

Sept. 22, 1953

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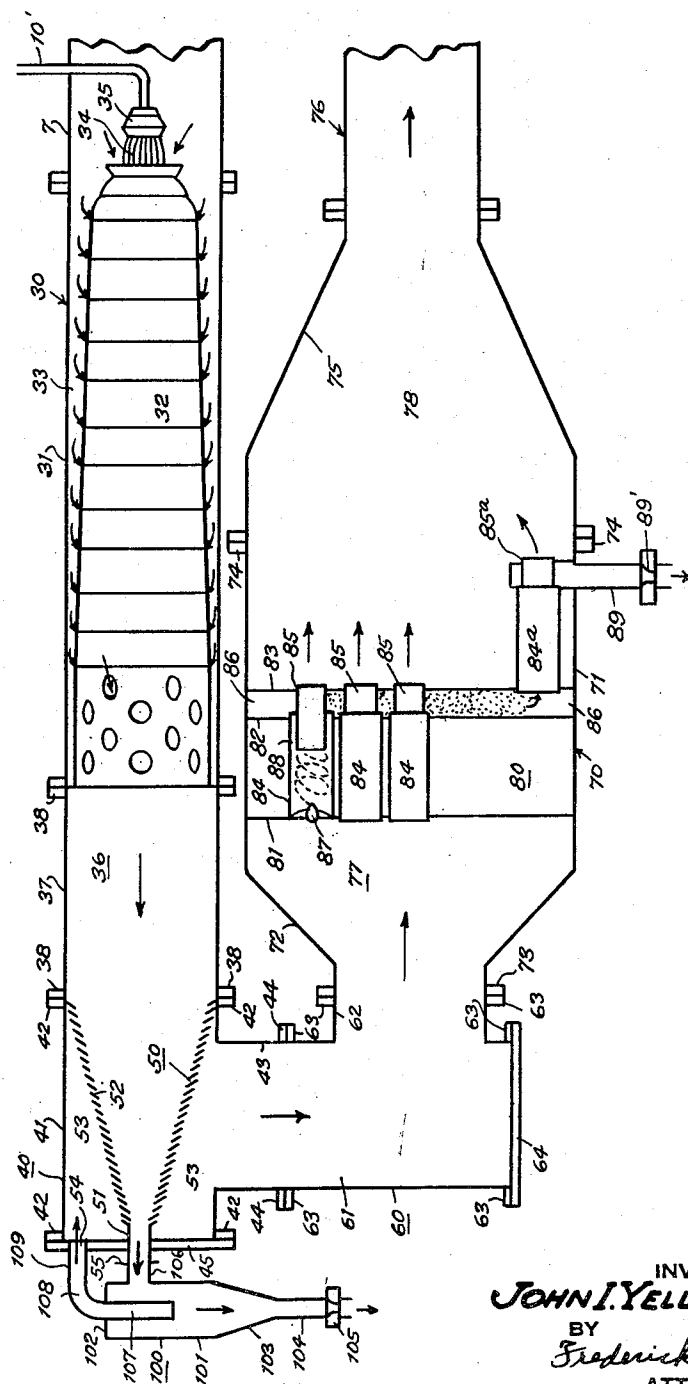
2,652,792

PRESSURIZED COMBUSTION AND ASH REMOVAL SYSTEM
FOR COAL-FIRED GAS TURBINE POWER PLANTS

Filed Nov. 23, 1951

3 Sheets-Sheet 1

Fig. 1



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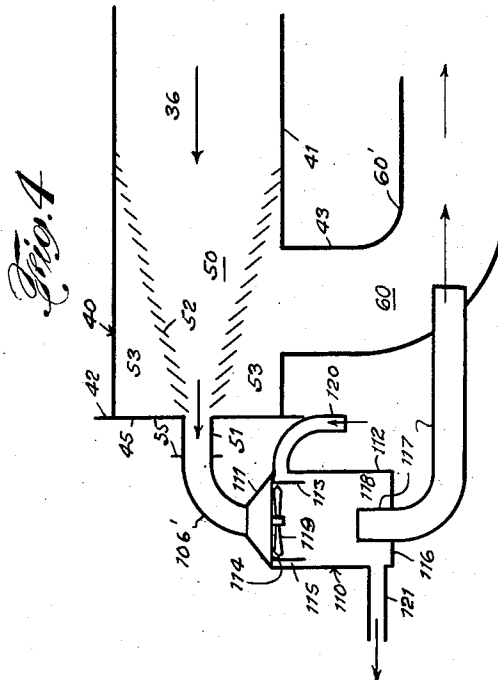
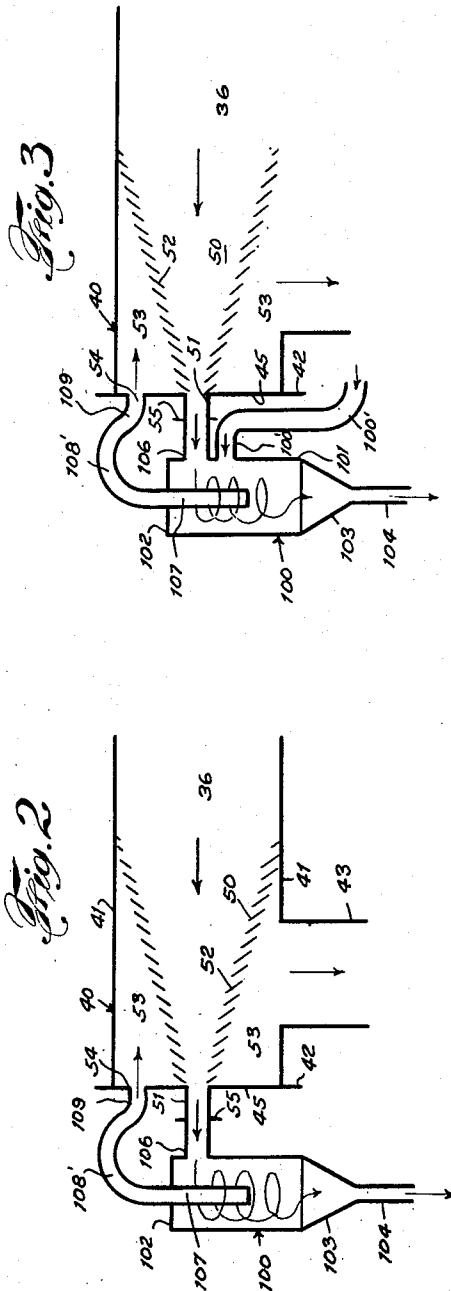
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Fig. 6.

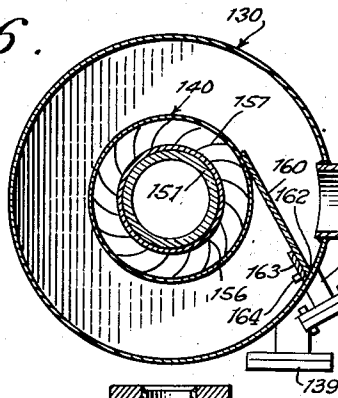


Fig. 7.

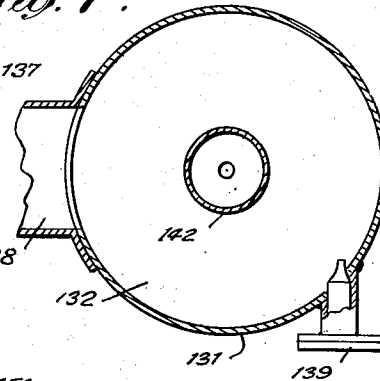
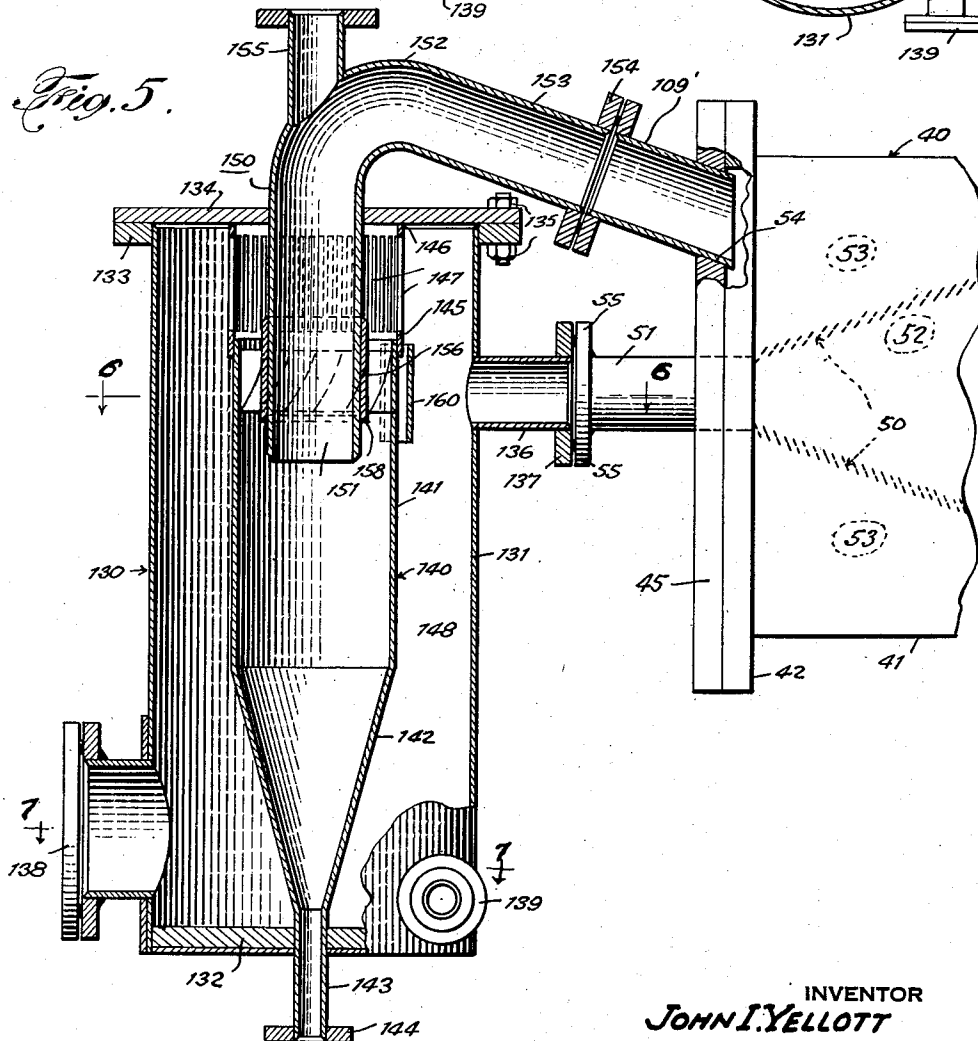


Fig. 5.



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UNITED STATES PATENT OFFICE

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PRESSURIZED COMBUSTION AND ASH REMOVAL SYSTEM FOR COAL-FIRED GAS TURBINE POWER PLANTS

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Application November 23, 1951, Serial No. 257,701

10 Claims. (Cl. 110—28)

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This invention relates to ash removal systems for coal-fired pressurized combustors generating motive fluid for gas turbines and other prime movers. More particularly the invention relates to ash removal systems for stripping ash and uncombusted residues from the products of combustion of pulverized coal burnt under pressure in combustors of the so-called film-cooled type.

In the combustion of pulverized coal under pressure conditions considerable difficulty is experienced in handling the solid residues of the combustion. Using a Pittsburgh #8 Seam containing 10% ash, the ash having a fusion point of 2700° F. with air heated to 1300° F., ash particles are found to range, by actual measurement, from 1 micron to agglomerates or large pieces of irregularly shaped masses up to 12 inches by 2 inches in size. These irregularly shaped masses arise from accumulations of ash on the walls of the combustor. With changes in combustor temperatures varying according to changes in turbine load, the ash accumulations on the combustor walls tend to crack off and are discharged in the motive fluid from the combustor. The handling of these over-sized masses is of great importance as they must be removed promptly to prevent clogging of the apparatus and closing down of the power plant. All of this must be done without imposing too heavy a burden on the ash removal equipment and cutting down the efficiency of the system by withdrawing too much of the motive fluid for ash removal purposes.

According to the principles of the present invention a louver separator is interposed between the combustor and the fine ash separator and the secondary flow from the louver containing the concentrated heavier ash is discharged from the system in a very small blowdown flow, with return of cleaned gas to the primary flow from the louver. Thus, with 4000 lbs. per hour of ash from the secondary louver flow the ash can be concentrated in 200 lbs. of blowdown air per hour or 0.2% of the total gas flow. With dual units the blowdown will amount to about 0.4% of the total. The louver separator is particularly adapted for handling hot sticky ash residues including low melting residues, such as Va_2O_5 . This material and the like is found in an appreciable quantity in the ash from residual oils, which ash is characterized by a lower melting point than coal ash.

The invention herein makes use of the fact that the gas pressure within the louver is sufficiently above the gas pressure outside the louver

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to use the differential in pressure to cause a secondary stream to flow through a suitable cyclone separator wherein the ash, which was conveyed from the louver by the secondary stream, is concentrated into a small blowdown stream. The major part of the secondary stream is then returned to the cleaned air side of the louver and the blowdown stream carries the separated ash through a blowdown nozzle into an atmospheric pressure collection system. The blowdown stream may be treated in an apparatus of the type shown in my allowed co-pending application, Ser. No. 148,594, filed March 9, 1950, for Method and Apparatus for the Separation of Particulate Material From Entraining Gaseous Fluids, to chill the ash to atmospheric temperature as expeditiously as possible without cooling the primary hot gaseous fluid, which is separated from the ash and returned to the system.

It is, therefore, among the features of novelty and advantage of the present invention to provide a novel method and apparatus for cleaning louver blowdown streams of contained ash and returning same to a cleaned gas stream.

It is also a feature of novelty and advantage of the present invention to provide a pressurized combustion system for pulverized solid fuels or other fuels having appreciable quantities of solid residues, wherein preliminary separation of residual masses from fine residues is effected, and the residual masses are concentrated and separated from a small blowdown stream, with the cleaned gas returned to the main system, and the separated ash discharged from the system at atmospheric pressure and temperature.

Other features of novelty and advantage include means for transferring the solids from the blowdown stream into a quenching stream and without substantial dissipation of heat from the original carrier stream.

Other features of novelty and advantage include secondary separators for massive residues, for self-contained reducing means and cooling means for the removed solids.

The above and other desirable features of novelty and advantage of the present invention will be more clearly understood by reference to the specification and accompanying drawings in which certain preferred embodiments of the invention are illustrated, by way of example only, it being understood that other modifications may be used without departing from the spirit and scope of the present invention.

In the drawings, like numerals refer to similar parts throughout the several views, of which:

Fig. 1 is a schematic view of a film-cooled, pressurized combustor for the pressurized combustion of combustive air-borne streaming entrainments of particulate residue-forming fuels, together with a novel ash separating and discharge system;

Fig. 2 is a schematic view of the coarse combustion residue separating and reducing elements of the device of Fig. 1;

Fig. 3 is a view similar to Fig. 2, showing the incorporation of coolant gas ash quenching and separating means;

Fig. 4 is a fragmentary view similar to Figs. 1-3, and showing coolant gas ash quenching means and separating means with separated ash blowdown and return of cleaned hot gas to the system;

Fig. 5 is a vertical section through a novel secondary ash treating device;

Fig. 6 is a horizontal section taken on line 6-6 of Fig. 5, and

Fig. 7 is a horizontal section taken on line 7-7 of Fig. 5.

The improvements of the present invention will be considered with a special reference to their incorporation in the motive fluid generator of the ash separating equipment of coal burning gas turbine power plants particularly designed for forming the primary power for generating electric locomotives.

A particular form of motive fluid generator which has been found specially suited for the pressurized combustion of combustive air-borne solids is illustrated, in part, in Fig. 1. In this system, tubular combustor casing 31, of combustor 30, suitably lagged, mounts a conical film type combustion chamber or flame tube 32 in such a manner as to form a tapering annular air chamber 33 therearound. The inlet end of this combustor chamber is continuous with a duct supplying preheated air from a regenerator, not shown. The pulverized fuel stream 34, from a suitable supply, not shown, discharges through nozzle 35 into the film-cooled flame tube or combustion chamber 32. At the outlet end, the combined combustion products and cooling air discharge into and mix in the plenum chamber 36. This chamber, as shown, comprises a tube section 37 having flanges 38, severally secured to like members of combustor casing 31, and the louver separator housing 40. The louver separator housing 40 comprises a T-shaped tubular housing having a top cross bar or tube 41 with flange 42 at the ends thereof, and a depending tubular leg 43 having flange 44. A conical louver separator 50 is mounted in the member 40 with the base of the cone secured by and between flanges 38 and 42 and the apical discharge pipe 51 mounted in end plate 45 of the member 40, plate 45 being secured to the end flanges 42. The body portion 52 of the louver is of truncated conical shape, and is comprised of spaced elements of suitable construction, as will be described more in detail hereinafter. A second T pipe 60, having a vertically disposed tubular cross arm 61, and a horizontal stub leg 62, is provided with flanges 63 at the ends of each of the arms. This member has the bottom end of cross arm 61 closed by plate 64 and the other end is secured to the louver separator casing 40, as shown. The fine ash-bearing motive fluid discharging across the elements 52 of louver 50 into the louver separator casing flow through T connector 60 into fore-chamber 77 of fine ash separator 70. The ash separator 70 comprises a

cylindrical body 71 having a truncated conical inlet end 72 terminating in flanged neck 73 which is secured to the discharge side of the T pipe or duct 60. The discharge end of cylinder 71 is flanged, as indicated at 74, and is connected to a second conical chamber 75 through the usual flanges and to a central discharge duct 76 for cleaned motive gas. A battery of fly ash separators, designated generally by the numeral 80, is mounted in member 70 in such a manner as to form a fore-chamber 77 and a cleaned gas plenum chamber 78. The individual fly ash separators in battery 80 are mounted between wall members 81, 82 and 83. The members 81 and 82 serve to spacedly support the casings 84 of the individual units, while the wall or septum 83 supports the discharge tubes 85, and, with member 82, forms a collecting chamber into which the ash separated out from the several separator units is segregated. The units 84, as shown, severally have a casing open at both ends, with a cleaned air discharge tube extending well up into the body of the casing while the mouth or inlet end is provided with spinners 87. The solids-bearing gas from the fore-chamber 77 passes axially through the separator units 84 while undergoing an initial centrifugal action or spin imparted by the spinners 87. The solids in the gas streams are concentrated at the inside wall of the units and travel through the annular channel 88 formed between the central discharge duct 85 and the casing 84 to discharge into the collecting chamber 86. The cleaned gas discharges through tubular sections 85 into the cleaned gas plenum chamber 78, and thence out through duct 76 to the turbine or other use device.

The separated ash in collector chamber 86 is treated in a separate ash concentrator unit 84a, having a cleaned air discharge tube 85a, and an ash discharge line 89 provided with an ash blowdown nozzle 89', discharging to any suitable receiver. The cleaned air tube 85a, as shown, discharges into the cleaned air plenum chamber 78, so that the ash discharged from the system is entrained in a minimum amount of motive fluid, and usually less than 1% of the total volume developed.

The separator system described immediately above, wherein the ash is removed from the separator system in two stages, and the primary battery of vortical whirl separators, which, as shown, may comprise a plurality of unitary separators, discharges cleaned air to the outlet, while the collected ash discharges of the said separators are reprocessed through a single unit to effect a final concentration of the separated ash, and its removal from the system, while retaining the heated, cleaned air separated therefrom, and returning it to the main cleaned gas stream. Thus, a maximum of ash separation is effected at the expense of a minimum amount of motive fluid which was used for the final blowdown.

Thus, it will be seen that fine ash separation and blowdown from a heated motive fluid can be effected without requiring extraneous equipment or operations and solely by the expenditure of a relatively small portion of the solids-bearing gas which is being cleaned.

As noted hereinabove, it is of paramount importance to segregate and remove oversize particles from the combustor, particularly when containing uncombusted carbonaceous material. Because of the accelerated combustion and fusion conditions obtaining in the flame tube of the

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combustor, as a result of the pressures obtaining therein, as well as of the quantity of combustible throughput, of the order of substantially one ton per hour per combustor, appreciable quantities of slag, or siliceous aggregates are formed on the walls of the combustor, and break off in the course of the combustion due to variations in temperature arising from variations in fuel feed, etc.

The desideratum in handling this material is to remove it as quickly as possible from the main motive fluid stream, and ahead of the main fly ash separator, the coarse material being quenched or cooled as quickly as possible, and conveyed or blown down to atmospheric storage. As the efficiency of the coal-fired gas turbine, on a competitive basis, depends on the complete utilization of all available heat units, the invention herein comprehends the recovery of available heat from the removed ash and its return to the motive fluid cycle.

Turning more particularly to Figs. 1 and 2, there is shown, schematically, a coarse ash separating and blowdown system with separator means for returning cleaned gas to the motive fluid plenum chamber. The motive fluid plenum chamber is formed between the walls of member 40 and the outer conical surface of element 52 forming the body of the louver. The plenum chamber is designated by the numeral 53 for purposes of convenience, and discharges directly into the motive fluid offtake 60. The plenum chamber 53 may be provided with a cleaned air inlet opening or return 54 formed in the end plate 45. Desirably, and as shown more in detail in Figs. 5 and 6, apical discharge pipe 51 has a terminal flange 55 to which the ash removal equipment is secured. As shown schematically in Figs. 1 and 2, the ash blowdown device comprises a cylindrical separator 100, having a body portion 101, closed top 102, tapering bottom 103, and blowdown pipe 104, discharging through blowdown nozzle 105. The body portion 101 is provided with a flanged intake 106 secured to flange 55 of discharge line 51 in pressure-tight relation. A cleaned air return line 107 depends axially from the top 102 into the body of the separator and below the inlet line 106. The line 107 discharges through a bend 108 (Fig. 1), or a gooseneck 108' (Fig. 2) and line 109 into plenum chamber 53, the line 109 being hermetically secured in pressure-tight relation in the inlet 54, described hereinabove.

The line 106 may discharge radially into the separator 100, as shown in Figs. 1 and 6, or tangentially as indicated in Figs. 2 and 3. Where residual oils, gases, and coals containing minimum amounts of ash-forming constituents are used, the vortical discharges of Figs. 2 and 3 may be made use of. However, where any considerable amount of residues, particularly of low melting ash constituents, are met with, the radial input and impact plate of the device shown in Fig. 10, will be utilized.

In my co-pending application, Ser. No. 148,594, filed March 9, 1950, for Method and Apparatus for the Separation of Particulate Material From Entraining Gaseous Fluids, I have disclosed and claimed devices for transferring solids from heated exhaust gases to a separate quenching air stream, without substantial diminution of the volume of the heated gases, while effecting substantially instantaneous quenching and removal of the transferred solids. In the drawings of Figs. 3 and 4 herein, I have shown

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the incorporation of the ash exchanger features of my above-identified case to the ash blowdown system herein. In the form shown in Fig. 3 and corresponding generally to the structures shown in Figs. 5 and 6 of my said application, a cold air inlet tube 100' discharges tangentially into separator 100 and immediately subjacent the tangentially disposed inlet 106 from the combustor 30. As described and claimed in that application, the cold air discharges tangentially from pipe 100' and spirals downwardly to chamber 100, scouring the inner walls thereof, and carrying the segregated ash particles, which are co-flowing in the same spiral from the upper inlet 106. The heated carrying gas, originally introduced through inlet 106, will be displaced toward the center of the separator by the cold gas introduced through subjacent line 100', with the simultaneous transfer of its originally contained ash to the sheath of cold air spiraling downwardly on the inner wall of the separator and out through discharge line 104, and a blowdown nozzle, not shown, to an atmospheric container. The cleaned heated gases will change direction and flow upwardly through cleaned air outlet 107 and connection 109, to return into the plenum chamber 53 of the louver separator. Desirably, the volume of gas introduced through line 100' as the quenching fluid, will be equivalent in amount to that discharged as ash carrier fluid through blowdown line 104, so that there is very little loss of heat units from the heated motive fluid originally blown down through louver outlet 51. Because of the construction of the louver there will be a pressure differential across the elements 52, with the result that the pressure in the combustor plenum chamber 36 will be higher than that obtaining in the louver discharge chamber 53, so that a pressure head will be imposed on line 107, which, coupled with the positive pressure on the separator by inlet line 106, will insure continuous circulation of the gases from the louver through the separator and back to the louver plenum chamber.

In the modification shown in Fig. 4, herein, the ash transfer principles embodied in the structure detailed in Figs. 2 to 4 of my application, Serial No. 148,594, are made use of. As described in the aforesaid application, this device includes an ash inlet 106' connected to louver discharge line 51. A separator 110 includes a cylindrical body portion 112, tapered end 111 connected to inlet 106', and closed end 116, axially mounting discharge pipe 117. An annular ring member 113, having a closed end 114, defines an annular chamber 115 which is in fluid communication with the tangentially directed inlet line 120. The tapered end 111 is in fluid communication with the interior of separator 110, a spinner 119 being mounted in the passage defined by the annulus 113. The discharge line 117 extends into the chamber 110 beyond the mouth of the tangential ash discharge line 121 and forms an ash collecting annular chamber 118 with the wall 112 and end wall 116 of the separator. The discharge line 117 is extended through the wall of pipe 60', downstream of the louver plenum chamber 53, to return cleaned heated air to the fly ash separator inlet stream.

The system illustrated in Fig. 4 operates in the following manner. The mixture of combustion gases, diluting air, entrained ash, uncombusted particles, and slag residues, discharges from chamber 36 axially into the louver separator 50.

Owing to the conical structure of the louver separator, there is a concentration of solid particles in the gas stream discharging through apical outlet 51. Because of the inertia of the oversized particles in the gas stream they will be entrained in and by the axial discharge stream, while the fine ash contained in the motive fluid, will remain suspended therein and be entrained thereby, as it effects a complete change of direction, at right angles to its original flow, and flows out between the elements 52 of the louver body into the plenum chamber 53 and the fine ash separator inlet 66. The oversized particles discharged through outlet 51 will flow through connector 106' and spinner 119 into separator chamber 110, the particles of oversized ash and solids being whirled outwardly, in spiral flow, to engage the inner surface of wall 112 and be collected in chamber 118 whence they are discharged through ash discharge outlet 121. The axially streaming gas which has been cleaned of its contained solids will discharge through line 117 to the fly ash separator inlet line 68, wherein it mixes with the fine ash-carrying motive fluid from plenum chamber 53. The pressure differential obtaining between the separator 50 and the outlet line 68' insures a positive flow of the ash-bearing motive fluid through separator 110, with return of cleaned, heated motive fluid to the fine ash separator inlet stream. This stripping of oversized particles and the like, from the primary ash separator and quenching of the particles and returning the cleaned heated gas to the system, in a volume substantially equivalent to the original input, is effected, in the present instance, by introducing a stream of quenching fluid, such as air, into separator 110 through tangential inlet line 120. The spiral flow of the incoming cooling gas causes it to hug the inner wall of the separator while simultaneously displacing the heated motive fluid co-flowing therewith. In this displacement, the separated solids are not displaced, and, consequently, are entrained in and by the cooling sheath which is co-flowing with the heated core gases and the separated particles are simultaneously quenched. By making the outlet or ash blowdown line 121 of the same capacity as inlet line 120 the cooling gases will flow, as a separate stream, through the separator, in engagement with the walls thereof, and out through discharge line 121, without any substantial admixture with the gases originally introduced through line 106'. Thus, the coarse combustible matter and heavy ash particles, originally separately in the louver, are removed from the system, with simultaneous quenching, and discharged to atmospheric storage, in a fraction of a second, without interfering with the main, hot motive gas stream and its flow from the combustor to the turbine, and without requiring withdrawal of any substantial portion of the motive gas stream for blowdown purposes. In fact, by properly correlating the inflow and outflow of the quenching gas the volume of the main gas stream can be maintained substantially constant while effecting simultaneous removal, quenching and blowdown of the separated solids.

In the operation of power plants of the type herein referred to when incorporated in generating electric locomotives and the like, accelerated combustion conditions impose a distinct burden on the equipment due to the severe size limitations and the heavy throughput volume. The relatively high temperatures obtaining in the combustion zone of the pulverized coal combustor,

wherein the coal is burned under pressure, as a combustible airborne streaming entrainment of fluidized coal particles, may result in the slagging of the ash constituents and the development or generation of agglomerates, including uncombusted combustible particles of appreciable size. These uncombusted masses and slagged ash constituents tend to build up as layers on the inner surfaces of the flame tube elements. These masses agglomerate to an appreciable wall thickness and then break off, as noted above, to form masses of relatively great size, running the gamut down to microscopic particles.

The speed of the turbine is directly dependent upon the quantity of fuel burned in the combustor. With variations in generator or train speed due to operative demands, there is a corresponding variation in the amount of motive gas required to be generated in the combustor with an accompanying variation in temperature within the combustor flame tube depending upon the varying combustible feed. These variations in temperature give rise to temperature differentials in the flame tube walls, with resulting shrinkage or expansion thereof, and consequent breaking off of the slag encrustations therefrom, and their discharge and removal in the motive gas stream. For heavy duty work, therefore, it is necessary to separately remove these bodies, as formed, to atmospheric storage, in a minimum of time, and without withdrawing appreciable quantities of heat units from the system. By the improvements in the present invention this is made possible with a minimum expenditure of motive fluid as the actual operating agent. In Figs. 5 and 6 there is illustrated a novel ash blowdown device which has given remarkably efficient results in full scale operating tests.

Referring now to Figs. 5 and 6, the novel secondary ash separator and quenching device will be seen to comprise an outer casing, an inner collection tube, a cleaned gas return, and ash quenching and removing equipment. The separator is designated generally by the numeral 130 and comprises an outer cylindrical casing 131 having a reinforced bottom 132 and a top collar or flange 133. A suitably gasketed head or cover plate 134 is secured on flange 133, in any suitable manner, as by stub bolts and nuts, designated generally by the numeral 135. A radial inlet tube 136 is secured in the wall of the separator about a quarter of the casing height from the top. This tube is flanged, as indicated at 137, and this flange is hermetically secured to flange 55 of louver separator outlet 51, in any suitable manner, well-known to those skilled in the art.

A suitably sealed clean-out aperture, designated generally by the numeral 138, is provided at the bottom of the casing. A pulverizing air jet device 139, is provided for the purpose of further reducing the oversize particles of ash. A fine ash collecting tube 140 is axially mounted in the casing, and comprises an upper cylindrical body portion 141, an inverted conical bottom 142 terminating in a discharge pipe 143. The latter may be flanged, as indicated at 144. The discharge pipe 143 is axially mounted in the bottom 132 of casing 130 and is hermetically secured in place, as by welding. An annular collar 145 is welded to the top end of tube 141 and has its upper surface 146 in varying engagement with the under side of cover plate 134. The collar 145 is slotted with a series of radial slots 147 providing access from the chamber 148 formed be-

tween the casing 130 and the collector tube 140 and the interior of the collector tube. An outlet tube 150 is axially mounted in the cover plate and is desirably welded thereto. The tube 150 depends well into the body 141 of collector tube 140. The tube 150 is comprised generally of a first depending tube section 151, a central elbow section 152 and a downwardly slanting outlet 153 having a flanged end 154. The elbow section 152 may be provided with a flanged viewing and cleaning tube 155. A flanged inlet tube 109' is mounted in aperture 54 of end plate 45 and louver separator section 40 and is hermetically secured to flange 154 in any suitable manner.

A collar 156 mounting spinner vanes 157 is secured in place on outlet tube section 151 by retaining ring 158, or by any other suitable means. The spinner vanes 157 are ground to fit into the inner diameter of collector tube body 141, and are fitted on the carrying collar 156 in such a manner as to dispose them below the plane of the bottom of the radial inlet slots 147 formed in collar 145.

It will be seen that blowdown gas, entraining heavier aggregates, will discharge through louver outlet 51 and inlet 136 into separator 130, with the heavier particles falling to the bottom of the casing, where they are further reduced by the action of tangential air jet 139. The lighter, gas-borne particles are introduced into the collecting tube through the slots 147 of collar 145 and thence downwardly through spinner vanes 157 into the body of the collector tube 140. The air jet 139 causes the aggregates collected at the bottom of separator 130 to be driven, in a spinning action, around the inside of the separator wall with a resultant abrasion and reduction of the particles. The resulting fine particles will be swept upwardly by the air stream from jet 139 and pass through the slots 147 into collector tube 140 together with the fine ash components of the original gas stream discharged through apical outlet of the combustor into the separator. The volume of air introduced through jet 139 will be relatively small and will serve to pick up heat units from the aggregates as they are being pulverized, thereby returning the heat units to the motive gas cycle. By reason of the spin imparted to the gas stream the contained solids will be centrifuged or spun outwardly, engaging the inner wall of tube section 141 in a descending spiral path, being collected in the conical bottom 142 and blown down through outlet 143, and a blowdown nozzle, not shown, to ash quenching and storage means. The gas stream entering collector 140, after discharging its contained solid particles, is caused to undergo a complete reversal of direction, travelling upward to outlet tube 150 and discharging through inlet 109' to be recycled to the plenum chamber 53 of the louver separator.

The separator described immediately above, along with the other separators, and embodying the principles of the present invention, markedly improve the overall efficiency of pressurized combustion systems utilizing pulverized coal. However, and as noted above, under heavy duty, high pressure operating conditions, in equipment of severely restricted size, such as obtain in locomotive operations, appreciable quantities of massive residues are formed during combustion, and must be reduced and removed from the system as expeditiously as possible, to prevent clogging, and without involving any appreciable loss of heat units from the motive gas system. This is ac-

complished by incorporating a breaker plate 160 in the separator 130 directly in the path of the gas streaming inwardly through inlet pipe 136. With the tubes 51 and 136 of substantially 4 inches diameter, any length of aggregate can be handled, up to the inner diameter of the tubes, and will be projected against impact plate 160, and broken thereon and thereby. The plate 160 is mounted at an angle, as shown, and serves to deflect the incoming gas stream as well as to break up the contained solid masses, so that the solids-bearing gas stream is caused to travel spirally within the upper portion of casing 130 before discharging through slots 147 into the central collecting tube. During the spiral travel of the solids-bearing gases the heavier particles will be discharged into the bottom of casing 130, all as previously indicated.

A feature of prime importance regarding breaker plate 160 is its renewability. Under actual, full scale operating conditions, the coarse, solids-bearing gas streams have been found to have a highly abrasive effect on any and all surfaces against which the solids impinge. As a practical matter, the use of special, abrasion-resistant alloys is less economical, because of unduly high cost of installation and replacement, than the use of replaceable impact plates of relatively cheap metals, such as cast irons, or cast steels having the necessary temperature resistance characteristics.

The plate 160 will desirably be mounted with the center of impact in the axis of inlet tube 136. With tube 136 having a 4 inch diameter it is desirable that impact plate 160 be half again as large in every dimension, that is about 6 inches on the side. This will take care of the spraying action of the gases issuing from the tube 136, so that the spray pattern will be effectually contained within the limits of the impact plate. The plate may be removably mounted as follows: A rectangular chamber 161 having top, bottom and side walls welded to each other, is welded in place on the outer surface of casing 130. A slot 162 is cut in the casing to receive plate 160 and its supporting arm 163. The supporting arm or plate 163 is detachably secured to plate 160 by any suitable means, such as screws or bolts, designated generally by numeral 164. The member 163 is detachably secured to chamber 161, the latter being desirably flanged, as indicated at 166. The joints between the flange 166 and the carrier plate 163 are suitably gasketed and the securing means may comprise stud bolts and nuts, or machine screws, all designated generally by the numeral 167.

It will now be appreciated that there have been provided novel pressurized combustion systems for the burning of residue-containing and forming fuels, both liquid and solid, with special ash blowdown, and quenching of the ash, while simultaneously recovering the major portion of heat units associated with the ash, and utilizing only a minor portion of the ash-bearing motive gas fluid as the entraining agent for blowdown of the separated residues.

I claim:

1. In a pressurized combustion system for the pressurized combustion of fluidized pulverized coal including a pressurized combustor and means to mix the products of combustion with a gaseous diluent and coolant to form an ash-bearing motive fluid, and ash separating means including a fly-ash separator receiving the ash-bearing motive fluid and delivering ash-free mo-

tive fluid, the improvements comprising a conical louver separator in axial alignment with the said combustor and receiving the said ash-bearing motive fluid, said louver having an apical outlet, whereby the coarse, motive fluid-borne solids are concentrated by the conical louver and discharge in a blowdown stream through said apical outlet, the cleaned gas from the louver being discharged to the fly ash separator; means for separating the ash from said blowdown stream to form a concentrated ash-carrying blowdown stream and a cleaned hot gas stream; means for returning the said cleaned hot gas stream to the motive fluid stream downstream of the louver separator, and separate means for removing the said concentrated ash blowdown stream from the said ash separating means.

2. A pressurized combustor system according to claim 1, characterized by the fact that the means used to separate the ash from the louver blowdown stream is a cyclone separator.

3. A pressurized combustor system according to claim 2, characterized by the fact that means are provided for introducing a stream of coolant gaseous fluid tangentially into the separator whereby to form a spiral sheath of cooling gas about the core stream of heated motive gases, and the solids originally carried in the heated core stream are centrifugally transferred into and entrained in and quenched by the coolant stream.

4. A pressurized combustor system according to claim 3, characterized by the fact that the blowdown means serving to remove the separated ash offtake stream has a capacity substantially equivalent in volume to the capacity of the coolant input.

5. A pressurized combustor system according to claim 1, characterized by the fact that the means for separating the ash from the louver blowdown stream comprises, a closed cylindrical casing with a radial inlet for the solids-bearing gas, a central collection tube, a slotted annulus on said tube and establishing communication between the casing and the tube, a cleaned gas discharge pipe establishing fluid communication between the collection tube and the downstream side of the louver separator, an ash blowdown line at the bottom of the collecting tube, and an impact plate mounted in the path of the solids-bearing gases blown down from the louver separator.

6. A pressurized combustor system according to claim 1, characterized by the fact that the means for separating the ash from the louver blowdown stream comprises, a closed cylindrical casing with an inlet for the solids-bearing gas, a central collection tube, a slotted annulus on said tube and establishing communication between the casing and the tube, a cleaned gas discharge pipe establishing fluid communication between the collection tube and the downstream side of the louver separator, and an ash blowdown line at the bottom of the collecting tube.

7. A pressurized combustor system according to claim 1, characterized by the fact that the means for separating the ash from the louver blowdown stream comprises, a closed cylindrical casing with a radial inlet for the solids-bearing gas, a central collection tube, a slotted annulus on said tube and establishing communication between the casing and the tube, a cleaned gas discharge pipe establishing fluid communication between the collection tube and the downstream side of the louver separator, an ash blowdown

line at the bottom of the collecting tube, an impact plate mounted in the path of the solids-bearing gases blow down from the louver separator, and air jet reducing and removal means for coarse agglomerates at the bottom of said cylindrical casing.

8. A pressurized combustor system according to claim 1, characterized by the fact that the means for separating the ash from the louver blowdown stream comprises a closed cylindrical casing with a radial inlet for the solids-bearing gas, a central collection tube, a slotted annulus at the top of said tube and establishing fluid communication between the casing and the tube, spinner means in the tube below the slotted annulus, whereby spin is imparted to the solids-bearing gases introduced into the collector tube and the solids are projected out of the said gases, a cleaned gas discharge pipe mounted axially of the spinner means and establishing fluid communication, with a reversal of gas flow, between the collection tube and the downstream side of the louver separator, a restricted ash blowdown line at the bottom of the collecting tube, and an impact plate in the path of the solids-bearing gases from the louver separator.

9. A pressurized combustor system according to claim 1, characterized by the fact that the means for separating the ash from the louver blowdown stream comprises a closed cylindrical casing with an inlet for the solids-bearing gas, an impact plate mounted in the path of said solids-bearing gas, a central collection tube, a slotted annulus on said tube and establishing communication between the casing and the tube, spinner means in the tube below the said slotted annulus, whereby spin is imparted to the solids-bearing gaseous fluid introduced into the collection tube, a cleaned gas discharge pipe establishing fluid communication, with a reversal of flow of the gas stream, between the collection tube and the downstream side of the louver separator, an ash blowdown line at the bottom of the collecting tube, air jet reducing means for coarse agglomerates at the bottom of said cylindrical casing, whereby reduced solids are carried upwardly in the casing and introduced into the collection tube through the apertures of the slotted annulus, and separate solids removal means in the bottom of the wall of the casing.

10. A combination pressurized combustion and ash removal system for coal-fired gas turbine power plant, comprising, in combination, pulverized coal supply means; pressurized combustive air supply means; a combustor including a multiple segment cold wall combustion chamber mounted in a casing and defining an annular duct therewith; a burner in the combustion chamber in fluid communication with the pulverized coal supply means and pressurized combustive air supply means, whereby a streaming entrainment of combustive air-borne coal particles is delivered to the said burner; secondary air supply means in fluid communication with the combustor casing and the hot and cold wall surfaces of the combustion chamber segments, whereby the inner and outer walls of the combustion chamber are cooled by films of air; a coarse ash separator comprising a conical louver in the discharge line of the combustor; a cylindrical separator; a fine ash separator; fluid connection means delivering cleaned gas from the said cylindrical separator to the fine ash separator; separate cleaned gas and ash discharge means for the fine ash separator, said cylindrical separator having an inlet re-

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ceiving coarse ash from the conical louver and discharging it to said cylindrical separator; and cold air inlet means in said cylindrical separator for establishing an ascending, spinning column of cold air, whereby coarse ash is quenched and ground, and removed in a stream of blow-down air.

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