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2 Sheets-Sheet 2

Fig. 2

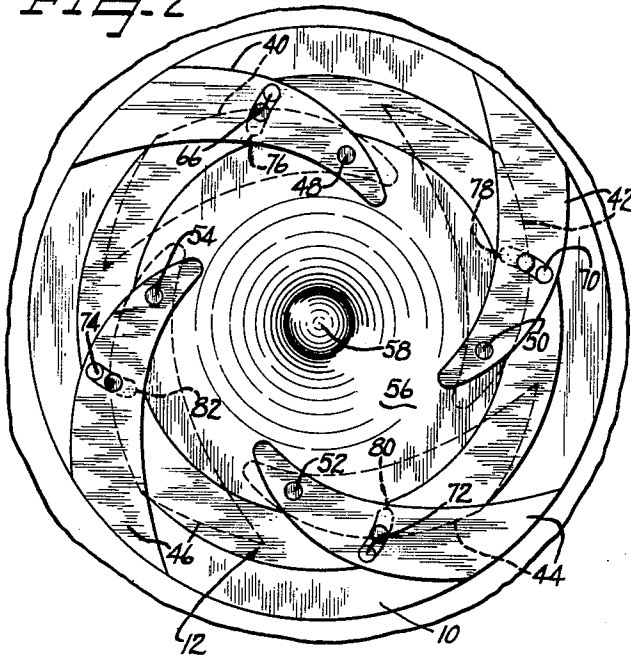


Fig. 3

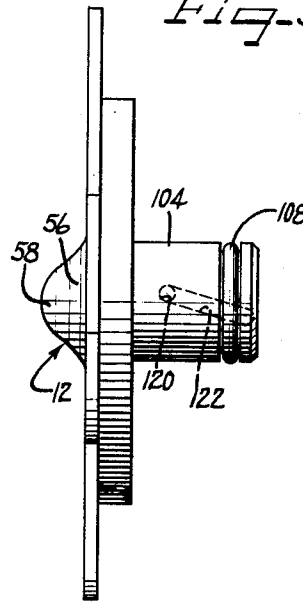
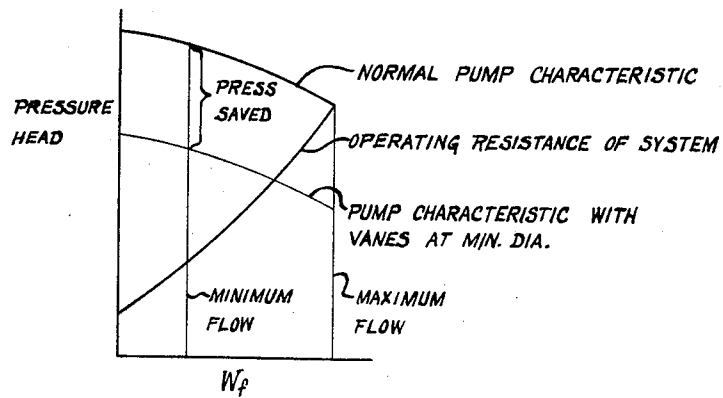


Fig. 4



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The present invention relates to improvements in pumps and more particularly to an improved rotary pump assembly wherein a pump element is operated at a constant speed and its delivery pressure is controllable during operation to accommodate varying demand.

In rotary pumps, such as the centrifugal type, applications are encountered wherein the output requirements vary and are not related to pump speed. In many such utilizations, the pump is driven at substantially constant speed, whereas the output delivery requirements vary from a minimum output to a maximum. Such an application is encountered wherein a centrifugal pump is used to deliver fuel, such as to a turbine. The fuel output requirements of the pump will vary with load, and will not be related to speed.

A pump is usually designed for operating at optimum efficiency at the maximum flow. At partial and at minimum required flow rates, the centrifugal pump, which will be operating at a constant speed, produces a considerable excess of discharge pressure, and operates at reduced efficiency. The temperature rise across a centrifugal pump is a direct function of the head rise, and is hyperbolically proportional to the efficiency. Not much can be accomplished by way of improving the efficiency at low flows, but if the pressure rise can be held to the lowest required value to overcome nozzle pressure drop, then the temperature rise across the pump will be held to a minimum.

The present invention contemplates the provision of a rotary pump capable of operation at constant speed with varying output pressure to avoid the above and other undesirable features, and to provide an improved method and apparatus for controllably varying the output of a pump which is improved over devices and methods heretofore used.

The present invention, in one form, contemplates the provision of a pump provided with a pump housing having an axial inlet and a volute-shaped discharge passageway leading to a pump outlet with a pump chamber within the housing between the inlet and outlet. Rotationally mounted within the pump chamber is a rotary impeller carrying pivotally mounted vanes which are adjustable in pivotal position to vary the output pressure head of the pump.

The impeller includes a pair of discs, with one disc pivotally supporting the vanes, and the other disc containing slots into which pins carried by the vanes project. With relative rotation of the discs, the pins move in the slots changing the pivotal position of the vanes and, hence, changing the output of the pump. Relative rotation between the discs is obtained by one of the discs being provided with a slot which extends at an angle to the axis of rotation of the disc, and the other disc provided with a reciprocating member carrying a pin extending into the slot. With relative reciprocation between the pin and slot, the discs are shifted rotationally with respect to each other. Relative axial movement

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between the pin and slot is achieved by a linear adjustment rod connected to a piston operating within a cylinder. Pressurized control fluid is admitted to the cylinder to control the position of the piston whereby the output of the pump is changed during operation and constant speed.

Accordingly, an object of the invention is to provide an improved rotary pump which can be operated at constant speed, and wherein the output pressure head can be controlled over a substantial range during operation.

Another object of the invention is to provide an improved method of pump operation which will increase overall efficiency and decrease undesirable results such as temperature increase at low delivery rates.

Another object of the invention is to provide an improved centrifugal pump wherein the discharge pressure can be reduced to the minimum pressure head necessary to thereby avoid the temperature rise which occurs at low flow conditions and improve low discharge efficiency.

Another object of the invention is to provide an improved apparatus for controlling the output of a pump employing elements which rotate with the pump, but which are rotated relative to each other by improved means, for adjusting the pump output, such as during operation.

A still further object of the invention is to provide an improved pump structure employing impeller elements operated within a housing for centrifugal pumping action.

A further object is to provide an improved pump having an improved structure for controlling pump output pressures which is reliable in operation and relatively uncomplicated for manufacture and assembly.

Other objects and advantages will become more apparent with the teaching of the principles of the invention and the disclosure of the preferred embodiments in the specification, claims and drawings, in which:

Figure 1 is a detailed vertical sectional view taken through the axis of a pump embodying the principles of the present invention;

Figure 2 is a vertical sectional view taken along line II—II of Figure 1 and illustrating the end appearance of the pump impeller;

Figure 3 is a side elevational view of the pump impeller unit with other parts removed; and,

Figure 4 is a graph illustrating operational features of the pump.

As shown in the drawings:

Figure 1 illustrates the pump assembly having a pump housing 10 with a rotor or impeller assembly 12 therein. The pump housing 10 is formed of a central tubular part 14, with a head end part 16 and a tail end part 18. The head end part 16 has a circular axial opening providing a pump inlet port 20. Within the head end 16 of the housing 10 is provided a pump chamber 22 which is somewhat cylindrical in shape, and which has at its edge a volute shaped chamber 24, for the centrifugal discharge of the fluid by rotation of the rotor assembly 12.

The rotor assembly extends back through the central part 14 of the housing 10 and into the tail part 18 where it is driven, such as by a driving gear 26 located within a cavity 28 in the housing. The housing parts 14, 16 and 18 are suitably joined, such as is illustrated, by a cap screw 30, which extends through a flange 32 in the central part 14 and threads into the head part 16. Leak-proof gaskets, such as 34 and 36, may be provided between elements of the housing parts which fit together in telescoping relationship.

The rotor assembly 12 carries a plurality of impeller vanes, as shown at 40, 42, 44 and 46, especially in

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Figure 2. The impeller vanes are supported for rotation on the rotor 12, and the support is primarily afforded by pivotal support pins 48, 50 52 and 54 secured to the base of the impeller vanes.

The support pins project into openings in a shaped driving front plate or disc 56. This disc 56 has a smooth raised central protuberance 58 for the smooth flow of fluid into the pump chamber 22.

As illustrated in Figure 1, the disc 56 is provided with angularly disposed holes arranged around the edge of the disc 56, and extending therethrough in an axial direction. The pin 48, for example, is shown projecting into the axial bored hole 60, and is provided with a groove to receive a snap ring 62 to lock the pin in the hole, and to hold the impeller vane 40 on the disc.

Behind the driving disc 56 is an adjacent control rear plate or disc 64 which is mounted to be carried with the driving disc, and the impeller vanes as the rotor assembly 12 is rotated. The two discs 56 and 64 are normally fixed with respect to each other as they are driven in rotation, but can be rotated relative to each other, and this will adjust the pivotal position of the impeller vanes. As will be noted, especially with reference to Figure 2, as the pivotal position of the impeller vanes change, their disposition or attitude with respect to the impeller assembly changes, and this will change the output performance of the pump.

To regulate the position of the vanes, each vane carries a position-control pin with the pins being shown at 66, 70, 72 and 74. The pins project rearwardly with each extending into a slot, with the respective slots being shown at 76, 78, 80 and 82.

The slots are formed in an annular ring 86 which is mounted on or secured to the second disc 64 so as to move therewith when it is rotationally adjusted relative to the driving disc 56. As illustrated in Figure 1, the annular ring 86 contains the slot 80, which slidably receives the pin 72. The angle of the slots is such that as the discs 56 and 64 are relatively rotated, the impeller vanes will be pulled inwardly or forced outwardly in a radial direction. The impeller vanes are shown in Figure 2 in their solid line position, as being set at maximum discharge pressure wherein the pins are at the outer ends of their respective slots. The dotted line positions of the impeller vanes show their position for minimum discharge pressure wherein the pins will be at the inner ends of the slots.

The relative rotation of the discs and the adjustment of the impeller vanes to vary pump output pressure is accomplished during rotation of the pump. In a preferred environment of the present pump, the pump will be driven at constant speed, and the vanes will be adjusted to obtain the desired pressure head output. At a low or minimum output head, the vanes will be drawn to their innermost position, and the undesirable effects of temperature increase, which occur with pumps heretofore used, are substantially reduced.

The rear disc 64 contains an integral tubular shaft extension 88. The shaft 88 is supported by sets of roller bearings 90 and 92 held within the cylindrically shaped internal bore 94 of the central housing part 14. The shaft 88 is also supported by a roller bearing assembly 96 which is also held within the cylindrical bore 94, and which is spaced from the roller bearings 90 and 92 by a tubular shaped spacer member 98. The ball bearing assemblies 90 and 92 abut against a reduced portion of the tubular bore 94 which forms a shoulder 100. The bearing assemblies and spacer tube 98 are held in place by an annular flanged cap member 102, which projects slightly into the cylindrical bore 94, and is held in place by means, not shown.

The driving disc 56 carries an annular projection 104 which forms a supporting hub for the plate, and which extends into a cylindrical bore 106 in the head end of the shaft 88 which integrally carries the disc 64. An

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O-ring seal 108 is located between the hub 104 of the disc 56 and the bore 106 of the shaft 88.

Within the hollow interior 110 of the hub 104 of the disc 56, a spool 112 is slidably located. The spool 112 has a finger projection 114 which extends into a groove or keyway 116 within the hollow bored section 118 of the shaft 88. This prevents rotation of the spool 112 relative to the shaft 88, and permits axial or linear movement of the spool.

The spool carries a pump control pin 120 which projects into a pump control slot 122. The pin 120 is secured to project radially from the spool, and the slot is cut in the inner surface 110 of the disc projection 104. The slot extends at a substantially constant radius but at an angle with respect to the axis of rotation of the rotor assembly. With this construction, as the pin 120 is forcibly moved in an axial direction, it slides along the slot 122 and forces relative rotation between the slot and pin, thus forcing the driving disc 56 to rotate relative to the control disc 64. This occurs because the spool 112 is locked in the groove 116 of the shaft 88 which is integral with the disc 64.

The spool 112 has an axial bore 124 in which is contained a coil compression spring 126. The coil compression spring 126 pushes against the base of the chamber 112 within the hollow projection 104 and pushes against the spool 112 to tend to urge the pin 120 in a rearward direction along the slot 122. Control of the spool 112 and of the position of the pin 120 in the slot 122 is obtained by an axially movable control rod 128 which extends through the hollow center 130 of the shaft 88. The control rod 128 has a flanged head 132 adjacent the coil compression spring 126, which projects over the shoulder formed by the reduced axial bore 134 which meets the larger axial bore 124 within the spool 112. The rod 128 also carries a locking ring 136 which drops in a slot in the rod, not shown, to lock the rod in an axial direction with respect to the spool, but to permit rotation of the spool with the pump rotor assembly.

Axial movement of the rod 128 is obtained by connecting the rod to a control piston 138. The control piston is slidably mounted in a cylindrical chamber 140. Control fluid ports 142 and 144 communicate with the ends of the control chamber 140 for the admission and release of control fluid to control the position of the piston 138. As the piston is reciprocated, the control rod 128, of course, will also be linearly reciprocated to move the pin 120 in the slot 122. It will be understood that while the pin and slot control arrangement illustrated obtains advantages and presents the preferred form, other arrangements may be utilized for accomplishing the relative rotation between the discs for the adjustment of the pump output pressure.

In operation, the pump is driven at a substantially constant speed by the driving gear 26 driving a pinion 146 keyed to the end of the shaft 88. The shaft carries the pump rotor assembly, and pumped fluid enters the housing inlet 20 and is discharged by operation of the impeller vanes 40, 42, 44 and 46 through the volute-shaped chamber 24. Each of the impeller vanes is supported on a pivotal pin 48, 50, 52 and 54, which is pivotally supported at the outer edge of the driving disc 56. Each of the impeller vanes also carries a control pin 66, 70, 72 and 74, which projects into a slot 76, 78, 80 and 82 in an annular ring 86 carried by the control disc 64. Relative rotation between the discs 56 and 64 will adjust the position of the impeller vanes to adjust the output head of the pump. This relative rotation is obtained by reciprocation of the spool 112, which pushes or pulls the pin 120 axially in the slot 122. The axial position of the spool is controlled by a control rod 128 connected to the control piston 138 operating within a cylinder 140 which receives control fluid through ports 142 and 144.

Figure 4 shows a graph portraying the operational

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characteristics of a pump in accordance with the present invention as compared with a centrifugal pump of the type heretofore used. The upper graph line labeled "Normal Pump Characteristic" illustrates the operation of the pump without changing the angle of the impeller vanes, or of a pump wherein no provision is made whereby the impeller vane angle can be changed. The curved line of pump discharge is plotted against pressure head increase across the pump.

The lower curved line of the graph is labeled "Operating Resistance of System." This curved line which plots resistance pressure against flow, indicates the increase in operating resistance, and in the case of fuel pump operating with an engine, the resistance is created by the fuel line, the fuel nozzles and the flow system.

The intermediate line is captioned "Pump Characteristic With Vanes of Min. Dia." This illustrates the operating characteristic of the pump with pressure increase across the pump plotted against the discharge. The vertical lines indicate minimum flow and maximum flow of the system.

It will be apparent, that the angle of the impeller vanes will have to be changed to increase the pressure head as the flow requirements increase from minimum to maximum to maintain the pressure above the operating resistance of the system. This will be done by the control which varies the angle of the vanes. It will also be apparent, that at less than maximum discharge, the normal pump characteristic yields a pressure head greater than necessary, and that a power saving can be obtained by reducing the pressure head. This is obtainable with the present invention.

In accordance with the method of the present invention, the output pressure head of the pump is reduced with flow requirements of the system. This can be done gradually and in direct relationship to the discharge flow requirements so that the minimum pressure discharge necessary is delivered to the system. The method is accomplished preferably by gradually diminishing the angle, or in other words, the circumference of the impeller vanes with reduction in flow requirements.

Thus, it will be seen that we have provided an improved pump assembly which meets the objectives and advantages hereinbefore set forth. The pump is capable of operation under varying flow demands and can be simply and easily controlled by the control apparatus shown to reduce or increase the discharge head with change in discharge requirements. The pump, therefore, can be operated at a point of improved efficiency at less than maximum output, inasmuch as the impeller vanes can be constantly adjusted to a position wherein the discharge is not at pressures higher than needed for the pump discharge output. Furthermore, since the pump impeller vanes can be set at an improved position for minimum or reduced discharge rates, efficiency is improved. Control is achieved by a non-complicated control including a piston and chamber assembly. If desired, the proper control of the discharge of fluid from the pump can be made and this fluid used to operate or position the piston.

We have, in the drawings and specification presented a detailed disclosure of the preferred embodiment of our invention, and it is to be understood that we do not intend to limit the invention to the specific form disclosed, but intend to cover all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by our invention.

We claim as our invention:

1. A rotary pump adapted for operation at constant speed and for control for varying pressure discharge comprising a driving member, a pump housing enclosing the driving member and having an axial inlet passageway and a peripheral discharge passageway with a communicating chamber enclosing said driving member, a plu-

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ality of pump vane elements, pivotal mounting means securing the vane elements to the driving member for pivotal movement about axes parallel to the rotational axis of the driving member, a control element adjacent said driving member mounted for rotation therewith and for controlled rotation relative to the driving member, elongated shaped slots in one of said elements opening in an axial direction, control pins secured to the other of said elements and projecting into said shaped slots, said slots shaped to pivot said vane elements inwardly and outwardly with relative rotation between said driving member and control elements, means defining an axially extending control chamber, a vane element control piston reciprocally mounted in said axially extending chamber, means for accommodating the flow of a control fluid to said axially extending chamber to control the position of the piston therein, and means connected between the piston and said control element for converting linear control motion to rotary motion whereby the control element adjustably controls the pivotal angle of the vane elements on the driving member to control the discharge pressure of the pump.

2. A rotary pump adapted for operation at constant speed and for controlled pressure output comprising in combination a pump housing having an axial inlet passageway and a spherical discharge passageway with a driving disc mounted within said pump housing, a plurality of centrifugal vane elements pivotally mounted at their base in an annularly disposed arrangement on said driving disc and adapted to deliver fluid to said volute-shaped discharge passageway, a control disc element with a hub mounted for rotation, a plurality of annularly disposed position control pins projecting axially and mounted on one of said elements, angled control slots in the other of said elements operatively receiving said pins and shaped to vary the angular position of each of the vane elements simultaneously with rotation of the control disc element relative to the driving disc, a driving shaft projecting axially from the driving disc and adapted to drive said driving disc and control disc element with the vane elements in driven rotation for constant speed operation of the pump, a generally axially extending groove in said hub angled with respect to the hub axis, a pump controlling pin projecting into said groove, an axially movable spool carrying said pump controlling pin, means fixing the rotational position of the spool with respect to said driving shaft and permitting axial movement of the spool whereby linear reciprocation of the pump controlling pin and spool will vary the position of the driving disc with respect to the control disc element and vary the angular position of said vane elements, a linear axially extending control rod connected to the spool and adapted for reciprocation to control the position of the spool with respect to the hub to thereby control the vane elements and pump output, and a control means including a cylindrical chamber with a piston movable therein connected to the linear control rod, said chamber having ports for receiving pressurized fluid to control the position of the piston therein and the output of the pump.

3. A pump comprising a housing having an internal chamber, drive shaft means mounted in said housing, a driving member rotatable with said drive shaft means, a control member rotatable with said shaft means but capable of limited rotation relative to said driving member, impeller vanes mounted on said driving member and located in said chamber, said impeller vanes movable relative to the driving member, position control means connected between said impeller vanes and said control member for varying the position of the vanes relative to the driving member with rotation of the control member relative to the driving member to change the area swept by said impeller vanes during rotation of said shaft means, a pin element, a slot element, one of said elements connected to said driving member and the other

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to said control member, said slot extending in a substantially helical direction so that axial movement of the pin will relatively rotate the control and driving members, and means operatively connected to said pin and slot elements moving them relatively axially.

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