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CENTRIPETAL TURBINE

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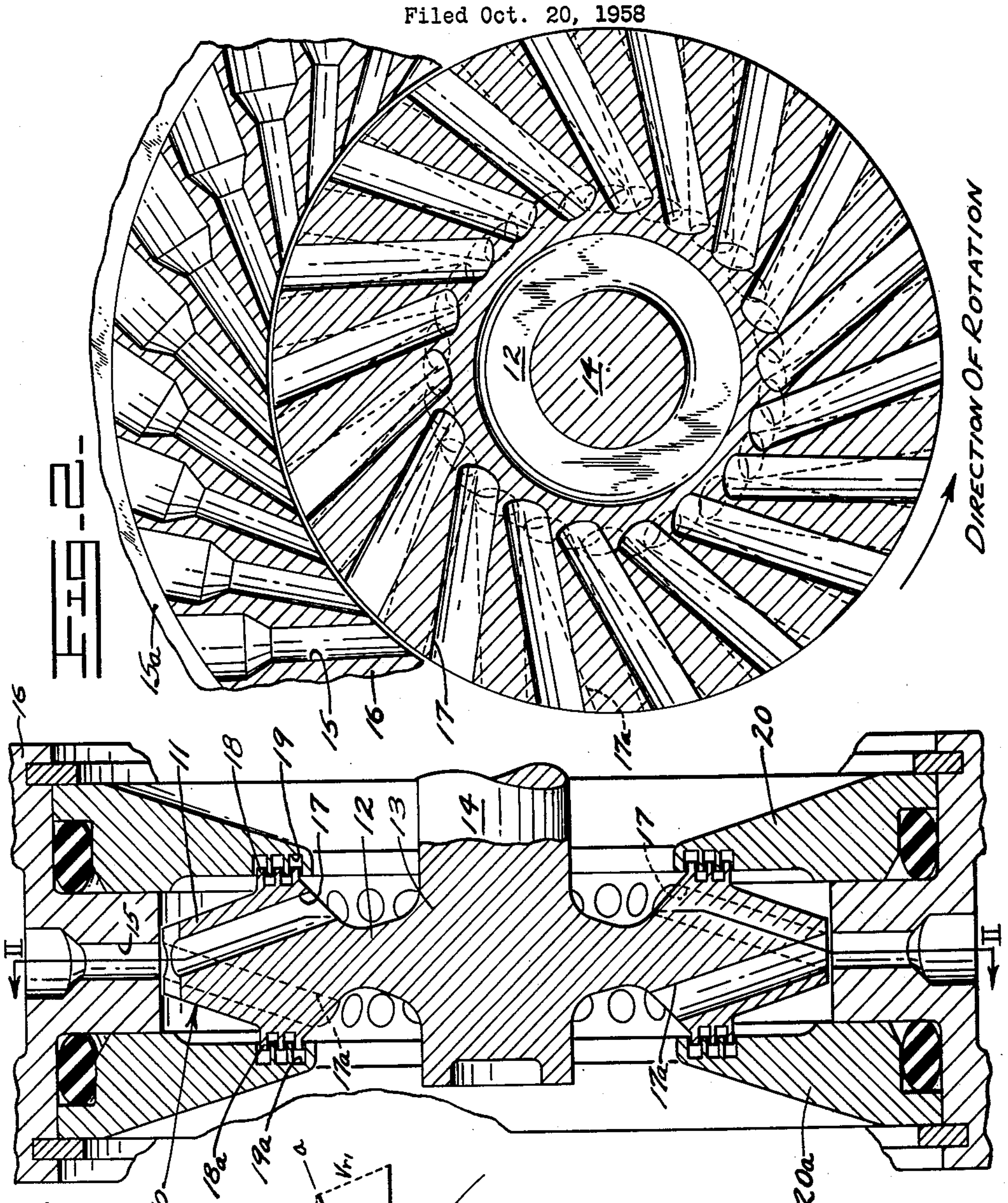

Fig. 2

Fig. 1

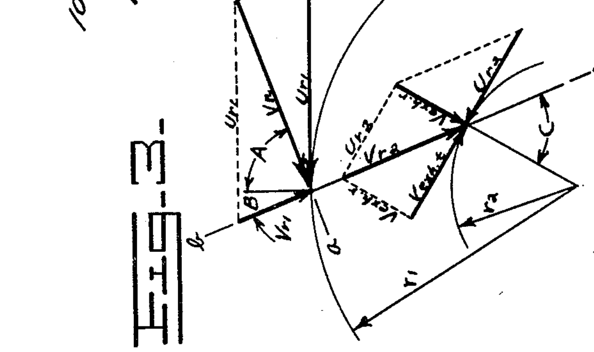

Fig. 3

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CENTRIPETAL TURBINE

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This invention relates to centripetal-type turbines, and particularly to rotor and nozzle structures for gas or fluid turbines, in which operating fluid passages therein are formed by drilling to provide a durable, easily manufactured high speed prime mover of good efficiency.

The blades, buckets, or vanes of conventional gas turbine nozzles and rotors are usually formed by stamping, precision forging, investment casting or by intricate contour machining; all of which involve costly manufacturing procedures. They also often present additional assembling and balancing problems of considerable complexity. Furthermore, lack of symmetry in conventional centripetal turbine rotors results in distortion and excessive stresses at high rotative speeds. These stresses are further aggravated by unbalanced exposure to high temperature gases. Furthermore, in blade-type constructions the blades are relatively thin in cross-section and are subject to fatigue failures resulting from aerodynamically excited vibrations which occur during high-speed operation. A further disadvantage with most blade-type rotor and nozzle designs is that the operating passages formed between the blades are all open to one side of the rotor, which results in turbulence and leakage and in appreciable axial thrust loads on the rotor shaft bearings causing undesirable friction and added possibility of eventual failure of the turbine.

It is, therefore, an object of the present invention to provide a turbine nozzle and rotor, each being of unitary or integral construction which is relatively simple to manufacture and which would require a minimum of additional assembling procedures.

Another object of this invention is to provide a unitary turbine rotor and a unitary nozzle which are relatively free of distortion caused by heat and high-speed operation.

Still another object of this invention is to provide a turbine rotor comprising a unitary body member having a plurality of circumferentially arranged passages therein which eliminate the possibility of fatigue failure from aerodynamically excited vibration.

A further object of this invention is to provide a turbine rotor wherein a plurality of circumferentially arranged operating passages open at their outlet ends alternately to opposite sides of the rotor virtually to eliminate axial thrust on the rotor shaft.

A still further object of this invention is to provide a turbine rotor wherein a plurality of circumferentially arranged drilled operating passages inclined from radial directions alternately open at their outlet ends to opposite sides of the rotor to permit the maximum number of passages to open about the outer periphery of the rotor.

Another object of this invention is to provide a centripetal turbine assembly wherein a minimum amount of the energy in the high velocity fluid stream issuing from the nozzle can bypass the rotor or be dissipated in turbulence and slip at clearance gaps between open sided rotor passages and stationary walls.

Other objects and advantages of this invention are made apparent in the following description wherein reference is made to the accompanying drawings.

In the drawings:

FIG. 1 is a central longitudinal sectional view through the rotor and nozzle of a turbine embodying the present invention;

FIG. 2 is a transverse sectional view of the same rotor

and nozzle taken along the line II—II of FIG. 1; and

FIG. 3 is a vector diagram illustrating the manner in which design factors of the turbine are selected.

As shown in FIG. 1 of the drawings, a turbine rotor **10** comprises an outer ring portion **11**, web member **12** of reduced cross section, and a hub member **13** which is preferably integral with a supporting shaft **14**. Hub **13** may, however, be separate from and secured to shaft **14** by conventional means. Rotor **10** is adapted to be driven by any gaseous fluid discharged from a plurality of radially inclined drilled passages **15** in a nozzle ring **16** which is located about the outer periphery of rotor **10**. Gas from any suitable source is supplied to the passages **15** through a circumscribing manifold partially shown at **15***a*.

A plurality of drilled passages indicated at **17** and **17***a* are aligned and closely spaced at their inlet ends about the outer periphery of ring **11** and align with the outlet ends of passages **15** in nozzle **16**. Passages **17** and **17***a* extend inwardly toward shaft **14** at corresponding angles from a plane normal to the axis of shaft **14** to permit the outlet ends of the passages to open alternately on opposite sides of web **12**. This arrangement assures that no axial thrust will be transmitted to shaft **14** by the gas exhausted from passages **17** and **17***a*. This arrangement also permits the employment of a maximum number of passages closely spaced around the outer periphery of ring **11** without interference at their ends nearest web **12**. A plurality of annular fins **18** and **18***a* formed integrally on opposite sides of rotor **10** mate with corresponding annular grooves **19** and **19***a* in a pair of side plates **20** and **20***a* fixed with relation to the nozzle ring **16**, thus forming a labyrinth seal to minimize the leakage of gas around the turbine rotor.

As best shown in FIG. 2 of the drawings, each passage **15** in nozzle **16** is inclined in a direction coinciding with the direction of rotation of rotor **10** and at an angle to a radial plane passing through its inlet opening and intersecting the axis of shaft **14**. The velocity component of the gases from the outlets of passages **15** is in a direction along the axes of passages **17** and **17***a* of rotor **10**. Each of the passages **17** and **17***a* is oppositely inclined or inclined in the direction of rotation of rotor **10** at an angle from a radial plane passing through its inner openings. Both of these angles of inclination can be selected in the design of a given rotor and nozzle depending upon the rotor speed and gas pressure ratio from the inlet to the outlet in order that the tangential component of the velocity of the exhausted gas will be equal and opposite to the tangential velocity of rotor **10** at the outlet of passages **17** and **17***a*. As a result, the gas will be exhausted radially from rotor **10** with little or no whirl, a requirement necessary for optimum efficiency in converting energy in the gas to shaft power.

An example of the manner in which the design factors are selected to obtain the foregoing results is illustrated in FIG. 3.

The vector diagram in FIG. 3 shows the velocity pattern of the nozzle and rotor. *a—a* is the axis of the nozzle passages which have an angle A from a plane radial to the rotor at their exit. V*n* is the velocity of gas flow through the outlet area of the nozzle passages. Ur_1 is the tangential velocity of the turbine rotor at radius r_1 of the outer end of the turbine rotor passage.

V*r* is the resulting velocity component of the gases entering the turbine rotor passage. By proper design of the passage and selection of the angle A in the manner well understood by designers of turbine machinery, Vr_1 is made to align with axis *b—b* of the passages in the rotor which are at an angle B from a plane radial to the rotor at radius r_1.

The gas flowing inwardly in the rotor does so against the centrifugal pressure field of a fluid-filled rotating system and to do so will expand. Therefore, the expanding gas must accelerate as it flows inwardly within the constant cross-section of the rotor passages. The gases attain an outlet velocity relative to the rotor of Vr_2 at radius r_2, the outlet radius of the rotor. This outlet velocity makes angle C from radial at r_2. Ur_2 is the tangential velocity of the rotor at the passage outlet. Proper selection of angles A, B, and C for a chosen rotor speed and gas pressure ratio from inlet to outlet of the machine will result in Vr_2 having a tangential exhaust component $Vexh._t$ equal and opposite to Ur_2. Then the absolute exhaust velocity from the turbine rotor $Vexh._r$ will be exactly radial with no tangential or whirl component.

I claim:

1. A turbine rotor comprising a hub, a web portion, an annular outer portion of greater thickness than the web portion all formed of a single piece of metal and straight drilled passages extending from the outer periphery of the outer portion to the space between the hub and outer portion, said passages terminating alternately

on opposite sides of the web portion whereby they may be closely spaced at the periphery without intersecting each other as they extend inwardly.

2. A turbine rotor comprising a hub, a web and a concentric annular outer portion all formed as an integral unit and drilled passages entering the periphery of the outer portion in alignment and extending alternately in opposite directions toward the opposite sides of the web.

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