

Jan. 15, 1935.

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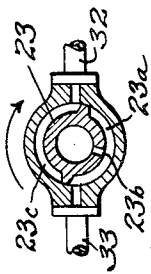
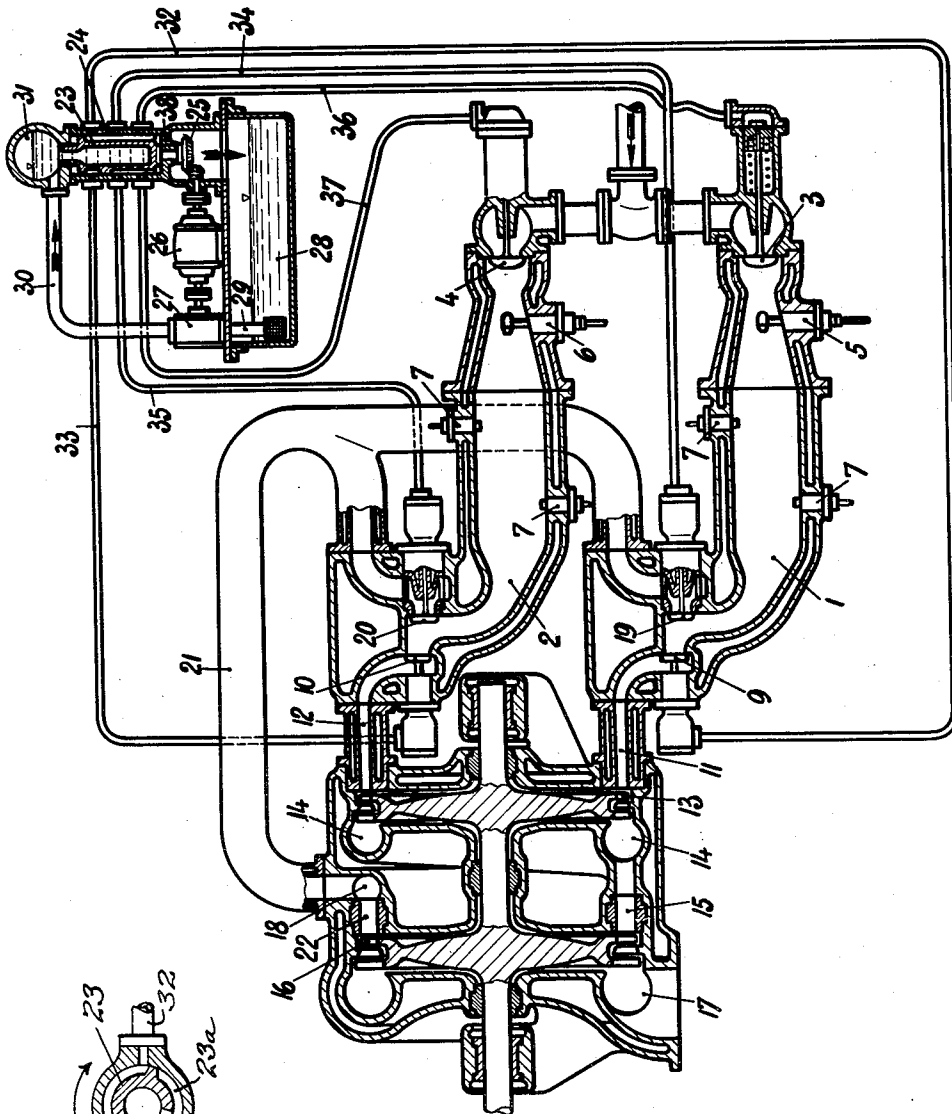
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COMPOUND EXPLOSION TURBINE

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Fig. 1.



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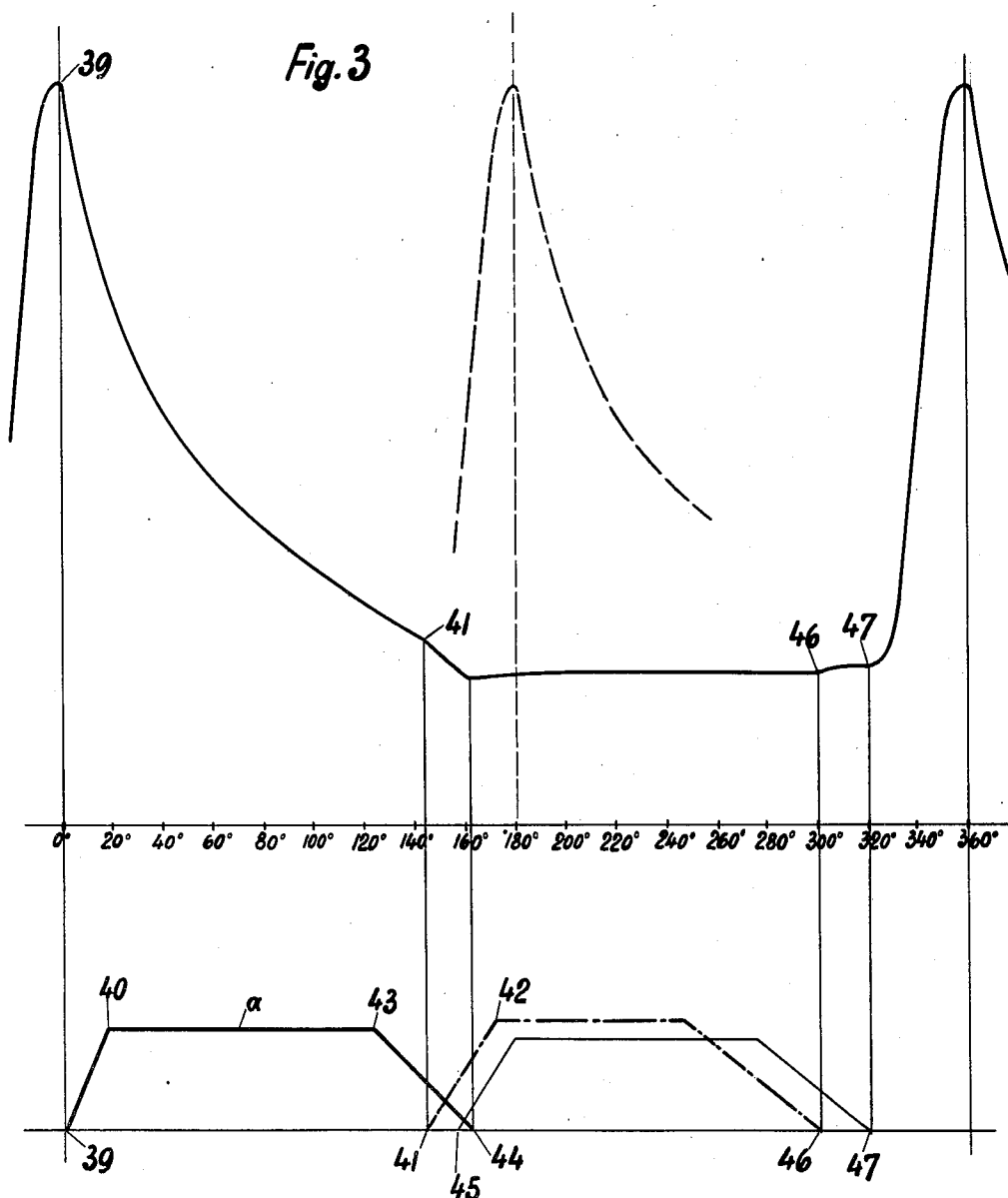
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COMPOUND EXPLOSION TURBINE

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COMPOUND EXPLOSION TURBINE

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2 Claims. (Cl. 60—41)

My invention relates to compound constant volume explosion gas turbines and has for its object to provide a power plant of this type having a novel and improved arrangement for leading off the residual gases which remain in the constant volume explosion chambers of such turbine following the expansion of an exploded charge.

In explosion gas turbines operating according to the constant volume explosion process and composed of at least two gas turbine rotors arranged one behind the other, of which the first operates as a pure explosion turbine, i. e. with gases of widely fluctuating pressure, while the second or subsequent turbine or turbines operate continuously with driving gas of less varying pressure (such arrangement being known as a compound gas turbine), it is not possible to prevent the pressure in the exhaust chamber of the first turbine from being subjected to a certain degree of variation in pressure since the rates of gas discharge during a cycle of an explosion chamber vary considerably on account of the decreasing pressure in such chamber; the flow capacity of the subsequent nozzles, however, varies much less because of the fact that the pressure in the housing of the first turbine does not change to a degree equal to that of the fluctuations in the said rates of gas discharge. The exhaust pressure thus rises at the beginning of the discharge of a chamber and falls as the discharge of the chamber approaches its end. These pressure variations can be reduced to a certain extent by making the volume of the turbine housing large, but aside from other disadvantages which are associated with it, such expedient does not quite suffice to produce such uniformity of pressure that the scavenging of the chambers can be accomplished with scavenging air at an economical, that is, at a sufficiently low superpressure. With such object in view, it is necessary to take into account the fact that when the scavenging air pressure is made equal to, say, the average exhaust pressure, the pressure in the turbine housing or exhaust chamber at the beginning of a discharge from an explosion chamber rises above the scavenging air pressure available for displacing the residual gases in another explosion chamber, so that it not only becomes impossible to expel such residual gases, but the live gases discharging from the first explosion chamber are forced back into such other chamber which at the same moment is being scavenged.

According to the present invention these dis-

advantages are overcome by conducting the residual gases which are expanded to approximately the counter-pressure of the first rotor, and the excess of scavenging air employed to expel such residual gases from the combustion chamber, through a separate exhaust or outlet opening and a separate conduit into a space which is independent of the pressure in the turbine housing, i. e. is not affected to any substantial degree by fluctuations in the pressure in the exhaust space of the first or explosion turbine. The residual gases and the excess of scavenging air that may be mixed therewith may thus be directed separately of the main working gas stream upon the second rotor of the compound turbine or upon a separate rotor.

The present invention is of particular advantage in connection with the improved mode of operation of an explosion turbine plant as described in the copending application of Hans Holzwarth, Ser. No. 546,730 filed June 25, 1931. As described in such application the explosion chamber is of elongated form and is provided with a conical inlet whereby the incoming charge of scavenging air, which is admitted when the explosion gases have expanded to substantially the pressure of such air, assumes the form of a piston and pushes the retreating gases before it. Due primarily to the shape of the explosion chamber and to the axial feeding of the air, no whirling and mixing of the air and gases occurs; on the contrary, there is formed a definite dividing zone between the incoming air and the retreating gases which is so sharply defined that the outlet valve can be timed to close at practically the instant that such dividing zone reaches the valve, so that substantially complete expulsion of the gases is obtained with very little or practically no loss of high pressure scavenging air. I have observed however that in practice, in a compound gas turbine plant, this dividing zone is at times a considerable distance in advance of the outlet valve when the latter closes, while at other times, a considerable amount of air has passed through the valve before the latter is closed. I have found that this irregularity is due to fluctuations in the pressure in the exhaust space of the first turbine, a rise in such pressure delaying the movement of the above mentioned dividing zone, while fall in such pressure causes excessively rapid movement of the air and hence escape of a certain amount thereof before the time arrives for the outlet valve to close. According to the present invention, wherein the residual gases of two or more explosion

chambers are discharged under substantially constant pressure into a space which is separate from the exhaust space in the first gas turbine, a substantially uniform resistance is presented to the scavenging air entering a chamber, so that the dividing zone between the scavenging air and gases moves at uniform velocity through the chamber during all cycles and hence is always at a fixed position at or near the outlet valve when the latter is closed.

Reference is had to the accompanying drawings which illustrate by way of example an embodiment of the present invention. In said drawings, Fig. 1 is a diagrammatic view, partly in section of my improved explosion gas turbine; Fig. 2 is a horizontal section through the hydraulic valve controller; while Fig. 3 is a diagram indicating the timing of the valves.

The numerals 1 and 2 designate two combustion chambers of an explosion gas turbine which are periodically charged with compressed air through the valves 3 and 4, respectively, and receive a quantity of fuel, such as liquid fuel, through the injection nozzles 5 and 6. The explosive mixture is ignited by a spark plug 7 or equivalent device and the high pressure gases generated by the explosion are discharged through the intermittently operated nozzle valves 9 and 10 from which they flow into the expansion nozzles 11 and 12 and are directed against the explosion turbine rotor 13. The gases exhausting from the turbine 13 flow through the two nozzle channels 14 into the nozzles 15 which direct them in a continuous stream against the rotor 16 where they give up their remaining available energy. The completely expanded gases flow through the exhaust pipe 17 into the atmosphere.

The expansion of the contents of the chambers 1 and 2 and their discharge through the nozzles 11 and 12 can occur only down to a pressure which is slightly higher than the pressure in advance of the rotor 13. If this pressure varies, then the scavenging air which is to expel the residual gases from the explosion chambers must be able to follow the fluctuations in pressure; or else, its pressure must be equal to and even slightly greater than the maximum back pressure in the explosion turbine housing, which involves a large expenditure of power in the air compressor. According to the invention, the discharge of the residual gases takes place not through the nozzles 11 and 12 and rotor 13, but to a place which is independent of the pressure fluctuations in the housing of such rotor, for example to a space 18 which is entirely separate of such housing. To this end, the explosion chambers are provided with the auxiliary exhaust valves 19 and 20 which are connected with the space 18 through the conduit 21. When the contents of a chamber have expanded to approximately the pressure in the housing of the explosion turbine, the nozzle valve 9 or 10 as the case may be is closed and the valve 19 or 20 opened to discharge the residual gases into the space 18 as scavenging air is charged into the combustion chamber. The space 18 is likewise provided with nozzles 22 which are so dimensioned that a pressure prevails in advance of the same which is somewhat lower than that of the scavenging air, or that of the charging air (combustion-supporting air of full charging pressure) if such air is employed to drive out the residual gases. The gases which have been brought to a high velocity in these nozzles are directed against the wheel 16 and perform work on the latter. Instead of employing

a space or a chamber 18, which in the present case forms a part of the nozzle channel leading to the second set of nozzles, an independent nozzle channel may be employed which conducts the residual gases and discharged scavenging air to a separate wheel.

It will be understood that suitable valve-operating mechanism, such as a hydraulic mechanism of the type disclosed in the patent to Hans Holzwarth, No. 1,810,768, may be employed to control the valves of the explosion chambers in proper sequence.

A satisfactory form of such mechanism is illustrated in Fig. 1 and consists of a rotary slide valve or revolver 23 which rotates in a stationary housing 24. The revolver 23 is driven by the electric motor 26 through the bevel gears 25, the motor at the same time actuating the oil pump 27. The latter sucks oil from a container 28 through the conduit 29 and forces the oil under pressure through the conduit 30 into an air chamber 21 which is in communication with the interior of the revolver 23. The revolver has three vertically spaced sections for the three types of valves, namely the air charging valves 3 and 4, the nozzle valves 9 and 10, and the auxiliary outlet valves 19 and 20. The uppermost section supplies pressure oil through the conduits 32 and 33 to the nozzle valves 9 and 10. The middle section delivers pressure oil to the auxiliary outlet valves 19 and 20 through the conduits 34 and 35; while the lowest section supplies pressure oil through the conduits 36 and 37 to the charging valves 3 and 4. In the case of the nozzle valves 9 and 10, such pressure oil operates to hold the valves closed against the pressure prevailing in the chamber; while in the case of the other valves the pressure oil acts to open the same. It will be understood that the valves are provided with pistons sliding in cylinders in known manner, as shown in connection with valve 3, the oil acting against the pressure of a spring. As shown in Fig. 2, each of the sections of the revolver has an arcuate channel 23a in communication with the interior of the revolver through a port 23b, and a channel 23c communicating with an exhaust space, such as the tank 28, through the passage 38. The respective oil conduits are brought alternately into communication with the interior of the revolver 23 containing oil under pressure or with the oil discharge through the channels 23c.

If, for example, oil under pressure is fed to the valve 3 by the conduit 36, it presses the piston toward the left against the pressure of the spring and opens the valve. As soon as the oil conduit 36 is connected with the oil discharge, the spring returns the piston and closes the valve. Fig. 2 shows a horizontal section through the distributor at the instant at which the nozzle valve 10 is opened. Pressure oil can now flow from the interior of the revolver 23 into the conduit 33, while the conduit 32 is connected with the oil discharge so that the nozzle valve 9 is closed.

Fig. 3 shows the sequence of valve actuation with the aid of a pressure-time diagram of the explosion chamber 2. The abscissae refer to angular degrees of the periphery of the distributor, and as the distributor rotates at constant velocity, this is equivalent to a time scale. The part of the diagram above the abscissa scale is the pressure time diagram which represents the pressure conditions in the explosion chamber. The diagrams below the abscissa scale represent the valve lift diagrams, the ordinates indicating the

lift of the various valves. At the point 39 the maximum explosion pressure is reached, and according to the lift diagram *a* shown in full lines, the nozzle valve 10 opens to the point 40 where it reaches its full opening. Immediately upon opening of the nozzle valve, the pressure in the chamber begins to fall and reaches the point 41 at the instant that the auxiliary exhaust valve 20 is opened whereby a discharge space of lower back pressure is provided and a more pronounced drop in pressure occurs. The auxiliary exhaust valve is completely opened at the point 42. In the meantime the nozzle valve 10 has begun to close at the instant 43 and is completely closed at the instant 44. The air charging valve 4 opens at the point 45 and the incoming air pushes the combustion gas residue out of the explosion chamber through the exhaust valve 20. The auxiliary exhaust valve is closed at the point 46 and the charging valve at the point 47. The fuel is admitted toward the end of the air charging period. The mixture is now ignited and upon rise of pressure to the maximum value the above-described process is repeated.

Variations from the specific form of the invention shown and described may be resorted to within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. In a compound constant volume explosion turbine, the combination of a plurality of pistonless explosion chambers each having inlet mechanism for introducing successive charges of compressed air and fuel for explosion therein at constant volume and having a main exhaust valve adapted to be intermittently operated to discharge the high pressure explosion gases to do all of their work outside such chamber, an explosion turbine rotor arranged to receive the intermittent streams of gases discharging from said chambers, a housing for said turbine providing an exhaust space for the gases exhausting from said turbine, a second turbine, means for conducting to the latter in a continuous stream the gases exhausting from the first mentioned turbine, each inlet mechanism adapted to charge air into its explosion chamber following the expansion of the exploded charges to expel the residual gases remaining in such chamber, each chamber having an auxiliary exhaust

opening for discharging from the chamber the residual gases expelled by said air, an exhaust chamber separate of the exhaust space of the first turbine, conduit means leading from the auxiliary exhaust openings and out of immediate communication with the exhaust space of the first turbine for conducting the discharged residual gases into said exhaust chamber, the latter being substantially unaffected by fluctuations of pressure in the housing of the first turbine, and a nozzle for directing the residual gases from said exhaust chamber, separately of the main stream of explosion gases, to the second turbine.

2. In a compound constant volume explosion plant, the combination of a plurality of pistonless explosion chambers each having inlet mechanism for introducing successive charges of compressed air and fuel for explosion therein at constant volume and having a main exhaust valve adapted to be intermittently operated to discharge the high pressure explosion gases to do all of their work outside such chamber, apparatus arranged to receive and utilize part of the energy of the intermittent streams of explosion gases discharging from said chambers, an exhaust chamber for the gases discharging from said apparatus, a turbine, means for conducting to the latter in a continuous stream the partially exhausted gases in said exhaust chamber, each inlet mechanism adapted to charge air into its explosion chamber following the expansion of the exploded charge to expel the residual gases remaining in such chamber, each chamber having an auxiliary exhaust opening for discharging from the chamber the residual gases expelled by said air, an exhaust chamber separate from the first mentioned exhaust chamber for receiving said residual gases, conduit means leading from the auxiliary exhaust openings and out of immediate communication with the first-mentioned exhaust chamber for conducting the discharged residual gases into said second exhaust chamber, the latter being substantially unaffected by fluctuations of pressure in the first exhaust chamber, and a nozzle for directing the residual gases from the second exhaust chamber, separately of the main stream of explosion gases, to said turbine.

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