Nov. 22, 1955 L. C. ROTH 2,724,338

COMBINATION CENTRIFUGAL-TURBINE PUMP

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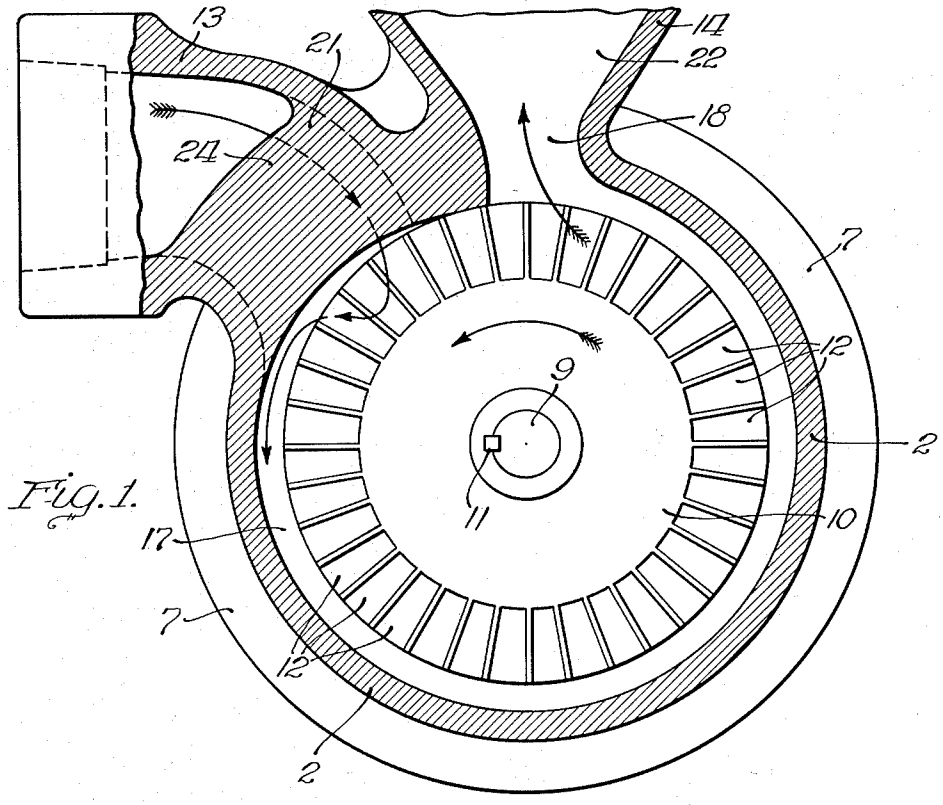
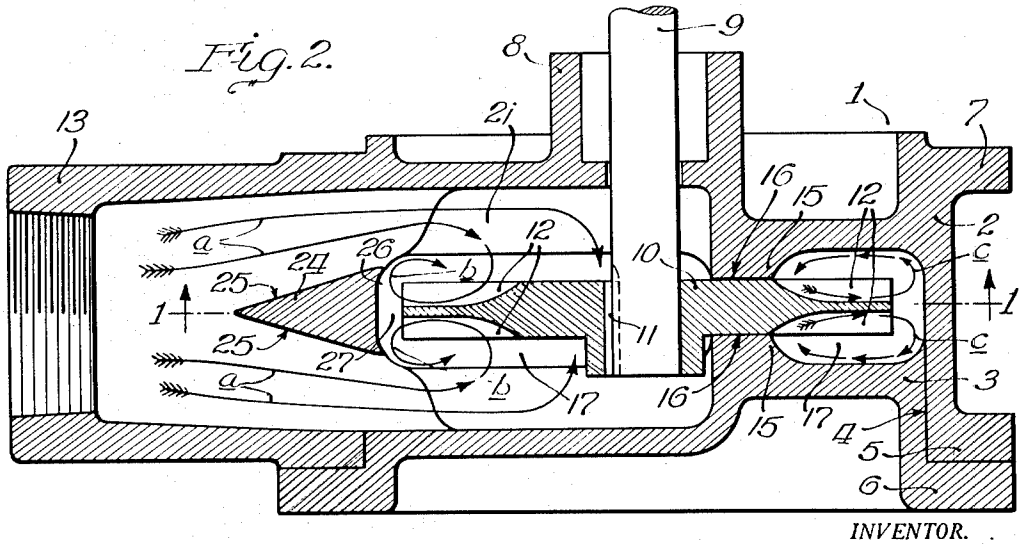


Fig. 1.

Fig. 2.



INVENTOR.
Leo C. Roth

BY
Brown, Jackson, Boettcher & Dienner
Attys.

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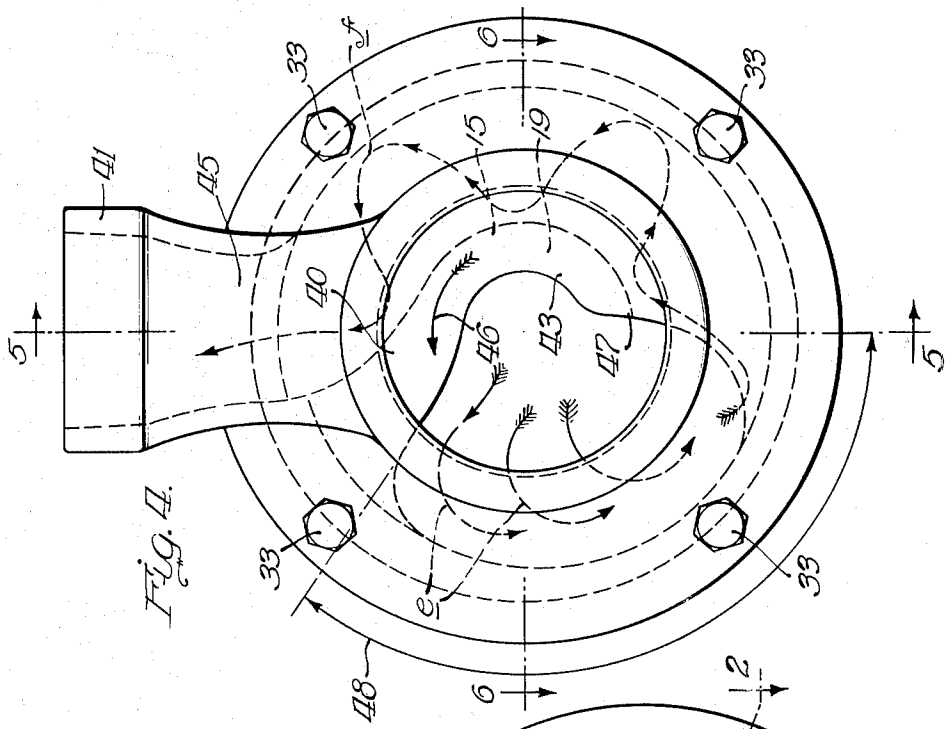


Fig. 4.

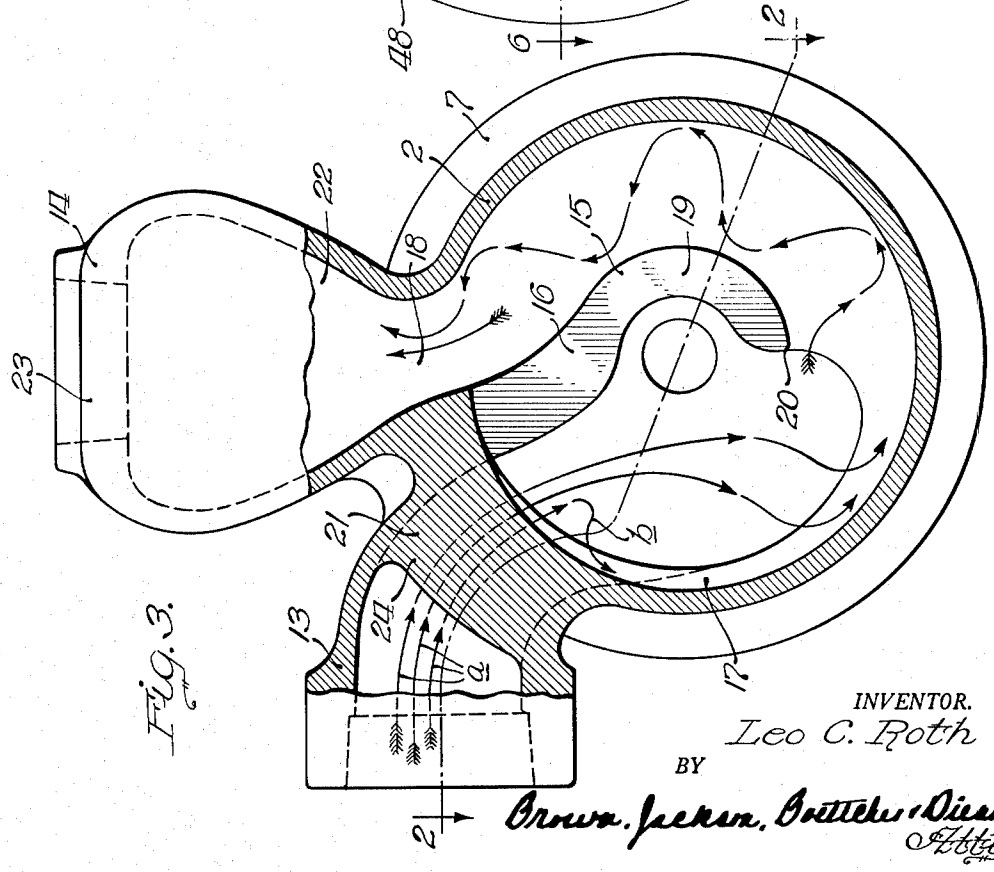


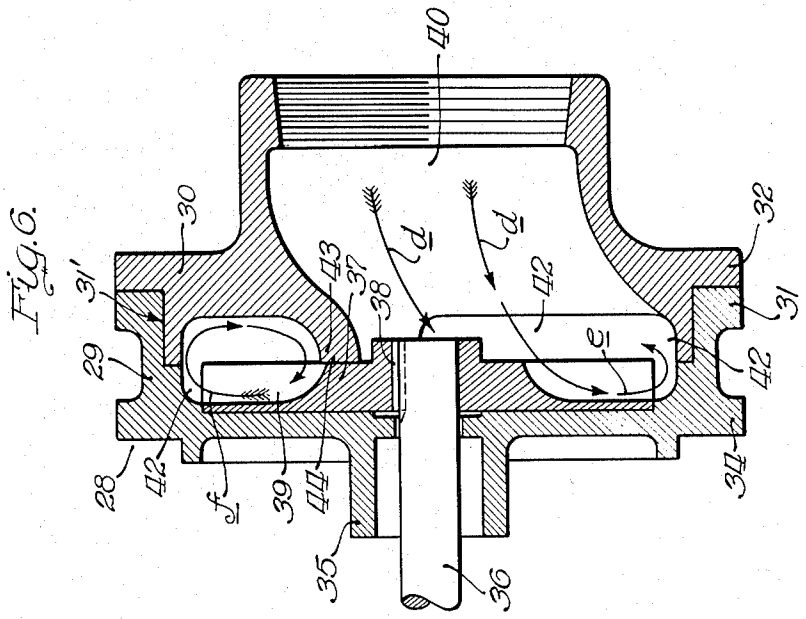
Fig. 3.

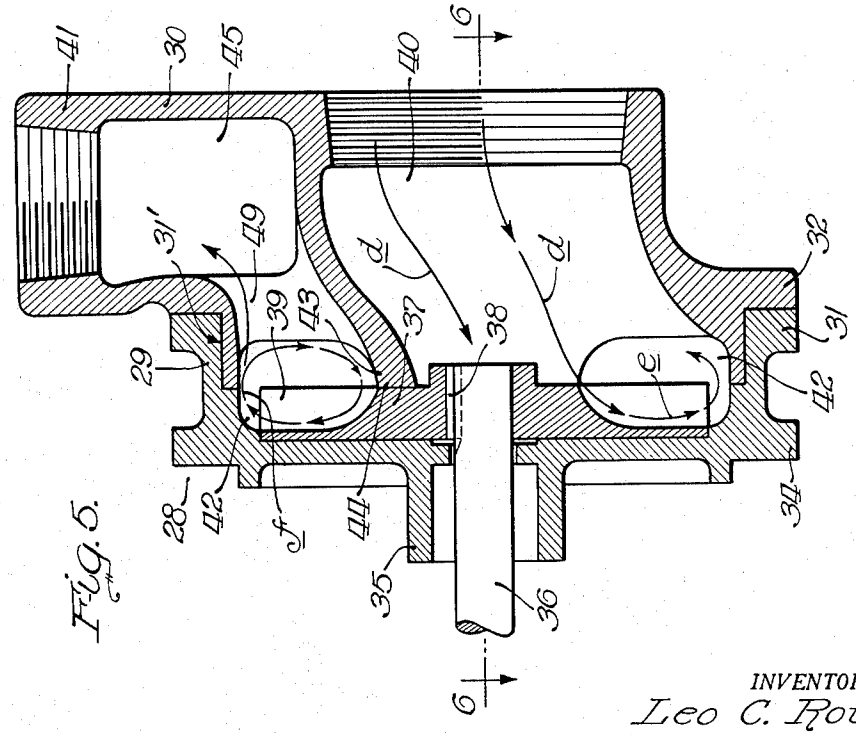
INVENTOR.
Leo C. Roth
BY
Brown, Jackson, Boettcher & Dienner
Attys.

Nov. 22, 1955 L. C. ROTH 2,724,338

COMBINATION CENTRIFUGAL-TURBINE PUMP

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INVENTOR.
Leo C. Roth

BY

Brown, Jackson, Boettcher & Dienner
Attys.

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COMBINATION CENTRIFUGAL-TURBINE PUMP

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Fig. 7.

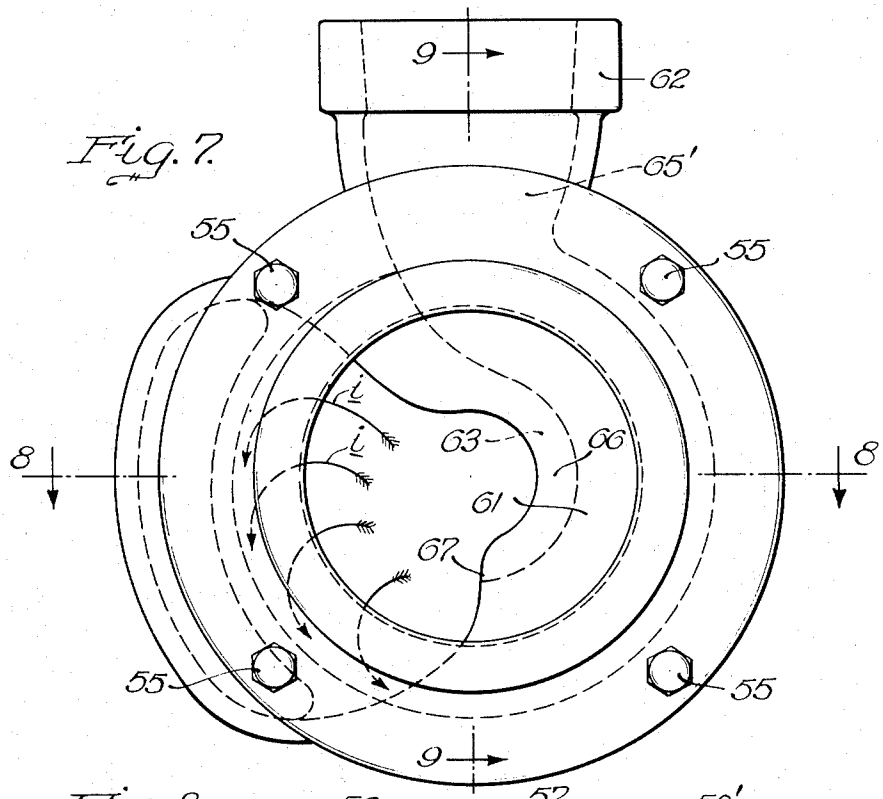
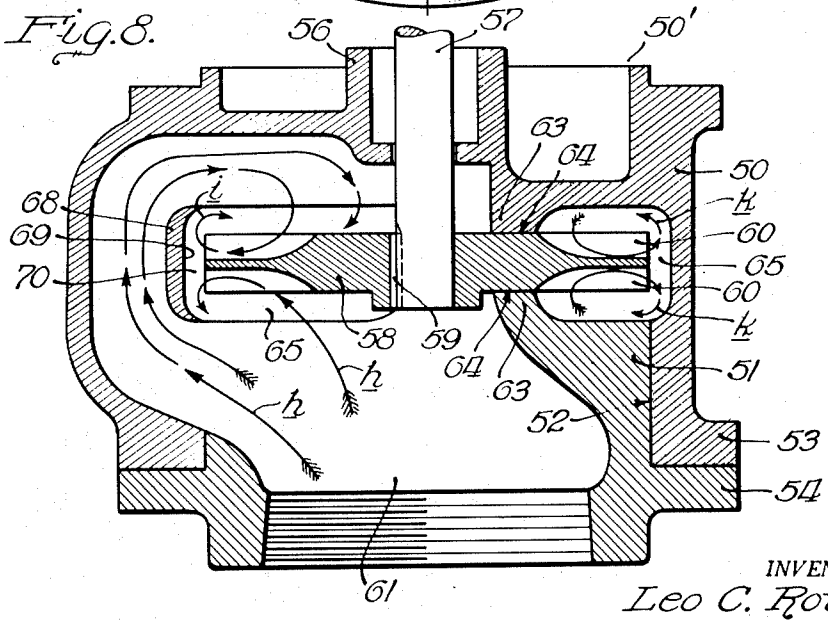


Fig. 8.



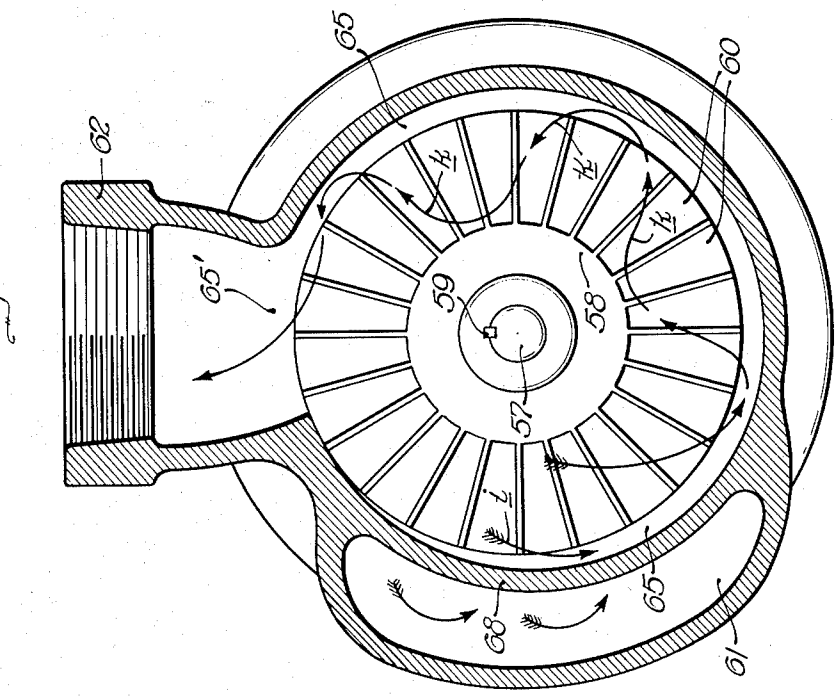
INVENTOR.
Leo C. Roth
BY
Brown, Jackson, Boettcher & Dienner
Attys.

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COMBINATION CENTRIFUGAL-TURBINE PUMP

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Fig. 10.



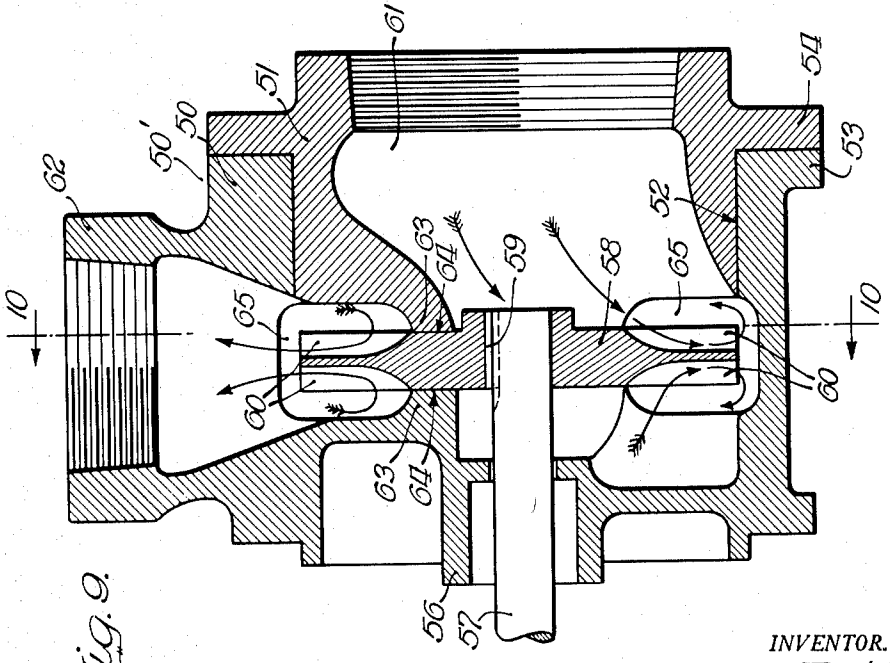


Fig. 9.

INVENTOR.
Leo C. Roth
BY
Brown, Jackson, Boettcher & Dienner
Attys.

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Fig. 11.

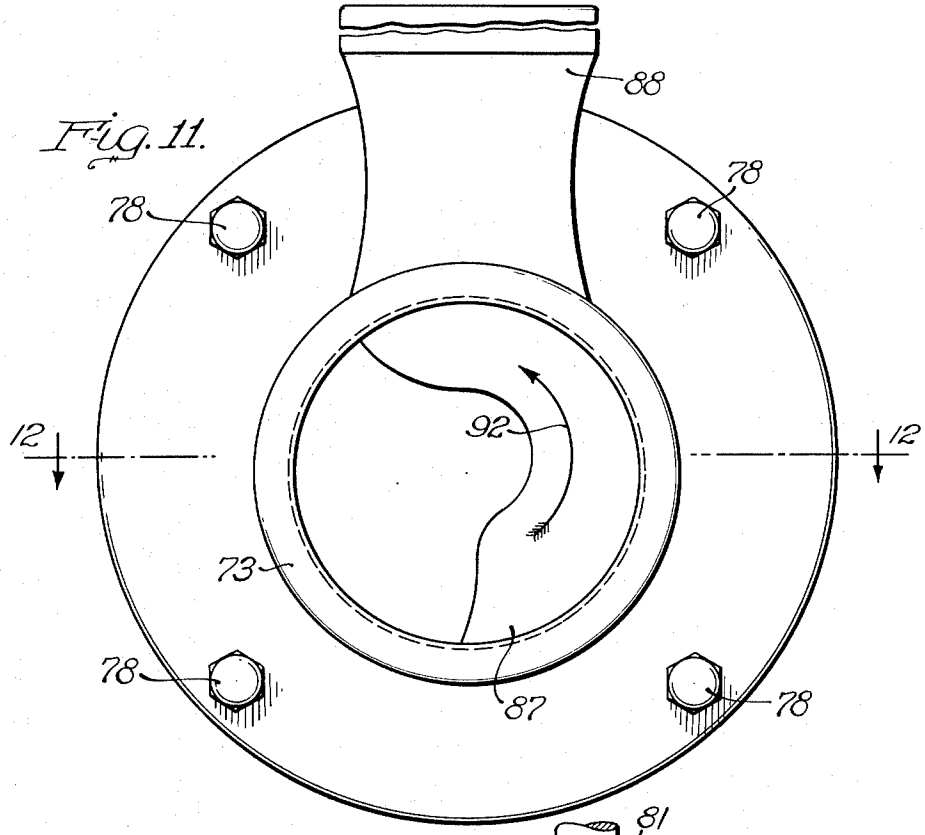


Fig. 12.

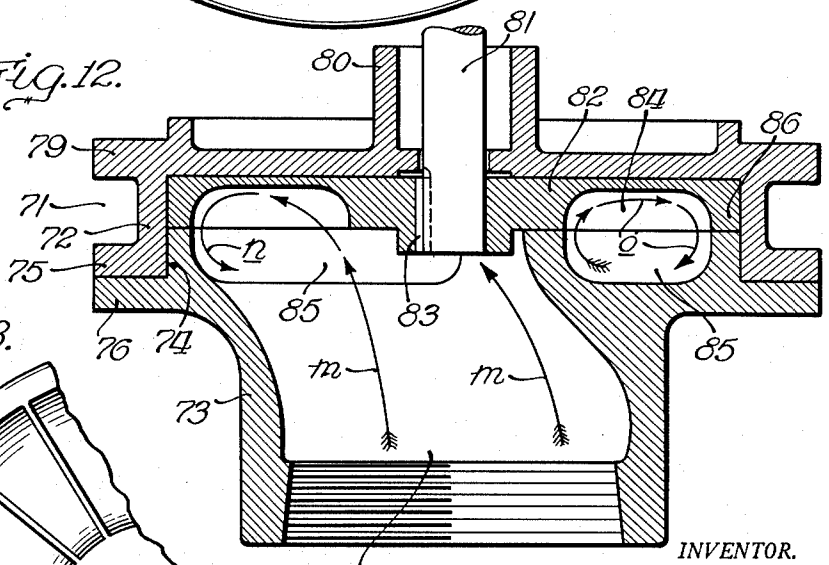
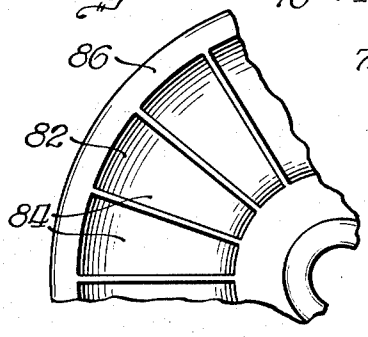


Fig. 13.



INVENTOR.
Leo C. Roth
BY
Brown, Jackson, Boettcher & Dienner
Attys.

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COMBINATION CENTRIFUGAL-TURBINE PUMP

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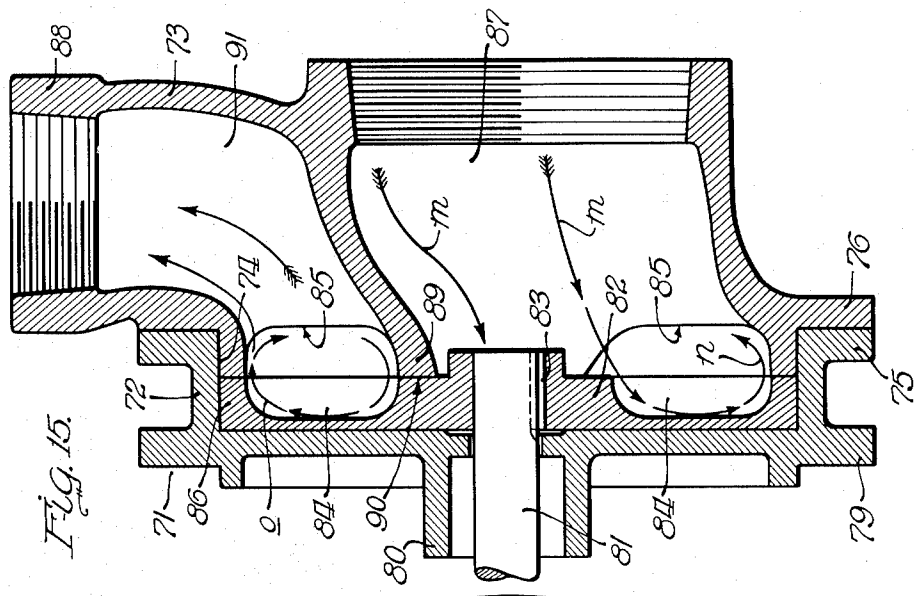


Fig. 15.

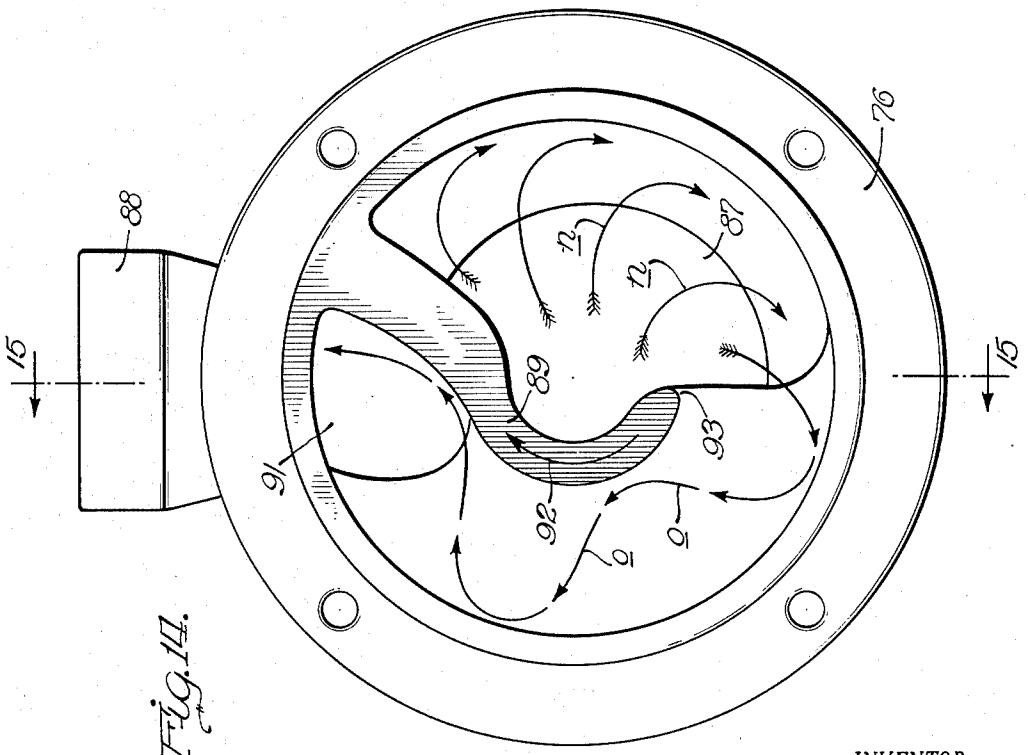


Fig. 14.

INVENTOR.
Leo C. Roth
BY
Brown, Jackson, Boettcher & Dienner
Attys.

United States Patent Office

2,724,338

Patented Nov. 22, 1955

2,724,338

COMBINATION CENTRIFUGAL-TURBINE PUMP

Leo C. Roth, Moline, Ill., assignor to Roy E. Roth Company, Rock Island, Ill., a corporation of Illinois

Application May 19, 1949, Serial No. 94,070

1 Claim. (Cl. 103—96)

This invention relates, in general, to new and useful improvements in pumps, and is particularly concerned with a combination centrifugal-turbine pump.

While the particular embodiments of the invention which I shall describe hereinafter in connection with the drawings are particularly adapted for use in handling boiling liquids, it is to be understood that the pumps of the present invention are not limited to such use, but may be employed for other purposes as suitable or desired.

Prior attempts have been made to combine two types of pumps into one and to operate them in unison. However, previous attempts to provide a combination centrifugal-turbine pump have been directed along the line of providing two separate stages, one centrifugal and one turbine, with a set of impeller vanes or blades for the centrifugal stage and a separate set of impeller vanes or blades for the turbine stage.

None of these prior two stage pumps have been concerned with obtaining improved ability to handle boiling liquids, and all of them have involved coupling together the separately acting sets of impeller vanes or blades and other complications in the construction and arrangement of the parts of the pump.

One of the main objects of the present invention is to provide an improved centrifugal-turbine pump which, with a small static suction head, will have the ability to handle boiling liquids with increased efficiency, and, more particularly, with generally the same efficiency as non-boiling liquids.

Another object of the invention is to provide a centrifugal-turbine pump which will have the ability to handle larger volumes of liquids at lower heads with greater efficiency than the conventional turbine pump.

Another object of the invention is to combine the centrifugal and turbine actions in a pump of only one stage, with the same impeller vanes or blades which act to produce the centrifugal action also acting to produce the turbine action, and without providing and coupling together separately acting sets of impeller vanes or blades; also without other complications in the construction and arrangement of the parts of the pump.

Another and more specific object of the invention is to provide a centrifugal turbine pump in which the centrifugal action and the turbine action are both produced in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller.

Another object of the invention is to provide a centrifugal-turbine pump having various features of novelty and advantages, and which is characterized by its simplicity in construction, its economy in manufacture, and its effectiveness in use with new and beneficial results which will hereinafter appear.

Further objects and advantages of the invention will appear from the following detailed description, taken in connection with the accompanying drawings which show the construction and operation of a number of illustrative embodiments of the invention.

In the drawings:

Figure 1 is a fragmentary transverse vertical sectional view through a pump embodying the present invention, taken substantially on the line 1—1 of Figure 2;

Figure 2 is a sectional view, taken substantially on the line 2—2 of Figure 3;

Figure 3 is a transverse vertical section similar to Figure 1 but with the impeller removed and portions of the inlet and outlet projections of the pump in elevation;

Figure 4 is an end view of another form of pump embodying the present invention, with the impeller removed;

Figure 5 is a vertical sectional view taken substantially on the line 5—5 of Figure 4;

Figure 6 is a horizontal sectional view taken substantially on the line 6—6 of Figure 5;

Figure 7 is an end view, with the impeller removed, of another form of pump embodying the present invention;

Figure 8 is a horizontal sectional view taken substantially on the line 8—8 of Figure 7;

Figure 9 is a vertical sectional view taken substantially on the line 9—9 of Figure 7;

Figure 10 is a vertical sectional view taken substantially on the line 10—10 of Figure 9;

Figure 11 is an end view, without the impeller, of a further embodiment of the invention;

Figure 12 is a horizontal sectional view taken substantially on the line 12—12 of Figure 11;

Figure 13 is a fragmentary face view of the impeller shown in Figure 12;

Figure 14 is an inside elevational view of the head of the pump shown in Figures 11 and 12; and

Figure 15 is a vertical sectional view taken substantially on the line 15—15 of Figure 14.

With reference now to the drawings, the pump shown in Figures 1, 2, and 3 is a centrifugal-turbine pump comprising a pump casing indicated in its entirety at 1, and formed of two contiguous sides or casing parts 2 and 3.

The casing part 3 has a cylindrical part which fits snugly at 4 within the casing part 2. The casing parts 2 and 3 are connected by contiguous outwardly extending flanges 5 and 6 held together, for example, by suitable bolts or the like (not shown). The flanges 5 and 6 are of generally annular form, and the casing part 2 has a second outwardly extending flange 7.

The casing part 2 has an outwardly extending tubular boss 8 in which may be disposed suitable packing (not shown) to prevent leakage between the casing part 2 and the rotary pump shaft 9. An impeller or rotation element 10 is fixed on the shaft 9, for example, by a key or spline 11 for rotation with the shaft. The impeller 10 has two sets of vanes or blades 12. One set of vanes 12 opens from one side of the outer marginal portion of the impeller, and the other set of vanes 12 opens from the other side of the outer marginal portion of the impeller. Both sets of these vanes 12 open radially from the outer periphery of the impeller.

The casing part 2 has a liquid inlet projection 13 and a liquid outlet projection 14. The inlet projection 13 extends substantially tangentially to the casing, while the outlet projection 14 extends substantially radially from the casing.

The inner sides of the casing parts 2 and 3 have opposed ribs 15 presenting sealing surfaces 16 which cooperate with the opposite sides of the impeller 10 and, as shown in Figure 2, define the pressure developing channel or passageway 17 of the turbine part of the pump. As shown in Figure 3, these ribs 15 or sealing surfaces 16 extend from position adjacent to the far side of the outlet 18 in the direction of rotation of the impeller inwardly toward the axis of the opening through which the pump shaft 9 extends. The inner ends of the ribs 15 or sealing surfaces 16 are curved or rounded at

19 partially around the axis of the opening through which the pump shaft 9 extends and in suitable spaced relation thereto.

The ribs 15 or sealing surfaces 16 terminate in position indicated at 20 in Figure 3. As viewed in Figure 3, the space within the pump casing clockwise of the ends 20 of the ribs 15 or sealing surfaces 16 constitutes the centrifugal part of the pump. The space within the pump casing counterclockwise of the ends 20 of the ribs 15 or sealing surfaces 16 and to the outlet 18, as the pump is viewed in Figure 3, constitutes the turbine part of the pump. It will be noted that the centrifugal and turbine parts of the pump are both arranged in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller. Moreover, as will presently appear, the same impeller vanes or blades 12, which act to produce the centrifugal action along the centrifugal part of the pump, also act to produce the turbine action along the turbine part of the pump.

The particular configuration of the ribs 15 or sealing surfaces 16, and the particular locations at which the ends 20 thereof terminate, may vary widely within the scope of the present invention. For example, the centrifugal portion of the pump may extend through about one-fourth, one-third, one-half, or any other part of the 360° rotation of the impeller, with the turbine part of the pump extending through substantially the remaining or any other desired part of such 360 degrees.

The interior of the inlet projection 13 opens into the inlet end of the passageway 17 at the beginning of the centrifugal part of the pump through an opening 21 formed in the casing parts as a continuation of the interior of the inlet projection 13. The outlet 18 opens from the outlet end of the passageway 17 at the end of the turbine part of the pump into a receiving or separating chamber 22 in the outlet projection 14. The chamber 22 has an outlet or discharge opening 23 through which the liquid is delivered from the pump.

A centrifugal baffle 24 is preferably placed across the suction of the pump, for example, by forming the baffle integral with the casing part 2 and in position extending across the inlet opening 21 as shown, described, and claimed in my copending application Serial No. 71,922, filed January 21, 1949. The particular centrifugal baffle 24 illustrated in the drawing is shown of tapered form, with its tapering sides 25 converging outwardly to a relatively sharp edge within the pump inlet. The inner face 26 of the baffle 24 is shown of generally concave form and spaced radially outwardly from the outer periphery of the impeller 10 to provide a free channel at 27 for directing the centrifugally hurled liquid down into the adjacent end of the channel or passageway 17 of the pump under pressure generated by centrifugal force.

In the operation of the pump, the impeller 10 is caused to rotate. The liquid enters the pump suction, is divided by the centrifugal deflector 24, and flows toward the center and toward the sides of the impeller 10 in the first section of the pump which is centrifugal. The direction of admission of the liquid is shown by the arrows *a* in Figure 3. The arrows *b* show, in general, how the centrifugally hurled liquid, instead of being directed toward the pump suction and impinging on the liquid entering the suction of the pump, with harmful or deleterious results, strikes the inner surface of the deflector 24 and is directed down into the inlet end of the channel or passageway 17.

As the incoming liquid is engaged by the impeller vanes 12, it is hurled outwardly and generally in the direction of impeller rotation by centrifugal force. This liquid, in motion, impinges on the centrifugal deflector face and on the outermost wall of the centrifugal casing. From here it is directed by the casing outer walls and under a pressure generated by centrifugal force into the entrance of the turbine part of the pump which begins as

the liquid passes the ends 20 of the ribs 15 or sealing surfaces 16 in the direction of impeller rotation.

The turbine action, which begins as the liquid passes the ends 20 of the ribs 15 or sealing surfaces 16, consists of a centrifugal push of the liquid to the periphery of the channel 17 at the turbine part of the pump, and a recirculation toward the root of the impeller vanes 12 repeated over and over, as indicated generally by the arrows *c* in Figure 2. Each of these recirculations imparts energy to the liquid, which results in static pressure.

From the foregoing description and the drawings, it will be apparent that, instead of being delivered into the channel 17 of the turbine part of the pump only by the static suction head which is available as in the conventional turbine pump, the liquid is forced centrifugally into the restricted channel at the turbine part of the pump. Undue restriction at the inlet to get a pressure building effect is avoided. Instead, the liquid enters a relatively large and unrestricted inlet at the beginning of the centrifugal part of the pump, and is then forced centrifugally into the relatively restricted channel at the turbine part of the pump. As a result, there is a more gradual application of pressure to the liquid, and the velocity of the liquid entering the turbine part of the pump is increased without lowering the absolute pressure. The ribs 15 or sealing surfaces 16 prevent by-pass of the liquid from the high pressure area to the low pressure area of the pump.

I have found that a pump according to the present invention has the ability to handle boiling liquid with higher efficiency, and, more particularly, with the same efficiency as non-boiling liquids (this presupposes a small static suction head). This is the result of large suction openings which enable the liquid to flow into the pump as fast as it can be pumped out. Once the liquid is engaged by the impeller vanes, there is never any removal of liquid faster than the ability of a small static suction head to force liquid in to replace it, thus preventing vaporization due to lowering absolute pressure. Once the liquid is engaged by the impeller vanes, it is always under pressure and there are no low-pressure or cavitation pockets in the pump.

The simplicity and improved arrangement of the parts of the pump are due to the combination of the centrifugal and turbine actions in a pump of only one stage and with the same impeller vanes acting at the centrifugal part and also at the turbine part of the pump. The production of the centrifugal action and the turbine action in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller also provides for simplicity in construction and improved arrangement of the parts of the pump.

The improvements of the present invention definitely improve the efficiency of the pump and provide a combination centrifugal-turbine pump which will not lose capacity in handling boiling liquids at low heads. Ordinarily, centrifugal pumps will not handle boiling liquids at low heads at the same volumes with the same static suction heads as they will handle cold or non-boiling liquids, while turbine pumps do not have the efficiency of the pumps of the present invention, particularly for the purposes set forth.

From the drawings and the foregoing description, it will be apparent that the pump shown in Figures 1, 2, and 3 has an impeller 10 with vanes or blades 12 on both sides, and liquid channels on both sides of the impeller. The pump shown in Figures 1, 2, and 3 also incorporates a centrifugal deflector as shown and described, and its suction enters the pump at the impeller periphery.

As will presently appear, the pump shown in Figures 4, 5, and 6 has the suction opening in the end or center of the pump, with vanes or blades on only one side of the impeller, and a liquid passage on only one side of the impeller.

With reference now to Figures 4, 5, and 6, the pump shown in these figures comprises a pump casing indicated in its entirety at **28** and formed of two contiguous sides or casing parts **29** and **30**.

The casing part **30** has a cylindrical part which fits snugly at **31'** within the casing part **29**. The casing parts **29** and **30** are connected by contiguous outwardly extending flanges **31** and **32** held together, for example, by suitable bolts **33**. The flanges **31** and **32** are of generally annular form, and the casing part **29** has a second outwardly extending flange **34**.

The casing part **29** has an outwardly extending tubular boss **35** in which may be disposed suitable packing (not shown) to prevent leakage between the casing part **29** and the rotary pump shaft **36**. An impeller or rotation element **37** is fixed on the shaft **36**, for example, by a key or spline **38** for rotation with the shaft. The impeller **37** has one set of vanes or blades **39** on only one side of the impeller. The vanes or blades **39** open from one side and radially from the outer periphery of the impeller.

The casing part **30** has a liquid inlet **40** which enters the pump in the end or at the center or axis of the pump. The liquid outlet projection **41** extends substantially radially from the casing and is spaced from the plane of rotation of the impeller in a generally axial direction. As in the embodiment of the invention illustrated in Figures 1, 2, and 3, the vanes or blades **39** of the pump shown in Figures 4, 5, and 6, extend to the periphery of the impeller **37**, and the liquid channel **42** extends beyond the impeller periphery.

The inner side of the casing part **30** has a rib **43** presenting a sealing surface **44** which cooperates with the adjacent side of the impeller **37**. As shown in Figure 4, the rib **43** or sealing surface **44** extends from position adjacent to the far side of the outlet **45** in the direction of rotation of the impeller (indicated by the arrow **46** in Figure 4) inwardly toward the axis of the opening through which the pump shaft **36** extends. Near its inner end the rib **43** or sealing surface **44** is curved or rounded around the axis of the opening through which the pump shaft **36** extends and in suitable spaced relation thereto.

The rib or sealing surface **44** terminates in position indicated at **47** in Figure 4. As viewed in Figure 4, the space within the pump casing clockwise of the end **47** of the rib **43** or sealing surface **44** constitutes the centrifugal part of the pump, as indicated in Figure 4 by the arcuate line **48**, with the arrow heads at opposite ends thereof. The space within the pump casing counterclockwise of the end **47** of the rib **43**, as the pump is viewed in Figure 4, constitutes the turbine part of the pump. As in the preceding embodiment of the invention, the centrifugal and turbine parts of the pump are both arranged in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller. Moreover, as in the preceding embodiment of the invention, the same impeller vanes or blades **39**, which act to produce the centrifugal action along the centrifugal part of the pump, also act to produce the turbine action along the turbine part of the pump.

As with the preceding embodiment of the invention, the particular configuration of the rib **43** or sealing surface **44**, and the particular location at which the end **47** thereof terminates, may vary widely within the scope of the present invention.

In the operation of the pump shown in Figures 4, 5, and 6, the impeller **37** is caused to rotate. The liquid enters the pump suction **40** and flows toward the blades **39** of the impeller. The direction of admission of the liquid is shown by the arrows *d* in Figures 5 and 6. The arrows *e* show, in general, how the centrifugally hurled liquid is directed down into the inlet end of the channel or passageway **42**.

As the incoming liquid is engaged by the impeller blades **39**, it is hurled in the direction of impeller rotation by centrifugal force. This liquid, in motion, impinges on the outermost wall of the centrifugal casing. From here, it is directed by the casing outer walls and under pressure generated by centrifugal force into the entrance of the turbine part of the pump which begins as the liquid passes the end **47** of the rib **43** in the direction of impeller rotation.

The turbine action, which begins as the liquid passes the end **47** of the rib **43**, consists of a centrifugal push of the liquid to the periphery of the channel **42** at the turbine part of the pump and a recirculation toward the root of the impeller blades **39** repeated over and over, as indicated generally by the arrows *f* in Figures 4, 5, and 6. Each of these recirculations imparts energy to the liquid, which results in static pressure. As the liquid reaches the outlet passage **49** (Figure 5), it passes through this passage to the outlet **45**, from which outlet **45** it is discharged from the pump.

As in the preceding embodiment of the invention, the liquid, instead of being delivered into the channel **42** at the turbine part of the pump only by the static suction head available as in the conventional turbine pump, is forced centrifugally into the restricted channel at the turbine part of the pump. Undue restriction at the inlet to get a pressure building effect is avoided, and as before, the liquid enters a relatively large and unrestricted inlet at the beginning of the centrifugal part of the pump, and is then forced centrifugally into the relatively restricted channel at the turbine part of the pump. As before, there is a gradual application of pressure to the liquid, and the velocity of the liquid entering the turbine part of the pump is increased without lowering the absolute pressure. The rib **43** or sealing surface **44** prevents bypass of the liquid from the high pressure area to the low pressure area of the pump.

As before, once the liquid is engaged by the impeller vanes, it is always under pressure, and there are no low-pressure or cavitation pockets in the pump. Also, as before, the production of the centrifugal action and the turbine action in a common plane disposed radially of the axis of the impeller and within the same 350° rotation of the impeller provides for simplicity in construction and improved arrangement of the parts of the pump.

The form of pump shown in Figures 7, 8, 9, and 10 of the drawings has an impeller wisetnavhorfikbv both sides, and liquid channels on both sides of the impeller, as in the embodiment of the invention shown in Figures 1, 2, and 3. In the pump of Figures 7, 8, 9, and 10, however, the suction or inlet enters in the end or at the center or axis of the pump.

Wtih reference now to Figures 7, 8, 9 and 10, the pump shown in these figures comprises a pump casing indicated in its entirety at **50'** and formed of two contiguous casing parts **50** and **51**. The casing part **51** has a cylindrical part which fits snugly at **52** within the casing part **50**. The casing parts **50** and **51** are connected by contiguous outwardly extending flanges **53** and **54** held together, for example, by suitable bolts **55**. The flanges **53** and **54** are of generally annular form.

The casing part **50** has an outwardly extending tubular boss **56** in which may be disposed suitable packing (not shown) to prevent leakage between the casing part **50** and the rotary pump shaft **57**. An impeller or rotation element **58** is fixed on the shaft **57**, for example, by a key or spline **59** for rotation with the shaft. The impeller **58** has two sets of vanes or blades **60**. One set of blades **60** opens from one side of the outer marginal portion of the impeller, and the other set of blades **60** opens from the other side of the outer marginal portion of the impeller. Both sets of blades **60** open radially from the outer periphery of the impeller.

The casing part **51** has a liquid inlet **61** which enters the pump in the end or at the center or axis of the pump. The liquid outlet projection **62** extends substantially radially from the pump casing.

The inner sides of the casing parts **50** and **51** have opposed ribs **63** presenting sealing surfaces **64** which cooperate with the opposite sides of the impeller **58**, and, as shown in Figures 8 and 9, define the pressure developing channel **65** along the centrifugal and turbine parts of the pump. As shown in Figure 7, the ribs **63** or sealing surfaces **64** extend from position adjacent to the far side of the outlet **65'** in the direction of rotation of the impeller **58** toward the axis of the opening through which the pump shaft **57** extends. The inner ends of the ribs **63** are curved or rounded at **66** partially around the axis of the opening through which the pump shaft **57** extends, and in suitable spaced relation thereto.

The ribs **63**, or sealing surfaces **64**, terminate in position indicated at **67** in Figure 7. The space within the pump casing clockwise of the ends **67** of the ribs **63** constitutes the centrifugal part of the pump. The space within the pump casing counterclockwise of the ends **67** of the ribs **63** to the outlet **65** as the pump is viewed in Figure 7 constitutes the turbine part of the pump. As before, the centrifugal and turbine parts of the pump are both arranged in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller. Moreover, as before, the same impeller vanes or blades **60**, which act to produce the centrifugal action along the centrifugal part of the pump, also act to produce the turbine action along the turbine part of the pump. The circumferential extent of the centrifugal part of the pump and the circumferential extent of the turbine part of the pump may vary within the scope of the present invention.

The suction of the pump is provided with a centrifugal baffle **68**. The baffle **68** is positioned at the inlet or suction of the pump, for example, by forming it integral with the casing part **50**, and in position extending across and spaced outwardly from the periphery of the impeller **58**. The baffle **68** is shown as having a generally concave inner space **69** spaced radially outwardly from the outer periphery of the impeller **58** to provide a free channel **70** for directing the centrifugally hurled liquid down into the adjacent end of the channel or passageway **65** of the pump under pressure generated by centrifugal force. The baffle is shown of a width greater than the width of the impeller, with the inner face of the baffle completely covering and extending beyond the opposite sides of the periphery of the impeller. The width of the baffle **68** may vary within the scope of the present invention.

In the operation of the pump shown in Figures 7, 8, 9 and 10, the impeller **58** is caused to rotate. The liquid enters the pump suction, is divided by the centrifugal deflector **68**, and flows toward the opposite sides of the impeller. The direction of admission of the liquid is shown by the arrows *h* in Figure 8. The arrows *i* show, in general, how the centrifugally hurled liquid strikes the inner surface of the deflector **68** and is directed down into the inlet end of the channel or passageway **65**.

As the incoming liquid is engaged by the impeller vanes **60**, it is hurled outwardly and generally in the direction of impeller rotation by centrifugal force. This liquid, in motion, impinges on the centrifugal deflector face **69** and on the outermost wall of the centrifugal casing. From here, it is directed by centrifugal force into the entrance of the turbine part of the pump which begins as the liquid passes the ends **67** of the ribs **63** in the direction of impeller rotation.

The turbine action, which begins as the liquid passes the ends of the ribs **63**, consists of a centrifugal push of the liquid to the periphery of the channel **65** at the turbine part of the pump, and a recirculation toward the root of the impeller vanes **60** repeated over and over, as indicated generally by the arrows *k* in Figure 8. Each of these recirculations imparts energy to the liquid, which results in static pressure.

As in the preceding embodiments of the invention, the liquid, instead of being delivered into the channel **65** of the turbine part of the pump only by the static suction head which is available as in the conventional turbine pump, is forced centrifugally into the restricted channel at the turbine part of the pump. As in the preceding embodiments of the invention, undue restriction at the inlet to get a pressure building effect is avoided, and the liquid enters a relatively large and unrestricted inlet at the beginning of the centrifugal part of the pump and is then forced centrifugally into the relatively restricted channel at the turbine part of the pump. As a result, there is a more gradual application of pressure to the liquid, and the velocity of the liquid entering the turbine part of the pump is increased without lowering the absolute pressure. The ribs **63** prevent by-pass of the liquid from the high pressure area to the low pressure area of the pump.

The pump shown in Figures 11–15 has the suction opening in the end or center of the pump, with blades or vanes on only one side of the impeller; also a liquid passage on only one side of the impeller. The impeller blades of this embodiment of the invention do not extend to the impeller periphery, and the outside diameter of the liquid channel is the same as the outside diameter of the impeller blades.

Referring now to Figures 11–15, the pump shown in these figures comprises a pump casing indicated in its entirety at **71** and formed of two contiguous casing parts **72** and **73**. The casing part **73** has a cylindrical part which fits snugly at **74** within the casing part **72**. The casing parts **72** and **73** are connected by contiguous outwardly extending flanges **75** and **76** held together, for example, by suitable bolts **78**. The flanges **75** and **76** are of generally annular form, and the casing part **72** has a second outwardly extending flange **79**.

The casing part **72** has an outwardly extending tubular boss **80** in which may be disposed suitable packing (not shown) to prevent leakage between the casing part **72** and the rotary pump shaft **81**. An impeller or rotation element **82** is fixed on the shaft **81**, for example, by a key or spline **83** for rotation with the shaft. The impeller **82** has one set of blades or vanes **84** on only one side of the impeller. The blades **84** do not extend to the impeller periphery, and the outside diameter of the liquid channel **85**, which is on only one side of the impeller, is the same as the outside diameter of the impeller blades **84**. The outer ends of the impeller blades **84** are closed by the annular impeller wall **86** which rotates in cooperation with the bore in the casing part **72**.

The casing part **73** has a liquid inlet **87** which enters the pump in the end or at the center or axis of the pump. The liquid outlet projection **88** extends substantially radially from the casing part **73** and is spaced from the plane of rotation of the impeller in a generally axial direction.

The inner end of the casing part **73** has a rib **89** presenting a sealing surface **90** which cooperates with the adjacent side of the impeller **82**. The rib **89** extends from position adjacent to the far side of the outlet **91** in the direction of rotation of the impeller (indicated by the arrow **92** in Figures 11 and 14) inwardly toward the axis of the opening through which the pump shaft **81** extends. Near its inner end the rib **89** is curved or rounded around the axis of the opening through which the pump shaft **81** extends, and in suitable spaced relation thereto.

The rib **89** terminates in position indicated at **93** in Figure 14. As viewed in Figure 14, the space within the pump casing counterclockwise of the end **93** of the rib **89**, and to this rib, constitutes the centrifugal part of the pump. The space within the pump casing clockwise of the end of the rib **89**, as the pump is viewed in Figure 14, constitutes the turbine part of the pump. As in the preceding embodiments of the invention, the

centrifugal and turbine parts of the pump are both arranged in a common plane disposed radially of the axis of the impeller and within the same 360° rotation of the impeller. Moreover, the same impeller vanes or blades **84**, which act to produce the centrifugal action along the centrifugal part of the pump, also act to produce the turbine action along the turbine part of the pump.

In the operation of the pump shown in Figures 11–15, the impeller **82** is caused to rotate. The liquid enters the pump suction **87**, and flows toward the blades **84** of the impeller. The direction of admission of the liquid is shown by the arrows *m* in Figures 12 and 15. The arrows *n* show, in general, how the centrifugally hurled liquid is directed down into the inlet end of the channel or passageway **85**.

As the incoming liquid is engaged by the impeller blades **84**, it is hurled in the direction of impeller rotation by centrifugal force. This liquid, in motion, impinges on the wall **86** and the adjacent wall of the pump casing. From here, it is directed by the casing outer walls and by the impeller wall under pressure generated by centrifugal force, into the entrance of the turbine part of the pump which begins as the liquid passes the end **93** of the rib **89** in the direction of impeller rotation.

The turbine action, which begins as the liquid passes the end **93** of the rib **89**, consists of a centrifugal push of the liquid to the periphery of the channel **85** at the turbine part of the pump and a recirculation toward the root of the impeller blades **84** repeated over and over, as indicated generally by the arrows *o* in Figures 12 and 15. Each of these recirculations imparts energy to the liquid, which results in static pressure. As the liquid reaches the outlet **91**, it passes through this outlet and is discharged from the pump.

The advantages described in connection with the preceding embodiments of the invention are obtained in substantially the same manner in the embodiment of the invention shown in Figures 11–15 and will not, therefore, be repeated.

The embodiments of the invention shown in the drawings are for illustrative purposes only, and it is to be expressly understood that said drawings and the accompanying specification are not to be construed as a definition of the limits or scope of the invention, reference being had to the appended claims for that purpose.

I claim:

A centrifugal-turbine pump comprising a pump casing having an inner periphery defining the outer periphery of an annular channel, said casing having a liquid inlet opening into said annular channel and a liquid outlet opening from said annular channel, an impeller rotatable in said casing, rib means integral with the interior of said pump casing and extending generally radially inwardly from said inner periphery of said pump casing and terminating at its inner end in a portion curved around the axis of said impeller toward said inlet but terminating at a free end spaced distance from the opening of said inlet into said annular channel to provide a relatively unrestricted centrifugal passageway extending circumferentially from the opening of said inlet into said annular channel toward said outlet and terminating at the free end of said curved portion of said rib means, said generally radially extending portion of said rib means extending completely to the inner periphery of said casing at position between said inlet and outlet to separate said inlet from said outlet, said rib means in cooperation with the inner periphery of said casing defining a turbine passageway more restricted than said centrifugal passageway and extending circumferentially from said free end of said rib means to said outlet, and a centrifugal baffle at the inlet to said centrifugal passageway, said baffle having an inner face spaced outwardly from the periphery of the impeller and wider than the periphery of the impeller, with the inner face of the baffle completely covering and extending beyond opposite sides of the periphery of the impeller whereby to prevent liquid thrown outwardly by the impeller from impinging on and disturbing the free entrance of the liquid into the pump.

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