Feb. 8, 1966 E. CHANTON 3,233,553

PUMPS

Filed Dec. 23, 1963 2 Sheets-Sheet 1

Fig. 1.

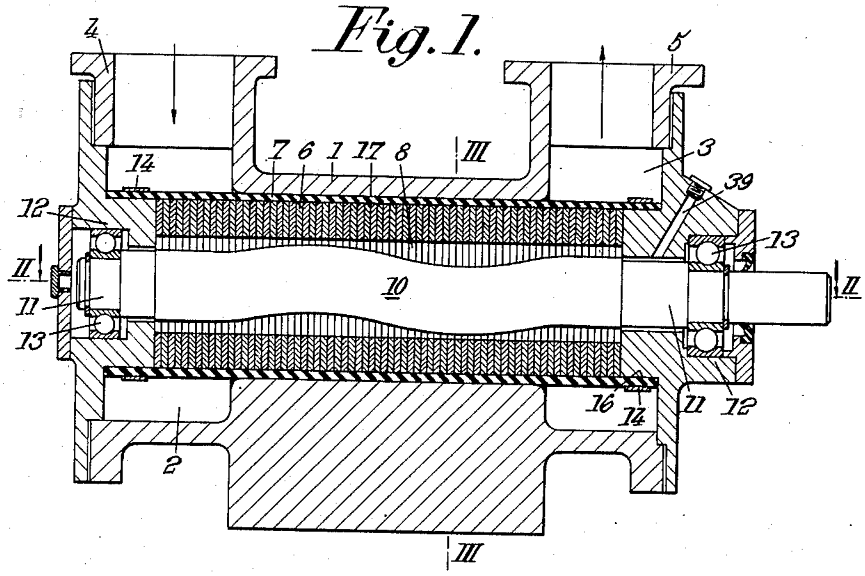


Fig. 2.

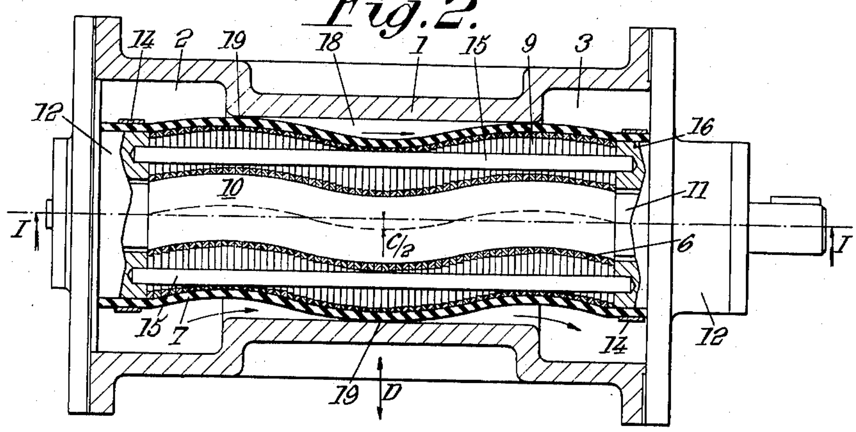


Fig. 3.

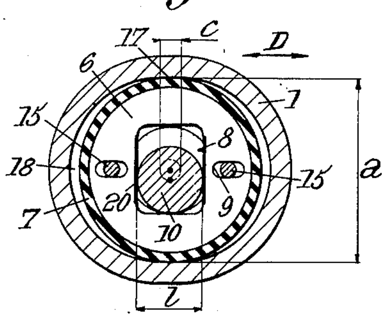
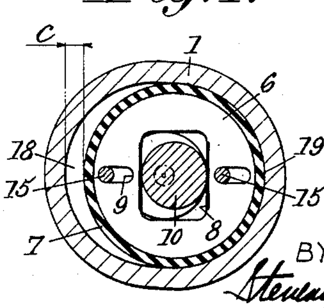


Fig. 4.



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Filed Dec. 23, 1963 2 Sheets-Sheet 2

Fig. 5.

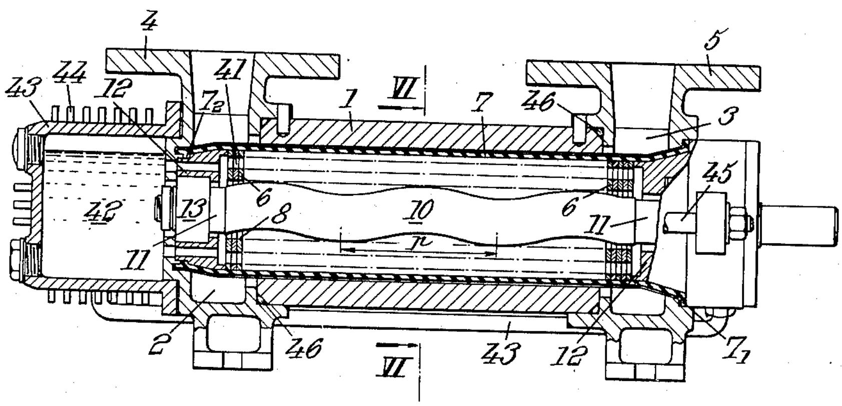


Fig. 7.

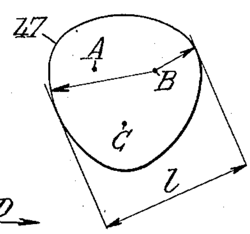
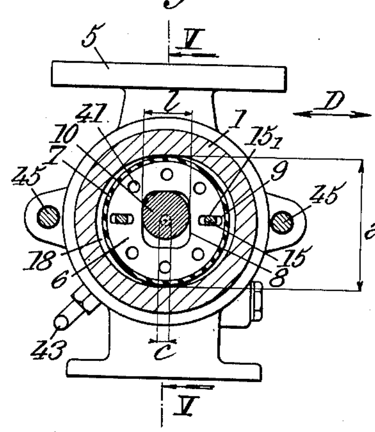


Fig. 6.



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3,233,553
PUMPS

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6 Claims. (Cl. 103—149)

The present invention relates to pumps for a fluid, either liquid or gaseous.

The invention relates to a pump comprising the following elements: a body having a cylindrical inner surface the respective axial ends of which are connected respectively to a suction orifice and to a delivery orifice, a shaft the middle line of which is of helical shape housed in said body, the length of this shaft being equal to at least one pitch of the helix, the cross section of this shaft being constant along its length and having the same total width l in all directions, the two ends of said shaft being joined to journals disposed along the axis of said helix; a plurality of identical transverse plates provided in their central portions with apertures having two rigid edges parallel to each other and perpendicular to a direction D, the distance between said edges being equal to l, said plates having their central apertures mounted on said shaft and being juxtaposed to one another; a flexible and fluidtight tubular sheath surrounding the juxtaposition of plates and forming therewith a deformable element fitting with a sliding fit in the body, the mean line of this element being sinuous but plane and every cross section thereof differing from the inner cross section of the body in which it is located only by a rectangle two sides of which are parallel to direction D and have a length c and the two other sides of which are equal to the greatest dimension of said cross sections in a direction perpendicular to D; and means for rotating said shaft which impart to every plate a rectilinear reciprocating movement of an amplitude c, parallel to D, thus creating between the external surface of the sheath and the inner surface of the body closed spaces moving longitudinally from one end of the body to the other and which serve to convey the fluid.

The present invention consists in giving said plates a circular external outline and in providing each of them in eccentric position with at least one slot elongated in direction D, through which passes, with some play in said direction D but without play in the direction perpendicular to D, a rectilinear guiding rod rigid with the body and extending parallelly to the generatrices thereof.

The function of the guiding rods is to prevent the plates from rotating about their centers when the helicoidal driving shaft rotates.

Therefore it is the presence of these rods which permits of making use of plates of circular outline, a shape which has great advantages concerning the manufacture of these plates and chiefly that of the sheath in which they are located. Said sheath may then consist of a mere tubular element of revolution about its axis. Furthermore as the tendency of the plates to rotate about their center is prevented by said rods, the sheath undergoes no torsional stresses, which is advantageous to preserve it in good state. Another advantage is that, on the one hand, due to this elimination of torsional stresses applied to the sheath and, on the other hand, due to the shape of revolution thereof, it is possible and easy to constitute it of two superposed envelopes, the external one resisting to the fluid to be pumped and the internal one resisting to the lubricant provided for the bearings and the plates.

Preferred embodiments of the present invention will be hereinafter described with reference to the appended drawings, in which:

FIG. 1 is a longitudinal section on the line I—I of FIG. 2 of a pump made according to the present invention;

FIG. 2 is a longitudinal section on the line II—II of FIG. 1;

FIG. 3 is a part cross section on the line III—III of FIG. 1;

FIG. 4 shows, similarly to FIG. 3, the same pump for another angular position of its driving element;

FIG. 5 is a longitudinal sectional view on the line V—V of FIG. 6 of a preferred embodiment of the pump according to the present invention;

FIG. 6 is a transverse sectional view on the line VI—VI of FIG. 5;

FIG. 7 is a cross section of a shaft adapted to be used in pumps according to the present invention.

It is already known to make pumps in the following manner.

Closed spaces are created between the inner rigid cylindrical surface of a hollow pump body and the undulated external surface of a deformable element having a flat sinuous middle line, disposed inside said body and these spaces are moved longitudinally from one end to the other of the whole.

In order to create said spaces, the two above mentioned surfaces are chosen in such manner as to be tangent to each other along, on the one hand, the crests of the undulations of the undulated surface and, on the other hand, at least one flat sinuous line in each of the two planes, parallel to said middle line, tangent to said two surfaces.

In order to move said spaces, the working portion of the deformable element is arranged in such manner that each of its transverse sections can undergo, without deformation, translatory rectilinear reciprocating sliding movements in a direction D, independently of the adjacent cross sections of said element, said sliding movements being guided by two opposed flat bearing surfaces of the body in which the deformable element is fitted, every cross section being designed in such manner as to apply in a fluidtight manner, at every end of its stroke, against the corresponding portion of said rigid surface, one of the two portions of its periphery which are joined to each other along said flat bearing surfaces, and the transverse sliding displacement of every cross section are controlled in such manner that each of them is slightly offset transversely with respect to the adjacent ones, and that the juxtaposition of these cross sections has an undulated or sinuous surface.

For this purpose every cross section of the deformable element is provided with an aperture including two rigid bearing elements facing each other (considered in direction D), a shaft of helical or substantially helical mean line being engaged in said apertures so that every cross section of said shaft is permanently tangent to the two rigid bearing sides of the corresponding aperture, and said shaft is rotated.

In order to constitute the deformable sinuous element it has already been proposed to make use of a juxtaposition of plates enveloped by a flexible and fluidtight sheath, but to prevent said plates from moving angularly under the influence of the rotation of the central helical shaft, which displacements would cause said shaft to be blocked, said plates (and therefore the inner surface of the cylindrical body) were given a rectangular transverse perimeter. This involves serious difficulties concerning, on the one hand, the manufacture and the guiding of the sheath and, on the other hand, the life of said sheath which is constantly subjected to torsional stresses to transmit to the body the torsional forces applied to the plates.

These drawbacks are avoided according to the present invention by giving the plates a circular outline and preventing rotation of said plates by means of longitudinal rods rigid with the body.

In the embodiment of FIGS. 1 to 4, the rigid pump body comprises a hollow cylinder 1 the inner cross section of which is in the form of two half circles (FIG. 3) of diameter *a* joined together by two straight line portions parallel to direction D and of a length *c*. This cylinder 1 is connected at its ends, respectively with two chambers 2 and 3 in communication with connections 4 and 5 for the suction and delivery pipes.

The deformable element having an undulated surface consists of the juxtaposition of thin plates 6 of circular outline (the thickness of said plates being for instance 1 mm.). The element constituted by the whole of said plates is fitted in a flexible and fluidtight sheath 7 the outer diameter of which is equal to *a*.

Each of the plates 6 is provided in its central portion with a rectangular aperture 8 the small sides of which are parallel to D. Each of the plates further comprises two slots 9 parallel to D and disposed symmetrically to each other with respect to aperture 8.

A shaft 10 extends transversely to said plates 6, through the aperture 8 thereof. The cross section of this shaft is a circle the diameter of which is equal to the length *l* of the small sides of every rectangular aperture 8. The mean line of this shaft, or to be more accurate, of the working portion of this shaft, is a portion of a helix having a diameter equal to *c* and a pitch equal to *p*. The length of this shaft portion is at least equal to *p*. The ends of said helical portion of the shaft may be gradually joined to the axis of the helix, as shown by FIG. 1, which permits, on the one hand, of keeping stationary the plates 6 corresponding to said ends of the shaft, when this shaft is rotated, and, on the other hand, of joining without discontinuity said shaft to journals 11 coaxial with the helix and mounted in bearings 12, with the interposition of ball bearings 13. Thus sheath 7 may be fixed on the outer cylindrical surfaces 16 rigid with bearing surfaces 12, by means of annular fixation means 14.

Through the slots 9 of plates 6 extend cylindrical rods 16 the cross section of which is a circle having a diameter equal to the width of said slots. These rods 15 are fixed at both ends to the pump body and they guide the transverse displacements of plates 6 while preventing any rotation thereof when shaft 10 is rotated.

At any time, deformable structure 6–7 has a sinuous shape and the mean line thereof is flat and sinuous with an amplitude of *c*/2. The system consisting of the whole of plates 6 and sheath 7 in which they are mounted remains tangent to the two flat surface portions of casing 1 which are parallel to slots 9 (and which are horizontal and designated by reference numeral 17 in FIGS. 1 and 3), and the crests 19 of the wavy structure 6–7 are tangent to the curved surfaces of cylinder 1 (FIGS. 2 and 4). Thus closed spaces 18 of a volume equal to ½ a.c.p. are created between sheath 7 and cylinder 1.

It suffices to rotate shaft 10, for instance manually or by means of an engine, to cause each of these spaces to travel from the upstream to the downstream end of the whole. As a matter of fact, every plate 6 undergoes a rectilinear horizontal movement of amplitude *c*.

FIGS. 3 and 4 show the respective positions occupied by a plate 6 for two angular positions of shaft 10 at 90° to each other.

It is noted that since the length of the active portion of the device is at least equal to one pitch of the helix every space 18 is separated from the upstream chamber 2 before being placed in communication with the downstream chamber 3. Therefore fluidtightness is ensured between these chambers, so that packing joints are unnecessary.

Furthermore, due to the fact of the fluidtight connection between sheath 7 and outer surfaces 16 the circuit for the fluid that is pumped is without communication with the inside of said sheath. It is therefore possible to feed a lubricant to the inside of this sheath for instance in order to reduce wear and tear due to the transverse sliding movements of plates 6 against one another and also to lubrify bearings 12. Conduit 39 (FIG. 1) has been provided for this purpose.

The pump works for both directions of rotation of shaft 10. When the direction of rotation of the shaft is reversed the direction of flow of the fluid is also reversed.

The portions of plates 6 which are most subjected to wear and tear are advantageously reinforced. This is the case of reinforcement 20 extending along the longer sides of apertures 8 (FIGS. 3 and 4). Each of these reinforcements may either be fixed on every plate 6 individually or consist of a flexible plate corresponding to the whole of said plates 6 and interposed between said apertures and the shaft.

The preferred embodiment of the invention illustrated by FIGS. 5 and 6 includes the elements designated by reference numerals 1 to 13 inclusive and also guiding rods 15 and spaces 18. It further includes the following features.

In order to reduce the wear between guiding rods 15 and the edges of slots 9, the contacting surfaces of these elements are increased by providing rods 15 with two flat bearing surfaces 15_1 parallel to direction D. These flat portions may be connected together by curved surfaces or they may consist of the faces of a drawn element having a rectangular or square cross section.

In order to reduce the wear by friction between every plate and the adjacent ones and also between every plate and shaft 10 and rods 15, the plates are made of a material having a very good coefficient of friction, in particular of a phenol resin reinforced with cotton and loaded with colloidal graphite, such as known under the trademark name of Celoron.

In order further to reduce the wear by friction between the plates, it is advantageous to provide them with a multiplicity of holes 41. This has the further advantage of improving lubrication and reducing the weight of the whole.

In order to improve the lubrification of the plates, it is advisable to cool down the oil 42 used for this purpose, which may easily reach a temperature of 50–60%. This cooling is obtained by circulating said oil in a closed circuit including an external portion 43 provided with cooling fins 44, said circuit being of course separated in a fluidtight manner from the circuit of the fluid that is pumped.

In order to facilitate the mounting of sheath 7 about the plurality of plates 6, this sheath is made in the form of a moulded resilient bag including a central portion in the form of a tube of revolution, and two end portions, each in the form of a frustum of a cone. One of said end portions is convergent toward the end of said portion whereas, on the contrary, the other end portion is divergent. The initial diameter of the tubular portion is smaller than the diameter of plate 6 so that, when said plates are introduced into the bag, they stretch it resiliently, thus eliminating any risk of play.

The fitting of the bag is advantageously performed in the following manner:

Rods and shaft 10 are first mounted in one of the bearings 12. Then plates 6 are stacked on these elements and the other bearing 12 is secured. The composite structure thus formed is inserted into bag 7 though the flaring end thereof, whereby said bag is expended. At the end of this operation, the two end portions (each in the form of a frustum of a cone) are elastically applied against corresponding frusto-conical seats complementary of the respective bearings 12. In order to ensure perfect fluidtightness, the annular edges forming the ends of bag 7 (one 7_1 on the right and the other 7_2 on the left) are applied against corresponding surfaces or bearings 12, for instance by screwing of external rods 45 secured to the axial ends of the pump body.

In a preferred embodiment of this pump body, every chamber 2 or 3 is moulded integral with the corresponding connection 4 or 5 and forms an independent piece which is axially applied against hollow cylinder 1 through the above mentioned rods 45, with the interposition of toroidal packing joints 46.

Merely by way of indication some dimensions of the elements of the construction illustrated by FIGS. 5 and 6 will now be given:

Sheath 7: 4 mm. thick, this sheath consisting of two layers superimposed on each other, one on the inside being relatively thick and made of an elastomer capable of resisting the action of the lubricating oils that are used and the other on the outside, thinner, inert with respect to the liquid that is pumped and consisting for instance of chlorosulfonated polyethylene known under the trademark name of Hypalon which substance might be replaced by the copolymer of fluorovinylidene and hexafluoropropylene designated by the trademark name of Viton, by polytrifluoromonochloroethylene or even by polytetrafluoroethylene, which is sufficiently resilient under the small thickness that is considered:

Inner diameter of the tubular portion of sheath 7: 62 mm. before mounting and 65 mm. after mounting;

Plates 6: made of the reinforced phenol resin designated by the trademark name of Celoron having a thickness of 1 mm. and a diameter of 75 mm.;

Number of plates: 250;

Shaft 10 made of nitrided steel having a diameter of 30 mm. and a useful length of 250 mm. (only 200 mm. of which correspond to a true helix, the remainder corresponding to the portions where said shaft is joined to the journals);

Pitch of the helix: 100 mm., for a diameter of said helix equal to 6 mm.;

Number of revolutions per minute of the shaft: 900;

Theoretical output: 2,700 liters per hour;

Practical output when the delivery pressure is zero: 2,700 liters per hour;

Practical output with a substantial delivery pressure: 2,300 l./h.

If use were made of a shaft 10 of the same diameter as the preceding one but corresponding to a helix having a diameter of 8 mm. and a pitch of 200 mm., the theoretical output would be 7,200 l./h.

Of course there may be modifications of the specific construction above described.

In particular the cross section of the helical shaft, while remaining constant along this shaft and having the same total width in all dimensions, might be noncircular; for instance it might have the shape of the Trezel eccentric cam shown at 47 in FIG. 7 the outline of this cam may be easily constructed by means of circular arcs from an equilateral triangle ABC having one of its apexes on the rotation shaft.

The number of pitches of the active portion of the shaft might be greater than 1 or 2, every shaft corresponding to a pumping stage.

If the fluid that is pumped is compressible the pitch of the helix would be variable along the shaft.

Of course the inner cylindrical surface of the pump body, instead of being integral with this body, might consist of a lining secured in said body.

Said surface, instead of being hard, might be semirigid, for instance made of hard rubber so as to improve fluidtightness of the spaces that are formed.

In a general manner, while the above description discloses what are deemed to be practical and efficient embodiments of the present invention, said invention is not limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the invention as comprehended within the scope of the appended claims.

What I claim is:

1. A pump which comprises, in combination, a pump body provided with a cavity having a cylindrical inner surface and respective suction and delivery orifices provided at the ends of said pump body respectively, said inner surface consisting of two half circular cylindrical portions of the same diameter disposed opposite each other, with their concavities turned toward each other and joined together by two parallel flat portions, a shaft having its mean line in the form of a helix disposed in said body coaxially therewith, the length of this shaft being at least equal to the pitch of said helix, the cross section of this shaft being the same over the length of said shaft and having the same width in all directions, said shaft including, at its respective ends, cylindrical trunnions journalled in said body coaxially therewith, a multiplicity of adjacent plates transverse to the axis of said helix, each of said plates being provided with a central aperture having two longer sides parallel to each other and perpendicular to the direction of the flat portions of the pump body inner surface, said two sides being at a distance from each other equal to the above mentioned width of the cross sections of said shaft, all of said plates having their apertures engaged on said shaft, the outline of each of said plates being circular, each of said plates being provided with at least one slot parallel to said last mentioned direction, all of said slots having the same width, at least one rod carried by said body in fixed positione and fitting slidably in said slots, and a fluidtight flexible tubular sheath surrounding all of said plates so as to form therewith a deformable structure housed in said cavity with a sliding fit, the ends of said sheath being secured in a fluidtight manner respectively to the suction orifice and to the delivery orifice of said pump body.

2. A pump according to claim 1 wherein the guiding rod has two flat surfaces parallel to said direction, against which surfaces the edges of said slots parallel to said direction are slidable.

3. A pump according to claim 1 wherein the tubular sheath comprises two layers superimposed on each other, that intended to come into contact with the fluid to be pumped being made of a material especially resistant with respect to this fluid.

4. A pump according to claim 1 wherein the plates are provided with a multiplicity of holes.

5. A pump according to claim 1 wherein said sheath is in the form of a moulded resilient bag stretched by the plates packed therein one end of said bag flaring out whereas the other one is slightly retracted.

6. A pump according to claim 1 wherein the mean line of the shaft is a variable pitch helix.

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MARK NEWMAN, *Primary Examiner.*

WARREN E. COLEMAN, *Assistant Examiner.*