Aug. 1, 1944. T. G. MYERS 2,354,874

SEAL FOR SUBMERSIBLE STRUCTURES

Original Filed Feb. 28, 1938 2 Sheets-Sheet 1

Fig. 1

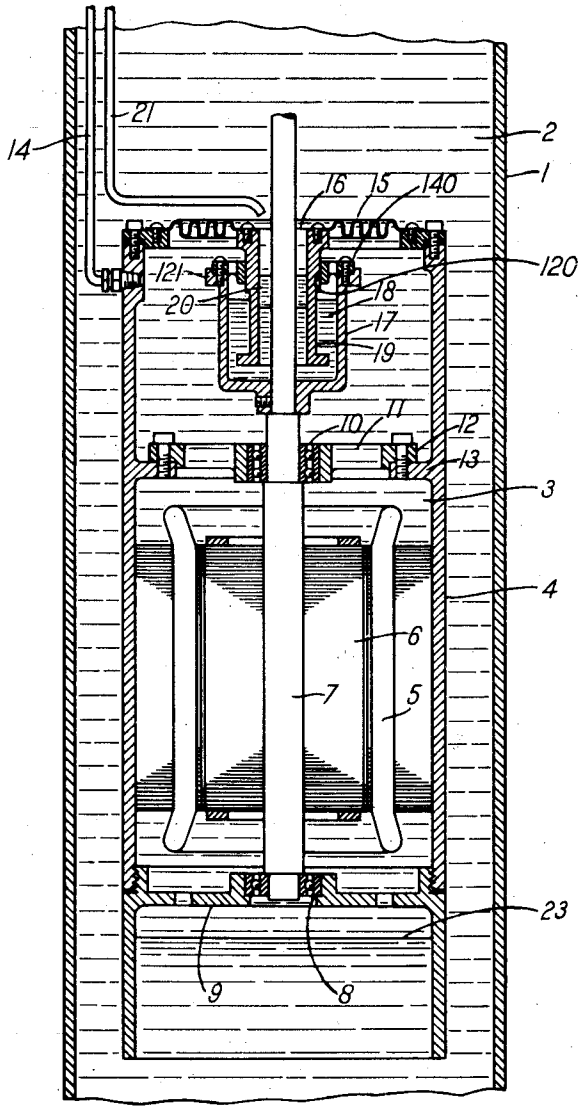


Fig. 2

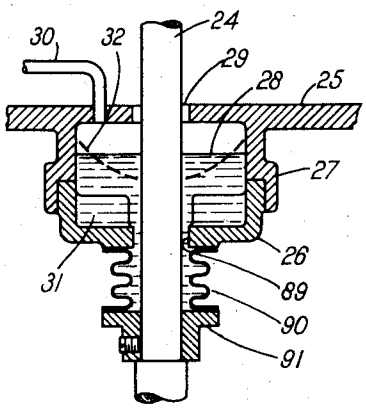
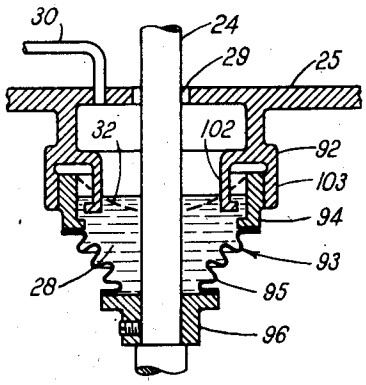


Fig. 3



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Fig. 4

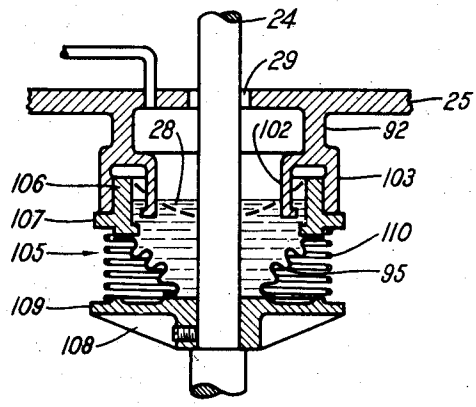
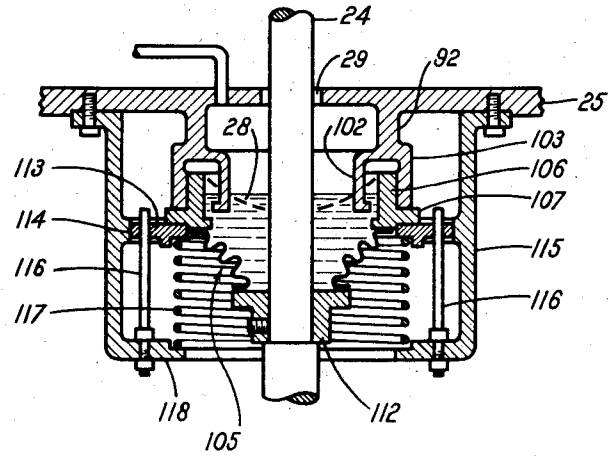


Fig. 5



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SEAL FOR SUBMERSIBLE STRUCTURES

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Original application February 28, 1938, Serial No. 193,121, now Patent No. 2,293,616, dated August 18, 1942. Divided and this application March 8, 1941, Serial No. 382,361

10 Claims. (Cl. 286—11)

This invention relates to seals for submersible structures, such for example as submersible electric motors adapted to be directly connected to pumps lowered into a well liquid. Installations of this general character have been proposed and used. They involve the problem of excluding the harmful well liquid from the windings, as well as from the bearing structures.

This application is a division of an application filed in the name of Thomas G. Myers on February 28, 1938, Serial No. 193,121, and entitled "Submersible structures," now Patent No. 2,293,616, issued August 18, 1942.

Various sealing devices for accomplishing these functions have been heretofore devised. In some of these, the motor casing is intended to be at least partially filled with an inert, neutral liquid that may also serve as a lubricant. In many instances, oil is a suitable liquid for this purpose. Problems, however, arise in connection with such fillings and seals, which it is the aim of this invention to solve. These problems may now be discussed.

Whenever two unlike liquids are in contact, such as mercury and water, and when there is some agitation, an emulsion of the two liquids results. Where mercury is used as a sealing medium and in contact with the neutral liquid and the well liquid, this emulsification harms the seal. In cases where the neutral filling liquid, such as oil, is in contact with well liquid, such emulsification or mixture would in time seriously reduce the insulation quality of the liquid in the casing, with resultant serious effects upon the motor.

It is one of the objects of this invention to prevent harmful emulsification or mixing of the liquids that are involved in systems of this character.

The manner in which this result is obtained may take several forms. Mechanical separation of the liquids in a novel way, forms another object of the invention.

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

Referring to the drawings:

Figure 1 is a view, mainly in longitudinal section, illustrating a form of the invention in use in a well;

Figs. 2, 3, 4 and 5 are fragmentary views, mainly in section and on an enlarged scale, of modified forms of the invention.

In Fig. 1 the well is shown as defined by a well casing 1 in which there is the well liquid 2. This well liquid may be water or the like which it is desired to pump out of the well.

For this purpose, use is made of a submersible electric motor, having the motor elements accommodated in a space 3 formed within a submersible casing 4. Within this space 3 there are accommodated the primary or stator windings 5; and the rotor 6 mounted on a rotary shaft 7. The motor, comprising the parts 5 and 6, may be of the conventional induction motor squirrel cage type, appropriately connected through waterproof cables to a source of electrical energy at the top of the well.

The shaft 7, shown in this instance as extending upwardly out of the casing, is intended to be directly connected to a pump (not shown). Provisions are made for ensuring against the entry of well liquid within at least that part of the casing 3 in which the motor windings and the shaft are located. The manner in which this is done will now be described.

The rotary shaft 7 is shown in this instance as being supported for rotation by a lower ball bearing structure 8, the outer race of which is supported on a transverse perforated wall 9 extending across the bottom of casing 4. Adjacent its upper end the shaft 7 is similarly rotatably supported by the ball bearing structure 10. The outer race of this ball bearing structure is shown in this instance as supported on a spider 11, having the flange 12 secured to an integrally formed flange 13 extending inwardly from the wall of casing 4. In the present instance, the casing 4 may be filled with a neutral liquid or gas, such as oil, carbon tetrachloride, or air. When the casing is filled with gas or air, it is desirable to have a layer of oil on top of the water to prevent absorption of the gas in the water.

The top or cover 15 of casing 4 is a flexible, corrugated diaphragm securely fastened in fluid tight manner to the casing, and has an aperture 16 through which the shaft 7 extends. In order to provide a fluid tight seal around the shaft 7,

use is made of a heavy sealing liquid. For this purpose a rotary cup 17 is shown as carried by the shaft 7 for the accommodation of a heavy sealing liquid 18, such as mercury. Depending into the body of sealing liquid 18 is the non-rotary sleeve-like annular member 19. This member is supported by the cover 15. The lower edge of this member 19 extends considerably below the surface of the body of liquid 18. In this manner the area of the top surface of the liquid 18 is divided so that a part of it is in contact with the filling in the casing 4. The inner annular part would normally be exposed to well liquid 2. In order for well liquid to pass into the casing it would have to pass through the inner annular portion of the liquid 18, around the lower edge of the non-rotary sleeve 19, and again upwardly through the outer annular portion of liquid 18. There is thus a liquid sealing effect provided by the elements just described.

In order to prevent any whip or vibration of the shaft 7 due to wear of the supporting bearings or other causes, from being imparted to the liquid filling in cup 17, along with the rotary movement of the shaft, means are provided to prevent relative lateral motion between cup 17 and the sleeve 19. This means may include a journal surface 120 formed on a split flange 140 fastened to the upper end of the sleeve 19, and engaged by a cooperating cylindrical surface 121 formed in the upper end of cup 17. Together these form a centering fit which maintains the members coaxial. With this arrangement, sleeve 19 must be supported so that it is free to follow lateral motion of the cup, otherwise whip and vibration which are bound to be present in the shaft would destroy the centering fit. Thus, by mounting the sleeve 19 on a yielding support, such as diaphragm 15, it is free to adjust itself to the variations in movement of the shaft, and the sealing surface of the liquid remains undisturbed.

As previously mentioned, the rotation of cup 17 sets up a rotation of the mercury 18, and where this mercury 18 is in contact with another liquid, an emulsion or mixture is apt to form; and especially is this true where there is relative motion between the liquids at the surfaces of contact.

In order to avoid an area of contact between the body of liquid 18 and the well liquid 2, there is superimposed upon the inner surface of liquid 18 a supplemental heavy liquid 20, which is carbon tetrachloride or the like. This carbon tetrachloride layer does not form an emulsion as easily as the mercury 18. Accordingly the emulsion or mixture between the mercury 18 and the well liquid is prevented.

Surfaces in contact with the mercury 18, such as of cup 17 and sleeve 19, may be appropriately treated to ensure against undesirable chemical action. Furthermore, a filler pipe may be provided, both for the carbon tetrachloride 20 and the mercury 18, indicated generally by 21.

Provision may be made to maintain the fluid pressure within casing 4 at about the same value as the liquid pressure exterior of the casing 4; or slightly above this exterior pressure. For this purpose various arrangements have been proposed and used. In the present instance, pressure balance is secured by leaving the bottom of casing 4 open, permitting the well liquid to rise normally to about the level indicated by the level 23. The flexible diaphragm 15 would serve to maintain the pressures within and without the casing equal, even though the bottom was tightly closed. In that case, however, some means, such as an outwardly opening check valve, or a pipe leading from the bottom of the casing to the top of the well, would have to be provided to permit replacement of the liquid filling of the casing when desired.

At the level 23 there is a pressure transfer between the fluid filling the casing 4 and the exterior well liquid. As long as there is sufficient air, fluid or liquid within the casing 4, this surface 23 is prevented from rising to any of the rotary parts of the apparatus or to the windings.

The prevention of emulsification illustrated in Fig. 1 may be secured in somewhat different ways. In Fig. 2 the rotary shaft 24 extends out of the top 25 of the casing, which in this form may be a rigid member. The shaft carries a rotary cup 26 in telescopic relation with the non-rotary depending sleeve-like member 27. The cup 26 has a central aperture 89 sufficiently large to provide substantial clearance around shaft 24 which passes through it and is connected to the shaft by a flexible member 90, such as a Sylphon, which is attached to a collar 91 secured to the shaft. Thus any vibration or misalignment of the shaft is not transferred to the cup. Within the space formed in the cup 26 and the member 27, there is disposed a sealing liquid 28, which may be carbon tetrachloride or mercury. The top surface of this liquid seal 28 is in contact with well liquid through the clearance aperture 29 in the top 25. A filler pipe 30, as before, may be provided for the seal.

Whatever emulsion or mixing may occur, due to the contacting well liquid and liquid 28, is reduced by centrifugal separation. For this purpose the cup 26 is provided with radial ribs or vanes 31. During rotation of the cup 26, these vanes cause the heavier part of the mixture to be thrown radially outwardly and against the overlapping sealing surfaces between the members 26 and 27. The dotted line 32 indicates the surface of the heavy liquid 28 under the influence of centrifugal force when the shaft 24 and cup 26 are rotated. The centrifugal separator action continues during periods of operation of the motor. It causes the heavier constituents of the mixture to be separated and to be urged by centrifugal action into proper sealing relationship.

In Fig. 3 is shown a further variation of the arrangement in which there is an annular sleeve dividing the surface of the liquid seal into two portions, as well as means for guiding the cup. Thus, the shaft 24 extends through an opening 29 in the rigid top member 25, which carries an annular depending member 92 surrounding the shaft. The lower end of this member is divided to form a skirt 102 and a cylindrical guide 103. The rotating cup 93 includes the upper ring 94, which rotatively engages the cylindrical guide 103, and is supported on the flexible member 95, which in turn is attached to collar 96 secured to the shaft. The cup 93 is sufficiently deep, so that the liquid sealing material which it contains will not reach the top of the cup when the latter is rotated at its usual speed. The centrifugal separator action is the same as in the form shown in Fig. 2, and in addition, a seal such as disclosed in connection with Fig. 1 is provided. The sealing liquid 28 is urged to better sealing relation with the rotary and non-rotary elements, by the resultant centrifugal force.

In Fig. 4 is shown another variation of the

arrangement in which an annular sleeve divides the surface of the liquid seal into two portions, and in which means are provided for guiding the cup, as well as maintaining it against axial movement. Shaft 24 passes through opening 29 in the rigid top member 25, which carries the annular depending member 92 with skirt 102 and cylindrical guide 103, as before. The rotating cup 105 is this case includes an upper ring 106 engaging the cylindrical surface of guide 103, the ring also having an annular lip 107 engaging the lower edge or shoulder of guide 103. This ring is supported on the flexible member 95 which is attached to a collar 108 secured to the shaft. The flange 109 of collar 108 is approximately the same outside diameter as lip 107, and a compression spring 110, confined between the lip and the collar, maintains the lip in contact with the guide. A sealing liquid 28 is provided as before The arrangement described effectively prevents vibration of the shaft being imparted to the surface of the sealing liquid adjacent the sealing surfaces, and aids in maintaining the effectiveness of the seal.

The modification shown in Fig. 5 differs from that of Fig. 4 in that the spring is stationary. Thus the collar 112 supporting the Sylphon does not have an extended flange. A ring 113 engages the under side of lip 107. This ring is guided concentrically with guide 103 by a cylindrical surface 114 formed in cage 115 which is supported by top 25. Ring 113 is maintained against rotation by stationary anchor pins 116 secured to the cage, but is free to move axially in response to spring 117, confined between it and an inwardly extending flange 118 on the cage. This spring is effective to urge lip 107 into engagement with the lower edge of the guide 103, the operation and advantages of the seal being the same as in the previously described form.

What is claimed is:

1. In a submersible structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a rotary cup carried by the shaft, a non-rotary member in telescopic relation with the cup and rigidly supported by the casing, a heavy sealing liquid carried by the cup, and extending to a level above the bottom level of the non-rotary member, and a flexible connection between the cup and the shaft.

2. In a submersible structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a rotary cup carried by the shaft, a liquid seal carried by the cup, an annular member rigidly supported by the casing and surrounding the shaft, said member including means forming a guide as well as a skirt extending into the seal to divide the surface of the liquid into a portion exposed to the inside of the casing, and a portion exposed to the outside of the casing, said cup having a portion in telescopic relationship with said guide, and means forming a flexible connection between the cup and the shaft.

3. In a submersible structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a rotary cup carried by the shaft, a liquid seal carried by the cup, an annular member rigidly supported by the casing and surrounding the shaft, said member including means forming a guide as well as a skirt extending into the seal to divide the surface of the liquid into a portion exposed to the inside of the casing, and a portion exposed to the outside of the casing, said cup having a portion in telescopic relationship with said guide, means forming a flexible connection between the cup and the shaft, and means to restrict axial movement of the cup relative to the guide.

4. In a submersible structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a rotary cup carried by the shaft, a liquid seal carried by the cup, an annular member rigidly supported by the casing and surrounding the shaft, said member including means forming a guide having a shoulder as well as a skirt extending into the seal to divide the surface of the liquid into a portion exposed to the inside of the casing, and a portion exposed to the outside of the casing, said cup having a portion in telescopic relationship with the guide, as well as a lip adapted to engage the shoulder, means forming a flexible connection between the cup and the shaft, and means urging said lip into engagement with the shoulder.

5. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a pair of coperating sealing members respectively supported by the casing and the shaft, said members having telescopic cylindrical guiding surfaces to prevent relative lateral movement between the members, the support for one of said members being flexible whereby lateral movement between the casing and the shaft is permitted, one of said members comprising a cup, said member carried by the shaft being otherwise free of the casing, and sealing liquid carried by the cup.

6. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a seal structure comprising a pair of relatively rotatable members, one of said members comprising a cup, said members being respectively supported by the casing and the shaft, means forming a guide for maintaining said members against relative lateral movement, the support for one of said members being yielding whereby the seal structure is adapted to follow lateral movements of the shaft with respect to the casing, said member carried by the shaft being otherwise free of the casing, and sealing liquid carried by said cup.

7. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a seal structure comprising a pair of relatively rotatable members, one of said members comprising a cup, said members being respectively supported by the casing and the shaft, means forming a guide for maintaining said members against relative lateral movement, the support for said cup being yielding whereby to permit lateral movement between the shaft and the casing, and sealing liquid carried by the cup.

8. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a seal structure comprising a pair of relatively rotatable members, one of said members comprising a cup, said members being respectively supported by the casing and the shaft, means forming a guide for maintaining said members against relative lateral movement, the support for said other member being yielding whereby to permit lateral movement between the shaft and the casing, said member carried by the shaft being otherwise free of the casing, and sealing liquid carried by the cup.

9. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, a seal structure comprising a pair of members having cylindrical guiding surfaces in tele-

scopic relationship, whereby relative rotation between the members is permitted and relative lateral movement is prevented, means whereby said members are respectively supported by the shaft and by the casing, one of said supporting means being yielding, whereby the seal structure is adapted to follow deflections of the shaft with respect to the casing, one of said seal members comprising a cup, said member carried by the shaft being otherwise free of the casing, and sealing liquid carried by the cup.

10. In a structure adapted to be submerged in well liquid, a casing, a shaft extending out of the casing, and a seal structure comprising a pair of relatively rotatable members, one of said members forming a cup, said members being supported by the shaft and the casing, means forming a guide for maintaining said members against relative lateral movement, means for yieldingly supporting one of said members, a sealing liquid carried by the cup, and means, carried by the member that cooperates with the cup, for forming an annular member depnding below the level of the sealing liquid, to divide the sealing liquid into portions that extend into the casing and out of the casing.

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