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P. B. O'REILLY

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COOLING SYSTEM FOR A SUBMERSIBLE ELECTRIC MOTOR

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FIG. 1.

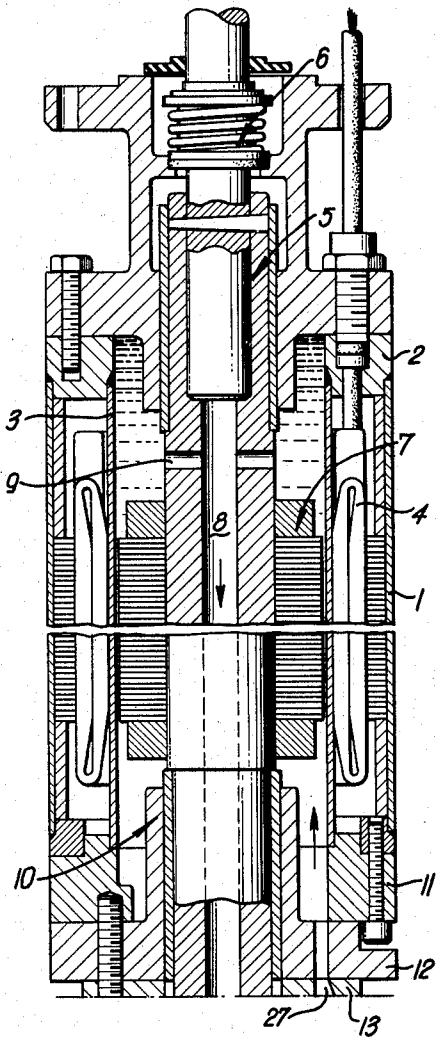


FIG. 3.

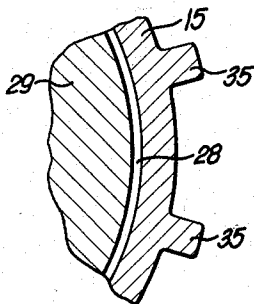
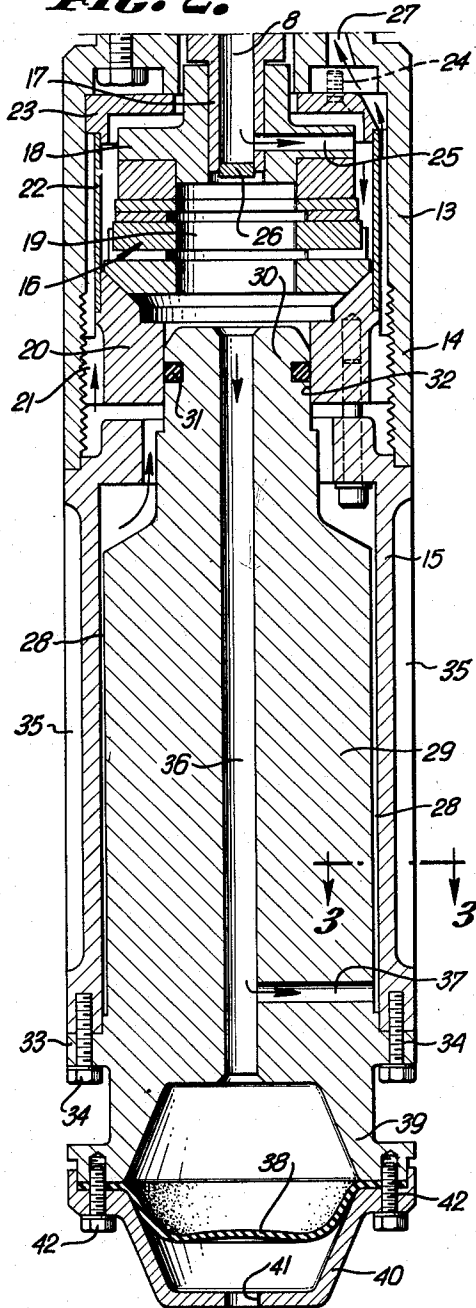


FIG. 2.



INVENTOR.

PAUL B. O'REILLY

BY

Flam and Flam

ATTORNEYS.

1

2

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Paul B. O'Reilly, Pico Rivera, Calif., assignor, by mesne assignments, to The Emerson Electric Manufacturing Company, St. Louis, Mo., a corporation of Missouri
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This invention relates to submersible motors, such as for operating pumps in wells. Such motors, being usable in wells and thus confined in a space having limited cross sectional areas, are so designed as to be economical of volume. For a given volume, therefore, it is important to have the motor deliver as much power as possible.

One of the important limiting factors in such motors is the temperature rise due to the electrical energy converted to heat as current flows through windings and conductors of the motor.

One way to reduce the temperature rise involves a heat exchange between the liquid sealed in the motor casing and the well water; for example, by circulating the liquid past a heat conducting wall exposed to well water.

It is one of the objects of this invention to improve in general such heat exchange provisions.

It is another object of this invention to provide a circulation for the liquid past the heat exchanger, such as to utilize a relatively small volume of liquid (such as water) for filling the casing. Accordingly, the expansion of the liquid due to a rise in temperature causes a relatively small volume change. There is correspondingly less tendency for the liquid to leak outwardly past the rotating shaft seal for the motor casing. Therefore, there is more likelihood of well water entering the casing past the seal; and when the internal liquid filling for the casing is water, it is preferable that the internal liquid be thus replenished.

It is another object to provide a circulation for the internal liquid such that the liquid pressure in the circulation stream is least adjacent the top of the circulation path, where the seal is located. Thus the pressure differential across the seal is in such direction as to cause flow of water into the casing from the well.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of one embodiment of the invention. For this purpose, there is shown a form in the drawings accompanying and forming a part of the present specification. This form will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of this invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is an elevation, partly in section, of the upper part of a submersible structure incorporating the invention, including the motor shown shortened in order to reduce the size of the figure;

FIG. 2 is a sectional view of the lower portion of a submersible structure shown in FIG. 1; and

FIG. 3 is an enlarged fragmentary sectional view, taken along a plane corresponding to line 3—3 of FIG. 2.

The motor part of the apparatus as shown in FIG. 1 includes a sheet metal casing 1, having an upper annular collar 2 and an internal sleeve 3. The sleeve 3, the collar 2 and the casing 1 form a closed and sealed space for the stator or primary windings 4. A liquid filling is usually provided within the sleeve 3.

A shaft structure 5 extends outwardly of the casing. A seal structure 6 around shaft structure 5, normally prevents ingress or egress of liquid into or out of the casing structure.

The sleeve 3 encloses the rotor structure 7 mounted upon the shaft structure 5. This shaft structure 5 has a vertical opening 8 connected as by the radial passages 9 with the liquid in the interior of the casing 1. Preferably this liquid is water; and since the stator windings 4 are sealed in the annular space between the casing 1 and the sleeve 3, this water is excluded from the windings 4.

The lower end of the shaft structure 5 is closed by a plug 26. It is shown as conveniently supported by the aid of journal bearings 10, as well as by a step or thrust bearing 16 (FIG. 2) which will be described in greater detail hereinafter.

The outer casing 1 is provided with a lower collar member 11. A flange coupling 12 is firmly attached to the collar 11. This flange is formed integrally with a hollow casing 13 (FIG. 2). This hollow casing 13 has a lower open end 14 which is internally threaded for accommodating an extension 15 for the casing.

Located in the casing member 13 is the stationary thrust bearing structure 16. The lower end 17 of shaft structure 5 carries a collar 18 which serves to support the shaft structure upon the bearing structure 16. This collar has one or more radial ports or openings 25 to provide a centrifugal pumping effect. The bearing structure 16 has a central opening 19. It is comprised of a series of shoes appropriately supported on collars, as in a Kingsbury bearing. Since the present invention is not concerned with the specific details of this bearing structure, further detailed description thereof is unnecessary.

The lowermost collar 20 of the bearing structure 16 is threadedly supported in the lower end of member 13. It is provided in its outer periphery with a plurality of angularly spaced slots 21, for defining a part of the path for the liquid circulation. The collar 20 is joined as by a sleeve 22 to an upper collar member 23 appropriately fastened to the member 13 as by the aid of several machine screws 24.

As indicated by arrows, an opening 27 in the coupler member 12 forms a path for liquid from the narrow annular space between sleeve 22 and the outer wall of the member 13, to the interior of sleeve 3 around rotor 7. How the water is moved by a pumping action will be described hereinafter. The water proceeds past the rotor 7 through the narrow gap between the rotor 7 and the sleeve 3, as shown in FIG. 1, then radially inwardly through the openings 9, downwardly through the port or opening 8. From the opening 8 the water or other liquid is pumped by centrifugal action through the ports 25 of collar 18. Thence the liquid flows downwardly inside of the sleeve 22 through the central openings 19 of the thrust bearing structure 16, and downwardly past a heat exchanger now to be described.

The heat exchanger device is such that the water or liquid circulates through a narrow annular space 28 formed between the extension 15 and a solid metal core or insert 29. This core or insert has an upper or neck portion 30 sealingly accommodated as by the aid of the O-ring 31 within a bore 32 formed in the stationary thrust bearing support 20. This solid member 29 is provided with a lower flange 33 attached as by machine screws 34 to the lower edge of the extension 15.

As shown most clearly in FIG. 3, the extension 15 is provided with a number of ribs 35 by the aid of which efficient heat exchange may take place between the liquid flowing through the narrow space 28, and the well water surrounding the extension 15.

The liquid flow into the narrow space 28 is effected by the aid of a vertical passage 36 communicating as by a radial passage 37 with the space 28.

From the narrow space 28, the flow of the liquid is upward past the neck portion 30 of the member 29, then through the narrow space hereinabove mentioned between the sleeve 22 and the member 13.

3

The complete circulatory system thus includes a pumping device including ports 25, which is located below the motor rotor 7. Accordingly, at the upper end of the motor structure there is a minimum of pressure tending to cause flow of the liquid filling past seal 6, outwardly of the casing 1.

Due to the narrow spaces in which the liquid filling is confined, the volume of the liquid filling is relatively small. Also, since the coefficient of expansion is low, there is correspondingly small change in volume upon a unit of temperature change. There is no great strain upon the seal structure 6 to cause it to open and leak liquid from the submersible structure into the well.

The lower end of the port 36 in the case member 29 is open. A flexible diaphragm 38 is clamped against the edge of the flange 39 extending from the member 29 as by the aid of a cap structure 40. Screws 42 hold the cap structure to the flange 39. Cap structure 40 permits entry of well liquid to the lower side of the diaphragm 38 as by the aid of aperture 41. A substantial balance between internal and external pressures is thus achieved, in a manner now well understood.

The inventor claims:

1. In a submersible motor adapted to be lowered in a well, said motor having a casing, a liquid filling for the casing, a stator structure in the casing, and isolated from the liquid filling, an end wall at the upper end of the stator structure, a shaft projecting through said end wall, a rotor structure carried by the shaft, and cooperable with said stator structure, a rotary seal located at said upper end wall for isolating the liquid filling from the well, the combination therewith of: means forming a passage in the shaft and having an upper opening in the casing between the seal and the upper end of the rotor structure, said passage having a lower opening beneath the rotor; pumping means having an intake connected to said lower opening of said shaft; a heat exchanger suspended from and closing the lower end of the casing and receiving the discharge of said pumping means, said heat exchanger defining a heat exchange path for return of the liquid filling to the casing at the lower end of said rotor structure at an area exterior of the shaft; and diaphragm means carried by the heat exchanger and exposed on opposite sides to the discharge of said pumping means and the liquid of the well respectively whereby

4

the pumping means and the diaphragm cooperate to cause the pressure of the liquid filling at the upper end of said rotor structure adjacent said seal to be substantially less than the pressure of the liquid of the well on the outside of said seal.

2. In a submersible motor adapted to be lowered in a well, and having a hollow rotary shaft extending upwardly out of the casing, a rotor carried by the shaft, a stator, a seal extending around the shaft to isolate the interior of the casing from the well, a liquid filling for the casing, a hollow extension joined to the lower end of the casing, and a thrust bearing structure located at the bottom of the shaft and supported within the casing, said structure having an open passageway below the shaft, the combination therewith of: a member extending upwardly into the extension and into the base of the thrust bearing, said member having an exterior surface closely spaced from the interior surface of the extension, to form a narrow space, and said member having a first passage extending from its upper end longitudinally downwardly, said first passage adjacent its lower end being provided with a port leading to the space between said surfaces; said member substantially entirely filling the extension with solid metal except for the passage between the extension and the member; means forming a second passage from the top of said space into the interior of the casing; said hollow shaft having openings above the rotor to receive the liquid from the casing interior; the lower end of the shaft being closed; a collar carried by said shaft adjacent said lower end; said collar and the shaft having cooperating ports for creating a pumping action on the liquid at the bottom of the shaft; said cooperating ports discharging the liquid from the shaft to the thrust bearing structure and into the upper end of said first passage; said member having a flange extending over the lower edge of the extension to cover said lower edge; and a diaphragm secured to the end of the member to form a chamber in communication with the first passage, and having an exterior surface exposed to the well water.

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