United States Patent

[11] **3,588,266**

[72] Inventors **John Lanfear Scott-Scott Bulkington;**
David John Sweetland, Bedworth, England

[21] Appl. No. **751,485**
[22] Filed **Aug. 9, 1968**
[45] Patented **June 28, 1971**
[73] Assignee **Rolls-Royce Limited**
Derby, England
[32] Priority **Aug. 11, 1967**
[33] **Great Britain**
[31] **36981/67**

[54] **LOW SPECIFIC SPEED ROTARY PUMP**
10 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **415/11,** 415/53, 415/159
[51] **Int. Cl.** **F01b 25/00,** F04c 15/02
[50] **Field of Search** 103/97, 115, 88, 103, 55; 230/114, 134, 119; 253/117; 415/159, 53, 143, 11

[56] **References Cited**

UNITED STATES PATENTS

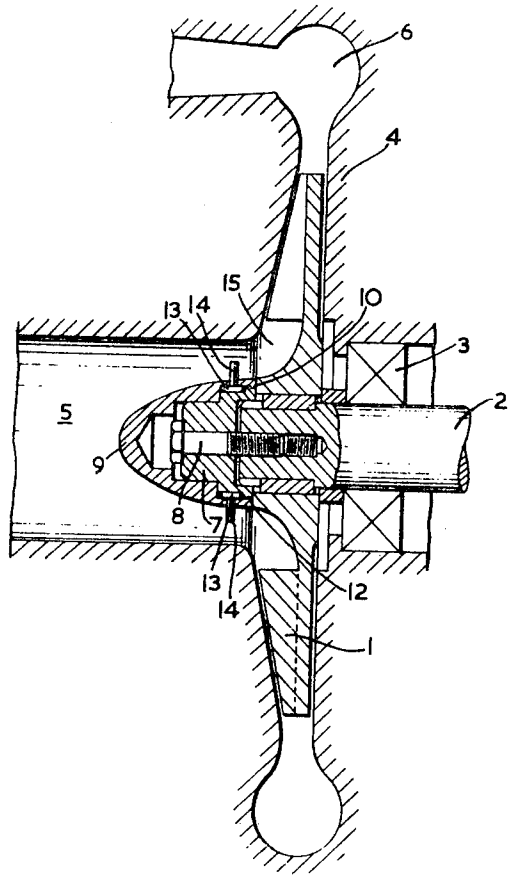
2,545,824	3/1951	McDonald	259/96
2,826,147	3/1958	Gaubatz	103/5
2,140,148	12/1938	Whitmore	230/114
2,737,897	3/1956	Dewees	103/115
2,835,202	5/1958	Lauck	103/101
3,120,813	2/1964	Singelmann	103/115
3,238,534	3/1966	Hartland	103/97
3,286,639	11/1966	Hutton	103/97
3,379,011	4/1968	Ohain et al.	103/258

FOREIGN PATENTS

910,693	2/1946	France	259/96
977,685	11/1950	France	230/134
62,510	6/1892	Germany	230/134
258,364	4/1913	Germany	230/130
817,077	10/1951	Germany	103/104
832,548	1/1952	Germany	103/115
725,909	3/1955	Great Britain	103/104

Primary Examiner—Henry F. Raduazo
Attorney—Mawhinney and Mawhinney

ABSTRACT: Mounting several bluff projections, such as cylindrical pins, at circumferentially-spaced positions around the impeller of a centrifugal pump upstream of the inlet to the impeller such that when the pump is operated with a low flow inlet angle and at a low suction pressure, each projection will produce a trailing cavity of gas or vapor. The trailing cavities are of helical form and become entwined with each other in the impeller inlet region and produce a fluid "barrier" which tends to reduce prewhirl conditions by preventing feedback of liquid from the impeller in an upstream direction and also produces stability of flow through the impeller.



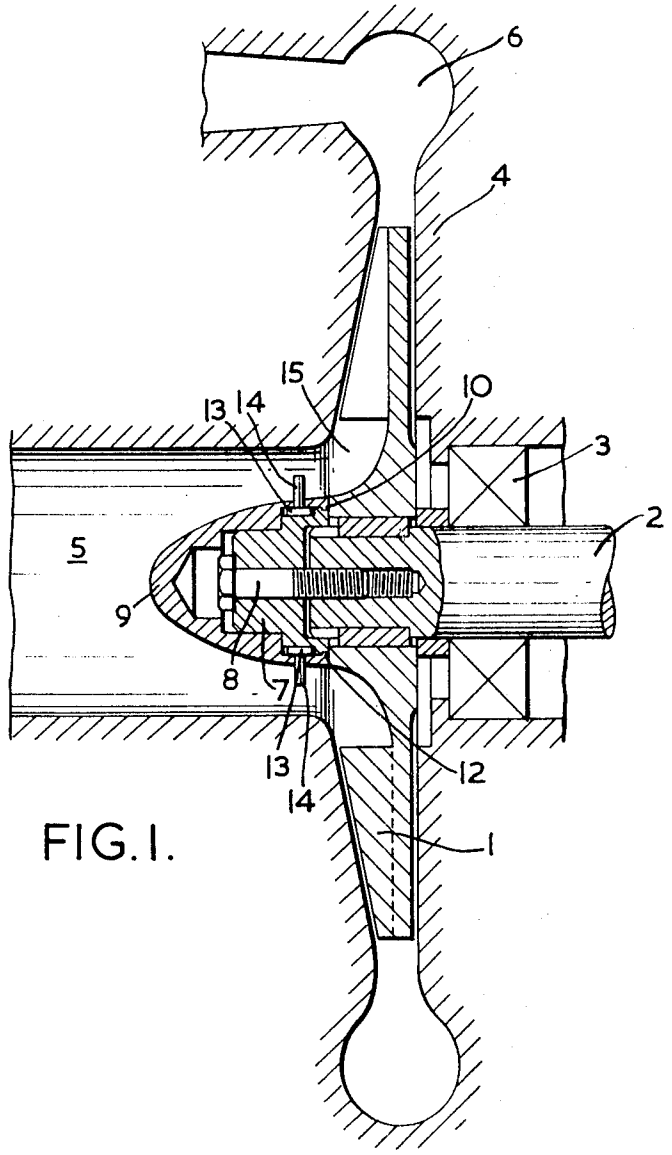


FIG. 1.

INVENTORS
JOHN LANPEAR SCOTT - SCOTT
& DAVID JOHN SWEETLAND

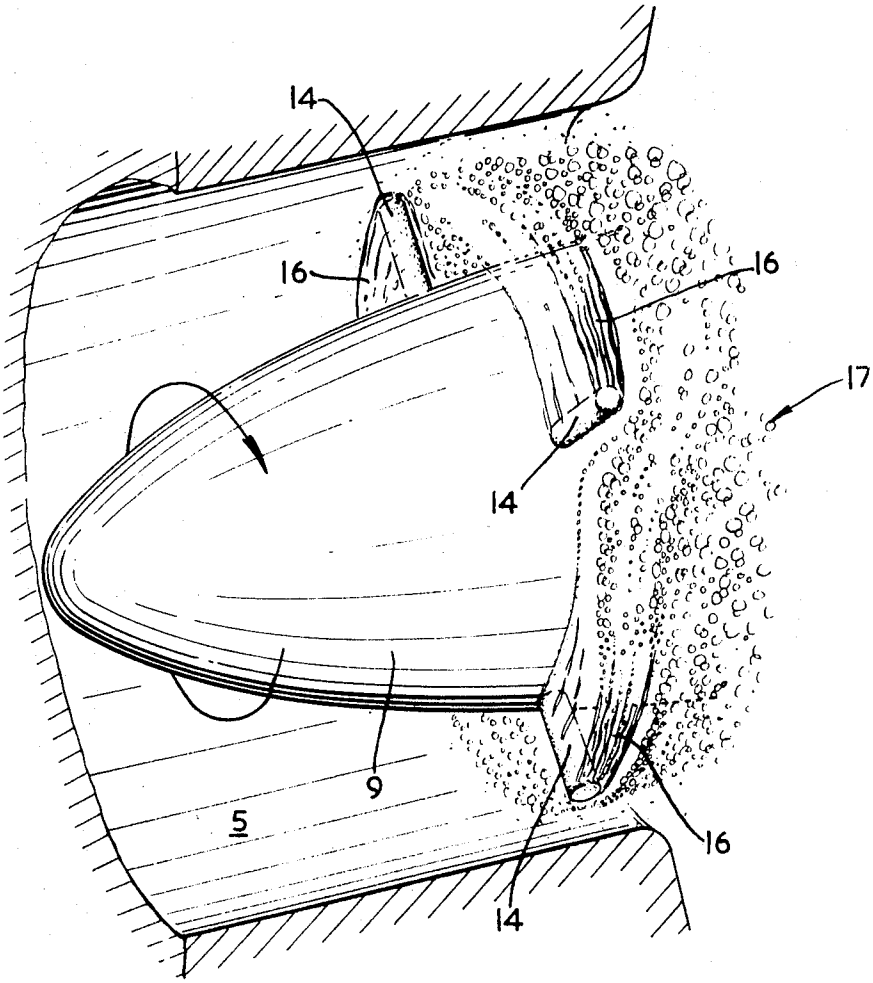


FIG. 2.

INVENTORS
JOHN LANFEAR SCOTT-SCOTT
& DAVID JOHN SWEETLAND

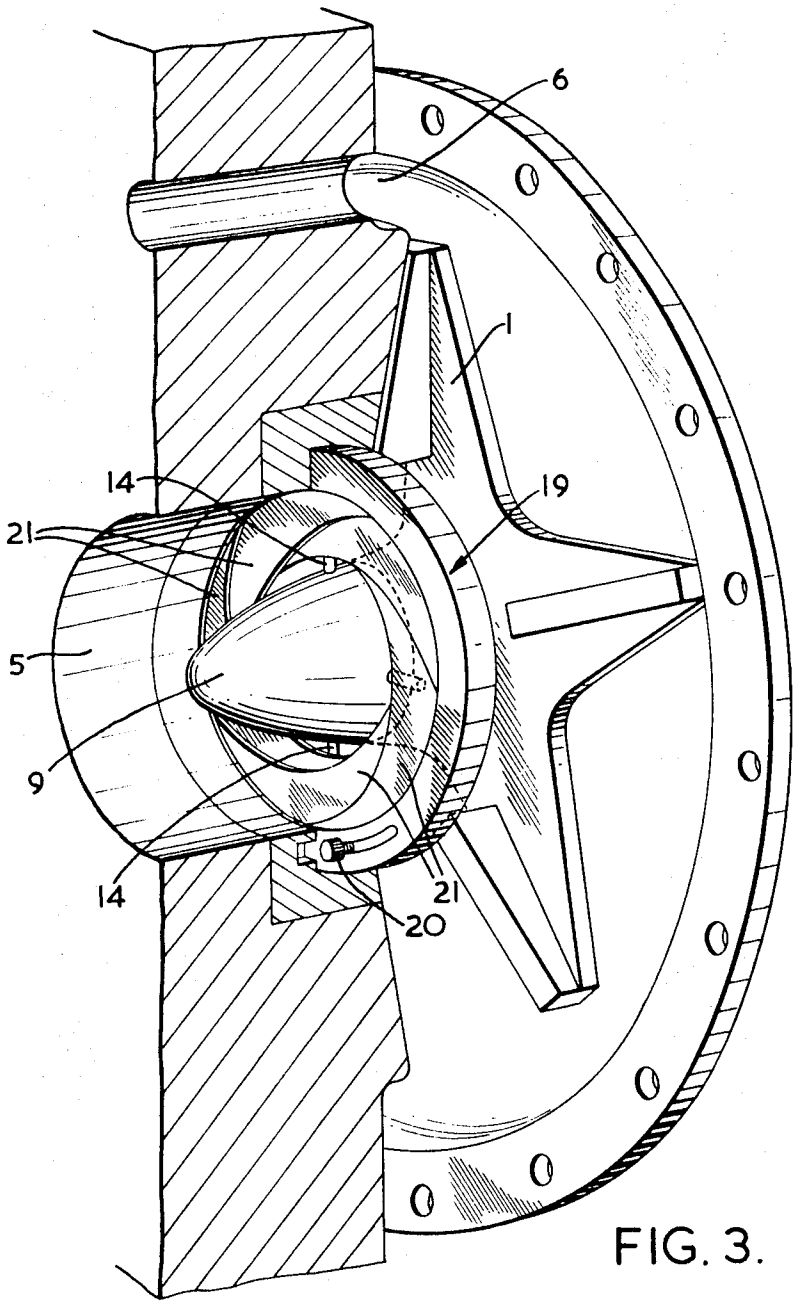


FIG. 3.

INVENTORS
JOHN LANFEAR SCOTT-SCOTT
& DAVID JOHN SWEETLAND

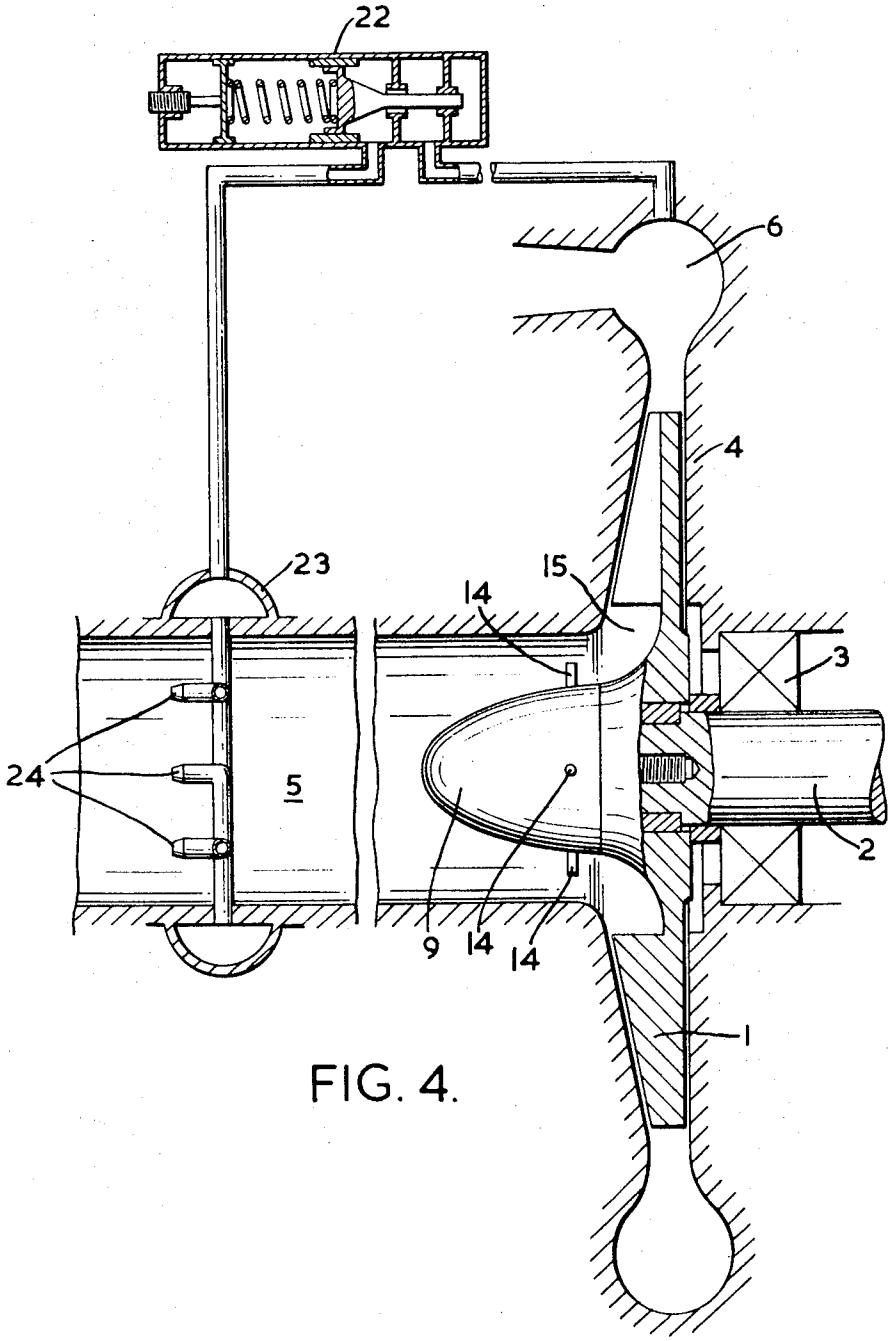


FIG. 4.

INVENTORS
JOHN LANFEAR SCOTT-SCOTT
& DAVID JOHN SWEETLAND

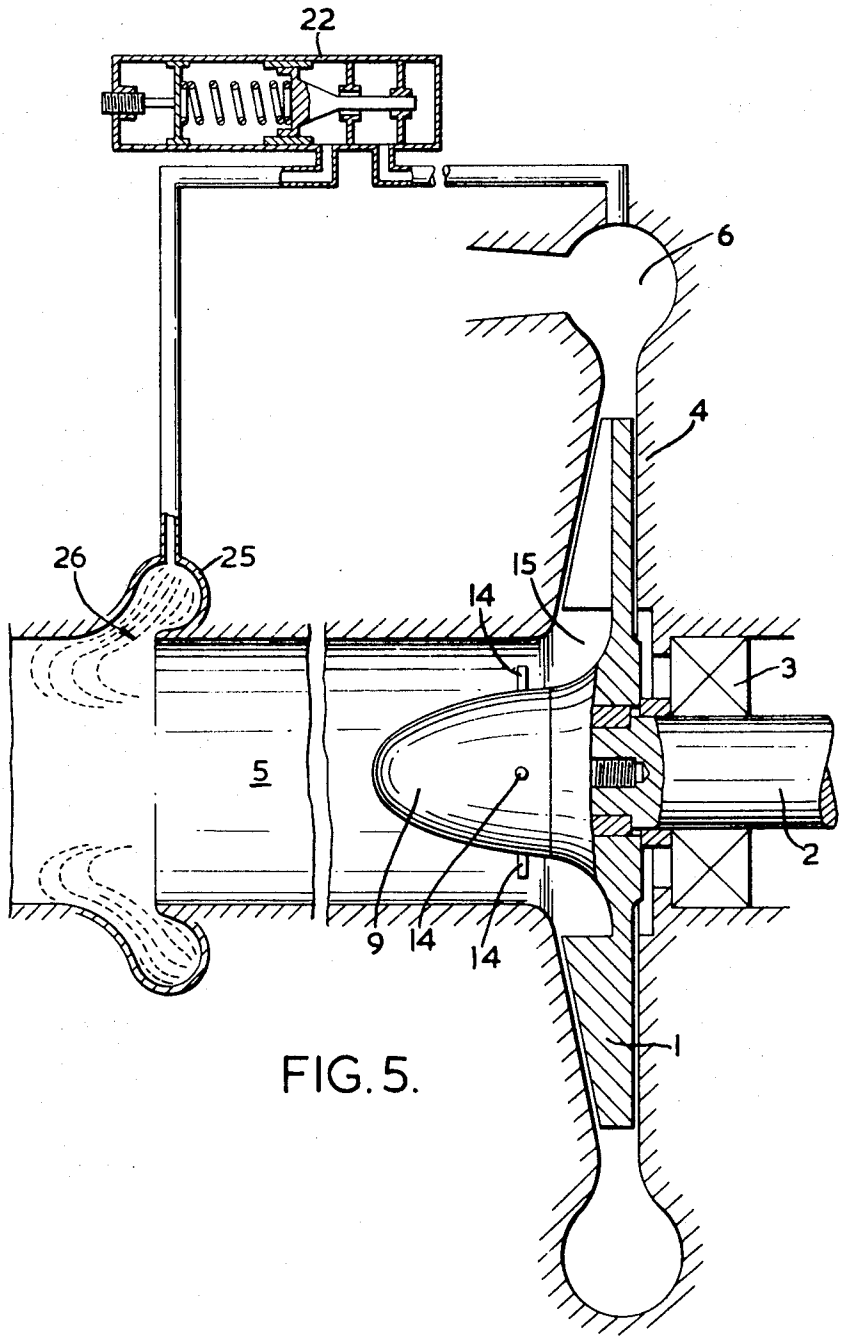


FIG. 5.

INVENTORS
JOHN LANFEAR SCOTT-SCOTT
& DAVID JOHN SWEETLAND

LOW SPECIFIC SPEED ROTARY PUMP

The invention relates to a rotary pump of the centrifugal kind for pumping liquid or a liquid and gas mixture (hereinafter called "liquid"). The pump is intended to be operated with a low flow inlet angle, for example less than 3° or 4°, and at a low suction pressure, the latter being for example of the order of 1 or 2 pounds per square inch above vapor pressure of the liquid. Such conditions of operation cannot easily be achieved by providing a bladed boost impeller upstream of the pump impeller, which is the conventional arrangement, because the blade angles required in the boost impeller would be so small as to make manufacture impracticable or flow therethrough negligible.

In a conventional centrifugal impeller, operation at a very low suction head leads to the formation of vapor-filled regions in the impeller eye. These regions appear in a random manner and cause both a decrease in flow and instability. These conditions are often aggravated by the presence of prewhirl. An object of the invention is to provide means for preventing or discouraging the formation of these regions and also to reduce the tendency for prewhirl to occur in the pump.

According to the invention, a rotor body to be mounted coaxially on an impeller of such a centrifugal pump at the upstream end thereof has a plurality of circumferentially-spaced bluff projections extending therefrom into the inlet passage of the pump.

On rotation of the impeller, the bluff projections will each produce trailing cavities of helical form which will merge together circumferentially and downstream of the plane of the projections to produce an annular cavity containing gas or vapor. The presence of such cavities will reduce the tendency of prewhirl by producing a "barrier" of fluid of lower viscosity than the liquid being pumped which will tend to prevent the feedback in an upstream direction of liquid from the impeller. The cavities will also exert a stabilizing influence on the flow through the impeller. Furthermore, the presence of the cavities will endow the pump with an improved capability for ingesting a mixture of liquid and gas or vapor.

When the cavities have formed, the pump can be operated at a ratio of inlet velocity to shaft speed, considerably lower than that possible for conventional bladed pumps and thus a pump having a rotor body in accordance with this invention can be made to operate at extremely low values of net positive suction head.

The bluff projections may have any cross-sectional shape having a bluff leading profile in the direction of their circumferential movement but they are preferably pins of circular cross section. The number of projections employed must be sufficient to cause the trailing cavities produced thereby to merge into a substantially complete annulus. Four pins of circular cross section arranged at intervals of 90° around the rotor body have been found to be suitable.

The projections are conveniently arranged normal to tangents to the circumferential face of the rotor body; but they may alternatively be inclined in either or both the axial and circumferential directions according to the shape of the profile of the rotor body and the cavity required.

The extent of the cavity in the direction of flow through the impeller may be controlled by adjustment of the radial lengths of the projections or the inclination of the projections to the true normal. For example, where cylindrical pins are employed, these may be made adjustable in either or both of these respects.

The rotor body may be in the form of an upstream nose portion to be fitted on to the upstream end of the pump impeller or a shaft therefor. Alternatively, the rotor body may be an integral upstream extension of the pump impeller.

The invention also includes a centrifugal pump having a rotor body mounted coaxially and upstream of its impeller and rotatable therewith as set out hereinbefore.

The flow through the pump may be varied in any of the following ways:

a. by providing an iris device upstream of the rotor body or in the plane of the projections thereof, whereby the area of flow past the projections can be altered,

b. by introducing liquid extracted from the pump delivery into the flow path leading to the rotor body in an upstream direction in such manner that momentum interchange will take place between the liquid flowing to the rotor body and the liquid introduced from the pump delivery, or

c. by introducing liquid extracted from the pump delivery into the flow path leading to the rotor body adjacent the boundary of said flow path to reduce the effective flow area leading to the rotor body.

By way of example, a centrifugal pump intended to be operated with a low flow inlet angle, for example less than 3° or 4°, and at a low suction pressure and having a rotor body in accordance with the invention, is now described with reference to the accompanying drawings, in which:

FIG. 1 is an axial section through the pump;

FIG. 2 is a diagrammatic perspective view of the rotor body from the upstream end thereof showing the formation of trailing cavities by the bluff projections carried by the rotor body;

FIG. 3 is a perspective view of the rotor body and impeller from the upstream ends thereof showing an iris device for controlling flow through the impeller;

FIG. 4 is an axial section through the pump shown in FIG. 1 and also showing, partly in section, means for introducing liquid extracted from the pump delivery into the flow path upstream of the rotor body to control flow through the pump, and

FIG. 5 is similar to FIG. 4 and shows, partly in section, alternative means for introducing liquid extracted from the pump delivery into the flow path upstream of the rotor body to control flow through the pump.

In FIG. 1, the impeller 1 of the pump is shown mounted on a shaft 2 supported in overhung manner in a bearing 3. The impeller is arranged in a housing 4 to receive liquid from an inlet 5 and to discharge said liquid into an outlet volute chamber 6. The shaft 2 is extended beyond the inlet end face of the impeller 1 and forms a spigot supporting a generally cylindrical block 7.

The block 7 carries a noselike cap 9 which fits closely on to the block and is secured axially thereon by a resiliently deformable annular lip 10 on the end of the cap 9 adjacent the impeller, which lip is a snap fit over an annular rib 12 on the block 7. Adjacent the rib 12, the block 7 together with the cap 9 defines several pockets spaced apart at equal circumferential distances around the block 7 and each receiving a head 13 of a cylindrical pin 14, the pins being the aforesaid bluff projections. The shanks of the pins 14 extend into the inlet passage upstream of the inlet region 15 to the impeller 1 and pass through holes in the cap 9. The heads 13 of the pins are larger than the holes in the cap 9 and so when the cap 9 together with the pins 14 has been fitted on to the block 7 and the lip 10 snapped into position, the pins 14 will be held against radial movement. There are for example, four pins 14 of which only two are shown in FIG. 1; but there may be another number. The block 7, the cap 9 and the pins 14 form the aforesaid rotor body.

The pins 14 may extend, as shown in FIG. 1, substantially normally to tangents to the outer periphery of the cap, i.e. radially of the axis of rotation; but they may alternatively be inclined in either or both the axial and circumferential directions. The pins 14 are conveniently of length of at least 30 percent of the distance across the flow passage at their plane of mounting. Also, the ratio of their length to diameter is preferably between 1 and 6.

When the impeller 1 is rotating and the suction pressure is sufficiently low, for example, of the order of 1 or 2 pounds per square inch above vapor pressure of the liquid being pumped, the pins 14 will each produce a trailing cavity 16 containing vapor or gas, as shown in FIG. 2. The cavities will be of helical form and will be entwined downstream of the plane of the pins

14 and will eventually merge together to form an annular cavity at 17 extending downstream into at least the inlet region 15 of the impeller 1. The cavity 17 makes it possible for the pump to be operated stably and also the cavity forms a "barrier" of lower viscosity than the liquid being pumped tending to prevent feedback in an upstream direction of fluid from the impeller, which would cause prewhirl.

As aforesaid, the flow through the pump may be varied in any one of three ways. The first is to provide an iris device upstream of the rotor body. Such a device is shown at 19 in FIG. 3. A control device 20 is provided to open or close obturating plates 21 of the iris device, in known manner, to vary the area of flow past the pins 14.

The second means for varying the flow through the pump is shown in FIG. 4 and comprises feeding back liquid delivered by the pump from the outlet volute 6 through a control valve 22 to a manifold 23 surrounding the pump inlet passage 5. The manifold 23 feeds the liquid through nozzles 24, facing in an upstream direction, to produce momentum interchange between the liquid flowing to the pump and the liquid fed back from the outlet volute.

The third means for varying the flow through the pump is shown in FIG. 5 and comprises feeding back liquid delivered by the pump from the outlet volute 6 through a control valve 22 to a manifold 25 having an opening 26 extending circumferentially around the pump inlet passage 5. Liquid introduced through the manifold 25 and the opening 26 has the effect of forming a boundary layer of liquid having a slower or negative velocity compared with that of the liquid flowing to the pump inlet, the boundary layer having the effect of reducing the effective flow area leading to the rotor body and the impeller.

We claim:

1. A rotor body to be mounted coaxially upstream of an impeller of a centrifugal pump for rotation with said impeller, the pump being intended to be operated with a low flow inlet angle and at a low suction pressure, wherein the improvement comprises said rotor body forms a detachable upstream nose portion of said impeller and has an annular lip of resiliently deformable material to be snapped over an undercut annular rib on said impeller, and said rotor body carries a plurality of circumferentially-spaced cylindrical pins extending outwardly from said rotor body transversely across the inlet passage of the pump, said cylindrical pins extending through holes in said rotor body and having root portions to be located between the rotor body and said impeller.

2. A centrifugal pump having an impeller and a rotor body mounted thereon in accordance with claim 1.

3. A rotor body to be mounted coaxially and upstream of an impeller of a centrifugal pump for rotation with said impeller, the pump being intended to be operated with a low flow inlet angle and at a low suction pressure, wherein the improvement comprises the rotor body forms an upstream nose portion to be fitted on to the impeller of said pump and has an annular lip of resiliently deformable material to be snapped over an undercut annular rib on said impeller and the rotor body has a plurality of circumferentially-spaced, rodlike, bluff projections extending outwardly from said rotor body transversely across the inlet passage of the pump.

4. A centrifugal pump comprising an impeller and a rotor body mounted coaxially and upstream of said impeller and rotatable with said impeller, the pump being intended to be operated with a low flow inlet angle and at a low suction pressure, the rotor body having a plurality of circumferentially-spaced, rodlike, projections extending therefrom transversely only partly across the inlet passage of the pump, each projection having a bluff profile at its leading edge to comprise non-pumping projections, and thereby producing trailing cavities of helical form extending from said projections.

5. A centrifugal pump as claimed in claim 4 having an adjustable iris device upstream of the plane of said bluff projections.

6. A centrifugal pump as claimed in claim 4 including means for introducing working fluid extracted from the pump delivery into the inlet flow path leading to the rotor body.

7. A centrifugal pump as claimed in claim 4 in which the bluff projections are cylindrical pins.

8. A centrifugal pump as claimed in claim 7 in which the pins each have a length of at least 30 percent of the distance across the flow passage at their plane of mounting.

9. A centrifugal pump as claimed in claim 8 in which the pins each have a ratio of length to diameter of between 1 and 6.

10. A centrifugal pump as claimed in claim 4 in which the rotor body forms an upstream nose portion mountable on the impeller, said bluff projections extending outwardly from said rotor body transversely across the inlet passage of the pump.