Aug. 4, 1964 J. C. GASLOW ETAL 3,143,078

WELL PUMP

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Fig. 1.

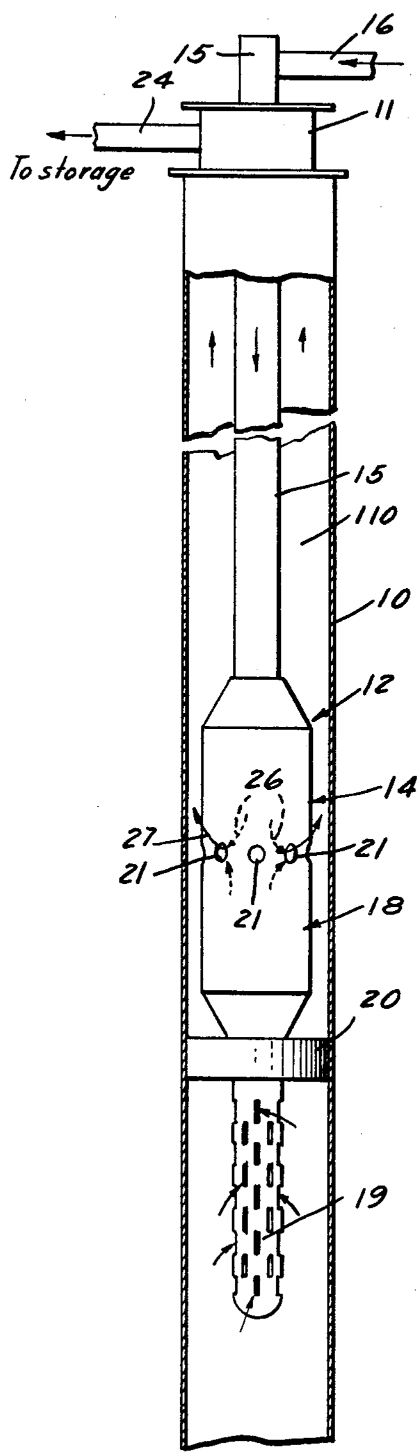
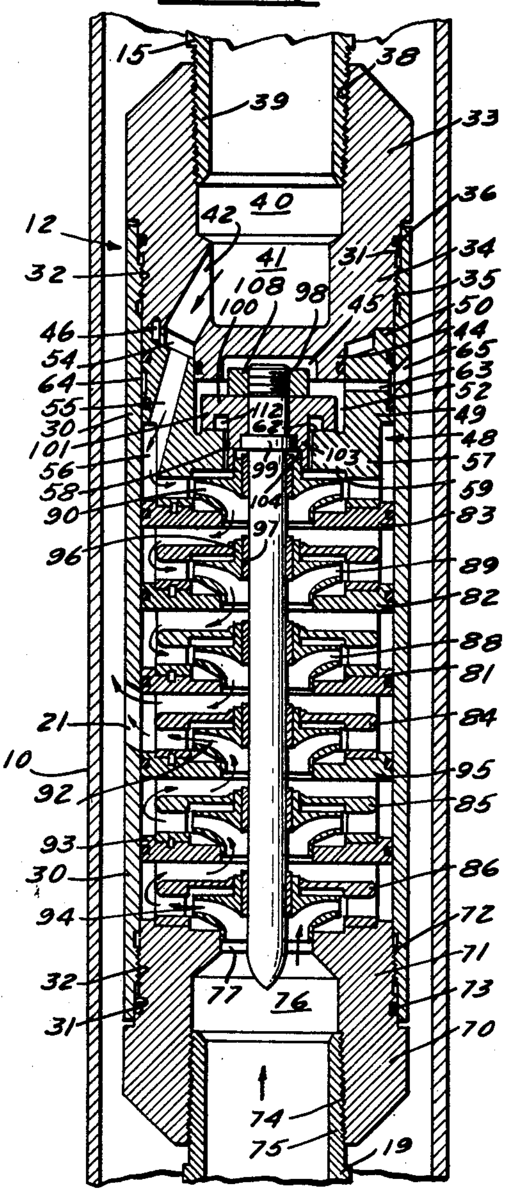


Fig. 2.



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Filed March 14, 1962 2 Sheets-Sheet 2

Fig. 3.

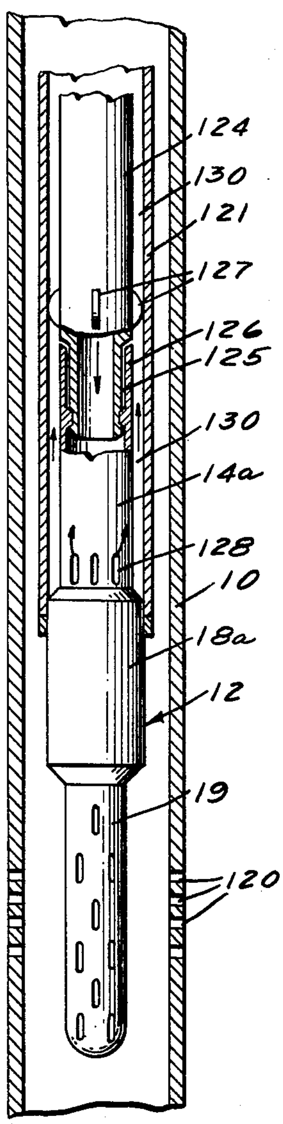
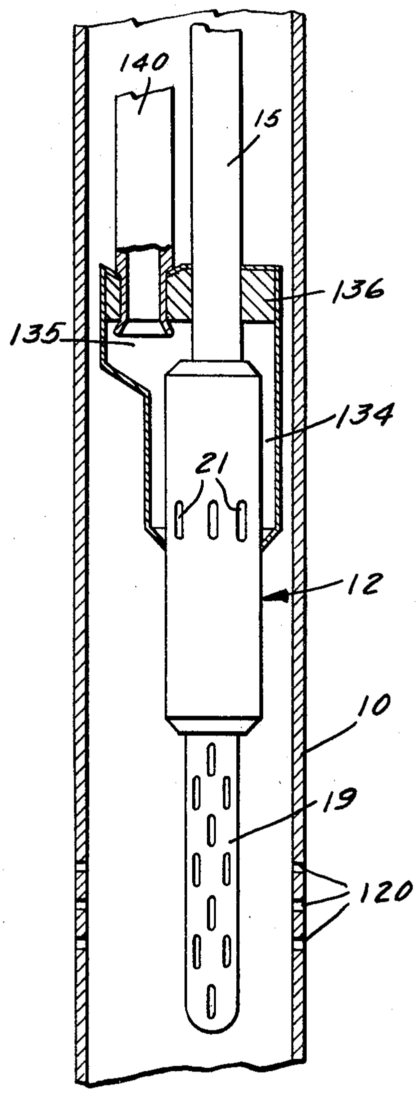


Fig. 4.



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WELL PUMP

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10 Claims. (Cl. 103—87)

This invention relates generally to fluid pumps and relates more particularly to turbo-lift pumps.

While the invention has particular utility in connection with centrifugal pumps for oil wells and the like, and is shown and described in such connection, it is to be understood that its utility is not confined thereto.

As is well known, various problems and difficulties are encountered in providing centrifugal pumps for oil wells and the like that will meet the various conditions found in such wells. For example, difficulty has been encountered in providing suitable balancing means for the turbine and pump unit and it is an object of the present invention to provide a turbo-pump having balancing means which will overcome said difficulty.

It is another object of the invention to provide balancing means for a turbo-lift pump which will operate effectively and will be free of sand or other foreign abrasive materials which have heretofore been a problem in oil well pumps.

It is still another object of the invention to provide apparatus of this character wherein the balancing system discharges into the produced stream, thereby providing increased efficiency.

A further object of the invention is to provide apparatus of this character wherein pump speed for most efficient operation may be readily provided.

It is a still further object of the invention to provide apparatus of this character wherein special lubricating means is not required.

Another object of the invention is to provide apparatus of this character which is not affected by high temperatures found in many wells.

Still another object of the invention is to provide apparatus of this character wherein the speed of the hydraulic driven unit can be varied to make the pump suit the well conditions by adjusting the drive fluid pressure and capacity.

A further object of the invention is to provide apparatus of this character wherein the unit can be adjusted to provide the most economical pumping system.

In some wells there is a considerable amount of gas produced at varying quantities and it is another object of the present invention to provide apparatus which will prevent gas locking in such wells.

Still another object of the invention is to provide apparatus of this character which does not require a special coupling between the power means or motor and the pump.

A further object of the invention is to provide apparatus of this character that is small and compact.

A still further object of the invention is to provide apparatus of this character that is relatively simple in construction.

Another object of the invention is to provide apparatus of this character that is highly efficient and reliable.

Still another object of the invention is to provide apparatus of this character that is relatively inexpensive to manufacture.

A further object of the invention is to provide apparatus of this character that has a relatively broad range of production capacities.

A still further object of the invention is to provide

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apparatus of this character that can operate at maximum efficiency regardless of changes in the liquid level in the well.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings, which represent certain embodiments. After considering these examples, skilled persons will understand that many variations may be made without departing from the principles disclosed and we contemplate the employment of any structures, elements, or modes of operation that are properly within the scope of the appended claims.

Referring to the drawings, which are for illustrative purposes only:

FIG. 1 is a diagrammatic side elevation of a turbine driven pump unit embodying the present invention installed in an oil well;

FIG. 2 is an enlarged longitudinal sectional view of the turbine driven pump unit;

FIG. 3 is a view similar to FIG. 1 but showing an alternative arrangement of the invention; and

FIG. 4 is a similar view showing still another alternative arrangement.

Referring more particularly to FIG. 1, there is diagrammatically shown oil well apparatus embodying the present invention. A casing 10 is shown installed in an oil well and at the upper end of the casing there is a well head 11. Operably disposed within the casing 10 is a turbo-pump, indicated generally at 12, which is of smaller outside diameter than the inside diameter of the casing, said turbo-pump being secured in the casing in any well known manner. The upper end portion of the turbo-pump, indicated generally at 14, is connected to a source of fluid under pressure by means of a conduit 15 which extends upwardly from the turbo-pump through the well head 11 and has a connection 16 at its upper end with a source of pressure fluid. Pressure fluid may be supplied from any suitable well known source, such as a pump, not shown.

The lower portion of the turbo-pump, indicated generally at 18, comprises the pump portion receiving fluid from the well through a strainer 19 which extends through a packer 20 which seals off the upper portion of the casing from the lower portion.

Fluid from below the packer enters the pump through the strainer and is discharged through openings 21 in the casing of the turbo-pump. The fluid from the pump follows the path indicated by the broken-line arrows 22 and when said fluid passes from said openings 21 it flows upwardly in the space between the turbo-pump and the conduit 15, thence to the well head, from which it is discharged through the conduit 24 for discharge in storage means.

Pressure fluid delivered to the conduit 15 flows down through said conduit to the turbine and drives same which, in turn, drives the pump, as will be more particularly pointed out hereinafter. The power fluid carried down through the conduit 15 to the turbine is discharged therefrom through the openings 21, the path of said power fluid is indicated by the broken-line arrows 26 and the arrows 27. This discharged fluid also flows upwardly within the casing in the space between said casing and the turbo-pump and conduit 15, said power fluid and production fluid mingling and flowing to the storage means through the conduit 24.

Referring now to FIG. 2, the turbo-pump is shown in greater detail.

Referring to FIG. 2, the turbo-pump 12 comprises a cylindrical case or housing 30 of smaller outside diameter than the inside diameter of the well casing 10. At each end the pump casing or housing 30 is provided with an enlarged diameter portion 31 which extends inwardly from the adjacent end of said housing and inwardly thereof is an internally threaded portion 32. At the upper end of said housing there is a turbine inlet head 33 having the same outside diameter as the outside diameter of the pump casing or housing 30, said turbine inlet head having a reduced diameter portion 34 having external threads 35 screwed into the adjacent internal threads 32 of the casing 30. Sealing means is provided between the reduced diameter portion 34 of the turbine inlet head and the adjacent enlarged portion of the pump casing or housing 30, said sealing means comprising an O-ring 36 disposed in an external annular groove provided therefor in said reduced diameter portion 34. It is to be understood, of course, that any other suitable sealing means may be employed.

An internally threaded bore 38 extends downwardly into the turbine inlet head 33 from its upper end for threadable reception of the externally threaded lower end 39 of the power fluid tubing 15. Below the threaded bore portion 38 there is an extension 40 of said bore below which is a reduced diameter recess 41 which has substantially the same diameter as the internal diameter of the tubing 15, there being a passage 42 which extends from the recess 41 downwardly and outwardly and opens at the lower end of said turbine inlet head.

Reduced diameter portion 35 of the turbine inlet head is provided with a downwardly extending reduced diameter portion 44 having a recess 45 in the lower end thereof and there is an annular shoulder 46 which extends inwardly from the periphery of the reduced diameter portion 34, said shoulder being normal to the axis of the turbine inlet head 33.

Below the turbine inlet head, indicated generally at 48, which includes an annular body portion or turbine inlet cover 49 fitted within the pump casing or housing 30, at its upper end, there is an upstanding peripheral flange 50, the upper end of said flange engaging the shoulder 46 of the turbine inlet head.

A cylindrical recess 52 extends downwardly from the upper end of the turbine inlet cover 49 and receives the lower end portion of the reduced diameter part 44 of the turbine inlet head, the lower end of said reduced diameter portion 44 being spaced upwardly of the bottom of said recess 52, to thereby provide a balancing fluid chamber. There is a counterbore 54 in the turbine inlet cover at the upper end of the recess 52 to provide a fluid connection between the passage 42 in the turbine inlet head and a passage 55 which extends downwardly and outwardly of the turbine inlet cover into the annular space 56 between a reduced diameter portion 57 which depends downwardly from the body portion 49 of the turbine inlet cover. An axial bore 58 extends downwardly from the chamber 52. The lower end of the reduced diameter portion 57 is provided with a shallow recess 59 in its lower end. About the bore 58 there is a raised shoulder 62, the outside diameter of said shoulder being spaced from the circumferential wall of the chamber 52, said shoulder 62 being normal to the axis of the turbo-pump mechanism.

Chamber 52 has a radially extending outlet passage 63 which terminates at its outer end in an annular external groove 64 which is in register with an outlet opening 65 in the pump casing or housings 30. Opening 65 is inclined upwardly and outwardly.

The opposite end of the pump casing or housing 30 is closed by a pump inlet head 70 which has a reduced diameter portion 71 extending into the adjacent end portion of said casing or housing 30. Reduced diameter portion 71 is provided with external threads 72 screwed into the adjacent internal threads 32 of the casing 30. Sealing means is provided between the reduced diameter portion 71 of the pump inlet head and the adjacent enlarged portion of the casing or housing 30, said sealing means comprising an O-ring 73 disposed in an external annular groove provided therefor in said reduced diameter portion 71. It is to be understood, of course, that any other suitable sealing means may be employed.

Pump inlet head 70 is provided with a threaded or tapped bore 74 which extends upwardly in said head for threadable reception of an externally threaded upward end portion or pin 75 of the strainer 19. From the bore 74 there is a bore or passage 76 having an outlet portion 77 at the upper end of said pump inlet head.

Both the turbine and the pump may have a plurality of stages, the number of stages depending on various factors of any particular installation, such as the pressure and capacity of the driving fluid, the r.p.m., and the pressure and capacity required of the pumping unit. As shown, the turbine is provided with three stages and the pump is provided with three stages.

Adjacent and upwardly of the discharge openings 21 there is an intermediate cover 81 and between said intermediate cover and the turbine inlet cover are covers 82 and 83. Below the intermediate cover 81 there is a pump discharge cover 84 and between said pump discharge cover 84 and the pump inlet head there are covers 85 and 86.

The covers have axially aligned openings therein and have chambers which house the impellers of the turbine and pump, respectively, the turbine impellers are indicated at 88, 89 and 90, respectively in the covers 81, 82 and 83, while the pump impellers are indicated at 92, 93 and 94 in the respective covers 84, 85 and 86.

The impellers are secured to a shaft 95 arranged axially of the mechanism. Each of the impellers is provided with a hub portion 96 which is received in respective openings provided therefor in the covers and said impellers are secured to the shaft in the usual well known manner by impeller locking sleeves 97.

Shaft 95 has an externally threaded upper end portion 98 and below said threaded portion 98 is an outwardly extending annular flange 99 spaced from said threaded portion 98 and receiving thereon a balancing disc or element 100, which is disposed in the balancing chamber 52, said disc being of somewhat smaller external diameter than the internal diameter of said disc and having a depending annular flange 101 which normally rests on shoulder 62 at the bottom of said chamber 52. Disc 100 also has a depending reduced diameter portion 103 which extends downwardly in the axial bore 58 of the turbine inlet cover and is provided with a recess 104 in which the hub of the impeller 90 extends. At the upper end of the recess 104 there is a recess provided for the flange 99. A lock nut 108 is screwed onto the threaded portion 98 of the shaft to secure the balancing disc on said shaft between the collar or flange 99 and said nut 108.

The impellers are all operably mounted in their respective covers and it will be noted that while said impellers are at a downward position they may move upwardly a limited amount in their respective impeller chambers, as the balancing disc moves upwardly under pressure at the under side thereof, as will be more particularly described hereinafter. It is also to be noted that the impeller covers have fluid passages therein so that power fluid may enter the covers of the turbine so as to act upon the impellers thereof and drive the shaft 95 which thereupon drives the pump impellers in the pump covers. The pump covers also have fluid passages therein for transmission of fluid actuated by the pump impellers.

When power fluid is forced down the power fluid tubing 15 it passes through the portions 40 and 41 of the turbine inlet head, through the passage 42 therein, into the annular space 54 and thence into the passage 55 in the turbine inlet cover 49. The fluid thereupon passes through the annulus 56 into the first inwardly extending vaned diffuser passages of the turbine inlet cover 49 to thereupon act upon the impeller 90 of the turbine to cause same to rotate. This power fluid then passes downwardly from the impeller into the space provided therefor in the cover 83 of the next adjacent turbine and outwardly to the annulus provided therefor as a fluid transfer portion of cover 83. From this annulus the power fluid flows inwardly through the vaned diffuser passages or openings provided therefor in the cover 83 to act upon the impeller 89. The fluid follows a similar course to the next impeller 88, and thence flows downwardly and passes from the turbine portion of the mechanism through the outlet ports 21 and thence upwardly in the annulus between the turbo-pump casing 30 and upwardly in the well in the annulus 110 between the tubing 15 and the casing 10. This fluid then passes through the well head and out the conduit 24 to a suitable storage container or the like.

Rotation of the pump impellers will draw production fluid through the strainer 19, passage 76 of the pump inlet head and outlet opening 77 into the central portion of the adjacent impeller 94. The production fluid will be forced outwardly by the impeller 94 through the outwardly extending openings provided therefor and into the diffuser annulus with which said outwardly extending openings or passages are connected. From the diffuser annulus the fluid will flow inwardly again through the passage in cover 86 into the central portion of the next impeller, 93. The fluid will then be forced outwardly by the impeller 93 and will follow a similar course to the impeller 92 which will force the production fluid outwardly again into the diffuser annulus provided therefor in the cover 84 and thence such production fluid will flow through the discharge openings 21 in the casing 30. The production fluid discharged by the impeller 92 will mingle in the adjacent annulus with the power fluid from the impeller 88 and will flow through the discharge openings 21 with such power fluid. The mixed fluid will, of course, follow the same course upwardly that has been described in connection with the flow of the power fluid to the production head and conduit 24.

Balancing of the mechanism is effected by the transmission of power fluid which enters the cover 49 through the inwardly extending ports thereof which are connected with the annulus 56, flows upwardly into the recess 59 of the turbine inlet cover and thence through the space between the portion 103 of the balance disc and adjacent surface of the opening 58 and thence into the annulus 112 in the underside of the disc 100. It is to be understood, of course, that the part 103 of the balance disc 100 has a relatively loose fit in the opening 58, so that the power fluid may pass upwardly into the annulus 112 and exert an upward force on the disc 100 to balance the downward force of the impeller mechanism. When the pressure of the power fluid in the annulus 112 exceeds the downward force of the impeller mechanism the disc 100 will be raised sufficiently to permit escape of pressure fluid in the annulus 112 into the chamber 52. The upward movement of the balance disc 100 will effect a corresponding upward movement of the shaft 95 and the impellers attached thereto and when the pressure is relieved in the annulus 112 by such upward movement the shaft and impellers will move downwardly again to the normal position. Pressure fluid that has escaped into the chamber 52 will pass outwardly through the passage 63, annulus 64 and outlet passage or port 65, into the annulus between the turbo-pump and the casing 10, and thence upwardly to the well head and conduit 24. Since the power fluid is free of foreign materials, such as would have an abrasive effect on the various parts of the mechanism, and such power fluid is used for the balancing mechanism, it will be apparent that wear on the balancing mechanism of the present invention will be at a minimum. It will also be noted that the balancing system discharges into the produced stream thereby providing for increased efficiency of the apparatus or mechanism.

Referring to FIG. 3, the casing 10 is provided with a plurality of perforations 120 through which oil will flow into the casing 10. The arrangement shown in

FIG. 3 requires no packer and the oil and the like entering the casing 10 through the openings 120 will pass through the strainer 19 and into the pump portion of the turbo-pump 12. The upper portion of the turbo-pump mechanism comprises a turbine 14*a* and the lower portion 18*a* comprises the pump. It is to be noted that the external diameter of the turbine 14*a* is smaller than the outside diameter of the pump 18*a* and there is a casing 121 which extends downwardly in the casing 10. Casing 121 is of smaller outside diameter than the inside diameter of casing 10 and the lower end of casing 121 is secured by any suitable well known means to the upper end of the pump 18*a*.

Concentrically disposed within the casing 121 is disposed tubing 124 which carries power fluid downwardly into the turbine 14*a*, the lower end of tubing 124 having a connection at 125 with the upstanding conduit 126 of the turbine 14*a*. The connection 125 may be of any suitable well known type. Tubing 124 has an outside diameter substantially smaller than the inside diameter of the casing 121 and is held in concentric position within casing 121 by arcuate flanges 127 which are annularly spaced apart on said tubing 124. With this arrangement power fluid and production fluid are mixed and discharge from the ports 128 of the turbo-pump mechanism and the mixed fluid rises to the well head in the annulus 130 between the turbine 14*a* and the tubing 124 and the casing 121, the fluid thus carried to the well head being conducted away to any suitable disposal point in the usual well known manner.

Referring to FIG. 4, the turbo-pump 12 is similar to that shown in FIGS. 1 and 2 and the discharge ports 21 discharge the mixed power fluid and production fluid into a casing 134 which is secured at its lower end to the casing of the turbo-pump. Casing 134 may be secured to the casing of the turbo-pump by welding or any other suitable means. At its upper end casing 134 is enlarged by an offset portion 135 and there is a sealing element 136 in the upper end portion of the casing, including the part 135. Power fluid is conducted downwardly through the conduit 15 to the turbine and passes through the seal 136 which provides a seal about said tubing to prevent the escape of fluid from the casing past said tubing. Communicating with the offset part 135 of the casing, there is a discharge conduit 140 having its lower end extending into the offset part 135 of said casing 134 to carry away the fluid discharged from the turbine and pump. Seal 136 also provides sealing means to prevent the escape of fluid from housing 134 past the conduit 140. In this arrangement a packer at the lower end of the turbo-pump is unnecessary, as in the case of the arrangement shown in FIG. 3.

The invention and its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the embodiments hereinbefore described being merely for purposes of illustration.

We claim:

1. Turbo-lift apparatus for installation in wells, comprising:

an elongated, hollow, cylindrical housing adapted to be lowered into a well casing;

a first inlet at the top end of said housing for introduction of power fluid thereinto;

a second inlet adjacent the bottom end of said housing for intake of production fluid thereinto;

an elongated shaft coaxially rotatably mounted in said housing;

a turbine impeller coaxially secured to an upper portion of said shaft;

a pump impeller coaxially secured to a lower portion of shaft;

means within said housing defining passages for flow of pressure fluid downwardly from said first inlet drivingly through said turbine impeller to an intermediate interior portion of said housing below said turbine impeller;

means within said casing defining passages for flow of production fluid upwardly from said second inlet through said pump impeller to said intermediate interior portion of said housing above said pump impeller;

a discharge port extending laterally directly through said housing from said intermediate interior portion of said housing to the exterior thereof;

and means for balancing axial thrust tending to displace said shaft and said impeller therein axially of said housing, including:

a cylindrical chamber coaxially positioned in the upper portion of said housing, said chamber having a lower, coaxial entrance bore in communication at its lower end with said first inlet, said entrance bore being of reduced inside diameter relative to the upper adjoining portion of said chamber, thereby forming an upwardly facing, annular chamber shoulder in said chamber surrounding said entrance bore,

a balancing member fixed coaxially on the upper portion of said shaft, said balancing member having an upper disk portion of an outside diameter greater than the inside diameter of said entrance bore, and a depending cylindrical hub portion of reduced outside diameter relative to said disk portion, thereby forming a downwardly facing annular disk shoulder at the juncture of said disk and hub portions, said disk portion being positioned coaxially in said chamber with said hub portion extending therefrom coaxially through said entrance bore, whereby the said downwardly facing annular shoulder of said disk is positioned over said upwardly facing annular chamber shoulder, the axial separation therebetween being variable in accordance with axial displacement of said balance means and said shaft relative to said chamber,

and duct means connecting the said chamber to the adjacent exterior portion of said housing, whereby power fluid may flow from said first inlet, between said shaft and said bore and through said axial separation into said chamber and thence out through said duct means, whereby the said disk portion may be subjected to fluid pressure from said first inlet with a resulting axial force thereon which varies in accordance with the said axial separation of said disk shoulder and said chamber shoulder as determined by axial displacement of said shaft from a predetermined position relative to said housing.

2. Turbo-lift apparatus for installation in wells, comprising:

an elongated, hollow, cylindrical housing of substantially uniform outside diameter adapted to be lowered into a well casing;

a first inlet at the top end of said housing for introduction of power fluid thereinto;

a second inlet adjacent the bottom end of said housing for intake of production fluid thereinto;

an elongated shaft coaxially rotatably mounted in said housing;

a plurality of turbine impellers coaxially secured to an upper portion of said shaft;

a plurality of pump impellers coaxially secured to a lower portion of said shaft;

means within said housing defining passages for flow of pressure fluid downwardly from said first inlet successively drivingly through said turbine impellers to an intermediate interior portion of said housing below said turbine impellers;

means within said casing defining passages for flow of production fluid upwardly from said second inlet successively through said pump impellers to said intermediate interior portion of said housing above said pump impellers;

a discharge port extending through said housing from said intermediate interior portion of said housing to the exterior thereof;

and means for balancing axial thrust tending to displace said shaft and said impellers thereon axially of said housing, including:

a cylindrical chamber coaxially positioned in the upper portion of said housing, said chamber having a lower, coaxial entrance bore in communication at its lower end with said first inlet, said entrance bore being of reduced inside diameter relative to the upper adjoining portion of said chamber, thereby forming an upwardly facing, annular chamber shoulder in said chamber surrounding said entrance bore,

a balancing member fixed coaxially on the upper portion of said shaft, said balancing member having an upper disk portion of an outside diameter greater than the inside diameter of said entrance bore, thereby forming a downwardly facing annular disk shoulder positioned over said upwardly facing annular chamber shoulder, the axial separation therebetween being variable in accordance with axial displacement of said balance means and said shaft relative to said chamber,

and duct means connecting the said chamber to the adjacent exterior portion of said housing, whereby power fluid may flow from said first inlet, between said shaft and said bore and through said axial separation into said chamber and thence out through said duct means, whereby the said disk portion may be subjected to fluid pressure from said fluid inlet with a resulting axial force thereon which varies in accordance with the said axial separation of said disk shoulder and said chamber shoulder as determined by axial displacement of said shaft from a predetermined position relative to said housing.

3. Turbo-lift apparatus for installation in wells, comprising:

an elongated, hollow, cylindrical housing of substantially uniform outside diameter adapted to be lowered into a well casing;

a first inlet at the top end of said housing for introduction of power fluid thereinto;

a second inlet adjacent the bottom end of said housing for intake of production fluid thereinto;

an elongated shaft coaxially rotatably mounted in said housing;

a plurality of turbine impellers coaxially secured to an upper portion of said shaft;

a plurality of pump impellers coaxially secured to a lower portion of said shaft;

means within said housing defining passages for flow of pressure fluid downwardly from said first inlet successively drivingly through said turbine impellers to an intermediate interior portion of said housing below said turbine impellers;

means within said casing defining passages for flow of production fluid upwardly from said second inlet successively through said pump impellers to said intermediate interior portion of said housing above said pump impellers;

a plurality of circumferentially spaced apart discharge ports extending through said housing from said intermediate interior portion of said housing to the exterior thereof;

and means for balancing axial thrust tending to displace said shaft and said impellers axially of said housing, including:

a cylindrical chamber coaxially positioned in the upper portion of said housing, said chamber having a lower, coaxial entrance bore in communication at its lower end with said first inlet, and through which the upper end of said shaft extends into said chamber, said bore being of reduced inside diameter relative to the adjoining upper portion of said chamber, thereby forming an upwardly facing annular chamber shoulder surrounding the said upper end of said shaft,

a disk member fixed coaxially to the upper end of said shaft within said chamber and having an outside diameter greater than the inside diameter of said entrance bore, whereby the lower marginal portion of said disk is seatable upon the said upwardly facing annular chamber shoulder and the axial separation therebetween is variable in accordance with axial displacement of said shaft relative to said housing,

and duct means connecting the said chamber to the adjacent exterior portion of said housing, whereby fluid from said first inlet may flow therefrom between the said shaft and said bore and through said axial separation into said chamber and thence out through said duct, whereby the said disk member may be subjected to fluid pressure from said first inlet with a resulting axial force thereon which varies in accordance with the said axial separation of said marginal portion of said disk and said chamber shoulder as determined by axial displacement of said shaft from a predetermined position relative to said housing.

4. Turbo-lift apparatus for installation in wells, comprising:

an elongated, hollow, cylindrical housing of substantially uniform outside diameter adapted to be lowered into a well casing;

a first inlet at the top end of said housing for introduction of power fluid thereinto;

a second inlet adjacent the bottom end of said housing for intake of production fluid thereinto;

an elongated shaft coaxially rotatably mounted in said housing;

a plurality of turbine impellers coaxially secured to an upper portion of said shaft;

a plurality of pump impellers coaxially secured to a lower portion of said shaft;

means within said housing defining passages for flow of pressure fluid downwardly from said first inlet successively drivingly through said turbine impellers to an intermediate interior portion of said housing below said turbine impellers;

means within said casing defining passages for flow of production fluid upwardly from said second inlet successively through said pump impellers to said intermediate interior portion of said housing above said pump impellers;

a plurality of circumferentially spaced apart discharge ports extending laterally directly through said housing from said intermediate interior portion of said housing to the exterior thereof;

and means for balancing axial thrust tending to displace said shaft axially of said housing, including:

a cylindrical chamber coaxially positioned in the upper portion of said housing, said chamber having a lower, coaxial entrance bore in communication at its lower end with said first inlet, and through which the upper end of said shaft extends into said chamber, said bore being of reduced inside diameter relative to the adjoining upper portion of said chamber, but of greater inside diameter than the outside diameter of said shaft, thereby forming an upwardly facing annular chamber shoulder surrounding the said upper end of said shaft and providing a clearance space between said bore and said shaft,

a disk member fixed coaxially to the upper end of said shaft within said chamber and having an outside diameter greater than the inside diameter of said entrance bore, said disk having a dependent, peripheral, annular flange, whereby the lower edge of said flange is seatable upon the said upwardly facing annular chamber shoulder and the axial separation therebetween is variable in accordance with axial displacement of said shaft relative to said housing,

and duct means connecting the said chamber to the adjacent exterior portion of said housing, whereby fluid from said first inlet may flow therefrom through said clearance space between the said shaft and said bore and through said axial separation into said chamber and thence out through said duct, whereby the said disk member may be subjected to fluid pressure from said first inlet with a resulting axial force thereon which varies in accordance with the said axial separation of said edge of said flange and said chamber shoulder as determined by axial displacement of said shaft from a predetermined position relative to said housing.

5. In turbo-lift apparatus for installation in wells, apparatus comprising:

an elongated, hollow, cylindrical housing adapted to be lowered into a well bore hole, said housing including a cylindrical case;

a first inlet head closing the top end of said case and having a first coaxial inlet at the top thereof for introduction of power fluid thereinto;

a second head closing the bottom end of said case;

said case intermediate said inlet heads being of substantially uniform inside diameter;

a plurality of separate generally cylindrically shaped turbine cover assemblies axially slidably assembled in coaxially superimposed relation within said case, each of said cover assemblies having at one end thereof an annular base portion with a coaxially central impeller discharge opening therein for receiving fluid discharged axially from an adjacent impeller, at the other end an annular diffuser portion surrounding and forming a coaxial, generally cylindrical impeller chamber, and axially intermediate said base portion and diffuser portion an annular separator forming a radial passage portion interconnecting said impeller discharge opening and said diffuser portion;

an elongated shaft extending coaxially through said cover assemblies;

an impeller rotatably fixed to said shaft in each of said impeller chambers and formed to receive fluid inwardly from the diffuser portion thereof and to discharge same axially through the impeller discharge opening of an adjacent base portion;

means within said first inlet head for conducting power fluid from said first inlet to the diffuser portion of the uppermost one of said cover assemblies;

and a discharge port extending laterally through an intermediate portion of said case communicating with the discharge opening of the base portion of one of said cover assemblies.

6. In turbo-lift apparatus for installation in wells, apparatus comprising:

an elongated, hollow, cylindrical housing adapted to be lowered into a well bore hole, said housing including a cylindrical case;

a first inlet head closing the top end of said case and having a first coaxial inlet at the top thereof for introduction of power fluid thereinto;

a second inlet head closing the bottom end of said case and having a second coaxial inlet at the bottom thereof for intake of production fluid thereinto, said case intermediate said inlet heads being of substantially uniform inside diameter;

a plurality of separate, generally annular shaped turbine cover assemblies axially slidably assembled in coaxially superimposed relation within the upper portion of said case, each of said cover assemblies having formed therein a coaxial, generally cylindrical turbine impeller chamber;

a plurality of generally annular shaped centrifugal pump cover assemblies axially slidably assembled in coaxially superimposed relation within the lower portion of said case, each of said cover assemblies having formed therein a coaxial, generally, cylindrical pump impeller chamber;

an elongated shaft extending coaxially through said turbine and pump cover assemblies;

a plurality of turbine impellers rotatably fixed to said shaft, one of each in each of said turbine impeller chambers;

a plurality of pump impellers rotatably fixed to said shaft, one of each in each of said pump impeller chambers;

means within the said first inlet head for conducting power fluid from said first inlet to the uppermost one of said turbine cover assemblies and thence successively drivingly through said turbine cover assemblies and said turbine impellers therein;

means within the said second inlet head for conducting production fluid from said second inlet to the lowermost one of said pump cover assemblies and thence successively pumpingly through said pump cover assemblies and said pump impellers therein;

and a discharge port extending laterally through an intermediate portion of said case communicating with the discharge of the lowermost one of said turbine cover assemblies and with the uppermost one of said pump cover assemblies.

7. In turbo-lift apparatus for installation in wells, apparatus according to claim 6 in which annular fluid seal means is provided encircling each of said turbine cover assemblies and pump cover assemblies in axially slidable sealing engagement with the inside surface of said cylindrical case.

8. In turbo-lift apparatus for installation in wells, apparatus comprising:

an elongated, hollow, cylindrical housing adapted to be lowered into a well bore hole, said housing including a cylindrical case;

a first inlet head closing the top end of said case and having a first coaxial inlet at the top thereof for introduction of power fluid thereinto;

a second inlet head closing the bottom end of said case and having a second coaxial inlet at the bottom thereof for intake of production fluid thereinto, said case intermediate said inlet heads being of substantially uniform inside diameter;

a plurality of separate, generally annular shaped turbine cover assemblies axially slidably assembled in coaxially superimposed relation within the upper portion of said case, each of said cover assemblies having formed therein a coaxial, generally cylindrical turbine impeller chamber;

a plurality of generally annular shaped centrifugal pump cover assemblies axially slidably assembled in coaxially superimposed relation within the lower portion of said case, each of said cover assemblies having formed therein a coaxial, generally cylindrical pump impeller chamber;

said turbine cover assemblies and said pump cover assemblies being clamped in said coaxially superimposed relation within said case by and between said first inlet head and said second inlet head;

an elongated shaft extending coaxially through said turbine and pump cover assemblies;

a plurality of turbine impellers rotatably fixed to said shaft, one of each in each of said turbine impeller chambers;

a plurality of pump impellers rotatably fixed to said shaft, one of each in each of said pump impeller chambers;

means within the said first inlet head for conducting power fluid from said first inlet to the uppermost one of said turbine cover assemblies and thence successively drivingly through said turbine cover assemblies and said turbine impellers therein;

means within the said second inlet head for conducting production fluid from said second inlet to the lowermost one of said pump cover assemblies and thence successively pumpingly through said pump cover assemblies and said pump impellers therein;

and a discharge port extending laterally through an intermediate portion of said case communicating with the discharge of the lowermost one of said turbine cover assemblies and with the uppermost one of said pump cover assemblies.

9. In turbo-lift apparatus for installation in wells, apparatus comprising:

an elongated, hollow, cylindrical housing adapted to be lowered into a well bore hole, said housing including a cylindrical case;

a first inlet head closing the top end of said case and having a first coaxial inlet at the top thereof for introduction of power fluid thereinto;

a second inlet head closing the bottom end of said case and having a second coaxial inlet at the bottom thereof intake of production fluid thereinto, said case intermediate said inlet heads being of substantially uniform inside diameter;

a plurality of separate, generally cylindrically shaped turbine cover assemblies axially slidably assembled in coaxially, end to end, superimposed relation within the upper portion of said case, each of said cover assemblies having at one end thereof an annular base portion with a coaxially central discharge opening therein for receiving fluid discharged axially from an adjacent impeller, at the other end an annular diffuser portion surrounding and forming a coaxial generally cylindrical turbine impeller chamber, and axially intermediate said base portion and diffuser portion an annular separator forming a radial passage portion interconnecting said central discharge opening and said diffuser portion;

a plurality of generally cylindrically shaped centrifugal pump cover assemblies axially slidably assembled in coaxially, end to end, superimposed relation within the lower portion of said case, each of said cover assemblies having at one end thereof an annular base portion with a coaxially central inlet opening therein for receiving fluid axially into an adjacent impeller, at the other end an annular diffuser portion surrounding and forming a coaxial generally cylindrical pump impeller chamber and for receiving fluid discharged radially from an impeller therein, and axially intermediate said cover portion and diffuser portion an annular separator forming a radial passage portion interconnecting said inlet opening and said diffuser portion;

an elongated shaft extending coaxially through said turbine and pump cover assemblies;

an impeller rotatably fixed to said shaft in each of said turbine impeller chambers and formed to receive fluid radially inwardly from its respective diffuser portion and to discharge same axially through the central discharge opening of an adjacent base portion;

an impeller rotatably fixed to said shaft is each of said pump impeller chambers and formed to receive fluid axially from the central inlet opening of an adjacent cover assembly and to discharge same radially through the diffuser portion of its impeller chamber;

means within the said first inlet head for conducting power fluid from said first inlet to the diffuser portion of an upper one of said turbine stator assemblies;

means within the said second inlet head for conducting production fluid from said second inlet to the inlet opening of a lower one of said pump cover assemblies;

and a discharge port extending laterally directly through an intermediate portion of said case communicating with the discharge opening of the base portion of one of the turbine cover assemblies and with the diffuser portion of one of the pump cover assemblies.

10. In turbo-lift apparatus for installation in wells, apparatus according to claim 8 in which annular fluid seal means is provided encircling each of said turbine cover assemblies and said pump cover assemblies in axially slidable sealing engagement with the inside surface of said cylindrical case.

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