May 29, 1934. P. C. GORDON 1,960,810

GAS TURBINE

Filed July 26, 1930 2 Sheets-Sheet 1

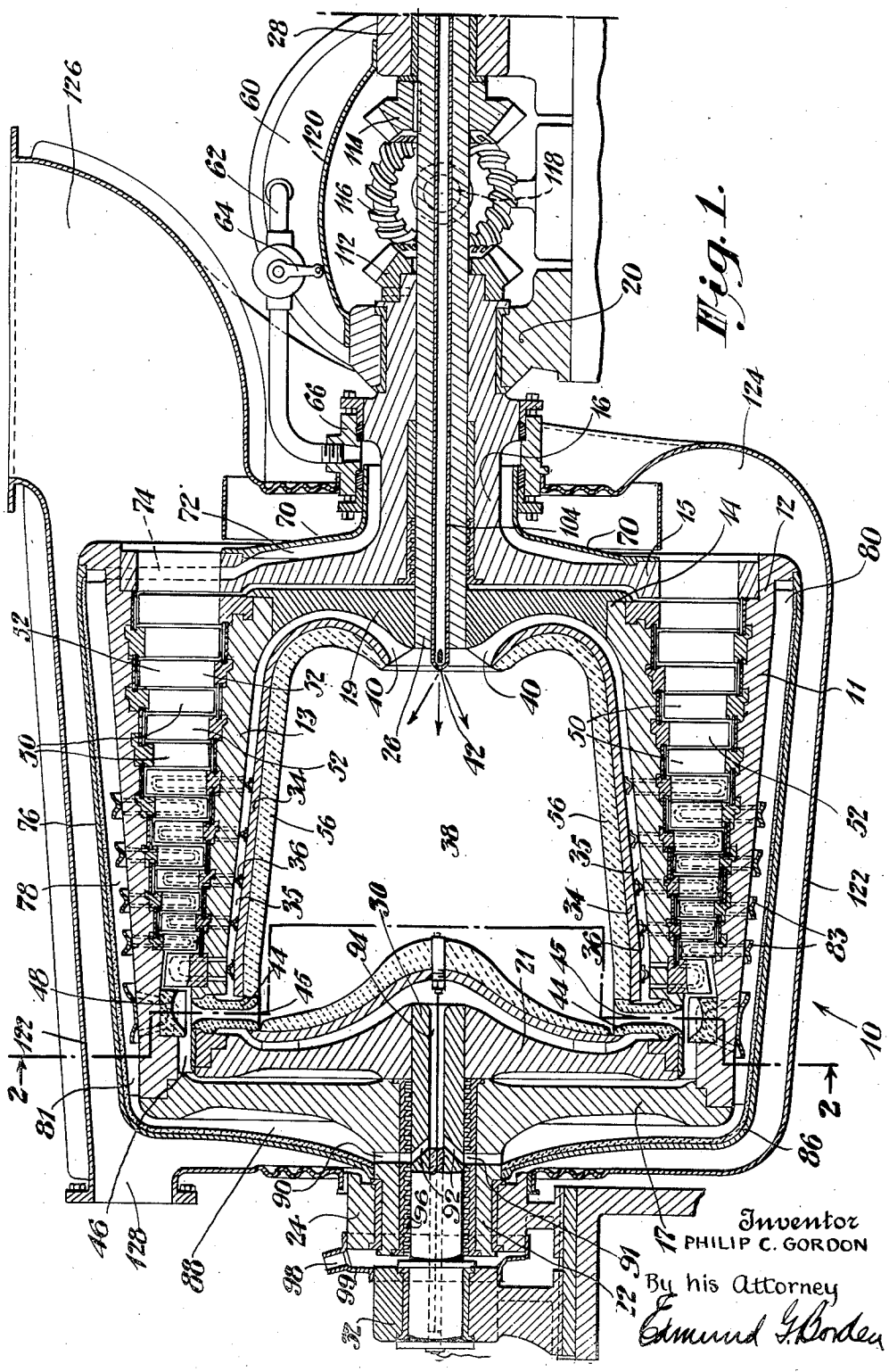


Fig. 1.

Inventor
PHILIP C. GORDON
By his Attorney
Edmund G. Borden

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Fig. 2.

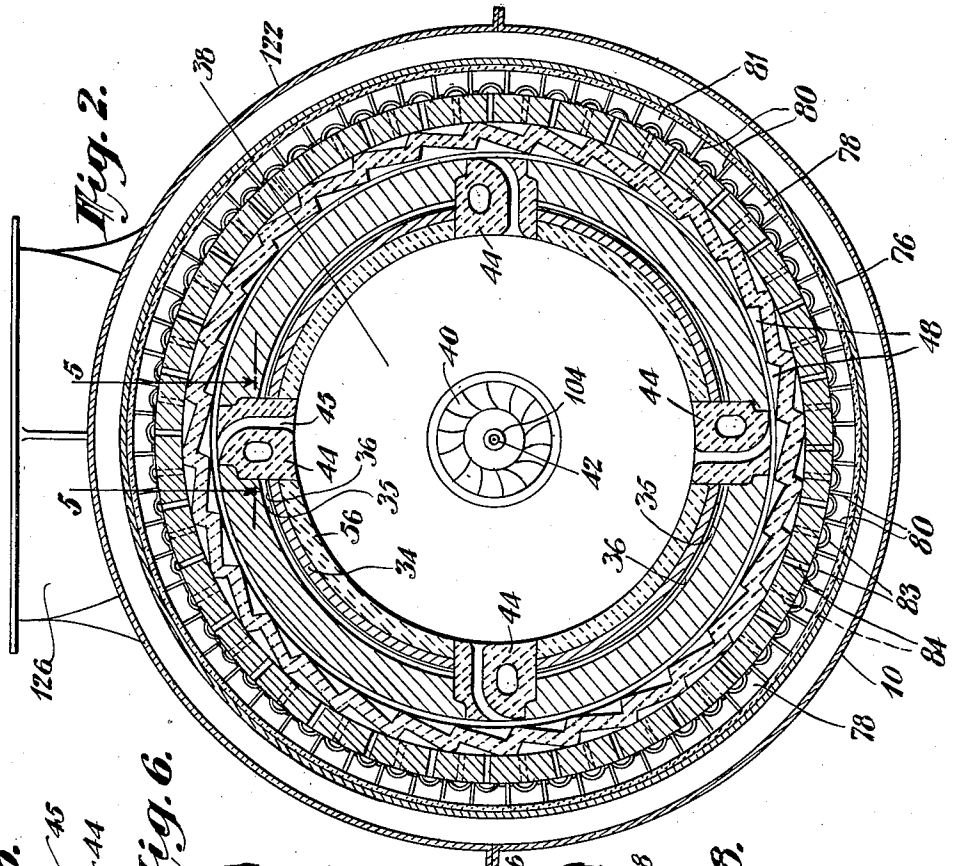


Fig. 5.

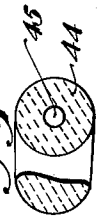


Fig. 6.

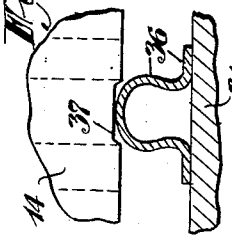


Fig. 7.

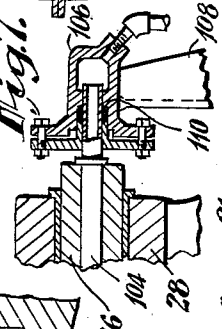


Fig. 8.

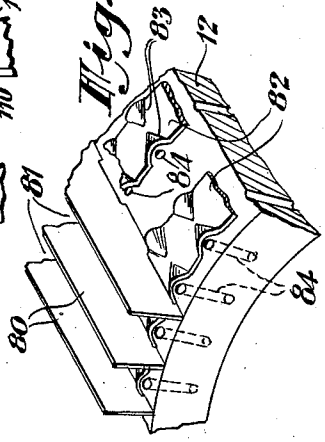
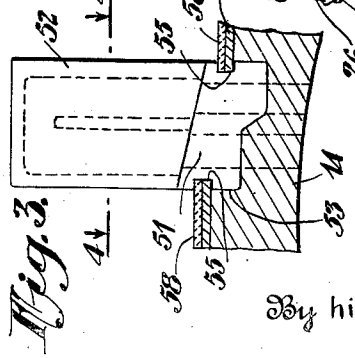


Fig. 4.



Fig. 3.



Inventor
PHILIP C. GORDON

By his Attorney
Edmund G. Borden

Patented May 29, 1934 1,960,810

UNITED STATES PATENT OFFICE

1,960,810

GAS TURBINE

Philip C. Gordon, Jersey City, N. J., assignor to Doherty Research Company, New York, N. Y., a corporation of Delaware

Application July 26, 1930, Serial No. 471,076

2 Claims. (Cl. 60—41)

This invention relates to combustion turbines and more particularly to combustion turbines of the type in which fuel is burned continuously at constant pressure in a combustion chamber and the resulting products passed through a nozzle and directed against the blades of the turbine.

It is among the objects of this invention to provide a gas turbine which shall be of simple and durable mechanical construction; which shall be efficient in operation and capable of consuming the lower grades of fuel.

It is a further object of this invention to conserve the space occupied by the turbine and to reduce the weight of the same as compared to other turbines of the same speed and horsepower.

To this end it is a feature of this invention to construct the turbine in the form of a plurality of concentric casings or shells mounted for rotation upon the same axis and having spaces therebetween, the innermost of said shells providing a combustion chamber and the spaces therebetween providing passages for the admission of compressed air to and the expansion and discharge of products of combustion from said combustion chamber. By this construction, as will be further pointed out in connection with the following detailed description, the gases in their passage through the turbine follow a winding course through a plurality of concentric annular chambers, thereby reducing the length as well as the weight and space occupied by the same.

It is a further object of this invention to provide a turbine having a high relative blade speed but at the same time obtain a low peripheral velocity of the blades, thereby obtaining the effect of high blade speed without incurring the mechanical stress of high peripheral velocity.

To this end that element of the turbine which is commonly held stationary and therefore called the stator is mounted to rotate in a direction opposite to the direction of rotation of the rotor so that the relative speed of the blades of the rotor to the blades of the element commonly held stationary is twice the actual velocity of the moving parts.

In the conventional turbine the first or highest stages are least efficient because the velocity of the gases in these stages is many times the velocity of the buckets or vanes so that the gases exert a component of only a small proportion of the correct relative velocity.

In accordance with the present invention the discharge from the combustion chamber is through a nozzle-like orifice or orifices which are mounted to rotate in a direction opposite to the rotation of the buckets and so constructed and directed that a torque reaction is produced within the nozzle as well as between the nozzle and the blades, thereby converting into turning effort not only the impulse against the blades but the reaction against and within the nozzle as well.

In conventional internal combustion turbines the temperature of combustion may be several thousand degrees and the radiation losses are therefore prohibitively high.

It is a further object of this invention to provide a construction in which all radiation of heat from the combustion chamber passes back to the incoming air and is thus retained in the system rather than dissipated to the atmosphere or to a cooling medium.

To this end it is a feature of this invention to provide for the heating of the combustion supporting air by passing the same about the turbine cylinders and casings and the combustion chamber thereby recovering radiation losses and preheating said air to obtain the best conditions for complete combustion.

It is a further object of this invention to provide a turbine which permits of complete expansion from a relatively high pressure to that of the atmosphere or receiver through a considerable number of efficient stages and without any excessive change in the diameter of the rotating elements, the respective diameters from beginning to end remaining sufficiently alike to avoid material strains due to differences in expansion.

Gas turbines have usually been designed around the necessity of furnishing a large excess of compressed air in order to limit the temperature within the nozzles and blades, that is, throughout the working elements of the turbine, to a temperature on the order of 1000° F. whereas in order to attain a commercially practical efficiency it is necessary to utilize air at temperatures of the order of 3000° F. at the beginning of expansion and to carry the expansion completely through to atmospheric or receiver pressure.

Since the net output of the turbine is the work done thereby minus the work absorbed by the compressor the quantity of air compressed to a given pressure should be as small as possible.

It is a further object of this invention to provide a combustion turbine in which only substantially the practical amount of compressed air that is essential for complete combustion and expansion is used.

To this end it is a feature of this invention to construct all parts exposed to products of combustion at high temperatures of refractory ma-

terial, provide efficiently for a considerable drop in pressure and temperature in the first stage of the turbine and to recover the heat of radiation from the various expansion stages by the incoming air, thereby providing a construction capable of utilizing products of combustion at high temperature and pressure and expanding the same to the final pressure and temperatures.

It is a further object of this invention to provide a construction in which all members under mechanical strain are allowed to expand freely without interference from other members and to protect such parts from contact with the hot gas, and to interpose between said gases and said strain bearing parts an insulating or cooling layer.

These and other objects of the invention will be apparent to those skilled in the art from a consideration of the following detailed description in conjunction with the accompanying drawings, in which:

Fig. 1 represents a longitudinal section through a gas turbine parts being shown in side elevation, which is constructed in accordance with this invention;

Fig. 2 represents a transverse section taken on the line 2—2 of Fig. 1;

Fig. 3 is a detail view on an enlarged scale of a turbine blade disclosing the method of inserting and holding the same in position;

Fig. 4 is a transverse section through a turbine blade taken on the line 4—4 of Fig. 3;

Fig. 5 is a transverse section through a refractory plug which forms a nozzle of the turbine and is taken on line 5—5 of Fig. 2;

Fig. 6 is a detail view disclosing the means for supporting the shell forming the combustion chamber of the turbine within the casing forming one of the rotating elements while permitting differences in expansion therebetween;

Fig. 7 is a detail disclosing the manner of attaching a fuel supply connection to the rotor of the turbine; and

Fig. 8 is a detail disclosing the small section of the outer casing of the turbine and the manner of attaching cooling fins and air deflectors thereto.

Referring to Fig. 1 reference numeral 10 indicates the turbine proper which is formed of an outer casing 12 and an inner casing 14. The casings 12 and 14 consist of hollow members 11 and 13, the ends of which are closed by discs 15, 17 and 19, 21 respectively. These discs are rigidly but detachably connected with the members 11 and 13 and in order that the same may rotate in opposite directions about the same longitudinal axis discs 15 and 17 are provided with hollow cylindrical extensions 16 and 22 projecting axially of the outer casing 12 to provide bearing surfaces which are journalled in bearings 20 and 24 respectively. The discs 19 and 21 which form the ends of the inner casing 14 are provided respectively with shafts 26 and 30 which are rigidly connected therewith and extend therethrough. These shafts project through the cylindrical extensions 16 and 22 of discs 15 and 17 and are journalled in suitable bearings 28 and 32 positioned beyond the bearings 20 and 24 of cylindrical extensions 16 and 22.

A hollow shell 34 having a lesser external diameter than the internal diameter of the inner casing 14 is positioned in said inner casing and held in spaced relation thereto by a series of retaining rings 36 which are adapted to hold the shell in position within said inner casing while permitting slight relative movements due to the difference in expansion between said shell and said casing. A space 35 is thus formed between the exterior surface of shell 34 and the interior surface of the inner casing 14. The interior of shell 34 provides a combustion space 38 which is in constant communication with space 35 by way of an air inlet passage 40 which opens axially of the combustion space.

Admission of fuel to the combustion space 38 is effected through a fuel nozzle 42 which opens into said space axially of the air inlet 40. A plurality of nozzle plugs 44 having passages 45 therethrough provides for the discharge of products of combustion from the combustion chamber to the first expansion stage of the turbine.

The inner casing 14 has a lesser external diameter than the internal diameter of the outer casing 12 to provide an annular chamber 46 therebetween. Since the member 11 is slightly frustoconical, increasing in diameter from left to right and since the member 13 is of similar construction but increasing in diameter from right to left the annular chamber 46 formed therebetween is of constantly increasing cross sectional area from left to right. This space is therefore adapted to accommodate a row of buckets 48 and a series of rows of blades 50 projecting inwardly from the outer casing 12 and alternating with a series of rows of blades 52 projecting outwardly from the inner casing 14. The length of the blades 50 and 52 increases from left to right to extend substantially across the chamber 46 as the same increases in width.

Referring particularly to Figs. 3 and 4 it will be seen that the turbine blades 50 and 52 are provided with a substantially rectangular base portion 51 adapted to be inserted in troughs 53 disposed in alternating planes upon the exterior surface of inner casing 14 and the interior surface of the outer casing 12. In the base portion 51 and extending the width thereof on either side of the same grooves 55 are provided. A series of rings 54 having external diameters equal to the interior diameters of each of the stages of progressively increasing diameters of outer casing 12 are provided for locking blades 50 to said casing, the arrangement being such that when the base portion 51 of the blades is inserted in the proper trough 53 the ring 54 may be inserted in the casing in a manner to project into grooves 55 in the blades thereby holding the same in place. In a similar manner the blades 52 on the inner casing 14 are held in position by rings 54 coacting with grooves 55 in the blades.

In order to supply compressed air to the combustion space 38 of the turbine a compressor 60 which may be of any conventional type but which is preferably of the type which compresses air substantially isothermally is provided. A pipe 62 controlled by a throttle 64 leads from the compressor 60 and is connected by a collar 66 surrounding extension 16 to supply air from the compressor to a passage formed between said extension and a jacket 70 surrounding the same and covering the end of disc 15. The jacket 70 is held or otherwise rigidly attached to the surface of disc 15 at a point just below the last series of blades 50 and provides with the same a chamber 72 for the passage of air from pipe 62 to the base of said blades. From thence the air passes through said blades by way of air passages 74 provided therethrough.

A jacket 76 extends about the circumference of casing 12 being welded or otherwise attached

thereto to form a space 78 therewith. The space 78 is divided by a series of fins 80 into a plurality of passages 81 extending longitudinally of said casing 12. A plurality of bands 82 as may be seen more particularly in Fig. 8 extend about the circumference of casing 12 being held in position by said fins. The edges of the bands between said fins are gouged up to provide hoods 83 over passages 84 which are drilled through casing 12 and provide by-pass passages for the circulation of air through blades 50.

A jacket 86 covers the end of casing 12 adjacent the disc 17 and provides therewith a space 88 for the flow of air from said passages 81 to a point adjacent the cylindrical extension 22. The jacket 86 is preferably welded to said extension at a point adjacent the bearing 24 providing an airtight connection therewith. A plurality of radial passages 90 through the cylindrical extension 22 provide for the passage of compressed air from said space 88 to an annular chamber 91 surrounding shaft 30. Radial passages 92 in shaft 30 connect the annular space 91 with a passage 94 extending longitudinally of said shaft and which opens into the space 35 formed between the shell 34 and the casing 14. Packing 96 is provided between the shaft 30 and the cylindrical extension in which it rotates to limit the leakage of air in its flow from passages 90 in the cylindrical extension 22 to the passages 92 in the shaft 30. A pipe 98 connected to a hood 99 between the bearings 24 and 32 permits such losses of compressed air as occur to be recovered.

As the air passes through the space 35 about the shell 34 en route to the air inlet passage 40 it is deflected through the blades 52 by means of retaining rings 36. The retaining rings 36 which may be particularly seen in connection with Fig. 6 are rigidly connected to shell 34 but are movable relative to casing 14 to the limited extent permitted by grooves 37 in the interior of said casing. The conformation of the rings 36 permits of the expansion or contraction of shell 34 to take up differences between the circumferential expansion of said shell relative to said casing, while longitudinal expansion is provided by the slippage of said rings for the width of said grooves.

It will be observed that while only a portion of the incoming air is deflected by the hoods 83 into the passages of the blades 50, the retaining rings 36 deflect substantially all of the air through each series of the blades 52. Since the air in the first blades that are cooled is colder than that in the latter the same degree of cooling is effected by the lesser quantity of air so that blades 50 and 52 are maintained at substantially the same temperatures.

As disclosed only the blades of the first few stages and the blades of the last expansion stage are provided with air cooling since beyond the stages shown the products of combustion are not at sufficiently high temperature to damage the material used in the blades and such heat as is left may be best extracted in the final stage only. All or part of the stages may be cooled however, either by the partial or total deflection of air as design conditions may warrant.

The air having been highly heated in the course of its passage about the exterior of casing 12, through the blades 50 and 52, and over the shell 34, passes to combustion chamber 38 by way of air inlet 40. At this point fuel is supplied thereto from fuel nozzle 42 to which fuel is conducted under pressure by way of a tube 104 extending through shaft 26.

The fuel tube 104 projects slightly beyond the outer end of shaft 26 as may be seen in Fig. 7 affording a convenient means for attaching a fuel supply connection 106 thereto while still permitting the rotation thereof. The fuel supply connection 106 is mounted upon a removable pedestal 108 so that the fuel supply tube 104 can readily be removed and a new supply tube inserted in the event that the nozzle 42 becomes clogged without delaying the operation of the turbine. Suitable packing 110 prevents fuel losses between the supply device 106 and the fuel tube 104 even though the fuel is at relatively high pressures.

The fuel and air being admitted into combustion space 38 in close proximity to each other and with considerable turbulence, due to the rotation of the combustion chamber itself, efficient combustion follows and since the fuel and the air supply is continuous this combustion is continuous at substantially constant pressure.

The combustion chamber 38 affords a relatively large space in which combustion may be completed before passing through the turbine nozzles 44 to act upon turbine buckets 48. The entire interior of the combustion space 38 is lined with a refractory material 56 limiting to a certain extent the passage of heat through the shell 34 and preventing contact of the highly heated gases which at the temperatures used are highly destructive of metals from contacting with the metallic portion of the shell 34. The nozzle plugs 44 are likewise of refractory material as well as the turbine buckets 48 and the blades 50 and 52. The locking rings 54 have a layer of refractory material 58 covering the same as may be seen more particularly in Fig. 3, so that the entire path of the gases both during and after combustion is lined with a refractory material.

As may be seen particularly in connection with Fig. 2 the passage 45 through the turbine nozzle 44 is so directed that it discharges tangentially of the exterior of inner casing 14. Since this casing is movable in a direction opposite to the direction of the discharge the reaction set up within the nozzle affords a component of the force tending to rotate the casing 14 in a direction opposite to the direction of the discharge while the force of the gases against the buckets 48 on the interior of outer casing 12 tend to rotate the outer casing in the opposite direction. The discharge from the nozzle 44 against the buckets 48 constitutes the first expansion stage of the turbine and since the gases at this point are moving at a very high velocity this stage has been designed to take advantage of an efficient and practical construction for converting the kinetic energy of the gases at this high velocity into useful work while the later stages of the turbine are designed to function efficiently at lower velocities.

The nozzle plug 44 is seated upon a shoulder formed in the casing 14, said shoulder being slightly rounded to permit variation in the seating of said nozzle therein due to longitudinal expansion of shell 34 relative to casing 12. The end of the nozzle plug passing through the shell 34 is slidable relative thereto and provided with slight clearances to permit said shell to expand without transmitting a strain to said nozzle. Since the air in the space 35 surrounding the shell 34 is at substantially the same pressure as the gases within the combustion space 38 little or no leakage occurs around the nozzle plug into or from said combustion space even though no packing is provided at this point.

The rotation of the outer casing 12 due to the

action of the products of combustion upon the turbine buckets 48 and the blades or vanes 50 is transmitted through the cylindrical extension 16 to a bevel gear 112 attached thereto while the rotation of casing 14 due to the reaction of the products of combustion within the passage 45 of the nozzle 44 and against blades 52 is transmitted through the shaft 26 to a bevel gear 114 opposite the gear 112. Gears 112 and 114 act to drive a gear 116 attached to a shaft 118 driving the compressor 60. The gearing is preferably covered with a suitable housing 120 so that the same may rotate in oil in accordance with accepted practice.

Power may be taken either from the compressor shaft 118 or from the shaft 26 or from the opposite end of the turbine through shaft 30 as desired.

An exhaust jacket 122 is preferably provided surrounding the entire turbine for the purpose of accumulating the products of combustion in an annular space 124 surrounding the discharge end of the turbine and conducting the same off through an exhaust passage 126. Ventilating air is admitted through an opening 128 to the jacket by the induction effect of the exhaust gases passing out through the exhaust passage 126.

It will be evident from the foregoing description that turbines constructed in accordance with the principles of this invention constitute simple, compact, durable and efficient power plants. It is further evident that the construction of the turbine in the form of a plurality of concentric casings has been utilized herein to achieve a number of very desirable ends including the convenient mounting of the two elements against which the products of combustion react for rotation in opposite direction, the cooling of the rotating elements by the incoming charge, and the conservation of the heat ordinarily dissipated by radiation, or given up to an external cooling medium. The use of a large excess of air for the purpose of maintaining combustion temperatures low is obviated.

Although there is herein described but a single embodiment of this invention it will be obvious to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth. It will be further obvious that certain features of the invention may be omitted in any given construction without altering the other desirable features.

Having thus described the invention what is claimed as new is:

1. A combustion turbine comprising a member, having a combustion chamber therein and mounted for rotation upon its axis, means to supply hot compressed air to said chamber at a point adjacent one end thereof, means to supply fuel to said incoming air, a plurality of nozzles in the periphery of said member adjacent the opposite end thereof, said nozzles being directed to discharge the gases from said chamber tangentially thereto, a casing surrounding the exterior of said member and mounted for rotation upon the same axis and in the opposite direction to the rotation of said member, deflecting buckets on said casing mounted to deflect gases from said nozzles, and vanes mounted upon said member to be acted upon by gases from said buckets, and vanes upon said casing coacting with said vanes on said member whereby the gases after being discharged from said chamber expand through a series of oppositely rotating blades.

2. A combustion turbine comprising a rotatably mounted outer casing, an inner casing, a shell forming a combustion chamber within said inner casing, means to supply fuel and air to said combustion chamber, nozzles loosely positioned in the wall of said shell and passing through said inner casing, means sustaining said shell within said inner casing while permitting small relative movements therebetween to provide for differences in expansion due to differences in temperature to which the parts are subjected, refractory buckets and blades attached to the inner surface of said outer casing against which products of combustion are directed by said nozzles to drive said outer casing.

PHILIP C. GORDON.