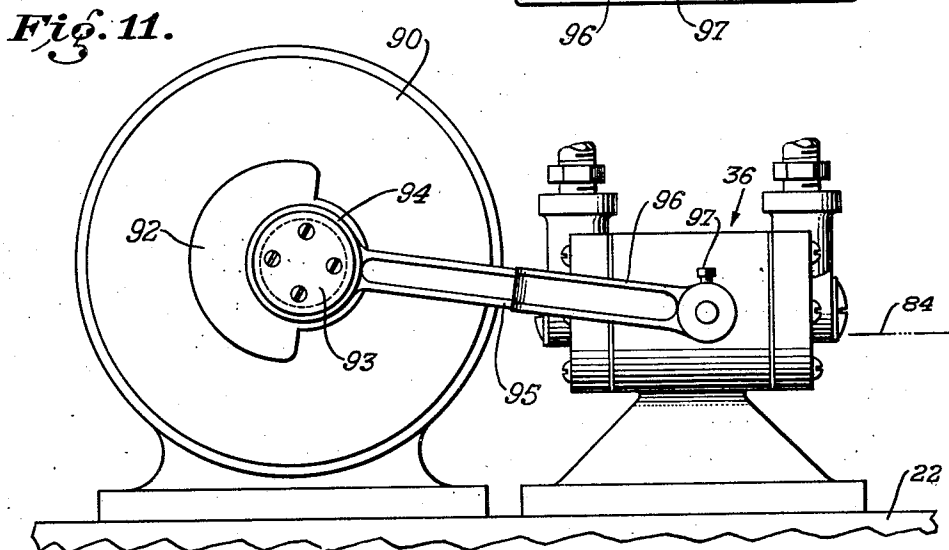
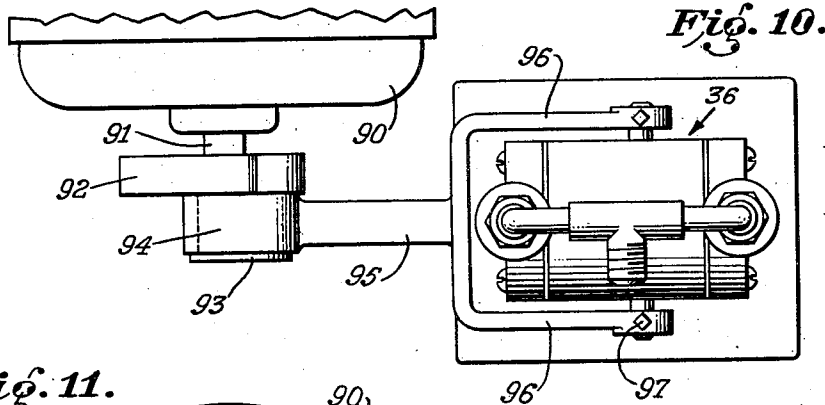
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UNITED STATES PATENT OFFICE

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COMPRESSOR AND ELECTRODYNAMIC ACTUATING MECHANISM THEREFOR

Florenz J. von Delden, Los Angeles, Calif.

Application May 27, 1938, Serial No. 210,416

9 Claims. (Cl. 230—55)

This invention relates to compressors and, more particularly, contemplates pump apparatus including mechanism for the production of two magnetic fields operable in conjunction with a pair of traveling solenoidal coils energized to a polarity alternately the same as and different from the polarity of the field magnets to reciprocate the traveling coils and a piston of a dual acting compressor with which the coils are associated.

The utilization of a solenoid is well known in electrically operated pumps. The solenoid is energized on alternate strokes of the piston and is operable to move the piston in one direction only. Part of the energy transmitted by the solenoid is required to compress or extend a spring which is relied upon to return the piston between solenoid-actuated strokes. Accordingly, only alternate strokes of the piston in such pumps are effective for the transmission of power and much of the energy imparted to the piston on its single power stroke must necessarily be absorbed by the actuating mechanism itself for the return stroke of the piston. The speed of the piston movement likewise depends on the strength and resiliency of the spring. To obviate these disadvantages the spring is substituted by mechanism adapted to produce a pair of magnetic fields by alternately energized solenoids on opposite sides of the reciprocating magnetic driven member. It is a general object to provide apparatus of this class having a greater power transmission value per watt required for its operation and in proportion to its size than heretofore possible.

More specifically, an object of the present invention is to provide a reciprocating motor comprising a pair of opposed magnetic fields of constant polarity in combination with a non-magnetic reciprocable body disposed therebetween and carrying a pair of traveling solenoidal coils associated with respective field magnets, said coils being of opposite polarity with respect to each other but each being alternately effective as a north and south pole due to energization by alternating current, whereby the field coils and the respective traveling coils will alternately attract and repel each other to actuate the reciprocable driven body.

Another object is to provide a compressor adapted for dual action in simultaneously creating effective pressure and suction on each stroke of a reciprocating piston.

Another and highly important object is to provide a pump assembly employing a reciprocating piston in combination with electrically actuated

mechanism adapted for synchronization with the fluid pump whereby the fluid will afford a braking action on the movement of the piston at each end of its stroke to permit maximum utilization of the available power.

Another object is to provide a novel form of valve for the cylinder head of the pump.

Still another object is to provide a field magnet incorporating a non-magnetic insert to obviate the formation of a closed circuit through the walls of the magnet and thereby obviate undesirable concentration of magnetic forces and creation of parasitic frequencies.

Other objects and corresponding advantages such as greater efficiency resulting in economy of operation, durability, and ease of assembly, will be apparent to those of skill in the art from an examination of the following description read in the light of the accompanying drawings, in which:

Fig. 1 is a plan view of the apparatus in combination with novel form of pump mechanism, both contained in a hermetically sealed case, the top of which is partially broken away;

Fig. 2 is a sectional view of the apparatus of Fig. 1 showing the pump in elevation;

Fig. 3 is a sectional view taken on lines 3—3 of Fig. 2;

Fig. 4 is a wiring diagram illustrating diagrammatically the pump and actuating mechanism therefor;

Fig. 5 is a broken section of the pump cylinder illustrating particularly one of the slots through the side wall of the cylinder through which a wrist pin extends;

Fig. 6 is a sectional view of the pump cylinder and closely associated parts;

Fig. 7 is a sectional view taken on lines 7—7 of Fig. 2;

Figs. 8 and 9 are sectional views on lines 8—8 and 9—9, respectively, of Fig. 6, illustrating the valves for the cylinder heads and piston, respectively;

Fig. 10 is a broken plan view of a pump unit illustrating a modified form of actuating mechanism therefor;

Fig. 11 is an elevation of the modification of Fig. 10.

Referring to the drawings in detail, the numerals of which indicate similar parts throughout the several views, 15 designates generally the case in which the apparatus of my invention is hermetically sealed, comprising a lower section 16 having keepers 17 for spiral spring mountings 18 on which the apparatus floats, and a flanged top 55

section 19 bolted or otherwise secured to a flange 20 integrally formed with the upper edge of the lower section 16. The upper surface of the top section is provided with a plurality of integral parallel ribs 21 to facilitate cooling of the case, as will be obvious.

A reciprocating motor and pump assembly of my invention having a capacity and arrangement particularly adapted for refrigeration units, with one form of which it is illustrated, is described as follows. It will be apparent that the structural principles disclosed are capable of other applications and adaptations in various modifications of the present invention.

With particular reference to Figs. 1 through 9, the reciprocating motor and pump unit is mounted on a base 22 having formed integral with its underside, keepers 23 for spring mountings 23a which are adapted to rest on the bottom of the lower section 16 of the casing for the resilient support of the unit. A pair of oppositely disposed horseshoe magnets 24 are secured to respective ends of the base by means of screws 25 shown in dotted lines in Fig. 2. A section of one side of each horseshoe magnet is cut away and a fiber or brass insert 26 is provided to complete the shape of the horseshoe for a purpose about to be described. A magnetic plate 27 connects the open ends of each horseshoe magnet 24, being secured to the edge of one side of the horseshoe by bolts 28, and to the aligned edge of the insert 26 at the opposite side of the magnet by non-magnetic bolts 28a. Upon energization of the magnets just described, the fiber or brass insert 26 thus prevents concentration of the magnetic forces at the corners of the magnets, and eliminates parasitic frequencies. Such frequencies would otherwise make themselves known, in a device of this character, on the driver coil assembly when the alternating current to the driver or traveling coils is cut off.

Clamped between plates 27 and the butts 24a of the respective horseshoe magnets are hollow fiber coil bodies 29 of conventional design on which the field coils 30 are wound. An opening 31 is formed in each plate 27 concentric with and of a diameter equal to that of the bore of the fiber body 29 with which it is associated. A sleeve 32, also preferably composed of fiber, encircles each coil. The coils are connected to a source of direct current later referred to.

An iron core 33 closely fits the bore of the fiber coil body 29 of each magnet, being held rigidly in position by a diametrically reduced, concentric, rearward extension 33a which is pressed into an opening formed in the butt of the magnet. The inner opposite end 33b of each core is likewise reduced in diameter to form a bevelled shoulder 34 and an annular oil chamber 35 between the core 33 and encircling coil 30 and plate 27.

Intermediate the magnets, a pump, generally indicated by numeral 36, is disposed, which comprises a horizontal cylinder 37 supported on a mounting 38 screwed to the base 22, the bore of the cylinder preferably being concentrically aligned with the bore of the fiber bodies 29 of the respective magnets. Cylinder 37 is provided with a vapor-inlet slot 38a (Fig. 6) through its top portion. A shield 39 open at one side is secured to the cylinder over the vapor opening 38a to prevent the ingress of oil liquid contained in the case (later referred to). The ends of the cylinder 37 are closed by heads 39a hereinafter described.

A piston 40 reciprocally disposed within the cylinder is of a substantially solid type but is pro-

vided with an axial passage 41 throughout its length. Passage 41 is in communication with slot 38a through oblique passages 42 which diverge from a common opening 43 in the upper portion of the piston. Opening 43 is in registry with slot 38a throughout the stroke of the piston due to the elongated shape of the slot. In each end of the piston, passages 44 extend obliquely from the central passage and open through the ends of the piston 40 intermediate the center and the periphery thereof. A flexible circular plate valve 45 of slightly lesser diameter than the piston is secured to each end of piston 40 by a screw 45a, threaded into the ends of the central passage 41, the edges of the valve being adapted to be raised from contact with the piston to uncover the oblique passages 44 in response to suction in the respective compression chambers between the ends of the piston and each head.

Each head 39a is provided with a transverse passage 46 opening into the adjacent compression chamber and extending into the center of the head where it is intersected by a second passage 47 extending through the upper side of the head. The bore of each passage 46 is enlarged adjacent the point of its intersection with passage 47 to form an annular valve seat 48. Each head 39a is formed with a threaded opening 49 through its outer wall which is in axial alignment with passage 46. A triangularly-shaped plate valve 50 (Fig. 8) is normally held on seat 48 by means of a pair of helical springs 51 and 52 retained in position by a head screw 53 threaded into opening 49. Each of said springs 51 is located in a hole drilled in the center of the inner end of respective screws 53 so as to bear against the center of valve 50. The second larger spring 52 encircles a portion of the shank of the screw so as to bear against the corners of the triangularly shaped valve 50. The cylindrical wall of each head encircling each valve seat 48 provides a guide 54 for the adjacent valve. The upper end of the bore of the passage 47 in each head is threaded to receive a tube 55. Tubes 55 are connected to opposite sides of a T-fitting 56 (Fig. 1) with which a coiled conduit 57 is connected to carry vapors from the pump through the side wall of the case into a shut-off valve fitting 58 secured on the outside of the case. On the opposite side of the case, a second shut-off valve fitting 59 is similarly attached in the inlet opening of the case.

Reciprocally encircling the reduced portion of each core is a non-magnetic hollow coil body 60 having a running fit with the core. Each body 60 is flanged at its outermost end as at 61 (Fig. 2) to form a sliding fit with the plate and the bore of the field coil body 29 in which it is disposed. Coils 62 are wound on each body 29 in opposite directions with respect to each other and are energized in operation by alternating current as will be hereinafter more in detail described, to alternately create an attraction and repulsion between the coils 62 and the respective magnets 24 with which they operate; polarity of the magnets 24 being constant due to their energization by direct current. The traveling coil bodies 60 are integrally connected to a pair of central hubs 63 disposed on opposite sides of the cylinder, by means of an integral web 64. Hubs 63 are provided with concentric openings in which the opposite ends of a wrist pin 65 (Fig. 3) are rigidly secured by set screws 66; the wrist pin extending through an elongated slot 67 (Fig. 5) formed in each side of the cylinder and transversely through the middle of the piston (Fig. 6) to reciprocate the latter.

Referring particularly to Fig. 4, wires 68 and 69 lead from a source of current (not further indicated) and are preferably connected through a conventional type rheostat potentiometer 70 to a transformer 71.

From the upper secondary winding A of the transformer as shown in the drawings, a wire 72 extends through a hermetically-sealed insulator 73 into the case and is connected to terminals 74 and 74a (Fig. 1), respectively, which are carried immovably by the Lase 22. Flexible conductors 75 connect the respective terminals to traveling coils 62, said coils being wound in opposite directions to insure their opposite polarity which changes periodically in accordance with the cycles of the alternating current supplied thereto, as will be obvious. The opposite ends of each coil 62 are grounded to the case as at 76. A wire 77 connected to the case completes the circuit through the winding A of the transformer.

Direct current is supplied to the magnets 24 by the provision of a rectifier tube 78 of conventional construction. B designates generally a second secondary winding of the transformer for the filament of the rectifier tube 78. The ends of a third secondary coil C of the transformer are connected to the anodes of the tube. From the middle of the third coil C, wire 79 leads through a sealed insulator 80, carried in one end of the case adjacent insulator 73, to one end of each field coil 24. The current returns through wire 81, extending through a third insulator 82 in the end of the case, to the wire leading from the rectifier tube 78 to the secondary winding of the transformer 71. A condenser 83 of any type well known in the art is connected between the wires 79 and the wire leading from the filament of tube 78 to smooth out the pulsations occurring in the rectified alternating current.

Upon closure of the circuit through the rheostat 70 the field coils of magnets 24 will be energized by a constant flow of direct current, thus maintaining the same polarity, while alternating current is supplied to the traveling coils to change the polarity of the last-named coils with each cycle of the alternating current. It will be observed that when the polarity of a traveling coil is the same as that of the stationary magnet in which it operates, they will tend to repel one another and to move the piston in a direction away from the field coil; conversely, when the traveling coils are of different polarity with respect to their adjacent stationary magnets, there will be a corresponding attraction between traveling and stationary coils which will move the piston on its opposite stroke. As the traveling coils are wound in opposite directions, their polarity will always be different so as to simultaneously repel and attract, alternately, the field coils of their respective stationary magnets and thereby reciprocate the piston.

To lubricate the piston and connected reciprocating parts, and primarily to maintain the coils cool, the case contains oil to a level indicated in dotted lines 84 of Fig. 2. Holes 85 (Fig. 7) are bored through base 22 between the point of contact of the field coils therewith and the sides of the horseshoe magnets in which the coils are wound to permit the oil to enter the zones between the base and field coils. It is also desirable to flow oil over the top of each traveling coil. For this purpose an L-fitting 86 (Fig. 2) is threaded into an axial hole 87 drilled in the center of the core 33 and opening externally of the magnet, 75 which hole 87 is communicated with oblique pas-

sages 88 opening through shoulder 34 into the oil chamber 35 between the diametrically reduced portion of the core and the field coil. A tubing 89 connected to each L-fitting 86 extends over the top of the respective magnets and is turned downwardly in front of the plate 27, opening over the traveling coils. It will be observed that electro-magnetic impulses above alluded to will cause the traveling coils to be drawn into the oil chamber on each alternate stroke and force oil trapped in chamber 35 through passages 87 and 88 of the core into the tube for ejection on the top of the traveling coils, there to absorb heat from the coils, thus, in effect, providing a forced feed oiling system.

In Figs. 10 and 11, a modified form of the pump-actuating mechanism of my invention is illustrated which comprises a motor 90 of conventional construction having a rotatable driven shaft 91. The motor is mounted on base 22 within the case 15 (not shown), but may be elevated with respect to the pump to permit its operation above the oil level 84 if desired.

A counterweighted eccentric 92 is rigidly attached on the outer end of the shaft 91. An eccentric pin 93 integral with eccentric 92 provides a bearing for the strap 94 of an eccentric rod 95 formed with a forked outer end. The bifurcations 96 of rod 95 are secured by a set screw 97 on opposite ends of the wrist pin 65 which extends through slot 67 of the cylinder and through the piston 40, whereby rotation of shaft 91 will reciprocate the piston of the pump in the manner and for the purposes described above in connection with the embodiment illustrated in Figs. 1 through 9.

The particular embodiments disclosed are primarily adapted for utilization in the refrigeration unit which is diagrammatically illustrated in Fig. 4 and particularly described as follows. Methyl chloride is supplied to the case from an evaporator 98, later referred to, through fitting 59 where it mixes with the oil vapor from the cooling oil contained in the case. As the piston is moved, the combined oil and methyl chloride vapors are drawn into the cylinder through inlet slot 38a and, passing through passages 41, 42, and 44 in the piston, enter the enlarging compression chamber by displacing valve 45, in response to the suction created therein. On the opposite stroke, valve 45 closes and the vapor is compressed and discharged through valve 50, while a new volume of vapor is drawn into the other compression chamber of the pump in a like manner for compression and discharge on the next succeeding stroke of the piston through valve 50 of the other cylinder head. The vapor thus ejected from the pump is conveyed through the coil conduit 57 through the wall of the case and through shut-off valve fitting 58 into a pipe 99 connected to condenser coils 100 where the vapor is transformed into a liquid, thereby providing the cooling effect desired. The liquid passes into a receiver 101 of any well known type from which it is conveyed, through an expansion valve 102 to the evaporator 90 where it is vaporized by a heater 103. Suction from the pump within the case is communicated through a pipe 104 connected between shut-off valve fitting 59 to evaporator 98 and assists in moving the vapors thus produced from the evaporator into the case.

While I have referred to methyl chloride as the gas which the present invention is adapted to compress, it is to be understood that modifications of the pump structure may be made for

use with other fluids, but in all such embodiments it is essential that the weight of the piston, the flexibility of the valves, the adjusted compression of the springs 51 and 52, and the power available from the coils regulating the speed of piston movement be synchronized with the weight and compressibility of the particular gas to be pumped whereby the pressure of the gas incident to its compression by the piston will form a cushioned abutment for the piston at the end of each stroke before the valves in the cylinder head open, thus permitting the utilization of substantially all power of the actuating mechanism to drive the piston on each power stroke, rather than to dissipate that power by employing it as a brake to halt the piston at the end of its preceding stroke.

While I have described but two embodiments of my invention, it will be apparent that numerous changes may be made in size, shape, design and number of the various parts to make it more adaptable for other uses, as, for example, the electro-dynamic reciprocating motor may be utilized to operate a plunger of the type with which conventional portable pneumatic hammers or chisels are equipped, without departing from the spirit of my invention as defined by the appended claims.

What I claim and desire to secure by Letters Patent is:

30 1. In a device of the character described, a base, a pair of magnets comprising field coils mounted on said base, means to energize said field coils by direct current, a pump mounted on said base between said magnets comprising a cylinder having a slot in its wall, a piston in said cylinder, a wrist pin connected to said piston extending through said slot, a pair of coil bodies connected to said wrist pin having a traveling coil wound on each end thereof in opposite directions with respect to each other, said coils being reciprocable in said magnets, and means to energize said traveling coils by alternating current to cause an attraction between one of said field coils and the traveling coils reciprocably disposed therein and a simultaneous repulsion between the other traveling coil and the stationary coil in which it reciprocates to reciprocate the piston.

2. In a device of the character described, a hermetically sealed case, a magnet in said case comprising a stationary coil, means connected to said coil to pass a direct current through the same in one direction constantly, a traveling coil movable in said magnet, means connected with said traveling coil to pass an alternating current through the same, a quantity of oil in said case to a level above the bottom of said traveling coil, a conduit from said magnet to a point over said traveling coil, reciprocation of said traveling coil in said stationary coil being adapted to force oil through said conduit for discharge on the top of the traveling coil.

3. In a device of the character described, a cylinder closed at each of its ends by a pair of hollow heads, a piston reciprocably disposed within said cylinder to form a compression chamber between each end of said piston and the respective heads, said cylinder having an intake slot in its wall and a side slot, said piston having an axial passage and oblique passages formed therein, said last-mentioned oblique passages extending from said axial passage to an opening in the upper side of the piston which is in registry with said intake slot opening and through opposite ends of said piston, a flexible plate valve secured to each end of the piston by a screw threaded into the ends

of the axial passage of the piston to normally close the oblique passages, each of said heads having a passage therethrough which is enlarged intermediate its ends to form a valve seat, a triangular plate valve in each head having its corners slidably contacting the walls of respective last-named passages, resilient means normally urging said triangular valves to their respective seats, a piston rod extending into the piston and laterally through said side slot in the cylinder, means connected to said piston rod to reciprocate the piston and thereby simultaneously draw fluid into one compression chamber and expel fluid from the other compression chamber.

4. In a device of the character described, a pump comprising a cylinder closed at its ends by a pair of cylinder heads, said heads each having a valved outlet passage for the pump, said cylinder having an intake slot in one wall thereof, a piston reciprocably disposed in said cylinder forming a pair of compression chambers in the cylinder at opposite ends of the piston, said piston having passages therein in registry with said slot and leading, respectively, to said compression chambers, a piston rod attached to said piston extending through a second slot in the cylinder wall, and means attached to the outer end of said piston rod to reciprocate said piston.

5. In a device of the character described, a compressor comprising a closed cylinder having a piston reciprocably disposed therein forming compression chambers in the cylinder at opposite ends of the piston, said cylinder and piston having intake passages extending through the wall of the cylinder and bifurcated through the piston to each compression chamber, means forming outlet passages from each compression chamber, and means to reciprocate said piston.

6. In a device of the character described, a horseshoe magnet having a stationary coil body therein, a coil wound on said coil body, a core within said coil of lesser diameter than said coil to form an oil chamber encircling said core, a traveling coil body movable in said stationary coil having a flange on its innermost end to form a close fit with the coil body and core, a traveling coil wound on said traveling coil body, said magnet and traveling coil being energized by two different currents to alternately magnetically attract and repel each other, a pair of pump elements comprising a piston and cylinder, said traveling coil body being connected to one of said elements, a fluid abutment within said cylinder of predetermined pressure at opposite ends of said piston to halt said piston at the end of each stroke and synchronize the moving weight with the pulsations of one of the currents.

7. In a device of the character described, a horseshoe magnet having a stationary coil body therein, a coil wound on said coil body, a core within said coil of lesser diameter than said coil to form an annular oil chamber encircling said core, a traveling coil body movable in said stationary coil having a flange on its innermost end to form a close fit with the stationary coil body and core, a traveling coil wound on said traveling coil body, means to energize said coils to, alternately, the same and different polarity with respect to each other, a fluid pump comprising a cylinder and a piston in said cylinder, said traveling coil body being connected to said piston, the stroke of said piston being limited by the fluid pumped to a length less than the distance of the piston travel independently of the limitation of

such travel by the fluid between changes in polarity of the stationary and traveling coils.

5 8. In a device of the character described, a fluid pump comprising a cylinder and a piston forming compression chambers in said cylinder at opposite ends of the piston, a head on each end of said cylinder, each having an outlet port therein, said cylinder having an inlet slot in the wall thereof, said piston having a passage therein communicating the slot in said cylinder with the chambers in said cylinder on opposite sides of the piston, a wrist pin attached to said piston extending through a slot in the cylinder, a reciprocable member connected to said wrist pin, means to

actuate said member to reciprocate said piston, an intake valve on each end of said piston normally closing said passages, outlet valves closing respective ports of said heads, said outlet valves being adapted to open substantially at the ends of the respective compression strokes and synchronized with the speed of the piston. 5

9. In a device of the character described, a horseshoe-shaped field magnet having a portion of one side wall formed of a non-magnetic material to eliminate parasitic frequencies and fluxes. 10

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