July 13, 1965 G. NEIDL 3,194,166

PUMPING PLANTS

Filed March 21, 1963 4 Sheets-Sheet 1

FIG. 1

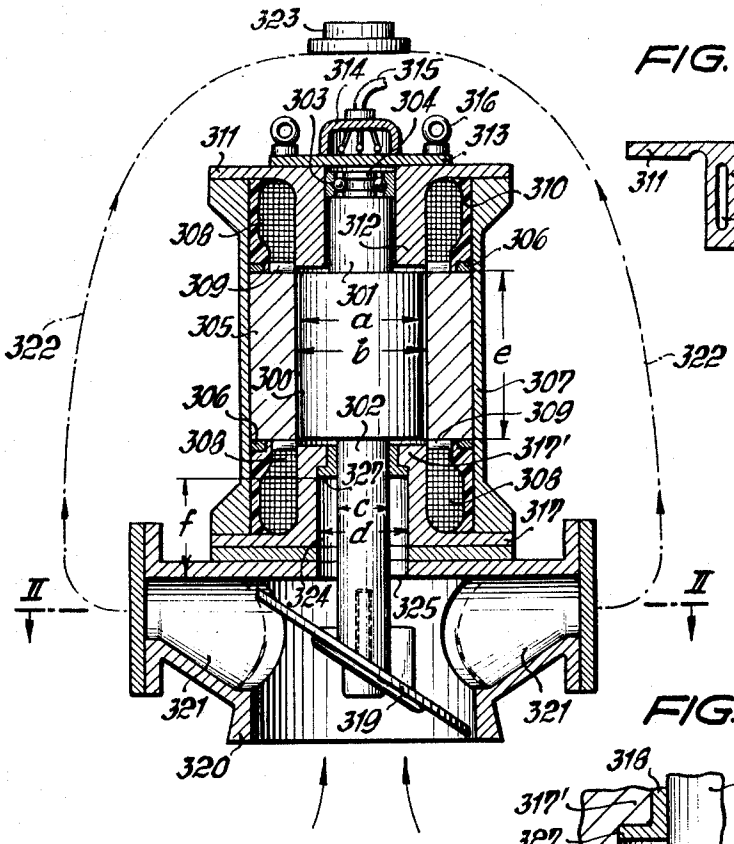


FIG. 6

FIG. 3

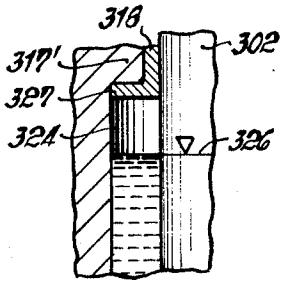
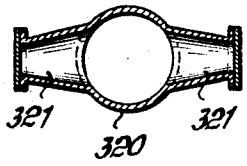


FIG. 2



INVENTOR
Georg NEIDL

Mestern, Ross & Mestern

July 13, 1965 G. NEIDL 3,194,166

PUMPING PLANTS

Filed March 21, 1963 4 Sheets-Sheet 2

FIG. 4

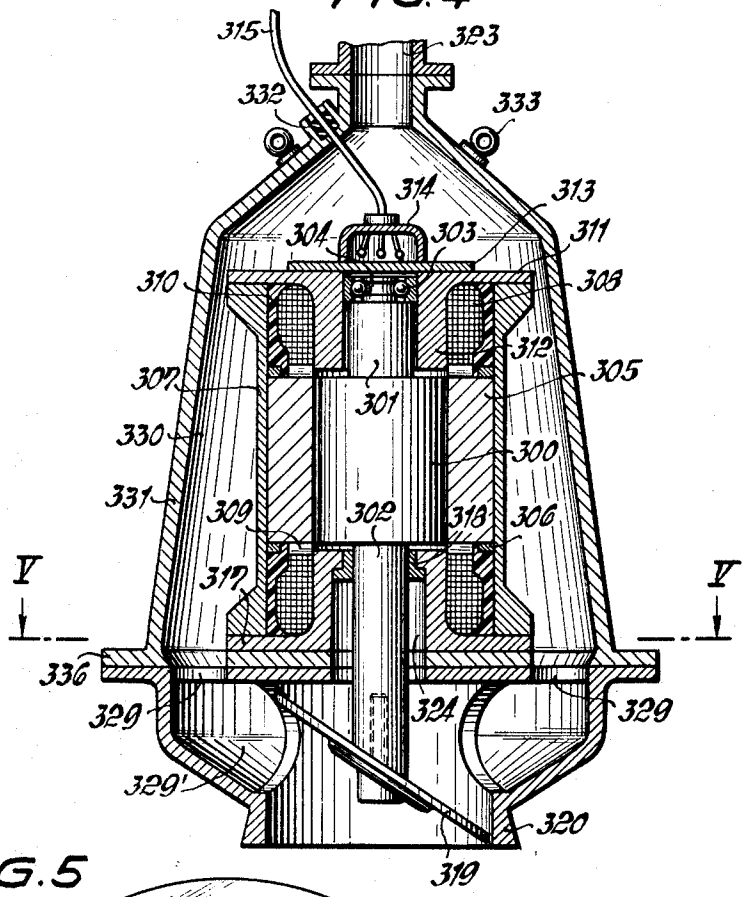
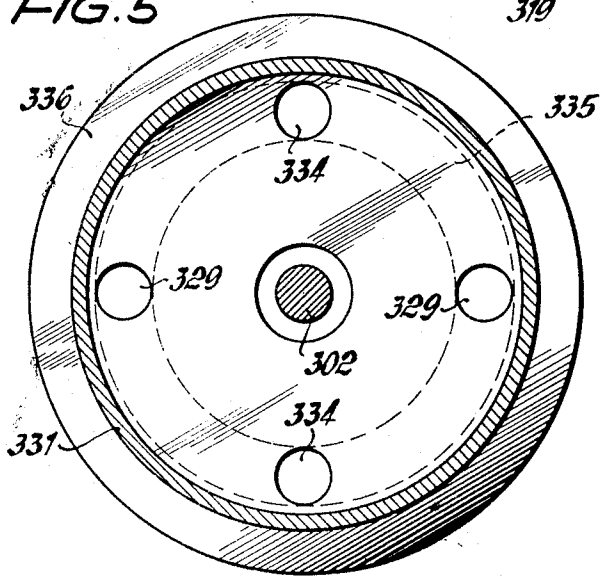


FIG. 5



INVENTOR
Georg NEIDL

Mestern, Ross & Mestern

July 13, 1965 G. NEIDL 3,194,166

PUMPING PLANTS

Filed March 21, 1963 4 Sheets-Sheet 3

FIG. 7

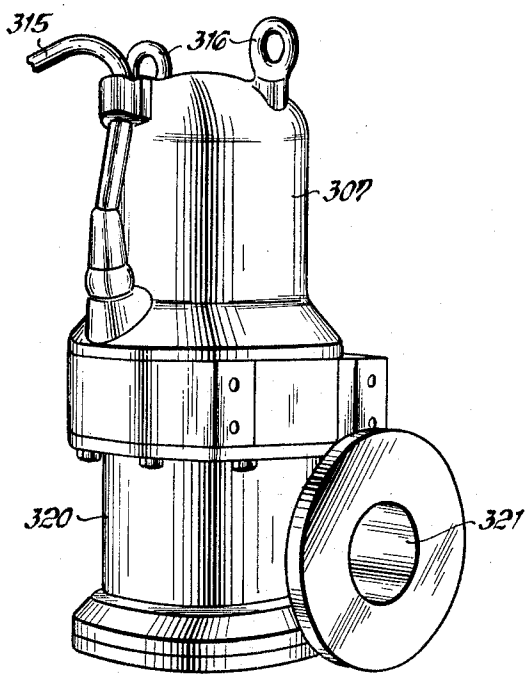
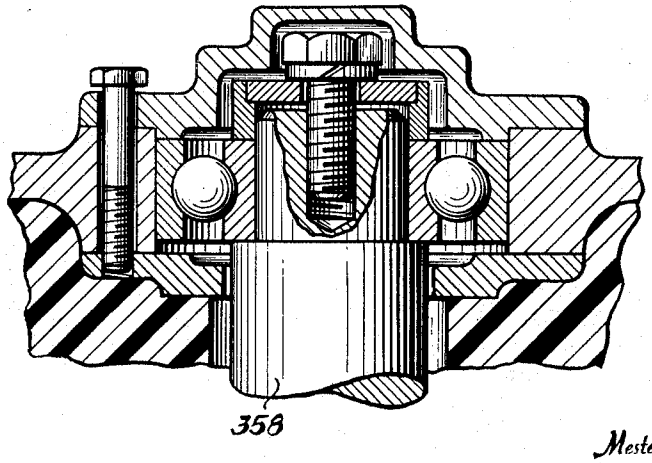


FIG. 9



INVENTOR
Georg NEIDL

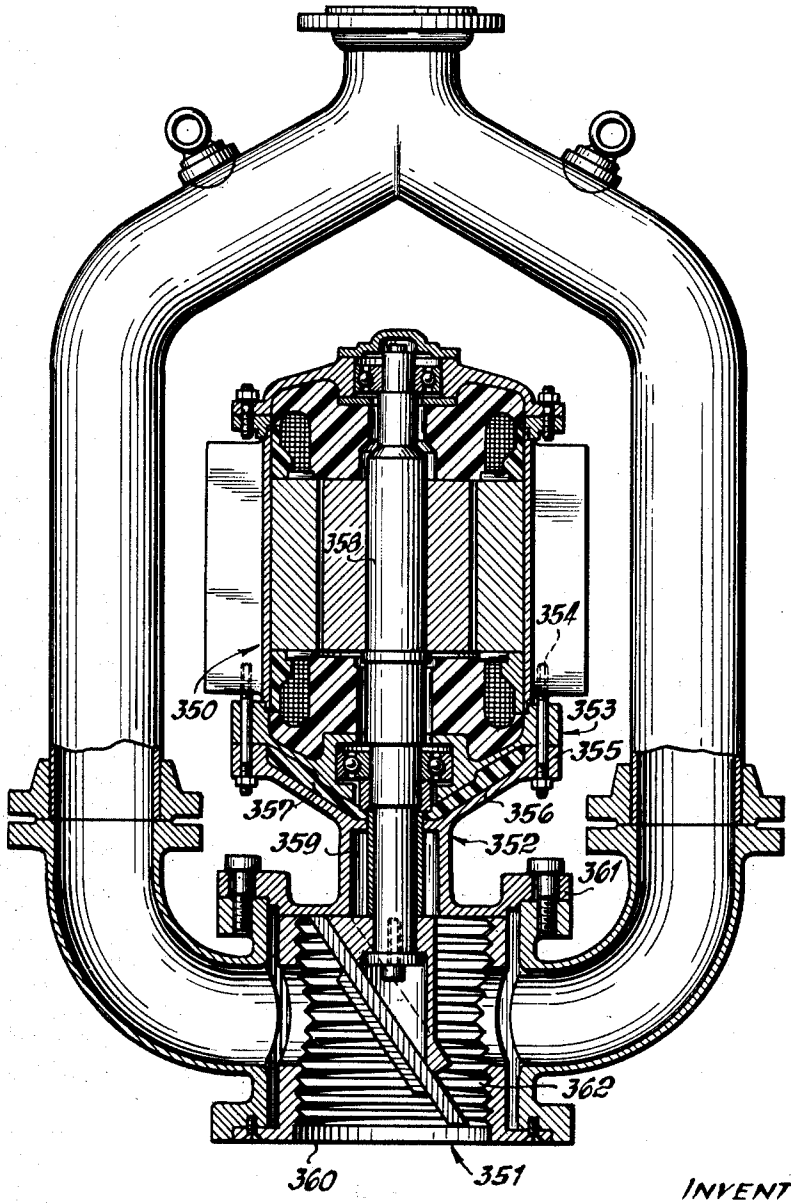
Mestern, Ross & Mestern

July 13, 1965 G. NEIDL 3,194,166

PUMPING PLANTS

Filed March 21, 1963 4 Sheets-Sheet 4

FIG. 8



INVENTOR
Georg NEIDL

Mestern, Ross & Mestern

United States Patent Office

3,194,166
Patented July 13, 1965

3,194,166

PUMPING PLANTS

Georg Neidl, Matschils, Triesen,
Furstentum, Liechtenstein

Filed Mar. 21, 1963, Ser. No. 267,390
Claims priority, application Germany, Mar. 23, 1962,
N 21,366
4 Claims. (Cl. 103—87)

This invention relates to a pumping plant wherein, preferably for purposes of the submerged mounting of the entire pump, the rotor of the electrometer driving the pump body is suspended inside the stator space.

The invention consists in that the stator containing the electric windings is arranged together with the windings inside the casing in a water-tight manner, and that further the bearing clearance of the top bearing, the clearance between the internal circumference of the stator and the external circumference of the rotor, and finally an annular cavity below the bottom bearing are all designed to be open towards the bottom, in such a manner that when the pump is sunk vertically into the liquid, to be let down to a prescribed maximum depth, under the action of the water pressure the air present in the said spaces is only compressed to such an extent that merely a part of the cavity below the bottom bearing is filled with the entering liquid.

The plant may be provided with an oblique disc pump in which, preferably for purposes of installing the whole pump under water, the stator is arranged inside the casing in a water-tight manner. In such a pump circumferential toothing is provided on the disc and a groove arrangement is provided on the internal periphery of the pump casing. However, an oblique pump disc may be used without the provision of teeth on the circumference of the disc or of grooves on the internal periphery of the casing.

As an improvement to and further development of the present invention, mass-produced electromotors are used which are inserted, with the interposition of an intermediate piece, between the casing of the electromotor and the casing of the oblique disc pump.

Further details of the invention are described in more detail with reference to the accompanying drawing, in which:

FIGURE 1 is a vertical section through an underwater pump with discharge pipes which are guided upwards around the casing of the pump;

FIGURE 2 is a top view of the pump according to FIGURE 1 drawn to a reduced scale;

FIGURE 3 is a fragmentary view of a cavity, arranged below the bottom bearing of the pump, in which water has penetrated;

FIGURE 4 is a vertical sectional view of another embodiment in which the actual pump casing is supplemented by a further, outer casing for upward conveyance of aspirated water into a discharge pipe.

FIGURE 5 is a cross-section through the machine along the line V—V of FIGURE 4;

FIGURE 6 is a part view of an upper bearing cover of the pumping plant in another embodiment;

FIGURE 7 is a perspective view of the pumping plant shown in FIG. 1;

FIGURE 8 is a vertical section through a further modified pumping plant; and

FIGURE 9 is again a vertical section, drawn to an enlarged scale through the upper suspension bearing of the pump shaft of the apparatus of FIGURE 8.

In the embodiment shown in FIGURES 1 to 3 the rotor **300** of an alternating current motor is designed as a short-circuit armature or squirrel-cage rotor. The rotor **300** has at its top and its bottom a respective shaft stub **301**, **302**. The shaft stub **301** is mounted in a roller bearing **303**, which has to take the actual weight of the armature **300** and the two shaft stumps and in addition supports the upper shaft stump **301** in the radial direction. At the upper end of the shaft stub **301** there is provided a journal **304** of smaller diameter, which is mounted in the roller bearing **303**.

The rotor **300** is surrounded by a stator **305**, which is inserted inside the motor casing **307** by means of pressure rings **306**. The windings **308** of the stator are connected with the stator by way of ties **309**.

The motor casing **307** is according to the invention, longitudinaly extended towards the top and the bottom, the free space between the stator windings **308** and the internal surface of the casing **307** being occupied by a filler material **310**, which solidifies after being poured in and encloses the stator in a water-tight and airtight manner inside the casing. The pouring of this filler material is preferably first carried out from above. Then after cooling the casing **307** is rotated through 180° and the corresponding cavity now at the top is likewise filled with the filler material.

The upper cover **311** is then screwed onto the casing, this cover having a sleeve **312** which fits so closely against the stator **308** and the shaft stub **301** that only a small clearance is left between the internal face of the sleeve **312** and the shaft stub **301**. On the other hand a small space must be provided between the upper end of the rotor **300** and the lower end face of the sleeve **312**, in order that the rotating armature does not rub. Further the cover **311** is so designed that it encloses the roller bearing **303** as closely as possible so that the air space caused by the roller bearing is also small.

Onto the upper cover **311** is screwed a further domed cover **313** whose domed part **314** houses a terminal box with the terminals for the electric cable **315**. On the domed cover there are provided eyes **316** for suspending the machine on lowering cables.

In the lower part of the casing **307** there is provided the lower cover **316** which is likewise equipped with a sleeve **317**, which encloses the lower stub **302**. The sleeve **317** has in the upper part a bush **318**, which surrounds the lower shaft stub **302** and thus supports it.

The lower end of the lower shaft stub **302** has obliquely fixed to it a pump-disc body **319**.

On the casing **320** there are provided, diametrically opposite one another, radially directed outlet connections **321** from which by-pass discharge pipes **322** are guided upwards, these pipes combining above the machine casing **307** to form a pressure manifold **323**.

The sleeve **317** is welded below the bush **318** to form a cavity **324**, through which the lower shaft stub **302** is guided. The inner generatrices of the two discharge connections **321** located at the upper culmination point are in alignment with the lower edge **325** of the cavity **324**.

The cavity **324** is formed in this way that its diameter

d inside the sleeve **317** is greater than the diameter c of the lower shaft stub **302**.

In order that, when the machine is placed in operation, the rotor together with the pump disc and the shaft stubs can take up a position symmetrically to the stator **305** inside the developing field of force, it may be advisable to design the roller bearing **303** not simultaneously as a thrust bearing, so that upon stoppage of the machine the lower end face of the rotor **300** lies on the upper end face of the sleeve **317**. In this case, upon starting of the machine, the rotor **300** is attracted into the rotary field of the stator **305** and hence upwards, so that the rotor is lifted away from the end face of the lower sleeve **317**.

If, according to the invention, the whole system is immersed in the fluid to be pumped, this fluid being pure water, sewage, sludge or any other desired viscous substance, then the air present in the machine casing **320** can escape via the two discharge connections **321** and the discharge pipes **322** (shown in dotted lines) into the common, vertical collecting pipe **323**. Hence the level of the material being pumped is theoretically fixed at the level of the edge **325**. According to the depth of sinking of the pumping plant and hence according to the extent of the excess pressure, the water level **326** will rise within the cavity **324**, as shown in FIGURE 3, and by selecting the size of the individual air spaces one can achieve the result that with a maximum immersion depth, there is still an air space below the lower end face of the bush **318**, so that the bush is not surrounded by fluid.

These conditions will be explained in more detail hereinafter by means of a numerical example:

Let it be assumed that the external diameter a of the rotor **300** amounts to 120 mm., whilst the internal diameter b of the stator **305** amounts to 121 mm. Then there is present between the rotor **300** and the stator **305** an air space of 0.5 mm. The length of the armature **300** is shown in FIGURE 1 at e and should be 200 mm. The diameter of the lower shaft stub **302** is designated c and should amount to 30 mm., whilst the internal diameter d of the cavity **325** is 40 mm. The length of the cavity **325** is designated f and is 150 mm.

Let it be assumed further that the air volume of the free space inside the roller bearing **303** including the volume of the annular gap between the shaft stub **301** and the cover **311** amounts to 10 cc. The air volume of the annular space between the armature and the stator is calculated as follows: The surface area of the entire stator cavity is calculated according to the formula $\pi/4 \cdot 121^2$ with a diameter of 121 mm. at 115 cm^2. From this must be deducted the surface area of the rotor which with a diameter of 120 mm. amounts to 113.1 cm^2. The difference between the said surface areas gives the surface area of the annular gap=1.9 cm^2. The volume of the annular gap then amounts, with the length e of 200 mm., to $1.9 \cdot 20 = 38$ cc.

The surface area of the cavity **324** is calculated from the 12.5 $cm.^2$ surface area corresponding to diameter d=40 mm. minus the surface area of the shaft stub corresponding to its diameter c=30 mm. and amounting to 7.1 $cm.^2$. The difference in the surface areas at 5.4 $cm.^2$ gives the cross-section of the annular cavity **324**, the volume of which with f=150 mm. length is approximately 81 cc.

If the whole unit is immersed in the fluid, then with an immersion depth of the magnitude zero, with respect to the lower edge **325**, the fluid level of the immersion material would be at the lower level **325**. On the other hand, if the unit is immersed to a depth of 10 m., then the immersed material, with an excess pressure of 10 m. head of liquid, and with an assumed specific weight of the immersion material of 1, penetrates via the annular surface **325** into the cavity **324** designated as a buffer chamber.

In order to calculate this depth of penetration, we will start for the sake of simplification from a isothermal compression, for which the following formula applies: $p_1 \cdot V_1 = p_2 \cdot V_2$. Here p_1 designates the pressure before the immersion=1.0 absolute pressure in atmospheres, whilst p_2=2.0 absolute pressure in atmospheres, i.e. the fluid pressure after immersion which acts in an upward direction against the annular surface **325** into the buffer space **324**. V_1 constitutes the sum of three volumes, i.e., the air space or volume of the bearing **303**=10 cc., that of the gap between stator and rotor amounting to 38 cc. and that of the buffer chamber **324**=81 cc. Finally V_2 designates the reduced volume which occurs as a result of the pressure p_2. Accordingly the following equation applies after the immersion:

$$V_1 = 10 + 81 = 129 \text{ } 130 \text{ cc.}$$

$$p_1 \cdot V_1 = p_2 \cdot V_2 = 1.0 \cdot 130 = 2.0 \cdot V_2$$

Thus $V_2 = 130/2$ or $V_2 = 65$ cc.

Naturally the volume of the roller bearing **303** remains unchanged at 10 cc. as also does the stator gap with 38 cc. This results in a volume of 48 cc. As, however, according to the calculation, the total volume still only amounts to 65 cc., then the free volume in the buffer chamber **324** is reduced to 65 minus 48, i.e. 17 cc., so that, as shown in FIGURE 3, water level **326** has risen in the annular cavity **324** to such an extent that a volume of 17 cc. remains between the lower face of the bush **318** and the water level **326**. As the annular chamber **324** has a cross-section of 5.4 cc., the level h according to FIGURE 3 is reduced to 17÷5.4=approximately 3 cm., whilst in the first instance according to FIGURE 1, the level h amounted to 15 cm. In this calculation the annular gap between the lower shaft stub **302** and the bush **318** has been disregarded for the sake of simplicity.

It can be seen from the above that at an immersion depth of 10 m. the water cannot penetrate into the electromotor at all, because the electromotor is a "filled motor" with respect to its stator and rotor and secondly the lower bush **318** is not even in contact with the water.

The intermediate ring **327** designated in FIGURE 1 constitutes a simple inventive means for lengthening the cavity **324**, in order to obtain suitably prescribed immersion depths with certainty so that the water level does not reach the lower annular surface of the bush **318**. The dimension f can thus be increased within certain limits. By this means not only the bush **318** but also the entire electromotor can be kept dry. One can also increase the diameter d of the cavity **324** in relation to the diameter c of the lower shaft stub **302** and have thus possibilities of increasing the buffer-chamber volume in both directions.

In order to keep the unit as light as possible, the sleeve **312** of the cover **311** can, as shown in FIGURE 6, be provided with cavities **328**.

According to the embodiment of FIGURE 4 there are provided instead of the discharge pipes **322** of FIGURE 1, the design of the pumping plant being otherwise the same, apertures **329** in the upper terminal wall of the pump casing **320**, so that the fluid sucked up enters through these apertures an annular chamber **330** provided outside the motor casing **307**, this chamber being formed by the provision of a hood **331** round the motor casing **307** tapering upwardly and opening into the discharge pipe **323**. In this embodiment the current cable **315** is guided through a bore in the hood and protected from penetration of water by a packing **332**. The carrying eyes **333** are in this embodiment secured to the hood **331**.

As shown in the sectional view of FIGURE 5, not only two diametrically opposite apertures **329**, but also additional openings **334** are provided in the pump-casing cover **320**. Finally, in order to have a particularly large transition cross-section, an annular aperture **335** may be provided in the upper casing cover as illustrated in dotted lines. The hood **331** is secured by means of a flange **336** to the pump casing **320**.

The machine may also be designed as a bore-hole pump. For this purpose the diameter of the pump is made correspondingly smaller, so that the armature and the stator of the electromotor must be made longer on account of the relatively smaller diameter, in order to obtain the necessary electric power.

The construction of the pumping plant according to the invention can also be used for pumps of normal design, that is to say for pumps wherein the pump rotor is not an oblique disc pump but, for example, a centrifugal pump impeller.

The filler mass **310** as shown in FIGURE 1 can also be used at the same time to fill the intermediate spaces between the individual groups of windings **308**. In this connection it may be expedient to use for the filler mass a material which has good heat conductivity in order to divert sufficiently outwardly the joulean heat generated.

Although the lower bush **318** is, according to the invention, not wetted by the water to be pumped, it may nevertheless be advantageous in certain cases to provide a stuffing-box packing on this bush **318**, so that a water- and moisture-repellent closure is obtained.

The unit according to the invention is, in contradistinction to known constructions, in full equilibrium, i.e. the unit never hangs askew, which is due particularly to the fact that the outflow of the liquid being pumped takes place by way of fully symmetrical outlet openings and outlet pipes.

From the perspective view in FIGURE 7 one can particularly clearly see the method of connecting the electric cable **315** and the form of the whole unit.

According to the embodiment shown in FIGURES 8 and 9 the mass-produced electromotor **350** is simply connected to the oblique disc pump **351** with the aid of an intermediate piece **352**, without any special adaptation of the casing of the electromotor. The lower cover **353** is screwed onto the flange **355** of the intermediate piece by anchor screws **354**. Between the lower motor cover **353** and the upper side **356** of the intermediate piece **352** there is preferably poured an insulating composition **357** and this intermediate space is thus filled and therefore has as little air as possible particularly in the vicinity of the rotating parts of the machine shaft **358**. The intermediate piece **352** has an annular space **359**, in which the air is compressed by penetration of water when the pump is lowered.

If such a plant is used for example as a dredger for pumping out, then the machines at the end of the dredging operation, usually therefore at nightfall, are lifted out of the water whilst the plant idles. Accordingly the annular space **359** can fill with fresh air again. It is different in a plant, for example, which is intended to be used as a sewage-pumping mechanism. This is sunk permanently in the sewage sump. In such a case, in modification of the inventive idea, on reaching of a certain maximum sewage level in the sewage sump, the circulating pump is automatically switched on exactly as when using normal pumps. On the other hand the stopping water level, that is to say the water level at which the machine automatically stops pumping, should not generally fall below the lowest edge **360** of the machine, because otherwise air is sucked through the machine in an undesirable manner. Generally such a machine is then switched off when the sewage just covers the lower part of the pump casing. This ensures that the pump contains no air pockets when the water level sinks. Otherwise the machine would begin to spin and accordingly cease or almost cease to pump.

During tests on the test stand it has been ascertained that the machine according to the invention pumps completely empty, that is to say right up to its lowermost edge, without spinning. This undesirable spinning only takes place when the water level sinks below the bottom edge **360**. In order to avoid this, there is used according to the invention a stopping electrode or a stopping float arrangement which switches on a retarding relay as soon as the water level has sunk to the upper edge **361** of the circulating pump. This relay establishes a slowing-down time of the circulating pump which can be set by hand. During this slowing-down time, the water level sinks to the lower edge **360** of the machine. At this moment frothing occurs between the sewage and the air, i.e. air enters the machine casing **362**. Only then does the machine stop after release of the relay.

By using such a retarding relay one ensures that the circulating pump and hence also the air space **359** can again fill with fresh air.

The air space inside the electromotor is, in the design according to the invention, so small that even when water does penetrate this small air space inside the electromotor, this water is evaporated on account of its small quantity in the shortest possible time by the heat produced by the running electromotor. The electromotor then runs without disturbance, except that its power factor, is increased or its efficiency somewhat reduced. This however is of no importance in coarse underwater operation, e.g., in dredgers, for pumping out ponds and the like.

If the motor is switched off and remains under water, then the water vapor condenses and water again penetrates the electromotor. At the next switching on the above-described operation is repeated.

If the motor is taken out of the water after being switched off, then the water runs out of the motor again.

In the latest electromotors the lacquer for the windings and other parts of the electromotor is of such high quality that penetration of water is to a certain extent harmless. Therefore, owing to the small extent of the empty spaces located in the motor, the penetration of the water is of no importance. In this connection the water by no means needs to penetrate so far into the motor that the latter is filled right up to the top with water. Thus is may happen that only as much water penetrates from below into the electromotor as to fill the latter half or three-quarters with water. Even when, through the intensive external cooling of the electromotor immersed in the water or sewage, the water which has penetrated the electromotor does not evaporate, it is only a question of such small quantities that the machine continues to work without disturbance.

Heat is consumed by the evaporation of the water or liquid in the filled electromotor. This favors at the same time internal cooling of the machine in an advantageous manner. The water vapor formed inside the filled motor may, in accordance with the inventive idea, be considered as a gas under pressure, which offers resistance to the penetration of the water from below. If condensation of the water vapor to water again occurs through cooling of the motor owing to a fairly long switching-off period, then the evaporation procedure is repeated after the electromotor is switched on.

I claim:

1. A totally submersible pumping plant comprising first housing means centered on a vertical axis;

an electromotor in said first housing means having a downwardly extending vertical shaft journaled coaxially therein and carrying an armature received with peripheral clearance in said first housing means;

an impeller cantilever mounted at a lower extremity of said shaft for rotation about said axis thereby;

second housing means surrounding said impeller and forming a downwardly open pumping chamber thereabout, said second housing means being formed with at least one generally radial outlet communicating with said chamber;

means forming an air compartment interconnecting said clearance and said chamber, said compartment constituting substantially the sole fluid communication with said clearance;

and bearing means interposed between said first housing means and said shaft at the junction between said compartment and said clearance, the air-enclosing volumes of said clearance and said compartment be-

ing so selected that, upon submersion of said pumping plant in an upright condition, the air within said clearance and said compartment is compressed and prevents entry of liquid into said first housing means through said compressor beyond said bearing means.

2. A totally submersible pumping plant comprising:
first housing means centered on a vertical axis;
an electromotor spacedly disposed in said first housing means and forming an annular conduit chamber therewith, said electromotor having a downwardly extending vertical shaft journaled coaxially in said first housing means and carrying an armature received with peripheral clearance;
an impeller cantilever mounted at a lower extremity of said shaft for rotation about said axis thereby;
second housing means surrounding said impeller and forming a downwardly open pumping chamber therearound, said second housing means being formed with at least one generally radial outlet communicating between said pumping chamber and said conduit chamber;
means forming an air compartment interconnecting said clearance and said pumping chamber, said compartment constituting substantially the sole fluid communication with said clearance;
and bearing means interposed between said first housing means and said shaft at the junction between said compartment and said clearance, the air-enclosing volumes of said clearance and said compartment being so selected that, upon submersion of said pumping plant in an upright condition, the air within said clearance and said compartment is compressed and prevents entry of liquid into said first housing means through said compartment beyond said bearing means.

3. A totally submersible pumping plant comprising:
first housing means centered on a vertical axis;
an electromotor in said first housing means having a downwardly extending vertical shaft journaled coaxially therein and carrying an armature received with peripheral clearance in said first housing means;
an impeller disk cantilever mounted at a lower extremity of said shaft at an angle thereto for rotation about said axis thereby and generation of a generally cylindrical surface by the periphery of said disk.
second housing means surrounding said impeller disk and forming a downwardly open substantially cylindrical pumping chamber therearound, said second housing means being formed with at least one generally radial outlet communicating with said chamber;
means forming an air compartment interconnecting said clearance and said chamber, said compartment constituting substantially the sole fluid communication with said clearance;

and bearing means interposed between said first housing means and said shaft at the junction between said compartment and said clearance, the air-enclosing volumes of said clearance and said compartment being so selected that, upon submersion of said pumping plant in an upright condition, the air within said clearance and said compartment is compressed and prevents entry of liquid into said first housing means through said compartment beyond said bearing means.

4. A totally submersible pumping plant comprising:
first housing means centered on a vertical axis;
an electromotor spacedly disposed in said first housing means and forming an annular conduit chamber therewith, said electromotor having a downwardly extending vertical shaft journaled coaxially in said first housing means and carrying an armature received with peripheral clearance;
an impeller disk cantilever mounted at a lower extremity of said shaft at an angle thereto for rotation about said axis thereby and generation of a generally cylindrical surface by the periphery of said disk;
second housing means surrounding said impeller disk and forming a downwardly open substantially cylindrical pumping chamber therearound, said second housing means being formed with at least one generally radial outlet communicating between said pumping chamber and said conduit chamber;
means forming an air compartment interconnecting said clearance and said pumping chamber, said compartment constituting substantially the sole fluid communication with said clearance;
and bearing means interposed between said first housing means and said shaft at the junction between said compartment and said clearance, the air-enclosing volumes of said clearance and said compartment being so selected that, upon submersion of said pumping plant in an upright condition, the air within said clearance and said compartment is compressed and prevents entry of liquid into said first housing means through said compartment beyond said bearing means.

References Cited by the Examiner

UNITED STATES PATENTS

2,764,943	10/56	Peters	103—87
2,839,006	6/58	Mayo	103—87
2,918,016	12/59	Olson	103—87
3,013,500	12/61	Bollinborn et al.	103—87
3,041,976	7/62	Maynard	103—87

FOREIGN PATENTS

77,426	4/18	Switzerland.

LAURENCE V. EFNER, *Primary Examiner.*
ROBERT M. WALKER, *Examiner.*