May 5, 1942. M. SPILLMANN ET AL 2,281,631

CENTRIFUGAL PUMP

Filed Oct. 6, 1939 3 Sheets-Sheet 1

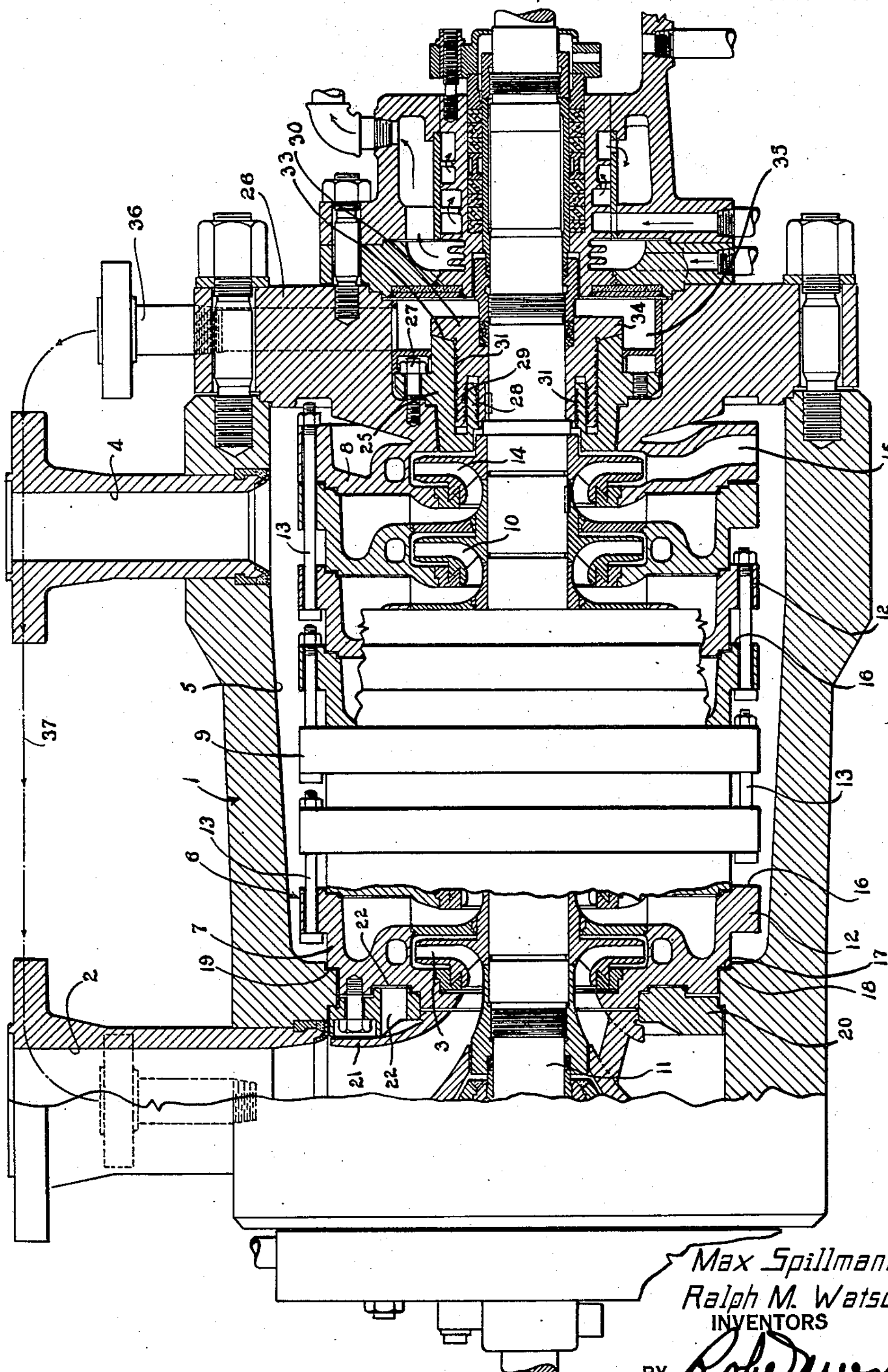


Fig. 1

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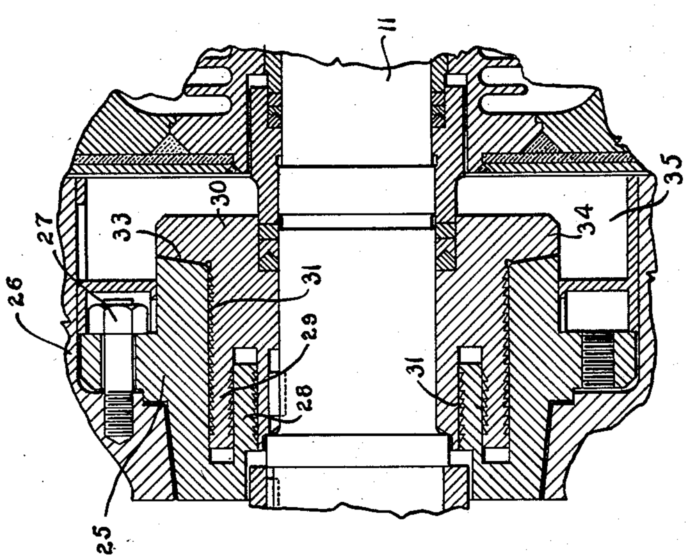


Fig. 3

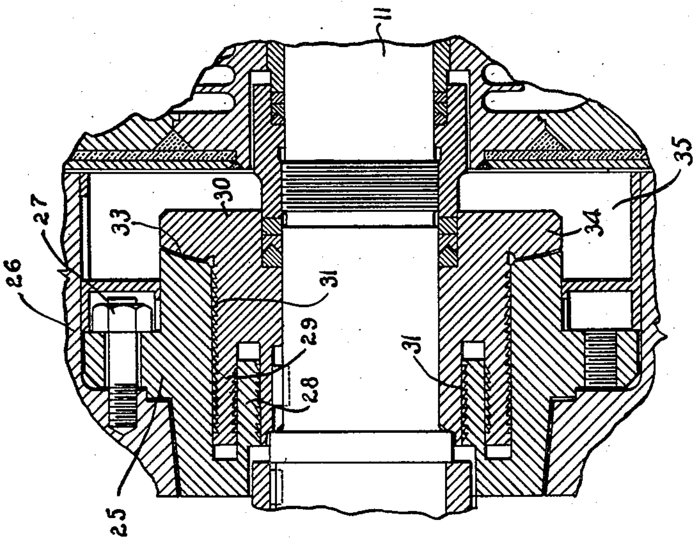


Fig. 2

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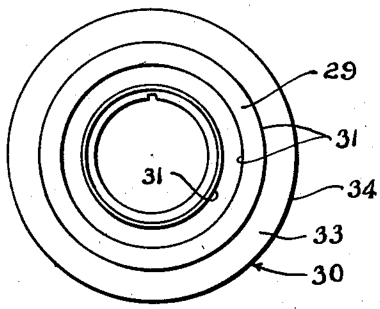


Fig. 4

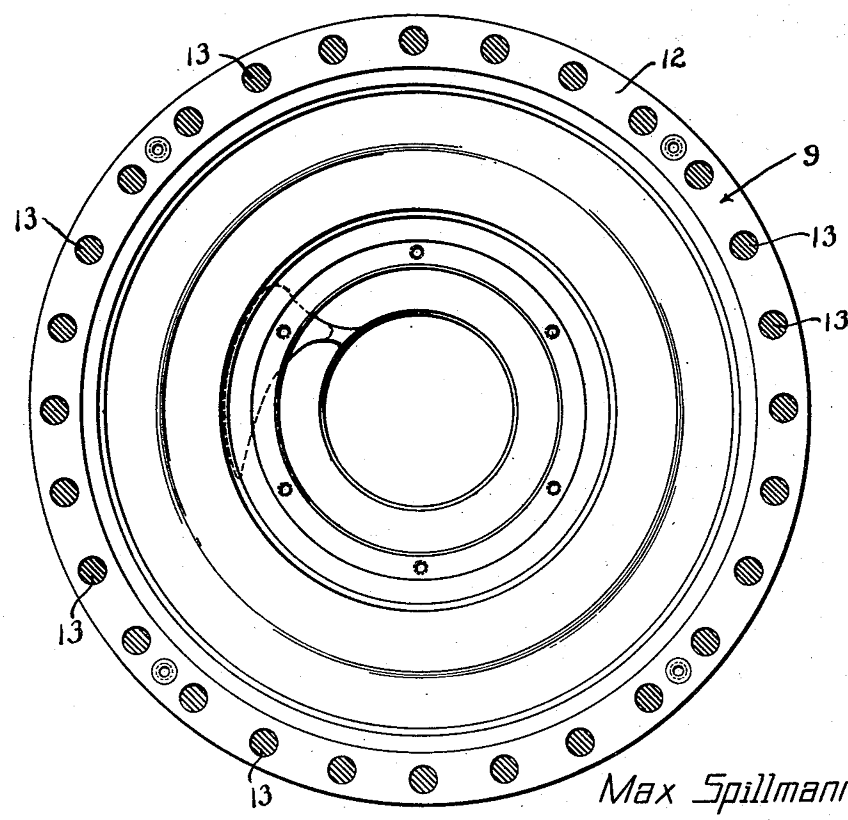


Fig. 5

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# UNITED STATES PATENT OFFICE

2,281,631

## CENTRIFUGAL PUMP

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Application October 6, 1939, Serial No. 298,168

3 Claims. (Cl. 103—112)

This invention relates to centrifugal pumps, and more particularly to high pressure multi-stage pumps for pumping hot liquids. An object of the present invention is to provide novel means for balancing the end thrust of the pump.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a centrifugal pump of the preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a longitudinal section through the pump showing parts in side elevation.

Figure 2 is an enlarged detail section of the balancing structure of the pump.

Figure 3 is an enlarged detail section of a slightly modified form of the balancing structure of the pump.

Figure 4 is an end view of the movable element of the balancing structure.

Figure 5 is an end view of one of the stage elements or diffuser rings of the pump.

Referring more particularly to the drawings, and with reference to the structure shown in Figures 1 to 5 inclusive, the multi-stage centrifugal pump comprises an outer casing 1, having a suction inlet 2 which opens into the suction eye of the first stage impeller 3 of the pump, and a final discharge outlet 4, which opens into the space 5 between the outer casing 1 and the inner casing 6 of the pump.

The inner casing 6 of the pump is built up of a plurality of stage sections comprising the first or suction stage 7, final or discharge stage 8, and the intermediate stage sections 9. The sections 7, 8 and 9 form the diffusion rings for the various stage impellers 10, which are carried by the shaft 11 of the pump. All of the stage sections which make up the inner casing 6 of the pump have annular flanges 12 formed thereon through which connecting bolts 13 extend. A plurality of connecting bolts 13 extend through each of the flanges 12, being circumferentially spaced thereabout, as shown in Figure 5 of the drawings. The bolts 13 staggerdly connect the adjacent section, as clearly shown in Figure 1 of the drawings. That is, the alternate bolts 13 serve to connect one of the stage sections to the stage section next thereto at one side, while the remaining bolts serve to connect the stage section to the stage section on the opposite side thereof. Thus all of the various stage sections 7, 8 and 9 are connected one to the other in a unitary structure, and in such manner as to compensate for expansion and contraction of the pump parts under temperature variances. The final or discharge stage impeller 14 discharges through its outlet 15 into the chamber 5 between the inner and outer casings 1 and 6 of the pump, and from this chamber outwardly through the discharge outlet 4. The discharge pressure of the pump acting upon the faces 16 of the various flanges 12 forces the stages toward the suction end of the pump, and forces the annular shoulder 17 formed on the suction or first stage section 7 tightly against the gasket 18, which in turn fits against the shoulder 19 formed on the outer casing 1, thereby holding the inner casing securely in position within the outer casing and preventing leakage of discharge fluid from the chamber 5 into the suction end of the pump. A supporting ring 20 is mounted within the outer pump casing 1 and bridges the joint between the first stage section 7 and the suction head or member 21. The supporting ring 20 has pressure equalizing openings 22 extending therethrough for equalizing pressure on opposite sides of the sealing ring.

The differences in the internal areas of the pump facing the discharge which is acted upon by the discharge pressures are greater than the areas acted upon at the suction sides of the impellers, as will be noted by particular reference to Figure 1 of the drawings, so that there is a thrust on the pump towards its suction end equal to the sum of the thrusts on the individual stages caused by such unbalanced areas. The unbalanced thrust towards the end of the pump is balanced or counterbalanced by the balancing structure at the discharge end of the pump. This balancing structure at the discharge end of the pump includes the element 25, which is rigidly connected to the head 26 of the outer casing 1 of the pump in any suitable manner, such as by the bolts 27. The member or element 25 is shaped to provide a labyrinth sleeve 28, which extends towards the outer end of the pump at its discharge end and cooperates with the sleeve 29 formed on the rotary member 30 to form a labyrinthian pressure break down for leakage of fluid from the final discharge impeller 14 of the pump. The member 30 is carried or rigidly connected to the shaft 11 of the pump and rotates therewith. The cooperating sleeves 28 and 29, together with the circumferential longitudinally extending surfaces of the members 25 and 30, which are indicated at 31, form a longitudinally extending pressure break down portion consisting of a labyrinthian or sinuous path. The longitudinally extending labyrinthian passage for the leakage fluid terminates at the entrance to the radial pressure break down passage 33, which is formed between the outer end of the member 25 and the inner surface of the annular flange 34 formed on the member 30. The radial pressure break down passage 33 opens into the final leakage chamber 35 from which the leakage passes through a suitable outlet 36, being returned to the suction of the pump, as indicated by the dot-and-dash line 37. If it is desired the leakage fluid from the chamber 35 may be delivered to any suitable point other than the suction of the pump without departing from the spirit of the present invention.

The pressure break down of the leakage fluid as counter-balancing thrust is divided between the cylindrical longitudinally extending labyrinth and the radial break down 33, so that as the pressure acting in the opposed direction to the impeller thrust increases, the cylindrical area of the radial break down increases, resulting in a greater flow of fluid through the balancing structure, whereas if the break down and counter-balancing effect is less than the combined thrust of the impellers the rotary shaft carried member 30 tends to close the space provided by the radial break down 33, reducing its area and causing a building up of pressure on the thrust balancing structure, so that theoretically it is possible to completely close off the radial pressure reduction passage and have discharge pressure of the pump on the balancing surfaces of the labyrinthian longitudinally extending break down structure. However, in actual practice the member 30, which is movable with the shaft, hunts or finds its proper counter-balancing position with respect to the stationary member 25, so as to maintain an accurate counter-balancing of the thrust of the impellers.

In high pressure centrifugal pumps the shaft 11 deflects and occasionally whips or vibrates transversely of its longitudinal axis during operation of the pump, which, if the radial break down passage 33 were perpendicular to the longitudinal axis of the shaft, would result in a pinching or closing of a part of this passage on one side of the shaft, thereby destroying the effectiveness and efficiency of the radial break down passage as a counterbalancing feature, in that it would be unable to reduce the area of the radial break down passage because of contact between the stationary element 25 and the rotating element 30 on one side of the shaft, while the radial break down remains open on the diametrically opposite side. To overcome this pinching or partial closing of the radial passage 33 during operation of the pump, the facing surfaces of the member 25 and the flange 34 of the member 30, which form the walls of the radial passage, are cut on a sphere, as more clearly shown in Figure 2 of the drawings, which sphere is scribed on radii taken approximately on a centerpoint on the longitudinal center of the shaft at a point sufficiently distant from the facing surfaces of the members 25 and 30 which form the radial break down passage to compensate for the deflection and/or whipping of the shaft, so that the area of the passage will remain constant, depending upon the thrust, irrespective of the deflection and/or whipping of the shaft.

The invention also embraces the cutting or forming of these facing surfaces which form the radial pressure break down passage on angles inclined with respect to the axis of the shaft, as shown in the modified construction illustrated in Figure 3, rather than being cut on an arc. The said angles are determined by the degree of whip or movement in the shaft of the pump, so as to prevent partial closing of the radial pressure breakdown passage and maintain the necessary proper area to the passage at all times irrespective of the whipping movement of the shaft.

In Figures 1, 2 and 3 of the drawings the longitudinal labyrinthian pressure break down passage is shown between the final discharge impeller 14 of the pump and the radial break down passage, so that the leakage fluid first travels through the labyrinthian passage prior to its travel through the radial passage into the chamber 35. However, in Figure 6 of the drawings a different arrangement or modification of the pump structure is shown.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a multi-stage centrifugal pump including a casing, a plurality of stage impellers and an impeller carrying shaft, a pressure break down thrust balancing structure comprising a stationary element carried by said casing and a movable element carried by said shaft, said elements having interengaging projections forming a longitudinal labyrinthian pressure break down passage extending longitudinally of the shaft, said elements having facing surfaces arranged to provide a radial pressure break down passage at the outlet end of said labyrinthian passage, said facing radial surfaces being inclined with respect to a plane perpendicular to the horizontal plane of the axis of said shaft to prevent constriction of the area of the radial break down upon flexing of said shaft.

2. In a multi-stage centrifugal pump including a casing, a plurality of stage impellers and an impeller carrying shaft, a pressure break down thrust balancing structure comprising a stationary element carried by the casing and a movable element carried by the shaft, said elements being constructed and arranged to provide a longitudinal labyrinthian pressure breakdown passage, said elements having facing surfaces arranged to provide a radial pressure break down passage at one end of said labyrinthian passage, said facing radial surfaces being cut on an arc scribed from a centerpoint on the longitudinal axis of said shaft to prevent constriction of the radial break down area upon flexing of the shaft.

3. In a multi-stage centrifugal pump including a casing, a plurality of stage impellers and an impeller carrying shaft, a pressure break down thrust balancing structure comprising a stationary element carried by the casing and a movable element carried by the shaft, said elements having facing surfaces arranged to provide a radial pressure break down passage, said facing radial surfaces being cut on an arc to prevent constriction of the radial break down area upon flexing of the shaft.

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