Jan. 4, 1966 G. J. HAARHUIS 3,227,089

CENTRIFUGAL PUMP

Filed April 21, 1964 2 Sheets-Sheet 1

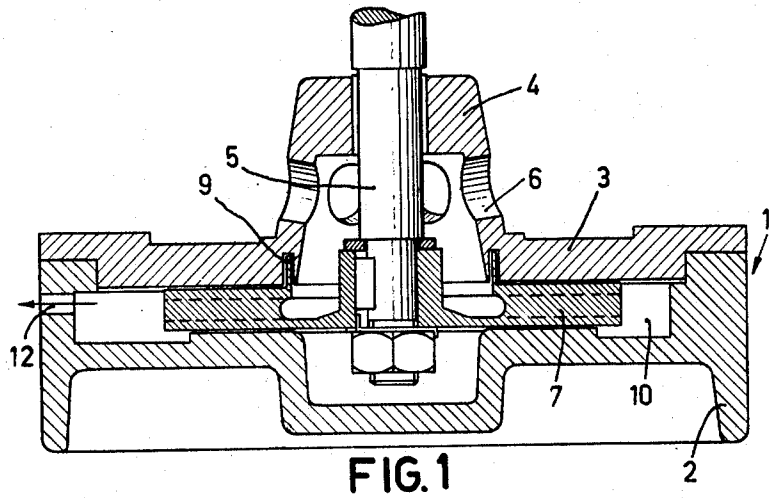


FIG. 1

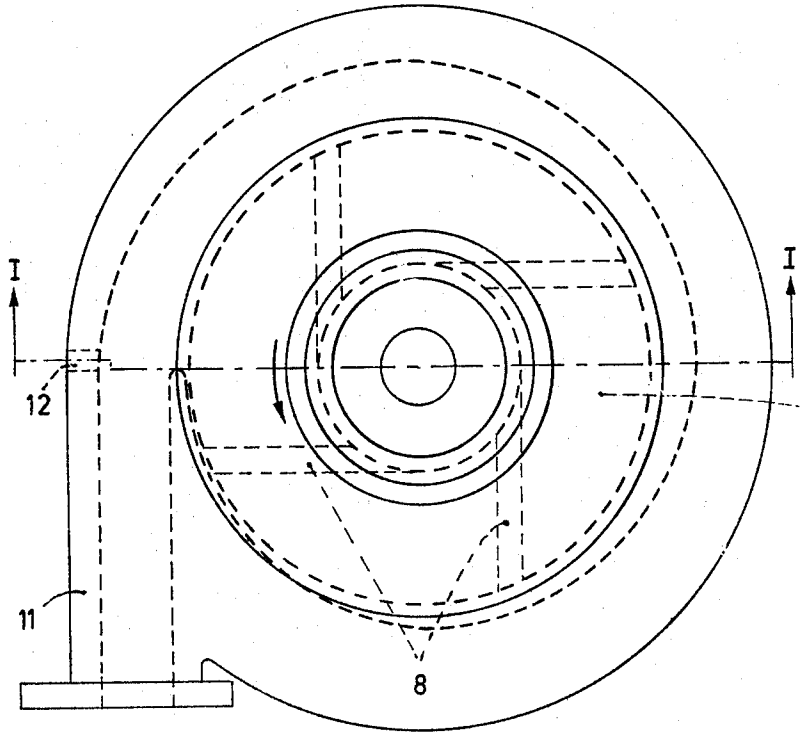


FIG. 2

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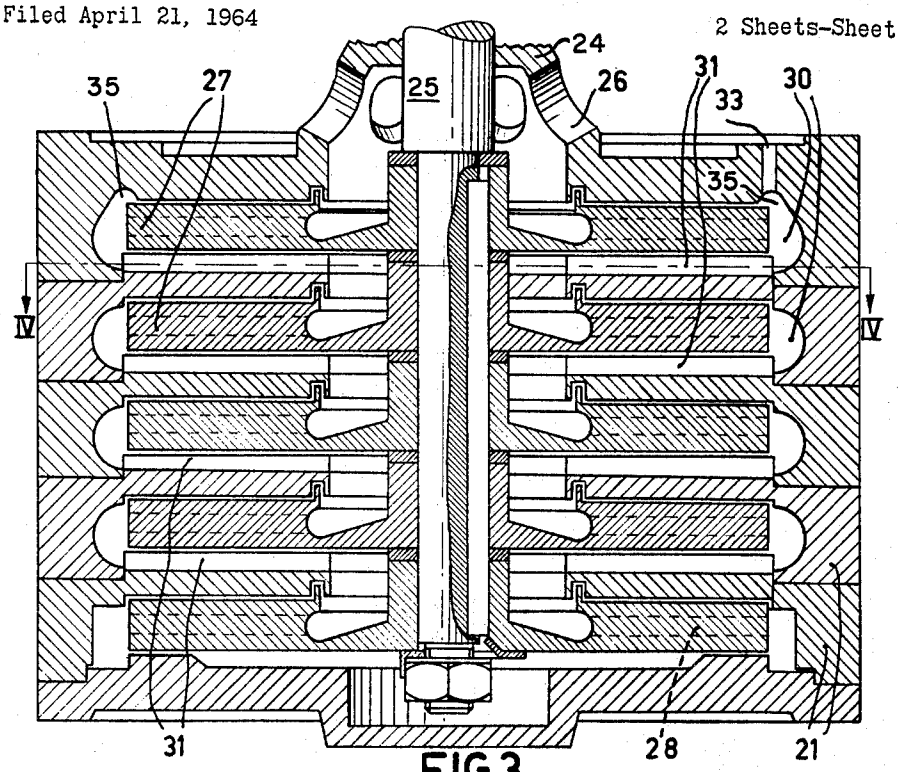


FIG.3

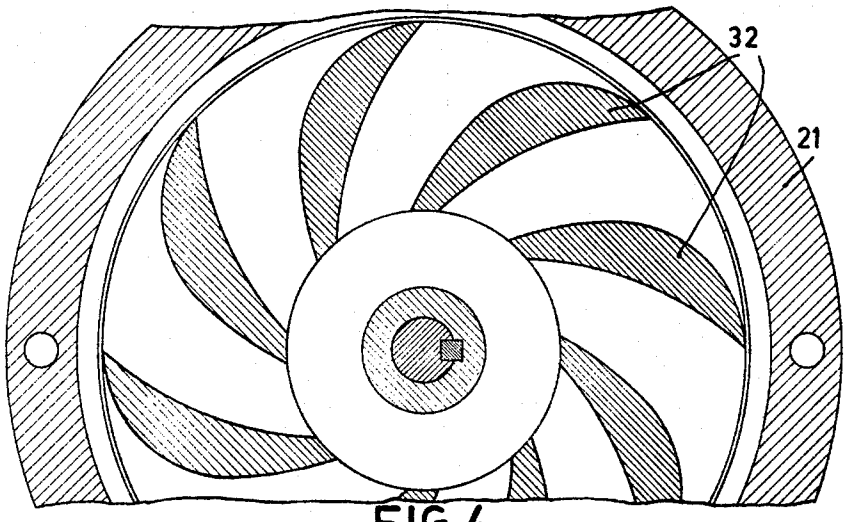


FIG.4

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CENTRIFUGAL PUMP

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1 Claim. (Cl. 103—103)

The invention relates to a centrifugal pump adapted to pump boiling liquids, such as liquefied gases, which comprises a casing containing one or more rotatable impellers each accommodated in a separate space. The said spaces are each provided with an inlet aperture communicating with the central portion of the relevant impeller containing one or more ducts for the liquid which extend from the centre to the periphery of the impeller. Each impeller is surrounded by a guide duct for the liquid and to this duct a discharge spout is connected, at least in a pump containing a single impeller.

As is known, in pumping boiling liquids by means of pumps of the kind under consideration vapour bubbles are formed at the suction end. To prevent an excessive amount of this vapour from entering the pump, such pumps are usually provided with means through which the excess vapour may escape before being entrained into the pump by the liquid. If the vapour enters the pump, the volume delivered and the raising height of the pump are adversely affected.

It has now been found that not all the vapour produced during suction is discharged, but that part thereof is entrained into the pump by the liquid and interferes with satisfactory operation of the pump.

In a known pump provided with an impeller, endeavours have been made to overcome the above-mentioned disadvantage by providing the part of the casing opposite the vanes with a row of apertures.

A further disadvantage of known pumps of the kind under consideration consists in that such pumps operate only if the liquid at the suction end is under a given minimum pressure (minimum suction height). If the level of the liquid in the container from which the liquid is pumped falls to a value such that the pressure of the liquid at the suction end falls below the said minimum pressure, excessive vapour bubble formation occurs and prevents satisfactory operation of the pump. This implies that with the known pumps a considerable amount of liquid is always left in the container.

Surprisingly, it has now been found that the above-mentioned disadvantages are overcome if according to the invention at least the liquid guide duct surrounding the first impeller through which the liquid passes and/or the liquid discharge spout connected to this guide duct is provided with one or more apertures in its outer wall.

Through these apertures a small stream of the liquid and vapour contained in the liquid guide duct is continuously discharged. If an excessive amount of vapour collects in the liquid, the delivery pressure of the pump falls off. This is prevented by the apertures according to the invention in that the pump is continuously flushed.

When the vapour has disappeared from this flushing liquid, the latter may be returned to the suction end of the pump. This flushing action provides quiet operation of the pump which continues to deliver until the level of the liquid has fallen to the inlet aperture of the pump. Consequently the pump according to the invention has a minimum suction height equal to zero.

A further advantageous embodiment of a centrifugal pump according to the invention, which is provided with a shaft on one end of which at least one impeller is mounted while the other end may be coupled to a driving device, is characterized in that when the shaft is arranged in a vertical position, the apertures open into the upper portion of the liquid guide duct and/or the liquid discharge spout.

A favourable embodiment of the centrifugal pump according to the invention which includes a single impeller, is characterized in that the wall of the liquid guide duct is provided with at least one aperture at an area immediately preceding the area where the liquid guide duct merges into the liquid discharge spout.

In a further advantageous embodiment of the centrifugal pump in accordance with the invention the wall of the liquid guide duct surrounding the first impeller through which the liquid passes is provided with an annular recess into which the aperture or apertures opens or open and into which at one side a slit between a wall of the impeller and the upper wall of the chamber containing the impeller opens and which at the other side merges in the liquid guide duct.

The annular recess ensures a ready flow of vapour to the aperture or apertures for exhausting this vapour. The annular recess acts as a peripheral channel for collecting vapour which from this channel can flow to the exhaust aperture or apertures. It has been found that the operation of the pump is much less satisfactory if the annular recess in accordance with the invention is omitted.

In order that the invention may readily be carried into effect, embodiments thereof will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

FIGURES 1 and 2 are an axial sectional view and a plan view respectively of a single-stage centrifugal pump and

FIGURES 3 and 4 are two sectional views, taken at right angles to one another, of a multi-stage centrifugal pump.

In FIGURES 1 and 2 a pump casing is designated by the reference numeral 1. This pump casing comprises a lower cover 2 and an upper cover 3. The upper cover 3 bears guiding means 4 for a pump shaft 5. The guiding means 4 is provided with inlet apertures 6 for the liquid to be pumped. The pump shaft 5 carries an impeller 7. This impeller 7 is provided with four liquid ducts 8 which extend from the inner circumference of the impeller to its periphery. It will be appreciated that the number of liquid ducts may be different in different pumps. The impeller is provided with sealing means 9 in the upper cover 3 of the pump casing.

The periphery of the impeller 7 is surrounded by a liquid guide duct 10 which terminates in a liquid discharge spout 11. A liquid discharge pipe may be connected to this spout.

At an area immediately preceding the area where the liquid guide duct 10 merges into the liquid discharge spout 11, an aperture 12 is provided. This aperture 12 is disposed so as to open into the upper portion of the liquid guide duct 10 in the operative position of the pump.

Although in the drawing the aperture 12 extends radially in the wall of the pump casing, it will be appreciated that it may also be provided in the upper cover 3. This is shown by broken lines in the figures.

The pump shown in the figure is of the type which is immersed in a liquid bath with its shaft in a vertical position. Thus the liquid has ready access to the impeller through the supply apertures 6. A discharge pipe through which the delivered liquid is discharged, is connected to the liquid discharge spout 11. The mixture of liquid and vapour flowing out of the aperture 12 returns to the liquid bath, from which the vapour can escape. As an alternative, the pump may be used without being immersed in a liquid bath. For this purpose

a supply pipe for the liquid to be pumped is connected to to the supply aperture in the pump casing. In this event, the liquid flowing through the aperture **12** may be returned to the supply pipe through a pipe which may include a vapour eliminator.

The diameter of the aperture **12** need not be large. It has been found that an aperture having a diameter of the order of 3 to 5 mm. provides a flushing action such that there is no inconvenient vapour formation in the pump.

A pump having a raising height of 6 meters and a delivery of 150 litres per hour operates satisfactorily with an aperture having a diameter of 4 mm. The surprising feature of this pump consists in that the pump empties the bath in which it is immersed until the level of the liquid has fallen to the supply aperture of the pump. Such a result is unobtainable with any of the known pumps.

In the figure only a single aperture is shown. It will be appreciated that the same results may be achieved with several apertures and also that the location of the aperture may be slightly varied.

FIGURES 3 and 4 shows a multi-stage centrifugal pump. This pump has a casing **21** built up of several parts. To the upper part of the casing **21** is secured a guiding means **24** for the pump shaft **25**. The guiding means **24** is provided with supply apertures **26** for the liquid to be pumped. The pump shaft **25** may be driven by a driving device, for example, an electric motor (not shown). The pump shaft **25** carries a number of impellers **27** which are each acommodated in a separate chamber in the casing **21**. Each impeller **27** is provided with a duct **28** for the liquid which extends from the inner circumference of the periphery. Each impeller is surrounded along the periphery by a guids duct **30** for a liquid. Each guide duct communicates with the suction end of the next impeller through a slit **31** between the impeller surrounded by the relevant duct and the wall of the chamber in which the said impeller rotates. Guide vanes **32** for the liquid are arranged in the slits **31**.

An aperture **33** is provided in the outer wall of the guide duct surrounding the first impeller through which the liquid passes.

This aperture **33** opens into an annular recess **35** which merges into the liquid guide duct **30**. The annular recess communicates through a slit between the impeller **27** and the upper wall of the pump with the suction end. Although the drawing shows only a single aperture **33**, several apertures **33** may open into the recess **35**. Such a recess may also be provided in the pump of FIG. 1. The annular recess provided in the upper portion of the liquid guide duct ensures satisfactory flushing of the pump because most vapour collects in the upper part of the duct. Viewed peripherally the aperture may be located arbitrarily. It has been found that the provision of an aperture in the duct surrounding the first impeller through which the liquid passes suffices to counteract the adverse influence of the formation of vapour bubbles

in the pump. The other ducts need not be provided with flushing apertures.

The pumps according to the invention are particularly suitable for pumping comparatively small amounts of liquefied air, oxygen, nitrogen, and so on.

What is claimed is:

A multistage vertically arranged centrifugal pump comprising a sectional casing divided horizontally with respect to the vertical axis of the pump, each section having a pumping chamber housing an impeller therein and in communication with the next succeeding stage, the pumping chamber in the first casing section being defined by a substantially flat upper surface and a substantially flat lower surface spaced axially from the upper surface and connected to the upper surface by an annular continuous surface defining a collecting channel, said first section having a central inlet communicating with the first impeller, said first stage impeller having a plurality of radially extending passages communicating with the central inlet and the collecting channel, the impeller having a continuous outer periphery terminating radially inwardly of the periphery of the collecting channel, an annular axially extending groove in the flat upper surface of the first stage collecting chamber adjacent the periphery of the impeller, whereby on rotation thereof the pumped fluid received by the annular collecting chamber is separated into high and low density fluid, and low density fluid collects in said annular groove in the upper surface and high density fluid passes downstream to the next adjacent stage, a plurality of axial apertures in said upper wall of the first stage communicating with said annular groove whereby the collected low density fluid is free to escape from the annular groove.

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