

Aug. 6, 1929.

G. B. WARREN ET AL

1,723,104

ELASTIC FLUID TURBINE

Filed Aug. 11, 1924

2 Sheets-Sheet 1

Fig. 1.

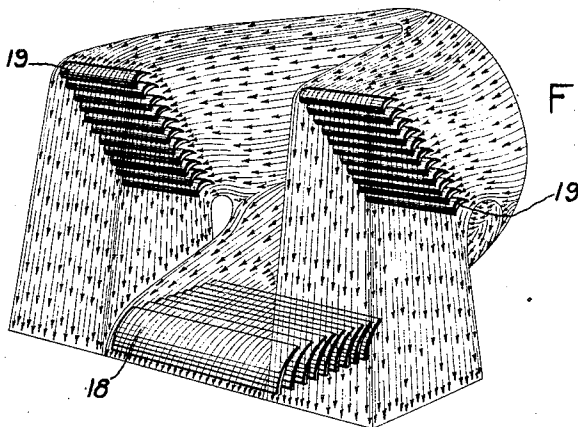
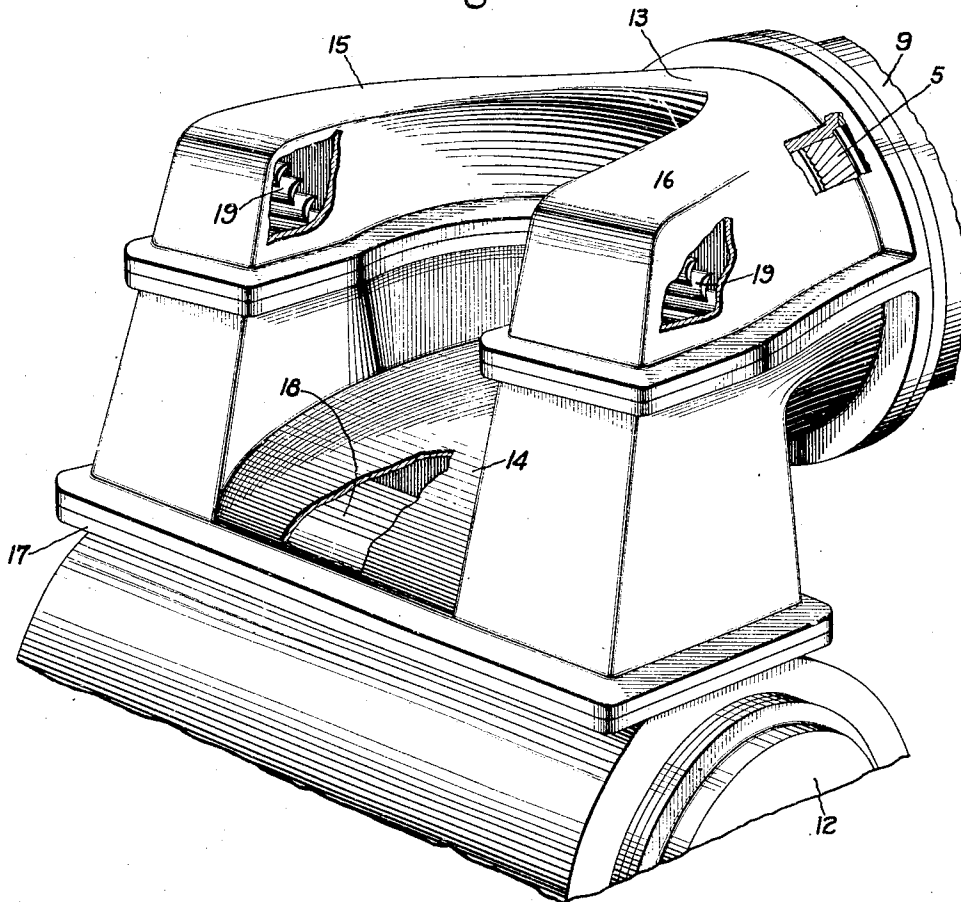


Fig. 2.

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Their Attorney

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2 Sheets-Sheet 2

Fig. 3.

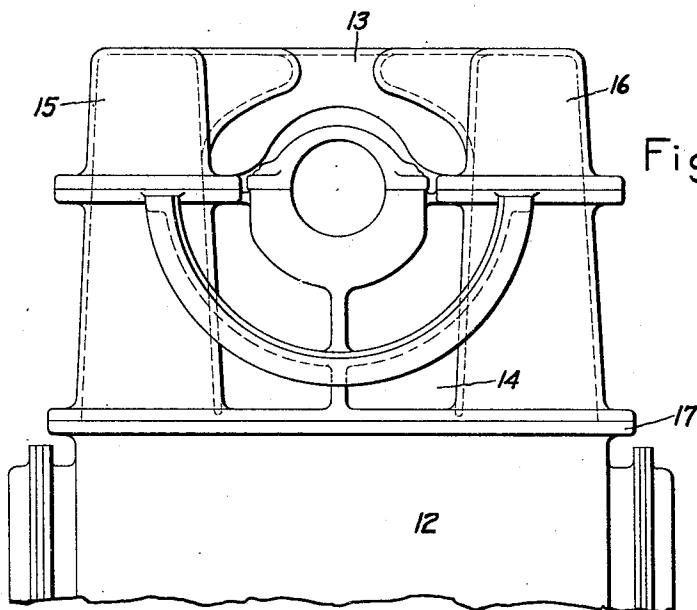
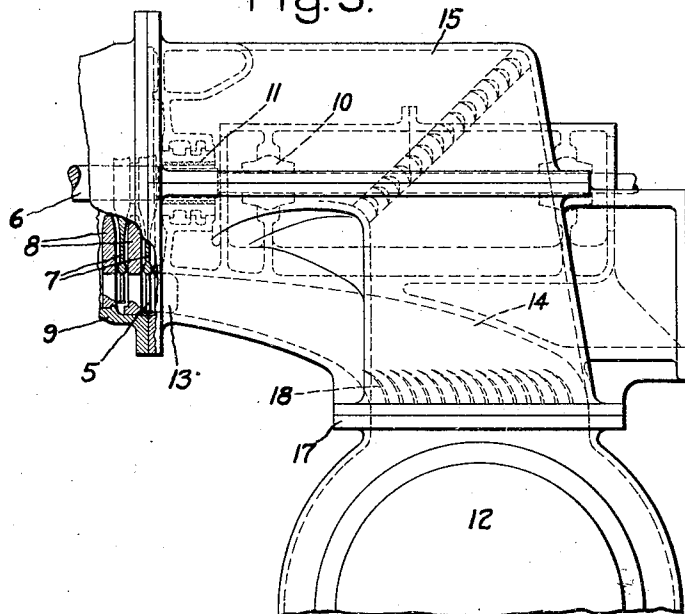


Fig. 4.

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Their Attorney.

UNITED STATES PATENT OFFICE.

GLENN B. WARREN AND HARRISON L. WIRT, OF SCHENECTADY, NEW YORK, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC FLUID TURBINE.

Application filed August 11, 1924. Serial No. 731,239.

The present invention relates to elastic fluid turbines and especially to turbines of relatively large capacities operating condensing, that is, exhausting into a condenser.

5 With the best modern engineering practice it is possible to maintain in a condenser under ordinary operating conditions, a vacuum of from $28\frac{1}{2}$ " to 29" of mercury which correspond to absolute pressures of $11\frac{1}{2}$ " to 1" of
10 mercury, the main limiting feature being the temperature of the cooling water available, and at present there appears to be little likelihood that this can be improved upon so that the possible condenser pressure seems fixed.
15 The thing of importance in connection with a condensing turbine is not the absolute pressure in the condenser, however, but rather the absolute pressure just beyond the last row of buckets and it has been the practice to try to
20 keep this pressure as near to the condenser pressure as possible. Furthermore, it has been recognized that if this pressure could be reduced below that existing in the condenser it would result in an increase in the efficiency
25 of the machine.

However, in the case of large turbines, the volume of exhaust fluid to be handled is enormous and in ordinary practice the pressure on the discharge side of the last row of buckets
30 has been somewhat greater than the condenser pressure, the increase being represented by the drop in pressure required to convey the exhaust fluid from the last row of buckets through the exhaust hood to the condenser.
35 In modern practice, this drop in pressure is of the order of 0.05" mercury to 0.15" mercury.

Also, in a turbine, the elastic fluid leaves the last row of buckets with a certain velocity, this velocity being required in order for the
40 elastic fluid to pass the last row of buckets, and the kinetic energy carried away by the elastic fluid stream by virtue of this velocity is termed, usually, the leaving loss. This kinetic energy is expressed by the formula
45 $E = \frac{1}{2}MV^2$ where E is the kinetic energy, M the mass, and V the velocity. Thus, it will be seen that the leaving loss increases with the square of the velocity which means, of course, that the velocity of the elastic fluid leaving
50 the last row of buckets should be kept as low as possible. In order to pass a given quantity of elastic fluid through the last bucket row, the velocity required varies inversely in accordance with the total bucket area so that it
55 is readily seen that by increasing the bucket

area, i. e., the length of the buckets and the diameter of the bucket ring, the velocity and, hence, the leaving losses are decreased. However, the permissible bucket ring diameters and bucket lengths are soon reached due to
60 mechanical considerations so that with large machines the leaving loss may be considerable, the leaving velocity being usually of the order of 700 ft. per second.

Now, it is apparent that if the energy represented by the leaving loss could be usefully employed, it would result in a gain in the efficiency of the machine and it has been proposed repeatedly to utilize this energy to decrease the pressure on the discharge side of
70 the last row of buckets by means of passing the exhaust elastic fluid through diffusers or passages which would serve to convert a portion of the velocity into pressure. By this means the kinetic energy of the exhaust fluid
75 would be used to effect the flow of the exhaust fluid to the condenser so that it would be possible to have a pressure on the discharge side of the last row of buckets which is lower than the condenser pressure.
80

In the application of Harrison L. Wirt, Serial No. 731,240, filed of even date herewith, there is disclosed a construction whereby the above-referred to result is obtained.
85 Such a construction comprises essentially an exhaust housing which comprises first an annular pasageway having an admission end of a radial width between walls, that is a difference between the inner and outer radii, equal substantially to the length of the buckets
90 of the last bucket row and a length preferably throughout its entire circumference but at least throughout the major portion of its circumference equal to at least twice the length of the buckets of the last bucket row
95 followed by a plurality of branches which change gradually from curved or semiannular passageways to approximately circular or rectangular passageways before reaching the condenser, such change taking place very
100 gradually with a continual increase in cross sectional area and without changing substantially the direction of the fluid flow until the greater portion of the diffusion has taken place. In accomplishing this result, it was
105 found, as pointed out in such application, that for the usual leaving velocities found in present day turbine design, an exhaust passage length equal to at least twice the diameter of the last stage wheel is required, and that the
110

area should increase until the final area perpendicular to the elastic fluid flow is of the order of two or three times as much as the annular admission area.

5 In the Wirt application referred to, the invention is shown as being carried out in connection with an elastic fluid turbine having two vertical condensers, one placed at each side of the axis of the turbine, there being
10 two branch passageways, one leading to each condenser, and such passageways being substantially straight. In some installations, however, for example when it is desirable that the condenser be horizontal and placed
15 beneath the plane of the turbine shaft, it is not so convenient from a manufacturing standpoint to utilize substantially straight passageways, and the primary object of our present invention is to provide an improved
20 construction whereby, while obtaining the advantages of the invention set forth in said Wirt application, we are enabled to utilize passageways which turn the exhaust fluid through substantially a right angle on its
25 way to the condenser.

A further object of our invention is to provide an improved exhaust hood for an axial flow turbine exhausting into a horizontal condenser.

30 For a consideration of what we believe to be novel and our invention, attention is directed to the following description and the claims appended thereto.

In the drawing, Fig. 1 is a perspective view
35 of a turbine construction embodying our invention; Fig. 2 is a diagrammatic view illustrating the elastic fluid flow; Fig. 3 is a side elevation of the construction illustrated in Fig. 1, and Fig. 4 is an end view of the construction shown in Fig. 3.

Referring to the drawing, 5 indicates the last row of buckets of an elastic fluid turbine 9, which turbine may be of any suitable type. In the present instance, it is shown as being
45 of the impulse type and as comprising a shaft 6 upon which are mounted bucket wheels 7 which rotate in stages formed by nozzle diaphragms 8. The bearing of shaft 6 at the low pressure end of the machine is indicated at 10 and the low pressure packing at 11. The condenser for the turbine is indicated at 12. Only the low pressure end of the turbine is shown in the drawing. It will be understood that the particular structure indicated is only
55 by way of example and is to be taken as typical of any suitable turbine structure to which our invention may be applied.

According to the particular embodiment of the invention illustrated in the drawing,
60 the elastic fluid is conveyed from the last bucket row 5 to condenser 12 by an exhaust housing which comprises first an annular expanding passageway 13 having an admission end of a radial width between walls, i. e.,
65 a difference between the inner and outer ra-

dii, equal substantially to the length of the buckets of the last bucket row and a length equal to at least twice the length of the buckets of the last bucket row, followed by three
70 branches 14, 15 and 16 which convey the elastic fluid from annular passageway 13 to opening 17 of the condenser. The branch 14 forms a passageway which conveys the elastic fluid from the lower part of annulus 13 to the condenser opening. This passageway is smoothly
75 curved downward with a gradual increase in cross section and is then cut off slantingly with respect to its center line and parallel to the axis of the turbine and discharges the stream at an angle of preferably about 30
80 degrees with the axis of the turbine. For directing the elastic fluid vertically downward into the condenser we may provide suitable blades 18 having a curvature such as to turn the elastic fluid through the desired angle,
85 and at the same time provide an increase in cross-sectional area and thereby obtain some additional diffusion.

Branches 15 and 16 provide two passageways which trend slightly to either side of
90 the center line and serve to convey the elastic fluid from the upper portion (preferably about the upper two-thirds) of annulus 13 to the condenser. These passageways gradually increase in area and extend in a substantially axial direction to a point directly over
95 condenser opening 17 at which point they turn abruptly downward and lead into the condenser opening on each side of passageway 14. At the bend in passageways 15 and 16, there are provided blades 19 which serve to turn the elastic fluid through a right angle and direct it smoothly from flow in a substantially horizontal direction to flow in a substantially vertical direction. The total
100 length of the passageways formed by branches 15 and 16 is equal approximately to twice the diameter of the last stage wheel, and we have found by making the passageways of such length and providing an abrupt
110 right angle turn with suitable blades for assisting in the turning of the elastic fluid that conversion of velocity into pressure can be effected. On the other hand, we have demonstrated by experiments that conversion
115 cannot be effected while gradually changing the direction of flow of the elastic fluid. We consider the utilization of a passageway having an abrupt right angle turn with blades for assisting in the turning of the elastic
120 fluid as being an important feature of our invention.

Fig. 2 shows diagrammatically the distribution of the flow in annulus 13 and the three
125 branches 14, 15 and 16, and the manner in which the blades 18 and 19 serve to change the direction of flow and it will be seen that flow at all times is in substantially straight lines. The greatest pressure regain occurs in the first part of the diffuser passages due to
130

the fact that the pressure and energy regain is proportional to the change in the squares of the velocity. The annular passageway 13 followed by the substantially straight portions of the passageways provided by the branches enables the principal part of the diffusion to take place before the direction of flow of the elastic fluid is changed.

By our above described arrangement, we are enabled to provide an exhaust hood in which diffusion will take place while at the same time the accessibility of the low pressure bearing and the low pressure packing is maintained. Also the location of the driven machine, such as a generator for example, directly adjacent to the low pressure end of the turbine, is not interfered with.

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

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

1. The combination with an elastic fluid turbine and a condenser located to one side of the axis of the turbine, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising a plurality of passageways which increase gradually in area and which extend first for a distance of the order of two last stage rotor diameters in the general direction of the flow of elastic fluid from the turbine and then turn abruptly to where they join the condenser, and blades at the points of turning for changing the direction of flow of fluid in the passageways.

2. The combination with an elastic fluid turbine and a condenser located to one side of the axis of the turbine, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising an annulus followed by a plurality of branches which form passageways which increase gradually in area and which extend first for a distance of the order of two last stage rotor diameters in the general direction of the flow of elastic fluid from the turbine and then turn abruptly to where they join the condenser, and blades at the points of turning for changing the direction of flow of fluid in the passageways.

3. The combination with an elastic fluid turbine and a condenser located in a plane below the turbine and having an inlet opening, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising an annulus which receives the elastic fluid from the last bucket row and three branches to which

the annulus discharges, one of said branches conveying elastic fluid from the lower portion of the annulus to the central portion of the condenser opening, and the other branches conveying elastic fluid from the upper portion of the annulus to the condenser opening on either side of the first branch.

4. The combination with an elastic fluid turbine and a condenser located in a plane below the turbine and having an inlet opening, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising an annulus which receives the elastic fluid from the last bucket row and three branches to which the annulus discharges, one of said branches conveying elastic fluid from the lower portion of the annulus to the central portion of the condenser opening, and the other branches conveying elastic fluid from the upper portion of the annulus to the condenser opening on either side of the first branch, said branches which convey fluid from the upper portion of the annulus having a part which extends to a point over the condenser followed by a downwardly extending part.

5. The combination with an elastic fluid turbine and a condenser located in a plane below the turbine and having an inlet opening, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising an annulus which receives the elastic fluid from the last bucket row and a plurality of branches to which the annulus discharges, said annulus and branches increasing gradually in area and serving to convey the exhaust elastic fluid away from the last bucket row and expand it without changing materially its direction of flow, and said branches then turning to where they join the condenser opening.

6. The combination with an elastic fluid turbine and a condenser located in a plane below the turbine and having an inlet opening, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the condenser, said housing comprising an annulus which receives the elastic fluid from the last bucket row and a plurality of branches to which the annulus discharges, said annulus and branches increasing gradually in area and serving to convey the exhaust elastic fluid away from the last bucket row and expand it without changing materially its direction of flow, said branches then turning to where they join the condenser opening, and blades at the points of turning for changing the direction of flow of fluid in the branches.

7. The combination with an elastic fluid turbine and a condenser located in a plane below the turbine and having an inlet opening, of an exhaust housing for conveying exhaust elastic fluid from the turbine to the

condenser, said housing comprising an annulus which receives the elastic fluid from the last bucket row and a plurality of branches to which the annulus discharges, said
5 branches increasing gradually in area and diverging from each other without substantial change in direction and then turning to

where they join the condenser opening, and bearing means for the turbine located in the space between said branches. 10

In witness whereof, we have hereunto set our hands this 9th day of August, 1924.

GLENN B. WARREN.
HARRISON L. WIRT.