Feb. 16, 1960 J. I. YELLOTT ET AL 2,925,143

ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

Original Filed Jan. 7, 1953 5 Sheets-Sheet 1

Fig. 2.

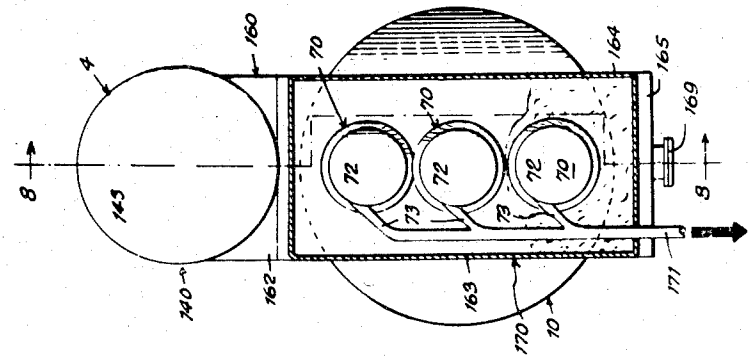
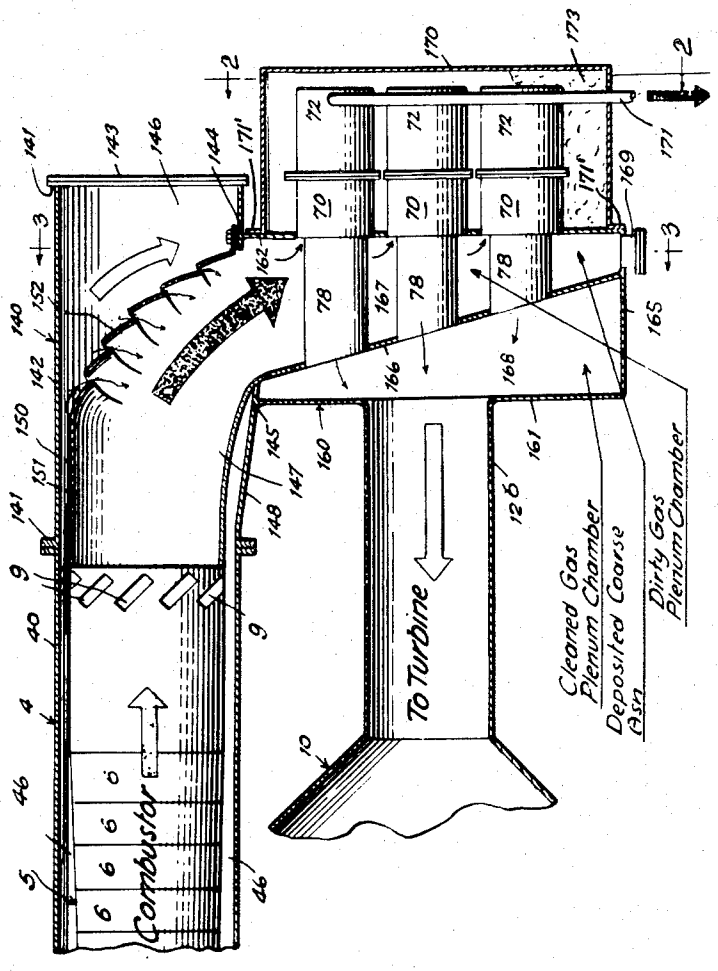


Fig. 1.



ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

Original Filed Jan. 7, 1953 5 Sheets-Sheet 2

Fig. 4.

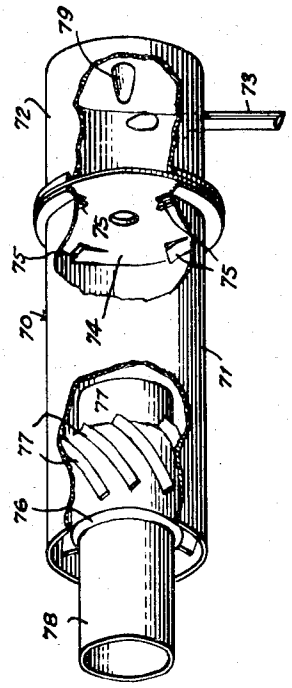
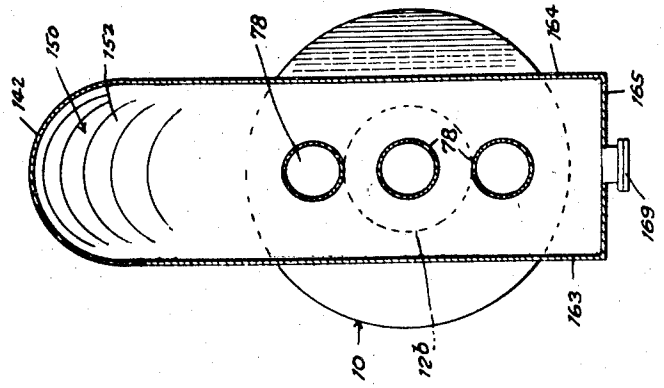


Fig. 3.



Feb. 16, 1960 J. I. YELLOTT ET AL 2,925,143

ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

Original Filed Jan. 7, 1953 5 Sheets-Sheet 3

Fig. 6.

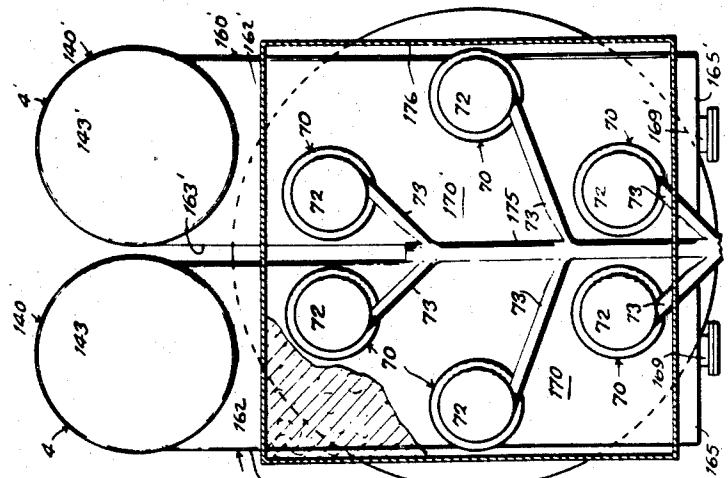
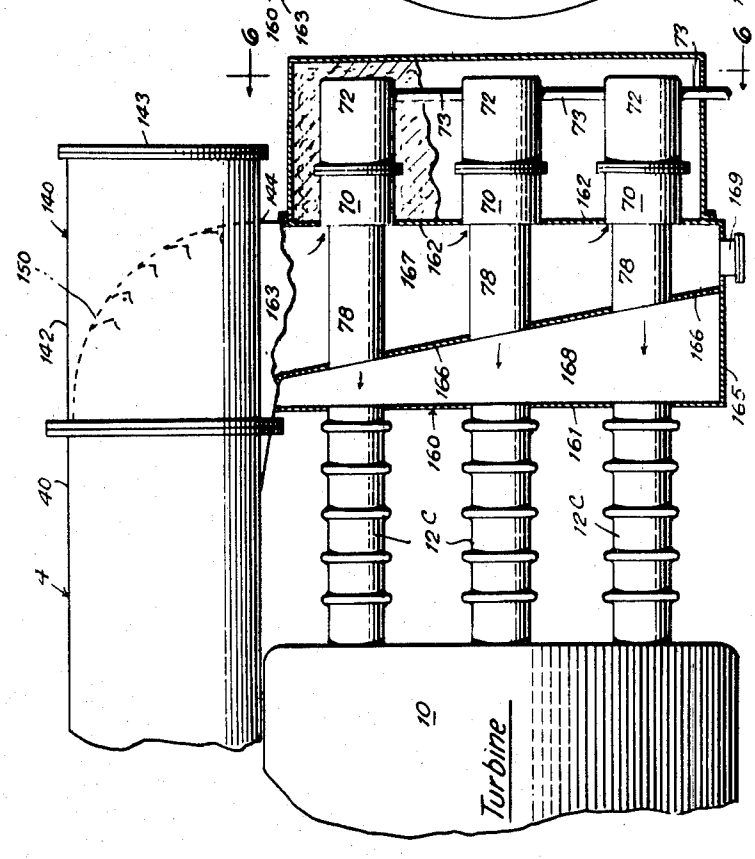


Fig. 5.



Feb. 16, 1960 J. I. YELLOTT ET AL 2,925,143

ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

Original Filed Jan. 7, 1953 5 Sheets-Sheet 4

Fig. 8.

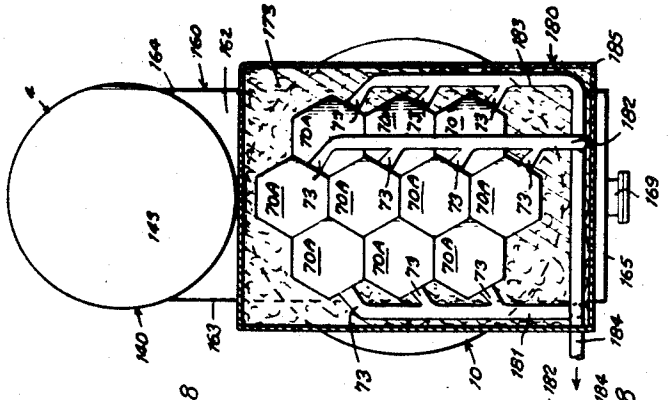
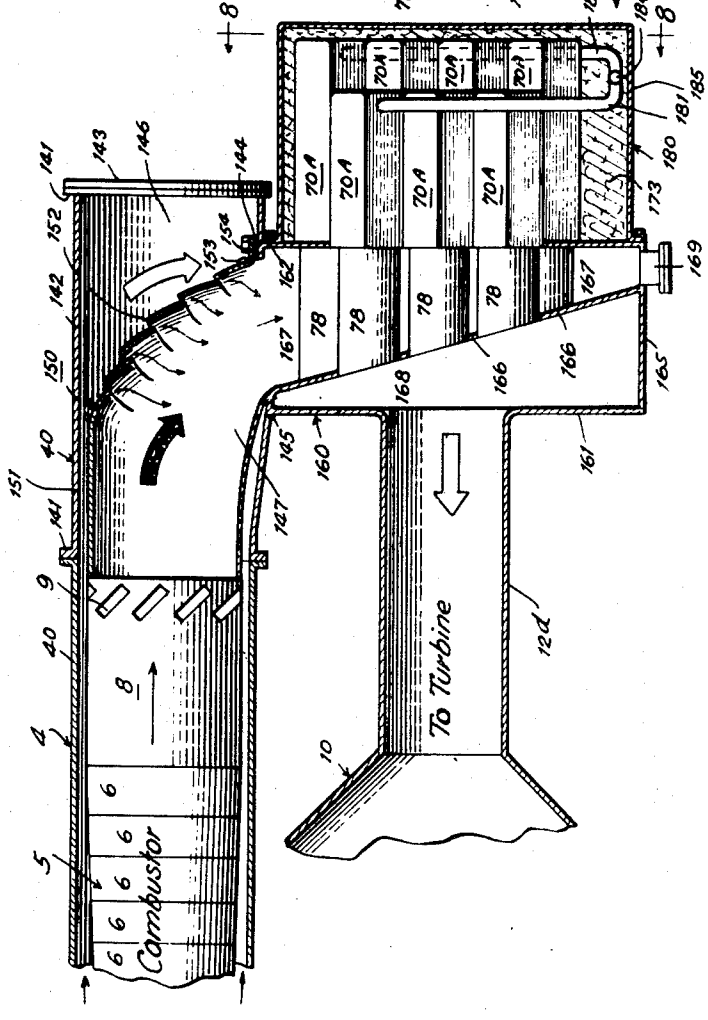


Fig. 7.



Feb. 16, 1960 J. I. YELLOTT ET AL 2,925,143

ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

Original Filed Jan. 7, 1953 5 Sheets-Sheet 5

Fig. 10.

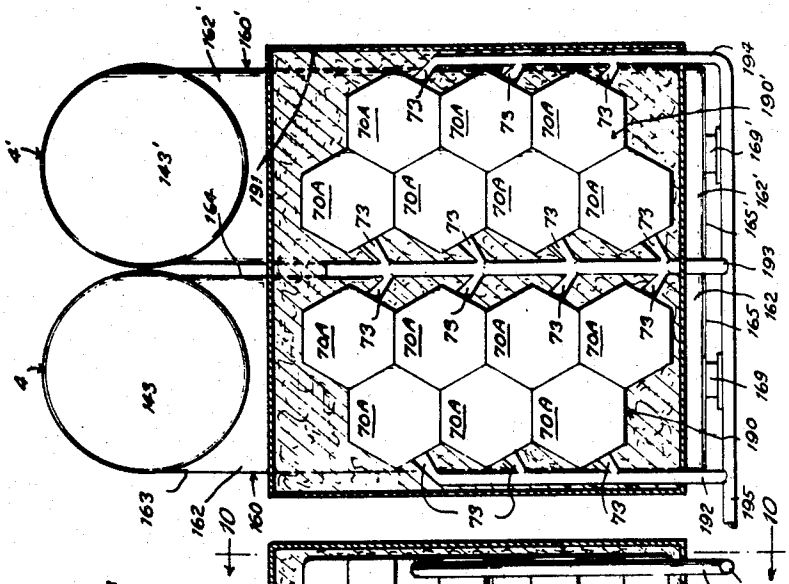
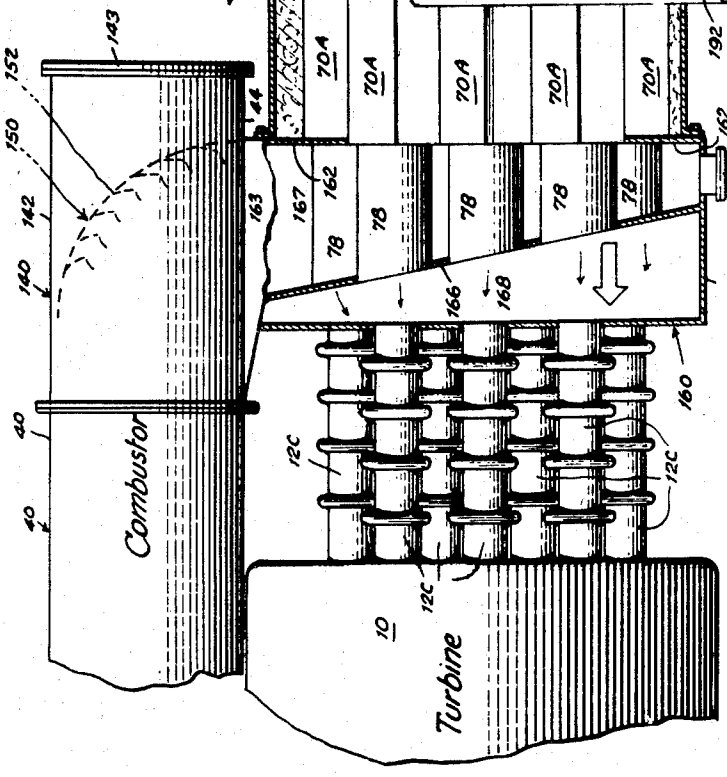


Fig. 9.



United States Patent Office 2,925,143 Patented Feb. 16, 1960

2,925,143

ASH SEPARATOR BATTERY WITH HORIZONTALLY DISPOSED SEPARATORS

John I. Yellott, New York, N.Y., and Peter R. Broadley, Elizabeth, N.J., assignors to Bituminous Coal Research, Inc., Washington, D.C., a corporation of Delaware

Original application January 7, 1953, Serial No. 330,077, now Patent No. 2,911,065, dated November 3, 1959. Divided and this application April 4, 1955, Serial No. 499,124

5 Claims. (Cl. 183—32)

This invention relates to ash disposal systems for pressurized combustors utilizing powdered coal, dispersed in pressurized streams of combustive air, as a gasiform combustible. More particularly, the invention relates to such systems as elements of gas turbine power plants for supplying ash and combustion residue-free pressurized motive fluid for the turbines. This application is a division of our application Serial No. 330,077, filed January 7, 1953, for Coal-Burning Gas Turbine Power Plants Incorporating Novel Self-Supporting and Pressure-Sustaining Vortical Whirl Separators Together With Improved Ash Quenching and Blowdown Means.

The pressurized combustion of fluidized, residue-forming fuels, such as powdered coal, as streaming entrainments of discrete particles in combustion air streams, is characterized by the fact that up to 50–60 percent of the charge of powdered coal is wholly or partially unburned during its travel through a combustor, so that vigorous after-burning of the incompletely burned combustible particles takes place in the ash separating equipment necessary in gas turbine power plants, and like systems. All of this is in marked contradistinction to the condition obtaining in central station power plants wherein powdered coal is burned at atmospheric or subatmospheric (forced draft) pressures, and the uncombusted combustible content of the resulting ash rarely exceeds four (4) percent of the original combustible charged.

To take the fullest advantage of economies now available, and to develop other worthwhile economies, hitherto thought impossible, the improvements of the present invention comprehend the utilization of combustion and ash handling equipment of novel design. In accordance with the teachings of the present invention, the initial cooling of solid residues from the combustor is effected by the secondary air of the system, while in the preferred form of the invention the ash removal equipment is simplified by eliminating pressure-sustaining casings for housing the batteries of vortical whirl separators, which separators now function as individual pressure-sustaining vessels, suitably insulated in light weight housings. The marked economies effected in weight reduction of the parts of the power plants herein are accompanied by important increases in operative efficiency. This desirable combination permits added savings in locomotive manufacture, operation, and maintenance, as well as in marine and stationary power plants.

The foregoing desiderata are substantially accomplished by the novel improvements of the present invention, according to which ash separator plenum chamber casings of uniform cross-section incorporate juxtaposed wedge-shaped input and output plenum chambers, of mutually inverse cross-section, in heat-exchanging relation. Vortical whirl separators of the type described and claimed in our prior application, Serial No. 257,702, filed November 23, 1951, for Vortical Whirl Separators and Method of Operation, are operatively coupled to the

said casings. The barrels and adjacent discharge sections of the individual separators are horizontally disposed and are secured on the outside of the input plenum chamber, and in fluid communication with the interior thereof, while the cleaned gas discharge tubes of the separators are hermetically embouched in the partitions or septa dividing the input and output plenum chambers, and deliver cleaned gas to the output or cleaned gas plenum chambers, whence it is delivered to gas turbines or other use devices, through suitable ducts.

The invention herein provides for increased efficiency of operation of gas turbine power plants using residue-forming fuels, in that the pressure losses inherent in earlier designs are substantially reduced through the elimination of sudden enlargements and reductions in the diameter of the gas-conveying conduits. By providing suitable housings or sheathing for the externally oriented ash separating barrels, these members can be heat insulated with relatively inexpensive heat-insulating materials. The separator units can be maintained at a substantially uniform operating temperature, without distortion which would otherwise be caused by temperature inequalities. The external mounting of the separator tubes makes possible inspection, cleaning, and like procedures, without the necessity of closing down the plant in order to open or dismantle the pressure tank hitherto used to contain the separator tubes.

The novel power plants of the present invention utilize the special vortical whirl separators of our above-identified application, which are pressure-sustaining and self-supporting. As a result of this important discovery, it has been found that it is possible to eliminate the costly and unduly bulky pressure-sustaining tanks or vessels in which the vortical whirl separators have been housed, and to mount the novel pressure-sustaining and self-supporting vortical whirl separators exteriorly of the input plenum chambers of special motive fluid conduits, ducts or casings. These novel motive fluid conduits connect a motive fluid source, such as a compressor and a combustor using residue-forming fuel dispersed in a current of combustive or primary air, with a use device, such as a gas turbine. The conduits, ducts, or casings, are divided, lengthwise (that is, in the direction of flow of the motive fluid) into a convergent, wedge-shaped dirty gas input plenum chamber, and an output or cleaned gas plenum chamber, the said plenum chambers being incorporated in casings having a common interior wall which serves as a support for the hermetically embouched, cleaned gas discharge tubes of the horizontally disposed vortical whirl separators, which tubes discharge cleaned gas into the output plenum chamber. Tangential blowdown lines for separated ash are provided for the discharge sections of the vortical whirl separators, and manifolds conduct the collective separated ash blow-down streams to an ash concentrator comprised of a single, low capacity (volume) vortical whirl separator, from which the concentrated ash is conveyed to suitable storage means, while the final quantum of cleaned gas is returned to the system, or vented to the atmosphere, as the exigencies of the operation of any particular installation may require.

The quenching of ash and other combustion residues, particularly unburned coal particles or agglomerates, must be effected as quickly as possible to prevent after-combustion in the pressurized ash separating equipment. The improvements of the present invention permit the separation of coarse combustion residues and unburned combustibles by projecting them from out of the rectilinearly flowing stream of motive fluid, combustion gases plus cooling and diluting secondary air, in which they are entrained, into a co-flowing, marginal stream of cooler, secondary air. This secondary air is introduced through louvers in the top of a downcomer duct mount-

ed in the discharge end of the combustor casing, which casing, as will be described more in detail hereinafter, subserves the function of a secondary air plenum chamber. The downcomer duct causes an abrupt change in the direction of flow of the horizontally projected stream of ash- and combustion residue-bearing motive fluid gases, with the result that the said heavier entrained material is transferred to the down-flowing marginal stream of secondary air, and is cooled and quenched therein, according to the "ash-transfer" principle, enunciated in the application of one of us. John I. Yellott, Serial No. 148,594, filed March 9, 1950, for Method and Apparatus for the Separation of Particulate Material From Entraining Gaseous Fluids, now Patent No. 2,650,675, issued Sept. 1, 1953.

The louvred ducts, per se, and in the novel combination with the combustors and ash-separating equipment herein, are more particularly disclosed and claimed in our companion divisional application Serial No. 499,123, filed April 4, 1955, now Patent No. 2,888,804, for Louvred Coolant Fluid Ash Quenching Systems for Pressurized Combustors Utilizing Powdered Coal.

The downcomer ducts can be of various configurations, according to the particular installations in which they are to be incorporated, and are severally hermetically connected to the input plenum chambers of the novel ash separator batteries herein. Means are provided at the bases of the ducts, or in fore chambers of the input plenum chambers, for receiving and withdrawing separated, quenched residues from the motive fluid, the fly ash contained in the fluid being separated therefrom in its passage through the battery of special vortical whirl separators forming an integral part of the ash separator system herein, and continuously removed from the system in a blowdown stream of motive fluid comprising up to 1–1½ percent of the total throughput volume of the fluid.

It is, therefore, among the features of novelty and advantage of the present invention to provide improved combustion and ash-separating equipment for pressurized, powdered coal-burning power plants generating pressurized hot motive fluid for expansion engines, such as gas turbines, and for space heating devices, and other uses.

Another feature of novelty and advantage of the present invention is the provision of motive fluid conduit or duct means, forming plenum chamber casings hermetically divided, in the direction of flow, into dirty gas input and cleaned gas output plenum chambers, in mutual heat-exchanging relation, and coupling the cleaned gas plenum chambers with use devices, such as gas turbines, the motive fluid being stripped of entrained solids by passage through special vortical whirl separators, horizontally mounted externally of the motive fluid duct means and severally coupling the said dirty gas input and cleaned gas output plenum chambers.

It is also a feature of novelty and advantage of the present invention to provide ash separating means for the turbine motive fluid, the separating means being comprised of batteries of horizontally mounted, vertically disposed, self-sustaining, heat-resistant and pressure-sustaining special reverse flow vortical whirl separators, incorporating blowdown lines for separated ash, and with or without light-weight heat-insulating casings therefor.

Other features of novelty and advantage of the present invention include the special horizontal orientation of reverse flow vortical whirl separators in batteries, as well as specially shaped separators, assembled in juxtaposed honeycomb relation to form batteries of mutually supported ash separators, with the juxtaposed barrels of the separators being in mutual heat-exchanging relation.

With these and other important features of novelty and advantage which may be incident to the improvements herein, the invention consists in the parts and combinations to be hereinafter set forth and claimed, with the understanding that the several necessary elements comprising the invention may be varied in construction, proportions and arrangements, without departing from the spirit and scope of the appended claims.

In order to make the invention more clearly understood, there is shown in the accompanying drawings means for carrying the same into practical effect, without limiting the improvements in their useful application to the particular constructions, which, for the purpose of explanation, have been made the subject of illustration.

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

Figure 1 is a longitudinal section through the discharge end of a combustor incorporating a downcomer duct having secondary air admitting louvers, and a modified ash separator battery having a box-like plenum chamber casing incorporating juxtaposed dirty gas inlet and cleaned gas outlet plenum chambers in mutual heat-exchanging relation, the dirty gas plenum chamber being hermetically coupled to the downcomer duct, with the individual vortical whirl separator units of the ash separator being shown in horizontal elevation, mounted exteriorly of the casing, and encased in an insulating housing;

Fig. 2 is a cross-section, taken on line 2—2 of Fig. 1, showing flow restrictive ash blowdown lines and discharge manifold therefor;

Fig. 3 is a cross-section of an input plenum chamber taken on line 3—3 of Fig. 1;

Fig. 4 is an elevational view, partly in broken section, of a horizontally mounted novel reverse flow vortical whirl separator, showing the details of the barrel or primary separator chamber and the adjacent discharge chamber with its tangential blowdown line;

Fig. 5 is a view similar to Fig. 1, showing multiple cleaned gas expansion ducts axially aligned with the cleaned gas discharge tubes of the separator units, and coupling the gas turbine and the cleaned gas output plenum chamber;

Fig. 6 is a vertical cross-section, taken on line 6—6 of Fig. 5, and showing duplex combustor and associated ash separator units, together with ash blowdown lines and common discharge manifold;

Fig. 7 is a longitudinal axial section through a combustor and associated ash separator, the flame tube and ash separators being shown in elevation, the separators being hexiform and mutually juxtaposed in a honeycomb assembly;

Fig. 8 is a cross-section taken on line 8—8 of Fig. 7, showing the rear elevation of the honeycomb assembly and associated ash discharge manifolds;

Fig. 9 is a view similar to Fig. 7, showing a honeycomb arrangement of hexiform vortical whirl separator units, together with a corresponding number of expansion ducts axially aligned with the cleaned gas discharge tubes of the separator units, and coupling the cleaned gas outlet plenum chamber to a gas turbine, and

Fig. 10 is a cross-section, taken on line 10—10 of Fig. 9, showing the mounting of duplex combustors and associated ash separators severally incorporating honeycomb assemblies of hexiform ash separator units, together with ash blowdown lines and manifolds therefor.

As discussed hereinabove, a feature of major importance in the design of any element of a power plant intended for use in locomotives is the restriction of the size of the element to the smallest dimensions possible, consonant with the performance required. In the case of pulverized coal-burning motive fluid generating equipment, all elements of the ash separating, ash concentrating, and storage equipment must be added to the equipment normally required for oil-burning gas turbine-powered generating electric locomotives. Such added equipment must be as compact as possible, simple to construct, service and repair, and exhibit an ash-separating efficiency beyond the capacity of any such equipment hitherto described, or available. In the novel design of the ash separating equipment forming the special feature of novelty in the systems (illustrated in Figs. 1–10), the

above recited desiderata are successfully attained, as will now be disclosed.

Turning to the detailed showings of Figs. 1, 5, 7 and 9, the improved ash-separating equipment will be seen to comprise a modified combustor discharge section, designated generally by the numeral **140**, a modified and louvered deflector **150** mounted in section **140** of the combustor and directing motive fluid from the combustor downwardly into the fore chamber or dirty gas input plenum chamber of the vertically disposed, box-like casing **160** embodying dirty gas input and cleaned gas output plenum chambers. Specially mounted batteries of horizontally disposed reverse flow vortical whirl separators **70**, are hermetically coupled to the exterior of the casing **160**, and establish fluid communication between the input and output plenum chambers thereof.

These devices, designated generally by the numeral **70** (Fig. 4) comprise primary separator or barrel sections **71** and adjacent bottomed discharge sections **72** provided with tangential blowdown lines **73**, as shown. An axially apertured diaphragm **74** is mounted between the barrel and discharge sections of the separators. These diaphragms are provided further with marginal struck-up skimmer blades **75**, extending into the barrel section and defining peripheral apertures establishing fluid communication between the said barrel and discharge sections, whereby centrifugally separated solids from the barrel section are delivered into the discharge section in spinning streams of motive fluid, and further separation of the solids then takes place with the eventual removal of the solids in a blowdown stream of motive fluid discharged through the tangential blowdown line **73**. At the intake end of the barrel section there is provided peripheral vortical whirl imparting means for incoming dirty gas, and an axial cleaned gas outlet tube. In the form shown herein, a collar member **76** mounts peripheral vanes **77**, severally set to give a discharge angle of substantially 30°. The outer edges of the vanes **77** are in frictional engagement with the inner surface of the cylindrical barrel section, and retain the collar **76** fixedly secured in the mouth of the barrel section of the separator. A cleaned gas discharge tube **78** is axially secured in the collar **76** and extends an appreciable distance on both sides thereof, so as to depend into the barrel section to place its mouth well below the downstream edges of the vanes **77**. The output or discharge end of the tube can extend any desired distance, depending upon the particular installation. Wear resisting plugs **79** (Fig. 4) may be axially disposed in the bases of the discharge sections to prevent abrasion.

In the single combustor units illustrated in Figs. 1–3, 7–8, the combustors **4** are provided with modified discharge sections **140**, of generally cylindrical shape, having flanged ends **141**, and a body **142**, capped by end cap plate **143**. The body is provided with a rectangular cutout **144** on its under surface to receive the top of ash separator casing **160**. The casing **160** is hermetically secured to the member **140** in any suitable manner, as by welding, indicated generally by the numeral **145**. A louvered curviform deflector **150** is mounted in the end section **140** of the combustor, and divides the latter into an upper, clean secondary cooling air plenum chamber **146**, and a lower, dirty motive fluid plenum chamber **147**. The deflector **150** comprises a rear body portion **151** of partially curviform section terminating in a downwardly directed forward louver section **152** provided with louvers **153** on its upper surface.

The ash separator casing **160** is comprised of respectively apertured front and back walls **161**, **162**, integral side walls **163**, **164**, and integral bottom **165**. A diagonally disposed, apertured separator or divider plate **166** is hermetically secured, as by welding, to the top edge of front wall **161**, and to the side walls **163**, **164**, as well as to the bottom **165**. The bottom edge of separator plate **166** is spaced from the rear wall **162**, as shown. The plate **166** divides the casing **160** into an input plenum chamber **167** for ash and combustion residue-bearing motive fluid, which is in fluid communication with plenum chamber **147** of the combustor, and into a cleaned motive gas plenum chamber **168** which is in fluid communication with a turbine **10**, or other use device, through expansion duct or ducts **12***b*. A cleanout port **169**, for separated coarse combustion residues and ash, is provided at the base of input plenum chamber **167**.

A feature of prime importance of the invention herein, and particularly of the ash separator system of the modifications presently under discussion, is the special mounting of the pressure-sustaining vortical whirl separators **70**, described in detail hereinabove. In this form of the invention, the separators **70** are horizontally arranged, in batteries, designated generally by the numeral **170**, in the following manner: The casings **71** of suitably aligned separators **70** are hermetically secured in appropriate apertures in rear wall **162** of plenum chamber casing **160** in any desired manner, as by welding, thereby placing the barrels of the individual separators in fluid communication with the dirty gas input plenum chamber **167**. The mouths of cleaned gas discharge tubes **78**, which severally bridge plenum chamber **167**, are hermetically embouched, as by welding, in the sloped partition member or divider plate **166**, being received in aligned apertures therein, and establishing fluid communication with the cleaned gas plenum chamber **168**. The tangential ash blowndown lines **73**, which, as noted above, severally receive separated solids from the discharge sections **72** of separators **70**, collectively discharge their motive fluid-borne separated solids into a depending ash discharge manifold **171** (Figs. 1 and 2), which is in fluid communication with the ash concentrating and storage units of the system, described in detail hereinabove. The ash blowdown lines **73** will incorporate individual flow restrictors, as shown, to prevent blowback of separated solids. The barrels of the horizontally disposed separators **70** are desirably cylindrical.

It will be seen that the ash separator system incorporating the novel plenum chamber casings **160** clearly fulfill the basic requirement of maximum ash separating efficiency with minimum bulk and weight of equipment. The heat conservation of the present system is effectively maintained by suitably lagging all exposed surfaces of the equipment with heat insulating material. The lagging of the exposed surfaces of the horizontally disposed, pressure-sustaining vortical whirl separators **70**, which are mounted on the outside of the plenum chamber casing **160**, may be effected in the following manner: A box-like housing or sheath **170**, generally conformed to the rear wall **162** of the plenum chamber casing **160**, is provided with flanged edges **171'**, which are secured to the wall **162** in any suitable manner, as by machine screws, not shown. The housings **170** are filled with suitable low-cost heat-insulating material **173**, such as glass wool, or asbestos fiber, which is packed in and around the horizontally disposed vortical whirl separators **70**, so as to effectually insulate them and prevent any significant heat loss through the exposed surfaces thereof.

Turning to Figs. 5 and 6, there is shown the method of mounting duplex combustors and ash separator assemblies incorporating horizontally mounted, self-supporting, and pressure-sustaining vortical whirl separators. In this system, the duplex combustors, **4**, **4'**, are arranged in substantial parallelism, and are severally provided with modified end discharge sections **140**, **140'**, debouching into input plenum chambers **167**, **167'**, of the parallel, juxtaposed box-like plenum chamber casings **160**, **160'**. Each of these casings mounts a battery of vortical whirl separators, **170**, **170'**, severally comprised of three separators, the horizontal axes of all the separators being arranged in parallelism and jointly intersecting the per-

imeter of a circle. In other words, the duplex array of separators is characterized by the fact that the axes of the several separators are equidistant from a common center. A common ash discharge manifold **175** is disposed between the batteries of separators **170, 170'**, and lies in a vertical plane coinciding with the vertical diameter of the turbine casing. The expansion ducts **12***c*, connecting the cleaned gas plenum chamber and the turbine, are equal in number to the vertical whirl separators of the juxtaposed batteries, and are severally coaxial therewith. A common shield or housing, **176**, is disposed over the separator batteries **170, 170'**, and is demountably secured to the casings **160, 160'**. The usual heat insulating filling **173**, of glass wool, asbestos fiber, or the like, is packed into the housing **176**, and in and around the individual vortical whirl separators of the encased batteries. The common ash discharge manifold **175** receives the individual ash blowdown lines **73** of the vortical whirl separators **70**, each said line being provided with a flow restrictor, as shown, to prevent blowback between the several separators. The ash discharge manifold **175** discharges to the ash concentrator **120** in the usual manner.

The combustor elements **140, 140'**, and the associated plenum chamber casings **160, 160'**, described immediately above, are also used in the modified ash separating systems illustrated in Figs. 7–10, and essentially characterized by the use of batteries of horizontally disposed vortical whirl separators having hexiform barrels and discharge chambers, which are mutually juxtaposed in honeycomb arrangements in the several batteries. These batteries are severally designated **180**, and **180'**. Turning now to Figs. 7–8, the separator battery **180** is seen to comprise three vertical rows of hexiform separators, severally designated generally by the numeral **70A**. The hexiform separators **70A** are essentially similar to the cylindrical separators **70**, which have been described in detail hereinabove, and this description will not be repeated, as it is not required for an understanding of the honeycomb arrangement of the horizontally disposed separators. The battery **180** is characterized further by the fact that the central row of separators extends rearwardly beyond the bilaterally juxtaposed rows to permit the coupling of the ash blowdown lines **73** of the middle separators to clear the ends of the discharge sections of the separators of the side rows. The blowdown lines **73** of the several rows are hermetically connected to blowdown manifolds **181, 182, 183**, as shown in Fig. 8, and these manifolds are coupled to a common, horizontally disposed ash blowdown manifold **184**, which discharges to a suitable ash concentrating and disposal system, as described hereinabove. The mouths of the barrels of the juxtaposed separators **70A** may be separately hermetically embouched in rear wall **162** of plenum chamber casing **160**, or they may be mutually hermetically joined, and the unitary array embouched in wall **162** in a single aperture conformed to the honeycomb-like periphery of the array, and hermetically secured thereto. With either of these arrangements, the barrels of the separators are placed in fluid communication with the input plenum chamber **167**, and the cleaned gas discharge tubes **78** will traverse this chamber, and have their several mouths received in aligned apertures in divider plate or tube sheet **166**, thereby establishing hermetic connection with the cleaned gas plenum chamber **168**. The plenum chamber **168** discharges to the gas turbine **10** through the usual expansion duct **12***d*. A flanged, box-like housing or sheath **185** is mounted over the battery **180** and is detachably secured to the plenum chamber casing **160** in the usual manner. Heat-insulating material **173**, of glass wool, asbestos fibers, or the like, will be packed in the housing **185**, in contact with the exposed surfaces of the honeycomb array comprising separator battery **180**.

In Figs. 9–10, there is shown a duplex combustor and ash separator system, generally similar to the system illustrated in Figs. 5–6, and described hereinabove. The new system is characterized by duplex honeycomb arrays of hexiform vortical whirl separators **70A**, forming separator batteries, severally designated by the numerals **190, 190'**, and housed in a unitary, detachable box-like housing or sheath **191**, incorporating the usual heat insulating filler **173**. The batteries **190, 190'**, are mirror images of each other and severally comprise two vertical rows of separators hermetically embouched in plenum chamber casing walls **162, 162'**, respectively. The outside rows of the batteries are comprised of three separators, mutually abutted, and interfitted with juxtaposed inner rows comprised of four mutually abutted separators. The separators are coaxial with a like number of expansion ducts **12***a* connecting the cleaned gas plenum chamber **168** and the turbine **10**. Each array of separators is hermetically embouched in suitably conformed apertures in walls **162, 162'**, of plenum chamber casings **160, 160'**. In the system shown in Figs. 9–10, it will be seen that the separators **70A** are of uniform length. As shown more particularly in Fig. 10, the ash blowdown lines **73**, severally provided with flow restrictors, debouch into vertical manifold **192, 193, 194**, which, in turn, debouch into common ash discharge manifold **195**. Manifold **195** discharges to the final ash concentrating and storage stage, as described hereinabove. Manifolds **192, 193** and **194** are severally provided with flow restrictors to prevent blowback from the common ash discharge manifold **195**.

There have been described and illustrated ash separating and cooling systems for use with combustors adapted for the pressurized combustion of powdered coal capable of performing and effecting all of the specifically mentioned features of novelty and advantage of the invention, as well as others which are apparent to those skilled in the art. Various uses of the present invention may be made using the described structures. According, it is apparent that variations as to operation, size and shape, and rearrangement of the elements may be made without departing from the spirit of the invention. Therefore, limitation is sought only in accordance with the scope of the following claims.

We claim:

1. In a gas turbine power plant of the character described, in which pulverized coal is carried and burned in a pressurized stream of primary air, and the gaseous products of combustion are diluted and cooled with secondary air to optimum turbine operating temperature to form an ash- and combustion residue-bearing gaseous motive fluid, an improved ash and residue separating means comprising a casing having an open top, closed sides and bottom, and apertured front and back walls, together with an apertured, diagonally disposed inner wall member integral with the side walls and having its upper edge slightly everted and integral with the top of the front wall, its bottom edge being integral with the bottom of the casing and spaced from the rear wall, the said diagonal inner wall member dividing the casing into an open-topped input plenum chamber, and a juxtaposed output plenum chamber having at least one discharge opening for cleaned gas in its front wall; a plurality of horizontally disposed, self-supporting, pressure-sustaining vortical whirl separators mounted in the apertures of the rear wall of the casing, and having their intake ends integral therewith, each said separator including a barrel section and an adjacent discharge section; an axial cleaned gas discharge tube and circumjacent vortical whirl-imparting intake means for each separator, each said tube being hermetically secured at its discharge end in an aperture of the diagonal inner wall and discharging into the cleaned gas plenum chamber; tangential blowdown lines for separated ash at the ends of the discharge sections, and discharging into a manifold; and a shield mounted over the separators and secured to the rear wall of the input plenum chamber of the casing, said shield having insulating material disposed therein and around the separators.

2. In a gas turbine power plant of the character described, in which pulverized coal is carried and burned in a pressurized stream of primary air, and the gaseous products of combustion are diluted and cooled with secondary air to optimum turbine operating temperature to form an ash- and combustion residue-bearing gaseous motive fluid, an improved ash and combustion residue separating means, comprising a plurality of box-like casings, each said casing having an open top, closed sides and bottom, and apertured front and back walls, together with an apertured, diagonally disposed inner wall member integral with the side walls and having its upper edge slightly everted and integral with the top of the front wall, its bottom edge being integral with the bottom of the casing and spaced from the rear wall, the said diagonal inner wall member dividing the casing into an open-topped input plenum chamber, and a juxtaposed output plenum chamber in heat-exchanging relation therewith and having a plurality of discharge openings in its front wall; a plurality of horizontally disposed self-supporting, pressure-sustaining vortical whirl separators mounted in the apertures of the rear walls of each said casing, and having their intake ends integral therewith, each said separator including a barrel section and an adjacent discharge section; a cleaned gas discharge tube and circumjacent vortical whirl-imparting inlet means for each separator, each said tube being hermetically secured at its discharge end in an aperture of the diagonal inner wall and discharging into the cleaned gas output plenum chamber; tangential blowdown lines at the ends of the discharge sections, all of the blowdown lines of the separators severally discharging into a common manifold, and a shield mounted over the adjacent separator assemblies and secured to the rear walls of the input plenum chambers of the casings, said shield having heat insulating material disposed therein and around the separators.

3. In a gas turbine power plant of the character described, in which pulverized coal is carried and burned in a pressurized stream of primary air and the gaseous products of combustion are diluted and cooled with secondary air to optimum turbine operating temperature to form an ash- and combustion residue-bearing gaseous motive fluid, the improved ash and combustion residue separating means, comprising casing having an open top, closed sides and bottom, and apertured front and back walls, together with an apertured, diagonally disposed inner wall member with the side walls and having its upper edge flared outwardly and integral with the top of the front wall, its bottom edge being integral with the bottom of the casing and spaced from the rear wall, the said diagonal inner wall member being apertured and dividing the casing into an open-topped input plenum chamber, and a juxtaposed output plenum chamber having at least one discharge opening in its front wall; a plurality of horizontally disposed, self-supporting, pressure-sustaining vortical whirl separators mounted in the apertured rear wall of the casing, and having their input ends integral therewith, each said separator including a hexiform barrel section and a coaxial, juxtaposed ash discharge section; a cleaned gas discharge tube and circumjacent vortical whirl-imparting inlet means for each separator, each said tube being hermetically secured at its discharge end in an aperture of the diagonal inner wall and discharging into the cleaned gas plenum chamber; tangential blowdown lines for separated ash at the ends of each of the discharge sections, the vortical whirl separators being arranged in vertical rows, comprising a center row and outside rows, the center row extending rearwardly beyond the laterally juxtaposed outside rows, the hexiform barrels of the separators being mutually abutted and interfitted in a honeycomb assembly, whereby uniform heat distribution is maintained throughout the said assembly; a manifold for each row of separators, and a common manifold receiving the discharges from the first said manifolds.

4. Power plant according to claim 3, characterized by the fact that a shield is mounted over the separator assembly and is secured to the rear wall of the input plenum chamber, and heat insulating material is disposed in the shield and around the separator assembly.

5. In a gas turbine power plant of the character described, in which pulverized coal is carried and burned in a pressurized stream of primary air, and the gaseous products of combustion are diluted and cooled with secondary air to optimum turbine operating temperature to form an ash- and combustion residue-bearing gaseous motive fluid, an improved ash and combustion residue separating means comprising a plurality of box-like casings, each said casing having an open top, closed sides and bottom, and apertured front and back walls, together with an apertured, diagonally disposed inner wall integral with the side walls and having its upper edge flared outwardly and integral with the top of the front wall, its bottom edge being integral with the bottom of the casing and spaced from the rear wall, the said diagonal inner wall member dividing the casing into an open-topped input plenum chamber, and a juxtaposed output plenum chamber having a plurality of discharge openings in its front wall; a plurality of horizontally disposed, self-supporting, pressure-sustaining vortical whirl separators mounted in the rear wall of the casing with the intake ends of the separator barrels flush with the inner surface of the said rear wall, each said separator including a hexiform barrel section and a coaxial, juxtaposed ash discharge section; a cleaned gas discharge tube and circumjacent vortical whirl-imparting inlet means for each separator, each said tube being hermetically secured at its discharge end in an aperture of the diagonal inner wall and discharging into the cleaned gas outlet plenum chamber; tangential blowdown lines at the ends of the discharge sections; all of the blowdown lines of the separators severally discharging through intermediate manifolds into a common ash discharge manifold, the hexiform barrels of the vortical whirl separators being arranged in two vertical rows in each casing, the hexiform barrels of the juxtaposed separators in each casing being mutually abutted and interfitted in a honeycomb assembly, whereby uniform heat distribution is maintained through each said assembly; and a shield mounted over the adjacent honeycomb assemblies of the hexiform barreled separators and secured to the rear walls of said casings, said shield having heat insulating material disposed therein and around the said separator assemblies.

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