Sept. 24, 1946. E. G. LANDBERG 2,407,987

MULTISTAGE CENTRIFUGAL PUMP

Filed April 3, 1942 2 Sheets-Sheet 1

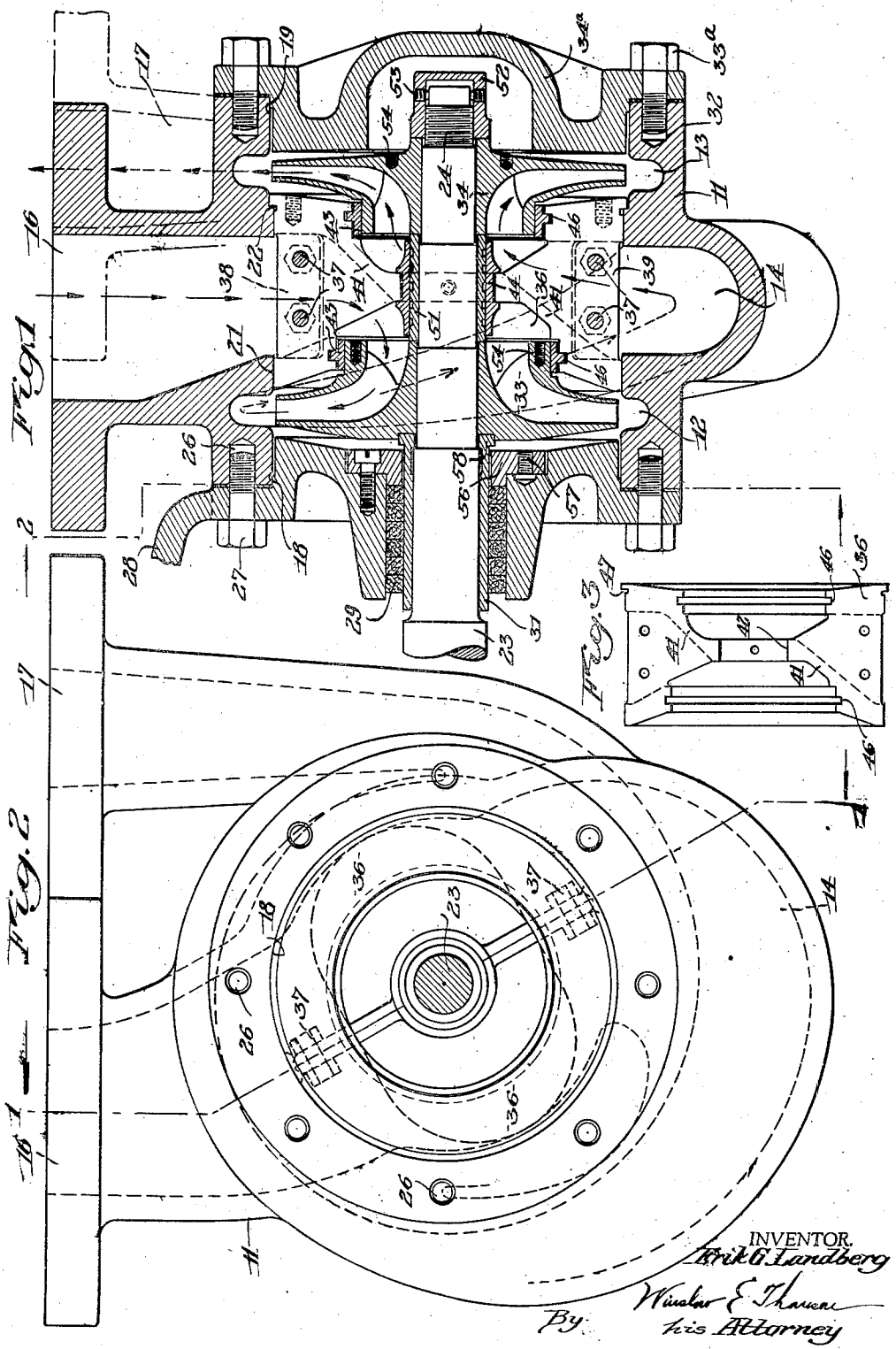


Fig. 1

Fig. 3

Fig. 2

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Fig. 5

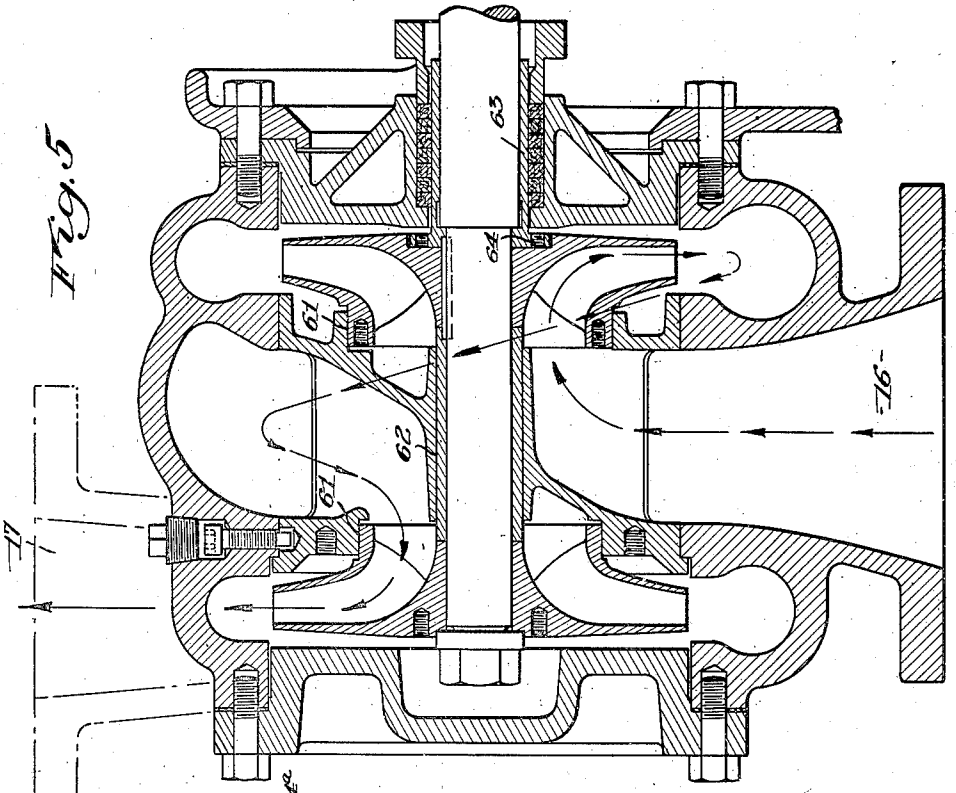
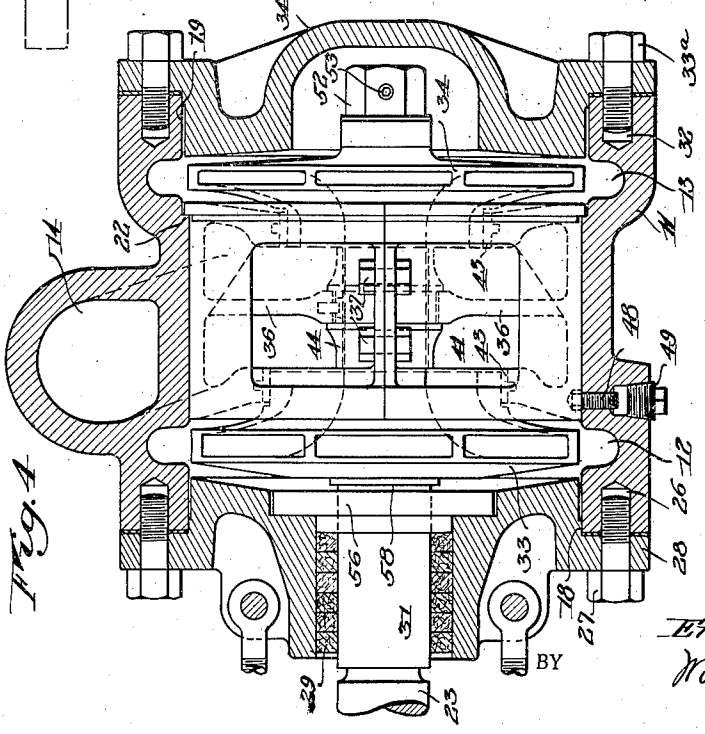


Fig. 4



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Patented Sept. 24, 1946

2,407,987

UNITED STATES PATENT OFFICE

2,407,987

MULTISTAGE CENTRIFUGAL PUMP

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Application April 3, 1942, Serial No. 437,574

3 Claims. (Cl. 103—109)

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My invention relates to centrifugal pumps and, more particularly to centrifugal pumps of the multi-stage type.

An object of my invention is to provide a multi-stage centrifugal pump of simplified construction which may be produced at a more reasonable cost.

Another object of my invention is to provide a multi-stage centrifugal pump in which the operating and wearing parts thereof, without disturbing pipe connections, may be readily withdrawn from the pump for the purpose of inspection or repair of the parts or for the purpose of renewing worn parts.

Another object of my invention is the provision of a diaphragm or partition element for a multi-stage centrifugal pump, the diaphragm being so constructed and arranged as to support and properly align suitable wearing rings for the pump impellers, together with means for enabling convenient renewal of said wearing rings.

Still another object of my invention is to provide a diaphragm or partition part for separating the stages of a multi-stage centrifugal pump which has openings governing the flow of liquid to the pump impellers, and the provision of means whereby the partition part may be adjusted so as to govern or throttle the supply of liquid to the impellers.

More specifically, my invention contemplates the provision of the multi-stage centrifugal pump in which the casing is formed of a single casting having an end opening through which the pump impellers may be withdrawn for the purpose of inspection and repair and without disturbing the pipe connections to the pump; the pump also being arranged so that the impeller wearing rings and other parts may be readily replaced when they have become worn.

Other objects and advantages of my invention will be pointed out in the claims and will be apparent from the following description, when taken in connection with the accompanying drawings, in which:

Fig. 1 is a sectional view taken through the pump of my invention, substantially on the line 1—1 of Fig. 2, in the direction indicated by the arrows;

Fig. 2 is an end elevation of the multi-stage centrifugal pump of Fig. 1 with parts thereof removed and taken substantially on the line 2—2 of Fig. 1, in the direction indicated by the arrows.

Fig. 3 is a view showing the diaphragm or partition element which separates the stages of the pump;

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Fig. 4 is a view partly in section showing the multi-stage pump of my invention; and

Fig. 5 is a view similar to Fig. 1 showing a modification of my invention.

The multi-stage centrifugal pump of my invention comprises, as shown in Fig. 1, a casing 11. The casing of conventional multi-stage pumps is split usually horizontally for the purpose of enabling access to the working parts. The casing of the multi-stage pump under consideration is preferably formed of a single casting which may be characterized as approximately barrel shaped. By this I mean that the casing has a continuous inner wall which in the preferred form of the invention is approximately circular. In making the casting the various water passages are cored therein, as for example, the volute 12 for the first stage impeller, the volute 13 for the second stage impeller and the cross over passages, or connecting chamber, 14 through which the liquid flows from the first stage volute 12 to the suction inlet of the second stage. Formed preferably integral with the casting are the parts defining the suction inlet 16 and the discharge outlet 17.

While I have shown in Fig. 1 the suction and discharge connections 16 and 17 as extending substantially vertically, it will be appreciated that this is optional. If desired these connections, instead of extending substantially parallel to each other, may be formed angularly with respect to each other. The casing has openings 18 and 19 at each end and is suitably machined to provide at least a minimum bore 21 and a shoulder 22, the purposes of which will later appear.

A drive shaft 23, extending through the opening 18 in substantially concentric relation with the bore 21, is provided with suitable shoulders for the reception of the parts mounted thereon and with a threaded end 24. The shaft may be driven by any suitable prime mover such as an electric motor or steam turbine.

The peripheral end of the casting defining the opening 18 is machined and provided with suitable tapped openings 26 adapted to receive studs or screws 27 for the purpose of holding in position a combined cover plate and adapter 28. The cover plate 28 serves also as a housing for a stuffing box, generally indicated by the numeral 29, between a bore of which and a shaft sleeve 31, suitable packing is provided. The packing may be held in position by any suitable means.

In the drawings I have shown the suction and discharge openings, or connections, arranged vertically. However, by removal of the screws 27, the entire casing may be adjusted about the axis of the shaft so as to locate the suction and discharge openings in any other desired position. It will be noted that the tapped openings 26 are equally spaced to enable this adjustment.

The machined periphery, defining the opening 19 at the opposite end of the casing, is similarly provided with tapped openings 32 for the reception of studs or screws 33a which are adapted to hold a cover or end plate 34a in position. It will be observed that the cover plate 34a may be removed without disturbing the pipe connections to the suction and discharge openings 16 and 17.

Mounted on the shaft 23 are a pair of impellers which may be of any suitable type. The first stage impeller is indicated by the numeral 33 while the second stage impeller is indicated by the numeral 34. Preferably the impellers are of the enclosed type and are arranged in opposed relation to each other for the purpose of obtaining approximate hydraulic balance. Since the pressures developed in the second stage are higher than those developed in the first stage, the resulting thrust is in a direction to the left, as viewed in Fig. 1. This resulting thrust may be compensated for by a suitable thrust bearing provided in the pump, but preferably provision for taking up end thrust is provided in the prime mover.

Within reasonable limits, necessitated by good hydraulic design of the suction passages of the impeller, the thrust in the direction to the left, as viewed in Fig. 1 may be decreased by increasing the diameter of the suction opening of the first stage impeller 33. This has the effect of decreasing the area of the right side wall of the impeller 33 over which the pressure in the first stage volute is effective, consequently cutting down the resulting pressure in a direction to the left, as viewed in Fig. 1. Similarly by decreasing the size of the suction opening of the second stage impeller, the area of the side wall of the second stage impeller 34 exposed to the pressure in the second stage volute is increased on the left hand side of the impeller, thus cutting down the resulting pressure in a direction to the left, as viewed in Fig. 1. By proper designing, the impellers may thereby be substantially hydraulically balanced so as to decrease the size of the thrust bearing required.

Between the suction openings of the impellers and supported by the casing, in concentric relation with the shaft, is a diaphragm or partition element 36 which separates the two stages of the casing, except for that fluid connection provided by the cross over passages 14. The diaphragm comprises a substantially cylindrical member which may be formed in two segmental halves one of which is shown in Fig. 3. The segmental halves may be bolted together as shown at 37 in Fig. 4, or may be loosely placed in relation to each other and held together by contacting portions of the casing, as will more clearly appear.

The diaphragm has a pair of opposed openings 38 and 39 which are separated from each other by a partition or dividing wall extending somewhat diagonally, as indicated at 41 in Fig. 3. The opening 38 in the diaphragm communicates with the suction opening of the first stage impeller and with the suction inlet 16 while the opening 39 communicates with the suction inlet of the second stage impeller and the cross over passages 14. The dividing wall 41 has a central bore 42 for the reception of the shaft. The dividing wall 41 and the shaft when the parts are in position, form a division in the pump casing so as to separate the casing stages except for the cross over passage 14.

The diaphragm 36 is adapted to carry impeller wearing rings 43 and a bushing 44. It will be noted that the diaphragm is provided with annular recesses 46 for the reception of the impeller wearing rings 43 and that the shaft bushing 44 is supported by the margins of the diaphragm bore 42. While the wearing rings 43 and the shaft bushing may be fixed with respect to the diaphragm, I prefer to support these parts loosely so that they may be free to adjust and align themselves as conditions may require. It will be noted that the impeller wearing rings and the shaft bushing may be assembled in position with respect to the two halves of the diaphragm and then the diaphragm may be bolted together or slipped into the casing unbolted as mentioned above.

The diaphragm carries an annular shoulder 47 which is adapted to engage the shoulder 22 formed in the casing member. As previously mentioned, the resultant hydraulic thrust is in a direction to the left, as viewed in Fig. 1, so that the hydraulic pressure developed within the casing holds the parts in position and in alignment. While the tolerances between the casing bore and the external diameter of the diaphragm are small, the diaphragm is inserted by slipping it into the bore, hydraulic pressure thereafter maintaining the shoulders 47 and 22 in engagement. For the purpose of locking the diaphragm against rotational movement, a set screw 48 is provided which engages the diaphragm. The opening in the casing through which the set screw 48 extends may be sealed by a pipe plug 49.

It will be noted from Fig. 1 that the openings 38 and 39 register with their cooperating openings in the casing and that the margins of the openings 38 and 39 register with portions of the casing bore. Thus, in the position of the parts shown, the full entrance openings through the diaphragm are available as fluid passages. By rotating the diaphragm, with respect to the axis of the shaft and resetting the set screw 48 in a new position, the effective area of the openings 38 and 39 may be reduced so as to throttle the supply of liquid to the impellers. It will be particularly noted that the rotation of the diaphragm with respect to the casing not only cuts down the amount of liquid which may flow to the first stage impeller but also cuts down the amount of liquid which may flow to the second stage impeller. Thus by varying the position of the diaphragm with respect to the suction opening, the flow of liquid to both impellers may be regulated and the characteristics of the pump varied thereby. Variations in the suction opening, as is well known in the art of centrifugal pumps, will vary the pump characteristics.

Mounted on the shaft between the impellers is a shaft bushing 51 which also serves as a spacer for the impellers. The outer periphery of the bushing may be suitably grooved to reduce leakage along the external surface of the shaft bushing. The parts are held in position on the shaft by a nut 52 threaded on the end of the shaft. Upon drawing up on the nut by means of a spanner wrench as indicated at 52, the parts may be drawn into a tight assembly.

It will be noted that all the parts within the

casing bore are smaller in diameter than the minimum bore 21. Thus, upon removal of the cover plate 34a the nut 52 may be removed. By employing suitable pull rods in the threaded openings 54, the impellers and the diaphragm may be removed through the opening 19. This may be accomplished without disturbing the pipe connections to the suction and discharge openings 16 and 17. If desired, in addition, a plate which forms the end wall of the stuffing box may be provided with threaded openings 57 for the reception of jack screws. Further, the stuffing box sleeve 31 may be provided with an annular shoulder 58 which, by means of the jack screws, may be engaged by the plate 56 so as to enable the stuffing box sleeve 31 to be "pulled." Thus, all rotating parts and all fixed parts, and particularly the wearing rings 43 and the shaft bushing 44, may be removed from the pump with a minimum of effort for quick inspection, repair and replacement should circumstances require.

In Fig. 5 I have shown a modification of my invention which is essentially the same as the pump previously described with certain exceptions. In the pump shown in Fig. 5, the casing is cast with the suction opening 16 spaced 180 degrees from the discharge opening 17. It will be appreciated that the suction and discharge openings may be placed in any desired relation with each other. A further difference in the arrangement shown in Fig. 5 lies in the fact that the impeller wearing rings and the shaft bushing, indicated by the numerals 61 and 62 are formed integral with the diaphragm. Thus the diaphragm may be made in one piece and, when it is desired to renew the wearing rings or bushings, a new diaphragm may be substituted. However, if desired the wearing rings and shaft bushing may be pressed into position so as to permit renewal of these parts without renewing the entire diaphragm. A further change is shown in the construction of the stuffing box and the means for removing the shaft sleeve 63. The end of the shaft sleeve 63 is provided with a flange having threaded openings 64 for the reception of jack screws or pull rods.

It will be appreciated that I have provided a multi-stage pump which may be produced at a reduced cost and which is extremely simple to service. Moreover, the worn parts thereof may be quickly removed and replaced without disturbing the pipe connections to the pump. While I have shown only a two-stage pump, it will be appreciated that additional stages may be provided with a pump constructed on the same principles. Such additional stages, to attain the maximum benefits of the invention, should be in multiples of two.

While I have shown the preferred forms of my invention, it will be appreciated by those skilled in the art that various changes and modifications thereof, particularly in the form and relation of parts may be made, without departing from the spirit of my invention as set forth in the appended claims.

I claim:

1. A multi-stage centrifugal pump comprising, in combination, a casing having a bore forming an interior wall which is continuous and unbroken in a direction about the axis of the bore, suction and discharge connections for said casing, a drive shaft extending through one end of said casing, a pair of impellers mounted on said shaft, a member forming a partition between said impellers, said member having a pair of openings each communicating with the inlet of one of said impellers, the margins of said openings registering with the casing in such manner as to determine the amount of liquid flowing to said impellers, means for releasably locking said member in said casing, said member being shiftable in said casing about the axis of said shaft to vary the amount of liquid flowing to said impellers, said casing having a normally closed opening at the end thereof opposite to that through which the shaft extends and the minimum bore of said casing being at least greater than the diameter of said impellers and said member whereby said impellers and member may be withdrawn through said opening in the casing, said casing and member having cooperating shoulders which are pressed against each other by the liquid pressures developed within the casing.

2. A multi-stage centrifugal pump comprising, in combination, a casing having suction and discharge connections, a plurality of impellers mounted in said casing, a shaft extending through one end of the casing upon which the impellers are mounted, a removable member mounted on said shaft between the impellers and separating the casing into stages, said casing having a normally closed opening at the opposite end from that through which the shaft extends and having at least a minimum bore of larger diameter than the diameter of the impellers and said member, enabling said impellers and member to be slipped off the end of said shaft and through the opening in the casing without disturbing said suction and discharge connections, said removable member and casing having cooperating shoulders which are held in contact with each other during operation of the pump by hydraulic pressure.

3. A multi-stage pump comprising, in combination, a casing, a plurality of separately formed impellers mounted in said casing, a diaphragm between and separating said impellers, said impellers being arranged with their inlet openings facing each other and said diaphragm having a pair of openings each communicating with the inlet opening of one of the impellers, a shaft casing and diaphragm and said impellers being upon which said impellers and diaphragm are mounted, said diaphragm being loose with respect to the shaft, cooperating shoulders on said casing and diaphragm and said impellers being so constructed and arranged that the resulting hydraulic thrust in said casing is in a direction such as to press said shoulders into engagement with each other.

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