Dec. 16, 1952 M. W. STOUT 2,621,601

CENTRIFUGAL PUMP ASSEMBLY

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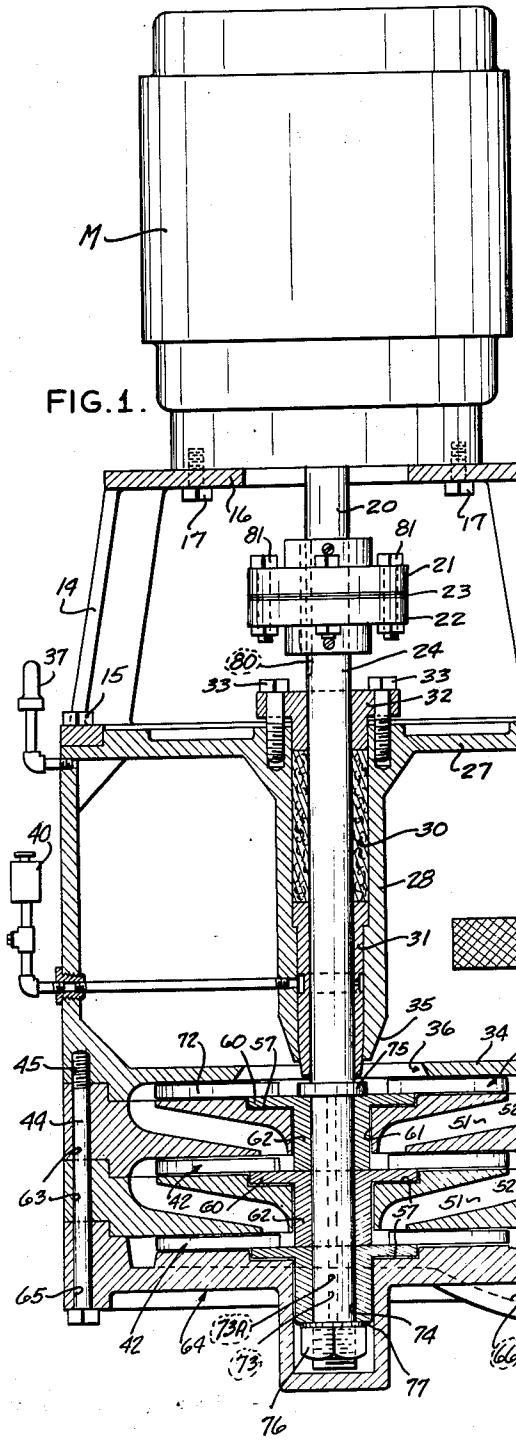


FIG. 1.

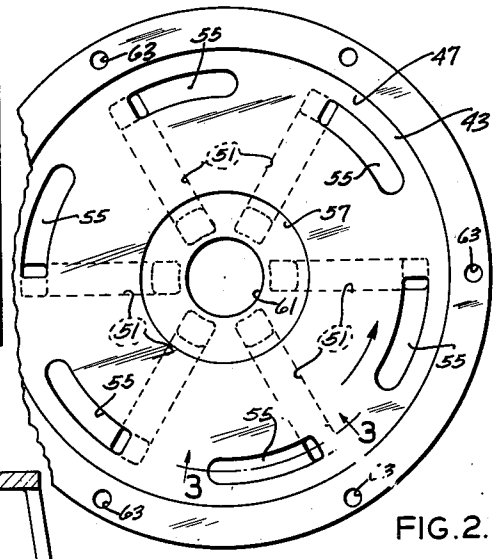


FIG. 2.

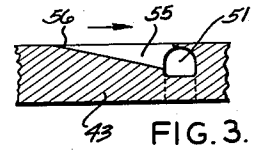


FIG. 3.

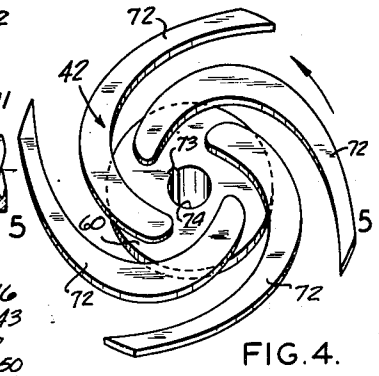


FIG. 4.

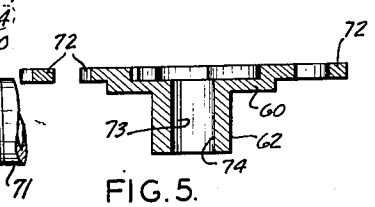


FIG. 5.

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CENTRIFUGAL PUMP ASSEMBLY

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13 Claims. (Cl. 103—108)

1

This invention relates to improvements in centrifugal pump assemblies, and particularly to centrifugal pumps adapted for operation against moderate pressure heads, and in other ways adapted particularly, but by no means exclusively, for use in steam systems for condensate return purposes.

Centrifugal pumps of prevalent design are known to require inordinate service attention for adjustment and replacement of parts, when utilized under conditions of high temperature and for delivery against at least moderate pressure heads. Conventionally constructed centrifugal pumps are further recognized, under many conditions of extreme service as requiring frequent adjustment and replacement of packing. The usual types of centrifugal pump assemblies are particularly inadequate when installed in boiler return lines or the like, wherein, unless considerable skill attends their installations, misalignment and deformation of the assembly often imparts serious warping, cocking, and other deforming stresses to the pump, by reason of expansion and contraction of the steam and water lines connected to and from the pump. It is accordingly a major objective of the present improvements to obviate each and all of the noted shortcomings and other disadvantages of prevailing pumps, particularly those in high temperature service.

A further and important object of the present invention is attained in an improved design and combination of impeller and stator structure which lends itself admirably to use either in single stage or multi-stage assemblies, enabling by the selection of the appropriate number of standardized elements, to increase or decrease the number of stages of a multistage pump in order best to adapt it to given operational requirements.

A still further objective embodied in the present improvements is attained in a combination liquid receiver or sump structure and pump, with facilities for assembling the pump to the sump structure so that it forms virtually a close-coupled part thereof, and so arranged that additional stages may be added to the pump through the addition only of a single impeller and a single stator element for each stage desired to augment a pump originally designed or installed.

Yet another highly important object is attained in an improved pump packing provision in a pump of the type noted, such that if desired, all shaft packing may be disposed entirely in a low pressure zone of the assembly, and so that the pump proper is entirely or virtually free of usual internal packing provisions, thus minimizing packing maintenance and expense.

One of the most important of the objects of the present improvements consists in an improved contouring or curvature of peripheral portions of the pump displacement chamber, and also in cooperation therewith, a particularly selected design and arrangement of discharge passages from such chamber, in a manner materially to increase pump efficiency.

2

Further objectives and advantages of the invention will more clearly appear from the following detailed description of a presently preferred embodiment of the invention, particularly when considered in connection with the accompanying drawing, in which:

Fig. 1 is a sectional elevation of a pump and liquid receiver assembly constructed to embody present improvements, the sectional portions of this figure being taken on a vertical median plane;

Fig. 2 is a face or plan view of one of the stator elements such as is utilized in either a single or multi-stage assembly, and in which certain of the discharge passages formed internally of the stator unit, are shown in dotted lines;

Fig. 3 is a fragmentary sectional view in an arcuate plane taken depthwise through a portion of one of the stator elements, specifically along line 3—3 of Fig. 2;

Fig. 4 is an isometric elevation of an impeller of open vane type such as preferably employed in the present assembly, and

Fig. 5 is a diametral sectional view of the impeller as taken along line 5—5 of Fig. 4.

The present disclosure, selected as exemplary, depicts a combined receiver and multi-stage centrifugal pump assembly of vertical shaft type, including its own power agency such as an electric motor, and is shown in a form such that, in smaller and moderate sizes, the assembly or unit may be if desired, supported solely by the piping which supplies and discharges the unit.

In reference to Fig. 1, a condensate receiver or sump is comprised of a preferably cylindrical body 10 formed for example as a semi-steel casting, and inlets to which may be provided in any suitable number, one thereof being indicated at 11, provided with a strainer, and serving to deliver condensate or other liquid to the chamber 12 within the structure 10.

Surmounting the member 10 is a motor base 13 shown as consisting of a series of spaced legs 14, the legs being interconnected at the bottom by a rigid annulus interfitting an annular seat at the top of the casing 10, and assembled thereto as by cap screws or the like 15. The motor M is directly supported by a top plate or deck 16, and assembled thereto as by screws 17 conveniently engaging tapped seats therefor in the lower end bell of the motor. The motor shaft 20 is preferably so journalled in the motor as to minimize end play and the otherwise free depending shaft portion is affixed to an upper half or head 21 of a shaft coupling, the mating half 22 of such

coupling cooperating with the head 21 through one or a plurality of shims 23 to enable an accurate axial adjustment of a pump shaft 24, for reasons later more fuly described.

Pump shaft 24 vertically traverses and extends downwardly beyond the receiver-forming element 10 for operating and supporting the pump impeller or impellers as will appear, it being noted at this point that the chamber 12 constitutes a relatively low pressure zone of the assembly, and accordingly has been selected as the optimum location for pump shaft packing.

A stuffing box is provided by a depending tubular projection or sleeve conveniently constituted as a part of the top cover element 27 of the receiver, the sleeve being indicated at 28, and containing packing of a type suitable for the particular service of the pump and indicated at 30. Gland provisions consist of an end block and bearing member 31 and an adjustable gland member 32 at the top, through which the packing 30 may be taken up by cap screws 33 or other suitable provision. It may here be noted that the sleeve 28 surrounds by far the major portion of the shaft 24, which otherwise would be exposed directly to the liquid in chamber 12, and preferably extends say within an eighth inch of the pump impeller, as will appear. This construction minimizes the turbulence of the body of receiver liquid which otherwise would result from any considerable length of shaft operating at high speed within the receiver. It will be noted further as advantageous, that the lower end of sleeve 28 is tapered or feathered toward the bottom of the receiver, this reduced portion of the sleeve being indicated at 35, and being of advantage in directing liquid into the pump intake, as will appear. Direct conduct of the liquid in chamber 12 to the inlet of the pump is provided with a minimum turbulence and internal frictional losses through a large pump-inlet and receiver-discharge opening 36.

When the pump assembly is utilized as a condensate returning agency in closed circuit steam systems, it is advantageous to provide an air vent unit, shown for completeness at 37. To facilitate lubrication of shaft 24 from a point external to the receiver member 10, there is provided a grease fitting 40 and a lubricant tube extending therefrom to a suitable point within the sleeve 28, thence to a ported groove formed in journal element 31.

Proceeding now to describe the pump proper, reference will be made to the vertical shaft multi-stage centrifugal assembly shown by the drawing. It will, however, appear as obvious from the foregoing and following description, that many of the features of improvement may with equal advantage, and with or without minor and obvious structural changes, be embodied in a horizontal assembly. With no change in structural detail other than the number of parts assembled and substitution of a longer or shorter shaft, the pump to be described may be utilized selectively as a single stage unit, or as a multi-stage unit, with any reasonable and desired number of stages.

With reference particularly to Fig. 1, it will appear that the bottom element 34 of the casing or receiver member 10 constitutes in effect a lateral closure or cover for the first stage of the pump. Complementing such closure on the opposite side of the first stage impeller indicated generally at 42, is a rugged, preferably one-piece block member constituting a stator, and indicated generally at 43. The elements 34 and 43 are assembled as through a suitable plurality of angularly spaced tie bolts 44, engaging tapped recesses 45 therefor in the bottom of the member 10. It is particularly to be noted that the member 34 is annularly and deeply undercut as at 46, and that the stator block 43 is centrally and circularly undercut as at 47, so that the members 34 and 43 are nested, and by means of the bolts or screws 44 are kept in accurate assembly and in absolute axial alignment under all conditions. This construction has been found fully to obviate any assembly disturbance due to cocking or other deforming stresses often otherwise resulting from changes in temperature of the assembly or the piping connected therewith. This is of particular advantage in installations wherein the piping may constitute the sole or major support of the unit. The opposite side of the stator block 43 is peripherally recessed as at 50, this undercut position being preferably identical with the recess 46. Thus in effect the peripheral portion of the stator block 43 is depthwise offset from the central portion of this body.

It is preferred to form the stator block 43 as an integral or one-piece structure, machined or otherwise formed to provide the external shaping described, and to form completely in this single element the passages directed from the displacement chamber to the pump or stage discharge. Thus the block has formed therein a plurality of passages, shown as six, and indicated at 51. As will appear from Fig. 1, each of these is of a trend initially depthwise of the block, thence over the major portion of the length of passage, continuing somewhat depthwise but predominantly radially, i. e., toward the axis of the pump, thence again curving near the point of discharge, approximately parallel to the axis of the pump. These passages are individually and collectively of generous size, and the curvature at each end of each passage 51 in a direction depthwise of the block, is gradual, and on a radius considerably exceeding that of the cross section (preferably circular) of the passage 51, this curvature being indicated at 52 (Fig. 1), the curvature at 52 being a continuation of that shown at 53 in the peripheral portion of the displacement chamber beyond the impeller 42. A contour preferably exactly similar to that indicated at 53, is imparted, as at 54, to the peripheral portion of the bottom recess of the block 43.

The stator block 43 is further characterized by a series of recesses 55 opening into one side or the upper face of the block, there being one of the recesses 55 for each of the passages 51. By preference the number and angular extent of the recesses 55 is such that they collectively occupy more than 180 degrees of a circle on this face portion of the block. Each recess 55 may be readily visualized by comparing the showings of Figs. 2 and 3, from which it will appear that each is characterized by a shallow vanishing end 56, and increases gradually in depth from such end, to a zone of communication with the connected passage 51 (Fig. 3). The slope of the bottom of each of the passages 55 is preferably of an order of 15–30 degrees to the plane of the communicating face of the block 43.

The block 43 is further provided with a central circular recess 57, the depth and area of which correspond by preference, closely to the comparable dimensions of a central sealing plate or disc 60 of the impeller 42, so that disc 60 works within and fully occupies the recess 57 with no more than minimum peripheral working clearances or

tolerances, and only sufficient clearance with the bottom of the recess to preclude frictional engagement under all conditions.

It should here be noted that throughout the assembly, particularly in the region of the impeller, all parts of the displacement chamber engaged by the impeller surfaces are accurately machined for adjacent operation with working clearances of the order of seven to eight thousandths inch at each side. The block **43** is provided with a central or axial bore **61** within which works the hub portion **62** of the impeller, with radial clearances of the order of seven to eight thousandths. Similarly, the opposite faces of the block **43** are machined to assure close parallelism in assembly, and for coaction with the side surfaces of the impeller, preferably with clearances not much exceeding those of the order stated. The passages through the stator block **43** includes those indicated at **63** through which extend the tie bolts **44**.

The stator assembly, whether the pump be of single or multi-stage type, includes discharge provisions exemplified presently by a bottom fitting **64** formed as a cover plate containing a discharge channel, and is provided with peripheral apertures **65** corresponding in number and size to those indicated at **63** for reception of tie bolts or screws **44**. It will be noted that this fitting **64** may, as shown, include one or the last stage displacement chamber of volute form. A discharge chamber or passage is formed in the fitting **64** as indicated at **66** and communicates with the termini of the several passages **51** of the preceding stage of the pump, the fitting being tapped as at **70** for the reception of a discharge line **71**.

Proceeding now to a description of the impeller **42**, the central disc **60** thereof has been noted as preferably circular in form. Formed or fastened upon, yet offset from the plane of one surface of disc **60**, are a plurality of open type vanes **72**, the impeller per se being thus of unshrouded type, but in assembly, due to the close working clearances between each edge or lateral surface of the vanes **72** and the adjacent surfaces of the displacement chamber, the elements forming the latter constitute, in reality, stationary shroud plates, the relatively small clearances serving effectively to prevent any turbulence laterally of the vanes and preventing any appreciable recirculation within the chamber. The inner ends of the vanes **72** are spaced outwardly from the shaft and from the hubs **62** of preceding impellers. It has been found by experience and usage of the pumps in service, that the arrangement described obviates any necessity for special impeller thrust-balancing provisions. The disc **60** has a small diameter, relative to the diameter of the vanes **72**; and thus it has only a small area exposed on top to the suction pressure at the opening **36** and on the bottom to the pressure of liquid that passed behind disc **60** into recess **57**. The greatly reduced end thrust obtained by using the small diameter disc **60** avoids undue upward thrusts on shafts **20** and **24**. The impeller is preferably formed of bronze or a similar non-rusting metal or alloy, as is each of the stator blocks and cover plates. The shaft **24** is preferably of stainless steel.

Assembly of the impeller or runner to the shaft **24** is provided for by a keyway **73** along the shaft aperture **74** of hub **62**, a companion keyway **73A** in the shaft, and a key of suitable length (not shown) occupying the keyways; setscrews of Allen or other type being employed to retain the keys. As an impeller abutment the shaft **24** is provided with a shoulder or collar **75**, the impeller or group thereof being axially positioned by coaction with such abutment, of a nut **76** preferably of bronze or otherwise non-rusting and a lock washer **77** of external toothed type between the nut and the adjacent face of the end hub **62**. Assembly of shaft **24** to the coupling head **22** may similarly be effected through a keyway **80** cooperating with a suitable key recess and key within the head **22**.

The foregoing description of stator block element **43** will of course apply equally to any additional similar stacked elements, one for each stage, in an assembly to constitute a multi-stage pump. The description of element **43**, including features of its shape, machining, passages, etc., will be understood as equally applicable to others of the plurality, when employed.

The manner and advantages of assembly of both the rotating and stationary elements of the pump are thought now to be apparent, but it may be noted for completeness that all such elements may be juxtaposed for assembly, by stacking them in operative and interfitting arrangement as clearly shown by Fig. 1, from which it will appear that the impeller, then the selected number of stator blocks, then discharge fitting **64**, will be stacked in this order, assembly of the discharge fitting of course following final securement of the impeller to shaft **24** as through the key and nut **76**. The impeller and block **43** of each stage, are brought together as noted, followed by the impeller and block **43** of each succeeding stage in turn, and preferably after the predetermined number of these elements are stacked and suitably interfitted, nut **76** is applied, followed by the fitting **64**. The stacked assembly may be built up on the bolts or screws **44** as stacking pins, then finally assembled thereby to the structure including adjacent elements **10** and **34**.

Because of the relatively close working tolerances involved it will usually be necessary to effect an adjustment thereof after initial assembly. This may readily be done by any suitable provision to enable an accurate axial adjustment of shaft **24**, this being conveniently accomplished in the present assembly, by releasing the head bolts **81** of the coupling and by removal or addition of the requisite number and thickness of shims **23** followed by reassembly of the heads of the coupling.

The operation of the pump assembly is thought now to have become fully apparent from the description of parts and purposes thereof, but it may be noted that when liquid is present in member **10**, it will directly enter the opening **36** in member **34** which may be considered as a top or side cover. The liquid thus fills the space between the inner ends of vanes **72** of the impeller operating preferably in the direction of the arrow (Fig. 4), this being the normal or forward rotation for most efficient operation. The displacement of liquid within the chamber will occur toward the periphery of this relatively narrow chamber, whence because of curvature **53** of the outer margin of the chamber the liquid will be gradually and with relatively low turbulence, deflected into the several recesses **55** where it will encounter the curved surfaces **52**, thence being impelled through each of the adjacent passages **51** to the zone of discharge, either into fitting **64** or to the inlet of the next stage, as the case may be. It has been found by repeated careful tests that the provisions of the recesses **55** and the gradual curva-

ture of portions 53 and 52, more than double the efficiency of the pump when otherwise similarly constructed, but with conventional discharge provisions.

The course of fluid in being displaced through successive stages of a multi-stage pump, will now be obvious from the foregoing description, inasmuch as the course of flow through each stage is similar to that of a single stage assembly.

Special mention should be made of the fact that the present pump, whether of single or multi-stage type, is or may be characterized by a total absence of packing internally of the pump proper. This has now become possible because of the sealing disc 60 with the recess therefor, the stationary vane-shroud provisions, the sealing provision about the impeller hub, and other features described. Thus the packing 30, which is axially beyond any high pressure zone of the pump, will exhibit a long life and require only infrequent service attention.

There should further be especially noted the particular advantage of the deeply recessed and widely shouldered external conformity of the stator block 43 or each of a plurality thereof, through which provision all interfitting stationary elements virtually supply their own alignment and registering provisions, the tie bolts 44 serving merely the function of keeping the stacked elements in axially compacted relation.

Although the invention has been described by making a detailed reference to a preferred embodiment, the detail of description should be understood solely in an instructive rather than any limiting sense, numerous variants being possible without departing from the full intended scope of the invention as defined by the appended claims.

I claim as my invention:

1. A centrifugal pump assembly including an impeller, an impeller driving shaft secured thereto, a stator provided with passages therethrough for discharge of liquid, a closure plate, said closure plate and said stator forming therebetween a pump displacement chamber, a small diameter recess extending rearwardly of said pump displacement chamber, an open-vane impeller operating in said chamber and recess, said impeller being provided with a small diameter central plate disposed in said recess, a plurality of vanes supported by said plate and disposed in said pump displacement chamber, said closure plate having an inlet opening registerable with and directly confronting said small diameter central plate, said plate and recess being circular and of substantially conforming diameter so as to provide not appreciably more than a working clearance of the plate with the recess therefor, said vanes having constant thickness and being offset from the plane of said central plate.

2. In a centrifugal pump, a stator including two detachably assembled side plates formed to provide a displacement chamber therebetween, an impeller operable in the displacement chamber, one of said side plates provided with an inlet opening, the other side plate consisting of a one-piece block structure provided with a plurality of arcuate recesses opening into the face of the block structure in the region of the impeller periphery, and discharge channels internally of the block each directed from one of said arcuate recesses to a zone of discharge.

3. The combination and arrangement of elements as recited by claim 2, but further characterized in that each of said arcuate recesses is of increasing depth from one end to the other, with its deepest end connected directly to the associated discharge channel.

4. In a centrifugal pump, a stator including two detachably assembled side plates, each of said side plates being recessed to form therebetween, a displacement chamber, an impeller operable in the displacement chamber, one of the side plates provided with an inlet opening, the other side plate consisting of a one-piece block structure formed to present a plurality of arcuate recesses open into the face of the block structure in the region of the impeller periphery, a discharge channel internally of the block directed from each of said recesses to a zone of discharge beyond the opposite face of the block structure, the internal periphery of the displacement chamber being uniformly curved on a substantial radius in the plane of the impeller axis in a manner to direct fluid flow from the impeller, toward the arcuate recesses thence into the discharge channels.

5. The combination and arrangement of elements as recited by claim 4 but further characterized in that the said arcuate recesses and the periphery of the displacement chamber are curved, on wide radii, in the plane of the axis of impeller revolution, said radii of curvature substantially exceeding that of the sectional radius of the discharge channels through the said block structure, said discharge channels being of substantially circular cross section and of substantially uniform diameter from the arcuate recesses through the block structure.

6. In a centrifugal pump, a stator including two detachably assembled side plates formed to provide a displacement chamber therebetween, an impeller operable in the displacement chamber, one of the side plates provided with an inlet opening, the other side plate consisting of a one piece block structure, provided with a plurality of arcuate recesses opening into the face of the block structure in the region of the impeller periphery, and discharge channels internally of the block structure directed depthwise, radially and toward the axis of impeller rotation, and extending from one end of each of said arcuate recesses to a substantially common zone of discharge.

7. In a multi-stage centrifugal pump, a plurality of stacked plate and block elements detachably assembled to provide between each pair of adjacent elements, a displacement chamber, impellers respectively identified with each stage, each operable in one of the displacement chambers, one of said plates provided with an inlet opening to the first stage of the pump, a subsequent stage being formed between a pair of the said stacked block elements, each of said block elements provided with a plurality of arcuate recesses opening into the face of the block structure in the region of an impeller periphery, each such arcuate recess being of tapering depth from one end to the other thereof, a discharge channel through the block having its inlet end connected with the end of greatest depth, of one of the arcuate recesses, each such discharge channel being thence directed depthwise, radially and toward the axis of rotation of the impellers, the said discharge channels collectively serving to interconnect displacement chambers identified with succeeding stages of the pump.

8. A multi-stage centrifugal pump including a pair of end cover plates, one at the inlet end of the pump provided with an inlet opening, the other cover plate at the discharge end of the

pump and adapted for connection to a discharge fitting, a series of stacked block elements between the cover plates, each of the block elements provided on one face with a peripheral annular seat of substantial depth, and on its opposite face with an annular projection of substantially the depth of said annular seat, the recesses and projections adapted thus to be interfitted when the block elements are stacked in assembly, tie rods by which the blocks and cover plates are assembled, each adjacent pair of the block elements being provided with openings for the tie rods, and being recessed to form therebetween a displacement chamber the depth of which is substantially equal to the depth of said annular projections and recesses, an impeller operating, one for each stage, in the said displacement chambers, and with not appreciably more than working tolerances between the sides of the impeller and the adjacent sides of the displacement chamber therefore, each of said blocks being of a one-piece construction and each having formed therein a series of evenly angularly spaced arcuate recesses, each recess opening into a displacement chamber in the immediate region of the periphery of the impeller therein, each said recess being of gradually tapering depth increasing in the direction of impeller rotation, a plurality of interstage passages formed in each block, each such passage having its inlet end communicating with the deepest end of one of said discharge recesses, each such interstage passage in the block being directed inwardly substantially along a radius on the axis of impeller rotation, and depthwise through the block, thence outwardly into the inlet of the subsequent stage, a shaft common to said impellers and extending depthwise through the several stator blocks, the stator blocks and cover plates being of such construction as to enable an increase or decrease in number of stages by selective addition to or removal from the assembly, of said block elements and impellers together with any required change in shaft length as the number of stages is varied.

9. In a centrifugal pump that comprises a housing, an impeller positioned within said housing, an inlet in one wall of said housing, an outlet from said housing, and a shaft that extends into said housing and supports said impeller, the improvement that comprises a recess in that wall of the housing which is opposite to and directly confronts said inlet, and an impeller with a central portion positioned within and rotating relative to said recess and with a plurality of vanes that are disposed outwardly of said recess and project outwardly beyond the periphery of said central portion of said impeller, said control portion of said impeller being in register with and directly confronting said inlet in said one wall of said housing, said vanes having the inner ends thereof disposed inwardly of the periphery of said central portion of said impeller.

10. In a pressurized pump and receiver system that includes a receiver to collect condensed steam to be pumped and a centrifugal pump with a central disc and outwardly projecting vanes to receive condensed steam from said receiver and to pump same, the improvement which comprises a thermostatic vent valve disposed adjacent the upper end of said receiver and an opening adjacent the bottom of said receiver which places said receiver in communication with said centrifugal pump, said vent valve venting air from said receiver but closing in response to the heat of steam within said receiver to prevent venting of steam from said receiver, said vent valve relieving partial pressures in said receiver due to air within said receiver whereby the total pressure in said receiver is due to steam being collected for pumping.

11. In a centrifugal pump that comprises a chamber, an inlet for said chamber, a plurality of circumferentially spaced outlets in one wall of said chamber, and an impeller rotatably positioned within said chamber, the improvement that comprises a plurality of recesses in said one wall of said chamber, said recesses being contiguous to said outlets and being adjacent the periphery of said impeller, said outlets being longitudinally directed of said chamber while said recesses are transversely directed of said chamber.

12. In a centrifugal pump that comprises a chamber, an inlet for said chamber, a plurality of circumferentially spaced outlets in one wall of said chamber, and an impeller rotatably positioned within said chamber, the improvement that comprises a plurality of recesses in said one wall of said chamber, said recesses being contiguous to said outlets and being adjacent the periphery of said impeller, the depth of said recesses progressively increasing toward said outlets.

13. A centrifugal pump including an impeller, a stator element in the form of a block of substantial thickness and forming one closure member of the pump, a second closure member, said impeller being disposed between said stator block and said second closure member, said impeller having a small diameter back plate and vanes that are secured to the front of said plate and project forwardly of said plate, said second closure member being provided with an inlet opening in register with and directly confronting said back plate of said impeller, said stator block and said second closure member defining a shallow circular space that receives said blades of said impeller, said stator block being provided with a recess that extends rearwardly of said shallow circular space and that is dimensioned to receive said back plate of said impeller with working tolerances, said stator block being provided with discharge passages formed therein which are of a trend depthwise of the stator block, and a power shaft connected to said impeller, said back plate of said impeller directly receiving liquid from said inlet opening and directing said liquid radially outwardly into said shallow circular space where said blades move said liquid to said discharge passages.

MINOR W. STOUT.

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