

May 1, 1962

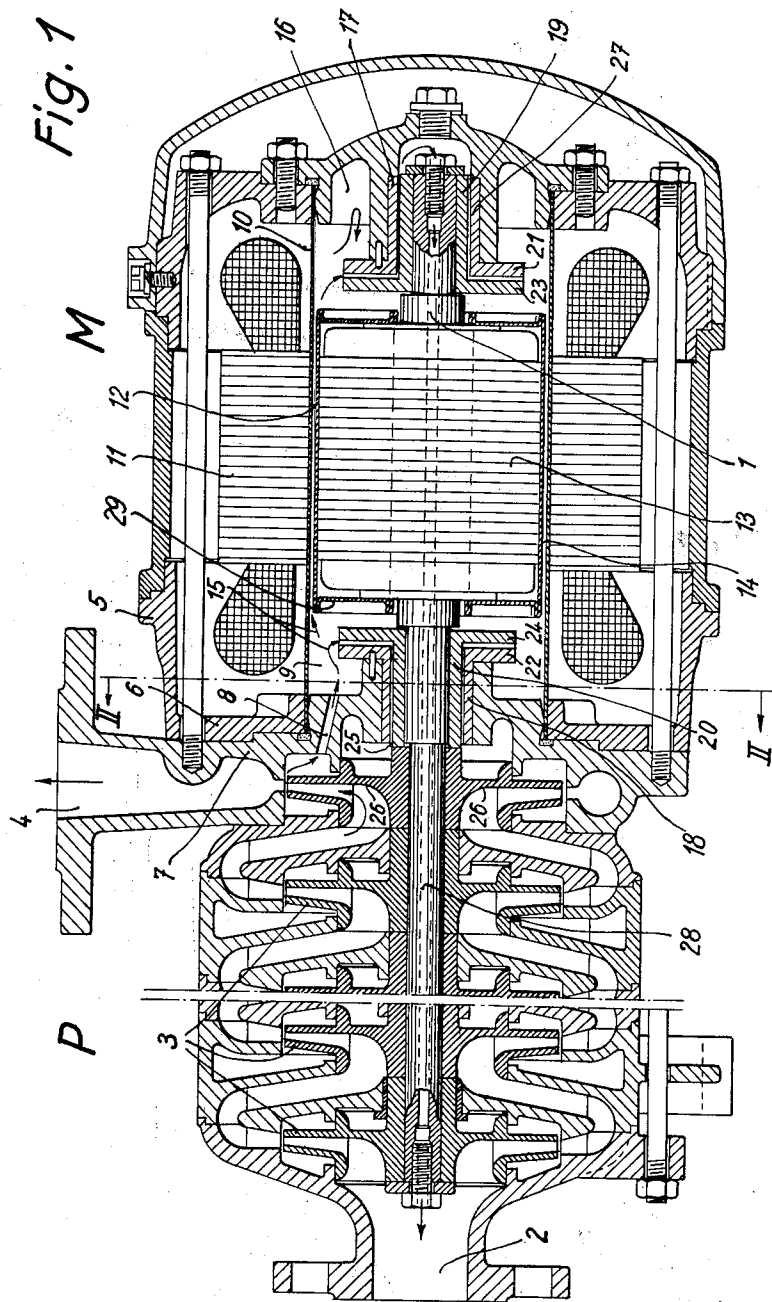
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3,031,973

CENTRIFUGAL PUMP WITH CANNED MOTOR

Filed Nov. 30. 1959

3 Sheets-Sheet 1



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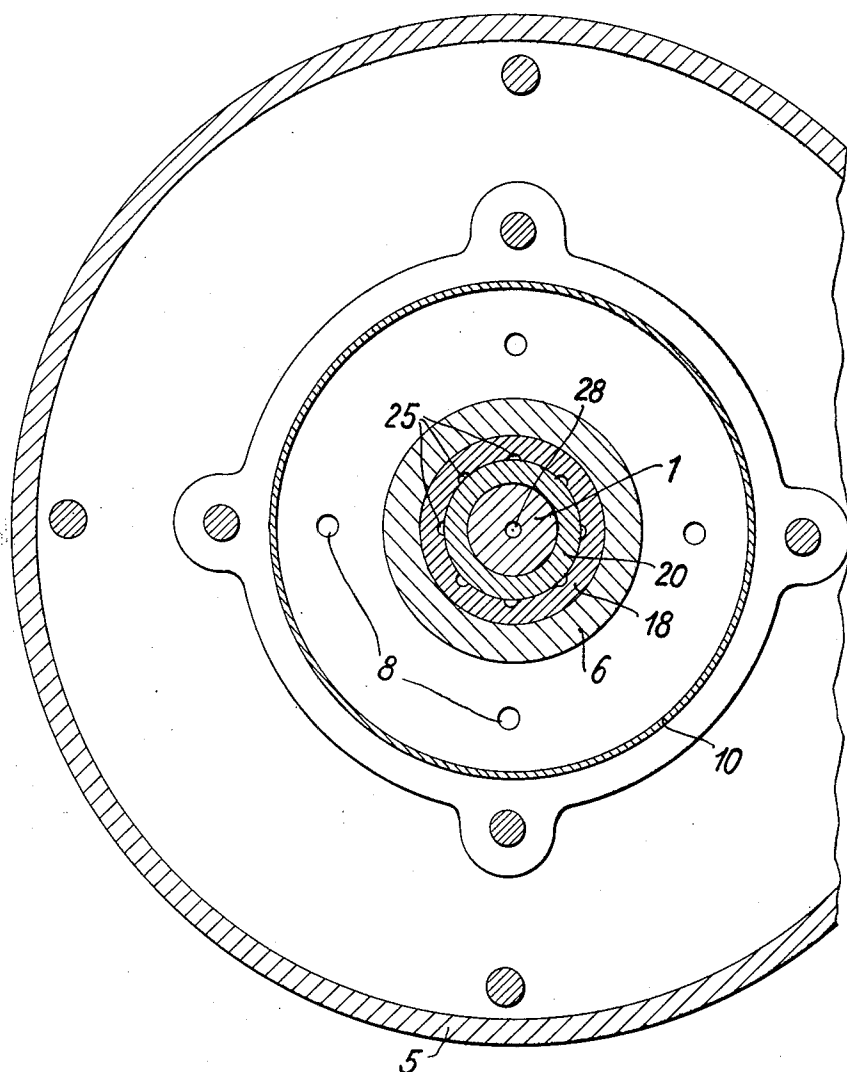
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Fig. 2



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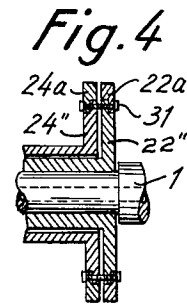
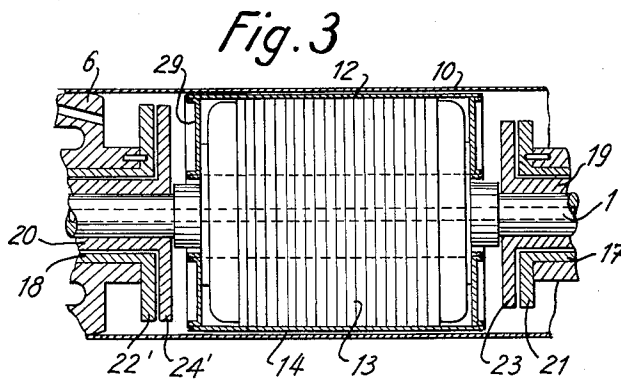


Fig. 5A

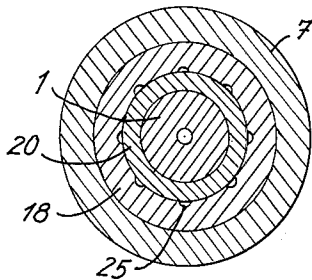


Fig. 5B

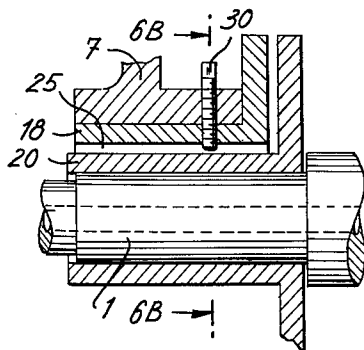
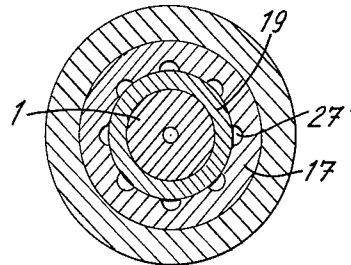


Fig. 6A

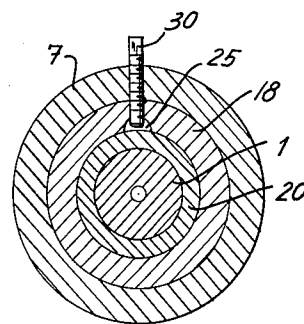


Fig. 6B

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Filed Nov. 30, 1959, Ser. No. 856,101

11 Claims. (Cl. 103-87)

The present invention relates to a centrifugal pump and, more particularly to a multiple-stage centrifugal pump which is driven by a so-called canned electric motor, the rotor space of which communicates with the liquid chamber of the pump.

Centrifugal pumps which are driven by such canned electric motors are known as such. In such units a part of the liquid which is conveyed by the pump is passed into the rotor space of the motor in order to cool and lubricate the motor.

Although numerous means have already been provided to compensate the axial thrust occurring in ordinary centrifugal pumps, there has as yet been no satisfactory solution of also compensating the axial thrust in multiple-stage centrifugal pumps in which this thrust assumes very great proportions.

It is therefore an object of the present invention to provide novel means for fully compensating the axial thrust occurring in a multiple-stage pump. For this purpose, the present invention provides a so-called canned electric motor, the rotor space of which is connected to the pump chamber so as to receive a part of the liquid conveyed by the pump. According to the invention the liquid which is conveyed by the pump into the spaces of the motor at both sides of the gap between the rotor and stator is passed back toward the low-pressure side of the pump through passages which are preferably provided within the bearing elements supporting the motor shaft. The motor shaft is further provided with a certain amount of end play which is utilized for alternately and inversely varying the cross-sectional area of the passages in the bearings at both sides of the rotor and for thus varying the flow of the liquid back to the pump.

By these means it is now possible, as will be subsequently described in greater detail, also to compensate the strong axial thrust occurring in multiple-stage centrifugal pumps by very simple means and in a fully satisfactory manner.

The mentioned connection between the rotor space of the motor and the low-pressure side of the pump to permit the passage of the part of the liquid which is pumped into the same may, according to the invention, be attained very simply and effectively if each of the two bearings of the motor shaft is designed so as to consist of a rotary bushing which is rigidly connected to the motor shaft and a stationary bushing forming the actual bearing which is rigidly secured to the motor housing and encloses the rotary bushing, and of an adjustable passage for the return of the liquid between these two bushings of each bearing which is formed by a flange projecting from each of the bushings at the sides facing toward the rotor, and one or more channels between the two bushings. The cross-sectional area of flow of the passages in the bearings at both sides of the gap between the rotor and the stator is therefore variable in accordance with the particular position of the motor shaft in its axial direction so that within the particular distance allowed by the end play of the shaft as determined by the two flanges on each bearing, the two passages may fully or partly open or close alternately in an inverse relation to each other.

The channels within the bearings are preferably provided along the inner wall of the stationary bushing in the form of grooves of a substantially semicircular cross section which extend in the axial direction and are distributed at uniform distances around the periphery of

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the wall. The channel or channels within each bearing may however, also be of any other suitable design and may, for example, be provided in the outer surfaces of the rotating bushings. The diameters of the bushing flanges and the size of the entire cross-sectional area of flow of the passage or passages of one bearing may be either the same as those of the other bearing or differ therefrom and they may also be adjustable, for example, by the provision of removable rings or the like on the flanges and suitable inserts in the channel or channels.

These and other objects, features, and advantages of the present invention will become further apparent from the following detailed description thereof, particularly when the same is read with reference to the accompanying drawings, in which—

FIG. 1 shows a central horizontal section of a multiple-stage centrifugal pump with any desired number of stages connected to a canned electric motor according to the invention so that both together form a single unit;

FIG. 2 shows, on an enlarged scale, a cross section taken along line II—II of FIGURE 1;

FIG. 3 is a partial longitudinal cross section similar to FIG. 1 and showing a modification which differs from the arrangement illustrated in FIG. 1 in that the flanges respectively located on opposite sides of the rotor have different diameters;

FIG. 4 is a partial longitudinal cross section illustrating a modified flange construction;

FIGS. 5A and 5B show respectively cross sections through the bearings located on opposite sides of the rotor and illustrating a modification in which the channels in the bearings at one side of the rotor have a cross section different from that of the channels in the other bearings; and

FIGS. 6A and 6B show respectively longitudinal and transverse cross sections through one of the bearings and illustrating a further modification in which the free cross section of the channel through the bearing is adjustable.

Referring to the drawings, the centrifugal pump, generally indicated at P, has a plurality of centrifugal stages connected in series behind each other, and it is driven by a canned electric motor, generally indicated at M and known as such, by means of a common shaft 1 which carries the rotor of motor M as well as the movable parts of pump P. The liquid which is to be conveyed by the pump enters the same at the low-pressure side through the inlet 2 and, after passing through the series of impellers 3, it is expelled at the high-pressure side through the outlet 4. The housing part 5 of motor M is rigidly bolted at its end wall 6 to a bearing plate 7 which forms the end wall of pump P toward the motor M.

This bearing plate 7 has a plurality of passages 8 therein which communicate with the high-pressure side of the pump and allow a small part of the pumped liquid to enter into the rotor space 9 of the motor which is enclosed within a cylindrical stator liner or sleeve 10 on the inside of the stator 11 and a jacket 12 encasing or "canning" the rotor 13 toward the outside. Stator liner 10 and rotor jacket 12 are spaced from each other at a certain distance 14 forming a gap, so that the liquid may pass under the pressure of pump P not only to the bearing of shaft 1 adjacent to pump P, but also through gap 14 to the bearing at the side of the motor remote from the pump as indicated by the arrows 15 in FIGURE 1. In this manner the motor is constantly cooled and its bearings are adequately lubricated.

Each of these bearings consists of a bushing 17 or 18, respectively, which is rigidly secured to the respective bearing plate or bearing cap 7 or 7', and of a bushing 19 or 20, respectively, which is secured to shaft 1 and therefore rotates with the shaft. The two stationary bushings 17 and 18 have flanges 21 and 22 facing toward rotor 13,

and the rotary bushings 19 and 20 also have similar flanges 23 and 24. These flanges 21 to 24 may all have the same diameter as shown in FIG. 1 or be of different diameters as shown in FIG. 3, and their diameters may even be adjustable, for example, by removable rings as shown in FIG. 4. It will be noted from FIG. 3 that the flanges 22', 24' at the left side of the rotor 13 have a diameter greater than that of the flanges 21, 23 at the right side thereof, while FIG. 4 shows flanges 22'', 24'', having each a stepped outer rim to which rings 22a, 24a, 10 having each an inner annular face matching the stepped rim of the flanges, may be removably connected by screws 31. Since it is an important feature of the invention that motor shaft 1 has a certain end play of approximately 2 to 3 mm., the two flanges of each pair 21 and 23 and 22 and 24 are spaced from each other accordingly so that, when shaft 1 is disposed in its central position between the stationary flanges 21 and 22 on bushings 17 and 18, the clearance between the flanges of each pair is one-half of the total end play of shaft 1.

Between the two bushings of each pair 17, 19, and 18, 20, a plurality of channels 25 and 27, respectively, are provided which lead back toward the low-pressure side of the pump and are preferably made in the form of grooves of a substantially semicircular cross section which extend in the axial direction within the inner walls of the stationary bushings 17 and 18 and are equally distributed along the periphery of these walls. Channels 25 within the bearing adjacent to the pump communicate through apertures 26 with the low-pressure stage of the last impeller of the pump, while channels 27 within the other bearing communicate with a channel 28 which extends centrally through the entire length of shaft 1 and terminates into the pump inlet 2. Thus, the liquid contained under pump pressure within the rotor spaces 9 and 16 will flow partly through the clearances between flanges 21 to 24 and then through channels 25 and 27 and apertures 26 and the central channel 28 to the low-pressure side of the pump.

The axial thrust occurring in the multiple-stage pump will be compensated according to the invention as follows:

When the operation of the pump is started, the liquid passes under pressure from the high-pressure side of the pump through passages 8 into the rotor space 9, as indicated by arrows 15, and against the left end surface 29 of rotor 13, whereby the rotor will at first be forced toward the right away from the pump to the extent as permitted by the end play of shaft 1. The faster the pump then continues to run and the more the pump pressure increases, the greater the axial thrust will also become. Due to this, motor shaft 1 will then tend to shift toward the left as far as its end play will permit. Flanges 22 and 24 will thereby engage with each other and shut off the flow to channels 25. Consequently, the fluid pressure again increases in rotor space 9 and rotor 13 together with its shaft will again tend to shift toward the right. This is possible particularly since the liquid contained in rotor space 16 can then at first easily escape toward the low-pressure side through channels 27 and the central channel 28 in shaft 1. The more rotor 13 is then forced toward the right, the closer the two flanges 21 and 23 will be moved toward each other and the less liquid can thus escape through channels 27, while at the same time flanges 22 and 24 will draw apart to allow the liquid again to flow through channels 25 in the bearing adjacent to the pump. This again reduces the pressure in rotor space 9, while the pressure in rotor space 16 again increases. This reciprocatory movement continues for only a very short time and finally results in a very stable equilibrium in which rotor 13 remains substantially in the central position of its end play. This also results at the same time in the desired compensation of the axial thrust in accordance with the size and load of the pump. During all of this time, shaft 1 floats, so-to-speak, within bearings of liquid

in the manner as above described, and a friction on flanges 21 to 24 and within the bearings 17 and 18 will also be avoided since these flanges never engage positively with each other, but are always separated at least by a thin film of oil.

The best possible operating conditions of the pump according to the invention may be attained by a selection of the most suitable diameter of flanges 21 to 24. It may for this purpose also be desirable to make the flanges 22 and 24 on the bushings adjacent to the pump either of a greater or smaller diameter than flanges 21 and 23 on the outer bushings 17 and 19, or to make the flanges on one or both bearings of an adjustable diameter, for example, by removable rings.

Furthermore it may be desirable to make the cross-sectional area of flow of channels 25 and 27 different from each other or even adjustable, for example, by suitable inserts. FIGS. 5A and 5B illustrate a modification in which the channels 27' are formed with a cross section greater than that of the channels 25, whereas FIGS. 6A and 6B show a modification in which only one channel 25 is provided, the free cross section of which is adjustable by means of a screw 30 passing through threaded apertures in members 7 and 18 and extending with an end portion thereof into channel 25.

Although my invention has been illustrated and described with reference to the preferred embodiment thereof, I wish to have it understood that it is in no way limited to the details of such embodiment, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. In an electric motor driven pump, in combination, a pump housing having a low pressure inlet and a high pressure outlet; pump impeller means in said housing for pumping fluid from said inlet to said outlet; an electric motor for driving said pump impeller means and having a stator and a rotor separated by a gap, said rotor having a pair of opposite end faces; a common shaft mounting said pump impeller means and said rotor for simultaneous rotation; a pair of bearings respectively located on opposite sides of said rotor and mounting said shaft turnably about its axis and shiftable for a limited end play in opposite directions along said axis; a pressure chamber at each side of said rotor and each in part defined by one of said end faces and connected to each other by said gap; a passage connecting one of said chambers with the high pressure outlet of said pump; a second passage within each bearing connecting the adjacent chamber with the low pressure inlet of said pump; and means for utilizing the end play of said shaft for gradually varying the cross sectional area of flow of said second passages in an inverse relation to each other depending on the amount and direction said shaft is axially shifted.

2. The combination as defined in claim 1, in which each of said bearings comprises a rotary bushing secured to said shaft, and a stationary bushing surrounding said rotary bushing and secured to the housing of said motor, said second passage within each of said bearings comprising at least one channel between said two bushings, said means comprising an outwardly projecting flange on each of said bushings at the side thereof facing toward said rotor, said flange on said rotary bushing of each of said bearings being movable within a certain distance toward and away from said flange on said stationary bushing of said bearing for varying the flow of liquid from one of said chambers toward said channel in said bearing, said bushings of both of said bearings being together adapted to determine the extent of said end play of said motor shaft.

3. The combination as defined in claim 2, in which said channel in said bearing at the side of said rotor facing toward said pump is connected to and communicates with a low-pressure point of said pump adjacent

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to said motor, said second passage further comprising a central bore extending through said shaft and connecting said channel in said other bearing remote from said pump with the inlet side of said pump.

4. The combination as defined in claim 2, in which all of said flanges on said bushings have the same diameter.

5. The combination as defined in claim 2, in which the two flanges on said bushings at one side of said rotor have substantially the same diameter but a greater diameter than said flanges on said bushings at the other side of said rotor.

6. The combination as defined in claim 2, in which said flanges on said bushings at least at one side of said rotor are adjustable so as to vary their diameter.

7. The combination as defined in claim 2, in which said channels within said bearings consist of a plurality of grooves extending substantially in the axial direction in the wall of one of said bushings of each bearing and directly adjacent to the wall of the other bushing of said bearing.

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8. The combination as defined in claim 7, in which said grooves are provided in the inner wall of said stationary bushing of each of said bearings and at substantially equal distances from each other around the periphery of said wall.

9. The combination as defined in claim 8, in which each of said grooves is of a substantially semicircular cross section.

10. The combination as defined in claim 2, in which said channel in one of said bearings has a cross-sectional area different from that of said channel in the other bearing.

11. The combination as defined in claim 2, in which said channel in at least one of said bearings is adjustable for varying the cross-sectional area thereof.

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