May 26, 1959 J. F. DI STEFANO 2,887,959

SUBMERGED BOOSTER PUMP

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Fig. 1

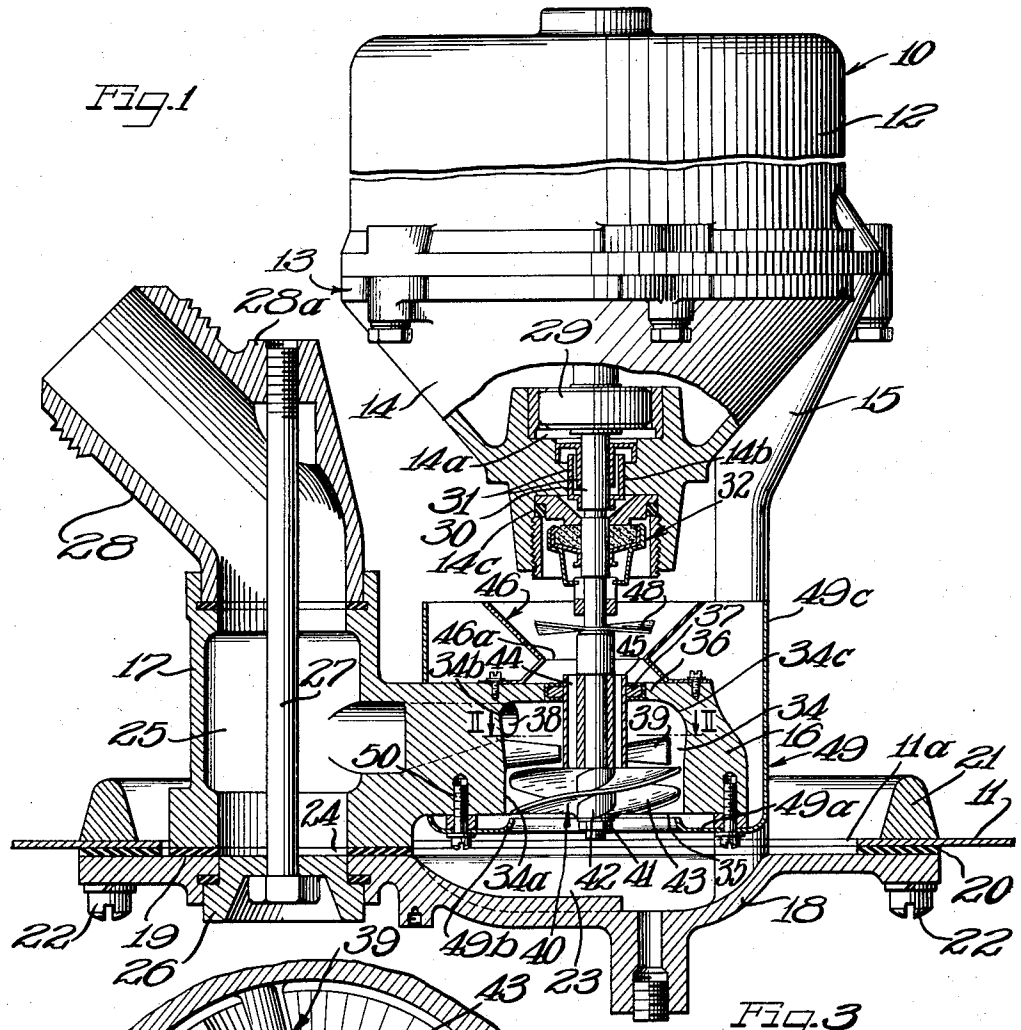
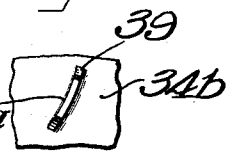


Fig. 3



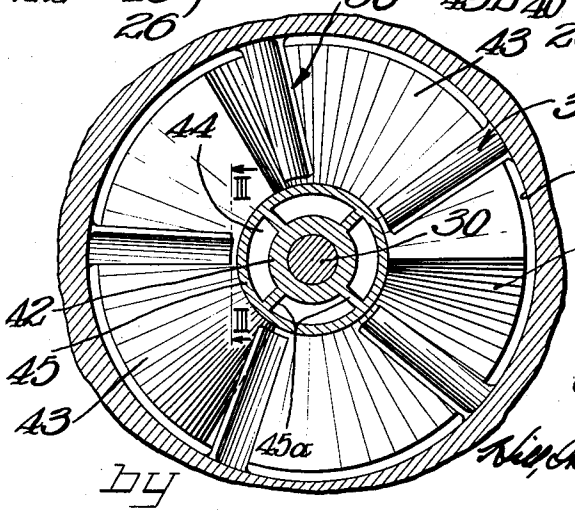


Fig. 2

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Fig. 4

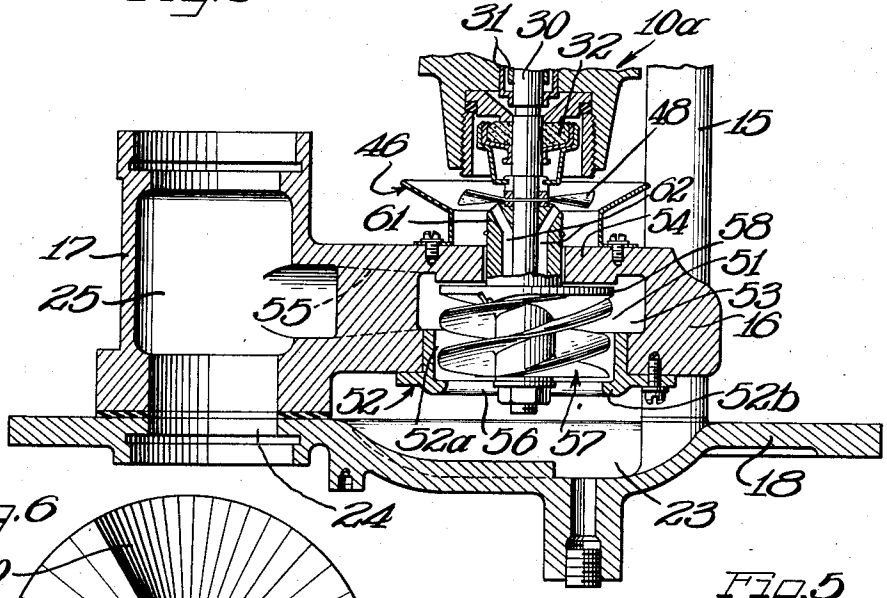


Fig. 6

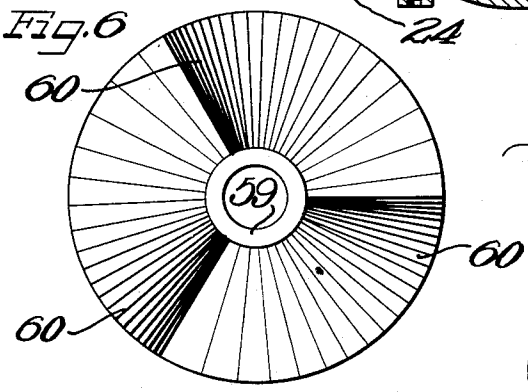


Fig. 5

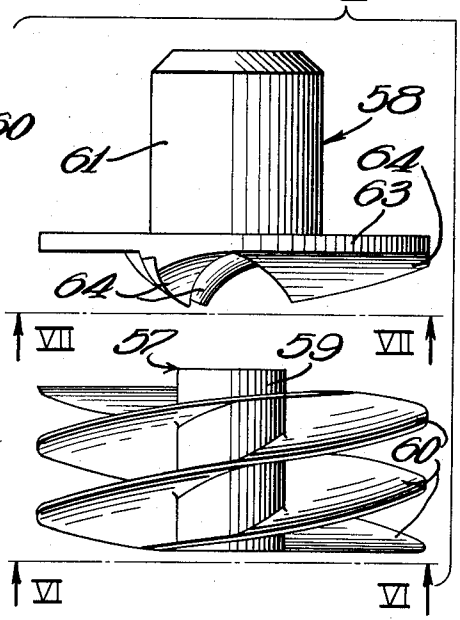
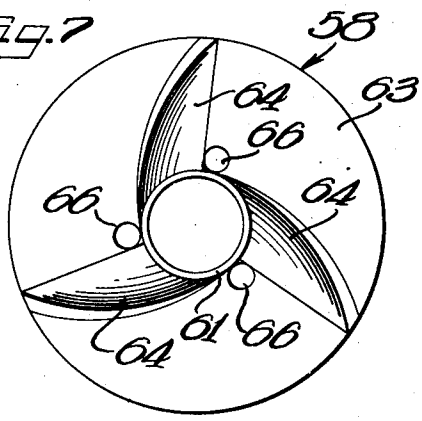


Fig. 7



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SUBMERGED BOOSTER PUMP

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8 Claims. (Cl. 103—113)

This invention relates to a vapor separating helicoidal pump. Specifically, the invention deals with a submerged pump and motor unit, especially useful for aircraft fuel systems, and having a helicoidal impeller together with an axial flow inducer for removing vapors from the helicoidal impeller.

This invention will be hereinafter specifically described as embodied in an electric motor and booster pump unit for submerged mounting in aircraft fuel cells, but it should be understood that the principles of this invention are generally applicable to vapor separating pumps, and therefore the invention is not to be limited to the hereinafter described preferred embodiment.

According to this invention, a pump body having an electric motor mounted thereon is equipped with a mounting plate for attachment to the wall of an aircraft fuel cell to support the pump body and motor in submerged relation with gasoline or other fuel in the cell. The pump body has a bottom inlet receiving the gasoline from a sump provided by the mounting plate. This inlet feeds the gasoline to an impeller chamber. An impeller in the form of a multi-helix is disposed in this chamber and mounted on a shaft depending from the motor. The chamber has a peripheral outlet communicating with an upstanding discharge head that selectively receives a conduit nipple or closure cap on either open end thereof for supplying fluid to a fuel tube either on the inside of the tank or on the outside of the tank. The impeller is effective to separate vapors from liquids in the impeller chamber under the influence of centrifugal force while advancing the liquids from the inlet toward the outlet. The lighter gas rich material collects near the axis of the impeller and is vented through the impeller hub to a space in the fuel cell between the motor and the pump body. An axial flow inducing propeller is mounted on the motor shaft in this space for inducing flow of the vapor laden liquid through the vent, thereby preventing the pump from becoming gas bound. In one form of the invention, the helical blades of the impeller discharge the liquid into a diffuser cone provided in the pump body. This cone is designed for conversion of velocity head into pressure head and is equipped with a series of peripherally spaced vanes for receiving the liquid from the paths between the helix blades. In another form of the invention, the paths between the helix blades are intersected by radial impeller blades for centrifugally discharging the liquid into a volute chamber surrounding a portion of the impeller chamber.

A feature of this invention, therefore, resides in the provision of a helicoidal pump with an axial flow inducing vapor removal attachment.

Another feature of the invention resides in the provision of a helicoidal pump with a diffuser cone adjacent the helicoidal impeller for converting the velocity head of fluid discharged from the impeller into a pressure head.

Another feature of the invention is the utilization of a single motor shaft to drive a helicoidal impeller and a vapor removing propeller.

It is, then, an object of this invention to provide a

helicoidal pump with an axial flow inducing vapor removing attachment.

Another object of the invention is to provide a helicoidal pump with a diffuser cone to convert the velocity head of fluid discharged from the helicoidal impeller into a pressure head.

A still further object of the invention is to provide a vapor separating helicoidal pump with flow passages vented to the outside of the pump body and with a propeller for inducing flow through these passages to release vapors from the pump body.

A specific object of the invention is to provide a pump body with a bottom inlet and a sealed end opposing the inlet receiving a passaged impeller hub in rotatable sealing relation for removal of vapors through the hub without release of liquids from the pump body.

Other and further objects of this invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred examples only, illustrate two embodiments of the invention.

On the drawings:

Figure 1 is a side elevational view, with parts broken away and shown in vertical cross section, of a booster pump assembly of this invention mounted in a tank such as an aircraft fuel cell.

Figure 2 is an enlarged transverse cross-sectional view, with parts in top plan, taken along the line II—II of Figure 1.

Figure 3 is a fragmentary end view of one of the diffuser vanes taken along the line III—III of Figure 2.

Figure 4 is a fragmentary view similar to Figure 1 but illustrating another embodiment of this invention.

Figure 5 is an exploded elevational view of the two stage impeller unit in the pump of Figure 4.

Figure 6 is an end view of the first impeller stage taken along the line VI—VI of Figure 5.

Figure 7 is an end view of the second impeller stage taken along the line VII—VII of Figure 5.

As shown on the drawings:

In Figure 1, the pump and motor unit **10** is illustrated as mounted in a fuel cell **11** in alignment with an opening **11***a* in the bottom wall of the cell. The unit **10** includes an electric motor **12** mounted on top of a casing or housing **13** which has a conical head portion **14** for receiving the bottom of the motor. Depending posts, such as **15**, support an annular pump body or casing **16** in spaced relation beneath the conical head **14**.

The pump body **16** is formed with an integral upstanding discharge head or socket **17**. The bottoms of the posts such as **15**, the pump body **16**, and the socket **17** terminate in flush relationship and a base plate **18** is positioned against the under side of the bottom wall of the fuel cell spanning the opening **11***a* thereof to support the entire assembly of the casing **13** and motor **12**. A gasket **19** is interposed between the base plate **18** and the casing part **16** and a second gasket **20** is interposed between the peripheral portion of the base plate and the bottom wall of the fuel cell.

A mounting ring **21** is positioned against the upper side of the bottom wall of the fuel cell around the opening **11***a* thereof and cap screws **22** extending through the periphery of the base plate **18** and through the bottom wall of the fuel cell are secured in the mounting ring to attach the base plate rigidly to the fuel cell. Means (not shown) are also provided for securing the casing **13** to the base plate.

The base plate **18** provides a sump **23** in free open communication with fuel in the cell **11** to receive the fuel therefrom. An opening **24** is provided in the base **18** in alignment with a passage **25** through the discharge socket

17 of the body 16. A cap 26 is held in seated relation, closing this opening, by means of an elongated bolt 27 which extends through the passage 25 and is threaded into a boss portion 28a of a nipple 28 on the top of the socket so that a single bolt serves to hold the cap and nipple on opposite ends of the socket 17. The cap and nipple can be reversed if desired.

The head 14 of the casing 13 contains a well 14a supporting a bearing 29 for the motor armature shaft 30. A pair of flame trap sleeves 31 surround this shaft 30 beneath the bearing 29 and are disposed in a passage 14b provided beneath the bottom of the well 14a. This passage communicates with an open bottom counterbore or well 14c receiving a seal assembly 32 therein. The seal assembly includes a stationary seal ring mounted in the counterbore 14c and a rotating seal ring mounted on the shaft 30 in rotating sealing contact with the stationary ring.

The pump body 16 has a chamber 34 therein with an open bottom end 35 and an apertured top wall 36 receiving a seal 37 in the aperture thereof. The chamber 34 has a cylindrical wall portion 34a extending upwardly from the open bottom 35 thereof to a slightly tapered conical chamber 34b which extends upwardly and is connected to the top wall 36 through a rounded corner 34c. A passage 38 connects the upper end of the conical chamber with the passage 25 in the socket 17. As shown, the passage 38 extends through the rounded corner 34c.

Diffuser vanes 39 project inwardly into the chamber 34 from the lower end of the conical wall 34b. As shown in Figure 2, five diffuser vanes are provided in equally spaced relation around the wall 34b. The vanes project radially inward but terminate in spaced relation outwardly from the axis of the chamber. Each blade 39, as shown in Figure 3, converges slightly from its root to its free inner end and is slightly inclined and curved to provide a concave front face 39a for a purpose to be hereinafter described.

A helicoidal impeller 40 is mounted on the lower end of the shaft 30 and held thereon by a nut 41 threaded on the shaft. The impeller has a hub 42 from which radiate a plurality of helix vanes or screw blades 43. Preferably three blades 43 are provided. Each blade is in spaced generally parallel relation with the adjacent blade to cooperate therewith for providing helical flow paths for fluid from the inlet 35. The blades have relatively flat leading ends to slice off the fluid in the opening 35 for gradually accelerating it in an axial direction to the upper end of the impeller where the fluid is discharged against the faces 39a of the blades 39. These blades 39 diffuse the liquid into the conical portion 34b at the upper end of the chamber 34. This conical portion is designed for converting the velocity head of liquid into a pressure head, whereupon the liquid under pressure is discharged through the tangential outlet 38 into the passage 25.

Rotation of the impeller 40 at relatively high speed serves to separate gases and vapors from the liquid. The heavy fully liquid material is thrown by centrifugal action to the radial outer portions of the paths between the helix blades 43 while the lighter gas fluid hugs the hub portion of the impeller. A passage 44 is provided between the hub 42 and a tube 45 connected therewith by a spider 45a and surrounding the upper portion of the hub to project through the seal 37 in sealing engagement therewith. This passage 44 communicates at its lower end with the discharge ends of the paths between the helix blades 43 and communicates at its upper end with the outside of the pump body.

A deflector member 46 is mounted on top of the pump body 16 and has a restricted throat 46a immediately adjacent the top end of the passage 44. The deflector diverges from this throat 46a and has an open top communicating freely with the fuel cell.

A propeller 48 is secured on the shaft 30 for rotation

therewith. The propeller 48 is positioned slightly above the throat 46a in the deflector 46 and is designed for creating an upward axial flow through the deflector. The impeller is thereby effective to axially draw the gas rich fluids out of the open top of the passage 44 for preventing the pump from becoming gas bound.

The helix blades 43 are of smaller diameter than the cylindrical bore or chamber portion 34a of the chamber 34, so that a gap is provided between the chamber wall 34a and the periphery of the helix blades. These helix blades are designed so as to deliver more fluid to the diffuser chamber than can be handled by the pump, so that a recirculation of fluid occurs within the helix paths between the blades. This recirculation is radially outward from the hub portion of the paths to the gap between the impeller and the chamber. The recirculation assists in the removal of the lighter gas rich fluids from the impeller paths and these fluids will discharge through the peripheral portion of the inlet 35 into the bottom of a deflector 49 having a bottom wall 49a spaced beneath the body 16 and supported from the body by means of cap screws 50. The bottom 49a is apertured to provide an opening aligned with the opening 35. An upturned lip 49b surrounds the aperture and projects slightly beyond the periphery of the opening 35 so as to provide an entrance gap to the bottom of the deflector. The deflector has a side wall 49c of generally cylindrical shape extending to a level substantially flush with the top of the deflector 46. The cup deflector 49 is effective to receive and direct the gas rich fluid away from the opening 35 to the pump for discharging the fluid back to the fuel cell at a level above the inlet of the pump, whereupon the bubbles in the fluid can rise to the surface of the liquid in the tank to burst at the surface and release the entrapped or entrained gases and vapors.

From the above descriptions of the pump and motor unit 10 it should be understood that the pump receives liquid through a bottom inlet, accelerates this liquid through helical flow paths of the impeller while separating gases and vapors from the liquid. The liquid material is diffused into a chamber and is discharged from this chamber under pressure. The gases and vapors separated by the impeller are drawn out of the top of the pump body under the influence of an axial flow propeller. Other gases and vapors are discharged back through the open bottom of the pump body through the recirculating action obtained by the overcapacity design of the screw vanes or helicoidal impellers.

The modified pump and motor unit 10a of Figure 4 is substantially identical with the pump and motor unit 10 of Figure 1, and, therefore, the same reference numerals have been used to designate identical or substantially identical parts of the two pumps. In the unit 10a, however, the pump body has an open bottomed chamber 51 equipped with an inlet throat ring 52 in the bottom open end thereof and having a surrounding volute chamber 53 around the upper end thereof. An apertured top wall 54 overlies the chamber 51 and a passage 55 connects the periphery of the volute 53 with the passage 25 of the socket 17.

The throat ring 52 has a cylindrical open top bore 52a and an inturned flange or lip 52b at the lower end thereof defining a restricted opening 56 to the chamber 51.

The two-stage impeller assembly is mounted in the chamber 51 on the shaft 30 and includes a three-vane helix portion 57 and a three-blade radial portion 58. The helical portion 57 as best shown in Figure 5 includes a hub 59 and three screw vanes 60. These screw vanes define helical paths therebetween and have relatively flat leading edges all terminating in a single horizontal plane and relatively flat top edges all terminating in a second horizontal plane spaced axially above the first plane. The lower portions of the vanes or blades 60 have relatively close running clearance relationship with the bore 52a of the throat ring 52 and the lip 52b of

the throat ring underlies the leading edges of these blades in relatively close running clearance relation so that the recirculation out of the inlet of the pump as described in connection with the unit **10**, does not take place in the unit **10***a*.

The upper portions of the blades **60** project above the top of the throat ring in opposed relation with the volute chamber **53**.

The radial stage **58** of the impeller assembly includes a hub **61** of larger diameter than the hub **59** and equipped with passages **62** therethrough as best shown in Figure 4. This hub **61** projects through the aperture in the top wall **54** of the pump body **16** and terminates immediately below the propeller **48** so that the passages **62** are under the influence of the axial pull from the propeller.

As best shown in Figures 5 and 7, the radial stage **58** of the impeller assembly has a flat radially extending flange **63** on the bottom end of the hub **61**. Three radical vanes **64** depend from the bottom face of this flange in equal spaced relationship around the hub. Each vane **64** is adapted to project into the end of a path between the helix blades **60** as best shown in Figure 4, so that the blades receive the fluid from the upper ends of the helix paths to radially discharge fluid into the volute or pumping chamber **53**. The flange **63** is perforated as at **66** to release the gaseous rich fluid collecting around the hub **59** of the impeller **57** to the passages **62**.

The unit **10***a* of Figure 4 operates under the influence of the two-stage impeller assembly to axially advance liquid from the inlet **56** to the vanes **64** which centrifugally discharge the liquid to the polute **53**. High speed operation of the impeller produces a gas-liquid separating effect on the fuel being pumped with the heavier fully liquid material being thrown centrifugally into the pumping chamber, and with the lighter gaseous rich material collecting around the central portion of the hub. This light separated fraction is removed through the upper end of the pump under the influence of the propeller **48** so that the gases and vapors are discharged back to the fuel cell and do not collect in the pump body where they would eventually cause the pump to become gas bound. The pump unit **10***a* therefore has the same type of vapor removal attachment as the pump **10**, but is equipped with a two stage helicoidal and radial impeller.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A submerged pump and motor unit comprising a base, a pump body on said base having an inlet and an outlet, a motor unit spaced above said pump body, said pump body having an open bottomed chamber facing the base forming said inlet to receive liquid from between said pump body and said base, a motor shaft extending outwardly from said motor between said motor unit and said body and into said pump body, a multi-vane helicoidal pump impeller on said shaft inside of said pump body having screw blades for advancing liquid from said inlet axially into said pump body and to said outlet, a propeller on said motor shaft in the space between said motor and pump bodies, means providing a vent passage extending from a central portion of said pump body at the discharge end of said screw blades to a point adjacent said propeller, an annular deflector on said pump body surrounding said propeller and having a diverging discharge mouth for directing flow of fluids acted upon by said propeller upwardly toward said motor body, a deflector cup surrounding said pump body having a bottom wall underlying a portion of said open bottomed chamber, said bottom wall having an aperture formed therein aligned with said inlet, said deflector cup having a generally cylindrical side wall extending to the level of said deflector to receive and direct the gaseous rich material from the peripheral portion of the pump body away from the pump inlet.

2. A vapor separating pump which comprises a pump body having an impeller chamber formed therein with an open bottomed end providing a pump inlet and a tapered conical chamber communicating with the upper portion of the impeller chamber, radial diffuser vanes in said conical chamber projecting inwardly from the side wall thereof into spaced relation from the central portion of said chamber, a multi-vane helicoidal impeller rotatably mounted in said impeller chamber, hub means on said impeller projecting through said conical chamber and having passage means formed therein to vent the upper end of said impeller chamber with the outside of the pump body, and a peripheral outlet formed in said pump body communicating with the upper end of the conical chamber, said impeller advancing liquids to said diffuser vanes, said diffuser vanes converting the velocity head of said liquids into a pressure head, and said hub means relieving gases and vapors from the central portion of the impeller to prevent the pump from becoming gas-bound.

3. A vapor separating pump which comprises a pump body having an impeller chamber formed therein with an open bottomed end providing a pump inlet, a multi-vane helicoidal impeller rotatably mounted in said impeller chamber, hub means secured to said helicoidal impeller projecting through an upper portion of said impeller chamber, said helicoidal impeller having screw blades with flat leading ends at said pump inlet to slice off fluid at the open bottomed end of said impeller chamber, said screw blades being of larger circumferential diameter than said hub means and together forming helical paths therebetween extending upwardly from said leading ends of said screw blades toward said hub means, means for discharging the fluid accelerated axially upwardly by said screw blades radially outwardly from the upper portions of said impeller chamber, an inducer propeller outside of said hub means and co-rotatable with said impeller, and means including said hub means forming axial passages extending from the upper portion of said helical paths upwardly to confine and direct vapor-rich fluid centrally of said inducer propeller and to be discharged radially thereof.

4. A vapor-separating pump as defined in claim 3, said means for discharging the fluid radially outwardly from the upper portion of said impeller chamber comprising a radial impeller co-rotatable with said helicoidal impeller and including a radially extending body portion having depending radial pumping vanes with said screw blades extending into the spaces between said radial pumping vanes.

5. A vapor-separating pump as defined in claim 3, said means for discharging the fluid radially outwardly from the upper portion of said impeller chamber including a radially extending flange having radial pumping vanes depending from one face thereof and being co-rotatable with said helicoidal impeller, said screw blades extending into the spaces between the radial pumping vanes, and said means including said hub means forming axial passages more particularly including vapor escape ports formed in said flange to provide a portion of said axial passages.

6. A vapor-separating pump as defined in claim 3, said means including said hub means forming axial passages comprising a sleeve-like deflector having an open top above the level of said inducer propeller.

7. A vapor-separating pump as defined in claim 3 and an electric motor body connected to said pump body, an electric motor in said motor body having a shaft extending outwardly therefrom and being connected in driving relation with said impeller.

8. A vapor-separating pump as defined in claim 3, said means for discharging fluid accelerated axially upwardly comprising radial diffuser vanes projecting inwardly from a side wall of said impeller chamber.

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