March 27, 1956 R. S. JOLLEY 2,739,878

VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

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Fig. 2.

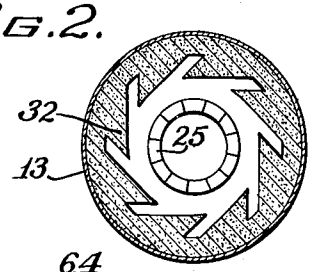


Fig. 1.

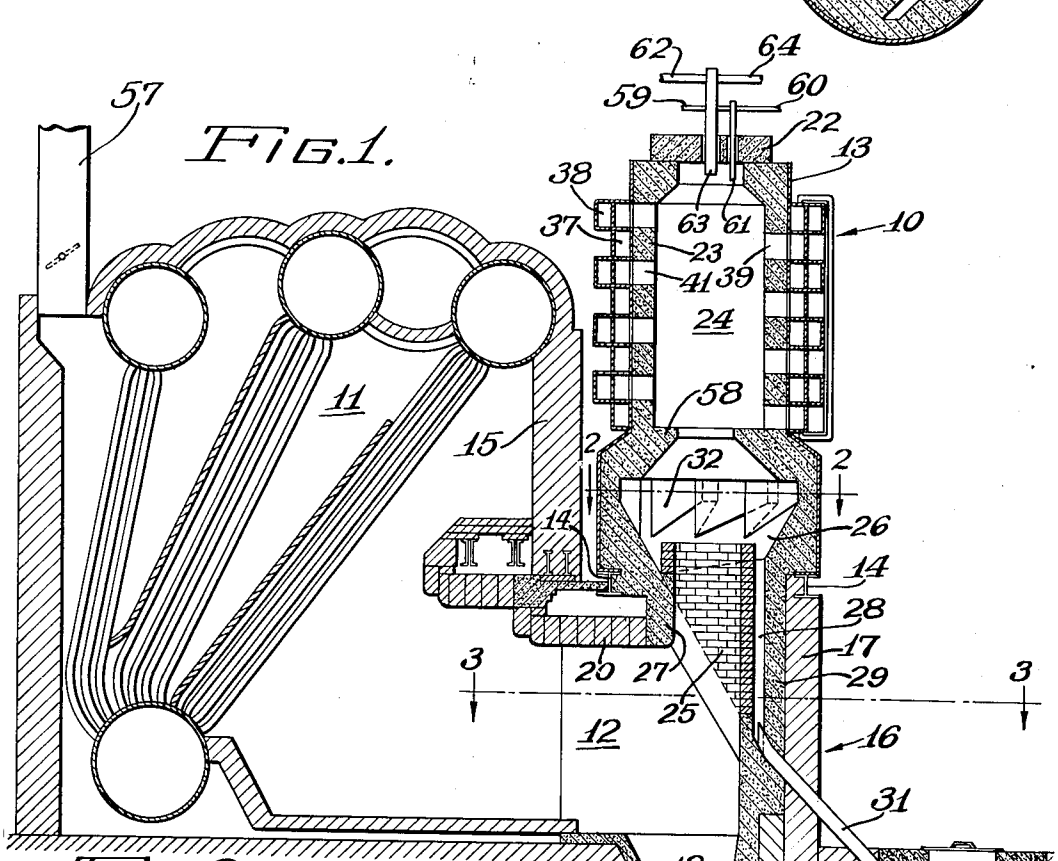
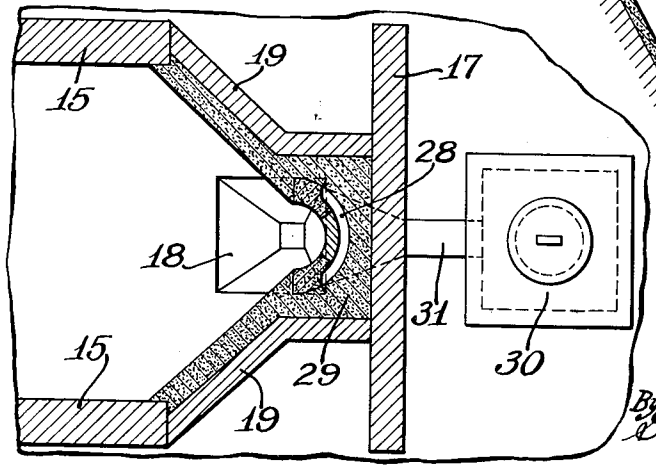


Fig. 3.



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VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

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FIG. 4.

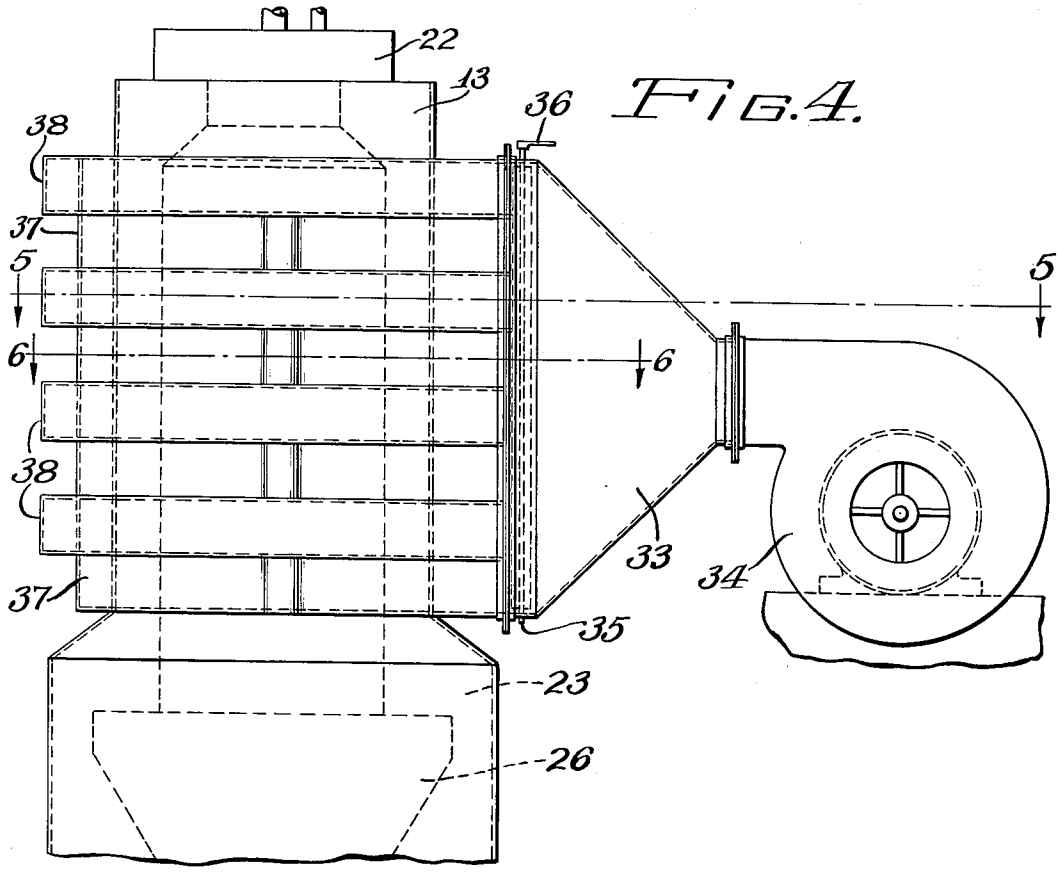
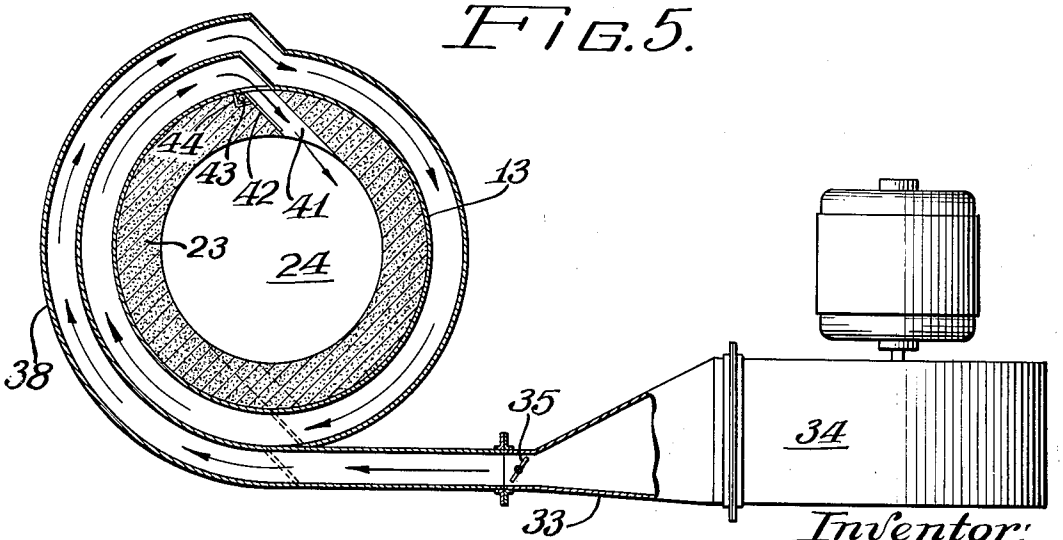


FIG. 5.



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VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

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FIG. 6.

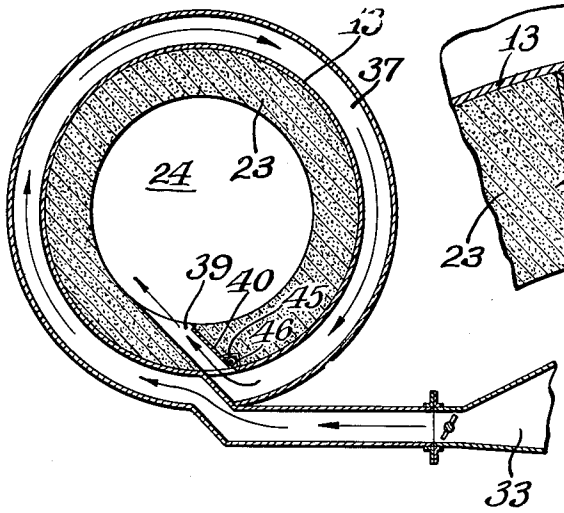


FIG. 7.

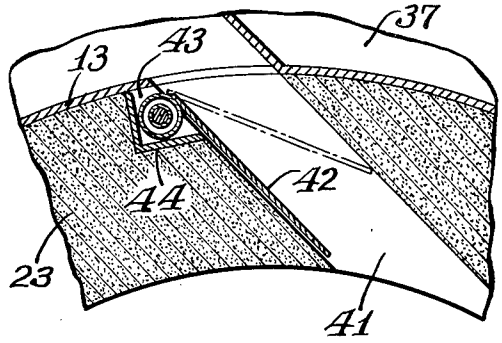


FIG. 8.

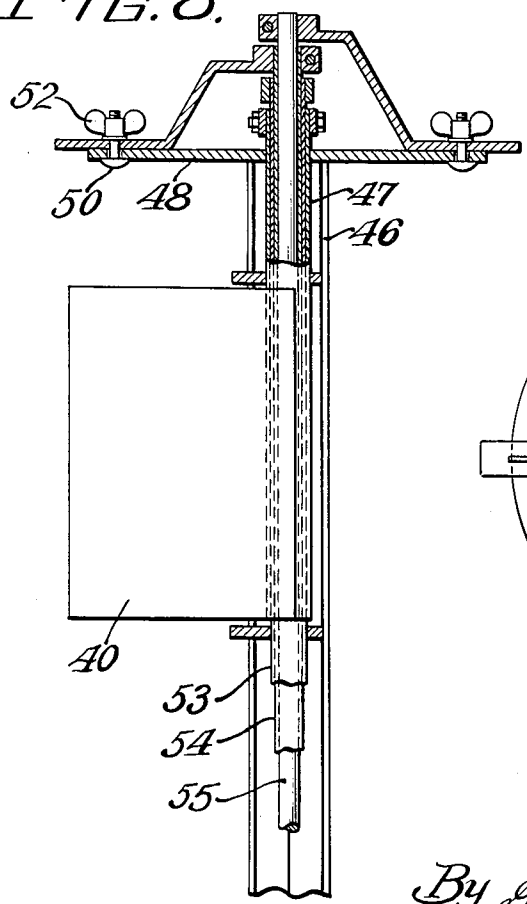
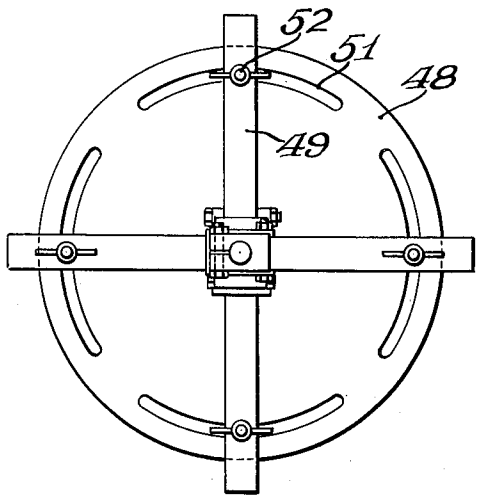


FIG. 9.



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VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

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Fig. 11.

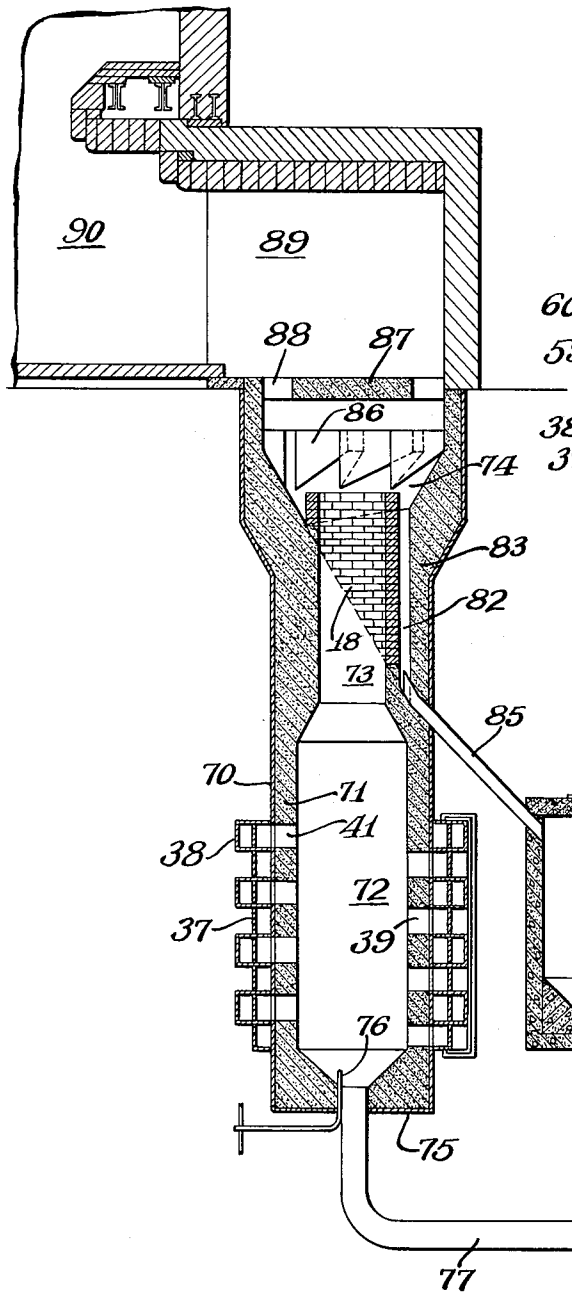
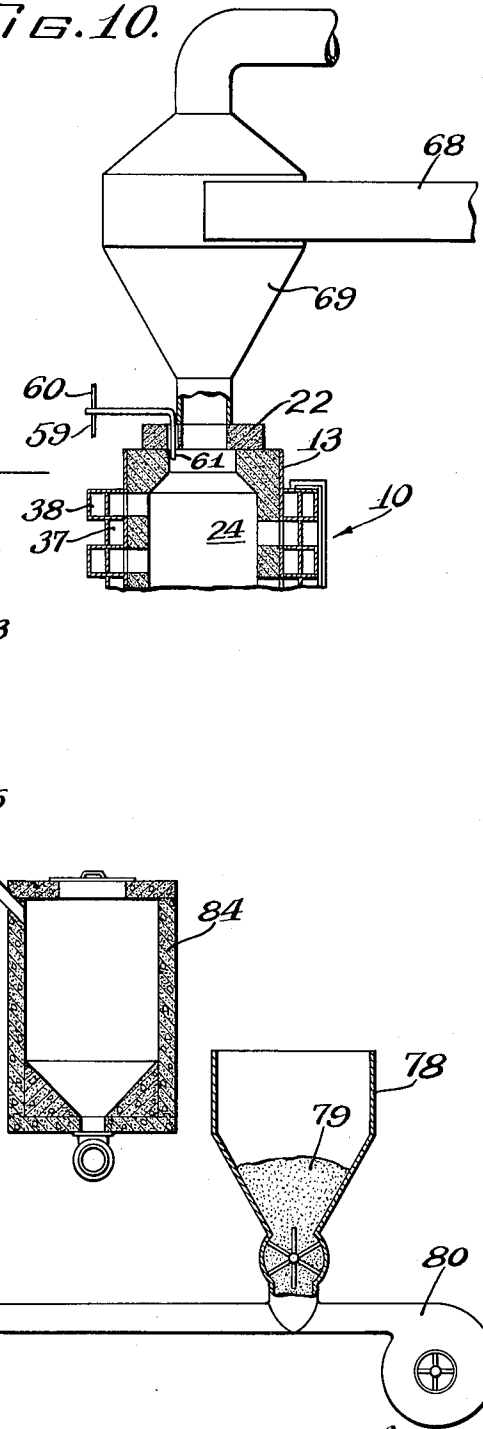


Fig. 10.



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VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

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FIG. 12.

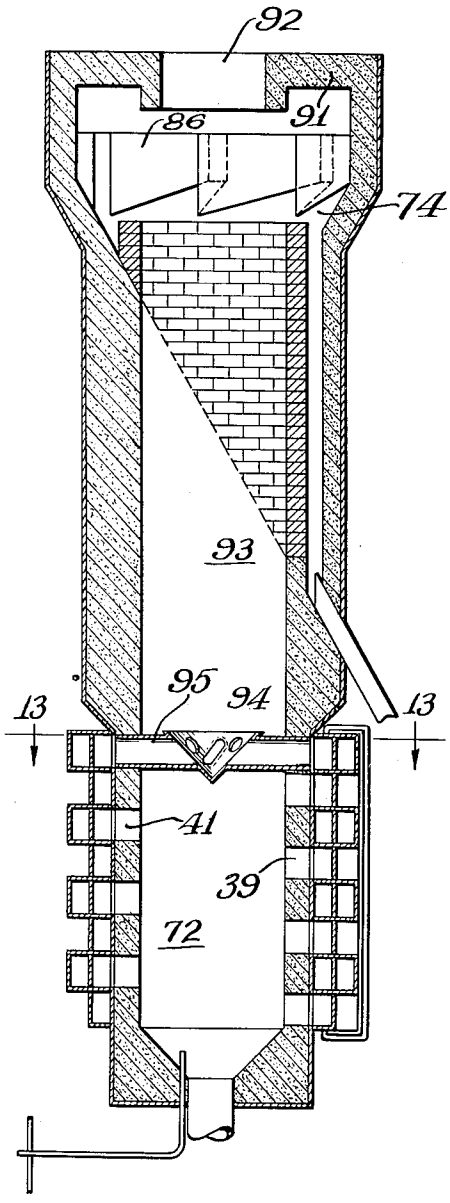


FIG. 13.

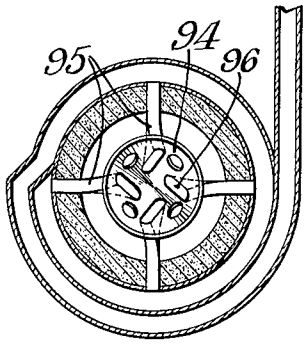


FIG. 14.

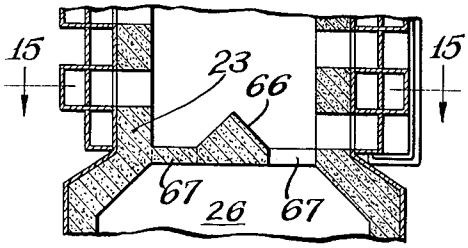
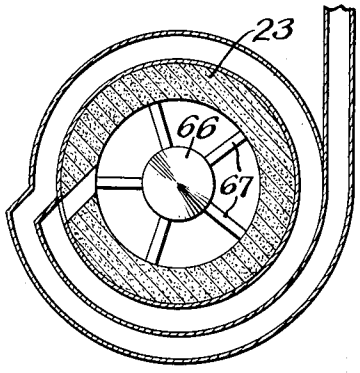


FIG. 15.



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United States Patent Office 2,739,878 Patented Mar. 27, 1956

2,739,878

VERTICALLY EXTENDING BURNER APPARATUS OF THE CYCLONE TYPE

Raymond S. Jolley, Wisconsin Rapids, Wis., assignor to Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a corporation of Wisconsin

Application October 23, 1951, Serial No. 252,784

8 Claims. (Cl. 23—277)

This invention relates to new and improved means for thermal conversion or burning of combustible liquids or solids in suspension and in a continuous manner.

More particularly, the present invention relates to a vertically extending burner or furnace of generally cylindrical form and of the "cyclone" type wherein combustion after being initiated is self-sustaining, and wherein the material to be converted is subjected to turbulence and a high temperature while confined in a small zone, and while passing therethrough in a generally helical path, may be rapidly and controllably subjected to complete or limited oxidation as desired.

The invention further relates to novel means in combination with a burner of the foregoing class, whereby solid or molten products of complete or partial combustion or oxidation may be substantially separated from the gaseous products of combustion, and whereby said gaseous products may be delivered to and utilized at a point where its heat may be required, such as for example, in connection with a steam boiler, without appreciable contamination of the boiler and its appurtenances by the said solid or molten materials which may be detrimental thereto or to its effective operation, or which solid or liquid materials may desirably be separately recovered for either waste or economic reuse. The invention further relates to a burner or furnace of the foregoing class wherein the air introduced for combustion and turbulence is introduced tangentially or secantly from a plurality of ports, adjacent ones being spaced from each other both peripherally and vertically, and at a controllable velocity and volume.

The invention further relates to the air cooling of the furnace walls and the employment of said air in a resultant preheated condition, as that introduced to the burner for the support of combustion therein.

The present invention further relates to and is characterized by novel means for separating the ash, or other solid or liquid material from the gaseous products of combustion, adjacent the periphery of the furnace and discharging it by gravity down an inclined plane and out of the furnace and connecting appurtenances, such as a boiler, and out of the contact with the gaseous products resulting from combustion.

The burner or furnace of the present invention is adapted for use in connection with means for utilization of its heat such as, for example, a steam boiler, or as an auxiliary to a steam boiler which may separately employ conventional fuel as its principal source of heat.

The apparatus of the present invention, as one particular example, is adapted for the burning of waste sulfite liquors recovered from pulp digesters used in the sulfite process, whereby this effluent may be effectively disposed of by burning to complete oxidation, recoverable heat utilized under a boiler, and resulting ash effectively separated from the gaseous products of combustion before they reach the boiler.

The apparatus of the present invention is likewise suitable for burning other disposable waste products of

the paper industry such as bark or shavings, recovery of the heat therefrom and separation and disposal of resulting ash. The apparatus of the present invention is likewise useful for the burning of other liquids containing combustible material and resulting in either ash or complete combustion or resulting in recoverable chemicals on incomplete combustion and controlled oxidation. For example, the apparatus of the present invention by reason of its features which permit control of both velocity and volume of air which can be introduced to the furnace, permits the burning of black liquor of pulp digesters used in the sulfate process, with a controlled and limited proportion of air, whereby oxidation of chemicals which are desired to be recovered is prevented, and such products separated and recovered from the gaseous products of combustion.

As a further example, the apparatus may be employed to burn crushed or pulverized coal, and solids not in the molten state separated, if necessary, by control of air to limit combustion, to prevent melting of the ash to a liquid.

As a further example of the uses to which my burner apparatus may be put, it may be employed to calcine lime with the air of an added fuel such as oil or gas, and excess air used to control temperatures to prevent melting.

Another example of the adaptability of my invention is for use in burning sulfur for the production of sulfurous acid for use in paper mills. Thus, sulfur may be introduced into the combustion zone of my device, in either molten or powdered form, and therein converted to sulfur dioxide with minimum production of undesirable sulfur trioxide. Due to the turbulence and high temperature confined in a small space, and my ability to closely control and proportion air, the process may be closely controlled so as not to over oxidize the sulfur. If desired, however, the burning may likewise be controlled so as to produce sulfur trioxide for the manufacture of sulfuric acid. The advantages in either event is that the low excess air obtainable by the present furnace causes less interference by the other gases in the absorption towers in the combination of SO_2 or SO_3 with the water. Any impurities may be separated by means of the ash collection portion of my burner, and the resulting gas in this case is cooled and dissolved in water, in conventional manner to form sulfurous acid.

Other objects, advantages and economies of my invention and the details of construction and parts thereof will be apparent from a consideration of the following specification and drawings, wherein:

Fig. 1 is a vertical sectional view of the burner apparatus of the present invention illustrated in connection with a steam boiler.

Fig. 2 is a section on the line 2—2 of Fig. 1.

Fig. 3 is a section on the line 3—3 of Fig. 1.

Fig. 4 is a fragmentary elevational view of the furnace portion of the apparatus of the present invention.

Fig. 5 is a view partly in section on the line 5—5 of Fig. 4.

Fig. 6 is a section on the line 6—6 of Fig. 4.

Fig. 7 is a fragmentary enlarged detail view of an air inlet port and its control damper as shown in the section of Fig. 5.

Fig. 8 is a detail view partially in vertical section illustrating damper control means.

Fig. 9 is a plan view of the damper control arrangement of Fig. 8.

Fig. 10 is an elevation partly in section illustrating means for feeding a solid material to the furnace of my burner apparatus.

Fig. 11 is a vertical section of a modified arrangement of my burner apparatus.

Fig. 12 is a vertical section of another modified arrangement of apparatus.

Fig. 13 is a section on the line 13—13 of Fig. 12.

Fig. 14 is a fragmentary vertical section of a modified detail of the apparatus of Fig. 12.

Fig. 15 is a section on the line 15—15 of Fig. 14.

Referring to the drawings, the reference numeral 10 generally designates the burner apparatus of the present invention disposed in proximity to a steam boiler generally designated as 11, and in communication therewith through the area 12 as illustrated in Fig. 1. This burner apparatus comprises a vertically extending generally cylindrical shell 13 mounted on the beams 14 exteriorly of the boiler wall 15, and on the base structure generally indicated as 16. This base structure comprises the end wall 17 extending down into the pit 18, and the side walls 19 which diverge to and join with the boiler walls 15. These, together with the refractory brick work structure 20, define a lateral opening from and adjacent the base of the furnace of the burner apparatus 10, and a communicating passage or area 12 between the indicated furnace and the boiler 11. The burner apparatus 10 thus has a bottom opening generally closed except for communication with boiler 11, and is provided with a top opening and a cover or top closure 22. The interior of the shell 13 is lined with refractory material 23 to define a primary combustion chamber or zone 24.

Spaced from and below the bottom of the combustion chamber 24, and concentric therewith is an inverted truncated tubular refractory brick work 25 which defines a continuous path from combustion zone 24 to the boiler 11 through the area 12. This tubular brick work 25 preferably has an outer diameter smaller than the inside diameter of zone 24, and projects upwardly into the funnel shaped portion of zone 26, and forms a closure therewith at one peripheral portion with the ledge 27 adjacent the boiler wall 15, and defines an arcuate duct 28 leading therefrom defined by an opposite outer peripheral portion of the tube 25 and the lining portion 29. The lower end of this duct 28 terminates at and communicates with the ash collection chamber 30 through the conduit 31 extending through the refractory lining 29 and the wall 17.

The downwardly inclined or funnel shaped portion of zone 26 has an enlarged mouth of greater internal diameter than that of chamber 24, and seats a plurality of inclined inwardly extending tangential vanes or baffles 32 terminating at a plane substantially parallel with that of the inner periphery of chamber 24 and having their inception exteriorly of said periphery. Although not shown, the tubular brick work 25 may have or be provided with surrounding or imbedded water cooling coils.

The section of the shell 13 which embraces the major portion of the combustion zone 24 is enveloped by a plurality of air conduits all joined to a common header or manifold 33, leading from the blower 34, as shown in Fig. 4, the common inlet to said conduits being controlled by the butterfly damper 35 actuatable by the hand control lever 36. These air conduits each embrace the shell for at least 360° and lead to damper controlled horizontally extending, inclined openings through shell 13 and its lining 23. Each adjacent opening is spaced from another both vertically and peripherally, the periperal spacings being approximately 180°. Although I have shown eight such air conduits, any number greater than two may be employed provided they embrace the major portion of the area of the primary combustion zone 24. These conduits comprise one or more conduits 37 which embrace the shell 13 for 360°, and one or more conduits 38 which extend around 540°. Thus, as shown in Fig. 6, the conduit 37, of generally rectangular section, leads from the manifold 33, extends 360° around the shell 13, and opens to the duct 39, controlled by the damper 40. As shown in Fig. 5, the adjacent conduit

38 completely embraces the steel shell 13, and partially embraces itself for another 180°, and terminates at the duct 41, controlled by damper 42, extending through shell 13 and lining 23, the duct 41 being spaced 180° from the adjacent duct 39.

The series of dampers 40 and series of dampers 42 may be each individually controlled as shown in the enlarged detailed views of Figs. 8 and 9, each series being controlled from a separate station suitably positioned above the top of the burner apparatus. Although one damper control arrangement for the dampers 40 is illustrated, it will be understood that two like arrangements, spaced 180° from each other, are employed, these likewise not being illustrated in Figs. 1 and 4, for the purpose of clarity of the latter figures. Thus, a vertical cavity 45 extends through the refractory lining 23 adjacent the shell 13 contiguous with the ducts 39, and receives the damper and shaft support 46. (A similar vertical cavity 43 extends through the refractory lining 23 adjacent shell 13 and contiguous with the ducts 41 and receives the damper and shaft support 44, as shown in Fig. 7.)

Thus, referring to the details of Figs. 8 and 9, the uppermost one of the dampers 40 is shown secured to the tube or shaft 47. This shaft 47 is disposed within the confines of the support 46, and extends through the plate 48 resting on the upper end of support 46. To the upper end of shaft 47 there is secured an arm 49, the outer end of which rests on plate 48 and is engaged thereto for limited arcuate movement by means of the bolt 50 passing through the arcuate slot 51 and the end of arm 49, and the wing nut 52. For control of the remaining three dampers 40 of the indicated series, a similar tube 53 is nested within tube 47, a tube 54 is nested within tube 53, and a shaft or rod 55 is nested within tube 54. Each of these members 53, 54 and 55 extends beyond the lower end of its adjacent outer tube and has a damper secured to its lower end portion, and similar to member 47, each extends through and above plate 48, and is similarly provided with an individual control arm engaged to the plate 48 for limited arcuate movement defined by a separate arcuate slot. Thus, each of the dampers 40 may be individually regulated and fixed in desired position. The same applies to the individual dampers of the series 42.

Thus, in operation of the apparatus, the volume and velocity of the air supplied by the blower 34 is first controlled by the common damper 35, and is then individually controllable by means of the dampers 40 and 42 so that the volume and velocity of the air introduced to the chamber 24 may vary or be controlled and differ at the points of introduction, and control obtained as to the nature and progress of combustion therein as the material to be burned or heat treated passes through the combustion chamber.

The various ducts 39 and 41 are all inclined in the same direction, and are thus adapted to introduce streams of air secantly in the primary combustion zone 24, and in a downwardly generally helical manner under the draft of the boiler stack 57. These ducts may all be inclined in a substantially tangential manner, that is with one side wall in substantially tangential relationship to the inner periphery of zone 24, or they may vary in inclination to a lesser extent, for example, from the top of zone 24 where they may be substantially tangential, to the bottom of zone 24 where they may approach a radial direction, or those ducts adjacent the top and bottom may be substantially tangential, and those adjacent the center portions may be of lesser inclination. Thus, in any event, the ducts are inclined so that the streams of air are introduced secantly, and where there is a variation in their inclination, further desirable turbulence is set up in the combustion zone, to inhibit, in operations when such is undesirable, the formation of a relatively hot vortex and a relatively cooler outer zone.

As a further aid in producing turbulence in zone 24,

I may provide the lower end of the primary combustion zone 24, with an annular baffle or refractory ring 58. Thus, the materials before passing out of zone 24, and into zone 26, where secondary combustion may take place, and ash separation occurs, the cooler materials along the wall of zone 24 are reversed in direction and commingled with the hotter materials along the axis of zone 24, thus bringing about better turbulence, and better mixing and burning within zone 24.

When it is desired to burn a liquid material in my apparatus, such as for example, waste sulfite liquor recovered from pulp digesters used in the sulfite process, the liquor should first be evaporated to as low a moisture content as is consistent with the ability to introduce it into the combustion zone by spraying or atomizing. Reduction of moisture content is desirable so that combustion may be properly sustained and completed to as large an extent as possible or desirable. A moisture content as low as feasible is desirable so as to prevent production of an unduly large amount of steam in the combustion chamber and waste of heat in doing so, and to prevent undue dilution of the gases of combustion and carrying of such steam into the boiler.

Thus, in the operation of my apparatus, for the above indicated illustrative purpose, the furnace is initially heated up by a pilot flame, such as for example, by introducing a mixture of fuel oil from line 59 and compressed air or steam from line 60 to atomizing nozzle 61 extending through the cover 22 into combustion zone 24. At the same time air is introduced by means of the blower 34 into zone 24 through the series of ducts 39 and 41. When the furnace has become sufficiently heated to support and continue combustion of the sulfite liquor, the pilot flame may be discontinued, and the sulfite liquor introduced through line 62 to nozzle 63 and atomized by air or steam under pressure introduced through line 64. The sulfite liquor at the time of introduction should have a solids content of from about 50% to about 65% as a result of previous evaporation treatment.

Air for combustion should be introduced in a slight excess over that theoretically required for complete combustion, although air excess must be kept as low as practical to prevent too much heat loss. It has heretofore been considered that this excess should be about 15 to 20%. However, with the apparatus of the present invention and by having a high turbulence and temperature within the furnace, the excess air may be as low as 3%. The total volume of air introduced into zone 24 is essentially controlled by means of the common damper 35 and the volume and velocity through any of the individual ducts 39 and 41 may be regulated by their respective individual dampers 40 and 42. Thus, not only can the volume of air be controllably proportioned, but the velocity of the air may be controlled and varied as desired from one duct to another in a direction vertically of the combustion zone. Thus, high velocities with limited volumes of air can be obtained and controllably varied in the direction of progress of the material through combustion zone 24. At the same time, by means of the high velocity of air and turbulence thereof due to introduction tangentially or secantly from a plurality of vertically and angularly spaced inclined ducts, intimate contact with the particles of the liquid to be burned is obtained and maximum and efficient combustion accomplished in a relatively small zone. This efficiency of operation is further enhanced by causing the air introduced to pass, for at least 360°, through the conduits 37 and 38 so as to cause the air, by heat exchange, to be preheated before being admitted to combustion zone 24. Further these air conduits by being disposed contiguous to each other envelop combustion zone 24 and serve to cool the shell 13 and refractory lining 23.

As the products from zone 24 pass outwardly and downwardly into ash collection zone 26, some additional or final combustion may take place, and before entering zone 26, they pass through ring baffle 58 which causes further turbulence by reversal of the components adjacent the periphery of zone 24, where the cooler and heavier gases tend to collect, and mix with the hotter less dense gases adjacent the axis of zone 24.

The solid particles and ash within zone 26 are thrown outwardly under the centrifugal force induced in zone 24 and impinge on and are separated from the gaseous materials by means of the vanes 32 which incline at an angle generally opposite to the direction of those of the air inlet ducts, and thus project into or against the direction of rotation of the descending stream of the products of combustion. Thus, the gaseous products of combustion continue to travel downwardly from zone 26 and into the boiler 11, through the tubular brickwork 25 and lateral passage 12. The solids and ash are entrapped by the vanes 32 and dropped by gravity around the outer periphery of the tubular brickwork 25 and then pass outwardly through the arcuate path 28 and into the ash receptacle 30 through conduit 31. Residual or lighter particles of ash or solids which may not have been separated from the gas streams by the vanes 32 are permitted to drop by gravity out of the gas stream and into the pit 18 whereupon they may be discharged through line 65.

Although I have shown the employment of the baffle ring 58 in Fig. 1, and its use is particularly desirable when the air ducts 39 and 41 are all of the same substantially tangential inclination, it may not be essential when the air inlet ducts vary in inclination and thus enhance turbulence. However, I may at the same time employ both a baffle ring and ducts of different inclination. Instead of the baffle ring 58, I may, to the same end, employ an axial baffle or target 66 supported by the spokes 67 extending from the ceramic wall 23, as shown by Figs. 14 and 15. These components 66 and 67 may be composed of refractory material, and if desired, may be internally water cooled, although not illustrated. When such axial target or baffle is employed, it serves to interrupt the downward movement of the components adjacent the axis of zone 24 and to better mix them with the components adjacent the periphery of said zone, before they pass into zone 26.

Fig. 10 diagrammatically illustrates means for introducing a solid particle material, such as bark, to be burned in the arrangement of apparatus generally illustrated in Fig. 1. This wood bark, suitably comminuted may be blown in under pressure through conduit 68 to chamber 69 and from thence through cover 22 into zone 24, and there subjected to combustion, and the resulting gaseous products and ash separated in the manner previously described.

Fig. 11 illustrates a modified arrangement of my apparatus which in principle is the same as that of Fig. 1. The essential difference here is that my entire burner apparatus, including the furnace and ash separation sections as a unit are adapted to be positioned beneath a communicating boiler. Thus, in the form illustrated in Fig. 11, the material to be burned is introduced to the bottom of the device and flows upwardly and the gaseous products of combustion are delivered from the upper portion of the apparatus to, for example, a communicating boiler. The ash and solids are separated and discharged downwardly by gravity as in the form of Fig. 1.

Thus, referring specifically to Fig. 11, the illustrated burner apparatus comprises the steel shell 70 provided with a refractory lining 71 which at its lower end portion defines the primary combustion zone 72, an intermediate zone 73 of reduced diameter and the funnel shaped ash collection zone 74 at the upper end. The bottom 75 of the unit is closed except for admittance of the pilot burner nozzle 76 and the feed line 77 for admitting material to be burned. In the present instance I have illustrated a hopper 78 for supplying a solid particle material 79 by means of the blower 80 through

feed line 77 and into combustion zone 72. It will be understood, however, that in lieu thereof I may introduce a liquid material at this lower end in the manner previously described with respect to Fig. 1.

Extending over a major portion of, and embracing the outer shell of combustion zone 72, are the series of air cooling and air supply conduits 37 and 38 leading to inclined ducts 39 and 41 as described with respect to the previous figures, and likewise provided with individual dampers and damper controls, common air supply and damper control, etc., and therefore, will not be described again in detail.

Extending from the upper portion of zone 73 and projecting into zone 74 is the tubular brickwork 81, similar to that indicated at 25 in Fig. 1. The brickwork 81 has an internal diameter equal to the diameter of zone 73, and at one portion of its outer periphery it defines an arcuate path 82 with the lining portion 83 for delivery of ash or other solid particle material into the ash collector 84 through the communicating conduit 85, by gravity.

As the products of combustion leave zone 72 and pass through zone 73 where secondary combustion may occur, and into zone 74, the particles of ash or other solids, which are thrown outwardly under centrifugal force, are entrapped by the baffles 86 which are arranged and inclined as described with respect to baffles 32, so as to cause these solids to be dropped around the outer periphery of the upper projection of brickwork 81 and to pass out by gravity through the path 82 as above indicated.

For the purpose of further reversing the direction of the gases leaving zone 74 so as to commingle the axial with the peripheral components, and to further aid in separation of ash, the upper or exit portion of chamber 74 is provided with the axial baffle 87 supported by the radial spokes 88. Although the zaffle 87 is of disc-like form, it may be of other shape, such as for example, an inverted cone similar to the target 66. The separated gaseous products of combustion thereafter pass through the lateral path 89 and into the boiler or other utilization zone 90.

Fig. 12 illustrates another modified arrangement similar to that of Fig. 11 in that material to be burned or converted is introduced at the bottom and the gaseous products of combustion and ash are separated at the top of the unit. Since the general arrangement and operation is the same as that of Fig. 11, only the characterizing and differing details of construction will be described. Thus, in Fig. 12, the upper end of the unit is closed with an annular baffle 91 leaving an axial outlet 92 for the gaseous products of combustion, and in this case the peripheral components of the stream of gas leaving zone 74, are reversed in direction to commingle with the axial components before leaving and to better entrap any escaping particles of ash.

The intermediate zone 93 in this case is of a diameter equal to that of the zone 72, and the path between the two is interrupted by the inverted axially disposed conical baffle or target 94 supported by the radial supports 95. Suitably, supports 95 are provided in a streamlined form similar to a four-bladed airplane propeller or of axial flow fan rotor construction. The target 94 and its supports 95 are preferably hollow so that they may be air cooled, and for this purpose air may be introduced from the uppermost embracing conduit 38, which in this case has ducts leading from it through the shell and lining, into the supports 95 and discharges through the apertures 96 in the target 94. This axial baffle 94 thus serves to increase turbulence in zone 72 and to better admix the peripheral and axial components of the upwardly and helically moving materials in zone 72 before entering zone 93 to better insure a more thorough and homogeneous combustion in the primary combustion zone 72, and thus acts similar to axial target 66 of Figs. 14 and 15.

I claim as my invention:

1. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, an elongated outlet at the opposed end of said chamber and axially aligned therewith for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, and generally horizontally disposed baffle means in said outlet in axial alignment with said combustion chamber at its end for mixing axial and peripheral components of the products of combustion from said chamber prior to discharge.

2. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the opposed end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, means in said combustion chamber outlet and axially aligned with said combustion chamber for substantially separating solid particles from the gaseous products of combustion, and conduit means extending through the walls of said apparatus for receiving and continuously discharging said solids by gravity.

3. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the opposed end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, and means in said outlet for substantially separating solid particles from the gaseous products of combustion comprising a plurality of peripherally disposed vertically extending baffles inclined in a direction generally opposed to the inclination of said air inlet ducts.

4. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the opposed end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, a plurality of air conduits each completely embracing the wall of the combustion chamber and leading to said air inlet ducts for cooling said wall and for heating the air prior to its introduction to

said chamber, damper controlled means for introducing air from a common source to said conduits under pressure, dampers in each of said ducts, means for individually regulating each of said dampers, transversely extending baffle means in said outlet for mixing axial and peripheral components of the products of combustion from said chamber prior to discharge from the apparatus, means in said outlet for substantially separating solid particles from the gaseous products of combustion, and conduit means extending through the walls of said apparatus for receiving and continuously discharging said solids by gravity.

5. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the opposed end of said chamber for receiving and discharging therethrough products of combustion, means for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, means in said outlet for substantially separating solid particles from the gaseous products of combustion comprising a concentric zone of enlarged diameter including a plurality of spaced vertically extending vanes projecting from the inner periphery of said zone, said vanes being inclined in a direction generally opposed to the direction of inclination of said air inlet ducts, a concentric annular projection of lesser diameter than said zone disposed below said vanes and adapted to receive thereabout solid particle matter separated by said vanes from the products of combustion, and conduit means leading from the outer periphery of said annular projection and through the wall of said apparatus for continuously discharging said solids by gravity.

6. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at one end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the opposed end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, adjacent ones of said ducts being vertically and peripherally spaced from each other, a plurality of air conduits each completely encircling the wall of the combustion chamber and leading to said air inlet ducts for cooling said wall and for heating the air prior to introduction to said chamber, damper controlled means for introducing air from a common source to said conduits under pressure, damper means in each of said ducts, means for individually regulating said dampers whereby to separately control the volume and velocity of air introduced at each of said ducts, means in said outlet for substantially separating solid particles from the gaseous products of combustion comprising a concentric zone of enlarged diameter including a plurality of spaced vertically extending vanes projecting from the inner periphery of said zone, said vanes being inclined in a direction generally opposed to the direction of inclination of said air inlet ducts, a concentric annular projection of lesser diameter than said zone disposed below said vanes and adapted to receive thereabout solid particle matter separated by said vanes from the products of combustion, and conduit means leading from the outer periphery of said annular projection and through the wall of said apparatus for continuously discharging said solids by gravity.

7. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at the upper end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the lower end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, means in said outlet for substantially separating solid particles from the gaseous products of combustion comprising a concentric zone of enlarged diameter including a plurality of spaced vertically extending vanes projecting from the inner periphery of said zone, said vanes being inclined in a direction generally opposed to the direction of inclination of said air inlet ducts, a concentric annular projection of lesser diameter than said zone disposed below said vanes and projecting into said zone and adapted to receive thereabout solid particle matter separated by said vanes from the products of combustion, and conduit means leading from the outer periphery of said annular projection and through the wall of said apparatus for continuously discharging said solids by gravity.

8. Vertically extending burner apparatus of the cyclone type defined by walls having an inner exposed refractory surface, comprising a substantially cylindrical combustion chamber, an inlet at the lower end of said chamber and means for introducing particle material in suspension therethrough for conversion in said chamber, a concentric elongated outlet at the upper end of said chamber for receiving and discharging therethrough products of combustion, a plurality of inclined ducts formed in and extending through the walls of the combustion chamber for introducing air under pressure thereto in a secantal direction and for providing therein a turbulent generally helical stream, said ducts being vertically and peripherally spaced from each other, means in said outlet for substantially separating solid particles from the gaseous products of combustion comprising a concentric zone of enlarged diameter including a plurality of spaced vertically extending vanes projecting from the inner periphery of said zone, said vanes being inclined in a direction generally opposed to the direction of inclination of said air inlet ducts, a concentric annular projection of lesser diameter than said zone disposed below said vanes and projecting into said zone and adapted to receive thereabout solid particle matter separated by said vanes from the products of combustion, and conduit means leading from the outer periphery of said annular projection and through the wall of said apparatus for continuously discharging said solids by gravity.

References Cited in the file of this patent

UNITED STATES PATENTS

76,010	Watts	Mar. 24, 1868
943,399	Dunnachie	Dec. 14, 1909
1,098,534	Servais	June 2, 1914
1,590,142	White et al.	June 22, 1926
1,771,829	Wagner	July 29, 1930
1,900,320	Wagner et al.	Mar. 7, 1933
1,933,255	Goodell	Oct. 31, 1933
2,050,400	Wagner	Aug. 11, 1936
2,088,679	Yamazaki et al.	Aug. 3, 1937
2,126,150	Stryker	Aug. 9, 1938
2,175,610	Linder	Oct. 10, 1939
2,605,176	Pearson	July 29, 1952

FOREIGN PATENTS

252,862	Great Britain	June 10, 1926