C. R. WALLER.

ELASTIC FLUID TURBINE.

APPLICATION FILED APR. 20, 1910.

**1,016,532.** Patented Feb. 6, 1912.

Fig: 1,

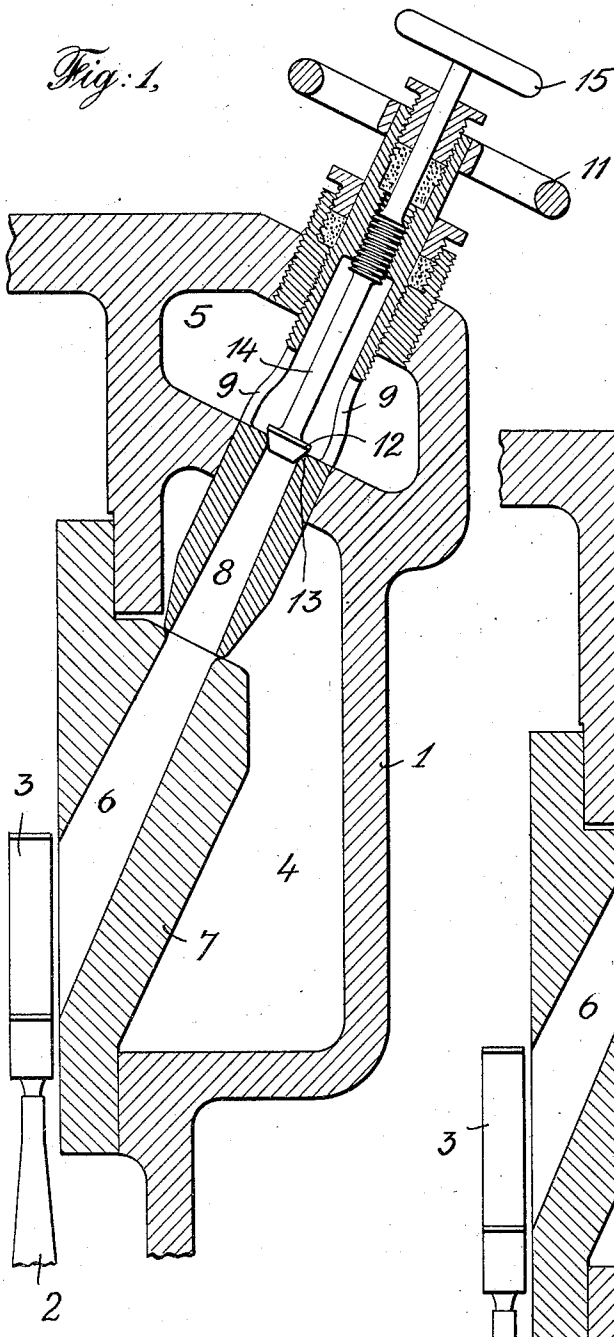
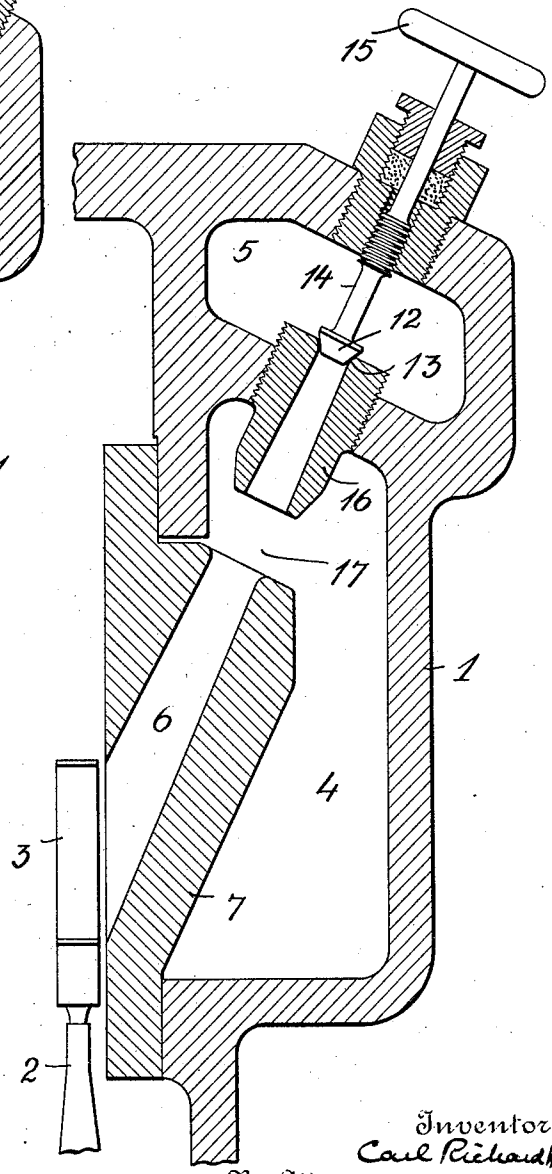



Fig: 2,

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## ELASTIC-FLUID TURBINE.

1,016,532. Specification of Letters Patent. Patented Feb. 6, 1912.

Application filed April 20, 1910. Serial No. 556,519.

*To all whom it may concern:*

Be it known that I, CARL RICHARD WALLER, a citizen of the United States of America, and a resident of Trenton, county of Mercer, and State of New Jersey, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

My invention relates to elastic fluid turbines, such for example as steam turbines, and particularly to combination high pressure and low pressure turbines of the impulse type. In such turbines it is customary to provide two series of nozzles, one for the high pressure working fluid, and the other for the low pressure working fluid, since for efficient working, nozzles specially formed according to the steam pressures used must be employed. Such turbines should be able to develop full rated horse power both when operating on low pressure working fluid, and when operating upon high pressure working fluid. The nozzles are customarily set in a circle, one portion of which, extending through a part only of its circumference, is occupied by the high pressure nozzles, and the remainder of which is occupied by the low pressure nozzles. It is obvious that in such a construction the turbine is incapable of developing as much power on steam of either pressure, as it could develop if nozzles for one pressure extended completely around the ring, and were set as closely together as is consistent with good working.

I have found that the two series of nozzles can be arranged in two concentric circles, the high pressure nozzles outside of, but registering with, the low pressure nozzles, and arranged to direct their jets of working fluid into the low pressure nozzles, said low pressure nozzles forming continuations of the high pressure nozzles, *i. e.*, being proportioned according to the same expansion law, as if they were physically parts of their corresponding high pressure nozzles, and having the same areas of cross-section that they would have if physically parts of their corresponding high pressure nozzles, so that each pair of high pressure and low pressure nozzles form in effect a single nozzle for the expansion of steam or other working fluid from the initial pressure at which the steam is received by the high pressure nozzles to a low pressure approximating that to which the low pressure steam is expanded by the low pressure nozzles when working alone; the combined nozzle thus produced being practically as efficient for high pressure fluid as if for the expansion of high pressure steam nozzles were provided adapted by their design to expand the steam down to the low pressure to which it is expanded by the high pressure and low pressure nozzles, working together as above described; the low pressure nozzles when operated on low pressure working fluid being nevertheless substantially as efficient, when expanding low pressure working fluid, as if the turbine were not provided with high pressure nozzles. I am thus able to obtain, in a single turbine, maximum power, whether working upon high pressure working fluid or upon low pressure working fluid, and the concentric arrangement of the two series of nozzles involves very little increase in size of the turbine, if any.

My invention consists therefore in two series of nozzles for different working fluids, arranged to register one with another, each two registering nozzles constituting together a single high pressure nozzle and one of them constituting by itself a low pressure nozzle; and my invention further consists in various other features of construction and arrangement, hereinafter described and particularly pointed out in the appended claims.

The objects of my invention are to cause a combination high pressure and low pressure turbine to develop full working power, whether operated upon high pressure working fluid or upon low pressure working fluid, to make the turbine efficient and to make it simple, compact, and easy to construct.

I will now proceed to describe my invention with reference to the accompanying drawings, illustrating more or less diagrammatically two embodiments of my invention.

In the drawings: Figure 1 shows a longitudinal section of a portion of a combination turbine such as referred to, the section being taken through one registering pair of nozzles, the construction shown being one in which the high pressure nozzles are adjustable axially. Fig. 2 is a similar view showing a construction wherein the high pressure nozzles are not adjustable axially.

Referring first to Fig. 1, 1 designates the casing of the turbine, 2 the rotor, 3 a bucket thereof, 4 a low pressure steam chest and 5 a high pressure steam chest. 6 designates a low pressure nozzle formed in a ring 7 set into an aperture in one wall of the low pressure steam chest, and 8 designates a high pressure nozzle registering with the low pressure nozzle, having in its sides openings 9 communicating with the high pressure steam chest, the end of the high pressure nozzle extending outward from the high pressure steam chest through a stuffing box 10, and having a hand wheel 11 whereby said high pressure nozzle may be screwed in or out so as to advance it into contact with the rear end of the low pressure nozzle, or to retract it away from such end of the low pressure nozzle, as desired. Within the high pressure nozzle a shut-off valve 12 is provided, said valve arranged to seat on the valve seat 13 of said nozzle and provided with a stem 14 and handle wheel 15 by which said valve may be retracted; and since, as shown, this valve stem 14 is itself carried by the high pressure nozzle, it will be seen that when the high pressure nozzle is retracted its shut-off valve is carried with it.

In operation, when the turbine is operating on low pressure working fluid, the high pressure nozzle is in its retracted position, and then low pressure working fluid from the low pressure steam chest may enter the low pressure nozzle and be expanded therein and directed thereby against the buckets of the rotor in the customary manner. When the turbine is to be operated upon high pressure steam, the high pressure nozzle is advanced until its end is against the end of the low pressure nozzle, or nearly so, and high pressure working fluid is admitted to the high pressure steam chest, and, valve 12 being away from its seat, such high pressure working fluid passes into the high pressure nozzle and thence into the low pressure nozzle, being expanded into such nozzles practically the same as if the two nozzles were one, and then impinges upon the buckets of the rotor.

If it be desired to operate the turbine with a few only of its low pressure nozzles in service, this can be accomplished by advancing the high pressure nozzles so that the latter cut off communication between their corresponding low pressure nozzles, and the low pressure steam chest, the high pressure nozzles then serving as valves for the low pressure nozzles.

In Fig. 2 I illustrate a somewhat simpler and alternative structure, wherein the high pressure nozzles, here designated by reference numerals 16, are not adjustable from the outside of the turbine, there being a considerable space 17 between the ends of the high pressure nozzles and the entrance of the low pressure nozzles. Two such nozzles, properly designed to work together, operate nearly as effectively, with this space 17 between them, as do the nozzles of Fig. 1 which are arranged so that one of said nozzles is moved into connection with the end of the other nozzle. But as there is apt to be some slight spreading of the steam jet from high pressure nozzle 16, beyond the limits of the entrance of the low pressure nozzle, the construction shown in Fig. 1, though slightly more complicated, is in general preferable.

It is to be noted that in the construction shown in Fig. 2, it is not intended or desired that there shall be any injector action of the steam from the high pressure nozzles when passing into the low pressure nozzles; that is to say, it is not intended that the high pressure nozzle discharge, in passing into the low pressure nozzles, shall draw from the space 4, for the effect of this would be to produce a partial vacuum in this space 4, which would be detrimental, and also would reduce the efficiency of the combined nozzles. Therefore, the form of the bore of the nozzles 6 is the same that it would be if these nozzles were physically continuous with nozzles 16, that is to say, if nozzles 16 were extended to engagement with nozzles 6, and also the cross-sectional area of nozzles 6 at different points is no greater than would be the case if nozzles 16 and 6 were continuous; also, nozzles 6 have no initial reversely-flared or reversely-tapering mouth portion, as they would have if there were to be injector action, but to the contrary, they have only the slight rounding at the mouth necessary, according to well-known laws of fluid flow, in order that when these nozzles 6 are being used by themselves, with low-pressure steam, such steam may enter the nozzles without shock, eddies, or wiredrawing.

As previously explained, the high pressure and low pressure nozzles, together, really constitute the real high pressure nozzles, but it is customary and convenient to speak of nozzles 8, (Fig. 1), or 16, (Fig. 2) as the high pressure nozzles in contradistinction to the nozzles 6, which are the low pressure nozzles.

It will be understood that the arrangement shown permits the operation of the turbine simultaneously upon high pressure and low pressure working fluid, as well as upon either the high pressure or the low pressure working fluid, and that as many of either group of nozzles may be in service as desired or required by conditions of operation. Automatic control of supply of working fluid to the steam chest may be effected by means such as shown and described in my patent applications Sr. Nos. 501,297 and 501,298.

The designs of the nozzles are such that

the low pressure nozzles, formed in the nozzle ring 7, are suitably proportioned to properly expand the working fluid from the pressure normally prevailing in the low pressure steam chest to that prevailing in the rotor chamber of the turbine into which such low pressure nozzle discharges the working fluid; and that the high pressure nozzles are so proportioned that when a high pressure nozzle and its corresponding low pressure nozzle are working together, that is to say, when the high pressure nozzle is discharging into the low pressure nozzle, the working fluid will be properly expanded from the pressure normally prevailing in the high pressure steam chest, to that normally prevailing at such times in the chamber to which the low pressure nozzle discharges.

What I claim is:—

1. In an elastic fluid turbine, the combination of a high pressure chest, a low pressure chest, a rotor, a low pressure nozzle arranged to conduct low pressure working fluid from the low pressure chest to the rotor, and a high pressure nozzle in line with the low pressure nozzle and arranged to project high pressure working fluid from the high pressure chest into the bore of the low pressure nozzle, the bore of said low pressure nozzle of such diameter and form that it constitutes substantially a continuation of the high pressure nozzle, as to expansion of the working fluid discharged into it by the high pressure nozzle, the two nozzles together forming a combined high pressure nozzle adapted to expand the high pressure working fluid to a low terminal pressure.

2. In an elastic fluid turbine, the combination of a high pressure chest, a low pressure chest, a rotor, a low pressure nozzle arranged to conduct low pressure working fluid from the low pressure chest to the rotor, and a high pressure nozzle in line with the low pressure nozzle and arranged to project high pressure working fluid from the high pressure chest into the bore of the low pressure nozzle, said low pressure nozzle forming substantially a continuation of the high pressure nozzle and at its mouth being devoid of reverse flare adapted to produce injector action, the two together forming a combined high pressure nozzle adapted to expand the high pressure working fluid to a low terminal pressure.

3. In an elastic fluid turbine, the combination of a high pressure chest, a low pressure chest, a rotor, a low pressure nozzle arranged to conduct low pressure working fluid from the low pressure chest to the rotor, and a high pressure nozzle in line with the low pressure nozzle and arranged to project high pressure working fluid from the high pressure chest into the bore of the low pressure nozzle, said low pressure nozzle forming substantially a continuation of the high pressure nozzle, the two together forming a combined high pressure nozzle adapted to expand the high pressure working fluid to a low terminal pressure, said high pressure nozzle movable toward and from the low pressure nozzle, and means for so moving it.

4. In an elastic fluid turbine, the combination of a high pressure chest, a low pressure chest, a rotor, a low pressure nozzle arranged to conduct low pressure working fluid from the low pressure chest to the rotor, a high pressure nozzle in line with the low pressure nozzle and arranged to project high pressure working fluid from the high pressure chest into the bore of the low pressure nozzle, said high pressure nozzle arranged to move longitudinally from a position in which its discharge end engages with the receiving end of the low pressure nozzle to a position in which a considerable distance separates the adjacent ends of the two nozzles, whereby said high pressure nozzle forms a valve for the low pressure nozzle, and means for so moving said high pressure nozzle.

5. In an elastic fluid turbine, the combination of a high pressure chest, a low pressure chest, a rotor, a low pressure nozzle arranged to conduct low pressure working fluid from the low pressure chest to the rotor, a high pressure nozzle in line with the low pressure nozzle and arranged to project high pressure working fluid from the high pressure chest into the bore of the low pressure nozzle, said high pressure nozzle arranged to move longitudinally from a position in which its discharge end engages with the receiving end of the low pressure nozzle to a position in which a considerable distance separates the adjacent ends of the two nozzles, whereby said high pressure nozzle forms a valve for the low pressure nozzle, means for so moving said high pressure nozzle, and an axial shut-off valve for the high pressure nozzle, carried thereby and adapted at will to open or close the bore of said high pressure nozzle.

6. In an elastic fluid turbine, the combination of two nozzles in series, arranged to coöperate with one another, and arranged to in effect form a single nozzle, the second nozzle corresponding in diameter and form of bore to the first nozzle and arranged to expand working fluid according to the same law as the first nozzle, one of said nozzles also arranged to be used independent of the other.

7. In an elastic fluid turbine, the combination of a steam chest, a nozzle leading therefrom and another nozzle leading into said steam chest and arranged, when in operation, to discharge into said first-named

nozzle, said two nozzles proportioned as to form and size of bore according to the same law to act together upon the same stream of working fluid and forming in effect a single nozzle adapted to expand the working fluid by joint action, to a low terminal pressure.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

CARL RICHARD WALLER.

Witnesses:
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F. R. ZELLEY.