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GAS SEPARATOR

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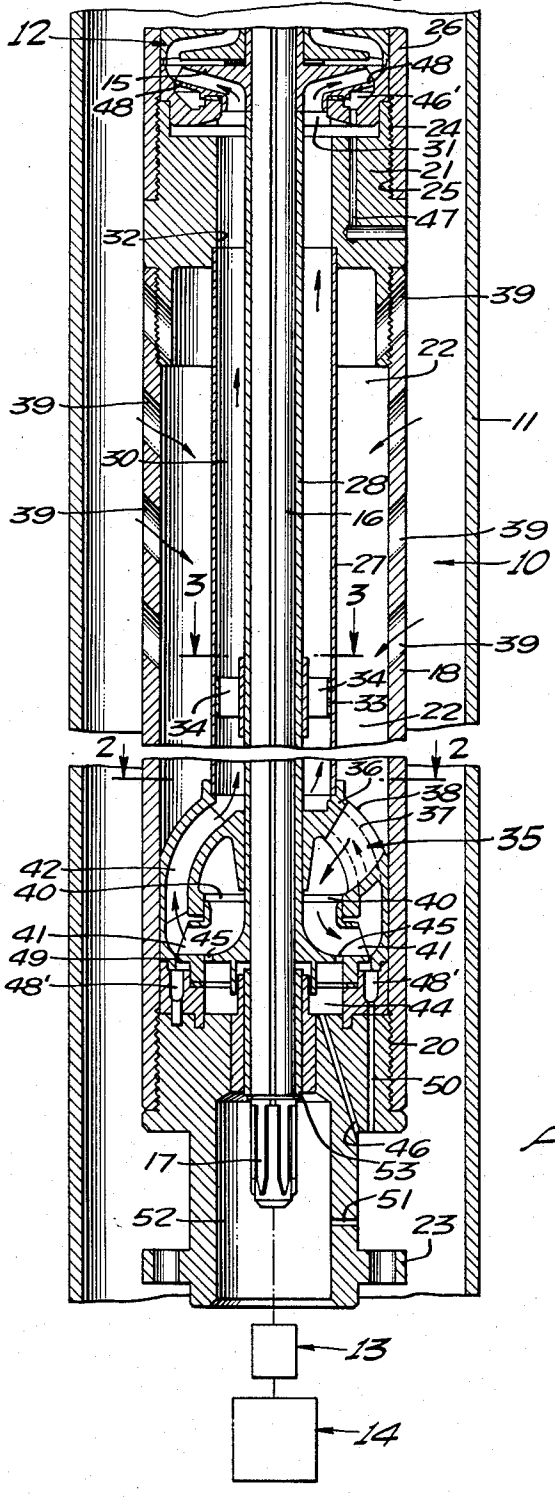


FIG. 1.

FIG. 3.

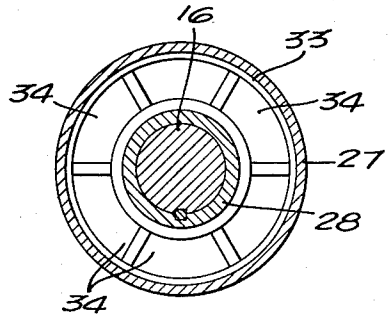
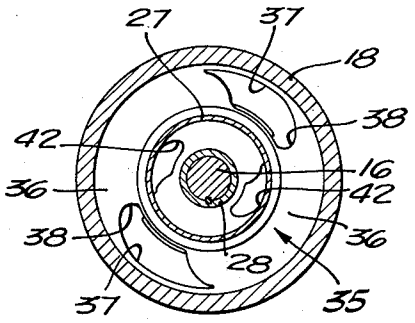


FIG. 2.



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GAS SEPARATOR

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15 Claims. (Cl. 103—102)

This is a continuation of application No. 132,167 filed August 17, 1961, having the same title.

This invention relates, in general, to gas separators and, more particularly, to new and improved gas separators for installation between a motor and the pump of a submersible motor pump assembly for oil and water wells.

In a submersible motor pump assembly it is common practice to provide an electric motor for driving a pump and to interpose therebetween a seal and a gas separator, all of which are provided with a common shaft driven by the motor with the pump located at the upper end of the assembly and with the connecting drive shaft extending through the seal section of the separator. Sometimes, the seal and the motor may be of one unit but, often each is a separable unit suspended from the pump with the interconnecting drive shaft extending therethrough and through the gas separator.

In oil-water wells in which a submersible motor-pump assembly is utilized, the presence of free and/or entrained gas oftentimes results in a reduction in the volumetric or mechanical efficiency of the pump. In some cases, the presence of gas may cause the pump to gas lock, thus restricting the flow of liquid to the pump.

Numerous attempts have been made to overcome the gas-lock problem such as providing special operating controls which automatically shut down the pump in the event of a gas-lock long enough for the gas to bleed off and then restart the pump automatically. This, of course, is unsatisfactory because of the necessity of the operating controls themselves and because of the unsatisfactory pumping rates and reduced efficiency which result.

Other attempts that have been made include means for pressurizing the inlet to the pump by providing a second impeller in the separator which will insure a supply of liquid to the inlet and which will separate some of the free or entrained gas prior to reaching the pump inlet. However, there has been found that such prior art separators themselves gas-lock at their impeller inlet which is as serious as the gas-lock problem in the pump itself.

Accordingly, a present object of this invention is to provide a gas separator for a submersible motor pump assembly which overcomes the deficiencies of the prior art gas separators.

Briefly, this invention comprises a gas separator for interposing between the motor, with or without a separable seal, and the pump, the latter being located at the upper end of the submersible motor pump assembly. The gas separator is provided with an outer housing with inlet ports therein and an inner sleeve or crossover tube, both of which are coaxial with the interconnecting motor with the pump unit. The outer housing is closed at the bottom to form a reservoir for a supply of fluid to an impeller which is operatively located between the outer housing and inner sleeve. The impeller has an inlet

which opens upwardly so that any gas tending to form at the inlet to the impeller may bubble back through the fluid in the reservoir. In the event of a gas surge, or a so-called "pumped off" condition, the upturned inlet prevents a continuous gas-lock or bubble, which would normally form under these circumstances to prevent fluid from entering the pump by operation of gravity when fluid is again available.

In the arrangement thus described, fluid which flows in a direction upwardly past the outside of the housing will flow downwardly on the inside of the housing. This reversal of flow separates some of the gas from the liquid. As the fluid enters the upturned inlet and is forced upwardly by the separator impeller, the fluid again reverses flow so that this again reduces gas entering the pump inlet.

Other features incorporated in this invention are means in the form of passages adjacent the impeller in the gas separator for the return of gas-liquid mixtures that may be forced by the weight of liquid into the impeller to thus increase the volumetric efficiency of this impeller and means in the form of ports adjacent the impellers of the pump itself to vent gas therefrom; this latter feature operating to insure flow when fluid is again available after a gas surge or after the pumped off condition.

Accordingly, still another object of this invention is to provide an improved gas separator for a submersible gas pumping assembly including an impeller unit having generally upwardly facing inlet defining means which functions to facilitate the automatic removal of gas.

Still another object of this invention is the provision of a gas separator for a motor pump assembly having means for increasing the volumetric efficiency of the impeller by venting gas liquid therefrom.

Still another object is the provision of a gas separator unit for a submersible gas motor pump assembly which eliminates the need for separate operating controls to shut the pump down to break a gas-lock.

Still another object of this invention is the provision of a gas separator having an impeller with an inlet thereto arranged to be gravity-fed and to thus provide a means for continuously preventing gas-lock.

Still another object of this invention is the provision of a gas separator in combination with a submersible pump wherein means are provided for venting gas in the pump fluid so that fluid may flow from the separator in the event of a gas surge or a pumped off condition.

Other objects and advantages of the invention will hereinafter be described or will become apparent to those skilled in the art, and the novel features of the invention will be defined in the appended claims.

Referring to the drawings:

FIG. 1 is a side elevational view in section illustrating the elongated gas separator unit connected to the pump unit and to the motor unit and submerged in a well casing;

FIG. 2 is an enlarged transverse sectional view taken along line 2—2 of FIG. 1 and looking in the direction of the arrows;

FIG. 3 is a transverse sectional view taken along line 3—3 and looking in the direction of the arrows.

In the drawings the gas separator, constructed in accordance with the teachings of this invention, is desig-

nated in its entirety as 10 and shown disposed in a well casing 11. The gas separator 10 is coaxially interposed between a multi-stage submersible-type pump, shown only partially but indicated in its entirety as 12, a submersible-type seal 13 and a submersible-type motor 14; the latter two units being illustrated schematically. The pump impellers 15 are driven by the motor 14 through a coaxial shaft 16 extending through the gas separator and the seal 13. Suitable splines 17 are provided in the shaft for appropriate connections between respective segments of the shaft from pump to motor.

The gas separator 10 is provided with an outer cylindrical housing 18 adapted to be spaced from the well casing 11 and is suitably closed at its bottom end by a lower nipple 20, and at its upper end by an upper nipple 21 to form an outer chamber 22. In the embodiment illustrated, the lower closure nipple 20 is provided with a flange 23 for connecting the gas separator to flanges on the seal in a conventional manner and the upper nipple 21 is provided with external threads 24 to mate with the internal threads 25 of the pump housing 26 for appropriate connection between the separator housing and the pump housing. Thus installed, the gas separator housing is suspended and forms part of the pump housing and in turn supports the seal 13 and motor 14.

Radially inwardly of the inner wall of the outer housing 18 is a second inner vertical cylindrical housing or sleeve 27 disposed coaxially with the shaft 16 and spaced from an impeller shaft sleeve 28 which form therebetween an inner or second chamber 30. Shaft sleeve 28 fits adjacent the shaft while sleeve 27 telescopes in the upper closure nipple 21 and connects and forms part of the inlet 31 to the pump 12 by reason of being connected to an internal bore 32 coaxial with the shaft 16. A plurality of spider bearings 33 (one shown) serve to position the sleeve 27 and are provided with openings 34 with a passage of fluid therethrough.

At the lower end of the sleeve 27 there is provided a separator pump, indicated in its entirety as 35, having a crossover housing 36 forming a partition with the cylindrical housing 18. This crossover housing is provided with separator pump inlets 37 which open upwardly as illustrated at 38, that is, they face in an upward direction so as to open into the outer chamber 22. As can be appreciated, fluid in the outer chamber 22 which entered through the plurality of radially inwardly downwardly diverted openings 39 in the entire housing 18 will enter the crossover housing 36 and enter the eye 40 to be impelled radially outwardly in accordance with the conventional pumping operation by centrifugal impeller 41 out the outlet 42 and upwardly through the inner chamber 30 to the passage 32 in the upper nipple closure 21 and thence to the pump impeller inlet 31. Thus, fluid in the outer chamber crosses over or reverses its direction in reentrant passages in the separator crossover housing and is pumped into the pump inlet 31 by operation of the gas separator pump impeller 41.

In operation, the entire assembly, i.e., pump, separator seal and motor, is lowered into a well casing, such as 11 shown in FIG. 1, and the entire assembly is supported in a conventional manner. When the pump 12 is operated by the motor 14, liquid in the well is caused to flow upwardly by the pump 12 and, as mentioned before, is usually a mixture of liquid and free and/or entrained gas and interferes with the pumping ability of the pump. Thus, as the mixture flows upwardly to enter the gas separator it is caused to reverse its direction as it enters through a plurality of downwardly inwardly directed openings 39. This reversal of direction causes some of the gas to be expelled.

It is to be noted that the housing inlet openings 39 are located in the upper portion of the housing, so that the remainder of the housing above the lower nipple 20 forms a reservoir. With the reservoir filled with liquid, some of the free and/or entrained gas is allowed to rise by the gravity, and bubble out the uppermost of the inlets.

During the continued operation of the separator, gas in the reservoir may form a bubble adjacent the gas separator impeller inlet 38. However, by reason of the upwardly opening direction of the inlet 38, this bubble will float upwardly through the fluid in the reservoir as it becomes larger and eventually works its way out the top of the housing inlets 39. Gravity operating on the fluid in the reservoir tends to aid in the removal of this bubble, so that the inlet will not gas-lock during its operation.

In the event that any gas enters along with the liquid into the gas separator impeller 41, the impeller will discharge such gas into an annular chamber 44 through passage 45 where it will be vented back into the fluid in the well through passage 46.

As previously mentioned, one of the important features of this invention is the fact that it automatically tends to overcome gas-lock when the fluid in the well becomes excessively gassy or during a momentary gas surge, or after a momentary drying up of the liquid entering the separator. When such an event occurs the gas separator pump will, of course, be exhausted of its supply of liquid, but upon liquid again entering the outer reservoir chamber 22 the influence of gravity on this liquid will overcome any pocket of gas that may tend to form in the inlet 38 in a manner described above in connection with the bubble that may form at this inlet during normal operation. With gravity thus causing fluid to force itself into the inlet, the pump impeller 41 is able to again automatically pressurize the inner chamber 30 and force liquid towards the pump 12. Should the gas surge last long enough to exhaust the fluid in the separator entirely, that is, to allow the inner chamber 30 to run dry, upon resuming of the pumping of the liquid in the gas separator impeller, means are provided for venting any gas pocket that may form in the inner chamber, so that liquid can flow towards the pump impellers. This is accomplished in the embodiment illustrated by an annular chamber 46' in the pump body and vented to the liquid in the well casing by a passage 47 in the upper nipple 21. This chamber 46' is in open communication with the fluid in the pump impellers by passage 48.

As is often the case, where the liquid being pumped is oil, sand is found in the liquid and may flow with the oil and enter the outer chamber 22 to flow with the liquid into the gas separator pump 35. Means in the form of an annular chamber 48' in communication with the impeller by passage 49 will collect this sand and return it to the well by passage 50.

In the embodiment illustrated, the lower nipple 20 is also provided with a passage 51 which vents a chamber 52 to the fluid in the well. This chamber 52 with its communication to the outside serves to prevent a large pressure build-up therein from any excess liquid that may flow past the first bearings 53 or cause by the expansion of liquid in the seal or motor 13 or 14 as the case may be.

While this invention has been disclosed for use in connection with a separate seal 13 and a separate motor 14 (which seal and motor are preferably the type disclosed and claimed in the co-pending patent applications of Joseph T. Carle entitled "Submersible Seal," Serial No. 88,096, now abandoned, and "Submersible Pump Motor," Serial No. 88,223, now U.S. Patent No. 3,112,403, both of which were filed on February 9, 1961), this invention may be utilized with any separate seal and motor or with a motor having its seal formed integrally therewith, or may be utilized as an integral part of the pump as desired.

While the various parts herein have been described as upper and lower or in a right or left position, such description refers only to the relative position of the parts as shown in the drawings and is not intended to be a limitation of the invention; it being understood that the appended claims should be construed as broadly as the prior art will permit.

I claim:

1. In a submersible gas separator unit having a vertically disposed cylindrical housing adapted to be received in spaced relation to an embracing well casing, means for connecting thereto a motor and a pump, a bottom closure means forming with said housing a reservoir portion, means defining a plurality of inlet openings adjacent the upper portion of said cylindrical housing at an elevation above said reservoir portion, sleeve defining means in said cylindrical housing forming a delivery passage from said cylindrical housing to the inlet of said pump and further forming with said housing an outer chamber between said sleeve and said housing, means defining a cross-over housing having an inlet thereto disposed within said reservoir and facing generally vertically upwardly in the direction of said first named housing inlets thereabove, and said cross-over housing having an outlet means communicating with the lower terminal of said sleeve and a second pump having an impeller positioned above said bottom closure and within said cross-over housing, said inlet means leading downwardly and centrally into said impeller, said cross-over housing outlet means being in communication with the peripheral outlet from said impeller and the lower terminal of said sleeve to thus form an intake to said first named pump, with said cross-over housing being effective to cause a reversal in the direction of flow of fluid as said fluid is pumped from said reservoir to the inlet to said sleeve..

2. In a submersible gas separator unit having a cylindrical housing, means for connecting thereto a motor located therebelow and a first pump loacted thereabove, a top closure for said housing, a bottom closure for said housing, the latter forming with said housing a reservoir in the lower portion thereof, means defining a plurality of housing inlet openings located below said top closure, the lowermost ones of which define the upper limit of said reservoir, said openings providing for the entry of liquid into said housing and reservoir therein and being effective to facilitate the separation of occluded gas from said liquid as said gas rises vertically from said reservoir, sleeve defining means in said cylindrical housing, said sleeve means extending into communication with said top closure leading to the inlet to said pump, and means defining a cross-over housing provided with generally vertically downwardly directed inlet passages, a second pump including a centrifugal impeller positioned above said bottom closure within said reservoir, said downwardly directed inlet passages leading centrally into said second pump impeller, said cross-over housing having an outlet passage communicating the lower terminal of said sleeve with the outlet from said impeller, said sleeve functioning as a delivery passage to the intake to said first named pump, said downwardly directed cross-over housing inlets further communicating with said reservoir thereabove, said inlets facing generally vertically upwardly toward said first named inlet openings in the upper portion of said cylindrical housing, whereby to facilitate the separation of occluded gas from the liquid in said last named inlets.

3. In a submersible gas separator for the removal of occluded gas from liquid prior to the introduction of said liquid into a pump having an inlet, said separator comprising means defining a generally vertically disposed cylindrical housing, a first outer chamber defined therein, means defining inlet openings into the upper portion of said first named chamber and including means providing for the separation of some gas from the liquid as the same rises in said first chamber during the flow of liquid into said first chamber, means defining a second chamber disposed within said first chamber and having a lower terminal opening into the lower portion of said first named chamber, the upper portion of said second named chamber leading to the inlet to said pump, means defining a cross-over housing disposed between said outer and inner chambers and including a centrifugal impeller operatively disposed with its inlet communicating with said first named chamber and its outlet communicating with said second chamber through cross-over passages therein, including means defining inlet passages to said impeller from above and centrally thereof, said passages having entrances facing generally vertically upwardly in the direction of said first named housing inlet means and connecting with said first chamber with the inlet to said impeller, said upwardly facing entrances functioning to facilitate the separation of occluded gas from the liquid in the area of said entrances, and means in said cross-over housing connecting the outlet from said impeller with said second chamber, whereby liquid in said first chamber is pumped by said impeller into said second chamber and thence to said inlet of said first named pump.

4. A submersible centrifugal gas separator device for separating occluded gas from liquid being pumped prior to the introduction of said liquid into a liquid pump, said device comprising means defining generally vertically disposed cylindrical housing adapted to be received in and lowered into a well casing, means in said vertical housing defining a first outer chamber, means defining top and bottom closures for said housing, inlet means opening into the upper portion of said vertical housing below the top one of said closure members, the lowermost ones of said openings defining with said housing and lower closure member a reservoir, a second chamber defining means within said first chamber having an upper terminal communicating with said pump, and means defining a cross-over housing between said first chamber and said second chamber, a centrifugal impeller operatively disposed within said cross-over housing, said cross-over housing including inlet passage defining means placing said first named chamber in communication with the inlet to said impeller above and centrally thereof and passage defining means placing the outlet from said impeller in communication with said second named chamber.

5. The separator claimed in claim 4 further including means for separating some gas from said liquid as the liquid flows into said first chamber.

6. The separator claimed in claim 4, wherein said impeller causes a reversal of flow of liquid from said first chamber into said second chamber.

7. The separator claimed in claim 4 wherein means are provided for venting gas from the liquid in said impeller.

8. The separator claimed in claim 4 wherein said pump has at least one impeller and means are provided for venting gas from the liquid in said impeller.

9. In a submersible gas separator unit, comprising a gas separator for a motor and a pump and including an outer cylindrical wall having top and bottom closures, means extending through said gas separator for connecting the motor and the pump, a reservoir, an apertured crossover housing including a rotary impeller means positioned above said bottom closure and within said reservoir, said crossover housing forming a partition with the cylindrical housing and including downwardly directed inlets leading through a chamber and into the impeller, a plurality of inlet openings in said cylindrical wall in the area thereof between said reservoir and a transverse plane adjacent to but below said pump, a coaxial sleeve in said separator in communication jointly with said crossover housing and said top closure and forming an intake for said pump, said crossover housing inlets communicating with said reservoir and facing toward the inlet openings in said cylindrical wall, and discharge passages in said crossover housing and impeller communicating with the coaxial sleeve and said crossover housing inlets.

10. In a submersible gas separator unit as claimed in claim 9, wherein a concentric sleeve carrying the impeller means passes through the crossover housing and the coaxial sleeve to the pump.

11. In a submersible gas separator unit as claimed in claim 9, wherein the crossover housing has an outlet

mouth provided with a seat adapted to receive the coaxial sleeve.

12. In a submersible gas separator unit as claimed in claim 9, wherein passages are provided in the impeller for discharging gas therefrom into an annular chamber and means defining a passage in said bottom closure for venting said chamber.

13. In a submersible gas separator unit as claimed in claim 9, wherein the pump includes a body, means in said body providing a chamber in communication with the intake for said pump and a means for defining a vent passageway in said top closure connected to said last named chamber.

14. In a submersible gas separator unit as claimed in claim 9, wherein the inlets in the crossover housing lead into an upwardly opening eye, said eye being disposed adjacent to the impeller.

15. In a submersible gas separator unit as claimed in claim 9, wherein the impeller is of the axial intake radial discharge type.

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