United States Patent [19]

Morf

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[54] **GAS TURBINE**

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[52] **U.S. Cl.** **415/203**; 415/186

[51] **Int. Cl.**[2] **F01D 1/08**

[58] **Field of Search** 415/202, 203, 205, 204, 415/186, 80, 211; 416/185, 186, 178

[56] **References Cited**

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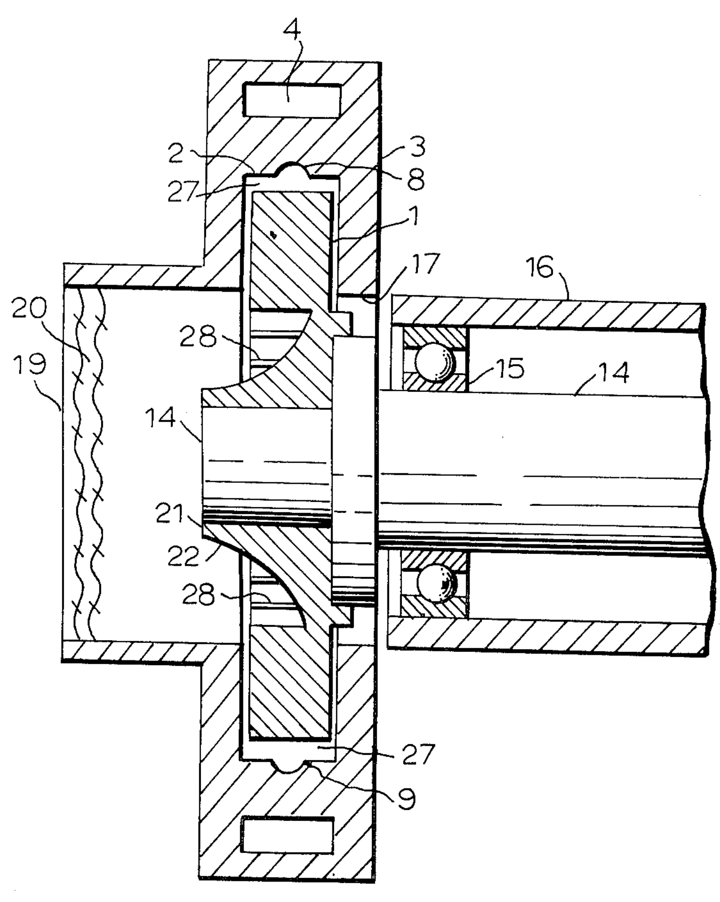
Attorney, Agent, or Firm—Sherman & Shalloway

[57] **ABSTRACT**

A quiet, high-speed gas turbine having a peripheral supply groove in the housing to supply the motive gas from an injector inlet to a plurality of blades simultaneously. The supply groove decreases in radial depth from the injector inlet to a point of extinction. The turbine blades are arranged to meet the motive gas at a very low angle of attack ranging from parallel, on one leading surface, to 20° or less on the other leading surface.

6 Claims, 5 Drawing Figures



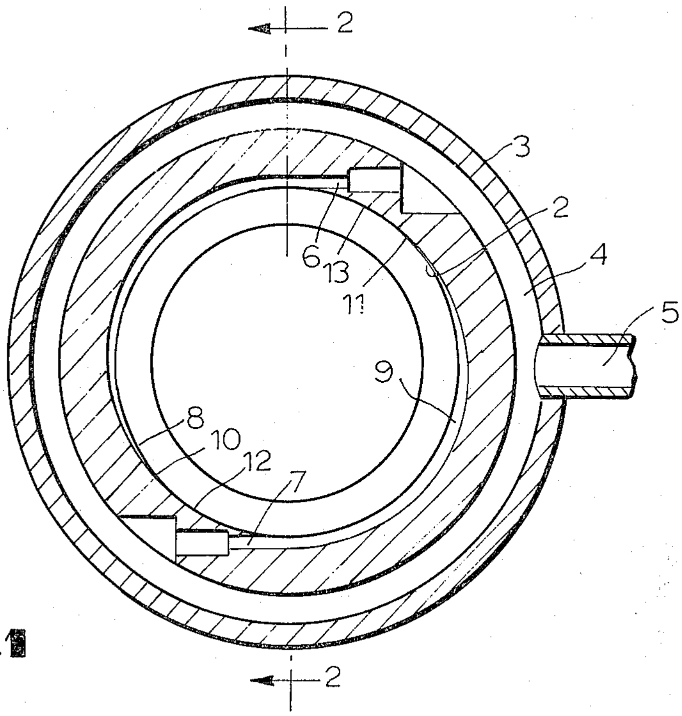


FIG.1

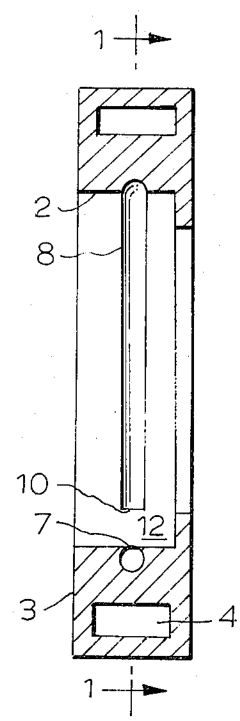


FIG.2

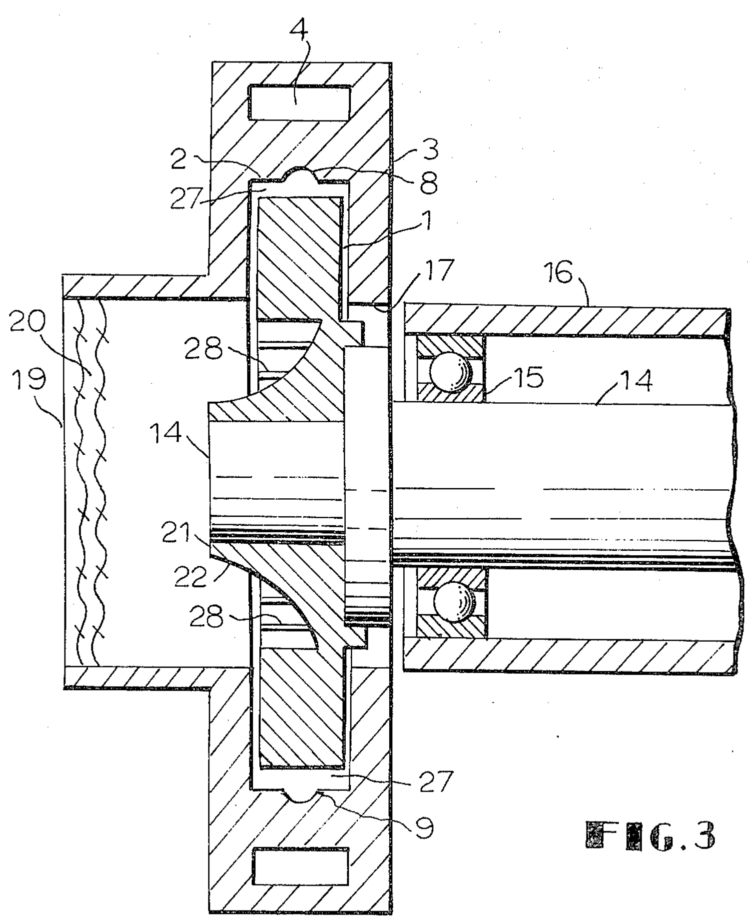


FIG.3

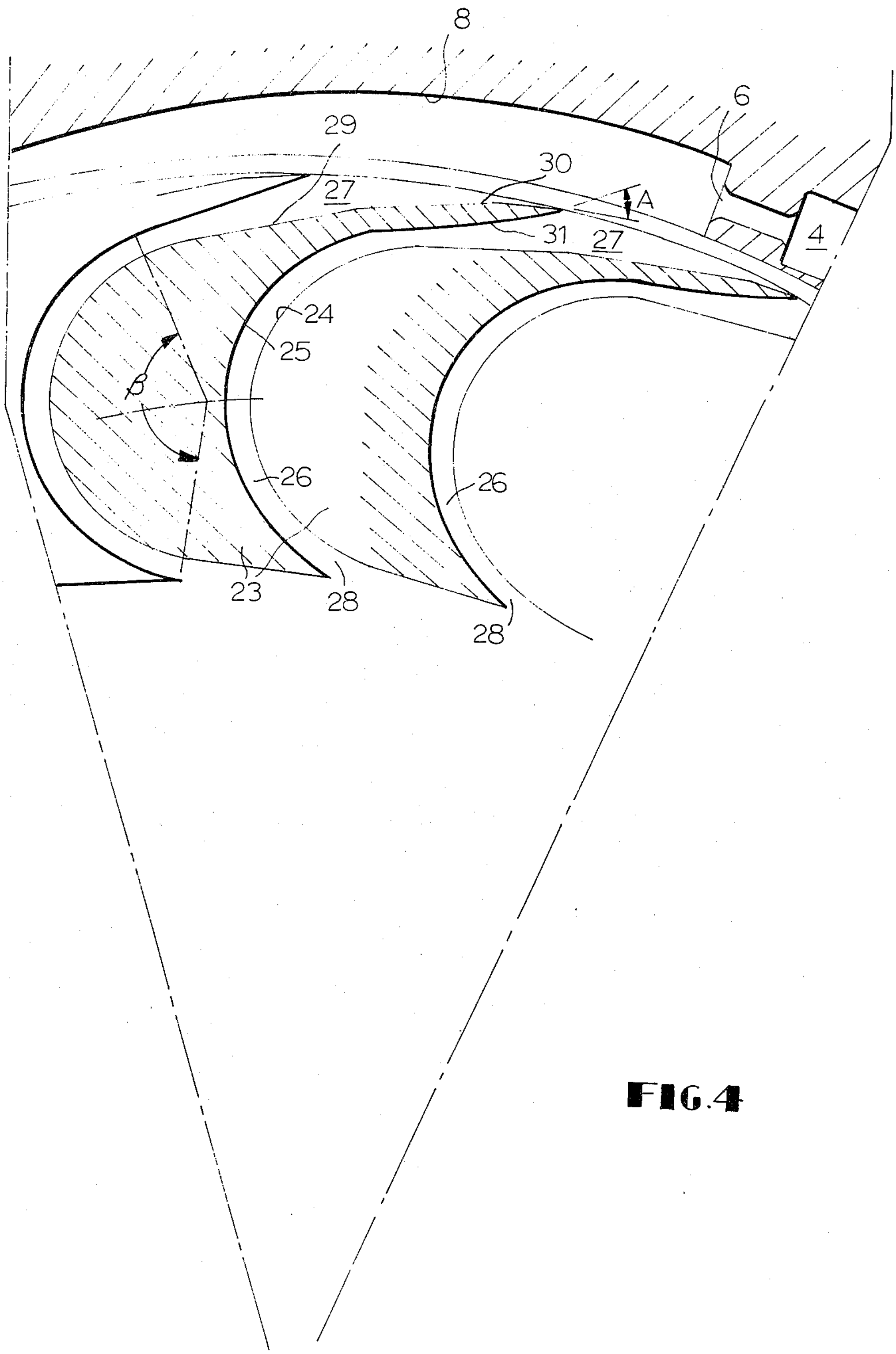


FIG. 4

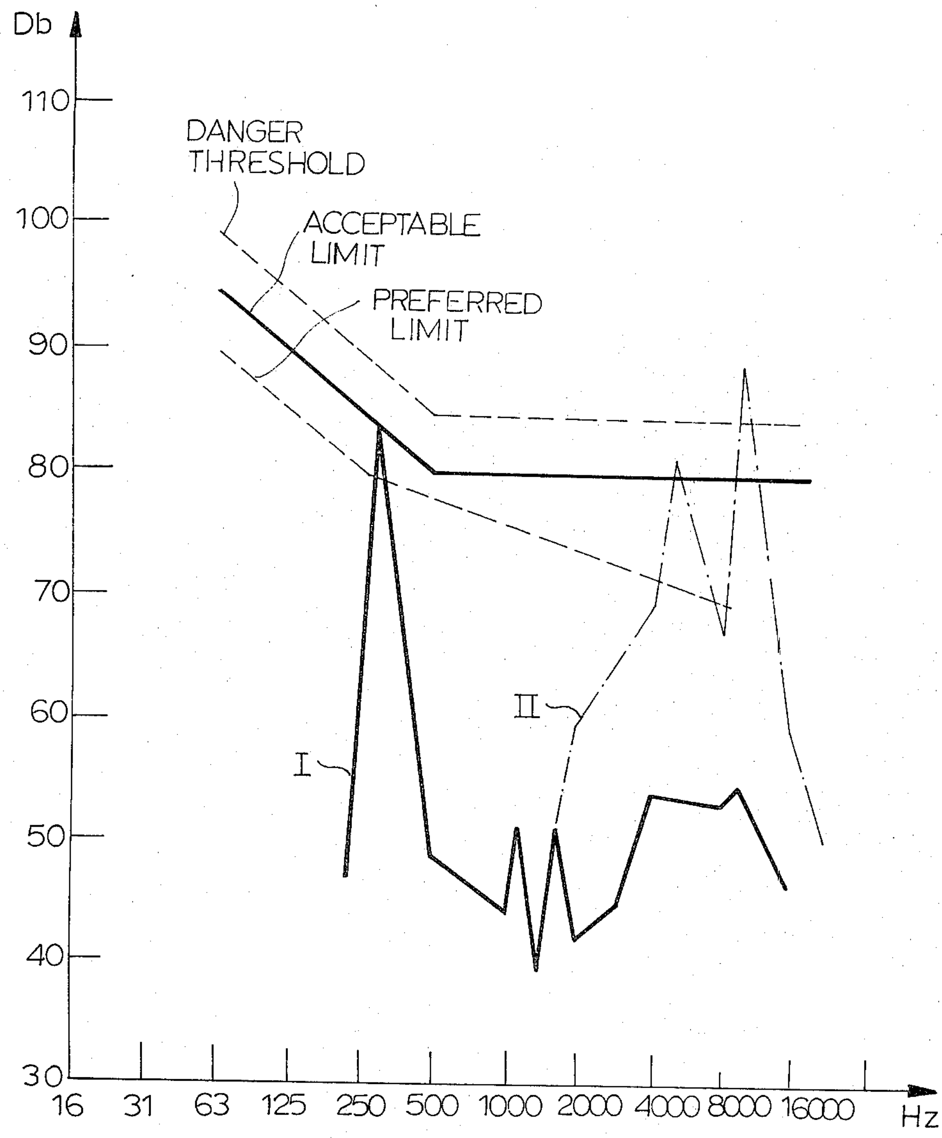

Db
110
100
90
80
70
60
50
40
30
DANGER
THRESHOLD
ACCEPTABLE
LIMIT
PREFERRED
LIMIT
I
II
16
31
63
125
250
500
1000
2000
4000
8000
16000
Hz

FIG.5

GAS TURBINE

BACKGROUND OF THE INVENTION

The present invention relates to fluid-driven turbines and is concerned, more particularly, with a turbine driven by gaseous fluid at high rotational speeds without problematical noise.

BRIEF DISCUSSION OF THE PRIOR ART

A variety of gaseous fluid turbines have been tried with varying degrees of effectiveness. One of the better turbines now available includes blades which are shaped for efficient conversion of the energy of the compressed, motive gas into useful torque and having a peripheral feed channel which decreases in depth and cross-sectional area from the motive gas inlet to a termination of extinction point and which opens to a plurality of blades. This type of turbine is disclosed in French Pat. No. 1,063,861.

However, even these improved turbines have not proved to be entirely satisfactory, particularly in terms of noise at high speeds, such as are necessary in the textile industry.

In the high-speed winding of yarns upon bobbins, the fluid turbine is required to operate at extremely high speeds of from several thousand RPM up to one hundred thousand RPM. At such speeds, the motive gas may be fed at supersonic velocities and high pressures. The resultant noise level can be dangerous or, at least, unbearable so that the applicability and versatility of prior turbines in this service has been quite limited.

Other problems are encountered with turbine drives in the textile industry.

When used for bobbin winding, the changing diameter of the wound bobbin imposes a speed-change on the turbine, since it is usual to maintain a uniform speed of the periphery of the increasing diameter of winding to produce a uniform yarn speed. Therefore, the turbine is required to have a relatively "flat" torque curve through this range in which it must operate.

High-pressure turbines, which work at inlet pressures of 3 to 8 bars, are best suited in this regard since they exhibit flat torque curves within their effective range. However, these high-pressure turbines have a disadvantage in being quite inefficient at the lower speeds.

Furthermore, these problems are coupled with fabrication and constructional problems which are encountered with the small diameters and minute clearances necessary in the relatively small turbines to be used for winding bobbins.

Therefore, a need has existed for a turbine which will deliver the torque requirements economically and without the production of hazardous noise levels.

SUMMARY OF THE INVENTION

In general, the preferred form of the present invention includes a bladed turbine wheel journalled in a closely-fitting rotor chamber in a housing, at least one injector in the housing for presenting motive gaseous fluid to the periphery of the turbine wheel, a supply channel in the housing and extended from the injector about the periphery of the rotor chamber a distance greater than the distance between adjacent blades of the turbine wheel, the supply channel being tapered over its length from adjacent the injector to a terminal point, the blades of the turbine wheel being open at the periphery of the wheel to receive motive fluid from the injector and the supply channel.

The blades of the turbine wheel are curvate and include both a generally convex wall and a generally concave wall, the radially-outer portion of the convex wall terminating in an intake section which is tangential to the motive gas stream, with the radially-outer portion of the concave wall terminating in an intake section which intersects the motive gas stream at an angle of less than **20** degrees, while the uniformly curved slots formed between adjacent blades include an arc of at least **140** degrees from the intake zone to the slot outlet.

OBJECTS OF THE INVENTION

It is an object of the invention to provide an efficient and quiet turbine.

It is a further object of the invention to provide an efficient and comfortably quiet turbine to work at high pressures in textile winding operations.

It is a still further object of the invention to provide an economical efficient and comfortably quiet turbine of small diameter for textile winding operations.

It is another object of the invention to provide a turbine capable of operating efficiently and at comfortable noise levels at high speeds of at least several thousand revolutions per minute.

It is a further object of the invention to provide a high-pressure high-speed turbine capable of operating with a generally flat torque curve in the range of textile winding speeds and at comfortable noise levels.

It is a still further object of the invention to provide a high-pressure high-speed turbine in which a plurality of blades are exposed to the impact of the motive gas stream simultaneously and in which the blades are efficient in converting the gaseous pressure and energy into useful torque.

It is a particular object of the invention to provide a turbine in which the blades present a minimal angle of attack to the motive gas stream and further confine the gas throughout an arc of at least 140°.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be better understood from the following description and with reference to the accompanying drawings, in which:

FIG. **1** is a sectional view of a preferred turbine housing according to the invention, taken transversely of the axis of the rotor;

FIG. **2** is a sectional view taken on lines **2—2** of FIG. **1**;

FIG. **3** is a sectional view similar to FIG. **2** and showing the rotor and drive shaft;

FIG. **4** is a view similar to FIG. **1**, on an enlarged scale, partly cut away and showing the details of the new rotor blades of the preferred turbine; and

FIG. **5** is a graph showing the comparative noise levels of the preferred turbine in comparison with prior art turbines at different frequencies.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the drawings, the preferred form of turbine according to the present invention includes a bladed turbine wheel **1** mounted for rotation in a close-fitting, rotor chamber **2** of a housing **3**.

The housing **3** includes an annular supply chamber **4** receiving high-pressure gas via a supply inlet **5**. The annular supply chamber 4 communicates with the rotor chamber 2 by means of a pair of diametrically-opposed, tangentially-aligned, motive gas-stream injectors 6 and 7, respectively, and circumferential supply channels 8 and 9, respectively. The axes of the peripheral injectors 6 and 7 are directed at between 80° and 90° to a radius of the rotor and rotor chamber so that the injectors are substantially tangential thereto.

The supply channels 8 and 9 gradually diminish in depth from a maximum, adjacent their respective gas stream injector 6 or 7, to a terminus or extinction point 10 and 11, respectively. The extinction points 10 and 11 are spaced from the adjacent, downstream injector on the circumference of the rotor chamber, preferably for an arc of at least 25°, to form a sealing area between the two inlet zones. Thus, the extinction point 10 of supply chamber 8 is circumferentially spaced from the gas stream injector 7 to provide a sealing area 12, while the extinction point 11 of supply channel 9 is spaced from the gas stream injector 6 to provide a similar, circumferential sealing area 13.

If desired, a single gas stream injector and supply channel may be employed or more than two such inlet zones may be selected, as long as adequate intermediate sealing zones are included. However, the dynamic balance and simplicity of two diametrically-opposed injection-inlet zones is preferred with the supply channel extending over an arc of about 150°, particularly for the small diameter turbines to be used in textile winding systems.

The bladed rotor 1 is drivingly mounted on a shaft 14 which is journalled by an anti-friction bearing 15 mounted on the housing 3 or a related structure 16. The housing 3 has, on one side, an aperture 17 for receiving the shaft 14 therethrough. On its side opposite from the aperture 17, the housing has a tubular extension 18 which terminates in an exhaust outlet 19 and which carries an exhaust dampener 20 therein.

The bladed rotor has a hub portion 21 having an inwardly-extending, concave outer surface 22 which permits discharge of the motive gas from between the blades into the tubular extension. As may best be seen in FIG. 4, the rotor 1 includes a plurality of blades 23 which include opposite convex and concave surfaces 24 and 25, respectively. The blades 23 are spaced apart to form a plurality of channels or slots 26 opening on the rotor periphery at slot-inlets 27 and opening inwardly toward the concave surface 22 of the hub 21 at slot-exits 28 to discharge the motive gas.

Each convex surface 24 of each of the blades is extended by a generally flattened area 29 which terminates in a curved inlet surface 30. The area 29 is smoothly connected to the convex surface 24 and the curved inlet surface 30. The curved inlet surfaces 30 are generally tangential to the axis of the injector at the point where the said axis meets the periphery of the rotor.

Each concave surface 25 of each blade is smoothly connected to a convex area 31 which meets the surface 30 at an angle of 20 degress or less. This angle called: angle of the attack dihedral is geometrically defined by the angle between the tangents, drawm from the top of the dihedral, to the surface 30 and to the area 31. The motive gas stream being generally tangential to the surface 30, therefore it meets the area 31 at an angle of 20 degress or less.

Therefore, it is apparent that the arrangement of flattened area 29, and inlet surfaces 30, 31, of adjacent convex and concave surfaces of adjacent blades, provide relatively wide, funnel-shaped slot-inlet zones for the smooth influx of the motive gas stream into the slots 26.

The slots 26 have curved zones beyond the flattened areas 29 and 31 and further extend along a substantially uniform curvature for an arc "B" of at least 140° to enforce a prolonged, smooth deflection of the gas to derive the maximum potential of work from the motive gas stream before it is released, via the slot outlets 28, toward the exhaust outlet 19.

EXAMPLE I (The Preferred Embodiment)

The preferred form of turbines was constructed for textile winding, with the following specifications:

Wheel diameter	90mm
Wheel blades	30 total
Injectors	2
Injector angle	90°
Supply channels	2 155° each

and otherwise in accordance with the description of FIGS. 1 to 4.

The turbine was operated under the following conditions:

Motive gas	Compressed air
Gas pressure (manometer)	4.2 bars
Gas stream velocity	480 m/sec
Injector rate	2 gms/sec
Rotational speed	20,000 RPM

The turbine was run in a sound-proofed chamber and analyzed by means of a Bruel and Kjor meter.

The decibel levels and frequencies of the test are plotted on the graph of FIG. 5 as the heavy, solid line "I". In FIG. 5, the levels of preferred (comfort), tolerance and danger are graphed and so identified.

It can be seen that the preferred turbine exceeded the 80 decibel limit only in the zone of the low frequency of about 330 Hz, which is still within the tolerance limit. This is, however, a ball-bearing noise corresponding to the frequency of the shaft, rather than being attributable to the turbine itself. The total sound level of this turbine, integrated throughout the full range of form 0 Hz to 20,000 Hz, which is the generally accepted normal audible range, is 82.5 Db. or 77 Db.A.

TEST II

For comparison, a turbine was similarly tested which had the following specifications, using an identical wheel as in example above:

Wheel diameter	90mm
Wheel blades	30 total
Injector	1
Injector angle	70°
Supply channels	None

The turbine was tested under the following conditions:

Motive gas	Compressed air
Gas pressure (manometer)	5 bars
Gas velocity	480 m/sec
Injector rate	2 gms/sec
Rotational speed	21,000 RPM

The results obtained with this turbine are shown by the "dot-dash" curve II in FIG. **5.** Actually, from start-up and through to about 1,800 Hz, the curves I and II are so close as to be merged on a graph of this scale. The curve II, therefore, exhibits the same bearing-noise peak at about 330 Hz and also falls to a low point at about 1,400 Hz.

However, at about 1,800 Hz, the curve II makes an extreme excursion, with increasing frequencies, into the unpleasant and dangerous decibel levels, while that of the present invention stays below about 55 Db. The contrasting curve II does not return to this 55 Db. level until it reaches about 16,000 Hz, at which frequency the curve I of the preferred turbine of the invention has dropped to about 45 Db., about 10 Db. lower.

In the comparison turbine of Test II, the total level for the frequencies of from 0 Hz to 20,000 Hz was 94.5 Db. or 91 Db.A. In particular, very bad noise levels of 83 Db. at about 5,200 Hz and of 90 Db. at about 10,500 Hz are encountered. The former is beyond the acceptable range, while the latter is particularly painful and makes the turbine of Test II unbearable and impossible to use.

The preferred turbine of the present invention is particularly effective in terms of power delivery and versatility. The turbine set forth in the Example delivered an output of 90 watts at 16,000 rpm, with a total yield of 0.2.

With additional injectors, the same size unit will deliver 750 watts at 30,000 rpm — still without noise problems. Greater power outputs and speeds are anticipated, but an effort has not been made to determine the actual limits of this size of the preferred turbine.

Therefore, it is apparent that the turbine of the present invention is particularly effective without provoking or encountering problems of noise.

The curved inlet surfaces **30,** the low-attack-angle inlet surfaces **31,** the tangential injectors **6** and **7,** the diminishing supply channels **8** and **9** and the **140** degree, curved slots **26** thus not only are particularly effective in converting the pressure and velocity of the compressed gas into useful torque, but also are effective in accomplishing these results in small diameter turbines without objectionable noise.

The turbine of the present invention avoids unnecessary shock or turbulent diversion of the motive gas stream, thereby utilizing the energy available in the compressed gas with a smooth transitional flow of the driving gas stream from the injector tangentially into the rotor chamber and at a minimum angle with respect to the inlet surfaces of the concavities of the blades. Once the motive gas stream is entered into the funnel-like inlet zones between adjacent flattened portions **29** and **31,** it is confined within and further exerts its driving force within the smooth transition presented by the wide-arc, curved slots **26** as it passes to the exhaust.

Various changes may be made in the details of the invention, as disclosed, without sacrificing the advantages thereof or departing from the scope of the appended claims.

What is claimed is:

1. A high-speed gas turbine comprising:

a casing having

a rotor chamber therein,

a turbine rotor,

compressed gas injection means including

at least one injector opening to said rotor chamber and aligned generally tangentially therewith,

a supply channel in the periphery of said rotor chamber and

said supply channel being tapered from a maximum dimension adjacent said injector to a terminal point remote from said injector,

said rotor having

a plurality of blades, said blades defining

a plurality of slots between adjacent blades, said slots each having

an inlet zone on the periphery of the rotor and

an outlet spaced radially inwardly from said inlet zone, each said blade including

a convex side and

a concave side, said slots being formed by adjacent pairs of concave and convex sides, each convex side having

an inlet curved surface generally tangential to the axis of said injector at the point where said axis meets the periphery of the turbine rotor, each concave side having

an inlet convex area converging toward the inlet surface of the respective convex side at an angle of less than 20°.

2. The turbine of claim **1** in which said slots each include a curved portion and said curved portion extends through an arc of at least 140°.

3. The turbine of claim **2** in which each convex side includes a generally flat portion associated with its inlet surface and said generally flat portion and the inlet convex area of the adjacent blade being positioned to converge toward said curved portion of said slot.

4. The turbine of claim **3** including a plurality of injectors and a supply channel at each injector, the terminal point of each supply channel being spaced on the periphery of the rotor chamber from the peripheral position of the next injector and defining a sealing zone therebetween.

5. The turbine of claim **4** in which each said sealing zone extends over an arc of at least 25°.

6. The turbine of claim **5** in which each injector is aligned with said rotor chamber at an angle of between 80° and 90° with respect to a radius of the rotor chamber.

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