May 14, 1935. J. A. WINTROATH 2,001,172

SUBMERSIBLE MOTOR DRIVEN PUMP

Filed Feb. 21, 1931 2 Sheets-Sheet 1

Fig. 2.

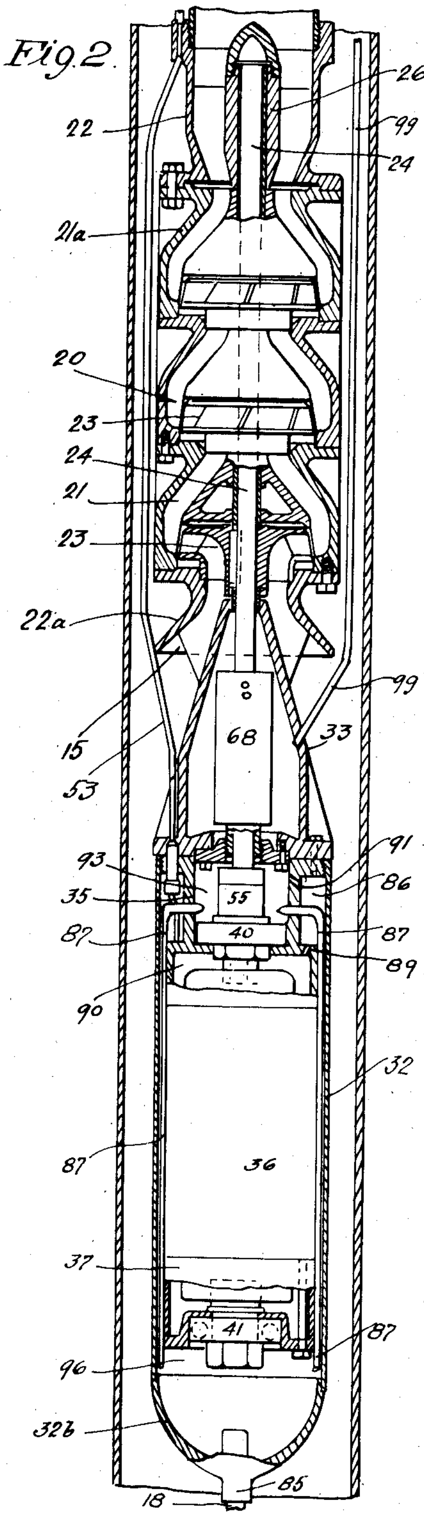
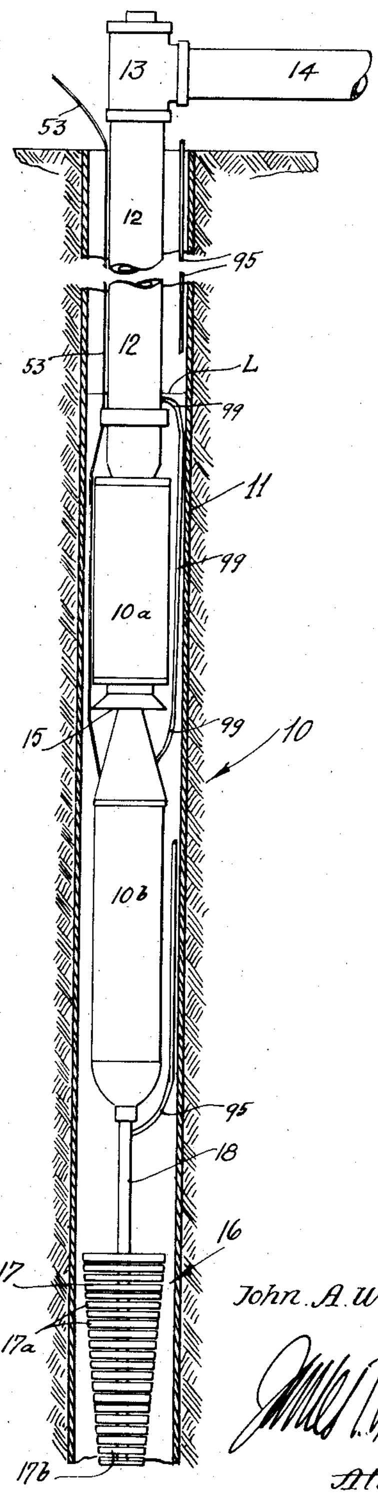


Fig 1.



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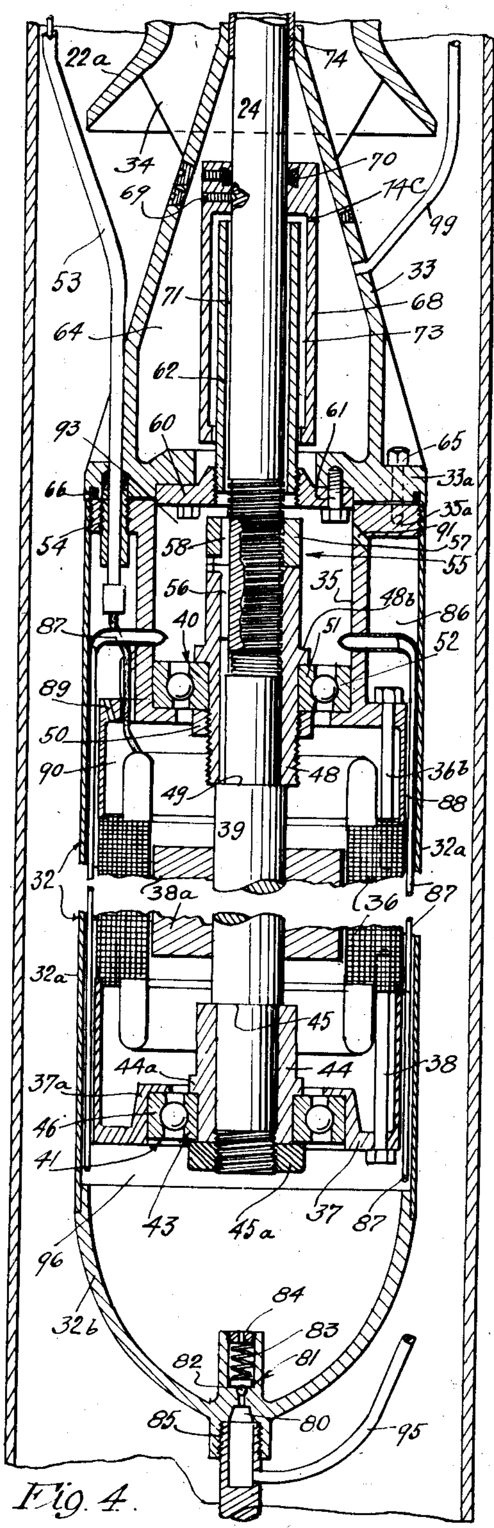
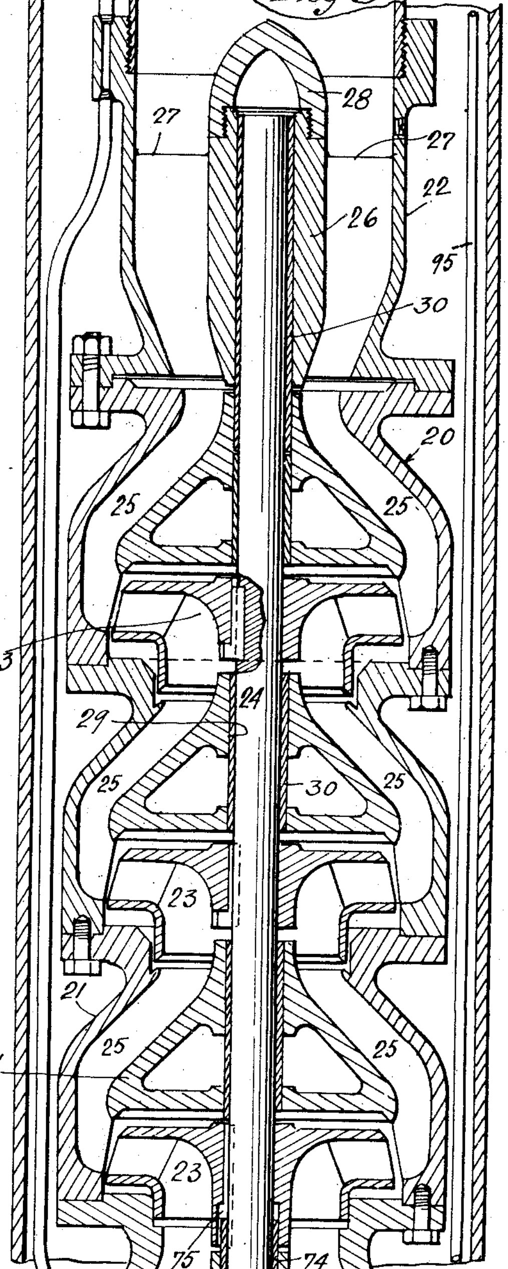


Fig. 4.

Fig 3



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UNITED STATES PATENT OFFICE

2,001,172

SUBMERSIBLE MOTOR DRIVEN PUMP

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Application February 21, 1931, Serial No. 517,481

3 Claims. (Cl. 103—87)

This invention relates in general to submersible motor and turbine well pumps, this type of pump differing from the usual motor driven pump of the extensible line shaft type, in that the motor, instead of being located at the ground surface and connected with the pump by a shaft extending to the depth of the pump, is carried as a part of the pump unit on the lower end of the eduction or discharge pipe and submerged in the well liquid.

The present type of submersible pump has been developed with the primary object of overcoming many of the undesirable and troublesome features of the extensible line shaft type, and in order that the accomplishments of the invention may be more fully appreciated, I shall mention briefly at the outset some of the inherent advantages had by the invention over extensible line shaft pumps. In the first place, the provision of a submersible motor obviates the necessity for the use of line shafting extending from the pump to the ground, also the shaft enclosing tubing and the line shaft bearings required to journal the shaft at spaced intervals in its enclosing tubing. Furthermore the expense in pump head construction at the ground surface is reduced to a minimum in that substantially all that is required in the submersible type is a simple connection with the eduction pipe which will serve to connect with a line for conducting the liquid pumped from the well. And again, with the present type of pump, no necessity arises for having to provide a ground surface housing, or other such means that may involve considerable expense, for protecting the motor from the elements.

As is commonly known, wells in which it is required to install the pump, frequently are crooked and make wide deviations from the vertical, all of which renders it impossible in an extensible line shaft pump to aline the shafting and bearings properly, with the result that the shaft is subjected to crystallization and the bearings to severe wear. Such difficulties of course are not experienced with the submersible motor pump inasmuch as the only connection between the pump and motor unit and the ground is the eduction pipe, and the latter can be caused to follow the course of crooked wells without great difficulty. As previously mentioned, the extensible line shaft pump involves the use of shaft enclosing tubing, and since the latter occupies considerable of the space in the eduction column, it follows that the eduction pipe must be made correspondingly larger in order to accommodate the amount of liquid being pumped. By doing away with the line shaft and its enclosing tubing, I am thus able to gain the advantages, which will be readily apparent, of the use of a small eduction pipe.

Further advantages are gained from the standpoint of manufacture and installation expense, in that the eduction pipe may be used in random lengths, whereas in the extensible line shaft type, the eduction pipe, shafting and shaft enclosing tubing sections, customarily are required to be in exact lengths with relation to each other, with the result that each unit length of the combined parts requires factory construction.

I may state that one of the greatest, if not the greatest difficulty encountered in submersible motor pumps, is that of preventing leakage or access of the well fluid to the motor casing, and the point at which leakage occurs is of course by way of the opening in the motor casing through which the drive shaft extends. Successful use of usual packing glands to prevent leakage into the casing around the shaft, is impossible because of the fact that the well liquid may be under such static pressure as to force its way through an ordinarily tight packing gland, and also due to the fact that the packing gland soon becomes worn to the point of permitting leakage, and no means is available for tightening it to compensate for wear. The problem of providing a fluid tight seal against the entry of well liquid to the motor casing is met by the invention through the provision of means comprising essentially a liquid seal, capable of excluding the well liquid, and so constructed as to be free from wear over an indefinite period. I may state that other forms of this general type of liquid seal are described and broadly claimed in my copending applications on Method of lubrication for submerged bearing structure, filed June 18, 1928, Ser. No. 286,112. The present invention deals, in some of its aspects, with the utilization of this general type of seal in submersible motor unit construction.

In the present pump, the motor operates in a lubricating oil within the motor casing, and the seal construction is such as to utilize the lubricant in the exclusion of the well liquid. It may be stated that this type of liquid seal is particularly adaptable for use in connection with submerisable motor units, in that it serves to take care of the expansion or displacement of lubricant from the motor chamber occasioned by the pumping action of the motor or as a result of heating of the motor.

Although perhaps the most salient objects of the invention have to do with the liquid seal and expansion chamber construction just referred to, the invention also includes within its scope, numerous features concerned with the construction and arrangement of the pump as a whole, and also the construction and arrangement of its constituents parts and combinations of these parts. However it will not be necessary to discuss at this point all of the various objects and novel aspects of the invention, since these will be made self evident in the following description.

For purposes of describing my invention, I have shown it to be embodied in a typical and preferred form of submersible motor. However it is to be understood that in so doing, I do not intend that the invention be regarded as impliedly limited to this particular construction, since it may be embodied in pumps other than that specifically shown, without departure from its intended spirit and scope. Reference is had for purposes of description to the accompanying drawings wherein.

Fig. 1 is a general view of the pump suspended on the eduction pipe beneath the standing level of the well liquid;

Fig. 2 is an enlarged sectional view of the pump including the motor and impeller units, certain parts of the motor section being shown in elevation;

Fig. 3 is a further enlarged sectional view of the pumping or impeller section; and

Fig. 4 is a sectional view, on somewhat smaller scale of the lower portion of the pump continuing from the lower end of Fig. 3.

Referring first to Fig. 1, the pump, generally indicated at 10 is shown suspended within the well casing 11 on the lower end of the eduction pipe 12, the latter having a suitable head or fitting 13 at the ground level, which may connect with a discharge pipe 14. The eduction pipe may be supported at the ground by any suitable means, such means however not being shown since it constitutes no part of the invention. The pump 10 is lowered to a point below the normal standing level of the well liquid within the casing, or to a point such that the pump suction inlet 15, hereinafter described, will fall below the level L of the well liquid column when the latter is pulled down during pumping operations.

I may conveniently describe, at this point, the strainer, generally indicated at 16, which serves to exclude from entrance to the pump suction intake 15 foreign bodies carried by the well liquid and which might cause injuries to the pump parts. The strainer consists essentially of a screen 17 of tubular formation and tapering toward its lower end 17b at which it is closed. The screen may conveniently be made from metallic sheet material cut so as to form spaced strips 17a, or the strips may be formed separately and arranged in spaced relation as shown. The upper end of the screen preferably will extend sufficiently close to the wall of the casing as to exclude particles of any considerable size from being taken upwardly past the screen. As a simple means for supporting the screen, I show it to be carried on a rod 18 depending from the lower end of the motor casing hereinafter described, through the strainer and attached to the bottom 17b thereof.

The pump may be characterized as comprising an upper impeller section 10a, and a lower motor section 10b, the latter being supported from the impeller section as will presently appear. Referring particularly to Figs. 2 and 3, the upper impeller section is shown to comprise a series of units 20, each consisting of an impeller bowl or housing connected to the next adjacent bowl, the uppermost bowl 21a being connected with the lower end of the eduction pipe 12 by way of adaptor or bearing housing 22. Connected to the bottom of the lowermost bowl is an annular casting 22a which forms the suction intake, the sides of said casting preferably being so formed as to flare downwardly and outwardly substantially as shown. Impellers 23 one within each of the bowls 21, are keyed to the pump shaft 24, the impellers operating, upon rotation of the shaft, to displace the well liquid taken in through inlet 15, upwardly through passages 25 in the bowls and into the discharge column in the eduction pipe 12. The upper end of the pump shaft 24 is journaled in a sleeve bearing 26, supported centrally within adapter 22 by means of ribs 27. I may state that the adapter, bearing sleeve 26 and ribs 27 may conveniently be formed as a single casting. The upper end of the bearing sleeve may be closed by a cap 28. Preferably bearing 26 and the central bores 29 in the impeller bowls through which the shaft extends, will carry sleeves 30 of suitable bearing material.

It will be understood that the described pumping section is to be regarded merely as typical of any suitable form of turbine pump which may be used in combination with the motor section, and also that while I have shown a pump comprising a certain number and arrangement of impeller units, the invention contemplates the use of any number and any suitable arrangement, or number of stages of such units.

The motor casing 32 is supported from the pump housing by way of a separating chamber casting or shell 33, the latter being joined to the pump suction intake casting 22a. Although shell 33 may be joined to or supported from the pump housing in any suitable manner, it preferably is formed integrally with member 22a, and as a convenient method for so joining these parts, I have shown them to be cast integrally, with interconnecting webs 34 between which the well liquid is taken into the pump. Shell 33 preferably is tapered toward its upper end so as to provide for maximum clearance and inlet opening between the downwardly flaring walls of the inlet casting 33.

The motor casing 32 comprises a cylindrical section 32a closed at its lower end by cap 32b, the joint therebetween being fluid tight. A substantially cup-shaped bracket 35 is threaded into the upper end of the motor casing, said bracket serving, as will appear, to support the motor assembly within the casing. The motor casing is attached to shell 33 by means of screws 65 extending through the bottom plate 33a of the shell and into the top flange 35a of the bracket, a gasket 66 being placed between the shell and casing sections to provide a fluid tight joint. The stator 36 of the motor is supported from bracket 35 and is shown to be attached thereto by screws 36b; and similarly secured to the lower end of the stator is a lower cup-shaped bearing supporting bracket 37 attached to the stator by screws 38. The rotor, diagrammatically indicated at 38a, is carried on shaft 39, the upper and lower ends of which are journaled in thrust bearings 40 and 41 carried in brackets 35 and 37 respectively. The inner ball race 43 of the lower bearing is carried on sleeve 44 bearing against annular shoulder 45 on the shaft, and is clamped between flange 44a on the sleeve and nut 45a threaded on the lower end of the shaft. The outer race ring 46 is seated within the cup shaped interior portion 37a of the bracket.

The upper end of the motor shaft is keyed to a sleeve 48 which bears at its lower end against shoulder 49 on the shaft, and the inner race ring 51 of the upper bearing 40 is clamped between sleeve flange 48b and nut 50. The outer race ring 52 is seated within the cupped interior of the bracket in a manner similar to the previously described outer race ring of the lower bearing. Preferably the bearings will be designed to take the shaft thrust in opposite directions, the lower bearing taking the up thrust and bearing 40 the down thrust. Current is supplied the stator 36 by way of conduit 53 leading to the ground surface, the lower end of the conduit extending into the motor casing through a fluid-tight packing gland 54 in the upper flange portion 35a of bracket 35.

I have provided at 55 a joint or coupling between the motor and pump shafts whereby they may be relatively adjusted for the purpose of properly positioning the impellers 23 within the impeller bowls. It is to be understood that various forms of adjustable connections between the shafts may be provided which will permit adjustment of the pump shaft for the purpose mentioned, the illustrated type of connection however being preferred for reasons of simplicity of construction and ease of adjustment. The lower threaded end of the pump shaft 24 is slipped into the upper end of sleeve 48 and is secured against rotation relative thereto by key 56. Threaded on the pump shaft and bearing against the sleeve is a nut 57 which also is locked against turning on its shaft by key 58. In order to adjust the position of shaft 24 relative to the motor shaft, the former may be slipped upwardly out of sleeve 48 so as to permit removal of key 58, whereupon nut 57 may be turned on the shaft and keyed thereto in adjusted position; and the pump shaft then reinserted in sleeve 48 with nut 57 bearing against the upper end of the sleeve.

A sleeve supporting ring 60 is secured by means of screws 61 to the underside of the bottom plate 33a of shell 33, and into ring 60 is threaded sleeve 62 which extends upwardly a suitable distance within the separating chamber 64. The joint between ring 60 and shell 33, and also that between said ring and sleeve 62, will of course be fluid-tight. Sleeve 62 may or may not be in close engagement with the shaft, but for the purpose of indicating that fluid flow may occur from the motor casing into the separating chamber, and vice versa, I have indicated a slight clearance space at 71.

An inverted cup-shaped seal member 68 is secured to the pump shaft by set-screws 69, the joint being made fluid-tight by packing 70. Cup 68 extends over and around the upper end of sleeve 62, and preferably downwardly to a point near the bottom of the separating chamber in order to provide for a maximum length of seal or displacement chamber. The seal cup is spaced from sleeve 62 to provide what may be termed a displacement chamber 73, the purposes and characteristics of which will appear more fully hereinafter. Carried within the upper end of shell 33 is a bearing sleeve 74 which preferably, though not necessarily, has a journaling fit with the pump shaft, the upper end of the bearing sleeve projecting within an annular groove 75 in the lowermost impeller 23. Although bearing sleeve 74 may fit the shaft more or less closely, access of well liquid to the separating chamber will occur between the bearing and the shaft; and although such flow of well liquid into the separating chamber may be more or less restricted, the static fluid pressure in the chamber will be substantially that of the static column in the chamber itself plus the pressure of the well liquid column standing above the upper end of the separating chamber.

It will be noted that shell 33 serves to substantially enclose and support, independently of the well liquid, a liquid column standing the height of the chamber. And therefore should for any reason the well liquid level fall below the upper or inlet end of the separating chamber, there will still be supported therein a column of liquid extendnig above the liquid seal formed by sleeve 62 and the sleeve enclosing cup 68. The advantages of so supporting a liquid column in connection with the seal, independently of the well liquid, will be seen to better advantage in the following description of the operation of the pump.

After assembling the pump unit prior to its lowering within the well, the motor casing 32 will be completely filled with oil, for example a suitable grade of transformer oil. The casing will be filled while standing in a vertical position and the lubricant introduced through an opening 80 in the lower end of the casing. Opening 80 normally is closed by a check valve 81 consisting of a ball 82 which seats under the influence of a comparatively strong spring 83 bearing at its upper end against apertured plug 84. For purposes of filling the casing with oil, attachment of a lubricant line may be made to socket 85 before screwing the screen supporting rod 18 thereinto.

The oil upon rising within the motor casing will force the air out ahead of it, and provision may be made whereby the oil will rise into space 86 at the outside of bracket 35, either by providing clearance between impact tubes 87, hereinafter described, and openings 88 within the lower portion of the bracket through which the impact tubes extend, or by drilling holes 89 so as to permit direct flow from space 90 into annular chamber 86. Holes 91 are drilled in the bracket at the upper end of chamber 86 in order to permit air therein to pass into the bearing chamber 93. The casing ordinarily will be filled with oil to the point of overflowing sleeve 62, and any overflow will pass downwardly through the displacement chamber 73 between sleeve 62 and the liquid seal member 68 into the bottom of separating chamber 64. All the air within the casing will similarly be discharged into chamber 64.

As shown most clearly in Fig. 4, a small bleeder opening 74c is provided at the upper end of the displacement space 73. Assuming the motor casing to have been filled with oil as described, before the unit is lowered within the well chamber 64 preferably is filled with oil up to a point near the level of orifice 74c. At this time the small plug in shell 33 directly opposite orifice 74c will be removed. The oil introduced to chamber 64 will rise therein and also within the displacement space 73, and any air present in the upper interior of 73 that would otherwise be entrapped therein in the absence of bleeder opening 74c, will be expelled through the opening as the oil rises. When the oil has risen to a level at or near the opening, and all of the greater portion of air within chamber 73 expelled, the opening may be closed by suitable means, access to opening 74c being had through the opening in shell 33 normally closed by the plug shown opposite opening 74c. Thereafter the plug will be inserted within the shell opening.

The pump may now be lowered within the well and to the desired depth of submergence beneath the surface of liquid in the well. At this time chamber 64 may become entirely filled with well liquid by restricted leakage into the chamber at 74. If it is desired to prevent contamination of the well liquid as a result of the lubricant in chamber 64 becoming displaced by well liquid after the unit has been submerged, the lubricant can be flushed from chamber 64, after the described filling operation, by displacing it with water poured into the chamber before lowering the unit into the well.

As the pump is started into operation, the motor will cause, by virtue of its pumping action, a certain amount of the oil to be displaced from the motor casing by overflowing the upper edge of sleeve 62, and the overflow oil will pass downwardly in chamber 73 and stand in a column on the surface of the well liquid that has risen a short distance within the lower end of space 73. In addition to the pumping action of the motor, a further amount of displacement of the oil therein will occur as a result of expansion due to heat generated by the motor. It may be stated with reference to the displacement chamber 73 that the volume of this chamber will be sufficient to accommodate or contain the overflow from the motor casing caused by the pumping action of the motor and the expansion of the oil. And preferably the volume of the displacement chamber will be somewhat greater than the volume of liquid which at any time will become displaced thereinto.

If the pump is shut down, the pressure of the hydraulic column in chamber 64 will tend to raise the air and lubricating oil columns in the displacement chamber 73 and to return the displaced oil to the casing via space 71. Return displacement into the casing may consist of the air column in chamber 73 above the level of the lubricating oil standing on the surfaces of the well liquid therein, or it may include a certain amount of the lubricant in addition to the air. However, in any event the volume of fluid returned to the casing chamber will be equal to that originally displaced, and the well liquid will rise no further than to its normal or original level in chamber 73. Since the air and displaced oil in chamber 73 are of lower specific gravity than the well liquid, it of course follows that by no possibility can the well liquid itself rise to the point of overflowing the upper edge of sleeve 62 into space 71.

I may state at this point that although the described method of first filling the motor casing with oil prior to lowering within the well will usually suffice, it may be possible to carry out a similar filling operation so as to completely expel all well liquid and air from the displacement chamber, after the unit has been submerged in the well liquid. Thus the unit may be completely filled with oil at the ground surface as previously described, and an oil conduit 95 is connected by suitable means to the bottom of the casing, for example the upper hollow end of rod 18, so as to enable oil from conduit 95 to be discharged into the casing past the check valve. The pump may then be lowered in the well and submerged beneath the liquid level therein, whereupon an additional quantity of oil may be forced down through conduit 95 (which extends to the ground surface) which will cause oil to be displaced from the casing into chamber 73 in an amount sufficient to displace from said chamber whatever air or well liquid that may be present therein. As will readily appear, the effect of this operation will be to provide a comparatively longer seal of oil in space 73 to exclude well liquid 64 from entrance to the motor casing. As a further possibility, chamber 64 in shell 33 may be filled with water or well liquid at the surface of the ground, and oil then introduced into the motor casing past check valve 81 to the point at which the oil will overflow sleeve 62 and completely fill chamber 73 so as to displace all well liquid therefrom.

During operation of the pump the well liquid being taken into the inlet 34 is drawn upwardly around the outside of the casing, and in flowing along the wall thereof the liquid serves as an effective means for cooling the motor by carrying away the heat generated. In order to prevent excessive heating in localized zones within the motor assembly, I have provided means whereby the oil is permitted to circulate freely within the casing and thereby evenly distribute the heat. Although various means may be provided for accomplishing this purpose I have shown, as typical, circulating or impact tubes 87 extending longitudinally of the casing between brackets 35 and 37, tubes 87 opening at their upper and lower ends into chambers 93 and 96, respectively. Tubes 87 serve primarily to conduct the comparatively warm or hot oil in the upper interior of the casing, downward into space 96 which is effectively cooled by the well liquid flowing past well 32b, and by maintaining this circulation, together with the pumping or circulating tendency of the motor, the oil in the motor casing is maintained at proper low temperatures.

It will be noted that chamber 64 is substantially closed from the well and that the column of liquid therein is supported independently of the well liquid so that the level of this independently supported column or well liquid will at all times stand above the overflow edge of sleeve 62. Therefore, if for any reason the level of the well liquid should fall below the pump inlet or the point of entry to chamber 64, the liquid seal for the motor casing will remain undisturbed, since the column of liquid in chamber 64 will continue to exert an upward pressure within displacement chamber 73 to hold the overflow from the motor casing in the upper interior of the liquid seal cup.

Although the space between bearing 74 and the pump shaft through which the well liquid has access to chamber 64 may be more or less restricted, when the well liquid stands at a level above this space, the pressure exerted by the well liquid to support the displaced column of oil in chamber 73, will equal not only the hydrostatic pressure of the column in 64, but in addition substantially the static pressure of the column of well liquid standing at the outside of the pump above the upper end of shell 33. The latter thus is effective exerting an additional pressure over and above that exerted by the independently supported column in 64, which is effective in holding up the volume of displaced oil in chamber 73.

Under certain circumstances it may be desirable to further increase the pressure within chamber 64 over that due to the static pressure of the column therein and the column of well liquid standing above the pump inlet. I have therefore made provision whereby a pressure equal to any part of, or the total head developed by the pump may be communicated to chamber 64. A pressure-communicating conduit 99 may be provided which establishes communication between chamber 64 and eduction pipe 12 at the upper discharge end of the pump unit 10b. In this case, neglecting the restriction to flow offered by the shaft opening in the upper end of shell 33, the pressure therein will equal substantially the total head developed by the pump. In case the pump is constructed with a plurality of pumping stages such as units 10a, the pressure conduit 99 may communicate at any point between stages or beyond the last stage, as desired. The effect gained by so communicating the discharge pressure of the pump unit to chamber 64 thus will be to maintain a higher pressure within the displacement chamber 73 than that representing the combined static pressure heads of the column within chamber 64 and the well liquid standing above the chamber.

I claim:

1. In a submersible well pump, a pump discharge pipe, a substantially fluid tight casing supported on said pipe, a motor in said casing, said casing containing a lubricating oil in which the motor is submerged, means providing a displacement chamber into which lubricant is adapted to be displaced from said casing, and means for introducing well liquid to said displacement chamber at a pressure in excess of the static head of liquid standing in the well above said chamber.

2. In a submersible well pump, a pump discharge pipe, a pump unit supported on said pipe, a motor unit below said pump, said motor unit comprising a substantially fluid-tight casing, a motor in said casing, and a motor shaft extending through an opening in the upper end wall of the casing and operatively connected to said pump; a shell providing a displacement chamber communicating with said opening, and a conduit interconnecting said shell with said discharge pipe at the discharge side of the pump.

3. In a submersible motor well pump, a lubricant containing motor casing, a motor operated pump, walls forming a well liquid chamber, seal means preventing leakage of well liquid from said chamber into the motor casing, and means for communicating through said seal means to the motor chamber, a pressure in excess of the static head of liquid standing in the well above said chamber, said means comprising a pipe connecting the discharge side of the pump with said chamber.

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