Jan. 13, 1953 O. HAENTJENS ET AL 2,625,110

PUMP FOR VERTICAL MOVEMENT OF LIQUIDS

Filed Nov. 10, 1948 4 Sheets-Sheet 1

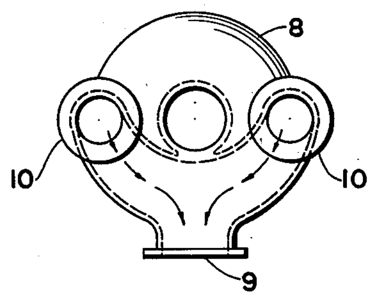
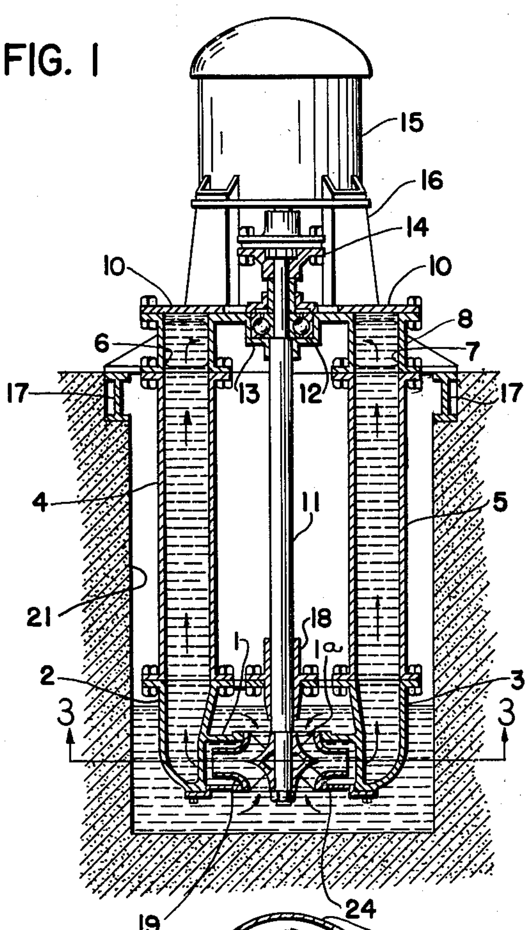


FIG. 4

FIG. 1



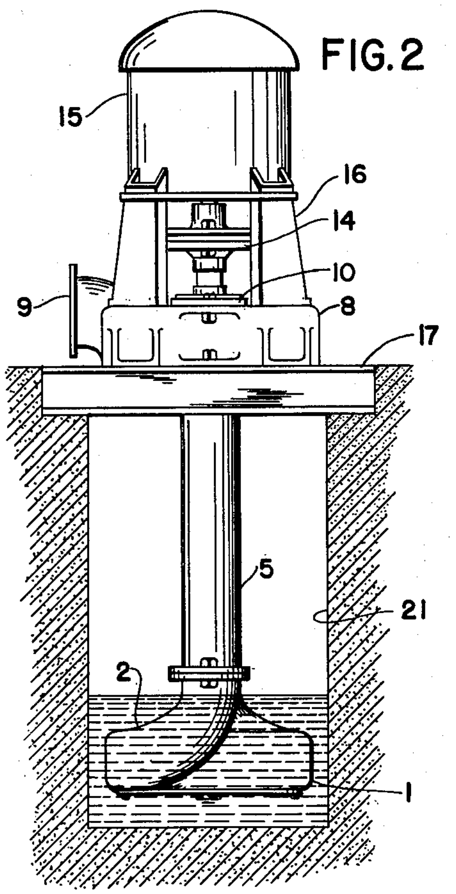


FIG.2

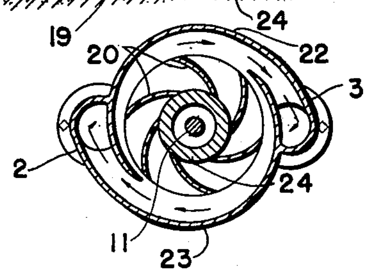


FIG. 3

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FIG. 5

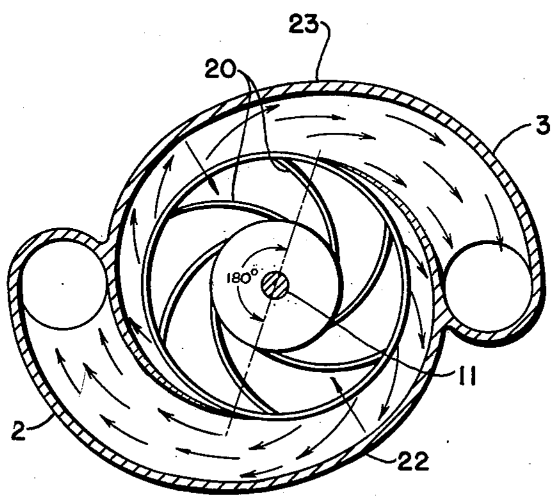

FIG. 6

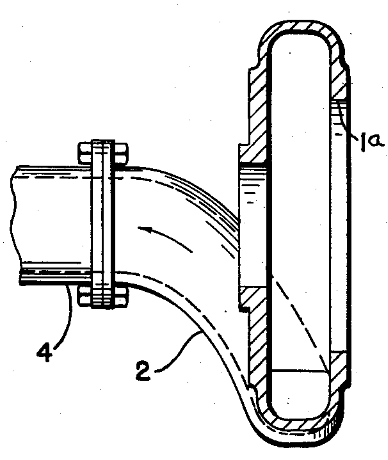

FIG. 7

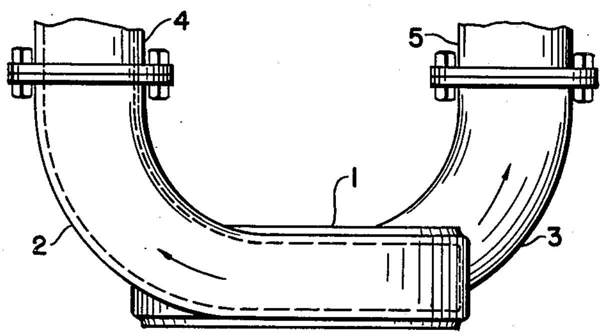

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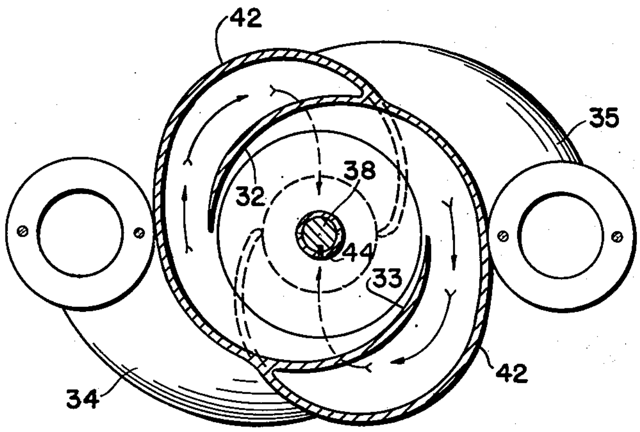
FIG. 9



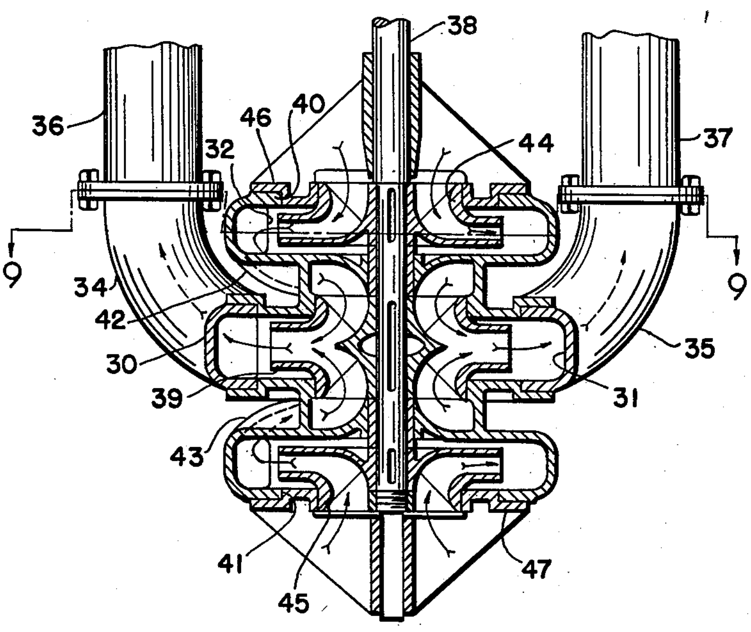


FIG. 8

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FIG. 10

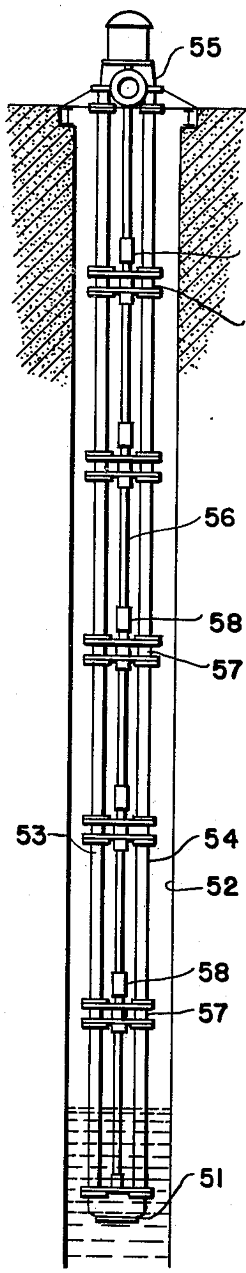


FIG. 11

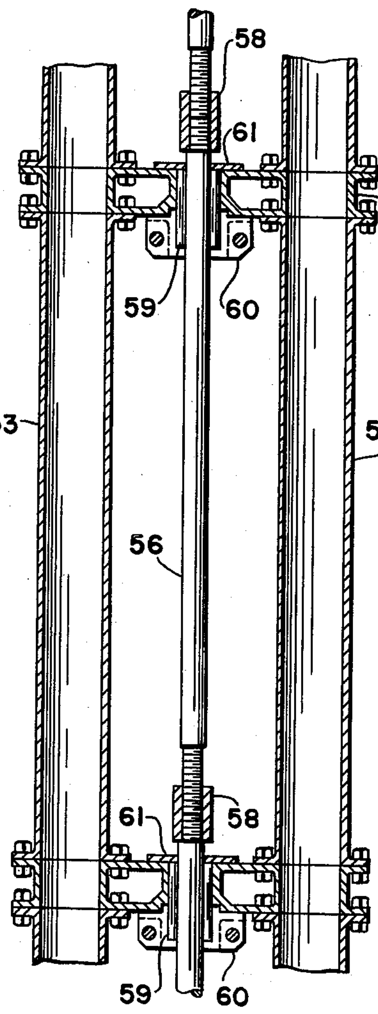
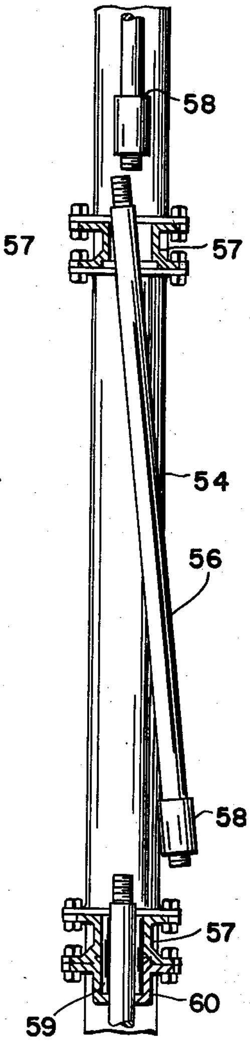


FIG. 12



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PUMP FOR VERTICAL MOVEMENT OF LIQUIDS

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Application November 10, 1948, Serial No. 59,286

6 Claims. (Cl. 103—102)

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This invention relates to mine or well pumps, particularly to pumps which are adapted to be suspended down in a mine from the surface of the mine so that the pump is itself positioned down in liquid, usually water, situated in the mine, which liquid is to be discharged from the mine by the suspended pump.

Water from such mines, usually coal mines, is frequently acidulous and normally gritty and often carries, in suspension or solution, compounds which settle or precipitate, thus forming a covering or crust over all wetted parts.

A good vertical mine pump should therefore have few parts that come in contact with the water and it should be so designed that the incrustation, which may form, can readily be removed.

The shafts of all water lubricated conventional "deep-well" pumps are placed within the discharge pipe and rotate in the water passing from the pump through the discharge line. If the water is of a corrosive nature, the shaft, for its full length, must be made of expensive corrosion resistant steel. The present invention places the shaft in the open. Only the bottom sections, which are submerged, run in water and should be of corrosion resistant material.

Furthermore, considerably more power is required to rotate a shaft at high speed when submerged in a liquid than when in air, and the shaft, running in water, is subject to wear.

The conventional "deep-well" type of pumps which have a center oil tube, that contains the bearings and drive shaft, do not eliminate the foregoing difficulties but rather actually give rise to additional problems. As oil is constantly introduced at the top of the oil tube, so as to drip through each bronze bearing, an overflow port at the bottom of the tube must be provided and a stuffing box also must be positioned at such portion of the pump. This stuffing box must seal against the full operating head of the pump and any leak will permit water, under pressure, to enter the oil tube. No adjustment of the stuffing box is possible without complete disassembly of the pump. The oil over-flow port is generally located just above the pump, thus when the pump is submerged to a considerable extent, the corrosive water enters the port and rises in the oil tube. This can be overcome in part by balancing this with oil, however this is an expensive and uncertain operation.

In the conventional pump the shaft is located within the discharge pipe and the flow of water is hampered by the revolving shaft and by its

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supporting bearings and supporting "spiders" which hold the bearing housing, or there may be within the pipe the shaft enclosing oil tube and supporting spiders.

The present invention meets the above requirements far better than pumps of the conventional "deep-well" turbine type design. In order to more fully appreciate the importance of the novel features described herein, it should be borne in mind that vertical mine pumps may be up to six hundred (600) feet in length and weigh up to fifty (50) tons or more, and that the lifting and field dismantling of such a pump is an expensive and time consuming task.

The general object of the present invention is to provide a pump with supporting piping and drive shafting in sectional lengths which will be more reliable than the conventional pumps under the severe operating conditions prevailing in mine service; and which will permit replacement of damaged or worn shafts or bearings, which are above the water level, without lifting the pump from its setting; and which will permit cleaning of the full length of discharge pipe without moving same from its operative position.

Among the specific objects of the invention are the following:

The elimination of the hydraulic downward thrust, produced by the single-suction impellers of conventional pumps, by substituting double suction impellers which produce no hydraulic end thrust.

The use of a double suction impeller to permit increased rotational speed, or pump capacity of approximately forty (40) per cent over that of an equivalent single suction impeller without jeopardizing the desired operating efficiency.

The placing of the drive-shaft outside of the discharge pipe where it is accessible.

The provision of a pump casing which has two volutes, the discharges of the volutes being diametrically opposed and discharging into separate pipes an equal volume of water; this twin volute so designed to eliminate hydraulic side thrust.

The use of one double suction impeller or a combination of one double suction and two sets of single suction impellers, each discharging through two volutes, arranged so that hydraulic end thrust is eliminated.

All of the aforementioned improvements are made possible by the use of a pump of novel design described hereinafter in detail, the desirability of which will be made more apparent as the specification proceeds.

For a better understanding of the invention, attention is directed to the accompanying drawings, wherein:

Fig. 1 is an elevation, partially in vertical section, of one pump unit assembly embodying the principles of the invention;

Fig. 2 is a side elevation of the assembly of Fig. 1;

Fig. 3 is a horizontal section taken on line 3—3 of Fig. 1;

Fig. 4 is a plan of the discharge head of the invention;

Fig. 5 is a schematic section similar to Fig. 3, showing the action of same;

Fig. 6 is a vertical section through the pump casing;

Fig. 7 is an elevation of the pump casing;

Fig. 8 is a vertical section through a pump casing and associated means comprising a slight modification of the device shown in Fig. 1;

Fig. 9 is a horizontal section taken on line 9—9 of Fig. 8;

Fig. 10 is an elevation of a further embodiment of the invention;

Fig. 11 is a fragmentary elevation, partly in longitudinal section, of a coupling shaft section or unit of the invention; and

Fig. 12 is a side elevation showing a further step in the replacement of the shaft section as shown in Fig. 11.

Reference is now made to the details of the structures shown on the accompanying drawings, and in Fig. 1 there is shown a pump casing 1 which has two diametrically opposed diffusers 2 and 3 formed therein. The diffusers 2 and 3 connect at their lower ends to diametrically opposed discharge outlets of volutes 22 and 23, provided in the casing 1 and the upper ends of the diffusers are suitably removably secured to the lower ends of the discharge pipes 4 and 5. The upper ends of the discharge pipes 4 and 5, which are positioned with their longitudinal axes extending in a vertical direction, are suitably secured to inlet ports or openings 6 and 7 that are formed on the lower portion of a discharge head 8. Usually this discharge head 8 is provided with one discharge outlet opening 9 which extends therefrom in a substantially horizontal direction and which may be connected to any conventional type of discharge conduit. In order to facilitate cleaning the discharge pipes 4 and 5, cleaning openings are formed in the upper portion of the discharge head 8 aligned with the longitudinal axes of the pipes 4 and 5 so that the entire length of the discharge pipe is accessible through the cleaning openings provided in such discharge head. Cover plates 10, or other similar devices, are usually provided and are removably secured to the discharge head 8 to cover the cleaning openings provided therein.

As a feature of the present invention, a driven shaft 11 extends vertically of the pump apparatus of the invention and this shaft 11 is positioned intermediate of the pipes 4 and 5 which are diametrically opposed and symmetrically positioned with relation to the driver shaft 11. The driver shaft 11 is supported by means of a conventional thrust bearing 12 that is positioned by a housing 13 which is secured to or formed integrally with the discharge head 8, as desired. The upper end of the driven shaft 11 protrudes beyond the discharge head and has one-half of a conventional coupling 14 secured thereto. The other half of the coupling 14 is secured to the drive shaft of any conventional driving member, in this instance a motor 15. The motor 15 is

supported by means of a motor stand 16 which may be secured to the discharge head 8. I-beams 17 are provided for supporting the discharge head 8 and thus the remainder of the pumping apparatus. These beams 17 thereby support the entire pumping apparatus as will hereinafter appear.

As previously indicated, the pumping apparatus of the invention is adapted for use in moving liquids vertically and the pump casing 1 normally will be submerged in the liquid being pumped. This liquid, usually water, should extend at least about six (6) inches vertically above the upper end of the casing 1. The drawing indicates that the casing 1 has an axial opening 1a extending therethrough. The casing 1 has its longitudinal axis vertically positioned. The shaft 11 extends vertically downwardly of the pumping apparatus into the casing 1 and may be positioned thereadjacent by means of a bearing 18 which may be secured to the upper portions of the casing 1. It will be noticed that the bearing 18 is immediately adjacent the casing 1 whereby the shaft 11 has only a minimum length overhang from such bearing. The casing 1 has a double suction impeller 19 positioned therein. This impeller 19 is provided with a plurality of conventional blades or vanes 20 and is secured to the lower end of the shaft 11 in any conventional manner. The double suction action of the impeller 19 means that the impeller is provided with inlet openings adjacent its hub portion on both the top and bottom surfaces thereof whereby water or other liquid will flow directly from a mine or well 21 in which the pumping apparatus is positioned directly into the casing 1 when the impeller 19 is driven.

An important feature of the present invention is that the casing 1 has the two identical, diametrically opposed volutes 22 and 23 formed therein with each volute extending approximately 180 degrees around the casing. Each volute 22 and 23 is provided with a discharge opening or outlet and each volute 22 and 23 connects to one of the diffusers 2 and 3 which in turn connect to the discharge pipes 4 and 5 to permit flow of fluid from the mine 21. The impeller 19 has a hub 24 from which the blades 20 extend. Conventional sealing rings are used to form substantially a water tight fit between the impeller 19 and the upper and lower portions of the casing 1 adjacent the axial opening 1a therein. Fig. 2 of the drawing shows that the diffusers 2 and 3 extend smoothly arcuately upwardly of the pumping apparatus whereby the diffusers efficiently reduce the high velocity of the liquid stream discharged from the impeller 19 and convert such high velocity to a pressure head to effect a vertical flow of liquid in the discharge pipes.

Fig. 5 shows, somewhat schematically, the forces which are produced in the volutes 22 and 23 and how such forces change as the liquid stream enters into and flows through the diffusers 2 and 3. The lines of resultant thrust in the casing 1 and associated means are also shown whereby it is seen that diametrically opposed hydraulic thrust forces are set up therein so that the pumping apparatus of the invention has no net resultant radial hydraulic thrust force set up therein due to the construction of the casing, volutes and diffusers. It also will be noted that the diffusers 2 and 3 start where the radially outer wall of the associated volute circumferentially overlaps the other of the volutes, and that the diffusers smoothly increase in area from the inlet ends thereof.

Reference is now made to the modification of the pumping apparatus of the invention shown in Figs. 8 and 9 wherein a multi-stage pump is shown in place of the single stage pump illustrated in Figs. 1 through 7 of the accompanying drawings. Such modified construction includes a pump casing 30 which has a high pressure stage or chamber 31 formed therein. The casing 30 has twin volutes formed therein and each volute connects to the inlet end of a diffuser 34 or 35, which in turn connects to a discharge pipe 36 or 37, respectively, for vertical discharge or flow of liquid passing through the casing 30. The casing 30 has a driven shaft 38 positioned therein and extending therethrough. This shaft 38 is driven in any conventional manner and has a double suction impeller 39 secured thereto in the portion of the shaft positioned in the high pressure stage 31. A set of low pressure casings are associated with the casing 30 and suitably secured thereto on opposite sides of the high pressure stage 31, which casings are shown to comprise low pressure casings 40 and 41 which are usually formed separate from the casing 30 and are associated therewith in axial alignment with same on the top and bottom sides of such casing 30. Each of the low pressure casings 40 and 41 forms a low pressure stage for the pump and has two diametrically opposed volutes formed therewith with each volute discharging into one of a pair of diffusers 42 provided for the casing 40 or diffusers 43 provided for the casing 41. Volutes 32 and 33 are shown for the casing 40 in Fig. 9 wherein the impeller in such casing is removed to show the diffuser and volute construction more clearly.

Figs. 8 and 9 show that the diffusers 42 and 43 each are of substantially tubular form and are of generally arcuate shape. The diffusers extend from the discharge end of the volutes provided in the low pressure casings 40 and 41 and connect to the inlet portion of the high pressure chamber 31 adjacent the hub portion of the impeller 39 provided therein. A single suction impeller 44 is suitably secured on the shaft 38 in the low pressure casing 40 and adapted to draw fluid downwardly thereinto whereas a single suction impeller 45 is similarly positioned on such shaft in the low pressure casing 41 and adapted to draw fluid upwardly into same for discharge through the associated diffusers 43 up into the high pressure chamber 31. It will be appreciated that the pressures produced in the low pressure casing and the high pressure casing 30 are cumulative. The sets of diffusers 42 and 43 retain the pressure set up in the liquid being expelled from the low pressure chambers and discharge such fluid to the inlet of the high pressure chamber under substantially the same pressure as that created in the low pressure chambers. Of course, additional sets of low pressure chambers and impellers, or stages, may be provided in order to provide additional pressure stages in a pump, if desired, but such additional stages must be installed in pairs on opposite axial sides of the high pressure chamber so that the hydraulic balance of the multi-stage unit is not disturbed. Separate cover plates 46 and 47 are usually provided at the ends of the multi-stage pump shown. The inlets of the impellers 39, 44 and 45 are tubular and the peripheries of same are associated with conventional sealing rings, usually T-shaped in section, that seal the impellers in the associated end plates or casings.

Fig. 9 best shows that the diffusers, in projection, are of smooth arcuate or curved shape and that the inlet end of each of these diffusers connects to the outlet of one of the volutes with each diffuser extending from a radially outer point of the low pressure stage of the pump to a radially inner discharge end of the diffuser that connects to an inlet opening of the high pressure stage of the pump. The diffusers 42 and 43 are similar to those described before and gradually increase in area from the inlet to the outlet thereof to aid in converting the velocity of the liquid therein over into pressure.

Fig. 10 illustrates a further modification of the invention wherein the sectionalized nature of the pumping apparatus is illustrated. That is, the present pumping apparatus is adapted to be used with sectionalized lengths of piping and shafting whereby installation and removal of the pumping apparatus is facilitated, even though used in appreciably deep wells or mines. In this instance a casing member 51 is positioned down in a well 52 and is submerged in liquid contained in such well. The casing 51 is supported by means of sectional discharge pipes 53 and 54 which are formed in short sections that are removably secured together with the upper end of the sectional discharge pipes 53 and 54 being secured to and supported by a discharge and drive unit indicated at 55. A sectional drive shaft 56 also is secured to the drive unit 55 and extends downwardly therefrom to the casing 51 for driving an impeller positioned therein. The shaft 56 usually is guided in bearing means provided at spaced vertical portions of the shaft 56. Usually yokes 57 extend between the discharge pipes 53 and 54 at the ends thereof and shaft 56 extends through these yokes 57. The adjacent ends of the shaft sections may be secured together by means of sleeves 58 that are in threaded engagement with adjacent ends of the sections of the shaft 56.

Figs. 11 and 12 show in enlarged detail the construction of the bearing means used to support or guide the shaft 56. The drawings also illustrate how one section of the shafting can be removed and be replaced, when desired, or how a bearing is to be replaced. In Fig. 11, a bearing 59 is shown. This bearing 59 is engaged with the shaft section 56 and is longitudinally split whereby the bearing can be sprung into engagement with the shaft 56, or two halves of a bearing can be brought into engagement with such shaft to provide a complete bearing therefor. The upper end of the bearing 59 extends into the yoke 57 and is positioned thereby whereas the lower end of the bearing 59 is supported by and secured in place by a bearing housing 60 that is removably secured to the lower portion of the yoke 57. Thus one of the bearings 59 can be replaced by merely removing one of the housings 60 and sliding the bearing 59 out of the yoke 57 after which the bearing can be removed from engagement with the shaft 56. In replacing one of the shaft sections 56, one sleeve 58 is disengaged from the shaft sections which it is secured to after or prior to which one of the bearings 59 is removed. Also a cover plate 61 that is carried by each of the yokes 57 on the upper surface thereof may also be removed to facilitate changing one of the shaft sections. After the one sleeve 58 is removed, the lower portion of the shaft then drops down a short distance until the impeller positioned on the end of such shaft rests against its associated casing. At such time, then a second sleeve 58, usually the one immediately below the sleeve previously removed is now disengaged from its associated shaft sections whereby the one shaft section is completely removed from the apparatus and it may be replaced or repaired, as desired.

In referring to the pump casings of the invention, usually the diffusers and volutes are formed integrally therewith although it is clearly within the scope of the invention to make the diffuser and/or the volute separate from the pump casing, when desired. The multi-stage pump of Figs. 8 and 9 may be made in any required number of parts to facilitate manufacture and assembly of same. It also should be noted that the inlet of each diffuser smoothly connects to the outer end of each volute and that the diffuser initially forms more or less of a continuation of the arc of the volute. Usually the impellers used in the pumping apparatus of the invention are of the closed type and this facilitates sealing same in the associated pump casing.

The bearings 59 may be formed from any conventional material. In all instances the discharge pipes and the pump casing will be supported by the discharge head, as is the driven shaft.

It will be appreciated that the pump of the invention in practice usually will be provided with sectional discharge pipes and shaft, as shown in Figs. 10 to 12. The casing 51 in Fig. 10 may be of the construction shown in Fig. 1 or Fig. 8, as desired.

While several complete embodiments of the invention have been disclosed herein, it will be appreciated that modification of these particular embodiments of the invention may be resorted to without departing from the scope of the invention as defined by the appended claims.

Having thus described our invention, what we claim is:

1. A pump for moving a fluid vertically and comprising a drive shaft, a pair of discharge tubes positioned symmetrically of said shaft on opposite sides thereof and extending in a vertical direction, a discharge head secured to said discharge tubes at the upper ends of same, said discharge head being provided with cleaning openings on the upper surface thereof in alignment with and of substantially the same size as said discharge tubes, said discharge head having a discharge opening in the side portion thereof, and means removably secured to said discharge head spaced from the discharge opening therein to cover said cleaning openings to permit convenient access to said discharge tubes without disassembly of the operating portion of the pump.

2. In a pumping apparatus, a casing with twin volutes, a driving shaft extending into said casing, an impeller positioned in said casing and attached to said driving shaft, a diffuser connected to each volute, two pipes located symmetrically around the driving shaft, said impeller discharging fluid into the volutes and through the diffusers into said pipes, said pipes being adapted to support the casing and to receive and discharge the fluid from the impeller, said shaft being formed in sections, means removably securing said shaft sections together, said shaft and means being exposed in the assembled apparatus to facilitate repair of same, said pipes also being formed in sections, yokes having parallel tubular portions therein secured to and connecting adjacent ends of sections of said pipes and having a bridge portion connecting the tubular portions

thereof, said bridge portions each having a bearing receiving recess formed therein from one edge portion thereof, a longitudinally split bearing received in each of said recesses and protruding therefrom, said bearings engaging and positioning said shaft, and bearing caps enclosing the exposed portions of said bearings and being removably secured to the bridge portions of said yokes, said shaft and pipe sections being of equal length and said shaft being supported only by said bearings and bearing caps to facilitate replacing said bearings or shaft sections.

3. In a pumping apparatus, a casing with twin volutes, a driving shaft extending into said casing, an impeller positioned in said casing and attached to said driving shaft, a diffuser connected to each volute, two pipes located symmetrically around the driving shaft, said impeller discharging fluid into the volutes and through the diffusers into said pipes, said pipes being adapted to support the casing and to receive and discharge the fluid from the impeller, said shaft being formed in sections, and means removably securing said shaft sections together, said shaft and means being exposed in the assembled apparatus to facilitate repair of same, said pipes also being formed in sections, yokes having parallel tubular portions therein secured to and connecting adjacent ends of sections of said pipes and having a bridge portion connecting the tubular portions thereof, said bridge portions each having a bearing receiving recess formed therein from one edge portion thereof, a longitudinally split bearing received in each of said recesses and protruding therefrom, said bearings engaging and positioning said shaft, and bearing caps enclosing the exposed portions of said bearings and being removably secured to the bridge portions of said yokes.

4. A deep mine pump for moving a fluid vertically and comprising a drive shaft, a pair of elongate discharge tubes positioned symmetrically of said shaft on opposite sides thereof and extending in a vertical direction, a discharge head having a flat upper surface secured to said discharge tubes at the upper ends of same, said discharge head being provided with a pair of cleaning openings in the flat upper surface thereof in alignment with and of substantially the size of said discharge tubes and including passages in alignment with and equal in size to said discharge tubes, said discharge head having a discharge opening in a side portion thereof, cover means removably secured to the top of said discharge head over said cleaning openings to permit convenient access to said discharge tubes without disassembly of the operating portion of the pump, a drive motor for said shaft, and support means carried by said discharge head on the upper surface thereof spaced from said cover means and extending upwardly from said discharge head to support said motor.

5. In a pumping apparatus, a casing with twin volutes, a driving shaft extending into said casing, an impeller positioned in said casing and attached to said driving shaft, a diffuser connected to each volute, two pipes located symmetrically of said driving shaft, said impeller discharging fluid into the volutes and through the diffusers into said pipes, said pipes being adapted to support said casing and to receive and discharge the fluid from said impeller, said shaft being formed in sections, means removably securing said shaft sections together, said shaft and means being exposed in the assembled appa-

ratus to facilitate repair of same, and yoke means for securing said pipes together and including a bridge member having parallel bores provided in opposed portions thereof, said bridge member being positioned intermediate adjacent ends of said pipe sections to space same from each other with said bores being aligned with the bores of such pipe sections and connecting same, means for securing said bridge member to adjacent ends of said pipe sections, and bearing means carried by said bridge member and engaging said shaft.

6. A pump as in claim 4 wherein a plurality of sections are provided in said tubes, said discharge head supports said tubes, yoke means are secured to and form part of said tubes and extend therebetween, and bearings for said shaft are carried by said yoke means.

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