

[54] **FREE TURBINE PUMP**

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[22] Filed: **July 24, 1972**

[21] Appl. No.: **274,594**

[52] U.S. Cl. **417/408**, 415/199 R, 415/501

[51] Int. Cl. **F04b 47/14**

[58] Field of Search 417/408; 415/199 R, 415/501

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[57]

ABSTRACT

A turbine oil well pump capable of being run into and out of the well hydraulically. The pump includes an axial flow turbine and an axial flow pump interconnected in end-to-end relation with the turbine above the pump. The turbine has a power fluid intake adjacent its upper end and a spent power fluid exhaust adjacent its lower end. The pump has a well fluid inlet adjacent its upper end, and adjacent the power fluid exhaust, and has a production fluid outlet adjacent its lower end.

7 Claims, 6 Drawing Figures

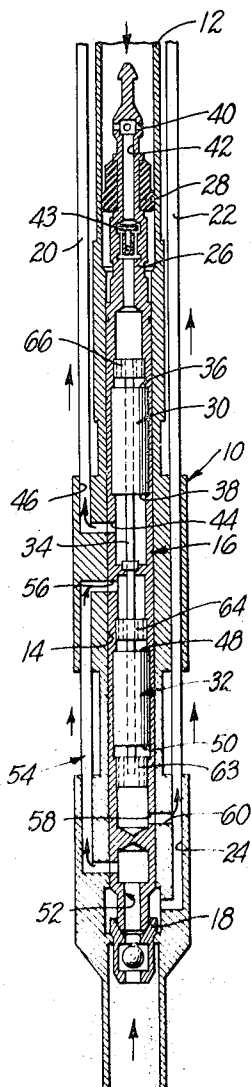


FIG. 4.

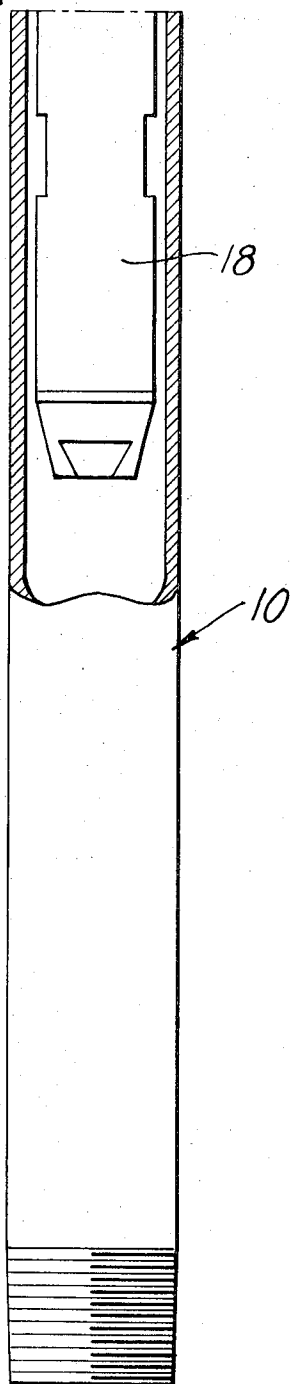


FIG. 1.

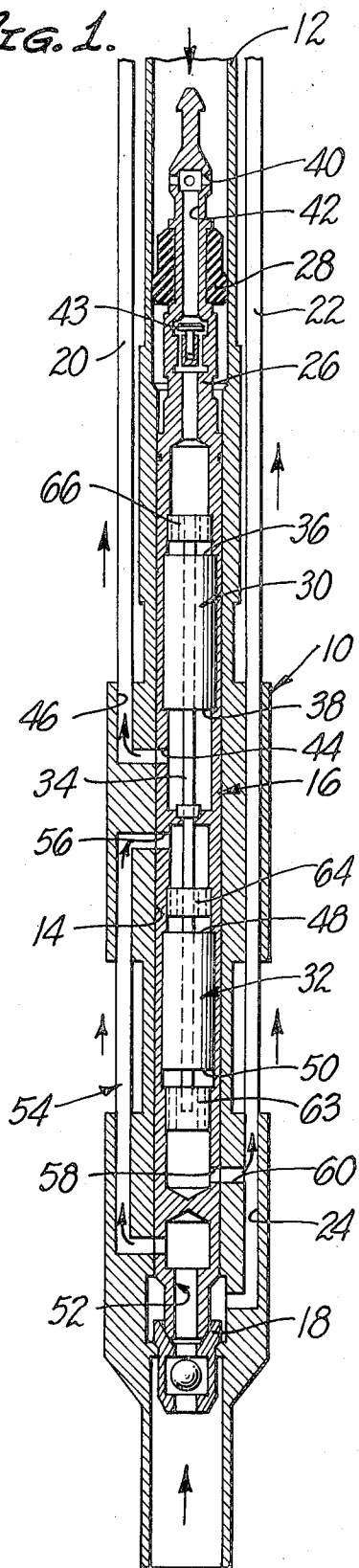


FIG. 2.

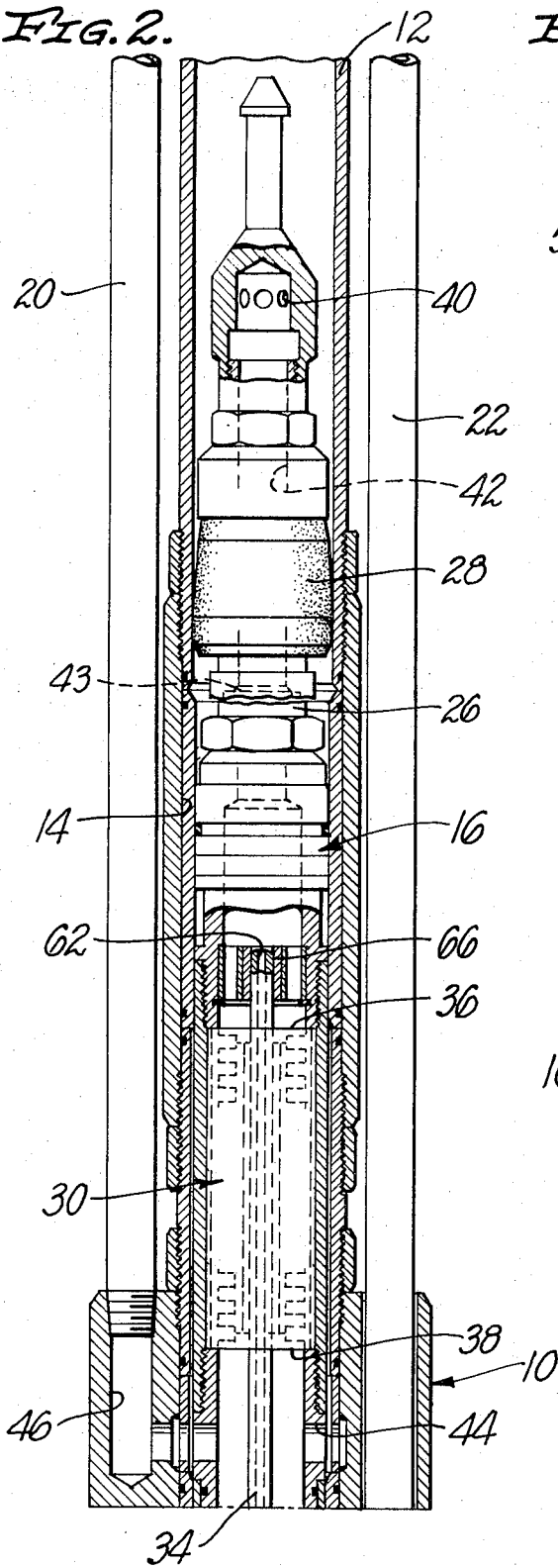


FIG. 3.

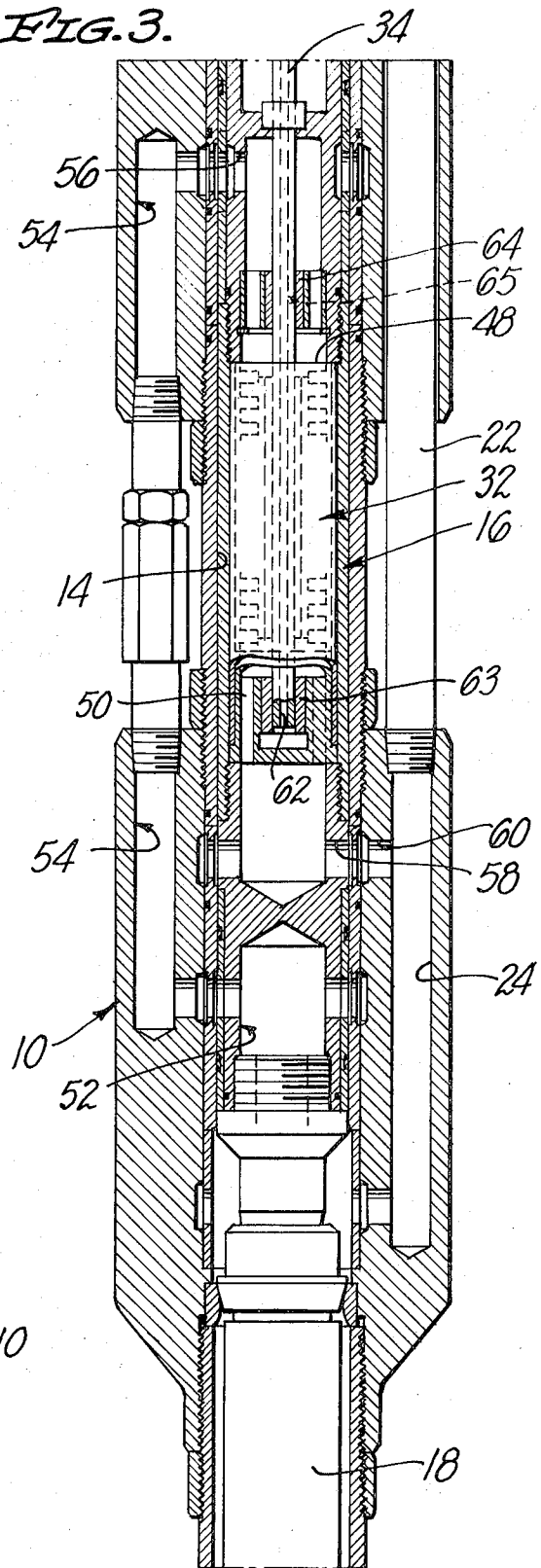


FIG. 5.

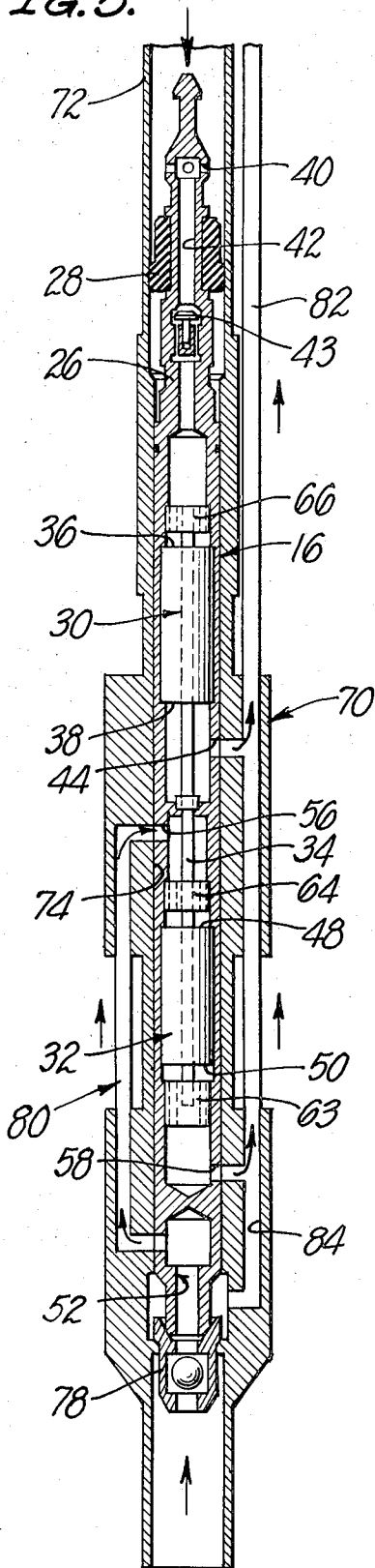
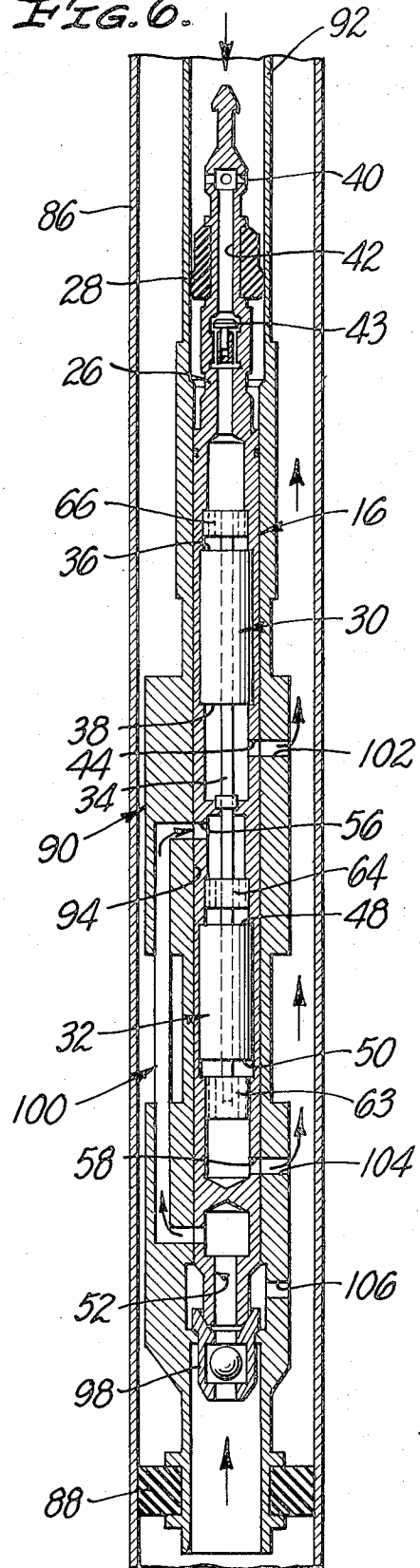


FIG. 6.



FREE TURBINE PUMP

BACKGROUND OF INVENTION

The present invention relates in general to pumps and, more particularly, to fluid operated pumps for oil wells, or the like.

Still more particularly, the invention contemplates a turbine pump capable of being circulated into and out of the well hydraulically.

SUMMARY AND OBJECTS OF INVENTION

The invention may be summarized as including, and a primary object is to provide a free turbine pump which includes: an axial flow turbine and an axial flow pump interconnected in end-to-end relation with the turbine above the pump; the turbine having a power fluid intake adjacent its upper end and having a spent power fluid exhaust adjacent its lower end; and the pump having a well fluid inlet adjacent its upper end, and adjacent the power fluid exhaust, and having a production fluid outlet adjacent its lower end.

An important feature of the foregoing construction is that the use of an axial flow turbine and an axial flow pump in end-to-end relation results in a minimum overall diameter for a given capacity.

Another important feature is that the aforementioned arrangement of the power fluid intake, the power fluid exhaust, the well fluid inlet and the production fluid outlet results in balancing the turbine and pump forces. More particularly, the turbine produces a downward force and the pump an upward one, the latter being achieved by locating the production fluid outlet at the bottom of the pump, which is an important feature.

Other important objects are to provide various systems in which the free turbine pump can be used, including, but not limited to, a free, parallel, closed power fluid system, a free, parallel, open power fluid system, a free, open power fluid system wherein the turbine and pump both discharge into the casing, and the like.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results which will be evident to those skilled in the art in the light of this disclosure, may be achieved with the exemplary embodiments of the invention illustrated in the accompanying drawings and described in detail hereinafter.

DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 is a semidiagrammatic vertical sectional view showing a free turbine pump of the invention in conjunction with a parallel, closed power fluid system;

FIGS. 2, 3 and 4 are vertical sectional views showing an actual physical embodiment of the free turbine pump of the invention in conjunction with a parallel, closed power fluid system, FIGS. 3 and 4 respectively being downward continuations of FIGS. 2 and 3;

FIG. 5 is a semidiagrammatic vertical sectional view showing a free turbine pump of the invention in conjunction with a parallel, open power fluid system; and

FIG. 6 is a semidiagrammatic vertical sectional view showing the free turbine pump of the invention in conjunction with an open power fluid system wherein the spent power fluid and the production fluid are discharged into the casing of the well.

DESCRIPTION OF EXEMPLARY EMBODIMENT OF INVENTION

The semidiagrammatic embodiment of FIG. 1 and the actual physical embodiment of FIGS. 2 to 4 will be considered simultaneously for convenience.

As illustrated in these figures, a bottom hole assembly 10 is suspended in an oil well, not shown, by a power fluid tubing 12, the power fluid being, for example, clean crude oil. The bottom hole assembly 10 provides a chamber 14 for a free turbine pump 16 of the invention. As will be explained in more detail hereinafter, the turbine pump 16 is hydraulically movable through the power tubing 12 between the surface and an operating position in the chamber 14. When the turbine pump 16 is in its operating position, it is seated on a standing valve 18 carried by the bottom hole assembly 10 at the lower end of the pump chamber.

Paralleling the power tubing 12 and connected at their lower ends to the bottom hole assembly 10 are a spent power fluid return tubing 20 and a production fluid tubing 22. These tubings respectively convey spent power fluid and production fluid from the well to the surface. The production tubing 22 has a downward extension passage 24 which communicates with the lower end of the pump chamber 14 just above the standing valve 18.

The turbine pump 16 is run in hydraulically by inserting it into the upper end of the power tubing 12 and then introducing fluid into the power tubing above the pump. This displaces the pump 16 downwardly through the power tubing 12 into its operating position in the pump chamber 14, wherein it is seated on the standing valve 18. Fluid in the power tubing 12 below the pump 16 is displaced upwardly through the return and/or production tubings 20 and 22. When it is desired to circulate the pump 16 out of the well hydraulically, fluid under pressure is introduced into the upper end of the production tubing 22, the return tubing 20 being closed at its upper end. Such fluid enters the pump chamber 14 beneath the pump 16 through the production tubing extension passage 24, and displaces the pump upwardly out of the pump chamber and upwardly through the power tubing 12. The pump 16 is provided at its upper end with the usual packer mandrel 26 carrying one or more packer cups 28 which prevent upward external bypassing of the pump 16 by the fluid used to circulate the pump upwardly out of the well.

The turbine pump 16 is provided adjacent its upper end with an axial flow turbine 30 and adjacent its lower end with an axial flow pump 32 arranged in end-to-end relation and interconnected by a common shaft 34.

The axial flow turbine 30 is provided with a power fluid intake 36 at its upper end and a spent power fluid exhaust 38 at its lower end. The power fluid intake 36 communicates with the power tubing 12 through ports 40 and an axial passage 42 in the packer mandrel 26. (A downwardly opening check valve 43 in the passage 42 prevents upward flow through this passage when circulating the pump 16 out of the well.) The power fluid exhaust 38 communicates with the return tubing 20 through ports 44 in the turbine pump 16 and a passage 46 in the bottom hole assembly 10.

The axial flow pump 32 is provided with a well fluid inlet 48 at its upper end, and adjacent the power fluid exhaust 38, and is provided with a production fluid outlet 50 at its lower end. Fluid from the well reaches the

well fluid inlet 48 through the standing valve 18, a passage means 52 in the turbine pump 16, a passage means 54 in the bottom hole assembly 10, and ports 56 in the turbine pump 16. The production fluid outlet 50 communicates with the production tubing 22 through ports 58 in the turbine pump 16, ports 60 in the bottom hole assembly 10, and the production tubing extension passage 24.

As shown in FIGS. 2 and 3, the shaft 34 interconnecting the axial flow turbine 30 and pump 32 is provided with an axial passage 62 extending its full length. This passage conducts power fluid under pressure from the upper end of the shaft 34 to the lower end thereof so as to axially balance the shaft, and to lubricate a lower bearing 63. A middle bearing 64 is lubricated by a small port 65, FIG. 3, communicating with the passage 62. An upper bearing 66 is exposed directly to the power fluid for lubrication purposes.

Considering the operation of the semidiagrammatic and actual embodiments of the invention illustrated in FIGS. 1 to 4, it will be apparent that power fluid under pressure from the power tubing 12 drives the axial flow turbine 30 and is discharged from the lower end of the turbine into the return tubing 20. The axial flow turbine 30 drives the axial flow pump 32, which receives well fluid through the well fluid inlet 48 at its upper end, and discharges the well fluid from the production fluid outlet 50 at its lower end into the production tubing 22.

One important feature of the turbine pump 16 is that the use of the axial flow turbine 30 and the axial flow pump 32 in end-to-end relation results in a minimum over-all diameter for a given capacity. This is particularly important in an oil well installation, where space is severely limited in many instances.

Another important feature of the invention is the aforementioned arrangement of the power fluid intake 36, the power fluid exhaust 38, and well fluid inlet 48 and the production fluid outlet 50. More particularly, the axial flow turbine 30 develops a downward force since the power fluid intake 36 is at the upper end of the turbine and the power fluid exhaust 38 is at the lower end thereof. Conversely, since the well fluid inlet 48 is at the upper end of the axial flow pump 32 and the production fluid outlet 50 is at the lower end thereof, the pump develops an upward force. Consequently, the forces developed by the axial turbine 30 and pump 32 oppose each other for force balancing purposes, which is an important feature.

The semidiagrammatic and actual embodiments of FIGS. 1 to 4 utilize the free turbine pump 16 of the invention in a parallel, closed power fluid system, wherein the spent power fluid and the production fluid are conveyed to the surface separately through the return and production tubings 20 and 22, respectively.

FIG. 5 shows the free turbine pump 16 of the invention as installed in a parallel, open power fluid system. More particularly, FIG. 5 shows a bottom hole assembly 70 supported in the well by a power tubing 72. The bottom hole assembly 70 provides a chamber 74 for the turbine pump 16, the latter being seated on a standing valve 78 when in its operation position.

The bottom hole assembly 70 provides a passage means 80 which corresponds to the passage means 54 of FIGS. 1 to 4 and which interconnects the passage means 52 and the ports 56 in the turbine pump 16. The installation of FIG. 5 includes a production tubing 82 which parallels the power tubing 72 and which commu-

nicates with the ports 44 and 58 in the turbine pump 16. Thus, both the spent power fluid from the axial flow turbine 30 and the production fluid from the axial flow pump 32 are conveyed to the surface through the production tubing 82. A downward extension 84 of the production tubing 82 communicates with the lower end of the pump chamber 74 so that the turbine pump 16 may be circulated out of the well by reversing the flow through the production tubing.

The free turbine pump 16 operates in the installation of FIG. 5 in the same manner as in the installations of FIGS. 1 to 4. Consequently, a further description is not necessary.

FIG. 6 shows the free turbine pump 16 in conjunction with an open power fluid system wherein the spent power fluid and the production fluid are discharged into a well casing 86. The mixture of production fluid and spent power fluid discharged by the turbine pump 16 in this installation is separated from the native well fluid by a casing packer 88 at the lower end of a bottom hole assembly 90 supported by a power tubing 92.

The bottom hole assembly 90 provides a chamber 94 for the free turbine pump 16, which is seatable on a standing valve 98 at the lower end of the chamber. A passage means 100 corresponding to the previously-described passage means 54 and 80 interconnects the passage means 52 and the ports 56 of the turbine pump 16. The ports 44 and 58 of the turbine pump 16 are connected directly to the casing 86 by ports 102 and 104 in the bottom hole assembly 90. Thus, the spent power fluid and the production fluid are discharged into the casing, which conducts same to the surface.

A port 106 in the bottom hole assembly 90 connects the interior of the casing 96 to the lower end of the pump chamber 94. Thus, when fluid is introduced into the upper end of the casing 86, such fluid enters the lower end of the pump chamber 94 through the port 106 to circulate the free turbine pump 16 upwardly to the surface through the power tubing 92 in the manner hereinbefore discussed.

The operation of the free turbine pump 16 in the installation of FIG. 6 is also the same as its operation in the installations of FIGS. 1 to 4 so that no further explanation is necessary.

Although exemplary embodiments of the invention have been disclosed herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention as defined by the claims hereinafter appearing.

We claim as our invention:

1. In a turbine pump for a well, the combination of:

- a. an axial flow turbine and an axial flow pump interconnected in end-to-end relation with said turbine above said pump;
- b. said turbine having a power fluid intake adjacent its upper end and having a spent power fluid exhaust adjacent its lower end; and
- c. said pump having a well fluid inlet adjacent its upper end, and adjacent said power fluid exhaust, and having a production fluid outlet adjacent its lower end.

2. A turbine pump as set forth in claim 1 wherein said turbine and said pump are interconnected by a shaft carried by an upper bearing above said turbine and a lower bearing below said pump, said upper bearing

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being exposed to power fluid in said power fluid intake for lubrication purposes, and said shaft having an axial passage for conveying power fluid to said lower bearing to lubricate same.

3. A turbine pump according to claim 2 including a middle bearing between said turbine and said pump, said shaft having a lubricating port connecting said passage to said middle bearing.

4. In a fluid operated, free turbine pump system for a well, the combination of:

- a. at least two tubings set in the well;
- b. a free turbine pump of a size to be movable through one of said tubings between the surface and an operating position in the well;
- c. said turbine pump comprising an axial flow turbine and an axial flow pump interconnected in end-to-end relation with said turbine above said pump;
- d. said turbine having a power fluid intake adjacent its upper end and having a spent power fluid exhaust adjacent its lower end;
- e. said pump having a well fluid inlet adjacent its upper end, and adjacent said power fluid exhaust, and having a production fluid outlet adjacent its lower end;

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g. one of said tubings being a supply tubing for conveying power fluid under pressure downwardly in the well from the surface;

h. said power fluid intake communicating with said supply tubing;

i. another of said tubings being a production tubing for conveying production fluid upwardly in the well to the surface;

j. said production fluid outlet communicating with said production tubing;

k. power fluid return means for conveying spent power fluid upwardly in the well from said power fluid exhaust to the surface; and

l. said well fluid inlet communicating with the well.

5. A free turbine pump system as defined in claim 4 wherein said power fluid return means is said production tubing.

6. A free turbine pump system as defined in claim 4 wherein said power fluid return means is a third tubing set in the well.

7. A free turbine pump system as defined in claim 4 wherein said power fluid return means and said production tubing comprise a casing set in the well.

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