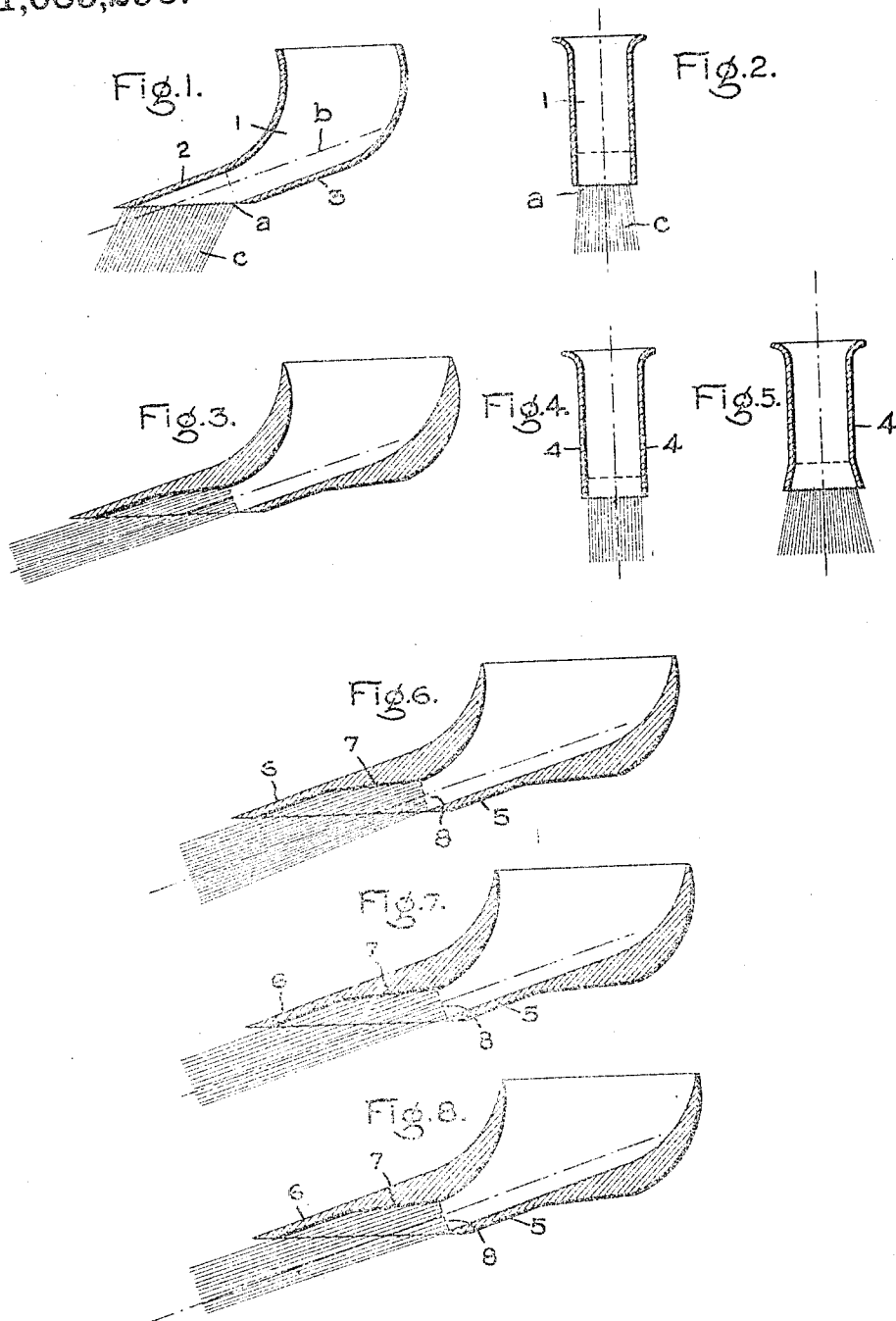


W. PAPE.
NOZZLE FOR TURBINES.
APPLICATION FILED JULY 17, 1912.

Patented Jan. 27, 1914

1,085,293.



WITNESSES:

Green Oxford
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UNITED STATES PATENT OFFICE.

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NOZZLE FOR TURBINES.

1,085,293.

Specification of Letters Patent.

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Application filed July 17, 1912. Serial No. 709,872.

To all whom it may concern:

Be it known that I, WILHELM PAPE, a subject of the Emperor of Germany, residing at Charlottenburg, Germany, have invented certain new and useful Improvements in Nozzles for Turbines, of which the following is a specification.

This invention relates to nozzles for elastic fluid turbines and its object is to provide a nozzle in which the elastic fluid can expand to the final pressure easily, whether or not this pressure is above or below that for which the nozzle is designed, and without changing appreciably the angle of the jet.

Tests have shown that a jet of steam in passing out of a tubular nozzle which has been cut off on a plane oblique to its axis is deflected very considerably from its original direction whenever the ratio of the pressures preceding and following its course through said nozzle is greater than the critical ratio; that is, a ratio of 1.7 for dry saturated steam. Inasmuch as the nozzle is so placed as to direct the jet in line with the surface of the bucket at the edge thereof, it follows that any such deflection impairs the efficiency of the engine, because there is a considerable impact upon the back of the bucket. This deflection of the steam jet is caused by the fact that the boundary walls of the nozzle permit the jet to broaden only in a direction at an angle to its axis, and the deflection from the axis of the nozzle becomes greater in accordance with the increase over the critical steam velocity as the jet leaves the nozzle. This tendency to expand in a direction oblique to the axis of the nozzle is more marked with a nozzle whose cross section is uniform throughout; but it occurs to a greater or less degree in the nozzles of the expanding type, when the final pressure is above or below the correct value. My invention aims to correct this tendency of the jet to diverge in this inefficient manner, and to this end it comprises a nozzle so constructed that the enlargement of the steam jet is only partially limited by the walls of said nozzle, and the expansion of said jet can therefore take place unhindered in accordance with the pressures preceding and following the nozzle. This result may be obtained in a simple manner by causing the smallest cross section of the nozzle to

coincide practically with the cross section of the opening into the receiving chamber.

The invention will be better understood by reference to the accompanying drawing, in which—

Figure 1 is an axial section of a nozzle as ordinarily constructed; Fig. 2 is a transverse section of the same; Fig. 3 is an axial section of my improved nozzle; Fig. 4 is a transverse section thereof; Fig. 5 is a similar section of a modification; and Figs. 6, 7 and 8 show the action of the improved nozzle with varying pressures.

The old form of nozzle 1 shown in Figs. 1 and 2 has its mouth cut off on a line *a* which is oblique to its axis *b*. The lines *c* indicate how the steam jet will be deflected from the axial direction whenever the velocity varies from the critical. In this form of nozzle, the top and bottom walls 2, 3 are parallel. If these walls should diverge to form the usual expanding nozzle, the jet of steam will remain in its original direction at velocities above the critical velocity, but the nozzle will give a maximum efficiency only for the pressure ratio upon which the calculation is based, while at every other ratio of expansion the efficiency falls off considerably.

If the nozzle is constructed with a greater expansion than that which corresponds to the ratio of pressures preceding and following the nozzle, then the steam pressure follows the free expansion too far below the true counter-pressure, rising thereafter by impulses to the said counter-pressure. The pulsations of compression in the broadened part of the nozzle result in an impairment of efficiency. My invention avoids the disadvantages of these two forms of nozzle by adopting the construction shown in Figs. 3 to 8. The side walls 4 of the nozzle may be either parallel, as shown in Fig. 4, or they may diverge at the lower edges, as shown in Fig. 5; the latter construction permitting a beneficial expansion of the jet in these directions as well. The bottom 5 of the nozzle is parallel with the terminal portion 6 of the top, but that portion 7 of the top between such terminal portion and the throat 8 of the nozzle is oblique to the axis of said nozzle, so as to contract it in cross section toward the throat, which is located so as to coincide with the rear end or

edge of said mouth. In such a nozzle, with only a partial limitation of the steam jet passage, the steam flows in a close jet in the direction of the axis of the nozzle out into the receiving chamber. The reason of this is that the instant the steam passes the narrow throat it can expand not only upwardly toward the top of the nozzle, but also unrestrictedly on the under side toward the receiving chamber. At a velocity of 800 to 1000 meters per second, the jet will assume the form shown in Fig. 6. At a lower velocity, say about 500 to 700 meters per second, the jet will expand only upwardly, the under side of the jet remaining practically in line parallel with the axis of the nozzle, as shown in Fig. 7. With still smaller steam velocity, from the critical value downward, the jet of steam issues at a flatter angle than that of the nozzle axis, as shown in Fig. 8, which is an advantage because of the greater ease with which it enters the bucket. Since the enlarged portion of the steam jet is not bounded on all sides, the steam expands down only to the true counter-pressure, so that any compression-pulsations are avoided.

The principal advantages of the invention are the following:—(1) No substantial deflection of the jet from the axis of the nozzle at high velocity. (2) No under-expansion, and therefore no compression-pulsations at a smaller ratio of expansion than that which corresponds to the pressure ratio upon which the calculation is based. (3) At steam velocities below the critical velocity, the exit of the steam is effected at a flatter angle than that given by the axis of the nozzle, so that the axial cross section of exit is entirely filled, and when nozzles are ranged side by side a close band of steam is obtained. (4) The part of the nozzle through which the steam flows at high velocity is of minimum length, and accordingly the friction losses also are reduced to a minimum, resulting in better efficiency.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. An expanding nozzle for elastic fluid turbines having its throat coincident with the rear end of its mouth and its top at and beyond the throat extending obliquely upward with reference to the direction of its bottom at the throat, so that the jet of fluid discharged from it may expand freely after passing the throat without being deflected downward.

2. An expanding nozzle for elastic fluid turbines having a diverging top at and beyond its throat, and the bottom of its expanding portion cut away to the point of smallest cross section of said nozzle, so that the jet of fluid discharged from it may expand freely after passing the throat without being deflected downward.

3. An expanding nozzle in which the expansion of the steam jet beyond the throat of the nozzle is unrestricted on its under side, and in which the terminal portion of the top is substantially parallel with the bottom and a portion of the top between the terminal portion and the throat extends obliquely upward with reference to the direction of the bottom of the throat and said terminal portion.

In witness whereof, I have hereunto set my hand this twenty-ninth day of June, 1912.

WILHELM PAPE.

Witnesses:

HENRY HASPER,
WOLDEMAR HAUPT.