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Jarry

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[54] **UNDERWATER PULSE JET MOTOR**

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[51] Int. Cl. **B63h 11/02**

[58] Field of Search 60/221, 222, 227; 115/16, 115/13, 11

[56] **References Cited**

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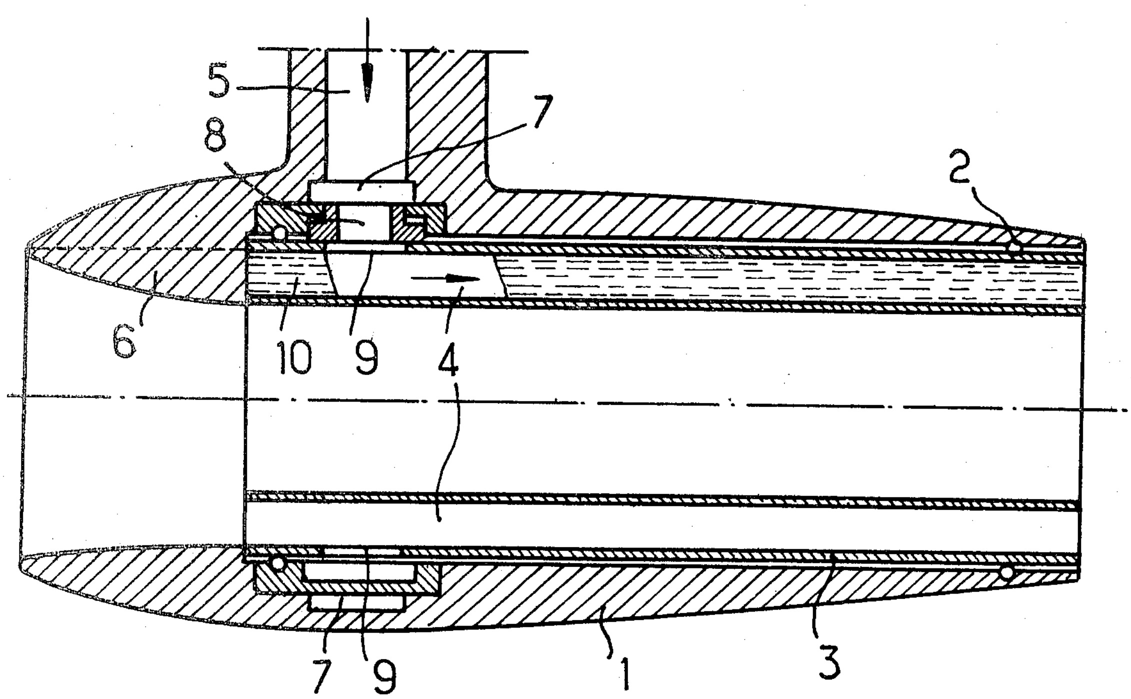
[57] **ABSTRACT**

An underwater pulse jet motor comprises a stator and, within the stator, a rotor which has axially extending ducts at its periphery. The stator includes a closing segment which closes off the forward ends of the ducts successively as they pass it during rotation of the rotor. Gas under pressure is injected into the ducts through an injection passage formed in the stator in alignment with the closing segment, injection openings in the ducts coming successively into register with the injection passage for this purpose. In order to form a buffer of water in each duct between the closing segment and the injection opening, the opening is disposed downstream of the upstream end of the duct, and an efficient seal against the escape of the gas between the upstream ends of the ducts and the closing segment is thus achieved. The buffer water can be arranged to flow at a restricted rate downstream into the central passage to provide an ejector effect to increase the water flow through the central passage at low forward speeds of the motor.

10 Claims, 9 Drawing Figures



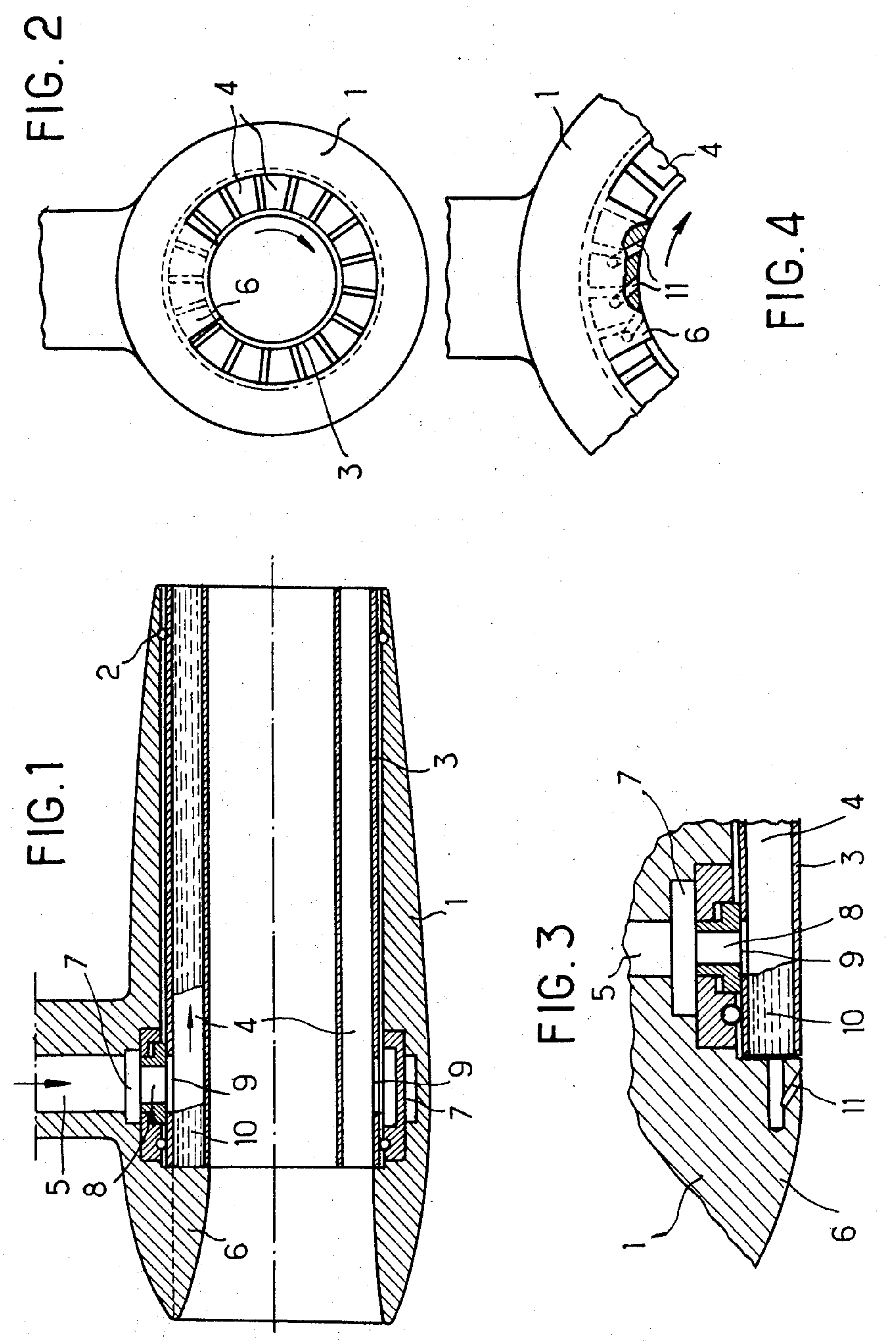


FIG. 1
FIG. 2
FIG. 3
FIG. 4

FIG. 6

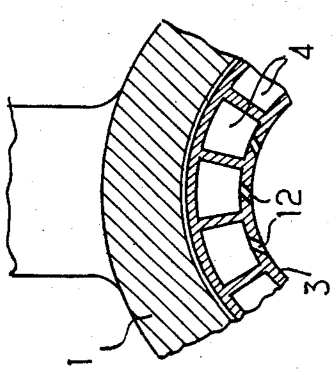


FIG. 8

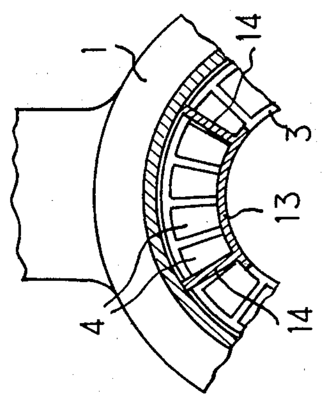


FIG. 5

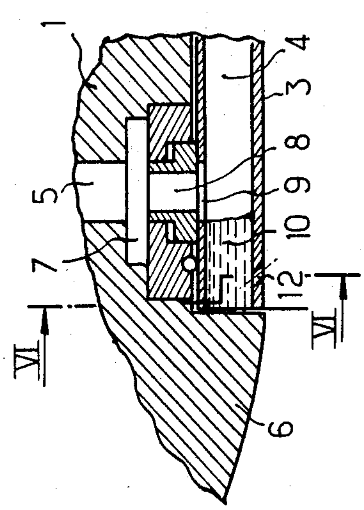
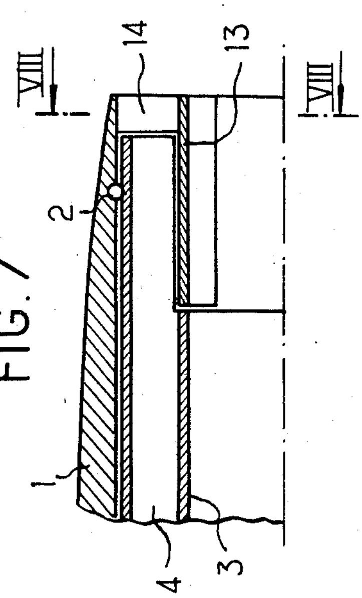


FIG. 7



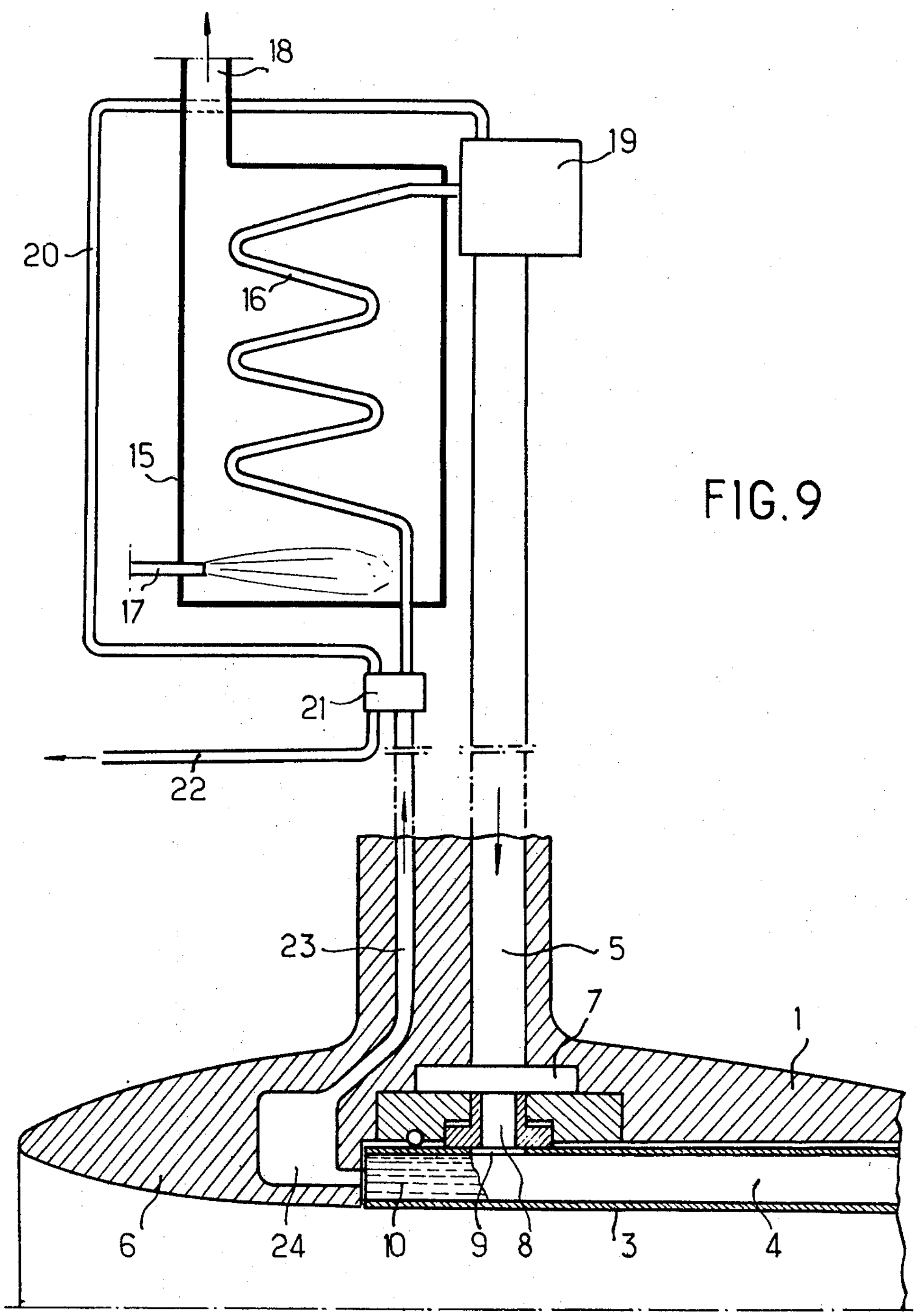


FIG. 9

UNDERWATER PULSE JET MOTOR

The present invention concerns an underwater pulse jet motor of the type comprising a stator within which is mounted for rotation a rotor provided at its periphery with longitudinal ducts, each constituting a pulse jet unit, and a pressurized gas source for successively feeding the ducts of the rotor through at least one fixed injection orifice formed in the stator and co-operating with a segment which is provided at the upstream end of the stator and which serves to close the ducts at their upstream ends.

Various forms of construction of pulse jet motors of this kind are known. However, their industrial use has involved considerable difficulties on account of the numerous technological problems, in particular the problem of establishing a seal between the stator and the rotor in the area where the closing segment is located. It is in fact extremely difficult, if not impossible, to establish a good gas-tight seal in this zone, and the resulting losses can considerably reduce the performance of the motor.

According to this invention there is provided an underwater pulse jet motor comprising a stator, a rotor mounted for rotation within the stator and provided at its periphery with longitudinally extending ducts having open upstream and downstream ends, a closing segment fixed with respect to the stator and closing off the upstream ends of said ducts successively during rotation of the rotor, the stator providing an injection orifice at the location of said segment, a pressurised gas source for supplying pressurised gas to the injection orifice, each of the ducts in the rotor having an injection aperture which comes into register with the said injection orifice when the upstream end of the said duct is closed off by the closing segment, said injection orifice and injection openings being disposed downstream of the upstream ends of the ducts whereby when the pressurised gas is supplied into the injection openings a buffer of pressurised water is formed between the closing segment and the injection openings.

It will be readily appreciated that as a result of this arrangement the problem of establishing a seal in the zone of the closing segment is automatically solved in that the pressurised gases injected into the ducts of the rotor are isolated from said segment by a buffer of water. It is obviously much easier to establish a water-tight seal than a gas-tight seal.

In one embodiment of the invention, ejector passages are formed in the closing segment to place the upstream portion of each of the ducts of the rotor in communication with a central passage provided for the flow of water through the rotor, these ejector passages being directed downstream at their ends adjoining the central passage. Thus, when the pressurised water forming the buffer escapes through the ejector passages in the closing segment, an ejector or siphon effect is achieved at the forward end of the rotor. This siphon effect causes water to be drawn in at the upstream end of the central passage and thus enables the rotor ducts to be filled when they pass out of alignment with the closing segment. It will also be appreciated that with an arrangement of this kind the time required for filling the ducts with water is considerably reduced so that the motor's performance is improved at low forward speeds of displacement of the motor.

Some embodiments of the invention will now be described by way of example with reference to the annexed diagrammatic drawings in which:

FIG. **1** is a simplified longitudinal section through an underwater pulse jet motor in accordance with the invention,

FIG. **2** is a front elevation of the motor of FIG. **1**,

FIG. **3** is a fragmentary sectional view illustrating a modification of the arrangement of FIGS. **1** and **2**,

FIG. **4** is a fragmentary front view corresponding to FIG. **3**, with some portions cut away,

FIG. **5** is a fragmentary sectional view illustrating a second embodiment of the invention,

FIG. **6** is a sectional view on line VI—VI of FIG. **5**,

FIG. **7** is a fragmentary sectional view illustrating a third embodiment of the invention,

FIG. **8** is a sectional view on the line VIII—VIII of FIG. **7**, and

FIG. **9** illustrates a fourth embodiment of the invention.

The pulse jet motor illustrated in FIGS. **1** and **2** has a hollow stator **1** having a profiled form suitable to enable it to move under water. Within the stator there is rotatably mounted, by means of roller bearings such as that shown at **2**, a hollow rotor **3**. On its periphery the rotor is provided with a series of longitudinal ducts **4** each constituting a pulse jet unit. These ducts extend along a part-helical path thus enabling the rotor to rotate automatically without the need for providing additional driving means.

Formed in a supporting strut at the top of the stator **1** is a port **5** connected to a pressurised gas source, not illustrated, which is designed to supply the gas to the ducts **4** of the rotor **3** in turn, and the port cooperates with a closing segment **6** provided on the top upstream portion of the stator. This closing segment is designed to seal hermetically and successively the upstream ends of the ducts **4** so as to enable the water contained in the ducts to be expelled in the downstream direction under the action of the pressurised gas supplied through the port **5**. It will also be seen that this closing segment, as shown in FIG. **2**, extends circumferentially over approximately four consecutive ducts.

The port **5** for supplying pressurised gas first communicates with an annular chamber **7** formed in the stator **1** around the upstream portion of the rotor **3**. This annular chamber communicates with a fixed injection orifice **8** which is disposed in the area where the closing segment **6** is located and which is disposed axially downstream of the upstream end of the rotor **3**. When the latter turns, the injection orifice **8** communicates in turn with the ducts **4** of the rotor by way of an injection opening **9** which is formed directly in each of these ducts and which comes into register with the injection orifice.

The mode of operation of a pulse jet motor will now be briefly described.

The ducts **4** are filled with water in a dynamic manner simply as a result of the speed at which the pulse jet motor moves, and when one of these ducts is brought into communication with the pressurised gas source by way of its opening **9** when the latter moves into register with the fixed injection orifice **8**, the water in the duct is immediately and automatically expelled downstream, since the duct in question is at that time closed at the upstream end by the closing segment. Rotation of the rotor **3** is maintained by the reaction of the mass of water on the lateral walls of the helical ducts 4, and thus ensures that the pulse jet motor operates continuously without the need for any other source of power.

Since the injection orifice 8 is disposed axially downstream of the upstream ends of the ducts 4, a buffer 10 of pressurised water is formed upstream when pressurised gas is injected into the duct in question; this buffer is delimited by the opening 9 of the duct and by the closing segment 6. The pressurised gas in the duct is thus isolated from the closing segment by a certain mass of water which ensures the establishment of a good seal in this zone. It will be appreciated that it is considerably easier to obtain a good watertight seal than a good gas-tight seal. Consequently the risk of leakage of gas at the closing segment is eliminated, and the performance of the pulse jet motor is thus improved accordingly.

It will also be appreciated that the pressurised water of the buffer 10, formed in this way in the upstream portion of each of the ducts 4 of the rotor, can be used for various purposes. FIGS. 3 and 4 illustrate one of these possibilities. A number of passages 11, three for example, are formed in the closing segment 6 for establishing communication between the upstream ends of the aligned ducts 4 and the ambient water. The outer ends of these passages are directed both towards the centre of the motor and downstream thereof.

Consequently, when the pressurised water of the buffer 10 escapes through the passages 11, it sets up an axial siphon effect which causes water to be drawn into the inlet end of the motor. This action facilitates the filling of the ducts of the rotor with water at the fixed point, and reduces the time for filling these ducts at slow speeds of travel of the motor. The passages 11 can, with advantage, be inclined sideways in the same direction as that in which the rotor rotates, as illustrated in FIG. 4, so as to increase further the siphon effect set up.

In the embodiment illustrated in FIGS. 5 and 6, passages 12 are formed directly in the inner wall of the rotor 3 in the upstream portion of each of the ducts 4. These passages 12 are directed downstream, and they are all also inclined in a common direction in relation to the radial direction, as illustrated in FIG. 6, so as not to intersect on the axis of rotation of the rotor 3. Ejection of the pressurised water of the buffer 10 through these inclined passages thus creates at the inlet to the motor an axial and rotary siphon effect in the direction opposite to that in which the rotor turns. This siphon effect obviously causes water to be drawn in, in the manner previously described, but because of its centrifugal action it also enables the speed of rotation of the rotor 3 to be regulated with precision. For this purpose a suitably rated centrifugal valve can be advantageously provided in each of the passages 12. It will also be appreciated that the particular arrangement just described can be used in conjunction with that illustrated in FIGS. 3 and 4.

It is obviously possible also to create a siphon effect in the downstream portion of the pulse jet with a view to obtaining uniform velocity distribution in the outlet plane and thus increasing the propelling power of the motor. The velocity at which water is ejected from the ducts of the rotor is always greater than the speed of travel of the pulse jet. It then suffices to establish connection between this high-velocity water and the water of low velocity of the surrounding area, for the purpose of achieving a siphon effect.

For this purpose and as illustrated in FIGS. 7 and 8, the rotor 3 is hollow over a certain portion of its length at its downstream end so as to connect the ducts 4 with the central passage of the motor. An inner plate 13, fixedly connected to the stator 1 by two webs 14 is however provided to close the cut away portion of the ducts in the zone where pressurised gas is injected. Thus, the siphon effect only takes place beyond said plate, that is to say where the velocity at which water is ejected is at its highest, whereas the greatest possible inertia of the column of water is maintained when injection occurs. This downstream siphon effect can of course be used in conjunction with the upstream siphon effect obtained with the aid of the arrangements illustrated in FIGS. 3 and 4, or 5 and 6.

Finally, FIG. 9 illustrates a third possible use of the pressurised water of the buffer 10 in the case where the pressurised gas source is constituted by a superheated steam generator. It will be appreciated that the use of superheated steam offers particular advantages in the powering of an underwater pulse jet motor. In particular the cycle may be an open one, the pulse jet performing the function of a condenser. Furthermore, since the superheated steam is condensible it disappears after ejection and this means that there is no wake. Finally, the steam generator is a fairly quiet unit in which combustion is continuous and therefore does not cause much pollution.

FIG. 9 shows a boiler 15 with a pipe coil 16, a burner 17 and a fume-exhaust duct 18. The pipe coil 16 runs into a steam accumulator 19 connected to the duct 5 for passing the steam into the annular chamber 7 of the stator 1. Part of the steam produced is also collected through a pipe system 20 for the purpose of actuating a pump 21 for supplying water to the boiler, this steam being discharged into the atmosphere through a pipe 22.

The pump 21 is supplied directly with pressurised water from the buffer 10 formed in each of the ducts 4 of the rotor when the superheated steam is injected. For this purpose, the pump is connected by a passage 23 to a pressurised water collector 24 which is formed in the upstream portion of the stator 1 and which is in communication with the upstream ends of the ducts 4 at the location of the closing segment 6. Thus, the pump 21 is supplied with water already at a certain pressure and therefore operates at a reduced pressure differential with regard to the vapour pressure required for supplying to the ducts of the pulse jet units. Consequently, this pump can be of lower power than normally, and it can therefore also be less costly.

It will be appreciated that all the particular arrangements that have been described can be used not only in the case of pulse jet motors comprising a hollow rotor as illustrated in the annexed drawings, but can also be used in the case of central-feed pulse jet motors disposed within an exterior hull.

I claim:

1. An underwater pulse jet motor comprising a stator, a rotor mounted for rotation within the stator and provided at its periphery with longitudinally extending ducts having open upstream and downstream ends, a closing segment fixed with respect to the stator and closing off the upstream ends of said ducts successively during rotation of the rotor, a stator providing an injec-

tion orifice at the location of said segment, a pressurised gas source for supplying pressurised gas to the injection orifice, each of the ducts in the rotor having an injection aperture which comes into register with the said injection orifice when the upstream end of the said duct is closed off by the closing segment, said injection orifice and injection openings being disposed downstream of the upstream ends of the ducts whereby when the pressurised gas is supplied into the injection openings a buffer of pressurised water is formed between the closing segment and the injection openings.

2. A motor as claimed in claim 1, wherein the rotor is annular to provide a central passage open for the flow of water therethrough, at least one ejector passage being provided for placing the location between the closing segment and the injection openings of each duct in communication with said central passage, at least when the injection orifice registers with the injection opening of the said duct, the end of said ejector passage which opens to the central passage being directed in a downstream direction.

3. A motor as claimed in claim 2, wherein a plurality of said ejector passages are formed in the closing segment.

4. A motor as claimed in claim 3, wherein said downstream ends of the ejector passages are directed at an angle to a direction radially of the rotor.

5. A motor as claimed in claim 2, wherein the rotor is formed with a plurality of said ejector passages one in each of said ducts.

6. A motor as claimed in claim 5, wherein said downstream ends of the ejector passages are all directed at a common angle to a direction radially of the rotor.

7. A motor as claimed in claim 1, wherein the rotor is annular and provides a central passage therethrough, the rotor having radially inner and outer walls which define the radially inner and outer boundaries of the ducts, the downstream end portions of said inner wall being cut away.

8. A motor as claimed in claim 7, wherein the stator provides a fixed part-annular wall in the downstream end portion of said central passage, said part-annular wall being aligned axially with said inner wall of the rotor and aligned circumferentially with the closing segment, and the upstream end of the part-annular wall being disposed adjacent the downstream end of the inner wall.

9. A motor as claimed in claim 1, wherein said pressurised gas source comprises a generator of superheated steam.

10. A motor as claimed in claim 9, further comprising a feed pump connected to supply water to said generator, and a passage which is formed in the closing segment and through which water from the upstream ends of the ducts can be fed to the pump.

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