March 15, 1960 E. GUENTHER 2,928,242

MULTI-COMBUSTION CHAMBER GAS TURBINE WITH ROTARY VALVING

Filed Dec. 16, 1954 2 Sheets-Sheet 1

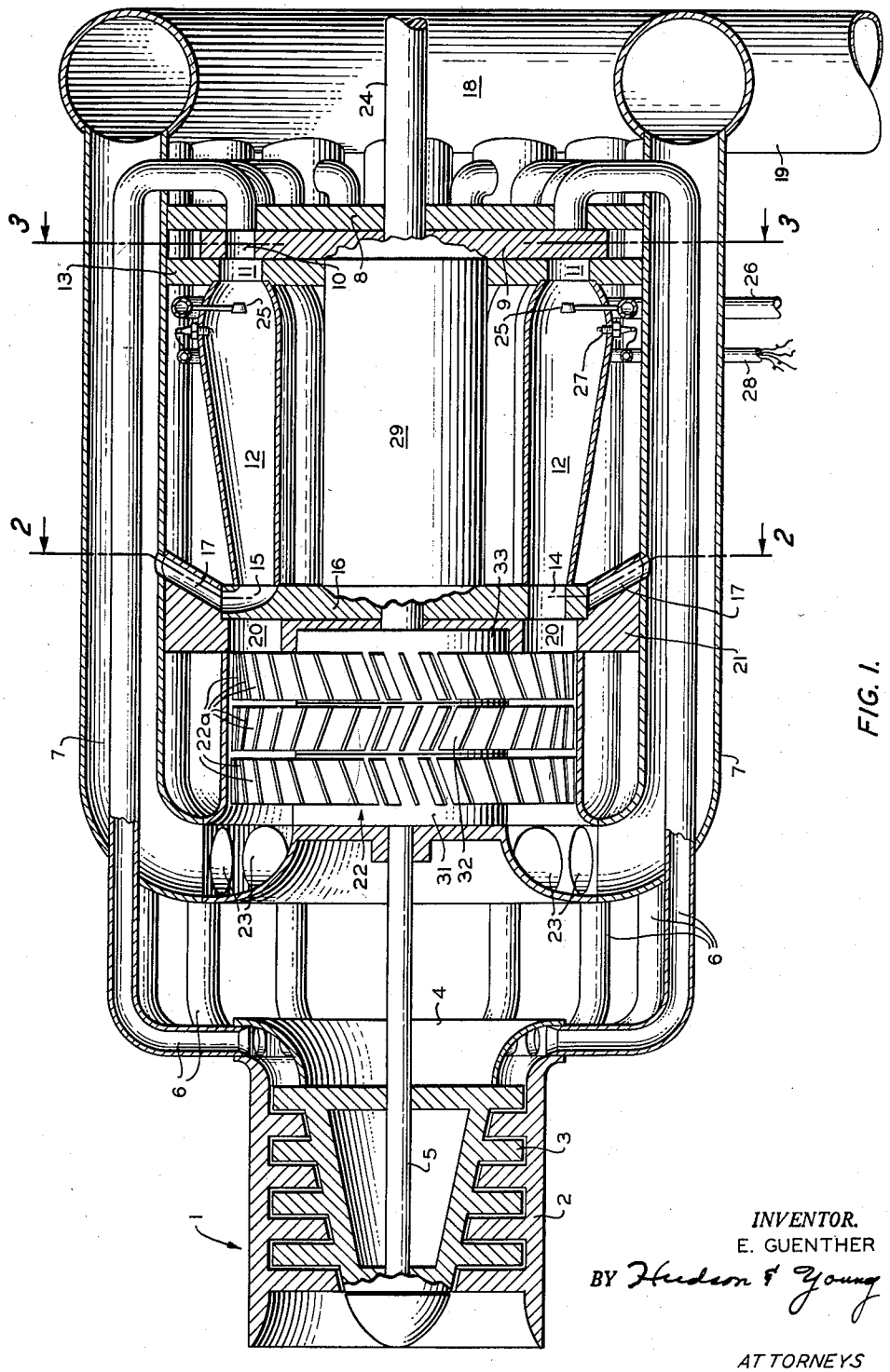


FIG. 1.

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FIG. 2.

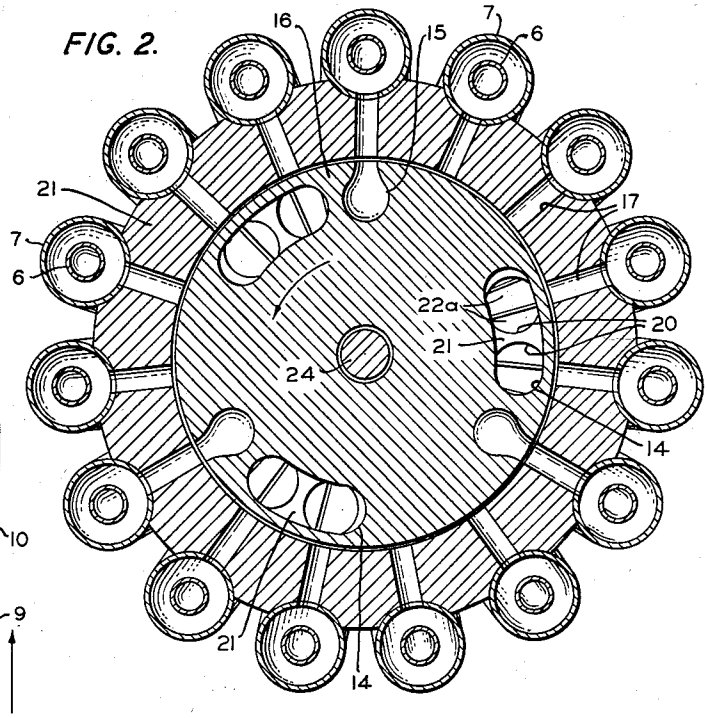


FIG. 4.

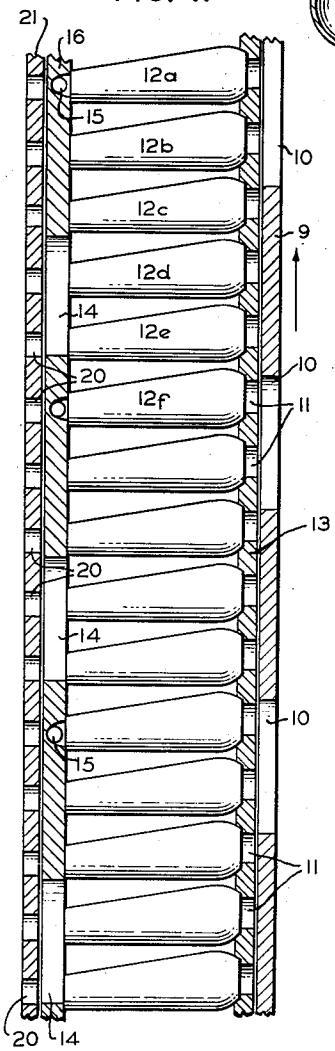
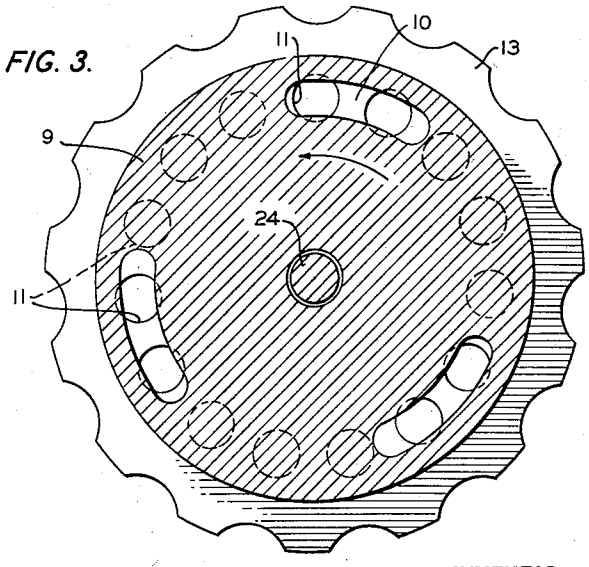


FIG. 3.



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2,928,242

MULTI-COMBUSTION CHAMBER GAS TURBINE WITH ROTARY VALVING

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2 Claims. (Cl. 60—39.39)

This invention relates to gas turbines generally, and in particular, to an improved gas turbine employing a plurality of combustion chambers arranged in a circular series with rotary inlet and exhaust valves, and having a scavenging cycle in order that the over-all temperatures be kept to a minimum.

A gas turbine unit consists of three essential components, (1) a rotary air compressor at the front, (2) one or more combustion chambers into which the compressed air is forced and into which liquid fuel is sprayed and ignited, and (3) a turbine revolving with the compressor on a common shaft. The compressor employed may be either a centrifugal or axial flow type. The cross-section of each combustion chamber may be generally rectangular or be circular in cross-section. The cross-section may be the same throughout the length of the combustion chamber; however, a cross-section decreasing towards the exhaust outlet is preferred. Only a small quantity of air is used for combustion to provide the necessary air:fuel ratio, the excess being used to dilute the combustion products and reduce the combustion temperature of, say 1,800° C. to about 850° C. at the entry to the turbine. The exhaust gases from the combustion chambers may discharge directly upon a single stage turbine; however, they are preferably used to drive a multi-stage turbine wherein the turbines may drive the compressor and/or air-screw or marine propellor, or other suitable apparatus. The exhaust gases may be used for jet propulsion or for other practical applications.

Even with the dilution of combustion gases by air as described above the exhaust gases leaving the combustion chambers are too hot for passage through the turbine without doing damage thereto. Hence, to permit the use of less heat resistant metals as well as lighter weight metals some additional cooling means is necessary. The general approach to this problem in the prior art has been to pass air through the combustion chambers immediately after the explosion cycle to purge the chambers of combustion gases and to cool them. However, the venting of the purge gas or scavenging gas from the system is a problem in certain types of turbine units.

Exhausting the scavenging air presents no problem in engines where the exhaust gases discharge directly onto a single stage turbine. Here the scavenging gases can be discharged directly from the combustion chamber through the turbine to the atmosphere, as shown, e.g. by U.S. 2,659,198. Since no back-pressure from the combustion cycle will be encountered, a rotary disc exhaust valve similar to the inlet valve is sufficient. Such means is inoperative, however, in a single stage turbine located at a comparatively remote distance downstream from the combustion chamber instead of directly in front of the outlet therefrom. In this case a considerable volume of space separates the exhaust valve axially from the turbine. This space will still be a high pressure combustion gas zone when the scavenging gases are expelled thereto, this being the next cycle. Hence, the back-pressure of the residual combustion gases in this space will block the scavenging gases which can exert only the pressure of the compressor. A similar back-pressure problem is presented by a multi-stage turbine. Here the pressure between the first and second stage of the turbine is substantially higher than the scavenging air from the compressor and hence the air could not enter the combustion chambers. The highest pressure will always be in the first stage adjacent the combustion chamber and this will be sufficient to back-pressure the scavenging gases which, as stated above, exert only the pressure of the compressor. Obviously one could overcome this back-pressure by using a powerful enough compressor but this introduces other problems, for example, excessive compressor weight and volume, critical features in aircraft.

The principal object of this invention is to provide an improved means for scavenging the combustion gases from engines employing a multi-stage turbine, or a remotely located single stage turbine.

A further object of this invention is to provide an improved gas turbine engine of the above-mentioned type which eliminates blow-back of combustion gases to the air compressor and thereby results in greater compressor efficiency.

Another object of this invention is to provide a multi-combustion chamber gas turbine with rotary inlet and exhaust valves and a scavenging cycle wherein the scavenging gases are discharged into a low pressure area external to the turbine.

According to the present invention, I provide a gas-turbine engine comprising a compressor, a plurality of combustion chambers arranged in a circular series with their longitudinal axes substantially parallel, a pair of rotary disc valves mounted at opposite ends of the series of combustion chambers, a power turbine, preferably a multi-stage turbine, and scavenging means which permits the scavenged combustion gases to be exhausted peripherally of the rotary outlet valve instead of axially therethrough. In this system back-pressuring of the combustion chamber is prevented.

During the scavenging cycle both ends of the combustion chambers are maintained open to admit air into the chambers, sweeping combustion gases through the peripheral outlets on the exhaust disc into the exhaust pipe connected thereto. The exhaust disc valve is then quickly closed and the inlet disc valve is quickly closed shortly thereafter. In this interval, the chamber is supercharged by the ramming effect of the mass of inlet air, along with vaporized fuel, against the closed exhaust valve, the quick closing of the inlet valve trapping the mixture within the chamber. This completes the compression cycle. In the subsequent ignition or expansion cycle the compressed charge is ignited. The rotary inlet valve remains closed but the exhaust valve opens to permit the expanded combustion gases to flow past the turbine blades and eventually to the atmosphere. The combustion chambers are preferably of the "can" type, wherein part of the preheated air by-passes the combustion chamber and mixes with the combustion gases, thus producing a cooler exhaust gas to impinge on the turbine or turbines. The next cycle is scavenging; the outlet to the turbine closes as the inlet valve and the peripheral exhaust port means open. The four cycles are thus completed.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which Figure 1 is a view, partly in section, of the improved gas turbine engine of this invention. Figures 2 and 3 are in cross-section along plane 2—2 and 3—3 of Figure 1. Figure 4 is a schematic view showing the operation of the disc valves and combustion chambers.

The power plant illustrated in Figure 1 includes an air compressor 1 having a conventional stator 2, rotor 3, air collector 4, and drive shaft 5. A circle of air ducts 6 branch from air collector 4 and extend through exhaust ducts 7 and supporting plate 8, terminating at the outer surface of rotary disk valve 9. The latter contains arcuate slots 10 registrable with the ends of air ducts 6 and with the inlet orifices 11 of combustion chambers 12. This portion of the apparatus is further illustrated in Figure 3. Supporting plate 13, through which orifices 11 extend, serves to support the inlet ends of combustion chambers 12. Exhaust slots 14 and scavenging gas ports 15 in rotary outlet valve 16 permit alternate exhaust for the power cycle and scavenging cycle, respectively. The scavenging gases pass through radial channels 17 into exhaust ducts 7, imparting heat to air ducts 6, and are vented through exhaust collector ring 13 which opens to the atmosphere through manifold outlet 19. During the power stroke the combustion gases exhausted through orifices 14 pass through slots 20, registrable therewith, in support member 21, driving turbine blades 22*a* of counter-rotating turbine 22. This section of the apparatus is further illustrated in Figure 2. From turbine 22 the gases pass through ports 23 into exhaust ducts 7, manifold 18, and stack 19. The rotation of turbine 22 operates through gear mechanism in gear housing 31 to drive compressor shaft 5. Simultaneously it operates through gear mechanism in gear housings 32 and 33 to drive power shaft 24, the latter transmitting power to a generator or other apparatus, not shown. Rotary valves 9 and 16 are rotated in unison by shaft 24 through suitable gear arrangement in valve gear housings 29, the latter rigidly affixed to both rotary valves. Since intermittent fuel injection is, of course, required, each combustion chamber is provided with an independent fuel injector 25 branching from fuel distributor line 26, and ignition means such as spark plug 27 energized through spark lead conduit 28.

As shown in Figures 2 and 3 the arcuate slots 10 and 14 in the rotary inlet disc 9 and outlet disc 16, respectively, are long enough to span the inlets to several combustion chambers. This uncovers the inlet and outlet of each chamber for a longer interval than would a circular orifice of approximately the same size as the inlets and outlets. Hence, the air can be admitted and gases exhausted from each chamber for a longer time during each cycle. Outlet valve 16 should be considered as rotating counterclockwise in Figure 2.

Figure 4 shows the cycles of operation of a 15 combustion chamber unit, the rotary inlet and exhaust valves being considered as moving upwards in the drawing and counterclockwise to conform with Figure 2. The outlet of chamber 12*a* is open to the scavenging port 15 in disc valve 16 and the inlet disc valve is open at this point to force air from the compressor through the chamber to displace burned gases through scavenging port 15. Chamber 12*b* is closed on the exhaust side and the inlet valve 10 is open to pressure the combustion chamber with air from the compressor. Chamber 12*c*, closed on both inlet and exhaust, has received its air and fuel quota and is commencing ignition. Chamber 12*d* is beginning the power cycle; it is closed at the inlet, and the exhaust valve is opening, releasing the combustion gases into the power turbine. Chamber 12*e* is completing the power cycle and will begin the scavenging cycle, as chamber 12*f* finishes the scavenging cycle. This cycle is repeated throughout the remaining combustion chambers. In this way six chambers are supplying powers at one time. Of the remaining nine chambers, three are on compression, three on ignition, and three are scavenging. Since the combustion chambers on power are spaced evenly around the turbine the forces are evenly balanced.

In view of the above description it is obvious that numerous modifications of the specific embodiment described can be devised. For example, a single stage or multi-stage turbine may be located some distance from the discharge of the combustion chambers, and still the combustion chambers could be satisfactorily purged between cycles by the method of the present invention. Also, a single stage turbine located near the discharge end of the combustion chambers could be employed, however, in this case the exhaust valve would not need a scavenging port, and could be similar in construction to the inlet valve. The heat exchange feature could be eliminated and the elements realigned so that the compressor discharges directly into the combustion chambers and the latter in turn discharge downstream from the compressor. Such an arrangement is conventional as shown in U.S. 2,515,644.

The advantages of this invention are several. Basically, as pointed out above, this invention mechanically prevents blow-back of exhaust gases from a multiple stage turbine or from a single stage turbine remotely located from the combustion chamber exhaust. This permits a scavenging cycle to follow the power cycle. It also means increased efficiency because the combustion pressure can be higher than the inlet air pressure. As a result a smaller air compressor can be used because it is unnecessary for the compressed air to overcome the pressure in the turbine. The cooling effect of the scavenging cycle also permits the use of lighter weight metals and less heat resistant metals.

Having thus described the invention and the advantages thereof, it will be understood that the invention is not to be limited to the details herein disclosed since numerous modifications of the embodiments described can be devised. To this extent the specification should be considered as illustrative, not limiting.

I claim:

1. In a gas turbine unit, a shaft, a group of elongated combustion chambers arranged in a circular series about said shaft and axially parallel thereto, said combustion chambers having inlets at one end and outlets at their other ends respectively, ignition and fuel injection means in said combustion chambers, a rotary disc inlet valve and a rotary disc exhaust valve mounted on said shaft adjacent said inlets and outlets respectively, a circle of regularly spaced axial orifices in each of said rotary disc inlet and exhaust valves registrable with said inlets and outlets respectively to admit compressed air thereto and withdraw exhaust gases therefrom respectively, a plurality of regularly spaced radial scavenging ports in said rotary disc exhaust valve, the inlet ends of said scavenging ports being arranged to register with said outlets and the discharge ends of said ports being at the periphery of said rotary disc exhaust valve, a multistage turbine rotatably mounted downstream from said rotary disc exhaust valve and positioned so as to be powered by exhaust gases discharged through said orifices in said rotary disc exhaust valve, an air compressor adapted to be driven by said turbine, means for transmitting compressed air from said air compressor to said rotary disc inlet valve, means for rotating both of said valves in unison so that said inlets and outlets are opened and closed in proper sequence for four cycles of compression, expansion, exhaust, and scavenging, the rotation of said valves being so adjusted that following the exhaust cycle the axial orifices in said rotary disc exhaust valve move out of alignment with the combustion chambers just exhausted while said inlet ends of said scavenging ports move into alignment with said combustion chambers and said axial orifices in said rotary disc inlet valve, the pressure of the exhaust gases in the first stage of said turbine being equal to or greater than the compressed air pressure so that purging of the combustion chambers would be prevented except for the closing of the exhaust orifices.

2. In an internal combustion gas turbine unit having four cycles, namely, compression, ignition and expansion, exhaust, and purging, in combination: a shaft, a plurality

of combustion chambers arranged in a circle about said shaft and axially parallel thereto, said combustion chambers having inlets at one end and outlets at their other ends respectively, a first disc mounted on said shaft adjacent said inlets, a plurality of regularly spaced axial arcuate inlet slots in said first disc arranged in a circle, said inlet slots being arranged to register with said inlets, a second disc mounted on said shaft adjacent said outlets, a plurality of regularly spaced axial arcuate exhaust slots in said second disc arranged in a circle, said exhaust slots being arranged to register with said outlets, a plurality of regularly spaced radial ports in said second disc, the inlet ends of said radial ports alternating with said exhaust slots in the same circle and the outlet ends of said radial ports being at the periphery of said second disc, ignition and fuel injection means in said combustion chambers, a power turbine positioned downstream from said second disc, an air compressor, a conduit connecting the outlets of said air compressor with said first disc for admission of air to said inlet slots, means for rotating said first and second discs in unison to admit compressed air to each of said combustion chambers while said outlets of said combustion chambers are closed by said second disc, thereafter to close said inlets with said

first disc while the air-gas mixture in said combustion chambers is ignited, thereafter to exhaust combustion gases to said turbine by aligning said exhaust slots with said outlets of said combustion chambers, and then to simultaneously open said inlet ends of said radial ports and said inlet slots to effect purging of exhaust gases through said radial ports to a low pressure zone; and an exhaust conduit enclosing said low pressure zone and said compressed air conduit to effect indirect heat exchange with the latter, thereby preheating the compressed air used in the system.

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