United States Patent [19]

Holste

[11] **3,782,108**

[45] **Jan. 1, 1974**

[54] **GAS TURBINE**

[76] Inventor: **Merrill R. Holste,** 2228 St. Stephens St., St. Paul, Minn. 55113

[22] Filed: **Sept. 25, 1972**

[21] Appl. No.: **292,075**

[52] **U.S. Cl.** **60/39.2,** 60/39.36, 60/39.66

[51] **Int. Cl.** **F02c 3/12,** F02c 3/08, F02c 7/12

[58] **Field of Search** 60/39.02, 39.03, 60/39.2, 39.22, 39.6, 39.63, 39.27, 39.36

[56] **References Cited**

UNITED STATES PATENTS

3,626,694	12/1971	Holste	60/39.36 X
3,045,894	7/1962	Ross	60/39.29 X
3,609,966	10/1971	Guillot	50/39.69 X
3,124,931	3/1964	Mock	60/39.27 X
3,255,586	6/1966	Hennig et al.	60/39.03

Primary Examiner—Al Lawrence Smith
Assistant Examiner—Robert E. Garrett
Attorney—Ralph F. Merchant et al.

[57] **ABSTRACT**

The disclosure is directed to a centrifugal flow gas turbine consisting of a centrifugal compressor and an inward flow power turbine interconnected by a spirally shaped combustion chamber. The compressor and power turbine are commonly mounted on a rotating shaft which also carries a flywheel to store rotational energy of the turbine after it has reached higher rotational velocities. Means are included for intermittently firing the turbine to maintain smooth and economical operation within a predetermined range of engine speeds.

22 Claims, 11 Drawing Figures

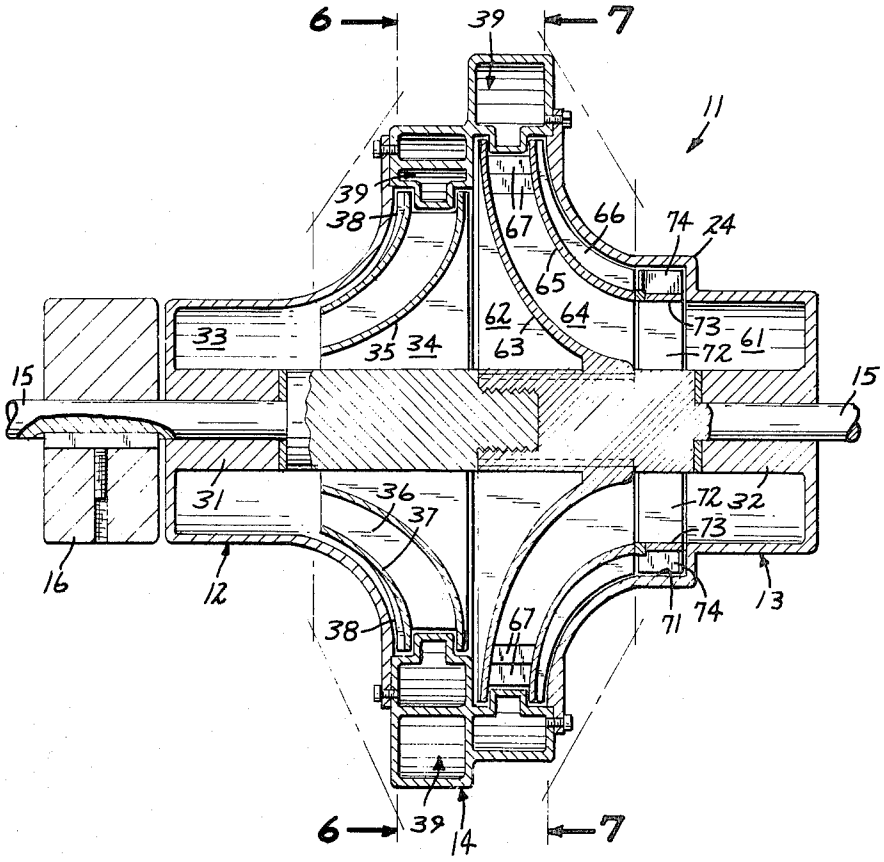


FIG. 1

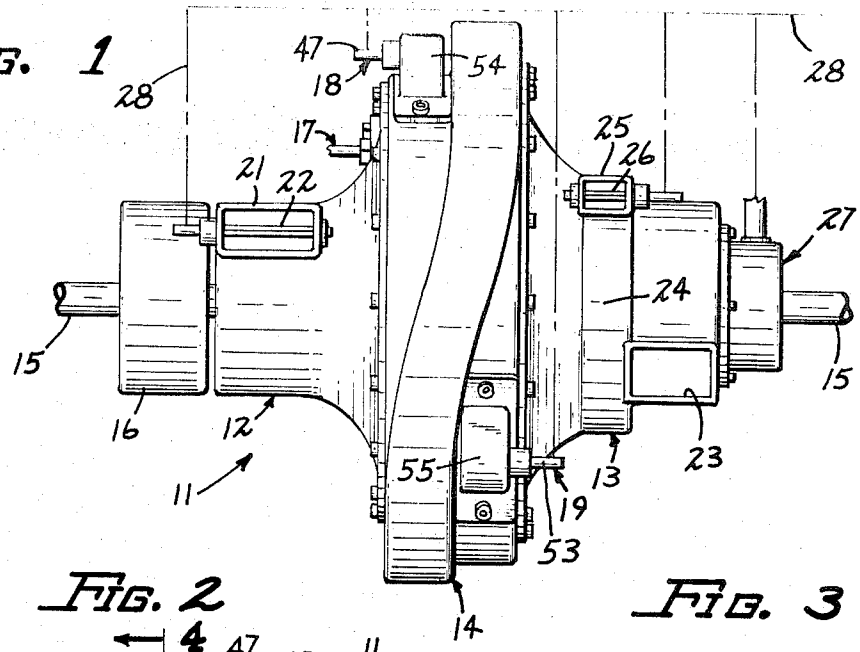


FIG. 2

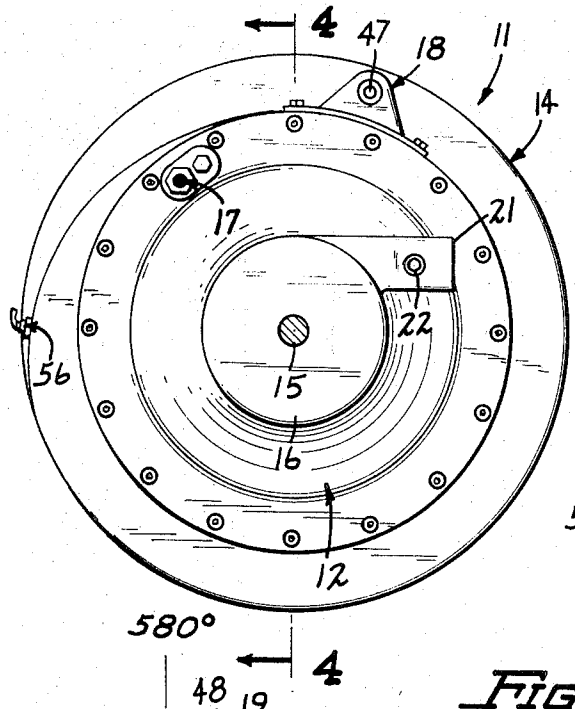
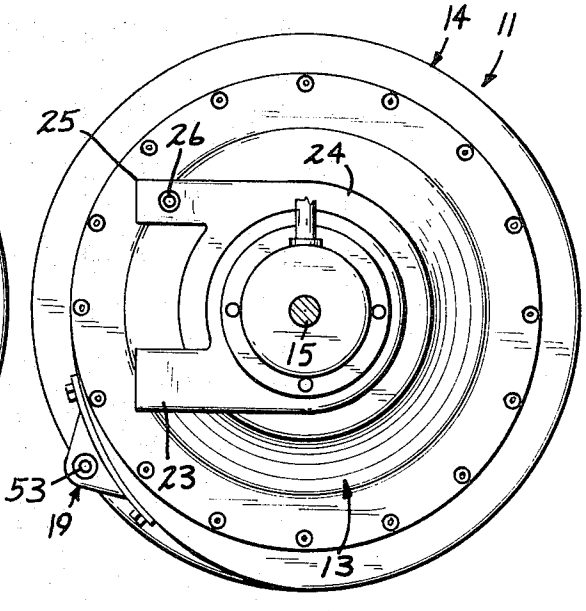


FIG. 3



580°

4

FIG. 8

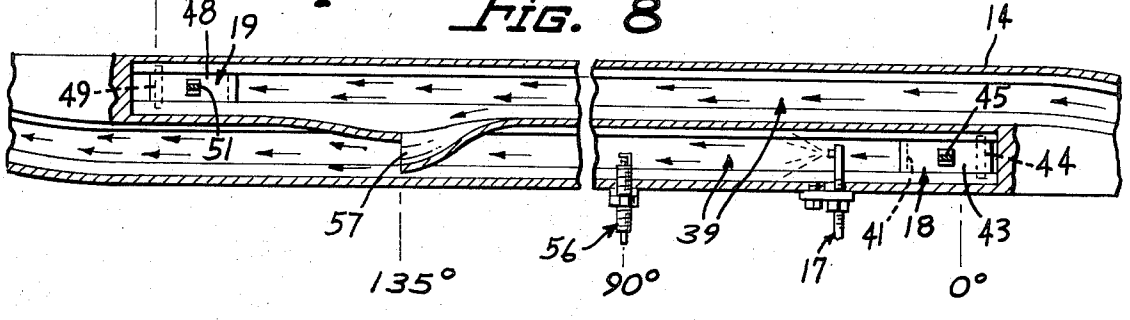
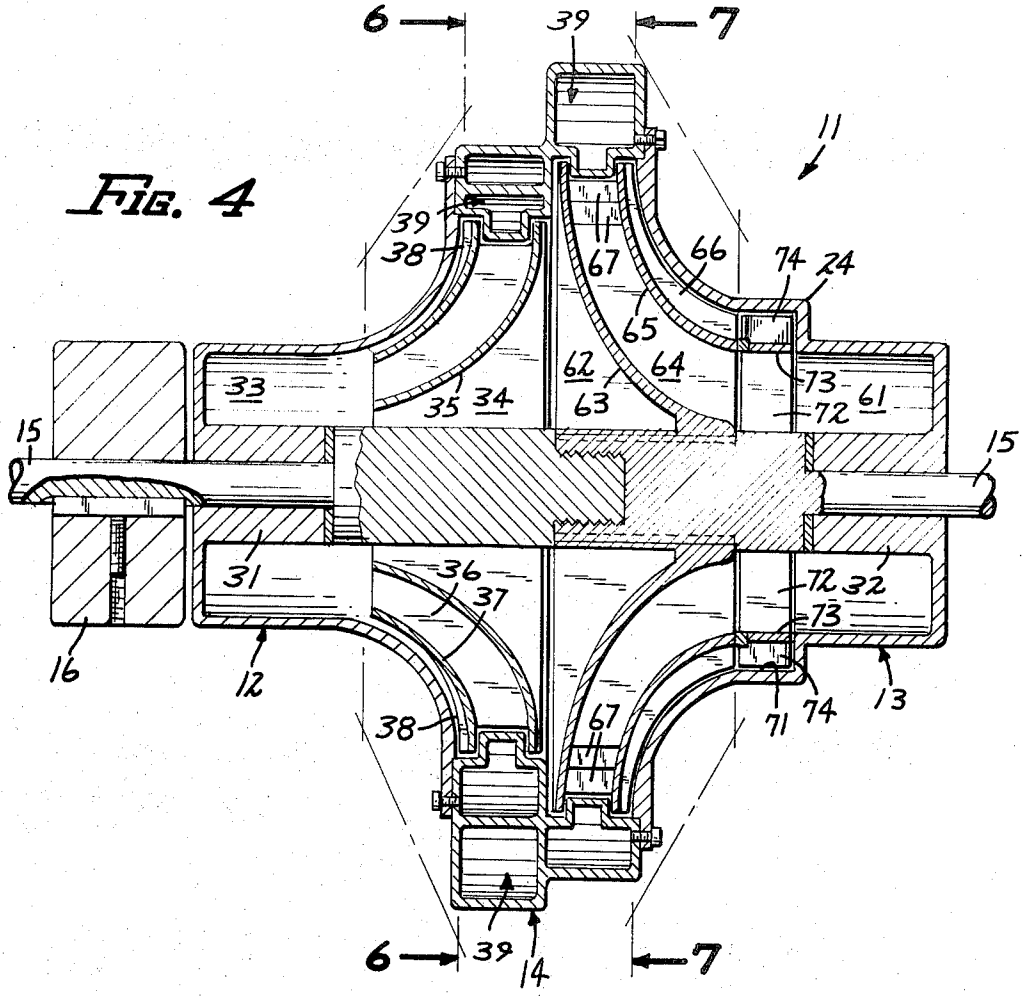


FIG. 4


6
7
39
11
39
38
67
66
74
24
65
62
64
73
72
61
63
33
35
34
15
15
31
36
37
72
32
73
16
12
38
67
71
74
13
6
39
14
7

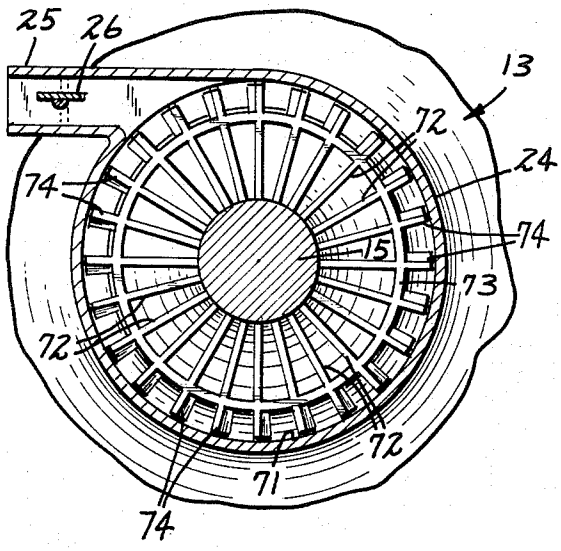

25
26
13
72
24
74
74
15
73
72
72
71
74

FIG. 5

FIG. 6

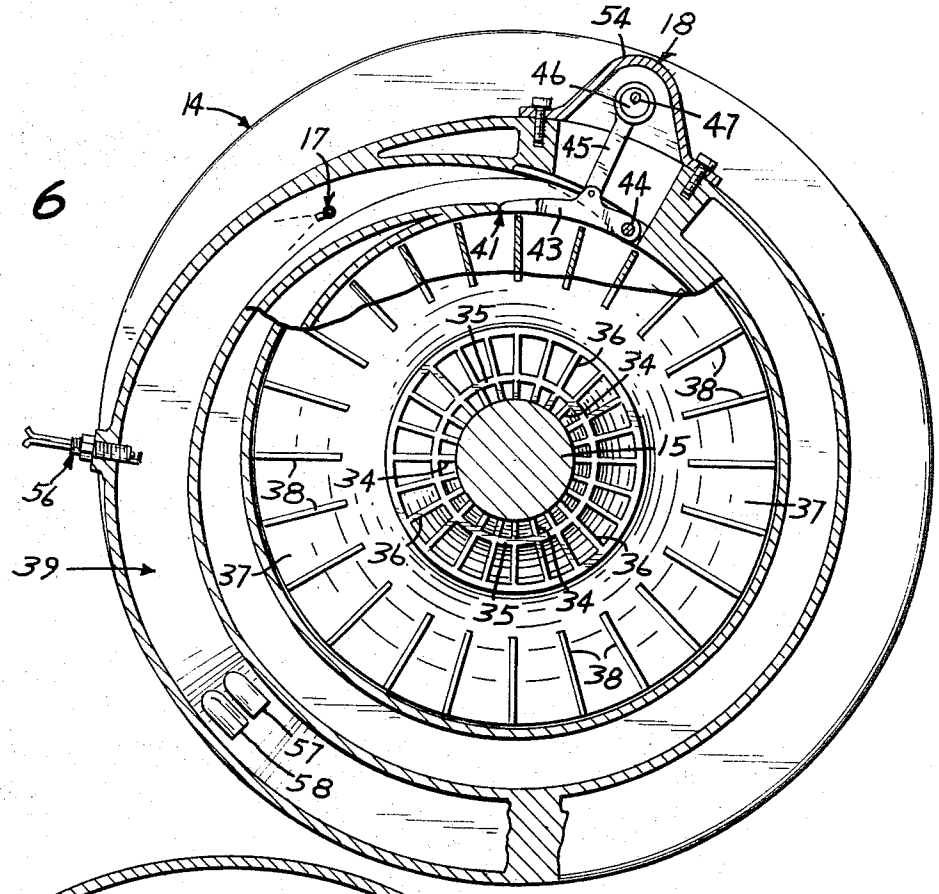
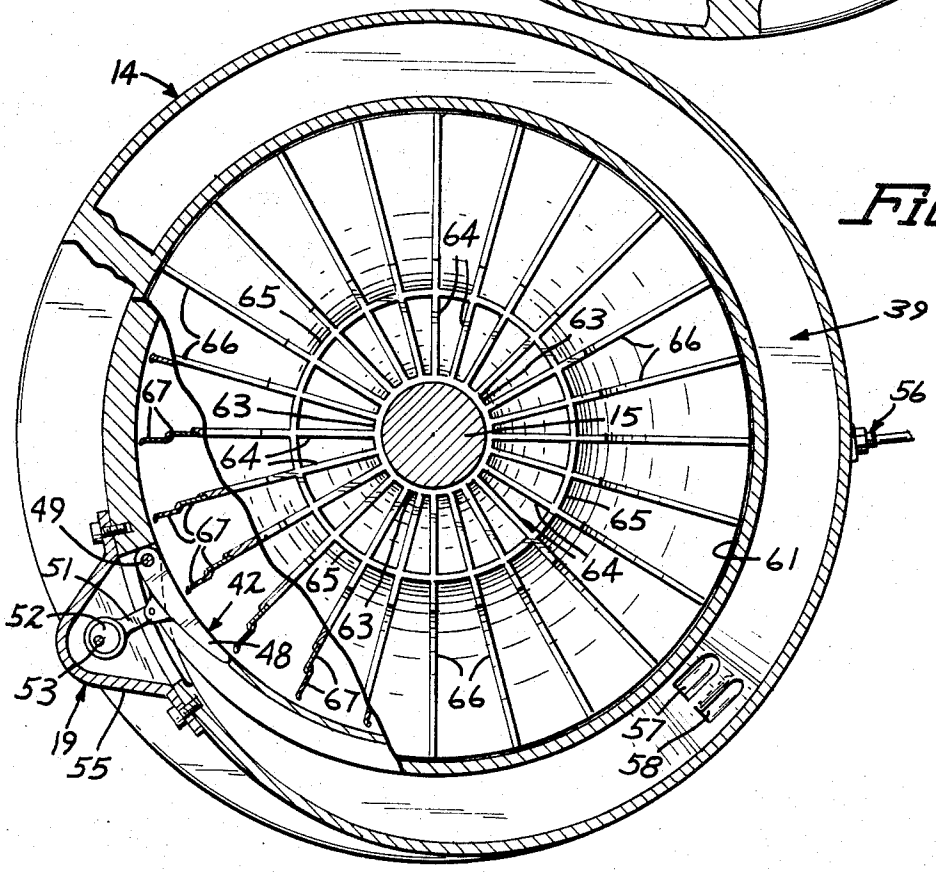

54
18
46
47
14
17
45
44
41
43
35
36
34
38
15
56
38
34
37
39
37
36
36
35
34
38
57
58

FIG. 7


14
64
65
63
66
39
56
66
67
63
15
64
49
67
65
61
51
42
64
52
65
63
48
53
67
66
19
55
57
58

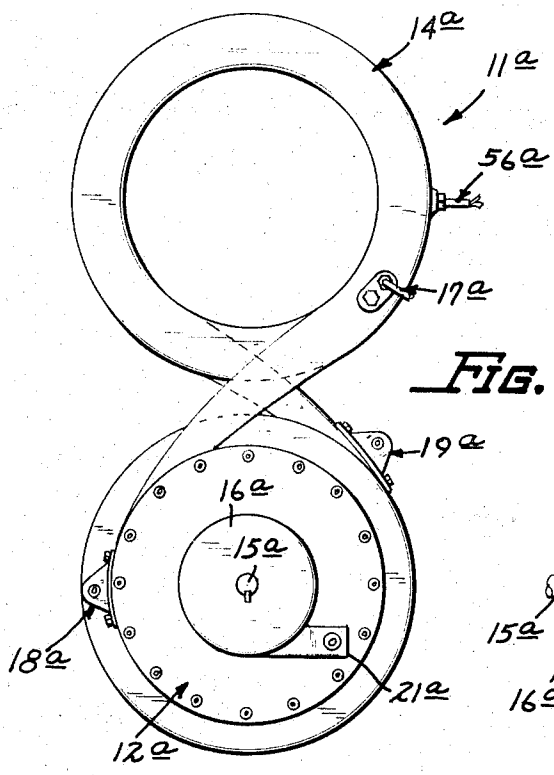


FIG. 9

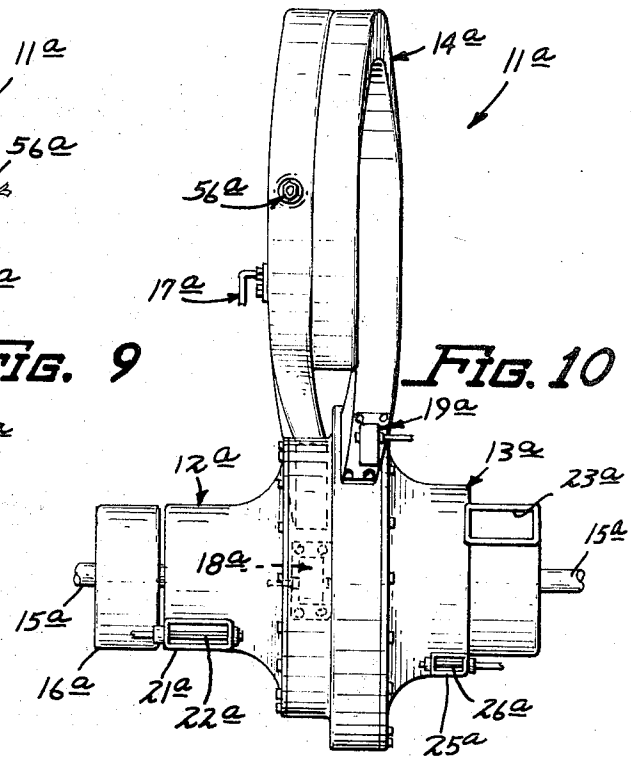


FIG. 10

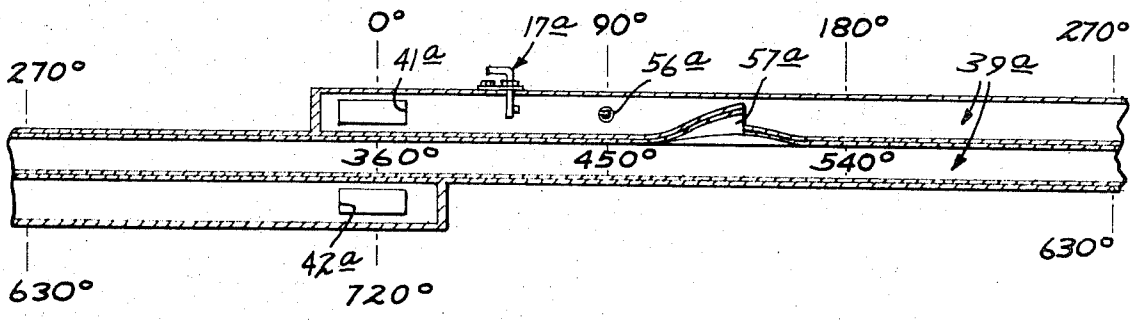


FIG. 11

GAS TURBINE

This invention is an improvement of my United States Pat. No. 3,626,694 issued on Dec. 14, 1971 and entitled "Centrifugal Flow Gas Turbine."

The aforementioned patent discloses a centrifugal compressor and inward flow power turbine having a combustion chamber which spirally encircles the turbine and preserves continuous, laminar flow of air throughout the operation. This invention is directed to a similar gas turbine and incorporates additional features and advantages which permit improved operation.

It is well known that internal combustion engines operate inefficiently at lower rotational velocities, particularly at idling speed. This inefficiency arises in part as a result of incomplete combustion of the fuel charge, which is accompanied by the exhaust of unburned, air-polluting hydrocarbons. Because most internal combustion engines spend a significant amount of time at idling speed (particularly those employed to power automobiles), they are significant contributors to the problem of air pollution. Further, since most idling occurs when the engine is unloaded (.e.g, waiting for a traffic light), much of this air pollution is entirely unnecessary and unjustified since no useful work is produced.

It is also well known that power turbines operate more efficiently at higher rotational velocities and operating temperatures. Consequently, if the operating speed of a power turbine can be economically held at a predetermined minimum level, even when unloaded, this can be beneficial both by increasing operational efficiency and decreasing the quantity of pollutants exhausted.

My invention offers a solution to the problem by storing rotational energy of the power turbine through the use of a flywheel and firing the turbine intermittently between predetermined upper and lower rotational speed limits. During the non-fired period, the turbine is idling or free wheeling; and the outlet to the turbine compressor is automatically closed to contain compressed air for immediate use upon re-firing when the lower limit is reached. The inlet and outlet of the combustion chamber are also closed at this time, and the closure members associated therewith are designed to smoothly conform with the combustion chamber walls, so that rotation of gases within the chamber will not produce tubulence that wastes power and slows rotational speed of the turbine-flywheel combination.

Another feature of my inventive gas turbine resides in the configuration of the compressor blades themselves. The outlet portion of the blades are broadened or increased in size relative to the inlet portion so that the blade tips hold a relatively large supply of compressed air in readiness to enter the combustion chamber immediately upon opening the chamber throttle. This additional rotational volume makes it possible for the air that passes through the compressor to slow its radial velocity while being compressed, and then to enter the combustion chamber in an essentially tangential direction. This configuration also assists in keeping the air entering the combustion chamber in a laminar, non-turbulent state.

Another improvement of my inventive gas turbine results from disposing the compressor intake and power turbine exhaust essentially perpendicularly to the axis of turbine rotation, rather than parallel thereto. The compressor inlet is appropriately spaced from the turbine axis so that intake air flows tangentially and naturally into the rotation of compressor blades. Similarly, the exhaust of gas from the power turbine is tangential relative to the turbine blades, thus preserving continuity of flow.

I also provide for the controlled admission of air to cool the turbine structure during firing. This consists of an air channel defined around the power turbine and a valve-controlled inlet communicating therewith. This valve is closed when the turbine is free-wheeling to maintain the proper operating temperature and thereby prolong the non-fired period.

In an alternative embodiment, I provide a combustion chamber which spirals through 720°, but which is spaced from the turbine housing rather than encompassing it. This configuration gives rise to better flame residence time and more complete combustion, while lowering temperature of the turbine rotational structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a centrifugal flow turbine engine employing the inventive principles;

FIG. 2 is an elevational view of the inventive turbine engine from the front end thereof;

FIG. 3 is a rear end elevational view of the inventive turbine;

FIG. 4 is an enlarged cross sectional view of the turbine engine taken along the line 4—4 of FIG. 2;

FIG. 5 is a cross sectional view of the turbine engine taken through the power turbine 72 of FIG. 4;

FIG. 6 is a sectional view taken along the line 6—6 of FIG. 4;

FIG. 7 is a sectional view taken along the line 7—7 of FIG. 4;

FIG. 8 is a generated diagrammatic view of the combustion chamber of the turbine engine;

FIG. 9 is an end elevational view of a centrifugal flow turbine engine having a combustion chamber of an alternative configuration;

FIG. 10 is a side elevational view of the alternative embodiment; and

FIG. 11 is a generated diagrammatic view of the combustion chamber of the alternative embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With initial reference to FIGS. 1–3, a centrifugal flow gas turbine engine represented generally by the numeral 11 consists of a compressor housing 12, a power turbine housing 13 and a combustion chamber housing 14 which spirally encircles the engine. Engine 11 also includes a rotating shaft 15, upon which a flywheel 16 is mounted. Operating in association with the combustion chamber 14 are a fuel injecting apparatus 17 and inlet and outlet throttling means 18, 19, all of which are discussed in further detail below.

Compressor housing 12 has an inlet duct 21 of rectangular cross section in which a control valve 22 is disposed. As best shown in FIG. 2, the flow path of compressor inlet duct 21 is essentially perpendicular to the axis of rotating shaft 15 and spaced therefrom so that intake air enters the compressor tangentially, as will become more apparent below. Similarly, turbine housing 13 has an outlet duct 23, also of rectangular cross sec-

tion but which includes no control valve. As shown in FIG. 3, outlet duct 23 is also perpendicularly disposed with respect to the axis of shaft 15 and spaced somewhat therefrom in order that the exhaust gases may leave engine 11 in a tangential fashion.

With specific reference to FIGS. 1 and 3, turbine housing 13 further includes an annular channel-defining structure 24 having a rectangular inlet duct 25 similarly disposed to permit the tangential entry of air. The volume of flow entering duct 25 is controlled by a valve 26. The function of the channel defined by structure 24 is described in further detail below.

With continued reference to FIGS. 1 and 3, turbine 11 further includes control apparatus 27 which is capable of sensing the rotational velocity of shaft 15 and which controls inlet valves 21, 25 and throttling means 18, 19, as described in further detail below. Such control is represented schematically by the broken line 28 and is of the regulating type.

With reference to FIG. 4, rotating shaft 15 is shown to be journaled in a first support 31 forming part of the compressor housing 12, and a second support 32 forming part of the turbine housing 13.

Compressor housing 12 defines an annular inlet chamber 33 which receives inlet air through the inlet duct as controlled by valve 22. The centrifugal compressor itself consists of a first set of radially disposed blades 34 connected to rotating shaft 15, an axisymmetrically shaped wall 35 overlying and connected to the outer edges of blade 34, a second set of blades 36 the inner edges of which are mounted on wall 35, a second axisymmetrically shaped wall 37 mounted on the outer edges of blades 36 and a third set of blades 38 the inner edges of which are mounted or cut into the outer periphery of wall 37. Each of the blades 36 increases in width from the inlet side to the outlet side for a purpose described below. The blades 34 and 36, together with the axisymmetric walls 35 and 38 project beyond the arcuate length of blades 36 to conform to the combustion chamber which is described immediately below. The purpose of the blades 36 is to receive air from the inlet chamber 33, to compress such air and deliver it to the combustion chamber. The blades 34 and 38 also receive and compress air from the inlet chamber 33, but such air is used for centrifugal sealing purposes as will be discussed below.

With reference to FIGS. 4, 6 and 7, the combustion chamber housing 14 defines a spirally shaped combustion chamber 39 having an inlet 41 (FIG. 6) directly communicating with the second set of turbine blades 36, and an outlet 42 (FIG. 7) which is at least 360 degrees and preferably 580 degrees or more downstream of inlet 39. The degree of opening of inlet 41 is governed by throttling means 18, which consists of a throttling member 43 that is pivotally movable between open and closed positions about a pin 44. The inner face of throttling member 43 is arcuately shaped to conform precisely to the wall of combustion chamber 39, thereby precluding any structural discontinuity which could otherwise result in turbulence of the gaseous flow. The throttling member 43 is pivotally movable between opened and closed positions by a linkage member 45 mounted on an eccentric bearing member 46. The position of eccentric bearing member is controlled by a rod 47 which projects outwardly as viewed in FIG. 1 to be controlled by the appropriate means represented by broken line 28. Similarly, the throttling means 19 for combustion chamber outlet 42 consists of a throttling member 48 mounted on a pivot pin 49, the position of which is determined by a linkage arm 51, an eccentric bearing member 52 and a control rod 53. Dome structures 54, 55 bolted to the combustion chamber 14 respectively protect the internal mechanism of the throttling means 18, 19.

Fuel injecting apparatus 17 preferably comprises a nozzle and is located immediately downstream of inlet 41, as seen in FIG. 6. An igniter plug 56 is disposed approximately 90 degrees downstream of the inlet 41 or at some location where the fuel is sufficiently vaporized and mixed with air to effect proper ignition.

Referring additionally to the generated view of FIG. 8, it can be seen that combustion chamber 39 spirally encircles the turbine engine 11 to the point that the upstream portion is side-by-side with the downstream portion. Providing communication between these upstream and downstream portions are a pair of louvered openings 57, 58 which are disposed a suitable distance downstream from the inlet 41, preferably about 135° as shown. Louvered openings 57, 58 are shaped so that the downstream portion of combustion chamber 41 widens, thereby decreasing the velocity of ignited gases and increasing their dynamic pressure at that point. A restriction is created in the upstream portion by louvered openings 57, 58, thereby increasing the gas velocity and reducing the dynamic fluid pressure. Thus, a pressure differential is created across the louvered openings 57, 58, and a portion of the downstream gas flow is introduced into the upstream gases in an essentially laminar, non-turbulent manner. The effect is to create a flame holder within combustion chamber 39 by passing hot, previously combusted downstream gases into the upstream air-fuel mixture, which is cooler and unignited. This intermixing or interleaving of hot gases at a temperature above the flash point of the incoming gas mixture serves to ignite the incoming air-fuel mixture and thereby create a self-maintaining circle of flame in the combustion chamber 39.

When the temperature of the combustion chamber 39 reaches a predetermined operating level, the igniter plug 56 may be turned off as the hot gases passing into the upstream portion through louvered openings 57, 58 will be well above the ignition point of the fuel-air mixture, and will therefore self-maintain ignition.

In FIG. 6, it may be seen that the cross sectional area of combustion chamber 39 increases downstream of the inlet 41. In accordance with Bernoulli's Law, this enlarged cross sectional area reduces the velocity of air entering chamber 39 from the centrifugal compressor, which increases the static pressure to effect proper combustion.

With specific reference to FIGS. 4 and 7, turbine housing 13 defines an outlet chamber 61 within which a power turbine is rotatably disposed. The power turbine resembles the centrifugal compressor, consisting of a plurality of radially disposed blades 62 having edges affixed to rotating shaft 15. The blades 62 correspond generally to the blades 34 of the centrifugal compressor and are disposed edge to edge. A first axisymmetrical wall 63 is secured to the outer edge of blades 62, corresponding to the axisymmetrical wall 35 of the compressor. A second set of blades 64 have their inner edges affixed to the wall 63 and their outer edges secured to a second axisymmetrical wall 65. Disposed in the gap lying between wall 65 and the turbine housing

13 are a plurality of blades 66 the purpose of which is described below.

Blades 64 do not extend solidly to the outer periphery of the power turbine, but instead terminate in a plurality of transverse blades 67, which are received in aligned slots formed in the axisymmetrical walls 63 and 65. These slots are preferably slightly larger than the ends of the transverse blades 67, thus allowing them to expand and contract in accordance with the temperature changes which they experience between non-operating and operating conditions. During operation, these centrifugal forces exerted on the blades 67 cause their outer or top edges to bear against the top inner face of the aligned slots. This in turn gives rise to tensional forces on the outer leading edge of each of the blades 16, while the inner edge is subjected to compressional force. This minimizes the tendency of the material from which blades 67 are formed to creep, flow or become deformed under the extremely hot conditions of operation. As best seen in FIG. 7, the blades 67 are overlapped or feathered in order to keep the combusted gases flowing non-turbulently toward the engine exhaust.

In a like manner to the centrifugal compressor, the axisymmetrical walls 63, 65 and the blades 62 and 66 extend arcuately beyond the extreme end of transverse blades 67 to conform to the shape of the combustion chamber 39. FIG. 4 shows the diameter of combustion chamber 39 to increase as it progressively spirals from the centrifugal compressor to the inward flow power turbine, thus requiring the power turbine diameter to be greater than that of the centrifugal compressor. This is done in order to compensate for the increased velocity of combusted gases, and the power turbine diameter is designed so that the tips of the power turbine blades move at approximately the same velocity as the gas entering the power turbine from the combustion chamber. The gases leaving the combustion chamber at such an increased velocity therefore give up their increased energy to the rotating power turbine blades in an optimum manner during flow from the periphery to the exhaust.

With reference to FIGS. 4 and 5 the annular structure 24 defines an annular channel 71 which is in direct communication with the inlet duct 25. As shown in FIG. 5, the control valve 26 for the inlet duct 25 is preferably of the butterfly type, as is the control valve 22 for the compressor inlet duct 21.

An additional and separate set of radially disposed blades 72 are affixed to the rotating shaft 15 and terminate in a circumferential wall 73. Projecting radially outward from the wall 73 is a set of blades 74 which are disposed in the annular channel 71. As shown in FIG. 5, the blades 74 have a slight pitch so that, upon rotation, cooling air received through the inlet duct 25 and control valve 26 is propelled upwardly into the blades 66.

In operation, with control valve 22 opened, air is admitted to the centrifugal compressor through the air inlet duct for compression prior to delivery to the combustion chamber 39. Because this intake flow of air is tangential and at right angles to the axis of rotation of shaft 15, the air flow is smooth and continuous because it naturally enters into the rotation of the compressor blades, and its momentum is conserved for more efficient compression. The blades 36 are the primary compressor blades for the combustion chamber 39, and the progressively increasing width of each gives rise to an increased rotational volume, and also enables the air passing through the compressor to slow its radial velocity while being compressed, and then to enter the combustion chamber in a tangential direction. This helps to maintain the air in a laminar, non-turbulent condition upon entering the combustion chamber 39, and insures more thorough and efficient combustion.

This feature of progressively increasing dimension is also important because it enables the blades 36 to store a relatively large supply of compressed air in the compression chamber with the throttling member 43 closed, whereby the stored compressed air can be instantly supplied to the combustion chamber 39 upon opening of the throttle means 18. This insures immediate response of the engine 11 and precludes the lag which inherently accompanies conventional turbine engines.

Upon entry of the compressed air through the inlet 41 and into the combustion chamber 39, it is mixed with fuel entering the chamber through the injector nozzle 17. Upon ignition by the igniter plug 56, pressure within the chamber 39 builds up and the expanding gases are released through the combustion chamber outlet 42 to impart force upon the transverse blades 67, blades 64 and ultimately blades 72. The exhaust duct 23 is angularly disposed in a manner similar to the inlet 21 to take full advantage of the residual momentum of the exhaust gases so as to move them through the exhaust system, thus eliminating back pressure on the power turbine. The resulting rotation of the power turbine portion of engine 11 can be utilized in a desired manner.

Lourverd openings 57 and 58 communicate the ignited fuel mixture, to a point upstream from the outlet 42 to a point downstream of the ignition plug 56. Thus, the flame not only progresses spirally through outlet 42, but also doubles back to ignite the incoming, cooler fuel mixture and maintains continuous ignition and combustion in chamber 39.

The exceedingly high forces resulting from compression, ignition and combustion in chamber 39 must be fully contained and channeled into the power turbine blades, in order to achieve highest engine performance. To this end, blade sets 34 and 62 (which are located in a common chamber) centrifugally compress air and direct it outwardly in a peripheral direction. Blades sets 38 and 66 operate in a similar manner to compress air and deliver it along the space defined between the stationary housing of engine 11 and the rotating portions. In so doing, the blades 66 serve to cool the combusted gases entering the power turbine and thereby preserve its blades. Further, the blades 66 provide the advantageous function of adding oxygen to the hot combined gases entering the power turbine, thereby making possible further combustion of carbon monoxide to carbon dioxide. Both of the blade sets 38 and 66 operate to cool the outer peripheries of the respective axisymmetric walls of the compressor and power turbine, thus maintaining their tensile strength to better support the heated transverse blades.

Thus, the four sets of blades 34, 62, 38, 66 work together to circulate air and produce centrifugal pressures that container the internal compressed gases, thus channeling compressed air into the combustion chamber 39 and forcing the combusted gas to leave the chamber only through the blades 64. It will be appreci-

ated that the blades **38** receive a supply of air through the compressor inlet **21**, whereas the blades **66** receive a supply through the auxiliary cooling inlet **25**. Thus, an optimum amount of energy generated by the combusted gases in chamber **39** is channeled through the blades **67** and **64** to achieve high engine performance.

As pointed out above, one of the primary features of my improved turbine engine resides in the inclusion of the flywheel **16**, which enables the turbine to run for extended periods of time in a predetermined range of rotational velocities without a continuous supply of fuel and air. In other words, the flywheel **16** acts as a momentum storing device and permits intermittent firing of the engine in accordance with predetermined upper and lower limits defining the desired rotational velocity range. Acting in conjunction with the flywheel **16** is control apparatus **27**, which senses rotational velocity of the shaft **15** and controls the inlet valves **22, 25** and throttling mechanisms **18, 19** in an appropriate manner. Specifically, control apparatus **27** permits the engine **11** to fire until a predetermined upper rotational velocity limit has been reached. At this point, throttling means **18** and **19** are actuated to close the throttle members **43** and **48** and thereby preclude the entry or exhaust of gases from combustion chamber **39**. It will be appreciated that the arcuate inner surface of the throttle members **43** and **48** assist in this shut down period by creating smooth, continuous race ways along the inner surface of the compressor and turbine housings, respectively, which tends to diminish turbulence and friction and thereby enchance extended rotational periods.

Simultaneous with the closing of throttle members **43** and **48**, valve **22** of inlet duct **21** is controlled to regulate the further entry of air into the centrifugal compressor. The valve **26** of inlet duct **25** is closed to preclude the entry of cooling air, thereby conserving the higher operating temperature of the engine **11** during idle periods, thus reducing heat-change stresses and conserving heat energy. Outlet duct **23** remains opened to eliminate the possibility of pressure build-up within the power turbine.

When rotational speed of the shaft **15** drops to a predetermined minimum, control apparatus **27** acts to open throttle means **18, 19**, control valves **22, 26** and to re-ignite the plug **56**. At this point of re-ignition, the compressed air previously stored within the chamber **33** is immediately supplied to the combustion chamber **39**, thus precluding any lag in response.

It will be appreciated that the flywheel **16** and control apparatus **27** together cooperate to permit intermittent firing of the engine **11** and enables the turbine to operate at an optimum rotational speed during idle periods without the time lag that normally occurs with conventional turbines. This intermittent firing also has the effect of significantly decreasing the emission of pollutants during idle periods, since the engine does not fire during such periods.

FIGS. **9–11** disclose an alternative embodiment of my improved turbine engine, in which like components are represented by like numerals with addition of the small letter *a*. The primary modification resides in the combustion chamber **39***a* which, as shown in FIGS. **9** and **10**, is spirally formed but does not encircle the turbine housing. Instead, combustion chamber **39***a* undergoes two complete revolutions in a position spaced from the turbine housing and connected therewith only at the throttle inlet and outlet. As indicated by the generated view of FIG. **11**, the fuel injector nozzle **17***a* is disposed immediately downstream of the throttle inlet **41***a* and ignition plug **56***a* is again positioned at the 90° point. Louvered openings **57***a*, remain at 135° downstream for the inlet **41***a*, also as before. However, outlet **42***a* of combustion chamber **39***a* is disposed a full two revolutions beyond the inlet opening **41***a* (720°). All other structure of the alternative embodiment is essentially the same. With the extended spiral length of combustion chamber **39***a*, the combusted gases travel a full 720°, thus giving rise to a greater residence time and more complete combustion. This not only increases efficiency in engine operation costs but also diminishes the discharge of pollutants by reason of the more complete combustion.

I claim:

1. A centrifugal flow gas turbine, comprising:

a. an elongated housing having an inner inlet and an exhaust;

b. a compressor mounted for rotation in the housing, the compressor having an inlet communicating with the housing inlet and an outlet;

c. a power turbine mounted in the housing for rotation with the compressor, the power turbine having an inlet and an outlet communicating with the housing exhaust;

d. a combustion chamber having an air inlet communicating with the compressor outlet, an outlet communicating with the power turbine inlet, a fuel inlet and means for igniting the fuel and air mixture in the combustion chamber;

e. flywheel means mounted for rotation with the compressor and power turbine;

f. and control means for effecting intermittent ignition within the combustion chamber wherein said control means is constructed and arranged to sense rotational velocity of the turbine engine, and to effect intermittent ignition and non-ignition within the combustion chamber between first and second predetermined rotational velocities.

2. The turbine engine defined by claim **1**, wherein the combustion chamber is spirally shaped.

3. The turbine engine defined by claim **2**, wherein the spirally shaped combustion chamber encircles the compressor and power turbine.

4. The turbine engine defined by claim **2**, wherein the spirally shaped combustion chamber comprises at least two complete revolutions spaced from the turbine housing in non-encircling relation therewith.

5. The turbine engine defined by claim **2**, wherein:

a. the compressor is of the centrifugal type, having an outlet disposed at its periphery;

b. and the power turbine is of the inward radial flow type having an inlet disposed at its periphery.

6. The turbine engine defined by claim **1**, and further comprising valve means for controlling the flow of air entering the housing inlet.

7. The turbine engine defined by claim **6**, wherein the control means is constructed and arranged to close the valve means when the combustion chamber is in a non-ignition state.

8. The turbine engine defined by claim **6**, wherein:

a. the housing has a predetermined axis;

b. and the housing inlet is disposed to define an air flow path transverse to the housing axis and spaced

therefrom so that air enters the compressor tangentially.

9. The turbine engine defined by claim **8**, wherein the housing inlet is rectangular in shape, and the valve means comprises a butterfly valve of commensurate shape.

10. The turbine engine defined by claim **1**, wherein:

a. the housing has a predetermined axis;

b. and the housing inlet is disposed to define an outward air flow path transverse to the housing axis and spaced therefrom so that combusted gases leave the power turbine tangentially.

11. The power turbine defined by claim **1**, and further comprising first valve means for adjustably restricting the combustion chamber inlet, and second valve means for adjustably restricting the combustion chamber outlet.

12. The turbine engine defined by claim **11**, wherein the control means is constructed and arranged to close the first and second valve means in the non-ignition state.

13. The turbine engine defined by claim **11**, wherein each of the first and second valve means comprises:

a. a throttle member mounted for pivotal movement relative to its associated inlet or outlet;

b. and means for pivotally moving the throttle member in adjustably restricting relationship with the associated inlet or outlet.

14. The turbine engine defined by claim **13**, wherein the combustion chamber is spirally shaped, the combustion chamber inlet and outlet are each disposed within the combustion chamber periphery, and the inner face of each of the throttle members is arcuately shaped to conform to the associated inner wall of the combustion chamber.

15. The turbine engine defined by claim **1**, wherein the compressor comprises a plurality of compressor blades each of which extends from a point proximate the housing inlet to a point proximate the combustion chamber inlet, the width of each blade increasing from the housing inlet to a point of maximum width at the combustion chamber inlet.

16. The turbine engine defined by claim **1**, wherein the second predetermined rotational velocity is greater in magnitude than the first predetermined rotational velocity, and the control means effects ignition of the combustion chamber up to the second predetermined rotational velocity, precludes ignition when the second predetermined rotational velocity is reached, and effects reignition when rotational velocity of the turbine falls below the first predetermined rotational velocity.

17. The turbine engine defined by claim **1**, and further comprising:

a. a space defined between the power turbine and the turbine housing, the space extending essentially between the combustion chamber outlet and the turbine exhaust and having an inlet establishing communication between the space and the ambient atmosphere;

b. and valve means operating in conjunction with said space inlet for variably restricting the volume of air admitted therethrough.

18. The turbine engine defined by claim **17**, wherein the space further comprises an annular chamber disposed proximate the housing exhaust, the space inlet being disposed to admit air tangentially to the annular chamber.

19. The turbine engine defined by claim **17**, and further comprising blade means forming part of the turbine for effecting radial air flow in said space toward the combustion chamber.

20. In a turbine engine including a turbine housing with a closeable inlet and an outlet; a compressor and a power turbine rotatably mounted in the housing; a combustion chamber having an inlet communicating with the compressor, an outlet communicating with the power turbine, a fuel inlet and means for igniting the fuel; and throttle means for adjustably restricting the combustion chamber inlet, the improvement comprising:

a. flywheel means rotatable with the compressor and power turbine;

b. and control means for effecting intermittent ignition within the combustion chamber, for opening the turbine housing inlet and throttle means during the ignition phase of operation, and for closing the turbine housing inlet and the throttle means during the non-ignition phase of operation wherein said control means is constructed and arranged to sense rotational velocity of the turbine engine, and to effect intermittent ignition and non-ignition within the combustion chamber between first and second predetermined rotational velocities.

21. The turbine engine defined by claim **20**, and further comprising a cooling space defined between the power turbine and turbine housing, an inlet for admitting ambient air to the cooling space and valve means for adjustably restricting the cooling inlet; and the control means is constructed and arranged to open and close the valve means in conjunction with opening and closing of the turbine housing inlet and throttle means.

22. The turbine engine defined by claim **21**, wherein said throttle means additionally comprises means for adjustably restricting the combustion chamber outlet.

* * * * *