Dec. 3, 1963 M. KAUFMANN 3,112,708

ROTARY PUMP

Filed March 21, 1961 3 Sheets-Sheet 1

Fig. 1

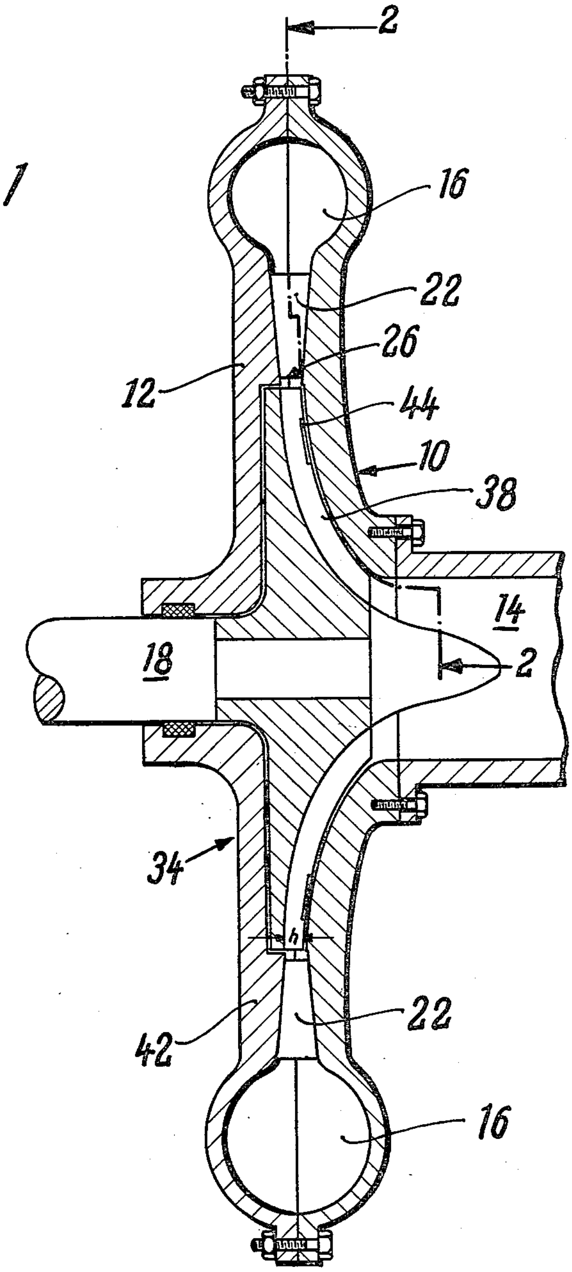

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Fig. 2

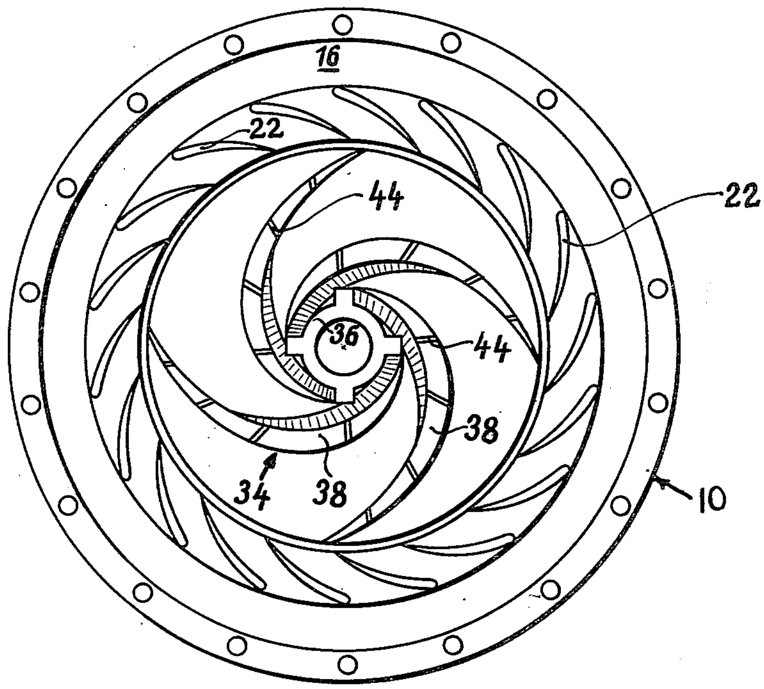

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Fig. 3

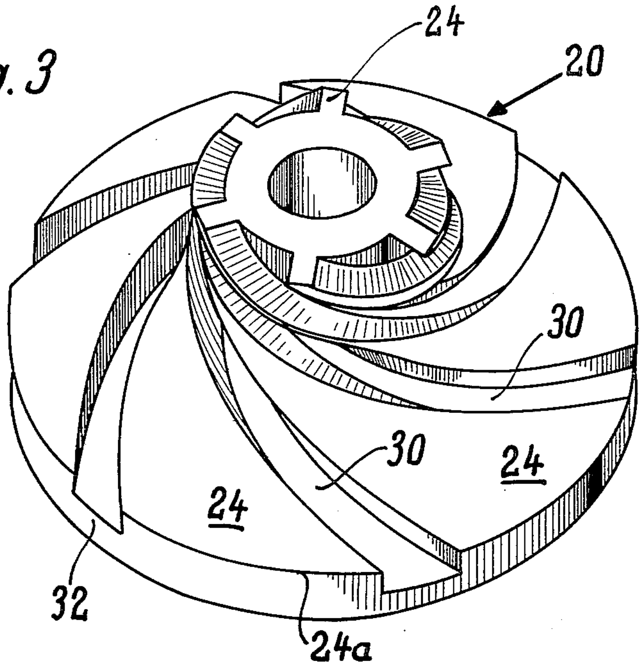
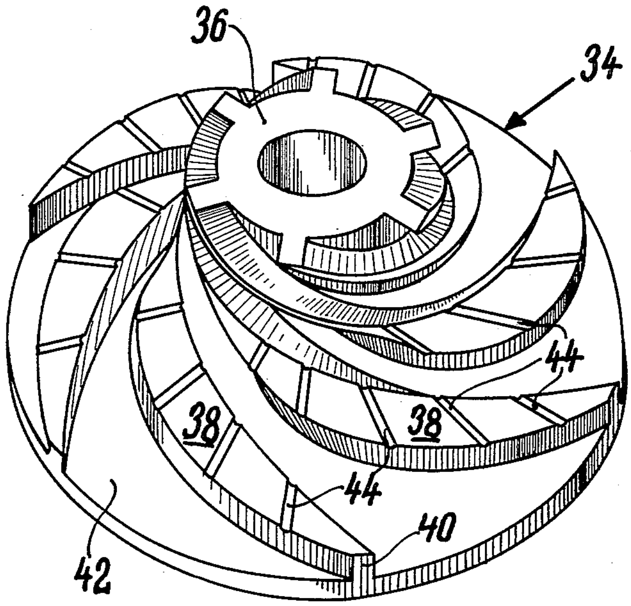


Fig. 4



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1

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ROTARY PUMP

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This invention relates in general to rotary pumps and in particular to a new and useful rotary or centrifugal pump construction with a low specific speed and having a blade configuration dimensioned and shaped for flow from a central inlet to a radial discharge and providing partial admission at the discharge to provide blades with adequate height at the peripheral discharge location.

The present invention has particular application in respect to a pump having a very low specific speed and particularly adapted for conveying liquids or liquefied gases. Pumps of this kind should have an output or efficiency as high as possible in spite of their low specific speed, and the impeller blade construction must be such to prevent the vaporization of the medium being pumped. The inevitable friction losses of such pumps are less disadvantageous if the locations of occurrence of said friction losses are shifted towards areas of higher static pressure of the medium being pumped, where, for instance in the case of liquefied gases, a local pressure drop of the medium does not result in the vaporization of said medium. A preferable area of higher static pressure of the pumped medium is the periphery of the impeller.

With conventional rotary pumps of the type mentioned, the vanes or blades of the rotors of such pumps cannot be constructed very high (axial width), particularly at the discharge. The economical limit of a low speed single stage centrifugal pump is usually at a minimum specific speed, being set by a formula,

$$n_s = \frac{n}{H3/4}\sqrt{\frac{G}{75}} \geqq 50$$

where n=the shaft speed in r.p.m., H=the discharge head (m) and G=flow weight (kilograms per second). If the pumps operate at speeds below the specific speed, they have poor efficiency for many reasons. One of these reasons is that the axial width of the discharge area, as determined by the height of the blade at the impeller circumference, must be made very narrow in conventional pumps having a very thin blade tip construction at the discharge area thereby defining a thin rectangular rather than a preferred square cross sectional discharge area at such location.

In accordance with the present invention, this disadvantage has been overcome by a pump construction in which the rotar includes a blade arrangement defining a partial admission at the periphery. This is accomplished by circumferentially covering the impeller blades in one instance and in pointing the blades in another embodiment. The cutting down on the circumferential extent or dimension of the tips of the impeller blades provides a square discharge flow area without changing the value of the area available for discharge. The loss in the total delivery head, which is caused by the partial admission construction of the blades when the ratio between the pressure or delivery head and the flow rate or throughout is very great, is very small. Thus, the advantages which are obtained by partial admission far outweigh the relative loss in delivery head. This provides an improved single stage pump construction which would require, in a normal construction, a several stage pump arrangement for effecting a similar pump operation.

According to the "theorem of momentum," only the

2

meridian component of the absolute exit velocity from the rotor is effected by the loss caused by the partial admission. The absolute exit velocity constitutes the velocity energy of the pumping medium which is to be converted, if possible, without losses. It follows that with increasing delivery heads pre stage the proportion of the meridian component in the absolute exit velocity becomes smaller and thus, also, the respective loss due to the partial admission construction.

In accordance with a preferred embodiment of the invention, the losses are reduced still further by pointing the rotor blades at the exit. By pointing the blade in this manner there is defined a large circumferentially extending exit area for the expansion of the fluid medium from partial to complete admission. Without pointing such blades, the medium can utilize only a small gap between the rotor circumference and the casing for such expansion. No additional losses occur at the side faces of the rotor, due to the partial admission construction when the rotor is covered on each side face. In a rotor, however, where the blades are completely free, very considerable gap losses occur producing a gap flow rotation at half the circumferential velocity of the end surfaces of the rotor. In order to prevent such gap losses, a pump is provided, according to a further modification of the invention, in which the blades or vanes have side faces with grooves or depressions defined thereon which extend substantially radially across the blade faces.

In accordance with another feature of the invention, an impeller is provided with a blade configuration in which the ends or circumferential tips of the blades are narrowed or pointed. In actual practice, it has been found to be preferable to form the blades with converging outer ends which are truncated or cut off short of making them blades with an actual pointed end. In this embodiment, the axial width of the blade at the discharge is maintained relatively constant but the flow area at the discharge is enlarged by increasing the spacing between the blades. In this manner part of the conversion of velocity into pressure is displaced from the annular gap about the impeller's circumference into a substantially triangularly shaped space between the pointed blades of the impeller, and thus reduces losses which are produced by full partial admission. In this respect, partial admission refers to the reducing of the circumferential length of the discharge area defined between adjacent impeller blades.

The impeller construction advantageously includes a disc or cover plate on one or both sides of the blade construction to facilitate the desired flow condition. While the invention is particularly applicable to low speed rotary pumps, the invention may be adapted for a wide range of pumping and rotor speed conditions. The pump may also be adapted to pumping liquid gases or ordinary liquids.

Acocrdingly, it is an object of this invention to provide an improved rotary or centrifugal pump.

A further object of the invention is to provide a rotary pump having an impeller with a plurality of individual, substantially radially extending blades defining flow passages from a central inlet to a peripheral discharge, and in which the flow passages are partially covered circumferentially to provide for partial admission at the discharge.

A further object of the invention is to provide a rotary pump particularly applicable for low specific speed, including an impeller having a central hub portion and a plurality of angularly spaced, radially extending impeller blades which are widened circumferentially to define a substantially square flow area at the discharge permitting the blades to be made of relatively large axial thickness.

A further object of the invention is to provide an impeller construction including a plurality of angularly spaced, radially extending blades having their outer edges pointed to define substantially triangular flow areas between adjacent blades.

A further object of the invention is to provide an impeller having a plurality of angularly spaced, radially extending impeller blades with grooves defined across end faces of the impeller blades to provide a rotation of the flow in the gap between the blades and the rotor casing comparable to the rotational velocity of the impeller.

A further object of the invention is to provide an impeller for a rotary pump which is simple in design, rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be made to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

In the drawings:

FIG. 1 is a longitudinal section of a rotary pump having a low specific speed, constructed in accordance with the invention;

FIG. 2 is a fragmentary section taken on the line 2—2 of FIG. 1 including a rotor of the type indicated in FIG. 4;

FIG. 3 is an inlet end perspective view of one embodiment of rotor; and

FIG. 4 is a view similar to FIG. 3 of another embodiment of a rotor.

Referring to the drawings in particular, the invention illustrated therein embodies a low specific speed rotary pump generally designated 10 having a casing 12 defining a central inlet 14 and an annular discharge 16. Rotatable within the casing 12 is a shaft 18 which carries a rotor or impeller generally designated 34 (FIG. 4). The casing is provided with a plurality of stationary vanes 22 located between the circumference of the rotor 34 and the discharge 16.

In accordance with the invention, in order to make sure that vanes or blades 38 of the rotor are made sufficiently large with regard to their height or axial extent, as indicated by the letter *"h"* in FIG. 1, even if the ratio between the delivery head and the flow rate or throughput is very great, the pump impeller is made to provide for partial admission at the rotor exit 26. The loss, which is caused by partial admission when the ratio between the delivery head and throughput is great, is relatively small so that the advantages which are obtained by the partial admission with regard to the losses are much more important and out-balance these disadvantages. A feature of the invention, however, is that some of these losses are eliminated and prevented, particularly by pointing the ends of the blades as indicated in the modification of FIG. 4.

Referring to FIG. 3, a modified rotor 20 is provided which includes an axially elongated hub portion 28. Blades 24 are defined at radial locations around the hub portion 28 and extend in an ever-widening axially and radially extending spiral and at their circumferences they are partially covered at *24a*. This produces a substantially constant cross sectional flow area 30 between adjacent blades from the inlet 14 to the discharge of the rotor at 26. In the construction indicated in FIG. 3, the rotor 20 includes a single end plate or supporting cover 32 located on a side remote from the inlet 14. However, it should be appreciated that another cover may be provided on the side adjacent the inlet so that the blades 24 are held therebetween.

In the construction of FIG. 3 the discharge flow area approaches a square cross section which is accomplished by covering part of the impeller circumference by blade material. With such a construction, the resultant impeller configuration permits sufficiently large (axially high) blades. This is an improved construction over a conventional pump construction for low specific speeds, which would require several stages.

In FIG. 4 there is indicated another embodiment of rotor construction generally designated 34 which includes a hub portion 36 and a plurality of blades 38 located at angularly spaced locations and extending outwardly from the hub in a spiral at such locations. Blades 38 extend axially and radially outwardly and are widened intermediate their lengths but pointed at their circumferential ends. In actual practice, due to casting and similar considerations, the blade tips 40 are cut off square. Thus, in the embodiments of FIGS. 3 and 4, the impeller blade construction is constructed to produce a displacing, of part of the conversion of the velocity into pressure, from the annular gap about the impeller circumference into a triangularly shaped flow space 42 between adjacent blades 38 of the impeller. In this construction the losses due to partial admission are reduced.

In order to prevent the gap losses which are produced by ordinary rotors, the blades or vanes 38 are provided with a plurality of grooves or depressions 44 cut across those faces thereof which extend substantially in radial directions in respect to the axis of the rotor 34. The grooves 44 provide for a rotation of liquid trapped between the blades and the ends of the casing so that a gap flow of liquid is obtained with a velocity the same as the full circumferential velocity of the impeller and gap losses are substantially prevented.

The blades may be constructed in accordance with the principles set forth in each of the embodiments indicated in each of FIGS. 3 and 4. The limitations on these structures are, of course, defined by the mechanical stresses which the blades would be subject to or given centrifugal force. For a total axial thickness of the impeller, that is, for a given axial height of the blades and a given thickness of the end covers or discs of the impeller, the maximum peripheral speed of the impeller is a function of the strength to weight ratio of the structure, strength of possible joining elements, blade angle and degree of partial admission.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the invention principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In a rotary pump having an axial inlet and a peripheral discharge; a rotor including an axially relatively elongated hub; and a plurality of blade elements extending from angularly spaced portions of said hub radially outwardly and axially in a spiral therefrom, said blade elements having portions of appreciable axial extent, adjacent blade elements being spaced to define flow channels directing flow of fluid radially outwardly and axially from said inlet to said peripheral discharge; and means providing at least one wall surface substantially perpendicular to the axis of said rotor and overlying a surface of each blade element lying in a radial plane; each blade element surface having grooves extending thereacross at spaced locations along the extent thereof for fluid flow between said channels.

2. In a rotary pump, a rotor as claimed in claim 1, said grooves extending radially across said blade element surfaces.

3. In a rotary pump, a rotor as claimed in claim 1, in which the peripheral ends of said blades are substantially pointed.

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