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SCREW PUMP

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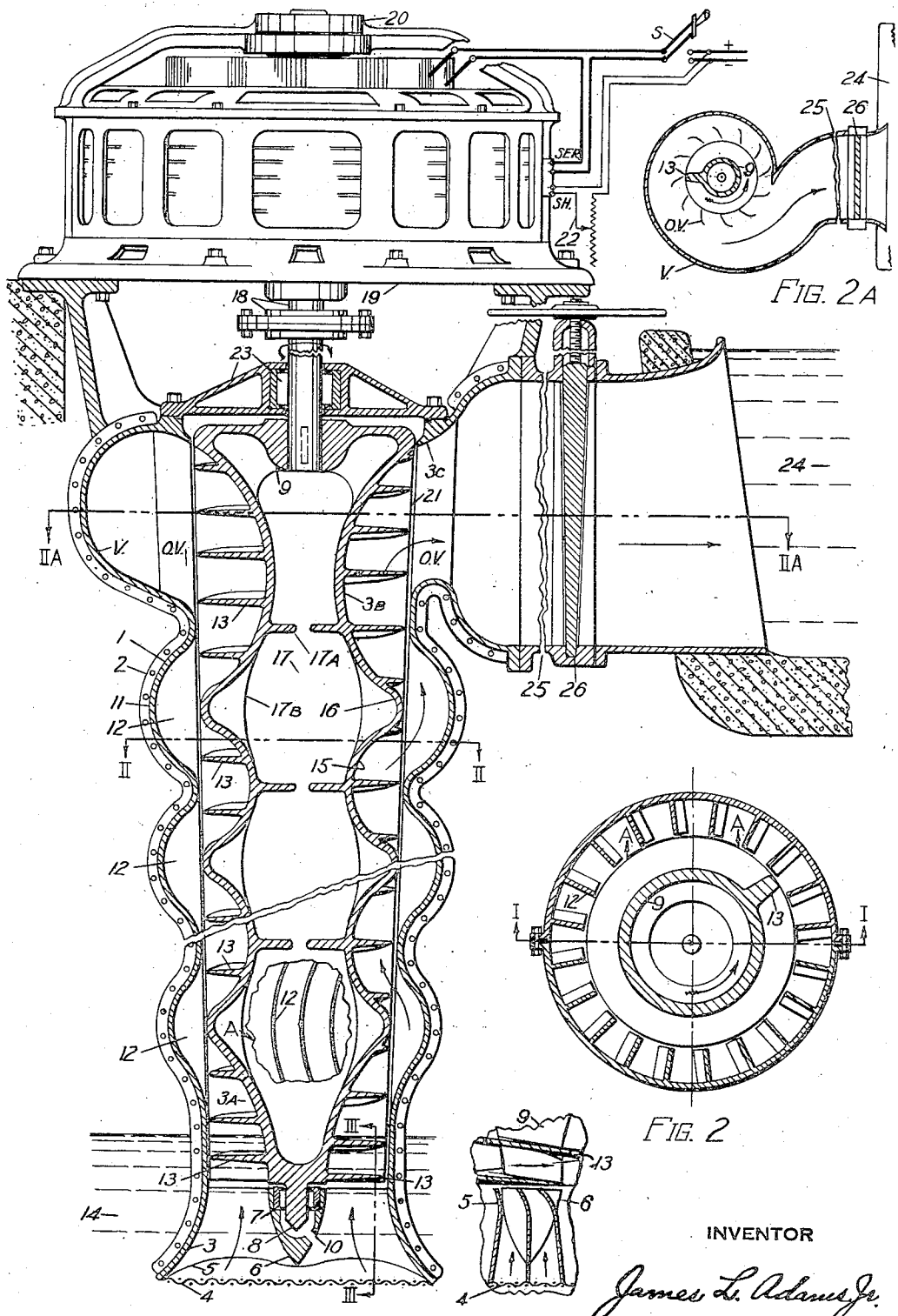


FIG. 2A

FIG. 1

FIG. 2

FIG. 3

INVENTOR

James L. Adams Jr.

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SCREW PUMP

James L. Adams, Jr., Youngstown, Ohio

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This invention relates to the art of hydraulics, and particularly to the development of high-efficiency, stream-line flow screw pumps, reversibly operable as turbines, if and when required, and capable of handling tremendous volumes of fluid, at very moderate maximum fluid velocities, and with an ultra-minimum of loss-of-head due to friction encountered in transit.

The listed features just mentioned constitute the most important objects of my present invention, but an added object of considerable importance is the production of an apparatus of very simple design and construction, well adapted to the provision of flow passages of great cross-sectional area, in which such areas are maintained substantially constant from end to end thereof, or varied only where the water velocity varies, and in inverse proportion thereto.

A further object of value is the development of a design of pump in which the fluid flow is made a reasonable approach to that of the straight-line type, with long radius hydraulic bends provided throughout, for all deviations from such a type of course, so as to cut all losses-of-head here to a minimum.

An added object of prime importance is to provide a design in which fluid is in effect carried through enmasse, or in slugs of very large bulb, only a minimum fraction of which will be brought into actual contact with moving vanes, or passages which are stationary, but in relative motion thereto. This is in order to cut down friction losses to a minimum, and increase the over-all efficiency. Another essential object is to obtain a device having relatively low velocities, at all points of contact of fluid with the moving structure, in contra-distinction to those usually pertaining at such points in a centrifugal pump, for example.

This again is in order to be able to lower the friction losses, and increase the efficiency of the device as a whole, which is very important in a large unit.

A supplementary object is to provide a pump in which the entire rotor can be freely removed endwise as a unit, when required, by simple removal of the top end bell and bearing, and/or the driving motor, as the case may be.

Yet another object is to distribute the lift widely in the vertical direction through the machine, so as to again require but low velocities of relative motion at any point therealong, and again increase the efficiency thereby.

An additional object is to combine, for the first time, all the above objects of value in a single working structure, which is very easily assembled, or gotten at later on for maintenance purposes, and with the possibility of repairs reduced to an ultimate minimum.

Other objects of material value will be self-evident to any one skilled in the art.

With all these and other objects in view, I have shown a preferred form of apparatus by which these ends may be attained in a practical way, and will describe its construction, and mode of operation herein, but such embodiment is to be taken as simply illustrative of my invention, and not as limiting the same, or the scope of my broader claims.

In the drawing, Figure 1 is a vertical axial section of the preferred form of my new pump, but with part of the rotor broken away at point A to show the preferred form of the stationary vanes in rear.

Figure 2 is a transverse section taken on the line II—II of Figure 1, looking with the arrows, Figure 2A ditto but on line IIA—IIA instead, and at one-third size, while Figure 3 is a vertical section taken on line III—III, of Figure 1, and intended to show the shape of the stationary entering vanes below.

In all the figures identical parts are indicated by the same part numbers, while feathered arrows show rotations, and plain arrows the liquid flows.

Referring now more particularly to Figure 1, there is shown at 1 an outer stator casing of coarsely corrugated exterior appearance, which may if desired be longitudinally split and bolted together, along a plurality of seams 2, and which at its lower end is provided usually, but not necessarily, with an entering Venturi bell 3, protected on its entrance side by a heavy cross grid or screen 4, which may, or may not, be made so as to be readily removable for cleaning purposes, said bell carrying by means of the radial vanes 5, set at a proper angle with the vertical, or curved as required, the stream-lined lower housing 6, mounting the roller-bearing 7, preferably made of stainless-steel or some non-rusting alloy, and with its rolling parts so caged that if pointed shaft 8, of main rotor 9, be withdrawn vertically, such parts will not fall out of place, but will readily receive shaft 8 again on its careful later return to operating position within the bearing. Suitable sand vents 10 will of course be placed at bottom of said housing 6, or the customary dirt seal (not shown), added around the top of bearing 7, as desired.

Within the large and peripherally directed in-

ternal corrugations 11, of main pump casing 1, and preferably cast integrally therewith, are a plurality of radially and more or less vertically directed thin and smooth vanes 12, whose preferably curved outline is best shown through the broken window A made in the rotor 9, which allows a view of these vanes at the back side of stator casing 1, and brings out the curvature provided to permit entrance of the fluid without shock, or sudden change in direction, but which eventually re-directs it more or less "against" the direction of rotation of the succeeding spiral vanes 13 of the rotor, which are positioned just above. These vanes 13 are also preferably cast integrally with the element to which they are attached, and are positioned so that with the indicated direction of rotation of the shaft 8, they will tend to "screw" down into the incoming fluid entering from the lower reservoir 14, and lift said fluid bodily, while any tendency of this fluid to take up rotation is repeatedly annulled by the successive entrances of said fluid into the stationary vanes 12, above mentioned.

This question of possible rotation of the whole body of fluid, en masse, is one of the weak points in the old Archimedes screw pump, which in many respects has much to be said in its favor, particularly for large installations. But if any attempt is made to speed up its action and so get a good output, the entire mass of liquid is always liable to get into full rotation and thus churn around indefinitely without raising any water at all. Its other great disadvantage is that it must be set at not over about 45 degrees from the horizontal, and the screw element must therefore extend to about 1.43 times the total lift, often giving an enormous total length of rotor. These disadvantages are not at all shared by the pump of my invention, in which rotation of the liquid to any material extent is impossible, and in which the total lift may be several times the total length of rotor, if so desired, while the vertical disposition of parts provides a materially easier type of construction, more readily handled by crane or otherwise.

Reverting to Figure 1, it will be noted that the rotor 9 is also of the corrugated type, with peripherally extending deep depressions or corrugations 15, followed axially by the pronounced ribs 16, all well rounded in the generally vertical direction of fluid travel, so as to present easy hydraulic bends to said fluid throughout its course, this likewise applying to all interior curved surfaces in the outer casing 1, the latter forming corrugations which are of about the same size as those on rotor, but staggered with relation thereto, so as to form fluid carrying passageways therebetween which are adapted to carry the same volume of flow throughout their length, but with somewhat lower velocities applying near the entrance into the pump, and at its final exit position, where the Venturi sections are located.

Note that it is impossible for the fluid to travel upward without repeatedly entering the rotor and then the stator passages, in succession.

The interior of rotor 9 is preferably made hollow so as to form the float chambers 17, which may or may not be inter-connected by passages 17_A, and ribbed as at 16_B, if desired for further strengthening, or stiffening longitudinally.

These float chambers 17 may be so designed as to just give sufficient buoyancy in the fluid used to carry the entire working weight of the rotor and connected parts 18 of the driving motor 19 (when it is being used as a generator), but said motor will nevertheless be provided at its top with a roller-bearing of the thrust type, or with a "Kingsbury" thrust bearing, as indicated at 20, and adapted to take care of all the unbalanced weight of the moving system plus the normal downward load-thrusts thereof as they occur.

The interior line of casing 1 and its included vanes 12 forms a cylindrical, or but very slightly coned surface, with the small end of the cone to the bottom.

The exterior outline of rotor 9 and its included spiral vanes 13 is made to match the cylinder or cone of said casing 1, with a small amount of running clearance as indicated at 21, and as best determined by trial, it being noted that if the two main machine elements 1 and 9 are made coned, a slight adjustment of this running clearance may be made at any time by variation of the thickness of liners interposed in the coupling means included under 18, above, or by other convenient expedients well known in the art. As shown, the coning is somewhat exaggerated.

Between motor 19, (which should preferably be provided with a control switch S, and with speed regulating devices, to give various running speeds as required, and as shown at 22), and the rotor 9, there may or may not be provided an intermediate bracket with bearing 23, also preferably of the roller type, and for pumps having ultra long working systems or barrels, as for very high lifts, there may even be occasionally required a further intermediate bearing located conveniently along the rotor, (but not shown).

Normally the length of rotor 9 and casing 1, will not equal the lift required, but only a moderate fraction thereof, although for high-capacity, low-lift pumps designed for enormous water-flows per minute, these parts may sometimes run to ¾ or over of the total lift to upper receiving pool 24, or even 100% of this, as in Figure 1. If the pump happens to be designed to run in reversed direction as a turbine occasionally, I add a short penstock 25, suitably valved as at 26, these being provided at this point for such type of operation only, usually.

In this event also, some well known type of governing device, (not shown), would necessarily be required, to definitely determine the speed under each load.

If a D. C., an induction, or a synchronous A. C. motor drive is used, these may be readily arranged for such reversed operation as generators, by well known means, but the latter two will usually require inclusion of a speed-change gear.

It will be noted that the longitudinal sections of the spiral vanes 13 may show the latter as transverse either to the axis of rotor, or to the flow of fluid, as may be deemed preferable.

The former disposition has been shown in Figure 1, as the simpler to cast.

It will also be noted that the slope of the spirals 13 may in some cases be altered at different positions along the rotor 9, so as to better conform with varying vertical velocities of flow encountered at successive positions therealong.

Thus at the entrance to the Venturi bell 3, and through the stationary vanes 5, as well as for the first spiral vanes 13 encountered, the fluid velocities will be increasing gradually, but still will not equal those finally attained farther on up in the pump. This is taken care of by the gradually decreasing diameters of the Venturi bell just mentioned, and by an extra radial depth of the passages through rotor 9, near its bottom end, together with a somewhat reduced angle of

slope for the first turn or two of the spiral vanes 13, encountered here, as shown in Figure 1. Thus Venturi section 3 is continued through the lower end of the rotor at 3_A, and a Venturi exit bell is formed by proper shaping of the top of the rotor at 3_B, and of the stator at 3_C.

Longitudinally straight, but radially curved outlet vanes are indicated at O. V.

Note that the outer passages up through vanes 12 appear to be smaller than those in general through the rotor spirals 13, but that when the respective radial distances out from the axis are considered, all these passages are found to be of substantially equal flow capacity, after counting in some slight local changes of flow velocity, as just above outlined. A volute for the emergent (or the entering) fluid flowing into (or out of) upper reservoir 24, is shown at V. Variations in total pump output are provided for by varying the speed of the drive. Priming of this pump will not be required, as it starts with the lower spiral vanes 13 submerged, and the total lift is well distributed throughout the length of rotor and casing, particularly for the lower lift, and very high capacity designs of pump.

In Figures 2, 2A and 3 no new parts appear, but the relations of parts already designated are in some cases brought out to better advantage than before.

In the operation of the pump of my invention, it will be observed that if the contained fluid can be prevented from gradually acquiring the rotation of the rotor, the spiral vanes must lift the liquid bodily up through the pump.

It is the precise function of the successive sets of more or less vertically directed stationary vanes 12, in the casing 1, to do just this, by not only redirecting the fluid toward the vertical flow direction periodically, but actually re-entering said fluid somewhat against the rotation of the spiral vanes 13, at each such time, and thus further obviating any material tendency toward rotation, in the rotor's direction.

And since the fluid is taken through in relatively large masses which are running at very moderate velocities only, and since only a minimum number of well smoothened vanes are encountered in transit, which come into physical contact with but a minor fraction of the actual total fluid contained in said masses, the friction losses, as well as the tendencies to rotation in these masses, are both low, in contra-distinction to the normal value of such losses in the usual centrifugal pump, for example. Hence my pump is well qualified for high capacity operations, where great horse-powers are involved, and the utmost operating efficiency attainable is a prime requisite. It is also readily designed for the speeds which are convenient to motor drives, but is more suited to variable speed D. C. motor operation, than for A. C. motor drives of the customary types, since the pump is fundamentally a constant-torque, variable-speed device, in which variations in flow are best attained by corresponding velocity changes, not ordinarily so readily provided by the usual A. C. motors, at high operating efficiencies.

I have therefore indicated a D. C. variable-speed shunt-wound motor drive in connection with my Figure 1, although I do not wish to specifically limit myself to such type of motor drive, or even to an electrically driven type of motor, although the latter is much the best if any reversal of function of the pump is to be attempted later on.

I claim:

1. In a screw pump, a rotor containing an externally and transversely corrugated element of substantially cylindrical outline, helical screw blades mounted on the corrugations of said element and lying within the generally straight, cylindrical outline of the said rotor, a stator surrounding the rotor and comprising an internally corrugated casing, with the corrugations partially displaced axially of said pump with respect to the corrugations on the rotor, a plurality of longitudino-radial guide vanes mounted in peripherally spaced relation within the corrugations of said casing, and forming a substantially straight cylindrical internal working face for said stator, with a slight radial clearance to the above cylindrical surface of the rotor, and a power driving means for the said rotor, the said blades and vanes being in general longitudinally out of alignment with each other.

2. A screw pump as in claim 1, in which the relative displacement of the corrugations of the stator and of the rotor provides a substantially annular fluid passage therebetween of substantially constant cross-section throughout as measured transversely to axis of the said pump, and at various positions along said axis, but with said passage entirely within said cylindrical working face, and then without the same radially, in alternating succession.

3. In a screw pump, an elongated working element comprising a series of longitudinally spaced helical screw sections, said element having a series of external, transverse corrugations mounting the said screw sections therein so as to form a substantially continuous, straight, cylindrical working surface outline thereon, an opposed working element comprising a series of similarly spaced internal corrugations, which are concentric with but axially displaced along said pump with respect to the said external corrugations, substantially longitudino-radial guide vanes mounted within the corrugations of said opposed working element to form a working face of continuous, straight, cylindrical outline matching, but in radial clearance relation to, the said cylindrical working surface first mentioned, whereby an axially directed fluid passageway of substantially constant cross-section is formed by and between the two sets of corrugations above mentioned and alternately wholly in each.

4. In a screw pump, a casing comprising a series of axially spaced internal corrugations, an end-bracket mounted removably on said casing, a relatively rotatable element comprising a series of similarly spaced external corrugations all relatively displaced axially of said pump with respect to the casing corrugations, substantially longitudinal guide vanes mounted within the corrugations of said casing, helical screw blades mounted within the corrugations of the said relatively rotatable element, a power driving means for the said pump, and fluid directing vanes in the casing mounting a foot-bearing adjacent the bottom end of the rotatable element, the said guide vanes and screw blades forming continuous and substantially straight cylindrical opposed working faces on the said casing and rotatable element respectively, providing for ready withdrawal of the latter axially upon the removal of said end-bracket.

5. In a screw pump, a member comprising a series of large peripheral corrugations with intermediate ridges, the said series being spaced axially of said pump, a relatively rotatable element

comprising a series of similarly spaced but radially oppositely directed corrugations with intermediate ridges, the ridges on the said member and the said relatively rotatable element being axially displaced relatively along said pump, substantially longitudino-radial guide vanes mounted within the corrugations of the said member, and helical screw blades mounted within the corrugations of said relatively rotatable element, the said vanes and blades forming opposed and closely adjacent continuous working surfaces each of substantially straight cylindrical form, and which lie substantially flush with the salient tips of the respective ridges mentioned.

6. A screw pump as in claim 5, in which the adjacent working surfaces of the member and of the element are characterized as being of slightly conical outline, enlarging in the normal direction of axial removal of the relatively rotatable element, the corrugations of the member being internal, and those of the rotatable element external.

7. In a screw pump, a hollow cylindrical casing, a cylindrical rotor concentrically mounted therein, internal corrugations on said casing, external corrugations on the said rotor, the respective internal and external corrugations being displaced relatively to each other in the axial direction of the said pump, longitudinal guide vanes mounted within the surface outline of the said internal corrugations; screw blades mounted within the surface outline of the said external corrugations, the said surface outlines forming substantially straight cylindrical working surfaces on the casing and the rotor respectively, with a slight working clearance therebetween.

8. In a screw pump, a holow rotor containing an internal air buoyancy chamber and being of generally cylindrical exterior outline but with a series of distinctly separate and axially spaced corrugations therealong, each of said corrugations mounting within its outer surface outline a screw blade section forming a substantially cylindrical exterior working face, a substantially cylindrical stationary casing concentrically surrounding said rotor, a series of distinct and similarly axially spaced internal corrugations distributed about uniformly along said casing but displaced axially with respect to those on the rotor, and a group of axial guide vanes mounted in each of said casing corrugations and forming an internal working surface of continuous cylindrical outline.

9. In a screw pump, a rotor comprising a series of axially spaced external corrugations separated by pronounced ridges, separate screw blade sections mounted one in each of said corrugations so as to form an external straight and continuous cylindrical working face substantially flush with said ridges, a stator comprising a series of similarly spaced internal corrugations mounted to surround but in axially displaced relation to those on the said rotor, pronounced ridges extending inward radially between the said stator corrugations, and axially directed guide vanes mounted wholly within the said corrugations last mentioned, so as to form an internal straight and continuous cylindrical working surface substantially flush with the tips of said inwardly extending ridges, whereby there is formed a substantially annular and axially directed fluid flow channel of nearly constant cross-section which lies radially wholly within the surface outline of the rotor and then radially within the surface outline of the stator in succession, and repeatedly, as the said channel continues along the said pump.

10. In a screw pump, an element containing a series of distinctly separate and axially spaced screw blade sections which provide a substantially annular and in general axially directed fluid passageway through each thereof, the said screw blade sections forming a substantially straight and continuous cylindrical working surface common to all of said sections, passageway blocking ridges mounted on said element one between each pair of said blade sections, an opposing member relatively rotatable with respect to the said element and mounted axially concentric therewith, a series of distinctly separate and axially spaced longitudino-radial guide vane sections forming a substantially straight cylindrical common working face directly opposed radially to and closely adjacent to the said working surface on said element, passageway blocking ridges mounted on said member one between each pair of said guide vane sections, which latter form more or less axially directed annular fluid passageways through each, and which are interrupted axially by the said ridges last mentioned, the said ridges on the element and on the said member being of annular form and displaced axially with respect to each other so as to form a continuous but sinuous complete passageway through the said pump about axially thereof, and a power means connected to said pump to rotate the said element and the said member relatively to each other.

11. In a screw pump, a tandem series of distinctly separate screw blade sections, a mounting therefor which provides a substantially cylindrical common working face, a tandem series of distinctly separate axially directed guide vane sections, a mounting therefor which provides a substantially cylindrical working face common to all the said vane sections and concentrically disposed with respect to the said blade sections, but with a small operative clearance therebetween of substantially straight tubular shape and extending as an unbroken hollow cylinder axially throughout the working length of said pump, the said blade sections and the said vane sections being axially displaced with respect to each other, and means formed as part of the said mountings which provides a continuous annular fluid passageway axially along the said pump but weaving in and out of the two types of sections alternately.

JAMES L. ADAMS, JR.