



## UNITED STATES PATENT OFFICE

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## EXPLOSION CHAMBER

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The invention relates to explosion chambers suitable for use in combustion turbines and more particularly to chambers of the indicated class in which coal dust is used as a fuel. The operation of such explosion chambers presents the problem of igniting the coal dust with certainty in the relatively short interval of time which is available for this purpose and with regard to the relatively low compression which is commonly developed in turbines of the designated type. The object of the invention is to overcome this difficulty by spraying easily ignited fluid fuel in finely divided form into the combustion chamber, in addition to the coal dust, and in such a manner that the danger of premature ignition is avoided. The introduction of the fluid fuel in accordance with the invention, takes place after the introduction of the coal dust. In this way any incandescent particles of coal dust or ash remaining from the previous explosion are extinguished before the easily ignited fuel is introduced. Furthermore such introduction of fluid fuel may take place with or without atomizing air and either through the same inlet with the coal dust or through an independent special inlet, as may be preferred. Other objects will appear from the description hereinafter and the features of novelty will be pointed out in the claims.

In the accompanying drawing, which illustrates an example of the invention without defining its limits, Fig. 1 is a diagrammatic fragmentary section showing a combustion chamber of a combustion turbine with the invention applied thereto; Fig. 2 is a fragmentary section, on an enlarged scale, illustrating the invention in detail; Fig. 3 is a detail view illustrating an actuating unit forming part of the invention; and Fig. 4 is a view, partly in section, of a distributor and interrupter for controlling the opening of the valves of the combustion chamber and for timing the operation of the igniting elements.

In Fig. 1 an installation including the novel features is diagrammatically illustrated, which includes a representation of one of the combustion chambers *v* customarily found, in a predetermined number, in combustion

turbines of the type in question. The communication between the chamber *v* and the usual nozzle *v'* is controlled in the customary manner by the conventional nozzle valve *z* and the usual electrically controlled spark plugs *y* or equivalent igniting devices are provided for igniting the fuel charge in the well known way. A suitable form of timing mechanism is shown in Fig. 4 which is substantially a duplicate of Fig. 4 of the patent to Hans Holzwarth, No. 877,194. The distributor, which is indicated by the letter *u*, comprises a hollow cylinder 28; a hollow revolver 29 which rotates within and is spaced from the cylinder; a worm wheel 30 on the revolver shaft driven by a suitable motor (not shown); an oil pump 32; an oil tank 33; a pipe 34 leading from the tank to the pump; a back-flow oil pipe 35 from the controller cylinder to the tank; an annular passage 36 around the cylinder and communicating with it through a number of ports; a pressure oil pipe 37 leading from the oil pump to the passage 36; a series of necks 38 on the revolver fitting within the controller cylinder and serving to maintain the oil pressure within the revolver; an annular series of equally spaced ports 39 in the wall of the controller cylinder, one port for each combustion chamber; oil pipes *q'* operative to place the ports 39 in communication with the operating cylinders of the respective air valves *b*; a second series of similar ports 41 in the controller cylinder; pipes *x'* arranged to place the ports 41 in communication with the respective operating cylinders of the scavenging valves *x* or, where the admission of the fluid fuel is effected with the aid of hydraulic mechanism, as described in said Patent No. 877,194, such pipes *x'* may be connected with the operating cylinders of the fuel valves; a third series of ports 43 in the controller cylinder; pipes *z'* operative to place these ports in communication with the operating cylinders of the respective nozzle valves *z*; a hollow neck 45 on the revolver serving, as the revolver turns, to place its interior in communication with the ports 39 successively, and thus admit fluid pressure to open the air valves in succession; a similar neck 46 cooperating with the ports

41 to open the scavenging valves in succession; and a similar neck 47 cooperating with the ports 43 to effect opening of the nozzle valves one after the other. When the necks 45, 46, 47 move out of registry with the respective ports, the respective pipes  $q'$ ,  $x'$ ,  $z'$  are relieved of pressure by the discharge of the pressure fluid from such pipes into the annular space between cylinder 28 and revolver 29, from which space the fluid flows through pipe 35 to tank 33. The interrupter may take the form of a fixed annulus upon which are arranged a plurality of contacts 50, one for each cylinder, each contact being connected to the secondary of induction coil 49 by a wire 53, the other terminal of the secondary being connected by a wire 52 to a brush which engages the shaft and is thereby electrically connected with an interrupter wiper 51 mounted upon the shaft and rotatable therewith to engage the contacts 50 in succession, thereby closing the secondaries of the induction coils and operating the spark plugs  $y$  in succession through the wires  $y'$  leading from the primaries of the induction coils. The construction further includes the usual valve  $x$  for controlling the admission of scavenging air to the combustion chamber  $v$ .

In the novel arrangement, the combustion chamber  $v$  of the engine is provided with a projecting, hollow casing  $g$  in which a tubular member  $a$  is axially fitted, said member  $a$  including an inner circular flange  $a'$  which projects into the combustion chamber  $v$  as shown in Fig. 2. At the base of the flange  $a'$  the member  $a$  is formed with a valve seat  $b'$  with which an air valve  $b$  is arranged to cooperate to control the communication between the interior of the member  $a$  and the combustion chamber  $v$ . The valve  $b$  comprises part of or is carried by a stem  $c$  connected with a piston  $e$  slidably mounted in a chamber  $e'$  formed in the member  $a$  at the outer end thereof and closed by means of a cap  $f$  as shown in Fig. 2; the piston  $e$  includes a stem  $e^2$  located in axial registry with the valve stem  $c$  and projecting outwardly beyond and slidable in the cap  $f$ . The valve stem  $c$  carries a plurality of external disks  $c'$  projecting radially outward in registry with annular recesses  $a^2$  formed on the interior surface of the member  $a$ , said recesses  $a^2$  being located in spaced relation to each other and each converging toward the valve seat  $b'$  as shown in Fig. 2. The valve stem  $c$  is provided with an axial channel  $n$  which is continued through the piston  $e$  and piston stem  $e^2$  and has its outer end in communication with a pipe  $n'$  leading to a fuel pump  $o$  as illustrated diagrammatically in Fig. 1. The inner end of the channel  $n$  terminates in a valve seat for the accommodation of a spring pressed fuel valve  $d$  whereby the communication between the channel  $n$  and a chamber  $b^2$

formed within the cylindrical valve body  $b^3$  is controlled. A plug  $d'$  closes said chamber  $b^2$  toward the combustion chamber  $v$  and is provided with restricted passages  $d^2$  which diverge toward the combustion chamber  $v$  and establish communication between the latter and the valve chamber  $b^2$ .

The member  $a$  includes a port  $a^3$  which registers and communicates with a passage  $s$  formed in the casing  $g$  and terminating at its outer end in a flat surface with which the casing  $g$  is provided. A control slide  $h$  is slidably mounted on the aforesaid flat surface and is maintained in position thereon by means of a yielding affixed cover  $i$  which carries a hopper  $t$  for containing a supply of coal dust. The hopper  $t$  is in constant connection with a port  $i'$  of the cover  $i$ , and the slide  $h$  is provided with an opening  $h'$  movable into and out of registry with the port  $i'$  to thereby control the connection between the hopper  $t$  and the interior of the member  $a$  by way of the passage  $s$  and the port  $a^3$ . The control slide  $h$  is slidably reciprocated by means of a bell-crank lever  $k$  carrying a roller  $k'$  in engagement with a cam  $m$  fixed upon a suitably driven shaft  $l$  and by means of a spring  $p$ . In addition to the parts so far described the interior of the member  $a$  is connected by means of a passage  $r$  with a pipe  $v''$  which in turn leads to a source of air under pressure; a branch connection  $t'$  connects the pipe  $v''$  Fig. 1 with the hopper  $t$  so that the pressure therein equals that within the member  $a$ , and the latter pressure accordingly does not resist the passage of the coal dust from said hopper  $t$  to the interior of said member  $a$ . An inclined inlet  $q$  is formed in the cap  $f$  and leads from the piston chamber  $e'$  to a pipe  $q'$  which in turn is connected with the oil controller  $u$ , whereby the admission of oil under pressure to the piston chamber  $e'$  is automatically controlled for the purpose to be more fully set forth hereinafter; the controller  $u$  is also connected with the scavenging air valve  $x$  for controlling the operation thereof in the well known way. It will be understood that the mechanism shown and described is, in practice, duplicated in an operative combustion turbine in the form of a plurality of units which operate in a predetermined manner to produce the desired sequence of operation in the complete turbine.

The operation of the structure so far referred to is as follows: As long as no pressure oil is forced into the chamber  $e'$  behind the piston  $e$  the latter is maintained in its rear-most position by the air pressure which exists within the member  $a$  through the connection  $r$ ; the valve  $b$  is accordingly held in its closed position against the seat  $b'$ . As soon as pressure oil by the action of the oil controller  $u$  is permitted to pass through the pipe  $q'$  and port  $q$  the pressure will become effective in the chamber  $e'$  and will accordingly force

the piston *e* to the left in Fig. 2, it being understood that the pressure of the aforesaid oil is in excess of the air pressure within the member *a*. This movement of the piston *e* is transmitted to the stem *c* and valve *b* and accordingly moves the latter in a direction away from the seat *b'* whereupon air will pass from the interior of the member *a* to the combustion chamber *v*. As the aforesaid air passes from the member *a* it flows through the annular space between the circular inner surface of the extension *a'* and the outer surface of the valve body *b<sup>3</sup>* and is formed thereby into a tubular stream of air which enters the combustion chamber in this form. While the air is being charged a predetermined measured charge of highly inflammable liquid is forced through the pipe *n'* by the action of the fuel pump *o* into the channel *n* of the valve stem *c*; this liquid fuel forces the valve *d* to an open position against the tension of its spring and passes into the chamber *b<sup>2</sup>* and through the divergent channels *d<sup>2</sup>* into the tubular stream of air flowing out of the extension *a'*. The divergent streams of liquid fuel passing into the tubular stream of air bring about a thorough mixture of fuel and air which passes into the combustion chamber as previously set forth. Shortly before the opening of the valve *b*, the port *h'* of the control slide *h* is brought into registry with the port *i'* and the channel *s* and thus permits a measured charge of coal dust to pass from the hopper *t* into the interior of the member *a*; it will be understood that the control slide *h* is continuously reciprocated by the action of the cam *m*, the bell-crank lever *k* and the spring *p*, the reciprocation being so timed and the port *h'* being so located that the aforesaid introduction of a measured charge of coal dust into the member *a* will take place at the desired moment. This charge of coal dust is picked up by the air within the member *a* and the coal-dust-laden air, by impact with the projections *c'*, is whirled about and thoroughly mixed and passes into the combustion chamber *v*. In the combustion chamber *v*, at the proper moment, ignition of the mixture of air and oil takes place first and causes ignition of the coal dust particles and thereby brings about an explosion in said combustion chamber, the products of the explosion passing through an open nozzle valve *z* into and through the nozzle *v'* to a place of use, for example against the rotor blades of a turbine in the customary manner. The aforesaid operative steps are repeated in proper sequence throughout any given period of operation of the turbine and result in a continuous operation of the turbine wheel during such period. It will be understood that the nozzle valve *z* is opened at the proper instant following an explosion, for example by the distributor *u* in the man-

ner disclosed in the above-mentioned patent to Holzwarth, No. 877,194.

Inasmuch as the ignition oil is generally more expensive than the coal dust and as only a small quantity of such oil is sufficient to properly ignite the aforesaid charge of coal dust, it is advantageous to operate under all load conditions with an equal but least possible quantity of ignition oil and to regulate only the amount of injected coal dust. In the illustrated example this is accomplished by providing a cam of inclined form as shown in Fig. 3 and mounting the same by means of a sleeve *m'* adjustably upon the shaft *l* or a suitable part thereof by means of a key and a keyway as shown in said Fig. 3. Obviously by adjusting the sleeve *m'* and with it the beveled cam *m* in axial directions, different portions of the active surface of the cam *m* may be made effective upon the roller of the bell-crank lever *k* whereby the throw of the latter and as a result the extent of reciprocation of the control slide *h* are varied to bring the port *h'*, and consequently the channel *s*, more or less completely into registry with the port *i'*. In this way the amount of coal dust charged into the member *a* may be varied.

The oil controller *u*, through the pipe *q'* supplies the oil pressure for operating the piston *e* to open the valve *b* and also controls the supply of oil through the pipe *x'* whereby the valve *x* is opened to admit scavenging air to the combustion chamber *v* at the proper time. The uncontrolled oil pump *o* driven by means of a cam *o'* located upon the shaft *l* (see Fig. 3) forces a definite amount of ignition oil through the pipe *n'* into the channel *n* at the proper time. In order to provide the desired correlated operations of the oil controller *u* and pump *o* these two elements are connected by means of a chain *u'* to operate in proper unison. The connection *i'* from the air supply *v''* to the hopper *t* creates a pressure in the latter corresponding to the pressure exerted within the member *a* and thereby prevents the latter pressure from interposing a resistance to the entrance of the charge of coal dust at the proper time.

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

I claim:

1. The combination with an explosion chamber, of a hollow valve member communicating with said chamber and provided with a valve seat, a valve cooperating with said seat to control the communication between the interior of said member and the explosion chamber, a valve stem carrying said valve and provided with an axial channel extending therethrough, means for forcing ignition oil through said channel, a con-

nection leading from the interior of said member to a source of air under pressure, a hopper for containing a supply of coal dust and a connection between said hopper and the interior of said valve member for introducing a charge of coal dust into the latter for mixture with the air therein.

2. The combination with an explosion chamber, of a hollow valve member communicating with said chamber and provided with a valve seat, a circular extension projecting from said member into said combustion chamber, a connection for introducing air under pressure into said member, a valve cooperating with said valve seat to control the passage of said air from said member into said circular extension, a circular valve body carried by said valve and cooperating with said circular extension to form the air into a tubular stream; a valve stem carrying said valve and provided with an axial channel, a piston connected with said stem, a pressure oil connection for directing oil under pressure against said piston to open said valve; means for forcing a supply of ignition fluid through said channel, a plug connected with said valve body and provided with divergent channels for directing divergent streams of ignition oil into said tubular stream of air for mixture therewith, a hopper for containing a supply of coal dust, a connection from said hopper to the interior of said valve member, a control slide controlling said connection and an adjustable cam for controlling the operation of said slide.

3. The combination with an explosion chamber suitable for use in explosion turbines, of mechanism arranged to introduce a coal dust and air suspension under super-atmospheric pressure intermittently into said chamber to fill the same, means for operating said mechanism intermittently, a valve at the inlet side of said chamber for separately charging an easily ignitable fluid fuel directly into said chamber, means for operating said fluid fuel valve in such time relation to the operation of said mechanism that the admission of fluid fuel begins after the admission of coal dust has begun, means for igniting the mixture, whereby an explosion at constant volume is produced without the performance of work in said chamber, and a nozzle valve at the opposite outlet end of said chamber operable to discharge the explosion gases from the chamber to perform their work outside such chamber.

4. The combination with an explosion chamber suitable for use in explosion turbines, of a hollow valve member communicating with said chamber and provided with a valve seat, a connection leading from the interior of said member to a source of air of higher than atmospheric pressure, a container for coal dust communicating with the in-

terior of said member, an air valve cooperating with said seat to control the communication between the interior of said member and said chamber, means whereby said air valve is intermittently operated at predetermined instants to fill said chamber with a coal dust and air suspension, valve mechanism at the inlet side of said chamber for separately admitting ignition oil directly into said chamber, means for operating said oil valve mechanism in such timed relation to the operation of the air valve that the admission of oil begins after the admission of coal dust has begun, means for igniting the mixture, whereby an explosion at constant volume is produced without the performance of work in said chamber, and a nozzle valve at the opposite outlet end of said chamber operable to discharge the explosion gases from the chamber to perform their work outside such chamber.

5. The combination with an explosion chamber suitable for use in explosion turbines, of a hollow valve member communicating with said chamber and provided with a valve seat, a connection leading from the interior of said member to a source of air under higher than atmospheric pressure, an air valve cooperating with said seat to control the communication between the interior of said member and said chamber, a container for coal dust arranged to discharge into said hollow valve member, an intermittently operated valve controlling such discharge, means whereby said air valve is intermittently operated at predetermined instants to fill said chamber with a coal dust and air suspension, valve mechanism at the inlet side of said chamber for admitting ignition oil directly into said chamber, means for operating said oil valve mechanism in such timed relation to the operation of the air valve that the admission of oil begins after the admission of coal dust has begun, means for igniting the mixture, whereby an explosion at constant volume is produced without the performance of work in said chamber, and a nozzle valve at the opposite outlet end of said chamber operable to discharge the explosion gases from the chamber to perform their work outside such chamber.

6. The combination with an explosion chamber suitable for use in explosion turbines, of a hollow valve member communicating with said chamber, a connection leading from the interior of said member to a source of air of higher than atmospheric pressure, a container for coal dust arranged to discharge into said hollow valve member, a coal dust valve controlling such discharge, mechanism for intermittently operating said coal dust valve to feed a measured charge of coal dust into said hollow member, a valve arranged to control the communication between the interior of said member and the

explosion chamber, means for intermittently feeding an operating fluid to said last-mentioned valve to open the same at predetermined instants to fill said chamber with a  
5 coal dust and air suspension, valve mechanism at the inlet side of said chamber for separately admitting ignition oil directly into said chamber, means for operating said valve  
10 mechanism in such timed relation to the operation of the air valve that the admission of oil begins after the admission of coal dust has begun, means for igniting the mixture, whereby an explosion at constant volume is  
15 produced without the performance of work in said chamber, and a nozzle valve at the opposite outlet end of said chamber operable to discharge the explosion gases from the chamber to perform their work outside such chamber.

20 7. The improvement in the art of generating power which comprises intermittently introducing a mixture of air and solid fuel into a combustion space of constant volume, charging a fluid fuel into said combustion  
25 space after the introduction of the solid fuel has begun, whereby such fluid fuel is protected by the preceding body of air and solid fuel against premature ignition by the hot residual gases and glowing fuel particles re-  
30 maining in the combustion space from the previous explosion, igniting the mixture while the combustion space is completely closed, so that combustion gases of high pressure are produced, discharging the gases  
35 from said space and converting the energy thereof into mechanical energy.

In testimony whereof I have hereunto set my hand.

RUDOLPH SCHILLING.

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