

Nov. 27, 1945.

C. L. BABB

2,389,753

HIGH PRESSURE CENTRIFUGAL PUMP

Filed Sept. 11, 1943

2 Sheets-Sheet 1

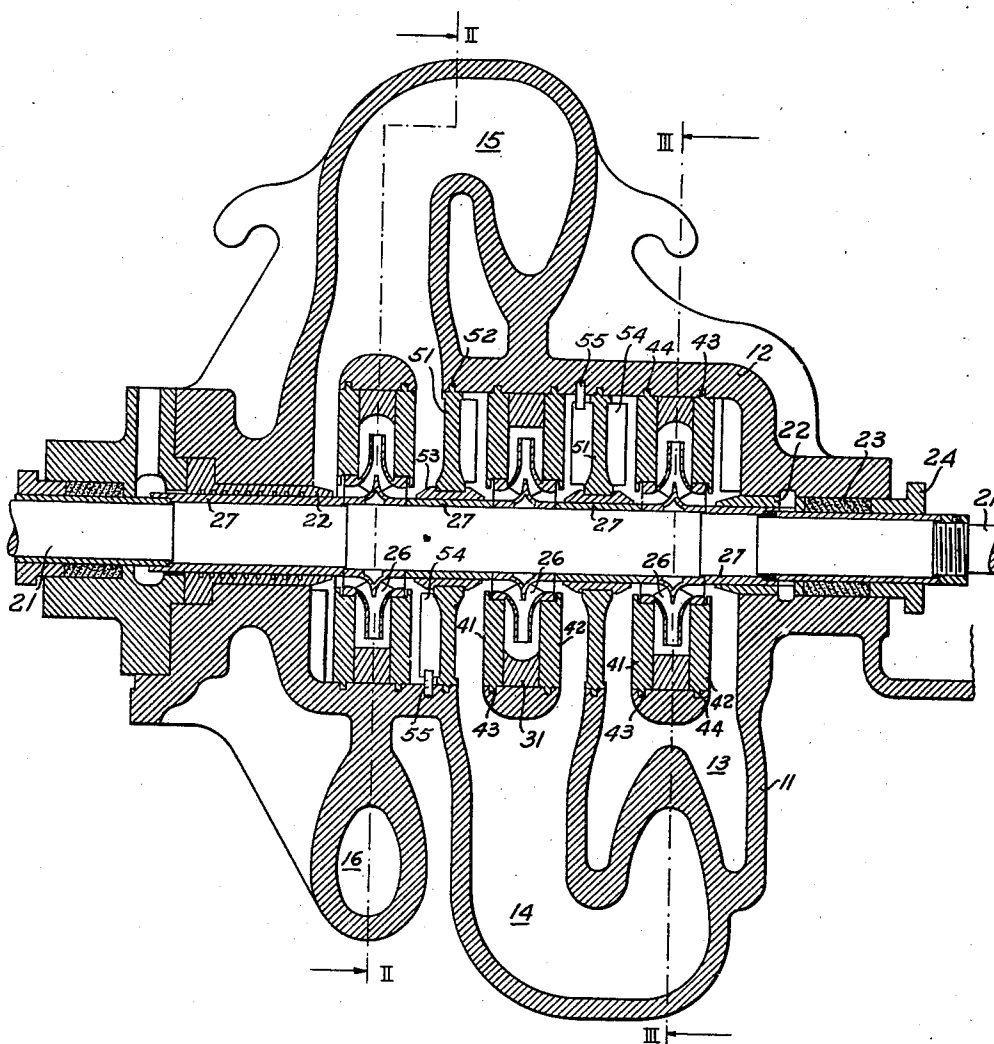


Fig. 1

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2 Sheets-Sheet 2

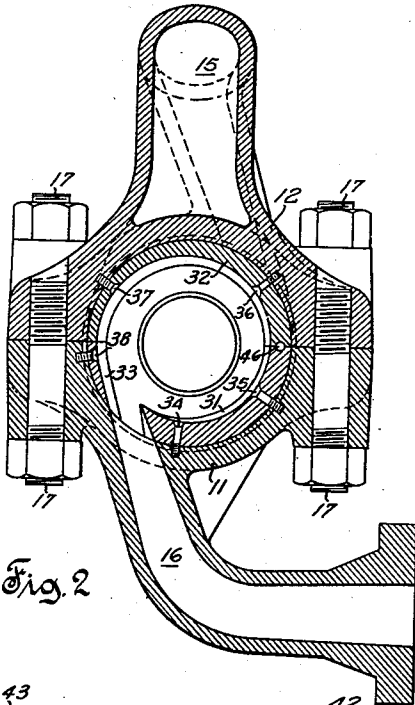


Fig. 2

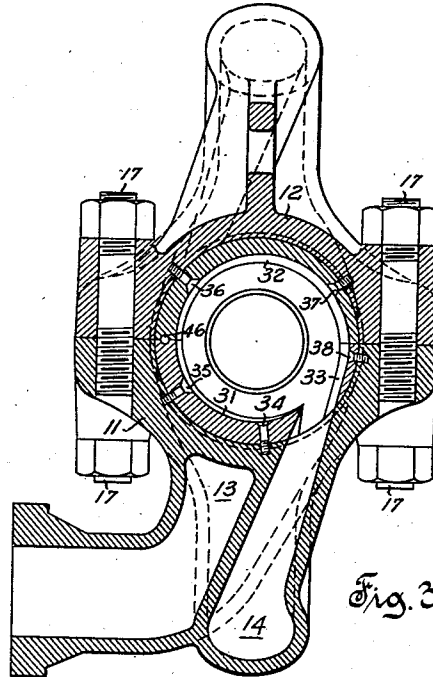


Fig. 3

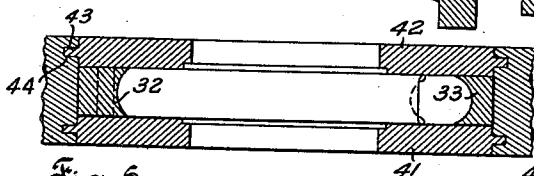


Fig. 6

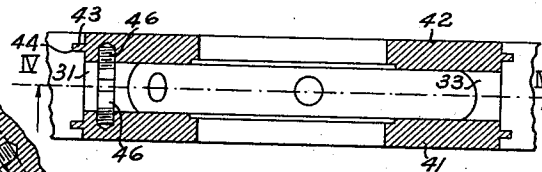


Fig. 5

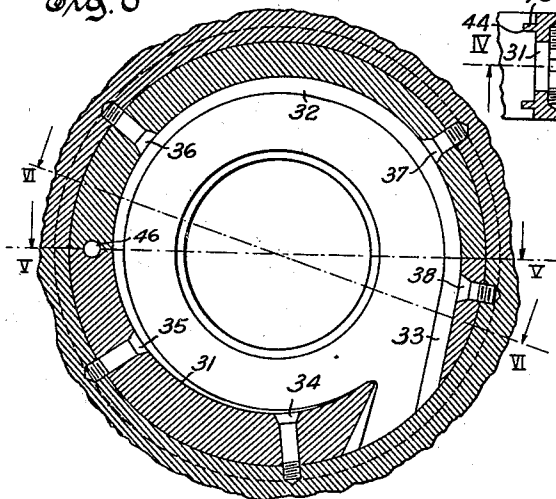


Fig. 4

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UNITED STATES PATENT OFFICE

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HIGH PRESSURE CENTRIFUGAL PUMP

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8 Claims. (Cl. 103-109)

This invention relates to improvements in centrifugal pumps and particularly to centrifugal pumps which are required to handle relatively small quantities of liquid at very high pressures.

In the usual centrifugal pumps, the pump casing is divided on a horizontal plane through the horizontal axis of the pump for convenience in manufacture and maintenance. And the volutes which produce conversion of the impeller discharge from velocity into pressure, are normally cast as parts of the casing. The high velocities produced in such high pressure pumps require that the volute passages be carefully shaped to secure the area and contour which will produce the most effective velocity-pressure conversion and that such passages be so finished as to avoid local turbulences and to minimize friction. The volute passages in high pressure pumps handling relatively small quantities of liquid are however very small in cross-sectional area and relatively complicated in shape thus making it very difficult to secure the proper finishing of the passage surfaces by chipping and grinding which are the only metal surfacing processes available.

When such pumps are used to supply a relatively small quantity of water such as 1000 g. p. m. at pressures of the order of 1800 pounds per square inch as in present day boiler feed pumps, the high velocities encountered cause erosion particularly in the volute passages receiving the discharge from the impellers where the velocity is highest. The cavities formed by such erosion must be filled by welding proper material into the cavities and must then be ground to the proper contour and finish. The operations required for repairing erosion in pump volutes are always expensive and frequently the erosion takes place in locations in which it is extremely difficult to do satisfactory welding or grinding.

In high pressure centrifugal pumps it was also found that it is exceedingly difficult to provide sufficient bolting to keep the horizontal joint tight. Prior constructions have been provided with two rows of bolts to hold the upper and lower casing parts together at the pressure mentioned. The inner row of bolts was located in portions of the pump casing between the several pump impellers as close to the horizontal axis of the pump as possible without interference with the various internal passages. The inner row of bolts was accordingly placed in portions of the casing surrounded at least in part by internal passages and projecting from the outer wall of the casing inwardly toward the center thereof. And the outer row of bolts was necessarily placed outside of the

outer walls of the internal passages. However, even the inner row of bolts was still a considerable distance from the center line of the pump and it was difficult to exert sufficient pressure thereon to produce a tight joint. Consequently at the high velocities encountered in pumps producing high pressures, erosion takes place at those portions of the joint projecting into the regions of high velocity and continues to such extent as to cause leakage to the exterior of the joint regardless of the pressure exerted by the outer row of bolts.

If the pump casing is bored out to such diameter as to permit the formation of volute passages within the bore with solid interstage diaphragms extending from the casing to support the pump shaft and the impellers, casing projections between the several impeller stages of the pump are eliminated and a single row of bolts can be provided which are placed at substantially uniform distances from the center line of the pump which was impossible heretofore. It is accordingly possible to secure a uniform distribution of pressure over the entire joint surface and to avoid points at which erosion may occur in the joint. The volute passages may then be formed as separate castings or may be made as a built up construction which may be individually finished to the contour and finish required and may then be secured in the bore of the casing. Any single volute may then be removed for repair and replacement whenever desired.

It is therefore an object of the present invention to provide a centrifugal pump in which at least the high velocity receiving portions of the volute passages are formed and finished separately and are then secured within the pump casing.

Another object of the invention is to provide a centrifugal pump in which the casing is bored out as a cylinder to receive at least the high velocity portions of the volute passages as structures to be inserted and seated in such bore.

Another object of the invention is to provide a centrifugal pump in which the volute passages are formed from separate diaphragms extending into a bore within the casing from the wall thereof with separate volute pieces placed between the diaphragms and shaped to provide the desired volute passage cross section.

Another object of the invention is to provide a centrifugal pump with separate diaphragms between the several impeller stages and extending inwardly from the outer wall of the pump casing

to form supports for the pump shaft and pump impellers.

Another object of the invention is to provide a centrifugal pump for producing high pressure in which the horizontal joint in the pump casing is kept tightly closed by a single row of bolts providing a uniform distribution of pressure over the entire casing joint area.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 is a vertical cross-sectional view of a pump constructed according to the present invention, the view being taken on a vertical plane through the longitudinal axis of the pump;

Fig. 2 is a vertical cross-sectional view taken on the plane of line II—II of Fig. 1;

Fig. 3 is a vertical cross-sectional view taken on the plane of line III—III of Fig. 1;

Fig. 4 is an enlarged fragmentary view taken on the plane of line IV—IV of Fig. 5 to show in detail, the manner in which the several separate portions forming the circumferential volute pieces are mounted and fastened in the casing of the pump;

Fig. 5 is a horizontal cross-sectional view taken on the plane of line V—V of Fig. 4 to illustrate the manner of mounting and securing the several volute forming diaphragms in the pump casing and to the circumferential volute portions to prevent both axial and rotational movement of such diaphragms, and

Fig. 6 is a view taken on the plane of line VI—VI of Fig. 4 to illustrate the particular configuration of the water conducting surface of the several portions forming one of the volutes.

Referring more particularly to the drawings by characters of reference, the reference numeral 11 designates the lower portion of a pump casing and reference numeral 12 designates the upper portion of a pump casing, the portions being formed by division of the casing on a horizontal plane through the longitudinal axis of the pump. Each of the casing halves is cast with the appropriate portions of the various internal passages so that joining of the casing halves completes the inlet passage 13, the interstage passages 14 and 15 and the discharge passage 16. The two casing halves are joined and are bored out on the axis of the pump to provide a cylindrical space somewhat larger than the diameter of the pump impellers. Such boring out of the casing provides a smooth finish on the interior of the casing and allows access to all portions of the above mentioned casing passages to provide for finishing of the surfaces thereof. All of the bolts 17 joining the two casing halves are set in a straight line in the casing flanges and relatively closely to the edges of such flanges thus providing considerable simplification in the bolt arrangement and placing the bolts in the best possible positions to secure uniform distribution of the pressure over the entire casing joint surfaces thereby preventing separation of such flanges.

A shaft 21 extends through casing 11, 12 and is sealed in the casing at the ends thereof by a pressure reducing bushing 22 spaced from the usual packing 23 and packing glands 24. A plurality of double inlet impellers 26 are mounted on the shaft in spaced relation to be severally supplied by a liquid to be pumped by way of passages 13, 14 and 15. As shown, the impellers are preferably of the double inlet type which are inherently balanced in the axial direction. Shaft

21 of course is protected against contact with the liquid by sleeves 27 made of non-corrosive material.

With the interior of the pump casing formed as a smooth cylinder, the usual volute passages into which the impellers discharge, are formed by separate pieces mounted in the bore in the casing halves. As is shown in the drawings, each volute passage is made of the circumferential volute pieces 31, 32 and 33 set into and secured in the casing and enclosed at the sides by the diaphragms 41 and 42. The circumferential portions of the volutes are substantially segments of a hollow cylinder and are necessarily made in three pieces because the casing is horizontally split and because a passage of the full cross-sectional area of the volute passageway must be provided to allow flow of the liquid from the volute into the passage leading to the inlet of the next stage. And the several circumferential volute pieces are also necessarily made with inner surfaces of different degrees of concavity and with increasingly greater depth from the so-called lip or cut-off point to the point of discharge from the volute. Thus the contour of the volute piece 31 varies from a substantially flat surface at the cut-off end to a concave surface of material depth at the end joining the volute piece 32, the depth of the volute piece 32 increases toward its end adjacent the volute piece 33 and even though the volute piece 33 is very short, the depth of its concave surface increases from the end adjacent the piece 32 to the discharge passage. Such constant change of depth and degree of concavity provides volute passages of constantly increasing area from the cut-off point to the discharge passage thus providing for uniform conversion of velocity to pressure throughout the entire volute. The circumferential volute pieces are individually held in position by pins 34, 35, 36, 37 and 38 extending through such volute pieces and threaded into the casing and the inner ends of the pins are fastened by welding to the volute pieces. It will be understood that the inner ends of the pins are ground to conform with the adjacent volute surfaces.

The diaphragms 41, 42 are each made as separate plates and extend from the interior surface of the casing bore to adjacent the inlet edges of each of the double inlet impellers 26 where suitable wearing rings are provided. Each of the diaphragms is accordingly annular in shape and each pair of diaphragms together with the circumferential volute pieces as described above, combine to form a complete volute inclosure for the discharge edge of an impeller 26 and for converting the velocity of the discharged liquid into pressure. The diaphragms 41 and 42 are provided on the outer periphery thereof with tongues 43 fitting into matching grooves 44 in the casing, the grooves being so located that the inner surfaces of the diaphragms contact with the sides of the volute pieces 31, 32 and 33. The diaphragms are accordingly held against lateral displacement by their tongue and groove joints with the casing and are held against rotational movement by pins 46 threaded into the diaphragms from the inner surface thereof and extending into matching apertures between the volute portions 31 and 32 formed by matching semi-circular grooves in the circumferential volute pieces on the horizontal division plane of the casing. The diaphragms are assembled on the shaft in their proper relation to the impellers and placed in the lower casing half 11 as the shaft is lowered into place in its bearings. The diaphragms are then locked in place

simply by lowering of the upper half 12 of the casing into its proper position on the lower half thereof.

Interstage diaphragms 51 are located between the several impellers 26 and are likewise annular plates with tongues 52 fitting into grooves in the interior of the pump casing. The inner peripheries of the diaphragms 51 are broadened and are seated in grooves provided therefor in split sleeves 53 fitting on the impeller shaft 21 and forming bushings between impeller stages which reduce interstage leakage to a minimum. The grooves in the casing and in the bushings 53 prevent lateral displacement of the interstage diaphragms and bushings. Each of the diaphragms 51 is provided with one or more fins 54 extending into the space adjacent the volute inclosures and pins 55 are fixed in the casing adjacent the diaphragms. The diaphragms may rotate until one or the other fins is stopped by the pin which then prevents further rotational movement of the diaphragm. The interstage diaphragms are therefore held against both lateral and rotational displacement after seating in the grooves and against the pin respectively. The diaphragms 51 are integral and hence must be mounted on the shaft 21 at the time the several impellers 26 and the volute diaphragms 41, 42 are mounted thereon.

In the manufacture and assembly of the various parts of the pump, the flanges of the two casing halves are faced and drilled to receive the bolts. A boring bar and tool are inserted through the opening in the end of the casing for the bearings and extension of shafts there-through and the casing is bored out on a given diameter. The interior of the pump casing is accordingly formed as a finished hollow cylinder and the grooves are likewise formed for receiving the tongues of the several diaphragms. The inlet, interstage and outlet passages are now finished by chipping and grinding to minimize resistance to the flow therethrough. Properly shaped and finished circumferential volute pieces are set into the casing on the surface of the bore and are fixed therein by pins extending through such pieces. The impellers and the interstage and volute diaphragms are assembled on the shaft and are lowered into the lower half of the casing to seat the tongues on the lower half of the interstage and volute diaphragms into the grooves provided therefor. The upper casing half is lowered on the lower casing half thus setting the tongues of all of the diaphragms into the grooves provided therefor in the upper casing half. The casing halves are then bolted together and the pump is completely assembled.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, an impeller mounted on said shaft, and an enclosure comprising volute pieces extending circumferentially about said impeller and divided into a plurality of segments individually mounted in said casing and diaphragm plates extending at right angles to the axis of said shaft from adjacent said casing along opposite sides of said volute pieces and individually circumferentially mounted in said

casing said enclosure being positioned within said casing about said impeller and forming a volute passage receiving the fluid discharged therefrom.

2. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, an impeller mounted on said shaft, and an enclosure comprising volute pieces extending circumferentially about said impeller and mounted directly in said casing and diaphragm plates adjacent to and co-operating with said volute pieces and having circumferential tongues entering grooves in said casing to prevent lateral displacement of said plates, said enclosure being mounted in said casing about said impeller and forming a volute passage receiving the fluid discharged therefrom.

3. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, an impeller mounted on said shaft, and an enclosure comprising volute pieces extending circumferentially about said impeller and mounted in said casing and diaphragm plates having circumferential tongues entering grooves in said casing and having pins extending into said volute pieces from said plates to prevent lateral and rotational movements thereof respectively, said enclosure being mounted in said casing about said impeller and forming a volute passage receiving the fluid discharged therefrom.

4. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, an impeller mounted on said shaft, and an enclosure comprising volute pieces extending circumferentially about said impeller and divided into a plurality of segments individually mounted in said casing and annular diaphragm plates peripherally mounted individually in said casing adjacent opposite sides of said volute pieces, said enclosure being mounted in said casing about said impeller and forming a volute passage receiving the fluid discharged therefrom.

5. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, a plurality of impellers mounted on said shaft, sleeves on said shaft between said impellers, an enclosure mounted in said casing and forming a volute passage for receiving the fluid discharged therefrom, and an interstage diaphragm mounted in a groove in each of said sleeves, said diaphragms having tongues formed circumferentially thereon to enter grooves in said casing for preventing lateral displacement of said diaphragms.

6. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, a plurality of impellers mounted on said shaft, an enclosure mounted in said casing and forming a volute passage for receiving the fluid discharged therefrom, and interstage diaphragms severally mounted on said shaft between said impellers, said diaphragms having a fin extending therefrom into engagement with a pin extending from said casing for preventing rotational displacement of said diaphragms.

7. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, a plurality of impellers mounted on said shaft, an enclosure mounted in said casing and forming a volute passage for receiving the fluid discharged therefrom, and interstage diaphragms severally mounted on said shaft between impellers, said

diaphragms having tongues formed circumferentially thereof to enter grooves in said casing and having a fin extending therefrom into engagement with a pin extending from said casing for preventing lateral and rotational displacement, 5 respectively, of said diaphragms.

8. In a centrifugal pump, a casing divided through the longitudinal axis thereof, a shaft extending through said casing, a plurality of impellers mounted on said shaft, and enclosures 10 each comprising volute pieces extending circumferentially about said impellers and diaphragm plates extending at right angles to the axis of

said shaft, said enclosures being severally mounted in said casing and severally forming volute passages for receiving the fluid discharged from the several said impellers, and interstage diaphragms having tongues formed circumferentially thereof to enter grooves in said casing and fins extending therefrom into engagement with pins extending from said casing for preventing lateral and rotational displacement of said diaphragms, said interstage diaphragms being severally mounted on said shaft between said impellers.

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