

Sept. 28, 1948.

A. J. HARLAMOFF
MULTISTAGE CENTRIFUGAL PUMP

2,450,137

Filed Dec. 1, 1944

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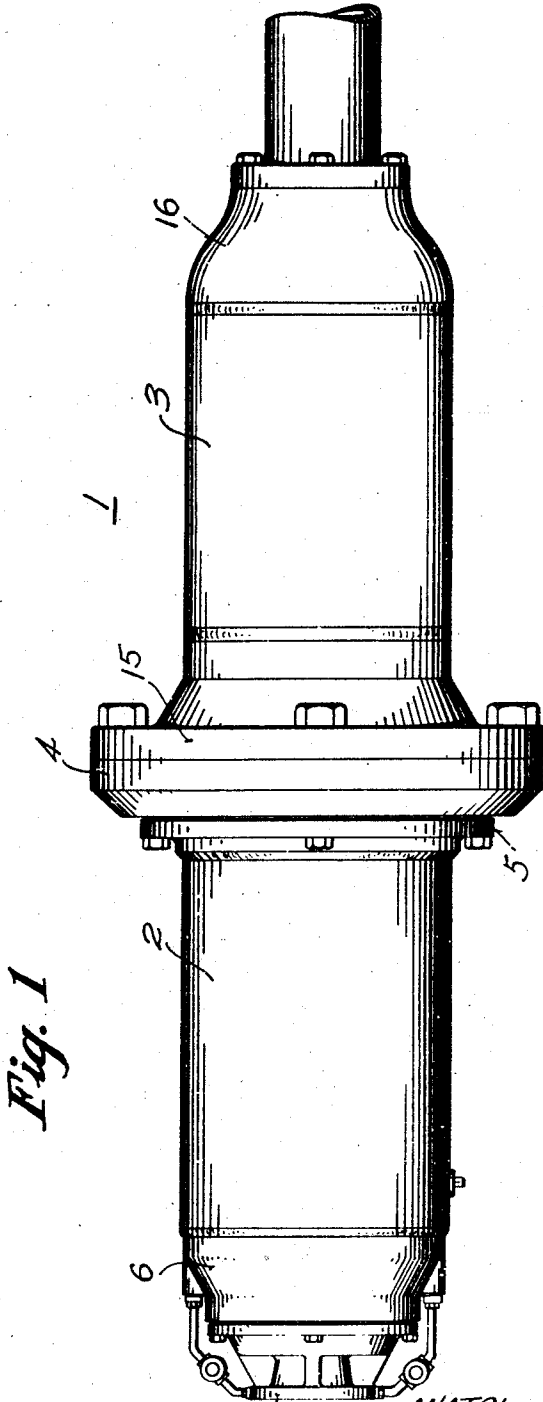


Fig. 1

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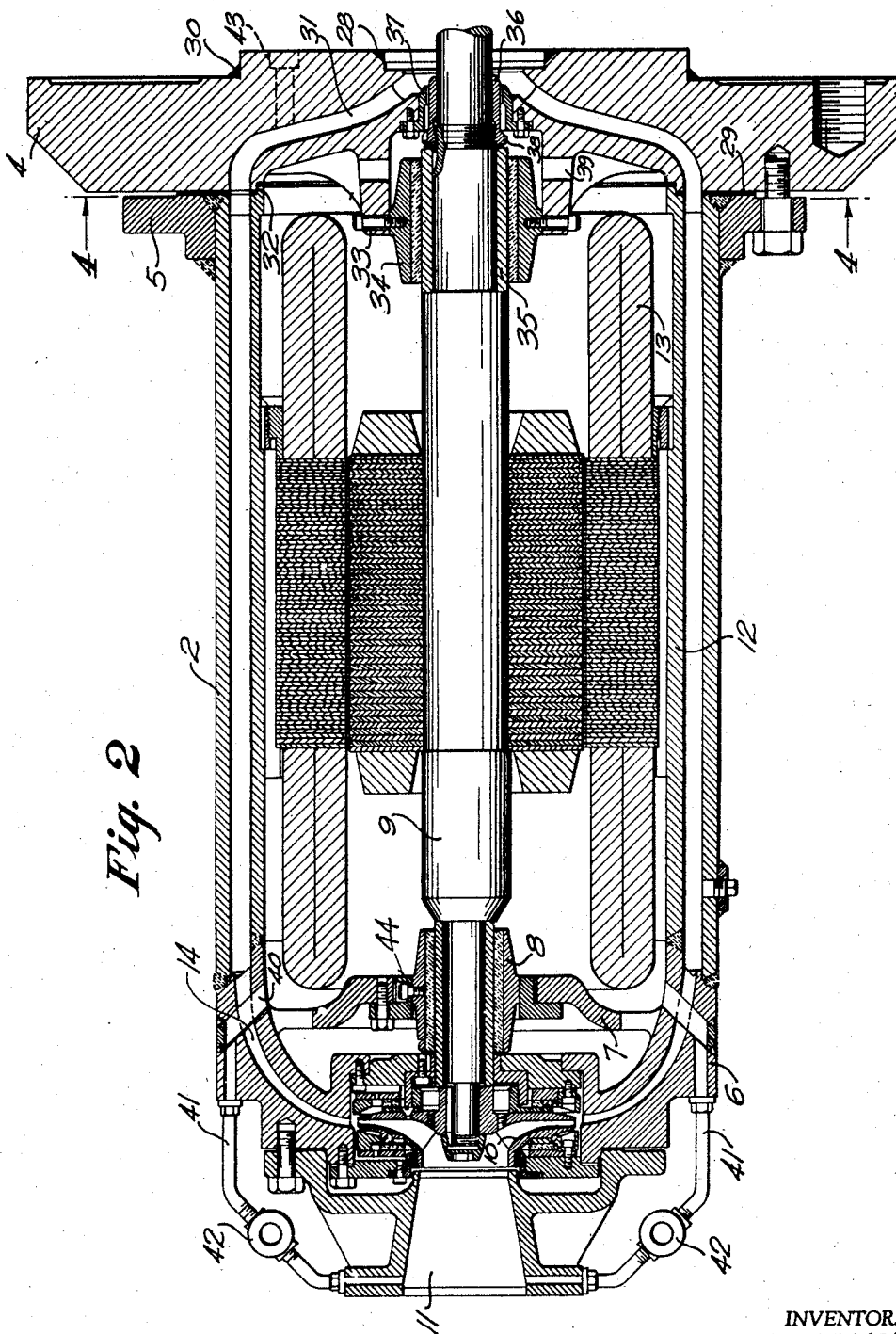
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Fig. 2



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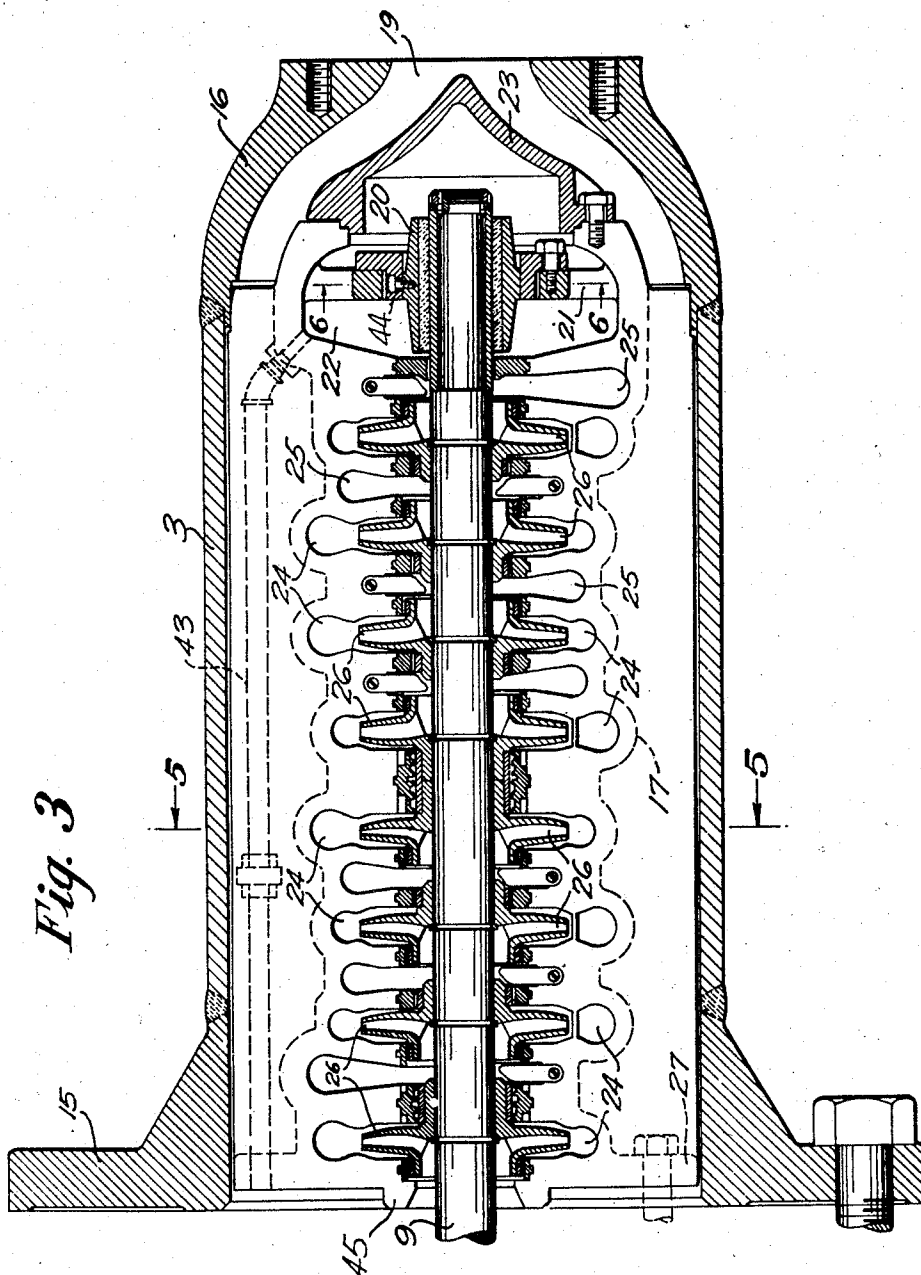
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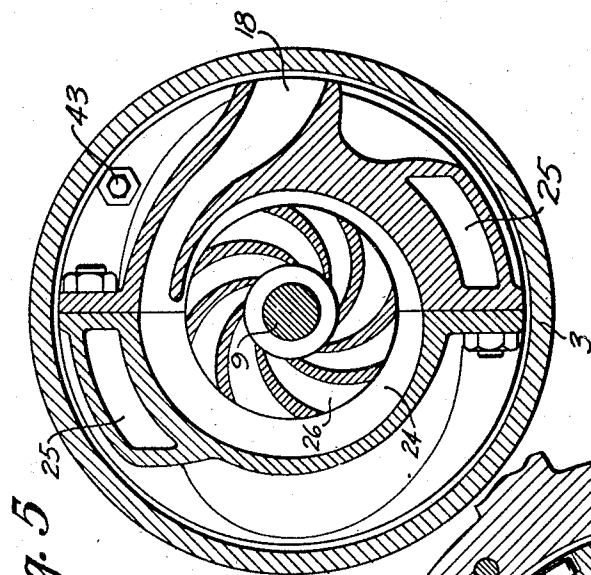


Fig. 5

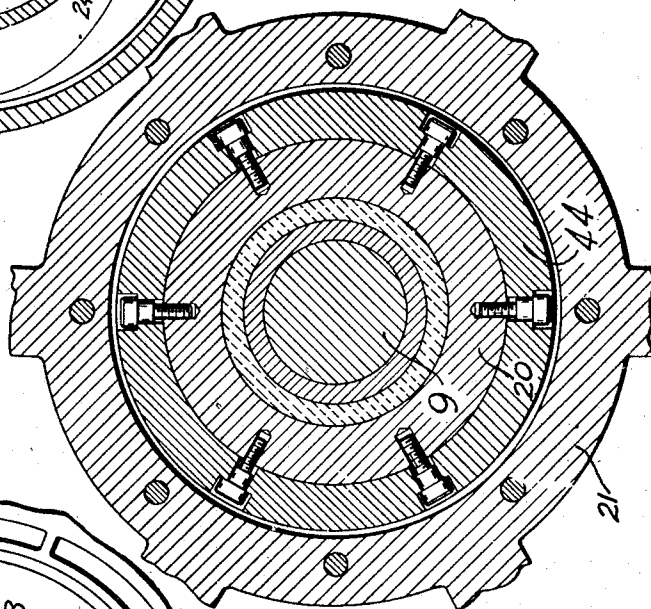


Fig. 6

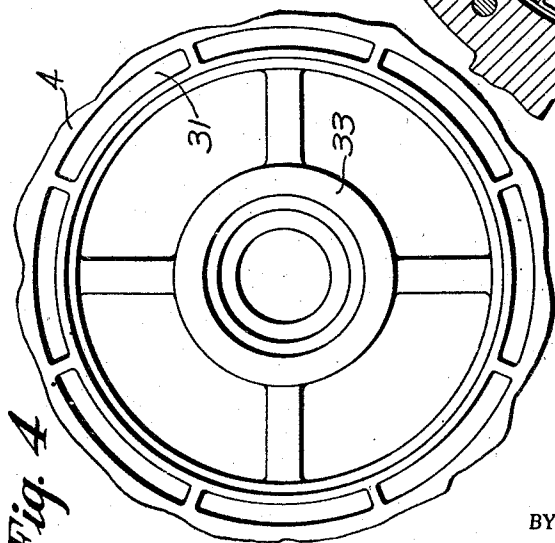


Fig. 4

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UNITED STATES PATENT OFFICE

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MULTISTAGE CENTRIFUGAL PUMP

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14 Claims. (Cl. 103-87)

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This invention relates to a multi-stage centrifugal pump.

The invention has been applied in the construction of double case pumps for use in high pressure pumping of volatile liquids and the like in which it is important to avoid the use of stuffing boxes and externally protruding shaft ends, and to maintain the head of the liquid entering the first stage above the vapor pressure of the liquid.

For this purpose it is also important that the liquid in the passages leading to the first stage impeller be free from turbulence and that the velocity of the liquid be relatively low as the liquid enters the eye of the impeller.

One of the principal objects of the present invention is to provide a multi-stage pump in which a short axial intake is employed avoiding the use of lateral intakes and thereby reducing hydraulic losses in the suction approach to the first stage impeller.

Another object of the invention is to provide a multi-stage double-case pump with a first-stage impeller of larger diameter than the others to produce substantially the same head for each impeller without enlarging the case and requiring additional cost.

Another object of the invention is to provide an efficient intake structure employing a booster impeller ahead of the main pump.

Another object is to provide a multi-stage centrifugal pump structure with the motor and impellers mounted on a common shaft and which has an axial intake and discharge adapting it for use as an in-line pump.

Another object is to improve the performance of the first-stage impeller operating at the suction end of the pump where danger of volatilization of the liquid is greatest.

Another object is to provide a construction for such a pump that will simplify manufacture and assembly thereof and reduce the cost of the same.

Another object is to provide an improved bearing structure for such a pump enabling a more accurate and readily adjusted alignment for the bearings.

Other objects will appear hereinafter in the description of a preferred embodiment of the invention illustrated in the accompanying drawings.

In the drawings:

Figure 1 is a side elevation of the pump showing its connection in a pipe line;

Fig. 2 is an enlarged axial section taken

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through the intake and motor end of the pump;

Fig. 3 is a similar enlarged axial section taken through the pump and discharge end;

Fig. 4 is an end elevation of the central dutchman header for connecting the two body sections of the structure together, looking from the left in Fig. 2 and taken before the bearing is assembled therewith;

Fig. 5 is a transverse section through the pump end, taken on line 5-5 of Fig. 3 and looking toward the dutchman; and

Fig. 6 is a transverse section taken on line 6-6 of Fig. 3 showing the lateral adjustment for the right hand bearing.

The pump 1 is enclosed in two end casings 2 and 3 joined together by a central dutchman header or partition 4. The outer end of casing 2 constitutes the intake and is adapted to be secured to the end of a pipe or conduit supplying liquid to be pumped. The outer end of casing 3 constitutes the discharge end and is adapted to be secured to the end of a pipe or conduit receiving the pumped liquid.

The casing 2 comprises a cylindrical body having a flange 5 welded to its inner end and a cast suction head 6 welded to its outer end. The suction head 6 has an inner flange 7 carrying a radial bearing 8 for the forward end of the motor and pump shaft 9. The head 6 also has a cup-shaped end for housing the first-stage impeller 10 which is mounted on the outer end of the shaft 9. A suction nozzle or adapter 11 is secured to the head 6 to direct the liquid to be pumped axially into the impeller 10.

The casing 2 contains an inner housing 12 spaced radially therefrom for housing the electric motor 13 which has its rotor mounted on shaft 9 to drive the same. The head 6 has a series of passages 14 therein for receiving liquid from impeller 10 and transmitting it to the radial space between housing 12 and casing 2 for longitudinal flow to the dutchman header 4.

The general construction of that portion of the pump just described, including the motor 13, casing 2, impeller 10 and the various bearings and seals for the latter are similar to that set forth in applicant's co-pending application Serial No. 551,809, filed August 30, 1944, for Centrifugal pump, now matured into Patent No. 2,406,847 of September 3, 1946.

The end casing 3 similarly comprises a cylindrical body having a flange 15 welded to its inner end and a cast discharge head 16 welded to its outer end. The casing 3 is adapted to enclose the pump housing 17 and to provide a chamber

and passage for the pumped liquid from the radial pump outlet 18 to the end discharge opening 19 in head 16. The pumped liquid in casing 3 surrounds the cast body of the pump housing 17 and places it under compression stress in operation.

The pump housing 17 is cast in two complementary longitudinal sections flanged along their sides and laterally bolted together as shown in Fig. 5.

The shaft 9 extends axially of the housing 17 to and through a bearing 20 adjustably mounted in a flange 21 in an end bearing chamber 22 in the housing. An end cap 23 of stream line shape is bolted on the end of the housing 17 to enclose the bearing.

The housing 17 contains a series of impeller volutes 24 interconnected by passages 25 for conducting the liquid being pumped therethrough in series. Each volute 24 contains an impeller 26 mounted on shaft 9 to rotate therewith. The order of the passage of liquid through the different impellers may be determined at will in designing the pump, it being desirable to avoid too long a pass over between stages, and to arrange one series of impellers in an opposite direction to that of the other series so as to balance the end thrust. For instance, in the pump illustrated there are eight impellers 26 or stages in housing 17, the first four impellers passing liquid therethrough from left to right, and the last four impellers passing fluid therethrough from right to left. Any suitable number of stages may be employed.

The housing 17 has a flange 27 at its inner end which is bolted to the dutchman 4 with a suitable gasket 28 therebetween. Likewise the flange 5 of casing 2 is bolted to the opposite face of the dutchman 4 with a gasket 29 therebetween; and flange 15 of casing 3 is similarly bolted to the dutchman 4 on the side of housing 17 and with a gasket 30 therebetween.

The dutchman 4 comprises a cast circular plate having its end faces machined for receiving the connections just described. The dutchman 4 has a header passage 31 therethrough for conducting liquid from the radial space between motor housing 12 and casing 2 inwardly to the entrance to the first impeller 26 in casing 17, the liquid being conducted axially into the impeller without the turbulence that would be present in the case of a lateral volute entrance thereto.

The dutchman 4 has a slip joint connection 32 with the end of the motor housing 12. The dutchman 4 also has a flange 33 in which is secured a central radial bearing 34 for the shaft 9. A shaft lining 35 is provided for the bearing and held in place by the threaded ring 36 on the shaft.

A pressure break down bushing 37 is disposed in dutchman 4 surrounding ring 36 and has a slight radial clearance to allow liquid to enter the motor chamber from the passage 31. The threaded ring 36 has radial fan elements 38 which direct the flow of liquid radially outward from the bearing 34 and towards openings 39 in flange 33 through which the liquid passes to the motor. By reason of this construction the liquid jetting through the radial clearance around ring 36 will be deflected away from the bearing 34 and towards openings 39 in flange 33.

The liquid passes to the left through the motor housing 12 and out through upper and lower passages 40 and conduits 41 to the inlet nozzle 11. The upper passage serves to prevent pocketing of gases in the motor housing 12 when volatile liquids are being pumped. The flow of liquid in

this manner is restricted by orifices 42 in conduits 41 to an amount only sufficient to provide the desired cooling of the motor.

There being no stuffing boxes in the construction, the right hand bearing 20 is submerged in liquid from the suction approach 25 to the right hand impeller 26. In order to provide a slight cooling flow of liquid which may also serve as a lubricant for bearing 20, a conduit 43 returns a predetermined restricted amount from the bearing chamber 22 to passage 31 in the dutchman 4.

The central bearing 34 is fixed in the dutchman 4, while end bearings 8 and 20 are laterally adjustable to accommodate any misalignment between the shaft and the housings 12 and 17. This adjustment is accomplished by mounting bearings 8 and 20 each in a flanged ring 44 having a body of slightly less diameter than the inside diameter of the respective supporting flange 7 or 21, and then doweling the ring 44 in place after adjusting the bearing.

In assembling the structure the motor stator is first secured in housing 12 and the bearing 8 temporarily located in flange 7. The shaft 9 with the motor rotor fixed thereon is then inserted to pass its left end through bearing 8 and position the rotor in the stator.

The dutchman 4 with its bearing 34 is then slipped on the right hand end of shaft 9 and casing 2 is bolted thereto. The impellers 26 are then successively secured in place on the shaft 9.

The shaft 9 is then pulled to the right sufficiently to enable the assembling of housing 17 upon the impellers. For this purpose the pressure break down bushing 37 is cut away to accommodate the threaded ring 36 which secures the shaft lining 35 for bearing 34 upon the shaft 9. After the two halves of housing 17 are bolted together the housing and shaft are moved to the left to enter the end flange 45 of the housing into a notch in the dutchman 4 for aligning the respective passages therein, and the housing 17 is bolted to the dutchman 4.

The bearings 8 and 20 are then adjusted in position, and cap 23 secured to the end of housing 17 to enclose the bearing 20. Conduit 43 is then applied, after which casing 3 is bolted to dutchman 4.

The assembly of impeller 10 is carried out similar to that described in applicant's copending application above referred to.

The motor housing or casing construction and assembly is of considerable advantage over previous constructions. The two cylindrical casings 2 and 12 are welded to the end head 6, casing 12 being welded first. The two casings 2 and 12 are concentric and provide a smooth passage of constant volume for liquid from the booster pump to the multi-stage pump.

After the motor is assembled in casing 12, the dutchman 4 with its central shaft bearing 34 is slipped over the shaft from the exposed right hand end. The slip joint 32 between the inner portion of the dutchman 4 and the end of casing 12 serves to center the latter and secure the same in final position. Bolting of flange 5 on casing 2 to the dutchman 4 serves to secure the outer casing 2 in final position with the passage between casings 2 and 12 registering with the passage 31 in the dutchman.

The construction is simple and rigid. It provides for cooling the motor by the flow of liquid around it and through it. The bearings as well as the motor are submerged in the pumped liquid

and no seals or stuffing boxes are required around the shaft.

While only a single stage booster impeller 10 is shown at the suction end, it will be understood that additional stages may be located to the left of the motor if desired. Furthermore, the casing 3 may be omitted where in-line construction is not necessary, or the discharge port there-through may be lateral instead of at the end.

Various embodiments of the invention may be employed within the scope of the accompanying claims.

I claim:

1. A pump of the class described, comprising a pump shaft, an electric motor having its rotor mounted on the pump shaft, a plurality of stages of impellers mounted on said shaft, a casing for said pump enclosing the motor and impellers and having an axial inlet opening at one end for fluid to be pumped, and a series of volutes each enclosing at least one impeller stage, said motor being disposed between different stages of impellers.

2. A pump of the class described, comprising a pump shaft, an electric motor having its rotor mounted on the pump shaft, a plurality of stages of impellers mounted on said shaft, a casing for said pump enclosing the motor and impellers and defining an inlet for the pump at one end, one of said impellers being mounted on the end of the pump shaft at the inlet for said casing to provide an efficient suction stage and separately balanced against end thrust of pumped liquid, and the remainder of said impellers being balanced against each other in direction to avoid undue longitudinal thrust on the shaft.

3. A pump of the class described to be disposed in a line for pumping volatile liquids, comprising a pump shaft, an electric motor having its rotor mounted on the pump shaft, a plurality of stages of impellers mounted on said shaft, a casing for said pump enclosing the motor and impellers and having an axial inlet opening at one end for receiving from the line the liquid to be pumped and an axial discharge opening at the opposite end for the pumped liquid, said casing comprising an outer cylindrical wall adapted to withstand the pressure of the pumped liquid and an inner housing for said motor and for said impellers, and passages in said casing for conducting the fluid to and from the successive impellers in series.

4. A pump of the class described to be disposed in a line for pumping volatile liquids, comprising a pump shaft, an electric motor having its rotor mounted on the pump shaft, a plurality of stages of impellers mounted on said shaft, a casing for said pump enclosing the motor and impellers and having an axial inlet opening at one end for receiving from the line the liquid to be pumped and an axial discharge opening at the opposite end for the pumped liquid, said casing comprising an outer cylindrical wall adapted to withstand the pressure of the pumped liquid and an inner housing for said motor and for said impellers, and passages in said casing for conducting the liquid to and from the successive impellers in series, the radial space between the outer casing and motor housing constituting one of said passages and being sealed from the space between the outer casing and impeller housing.

5. In a pump of the class described, a pair of generally cylindrical casings disposed in axial alignment joined at their inner ends to a parti-

tion providing an axial passage connecting said casings, one of said casings having an axial opening at its outer end for the inlet of liquid to be pumped and the other of said casings having an outlet for the discharge of pumped liquid, a motor disposed in said inlet casing and having its shaft extending through said central partition into the other casing, and a multi-stage pump in said latter casing having its impellers mounted on said shaft.

6. In a pump of the class described, a pair of generally cylindrical enclosures joined at their inner ends to a partition and disposed in axial alignment, one of said enclosures having an axial opening at its outer end for the inlet of liquid to be pumped and the other of said enclosures having an outlet for the discharge of pumped liquid, a motor disposed in said inlet enclosure and having its shaft extending through said central partition into the other enclosure, a multi-stage pump in said latter enclosure having its impellers mounted on said shaft, and a booster impeller on the end of the shaft between said motor and inlet opening to effect passage of liquid to be pumped longitudinally around the motor to said multi-stage pump.

7. In a pump of the class described to be disposed in a line for pumping liquids, a pair of generally cylindrical casings joined at their inner ends to a partition and disposed in axial alignment, one of said casings having an axial opening at its outer end for the inlet of liquid to be pumped and the other of said casings having an outlet for the discharge of pumped liquid, a motor disposed in said inlet casing and having its shaft extending through said central partition into the other casing, and a multi-stage pump in said latter casing having its impellers mounted on said shaft, the space between said pump and casing constituting a chamber for pumped liquid under pressure.

8. In a pump of the class described, a pair of generally cylindrical enclosures joined at their inner ends to a partition and disposed in axial alignment, one of said enclosures having an axial opening at its outer end for the inlet of liquid to be pumped and the other of said enclosures having an outlet for the discharge of pumped liquid, a motor disposed in one of said enclosures and having its shaft extending through said central partition into the other enclosure, and a multi-stage pump in said latter enclosure having its impellers mounted on said shaft, said shaft having a fixed central radial bearing in said partition and laterally adjustable and radial bearings in said enclosures.

9. In a pump of the class described, a pair of radially spaced cylindrical casings defining a longitudinal cylindrical passage therebetween for pumped liquid and a chamber inside the inner casing for a motor, a cast forward end head for both casings and adapted to house an impeller and providing a series of passages in alignment with the discharge outlet of the impeller and registering with the passage between the casings to deliver pumped liquid thereto, and a similarly cast rear end head for both casings and having a series of passages therein to receive pumped liquid from the passage between the casings and deliver the same to a central discharge outlet.

10. In a pump of the class described, a pair of radially spaced cylindrical casings defining a longitudinal cylindrical passage therebetween for pumped liquid and a chamber inside the inner casing for a motor, a cast forward end head for

both casings and adapted to house an impeller and providing a series of passages in alignment with the discharge outlet of the impeller and registering with the passage between the casings to deliver pumped liquid thereto, and a similarly cast rear end head for both casings and having a series of passages therein to receive pumped liquid from the passage between the casings and deliver the same to a central discharge outlet, one of said heads being welded to said casings and the other of said heads providing a slip joint with the inner casing and being removably secured to the outer casing.

11. In a pump of the class described, a pair of radially spaced cylindrical casings defining a longitudinal cylindrical passage therebetween for pumped liquid and a chamber inside the inner casing for a motor, a cast forward end head for both casings and adapted to house an impeller on the end of the motor shaft and providing a series of passages in alignment with the discharge outlet of the impeller and registering with the passage between the casings to deliver pumped liquid thereto, and a similarly cast rear end head for both casings and having a series of passages therein to receive pumped liquid from the passage between the casings and deliver the same to a central discharge outlet, said heads carrying the end bearings for the motor and pump shaft.

12. In a pump of the class described, a pair of radially spaced cylindrical casings defining a longitudinal passage therebetween for pumped liquid and a chamber inside the inner casing for a motor, a cast forward end head for both casings and adapted to house an impeller and providing a series of passages in alignment with the discharge outlets of the impeller and registering with the passage between the casings to deliver pumped liquid thereto, and a similarly cast rear end head for both casings and having a series of passages therein to receive pumped liquid from the passage between the casings and deliver the same to a central discharge outlet, said heads additionally providing passages for the flow of pumped liquid through the motor chamber from the rear to the forward end under the pressure differential produced by the impeller.

13. A pump of the class described comprising a pump shaft, a plurality of stages of impellers carried by said shaft and having separate volutes connected in series, an electric motor having its rotor mounted on the pump shaft between two of said impeller stages, and a casing for said pump having axial inlet and outlet openings to connect with the pipes through which the pumped liquid passes.

14. A pump of the class described to be employed in a pipe line for carrying liquids, which comprises a pump shaft, a plurality of stages of impellers mounted upon said shaft, an electric motor mounted upon said pump shaft between two of said stages of impellers and in axial alignment therewith, and a casing housing said pump and motor and having axial inlet and outlet openings for connection to the pipe line and provided with a passage extending longitudinally of said motor for longitudinal flow of the liquid in the pipe line entering the pump through said inlet from one impeller stage to another impeller stage and back into the line through said outlet without hydraulic losses.

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