United States Patent [19]

Lockwood, Jr.

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[54] **FRICTION IMPULSE GAS TURBINE**

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[52] **U.S. Cl.** **60/39.15**, 60/39.43, 60/39.52

[51] **Int. Cl.** **F02c 7/02**

[58] **Field of Search** 60/39.52, 39.43, 39.75, 60/39.15, 39.17

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Primary Examiner—Carlton R. Croyle

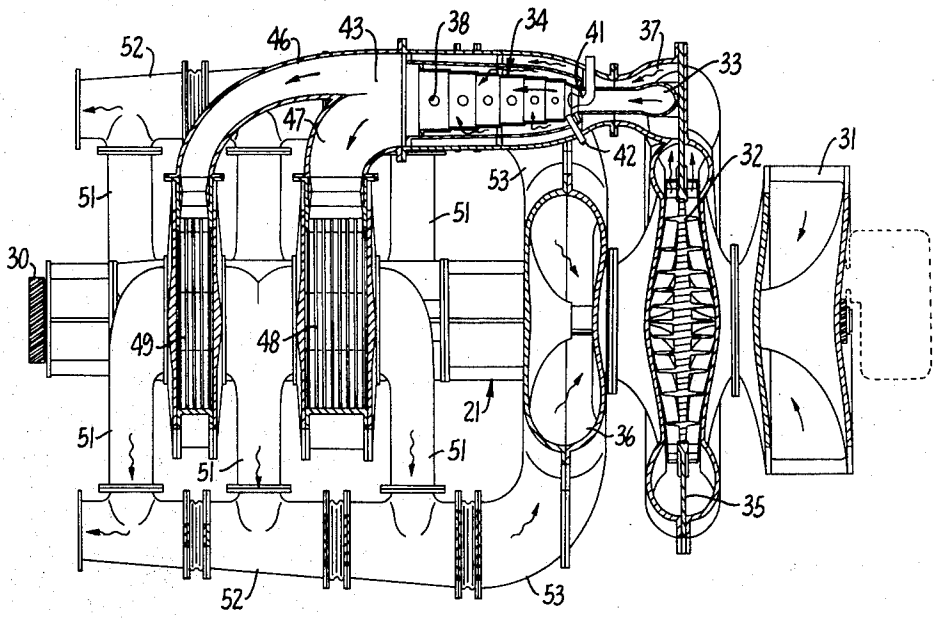
Assistant Examiner—Warren Olsen

[57] **ABSTRACT**

The friction impulse turbine includes four basic sections in order as follows: an air compressor section, a combustor section, a compressor drive section and, finally, the power output section deriving power from the hot gases from the combuster. These components are found in other turbines but, due to the design of the drive blades and lack of recirculation of a portion of the exhaust gas, they are more expensive to build and less efficient. The basic advantages of my turbine include each of the following:

a. less expensive to build;
b. less delay in responding to changes in power settings;
c. no close tolerances;
d. simplified turbine blade design, making it easy to manufacture;
e. better efficiency due to higher combustor temperatures;
f. less pollution in the exhaust;
g. better control over the combustion process; and
h. reduced noise.

7 Claims, 20 Drawing Figures



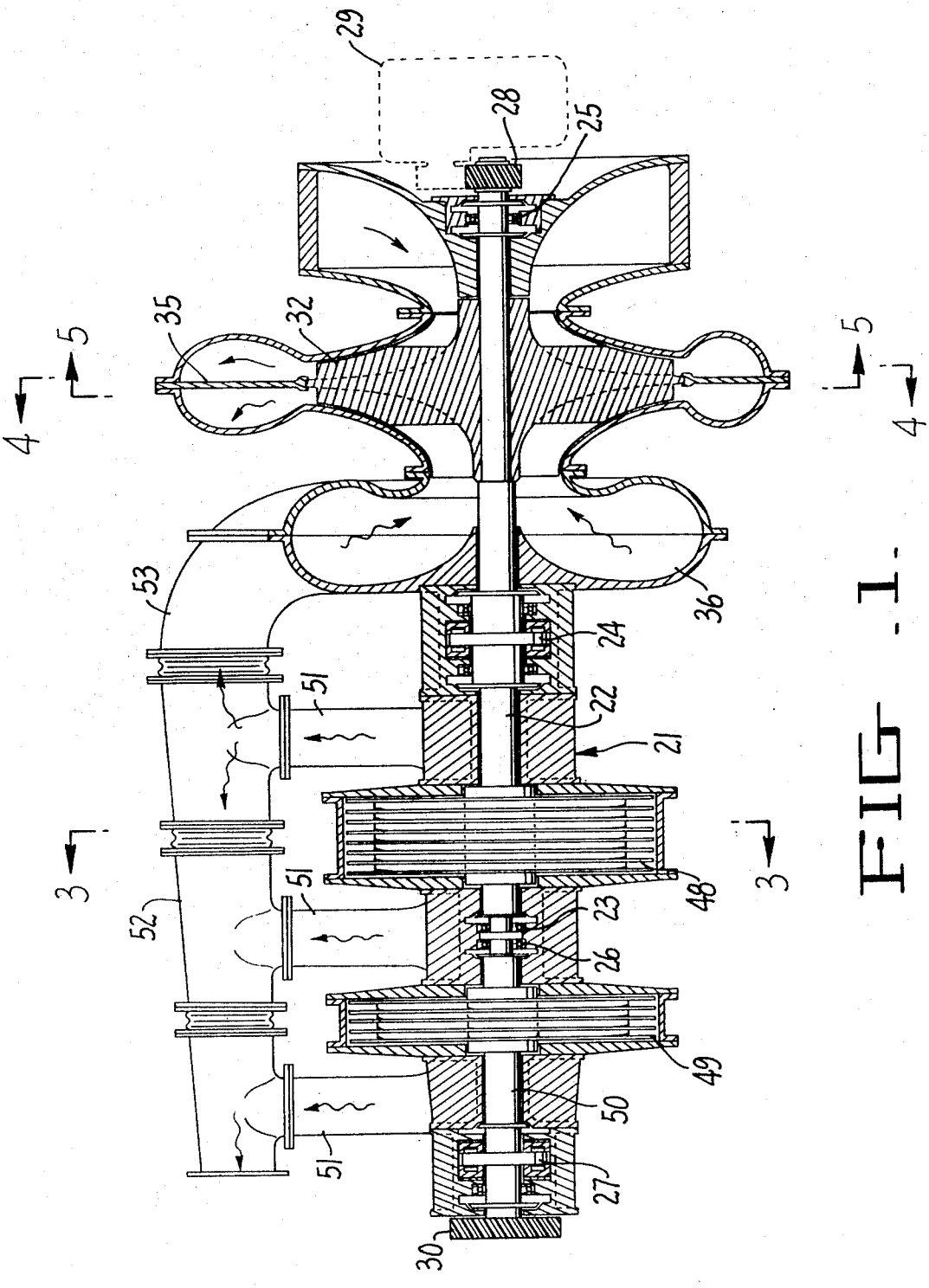


FIG. 1.

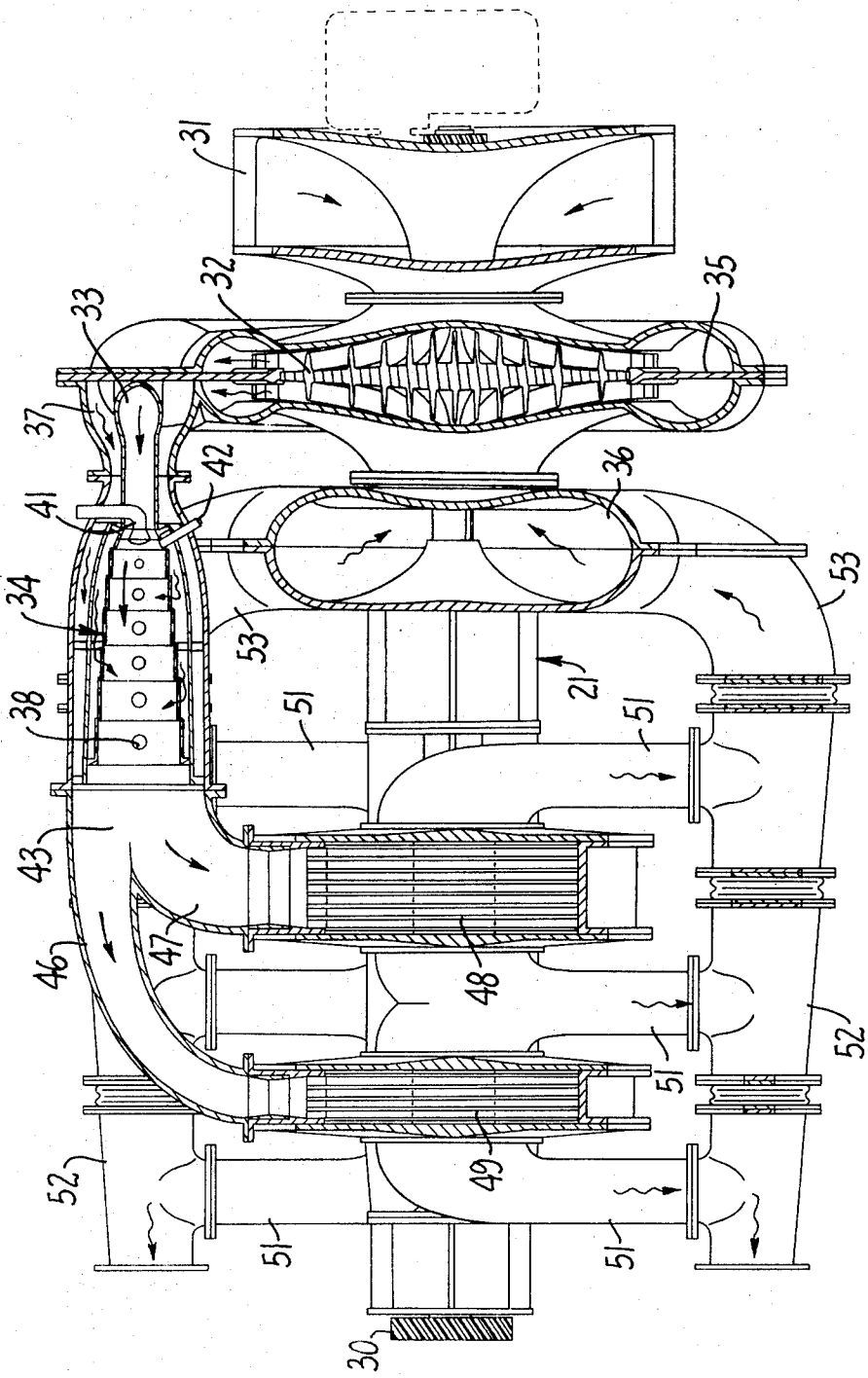

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FIG. 2.

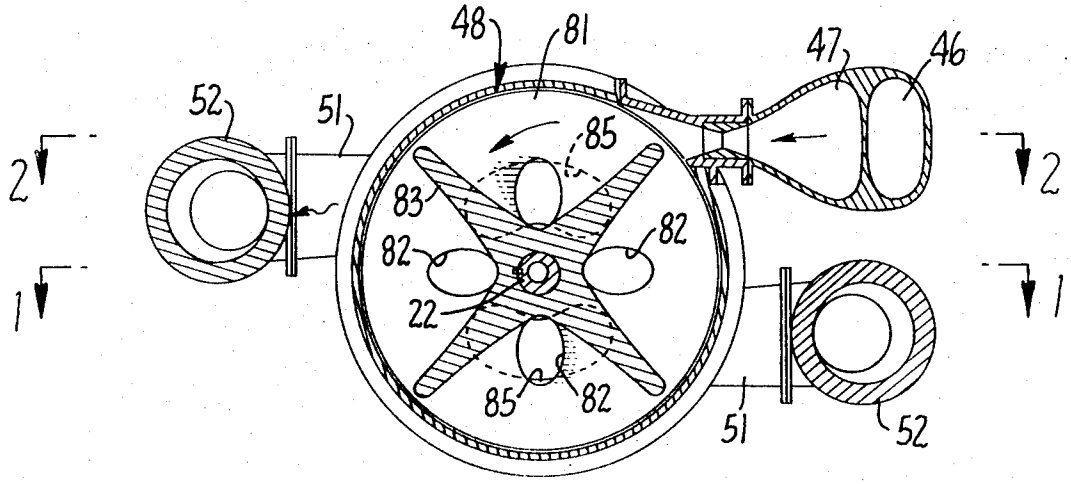


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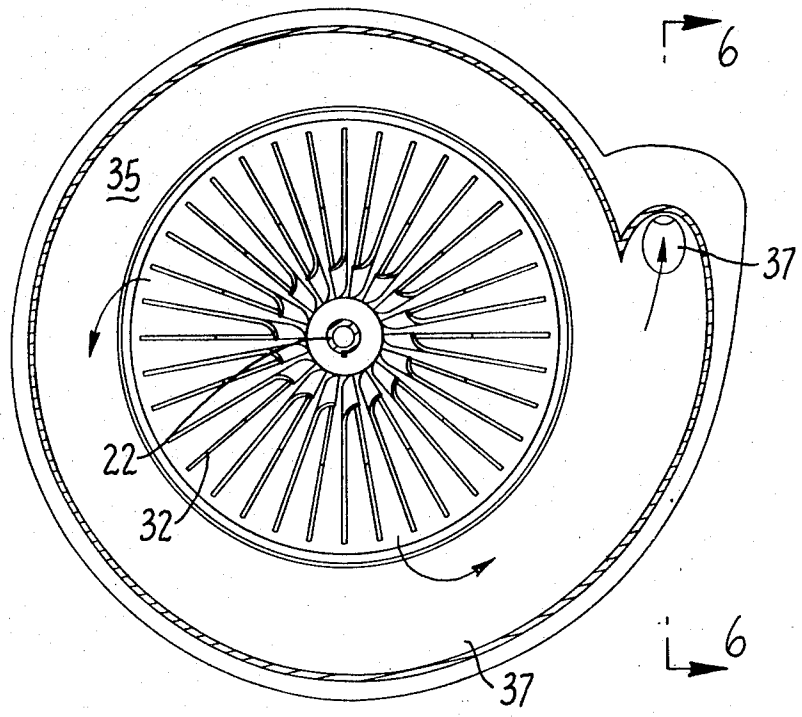


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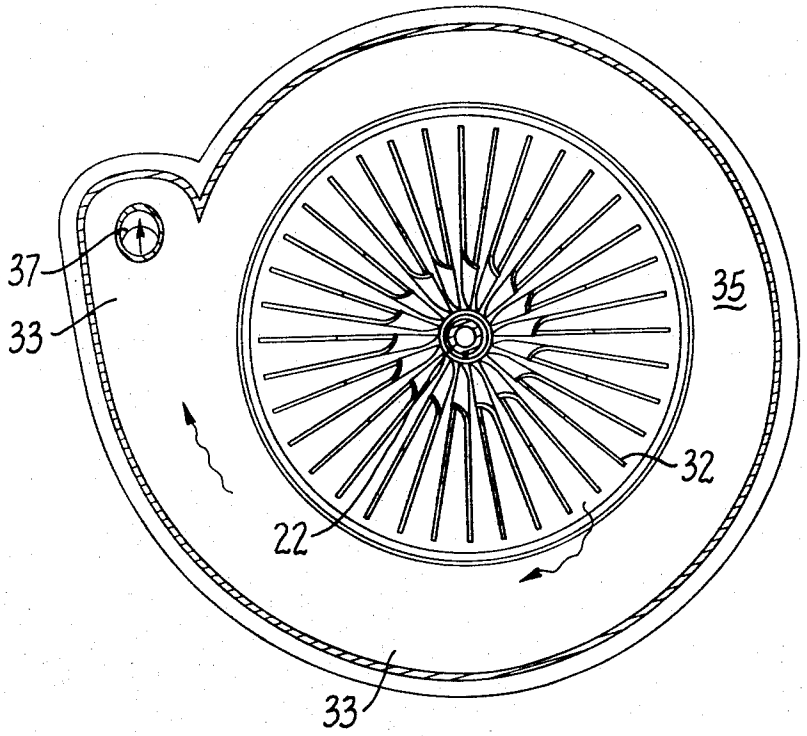


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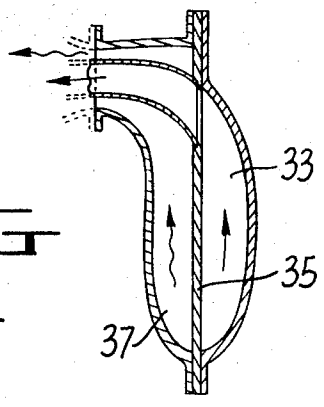


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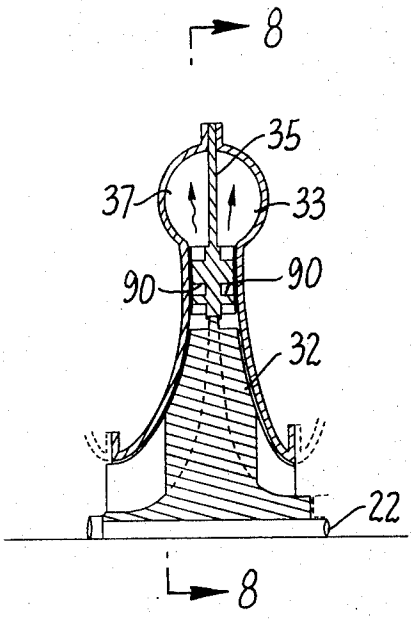


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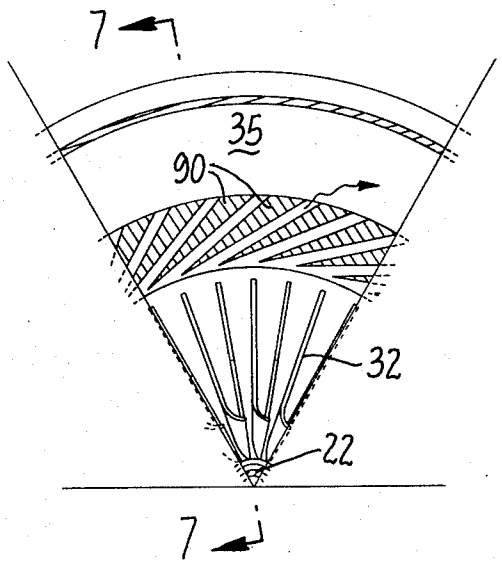


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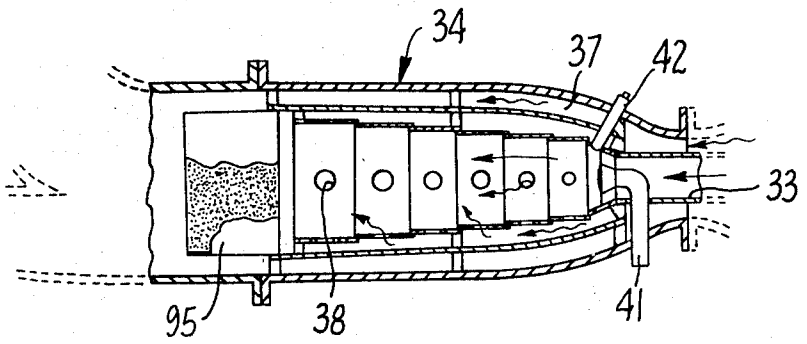


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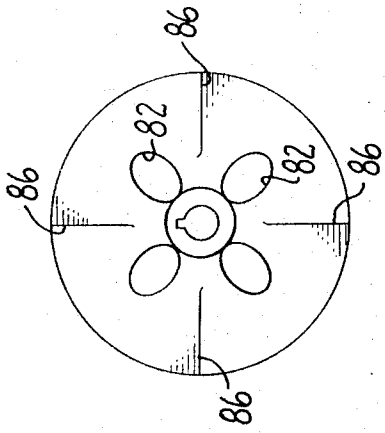


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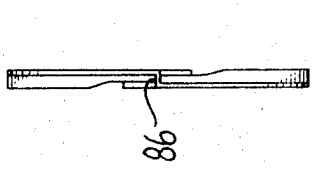


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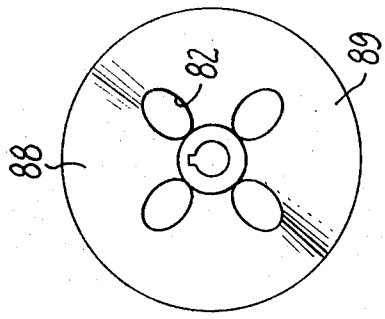


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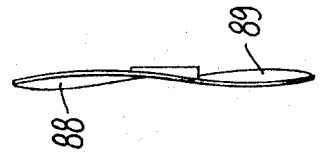


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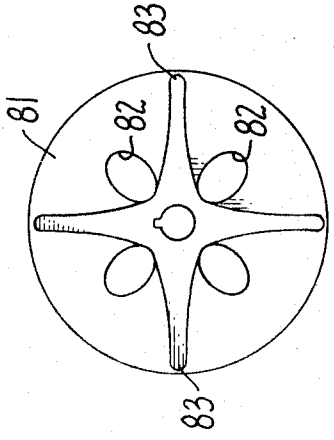


FIG. 11.

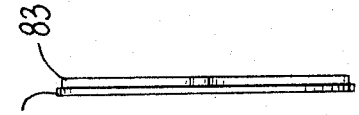


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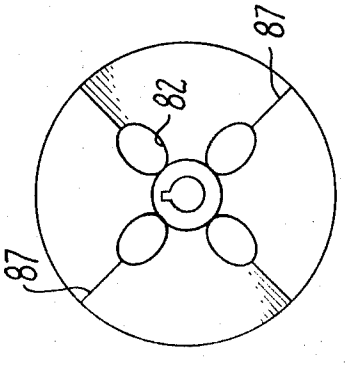


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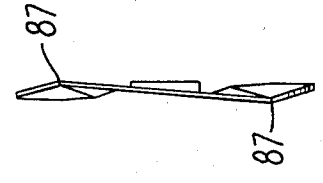


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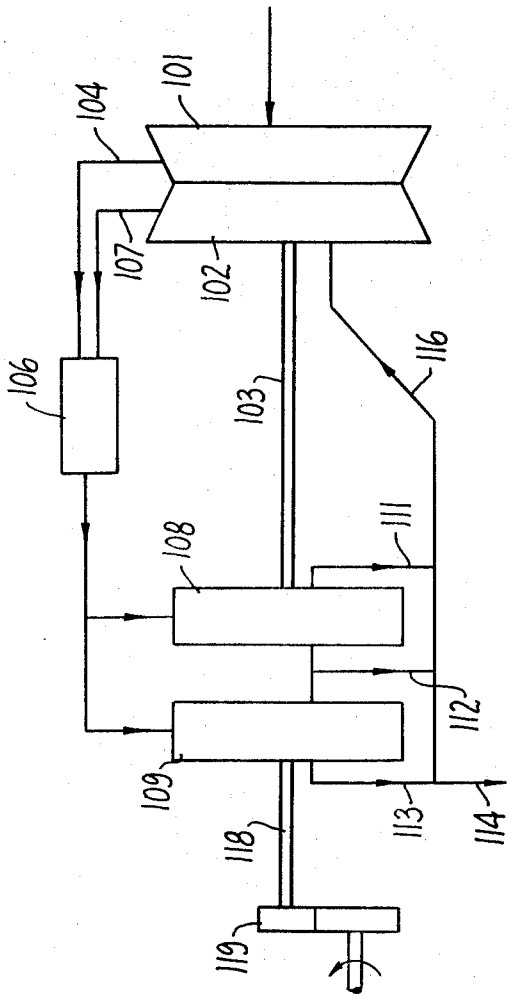

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FIG. 18.

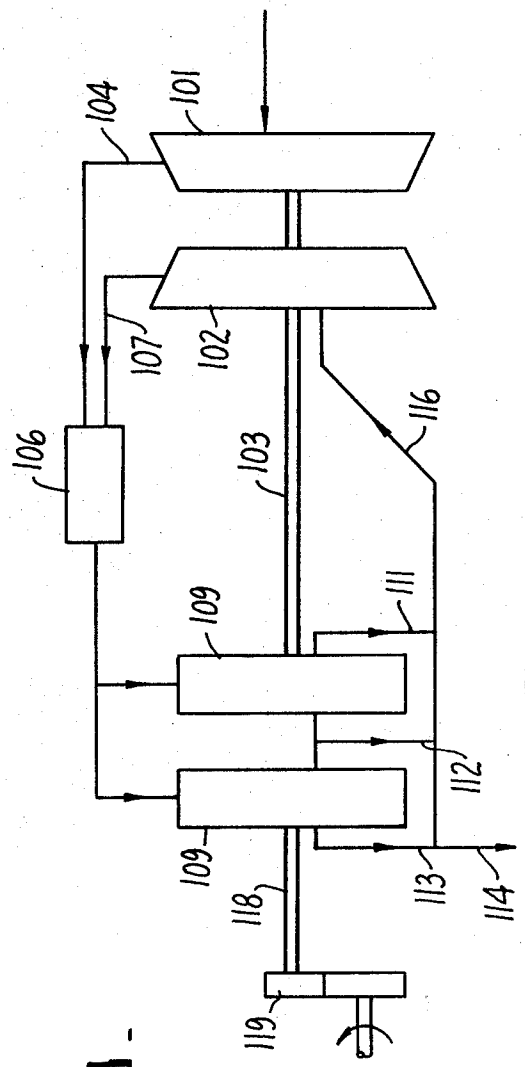

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FIG. 19.

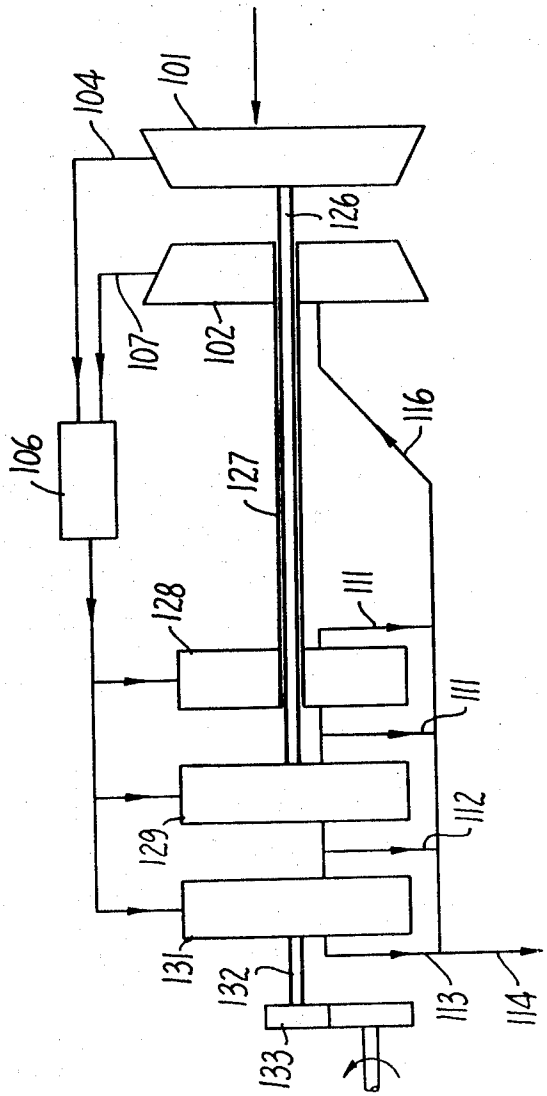

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FIG. 20.

FRICTION IMPULSE GAS TURBINE

BACKGROUND OF THE INVENTION

Turbines have been built heretofore but these have lacked the simplified blading and recirculation of at least a portion of the exhaust gas. Hence they are more expensive to build, are less efficient in operation and provide a relatively high nitrogen oxide content in the exhaust gas.

SUMMARY OF THE INVENTION

It is in general the broad object of the present invention to provide an improved compressor turbine-construction.

A further object of the invention is to provide a combined compressor turbine construction which is less expensive to build, responds promptly to a change in power setting and does not require any close tolerances.

Further, the turbine of this invention includes a simplfied blade design making it easy and inexpensive to manufacture. Further, because of the higher combustion temperatures utilized, it has a higher efficiency. Additionally, the turbine provides a better control over the combustion process which results in less atmospheric pollution and operates with a reduced exhaust noise.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross section taken along the line **1—1** in FIG. **3.**

FIG. **2** is a cross section taken along the line **2—2** in FIG. **3.**

FIG. **3** is a section taken along the line **3—3** in FIG. **1.**

FIGS. **4** and **5** are sections taken respectively along the lines **4—4** and **5—5** in FIG. **1.**

FIG. **6** is a sectiona taken along the line **6—6** in FIG. **4.**

FIG. **7** is a section taken along the line **7—7** in FIG. **8.**

FIG. **8** is a section taken along the line **8—8** in FIG. **7.**

FIG. **9** is a section taken through an alternate form of the combustion device.

FIGS. **10** through **17** illustrate various blade constructions which can be employed; FIGS. **10, 12, 14** and **16** being taken in side elevation while FIGS. **11, 13, 15** and **17** are taken in plan view.

FIGS. **18, 19** and **20** are diagrammatic showings of various arrangements of the power units.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Before proceeding to a detailed disclosure of the preferred embodiment, the following general observations are made as to each of the general components of the device.

Compressor: The compressor is designed to perform two functions. It draws air in from outside the engine, compressing it by changing the velocity pressure into static pressure. It also places a suction on the exhaust manifold and compresses the proper proportion of the exhaust gases up to the same pressure as the outside air. In its preferred form, the compressor is shown as a single disc with the ambient air compressor on the front side and the exhaust air compressor on the back side (FIGS. **1, 2, 4, 18**). The compressor can also include two separate discs (FIG. **19**), one to compress the ambient air and one to compress the exhaust; these discs are on a shaft driven by the compressor drive section. In another form, (FIG. **20**), the two discs would rotate at different speeds to provide the proper proportion of ambient air and exhaust gas at the same pressure in the high pressure air collection manifold.

The ambient air compressor and the exhaust gas compressor are both on the same disc and driven by a common drive and they are made of stainless steel (FIG. **1, 2** and **18**). If the separate compressor design is used (FIGS. **19** and **20**) the ambient air compressor can be made of aluminum or equal which can withstand the high centrifugal stresses during operation.

Combustor: The compressed ambient air (**21** percent oxygen content) and the compressed exhaust are piped to a combustor assembly. Both gases are kept separate initially by the seal between the two compressors and later by concentric or separate piping. The compressed ambient air is piped to the inner part of the combustor assembly. If concentric piping is used to transport the ambient air from the compressor, the ambient air is in the inner pipe surrounded by the exhaust gas. The resultant heat transfer raises the temperature of the ambient air, thus improving the engine efficiency. One can also deliver the compressor products to the combustor by separate pipes, the ambient air being piped to the center shell of the combustor while the recycled exhaust gas is piped to the annulus assembly of the combustor to cool the shell of the combustor, being introduced in the back of the flame in the combustor to cool the combustor exhaust gas to approximately 1,800° F.

The combustor is constructed of stainless steel with an inner chamber made of Inconel or ceramic coated stainless steel or equal. It may also be made completely of ceramics when materials that can withstand the stresses are used.

The fuel, mixed with the compressed ambient air and combustion gas, is ignited by an ignitor. The self-supporting combustion takes place in the inner chamber of the combustor, completely burning the fuel. The combustor is designed so that some of the excess ambient air for combustion is introduced at the base of the flame at the point of initial fuel-air mixture introduction to cool the base of the flame. The remainder of the ambient air is introduced into the main body of the flame and mixed with some of the recirculated and compressed exhaust, reducing the formation of oxides of nitrogen and promoting better air fuel mixing to eliminate unburned hydrocarbons.

The outer chamber of the combustor has recycled exhaust gas which is mixed with the burning fuel and air to reduce the flame temperature during the combustion process and after the combustion products leave the inner combustion chamber.

Power Derivation: The hot exhaust and combustion products from the combustor are mixed and then are separated into separate streams of different volumes depending upon the ratio of power output to the compressor power required. One stream enters the nozzle assembly for the compressor drive turbine whereby the gas is accelerated and cooled prior to coming into contact with the turbine blades. If two compressor drive assemblies are used, two gas streams are acceler-

ated through different nozzles before entering their respective drive turbines. The second gas stream enters the power output turbine and is accelerated to the proper velocity before it contacts the turbine blades.

The hot gas nozzles can deliver gas at sub-sonic, sonic or super-sonic speeds, depending upon the desired rotational speed of the respective turbine. Turbines on the same engine may have different speeds and different diameters. The high temperature gas nozzles may be made of high temperature alloys or ceramics.

The hot gas enters each of the turbines tangentially where it passes between the discs of the blade assembly. The energy from the gas stream is passed to the turbine through the friction of the fluid passing over the surface of the blades while the rest of the energy is passed on to the turbine by the impact of the gas against the impulse section of the blade.

The turbine drive section consists of a set of disc type of blades firmly fixed perpendicularly to the axis of the shaft and spaced on the shaft such that they absorb power from the flow of gas over their surface. The power is transmitted to the blades by boundary layer friction and impulse.

The blades consist of discs and spacers stacked alternately along the shaft. The discs can be made of any diameter depending upon the rotational speed desired. The discs have a hole in the center and a number of holes equally spaced around the center of the discs, (FIGS. **10–17**). These holes act as exhaust ports and can be round or eliptical to reduce the stress concentration when the disc is rotating.

The surface of the discs are roughened so that the boundary layer developed between the hot gas and the surface of the disc will be thicker. Each disc can be stamped so that it has a displacement one-half the thickness of the spacer between adjacent discs. The displacement is designed so that adjacent discs touch at the same point. This touching displacement develops the power from the impulse component of the high velocity gas. Three designs of this disc blade are the elipse-stamped blade, the diamond-stamped blade, and the square-stamped blade. The disc pack has a flat disc with the exhaust holes at each end.

Between each blade there is a circular spacer that is from one to two times the thickness of the disc blade and made from the same material. The maximum diameter of the spacer is equal to the smallest distance from the exhaust opening to the center of the shaft. There are N–1 spacers where N= number of discs.

Another design of the turbine blading is a composite design. The discs are the same design as the stamped design except there is no displacement along the shaft axis stamped in the composite blades. The surface of the discs is roughened to increase the boundary layer thickness.

The spacers for the composite design are also from one to two times thicker than the discs and are star-shaped. They have the same number of impulse blades as there are exhaust holes in the spacer with its sides tangent to the exhaust ports on both sides of it. The blade length is the same or slightly shorter than the diameter of the disc blade on both sides of it. There are always N-1 bladed spacers where N is the number of the disc-type blades. The power output of the engine is determined among other things by the number of disc-type blades in the drive section disc pack.

The hot gas from the combustor accelerates and expands as it passes through the nozzle assembly. This reduces its temperature before it contacts the blades, so the blades can be of less expensive materials than previous blades of other turbine designs or they can be designed to rotate at a higher speed.

The blades are keyed to the shaft and fixed in position by a lock nut on eacn end of the disc pack. This locking nut is designed so that it will not loosen while the blades are accelerating or decelerating during changes in power settings or starting up and shut down. These lock nuts can also be used for balancing the turbine.

The turbine drive assemblies are housed in a cylindrical casing that has an inside diameter approximately one-sixteenth to three-sixteenths larger than the diameter of the disc pack that will be used in it. The housing has an inlet tangential to its shell where the high velocity gas enters before it hits the blades.

The ends of the casing are designed to be a structural part of the engine and connect to the bearing housings. The turbine shaft goes through the center of the casing end plates. The end plates also have the exhaust openings. The openings are located so that any two or more exhaust holes in the disc are always lined up with the exhaust openings in the end plates. The exhaust manifold is connected to these exhaust openings on the end plates. The turbine housings have no seals or close tolerances.

An alternate exhaust port on the turbine casing can be located approximately 300° around the casing in the direction of the hot gas stream and tangential to the discs. In this construction the end plates only have openings for the turbine shaft. The exhaust manifold is connected to the exhaust ports.

The exhaust manifold is designed to collect all the exhaust from the drive turbines in a common collection chamber. Part of the exhaust gas, generally an amount equal to the amount of ambient air drawn into the ambient air compressor, is vented to the atmosphere. The rest is piped to the inlet of the exhaust recycle compressor, either the back of the single compressor disc design or the separate exhaust compressor in the two compressor designs.

This engine will be quieter than conventional turbines because the turbine nozzles noise will be reduced by the efficiency and baffling effect of the blading. Turbine inlet noise will be reduced because there is less air entering the engine per horsepower produced due to the recycled gases.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring particularly to FIGS. **1** and **2**, the device of this invention includes a casing structure, generally indicated at **21**, and having a composite shaft extending centrally of the casing and supported at spaced points by bearings **23, 24,** and **25.** Power output shaft **50** is supported on bearings **26** and **27** and carries a power takeoff gear **30.** At the righthand end of shaft **22** I provide a gear **28** which is driven by a motor **29** to start the device in operation. Gear **28** may also drive other accessories, such as a generator and oil and fuel pumps. An air inlet **31** is provided adjacent the righthand end of shaft **22** and includes a double sided impeller **32** on Shaft **22** for forcing air from one side into inlet passage **33** (FIG. **5**) leading to the combustion structure, gener-

ally indicated at **34.** Exhaust gases from passage **36** (FIG. **4**) are forced by the other side of impeller **32** into passage **37** on the outside of the combustion structure **34.** The two sides of the compressor section are separated as at **35.** The compressed recycled gases are admitted through apertures **38** into the combustion structure to mix with the fuel air mixture undergoing combustion in the combustor. The fuel is supplied through line **41** while combustion is initiated by the combustion device **42.** The combined mixture of hot combustion gases and freshly ignited gas issue from the combustor into outlet **43** from whence the gas is passed through ducts **46** and **47** into turbine structures, generally indicated at **48** and **49.** Turbine **48** is mounted on shaft **22** and turbine **49** is mounted on power output shaft **50.** Gases passing through the turbine structures **48** and **49** pass into ducts **51** and manifolds **52.** Ducts **53** lead from manifolds **52** and return a portion of the hot combustion gases to passage **36** for return to the combustor. Manifolds **52** also exhaust excess gas from the turbines for discharge to the atmosphere. Power, generated by turbine **49,** is taken from shaft **50** by gear **30.**

Configuration of the turbine bladings can take various forms. For example, in FIGS. **3, 10** and **11** the blading is in the form of a flat disc **81** having a plurality of centrally positioned elliptical apertures **82** for permitting hot gases to pass through the blades between the spaced arms **83.**

In the blade form shown in FIGS. **12** and **13,** much the same configuration is utilized but the circular disc is deformed to provide stepped quadrants with spaced radial arms **86.**

In FIGS. **14** and **15,** the four quadrants of the blade are displaced with respect to one another to form ridges **87,** as appears in FIG. **14.**

In the form shown in FIGS. **16** and **17** opposite sides **88** and **89** of the blade are deformed with respect to one another so they operate in different planes. An alternate form of the compressor section is shown in FIGS. **7** and **8** in which stator blades **90** direct the compressed gases toward passages **33** and **37.**

Similarly, FIG. **9** illustrates another form in which the combustion section is provided with flame conditioning system, generally designated as **95,** to complete the combustion process and dissipate sound. In the schematic devices shown in FIGS. **18** and **19,** that shown in FIG. **18** largely represents the device shown in FIGS. **1** and **2** wherein the incoming air compressor **101** is mounted on one end of shaft **103** with recycling gas compressor turbine **102** mounted immediately adjacent thereto. The balanced compressors **101** and **102** deliver the ambient air through line **104** and the recycled gas through line **107** to combustor **106,** the stream of combustion gases derived from turbine wheels **108** and **109** being taken off through lines **111, 112,** and **113.** A portion of the gas is discharged through line **114** and the remainder returned to the compressor **102** through line **116.** The power from the unit is taken off from the turbine wheel **109** through shaft **118** and is delivered to gear **119.**

The form of device shown schematically in FIG. **19** is much like that in FIG. **18** except that the compressor wheels **101** and **102** are separated one from the other but both are mounted upon the shaft **103.**

In that form of device shown in FIG. **20,** the compressor wheel **101** is driven by shaft **126** which passes through hollow shaft **127,** the latter being driven by turbine wheel **128** while shaft **126** is driven by turbine wheel **129.** Turbine wheel **131** is mounted separately on shaft **132** to drive power output gear **133.**

I claim:

1. A turbine means, comprising: a casing means having an air inlet and an air outlet therein, an elongate rotatable shaft means supported within the casing means and extending axially thereof, first compressor blade means fixed on the shaft means in the casing means for rotation with the shaft means to draw air inwardly through the inlet and force it outwardly through the outlet, fuel combustion means adjacent the casing means, said fuel combustion means including an inner combustion chamber surrounded by an exhaust gas mixing chamber to mix exhaust gas with the main flame in the combustion chamber, and an outer chamber for circulating exhaust gas over the exhaust gas mixing chamber to control the temperature of the gas delivered to the turbine means, a first passage means extending from the outlet to the fuel combustion means for delivering air from the first compressor blade means to the fuel combustion means, a compressor drive turbine means fixed on the shaft means, an output drive turbine means fixed on the shaft means, separate passage means extending in parallel from the fuel combustion means to each of the compressor and output drive turbine means for separately delivering exhaust gases from the fuel combustion means to each of the turbine means, a common exhaust gas manifold adjacent the casing means for each of the turbine means, separate exhaust passage means leading from each of the turbine means to the exhaust manifold means to deliver exhaust gases from the turbine means to the exhaust manifold means, second passage means connected between the exhaust manifold means and the casing means to deliver a portion of the exhaust gases from the exhaust manifold means to the casing means, a second compressor blade means fixed on the shaft means adjacent the first compressor blade means for receiving said portion of the exhaust gases from the exhaust manifold means to compress the exhaust gases, and third passage means leading from the second compressor blade means to the fuel combustion means for delivering the compressed exhaust gases to the fuel combustion means to increase the efficiency of the turbine and reduce the pollution effect.

2. A turbine means as in claim **1,** wherein said compressor drive turbine means and said output drive turbine means each comprise friction impulse turbine means.

3. A friction impulse turbine as in claim **2,** wherein said first and second compressor blade means are on opposite sides of a disc for rotation together, said compressor blade means and said compressor drive turbine means fixed on opposite ends of a shaft, and said output drive turbine means fixed on a separate shaft.

4. A friction impulse turbine as in claim **2,** wherein said first and second compressor blade means are separately fixed on a shaft near one end thereof and adjacent one another, and said output drive turbine means is fixed on a separate shaft.

5. A friction impulse turbine as in claim **2,** wherein said first compressor blade means is fixed on one end of a first shaft and a first compressor drive turbine means is fixed on the other end of said shaft, said second compressor blade means fixed on one end of a sec-

ond shaft disposed concentrically around said first shaft, second compressor drive turbine means fixed on the other end of said second shaft, said output drive turbine means fixed on one end of a third shaft separate from said first and second shafts, and separate passage means extending in parallel relationship from the fuel combustion means to each of said turbine means.

6. A friction impulse turbine as in claim **2,** wherein a flame conditioning means is in the path of the exhaust gas from the fuel combustion means to complete the combustion process and reduce the noise of the exhaust.

7. A friction impulse turbine as in claim **2,** wherein the third passage means is disposed concentrically around the first passage means so that the heat of the exhaust gases conducted therethrough is transferred to the air in the first passage means to elevate the temperature thereof and thus increase the efficiency of the engine, and the passage means to the respective output drive turbine means and compressor drive turbine means are proportioned to obtain desired different flow rates therethrough depending on the requirements of the turbine.

* * * * *