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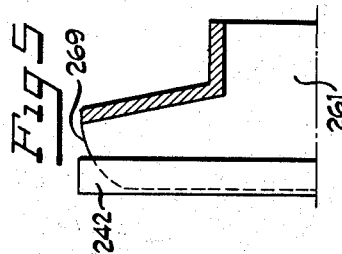
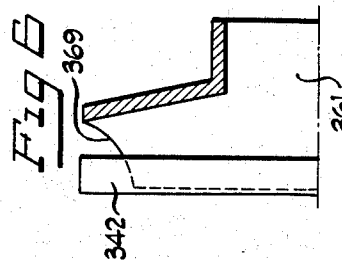
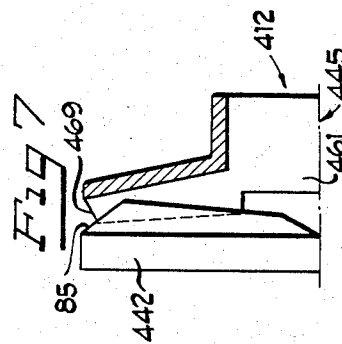
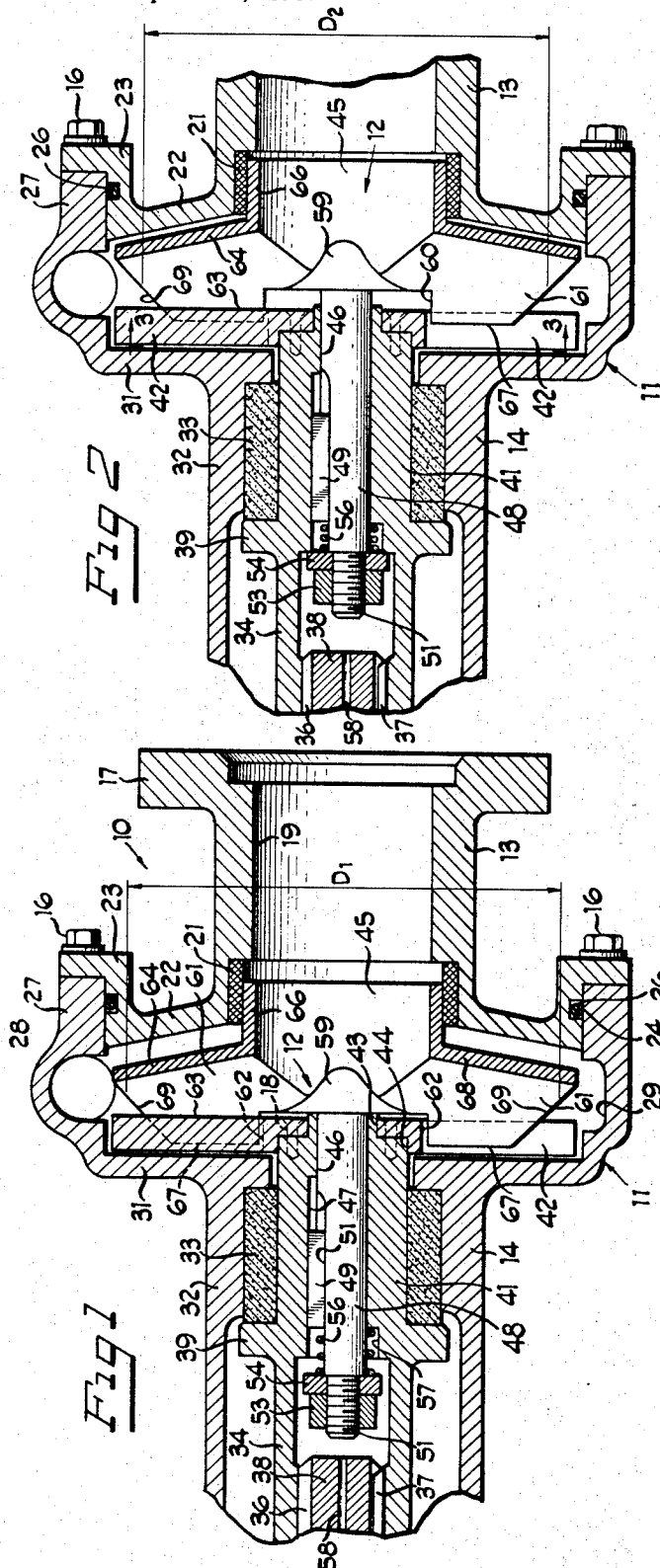
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3,407,740

VARIABLE GEOMETRY CENTRIFUGAL PUMP

Filed April 14, 1967

2 Sheets-Sheet 1



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Fig 3

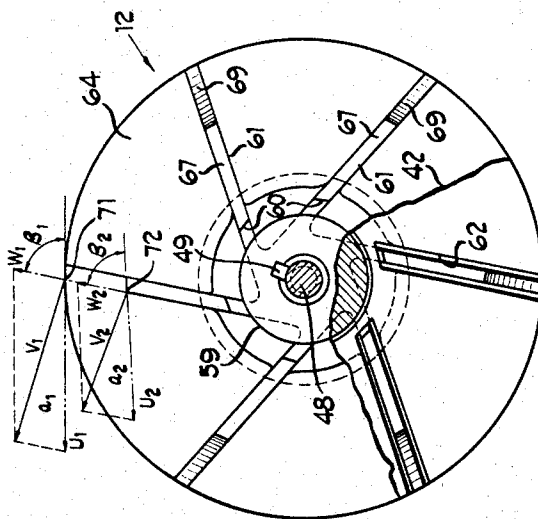
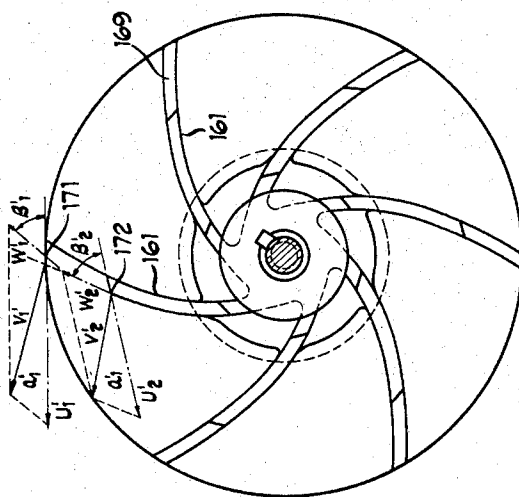


Fig 4



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VARIABLE GEOMETRY CENTRIFUGAL PUMP
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ABSTRACT OF THE DISCLOSURE

A variable capacity centrifugal pump which includes a two-section impeller and which is axially adjustable to vary the pump flow rate. The diameter across the impeller vanes converges toward the axis of rotation, and the vanes are masked to present various effective impeller diameters at various adjusted positions. Axial movement of one member results in adjustment of both the effective cross-sectional flow area and the effective impeller diameter.

Summary of the invention

The present invention relates generally to variable capacity centrifugal pumps and more particularly to such pumps which are adjustable to vary their operational characteristics.

Heretofore variable capacity pumps have been provided in which sections of the impeller have been axially adjustable for varying the flow rate of the pump while maintaining a constant impeller diameter. The vanes of prior impellers impart identical velocity components to the fluid along the axial extent of the vane outer edge. Inasmuch as the pressure of the fluid is dependent in part upon the velocity imparted to it by the impeller vane, at least a portion of the pressure generating capabilities of the pump remained invariable. Variation of capacity was obtained by varying the effective cross-section flow area of the fluid passage through the pump.

It is an object of the present invention to extend the operating range of variable capacity pumps by providing additional pressure variations through an impeller having a variable effective diameter. Such variable effective diameter can be advantageously provided by vanes having oblique outer or peripheral edges. One factor influencing the variable pressure capabilities is the difference in velocity of different incremental portions of the vane outer edge. For a given rotational impeller speed, different increments of the vane edge rotate at different linear velocities because of their different radial spacing from the axis of rotation. A further factor influencing the variable pressure characteristic is the direction of the velocity components of the fluid leaving the edge of the impeller vane. Where the edge of the vane is oblique, and the vane is offset from the axis of rotation, each increment of the edge has a slightly different angular relationship with respect to a plane extending along the impeller axis, resulting in a different direction for the fluid velocity components generated by that particular edge increment. Thus the fluid velocities generated along the oblique edge of the vane, differ in both magnitude and direction, and masking selected portions of the edge provides a means for varying the pressure performance characteristics of the pump.

Brief description of the drawings

In the drawings:

FIGURE 1 is a longitudinal section view taken along the axis of a pump according to the present invention;

FIGURE 2 is a view similar to FIGURE 1 showing portions of the impeller assembly in adjusted position for varying the performance characteristics of the pump;

FIGURE 3 is a view taken along the line 3—3 of FIG-

URE 2 with portions of the impeller base section broken away to more clearly reveal the vane section of the impeller assembly; and

FIGURE 4 is a view similar to FIGURE 3 showing a modification of impeller vane construction.

FIGURES 5 and 6 are fragmentary plan views illustrating slightly modified forms of the invention.

FIGURE 7 is a fragmentary plan view illustrating still another modified form of the invention.

Description of the preferred embodiments

Referring now to the drawings and more particularly FIGURE 1 thereof, the reference character 10 generally indicates a portion of a variable capacity centrifugal pump according to the present invention including a casing 11 and an impeller 12.

Casing 11 is formed of front and rear body units 13 and 14 secured to each other in endwise assembly by cap screws 16. Front body unit 13 is provided with a mounting flange 17 for connection to a fluid source. Extending axially inwardly from flange 17, internally of body unit 13, is a throat 19 providing an inlet for pump 10.

Front body unit 13 is provided with a wear ring 21 adjacent throat 19 which may advantageously be composed of a graphitic composition providing both a bearing and a fluid seal around portions of impeller assembly 12. A web portion 22 extends annularly about throat portion 19 terminating in a stepped flange 23. A groove 24 in stepped flange 23 provides a seat for O-ring seal 26. Stepped flange 23 is secured to mating flange 27 of rear body unit 14.

Rear body unit 14 is radially enlarged adjacent flange 27 to provide a scroll-like configuration 29 within the casing, including outlet port 28. A second weblike portion 31 extends between scroll portion 29 and an axially extending tubular portion 32 of rear body unit 14 rotatably supporting an end of impeller assembly 12.

Impeller assembly 12 includes a base section 42, and a vane section 45 arranged for relative axial movement with respect to each other to vary the size of the fluid passage extending between inlet throat 19 and the outlet port 28. The fluid passage extending through the pump is defined in part by the front face 63 of base section 42 and the annular web 64 of vane section 45. Varying the size of the flow passage as defined by face 63 and annular web 64 provides a means for varying the capacity or flow rate of the pump.

The hollow drive member 34 includes splines 36 carried on an inner surface thereof engageable with mating splines 37 of shaft 38. Drive member 34 includes collar portion 39 adjacent a journal portion 41, both of which engage sleeve bearing 33 for concentrically and axially aligning impeller assembly 12 with respect to pump casing 11.

The disklike impeller base section 42 is bored and counterbored at 43 and 44 for assembly with journal portion 41 of drive member 34 and may be secured thereto by screws 18. Base section 42 is provided with a plurality of grooves 62 extending inwardly from the front face 63 thereof, and may, if desired, extend entirely therethrough in the manner of slots. Journal portion 41 of drive means 34 is counterbored at 46 and provided with a key seat 47 therein. A shaft 48 is axially slideable in bore 46 guided by key 49 engaged with keyways 47 and 51. The rearward end of shaft 48 is provided with screw threads 52 and a nut 53 bearing against collar 54. Compression spring 56 is fitted between collar 54 and recess 57 in journal portion 41 of drive member 34, biasing shaft 48 in an axially rearward direction. Shaft 38 includes an aperture 58 through which pressure fluid can be admitted to bear on nut 53 and the exposed end of

shaft 48 for adjusting the axial position thereof against the bias of spring 56.

Vane section 45 of impeller assembly 12 includes a plurality of vanes 61 extending outwardly from a hub-like spinner 59 located on the forward end of shaft 48. Both vane section 45 and base section 42 are rotatably driven by drive member 34 which in turn is driven by shaft 38. The rearwardmost portions 67 of vanes 61 extend into the grooves or slots 62 such that disk-like base member 42 masks a portion of the axial length thereof. The forward portion 68 of vanes 61 merge into the annular web 64 surrounding a tubular hub portion 66 in alignment with throat 19 of casing 11. Tubular hub portion 66, annular web 64 and vanes 61 together with the shaft 48, form vane section 45 of impeller assembly 12. The rearwardmost portion 67 of vanes 61 are provided with an inner stepped portion 60 arranged to clear the bottom portion of grooves or slots 62.

The outer edges 69 of vanes 61 are oblique with respect to the face 63 of base section 42, adjacent axial increments thereof varying in radius from the axis of rotation of the impeller assembly. As shown more clearly in FIGURE 3, vanes 61 may be of planar configuration parallel with but offset from the axis of rotation of the impeller assembly. In the construction shown in FIGURE 3, oblique vane edges 69 are oriented in a conical configuration, the axis of which is on the axis of rotation of impeller assembly 12.

Vaness 161, shown in FIGURE 4, are of nonplanar configuration, however, the outer edges 169 thereof are also oriented in a conical configuration.

Further inspection of FIGURE 3 reveals some of the unobvious features of the oblique edge configuration 69. For example, adjacent increments of oblique edge 69 are circumferentially and radially displaced from each other. Thus adjacent incremental portions of edge 69 travel at slightly different velocities in slightly different directions thereby imparting different vector velocities to the portions of fluid in contact therewith. For example, a portion of fluid contacting vane 61 at the location 71 has an outward velocity component W_1 parallel to the planar vane 61 at the angle B_1 with respect to linear velocity component U_1 , resulting in a fluid velocity V_1 at the angle a_1 . For purposes of comparison, a distant increment at location 72 is also illustrated. Another portion of fluid in contact with vane 61 at location 72 has an outward velocity component W_2 parallel to planar vane 61 but at a different angle B_2 with respect to the linear velocity U_2 . It should be observed that the linear velocity components U_1 and U_2 are not parallel to each other and are of different magnitudes even though they are generated by the same planar vane 61. Where the vanes 161 are of nonplanar configuration the magnitudes and directions of the various velocity components, as illustrated at locations 171, 172 and signified by primed reference characters, show an even greater difference.

As described above, each incremental portion of the oblique edge 69 or 169 imparts a different velocity to the fluid in contact therewith, the cumulative effect being approximately equal to the median value between the extremes. Where portions of vane 61 and 161 are masked within the grooves or slots of base section 42, the corresponding incremental edge portions are removed from effective contact with the fluid, the remaining edge portions determining the velocity imparted to the fluid. Thus as illustrated in FIGURES 1 and 2, vanes 61 have an effective or median diameter D_1 midway between the vane outer extremity and the point of intersection with the face of base member 42. As illustrated in FIGURE 2, the vanes have a different effective diameter D_2 which is smaller than D_1 when the impeller sections 42, 45 are moved apart to increase the size of the flow passage.

Inasmuch as the pressure imparted to the fluid is proportional to the velocity with which it leaves the impeller, it is believed evident that the impeller vanes of the present

invention, having converging edges which can be masked to provide different effective diameters, are capable of providing a wider range of operating pressures than is possible with pumps having a fixed impeller diameter. The wider range of operating pressures provided by the variable diameter impeller, together with the variable flow rate provided by axial adjustment of the impeller sections, thus provide a variable capacity pump having an extended operating range in terms of pressure-volume capacity.

Referring now to FIGURES 5 and 6, there are shown slightly modified forms of impeller vane construction.

In FIGURE 5 vanes 261 are provided which include outer oblique edges 269 which converge in a direction toward a base 242 but not linearly. The edge shape is convex as viewed from the exterior of the pump housing. With this construction movement of one of the separate impeller sections with respect to the other produces an alteration of the effective impeller diameter in a manner similar to that of the arrangement of FIGURES 1 through 4. However, the rate of change of effective diameter in relation to the change in axial height of the impeller outlet is slightly varied as compared to the corresponding rate of change obtainable with the construction of FIGURES 1 to 4.

FIGURE 6 illustrates an impeller having vanes 361 which include outer edges 369 which are convex as viewed from the exterior of the pump. Again a non-linear change in effective impeller diameter is produced by this arrangement.

Referring now to FIGURE 7 there is shown a still further modification of the invention. An impeller 412 is provided which includes a base section 442 and a vane section 445. The vane section includes a plurality of vanes 461 having oblique outer edges 469 similar to those of the impeller of the embodiment shown in FIGURES 1 through 4. However, the base section 442 does not include grooves such as the grooves 62 shown in FIGURE 1, but rather includes a plurality of masking fins 85 which co-operate with the vanes of the impeller vane section. As in the previous described embodiments one of the separate impeller sections is movable with respect to the other and movement of that section is effective to change the effective impeller diameter to provide the desired variation in performance characteristics.

Having shown and described a preferred embodiment of the invention together with a modified form thereof, it is understood that various other modifications and variations of the construction shown, are included within the spirit of the invention and scope of the following claims.

I claim:

1. A variable geometry centrifugal pump including a casing having an inlet and an outlet and a rotatable impeller mounted within said casing, said impeller including a base section and a vane section, said base section including vane receiving means, said vane section including a plurality of vanes having outer peripheral edges, at least a portion of said outer peripheral edges being oblique to said base section having adjacent increments thereof varying in radial disposition with respect to the axis of rotation of said impeller, said impeller section being positioned with said oblique outer peripheral edges disposed partially within said vane receiving means of said base section at least partially masking said vane oblique outer edge portions to define an impeller diameter at said base section, the remainder of said outer peripheral edges extending from said base section to define an effective pumping diameter of said impeller, one of said base section and vane section being movable with respect to the other thereof to vary the amount of said oblique outer peripheral edges disposed within said vane receiving means thereby varying the impeller diameter at said base section and the length of said oblique outer edges extending from said vane receiving means to vary the effective pumping diameter of said impeller.

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2. The invention according to claim 1 in which said vane edge portions extend circumferentially away from a plane through the axis of rotation of said impeller, adjacent axial increments of said vane edge portion varying in circumferential displacement from said plane.

3. The invention according to claim 1 in which said vane edge portions are disposed within a convergent surface of revolution generated about the axis of revolution of said impeller.

4. The invention according to claim 1 in which said base and vane sections define a fluid passage extending between said casing inlet and outlet, relative movement of said base and vane sections toward and from each other being effective to simultaneously vary the effective diameter of said impeller vanes while varying the size of said flow passage, said simultaneous variation of flow passage size and effective vane diameter providing an extended operating range of pressure-volume characteristics for said pump.

5. The invention according to claim 1 in which said vane edge portion presents a smaller radial dimension adjacent the intersection of said base section and vane section, said base and vane sections coacting with each other to simultaneously increase the effective diameter of said impeller while restricting said flow passage.

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6. The invention according to claim 1 in which said base section of said impeller is secured against axial movement in said casing remote from said inlet, and includes a disk member provided with a pattern of grooves in a face thereof, said vane section of said impeller including a shaft member extending through said disk member providing means for axially adjusting said vane section toward and from said base section, said vanes partially extending into the grooves face of said disk member.

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