

Oct. 1, 1957

E. SCHINDLER

2,808,012

FUEL BURNING APPARATUS

Filed March 10, 1952

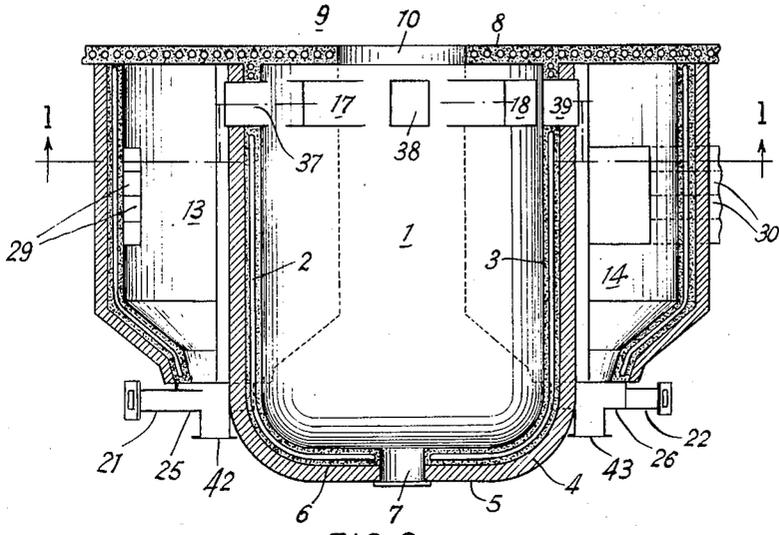


FIG. 2

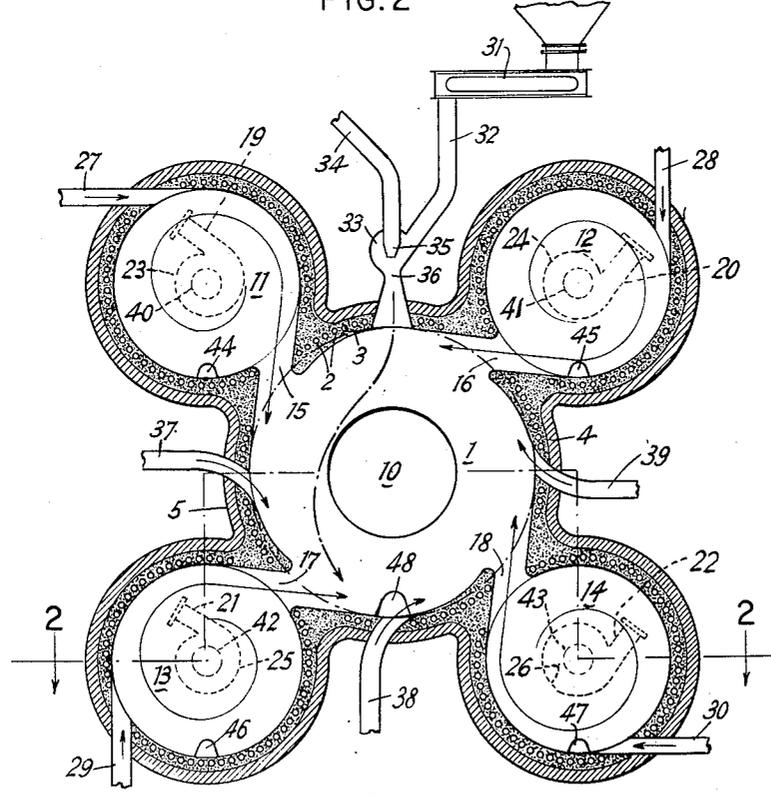


FIG. 1

INVENTOR.
Ewald Schindler
BY
J. Moran
ATTORNEY

1

2,808,012

FUEL BURNING APPARATUS

Ewald Schindler, Oberhausen, Rhineland, Germany, assignor to The Babcock & Wilcox Company, Jersey City, N. J., a corporation of New Jersey

Application March 10, 1952, Serial No. 275,695

9 Claims. (Cl. 110-28)

The present invention relates in general to methods of burning ash-containing solid fuel and to the construction and operation of a particular form of fuel burning apparatus by which the benefits of these methods may be attained. A purpose of the invention is to develop a high output of high temperature heating gases substantially free of slag and/or ash particles. In practicing the invention, the fuel is directed through successive zones each of which may be provided by a cyclone type furnace chamber, similar to cyclones disclosed, for example, in U. S. Patent Bailey 2,357,301, issued September 5, 1944. Thus, a granular, ash-containing, solid fuel in a stream of primary air, at superatmospheric pressure, is directed tangentially into a fluid cooled cyclone chamber and caused to follow a helical path of travel therein, with secondary air and possibly tertiary air in regulable quantity also being admitted, whence the furnace gases are discharged tangentially into a similar fluid cooled chamber which in accordance with the present invention, is also of the cyclone type.

In the furnace gases discharging from the first cyclone zone at a velocity of about 50 m./sec., there still is contained a large portion of the energy due to the relatively high initial pressure at which air is delivered to the cyclone, and increased by a portion of the flow energy resulting from the thermal increase in volume to 6 to 8 times the volume of the relatively cold entering air, which flow energy is produced with a thermal efficiency close to 100 percent. This energy is practically of no benefit in known cyclone furnace installations in that the discharging gas stream fills the spatially larger secondary furnace chamber which is customarily provided.

It is therefore an object of the present invention to make use of the flow energy of gases discharging from a cyclone furnace by providing a secondary chamber which also is formed as a cyclone furnace, and by directing such gases tangentially into the secondary combustion zone thus provided. Due to the small cross-section of the flowing band of furnace gases, this measure results in an effective mixing of the gases, thereby improving the degree of combustion, and also contributing to better slag separation. Moreover, with cyclone furnaces thus combined, it is also possible to improve the degree of combustion by the addition of quaternary air in the secondary cyclone chamber.

The manner in which the primary and secondary cyclone chambers may be arranged in spatial relation is subject to considerable variation; for example, their respective longitudinal axes may cross in any desired angular relation, particularly at right angles, or their axes may lie parallel. The axis of either the primary or the secondary chamber may extend vertically and that of the other cyclone chamber approximately horizontally. The combustion gases may be discharged from the primary cyclone either axially or tangentially, and provision made whereby the liquid slag can drain from the primary cyclone into the secondary cyclone or be tapped from both separately. The gases may be discharged

2

from the secondary cyclone axially or tangentially upwardly downwardly or laterally. The primary cyclone chamber may be of the same size as, or of greater or smaller size than, the secondary cyclone chamber.

5 Furthermore, and subject to the variations above mentioned, several primary cyclone furnaces may open into a common secondary cyclone chamber, with the primary cyclones preferably arranged circumferentially at equal angular spacings and discharging into the secondary cyclone in the same direction of rotation.

10 These different possibilities, however, concern only the spatial arrangement of the respective cyclone chambers, selected in accordance with the problems to be solved. However, irrespective of the specific arrangement, the combination permits of various methods of operation. For example, the degree of combustion can be influenced to a large extent by the regulable addition of quaternary air into the secondary cyclone chamber alone, and this preferably tangentially in the same direction of rotational movement as the furnace gases, and at the same axial position relative to the length of the chamber, but relatively displaced circumferentially from the location, or locations, at which gases enter from the primary cyclone chamber or chambers. When the gases are admitted at a single location, as from a single primary furnace, the inlet for quaternary air is displaced from the inlet for gases at an angle of about 180°.

15 It is also permissible to introduce fuel, even different fuels, into the respective primary and secondary chambers. If two fuels such as coke and a rich coal are to be burned simultaneously, the coke, which is more difficult to burn than the coal, is directed in a stream of primary air into the primary cyclone chamber, while the rich coal together with quaternary air, or special quintary air, is directed into the secondary cyclone chamber. By regulating the proportion of secondary air which is added, it is possible to cause the coke to be burned completely or only partially, or to be partially or completely gasified, so that, depending on the mode of operation, there is produced, and discharged into the secondary chamber, either an extensively burned flame, or a combustible gas with a deficiency of air. Quaternary air is supplied to the secondary chamber in an amount sufficient to cause the combustible gas to burn and support the combustion of the rich coal. Under certain conditions, the fuel in the primary chamber may be gasified only in part, so that a solid fuel residue remains which is passed into the secondary chamber. It is then advisable to maintain the temperature in the primary chamber below the melting point of the slag.

20 When conveying different fuels into a cyclone chamber tangentially or with torsion, that is, in such manner as to produce a helical or torsional movement there-through, there sometimes are formed coke agglutinations which disturb the torsion and the slag drainage and sometimes necessitate taking the furnace out of operation. These accumulations generally occur at a certain angular distance from the point of injection, and it has been found that they do not appear when the fuel is injected at a steep angle to the inner wall surface, preferably radially into the chamber. The fuel is then required to travel a long distance before it reaches the chamber wall where it is entrained by the circulating air current, so that there is no opportunity for the formation of local deposits.

25 The introduction of fuel in this manner crosswise through the circulating air current, requires high velocity which is imparted to it by the current of primary air or by suitable introduction of quintary air. The circulating air current tends to oppose the inward movement of fuel as a result of the centrifugal force, so that a device must be employed which on the one hand accelerates the fuel

3

and on the other hand produces a positive pressure zone which prevents the furnace gases from escaping through the fuel inlet. The device best suited for the purpose is a known type of acceleration nozzle.

The various features of novelty which characterize this invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which a selected embodiment of the invention has been illustrated and described.

Of the drawings:

Fig. 1 is a transverse sectional view of a multi-chambered cyclone furnace unit constructed in accordance with the invention, as seen along planes indicated by line 1—1 in Fig. 2; and

Fig. 2 is a longitudinal sectional view of the furnace unit, as seen along planes indicated by line 2—2 in Fig. 1.

In more detail, the fuel burning apparatus illustrated in the drawings comprises a multiple cyclone furnace unit in which primary cyclone chambers 11, 12, 13 and 14 are circumferentially distributed about a centrally positioned secondary cyclone chamber 1 and furthermore are arranged to discharge solely into the common central chamber 1 which serves as a secondary combustion chamber from which the furnace gases are discharged through a circular end wall opening 10. The secondary cyclone chamber 1 is of circular-cylindrical cross section and is formed in known manner mainly by cooling tubes 2 which are associated with the water tube system of a vapor generator, not shown, of which the illustrated cyclone furnace unit constitutes the firing means, similar to the relationship disclosed, for example, in the aforesaid U. S. Patent 2,357,301. The chamber 1 is lined in known manner internally with refractory composition 3 and externally with insulating materials 4, and is surrounded by a gas-tight sheet metal shell 5. This chamber is closed at one end by a transverse wall 6 having an observation window 7 therein and, at the opposite end, by the cooling tube wall 8 of the radiant chamber 9 of the associated vapor generator, not shown, into which the furnace gases are discharged through the circular opening 10.

The four primary cyclone furnaces or chambers 11, 12, 13 and 14, suitably of smaller internal diameter than the secondary chamber 1, are formed with walls constructed in substantially the same manner as described for corresponding walls of chamber 1, except that for these primary chambers the end wall 8 is substantially continuous, being formed with slag outlets only, as hereinafter described. The primary chambers 11 to 14 are formed about longitudinal axes which are parallel to the longitudinal axis of the secondary chamber 1, and communication between chambers is provided through passages 15, 16, 17 and 18 which open tangentially from the respective primary chambers 11, 12, 13 and 14 in a common direction of rotation, at one end, adjacent wall 8, and which open tangentially into the central secondary chamber 1, at the same end. In the form shown, the passages 15-18 are directed in such a manner that the current of gases issuing therefrom is caused to circulate within the secondary chamber 1 in a counterclockwise direction, as is evident from Fig. 1.

Primary air is supplied in regulable quantity to the respective primary chambers through conduits 19, 20, 21, 22, in known manner, and with right hand torsion; that is, in a clockwise direction as seen in Fig. 1. The fuel, suitably in coarsely pulverized or granular form, is injected into these conduits in regulable quantity by feeders, not shown. There is thus provided a fuel-air mixture which enters each head 23, 24, 25, 26 tangentially and passes over the inner surface thereof, suitably of conical formation, and thence onto the cylindrical inner surface of the respective primary cyclone chambers, where secondary air is added in regulable quantity through tangentially directed nozzles 27, 28, 29 and 30. The fuel burns in the

4

current of air advancing in a right-hand spiral toward the end wall 8, and the furnace gases pass over through the tangential openings 15, 16, 17 and 18 into the larger secondary cyclone chamber 1, in which they again flow with right-hand torsion to the end wall 6 where their direction of axial movement is reversed, partially as a result of the interior wall formation, thereby causing the gases to flow in an axial direction toward and through the gas outlet 10 into the radiant chamber 9.

With the aid of a feeder 31, provision is made for delivering solid granular fuel into the secondary chamber 1 through a radially directed nozzle 36, the feeder discharging through a pipe 32 into a spherical conduit section 33 into which quintary air flows in a regulable quantity from a pipe 34 through nozzle 35 and thus, together with the entering fuel, is caused to flow into chamber 1 through nozzle 36, the fuel following approximately the path indicated toward the opposite wall of the chamber. Quaternary air is introduced in regulable quantity into the cyclone chamber 1 through nozzles 37, 38, 39 in the direction of torsion of the furnace gases, at positions angularly displaced from the gas inlets 15, 16, 17, 18. The tertiary air is introduced through the heads 40, 41, 42, 43 in known manner into the primary chambers 11, 12, 13, 14.

In the embodiment disclosed, slag outlets 44, 45, 46, 47, 48 are provided adjacent the bottoms of the respective cyclone chambers at a common end to permit the drainage of molten slag therefrom directly into the radiant chamber 9 or, as will be understood, into a known ash-disposal device or system, not shown.

The operation of the multiple cyclone furnace disclosed is effected in a manner that the fuel, in coarsely pulverized or granular form, is introduced in a stream of primary air through each of the conduits 19, 20, 21, 22 and thus caused to enter the respective primary cyclone chambers 11, 12, 13, 14 tangentially so as to effect a helical path of travel thereof along and against the circumferential wall of each chamber. Secondary air in regulable quantity is introduced tangentially through the respective inlet nozzles 27, 28, 29, 30, and possibly tertiary air axially through the heads 40, 41, 42, 43. The inlets to the nozzles 36, 37, 38, 39 are closed, or only slightly opened, to furnish cooling air. To this extent, the operation of each of the primary chambers is generally the same as described for similar cyclone furnace chambers in the aforesaid U. S. Patent 2,357,301. There is thus maintained a whirling stream of coal and air which is burned at temperatures above the ash fusion temperature. The centrifugal effect of the whirling stream causes the ash particles to deposit in a molten condition on the furnace wall areas and to form thereon a film or layer of molten slag on which the larger fuel particles are caught and burned. The slag layer rapidly reaches an equilibrium thickness and, as additional ash is deposited, the excess slag drains to the bottom slag discharge opening.

As disclosed herein, the gases from the respective primary chambers, instead of being permitted to discharge directly into a spacious radiant zone such as is provided by chamber 9, are discharged through separate passages 15, 16, 17, 18, of relatively small cross section, and caused to continue in a helical path, similarly of restricted cross section, throughout the length of the secondary chamber 1, prior to the ultimate discharge of all gases from that chamber. In this manner, the flow energy of gases discharging from the respective primary chambers is utilized to good advantage, with the result that an effective mixture of the gases takes place whereby the degree of combustion is substantially improved, and a more nearly complete separation of the slag is effected. The arrangement also provides for the admission of quaternary air, if necessary, as a further available step for improving combustion conditions.

In the case of overload, or of two different fuels, par-

ticularly fuels difficult to burn, fuel and quinary air are introduced additionally through the nozzle 36 into the larger, secondary chamber 1, and quaternary air through the tangentially directed nozzles 37, 38 and 39, in regulable quantity. In the event of load reduction, the primary cyclone chambers 11, 12, 13, 14 are disconnected successively and, in case of minimum load, the central cyclone chamber 1 alone is operated. If desired, several cyclone chambers 1 may be arranged to discharge to a single radiant chamber 9, so that the minimum load may be further reduced by taking out of operation one or more of the secondary cyclone chambers.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. A cyclone furnace unit for burning ash-containing solid fuel which comprises wall means defining a primary cyclone chamber of substantially cylindrical form about a longitudinal axis, means for introducing a stream of air and said ash-containing fuel in suspension into an end portion of said chamber and effecting a helical path of travel thereof along and against the circumferential wall of said chamber toward and into the opposite end portion of said chamber, said primary chamber having an outlet passage for said air-fuel stream and accompanying products of combustion opening from said opposite end chamber portion in tangential relation to said circumferential wall, other wall means defining a secondary cyclone chamber of substantially cylindrical form about a separate longitudinal axis and having an inlet passage formed at one end of said secondary chamber as a continuation of said outlet passage and arranged tangentially of said secondary chamber for developing a helical path of travel of said air-fuel stream along and against the circumferential wall of said secondary chamber for movement toward the opposite end of said secondary chamber, a slag outlet opening from a lower portion of each of said chambers, and a gas outlet opening from said secondary chamber in the vicinity of its longitudinal axis.

2. A cyclone furnace unit as defined in claim 1 wherein said chambers are formed about axes which are substantially parallel and of substantially horizontal arrangement, said outlet passage being arranged to open from a lower portion of said primary chamber, and said continuing inlet passage being arranged to open into an upper portion of said secondary chamber.

3. A cyclone furnace unit as defined in claim 1 and further comprising means for separately introducing a fuel and air mixture radially into said secondary chamber at a velocity sufficiently high to cause the fuel of said separately introduced mixture to penetrate and cross the helical path of travel of fuel and air along said circumferential wall.

4. A cyclone furnace as defined in claim 3 and further including means for directing additional combustion air tangentially into said secondary chamber substantially in the direction of travel of said air-fuel stream along its circumferential wall.

5. A cyclone furnace unit as defined in claim 1 wherein the circumferential walls of said primary chamber and said secondary chamber are arranged to provide an intermediate wall portion common to both of said chambers, said primary chamber outlet passage and said secondary chamber inlet passage being formed in said common wall portion.

6. A cyclone furnace unit for burning ash-containing solid fuel which comprises wall means defining a primary cyclone chamber and a secondary cyclone chamber each of substantially cylindrical form about a longitudinal axis

laterally spaced from the longitudinal axis of the other, means for introducing a stream of air and said ash-containing fuel in suspension into an outer end portion of said primary chamber and effecting a helical path of travel thereof along and against the circumferential wall of said chamber for movement toward the opposite inner end of said chamber, a wall substantially closing said primary chamber at said inner end for preventing the longitudinal discharge of said air-fuel stream and accompanying products of combustion from said primary chamber, said secondary chamber at its corresponding inner end having a wall formed with a gas outlet and having its opposite outer end closed, said chambers having a common connecting passage therebetween for directing said air-fuel stream and accompanying products of combustion into said secondary chamber, said connecting passage opening tangentially from said primary chamber at a location adjacent its closed inner end and opening tangentially into said secondary chamber at its corresponding end for effecting a helical path of travel of said air-fuel stream in an annular zone along and against the circumferential wall of said secondary chamber toward the closed outer end thereof by which the axial direction of travel of said stream is reversed for movement through an axial region in the direction of said outlet, said gas outlet having its perimeter radially spaced throughout from said circumferential wall of said secondary chamber whereby there is provided an intervening annular space of sufficient radial extent for travel of said air-fuel stream in said annular zone.

7. A cyclone furnace as defined in claim 6 and further characterized by said secondary chamber having its closed end concavely curved at least adjacent its perimeter to a substantial radius toward the interior of the chamber whereby gases resulting from the combustion of said fuel are deflected into the vicinity of said longitudinal axis for discharge through said gas outlet.

8. A cyclone furnace unit for burning ash-containing solid fuel which comprises a plurality of primary cyclone chambers and a single secondary cyclone chamber each of cylindrical formation about a longitudinal axis substantially parallel to the axis of the other, means for introducing air and ash-containing fuel in suspension into an end portion of each of said primary chambers and effecting a helical path of travel thereof along the circumferential wall of each primary chamber toward the opposite closed end thereof, a common connecting passage opening tangentially from each primary chamber at a location adjacent said closed end and opening tangentially into said secondary chamber for effecting a helical path of travel of said air-entrained fuel throughout the length of said secondary chamber, said connecting passages from the respective primary chambers opening therefrom in a common direction of rotation and opening into said secondary chamber at circumferentially spaced locations, and means for introducing additional combustion air into said secondary chamber at a location angularly spaced from the locations at which said air-entrained fuel is introduced from said passages.

9. A cyclone furnace unit for burning ash-containing solid fuel which comprises a plurality of separate primary cyclone chambers of substantially cylindrical formation about a longitudinal axis, means for introducing a stream of air and ash-containing fuel in suspension into each of said primary chambers and burning the fuel under furnace chamber temperatures above the ash fusion temperature while passing through a helical path of travel along and against the circumferential wall of each primary chamber, other wall means defining a secondary cyclone chamber of substantially cylindrical formation about a separate longitudinal axis and having a gas outlet at one end thereof, a gas outlet passage from each primary chamber at a location adjacent one end thereof and opening into said secondary cyclone chamber tangentially to the circumferential wall thereof for effecting

7

a helical path of gas travel throughout the length of said secondary cyclone chamber, said gas outlet passages from all of said primary chambers opening into said secondary cyclone chamber in circumferentially spaced tangential relation and directed in a common direction of rotation therein, and a slag outlet opening from a lower portion of each of said chambers.

References Cited in the file of this patent

UNITED STATES PATENTS		5
901,232	Eldred -----	Oct. 13, 1908

1,776,841	
1,823,117	
2,151,079	
2,357,303	

2,241	
302,255	
305,270	
518,173	

8

Murray -----	Sept. 30, 1930
Murray et al. -----	Sept. 15, 1931
Bowen -----	Mar. 21, 1939
Kerr et al. -----	Sept. 5, 1944

FOREIGN PATENTS

Australia -----	June 8, 1926
Great Britain -----	Dec. 11, 1928
Great Britain -----	Feb. 1, 1929
Germany -----	Nov. 24, 1931