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3,154,020 10/1964 Sieghartner 415/113
3,247,797 4/1966 Sieghartner 415/143
3,261,297 7/1966 Daniel 415/213
3,385,225 5/1965 Hagemann 415/143

FOREIGN PATENTS

711,791 10/1941 Germany 415/143

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[54] **COMBINATION CENTRIFUGAL-TURBINE PUMP**
6 Claims, 12 Drawing Figs.

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179

References Cited

UNITED STATES PATENTS

2,368,530 1/1945 Edwards 415/143
2,875,698 3/1959 Roth 415/143

ABSTRACT: A centrifugal-turbine pump capable of pumping liquids at or near the boiling point with suction heads not greater than 1 foot having a pump casing with first and second pumping chambers laterally disposed and a drive shaft disposed axially of the pumping chambers. A high-pressure regenerative turbine impeller fixed for rotation with the driving shaft. The second pumping chamber extending angularly about the periphery of the turbine impeller and having a discharge opening radially from the turbine impeller. The casing having a suction entrance for the turbine stage opening laterally from the first pumping channel to the second pumping channel. A centrifugal impeller fixed for rotation within the first channel and with the drive shaft and turbine impeller.

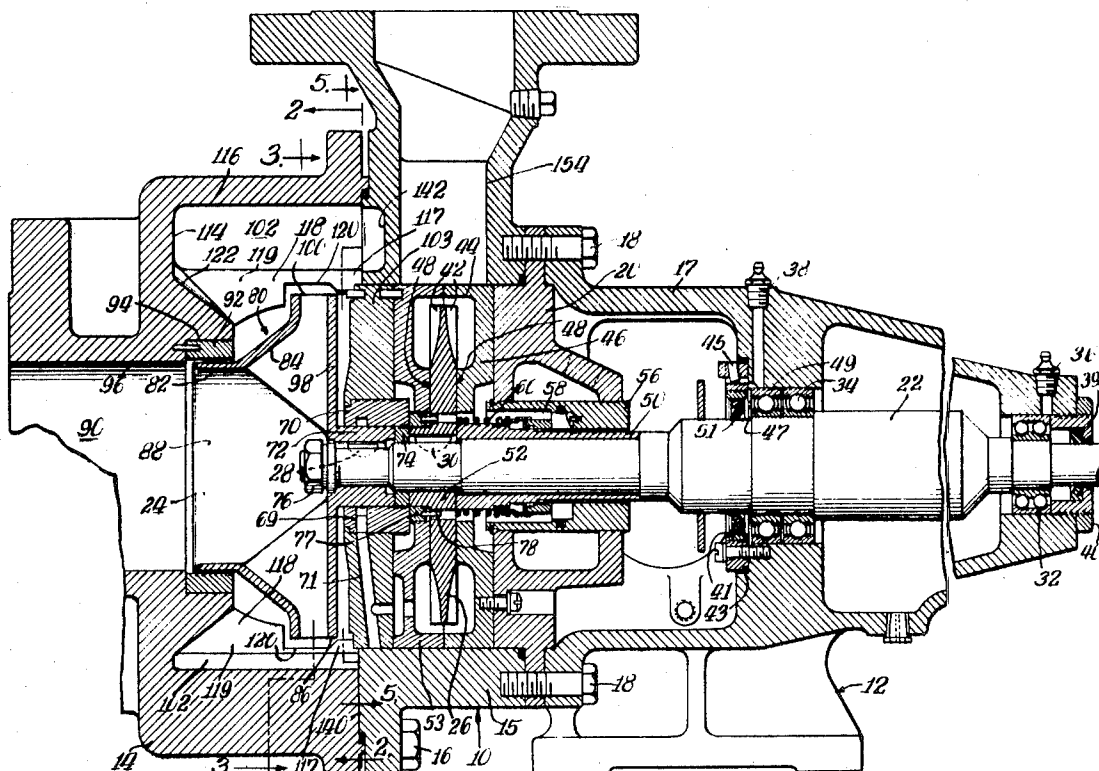
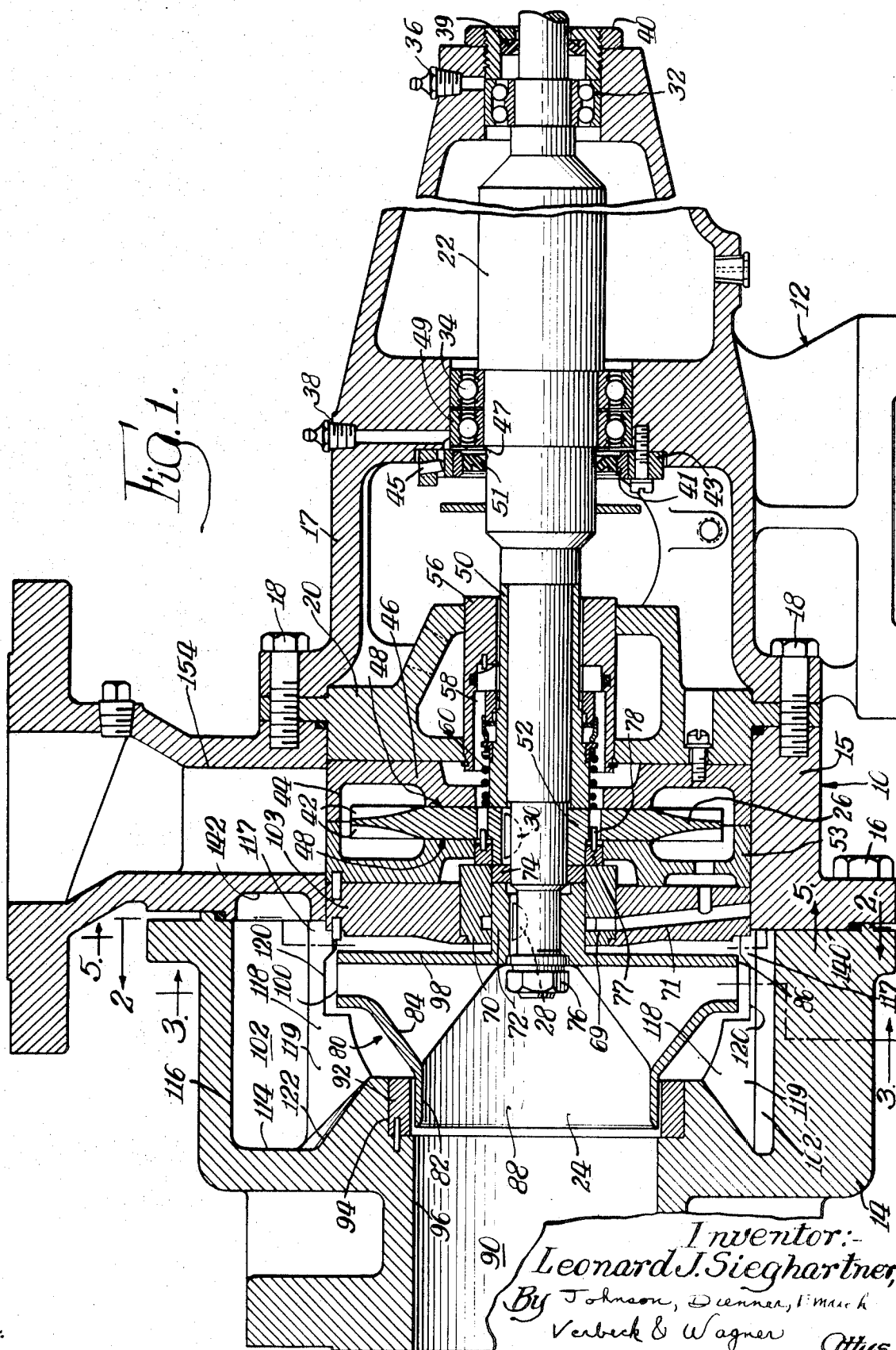
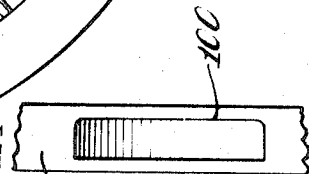
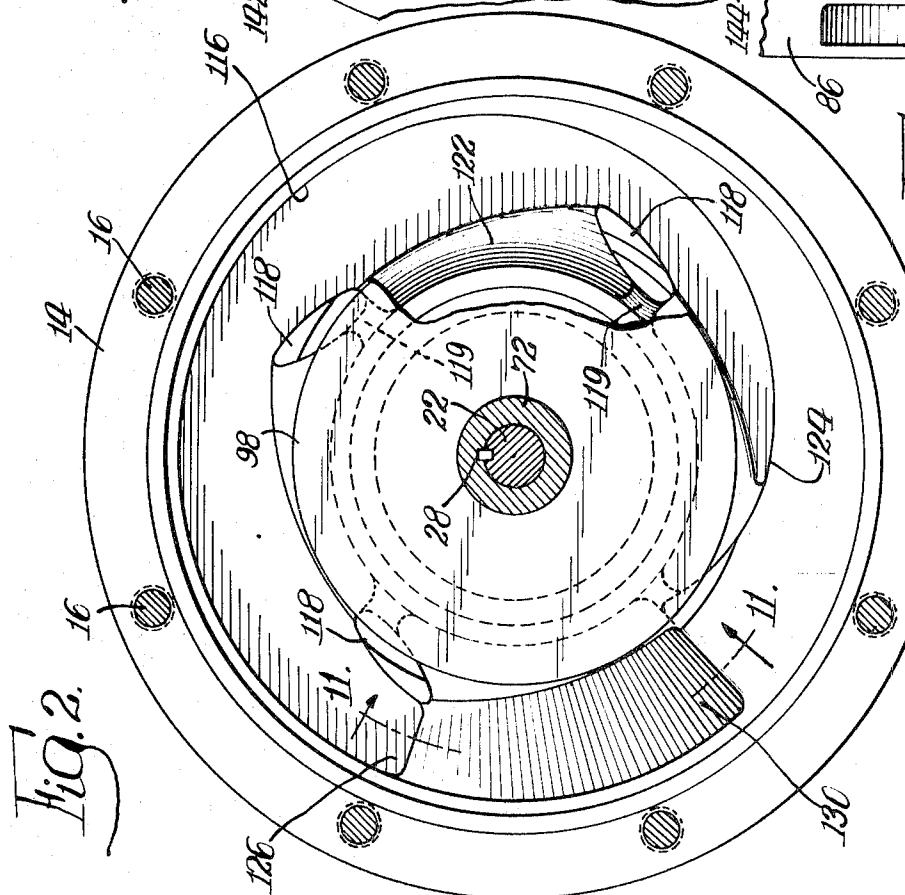
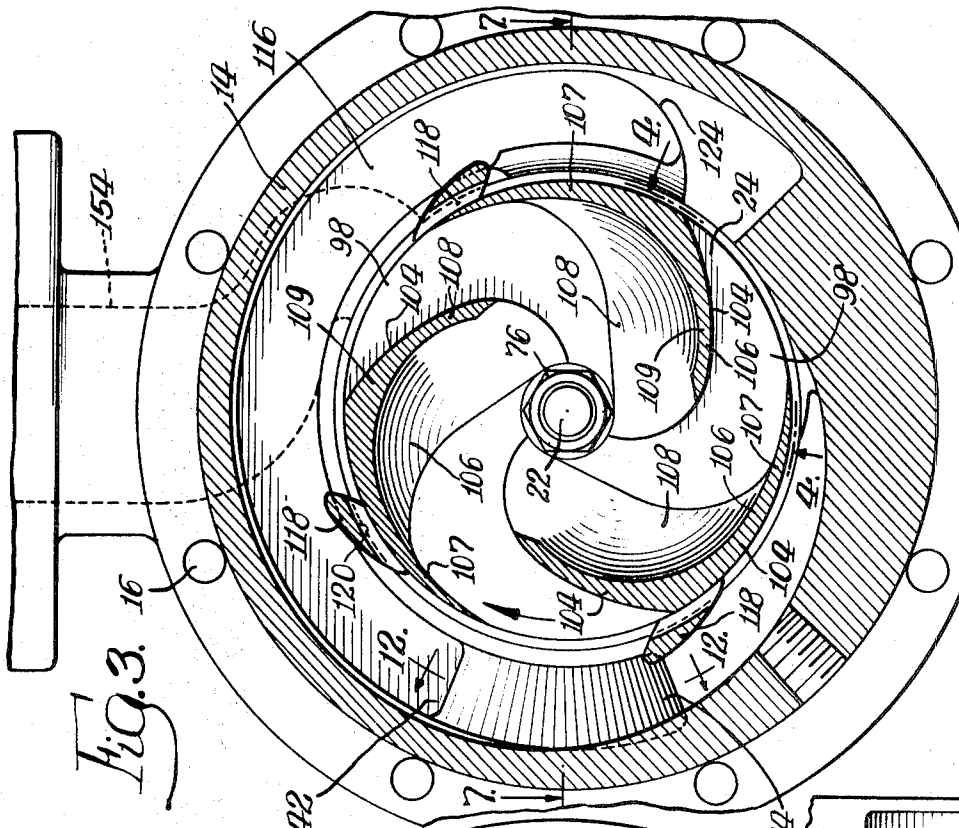
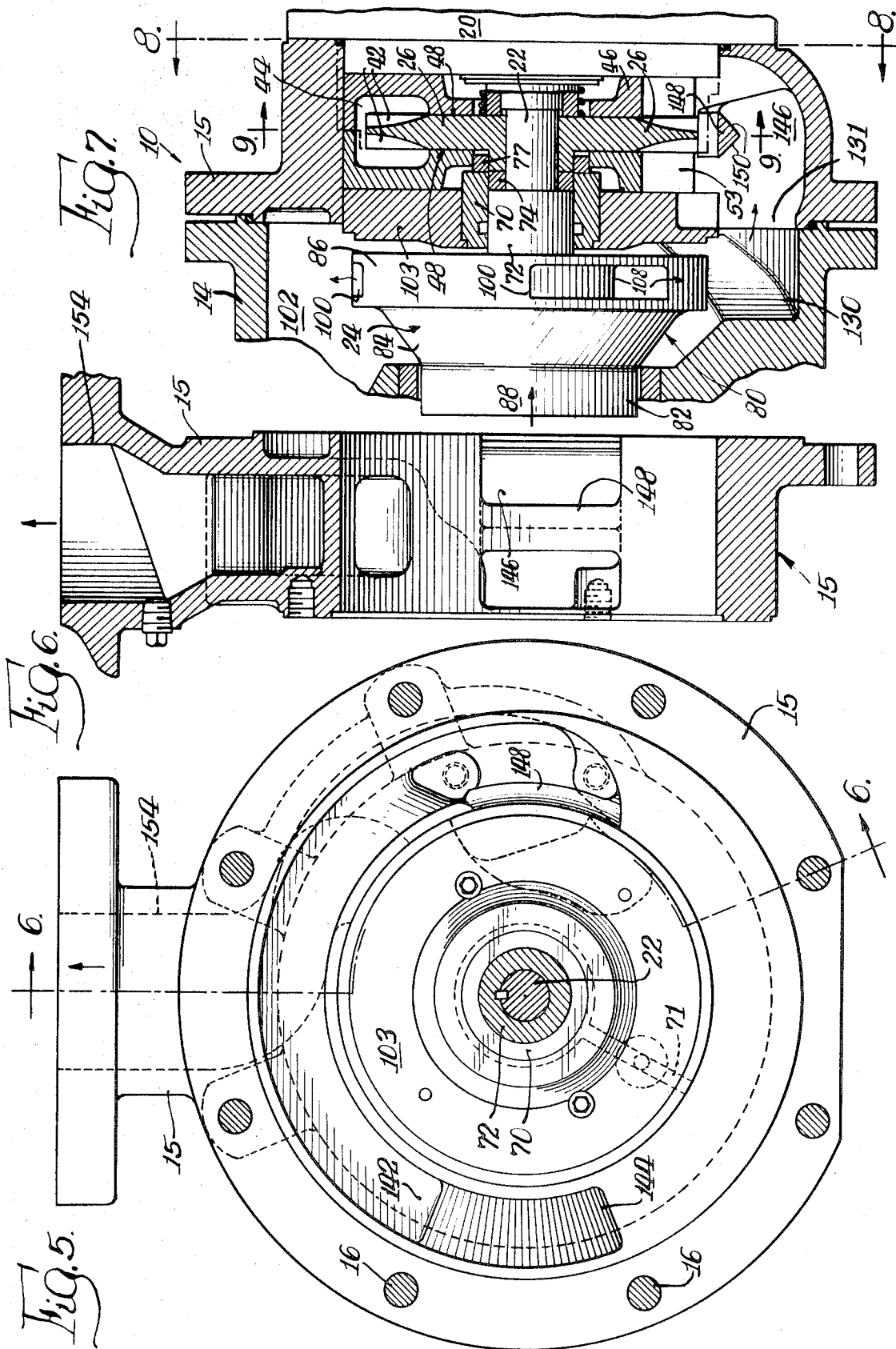


Fig. 1.



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COMBINATION CENTRIFUGAL-TURBINE PUMP

BACKGROUND OF THE INVENTION

This invention relates to a liquid pump for handling liquids at or near the boiling point, and more particularly relates to a combination centrifugal-turbine pump.

The problems in pumping a liquid at or near the boiling point are thoroughly discussed in U.S. Pat. No. 2,875,698, issued to L. C. Roth and assigned to the same assignee as this invention. In this patent, a combination centrifugal-turbine pump is disclosed, which has been found to perform very satisfactorily. This invention is directed to improvements over the combination centrifugal-turbine pump disclosed in the above-identified Roth patent. The addition of a centrifugal stage prior to a turbine stage as disclosed in the Roth patent, has been found to satisfactorily pump liquids at boiling point with suction heads of 1 foot or less.

Accordingly, one object of this invention is to provide a new and improved combination centrifugal-turbine pump having a higher volume capacity with a given casing diameter than is possible with previous designs.

Another object of this invention is to provide a new and improved combination centrifugal-turbine pump capable of operating with lower r.p.m. of the rotor to produce the same volume for a given casing diameter than is possible with previous designs.

A further object of this invention is to provide a new and improved combination centrifugal-turbine pump having a more uniform radial load balance on the impeller shaft assembly.

Further objects and advantages of the invention will appear from the following detailed description, taken in connection with the accompanying drawing, which shows the construction and operation of an illustrative embodiment of the invention.

DESCRIPTION OF DRAWING

For a better understanding of this invention, reference may be had to the accompanying drawing, in which:

FIG. 1 is a longitudinal sectional view illustrating a centrifugal-turbine pump embodying the principles of this invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1 and looking in the direction of the arrows;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1 and looking in the direction of the arrows;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3 and looking in the direction of the arrows;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 1 and looking in the direction of the arrows;

FIG. 6 is a sectional view taken along the line 6—6 of FIG. 5 and looking in the direction of the arrows, illustrating the main body of the pump casing;

FIG. 7 is a sectional view taken along the line 7—7 of FIG. 3 and looking in the direction of the arrows;

FIG. 8 is a sectional view taken along the line 8—8 of FIG. 7 and looking in the direction of the arrows;

FIG. 9 is a sectional view taken along the line 9—9 of FIG. 7 and looking in the direction of the arrows;

FIG. 10 is a sectional view taken along the line 10—10 of FIG. 8 and looking in the direction of the arrows;

FIG. 11 is a sectional view taken along the line 11—11 of FIG. 2 and looking in the direction of the arrows; and

FIG. 12 is a sectional view taken along the line 12—12 of FIG. 3 and looking in the direction of the arrows.

DESCRIPTION OF PREFERRED EMBODIMENT

There is illustrated in FIG. 1, a combination centrifugal-turbine pump having a case, generally designated by the reference numeral 10, which is supported on a frame 12. A case head 14 is secured to the main body 15 of case 10 by means of a plurality of cap screws 16. Inboard cover 20 is secured between main body 15 and case extension 17 by means of cap screws 18.

A shaft 22 is rotatably supported in the case extension 17. A centrifugal impeller 24 and a turbine impeller 26 are fixed to rotate with the shaft 22 by keys or splines 28 and 30, respectively. The shaft 22 is journaled for rotation in case extension 17 by means of an outboard bearing 32 and an inboard bearing 34, which are lubricated through grease fittings 36 and 38, respectively. An adjusting collar 39 and lock collar 40 provide for positive adjustment of the shaft-impeller assembly.

An inner adjusting collar 41 is screwed into an inner housing cap 43 and is locked in position by a setscrew 45 and the split side of the housing cap 43. A spring 47 bears against the bearing outer race 49 of inboard bearing 34 to preload the shaft-impeller assembly toward the shaft extension end. A lip type seal 51 is used to protect the bearings from dirt and liquids.

The turbine impeller 26 has vanes or blades 42 opening from the opposite side and peripherally from the impeller which are operable in a channel 44. The turbine impeller 26 rotates between inner and outer liners 46 and 53 which cooperate with the opposite sides of the impeller 26 to form sealing surfaces 48.

A shaft sleeve 50 surrounds the shaft 22 and abuts against the inboard end of the hub 52 of the turbine impeller 26. A stuffing box 56 is disposed between the shaft 22 and the inboard cover 20.

To allow the use of various styles of seals and/or packing, a sleeve 58 is placed between the impeller 26 and shaft shoulder and cooperates with a seal rotating unit, having a spring 60, to place the center of the shaft in tension and the sleeves impellers and spacers in compression. No gaskets are needed at the sleeve-shaft shoulder joint to seal, for an excellent finish on both sleeve and shaft shoulders combined with high loading per square inch effectively stops leaks of liquids or gases at this joint. The seal shown is a balanced type of seal but any other type of seal or packing may be used to suit the liquid and pumping conditions.

An annular stationary bushing 70 is disposed within the case 10 and surrounds the hub 72 of the centrifugal impeller 24 and an impeller spacer 74. The centrifugal impeller 24 is held on the end of the shaft 22 by means of a nut 76. The stationary bushing 70 acts in conjunction with a ring 77, which is driven by pins 78 extending into the turbine impeller 26 to prevent leakage of high-pressure liquid back into the low pressure centrifugal case. An annular groove 69 cut into the I. D. bushing 70 is connected by a passageway 71 of outboard cover 103 to a low-pressure point in the turbine working channel about 15° from the suction entrance to the turbine stage. This groove 69 bleeds off liquid which passes ring 77 and bushing 70 to a slightly pressurized part of turbine stage where it will not have a detrimental effect on either the turbine or centrifugal stage. This sealing arrangement is described in complete detail in U.S. Pat. No. 3,154,020, issued to Leonard J. Sieghartner, and having the same assignee as this invention.

Centrifugal impeller 24 has a one-piece housing 80 (FIGS. 1 and 7) having an inner annular rim portion 82, an intermediate flared skirt portion 84, and an outer annular rim portion 86. An inlet opening 88 is formed in the inner end of the housing 80 and is in direct communication with inlet opening 90 of case head 14. The inlet opening 90 is very large as compared with the overall diameter of impeller 24. The inner rim portion is rotatably supported by a bushing 92 seated in an annular groove 94 at the outer end of cylindrical wall 96 which defines inlet opening 90. At the outer end of housing 80 for impeller 24 is a circular wall 98 having a central hub 72.

Centrifugal impeller 24 has three equally spaced discharge openings 100 (FIGS. 3, 4 and 7) which are formed in the peripheral surface of outer rim portion 86 of housing 80. These discharge openings 100 are in direct communication with volute channel 102 extending generally angularly about and spaced outwardly from the periphery of the centrifugal impeller 24.

The centrifugal impeller provided in the pump of this invention is of a special type having a very low-pressure creating

characteristic and a higher volumetric efficiency as compared with prior centrifugal impeller designs. A higher volumetric efficiency is possible by virtue of the deep blades 104 (FIG. 3) having a particular design formed in centrifugal impeller 24. Blades 104 are in equal space relation about the center of wall 98 and the axis of shaft 22 and have identical shapes. Each blade 104 comprises an outer curved portion 106 extending perpendicular from plate 98, having a constant axial width and an inner curved portion 108 gradually increasing in axial width from the center of centrifugal impeller 24 in a diverging outward direction towards the opposite ends of the outer curved portion 106. The outer curved portion 106 comprises a first arcuate segment 107 with an outer surface concentric with the center of impeller 24, and a second arcuate segment 109 extending inwardly from one end of the first arcuate segment 107 a short distance so as to leave a space between its innermost end and the center of impeller 24. Thus the first arcuate segment 107 of the three outer curved portions 106 form the outer annular rim portion 86 of housing 80 and the spacing between adjacent segments 107 defines discharge outlets 100 for centrifugal impeller 24.

By virtue of the specially designed blades 104, the liquid entering inlet 88 impinges against rotating circular plate 98 and is smoothly directed outwardly along the inner curved portions 108 and outer curved portions of blades 104 to the three discharge outlets 100 into volute channel 102. The impeller blades 104 are arranged so that the liquid is more restricted in leaving the discharge outlets 100 than the liquid entering through inlet 88 so that nowhere in impeller 24 is there a drop in pressure, but rather a steady increase in pressure with the least possible disturbance. The particular shape of blades 104, with the inner curved portion 108 tapering down to the center of impeller 24 aids the impeller pressure buildup.

Volute channel 102 has a specially designed interior for guiding a large volume of liquid at the boiling point from the three outlets 100 of centrifugal impeller 24 into the channel 44 of the turbine stage. To prevent boiling of the liquid being pumped, it is essential that the volute channel 102 be designed to avoid any disturbance being introduced to the liquid.

The volute channel 102 is formed in the case head 14 and enclosed at its outer end by main body 15 of case 10 and outboard cover 103. A cavity 116 is formed in case head 14 to define volute channel 102 and extends laterally away from outboard cover 103 and discharge outlets 100 of centrifugal impeller 24. Extending generally perpendicular from wall 114 of the cavity 116 are three equally spaced diffuser vanes 118 (FIGS. 2 and 3). These vanes 118 have at their outer end 117 a generally spherical cross section with a cutout 120 to accommodate the outer rim portion 86 of the centrifugal impeller 24. The base 119 of the three vanes 118 are supported on a slanting wall 122 which diverges outwardly from the rear wall 114.

As illustrated in FIG. 2, the cavity 116 gradually increases in volume from its closed end 124 to its open end 126. At the open end 126 of the cavity 116, an inclined block 130 is provided which extends forwardly from the rear wall 114 of the cavity 116. The inclined block 130 directs the liquid from the impeller stage forwardly to the entrance 131 to channel 44 of the turbine stage. As illustrated in FIG. 11, the inclined block or guide ramp 130 for directing the liquid into the turbine stage extends at an obtuse angle away from the innermost wall 114 towards the outer end of the cavity 116 formed in the case head 14.

Diffuser vanes 118 provide an important function in the operation of the centrifugal stage, for they serve to straighten the flow of liquid exiting from discharge outlets 100 of centrifugal impeller 24. By virtue of their close proximity to the outer rim portion 86 of impeller 24, diffuser vanes 118 also provide for multiple outlets for impeller 24 resulting in a more uniform radial load balance on the impeller shaft assembly.

As illustrated in FIG. 3, the face 140 of main body 15 in opposing relation with the case head 14 has a shallow cavity 142 having an identical cross-sectional shape to cavity 116 in case

head 14. At the suction entrance 131 to channel 146 of the turbine stage, a slightly inclining surface 144 (FIG. 12) is provided which mates with inclined block 130 (FIG. 11) to guide the liquid into the turbine stage.

Channel 146, which is formed in the main body 15 of casing 10, provides a passageway for the liquid into liquid channel 44, which is formed about the outer periphery of turbine impeller 26 between inner and outer liners 46 and 53.

A baffle 148 is placed across the suction of the turbine stage by forming the baffle 148 integral with the main body 15 (see FIG. 6) and in position extending across the inlet to channel 44. The particular baffle 148 illustrated in the drawing is shown of tapered form, with its tapering sides 150 converging outwardly to a relatively sharp edge. Baffle 148 prevents the liquid thrown from turbine impeller 26 from interfering with the incoming liquid.

Provided in body portion 15 of casing 10 is an outlet 154 (FIG. 6) for the turbine stage which is in direct communication with liquid channel 44. To prevent the pressurized liquid from escaping to the suction of the turbine stage, a pair of block members 156 (FIGS. 8 and 9) are integrally formed with inner and outer liners 46 and 53 to interrupt liquid channel 44.

In the operation of the pump, the liquid enters the suction entrance or inlet 88 of the centrifugal impeller 24 and is discharged through outlets 100 from the periphery of centrifugal impeller 24 into the volute channel 102 at increased pressure and higher velocity. The liquid discharged from outlets 100 impinges against vanes 118, which serve to straighten the flow. The liquid is directed to the rear wall 114 of cavity 118 in a swirling motion towards inclined block 130, where the liquid is guided towards suction entrance 131 of the turbine stage. The liquid then passes through suction entrance 131 into the annular liquid channel 44 of the turbine stage. The regenerative pumping action of turbine impeller 26 builds up sufficient pressure to deliver the liquid to the outlet 154 of the turbine stage, by constant recirculation of the liquid through the impeller vanes 42 and annular channel 44.

I claim:

1. An improved centrifugal-turbine pump capable of pumping liquids and liquified gases at or near the boiling point thereof with suction heads not greater than about 1 foot, having a pump casing with a first pumping channel and a second pumping channel disposed laterally of said first pumping channel, a drive shaft disposed axially of said pumping channels, a high-pressure regenerative turbine impeller fixed for rotation with said driving shaft, said second pumping channel extending generally angularly about and spaced outwardly from the periphery of said turbine impeller and having a discharge opening generally radially from said turbine impeller, said casing having a suction entrance for the turbine stage opening laterally from said first pumping channel to said second pumping channel, and a centrifugal impeller fixed for rotation within said first pumping channel and with said driving shaft and turbine impeller, said centrifugal impeller having a large diameter axial inlet opening of substantially the same as a suction inlet for the centrifugal stage defined by said casing, said centrifugal impeller comprising a plurality of equally spaced blades for said centrifugal impeller inwardly from the periphery of said first pumping channel, each of said blades having an outer curved portion of constant axial width and an inner curved portion gradually increasing in axial width from the center of said centrifugal impeller in a diverging outward direction towards the opposite ends of said outer curved portion, each of said outer curved portion having a first arcuate segment concentric with said center and a second arcuate segment extending inwardly from one end of said first arcuate segment a short distance leaving a space between its innermost end and said center, where a plurality of equally spaced discharge outlets for said centrifugal impeller is defined by openings provided between the adjacent ends of said first arcuate segments.

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2. An improved centrifugal-turbine pump of claim 1, wherein said centrifugal impeller includes at least three of said blades.

3. An improved centrifugal-turbine as defined in claim 1, wherein said first pumping channel is defined by a cavity in said casing extending laterally away from said turbine stage to a rear wall with the area of said cavity annular about the periphery of said centrifugal impeller and increasing in volume between a closed end and an open end, and an axially inclined block in said cavity between said rear wall and said suction entrance for the turbine stage to guide the liquid into said turbine stage.

4. An improved centrifugal-turbine as defined in claim 3, wherein said first pumping channel further includes a plurality of spaced diffuser vanes extending from said rear wall towards said turbine stage and disposed in close proximity to said periphery of said centrifugal impeller to straighten the flow of liquid exiting from said discharge outlets of said centrifugal impeller.

5. An improved centrifugal-turbine pump capable of pumping liquids and liquified gases at or near the boiling point thereof with suction heads not greater than about 1 foot, having a pump casing with a first pumping channel and a second pumping channel disposed laterally of said first pumping channel, a drive shaft disposed axially of said pumping channels, a high pressure regenerative turbine impeller fixed for rotation with said driving shaft, said second pumping channel extending generally angularly about and spaced outwardly from the

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periphery of said turbine impeller and having a discharge opening generally radially from said turbine impeller, said casing having a suction entrance for the turbine stage opening laterally from said first pumping channel to said second pumping channel and a centrifugal impeller fixed for rotation within said first pumping channel and with said driving shaft and turbine impeller, said centrifugal impeller having a large diameter axial inlet opening of substantially the same as a suction inlet for the centrifugal stage defined by said casing, said centrifugal impeller comprising a plurality of equally spaced blades for said centrifugal impeller inwardly from the periphery of said first pumping channel, said first pumping channel defined by a cavity formed in said casing extending laterally away from said turbine stage with the area of said cavity annular about the periphery of said centrifugal impeller and increasing in volume between a closed end and an open end, and an axially inclined block in said cavity between said rear wall and said suction entrance for the turbine stage to guide the liquid into said turbine stage.

6. An improved centrifugal-turbine as defined in claim 5, wherein said first pumping channel further includes a plurality of spaced diffuser vanes extending from said rear wall towards said turbine stage and disposed in close proximity to said periphery of said centrifugal impeller to straighten the flow of liquid exiting from said discharge outlets of said centrifugal impeller.

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