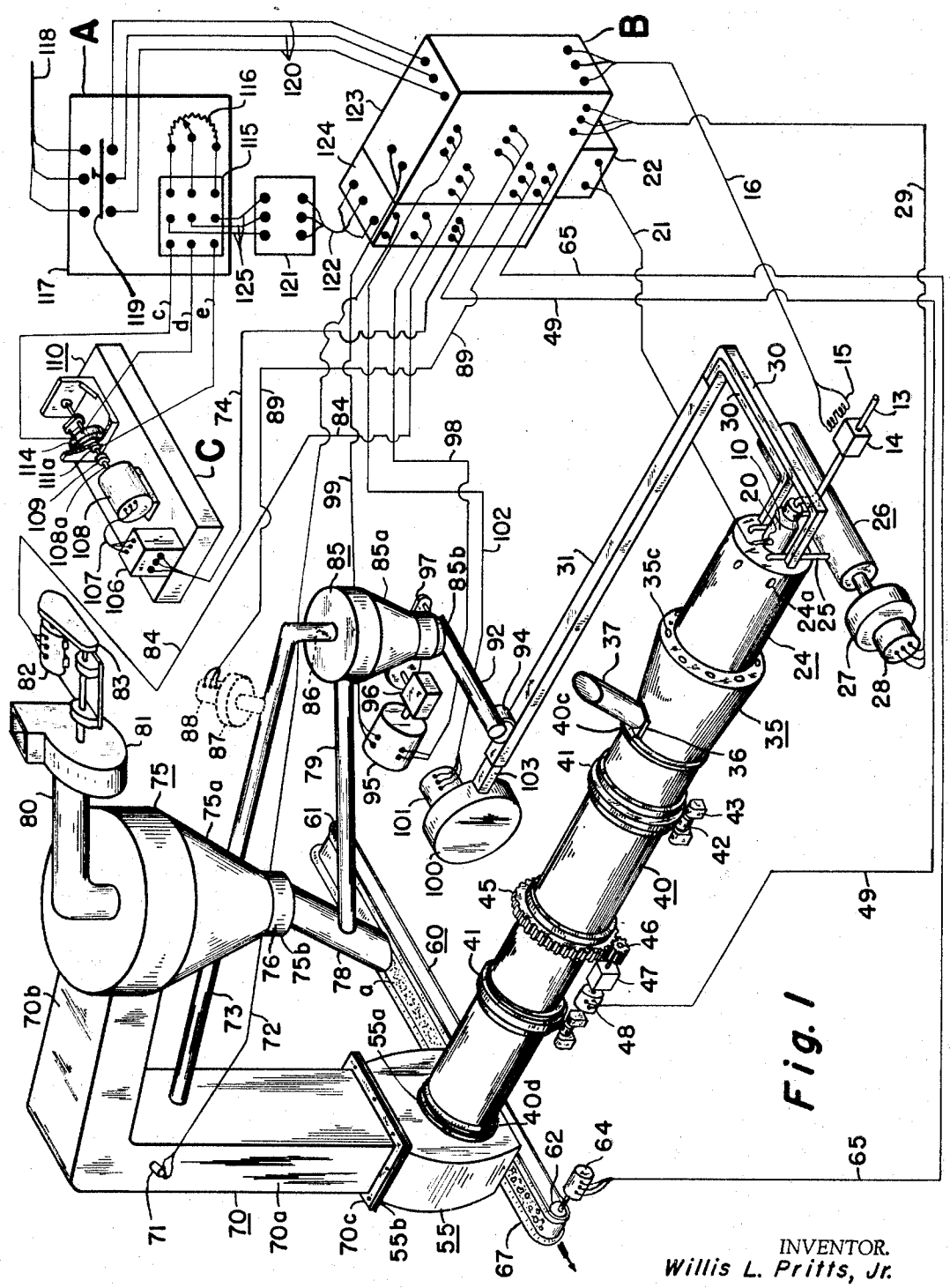
June 11, 1968 W. L. PRITTS, JR 3,387,380

COAL DRYING APPARATUS

Filed May 5, 1961 4 Sheets-Sheet 1



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COAL DRYING APPARATUS

Filed May 5, 1961 4 Sheets-Sheet 2

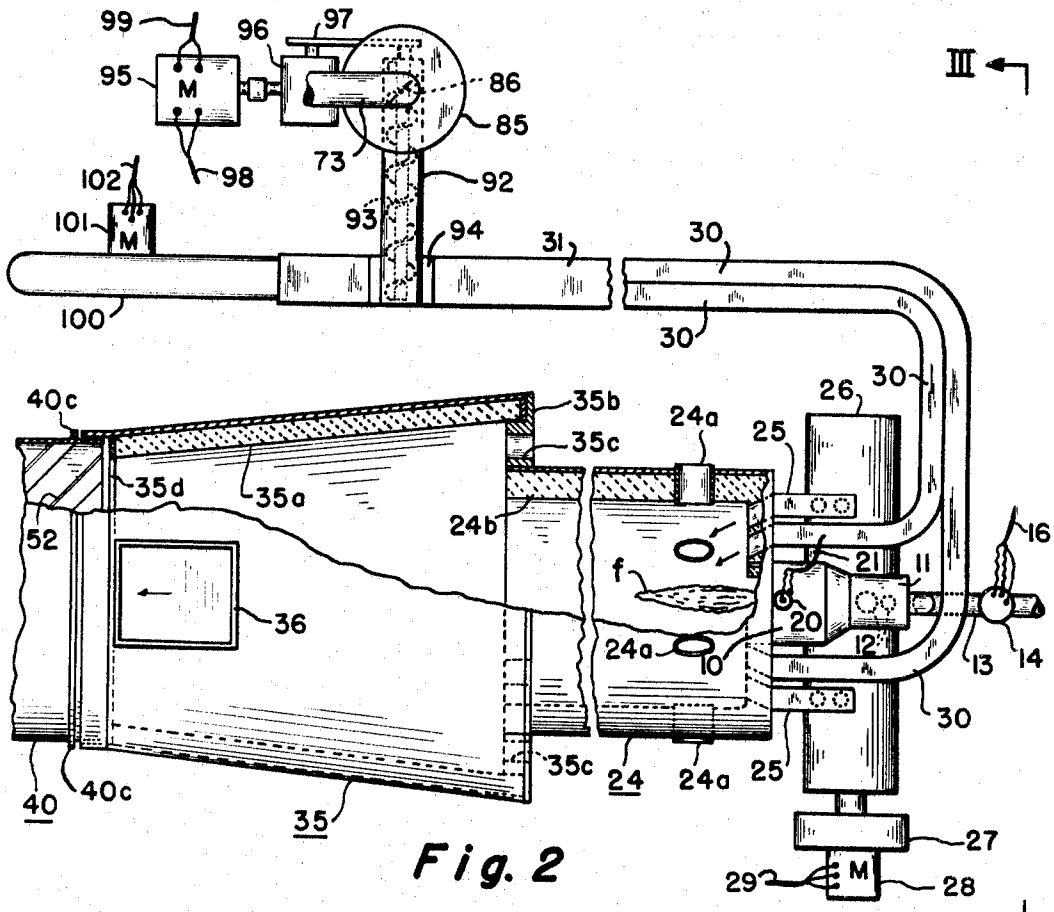


Fig. 2

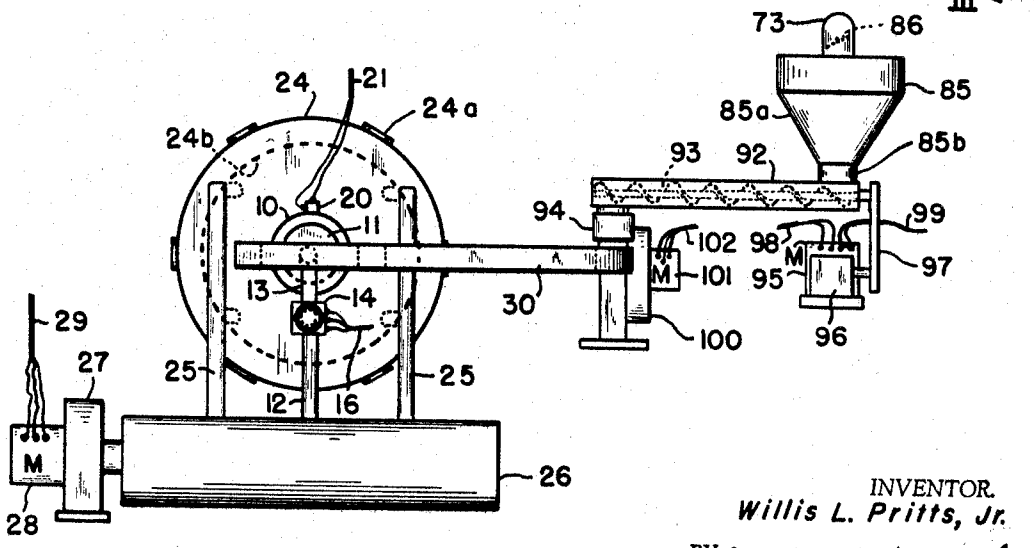


Fig. 3

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COAL DRYING APPARATUS

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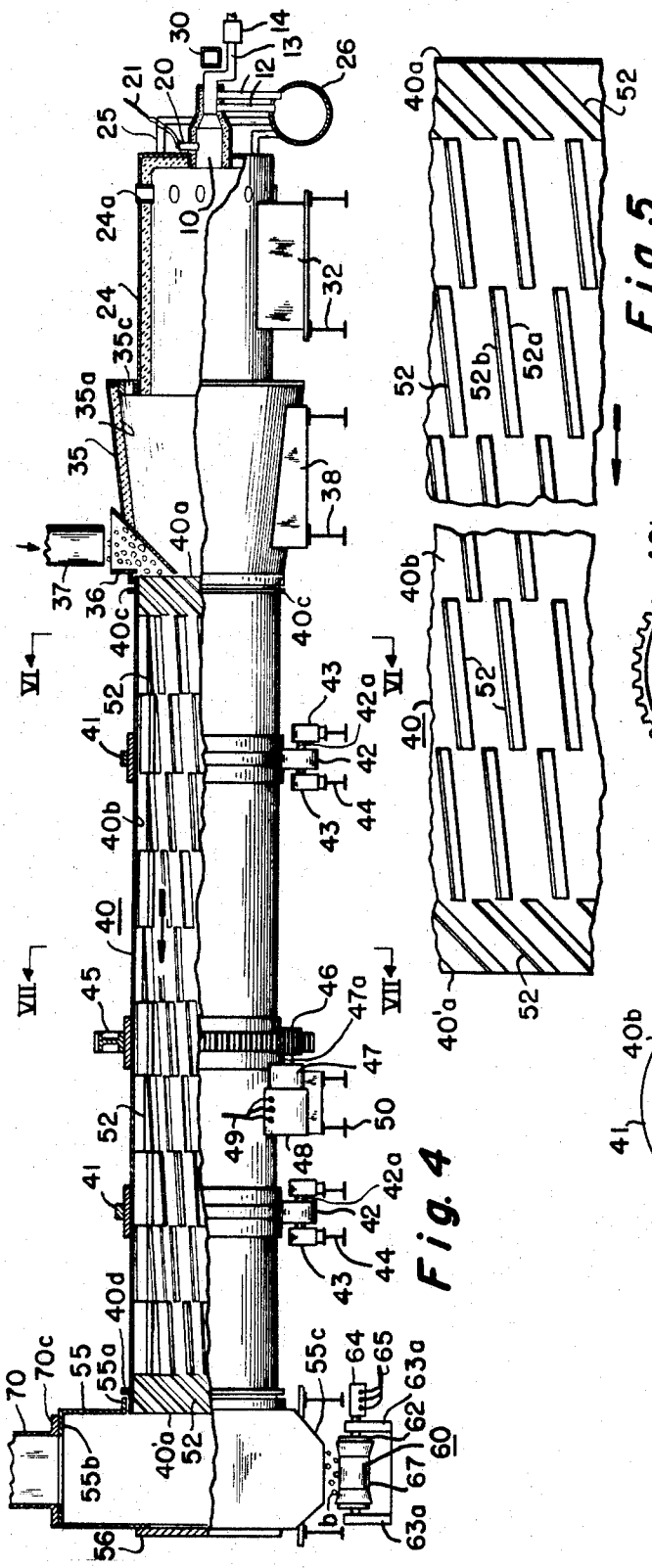


Fig. 4

Fig. 5

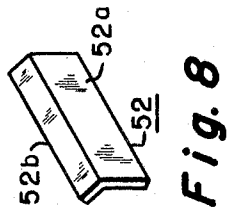


Fig. 8

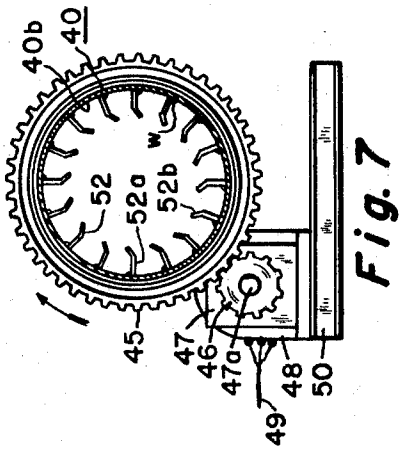


Fig. 7

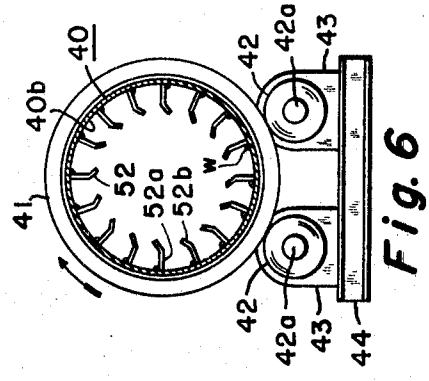


Fig. 6

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COAL DRYING APPARATUS

Filed May 5, 1961 4 Sheets-Sheet 4

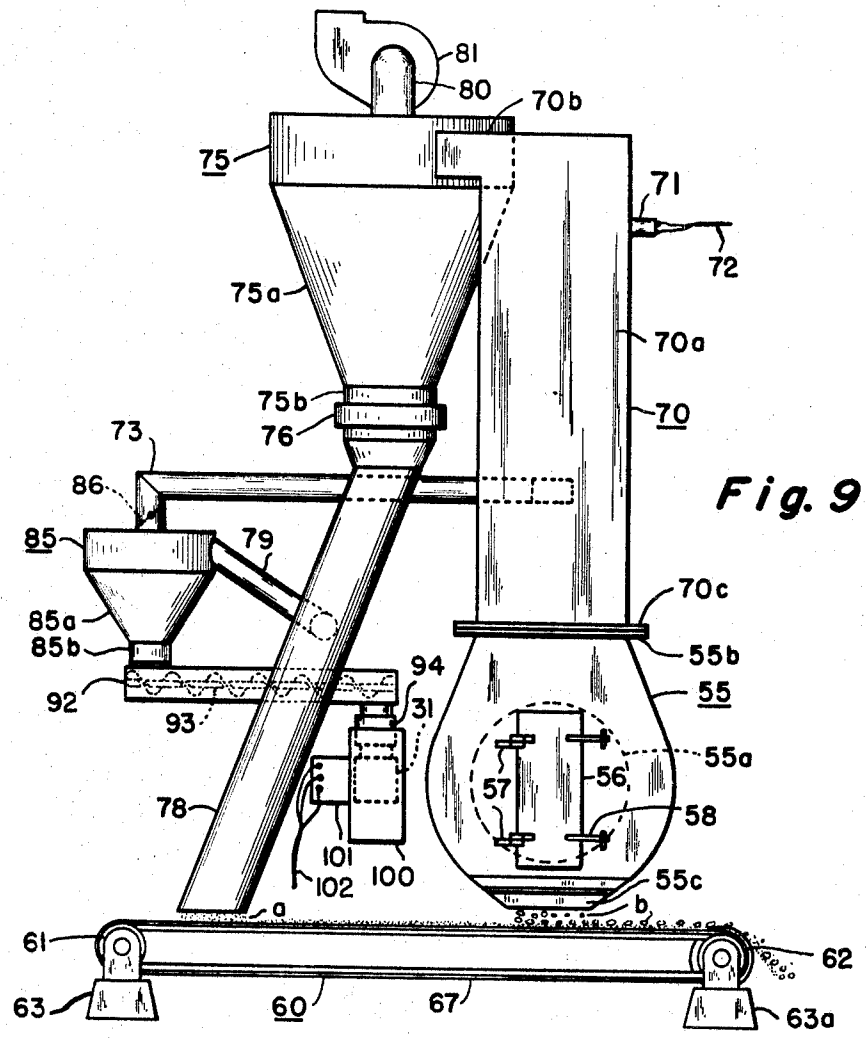


Fig. 9

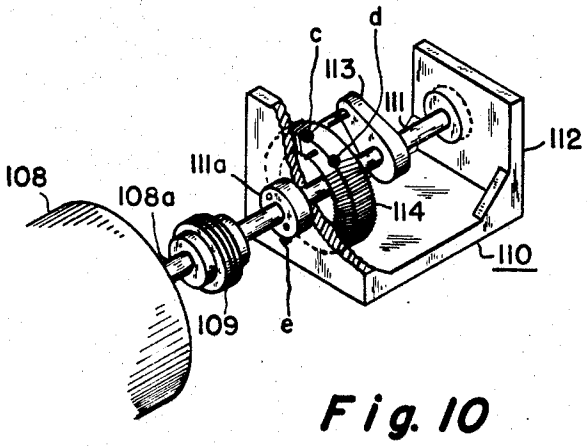


Fig. 10

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United States Patent Office 3,387,380 Patented June 11, 1968

3,387,380

COAL DRYING APPARATUS

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Continuation-in-part of application Ser. No. 4,804, Jan. 26, 1960. This application May 5, 1961, Ser. No. 107,972

4 Claims. (Cl. 34—48)

This invention relates to thermo-drying apparatus and procedure for a burden of combustible material, such as coal, and particularly, to procedure and apparatus for effecting an improved and more economical processing of a coal burden to remove moisture therefrom, as effected by the application and passing of heated (hot) gas therethrough while agitating the burden during its passage through a drying chamber.

This is a continuation-in-part of my co-pending application Ser. No. 4,804, filed Jan. 26, 1960, entitled "Apparatus and Procedure for Drying Coal," now abandoned in favor of the present application.

A phase of the invention pertains to the drying of somewhat brittle pieces of material, such as a coal burden, without subjecting any portion of the burden during its drying operation to burning or combustion, to controlling the drying operation by varying the rate of feed of portions of the dried burden that are employed as the principal source of fuel for producing hot combustion gas in a combustion chamber (as distinguished from controlling the rate of combustion by varying the supply of an oxygen-containing gas, such as air, that is employed with the fuel), and to the utilization of a residual or pulverulent portion of the dried burden as the source of fuel for providing hot drying gas or gases used in processing the burden.

There has been a need for a practical, efficient, fully safe and economical system or procedure for fully drying coal without burning the combustible burden during the drying operation.

Another phase of the invention has been to provide a drying system and procedure for a coal burden that can be readily started-up and shut-down at a moment's notice, that will make use of a portion of the pulverulent finer size content of the coal burden, after it has been dried, as the principal source of fuel, and that can separate-out gas-suspended dried coal dust fines and employ such less valuable or residual content of the burden as fuel for providing heated drying gases in such a manner as to assure a fully continuous combustion of such dust as fuel during the drying operation and without danger of dust explosion or stoppage of the supply of hot gases.

It has thus been an object of my invention to devise a new system and procedure for drying a combustible burden of solid material, such as coal, which is not restricted as to size of the coal, making possible the drying of lump sizes down through one inch, ¾ inch to substantially zero sizes;

Another object has been to effectively and efficiently dry a coal burden in such a manner as to positively avoid any burning of the burden while it is being dried;

Another object of my invention has been to control a drying operation with respect to the moisture content of the material being dried, by controlling the quantity of fuel supplied to a combustion chamber that is employed for providing hot gases for the drying operation, and

without the necessity of closely controlling the supply of air or oxygen employed with the fuel in effecting combustion;

A further object of my invention has been to devise an operating layout and procedure for drying a coal burden which will positively inhibit burning of the coal burden during the drying operation, and which will, at the same time, increase the efficiency of the drying, as effected by the movement of hot gases through the burden;

A still further object of my invention has been to devise a system and procedure for drying coal employing hot gases for the drying operation and in which, the temperature of the gases may be automatically proportioned in accordance with the amount of moisture to be removed and irrespective of the quantity of the coal burden being processed;

These and other objects of my invention will appear to those skilled in the art from the drawings, the specification and the claims.

In the drawings, FIGURE 1 is a perspective view of an apparatus layout or operating system employing and illustrating principles of my invention;

FIGURE 2 is an enlarged fragmental plan view, partially in section, and particularly illustrating combustion and gas mixing parts of the system, and the feed of fuel and air to the combustion chamber unit.

FIGURE 3 is a front end view in elevation of the scale of and taken along the line III—III of FIGURE 2;

FIGURE 4 is a side view in elevation, on a reduced scale from FIGURES 2 and 3, and partially in section of the longitudinal drying unit assembly shown in the layout of FIGURE 1;

FIGURE 5 is an enlarged, inside, fragmental development showing details of the construction of a kiln drying unit of FIGURE 4;

FIGURE 6 is an end section in elevation taken along the line VI—VI of FIGURE 4 and on a slightly enlarged scale;

FIGURE 7 is an end section in elevation on the scale of FIGURE 6 and taken along the line VII—VII of FIGURE 4;

FIGURE 8 is an enlarged perspective view showing the typical construction of flight or vane members that are shown in FIGURE 5, as defining burden-flow passageways along the inside of the kiln drying unit;

FIGURE 9 is a transverse back end view in elevation on a slightly enlarged scale as to FIGURE 1, illustrating a discharge chamber unit and an associated conveyor;

And, FIGURE 10 is an enlarged side view in elevation, particularly illustrating an automatic unit (shown in FIGURE 1) for controlling the feed of selected coal dust used for fuel.

In carrying out my invention, I have been able to prevent any possibility of an explosion in a system having a combustion chamber that utilizes fines (coal dust) of the processed or dried burden as its fuel. In this connection, instead of attempting to operate on the basis of restricting or controlling the oxygen or air content in the combustion chamber and in the drying chamber, I have been able to provide a substantially constant and excess supply of oxygen-containing air and, in such a manner, as to assure a full combustion of the coal dust employed as fuel, and without burning the coal burden being dried in a drying kiln unit. I also make use of the oxygen-containing gas or air as a tempering medium to reduce the temperature

of the hot combustion gas being introduced into the drying chamber and, at the same time, provide an increased volume of gas at a lower and safe drying temperature, such that the drying operation will be fully and efficiently accomplished.

A pilot flame supplied by an auxiliary fuel, such as natural gas or a gaseous oil vapor, is maintained at all times during the burning of the coal dust fuel to assure the continuance of the burning operation and prevent any possibility of explosion in the combustion chamber. In addition, in accordance with my procedure, the system or the operation may be shut-down at a moment's notice by discontinuing the supply of coal dust fuel to the combustion chamber and shutting-off the auxiliary or pilot flame. The operation can then be started at a moment's notice by employing a suitable igniter, such as an electric spark plug **20**, to again ignite the pilot flame after the auxiliary fuel supply has been turned-on. The full production of hot combustion gas is accomplished by again feeding the coal dust to the combustion chamber.

A tempering or mixing chamber unit **35** is interposed between the combustion chamber unit **24** and the drying kiln unit **40**, and the coal burden to be dried is shown introduced through such intermediate unit into the kiln, while the temperature of the hot combustion gas leaving the combustion chamber is lowered or reduced by the addition of a large quantity of tempering air that is drawn in or introduced from the surrounding atmosphere into the mixing chamber unit and is mixed therewith and thus, heated thereby to a uniform, lower, but highly effective drying temperature. For example, if the temperature of the combustion gas leaving the combustion chamber is about 3000° F., then the temperature of the mixed gas entering the kiln unit may be in the neighborhood of about 1500° F. Finally the operation of the system is proportioned to the requirements of the drying operation from the standpoint of the amount of moisture in the coal burden by means **71** that is sensitive to the temperature of gas issuing or being drawn from the drying chamber, to increase the flow of coal dust fuel when the temperature of issuing gases is decreased and conversely, when the temperature of the issuing gas is increased, to decrease the supply of fuel to the combustion chamber.

I have evolved a new process for drying a burden of coal which is not critically limited as to the size range of the coal, in that it will effectively dry lump coal down through one inch, ¾ inch to substantially zero sizes of coal particles and will do so without any danger of burning the coal during the drying operation and further, which will make possible the development of a large volume of heated drying gas. It makes possible the utilization of a gas-borne, residual portion of dried coal dust produced by the drying operation as the source of fuel for the combustion unit.

I move and can supply a continuous coal burden along a drying chamber in a progressive manner, while agitating it and passing hot gas therethrough during its movement. The main dried coal burden or mass is then progressively fed from an outlet of the drying chamber and may be then conveyed to a suitable collecting hopper. Dried coal dust which is carried-off in substantial suspension with the hot drying gas discharged from the outlet of the drying chamber, is shown separated out from the exhaust gas and lower specific gravity flocculent ash by moving it in a whirling circular path in a separator and collecting it centrally from such path as a mass. A portion of this collected dried coal dust, thus separated out, is then selected in accordance with fuel demands and positively fed and then mixed with a positive flow of air for feed into the combustion chamber. The remaining (larger) portion *a* of the coal dust which is not required for fuel purposes in the process may then be discharged upon or combined with the generally larger size dried coal mass *b* that is being collected at the discharge end of the drying chamber.

Air or an oxygen-containing gas for the combustion chamber is supplied in a substantially constant quantity, at least in a quantity sufficient (stoichiometric) to assure a full combustion of the coal dust (product) fuel, but preferably in a constant excess quantity in the combustion chamber, while the coal dust is being carried as a suspension by the positive flow of air with which it is mixed. The coal dust being supplied to the combustion chamber unit **24** is immediately ignited by the employment of a pilot flame *f* which is maintained, by mixing air and a suitable fuel gas, such as natural gas or vaporized oil. The hot gas issuing from the combustion chamber unit which may have a temperature of 3000° F. plus or minus, is then passed into the tempering chamber unit into which atmospheric air is being continuously introduced or pulled, for example, at the rate of 40,000 cubic feet per minute. This causes a tempering of the hot combustion gas, reducing its temperature approximately ½ and also, at the same time, providing a greatly increased volume of hot tempered gas for introduction into the drying chamber.

In this way, I eliminate the need for a supply of extremely high temperature gas to the drying chamber, by providing a more efficient drying means in the nature of a tempered, lower-temperature, larger volume of hot gas that efficiently removes the moisture from a coal burden that may be introduced through the mixing chamber **35** into the inlet end of the drying kiln unit. The drying kiln **40** is rotated and provided with means for progressively advancing the coal burden spirally across flight rows that define flow passageways to its outlet end, while enabling the mixed hot gas to efficiently move through the coal burden and dry it in such a manner and at a temperature such that there is no danger of any combustion of the burden. A thermo-couple **71**, within a discharge duct unit **70** for the gases issuing from the drying chamber, is employed to proportion the feed of coal dust used as fuel to the combustion chamber in accordance with the principles above enumerated.

Thus, in accordance with my invention. I supply tremendous amounts of heated air, so that moisture is immediately absorbed, yet is controlled so completely that the coal practices themselves do not absorb excess heat. The moment that moisture is there, automatically the heat is not. Heretofore, it was impossible to get capacity in coal driers, because of the inability to anticipate and control heat and particularly, for large quantities of a coal burden containing moisture, and where the moisture content varies during the drying process. By supplying an excess of air and assuring a full combustion of the coal dust supplied as fuel to a hot gas-evolving combustion chamber, the procedure is explosion-proof, and the temperature of the combustion chamber can be much lower than would be necessary, if reliance had to be placed upon the use of a negative charge of oxygen as, for example, by bringing back processing gases into a combustion chamber. Actually, the dried coal being discharged from the kiln unit can be picked up by the hand, without danger of burning the hand and, at the same time, the coal is completely dried as its initial moisture has been fully eliminated. By making use of coal dust, large quantities of coal may be effectively dried, using a volume of drying gases in the neighborhood of 40,000 to 50,000 cubic feet per minute, depending on the size of the drier. The movement of the coal burden of somewhat brittle pieces through the dryer, of course, produces dust during the operation, and also some dust may be carried with the feed of the coal burden to the drier. The finer or residual dust, as dried, is what is used as the essential source of fuel.

I have found that the coal dust produced by the drying of the burden is in more than sufficient quantities for the production of combustion gases. For example, an average installation may make about ten tons of dust per hour, whereas the maximum requirements for burning

may be in the neighborhood of one to two tons per hour. In this connection, I can, if desired, approach a white heat in the combustion chamber (in the neighborhood of 3400° C.), but prefer to operate at a slightly lower temperature to increase the life of the apparatus. I have been the first to make practical the use of kiln drying for coal and the employment of solid fuel in the drying of coal. There is very little noticeable ash produced, thus grates are unnecessary in the combustion chamber unit. Further, in accordance with my procedure, the fire produced by the dust does not have to be held or does the pilot flame *f* have to be maintained when it is desired to discontinue the drying operation. As contrasted to prior attempts in this field, I have been able to remove substantially 100% of the moisture without danger of burning the combustible (coal) burden.

Referring particularly to the drawings and to FIGURES 1, 2 and 3, I have shown a pilot fuel supply chamber unit **10** mounted substantially centrally of an inlet end of the fuel combustion chamber unit **24** to provide, at all times, during the drying operation, a pilot frame *f* within the chamber of the unit **24** (see FIGURE 2). The pilot fuel unit **10** converges at its inlet or outer end into a mixing chamber portion **11** into which air and gaseous vapor, such as fuel gas or vaporized oil may be introduced and mixed for supplying the unit **10**. As shown, a substantially constant quantity of air may be supplied by a pair of branch pipes or conduits **12** that are connected to an air manifold **26**. A substantially constant supply of fuel gas may be supplied by a pipe or conduit **13**. During any period when the drying operation is to be shut-down, the pilot flame *f* may be turned-off by de-energizing a magnetic holding coil **15** of a shut-off valve **14** that is normally urged to a closing position by a resilient spring. As a result, the valve **14** may be opened and closed by an electrical, remote control means. As shown, electric leads from the coil **15** are connected by electric cable **16** to a part **123** of a remotely-located main control electric unit B.

For automatically or remotely lighting the pilot flame *f*, I have shown a spark plug igniter **20** mounted to extend into the chamber of the unit **10**, adjacent its outlet end, and adjacent the inlet end of the combustion chamber unit **24**. A pair of electric leads are connected through electric cable **21** to a transformer **22** on the control panel B. By this means, when the drying operation is to be initiated, I electrically energize the coil **15** to open the valve **14** and then employ the voltage step-up transformer **22** to send a spark-producing current through the cable **21** to the spark plug **20** to start the pilot flame *f*.

As shown particularly in FIGURE 1, the combustion chamber unit **24** is of substantially longitudinal-cylindrical shape and extends along a substantially horizontal plane from the pilot unit **10** to, at its outlet end portion, fit within an inlet end portion of mixing chamber unit **35**. The unit **35** is shown of substantially frusto-conical shape and, as shown in FIGURE 2, has an inner refractory chamber wall **35***a* of the same shape, a somewhat angle-shaped inlet flange portion **35***b*, and a ring-like, circular outlet flange portion **35***d*. The front or inlet flange portion **35***b*, as shown particularly in FIGURES 1 and 2, has a series of circularly spaced-apart, end, air inlet ports or openings **35***c* therethrough for introducing tempering air into the chamber. The combustible material burden, such as coal, that is to be dried is introduced from a supply conduit **37**, through a down-chute **36** and the unit **35** into a rotary, cylindrical, longitudinally-horizontally-extending drying kiln unit **40**. It will be noted that the flange **35***b* forms a tight sleeve-fit over the outlet end portion of the combustion chamber unit **24**, and that the flange **35***d*, with an extending portion of the metal wall of the unit **35**, forms an internal limit stop and bearing for rotatably receiving an inlet end portion of the kiln unit **40**. As shown in FIGURE 4, the unit **35** may be supported on a floor or the ground by structure **38** and the unit **24** may be supported in a similar manner by structure **32**.

Hot combustion gas for supplying the heat used in the drying operation is generated or evolved in the refractory-lined chamber **24***b* of the combustion chamber unit **24**. As shown particularly in FIGURES 1, 2, 3 and 4, a constant supply of air may be introduced through the inlet end of the unit **24** by a pair of spaced-apart branch supply lines **25** that are connected to the primary air supply manifold **26**. Air is introduced under a positive pressure head to the manifold **26** from the atmosphere by a blower **27** that is actuated by an electric motor **28**. As shown particularly in FIGURE 1, electric leads from the motor **28** are connected by a flexible electric cable **29** to the part **123** of the control unit B. Provision is also made for providing a secondary supply of air to the unit **24** through peripherally spaced-apart inlet ports **24***a* (see FIGURES 2 and 3) that are located about its periphery adjacent its inlet end portion; the purpose is to assure a full supply of air for supporting combustion and, as previously pointed out, preferably an excess of air. Solid fuel particles, such as coal dust, constituting the source of fuel for combustion in the unit **24** may be introduced to the inlet end of the unit **24** through a pair of branch duct lines **30**. The dust-like fuel supply is moved primarily as a suspension within a positive-flow air stream from a main fuel supply duct **31**, in an unrestricted path through the branch lines **30** into the end of the unit **24**.

As shown particularly in FIGURES 4 and 5, the kiln unit **40** has a substantially cylindrical metal wall **40***b* that, at the inner periphery of its inlet end **40***a* and outlet **40'***a*, is provided with flight rows of vane members **52** that have a greater slope or inclination than flight rows along its main extent or midsection. The inlet end portion of the unit **40** has an inwardly-spaced bearing ring flange **40***c* that cooperates with the outlet end portion of the unit **35** during the rotative movement of the unit **40**, and has a similar ring flange **40***d* about its periphery adjacent its outlet end in a slightly spaced relation from such end that is adapted to make bearing and rotative engagement with an inlet flange portion **55***a* of a discharge chamber unit **55** to define a rotating bearing joint therewith.

To facilitate the progressive forward movement or rotative advance of the burden being dried in the unit **40**, flight rows are provided along the inner peripheral extent of the chamber wall **40***b*. The flight rows for the portions **40***a*, **40'***a* and **40***b*, as shown particularly in FIGURES 5, 6 and 7, are defined and provided by angle-shaped flight members or vanes **52**. As shown particularly in FIGURES 6, 7 and 8, each vane **52** has a vertical portion **52***a* that is mounted and secured, as by weld metal *w*, to extend radially-inwardly of the wall, and has a bent-over or forwardly sloped or inclined foot portion **52***b* that is adapted to extend and slope in the direction of the rotation of the unit **40**. Also, as shown, the vanes **52** of each row along the unit **40** are, at their ends, positioned in a spaced alignment between their adjacent flights or rows, such that the vanes **52** of each peripheral row or flight have a staggered relationship with those of adjacent rows or flights, and define open passageways longitudinally along the full extent of the internal wall **40***b*. These vanes **52** thus serve to not only spirally advance the material burden being dried, but also to agitate it and permit hot drying gas to enter into intimate contact with the particles thereof during the advance along the kiln **40**.

As shown particularly in FIGURES 1, 4 and 6, the unit **40** is provided with a pair of longitudinally spaced-apart circular roller flanges **41** about its periphery, each of which engages a pair of idler bearing rollers **42** to support the kiln during its rotative actuation. Each roller **42** is mounted on a shaft **42***a* that is carried by a pair of journaling end-bearings **43**. The end bearings **43** are sup-

ported on stands 44. For rotating the kiln 40, I have provided a longitudinally-centrally disposed ring gear 45 that is secured about its outer periphery on the kiln, and that meshes with a pinion gear 46. The shaft of an electric motor 48 drives a speed reduction unit 47 whose shaft 47*a* carries the driving pinion gear 46. Electric connections or leads from the motor 48 are carried by electric cable 49 to the part 123 of the control panel B. As shown in FIGURE 4, the drive unit is supported on a stand 50.

Referring particularly to FIGURES 1 and 9, the dried combustible material burden, such as coal, is discharged from the outlet end portion of the rotating kiln unit 40 into a vertically-positioned discharge chamber unit 55 which is open at its top end to discharge hot gas effluent, etc., into a discharge dust unit 70. A flange 55*b* surrounds the open top end of the unit 55 and may be secured to a bottom flange 70*c* of the discharge duct unit 70 by rivets or bolt and nut assemblies.

The mass *b* of the dried burden which is introduced into the unit 55 is discharged downwardly through a converging wall portion 55*c*, and its open bottom end upon a suitable conveyor means, such as a belt conveyor 60. The mass *b* will, of course, be made up principally of the larger size coal lumps or particles, but may include smaller particles, including dust that is not gas-borne. As shown particularly in FIGURE 9, the unit 55, at its back vertical end, may be provided with an inspection door 56 that is hinged at 57 and is normally maintained in a closed relation by latches 58.

The conveyor 60, of a continuous belt type, is employed for discharging coal masses, including the larger particles or lumps *b* of the main discharge and dust *a* from the separating apparatus, to a suitable collecting hopper, not shown. The belt 67 of the conveyor 60 is mounted over a pair of spaced rollers 61 and 62 at its opposite ends that have a concave-shaped surface to thus shape the upper portion of the belt 67 for better retaining the dried burden thereon. The roller 61 is shown as an idler type, while the roller 62 is shown as a driven type, being actuated by an electric motor 64 (see FIGURES 1 and 4). Electric leads from the motor 64 are connected through an electric cable 65 to the main part 123 of control panel B. Shafts of the rollers 61 and 62 are shown mounted on bearing stands 63 and 63*a*.

Hot gases issuing from the discharge end of the rotating kiln unit 40 pass into the discharge chamber unit 55 and are drawn upwardly through the discharge duct unit 70 into a collector-separator 75, such as of a cyclone type. As shown in FIGURES 1 and 9, the unit 70 has a vertical leg portion 70*a* and a horizontal leg portion 70*b* along which the hot gas and the gas-borne dried coal dust are carried into the separator unit 75. Within the upper end of the unit 75, the hot gases and the dried coal dust are whirled in a circular path, in such a manner that the dust separates out centrally and moves down a downwardly-converging cone or funnel-shaped portion 75*a*, while the hot exhaust gas (or gases) is drawn upwardly out through discharge duct 80 by a suction-producing exhaust blower 81 and may be discharged to the atmosphere. The blower 81 is shown actuated by an electric motor 82 and a chain-driven speed reduction unit 83. The electric leads from the motor 82 are carried by electric cable 84 to the main part 123 of the master control panel B.

As shown particularly in FIGURE 1, a temperature-sensitive electric, thermo-couple 71 is positioned to extend within the leg portion 70*a* of the discharge duct unit 70 and its electric leads are connected by an electric cable 72 to a secondary part 124 of the control unit B. Automatic unit C is used with the part 123 for automatically-controlling the feed of coal dust fuel into the combustion chamber 24 at a rate depending upon the temperature of the discharge gas moving along the duct unit 70.

A second and smaller separator-collector unit 85, preferably also of a cyclone type, is at its upper end connected through a suction line duct 73 to the leg 70*a* of the unit 70. If desired, the suction action in the duct 73 may be augmented or supplemented by a positively-driven suction blower 87 that is actuated by a motor 88. As shown in FIGURE 1, the electric leads of the motor 88 are connected through a cable 89 to the part 123 of the main control panel B.

Collected and separated-out dried coal dust from the unit 75 moves down through a funnel or cone-shaped collecting portion 75*a*, through an air lock 76, into a cylindrical discharge portion 75*b*, and thence, into a discharge chute or main delivery duct 78 which, at its lower end, is positioned to discharge dried coal dust *a* upon the belt conveyor 60. The portion of the dried coal dust which is to be used as fuel in maintaining combustion in the combustion chamber unit 24 is drawn-off from the duct 78 by suction force applied to a branch duct 79, into the top portion of secondary separating unit 85. It will be noted that suction force is applied by the duct 73 through the top of the secondary unit 85 to the duct 79 that is shown connected between the side of the main duct or delivery chute 78 and the side of the upper portion of the secondary separator-collector unit 85. It will be noted that the suction line or conduit 73 has a damper 86 therein to control the effective amount of suction applied to the top of the secondary unit 85. The gas which is carried into the secondary unit 85 passes out through the suction duct line 73 into the main discharge duct unit 70, while coal fuel dust swirls downwardly along within its cone-shaped collecting portion 85*a*, being discharged through cylindrical delivery end portion 85*b* into a horizontal delivery duct or conduit 92 that, at its discharge end, is connected to the main fuel supply duct 31 through an air lock 94.

A positive-feed screw conveyor 93 is shown operatively-mounted along the horizontal delivery conduit 92 and is energized by a variable-speed electric motor 95 through a gear reduction unit 96, and a chain drive 97. Drive-energizing electric leads (two-phase) from the motor 95 are connected through an electric cable 99 to the part 123 of main control panel B and to two lines of the three-line leads 120. The speed of the motor 95 is controlled by varying its field excitation through cable 98, part 124 of unit B, and by means of unit C, to control the rate of feed of the dried coal dust that is used as fuel by means of the screw conveyor 93, proportionately to the temperature indications made by the thermocouple 71. As shown particularly in FIGURE 1, this is primarily accomplished by the automatic unit C which is shown mounted on a platform or panel 105.

A blower 100 which is actuated by motor 101 supplies atmospheric air under pressure or positive flow through its air delivery conduit 103 into an inlet end of the main fuel supply duct 31, ahead of the delivery of coal dust to such duct. As a result, the coal dust entering the duct 31 becomes suspended by the air and is forced under pressure along the duct 31 and branch lines or conduits 30 into the combustion chamber unit 24. As shown in FIGURE 1, the motor 101 is connected by electric cable 102 to part 123 of the control unit B.

The unit C (see FIGURES 1 and 10) has a controller and magnetic modulator 106 of a suitable commercial type (such as represented by a 8000 series Wheelco unit) that is connected by cable 74 to the part 124 of the unit B. The part 124 includes electric connections from the thermo-couple cable 72 to the cable 74 of the controller 106, and an electronic control unit (such as illustrated in Wheelco bulletin No. 2750). The unit C may employ a (Louis Allis Co.) controller 106 and a small, variable speed reversing motor 108 (such as a small Louis Allis Co. MF421A motor). As shown, the controller 106 is connected by electric cable 107 to impart variable energization to the motor 108. The motor 108 is adapted to turn back and forth about 330°, depending upon its field excitation, as controlled by 106 and the thermo-couple 71.

As shown, shaft 108*a* of the motor 108 is coupled through an insulating coupling 109 to a conductor shaft

111. A potentiometer unit 110 is mounted, as by a set screw, on one end of a U-shaped plastic or insulator frame 112 which journals the shaft 111. A variable-position potentiometer contact arm 113 has its sleeve secured, as by a set screw, on the shaft 111 to turn therewith, along and make a sliding electric contact, with a current-control winding 114 of the potentiometer unit 110. Thus, a change in the field excitation of the motor 108 causes a change in the current passing through the potentiometer unit 110 by reason of the position of the arm 113 with respect to the winding 114. This variation in current is applied through leads *c*, *d* and *e* to a double-throw control switch 115 of a manual control panel A. It will be noted that the leads *c* and *d* are connected to opposite ends of the winding 114, and that the lead *e* is connected to a conductor sleeve 111*a* that is secured, as by a set screw or bolt, to the frame 112, and conducts current from lead *e* through its rotatable journaling of the shaft 111, through the shaft 111, to the arm 113.

The three leads of centrally-positioned throw arms of the switch 115 are connected through electric connections 125 to a relay unit 121 and through leads 122, to the part 124 of the control unit B. When the throw arms of the switch 115 are thrown to the left of FIGURE 1, variation in the electro-magnetic field of the motor 95, as effected by the potentiometer 110 of unit C, is applied through electric leads 125, the relay unit 121, electric leads 122, and is applied by the part 124 of unit B, through electric cable 98 to the field winding of the motor 95. However, when the arm of the switch 115 is thrown to the right, this energization of the motor 95 may be manually controlled, if desired, by a manual potentiometer 116. It will be noted that the switch 115 and the manual potentiometer 116 are mounted on a panel 117 which may be positioned on the wall of the building.

In FIGURE 1, 118 represents a suitable source of electricity (three-phase) that is connected through push-button switch 119 and leads 120 to the part 123 of the unit B. The unit B contains relay controls for the various motor drives, etc., and the unit 121 may have a relay operating recording unit and a safeguard relay unit (such as sold by Barber-Colman Company as Wheelco units, the safeguard unit being a 1570 Wheelco). Thus, the entire system may be stopped and started by the switch 119. The amount of field excitation of the fuel feed motor 95 is thus controlled through cable 98, the part 124 of the unit B, unit 121, and either unit C or the manual potentiometer 116.

A highly important feature of my invention is the fact that I can and desirably introduce or maintain a substantially constant supply (volume or quantity) of the oxygen-containing gas or air as to the combustion chamber unit 24 and essentially, control the heating cycle by varying the supply of the fuel (dried fine particles of coal). Although the dried fuel may be supplied from any suitable source, I have been able to and desirably use a selected portion of the fuel dust which would normally be lost to the atmosphere with the exhaust gas. By so doing, I not only provide a highly economical process, but one which, in effect, cleans the exhaust gas before it is introduced into the surrounding atmosphere. In making possible the elimination of the need to control combustion heat by introducing greater or lesser amounts of air, I provide a system or process that assures complete and absolute safety in drying a combustible material or fuel such as coal.

Although in FIGURE 2 I have, for the purpose of illustration, shown ports 35*c* for introducing tempering air from the atmosphere into the mixing chamber unit 35, I have also employed a fully continuous end opening or passageway between the units 35 and 24. In the latter construction, external supports may be used with the units 24 and 35 to maintain them in an axially and radially-centrally aligned relation with each other at their cooperating end portions.

What I claim is:

1. In apparatus for drying a burden of coal pieces in an elongated rotatable kiln having opposed inlet and outlet end portions, a mixing chamber unit having opposed inlet and outlet portions and having its inlet portion connected to the inlet end portion of the kiln for delivering a tempered mixture of air and hot combustion gas thereto, a delivery chute extending into said mixing chamber unit and towards the inlet portion of the kiln for feeding the coal burden to the kiln, means for supplying atmospheric air to said mixing chamber unit for mixing with and tempering hot combustion gas therein, an elongated combustion chamber unit having opposed inlet and outlet end portions and having its outlet end portion connected to the inlet end portion of said mixing chamber unit to supply hot combustion gas thereto, a pilot mixing chamber having opposed inlet and outlet end portions and having its outlet end portion connected to the inlet end portion of said combustion chamber unit, means for supplying air and a fuel vapor to said pilot mixing chamber unit for supporting a pilot flame within the inlet portion of said combustion chamber unit, a discharge chamber unit connected to the outlet end portion of the kiln and having a portion for delivering the dried coal burden from the kiln, a conveyor constructed to receive the dried coal burden from said discharge chamber unit, a suction duct unit connected to an upper outlet end portion of said discharge chamber unit for drawing hot gas and dried coal dust therealong, a cyclone separator collector unit connected to an outlet end portion of said suction duct unit for receiving the hot gas and dried coal dust and separating out and collecting the dried coal dust, a delivery chute connected to said cyclone unit for delivering the dried coal dust therefrom to said conveyor, a second cyclone unit connected by a suction line to said delivery chute for drawing-off a portion of the dried coal dust therefrom, a fuel supply duct connected to a discharge end portion of said second cyclone unit, motor-driving means for positively feeding the dried coal dust from said second unit into said fuel supply duct, means proportioning the feed of said motor-driving means to the temperature of the hot gas being drawn along said suction duct unit, means connected to said fuel supply duct for applying a positive flow of air to mix with the dried coal dust being supplied thereto and feed the mixture positively forwardly along said fuel supply duct, said fuel supply duct being connected to the inlet end portion of said combustion chamber unit for feeding the mixture of air and dried coal dust thereto for ignition by the pilot flame and combustion therein to evolve hot combustion gas, an igniter projecting into said pilot mixing chamber unit adjacent the inlet end portion of said combustion chamber unit for igniting the pilot gas mixture and initiating the pilot flame, and control means for stopping and starting the supply of fuel vapor to said pilot mixing chamber unit and for stopping and starting the feed of the mixture of air and dried coal dust to said combustion chamber unit.

2. In apparatus as defined in claim 1 wherein, the kiln is of substantially cylindrical shape and has a series of coal-burden-advancing vane flight rows projecting inwardly therefrom, and the vane flights of each row are in a staggered through-passageway-defining relationship with the vanes of adjacent flight rows.

3. In apparatus as defined in claim 1 wherein said mixing chamber is of substantially frusto-conical shape, and at its inlet end portion, has ports for introducing tempering air thereto to mix with and temper hot combustion gas being introduced from said combustion chamber unit.

4. In apparatus as defined in claim 1 wherein said means proportioning the feed of said motor-driving means includes a motor-driven potentiometer for varying the excitation of said motor-driving means proportionately

to the temperature of the hot gas being drawn along said suction duct unit.

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