Oct. 13, 1964 J. T. CARLE 3,153,160

SUBMERSIBLE SEAL

Filed Feb. 9, 1961 5 Sheets-Sheet 1

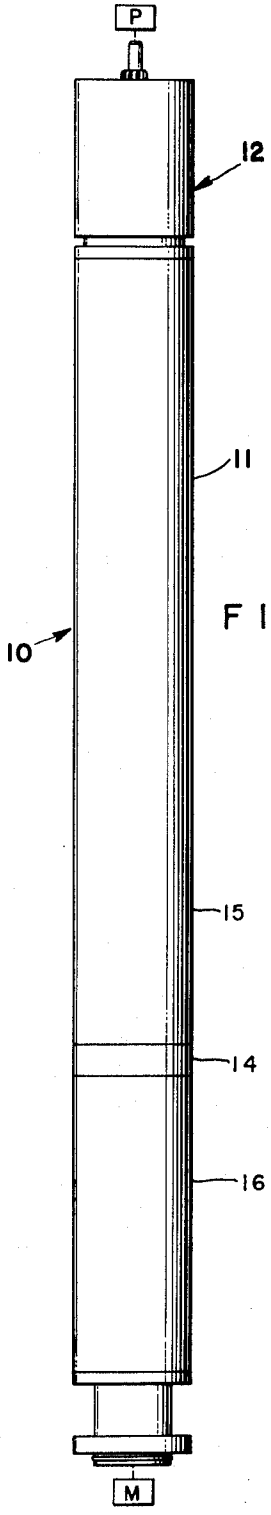


FIG. 1.

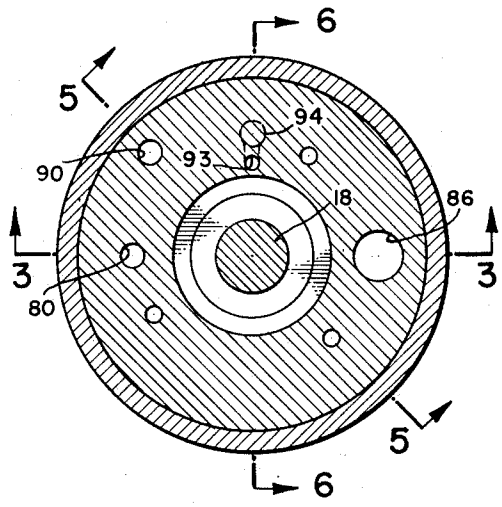


FIG. 2.

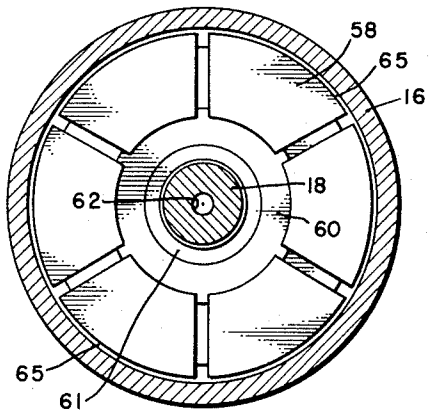


FIG. 4.

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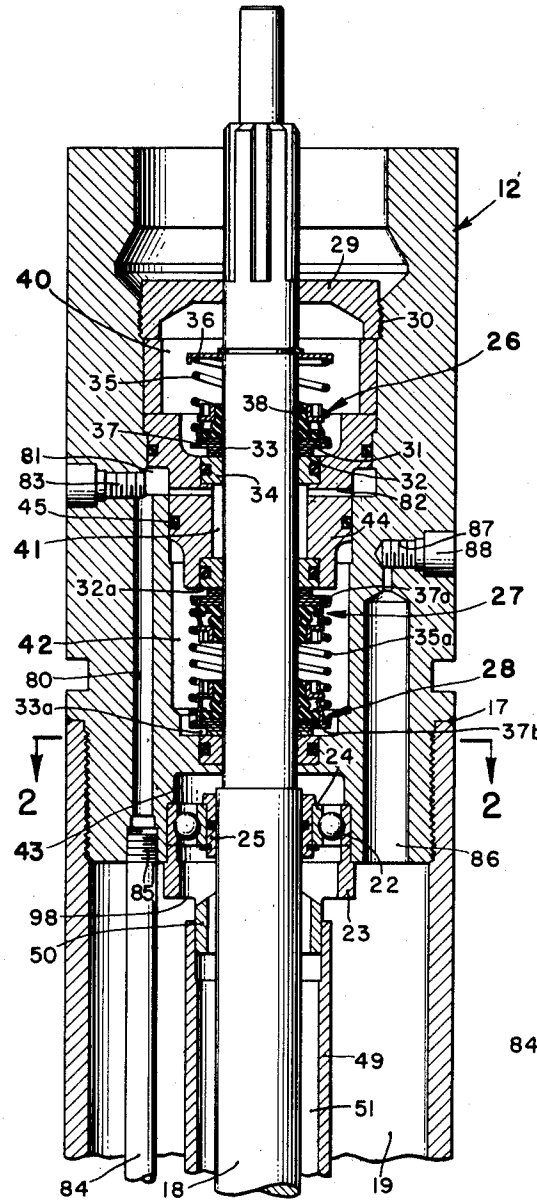
BY

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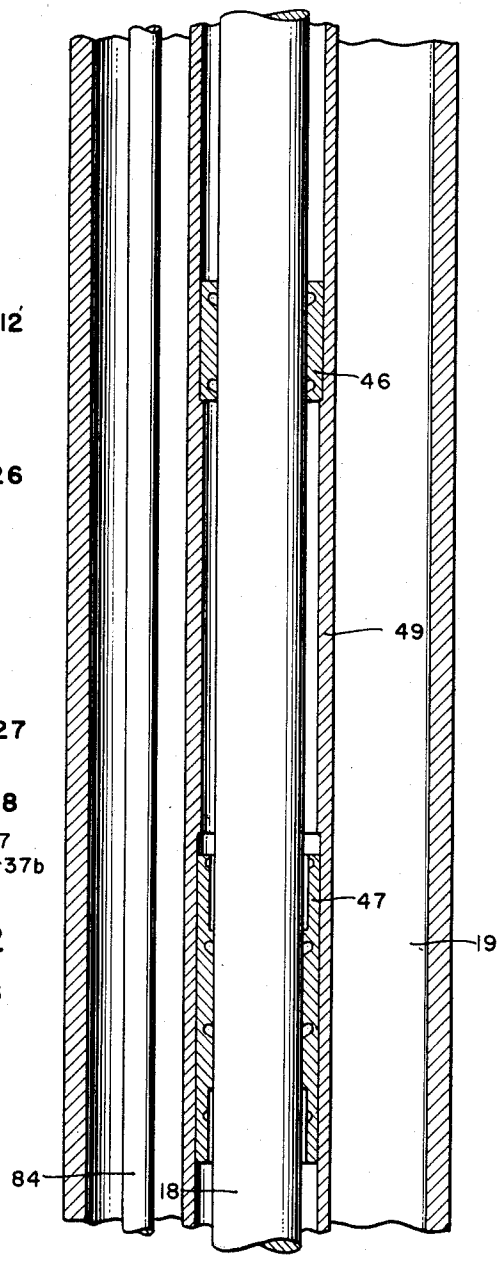
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SUBMERSIBLE SEAL

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F I G. 3a.



F I G. 3b.

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SUBMERSIBLE SEAL

Filed Feb. 9, 1961 5 Sheets-Sheet 3

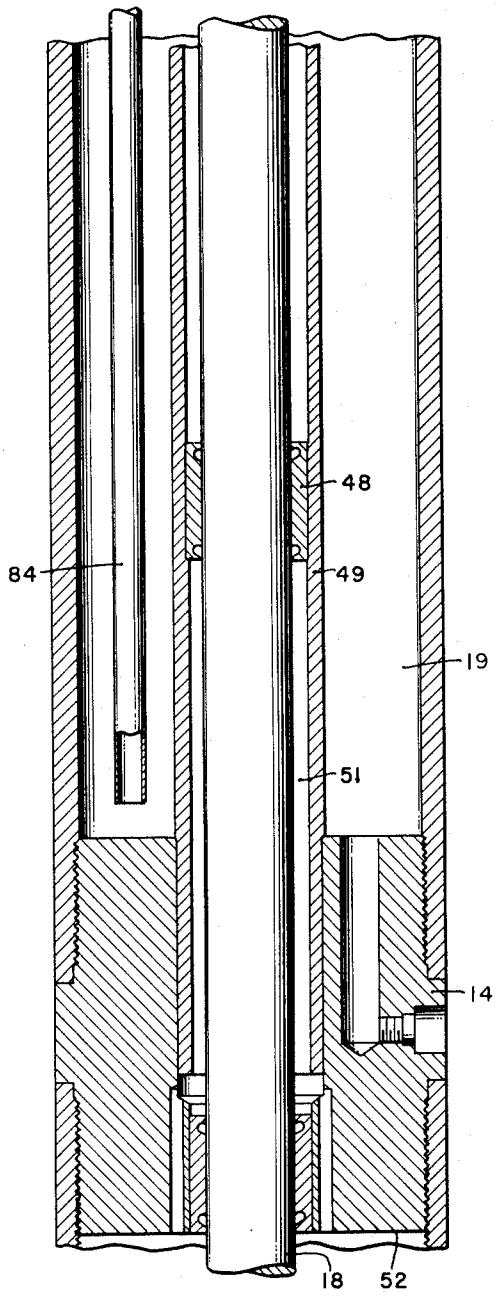


FIG. 3c.

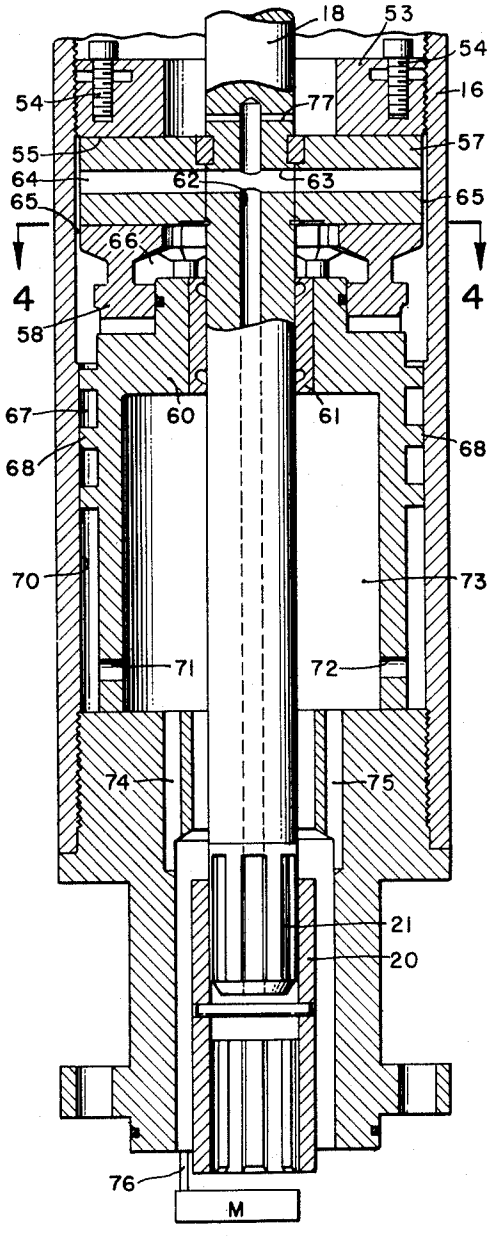


FIG. 3d.

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SUBMERSIBLE SEAL

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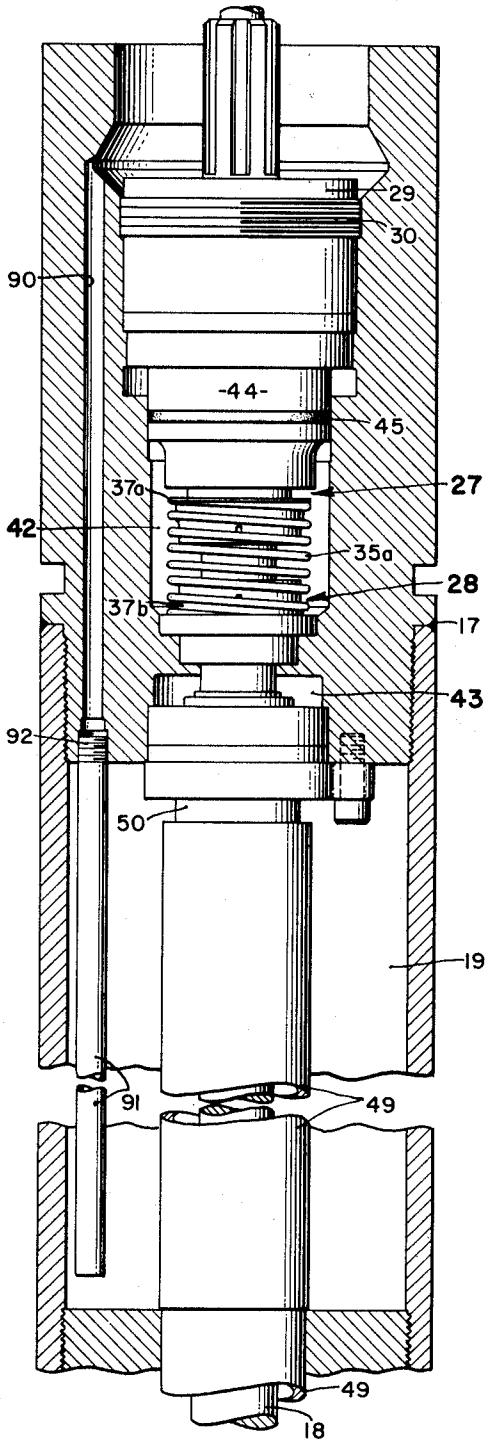


FIG. 5.

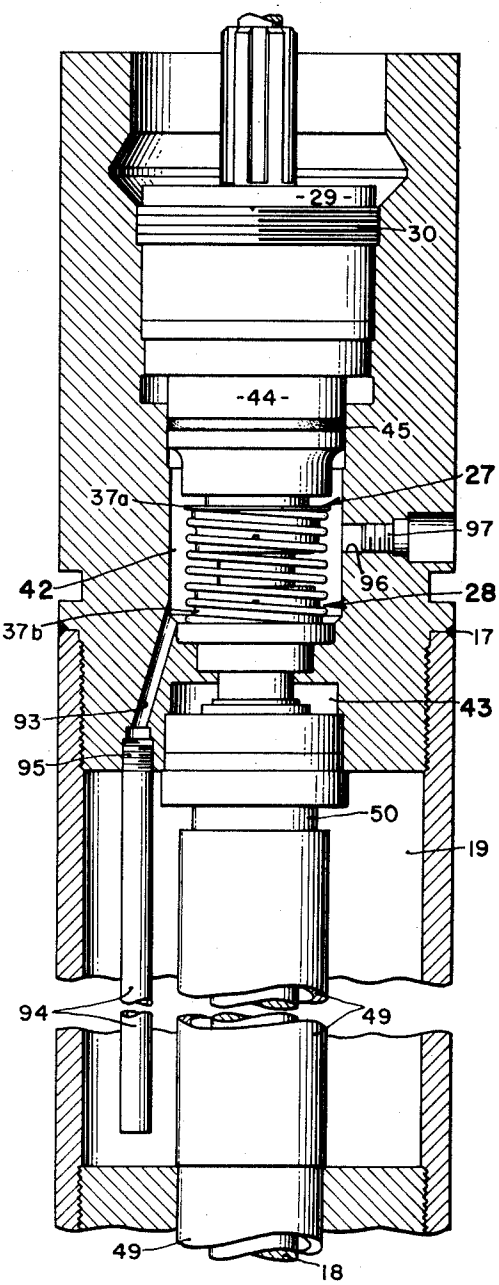


FIG. 6.

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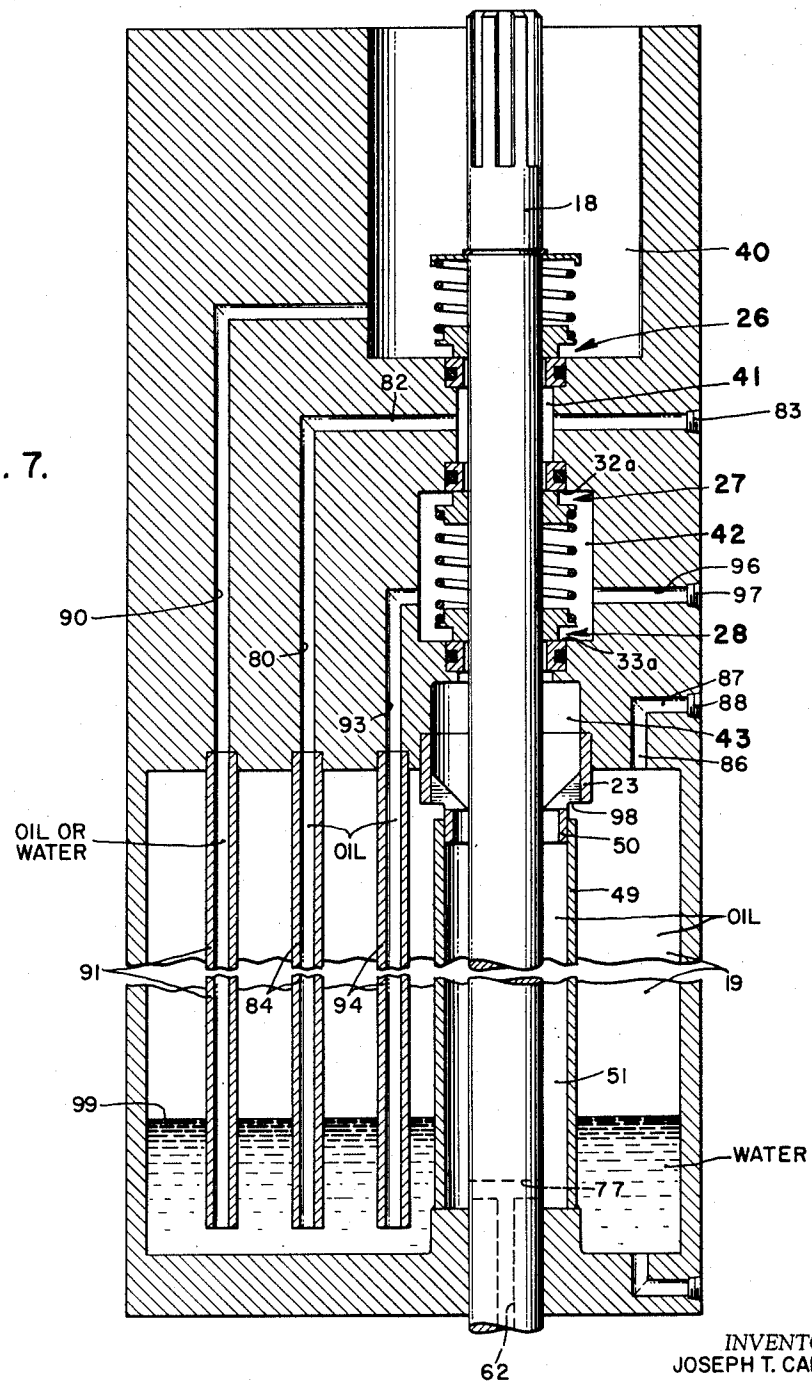
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SUBMERSIBLE SEAL

Filed Feb. 9, 1961 5 Sheets-Sheet 5

F I G. 7.



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United States Patent Office 3,153,160 Patented Oct. 13, 1964

3,153,160

SUBMERSIBLE SEAL

Joseph T. Carle, Tulsa, Okla., assignor to Borg-Warner Corporation, Chicago, Ill., a corporation of Illinois

Filed Feb. 9, 1961, Ser. No. 88,096
15 Claims. (Cl. 310—87)

This invention relates, in general, to a submersible type seal adapted to be interposed between a pump and motor unit to isolate the internal lubricating and cooling liquid in the motor from the external fluids in which the pump seal and the motor are immersed. In particular, this invention relates to a new and improved arrangement of rotating mechanical seals and other means which cooperate in a novel manner for preventing the admixture of internal fluids in the seal and motor with the external fluids, to thus protect a motor submersed in such external fluid which, if allowed to migrate into the motor, would adversely affect its operation.

By way of explanation, it is known that submersible electrical motor-pump-seal units have been developed to meet a wide variety of pump services and conditions. For example, they are widely used for pumping oil, water, or oil-water mixtures from deep wells. The motor casing, intended to be at least partially filled with an inert neutral liquid that also may serve as a lubricant, cannot be allowed to mix with the fluid in which it is submersed without harming the windings as well as the bearing structures of the motor. Thus, when it is considered that, for such uses, the submersible motor and seals must be capable of running submersed for long periods of time, it will be appreciated that any migration of the fluid being pumped, even at an infinitesimal rate, constitutes a serious defect, and it is a general object of this invention to provide an effective means to insure against the entry of external fluid to the operating parts of the motor.

Otherwise stated, the general object of this invention is the provision of a means for isolating the external fluid in which the seal and the motor are immersed from the internal fluids in the seal and the motor.

A more particular object of this invention is the provision of a new and improved means of sealing the motor from the external liquids by a new and improved arrangement of rotating concentric mechanical seals, breather tubes and chambers which cooperate to insure a greater degree of sealing ability and to provide a longer life of such seals.

Briefly, the general and particular objects of this invention are accomplished by the provision of a chamber within the submersible seal, which provides for the expansion of the liquid in the motor due to the rise of temperatures during operation of the motor and the corresponding contraction of the liquid in the motor as it cools down when the motor is stopped. Means are also provided to equalize the pressures of the fluid inside the seal with the pressures of the fluid being pumped. This is accomplished by means of a breather tube, and inasmuch as the fluid being pumped is usually water, oil, or oil-water mixtures, the net result is a volume of water in the seal casing itself by reason of the fact that the expansion and contraction of the lubricating fluid from the motor tends to provide a net loss in fluid which otherwise must be filled by the fluid being pumped. As a result, the volume of water and the volume of oil provide what is called an oil-water interface. By the new arrangement of the mechanical rotating seals, chambers, and breather tubes, all of which cooperate with the lubricating fluid and the water on each side of the oil-water interface to prevent a breakdown of the submersible seal for a considerable length of time. The cooperation

of these various elements of the pump heretofore mentioned, is such that the net loss of lubricating fluid in the seal is reduced to a point where the life of the seal, that is, its ability to prevent water from entering the motor, is considerably lengthened.

Accordingly, still another particular object of this invention is a new and improved means for reducing the loss of lubricating fluid in the submersible seal so as to increase the ability of the seal to prevent water from entering the motor windings for a longer period of time.

Other additional objects and advantages of this invention will be apparent to those skilled in the art after a study of the drawings and the following specification which form a part hereof, and wherein:

FIG. 1 is an elevational view of a submersible seal section illustrated in its entirety;

FIG. 2 is an enlarged cross-sectional view, taken along line 2—2 of FIG. 3*a*, and illustrating to advantage the the cross-sectional arrangement of the breather tubes;

FIG. 3*a* is an enlarged fragmentary elevational view of the top portion of the submersible seal shown in FIG. 1, taken along line 3—3 of FIG. 2, illustrating to advantage the arrangement of the mechanical seal means and a portion of one breather tube;

FIG. 3*b* is an enlarged fragmentary elevational view of a mid-portion of the submersible seal shown in FIG. 1, taken along line 3—3 of FIG. 2;

FIG. 3*c* is still another fragmentary view of the lower portion of the submersible seal shown in FIG. 1 taken along line 3—3 of FIG. 2;

FIG. 3*d* is still another enlarged fragmentary elevational view of the bottom or lowermost portion of the submersible seal shown in FIG. 1 taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged elevational fragmentary view illustrating to advantage one of the bearing shoes of the submersible seal shown in FIG. 1 and taken along line 4—4 of FIG. 3*d*; and

FIG. 5 is an enlarged fragmentary elevational view of the top portion of submersible seal shown in FIG. 1 taken along line 5—5 of FIG. 2 and illustrating still another breather tube;

FIG. 6 is an enlarged fragmentary elevational view of the top portion of the submersible seal shown in FIG. 1 taken along line 6—6 of FIG. 2 and illustrating still another breather tube; and

FIG. 7 is a schematic elevational showing of the submersible seal illustrating the breather tubes and their respective location for purpose of explanation of their operation.

Turning now to the drawings and in particular to FIG. 1, the submersible seal section is illustrated in its entirety as **10** and is provided with a casing **11** and adapted to be connected to its lower end to a submersible motor M and to be connected at its upper end to a submersible pump; all three parts being sometimes referred to as the pump section, seal section and motor section, respectively.

The casing **11** is made of a plurality of parts such as seal retainer **12** at the upper end of the casing (FIGS. 3*a*, 5 and 6), base **13** (FIG. 3*d*), tube guide **14** (FIG. 3*c*) and a plurality of tubings such as **15** and **16**, all of which are suitably affixed together as by threading and welding illustrated for example at **17** in FIG. 3*a* to form an elongated shaft seal for the rotating shaft **18** disposed therein and to form a main chamber **19** for an oil-water interface to be described in detail hereinafter.

As previously mentioned, a primary feature of this invention is to suitably isolate the lubricating fluid from the fluid in the well in which the motor and seal are adapted to be immersed so that there will be no interchange or ad-

mixture of this pumped fluid with the fluid in the seal and in the motor as the shaft 18 rotates by reasons of its connection to the motor to which the shaft 18 is connected by the coupling 20 (FIG. 3*d*) and splines 21 as shown therein.

Turning now to FIG. 3*a*, it will be seen that shaft 18 extends through and upwardly beyond the seal retainer 12 and is journalled in bearing means 22 of the ball-bearing type; the outer race 23 of which is affixed to the seal retainer 12, and the inner race 24 of which is affixed to a bearing adapter 25 so as to rotate therewith and with the shaft 18.

As shown in this figure, the seal retainer 12 is suitably bored and counterbored to receive a plurality of concentric mechanical seal assemblies or rotating sealing means, indicated in their entireties as 26, 27 and 28, respectively. Sealing means 26, 27, and 28, are each substantially identical and are isolated from the oilwell fluid being pumped by a sand cap 29 threaded as at 30 into the suitably threaded seal retainer as shown.

Mechanical sealing means 26 comprises a rotating seal 31 of any suitable material having a radial sealing surface 32 which rotates on a non-rotating radial sealing surface 33 of a stationary seal ring 34, also of any suitable material. Rotating seal ring 31 is urged into sealing engagement with the non-rotating seal ring 34 by a helical spring 35 reacting against snap ring 36 and spring ring 37, the latter being affixed to seal ring 31. Suitable flexible plastic shaft seal means 38 is provided to prevent leakage between the shaft 18 and the outer rotating sealing means 31 by being squeezed on shaft 18 by ring 39 at one end by the operation of ring 37 and spring 35 on the other end. As can be appreciated, this rotating mechanical sealing means 26 prevents leakage during rotation of the shaft between a cavity or chamber 40, and a chamber 41 disposed below the stationary ring 34.

Since the mechanical sealing means 27 and 28 are substantially identical to the sealing means 26 and concentric therewith, no further description is deemed necessary herein except to point out that the intermediate sealing means 27 is disposed in a reverse direction from the two sealing means 26 and 28; that is, the two radial sealing surfaces 32*a* and 33*a* are reversed. Also, the snap ring 36 is not necessary inasmuch as one helical coil 35*a* cooperates with the seal rings 37*a* and 37*b*, respectively, to urge the respective rotating seal rings towards the non-rotating seal rings. The suffixes *a* and *b* are used to designate like parts with like functions in sealing means 27 and 28 where necessary to be pointed out for purposes of description herein.

With the sealing means disposed in the manner described and shown, the area within the seal retainer 12 is thus divided into three chambers, two chambers 40 and 41 having previously been identified, and chamber 42 (in which the two sealing means 27 and 28 are disposed) is isolated from the chamber 41 by operation of the sealing means 27. Too, sealing means 28 serve to isolate still another chamber 43 in which are located bearing means 22 and which open into the main chamber 19 of the seal 10. As is also apparent, these chambers are defined in part by a suitable seal carrier such as 44 which is used to accommodate the boring and counterboring of the seal retainer 12 in order to suitably dispose the substantially identical sealing means 26, 27 and 28 therein. Also, suitable sealing means such as O-ring seals 45 may be disposed where thought necessary to prevent leakage.

In FIGS. 3*b* and 3*c* it can be seen that the shaft 18 is suitably journalled throughout its length by a plurality of sleeve type bearings such as 46, 47 and 48 disposed within a bearing tube 49 to accommodate the rotation of and to enter the shaft. The number of such bearings will, of course, depend upon the length of the shaft, three being shown for the purposes of illustration only. Bearing tube 49 terminates at its upper end adjacent the seal retainer 12 and encompasses a portion of the bearing cup 50 formed integrally with the outer race 23 of the ball-bearings (FIG. 3*a*) and terminates at its lower end by being received in the tube guide 14, previously mentioned. Bearing tube 49 is sealed in any suitable manner to tube guide 14 to form an inner chamber 51 closed at the bottom and open at the top through bearing cup 50. Tube guide 14 is provided with radial surface 52 which is spaced slightly above an upthrust ring 53 (FIG. 3*b*) serving to take the thrust of the lower bearings (to be described). Upthrust ring 53 is suitably threaded in the tubing 16 and retained in its predetermined position by any suitable means such as bolt and slot 54 which provides a wedging action in the threads.

The lower radial surface 55 of the upthrust ring is operatively engaged by a rotatable thrust runner 57 affixed to shaft 18 and which serves as a bearing in cooperation with bearing shoe 58 (see also FIG. 4). Bearing shoe 58 is suitably retained in the tubing 15 by a bearing retainer 60 and provides a suitable means of locating a sleeve bearing 61 in which the shaft 18 may rotate.

It is to be noted that the shaft 18 is also axially centrally bored as at 62. Bore 62 also communicates with a radial bore 63 which in turn communicates with radial bore 64 in the thrust runner 57 to provide open communication for the flow of lubricating fluid, such as oil, from the lower end of the shaft out through the bore 64 and thence down along passage 65 provided by the clearance between the thrust runner and tubing 16, in and out of the multiple cavities 66 in the bearing shoe, along the spirallying passage 67 formed by ridges 68 on bearing retainer 60 extending radially outwardly toward the inner walls 70 of tubing 16. The flow of lubricating fluid then continues through apertures 71 and 72 into the cooling chamber 73 to be returned to the motor from whence it came through passages 74 and 75 and into passage 76 shown schematically in FIG. 3*d*.

The flow of lubricating fluid through the bores 62–64 and thence down along the outside of bearing retainer 60, provides a means of lubricating and cooling the entire bearing assembly composing presently identified parts 57–61, with the walls of the bearing retainer 60 and the spiralling passages 67 serving to force the lubricating fluid along the inside wall 70 to be cooled by the outside well fluid before it returns to the pump housing.

As can be appreciated and as previously explained in connection with the coupling 20, the shaft 18 of the seal section 10 is connected to be driven by submersible motor M.

As is conventional in some submersible motors, means are provided so that cooling and lubricating fluid may flow into an expansion chamber such as 19 of the seal section. This chamber 19 conventionally provides a means for compensating for expansion of the lubricating fluid in the motor due to the heating thereof during operation of the motor, and permits the contracting fluid to return to the motor when the motor cools. Directly communicating to well fluid from chamber 19 through tube 91, passage 90 and chamber 40, an oil-water interface will develop in the lower end of chamber 19 after the unit has been installed in the well, and usually before being started (as a result of gravity separation). This interface will occur at the level of the lower ends of tubes 84, 91 and 94. With the first start and warmup, expanding oil will flow out through tube 91, and when a stable heat level has been reached, no additional oil will escape. When first shut down and cooling begins, well fluid (usually water or brine) will be drawn in through chamber 40, passage 91 and into the bottom of chamber 19. This will create an oil-water interface which will rise above the lower level of tubes 84, 91 and 94, reaching a stable level when the unit has fully cooled to ambient temperature. This oil-water interface will not rise above the stabilized level of the position when cooled (as above). Each time the unit is started and stopped, the interface will rise or fall ac-

cordingly, thus providing for expansion and contraction of the lubricating oil.

As more particularly explained in the submersible motor disclosed and claimed in the copending patent application entitled "Submersible Pump Motor," Serial No. 88,223, filed concurrently herewith by Joseph T. Carle, fluid in chamber 73 forms part of a secondary circulating system for the purpose of lubricating and cooling the bearings in the motor as well as in this portion of the seal section as previously explained. It is to be noted, however, that while this seal section is particularly adapted to be used with the submersible motor disclosed and claimed in said copending application, this seal section may be utilized with any motor having a means of circulating cooling fluid to the chamber and allowing it to return to the motor during the cooling thereof.

Also, bore 62 of shaft 18 extends upwardly beyond radial bore 63 and communicates with a valve bore 77 which opens into the chamber 19 through chamber 51 and port 98 for a purpose to be described.

Turning again to FIGS. 2, 3*a–c*, it can be seen that the seal retainer 12 is also provided with a plurality of coaxial bores disposed radially about the axis of rotation of the shaft 18. Each of these bores and their purpose will now be described.

In FIG. 3*a*, bore 80 communicates at its upper end with an opening 81 and with chamber 41 by radial passage 82 in the bearing retainer 48. Communication between opening 81 and the outside of the casing is prevented by a threaded cap sealing means 83, the latter being used to fill chamber 41 with lubricating fluid. The lower end of the bore 80 is in communication with a first breather tube 84 affixed to the lower end of the seal retainer 12 in any suitable manner such as by threading as it 85. As can be seen in FIGS. 3*a*, 3*b* and 3*c*, this breather tube 84 extends down to, but a short distance above, the top surface of the tube guide 14.

The other coaxial bore 86 shown in FIG. 3*a* is a filler bore which communicates with the chamber 19 and with a radial bore 87 in the seal retainer 12 to aid in the filling of seal chamber 19 with lubricating fluid, as will be explained in more detail hereinafter. Radial bore 87 is suitably threaded to receive the seal cap 88 in a conventional manner.

Turning now to FIG. 5, it will be seen that the seal retainer 12 is also coaxially bored as at 90. Bore 90 communicates at its upper end with chamber 40 of the seal retainer above the sand cap 30, and at its lower end with a second breather tube 91 affixed to the seal retainer in any suitable manner as by threading 92. In a manner similar to breather tube 84 it extends to a position immediately above the tubing guide 14 so as to provide a means of communication between that area and the chamber 40.

In FIG. 6 seal retainer 12 is shown to be diagonally bored as at 93 to provide a means of communication between the chamber 42 in which the sealing means 27 and 28 are located. Bore 93 communicates with a third breather tube 94 suitably threaded into the lower end of the seal retainer as at 95. This tube 94 also provides a means of communication to the area immediately above the tube guide 14 in a manner similar to breather tubes 84 and 91. A radial bore 96 and sealing screw cap 97 is provided to aid in the filling of chamber 42 with lubricating fluid.

Having thus described the preferred specific embodiment disclosed in FIGS. 1–6, attention is now invited to FIG. 7 which discloses the seal section 10 schematically and which will be referred to for the purpose of explaining the operation of a seal section constructed in accordance with the teachings of the invention.

In this figure it is to be noted that the breather tubes are disposed in one common plane as an easier way to show the function of these breather tubes in connection with the sealing means 26, 27 and 28. In this figure it can clearly be seen that tube 84 and passage 80 clearly communicate with chamber 41; that tube 91 and passage 90 communicate with chamber 40, and that tube 94 and passage 93 communicate with chamber 42. Also in this figure, the screw cap 29 is omitted because it does not absolutely prevent leakage toward sealing means 26 and consequently chamber 40 is substantially open to well fluid.

Prior to submersion in a well, the chambers 19 and 51 are filled with lubricating fluid; chamber 40 being normally open to well fluid. Filler bores 86, 96 and 82 are air vents, while actual filling is done through drain and fill valve in the side of the motor head (using a pump). Air vents are closed with plugs after air is vented during filling operation. During the operation of the motor, seal section, and pump in well fluid, well fluid is free to enter chamber 40 and consequently will communicate with bore 90 and breather tube 91 with the lubricating fluid in chamber 19. By reason of the inability of oil and water to mix, an oil-water interface results, as indicated schematically at 99. The purpose of the breather tube 91 is to provide for the expansion and contraction of the lubricating fluid in the submersible seal and motor, and for an equalization of pressures between the lubricating fluid in the seal and the pressures of the well fluid on the outside of the seal casing. It can be appreciated that during the operation of the seal section, as well as the motor, the expansion and contraction of the lubricating fluid will cause the interface 97 to raise when the motor is shut down and cools, and to lower when the motor is started and warms to operating temperature. As previously mentioned, the expansion and contraction of the lubricating fluid in the motor runs in and out of bore 77 in the shaft, chamber 51, chamber 19, and then in and out of breather tube 91, passage 90 and chamber 40 where it communicates directly with well fluid through an opening in the attached pump base (not shown). Therefore, the previously mentioned oil-water interface will develop as indicated. Sail interface will raise and lower, depending upon whether the motor is cooling after being shut down, or heating after starting. Upper and lower limits of the interface level will not normally exceed 10% (ten percent) of the capacity of chamber 19, the balance of the capacity of this chamber being used as oil reserve in the event of leakage anywhere in the seal. When or if the oil-water interface rises to port 98, well fluid may enter the motor through chamber 51 and passage 77, and result in damage.

Breather tubes 84 and 94, and passages 80 and 93 provide for pressure equalization between sealing means 26, 27 and 28, and further, as explained below, serve to prevent loss of reserve oil if the mechanical seals begin to leak.

While the explanation of the phenomena is not completely known, it is well known that when rotating mechanical seals begin to leak they apparently function as centrifugal pumps, pumping liquid, which in this case is oil, radially outwardly by apparent centrifugal force and at the same time exhausting the oil reserve in chamber 19 and allowing the oil-water interface to rise above port 98, which would be fatal to the operation of the motor as previously alluded to. Knowing this of rotating mechanical seals, the improvements of the arrangement of three mechanical seals, chambers, and breather tubes, as well as their cooperation with the oil-water interface 97, permits the life of the seal section to be extended indefinitely.

It will be seen from the following explanation that this arrangement functions to provide for a minimum net loss of oil, so that water will be prevented from entering the motor until the last possible moment, that is, until the water reaches the outlet 98 to the chamber 51 by having displaced all the oil in the seal chamber 19.

Taking first mechanical seal 26, it can be seen that

should this seal leak first, oil in the chamber will be pumped by this seal out of chamber 41 into the chamber 40 until all of the oil in the tubes 84 and 80 is exhausted. It can be appreciated that since this pumping ability of the mechanical seal is infinitesimal, the length of time for the oil in the tube and bore 80 to be exhausted will be a considerable length of time. Nonetheless, when this oil is exhausted, further pumpage by the leaking seal will consist only of water entering the bottom of tube 84, this water being replaced through passage 90 and tube 91, and therefore, continued leakage through seal 26 merely cycles water and does not exhaust oil from chamber 19.

Obviously, after water fills the chamber 41, mechanical seal 27 will continue to prevent water from entering chamber 42 until it too begins to leak.

Should mechanical seal 27 thereafter begin to leak and since it works apparently like a centrifugal pump, it will tend to pump water from chamber 41 to mix in the oil in chamber 42, with the result that oil and water is pumped into bore 93, breather tube 94, and into the water side of the oil-water interface. In this condition or during this period, it can be appreciated that still there is no net loss of oil such that water is able to enter the chamber 51 to endanger the motor.

Similarly, by reason of the disposition and operation of mechanical seal 28, its tendency is to pump oil from chamber 43, which communicates with chamber 19 through port 98, into chamber 42 and thence bore 93 and tube 94, discharging below the oil-water interface where gravity separation takes place. By this cycling and gravity separation action, no oil is lost from chamber 19 or 51.

The above explanation, of course, is predicated on leakage of mechanical seals 26, 27, and 28, and in that order. It is apparent that should mechanical seal 27 or mechanical seal 28 leak prior to mechanical seal 26, the net result will be substantially the same. Inasmuch as mechanical seal 27 tends to pump from chamber 41, it will tend to allow water to enter the breather tube 84, bore 80, and into chamber 41, even though water does not enter through seal 26. Nonetheless, again, the amount of oil still available to prevent water from entering chamber 51 is constant since seal 27 is now cycling only water. On the other hand, leakage of mechanical seal 28 prior to the leakage of either mechanical seal 27 or 26 will merely cause a recirculation of oil from chamber 43 and chamber 19 to chamber 42 and back to the bottom of chamber 19 through 93 and 94 with no net loss in oil available to prevent water from entering the chamber 51.

In effect, when seals 28 and 29 are both leaking and thereby become centrifugal pumps, and since they are of equal diameter, they act as "opposed pumps" each cancelling out the effect of the other, and returning their discharge through the common passages 93 and 94 to the bottom of chamber 19 where oil-water separation takes place.

With the above explanation of the operation of the mechanical seals, it can be seen that the oil in chamber 19 above the interface can last a considerable length of time before water is allowed to enter the motor, since all the oil in chamber 19 must be completely replaced with water.

In theory, all seals can leak simultaneously without loss of oil when the unit is in operation. If all seals continue to leak when the unit is not operating, oil will gradually be lost from chamber 19 and will allow water to enter chamber 51.

In order to make the functioning and this new and improved arrangement in the submersible seal more understandable, the following table is proposed to show the leakage in the particular mechanical seal, the liquid cycling, and the net loss of oil by reason of the leakage in a particular seal:

Leak In Mechanical Seal No.	Liquid Cycling	Net Loss of Oil
26	Water	None.
27	do	Do.
28	Oil	Do.
26 and 27	Water	Do.
26 and 28	Oil and Water	Do.
27 and 28	do	Do.
26, 27 and 28	do	Do.

While the above explanation is based upon the concept that a mechanical seal, when leaking, acts as a centrifugal pump, this is by way of explanation of its theory of operation only, and it is apparent that any other theory of operation of such mechanical seals upon leakage would cause the same result. For example, if the theory is that water enters mechanical seal 26 to displace oil in the chamber 41, the net result will be the same because enough water must enter the chamber 41 to replace all the oil in that chamber, plus that available to it in bore 80 and tube 84. This explanation of the operation of mechanical seals 27 and 28 during leakage based on this theory would result in the same net effect, inasmuch as it is being essential to note that this arrangement prevents water from entering the motor until the oil is completely displaced from the chamber 19.

Finally, it is to be noted also that in FIG. 7, the sleeve bearings 46, 47, and 48 were omitted as performing no function in the operation of the fluid transfer as contemplated by this invention. The bearings are so constructed so as to not impede the transfer of lubricating fluid therethrough as the motor heats and cools (this flow being relatively slow) i.e., the usual and customary spiral grooving in such bearings permits such transfer.

From the above explanation it can be seen that a new and improved seal section for use with a submersible motor and pump has been disclosed, and while the specific details of the preferred embodiment of the invention only has been herein shown, changes and alterations may be resorted to without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and the motor are to be submerged comprising means defining a chamber, lubricating fluid in said chamber, ambient fluid in said chamber, means communicating said chamber with said motor, a first rotary seal means, a second rotary seal means, a third rotary seal means, said first and second rotary seal means defining a second chamber, said second and third rotary seal means defining a third chamber, said second chamber and said first and second rotary sealing means being arranged to transfer ambient fluid to said first chamber upon failure of either or both of said first or second rotary sealing means, said third chamber and said second and third rotary sealing means being arranged to transfer ambient fluid to said first chamber upon failure of said second rotary sealing means, said second and third chambers and said first, second and third sealing means being arranged to prevent ambient fluid from entering said motor until ambient fluid displaces the lubricating fluid in said first chamber, second chamber and third chamber and then only upon failure of said third rotary sealing means.

2. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, a first chamber in said housing, lubricating fluid in said first chamber, ambient fluid in said first chamber, said fluids forming an interface therebetween, ambient fluid outside said first chamber, means communicating said first chamber with said motor, and means for sealing said motor from said ambient fluid

in said first chamber until said lubricating fluid in said first chamber is exhausted from said first chamber comprising, rotary sealing means associated with another of said chambers and arranged so that, upon failure of said sealing means, the ambient fluid inside said first chamber is transferred to the position of said fluid outside said first chamber until said ambient fluid in said first chamber displaces said lubricating fluid.

3. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, a plurality of sealing means disposed between said inner and outer chambers, lubricating fluids in said chambers, ambient fluid in some of said chambers and said fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor, means communicating said inner chamber with said outer chamber, and means for sealing said motor from said ambient fluid in said outer chamber until said lubricating fluid in another chamber is exhausted comprising, rotary seal means interposed between said inner and outer chambers and arranged so that, upon failure of said seal means, the ambient fluid in said inner chamber is transferred to the position of said fluid outside said first chamber until said ambient fluid in said inner chamber displaces said lubricating fluid in both said chambers.

4. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, lubricating fluid in said inner chamber and ambient fluid in said inner chamber, said fluids forming an interface therebetween, ambient fluid in said outer chamber, means communicating said inner chamber with said motor, means communicating said inner chamber with said outer chamber, and means preventing ambient fluid outside said housing from entering said inner chamber until said lubricating fluid in said outer chamber is exhausted comprising, rotary seal means interposed between said inner and outer chambers and arranged so that, upon failure of said seal means, ambient fluid outside the housing displaces the ambient fluid in said outer chamber whereupon said ambient fluid in said outer chamber displaces said lubricating fluid.

5. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, lubricating fluids in said chambers, means communicating said outer chamber with the ambient fluid outside said housing for permitting unrestricted flow of ambient fluid outside said housing to said outer chamber, ambient fluid in said inner chamber, said lubricating fluid and said ambient fluid forming an interface in said inner chamber, means communicating said inner chamber with said motor, means communicating said outer chamber with said inner chamber, and means preventing ambient fluid outside said housing from entering said inner chamber except through said first mentioned communicating means until said lubricating fluid in said outer chamber is exhausted comprising, rotary seal means interposed between said inner and outer chambers and arranged so that, upon failure, ambient fluid outside said housing displaces the ambient fluid in said outer chamber until said ambient fluid in said outer chamber displaces said lubricating fluid.

6. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, lubricating fluid in said inner chamber, ambient fluid in said inner chamber, and said fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor, and means for sealing said motor from said ambient fluid in said inner chamber until said lubricating fluid in said chamber is exhausted comprising, rotary seal means interposed between said inner and outer chambers, means communicating said seal means with said ambient fluid in said inner chamber whereby, upon failure, ambient fluid outside the housing and leaking past said seal means is transferred to the ambient fluid in said inner chamber so that, until said ambient fluid in the inner chamber displaces said lubricating fluid, no ambient fluid will enter said motor.

7. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing, first and second chambers in said housing, said first and second chambers being arranged in spaced relation, lubricating fluid in said first chamber and in open communication with said motor, ambient fluid in said first chamber and forming an interface with said lubricating fluid but prevented from entering said motor by means including, rotary seal means interposed between said first and second chambers and arranged so that upon failure, ambient fluid outside said second chamber and the ambient fluid in said first chamber is transferred to the position of said fluid outside said first chamber until said ambient fluid in said first chamber displaces said lubricating fluid.

8. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, lubricating fluid in said inner chamber, ambient fluid in said inner chamber, said fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor, and means for sealing said motor from said ambient fluid in said inner chamber until said lubricating fluid in said inner chamber is exhausted comprising, a plurality of rotary seal means interposed between said inner chamber and said other chambers, means communicating each said seal means with said ambient fluid in said inner chamber so that, upon failure of any or all of said seal means, ambient fluid outside the housing is transferred to the ambient fluid in one of said other chambers.

9. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, lubricating fluids in each of said chambers, ambient fluid in each of said chambers, said fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor, means communicating said inner chamber with said outer chamber, and means for sealing said motor from said ambient fluid in said inner chamber until said lubricating fluid in said inner chamber is exhausted comprising, a plurality of rotary seal means interposed between said inner and outer chambers, means communicating each said seal means with said ambient fluid in said outer chamber so that, upon failure of any or all of said seal means, ambient fluid outside said chambers is transferred to the ambient fluid in said outer chamber.

10. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing comprising a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, lubricating fluids in each of said chambers, ambient fluid in each of said chambers, said fluids forming an interface in said inner chamber, means communicating said inner chamber with said outer chamber, and means preventing ambient fluid outside said housing from entering said inner chamber until said lubricating fluid in said outer chamber is exhausted comprising, a plurality of rotary seal means interposed between said inner and outer chambers, means communicating each said seal means with said ambient

fluid in said outer chamber so that, upon failure of any or all of said seal means, ambient fluid outside the housing is transferred to the ambient fluid in said outer chamber.

11. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, an outer chamber in said housing, lubricating fluids in each of said chambers, means communicating said outer chamber with the ambient fluid outside said housing for permitting unrestricted flow of ambient fluid outside said housing to said outer chamber, ambient fluid in said inner chamber, said lubricating and ambient fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor, means communicating said outer chamber with said inner chamber, and means preventing ambient fluid outside said housing from entering said inner chamber except through said first mentioned communicating means until said lubricating fluid in said outer chamber is exhausted comprising, a plurality of rotary seal means interposed between said inner and outer chambers, means communicating each said seal means with said ambient fluid in said outer chamber so that, upon failure of any or all of said seal means, ambient fluid outside said housing is transferred to the ambient fluid in said outer chamber.

12. In a submersible seal for the protection of an electric motor and the like from ambient fluid in which the seal and motor are to be submerged comprising, a housing containing a plurality of chambers, an inner chamber in said housing, lubricating fluid in said inner chamber, ambient fluid in said inner chamber, said fluids forming an interface in said inner chamber, means communicating said inner chamber with said motor to permit the interchange of lubricating fluid therebetween, means for cooling said lubricating fluid so interchanged, and means for sealing said motor from said ambient fluid in said inner chamber until said lubricating fluid in said inner chamber is exhausted comprising, rotary seal means interposed between said inner and outer chambers and arranged so that, upon failure, ambient fluid outside said outer chamber and the ambient fluid in said inner chamber is transferred to the position of said fluid outside said first chamber until said ambient fluid in said inner chamber displaces said lubricating fluid.

13. In a submersible seal for the protection of an electric motor adapted to drive a pump from ambient fluid in which the seal, pump, and motor are to be submerged comprising, a housing containing a plurality of chambers, a shaft extending through said seal and connected to said pump and motor whereby said motor may drive said pump, a first chamber in said housing, lubricating fluid in said first chamber and in open communication with said motor, means communicating ambient fluid to said first chamber, said fluids forming an interface in said first chamber, means preventing ambient fluid from entering said motor by means including said lubricating fluid as well as rotary seal means disposed about said shaft and arranged so that, upon failure, ambient fluid outside another of said chambers and the ambient fluid in said first chamber is transferred to the position of said fluid outside said first chamber until said ambient fluid in said chamber displaces said lubricating fluid.

14. In a submersible seal for the protection of an electric motor adapted to drive a pump from ambient fluid in which the seal, pump, and motor are to be submerged comprising, a housing containing a plurality of chambers, a shaft extending through said seal and connected to said pump and motor whereby said motor may drive said pump, a first chamber in said housing, lubricating fluid in said first chamber and in open communication with said motor, means communicating ambient fluid to said first chamber, said fluids forming an interface in said first chamber, means preventing ambient fluid from entering said motor by means including said lubricating fluid as well as a plurality of rotary seal means disposed about said shaft and interposed between said first chamber and aonther of said chambers and arranged so that, upon failure, ambient fluid flows from outside said first chamber to the ambient fluid inside said first chamber until said ambient fluid in said first chamber displaces said lubricating fluid, each said rotary means including a stationary member and a rotary member, with two of said rotary seal means disposed operatively back-to-back so that, upon failure, said two seal means function opposite one another.

15. In a submersible seal for the protection of an electric motor adapted to drive a pump from ambient fluid in which the seal, pump, and motor are to be submerged comprising, a housing containing a plurality of chambers, a shaft extending through said seal and connected to said pump and motor whereby said motor may drive said pump, a first chamber in said housing, lubricating fluid in said first chamber and in open communication with said motor, means communicating ambient fluid to said first chamber, said fluids forming an interface in said first chamber, means preventing ambient fluid from entering said motor by means including said lubricating fluid as well as a plurality of rotary seal means disposed about said shaft and arranged so that, upon failure, ambient fluid outside said first chamber and the ambient fluid inside said first chamber is transferred until said ambient fluid in said first chamber displaces said lubricating fluid, each said rotary seal means being in communication with ambient fluid in said first chamber, some of said seal means acting to transfer ambient fluid outside said first chamber to ambient fluid inside said first chamber and the remainder of said seal means acting to transfer ambient fluid outside another chamber to the ambient fluid outside still another chamber.

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