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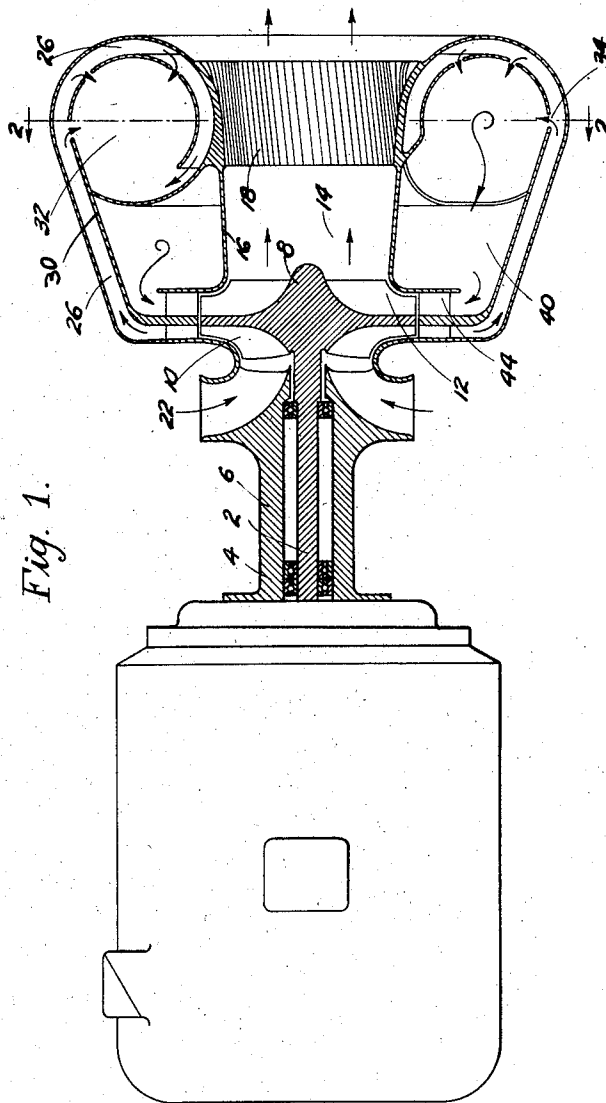
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2,855,754

GAS TURBINE WITH COMBUSTION CHAMBER OF THE TOROIDAL
FLOW TYPE AND INTEGRAL REGENERATOR

Filed Dec. 31, 1953

3 Sheets-Sheet 1



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Fig. 2.

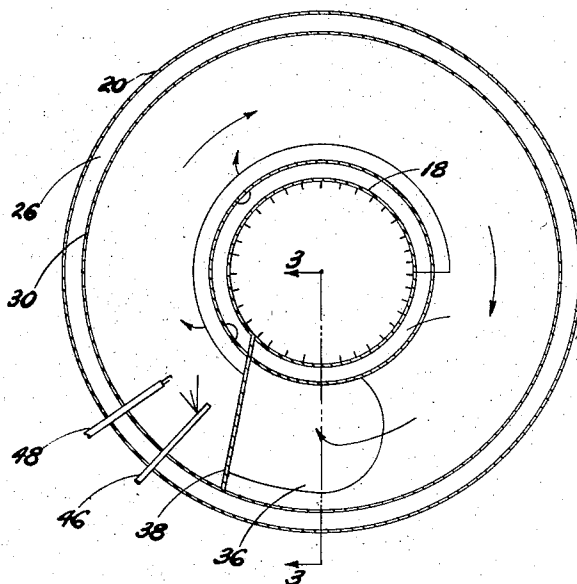
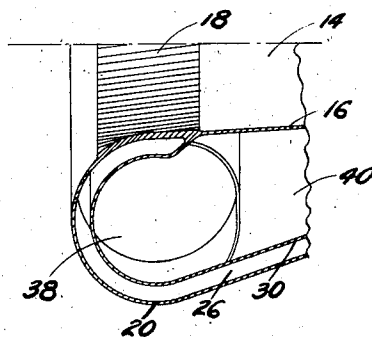


Fig 3



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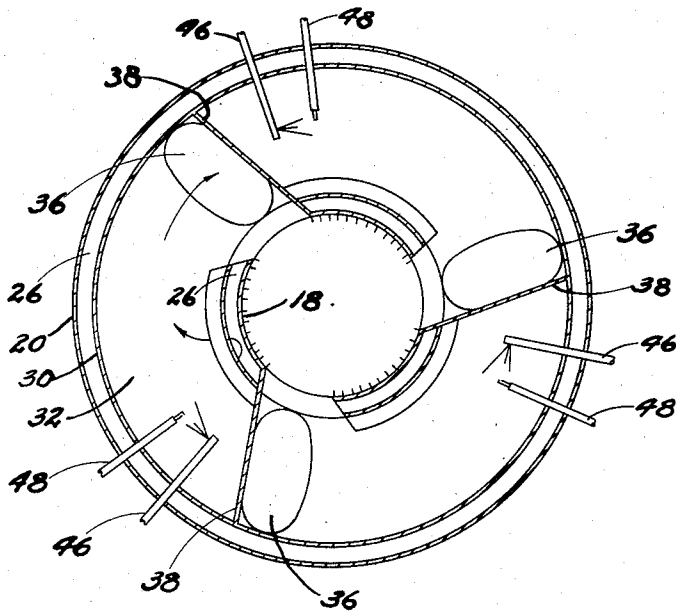
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Fig. 4.



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GAS TURBINE WITH COMBUSTION CHAMBER OF THE TOROIDAL FLOW TYPE AND INTEGRAL REGENERATOR

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4 Claims. (Cl. 60—39.36)

This invention relates to improvements in gas turbines and has for its principal objects the compactness of structure and the increase in performance of such turbines.

In the conventional gas turbine unit air or other oxidizing gas is compressed and fuel injected in a combustion chamber for burning. The combustion gas thus formed is supplied to a turbine which in turn rotates an impeller to effect an initial compression of the air. Power may be derived from the unit either by direct mechanical connection with the turbine shaft or from the reaction of the gas discharged from the unit as in the case of the jet propulsion engine. The instant invention is applicable to either field since it deals with the turbine portion from which power can be derived either through the torque furnished by the turbine wheel from the exhaust gases of combustion or from the reaction of the gas discharged from the turbine.

It is a feature of this invention to combine into one combustion chamber the salutary features of the annular type and the cannular type combustion chambers whereby the annular discharge from the compressor will maintain a constant pressure gradient along its outlet and wherein a long flame path is maintained so as to effect good performance within the combustion chamber.

It is a further feature of this invention to effect a reduction in overall diameter, length and weight so as to decrease the cost of manufacture and to increase the operating performance of the gas turbine.

It is a further object of this invention to provide regeneration to the combustion chamber inlet air so as to increase the overall efficiency of the gas turbine.

Further objects and features of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a longitudinal section of one form of gas turbine embodied in the principles of the invention, and

Fig. 2 is a sectional view taken substantially on the line 2—2 of Figure 1, and

Fig. 3 is a sectional view taken substantially on the line 3—3 of Figure 2.

Fig. 4 is a sectional view of a multiple unit combustion chamber.

In order to facilitate an understanding of the invention, reference is made to the embodiment selected for the purpose of illustration, and specific language is used to describe the same. It will, nevertheless, be appreciated that no limitation of the scope of the invention is thereby intended, and that such further modifications and alterations of the structure and function of the parts herein described are contemplated as would be effected by those skilled in the art without the exercise of invention.

Referring now to Figure 1, it will be observed that the illustrated unit consists on the left hand side of an electric alternator schematically drawn as an example of a load on the gas turbine. The power unit itself appears on the right hand side of Figure 1, and has its shaft coupled to the shaft of the generator. The power unit

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illustrated in Figure 1 shown in longitudinal cross section, is a centrifugal compressor-centripetal turbine type of gas turbine but it is understood that the invention is not limited to this specific type of gas turbine.

Starting at the right hand edge of the electric alternator load, the turbine shaft 2 is connected by gearing or any suitable means to the generator shaft. The turbine shaft is journaled in bearings 4 of the antifriction type which are mounted in the shaft housing 6. The turbine shaft 2 is integrally connected with the rotor assembly 8 (as viewed in Fig. 1) but it may be directly connected by any suitable means such as a spline connection to the rotor assembly 8, whose left hand face (as viewed in Fig. 1) forms the impeller 10 for the radial flow compressor unit, and whose right hand face forms the wheel for the turbine 12.

Proceeding axially from the rotor assembly 8, the exhaust diffuser 14 is bounded by the cylindrical wall 16 which carries outward to a finned wall 18 to the exhaust outlet of the turbine.

The outer casing 20 of the gas turbine has an air inlet opening 22 wherein the inlet air enters and is compressed by the centrifugal compressor 10 and is discharged into the annular outer passageway 26, which is bounded by the outer shell 20 and the inner wall 30 of the outer passageway 26. The outer passageway 26 extends axially the entire length of the turbine where it merges tangentially into the toroidal combustion chamber 32. The inner wall 30 of the outer passageway 26 may extend, as shown, part way around a circle centered on the annular axis of the toroidal combustion chamber 32, and contains apertures 34 in that portion of its length adjacent the combustion chamber 32. The inner wall 30 is closed off for a portion of its circumference (as viewed in Fig. 2) adjacent the discharge outlet 36 so as to insure that all of the entering primary air will be in the combustion chamber 32 at a circumferential distance before the discharge outlet 36 to insure proper and complete burning and mixing.

The combustion chamber 32 is generally toroidal in shape divided by a baffle plate 38 (as viewed in Fig. 3) which is transverse to the combustion chamber 32 and adjacent the discharge outlet 36. The baffle plate 38 divides the combustion chamber 32 so that the entering primary air must circulate around the circumference of the chamber in one direction toward the discharge outlet 36. Further, the burned gases cannot recirculate around the combustion chamber but must discharge through the discharge outlet 36 into the plenum chamber 40.

It will be evident that in this construction air for combustion comes to the toroidal combustion chamber 32 in an axially flowing annular sheet through the annular passageway 26 around chamber 40, and then because of the tangential relation to a circle about the annular axis of the toroidal chamber 32, this inflowing sheet of air enters the toroid in such a way as to be curled inwardly (so to speak) around that annular axis by the curvature of the outer wall of the combustion chamber. Within the toroid, air is fed radially inward from this sheet toward the annular axis of the combustion chamber and, except near the discharge outlet 36 where the inner wall 30 is closed off, a part of the sheet of air sweeps around the combustion chamber wall in a circular direction (with reference to the annular axis of the combustion chamber), while air is also being carried in a direction along the annular axis of the combustion chamber to the outlet. There is at least one localized outlet providing an axial flow discharge to the chamber 40. Thus the air does not pass from combustion chamber inlet to outlet by a course directly across the circular section of

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the toroid, but passes around a substantial arcuate part of the length of the combustion chamber toroid, affording a substantial length of combustion path, with air being fed radially toward the annular axis of the toroid for combustion along that path.

The plenum chamber 40 is bounded by the inner wall 30 of the outer passageway 26 and by the wall 16 of the exhaust chamber 14. The burning gases entering the plenum chamber 40 circulate around the plenum chamber which provides further mixing of the gases before discharging into the turbine nozzles 44.

The hot gases exit from the plenum chamber through the turbine nozzles 44 which are mounted by any suitable means, as for example by welding, between plenum chamber wall 16 and the inner wall 30 of the outer passageway 26 so that the hot gases are directed against the blades of the turbine wheel 12, whence they are discharged into the exhaust chamber 14 and pass the finned wall 18. The hot gases impinging on the turbine wheel force that wheel to rotate and thus provide the output power for the gas turbine.

The discharge outlet of the unit being the center of the toroidally shaped combustion chamber 32 provides regeneration for the entering primary air, by reason of the heat exchange effected through the common wall 18 of the hot exhaust gases in the exhaust chamber 14 and the cooler primary air of the outer passageway 26, thereby raising the temperature of such primary air, thus requiring less fuel to be such primary air to its operating temperature and thereby increasing the overall efficiency.

The fuel necessary for combustion is injected into the combustion chamber 32 by the fuel injector 46 (as viewed in Fig. 2) which may be mounted by any suitable means on the outer surface of the combustion chamber 32 near the partition 38 and on its side away from the outlet 36. The mixture of fuel and air is ignited by the igniter 43 which too is mounted on the outer surface of the combustion chamber 32.

It should be understood that the combustion chamber 32 may be made in two or more sections (as appears in Fig. 4) instead of one section as illustrated in Figs. 1-3 so that the toroidal combustion chamber will contain two or more complete sections, each with a separate baffle plate, separate discharge outlet, separate fuel injector and separate igniter. Each section will act as a complete combustion chamber and will discharge the burning gases into the same plenum chamber. Such a multiple arrangement will increase the overall efficiency of the gas turbine.

The toroidal combustion chamber 32 bounded by the outer casing 20 and the inner wall 30 of the outer passageway 26 for a portion of its circumference is such as to insure that the entering primary air will follow a toroidal path thereby materially decreasing the actual peripheral length of the chamber required to obtain proper mixing and burning characteristics. The air admission ports or apertures 34 in the inner wall 30 adjacent the combustion chamber 32 are of sufficient number to admit the primary air at various positions around the circumference of such portion of the inner wall 30, thereby insuring further and proper mixing of such primary air.

I claim:

1. A combustion chamber for use with a gas turbine

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comprising an outer casing having an arcuate inner liner which divides the chamber into an outer passageway and an inner passageway wherein combustion takes place, a duct for introducing inlet air into the outer passageway about the outer periphery of the casing, so that air flows about the edge of the liner into the inner passageway, a portion of the wall of the casing being cut away to form a discharge outlet, and a baffle extending transversely of the inner passageway adjacent the outlet, the portion of the edge of the liner adjacent the outlet connecting with the casing to separate the inner and outer passageway so that air cannot pass directly from the inlet duct into the outlet without passing through the inner passageway.

2. A combustion chamber according to claim 1 wherein the liner is provided with a plurality of apertures which extend between the inner and outer passageways thereby supplying some portion of the secondary air for the combustion taking place in the inner passageway.

3. In a gas turbine having a compressor and a turbine on a common axis of rotation, a fixed toroidal combustion chamber around said axis, means defining an annular passage for air extending from the compressor outlet to the outer part of the toroidal combustion chamber in tangential relation thereto, relative to a circle about the annular axis of the toroidal chamber, whereby over a substantial arcuate length of said toroidal chamber air sweeps around the outer wall of said chamber on a circle about its annular axis and also along said annular axis, with flow radially inward toward said annular axis, together with at least one localized outlet in the wall of said combustion chamber providing discharge for combustion gases, a partition across said chamber adjacent said outlet to block flow along said annular axis, and a fuel inlet and ignition means adjacent said partition on its side away from said outlet, whereby combustion occurs over an extended path from fuel inlet to chamber outlet with addition of air to the combustion mixture along said path.

4. A combination as in claim 3 in which the compressor acts centrifugally and the turbine acts centripetally, the toroidal combustion chamber is at the discharge side of said turbine and there is an inner, annular, axially extending partition spaced from said air passage means and connecting with the inner wall of said toroidal combustion chamber to define an annular plenum chamber on its outer side and a generally cylindrical exhaust chamber on its inner side, the said plenum chamber being in communication with the turbine inlet at one side and with the combustion chamber outlet at the other side, and said cylindrical chamber receiving the turbine exhaust at one side and discharging at its other side through the central opening of the combustion chamber toroid, to effect heat exchange between the turbine discharge gas and air sweeping the wall of the combustion chamber.

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