United States Patent [19]

Walker

[11] **3,859,935**

[45] **Jan. 14, 1975**

[54] **PROCESS USING A COMBINATION, OIL, GAS, AND/OR SOLID BURNER**

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[73] Assignee: **Peabody Gordon-Piatt, Incorporated,** Winfield, Kans.

[22] Filed: **Mar. 11, 1974**

[21] Appl. No.: **449,913**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 294,620, Oct. 3, 1972, Pat. No. 3,827,851.

[52] **U.S. Cl.** ..... **110/22 A,** 110/28 B, 431/175, 431/284

[51] **Int. Cl.** **F23c 1/02**

[58] **Field of Search** ..... 431/174, 175, 177, 178, 431/183, 184, 283, 284, 285; 110/22 R, 22 A, 28 B

[56] **References Cited**

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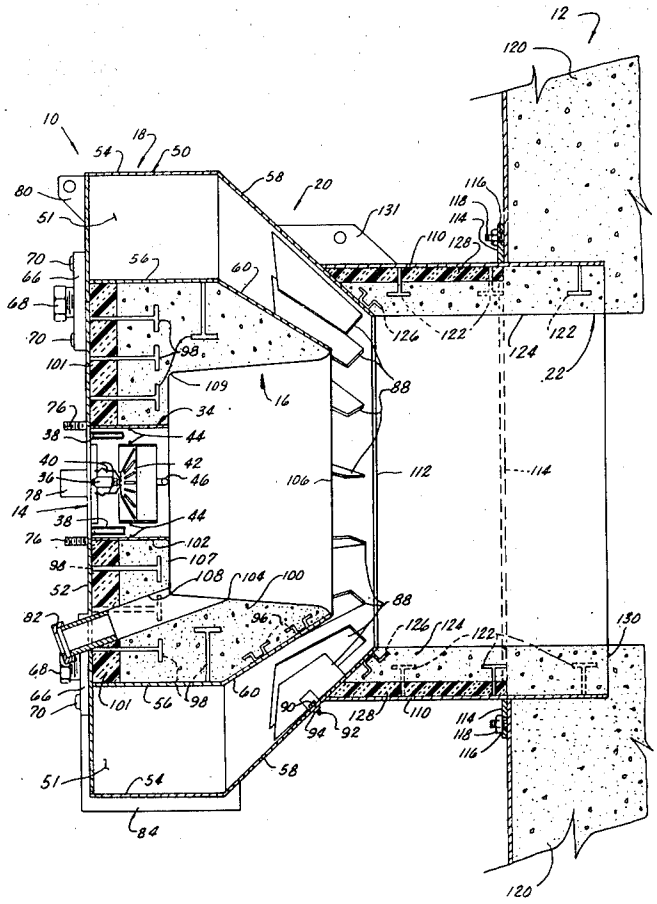
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Primary Examiner—Carroll B. Dority, Jr.
Attorney, Agent, or Firm—John H. Widdowson

[57] **ABSTRACT**

A process utilizing a burner that is adapted to burn oil, gas, and/or solid fuels having an inner oil and/or gas burner, a primary combustion chamber in coaxial relation with the conventional burner, a passageway surrounding the primary combustion chamber in flow communication therewith and a source of oxygen containing gas and source of combustible particulate solid material, and a conduit in communication with the passageway and mountable in a furnace wall. The process introduces the combustible particulate solid material into the burner. Preferably, the particulate material is dried in the process prior to its introduction into the burner.

10 Claims, 6 Drawing Figures



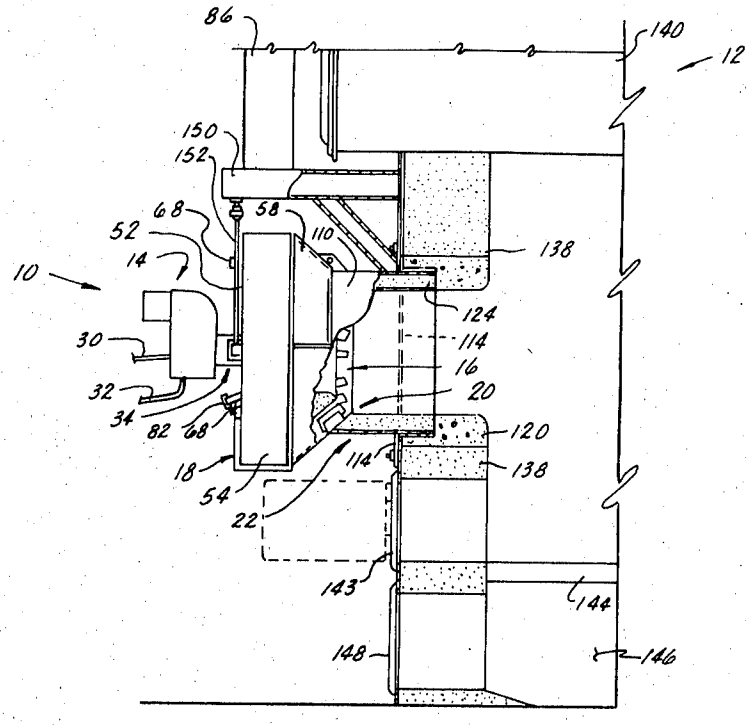


FIG. 1

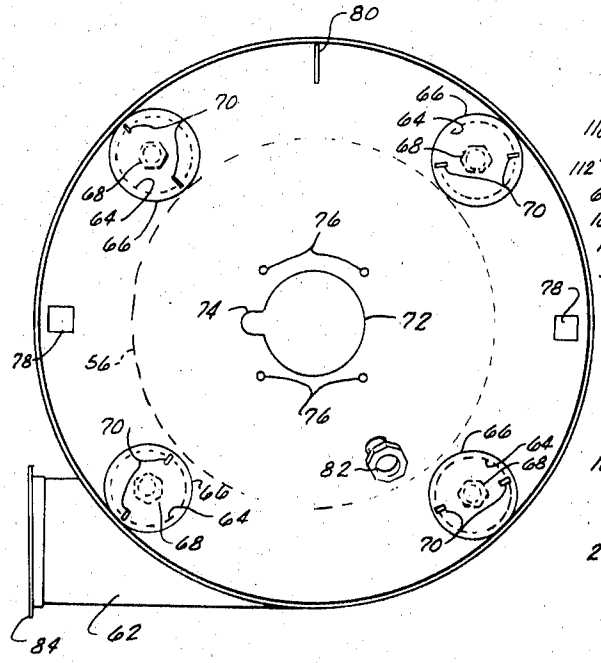


FIG. 4

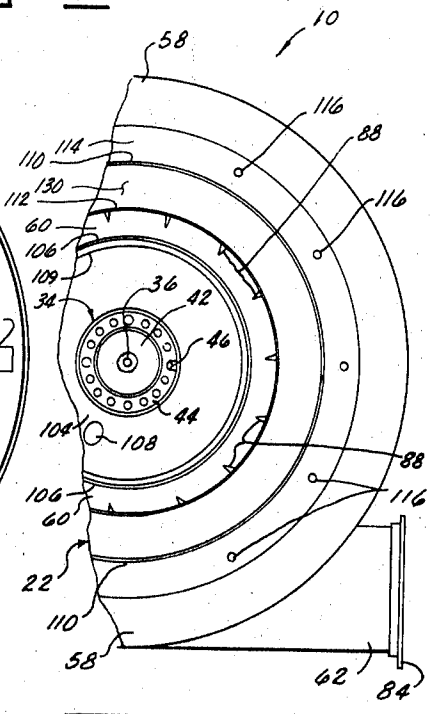


FIG. 3

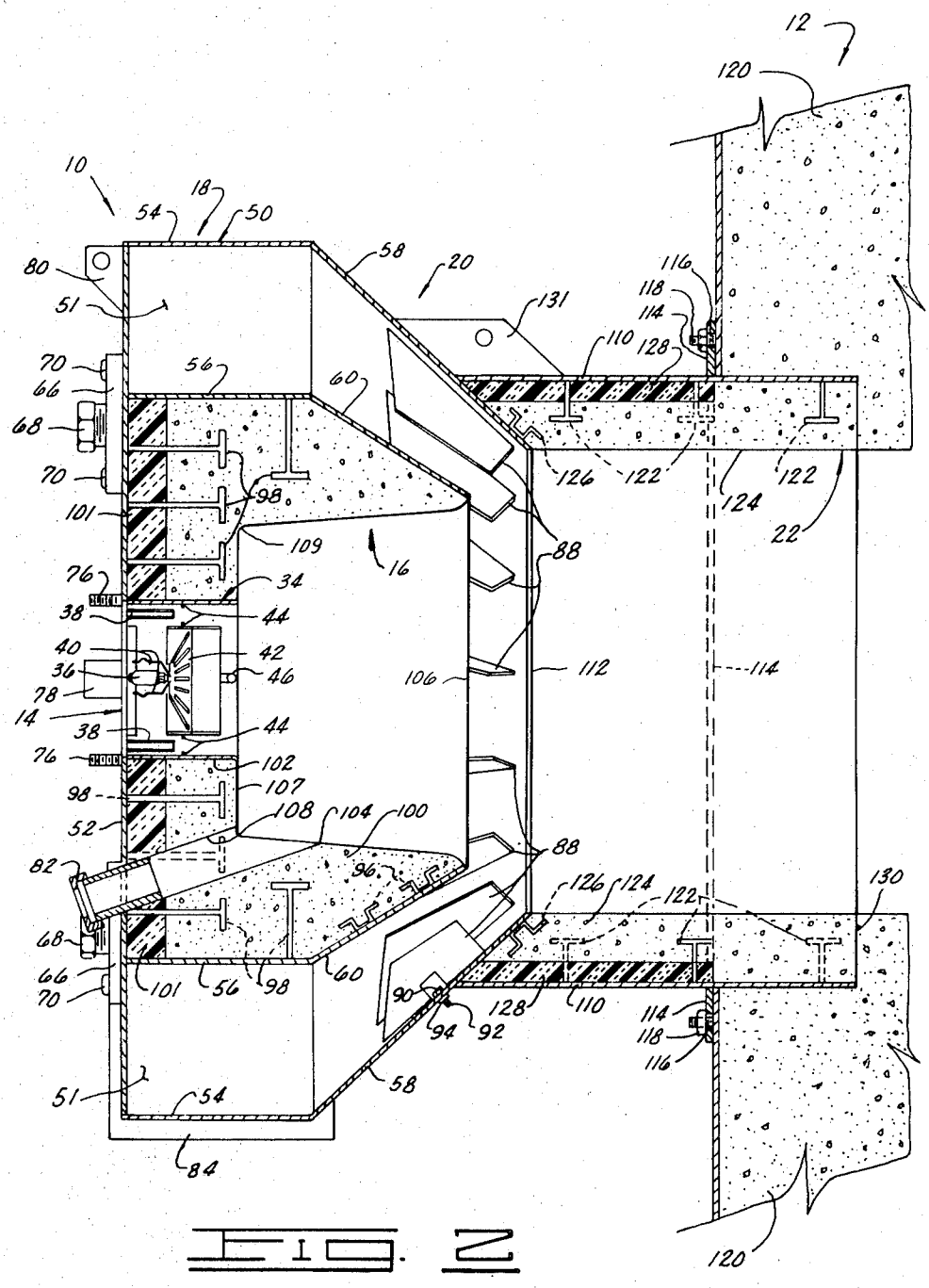

12
120
10
18
54
50
58
20
80
51
131
116
118
114
110
128
70
56
60
66
68
70
126
122
124
122
22
101
98
109
16
88
76
34
38
44
40
42
36
46
106
112
114
78
14
38
44
76
102
107
98
108
104
100
52
88
82
96
126
124
122
130
68
66
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128
110
114
118
116
94
92
51
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58
84
120

FIG. 2

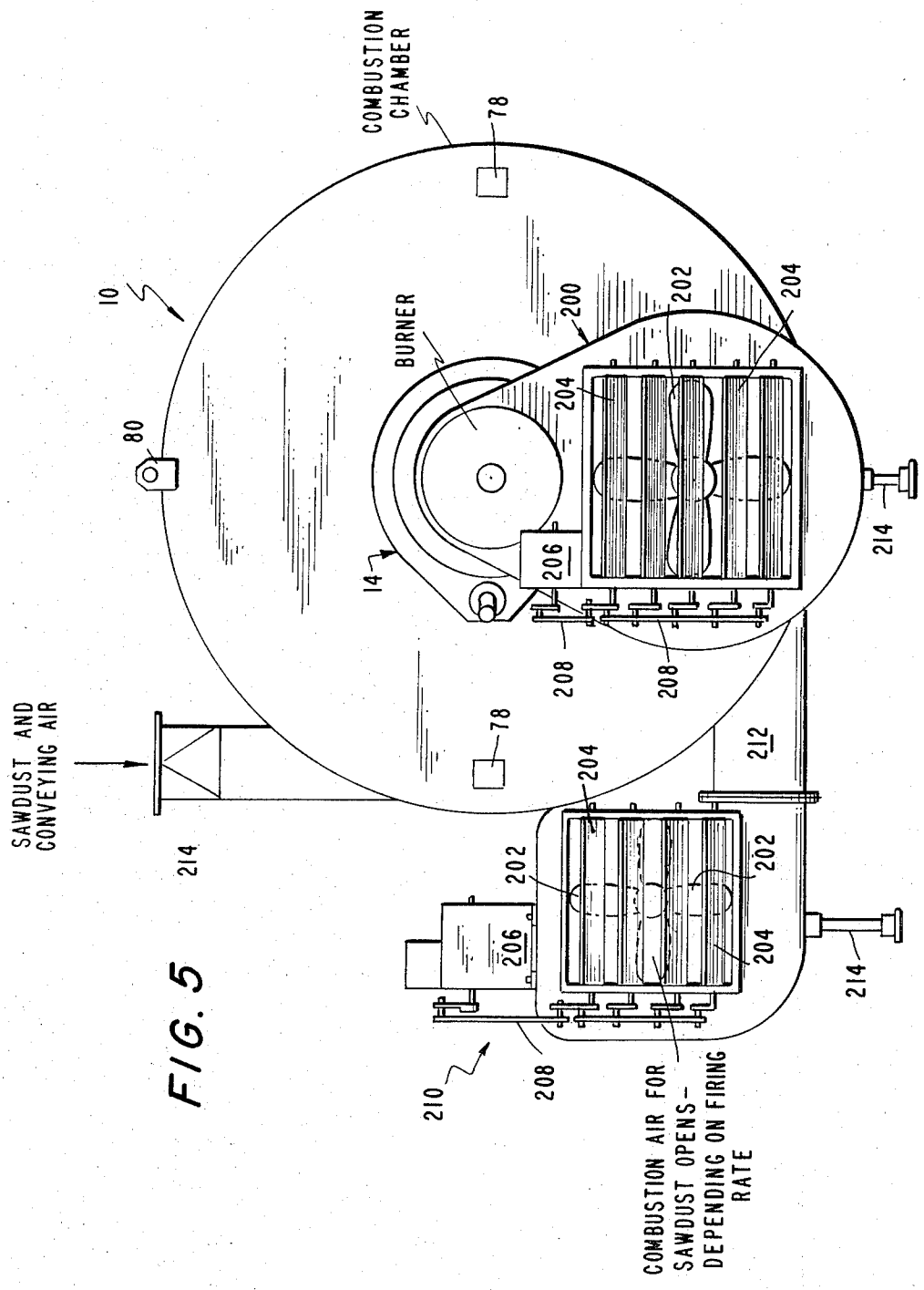

COMBUSTION CHAMBER
78
10
BURNER
200
202
204
80
14
206
208
214
212
SAWDUST AND CONVEYING AIR
210
COMBUSTION AIR FOR SAWDUST OPENS- DEPENDING ON FIRING RATE

FIG. 5

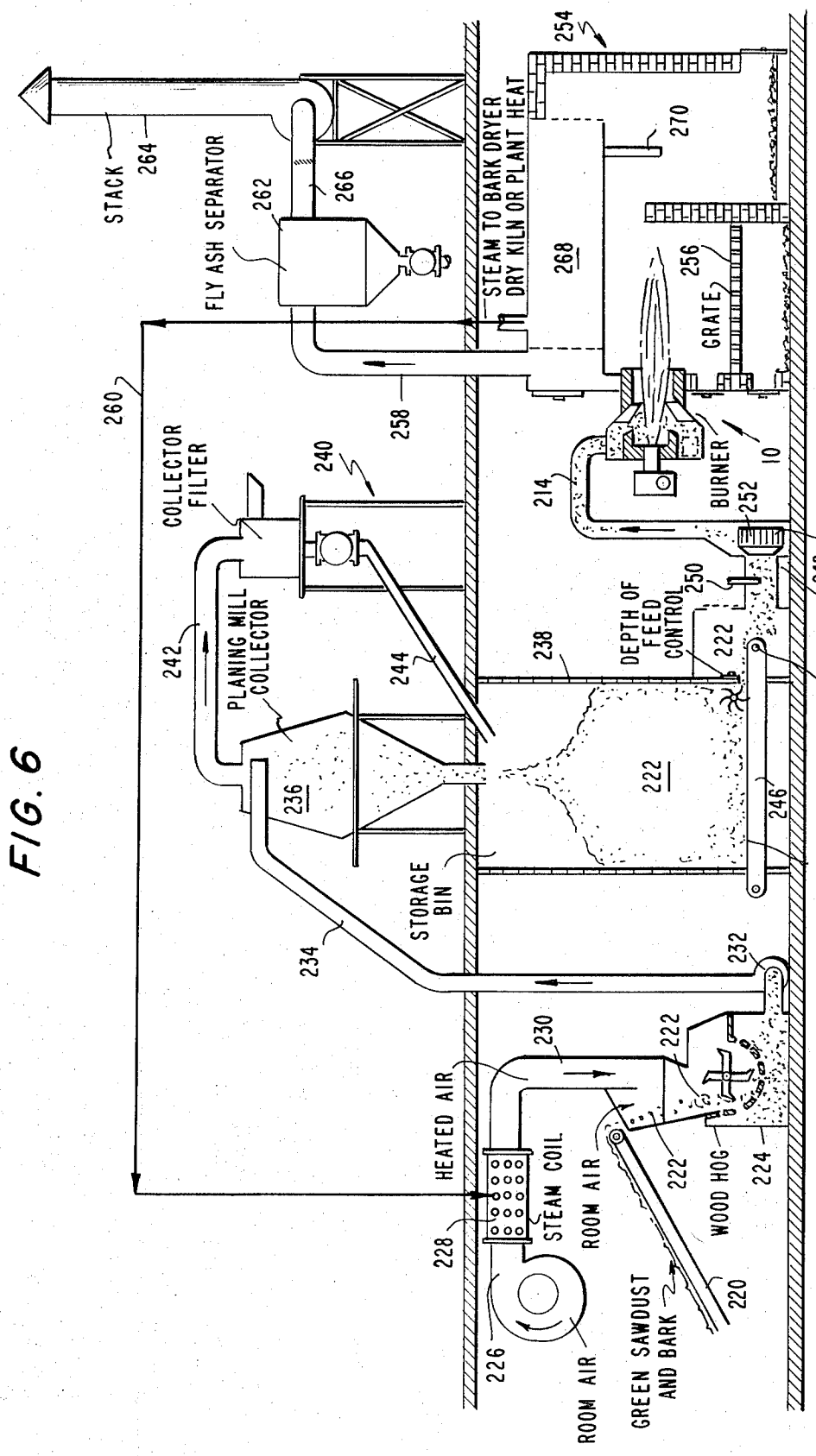

STACK
264
FLY ASH SEPARATOR
262
266
STEAM TO BARK DRYER
DRY KILN OR PLANT HEAT
254
270
HRT BOILER
268
256
GRATE
260
258
COLLECTOR
FILTER
240
214
BURNER
10
CONVEYING AND
COMBUSTION AIR
FAN
252
248
250
DEPTH OF
FEED
CONTROL
242
PLANING MILL
COLLECTOR
244
238
222
VARIABLE SPEED
DRIVE METERING
CONTROL
236
246
STORAGE
BIN
CONVEYOR
234
232
230
222
HEATED AIR
STEAM COIL
ROOM AIR
WOOD HOG
224
228
220
226
ROOM AIR
GREEN SAWDUST
AND BARK

FIG. 6

PROCESS USING A COMBINATION, OIL, GAS, AND/OR SOLID BURNER

This is a continuation-in-part application of my copending application, Ser. No. 294,620, filed Oct. 3, 1972 and now U.S. Pat. No. 3,827,851.

Numerous types of conventional processes use multi-fuel burning devices which are known in the prior art as operable to burn individually and simultaneously liquid, gaseous, and solid particle fuels. These prior art devices are adapted to burn oil, natural gas, liquid propane gas, and an air suspension of either coal particles or wood particles. In all of the prior art devices used in those conventional processes the nozzle and burner cone structural portions of the burners are constructed in a special and sometimes very complicated manner to properly place the materials in such a position at the throat of the burner so the combustion is maximized and may operate individually or simultaneously as desired. These prior art multi-fuel burning devices have numerous fuel directing structures to swirl or twist the flow of fuel coming from the flame end of the burning device. These swirling and flow twisting devices depend upon auxiliary mechanical means not included in the combustion portions of the burning apparatus to accomplish the flame and fuel flow. In all the prior art multi-fuel burning devices the apparatus is specifically constructed to burn the fuels individually or simultaneously through means of the complicated burner structures, and the burner structures are not particularly adapted to use any existing burner components or dual combination burners.

In one preferred specific embodiment, a process utilizes a combination burner structure which includes an inner burner for oil and/or gas fuels mounted with a refractory primary combustion chamber and a wood-air mixture passageway surrounding the oil and/or gas burner and in flow communication with the primary combustion chamber outlet which is operable to burn either oil, gas, or solids either separately or in any combination thereof. The inner burner is a conventional oil and/or gas burner of the forced draft type having a blower adapted to force air through the burning device, oil burning nozzles, and gas burning nozzles; the outlet of the burner is adapted to be placed in the small portion of the primary combustion chamber. The remaining structure of the combination burner includes the primary combustion chamber with an annular passageway therearound having a manifold connected thereto to pass an oxygen containing gas and solid fuel mixture from appropriate sources into the passageway at the outlet of the primary combustion chamber, and a conduit connecting the burning device with a furnace wall or the like. The combination burner structure is connected with a furnace or the like by a conduit connecting the outlet of the passageway surrounding the primary combustion chamber to the firebox portion of a furnace. The process introduces the particulate combustible material into the burner. The particulate material is preferably dried before introducing it into the burner.

One object of this invention is to provide a process which utilizes a combination oil, gas, and/or solid burner structure overcoming the aforementioned disadvantages of the prior art devices.

Still, one other object of this invention is to provide a process having use of a combination oil, gas, and/or solid burner adapted to burn oil, gas or solid fuels simultaneously or individually.

Still, another object of this invention is to provide a process which uses a combination burner adapted to burn oil, gas, or solid fuels individually or simultaneously and utilizing a conventional oil and/or gas burner therein.

Yet, another object of this invention is to provide a process which utilizes a combination burner having in coaxial relation a conventional oil and/or gas burner, a primary combustion chamber, a passageway to introduce an oxygen containing gas and solid fuel mixture at the outlet of the primary combustion chamber, and a conduit to connect the combination burner to a furnace wall or the like.

Yet, an additional object of this invention is to provide a process having use of a combination burner with adjustable vanes in a passageway therein for directing the flow of an oxygen containing gas and solid fuel mixture to the outlet of the burner.

Still, one other object of this invention is to provide a process for burning combustible particulate material having a combination burner with means to control the combustion of its oil, gas, or solid fuels supplied thereto separately or in combination depending on whether the burner is operating with the fuels individually or in any combination thereof.

Various other objects, advantages, and features of the invention will become apparent to those skilled in the art from the following discussion, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a side elevation view of the combination burner mounted with a furnace, showing only a portion of the furnace and having portions of the combination burner and furnace wall cut away for clarity;

FIG. **2** is a side elevation view of the combination burner and the adjacent portion of a furnace burner entryway showing in cross-section the furnace wall and the combination burner with the oil and/or gas burner housing portion thereof shown in full view;

FIG. **3** is a flame end elevation view of the combination burner alone having portions thereof cut away;

FIG. **4** is an elevation view of the combination burner manifold taken from the outer end having the oil and/or gas burner apparatus removed therefrom;

FIG. **5** is a side elevation view of the combination burner having an auxiliary blower in communication with the plenum chamber of the burner structure; and

FIG. **6** is a schematic diagram disclosing the process which utilizes the combination burner.

The following is a discussion and description of preferred specific embodiments of the process and the combination oil, gas, and/or solid fuel burner structure of this invention, such being made with reference to the drawings, whereupon the same reference numerals are used to indicate the same or similar parts and/or structure. It is to be understood that such discussion and description is not to unduly limit the scope of the invention.

Referring to the drawings in detail and in particular to FIG. **1**, a combination oil, gas, and/or solid fuel burner structure used in the process of this invention, indicated at **10**, is shown mounted with the burner end portion of a furnace apparatus, indicated at **12**. The combination oil, gas, and/or solid fuel burner **10** includes a conventional oil and/or gas burner apparatus or inner burner **14** mounted with a primary combustion

chamber **16**, a manifold or plenum chamber **18** to contain an oxygen containing gas and the particulate solid fuel mixture, a passageway with flow-directing vanes **20** therein to pass the solid fuel mixture to a position adjacent the outer end of the primary combustion chamber **16**, and a connecting conduit **22** adapted to connect the combination burner with the furnace apparatus **12**. The combination burner **10** of this invention is adapted to be connected with oil, gas, and solid fuel sources and operate to burn each in combination or individually as desired and to control the combustion thereof. Oil and gas fuels are supplied to the conventional combination oil and/or gas gurner portion of the combination burner **10** by means appropriate and well known in the conventional oil and gas burner art. Solid material is supplied in particulate form to the combination burner **10**. Preferably, the solid fuel is a combustible fuel having a small amount of ash, for example, wood, some plastic materials, and coal which can be particulated into small pieces by hogging equipment or other grinding methods; such fuel is transported to the combination burner by an air blower system that is auxiliary to the actual combination burner and is adapted to move the particular solid fuel in a stream of air. In the solid fuel transportation device the air furnishes means to move the wood and a supply of air for combustion of the solid material.

The inner burner portion **14** of this invention is a conventional type of oil and/or gas burner adapted to burn oil or gas or the combination thereof in a forced airflow environment. The conventional burner **14** is shown connected to an oil line **30** and a gas line **32** and has a blower, generally illustrated as **200**, adapted to force air through the outlet portion **34** which contains the oil and gas nozzles and other apparatus of the burner. Blower **200** has a fan **202** for sucking air through louvers **204** to provide the oxygen for combustion. The louvers **204** have controlled openings which are regulated by a servo-controller means **206** (well known within the art) via linkage means **208**. The conventional burner structure **14** is essentially the same as conventionally used for the burning of oil and/or gas fuels and includes a pilot burner and flame detector having portions of the apparatus modified to make the control system compensate and consider the solid fuel burning. FIG. **2** shows in detail the outlet portion **34** of the conventional burner **14** in place in the remaining portions of the combination burner structure **10**. The outlet portion of the conventional burner **34** includes an oil distribution nozzle **36**, gas distribution nozzles **38**, oil flame ignition devices **40**, an oil nozzle baffle **42**, and gas nozzle baffles **44**. The end portion of the conventional burner outlet portion **34** is positioned at the interior mouth of the primary combustion chamber **16**. The conventional burner **14** has a pilot burner **46**, visible in FIG. **2** and FIG. **3** of the drawings, extending into the outer portion **34** from the exterior thereof adapted to maintain and direct a flame in the direction of a flame normally produced by the conventional burner and adapted to be used in lighting the burner apparatus.

The primary combustion chamber **16**, manifold **18**, and passageway **20** are constructed in an integral fashion as shown in FIG. **2** of the drawings. The primary combustion chamber **16** is a frust-conical structure and is referred to in the hereinafter as a cone. The cone **16** forms an inner cone-like portion of the assembly with the manifold **18** and passageway **20** therearound enclosed by an outer cone assembly generally indicated at **50**. The outer cone assembly **50** includes a circular front cover **52** to which the conventional burner apparatus **14** is mounted, a plenum outer ring **54**, a plenum inner ring **56**, a passageway outer cone **58**, a passageway inner cone **60**, and a plenum inlet **62**. The front cover member **52** is a circular plate member having a plurality of access holes **64** on the periphery thereof to provide access to the plenum chamber **51**. Preferably, four (**4**) access holes are provided into the plenum chamber **51**, these having access hole covers **66** with viewing ports **68**. The access hole covers **66** are threadedly attached to the front cover **52** and removable by the use of lugs **70** on their outer portion. The front cover has an aperture **72** in the center thereof to receive the outer portion **34** of the conventional burner apparatus **14** with a notch **74** therein to receive the pilot burner **46**. The front cover **52** also has a plurality of lugs **76** extending therefrom to secure the conventional burner **14**. The combination burner **10** when mounted is supported partially by collars **78** secured to opposite sides of the front cover **52**. A flame viewing port **82** is provided in the structure of the combination burner **10** with the eye piece portion thereof extending through the front cover **52** as shown in FIG. **2** and FIG. **4**.

The manifold structure **18** is bounded on one side by the outer peripheral portion of the front cover **52**, on its outer portion by the plenum outer ring **54**, on its inner portion by the plenum inner ring **56**, and on its other side by the passageway **20**. The plenum chamber **51** is comprised of the annular ring-like space formed between the inner and outer plenum rings, the outer peripheral portion of the front cover **52** and the inner and outer cone portions **60** and **58**, respectively, of the passageway **20**, and the plenum chamber is opened to the connecting conduit **22** at the mouth of the cone **16**. The plenum inlet **62** is constructed to be tangent to the circular manifold assembly **18** and is provided with a flange thereon **84** to connect the plenum inlet **62** to a solid fuel mixture feed chute **86** or equivalent inlet conduit. FIG. **1** shows the plenum feed chute vertically disposed and leading to the combination burner apparatus **10**. In preferred construction of the feed chute apparatus, it would necessarily include inspection and access covers and the necessary clean-out fixtures. Specific details of the feed chute **86** and other accompanying apparatus are not shown in the drawings as they are not particular details of the herein disclosed invention. The plenum inner and outer rings **56** and **54**, respectively, are cylindrical members positioned coaxially relative to each other and to the conventional burner apparatus **14**; they are preferably welded in construction to the front cover **52**. The passageway outer and inner cones **58** and **60**, respectively, are frusto-conical forms positioned coaxially relative each other and relative to the conventional or inner burner apparatus **14**; they are preferably in construction welded to the inner and outer plenum rings **56** and **54**, respectively, producing a substantially sealed plenum chamber **51**.

In the interior portion of the plenum chamber outlet, the passageway portion **20** thereof has a plurality of vanes or baffles **88** mounted therein. The vanes **88** serve to direct air and solid mixture flow through the passageway **20** into the interior of the conduit **22**. The vanes **88** are preferably adjustable in their angular posi-

tion and for this purpose have a stud bolt **90** secured thereto that has a nut-shaped outer end portion **92.** The nut-shaped portion **92** is engaged by a nut **94** on the threaded shank portion thereof to hold same in a fixed position relative the passageway outer cone **58.** The vanes **88** are preferably shaped as shown in FIG. **2** of the drawings. The stud bolt **90** and lock nut **94** of the vane apparatus enable each vane to be turned in its relative position inside the passageway by use of wrenches contacting the lock nut **94** and nut-shaped outer end portion **92** of the stud **90** on the exterior of the passageway outer cone **58.** The nut **94** locks the position of the stud **90** and the vane **88,** and the nut-shaped portion **92** of the stud **90** can be used to rotate the angular position of the vane **88.**

On the interior of the inner plenum ring **56** and the inner passageway cone **60** a plurality of refractory anchors are attached thereto. These anchors function to hold the refractory material of the refractory cone **16** in position and in contact with the plenum rings and passageway cone **58** and **60.** Preferably, U-shaped anchors **96** are used on the passageway inner cone **60,** and T-shaped anchors **98** are used on the plenum inner ring **56.** The refractory material indicated at **100** is preferably a plastic type of refractory material which is moldable into the desired shape needed to form the refractory cone **16** of the combination burner **10** of this invention. A layer of insulative material, indicated at **101,** is placed between the refractory cone **16** and the front cover **52** in the circular area inside the inner plenum ring **56.**

The cone or primary combustion chamber **16** is formed between the front cover **52,** the plenum inner ring **56,** the passageway inner cone **60,** and has an aperture therethrough connecting with the aperture **72** on the front cover to receive the outlet portion **34** of the conventional oil and/or gas burner apparatus **14.** Primary combustion of fuels introduced by the combination burner takes place in the primary combustion chamber **16** or cone before the wood fuel is introduced into the combustion process. The cone **16** has a generally cylindrical sidewall **104** connecting the cone aperture **102** to the cone outer rim **106** in a general frustoconical form. The cone **16** preferably has a planar bottom **107** around the aperture **102** and rounded corners **109** at the sidewall junction. The refractory material anchors **96** and **98** are embedded within the refractory material **100** and constructed so as to be spaced a sufficient distance from the conical sidewall **104.** An additional aperture **108** is provided through the cone structure **16** as indicated at **108** connecting the viewing port **82** with the interior of the cone terminating at the conical sidewall **104.** The viewing port aperture **108** is constructed and placed so as to provide a person with a view of that portion of the burner structure in which combustion has taken place. The viewing port **82** is positioned as generally shown in FIG. **2** of the drawings.

The connecting conduit portion **22** of the combination burner apparatus **10** includes an outer conduit wall **110** lined with refractory material, mounted with the passageway outer cone **58** and mountable with the structure of a furnace. The conduit outer wall **110** is cylindrical and positioned coaxiliar with the conventional or inner burner apparatus **14,** the manifold **18,** and the passageway cone **20;** it is secured to the passageway outer cone **58** a short distance thereon and spaced from its rimmed portion **112.** A mounting ring **114** is secured to and extends perpendicularly from the conduit outer wall **110** and has a plurality of apertures **116** therethrough adapted to be engaged by stud bolts **118** which extend from the furnace wall **120.** A plurality of refractory anchors **122** having a T-shape extend inwardly from the conduit outer wall **110** to engage the refractory material **124.** Additionally, other refractory anchors indicated at **126** extend outward from the outer small end portion of the passageway outer conduit **58** to engage the end portion of the refractory material **124** in contact with that surface. A portion of insulative material indicated at **128** is placed inside the conduit outer wall **110** adjacent to the passageway outer cone **58** as shown in FIG. **2** of the drawings. The refractory material **124** is preferably a plastic refractory material and molded to form inside the cylinderical outer wall **110** of the connecting conduit **22.** The inner end portion of the connecting conduit **22** is indicated at **130;** this end is preferably cut off flat so that it may be joined with the furnace wall interior and shaped accordingly. A lifting lug **131** is provided on the upper portion of the combination burner apparatus at the junction of the passageway outer cone **58** and the outer portion of the conduit outer wall **110** as shown to be used in installation of the burner apparatus **10.**

FIG. **1** shows the combination oil, gas, and/or solid fuel burner apparatus of this invention **10** mounted with a furnace **12.** The combination burner **10** is mounted with the furnace wall by having the mounting ring **114** secured to the furnace wall **138,** and having cantilevered beams **150** extending from the furnace wall above the burner apparatus **10** secured to the burner apparatus with vertical support members **152.** The furnace structure **12** includes a furnace wall **138** through which the burner apparatus is mounted, a fire area into which the flame of the burner apparatus is directed, a boiler **140** above the fire area, fire access door **143,** grates **144,** and ashpit **146,** and an ashpit cleanout door **148.** In the actual mounting of the burner apparatus **10** the outlet conduit **22** thereof enters the furnace wall **138** in a refractory mouth portion **120.** The mounting ring **114** around the outlet conduit **122** is secured to the furnace wall **138.** To compensate for the weight of the burner apparatus additional support is shown on the outer portion thereof to illustrate an additional support structure. A pair of cantilevered beams **150** extend outward from the furnace wall **138** above the burner apparatus **10,** one on each side thereof, and are joined by connecting members **152** with the collars **78** on the front cover **52.** The connecting members **152** are preferably joined by a universal joint for adjustment in mounting the burner apparatus. The lifting lugs **80** and **131** are provided as integral members of the burner apparatus and are convenient to use in installation of the burner apparatus **10.** In addition to the electrical, oil, and gas power required by the conventional burner apparatus **14,** a feed chute **86** must be installed to move with material to the burner apparatus **10** in an airflow. The outlet mouth portion from the burner apparatus **10** indicated at **120** and formed with the furnace wall **138** is shown as a rounded inlet in the drawings; however, such may be shaped as desired when necessary for a particular use or installation of the burner apparatus, and such is preferably constructed from plastic refractory material.

FIG. **5** discloses an auxiliary blower, generally illustrated as **210,** having the fan **202** and the servo-

controller means **206** for regulating the controlled openings of the louvers **204** via linkage means **208.** Support members **214** support the auxiliary blower **210** and the blower **200.** Blower **210** is in communication with the plenum chamber **51** and the conduit **58** via conduit **212** and provides combustion air when the conveying air for the combustible particulate material (e.g., sawdust) in conduit **214** is less than that required to provide combustion air for the total input to the burner **10.**

With continual reference to the drawings, in particular FIG. **6,** for operation of the process of this invention, a conveyor means **220** deposits combustible particulate material **222** into a wood hog/dryer **224** wherein the particulate material **222** is dried by free falling concurrently with heated air produced through conduit **230** by a blower **226** moving room air over a steam coil **228.** Drying permits burning in suspension and eliminates smoke to pass present pollution control requirements. Blower **232** transfers the dried particulate material through a conduit **234** into a planing mill collector means **236** from where it is passed by gravity into a storage bin **238.** A collector filter means **240** is in communication with the planing mill collector **236** through conduit **242** and **244,** and is a well known means within the art for collecting the light ends of the particulate matter. Conveyor means **246** transfers the dried particulate matter from bin **238** into an air gate bin, generally indicated as **248,** having an air gate **250** which preferably can only open to about 60 percent of the maximum flow in order to obtain a minimum firing rate through conduit **214.** A conveying and combustion air fan **252** conveys the dried particulate material plus combustion air through conduit **214** and into the burner **10.** Fan **252** is preferably a high pressure conveyor and conduit **214** is preferably small such that only about 25 percent of the air required for combustion is used to convey the fuel. The remaining 75 percent of the air required for combustion is preferably supplied by the auxiliary blower **210** (see FIG. **5**). The advantage of these operating conditions is that the burner **10** can operate at a lower firing rate (thus more efficient) than the system where all of the combustion air has to be provided by the fan **252.** This latter system is hindered in that due to turbulent conditions throttling of the combustion air (or conveying air) by fan **252** can only be to about 60 percent of the maximum. If the conveying airflow is reduced to less than about 60 percent of the maximum, the velocity in conduit **214** will not be high enough to carry the particulate matter. Therefore, the preferred embodiment is to keep the pressure of the conveying air high and about constant in a small diameter conduit **214** such that throttling air is essentially provided by fan **252** and combustion air is generally provided by the auxiliary fan **210.** This preferred embodiment has been found to be most efficient.

Burned particulate material is discharged into an HRT boiler, generally indicated as **254,** having a grate **256** and conduits **258** in communication therewith for conducting fly ash into a fly ash separator **262** which is in communication via conduit **266** with a stack **264.** Drum **268** is positioned within boiler **254** and receives heat therefrom to turn water entering through conduit **270** into steam so that the steam coils **228** might be replenished via conduit **260.**

In the use and operation of the burner apparatus **10** of this invention, it is necessary to supply the burner apparatus with the types of fuel necessary for its operation; namely, oil, gas (such as natural gas or liquid petroleum gas), and particulate solid material. The oil and gas fuels can be supplied to the burner apparatus **10** as required by the particular conventional combination burner apparatus **14,** which is a part of this invention. The particulate solid fuel is preferably wood, plastic, coal or other suitable substitutes which can be made very small in particle size so they will burn in suspension and only the ash will fall to the grate. It is to be noted the particulate solid fuel supplied need not be homogeneous in size or kind. This fuel is preferably stored in quantity and can be moved from the storage area by gravity or mechanical conveying systems. Depending upon the situation, the mechanical conveyance can be accomplished by the use of blowers, screw augers, or conveyor belts and the like. In the event the conveyance system is not an air distribution type, the solid fuel must be fed into an auxiliary blowing device connected to the burner apparatus. The gaseous stream which conveys the solid material to the burner apparatus furnishes the energy to carry the solid fuel particles through the feed chute **86,** the manifold **18** and on through the passageway **20** and also supplies oxygen for combustion of the solid fuel. Normally air can be used to supply the oxygen containing gaseous stream to carry the particulate wood material to the burner apparatus; however, it is to be understood that any gas can be used which has an oxygen content sufficient to sustain combustion of the solid fuel.

In the normal operation of the combination burner in the process invention when operating on all three fuels, (oil, gas and solid), the solid fuel and air mixture enters the burner manifold inlet **62** and passes through the plenum chamber and passageway under pressure, then is driven into the existing oil and/or gas flame furnished by the auxiliary oil and/or gas burner apparatus **14.** As the solid fuel mixture passes through the manifold **18,** and more particularly through the passageway **20** with the vanes **88** therein, it is thoroughly mixed before leaving the discharge end of the passageway **20.** The turbulence of the solid fuel mixture from the auxiliary burner **14** mixing with the turbulence of the solid fuel mixture from the passageway and the immediate introduction to the high temperature flame area maintained by the auxiliary burner **14** results in a rapid combustion of all the introduced fuels. Normal operation of the burner apparatus **10** can include operation of the conventional burner apparatus **14** along with the solid burning portion of the device; however, it is to be noted that the conventional burner apparatus **14** can be operated without the benefit of the solid fuel, and likewise the burner apparatus **10** can be operated without the conventional burner apparatus **14** being in operation. The conventional burner apparatus **14** is necessary to start the solid fuel flame burning and may be necessary to maintain the solid fuel flame depending upon the firing conditions.

In conjunction with the physical apparatus of the combination burner **10** the device necessarily has auxiliary control devices necessary for its operation. One controlling device controls the amount of solid fuel and air or oxygen containing gas delivered to the burner. The input of solid fuel mixture will increase or decrease as required to maintain desired conditions in the boiler. If the burner is unable to maintain the desired steam pressure the control will cause more of the solid fuel

mixture to be delivered to the burner; in the event it is still unable to maintain the desired steam pressure, the conventional burner apparatus **14** is actuated so as to increase the heat produced as necessary. Another portion of the control device regulates the conventional burner apparatus **14** and is adapted to function mainly upon the start-up of the burner or as needed. Upon start-up of the burner apparatus **10,** the operating and limit controls of the auxiliary burner apparatus are actuated first. The auxiliary burner **14** purges the furnace for the normal prepurge cycle commonly associated with conventional oil and/or gas burner devices. The pilot system is then energized and the main fuel is ignited; in this instance it can be either oil and/or gas fuel. After the flame has been proved by a flame safeguard system on the conventional burner apparatus, the blower system for the solid fuel is started and the flow control apparatus allows movement of solid fuel into the feed chute **86** and on into the burner apparatus **10.** At any time during the operation of the burner apparatus, if a flame is not proved by the safeguard system, then the auxiliary burner apparatus fuel valves will close and stop that system, and the solid burner blower system will stop and the volume control will close thereby shutting down the burner apparatus. If any time in the operation of the burner apparatus **10** any operating or limit control therewith opens, then the auxiliary burner fuel valves will close and the wood blower will stop, and its volume control will close thereby stopping operation of the burner apparatus. In any of the shut-down modes or operations it is preferred that the blower of the conventional and auxiliary burner apparatus **14** post-purge the furnace for a short time before stopping.

In the manufacture of the combination oil, gas, and-/or solid burner structure utilized in the process of this invention, it is obvious that the burner structure can be produced by means consistent with current burner manufacture to achieve the end product. The combination burner apparatus of this invention can be installed with a blower furnace or other furnace in the same manner as a conventional combination burner apparatus in the prior art, making only small allowances for support of the outer portion of the structure.

In the use and operation of the combination oil, gas, and/or solid burner structure of this invention, it is seen that same provides a means of burning simultaneously or individually oil, gas, and/or solid fuels and that same is adaptable for use with furnaces the same as other prior art and conventional combination burner structures. Additionally, in the use and operation of the combination burner structure of this invention, it is seen that same provides a means of burning solid material in a forced airflow along with oil or gas fuels and in any combination therewith.

As will become apparent from the foregoing description of the applicant's process and combination oil, gas, and/or solid burner structure, relatively simple means have been provided to burn particulate solid fuel in combination with oil and/or gas fuels. The process and combination burner structure are simple to use, adapted to be used with conventional oil and/or gas burner devices and requires little additional apparatus for its operation and installation with a furnace. The process and combination burner structure is economical in that it allows use of oil, gas, and particulate solid fuels to be used in the burner or any combination thereof, whichever is most economically suitable depending upon the cost of the fuels at a particular location. The process and burner apparatus of this invention is adapted to burn solid combustible material which can be combustible scraps or by-products of a manufacturing facility.

While the invention has been described in conjunction with preferred specific embodiments thereof, it will be understood that this description is intended to illustrate and not to limit the scope of the invention, which is defined by the following claims.

I claim:

1. The process for burning combustible particulate material comprising introducing said particulate material into a combination burner means adapted to burn oil, gas, and/or solid fuels, having a fuel oil and/or gas inner burner means having means therewith to connect same to a source of oxygen containing gas, a primary combustion chamber having a divergent end portion and positioned adjacent and in substantially coaxial surrounding relation with the outlet of said inner burner means, a passageway, the outer end thereof adjacent and in flow communication with the outlet of said combustion chamber, means with the inlet of said passageway to connect same to a source of oxygen containing gas and a source of particulate combustible solid material, a conduit in one end portion surrounding and in communication with said outlet end of said passageway and said primary combustion chamber and mountable in the other end portion in a furnace wall or the like, said combination burner means being constructed and adapted to burn fuel oil and/or gas in said inner burner means and said combustion chamber, and simultaneously or alone subsequent to said burning burn combustible particulate solid material passed with oxygen containing gas through said passageway into the outlet of said combustion chamber, said passageway in operation passes said solid material and said oxygen containing gas mixture into said conduit at said divergent end portion of said combustion chamber for the combustion of said mixture, said passageway is annular and surrounds said divergent end of said primary combustion chamber, said passageway has a plurality of adjustably mounted air-directing vanes therein, and said means with the inlet of said passageway to connect same to a source of oxygen containing gas and a source of particulate solid material is a manifold means.

2. The process of claim **1** additionally including drying said combustible particulate material in a drying zone prior to said introducing.

3. The process of claim **2** additionally including passing said dried particulate material into a storage bin prior to said introducing.

4. The process of claim **1** wherein said burner additionally includes an auxiliary blower means in communication with said passageway therein to supply the majority of the air for combustion.

5. The process of claim **1** wherein said primary combustion chamber has a generally frusto-conical interior portion, and said inner burner means has the outlet thereof in a burner aperture at the apex portion of said primary combustion chamber adapted in operation to direct a flame on the interior thereof toward the divergent end portion thereof.

6. The process of claim **5** wherein said manifold means has an annular manifold portion having an inlet thereto operably connected to said oxygen containing

gas and said solid material sources and an outlet therefrom connected said passageway at said inlet thereof, and said air-directing vanes are adapted in operation to direct said solid material and said oxygen containing gas in a mixture of fuel in a straight or a swirling manner relative said primary combustion chamber.

7. The process of claim **6** wherein said cone is constructed of refractory type material, and said conduit is lined with refractory type material.

8. The process of claim **6** wherein said oxygen containing gas is air.

9. The process of claim **8** wherein said particulate solid material is wood material.

10. The process of claim **8** wherein said particulate solid material is plastic material.

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