June 14, 1955 O. KRIEGBAUM 2,710,579

DEEP-WELL PUMPS

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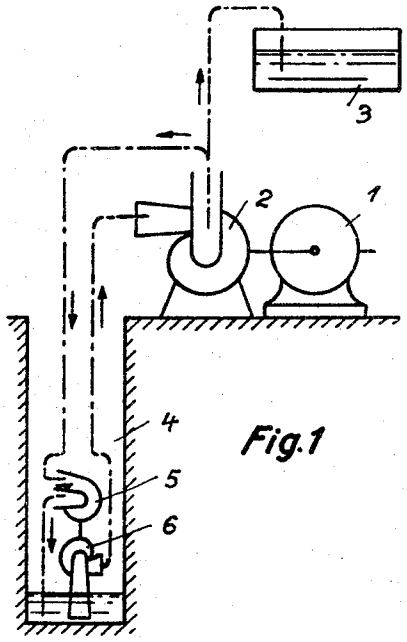


Fig.1

Fig.2

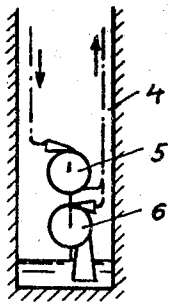
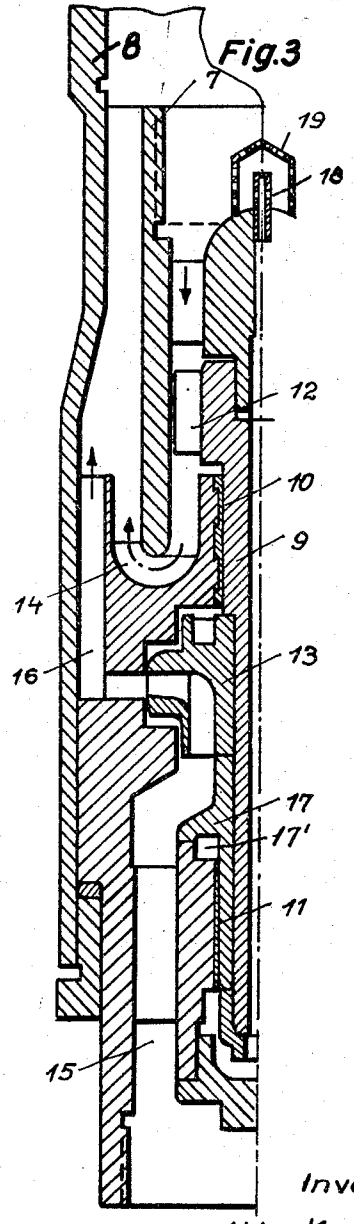


Fig.3



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Fig. 4

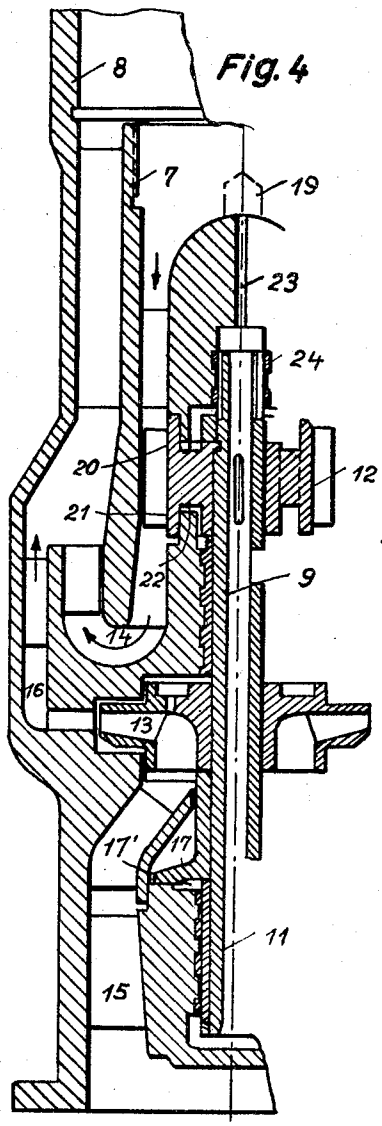
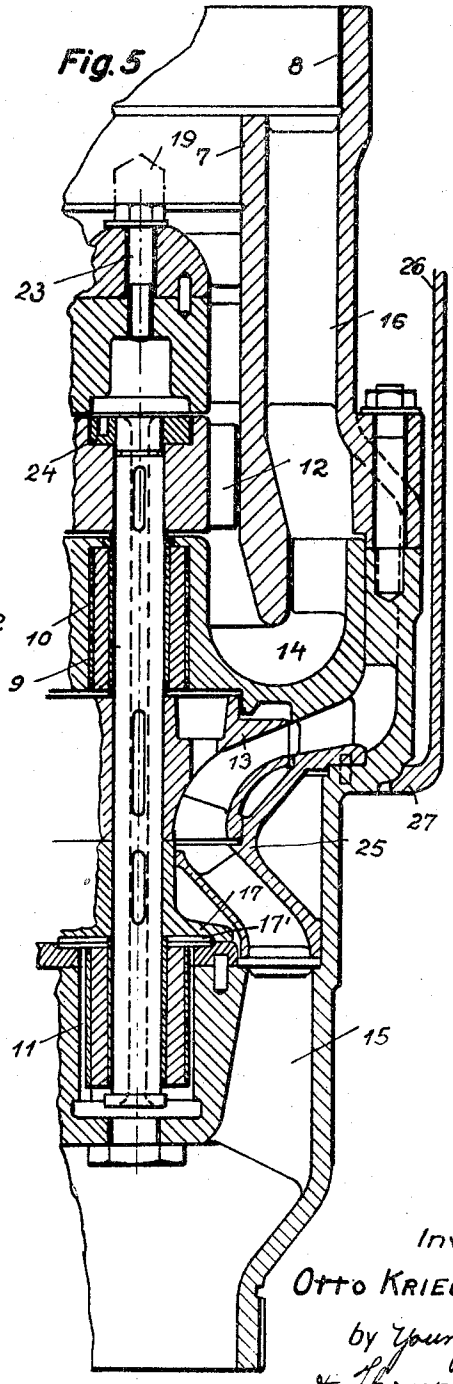


Fig. 5



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DEEP-WELL PUMPS

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3 Claims. (Cl. 103—87)

This invention relates to means for raising liquid from deep wells, bore holes, shafts and the like, hereinafter generally referred to as bore holes, more particularly from those of great depth.

It is known to pump water, oil or the like out of bore holes by means of a centrifugal pump arranged upon the bottom of the bore hole and connected by means of a long shaft with a motor at the surface. Such devices are unsatisfactory, because they involve, especially in the case of deep bore holes, great expenditure of constructional materials, and in consequence of the friction in numerous bearings they dissipate a great deal of power.

On account of these defects, so-called sub-aqueous or submerged pumps have been adapted instead. Here it is a question of an electric motor evolved for this purpose, which is combined with the pump, and can be suspended in the bore hole with the latter as a structural unit. With these composite units the electric motors have to be provided with a diving bell, to protect the winding from the water. Otherwise the motors would have to be constructed as submerged rotors, the rubber-insulated winding of which can remain in the water. It is however that the motors of submerged pumps, notwithstanding all precautions, are very sensitive and not sufficiently reliable in operation. Upon failure of the diving-bell device, or in the case of the smallest leakage of the submerged rotor winding or of the current-supply cables, the entire unit becomes inoperative. If these pumping units are employed for raising oil, there is a further disadvantage in the risk that in the event of sparking, and the occurrence of oil gases, explosions may occur. It is particularly disadvantageous, however, that the motors of submerged pumps, with the usual number of 50 periods per second, only permit of a speed of not more than 3000 revolutions per minute. At this speed, however, a single-stage centrifugal pump of moderate power attains a delivery height of only about 50 to 60 metres. For bores of greater depth, therefore, multi-stage submerged pumps are necessary. These however involve more powerful driving motors, which in their turn, on account of their larger dimensions, pre-suppose bore holes of larger diameter. The greater the diameter of the bore hole, however, the more does the expenditure of time, labour, material and money for sinking the bore hole increase. Known subaqueous or immersion pumps of an efficiency which is satisfactory as regards both power and price are therefore available only for limited bore-hole depths.

It would be possible to install above ground a relatively large ordinary centrifugal pump the pressure water of which would be supplied for the greater part to a water-jet pump located in the bore hole, and the service water of which, together with its power water, would be supplied to the centrifugal pump at the ground level. Water-jet pumps, however, as is known, have a very low efficiency, and are therefore likewise inadmissible, apart from the question of dimensions, for the raising of liquid from bore holes.

According to the invention the problem set forth is

solved in a simple and advantageous manner by associating with a pressure-medium generator, for instance a main pump, located at the surface level, an engine set capable of being inserted in the bore hole, consisting of a rotary engine operated by the pressure fluid, for instance a turbine, and a centrifugal pump or turbine pump driven thereby. Preferably the construction is such that the turbine and the centrifugal pump form a unit, that is to say, they can be put in and brought out as a unitary structural whole. Preferably the turbine rotor and the pump impeller will be mounted upon a common shaft.

The turbine is fed by the main pump. It sets in rotation, the centrifugal pump, which sucks out of the bore-hole the liquid to be raised, water for example, and feeds it through a delivery pipe, together with the operative liquid of the turbine, water for instance, to the main pump at the surface. This pump diverts the service water to the consumer and returns the power water to the turbine in the bore hole.

For the path of the water through the machine unit there are two possibilities. The arrangement may be such that the turbine consumes either the entire head right down to the pressure before admission to the centrifugal pump, or it may be such that the turbine consumes only the head down to the delivery pressure of the centrifugal pump. In the former case the water that drives the turbine is either discharged from the turbine into the ground water at the bottom or is fed directly to the suction side of the centrifugal pump, and from the latter is conveyed, together with the service water, to the main pump. In the second case the power water consumed by the turbine, together with the water delivered by the centrifugal pump, is fed directly to the main pump. The second solution is to be preferred, on the ground of better over-all efficiency.

Since for the functioning of the engine set consisting of the turbine and the centrifugal pump the relieving of the axial thrust of turbine and pump is important, a further feature of the invention consists in so arranging the pump rotor and the turbine rotor that their axial thrusts are opposite to one another, and thereby to a material extent counteract one another. This opposite arrangement of the turbine and pump rotors is obtained by arranging the turbine and pump in such a way that the water flows in to both from above, or to both from below.

A further possibility for relieving axial thrusts consists in the use of a balancing or relieving disc known in itself, which here however, in a further development of the inventions, serves for relieving the entire rotor embracing the pump impeller and the turbine wheel, and is so arranged that it is subjected on one side to the highest pressure occurring, namely the pressure before the turbine inlet, and on the other side to the lowest pressure, namely the pressure before the pump inlet. This renders it possible, with a comparatively small balancing disc, to obtain an extensive balancing of the axial thrusts.

To the balancing disc, according to a further feature of the invention, the pressure water is supplied with the pressure before the turbine, preferably through the common shaft, constructed as a hollow shaft. It is advisable in this case to pass the pressure water through the lower guide bearing of the shaft for the lubrication thereof. On this account the balancing disc may be arranged between the centrifugal pump and the lower journal bearing.

In a further development of the ideas of the invention with respect to balancing, it is provided to bring about another special partial balancing of the axial thrust of the turbine by equipping the disc which carries the blading of the turbine wheel, and which is provided both

on the admission side and on the exhaust side with a gap packing, with axial ducts, which serve to equalize the pressure on both sides of the turbine wheel. The construction may be such that the water flowing outwards through the gaps passes through the upper journal bearing of the shaft for the lubrication thereof. This water passing through the clearance space is preferably withdrawn at the same place as the pressure water for the balancing disc. In order to prevent sand entering the bearings and the clearance packings a filter may be interposed before the point of withdrawal of the balancing, clearance-packing and lubricating water.

It is advisable to provide the turbine with a distributor or guide apparatus and a rotor of axial construction. The channels are then open on all sides. Consequently there is the advantage of simplicity of manufacture. A particularly important advantage is that this construction enables the diameter of the casing to be kept small.

The pump may have a runner of radial or semi-axial construction. If desired it may even have a channel rotor. It will preferably have a one-piece inlet and outlet guide, the admission part of which may serve at the same time as a casing for the balancing water.

For the attainment of an upwardly directed axial thrust counteracting the intrinsic weight of the rotor, it would be possible, if desired to admit the water into the impeller of the pump from above. In this case the impeller side plate may be employed as a rotating balancing disc, and the guide-wheel side plate as a stationary thrust disc or counter-disc.

It has also been found particularly advantageous to provide the machine unit with two concentric tubes, to the inner one of which the pipe for the power water for the turbine can be connected, and to the outer one the pipe for the delivery water. The machine set therefore possesses, in a sense, a casing consisting of two concentric cylinders, which are equipped with pipe unions for the power-water and delivery-water pipes one inside the other. This construction helps to keep the over-all diameter small so that a pumping unit of comparatively large power can be introduced into narrow bore holes.

By this invention the defects hereinbefore described of known devices are obviated. In particular the liability to disturbance inherent in known deep-wall pumps is eliminated. Since the main pump, at the ground level, may be driven not only by an electric motor but even by a heat engine, the pumping apparatus according to the invention is entirely independent of any source of current. Accordingly the main pump is characterised by an extensive adaptability to practical operation. Since any required pressure may be adopted for the pressure medium above ground, the centrifugal pump may be driven at a speed corresponding to current needs. An increase in speed, which is thus readily obtainable, leads however to a considerable increase in the lift or delivery head. With this is associated a further important advantage. Since the quantity delivered increases in proportion to the increase in speed, it is possible, without reducing the delivery, to employ a smaller pump and therefore a narrower bore hole. This however is already of great importance, on account of the time and expense involved in sinking a bore hole. When raising liquid from a group of deep wells there is the special advantage that the pressure fluid can be provided by a single main pump, feeding a number of machine sets located in different bore holes. From this single main pump the service water raised from all the deep wells can then of course be led to the various consumer points. Since this involves a comparatively large main pump, the latter will work with very good efficiency.

Further features and advantages of the invention are explained in the ensuing description of the drawing, which illustrates a few constructional examples of the invention.

Figures 1 and 2 are diagrammatic views representing the fundamental arrangement according to the invention with Figure 2 showing a modification of Figure 1.

Figure 3 is a longitudinal section of a portion of a turbine pump for use in the arrangement according to Figure 2.

Figure 4 is a longitudinal section showing a modification of Figure 3.

Figure 5 is a longitudinal section showing a further form of construction.

A motor 1 drives a main pump 2, which is located at the surface level, and which supplies the water raised partly as service water to a consumer, for instance to a reservoir 3, and partly as power water to a turbine 5 located in the bore hole 4. This turbine, together with a centrifugal pump 6 driven thereby, forms a machine unit which can be conveniently introduced into and withdrawn from a bore hole.

In the construction illustrated in Figure 1, the water leaving the turbine 5 flows on to the bottom of the bore hole and then directly into the suction inlet of the pump 6, which furthermore draws in the service water by suction and forces it, together with the power water from the turbine 5, to the main pump 2.

In the construction according to Figure 2, the same pressure prevails at the turbines outlet as on the pressure side of the bore hole pump 6, so that the water leaving the turbine can be introduced directly into the delivery pipe of this pump.

The turbine pump unit of Figure 3 comprises two concentric pipes 7 and 8. The pipe 7 can be connected to the pipe through which power water flows to the turbine. The pipe 8 is connected to the delivery pipe.

Upon a hollow shaft 9, which is supported by means of two guide or journal bearings 10 and 11, is mounted the turbine blading 12 and the pump wheel 13. From the turbine the power water flows by way of a bend 14 into the delivery pipe 8, while the service water, sucked in by the pump from the bottom of the bore hole through an annular space 15 passes through an annular space 16 into the delivery pipe 8. In the latter the service water, together with the power water, flows to the main pump 2.

Between the lower guide bearing 11 and the pump impeller 13 there is mounted upon the common hollow shaft 9, a counter disc 17, which on its upper surface is subjected to the pressure that prevails on the suction side of the pump. The pressure water for the other side or space 17' of the balancing disc is taken from the pipe 7 at a point 18 at the upper end of the hollow shaft 9 and is supplied through the hollow shaft 9 and around its lower end to the counter disc 17. On its way the pressure water flows through the lower guide bearing 11 and effects the lubrication thereof.

A filter 19 is preferably located in front of the withdrawal point 18 at the upper end of the hollow shaft 9, so that sand and other foreign substances are excluded.

A turbine-pump unit of Figure 4 is distinguished from that of Figure 3 primarily by the fact that an additional balancing device for the turbine wheel 12 is provided. This balancing device is sealed in relation to the machine body on the inlet side and on the outlet side by means of clearance gap packings 20 and 21, and is furthermore provided with ducts 22 which connect the two sides with one another, so as to equalise the pressure. Part of the water flows through a duct 23 and the hollow shaft 9 to the counter disc 17 and passes through a bearing 24, which is lubricated and acts as a water seal for the clearance-gap packing 20 on the admission side of the turbine, and in consequence of the ducts 22 to the clearance-gap packing 21 on the exhaust side of the turbine.

In the constructional example of Figure 5, for the pump impeller, an insertible distributor or guide apparatus 25 surrounding it is provided, the inlet and outlet portions of which are in one piece. The inlet portion

of this guide apparatus serves at the same time as a casing for the water of the counter disc **17**.

As Figure 5 shows, the machine set may be suspended from a stationary jacket tube **26**, which is equipped with a carrying ring **27**, upon which the casing of the turbine pump unit rests in a fluidtight manner. When such a jacket tube is used, the outer delivery tube **8** may be omitted. The jacket tube greatly facilitates the introduction and withdrawal of the machine set and of the associated suction pipe and the foot valve that shuts off the latter. In particular in the case of great depths the jacket tube presents noteworthy advantages. When installing the machine set the jacket tube is introduced first, after which the suspension of the machine set, with its power-water pipe, can be quickly and easily effected. When removing the machine set the jacket tube may remain in the bore hole.

The pressure medium, that is, in the case of pumping water, the power water, need not necessarily be supplied to the turbine by a main pump. Any other suitable means of producing pressure fluid may be employed. Thus for example the power water pipe may be connected to a hydraulic main.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. Apparatus for raising liquids from deep wells, bore holes, shafts and the like, more particularly from those of great depth and operable by a pressure fluid, comprising a machine unit which is capable of being introduced into the well and having an axial turbine operated by the pressure fluid and a centrifugal pump driven by and arranged below the turbine, a hollow shaft in

the unit on which the turbine and pump are mounted for conveying a liquid drive medium, a pair of concentrically arranged pipes one of which is connected to the centrifugal pump to convey the liquid from the well and the other is connected to the turbine to receive the liquid from the shaft, a counter disc mounted on the shaft between the pump and the bottom end of the shaft which on one side is subjected to the pressure of the turbine inlet and on the other side to the pressure of an inlet of the centrifugal pump, and a lower guide bearing on the bottom end of the shaft.

2. Apparatus for raising liquids according to claim 1 in which gap packings connected by ducts are provided at the inlet and outlet ends of the turbine to equalize pressure.

3. Apparatus for raising liquids according to claim 1, in which a filter is provided at the top end of the hollow shaft.

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