

Nov. 21, 1944.

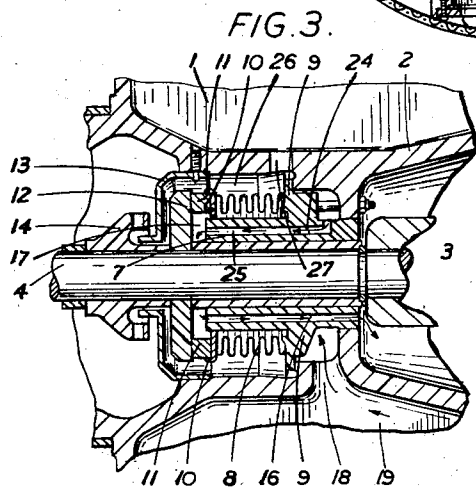
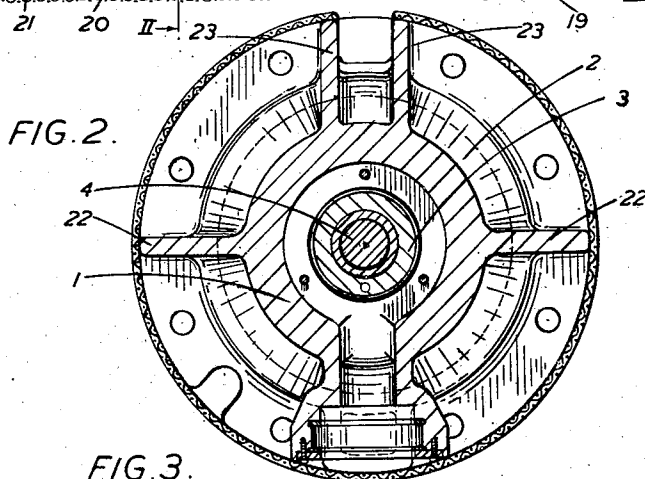
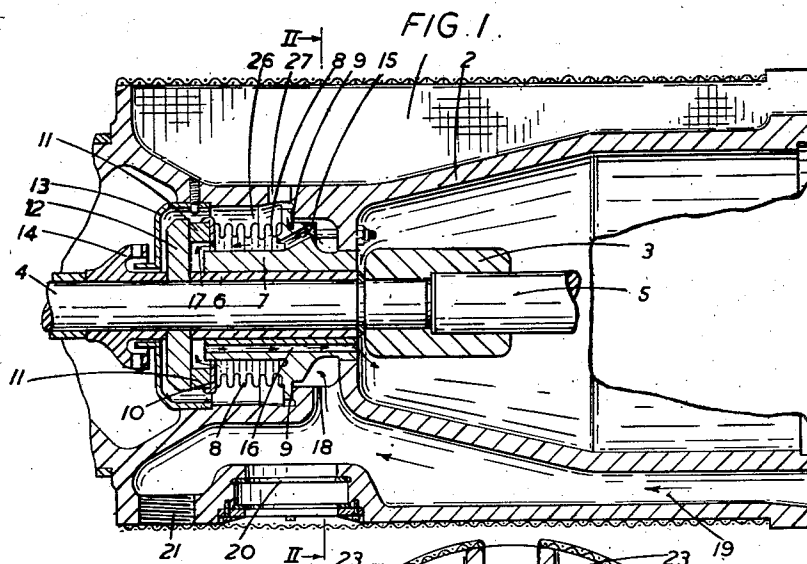
G. P. E. HOWARD

2,363,420

SUBMERSIBLE PUMP

Filed May 5, 1942

3 Sheets-Sheet 1



INVENTOR
G. P. E. HOWARD
BY *Robert R. Roll*
ATTORNEYS

Nov. 21, 1944.

G. P. E. HOWARD

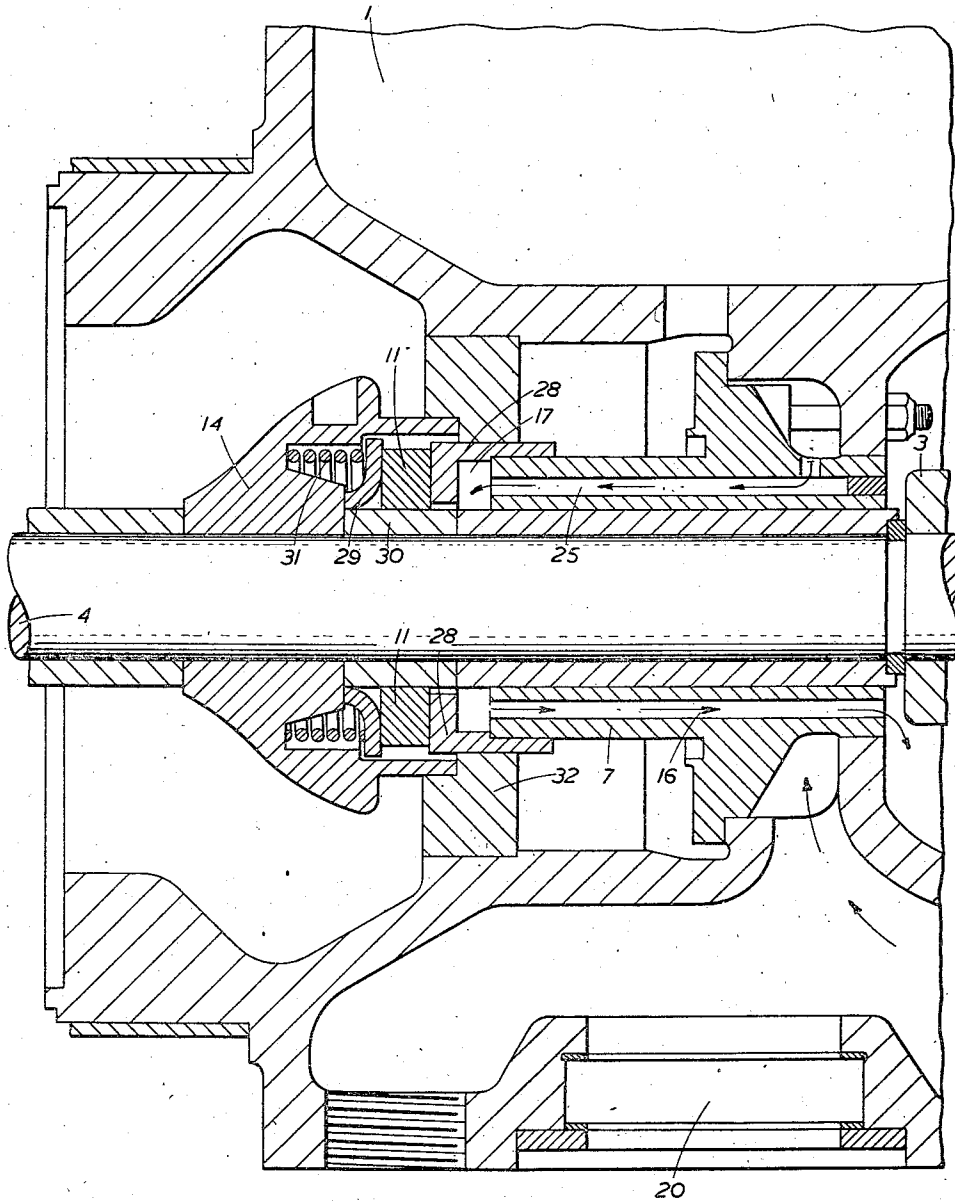
2,363,420

SUBMERSIBLE PUMP

Filed May 5, 1942

3 Sheets-Sheet 2

FIG. 4.



INVENTOR
G.P.E. HOWARD
BY *Robert G. Robb*
ATTORNEYS

Nov. 21, 1944.

G. P. E. HOWARD

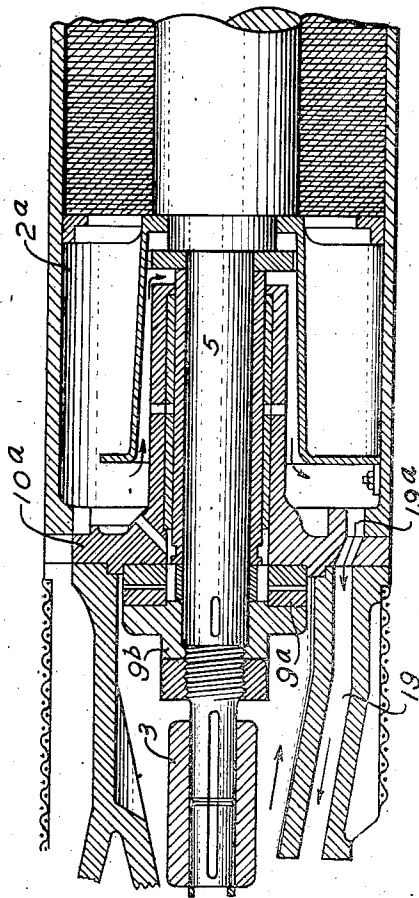
2,363,420

SUBMERSIBLE PUMP

Filed May 5, 1942

3 Sheets-Sheet 3

FIG. 5.



INVENTOR
G. P. E. HOWARD
By *Robb & Robb*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,363,420

SUBMERSIBLE PUMP

Giles Philip Elliot Howard, Coleshill, Amersham,
EnglandApplication May 5, 1942, Serial No. 441,844
In Great Britain May 5, 1941

11 Claims. (Cl. 308—36.2)

This invention relates to submersible pump units of the kind comprising a centrifugal pump directly coupled to a driving motor to form a unit which is enclosed in a liquid-tight casing, and is concerned with the problem of ensuring long life of the bearings of the unit in working conditions which do not admit of normal lubrication and attention.

In my co-pending application I have described an arrangement whereby the bearings both of the pump and of the motor are lubricated with the liquid (usually water) in which the pump unit is submerged, said arrangement comprising means for maintaining the liquid film in the bearings at a sufficiently low temperature to ensure adequate viscosity for the purpose in view. With the arrangement disclosed in the said application there is inevitably some fluid interchange between the cavities in which the bearings are enclosed, on the one hand, and the cavities in the pump which are traversed by the pumped liquid, on the other hand, so that even though the bearing chambers may be initially filled with clean liquid, this liquid is bound to become replaced in the course of time by pumped liquid which in the case of water almost invariably contains solid matter in suspension. This circumstance is of little or no consequence if the pump is used for instance in water coming from chalky or clayey strata. However, in many cases, as for instance when the pump is to be used in water which contains destructive abrasive matter, it is desirable to prevent the access of the surrounding liquid in its raw state to the bearings, and more particularly to the bearings of the motor and the main or bottom bearing of the pump, and it is the purpose of the present invention to achieve this result.

According to the invention, in a submersible pump unit of the kind described, the upper motor bearing, the chamber containing the coupling between the motor and pump shafts, and the lower pump bearing, constitute a sealed water circulating system. Accordingly, means are provided to prevent the entry of the pumped fluid surrounding said bearing into said water chamber through the bearing, whereby said chamber and bearing constitute a sealed water circulating system.

To this end, we may provide concentrically with and outside the bottom pump bearing a sheet metal bellows carrying at one end a carbon ring which is pressed axially, by the inherent resilience of the bellows, against a flange mounted on the pump spindle and rotating with it, while

the other end of the bellows is sealed against a flange on the bearing shell which in its turn is sealed in the end of a chamber in the admission piece separating the pump from the motor. This form of sealing is not novel, per se. Its use in the normal manner would, however, prevent the movement or circulation of cool liquid past the outside of the bearing and through the bearing clearance.

Such movement or circulation of relatively cool liquid is essential for satisfactory operation under full film conditions, of a journal bearing, particularly if the liquid is water which has, even at normal temperatures, a very low viscosity. It is common knowledge that the load capacity of a bearing is proportional to the viscosity of the lubricant, and it follows that in the present case if the liquid in the bearing is allowed to become stagnant it will become hot owing to shearing of the film during operation, and the viscosity will fall. If this condition is allowed to continue unchecked, the viscosity will fall below an effective value and the bearing will fail. In the case of bearings in an electromotor, the electrical and mechanical losses of the motor will add to the heating effect of the bearing losses.

In order to overcome this difficulty, according to a further feature of the invention, the sealed chamber enclosing a pump bearing is in circulating communication with an adjoining sealed cooling chamber containing means for setting up forced movement of the liquid enclosed therein. The bearing enclosing chamber thus constitutes an annex of an externally cooled chamber, and the circulation of liquid between these two chambers is utilised to induce a subsidiary lubricating flow of liquid through the bearing clearance.

It will be understood that in order to achieve the desired sealed condition of the motor it is also necessary to seal the point of ingress of the leads to the motor housing, and conventional expedients may be employed for this purpose.

In the case of the bottom pump bearing, when the pump unit comprises a dual-purpose admission piece containing the aforesaid adjacent cooling chamber with which the sealed bearing enclosing chamber communicates, this chamber may conveniently be the cavity formed by a socket portion of the admission piece enclosing the coupling between the pump and the motor. In this case the coupling itself sets up the forced vortex in the cooling chamber requisite for effecting heat exchange between the circulating liquid and the wall of the cooling chamber swept by the

cold pump liquid entering the first stage of the pump.

It will be understood that the circulation may be further promoted by the forced vortex pressure generated by the motor rotor itself. For this purpose the said annular space behind the bearing sleeve may be arranged to communicate with a passage leading from the cavity surrounding the top motor bearing, past the outer wall of the cooling chamber to the upper part of this chamber. In this case the chamber enclosing the bottom pump bearing and the chamber enclosing the top motor bearing are both in communication with each other and with the cooling chamber situated between them, and all three chambers constitute a circulating system which is completely sealed off from the pumped liquid in which the unit is submerged.

Means have to be provided to allow for expansion and contraction of the enclosed liquid due to temperature changes, and for this purpose we provide a small ceramic filter of sufficiently fine grain at a convenient point in an outer wall of the sealed system, through which a "breathing" interchange may take place between the enclosed body of liquid and the surrounding liquid.

In order to ensure satisfactory starting of the unit, it may be desirable to provide two such filters, one at the top and the other at the bottom of the sealed volume, so that as little air as possible may be trapped, or it may be preferred to provide filling plugs by which an initial filling of clean liquid may be inserted.

In order that the invention may be clearly understood and readily carried into practice, reference will now be had, by way of example only, to the accompanying drawings illustrating the invention, in which—

Figure 1 is a longitudinal section of a combined admission piece and connecting member for the motor and pump of a submersible pumping unit, disposed in a horizontal position, with the present invention applied thereto.

Figure 2 is a cross-section on the line II—II of Figure 1.

Figure 3 is a fragmentary section of a modified construction corresponding to Figure 1.

Figure 4 illustrates a further modification of the construction shown in Figure 3.

Referring to Figures 1 and 2, the pump and motor are connected together by an admission piece 1, having a cavity formed by a socket 2 which contains the coupling 3 for the pump and motor shafts 4 and 5 respectively, the cavity being maintained full of water which is kept in a state of turbulence and circulation by the rotating coupling 3. As in the aforesaid construction the end of the socket 2 carries the pump bearing 3a, along which the water travels, for lubrication purposes, from the socket 2, but in the present case the bearing is enclosed in a sealed chamber which forms part of a closed water circulating system, including in the present case not only a chamber containing the pump bearing but also the chamber containing the top motor bearing.

The motor end of this pump construction illustrated in Figure 5, and as disclosed specifically in my co-pending application Serial No. 441,843, filed of even date herewith, shows this motor bearing enclosed in a chamber 2a adjacent the motor 2b. The shaft 5 extends through the end plate 10a, and the thrust bearing 9a held by the locking collar 9b, said thrust bearing and

collar being located in the cavity or chamber of the socket 2 which also contains the coupling 3.

The bearing sleeve 6 is located in a bearing shell 7 mounted in and projecting from the end of the socket 2, and the bearing shell 7 is surrounded and enclosed by a sheet metal bellows gasket 8 which is fixed to the flange 9 on the bearing shell 7 at one end, and at the other end is attached to an annular plate or ring 10 whose inner periphery is arcuately slotted and between the slots makes contact with the bearing sleeve 7. The ring 10 carries on its outer surface a carbon ring 11 which is pressed by the resilience of the bellows 8 against an annular plate or flange 12 mounted on and rotating with the shaft 4.

The flange 12 is enclosed by a casing 13 attached to the inner wall of the admission piece 1, and the mouth of the casing 13 is covered over by the sand bell 14 mounted on shaft 4, which serves in the usual manner to prevent easy access of solid matter into the casing 13.

Through the bearing shell flange 9 are formed holes 15, and formed in the bearing shell 7 are longitudinal bores 16 which provide communication between the interior cavity of socket 2 and the space or cavity 17 at the end of the bearing formed by the flange 12 and the carbon ring 11. The arcuate slots along the inner periphery of ring 10 provide communication between the interior of the bellows 8 and the space 17 at the end of the bearing.

The water within the cavity of socket 2 is kept in a state of turbulence by the rotating coupling 3, and circulates through the cavity of socket 2 and the chamber at the top end of the motor as described in our co-pending application aforesaid.

The water in the socket 2 is induced to flow by the coupling 3 in the direction of the arrows shown in Figure 5, through the passages in the thrust bearing 9a, the end wall 10a, around the motor bearing and into the chamber 2a, and thence through passages 19a, 19, 18, 15 into the bellows 8 and chamber 17, and then through passage 16 back to the water chamber 2a. Thus, the water in this closed circuit effects cooling of the pump bearing and the motor bearing, the heat taken up being dissipated through the walls of the socket 2.

The passage 19 has an opening fitted with a ceramic filter 20 and also has a filling plug aperture 21, so that the water circulating system through the bellows 8 and bearing 6, 7 can be filled up when required, and is maintained quite independent of the liquid being pumped, which flows through the admission piece 1 over the outside of the socket 2 and absorbs heat transferred to the wall of the socket from the motor bearing and the end coils of the motor winding, by the water contained in the socket and chamber 2a, as well as by conduction from the shell 7 of the pump bearing.

It will be understood that the ceramic filter 20 affords a "breathing" interchange of liquid between the sealed water circulating system of which the passage 19 forms part and the pumped liquid surrounding the admission piece 1.

The cooling of the socket is facilitated by the external ribs 22 which support it, and a channel for the leads to the motor is formed by a pair of spaced ribs 23.

It will be obvious that if desired the external surface of the bearing sleeve 6, or the internal

surface of the bearing shell 7, may be spirally grooved to facilitate the passage of lubricating water along the bearing.

In the modification illustrated by Figure 3, which is intended for shafts of larger diameter than Figures 1 and 2, in addition to the longitudinal bores 16 for supplying cooling water for the bearing shell 7 to the cavity 17 at the end of the bearing formed by flange 12 and carbon ring 11, the bearing shell 7 also has other longitudinal bores 24 providing communication between the cavity 17 and the space below the bearing communicating through port 18 with passages 19. Thus the water entering space 17, through bores 16, from socket 2, leaves space 17 through bores 24 and re-enters into circulation through portion 18 and passage 19.

Whilst in the case of Figure 1 water flows through the bellows 8, in the case of Figure 3 there is no circulation of water through the bellows 8 which will merely contain stagnant water, the bellows 8 in this case serving solely as a resilient means for holding the annular plate 10 and carbon ring 11 up to the flange 12 so as to form the closed cavity 17 at the end of the bearing. If, however, it is desired to have the return flow of water through the bellows 8 of Figure 3 instead of through the bores 24 in the bearing shell 7, the bores 24 may be replaced by short longitudinal bores communicating by radial bores with the interior of the bellows 8, the water passing out of the bellows through a bore in flange 9 corresponding to the bore 15 of Figure 1.

In both of the above constructions the bellows gasket 8 is accommodated in a cavity 26 of the admission piece 1, formed at the end of socket 2, which communicates through a port 21 with the passage within the admission piece 1 through which the pumped liquid is drawn into the pump, so that the bellows 8 itself is water cooled, and heat transferred to it by the water circulated through the bearing 6, 7 is in turn transferred to and removed by the pumped liquid.

Figure 4 illustrates a modified construction which dispenses with the use of the bellows 8. This construction is somewhat similar to that of Figure 3 inasmuch as the bearing shell has the same passages 16 and 25 for the flow and return of the water between the chamber containing the coupling 3 and the cavity 17 at the end of the bearing shell 7. In this case, however, the cavity 17 is formed by a cap 28 forming an extension on the end of the bearing shell 7, against which the carbon ring 11 is pressed by a rubber washer 29, mounted in a cavity in the said bell 14 which surrounds and encloses the carbon ring 11. The rubber washer 29 is an undersize fit on the sleeve 30, so that it becomes deformed into the cup shape shown and it may be pressed against the carbon ring 11 by a spring 31 mounted behind it in the cavity of the said bell 14. The rim of said bell rotates in a recess in plate 32 surrounding the cap 28.

The water circulation is the same as in the case of Figure 3, the difference between the two constructions residing in the method of forming the sealed cavity 17 at the end of the bearing.

It will be understood that by virtue of the described arrangement the motor is entirely sealed from the pump, so that none of the main pumped liquid can find its way into the interior of the motor. Since the casing enclosing the motor bearings and bottom pump bearing is en-

tirely sealed from the surrounding liquid apart from the filter and the seal around the shaft, it is not necessary to provide additional sealing means for the top and bottom motor bearings of the form provided, as herein described, for the bottom pump bearing.

An analogous arrangement may be provided if desired for the top pump bearing, but the provision of such means in connection with this bearing is less important than in connection with the main or bottom bearing of the pump, while it is also more difficult to provide the requisite cooling chamber and breathing filter. For these reasons it will generally be preferable to allow the top pump bearing to be lubricated and cooled by liquid derived from the impelled flow.

As already mentioned, submersible pumps are in the great majority of cases used for pumping water. It will however be understood that the present invention is applicable to any submersible pump irrespective of the nature of the liquid handled, provided such liquid has sufficient viscosity at the working temperatures to serve as lubricant in the manner described. It has already been proposed, for the purpose of pumping volatile liquids, to immerse a centrifugal pump unit of the kind described bodily in a vessel containing such liquid, in order to avoid the necessity for providing stuffing boxes. A pump unit embodying the means according to the present invention is particularly well suited for use in this manner, and a particularly convenient arrangement consists in suspending the pump unit from the top by the delivery connection in a sealed vessel to which the liquid to be pumped is supplied, it being merely necessary to ensure that the level of this liquid in the vessel is maintained above the level of the pump take.

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

1. A submersible pumping unit of the kind described, comprising in combination a pump, pump and motor shafts, said unit including a water chamber containing a coupling between the motor and pump shafts and communicating with a pump shaft bearing, wherein means are provided to prevent the entry of the pumped fluid surrounding said bearing into said water chamber through the bearing, whereby said chamber and bearing constitute a sealed water circulating system in which the coupling induces a flow of the water in the chamber, through the motor and pump shaft bearing.

2. A pumping unit according to claim 1, wherein one end of the pump bearing is enclosed in a cavity which is sealed in regard to surrounding liquid, and the other end of the bearing communicates with the chamber containing the coupling.

3. A pumping unit according to claim 1, wherein the pump shaft bearing is surrounded by a shell and a bellows gasket connected at one end to said shell and at its other end coacting with a friction ring sealing the water chamber against entry of the pumped fluid into said chamber and wherein the cavity at the end of the pump shaft bearing communicates with the coupling chamber not only along the bearing clearance but also through longitudinal bores in the bearing shell.

4. A submersible pumping unit of the class described, comprising in combination a pump, pump and motor shafts, and a water chamber

containing a coupling between the motor and pump shafts and communicating with a pump shaft bearing, wherein means are provided to prevent the entry of the pumped fluid surrounding said bearing into said water chamber through the bearing, whereby said chamber and bearing constitute a sealed water circulating system, and wherein a wall of said water circulating system over which the pumped liquid passes contains a filter to permit the "breathing" interchange of liquid through the filter.

5. A submersible pumping unit of the kind set forth, having a pump shaft, a bearing and shell therefor located in the path of the pumped liquid, including a chamber communicating with one end of the bearing, liquid circulating means in said chamber operated by the pump shaft, a closed cavity communicating with the other end of said bearing, flow and return passages through the bearing shell providing communication between said chamber and said cavity, an annular extension on the bearing shell surrounding the pump shaft, a flanged member on said shaft, an annular carbon member bearing on said annular extension, a rubber sealing ring between said carbon member and said flanged member, and a spring bearing between said flanged member and said rubber sealing ring to press it against said carbon member.

6. In a submersible pumping unit, the combination of a motor and shaft therefor for pumping a fluid in which the unit is submerged, a motor shaft bearing, a pump shaft driven by the motor shaft and a bearing therefor spaced from the motor bearing, a chamber in which the motor bearing is located, a separate chamber in which the pump bearing is disposed, passages establishing communication between the chambers aforesaid, said chambers and passages containing a cooling liquid and constituting a sealed liquid circulating system, and motor-operated means between said chambers for inducing a closed circulation in said system around the said bearings to cool the same separately from the fluid being pumped.

7. A submersible pumping unit as claimed in claim 6, wherein the motor-operated means con-

stitutes the coupling between the motor and pump shafts.

8. A submersible pumping unit as claimed in claim 6, combined with means in the chamber containing the pump bearing for sealing said bearing from the fluid pumped, including liquid receiving passages permitting the cooling liquid to circulate in the closed system over and around the pump bearing and back to the motor bearing chamber.

9. In a submersible pumping unit, the combination of a motor and shaft therefor, a motor shaft bearing, a pump shaft driven by the motor shaft and a bearing therefor spaced from the motor bearing, a chamber in which the motor bearing is located, and adjustable sealing member surrounding the pump bearing for sealing off said bearing from the fluid pumped and forming liquid receiving passages communicating with the motor bearing chamber, and motor-operated impeller means between the sealing member and last-named chamber for inducing flow of liquid from the motor bearing chamber through the pump bearing chamber, said circulation constituting a closed circulation system independent of the fluid pumped.

10. A submersible pump as claimed in claim 9, wherein the adjustable sealing member comprises a bellows surrounding the pump bearing in spaced relation thereto and holding the liquid in the closed system from escape from the pump bearing chamber along the pump shaft.

11. In a submersible pumping unit, the combination of a motor and shaft therefor, a motor shaft bearing, a pump shaft driven by the motor shaft and a bearing therefor spaced from the motor bearing, a chamber in which the motor bearing is located, a separate chamber in which the pump bearing is disposed, a third chamber intermediate the other two chambers, through all of which chambers a cooling liquid is adapted to circulate, and a coupling for the motor and pump shafts arranged in said third chamber to induce flow of the cooling liquid in a closed cycle through said chambers and about said bearings.

GILES P. E. HOWARD.