

PATENT SPECIFICATION

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- (21) Application No. 59447/72 (22) Filed 22 Dec. 1972
 (31) Convention Application No. 213 363
 (32) Filed 29 Dec 1971 in
 (33) United States of America (US)
 (44) Complete Specification published 12 Nov. 1975
 (51) INT CL² B05B 1/02
 (52) Index at acceptance
 B2F 10A1B4 10A3B 11A 11X 2J 2M 8A 8C



(54) LIQUID JET NOZZLE

(71) We, MARCONA CORPORATION, a corporation organised and existing under the laws of the State of New York, United States of America, of 1 Maritime Plaza, San Francisco, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid jet nozzles and is particularly although not exclusively applicable to moveable forms of such nozzles particularly suitable for emitting a very high velocity, coherent stream for creating high impact forces at considerable distances from the nozzle.

The invention provides a liquid jet nozzle from which a liquid is discharged at high energy in a uniform stream of high velocity comprising a hollow stem including a first section having the shape of a circular cylinder, means for connecting said cylindrical section to a source of liquid under pressure, a nozzle head connected to one end of said cylindrical section, said head having first and second reducing sections each with a progressively reduced internal cross-section, said first reducing section having a back wall portion towards which the centre line of said first reducing section approaches said back wall portion being aligned as a continuation of said stem, and a front wall portion which approaches said back wall portion, said second reducing section having a front wall portion which, together with the front wall portion of said first reducing section follows a re-entrant path with respect to a hypothetical extension of said cylindrical section, said nozzle head terminating in a nozzle orifice opening oriented at a substantial angle of flow change measured from the axis of the cylindrical section of the stem, said head being constructed and arranged to be confined throughout its extent within a

hypothetical cylindrical extension of said cylindrical section, thereby serving to change the direction and velocity of the flow of liquid by said substantial angle within that hypothetical extension. 50

The following is a specific description of one embodiment of the invention, reference being made to the accompanying drawings in which: 55

Figure 1 is a side elevational view partly in cross-section and partially broken away, of a rotatable liquid jet nozzle constructed in accordance with the present invention. 60

Figure 2 is a cross-sectional view taken along the lines 2—2 of Figure 1.

Figure 3 is an enlarged view of the nozzle head portion of the jet nozzle of Figure 1.

Figure 4 is an isometric sketch showing the interior contours of the nozzle head of Figures 1 and 3. 65

Figure 5 is a cross-sectional view of another embodiment showing a modification of the nozzle head constructed in accordance with the present invention. 70

Referring particularly to Figure 1 wherein the overall structure of the jet nozzle of the present invention is set forth in connection with its installation in the inner bottom of a ship (not shown). The inner bottom 10 is provided with an opening 12 therein which drains into a sump 14, terminating in its lower portion in a flange ring 16 to which a sealing member 18 and upper housing member 20 are secured, as with bolts 22 and 24. The central portion of the sump is provided with an opening 26 which leads on one side to a discharge outlet 28 to remove material entering the sump. Centrally disposed within the sump 14 and the opening 26 therein is a jet nozzle 30 to be hereinafter described. 75 80 85

The lower end 32 of the upper housing is fitted with a high pressure liquid inlet housing 34 which is sealed from the upper housing by a packing seal and bearing 36 and an additional seal and bearing 38. The lower end of the inlet housing is provided 90

with a stem bearing and seal 40 which, together with the upper bearing and seal 36, 38, provide support for the stem 42 of the jet nozzle. Means 43 are provided for rotating the jet nozzle and for controlling its elevation in a vertical sense, such means being similar for example to that shown in U.S. Patent Specification No. 3,606,036. A high pressure source 44 of liquid is connected to the inlet housing through a suitable flange connection 46.

Referring now more particularly to Figures 1 and 2, there is shown in detail the nozzle for forming the traversing liquid jet of high energy disposed immediately above a grating (not shown) which overlies the sump and which prevents consolidated materials from entering the sump before being broken up. The jet nozzle includes the hollow stem shaft 42 which is set in the seals and bearings 36, 38 and 40, and which has near its lower end inlet openings 50 for permitting high pressure liquid to enter within the shaft. The hollow shaft is circularly cylindrical and extends upwardly to a nozzle head 52, the outlet of which consists of a nozzle orifice 74 mounted in the head. The upper end of the head 52 is closed with a sealing cap 56 which may be made of metal but is preferably of suitable elastomeric material which cushions the impact of material filling thereupon, and in certain applications, may be extended to seal over the opening of the sump with which it may be associated. Furthermore, the sealing cap extends slightly beyond the perimeter of the nozzle head to provide protection for the nozzle and to effect a closure seal when the unit is lowered into the sump as shown in Figure 3. In the section of the stem between the inlet passage 50 and the nozzle head 52, a plurality of straight vanes 58 are positioned (Figure 2), which may take any of various conformations, that being shown in Figure 2 consisting of a generally square elongate lattice aligned with axis of the stem and extending for a substantial distance therealong to define a plurality of smaller passageways 60, each of uniform cross-section throughout its length to thereby induce liquid flowing through the stem into parallel non-vortex flow substantially free of gross turbulence.

Referring particularly to Figures 3 and 4, there is shown in detail the liquid jet nozzle head which generally consists of a successive first and second sections 70, 72 terminating at the end of the second portion in a nozzle orifice 74. The first and second sections of the nozzle head carry the liquid through a sweeping arc, first in a general direction away from the orifice nozzle along arrow 76 and then back towards it along arrow 78. The entire first and second sections 70, 72

are enclosed within a cylindrical extension 80 of the stem and are connected thereto by a suitable weld at 82. In this way, the entire assembly is adapted for rotation about the axis of cylindrical extension 80 while presenting a minimum of protuberances or other means which might come in contact with adjacent solids or other materials and impair the ability of the unit to rotate.

As seen particularly in Figure 4, the first and second sections taken together generally include a forward wall portion 84 immediately beneath the orifice nozzle 74 and a rear wall portion 86 which continues from the orifice nozzle into the cylindrical section and becoming gradually more and more tangent therewith. The forward wall portion 84 is re-entrant with respect to the cylindrical surface between the orifice nozzle and the cylindrical stem section at 82 and forms a continuous throat like restriction, with rear wall, and side wall portions 88, 90, which is a generally tubular channel of constantly reducing diameter from the stem section to the orifice nozzle.

More particularly, the nozzle head of the present invention can be described as continuous smooth development of two sections, the lower section 70 extending from weld line 82 up to about line 92, the latter being the limit of extent of the re-entrant dip. This lower section takes the form of an eccentric reducer, having the approximate shape of the frustum of an unsymmetrical cone, the lower front, back, and side wall portions of which are gradually curved into conformity and rear wall portion extends into tangency with the stem cylinder 42. The cone has a substantially straight back wall portion which continues in tangency with the extension, either imaginary or real, of the stem cylinder, up to the upper limit of this section. The front wall portion of the section falls inwardly towards the back wall portion while maintaining generally circular sections with the side and back wall portions.

The upper section of the nozzle head extends from line 92 to the orifice nozzle and generally includes a member having the shape of an elbow, the initial diameter of which corresponds to the upper diameter of the lower section 70 and reduces in size in a uniformly, continuous manner, to the orifice nozzle. The upper and lower sections are so aligned that their line of centers lies in a plane such that the center line 76 moves rearwardly toward the back wall portion in the lower section 70 and center line 78 progressively moves forward toward the front wall portion in the upper section 72, that is to say, the bend of the upper section is oriented in the opposite direction from the direction of the bend of the lower section. In this way, the two sections

together define a tubular volume of continuously reducing cross-section directing the flow first away from the orifice and then towards it in a continuous turning movement, first toward the back wall portion and then into parallelism with the back wall portion and then is directed into a substantial angle with respect to the cylindrical stem as it approaches the orifice nozzle.

Nozzle orifice 74 is mounted to the end of the nozzle head upper section and is formed with a converging frustrum 96 of a cone terminated at its outer end by a relief 97 which is formed to provide a circular knife edge 98 which facilitates clean separation of flow of the liquid steam as it leaves the orifice.

Seen as a problem in turbulence or non-laminar flow, the present nozzle head appears to induce sufficient reduction or compensation in liquid vortex formation as to induce a marked improvement in the resulting jet coherence as measured by jet force of impact and divergence at significant distances from the nozzle. Some additional improvement can be obtained by inserting a second set of straightening vanes 99 immediately before the nozzle orifice as shown in Figure 5 and by using curved converging vanes (not shown) to continuously connect vanes 99 toward the nozzle.

By way of example, the following dimensions were found quite satisfactory when operated with water supplied at 250—300 pounds per square inch from a 6" line:

lower reduction section input diameter — 6 inches

lower reduction section output diameter — 3 inches

upper reduction section input diameter — 3 inches

upper reduction output diameter — 2 inches

nozzle orifice cone — 2" down to 1 1/4" (15°—17°).

For the purpose of definition, the angle of change of the flow of liquid effectuated by the nozzle is measured from the axis of flow of liquid entering the nozzle to the axis of flow of liquid leaving the nozzle. In this regard the nozzle of the present invention serves to change the direction and velocity (momentum) of a liquid stream through a substantial angle. As used herein, a substantial angle refers to an angle of flow change of about 90° since stream coherence after redirection through about 90° is a principal objective of the present invention. It has been found, however, that the present invention produces very satisfactory results when the angle of flow change is less than 90°, even as low as 45°. When flow change angles of less than 90° are used, the throat-like restriction of the nozzle remains about

the same, while the elbow portion is changed to reflect the desired amount of re-direction. One common feature of the above described nozzles is that the lower or eccentric portion reduces the cross-section of the stream without determining the final direction of the stream and cooperates with the other portion to ensure equal stream velocities on opposed sides of the nozzle. The other reducing portion makes the major change in overall stream direction. In operation the re-entrant path taken by the portion of the stream flowing along front wall portion 84 tends to have a path length more nearly equal to the portion of the stream travelling along the back wall portion 86. The geometry of the nozzle tends to equalize the velocity of each portion of the liquid stream and this reduction in velocity differentials within the stream is believed to explain the greatly improved performance of the present nozzle.

Thus, there has been disclosed a liquid jet nozzle which provides a significant increase in velocity, thrust and impact forces at a distance by controlling turbulence and which is therefore suitable for operations where application of high forces from a liquid stream is required together with adjustment of the nozzle. When tested against a standard straight Harris nozzle at 50 feet, the nozzle of the present invention has proven quite satisfactory, any serious loss in efficiency in the bend being negligible. Effective ranges of various nozzles constructed in accordance with the present invention have extended as far as 100 feet. Angles of deflection between 90° and 45° have been found satisfactory. While input heads of 250—300 psi were disclosed in the specific example herein, many other pressure values may be used, from about 100—600 psi depending upon the size of the unit and the service application.

While a specific disclosure and embodiments have been shown herein it should be realized that many modifications and changes can be made by those skilled in the art without departing from the scope of the present invention. For example, while the present disclosure shows movement of the jet nozzle about a single fixed axis, it is believed that a swivel or ball mounting would be required in many applications such as fire fighting, mining, or cleaning to provide universal movement. Accordingly, the scope of this invention should be understood in a broader context limited only by the following claims as interpreted in the light of the foregoing example.

WHAT WE CLAIM IS:—

1. A liquid jet nozzle from which a liquid is discharged at high energy in a uniform stream of high velocity comprising a hollow



together define a tubular volume of continuously reducing cross-section directing the flow first away from the orifice and then towards it in a continuous turning movement, first toward the back wall portion and then into parallelism with the back wall portion and then is directed into a substantial angle with respect to the cylindrical stem as it approaches the orifice nozzle.

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Seen as a problem in turbulence or non-laminar flow, the present nozzle head appears to induce sufficient reduction or compensation in liquid vortex formation as to induce a marked improvement in the resulting jet coherence as measured by jet force of impact and divergence at significant distances from the nozzle. Some additional improvement can be obtained by inserting a second set of straightening vanes 99 immediately before the nozzle orifice as shown in Figure 5 and by using curved converging vanes (not shown) to continuously connect vanes 99 toward the nozzle.

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For the purpose of definition, the angle of change of the flow of liquid effectuated by the nozzle is measured from the axis of flow of liquid entering the nozzle to the axis of flow of liquid leaving the nozzle. In this regard the nozzle of the present invention serves to change the direction and velocity (momentum) of a liquid stream through a substantial angle. As used herein, a substantial angle refers to an angle of flow change of about 90° since stream coherence after redirection through about 90° is a principal objective of the present invention. It has been found, however, that the present invention produces very satisfactory results when the angle of flow change is less than 90°, even as low as 45°. When flow change angles of less than 90° are used, the throat-like restriction of the nozzle remains about

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1. A liquid jet nozzle from which a liquid is discharged at high energy in a uniform stream of high velocity comprising a hollow

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- stem including a first section having the shape of a circular cylinder, means for connecting said cylindrical section to a source of liquid under pressure, a nozzle head connected to one end of said cylindrical section, said head having first and second reducing sections each with a progressively reduced internal cross-section, said first reducing section having a back wall portion towards which the centre line of said first reducing section approaches, said back wall portion being aligned as a continuation of said stem, and a front wall portion which approaches said back wall portion, said second reducing section having a front wall portion which, together with the front wall portion of said first reducing section follows a re-entrant path with respect to a hypothetical extension of said cylindrical section, said nozzle head terminating in a nozzle orifice opening oriented at a substantial angle of flow change measured from the axis of the cylindrical section of the stem, said head being constructed and arranged to be confined throughout its extent within a hypothetical cylindrical extension of said cylindrical section, thereby serving to change the direction and velocity of the flow of liquid by said substantial angle within that hypothetical extension.
2. A liquid jet nozzle as claimed in claim 1 in which the centre line of said reducing sections lies in a plane.
3. A liquid jet nozzle as in any of the preceding claims, further including a plurality of vanes positioned in the cylindrical section and aligned therewith to permit passage of the liquid therethrough in substantially non-turbulent flow.
4. A liquid jet nozzle as claimed in any of the preceding claims, wherein the first reducing section consists of a reducing

throat having the shape of a frustrum of an unsymmetrical cone, the larger diameter end of which is connected to and forms a continuation of said stem, and the second reducing section consists of a hollow member having the shape of an elbow with a bend having a centre line which lies in the same plane as the centre line of said unsymmetrical cone, said first and second reducing sections being arranged so that the back wall of the nozzle forms a continuously turning surface while the front wall assumes a re-entrant shape.

5. A liquid jet nozzle as in claim 4, having a nozzle orifice section mounted at the discharge end of said reducing sections, said orifice section having the shape of a frustrum of a cone in order to reduce further the cross-sectioned area of the stream of liquid, the orifice section terminates at its smaller discharge end with a short cylindrical section, the terminal edge of which is formed as a knife edge.

6. A liquid jet nozzle as claimed in claim 5, further including a plurality of straightening vanes positioned immediately adjacent said orifice section to aid in eliminating turbulent flow of liquid therethrough.

7. A liquid jet nozzle as claimed in any of the preceding claims wherein means are provided for at least partially rotating the hollow stem about the axis of the cylinder.

8. A liquid jet nozzle substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 4 or Figures 1 to 4 as modified by Figure 5 of the accompanying drawings.

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