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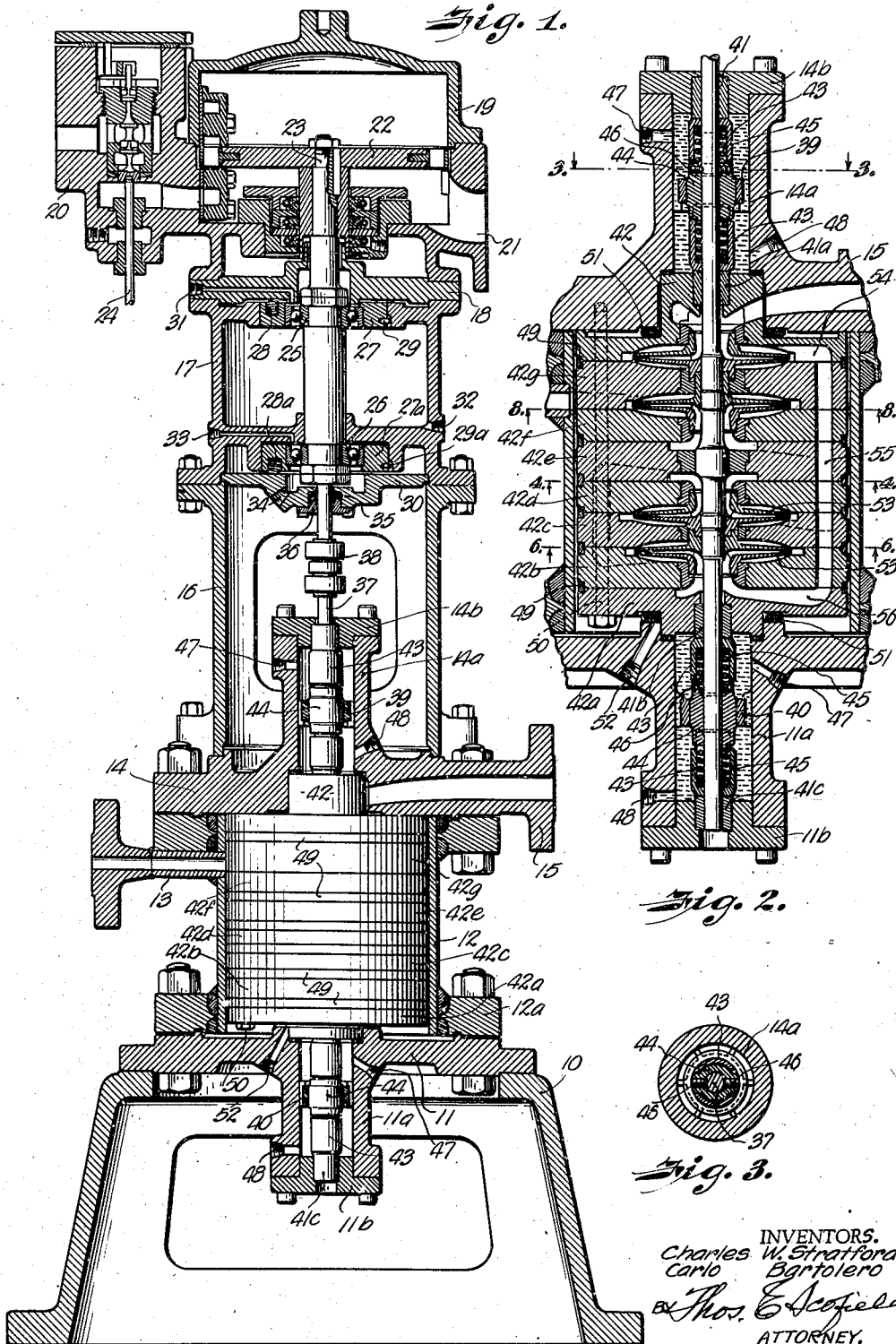
C. W. STRATFORD ET AL

2,395,793

CENTRIFUGAL PUMP

Filed March 4, 1943

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

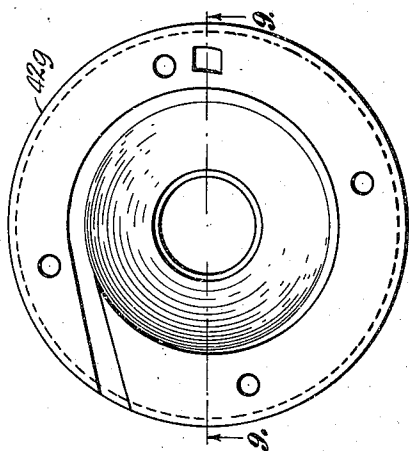


Fig. 8.

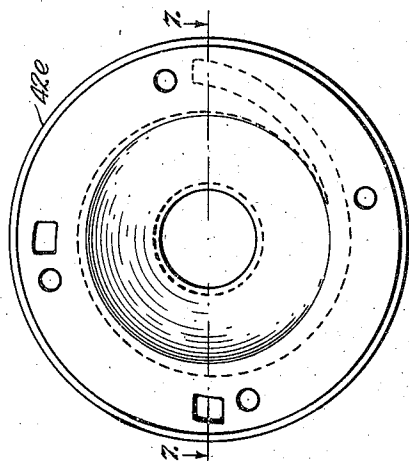


Fig. 6.

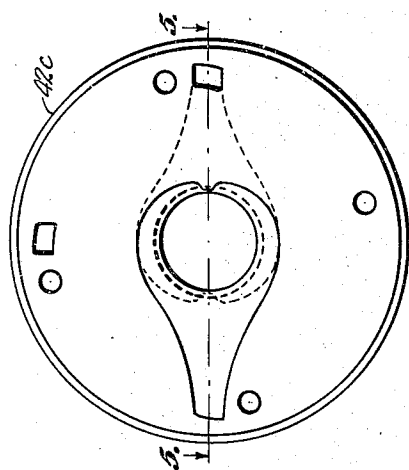


Fig. 4.



Fig. 9.

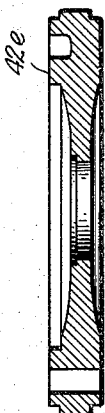


Fig. 7.



Fig. 5.

BY

INVENTORS.
Charles W. Stratford
Carlo Bartolero
Thos E. Hoofield.
ATTORNEY.

UNITED STATES PATENT OFFICE

2,395,793

CENTRIFUGAL PUMP

Charles W. Stratford, Kansas City, Mo., and Carlo Bartolero, Oakland, Calif., assignors to Stratford Development Corporation, a corporation of Delaware

Application March 4, 1943, Serial No. 477,928

4 Claims. (Cl. 103—87)

Our invention relates to improvements in centrifugal pumps and refers more particularly to high speed, high head multistage centrifugal pumps having relatively low through-put capacities and low specific speeds.

Pumps of this type are adaptable for use in pilot plants, small commercial plants for supplying high pressure fluids for use in hydraulic presses and for miscellaneous other purposes. The advantages in the pump construction lie primarily in the employment of a pump housing sealed against leakage at its ends by double mechanical seals which function to maintain the pump housing aligned tight, assuring the operation of the end bearings which are between the seals in clean lubricant and also as dampeners against torsional vibration, this latter function being important where a relatively small diameter shaft is running at exceedingly high speed.

A further advantage and feature of novelty is the spring balancing or end thrust cushioning of both the prime mover and the pump, eliminating jolting and jarring of the mechanism and adding materially to the service life of the bearings. Finally, the construction of the main pump body as being divided at diametrical planes to provide sections which are separable axially to fully expose all rotor chambers, flow channels, volutes, suction openings and cross-overs, facilitates machining, finishing, cleaning and maintenance. The smooth finishing of all flow surfaces materially contributes to increased efficiency, particularly in pumps of low capacity with small areas in which fluid flow is at such a high rate of speed and friction loss becomes important. Superfinished surfaces are used between the pump sections to eliminate gaskets and reduce leakage to a minimum.

A further advantage, particularly in the assembly, is the use of aligning rings between the sections.

In the drawings which are to be read in conjunction with the specification and wherein like numerals are used to indicate like parts in the various views:

Fig. 1 is a vertical section taken through the pump and prime mover,

Fig. 2 is a composite vertical section taken on a plurality of vertical planes through the pump to show more clearly the fluid travel,

Fig. 3 is a view taken along the line 3—3 in Fig. 2 in the direction of the arrows,

Fig. 4 is a view taken along the line 4—4 in Fig. 2 in the direction of the arrows,

Fig. 5 is a view taken along the line 5—5 in Fig. 4 in the direction of the arrows,

Fig. 6 is a view taken along the line 6—6 in Fig. 2 in the direction of the arrows,

Fig. 7 is a view taken along the line 7—7 in Fig. 6 in the direction of the arrows,

Fig. 8 is a view taken along the line 8—8 in Fig. 2 in the direction of the arrows, and

Fig. 9 is a view taken along the line 9—9 in Fig. 8 in the direction of the arrows.

Referring to the drawings and to Fig. 1 thereof, the pump and turbine assembly is supported by a standard 10. The enclosure for the pump mechanism consists of a bottom 11, including a seal housing 11a supplied with a lower flange 11b. The bottom enclosure plate 11 is mounted on standard 10 and is bolted to the pump body casing or housing 12 by means of flange 12a. From the side of the casing 12 is a discharge nozzle 13. Casing 12 is enclosed at the top by a closure plate 14 bolted to the casing 12 by a suitable flange. A flanged inlet nozzle 15 extends from one side of the top enclosure. Although in Fig. 1 the inlet nozzle 15 is shown at 180° from the outlet or discharge nozzle 13, the relative position of the inlet and outlet nozzles may not be in this relationship as their location will depend upon the place where the fluid is to be introduced into the initial stage and where the discharge will be located at the final stage. Likewise in Fig. 2, where a composite section has been shown, freedom has been taken with the cross sectioning of the multistages in order that the fluid flow may be more easily followed.

To return to the construction shown in Fig. 1, top enclosure 14 has a seal housing 14a with a flanged end 14b similar to the bottom enclosure of the pump.

Mounted upon and bolted to the top enclosure is the turbine support 16 and bolted to the top flanges of the turbine support is a turbine standard 17. The turbine has a bottom enclosure plate 18, housing 19, an inlet control valve mechanism 20 and an outlet or discharge 21. The turbine wheel is shown diagrammatically at 22 keyed to the turbine shaft 23. A control valve mechanism 20 is connected by shaft 24 to any suitable source of control (not shown and not part of the present invention).

Also, it will be understood that although a turbine has been shown as a prime mover for driving the pump, any source of power may be used, such as a high speed motor, in place of the turbine.

As previously indicated, the novelty in the construction resides primarily in, first, cushioning end thrust of the prime mover by flexible mountings, second, cushioning end thrust of the pump by flexible cushioning means, third, sealing the pump at its ends by mechanical seals on each side of the pump bearings, eliminating the necessity of stuffing boxes, and, fourth, dividing the pump chambers into sections so as to freely expose the flow channels, volutes, cross-overs and passage-ways to provide access thereto in order to facilitate machining, finishing and cleaning.

These separate features and the construction which provides them will be explained in order.

The turbine shaft 23 operates in an upper ball bearing 25 and a lower ball bearing 26. The inner race of bearing 25 is supported upon a shoulder formed in the turbine shaft. The outer race is fitted into a ring 27 which has holes partially drilled therethrough from above to receive compression springs 28. These springs seating against the bottom plate 18 of the turbine and against ring 27 keep a constant downward pressure or thrust upon shaft 23. To prevent rotation of ring 27 pins 29 extend partially into the periphery of the ring and into slots in the upper flange of standard 17 permitting slight axial movement of the ring corresponding to the distance between plate 18 and the flange but preventing rotary movement.

A similar construction is found for the support of the lower bearing 26. Bearing ring 27a is urged upwardly by springs 28a seating against plate 30 and ring 27a urging the ring and bearing as well as the shaft 23 in an upward direction counterbalancing the effect of springs 28. Pins 29a permit axial movement of the ring and ball bearing assembly but prevent rotary movement thereof. Oil is supplied to the upper bearing through duct 31 passing down through the upper bearing into the housing surrounding the shaft and out through vent or drain 32. Oil to the lower bearing is supplied through duct 33 and is discharged through duct 34. Holding nuts are positioned above and below the bearings 25 and 26 to keep them firmly seated on the shoulders formed on the shaft.

By thus cushioning the end thrust of the prime mover shaft, whether it be turbine or motor, jolting of the mechanism and consequent failure of parts is to a great extent eliminated. A seal ring 35 held in place by plate 36 prevents leakage of oil around the lower end of the turbine shaft. The turbine shaft is coupled to the top of the pump shaft 37 by means of coupling 38.

Our second feature is the assembly for cushioning end thrust of the pump shaft, probably best shown in Fig. 2. Shaft 37 is carried by an upper bearing 39 mounted within the seal chamber 14a and a lower bearing 40 positioned in the lower seal chamber 11a. The cushioning mechanism includes mechanical seals positioned above and below the bearings 39 and 40. The mechanisms are identical in construction and description of one will suffice. Rings 41, 41a, 41b and 41c, formed of a mixture of metalized carbon or other appropriate material, surround the shaft 23 and form a part of the mechanical seals above and below the bearings 39 and 40. Rings 41 and 41c are held in the end closure plates of the pump 14b and 11b respectively. Ring 41a is carried in a receptacle of the upper pump section and ring 41b in a like receptacle formed in the lower pump section 42a. Abutting against the inner ends of rings 41 and 41c and the outer ends of rings 41a and 41b are spring housings 43, the skirts of which telescope slightly with bearing sleeves 44, as shown in dotted lines in Fig. 2. Within the spring housings are compression springs 45 positioned on both sides of upper bearing 39 and lower bearing 40. The axial pressure imposed by the springs is equal and being of the order of 300 pounds per square inch so that there is a counterbalanced spring pressure on bearing 39 of 300 pounds and a like counterbalanced pressure on bearing 40. The bearing sleeves 44 are affixed to the shaft 23 by set screws

46, shown in Figs. 2 and 3. Due to the axial pressure of the springs which seat on the edges of sleeves 44 and against the inside top of spring housings 43, seal surfaces are formed between the abutting surfaces of the seal rings and the end surfaces of the spring housings. These sealing surfaces are super-finished to reduce leakage to a minimum. Furthermore, these seals operate under flood lubrication so that there is a very low coefficient of friction. Lubrication is supplied to the upper and lower seal housings 14a and 11a through ducts 47 and discharged through ducts 48. The circulating lubricant or seal oil is maintained under pressure at all times in excess of the pressure of the fluid in the pump, thus preventing leakage through the seal, supplementing the sealing action of the springs and furnishing clean lubricant to the bearings and seal faces.

Referring now to the manner in which the pump body is divided into sections in order to expose the flow channels of the different stages of the pump. The pump as shown in the drawings has four stages. The number of stages will depend entirely upon the service for which the pump is to be used. The body of the pump which makes up the chambers for the rotors and flow channels communicating therebetween, consists of an upper section 42 and a lower section 42a, previously mentioned, and intermediate sections designated from bottom to top by the numerals 42b, 42c, 42d, 42e, 42f and 42g. The adjacent edges of the pump sections are grooved where necessary to receive a plurality of alignment rings 49 which serve to position the sections accurately when they are assembled. The contacting faces of the sections are super-finished or finished to a surface which approaches optical flatness, thus the necessity of gaskets is eliminated. The sections are held together by a plurality of bolts 50, shown in dotted lines in Fig. 2. The location of the bolt holes through the section is indicated in Figs. 4, 6 and 8, although the number of bolts and their location is governed to a great extent by the number of stages of pump and the location of the flow channels. Between the upper and lower sections and the end closure members of the pump are gaskets 51 which assure a pressure-tight joint between the pump sections and the ends of the pump casing. An outlet vent 52 serves as a tell tale to indicate leakage of high pressure fluid by the gasket.

From the faces of the adjoining sections are routed out the rotor chambers, suction openings, cross-overs and fluid flow channels of the pump which produce a continuous passageway from the inlet to the first stage to the outlet or discharge from the final stage. Upon the pump shaft 23 and within the chambers of the different pump stages are rotors 53. The rotor hubs and stationary portions of the adjoining sections which surround them are given a small amount of end clearance to accommodate the cushioning effect of the spring mounting at the ends of the pump.

Fluid to be pumped enters through the inlet nozzle 15 and is charged into the throat of the first stage or top rotor where there is positioned an anti-rotational vane assuring uniform feed to the suction or first stage. From the periphery of the rotor the fluid is discharged into horizontal duct 54, thence through a vertical duct 55 which connects with a horizontal duct 56 in lower section 42a. The duct 56 communicates with the inlet throat of the bottom rotor and is fed to the rotor from below. The discharge from the

bottom rotor or second stage is out through the duct shown in dotted lines in section 42b then upwardly to the horizontal duct machined in the lower surface of section 42e into the inlet throat of the third stage which is rotor number three from the top. The discharge from the third stage is out through a duct formed in the upper face of section 42c thence upwardly through a duct which in the drawings corresponds to vertical duct 55 but which in reality is cut through the pump sections at a different location than is shown. The fluid then flows through a cross-over duct formed in the upper part of section 42e into the inlet throat of the fourth stage, which is the second rotor from the top. Discharge from this fourth stage is out through a duct shown in dotted lines formed in the lower surface of section 42g, thence through outlet nozzle 13. Figs. 4 to 9 inclusive are views of the pump sections to show how the body of the pump is divided to freely expose the inlet openings, rotor chambers, volutes, cross-overs and connecting flow channels so that all forming and machining operations are relatively simple. By separating the pump body into a plurality of sections and separating the sections so that the flow channels and rotor chambers are freely exposed when disassembled, a smooth finish can be given the surfaces over which the fluid passes. This greatly reduces friction which becomes an important item when fluids flow at such high speed, and materially contributes to increased efficiency. The exposure of the flow channels and rotor chambers also greatly facilitates cleaning and accessibility for maintenance. As suggested, the pump sections as assembled are held in coaxial relationship by means of alignment rings arranged to cover the contact surfaces of the sections. The rotors as well as the pump chambers and flow channels are suitably finished to reduce disc friction.

By way of illustration, it is contemplated that the pump will have rotational speeds of from 7000 R. P. M. to 20,000 R. P. M., developing a head of from 2000 to 6000 feet with a capacity from 20 gallons to 60 gallons per minute. Two, four, six or eight stages will be conventional according to the head desired but the number of stages is not critical in so far as the invention is concerned except to deliver required head and fulfill the service for which the pump is employed.

In brief then, the construction provides a high speed high head centrifugal pump with a low specific speed and low capacity. Both the pump and prime mover are flexibly mounted and spring cushioned against end thrust. The end bearings of the pump are sealed on both sides with mechanical seals which prevent leakage from the pump body to the atmosphere through the bearings, assuring clean lubricant for the bearings, the seals functioning both as a closure for the pump and as dampeners against torsional vibration of the shaft. Finally, the separation of the body portion of the pump into sections renders flow channels accessible for machining and finishing.

The above features are believed to be novel in the pump art, particularly when applied to a pump of the multistage volute type.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in de-

tails within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, we claim:

1. In a multi-stage high speed high head pump of the volute type, the combination with a shaft, rotors mounted thereon and a housing enclosing the rotors, said housing comprising a plurality of assembled sections arranged coaxially on the shaft, the adjacent surfaces of said sections formed with connected cross-over apertures, registering volutes and rotor chambers for directing the flow of fluid through the successive pump stages, said sections of predetermined width rendering the sections separable at locations to freely expose the rotor chambers, cross-overs and volutes when disassembled, a shell surrounding the pump sections inlet and outlet ports to said shell supporting bearings for the shaft at the ends of the shell, mechanical seals surrounding the shaft on both sides of supporting bearings and outside the outer stages of the pump, and spring mountings on both the inboard and outboard sides of the end bearings between the bearings and shell for resiliently supporting the shaft and rotors in the shell.

2. In a multistage high speed high head pump of the volute type, the combination with a shaft, rotors mounted thereon and a housing enclosing the rotors, said housing comprising a plurality of assembled plate-like sections arranged coaxially on the shaft, the adjacent surfaces of said sections having formed therein connected cross-over apertures, registering volutes and rotor chambers for directing the flow of fluid through the successive pump stages in the following sequence, into one end stage, thence to the opposite end stage and finally through the intermediate stages, a shell surrounding the pump sections and inlet and outlet ports to said shell.

3. In a multistage high speed high head pump of the volute type, the combination with a shaft, rotors mounted thereon and a housing enclosing the rotors, said housing comprising a plurality of assembled plate-like sections arranged coaxially on the shaft, the adjacent surfaces of said sections having formed therein cross-over apertures, registering volutes and rotor chambers for directing the flow of fluid through the successive pump stages in the following sequence into an inlet outboard of one of the end stages, thence to an inlet outboard of the opposite end stage, thence to inlets in successive intermediate stages positioned at opposite sides of the rotors whereby their thrust upon the end sections is equalized and minimized.

4. In a multistage high speed high head pump of the volute type, the combination with a shaft, rotors mounted thereon and a housing enclosing the rotors, said housing comprising a plurality of assembled sections arranged coaxially on the shaft, the adjacent surfaces of said sections formed with connected cross-over apertures, registering volutes and rotor chambers for directing the flow of fluid through the successive pump stages, a shell surrounding the pump sections, inlet and outlet ports to said shell, supporting bearings for the shaft at the ends of the shell, and spring mountings on both the inboard and outboard sides of the end bearings and between the bearings and the shell for resiliently supporting the shaft and rotors in the shell.

CHARLES W. STRATFORD.
CARLO BARTOLERO.