May 22, 1923. 1,456,051

W. D. CARTER

CENTRIFUGAL PUMP

Filed May 14, 1920 2 Sheets-Sheet 1

Fig. 1.

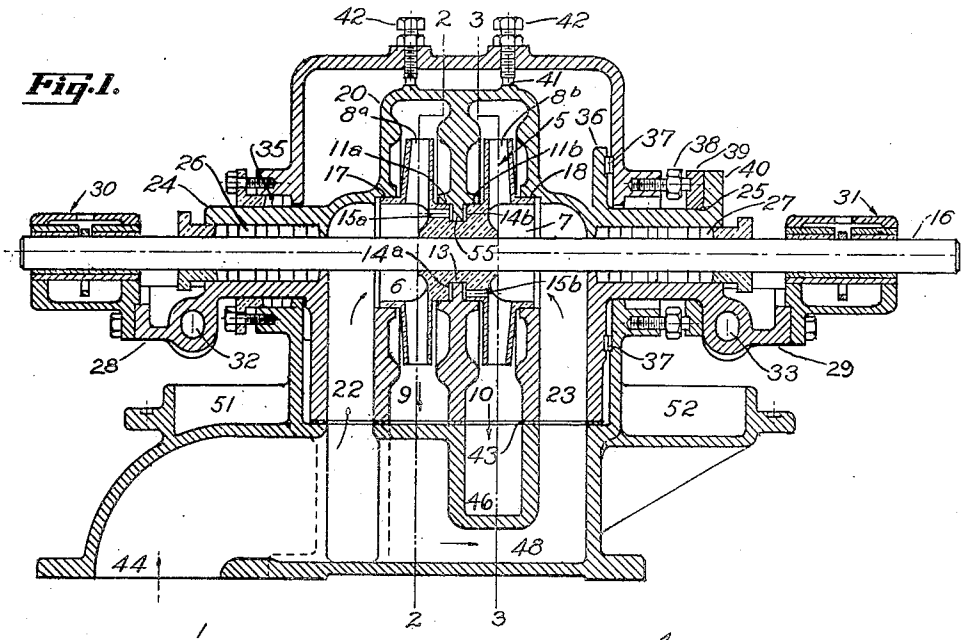


Fig. 2.

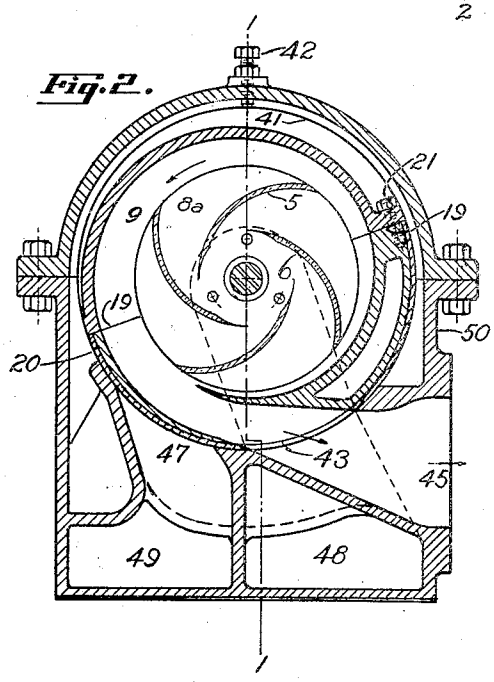
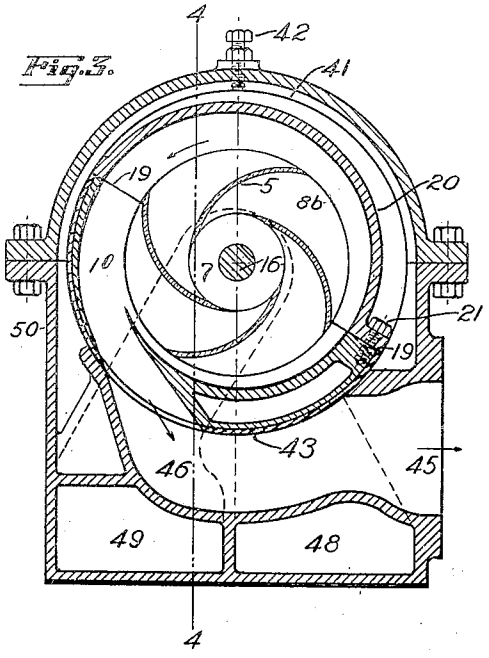


Fig. 3.



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Fig. 5.

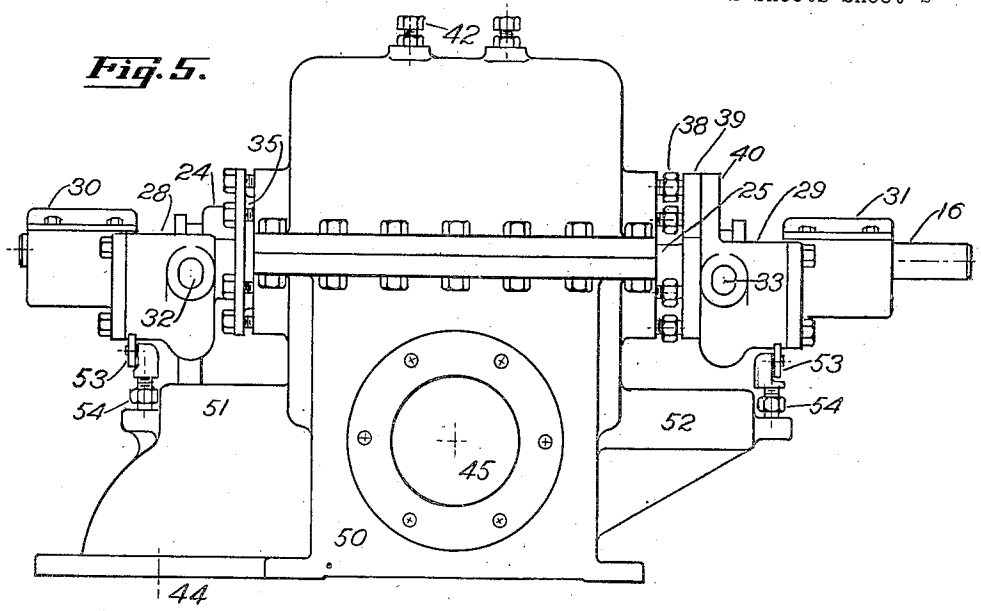


Fig. 6.

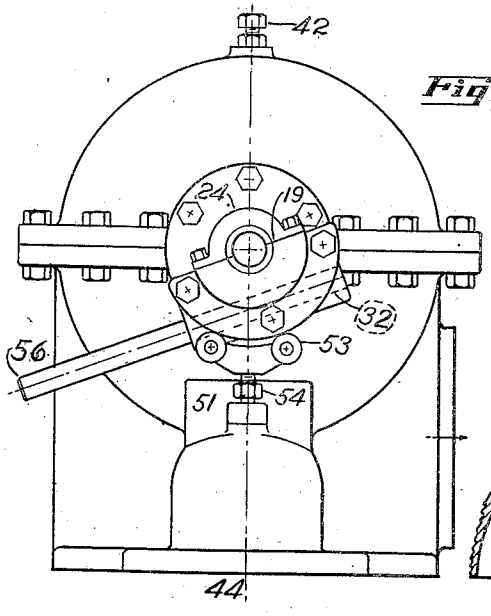
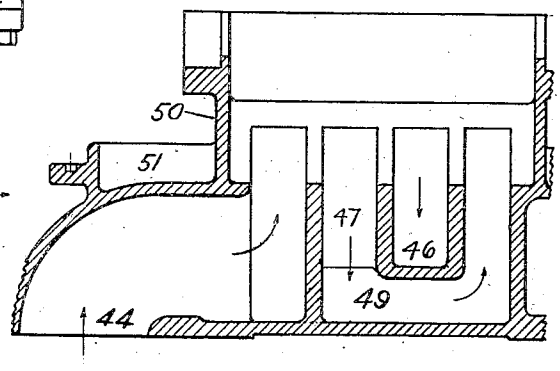


Fig. 4.



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UNITED STATES PATENT OFFICE.

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CENTRIFUGAL PUMP.

Application filed May 14, 1920. Serial No. 381,455.

To all whom it may concern:

Be it known that I, WILLIAM D. CARTER, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented a new and useful Improvement in Centrifugal Pumps, of which the following is a specification.

This invention relates to an improved construction for centrifugal, turbine or similar pumps of the multi-impeller type and pertains particularly to improvements in multi-service pumps of the type illustrated in my Patents Nos. 1,260,639 and 1,267,512, in which a pair of casing sections are movable with relation to each other so as to bring suitable ports of one casing into register with selected ports of the other casing and thereby permit the impellers to operate in parallel, in series, or in multiple series.

The object of this invention is to simplify and safeguard the bearings of a multiple-service centrifugal pump. This object is attained first by means of an improved hydraulic impeller balancing device which makes a thrust bearing unnecessary; second by the method of supporting the bearings which insures their accurate alignment under all of the several operating positions of the pump; and third by the casing construction which facilitates the opening of the pump for inspection or removal of the operating parts, all without subjecting the bearings to possible misalignment or injury.

The invention further consists of the parts and the construction and combination of parts as hereinafter more fully described and claimed, having reference to the accompanying drawings, in which—

Fig. 1 is a longitudinal vertical cross section of a double service centrifugal pump, taken on line 1—1, of Fig. 2, with the passages in position for combining the flow from the two sides of the double impeller in parallel, and showing the bearings carried by the inside or volute casing.

Fig. 2 is a cross section taken on line 2—2, of Fig. 1, with passages connected as in Fig. 1, and showing the inside and outside casings split longitudinally, and the upper and lower parts held together by bolts.

Fig. 3 is a cross section taken on line 3—3, of Fig. 1, but showing passages connected so as to combine the flow from the two sides of the double impeller in series.

Fig. 4 is a longitudinal vertical cross section of the lower part of the exterior casing taken on line 4—4, of Fig. 3, and showing the course of the water when the two sides of the double impeller are operating in series.

Fig. 5 is a side elevation of the pump showing the horizontally split casing, the location of the casing jack-screws, and the arrangement of the bearings.

Fig. 6 is an end elevation of the same double service pump showing the position of the turning lever when the passages are set for parallel flow, and also showing the location of the casing lifting jack at one end of the pump.

Referring to the drawings in detail and particularly to Figs. 1 and 2, 5 indicates a double impeller having two independent stream passages with entrance openings at 6 and 7, and peripheral discharge openings between the vanes as at 8^a and 8^b.

The volute casing 20 has flanges 17 and 18 which make running joints in the usual manner with the outside surfaces of the impeller necks surrounding entrance openings 6 and 7 respectively.

The volute casing 20 is split longitudinally on a plane passing through the center of the shaft 16, as indicated by line 19 in Figs. 2, 3 and 6, so that the volute casing 20 can be opened and the contained parts inspected or removed by loosening bolts 21 shown in Figs. 2 and 3. This greatly facilitates the removal of the impeller and shaft, especially in large pumps, without subjecting the bearings to the eccentric strains which are often imposed on them in opening pumps of the end-opening type.

Volute casing 20 contains volute passages 9 and 10 which receive water from the respective peripheral impeller openings 8^a and 8^b, and discharge it into manifold casing 50. Volute casing 20 likewise contains inlet passages 22 and 23.

Volute casing 20 is provided with trunnions 24 and 25 which contain stuffing boxes 26 and 27 around shaft 16. These trunnions carry brackets 28 and 29 for supporting bearings 30 and 31, and have holes 32 and 33 cast in them to receive bars or levers 56 for turning the volute casing 20 as shown in Fig. 6.

Since bearings 30 and 31 are carried by rigid extensions of volute casing 20, it is obvious that their proper alignment will not be subject to any motion of volute casing 20 on its supporting seat in outside casing 50.

Trunnion 24 passes through a stuffing box 35 in the outside casing 50 and the opposite end of volute casing 20 carries a flange 36 which, by means of gasket 37, forms a water-tight joint with the outside casing 50.

Jack-bolts 38 are threaded into the end of outside casing 50 and may be backed against the split ring 39 which in turn presses uniformly against the split flange 40 at the end of trunnion 25, and so pulls flange 36 tightly against gasket 37.

Flanges 41 have an outside cylindrical surface concentric with the seat or surface of contact between the volute casing 20 and the outside casing 50. Set-screws 42 are provided to engage flanges 41 in order to hold inside casing 20 and manifold casing 50 together at their surface of contact.

A brass or other non-corrosive facing 43 may be provided on the outside cylindrical surface of the volute casing 20. A similar facing may be placed on the concave cylindrical surface or seat in the manifold casing 50 if desired to avoid all corrosion there and any consequent sticking together of the two casings.

The above facings could serve as gaskets although the leakage at this seat, between accurately machined surfaces will be insignificant.

The exterior casing 50 is also made in two main sections which are bolted together on a plane passing through the center line of the shaft. The top half serves primarily as a cover; and the lower half contains the main suction opening 44, the main discharge opening 45, and the several manifold passages used to connect the openings in the volute casing 20 in parallel or series as conditions may require.

These manifold passages are indicated by the numbers 46, 47, 48 and 49, in Figs. 1, 2, 3 and 4, and will be referred to again in describing the operation of the pump.

Drip boxes 51 and 52 are provided to collect any water which may drip or spill from the stuffing boxes.

Rollers 53 are carried on jack-screws 54, and are designed to lift the volute casing 20 slightly from its seat in the outside casing 50 by bearing upward against the cylindrical surfaces of the bearing brackets 28 and 29.

For low head service the position of the casing is as shown in Figs. 1 and 2. In this position the passages are connected so that the two sides of the double impeller operate in parallel as in a double suction pump, and the flow is as follows:

Referring to Figs. 1 and 2 the water enters the outside casing 50 through the suction opening 44. Part of it passes through entrance passage 22 in the volute casing 20 to entrance opening 6 in the impeller, and the other part flows through manifold passage 48, and volute casing entrance passage 23, into the impeller entrance opening 7. The two sides of the impeller discharge the water, under approximately the same pressure, into volute passages 9 and 10, from which it is combined in the manifold casing 50 and discharged through main discharge opening 45.

For high head service the volute casing 20 is rotated to the position shown in Fig. 3 so that water enters the main suction opening 44 as before, passes through volute casing inlet passage 22, see Figs. 1 and 4, to entrance opening 6 in impeller 5, thence through volute passage 9, manifold passages 47 and 49, and volute inlet passage 23 to impeller entrance opening 7; and from impeller discharge 8^b and volute passage 10, it is discharged into manifold passage 46 and so on through main pump discharge opening 45. In this connection it is evident that the water has passed through the two sides of the impeller in series, thereby receiving approximately twice the pressure obtained in the above low head position.

It is obviously practical to assemble on the same shaft a larger number of impellers than shown here, and to arrange connecting passages to permit of more than two combinations of connections, and therefore to give a greater number of services—all in accord with the principles of this invention. For instance, in my Patent No. 1,260,639, a three-service pump is shown which is capable of parallel, series, or multiple series operation.

If the volute casing 20 were left in one position and not moved in its seat in the outside casing for a long time, it is possible that the above seat might stick and make it difficult to turn the volute casing. Such a corroded joint which has a very small surface can be broken loose easily if pressure can be applied approximately at right angles to the surfaces of contact, after which the surfaces will slide easily enough.

Consequently the set-screws 42, which are provided to hold the volute casing 20 against its seat in the outside casing 50 when the pump is in operation, can be loosened and clearance thereby provided to permit of a slight raising of the volute casing 20 in an emergency for the purpose aforesaid.

To facilitate the separation of the above surfaces of contact the flange and gasket joint 36—37 is provided at one end of the volute casing, although it is possible that enough motion could be obtained through a stuffing box such as stuffing box 35 shown at tht other end of the volute casing.

In very large pumps a pair of roller jacks

53—54, as shown in Figs. 5 and 6, are provided to raise the weight of the volute casing 20 and to facilitate turning it. Other lifting devices may also be employed for this purpose.

In centrifugal and turbine pumps a serious problem is often encountered in overcoming the longitudinal thrust of the impeller, or impellers in the case of multi-impeller pumps, due to the different water pressures exerted on different areas on the two sides of the impellers. The problem requires special treatment where the impellers must operate either in parallel or series, when it is desired to dispense with a thrust bearing and its accompanying difficulties.

The hydraulic balancing device here shown which forms part of this invention, is located between the two peripheral discharge openings 8^a and 8^b of the double impeller.

It consists of the following construction, in which the chambers 14^a and 14^b are formed between the inner faces of the impeller and the two sides of the stationary central partition of the volute casing. Concentric flanges, one on each side of the central stationary partition, cooperate with similar flanges on the two sides of the impeller to form running joints 11^c and 11^b surrounding chambers 14^a and 14^b. A similar running joint 13 of smaller diameter separates the two chambers 14^a and 14^b, and is formed between the central partition and a close running concentric surface of the impellers.

Chamber 14^a is in leakage connection through running joint 11^a, with volute passage 9; and chamber 14^b is in leakage connection through running joint 11^b with volute passage 10. Ports 15^a connect chamber 14^a with impeller entrance passage 6; and ports 15^b connect chamber 14^b with impeller entrance passage 7. Ports 15^a and 15^b are closed and opened alternately as one or the other sets of ports moves towards or away from the central partition of the volute casing.

When the pump is running as a single-stage double-suction pump, the operation of the hydraulic balancing device is as follows: Approximately equal pressure exists in volute pasages 9 and 10, and also in impeller entrance passages 6 and 7. If the above pressures could be maintained exactly equal in practice, and if the pressure-areas were exactly equal, there would of course be no end thrust when the pump is operating as a double-suction single-stage pump. However this is seldom the case owing to unequal friction in the various water areas, and to unequal leakage through the several running joints; and so in most types of pumps a thrust-bearing is provided to receive the unbalanced end-thrust.

With the construction shown a thrust bearing is not required, for if there should be any unbalanced pressure, resulting in a slight movement toward the suction-end of the pump, ports 15^a would be moved away from the central partition and thereby opened, while ports 15^b would be moved toward the central partition and closed.

The opening of ports 15^a would place chamber 14^a in communication with the low pressure impeller entrance opening 6, thereby tending to reduce the pressure in chamber 14^a and to move the impeller in a direction away from the suction-end of the pump. The closing of ports 15^b would permit the pressure in chamber 14^b to rise, owing to the leakage of higher pressure water through running joint 11^b, and this would likewise tend to move the impeller away from the suction end of the pump.

The leakage through the small running joint 13 would not materially affect the above result and so both chambers would operate to bring the impeller back away from the suction-end of the pump.

If on the other hand unbalanced forces should tend to move the impeller too far in the opposite direction, it is obvious that a similar reversal of conditions would ensue, and the impeller would find a position of equilibrium through the automatic adjustment of pressures in the two chambers 14^a and 14^b.

When the pump is running as a two stage single-suction pump the same general results will be obtained although the pressures operating in impeller entrance 7, volute passage 10 and consequently in chamber 14^b, will tend to be approximately one stage higher than those obtained on the opposite side of the impeller.

The operation may be explained clearly by first assuming as a hypothetical case, that running joints 11^a and 11^b do not exist, and therefore that chamber 14^a is in direct connection with volute passage 9 and chamber 14^b is in direct connection with volute passage 10. In this case there would obviously be an unbalanced force toward the suction end of the pump approximately equal in amount to the single stage pressure of impeller entrance passage 7 against a circular area whose circumference is that of the running joint 13.

In considering the operation of the actual construction shown it is only necessary to add or subtract this initial unbalanced force from other forces which may be clearly analyzed.

It is necessary to consider only the two extreme positions of the impeller, and if the unbalanced force prevailing in either position tends to move the impeller toward the opposite end, it is obvious that a position of equilibrium will be found somewhere between the two extreme positions.

For instance if the impeller should be in its extreme position away from the suction-end of the pump, port 15^a would be closed and port 15^b would be opened. Chamber 14^a would therefore be of the same pressure as volute passage 9 with which it is in leakage connection through running joint 11^a; and chamber 14^b would be of the same pressure as impeller entrance opening 7 by connection through open ports 15^b.

The walls of chamber 14^a would therefore be subjected to the same pressure as in the hypothetical case where running joints 11^a and 11^b were eliminated, but the side-walls of chamber 14^b would be under one stage less pressure than in the hypothetical case.

Consequently an unbalanced force equal to one stage pressure on the wall area of chamber 14^b would be added to the initial force pressing the impeller toward the suction and away from the extreme assumed position.

If on the other hand the impeller should be in its extreme position toward the suction-end of the jump, port 15^a would be open and port 15^b would be closed. Chamber 14^a would therefore be subjected to the same pressure as impeller entrance opening 6 by connection through ports 15^a; and chamber 14^b would build up to the same pressure as volute passage 10 with which it is in leakage connection through running-joint 11^b.

Chamber 14^b would therefore be of the same pressure as in the hypothetical case where running joints 11^a and 11^b were eliminated; but the side walls of chamber 14^a would be under one stage pressure less than in the hypothetical case. Consequently the resulting force would be the algebraic sum equivalent to one stage pressure on the side wall area of chamber 14^a pressing away from the suction-end-of the pump, and the initial force equivalent to one stage pressure on the area bounded by running-joint 13 in the opposite direction. Since the area of the former is much larger than the latter area, the unbalanced force would tend to move the impeller toward its opposite extreme position. Consequently a position of equilibrium would be automatically assumed between the two extreme positions in the endwise motion of the impeller.

This balancing device is effective in balancing any number of impellers mounted on the same shaft and operating in parallel, in series, or in multiple series.

It is obviously possible to modify the construction shown without departing from the principles of the invention. For instance ports 15^a and 15^b could be carried through the volute casing stationary wall at 55 and connected with passages having pressures approximately equal to impeller entrance openings 6 and 7 respectively. Or ports 15^b could connect with impeller entrance passage 6 instead of with impeller entrance passage 7 with a possible variation in the relative diameters of the running joints 11^a and 11^b.

These and other modifications are possible without departing from the spirit of this invention and without detracting materially from the efficiency of the balancing device under either series or parallel operation.

All of the features herein described contribute to the object sought, namely to simplify and safeguard the bearings which are of prime importance in the successful operation of a centrifugal or turbine pump.

Having thus described my invention, what I claim and desire to secure by Letters Patent is—

1. In a multiple service pump having impellers assembled on a shaft, a casing surrounding the impellers, shaft bearings supported by the casing on each side of the impellers, and another casing surrounding and supporting the first casing.

2. In a multiple service pump having impellers a sectional inside casing surrounding the impellers and partable on a plane through the axis of rotation of the impellers, a sectional outside casing surrounding the inside casing and partable likewise on a plane through the axis of rotation of the impellers, an extension on each side of the inside casing passing through the outside casing, and a bearing supported on each extension of the inside casing.

3. In a multiple service pump, a plurality of impellers, an inside casing section surrounding the impellers, an outside casing section surrounding the inside casing section, an extension on each side of the inside casing passing through the outside casing, a movable water-tight joint between the inside and outside casings where the extensions to the inside casing pass through the outside casing.

4. In a multiple service pump, a plurality of impellers assembled upon one driving shaft, a longitudinally split inside casing surrounding the impellers, a longitudinally split outside casing surrounding the inside casing except at its ends, stuffing boxes to prevent leakage where the inside casing passes through the outside casing, and shaft bearings formed in the ends of the inside casing.

5. In a multiple service pump, a plurality of impellers assembled upon one driving shaft, a longitudinally split inside casing surrounding the impellers, a longitudinally split outside casing surrounding the inside casing except at its ends, and means to press laterally on the ends of the inside casing.

6. In a multiple service pump, a plurality of impellers assembled upon one driving shaft, a longitudinally split inside casing

surrounding the impellers, a longitudinally split outside casing surrounding the inside casing except at its ends, a stuffing box at one end and a ring gasket at the other end to prevent leakage where the inside casing passes through the outside casing.

7. In a multiple service pump, a pair of concentric casing sections having a concentric surface of contact between them, and means for holding together or separating the casings at their surface of contact.

8. In a pump of the character described, a shaft, a plurality of impellers secured thereon, a volute casing surrounding the impellers, a journal member at each end of the casing for the reception of the shaft, an exterior casing enclosing the volute casing, and bearing members in said exterior casing for the reception of the shaft bearings.

9. In a pump of the character described a shaft, a plurality of impellers secured thereon, a volute casing surrounding the impellers, a journal member at each end of the casing for the reception of the shaft, an exterior casing enclosing the volute casing, bearing members in said exterior casing for the reception of the shaft bearings, a plurality of inlet and discharge passages formed in the volute casing, two sets of passages formed in the exterior casing, means permitting movement of the volute casing within the exterior casing to bring the inlet and the discharge passages into register with one set or another of the sets of passages formed in the exterior casing.

10. In a pump of the character described a shaft, a plurality of impellers secured thereon, a volute casing surrounding the impellers, a journal member at each end of the casing for the reception of the shaft, an exterior casing enclosing the volute casing, bearing members in said exterior casing for the reception of the shaft bearings, a plurality of inlet and discharge passages formed in the volute casing, two sets of passages formed in the exterior casing, means permitting movement of the volute casing within the exterior casing to bring the inlet and the discharge passages into register with one set or another of the sets of passages formed in the exterior casing, means permitting a limited lateral movement of the volute casing within the exterior casing, and means for imparting a lateral movement to the volute casing.

11. In a pump of the character described a shaft, a plurality of impellers secured thereon, a volute casing surrounding the impellers, a journal member at each end of the casing for the reception of the shaft, an exterior casing enclosing the volute casing, bearing members in said exterior casing for the reception of the shaft bearings, means permitting a slight lateral movement of the volute casing and bearings with relation to the bearings in the exterior casing, and means for imparting a lateral movement thereto.

12. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a seat member formed between the two casings, means permitting a slight lateral movement of the volute casing with relation to the seat member, and means for imparting a lateral movement to the volute casing.

13. In a pump of the character described a volute casing, an exterior casing enclosing the same, a pair of extensions, one on each end of the volute casing, bearing members in the exterior casing for the reception of said extensions, a seat member formed between the volute casing and the exterior casing, and means permitting lateral movement of the volute casing and the extension formed thereon with relation to the seat member and the bearings formed in the exterior casing.

14. In a pump of the character described a volute casing, an exterior casing enclosing the same, a pair of extensions, one on each end of the volute casing, bearing members in the exterior casing for the reception of said extensions, a seat member formed between the volute casing and the exterior casing, means permitting lateral movement of the volute casing and the extension formed thereon with relation to the seat member and the bearings formed in the exterior casing, and a pair of screw jacks, one adjacent each bearing member engageable with the volute casing extensions to impart a lateral movement thereto.

15. In a pump of the character described a volute casing, an exterior casing enclosing the same, a pair of extensions, one on each end of the volute casing, bearing members in the exterior casing for the reception of said extensions, a seat member formed between the volute casing and the exterior casing, means permitting lateral movement of the volute casing and the extension formed thereon with relation to the seat member and the bearings formed in the exterior casing, a pair of screw jacks, one adjacent each bearing member, an arm supported by each screw jack, and a pair of rollers on each arm engageable with the volute casing extensions to support the same.

16. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a seat member formed between the two casings, a plurality of registering passages formed in said casings, passing through the seat member, and means carried by the ex-

terior casing adapted to exert a lateral pressure on the volute casing to retain it in snug engagement with the seat member.

17. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a seat member formed between the two casings, a plurality of registering passages formed in said casings, passing through the seat member, and means carried by the exterior casing adapted to exert a lateral pressure on the volute casing to retain it in snug engagement with the seat member, said means comprising a screw supported by the exterior casing and engageable with the volute casing.

18. In a pump of the character described a volute casing, an exterior casing enclosing the same, a pair of extensions, one on each end of the volute casing, bearing members in the exterior casing for the reception of said extensions, a seat member formed between the volute casing and the exterior casing, means permitting lateral movement of the volute casing and the extension formed thereon with relation to the seat member and the bearings formed in the exterior casing, a pair of screw jacks, one adjacent each bearing member, an arm supported by each screw jack, a pair of rollers on each arm engageable with the volute casing extensions to support the same, and other means for imparting a lateral movement to the volute casing to raise it away from the seat.

19. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a shaft bearing on each end of the volute casing, a bearing at each end of the exterior casing through which said shaft bearings extend, and means for imparting a turning movement to the volute casing with relation to the exterior casing.

20. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a shaft bearing on each end of the volute casing, a bearing at each end of the exterior casing through which said shaft bearings extend, a stuffing box on each shaft bearing, and a stuffing box in one of the exterior housing bearings to prevent leakage between the shaft bearing and the exterior housing.

21. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a shaft bearing on each end of the volute casing, a bearing at each end of the exterior casing through which said shaft bearings extend, an annular flange on one end of the volute casing, a packing gasket interposed between said flange and the exterior housing, and means for exerting an endwise pressure on the volute casing to exert a pressure upon the gasket.

22. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a shaft bearing on each end of the volute casing, a bearing at each end of the exterior casing through which said shaft bearings extend, an annular flange on one end of the volute casing, a packing gasket interposed between said flange and the exterior housing, and means for exerting an endwise pressure on the volute casing to exert a pressure upon the gasket, said means comprising a second annular flange formed on one of the shaft bearings and screws interposed between said flange and the exterior housing.

23. In a pump of the character described the combination with the volute casing and the exterior casing enclosing the same, of a shaft bearing on each end of the volute casing, a bearing at each end of the exterior casing through which said shaft bearings extend, a stuffing box on each shaft bearing, a stuffing box in one of the exterior housing bearings to prevent leakage between the shaft bearing and the exterior housing, an annular flange formed on one end of the volute casing, a gasket interposed between said flange and the exterior housing, a second annular flange on the adjacent shaft bearing, and screws interposed between said flange and the exterior housing to exert a pressure on the gasket interposed between the first named annular flange and the exterior housing.

24. In a pump of the character described a plurality of impellers, a shaft upon which the impellers are secured, a divided volute casing enclosing the impellers, a bearing member at each end of the volute casing for the reception of the shaft, a divided exterior casing enclosing the volute casing, and bearings formed in said exterior casing for the reception of the shaft bearings formed on the volute casing.

25. In a pump of the character described a plurality of impellers, a shaft upon which the impellers are secured, a divided volute casing enclosing the impellers, a bearing member at each end of the volute casing for the reception of the shaft, a divided exterior casing enclosing the volute casing, bearings formed in said exterior casing for the reception of the shaft bearings formed on the volute casing, a plurality of registering passages formed in the volute casing and in the exterior casing, a seat member formed between the volute casing and the exterior casing, means carried by the exterior casing for exerting a lateral pressure on the volute casing against the seat member, and other means carried by the exterior casing for

raising the volute casing with relation to the seat member.

26. In a pump of the character described a volute casing, a shaft bearing on each end thereof, an exterior casing enclosing the volute casing, and bearing members in said exterior casing for the reception of the shaft bearings and for the support of the volute casing.

27. In a pump of the character described a pair of opposed impellers, a volute casing enclosing the same, a partition member within the volute casing separating the impellers and a hydraulic thrust chamber formed between each impeller and said partition member.

28. In a pump of the character described a pair of opposed impellers, a volute casing enclosing the same, a partition member within the volute casing separating the impellers, a hydraulic thrust chamber formed between each impeller and said partition member, and a port formed on each impeller, said ports communicating at one end with the suction side of each impeller and at the opposite end with the adjacent hydraulic thrust chamber.

29. In a pump of the character described a pair of opposed impellers, a volute casing enclosing the same, a partition member within the volute casing separating the impellers, a hydraulic thrust chamber formed between each impeller and said partition member, an annular hub-like projection on each impeller in which the ports are formed, and an annular flange on each side of the partition member forming a running joint with the respective hub members.

30. In a centrifugal pump a pair of interspaced impellers, a volute casing enclosing the same, separate intake passages formed in the casing connecting with the respective suction sides of each impeller, a central partition member in the volute casing forming separate discharge passages for each impeller, and a hydraulic thrust chamber formed between each impeller and the central partition member.

31. In a centrifugal pump a pair of interspaced impellers, a volute casing enclosing the same, separate intake passages formed in the casing connecting with the respective suction sides of each impeller, a central partition member in the volute casing forming separate discharge passages for each impeller, a hub member formed on the inner side of each impeller, an annular flange formed on each side of the partition member forming a running joint with the respective hub members, a hydraulic thrust chamber formed between the partition member and each hub member, and a discharge port formed in each hub member, said ports communicating at one end with their respective hydraulic thrust chambers, and at their opposite ends with areas of lower pressure.

32. In a centrifugal pump a pair of interspaced impellers, a volute casing enclosing the same, separate intake passages formed in the casing connecting with the respective suction sides of each impeller, a central partition member in the volute casing forming separate discharge passages for each impeller, a hub member formed on the inner side of each impeller, an annular flange formed on each side of the partition member forming a running joint with the respective hub members, a hydraulic thrust chamber formed between the partition member and each hub member, a discharge port formed in each hub member, said ports communicating at one end with their respective hydraulic thrust chambers, and at their opposite ends with the suction sides of the impellers, and means permitting a limited endwise movement of the impellers with relation to the hydraulic thrust chambers to permit opening and closing of the respective discharge ports.

33. In a centrifugal pump, an impeller having a pair of opposed intake openings and a pair of spaced independent annular discharge passages, a stationary partition extending between the annular discharge passages of the impeller, a pair of concentric flanges on each side of the stationary partition, a third concentric flange of smaller diameter located between the other flanges on the stationary partition, corresponding concentric flanges on the impeller designed to run in close proximity to the flanges on the stationary partition, a chamber formed between each side of the stationary partition and the impeller and bounded by the respective adjacent faces of the corresponding concentric flanges on the stationary partition and the impeller, and ports connecting each pressure chamber with a water area of lower pressure and arranged to open and close with the endwise movement of the impeller.

34. In a centrifugal pump the combination of a casing, an impeller shaft, twin impellers on the shaft with individual inlets and a suitable outlet, and means between the impellers forming an automatic hydraulic counterbalance for the impellers.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

WILLIAM DOUGLAS CARTER.

Witnesses:
MONTAGUE FERRY,
A. M. CARTER.