

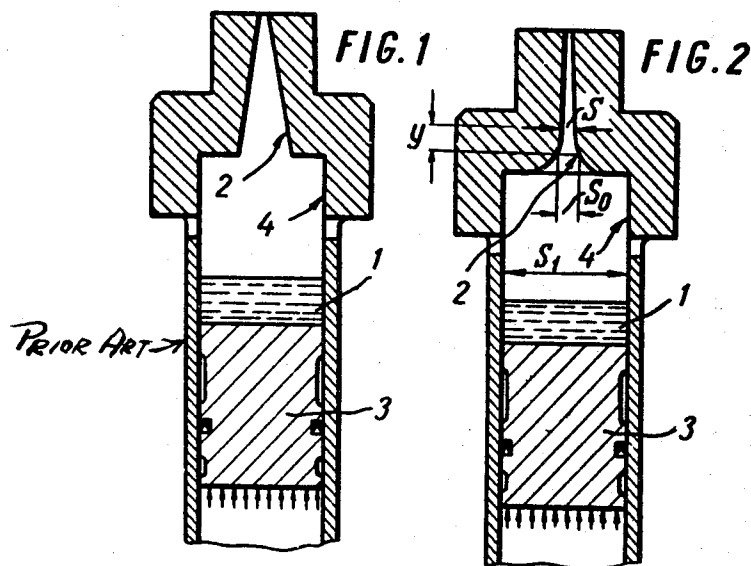
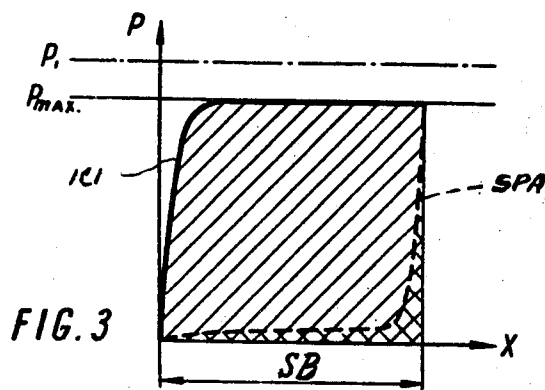
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JET NOZZLE FOR OBTAINING HIGH PULSE DYNAMIC PRESSURE HEADS

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ABSTRACT OF THE DISCLOSURE

The invention consists in a jet nozzle for obtaining high pulse dynamic pressure heads in installations which utilize the impact of a freely accelerated piston acting on a liquid and forcing the same through a nozzle having an internal cavity which is free of liquid at the instant of impact against the piston and in which the internal cavity is shaped so that the static pressure of the liquid braking the piston remains constant or approximately constant at the entry of the liquid into the internal cavity in the process of braking in order that the pressure is initially rapidly raised up to the maximum active pressure in the impact chamber and then is maintained constant.

The present invention relates to jet nozzles for obtaining high pulse dynamic pressure heads, mostly of liquid in installations employing an impact of a freely accelerated piston upon the liquid at the entry to said jet nozzle internal cavity which is free from liquid by the instant of impact.

It is well known that when a liquid layer enters a contracting internal cavity of the jet nozzle, the forepart of said liquid acquires a considerable portion of kinetic energy at the cost of the energy of the whole mass of moving liquid.

In nature, for example, in some fiords, intensifications of tidal waves take place, fiords walls serving as a convergent contracting channel wherein the force of a tidal wave is largely intensified.

Widely known at present is the phenomenon of cavitation consisting in that at a great velocity of rotation of propellers, or blades of centrifugal pumps, bubbles form, these bubbles being broken by the pressure of liquid. At the instant the radius of the spherical surface of the bubble diminishes to zero, the dynamic head of the liquid forepart on the bubbles surface increases to such an extent that it is capable of destroying even the metal surface of a propeller.

Many attempts have been made to utilize the principle of acceleration of the forepart of liquid moving in a contracting cavity of a jet nozzle in installations of different designs for obtaining ultrahigh dynamic pressure heads.

One of these attempts may be exemplified, for instance, by the proposal to speed up a portion of liquid in a jet nozzle having a conical cavity using kinetic energy of fast-moving piston as a source of energy for accelerating said liquid.

In this case the pressure of liquid in an impact chamber behind the cavity, as a function of the piston travel when said piston is such that as the length of the braking path increases, the pressure in the impact chamber at first changes slowly and then rises abruptly.

It is an object of the present invention to overcome the aforesaid disadvantage.

It is a particular object of the present invention to provide a jet nozzle with an internal cavity of such a profile so as to ensure a multiple increase in energy transferred by a piston to liquid as compared with presently known constructions of jet nozzles.

According to the invention, this problem is solved by shaping the internal cavity of the jet nozzle so that the

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static pressure of liquid braking the piston will remain constant or approximately constant at the entry to the internal cavity in the process of braking.

The particular object of the invention is to provide an arrangement in which the internal cavity of the jet nozzle is shaped so that the pressure initially sharply increases up to the maximum active pressure and is then maintained constant.

The invention will be more apparent from a consideration of the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view illustrating a jet nozzle of the known type,

FIG. 2 is a similar longitudinal sectional view of a jet nozzle having an internal cavity shaped in accordance with the teachings of this invention, and

FIG. 3 is a graph of the pressure of the liquid in the impact chamber expressed as a function of piston travel in the process of braking.

In the known type arrangement as expressed in FIG. 1, it is proposed to speed up a portion of liquid 1 in a jet nozzle having a conical internal cavity 2 utilizing the kinetic energy of a fast moving piston 3 as a source of energy for accelerating the liquid. In this instance the pressure of the liquid in the impact chamber 4 behind the cavity, is expressed as a function of the piston travel when the piston is being braked and is quantitatively denoted in FIG. 3 by the thick detached line SPA. In addition, the permissible pressure P_1 in the impact chamber is limited by the thin broken horizontal line, while the maximum pressure P_{max} in the chamber is limited by the thin solid line. The energy transmitted by the piston to the liquid when the latter is being accelerated in a jet nozzle with a conical internal cavity, the prior art arrangement of FIG. 1, is proportional to the cross-hatched area depicted in the graph in FIG. 3.

When the jet nozzle has a conical internal cavity as at 2, as the length of the braking path SB increases the pressure at first changes slightly and then rises abruptly as denoted by the curve SPA. The maximum active pressure P_{max} should not exceed the permissible pressure P_1 as otherwise the impact chamber will be destroyed. It is quite obvious that in such instance the energy imparted to the liquid is small and cannot be considerably increased as the value of P_{max} is limited. The amount of energy imparted to the portion of the liquid 1 by piston 3 during the process of braking will be increased only by changing the character of the function $P=f(x)$.

The nozzle of the invention is illustrated in FIG. 2 and the graph in FIG. 3 clearly denotes the advantages of the invention as compared to the FIG. 1 arrangement.

In FIG. 3 the curve ICI shown by a thick solid line indicates a graph of a function $P=f(x)$ for the proposed profile of the jet nozzle internal cavity.

Thus, the graph in FIG. 3 clearly shows that the pressure in this case, curve ICI resulting from the use of the FIG. 2 arrangement, at first is sharply raised up to P_{max} and then is maintained constant as contrasted with curve SPA resulting from use of the FIG. 1 arrangement.

In this case, energy imparted to liquid increases many times.

In each individual case the internal cavity of the jet nozzle is shaped depending on the compressibility of liquid and construction parameters of the installation.

In case of an incompressible liquid, the shape of the internal cavity is determined by the equation:

$$S = k_1 \cdot S_0 \cdot e^{\frac{-y}{k \cdot k_2}}$$

wherein:

S is the variable of the inside sectional area of the jet nozzle cavity;

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S_0 is the value of the jet nozzle cavity entry sectional area;

y is the variable coordinate along the axis of the jet nozzle;

e is the base of the natural logarithm;

k_1 is a coefficient equaling $0.6 \div 1$;

k_2 is the second coefficient equaling $0.7 \div 1$;

and

k is the construction parameter expressed by the following relation:

$$k = \frac{S_0 \cdot M}{\rho \cdot S_1^2}$$

in which

ρ is the density of liquid;

M is the mass of the piston;

and

S_1 is the value of the sectional area of the piston.

At $P_{\max}$ of up to 3000 kg./sq.cm. such a liquid as water is practically not compressed at all, and the jet nozzle may be shaped in accordance with the above relation.

In laboratory testing of a high-pressure pulse installation with the jet nozzle internal cavity profile satisfying the foregoing relation, pressure of 70,000 kg./sq.cm. was obtained in a pulse jet at the nozzle outlet.

As was proved by numerous experiments, such streams can crush rocks of any hardness. They pierce copper plates 120 mm. thick and steel plates 30 mm. thick.

According to theoretical estimates, a proper shape of the jet nozzle internal cavity with due regard for the liquid compressibility, as well as the provision of a proper vacuum in the jet nozzle internal cavity can make it possible to obtain dynamic pressure heads of the order of 500,000—1,000,000 kg./sq.cm.

What is claimed is:

A jet nozzle for obtaining high pulse dynamic pressure

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heads in installations employing an impact of a freely accelerated piston against liquid at the entry thereof to said jet nozzle, said jet nozzle having an internal cavity which is free from liquid at the instant of and the shape of said internal cavity being expressed by the equation,

$$S = k_1 S_0 e^{\frac{-y}{k \cdot k_2}}$$

to provide pressure of up to 3000 kg./sq.cm. in front of said jet nozzle; wherein:

S is the variable of the inside sectional area of the jet nozzle cavity;

S_0 is a value of the jet nozzle inlet sectional area;

y is the variable coordinate along the axis of said jet nozzle;

e is a base of natural logarithm;

k is the construction parameter expressed by the following relation:

$$k = \frac{S_0 \cdot M}{\rho S_1^2}$$

wherein:

ρ is the density of liquid;

M is the mass of the piston;

and

S_1 is the value of said piston cross-sectional area.

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