Jan. 25, 1966 HIDEKUNI YOKOTA ETAL 3,230,890

CENTRIFUGAL PUMP

Filed Nov. 15, 1963 3 Sheets-Sheet 1

FIG. 1

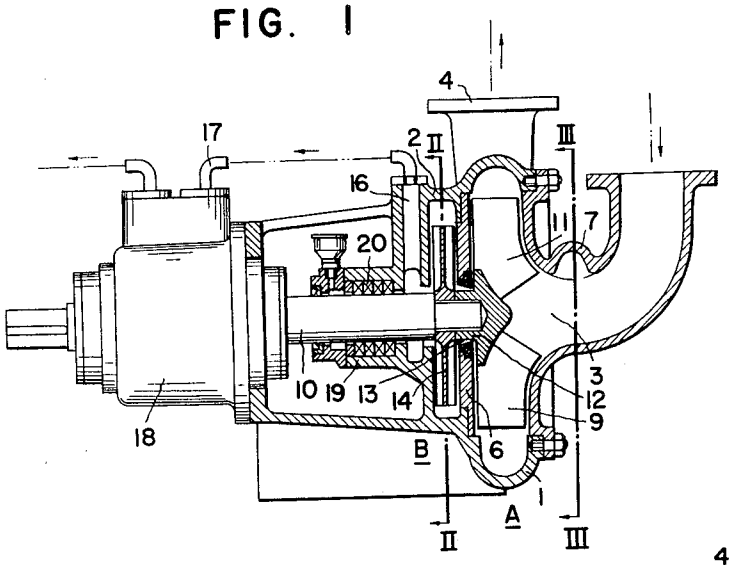


FIG. 2

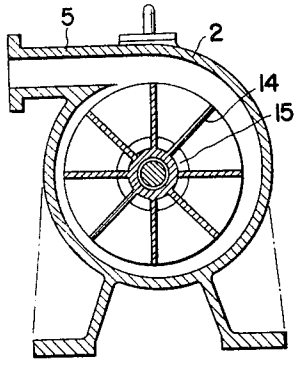


FIG. 3

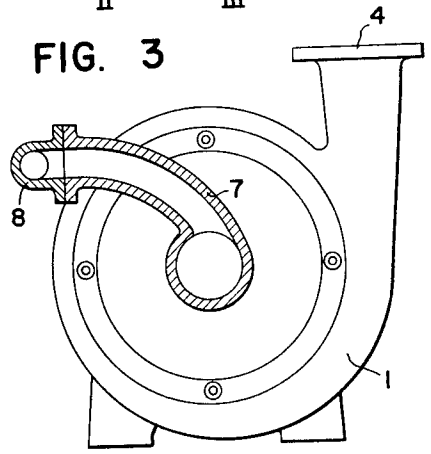


FIG. 4

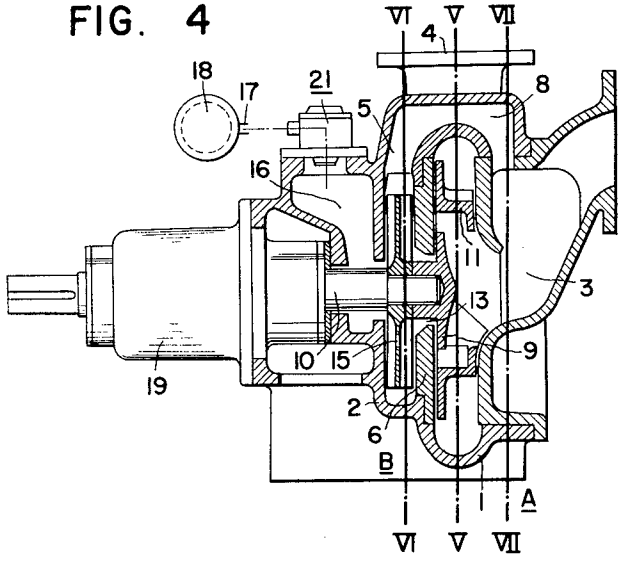
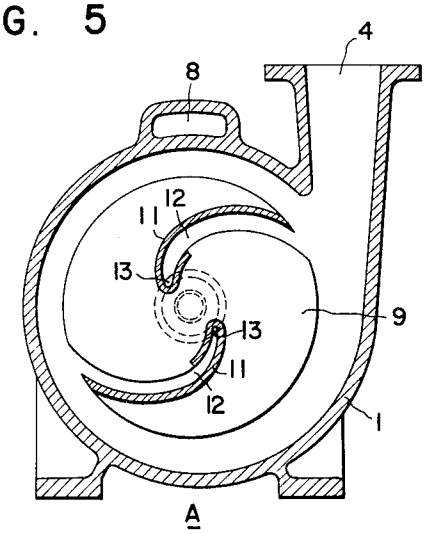

VI
V
VII
4
18
17
21
5
8
16
11
3
13
9
10
15
19
2
6
B
A
VI
V
VII

FIG. 5


4
8
12
11
13
9
13
11
12
1
A

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CENTRIFUGAL PUMP

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FIG. 6

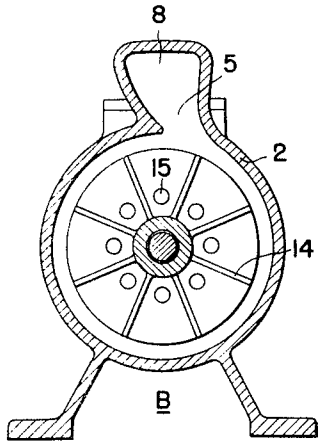


FIG. 8

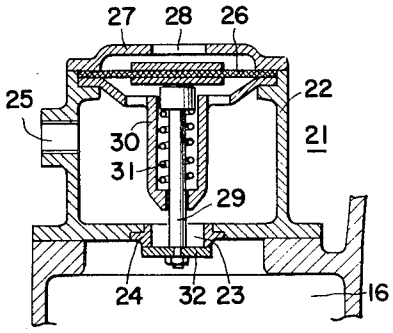
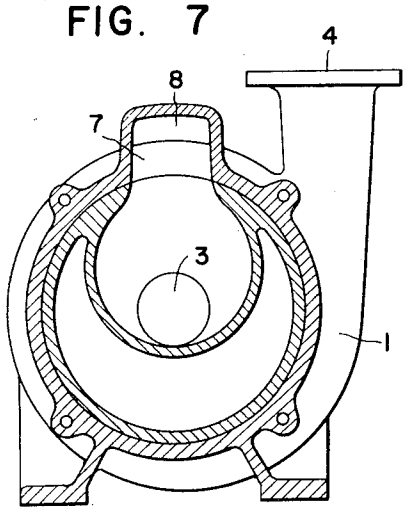


FIG. 7



United States Patent Office 3,230,890 Patented Jan. 25, 1966

3,230,890

CENTRIFUGAL PUMP

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Filed Nov. 15, 1963, Ser. No. 324,065
Claims priority, application Japan, Nov. 20, 1962, 37/52,259; Mar. 23, 1963, 38/15,229
2 Claims. (Cl. 103—113)

This invention relates to centrifugal pumps and more particularly to a new centrifugal pump suitable for pumping high-viscosity, mud-like fluids containing large amounts of bubbles.

The pumping of high-viscosity, mud-like fluids containing large amounts of bubbles by means of centrifugal pumps is generally considered to be extremely difficult. At the same time, there is a great demand for a simple, safe, and reliable means for pumping such muddy fluids containing additional foreign solid matter.

It has been found that the reason for this difficulty of conventional centrifugal pumps to be immediately used for above mentioned purpose even when combined with vacuum pumps is that air cavities formed near the central portion of the impeller due to centrifugal separations are not easily replaced by the fluid of the nature above mentioned.

The principal object of this invention is to provide a centrifugal pump adapted for use in pumping bubble-containing mud-like fluids of high viscosity.

Another object of this invention is to provide a centrifugal pump in which air cavities formed in the working chamber thereof are effectively removed.

A further object of this invention is to provide a centrifugal pump combined with a vacuum creating means wherein the ingress of the fluid into the vacuum creating means is effectively prevented.

According to the present invention, there is provided a centrifugal pump (referred to hereinafter as the "main pump") adapted for pumping of the above mentioned muddy fluid, and in side-by-side relation to the main pump is arranged another centrifugal pump (referred to hereinafter as the "auxiliary pump") for drawing air cavities in the main pump. The auxiliary pump is, through the suction inlet thereof, in communication with the central area of the main pump chamber and is, through the discharge outlet thereof, in communication with the suction inlet of the main pump. The central area of the auxiliary pump chamber is in communication with a suitable vacuum creating means through a suction passage, so that air cavities in the main pump chamber will be drawn into and forced through the auxiliary pump chamber to the vacuum creating means in order to ensure a continuous fluid flow through the main pump chamber.

According to another object of this invention, there is provided a valve means between the auxiliary pump and the vacuum creating means, which valve means is constructed so as to open the suction passage from the auxiliary pump to the vacuum creating means when the vacuum creating means is operative and to close the same when the vacuum creating means is inoperative, thus preventing ingress of fluid to the vacuum creating means.

The nature, principles, and details of the invention, as well as other objects and features thereof, will be more clearly apparent from the following description taken in connection with the accompanying drawings in which like parts are designated by like reference characters, and in which:

FIG. 1 is a side elevational view, partly in vertical section, showing a prefered embodiment of the centrifugal pump of this invention;

FIG. 2 is a section taken along the line II—II of FIG. 1, the view looking in the direction of the arrows;

FIG. 3 is a section taken along the line III—III of FIG. 1, the view looking in the direction of the arrows;

FIG. 4 is a side elevational view, partly in vertical section, showing a modified centrifugal pump according to this invention;

FIG. 5 is a section taken along the line V—V of FIG. 4, the view looking in the direction of the arrows;

FIG. 6 is a section taken along the line VI—VI of FIG. 4, the view looking in the direction of the arrows;

FIG. 7 is a section taken along the line VII—VII of FIG. 4, the view looking in the direction of the arrows; and

FIG. 8 is a sectional view of an embodiment of a valve employed in the centrifugal pump of FIG. 4.

Referring now to FIGS. 1 through 3, there is shown a pump including a main pump A having a casing **1** and an auxiliary pump B having a casing **2**, said casings being arranged in side-by-side relationship to each other. The main pump casing **1** has a suction inlet **3**, a discharge outlet **4**, and the auxiliary pump casing **2**, a discharge outlet **5**, which communicates with the suction inlet **3** of the main pump A through a connecting pipe **8** and a return passage **7** leading into the suction inlet **3**. Within the main pump casing **1** there is an impeller **9** provided with blades **11** and the impeller **9** is mounted on a driving shaft **10**. The impeller **9** is shown as being of open type having no shroud but the impeller may be of any known type according to the nature of fluid to be treated. Between the main pump casing **1** and the auxiliary pump casing **2** there is disposed a partition plate **6** serving as side walls of both the main and auxiliary pump casings. The partition plate **6** is provided with a centrally cut opening through which the driving shaft **10** extends. The opening of the partition plate **6** is so formed that the diameter thereof is slightly larger than that of the shaft **10** and increases gradually toward the auxiliary pump B. Thus, it will be apparent that a gap **13** between the outer face of the impeller hub and the inner surface of the opening of the partition plate **6** is greater on the side of the auxiliary pump B and smaller on the side of the main pump A. The tapered form of the gap **13** serves to prevent the gap from being clogged with foreign matter. The members which form the gap **13** may be made of a combined hard material and rubber to increase their durability, or may be provided with teeth to crush foreign matter and fibrous materials. In any case, it is necessary to suitably throttle the inlet of the auxiliary pump B at the gap **13** in relation to the pumping capacity of the auxiliary pump B.

Within the auxiliary pump casing **2** there is an impeller **14** having therethrough openings **15** in the central portion thereof and the impeller **14** is also mounted on the driving shaft **10**. The auxiliary pump casing **2** has an air suction passage **16** which extends from the central portion of the auxiliary pump B so as to communicate with an intake **17** of a vacuum pump **18**, which is driven by the driving shaft **10** together with the impellers **9** and **14**. About the driving shaft **10** there is provided a stuffing box **19** containing sealing material **20** therein.

In operation, when the pump is driven with the discharge outlet **4** thereof closed, the air on the suction side of the main pump is drawn into the vacuum pump **18** through the inlet **3**, the impeller **9**, the gap **13**, the impeller **14**, the passage **16**, and the intake **17** of the vacuum pump **18**, and at the same time through the inlet **3**, the return passage **7**, the connecting pipe **8**, the discharge outlet **5** of the auxiliary pump B, the impeller **14**, the pas-

sage 16, and the intake 17 of the vacuum pump 18. Thus, the vacuum established in the pump chamber causes the fluid to be treated to flow into the suction inlet 3 and thence into the chamber of the main pump A so as to fill the chamber. The fluid thus introduced into the chamber of the main pump A tends to advance to fill the return pasage 7, the connecting pipe 8, and the discharge outlet 5 of the auxiliary pump B, and reach the chamber of the auxiliary pump B. However, the auxiliary pump B is so designed that the impeller 14 thereof may operate to overcome the vacuum developed by the vacuum pump 18, and, therefore, the pump B prevents the fluid from being drawn from the pasage 7 to the auxiliary pump B, thereby functioning as a kind of check valve.

Thus, the fluid in the chamber of the main pump A flows through the gap 13 into the auxiliary pump B, and thence through the discharge outlet 5 and the return pasage 7 back to the chamber of the main pump A because of the fact that the gap 13 which is an inlet of the auxiliary pump B is throttled.

It will be apparent, therefore, that the fluid introduced into the auxiliary pump chamber never flows into the air suction passage 16, and the vacuum pump 18 is maintained free of the fluid.

When the fluid contains much air, it is introduced into the main pump A with a number of cavities. Under such a condition, the cavities are expelled from the main pump chamber through the gap 13 into the auxiliary pump chamber. The auxiliary pump, being also a strong centrifugal separator, centrifugally separates the air from the fluid and delivers the remaining fluid from the discharge outlet 5 back to the main pump A, thus attaining a continuous and reliable pumping operation. The openings 15 serve to pass the cavities from the gap 13 to the passage 16.

In the practical use of the pump as described above, in case an equipment having a positive suction head is adopted and the viscosity of the liquid to be treated is not high, a particular vacuum pump is not necessary. In this case, it is only necessary to lead the air suction passage 16 up to a position higher than the liquid suction level by means of a pipe device and more favorable effects can be expected by providing a check valve adapted to check suction of the external atmosphere into the passage at the extreme or intermediate portion of the passage.

Referring now to FIGS. 4 to 8, there is shown a modified form of the pump according to this invention. The construction of this modified form is substantially the same as that shown in FIGS. 1 to 3 with the exception that the modified pump is provided with a safety valve 21 which is inserted between the air suction passage 16 and the intake 17 of the vacuum pump 18 and may be positioned on the casing of the pump. The embodiment illustrates a particular example in which a semi-open type impeller and a special contrivance adapted to decrease cavitation at the back surface of the blades are provided. In other words, at the shroud of the impeller, a slit 12 is provided along the back surface of each blade 11 so that the inside end portion of the slit 12 faces the gap 13. Accordingly, the back surfaces of the blades 11 are always in direct communication with the vacuum pressure of the vacuum pump. The safety valve 21 includes a valve casing 22, which has in the bottom plate thereof an opening 23 in which is fitted a valve seat 24. The valve casing 22 is also provided in the side wall thereof with a port 25 communicating with the intake 17 of the vacuum pump 18. In the upper part of the casing 22 there is a diaphragm 26 extending transversely thereacross and secured at its periphery to the casing 22 in air tight relation thereto. A cover 27 is secured to the upper end of the casing 22, and the cover 27 is provided with an opening 28. Immediately under the diaphragm 26, there is a valve rod 29 which extends vertically and centrally through the casing 22 and which is supported by a support 30 for permitting vertical movement. The valve rod 29 is always urged upwardly by a coil spring 31 and is provided at the lower end thereof with a valve head 32 abuttingly engageable with the valve seat 24. The coil spring 31 is so designed that when the pressure in the valve casing 22 is equal to the external atmospheric pressure, that is, when the vacuum pump is inoperative, the valve head 32 is in contact with the valve seat 24. The diaphragm 26, in practice, may be replaced by other equivalent means such as a bellows or piston.

The pump described above in connection with FIGS. 4 to 8 is suitable for use in the case where the level of fluid to be pumped is higher than that of the pump. Then, when the pump is inoperative, the fluid to be treated is caused to flow into the pump chamber. However, the rise of the fluid level in the auxiliary pump chamber is limited because the valve 21 closes the passage 16, thus causing air to be confined in the upper part of the passage 16.

In operation, when the pump is started, the fluid flows from the main pump chamber through the throttled gap 13 into the auxiliary pump chamber, while the fluid in the air suction passage 16 is delivered to the discharge outlet 5 of the auxiliary pump B by the rotating impeller 14, thus flowing back to the main pump chamber through the return passage 7. In such a condition, the rotating impeller 14 of the auxiliary pump B holds air cavities near the central portion thereof.

When the pressure in the valve casing 22 decreases because of the operation of the vacuum pump 18, the diaphragm 26 is displaced downward by atmospheric pressure to cause the rod 29 to move downward against the force of the spring 31, thereby permitting the valve 21 to open, whereby the pressure in the passage 16 is decreased together with the pressures in the central parts of the main and auxiliary pumps A and B. Thus, the required pumping operation is accomplished.

If air cavities are formed in the central area of the main pump chamber by the introduction of air-containing fluid, they will be expelled into the auxiliary pump chamber and thence into the air suction passage 16. The auxiliary pump B of this example is also of such design that the impeller 14 thereof may operate to overcome the vacuum developed by the vacuum pump 18. Therefore, the fluid being treated is prevented from entering into the air suction passage 16. The impeller may be formed so as to promote its dual function as a centrifugal separator.

The safety valve 21 is important because, when the pump ceases operation, the fluid would enter the suction side of the vacuum pump 18 when the safety valve 21 is not used. The ingress of fluid into the vacuum pump 18 is undesirable and will always cause pump failure if it is of a nature harmful to this pump.

While we have disclosed preferred embodiments of this invention, it is to be understood that various changes and modifications may be made therein without departing from the spirit and scope of this invention. For example, there may be provided a float valve in the air suction passage 16 for preventing undesirable ingress of the fluid into the vacuum pump 18 in the case of damage to the impeller 14 or of pump stoppage. The suction line between the air suction passage 16 and the intake 17 of the vacuum pump 18 may have a fluid sump with a check valve for fluid disposal at the bottom thereof for the sake of safety. Furthermore, the auxiliary pump impeller 14 may have two impeller plates for efficient centrifugal separation of fluid from air, and the openings 15 provided in the impeller 14 may be arranged eccentrically and in a staggered state.

What we claim is:

1. A centrifugal pump assemblage comprising a main pump having a casing, a driving shaft, a main centrifugal impeller mounted on said shaft within the casing, a suction inlet and a discharge outlet communicating with said casing, an auxiliary pump having an auxiliary casing

disposed in side-by-side relationship to the main pump casing, a common wall between said main and auxiliary casings, an auxiliary centrifugal impeller, said driving shaft extending through the auxiliary pump casing and through said common wall, said auxiliary impeller being mounted on said shaft within said auxiliary pump casing, said common wall having a central suction inlet opening therein providing communication between said main pump casing and said auxiliary pump casing, means on said shaft serving to restrict the cross sectional area of said central suction inlet opening, a discharge outlet from said auxiliary casing communicating with the suction inlet of the main pump casing, whereby dense fluid is discharged from said auxiliary pump casing to the suction inlet of said main pump casing, and a vacuum pump having a suction inlet in communication with said auxiliary pump casing, whereby gaseous medium is withdrawn from said auxiliary pump casing, the pumping capacity of the vacuum pump being such that the vacuum developed thereby is overcome by the pumping action of the auxiliary pump.

2. A centrifugal pump assemblage comprising a main pump having a casing, a driving shaft, a main centrifugal impeller mounted on said shaft within the casing, a suction inlet and a discharge outlet communicating with said casing, an auxiliary pump having an auxiliary casing disposed in side-by-side relationship to the main pump casing, a common wall between said main and auxiliary casings, an auxiliary centrifugal impeller, said driving shaft extending through the auxiliary pump casing and through said common wall, said auxiliary impeller being mounted on said shaft within said auxiliary pump

casing, said common wall having a central suction inlet opening therein providing communication between said main pump casing and said auxiliary pump casing, means on said shaft serving to restrict the cross sectional area of said central suction inlet opening, a discharge outlet from said auxiliary casing communicating with the suction inlet of the main pump casing, whereby dense fluid is discharged from said auxiliary pump casing to the suction inlet of said main pump casing, a vacuum pump having a suction inlet in communication with said auxiliary pump casing, whereby gaseous medium is withdrawn from said auxiliary pump casing, the pumping capacity of the vacuum pump being such that the vacuum developed thereby is overcome by the pumping action of the auxiliary pump, and valve means in the suction inlet between the auxiliary pump and vacuum pump, said valve means being openable in response to the operation of the vacuum pump.

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