April 28, 1931. F. HOFMANN 1,802,469

COMBUSTION TURBINE

Filed Feb. 15, 1927

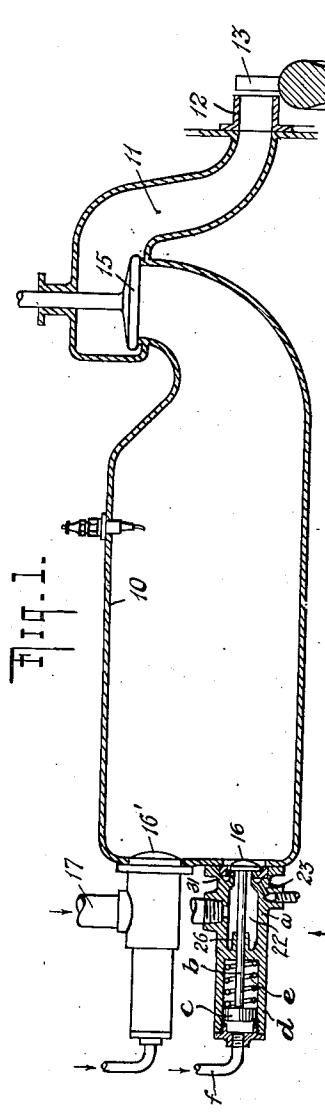


Fig. 1.

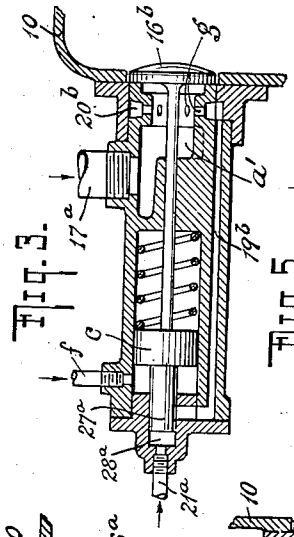


Fig. 3.

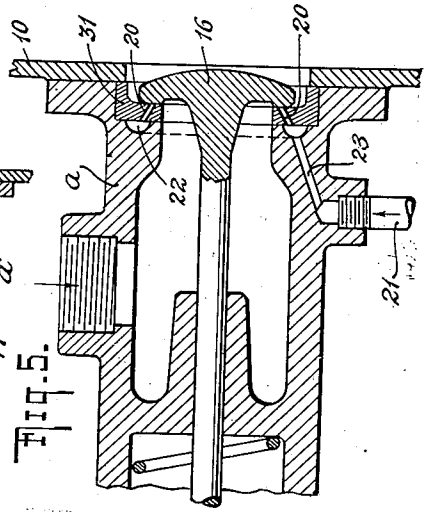


Fig. 5.

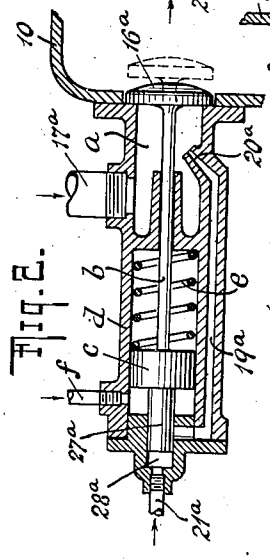


Fig. 2.

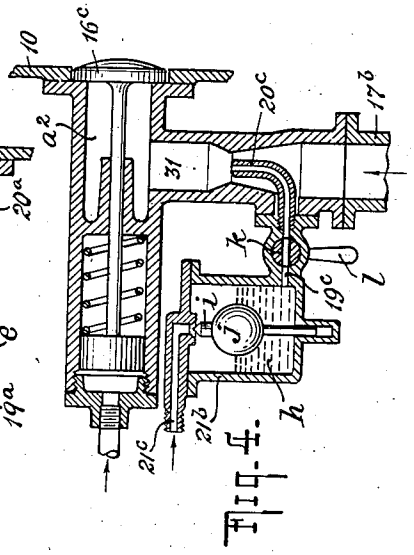


Fig. 4.

WITNESS

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UNITED STATES PATENT OFFICE

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COMBUSTION TURBINE

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The invention relates to combustion turbines of the explosion type and more particularly to the scavenging systems thereof. In such turbines the products of combustion remaining in the combustion chambers after the explosions have taken place, must be removed therefrom by scavenging air prior to the admission of new fuel charges into said combustion chambers. This scavenging air, in addition to its other functions, serves also to cool the nozzle valves, the nozzle chambers and the nozzles, and indirectly the blades, of the turbines in question. From the standpoint of economy it is desirable to create the necessary volume of such scavenging air with the least expense of power, while technically it is most desirable to increase to the highest point the ability of said scavenging air to absorb heat. The object of the present invention is to provide a novel method and simple arrangements whereby both of the conditions will be met in an efficient and satisfactory manner. Other more specific objects will appear from the description hereinafter and the features of novelty will be pointed out in the claims.

In the accompanying drawings which illustrate examples of the invention without defining its limits, Fig. 1 is a diagrammatic sectional view of a combustion chamber with the invention embodied therein; Fig. 2 illustrates a modified form of the invention; Fig. 3 is a further modification which differs from Fig. 2 in the means provided for directing a moistening agent into the body of scavenging air; Fig. 4 shows another embodiment of the invention employing a Venturi tube whereby a moistening fluid is sucked up by the scavenging air as it flows into the charging valve; and Fig. 5 is a section on an enlarged scale through the scavenging air valve shown in Fig. 1.

Referring more particularly to Fig. 1 of the drawings 10 represents a conventional explosion chamber of a combustion turbine, which chamber at one end communicates with the nozzle chamber 11 terminating in a nozzle 12 located in operative proximity to the blades 13 of the rotor 14 customarily forming part of such combustion turbines. The communication between the combustion chamber 10 and the nozzle chamber 11 is controlled by means of a nozzle valve 15 operated in any usual and conventional manner. At its opposite end the combustion chamber 10 is provided with an inlet valve 16 for controlling the admission of scavenging air into the explosion chamber whereby the latter is scavenged and the products of combustion remaining after an explosion has taken place, are expelled therefrom. The valve 16 is connected by means of a pipe 17 with a source of air under pressure. The valve 16 shown in Figs. 1 and 5 may be hydraulically controlled and to this end the stem *b* of the valve may be provided with a piston *c* slidable within a cylinder *d* forming an extension of the valve casing *a*. A spring *e* is arranged to urge the valve against its seat 31. A conduit *f* is adapted to be connected alternately to a source of oil under pressure and to an exhaust space for such oil, so that the valve is opened at predetermined instants by the oil under pressure and closed by the spring upon exhaust of such oil. As so far described the turbine may be of any usual form and arrangements, the illustration in Fig. 1 being diagrammatic in character; generally speaking, turbines of the class in question include also inlet valves, such as valve 16; for the combustion air and for the fuel, which valves are located at the same end of the combustion chamber 10 as the valve 16. As these valves form no part of the present invention they have not been shown in detail; the construction and operation of such valves are disclosed, for instance, in the patent to Holzwarth No. 877,194. In the form of the invention shown in Figs. 1 and 5 the seat 31 of the valves 16 is in the form of a flanged ring set into the valve casing *a* and provided with apertures 20 (shown more clearly in Fig. 5) which are inclined with respect to the axis of the valve 16 and converge inwardly towards said axis. The arrangement is such that in its closed position the valve 16 covers and thereby closes the exit ends of said apertures 20. The latter at their inlet ends communicate with an annular channel 22 formed in the valve casing *a* and connected by means

of a passage 23 with a pipe 21 which leads to a source of supply of moistening fluid, such as water or steam.

In the operation of the turbine, after an explosion of the fuel mixture has taken place in the combustion chamber 10, the inlet valve 16 is opened to admit a current of scavenging air into said chamber which not only scavenges the latter by expelling therefrom the products of combustion remaining in the chamber 10 subsequent to said explosion, but also serves to exert a cooling action on the nozzle valve 15, the nozzle chamber 11, and indirectly the blades 13 of the rotor 14. As the valve 16 is opened to admit scavenging air into the combustion chamber 10, the exit ends of the apertures 20 will be uncovered and thereby will at the same time admit a supply of moistening fluid into the combustion chamber. This fluid enters said chamber in the form of jets or sprays which converge toward each other from said apertures 20 and become mixed with the scavenging air. In this way a supply of moistening fluid is introduced into the combustion chamber 10 into the presence of the scavenging air therein and becomes mixed with the supply of scavenging air in said chamber 10. In other words, the scavenging air either coincidentally with its entrance into the chamber 10 entrains moistening fluid or approximately at the same time is moistened within said chamber.

In the form shown in Fig. 2, the air inlet valve 16*a* controls the communication between the interior of the casing *a* and the entrance end of the combustion chamber 10, the casing *a* being connected by means of a pipe 17*a* with a source of scavenging air. The valve 16*a* is carried by a valve stem *b* upon which a piston *c* is mounted; the latter is slidable in a cylinder *d* projecting axially from the chamber *a*, said piston *c* being acted upon by a spring *e* to maintain the valve 16*a* in its closed position and to return it thereto. The cylinder *d* is connected by means of a pipe *f* with a source of hydraulically or otherwise developed pressure arranged to become effective upon the valve piston *c* at the proper time to shift it to the right in Fig. 2 and to thereby adjust the valve 16*a* to its open position. The piston *c* carries an auxiliary piston 27*a* which slidably extends into an auxiliary cylinder 28*a* connected by means of a pipe 21*a* with a source of moistening fluid either liquid or gaseous. A tube 19*a* extends lengthwise of the cylinder *d* and has its inlet end in connection with the auxiliary cylinder 28*a* and controlled by the auxiliary piston 27*a*. At its opposite end the tube 19*a* terminates in a nozzle 20*a* projecting in an upward direction at an inclination toward the valve seat against which the valve 16*a* closes.

In the operation of the turbine provided with this form of the invention the pressure developing medium entering the cylinder *d* through the pipe *f* will, at the proper time, become effective upon the piston *c* to shift the same to the right in Fig. 2 and thereby adjust the valve 16*a* to its open position as indicated by dotted lines in Fig. 2. This operation of the valve 16*a* occurs subsequently to the explosion of a fuel charge in the combustion chamber 10 and serves to admit a supply of scavenging air to the latter whereby the products of combustion, remaining in said chamber, are expelled therefrom. As this adjustment of the valve 16 to its open position takes place the auxiliary piston 27*a* is caused to describe a corresponding movement to the right in Fig. 2 which is sufficient in extent to uncover the inlet end of the tube 19*a* and to thereby bring said tube into open communication with the pipe 21*a* and consequently with the source of moistening fluid. As this occurs the moistening fluid will be expelled from the nozzle 20*a* and will be ejected therefrom in the form of a jet or spray which passes by the open valve 16*a* into the combustion chamber 10 and becomes mixed with the scavenging air therein.

In the form shown in Fig. 3, a tube 19*b* corresponding to the tube 19*a* of Fig. 2 instead of terminating in a nozzle such as 20*a*, communicates with an annular channel 20*b* located in close proximity to the seat against which the air inlet valve 16*b* seats itself in its closed position. The annular channel 20*b* is provided with apertures *g* which project radially inward and establish communication between the channel 20*b* and the casing *a'* which corresponds to the casing *a* of Fig. 2. Otherwise the form shown in Fig. 3 may be constructed and operate in the same way as the form shown in Fig. 2.

After the valve 16*b* is opened the inlet end of the tube 19*b* will be uncovered as in Fig. 2 and moistening fluid will accordingly pass through the apertures *g* in the form of jets or sprays and into the current or scavenging air flowing from the casing *a'* past the open valve 16*b* into the combustion chamber 10. The apertures *g* and accordingly the jets of moistening fluid passing inwardly therethrough are located at the point at which the speed of inflowing current of scavenging air is greatest whereby a most efficient combination of the moistening fluid with such air is effected. In this form the ejection of the moistening fluid through the apertures *g* may be controlled either to produce a continuous flow through said apertures or a periodical ejection therethrough.

In the form illustrated in Fig. 4 a Venturi tube 31 communicates at one end with the interior of the valve casing a^2 corresponding to the previously mentioned casings *a* and *a'* and at its other end is connected by means of a pipe 17*b* with a source of scavenging air

under pressure. An injector nozzle 20*c* extends into the Venturi tube 31 and is connected by means of a passage 19*c* with a collecting vat 21*b* arranged to contain a supply of clear water or other suitable moistening fluid *h* and connected by means of a pipe 21*c* with a source of supply of such moistening fluid. A float valve *i* carried by a float *j* serves to automatically control the communication between the pipe 21*c* and the interior of the vat 21*b* whereby a supply of fluid *h* is continuously maintained in said vat. A valve *k* is manually operated, for instance by means of a handle *l*, to control the connection between the chamber and the nozzle 20*c*.

As the air valve 16*c* in this form of the invention is opened to admit a supply of scavenging air to the combustion chamber 10 as in the forms previously described, the scavenging air will flow from the pipe 17*b* through the Venturi tube 31 and chamber a^2 into the chamber 10. The current of scavenging air in flowing through the Venturi tube 31 will develop a suction or ejector action in the nozzle 20*c* and thereby serve to draw the moistening fluid *h* through said nozzle in the form of a spray or jet. In other words, as the scavenging air passes the nozzle 20*c* it entrains moistening fluid *h* issuing from said nozzle.

In all of the arrangements the humidifying or moistening of the scavenging air, either with clear water, with vaporized water in the form of steam, or with any other suitable moistening agent, takes place either coincidentally with the introduction of the scavenging air into the combustion chamber or at approximately the same time. The moisture entrained in the aforesaid scavenging air causes the development of steam owing to the high temperature of the walls of the explosion chamber. As in a mixture of gases the pressure of the mixture is equal to the sum of the "partial" or individual pressures of its constituents, the partial pressure of the air is decreased by the development and admixture of steam, the total pressure remaining unaffected, whereby an increase in the volume of the air is caused, so that a smaller quantity of scavenging air need be employed. The mixture of air and moistening fluid and more particularly the mixture of air and steam develops a much higher and more efficient cooling action than air alone. The moistening fluid instead of being added to the air in the form of previously created steam or vapor, may also, in part, comprise cominuted or atomized water which first becomes vaporized as it escapes into the combustion chamber on its way through the chamber and through the associated elements. The addition of water can therefore take place in liquid form or in the form of vapor and may occur during the entire period of entrance of air into the chamber 10 or during a part of said period. It may begin for instance after the entrance of the latter into the said chamber. Other timing arrangements may be adopted without departing from the nature of my invention as set forth in the claims. By adding the moistening fluid to the scavenging air the formation of scale in the combustion chamber on the associated elements is reduced and practically done away with. If clean water is not available it is desirable to previously remove the scale either wholly or in part. This may be done by using cleared hot water in the turbine, as with a temperature of over 60° the scale for the most part will easily fall away. When steam is employed it is of advantage to use the exhaust steam of the turbine.

Various changes in the specific forms shown and described may be made within the scope of the claims without departing from the spirit of my invention.

I claim:

1. In a combustion turbine of the explosion type, the combination of an explosion chamber, a controllable inlet for introducing, subsequently to the introduction, ignition and expansion of the explosive charge, scavenging air into said chamber for scavenging the same, and means whereby a liquid moistening fluid, in the form of jets, is introduced into the body of said air for admixture therewith.

2. In a combustion turbine of the explosion type, the combination of an explosion chamber, an air conduit for introducing scavenging air into said chamber, an air valve controlling the admission of said scavenging air to said chamber, and means operating coincidentally with the opening of said valve for introducing a moistening liquid agent into the body of said air for admixture therewith.

3. In a combustion turbine of the explosion type, the combination of an explosion chamber, an air conduit for introducing scavenging air into said chamber, a valve casing connected with a source of moistening fluid, an annular member in said casing constituting a valve seat and provided with inwardly converging apertures, an annular channel in said casing connected with said apertures and communicating with said source of moistening fluid, an air valve cooperating with said seat to control the admission of said scavenging air to said chamber and also controlling said apertures for the coincidental admission of moistening fluid into the body of said scavenging air.

4. The improvement in the art of generating power with the aid of explosion gases obtained by the successive explosions of combustible mixtures of fuel and air intermittently charged into a confined explosion space, which comprises charging air into

such space, after the explosion of a charge therein and the expansion of the resulting combustion gases, to scavenge said space of the residual hot explosion gases, and substantially simultaneously charging moisture into such space and thereby converting such moisture into steam, whereby the quantity of air necessary to scavenge such space is reduced and a greater cooling effect is obtained.

In testimony whereof I have hereunto set my hand.

FRIEDRICH HOFMANN.