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(54) LOW NO× FUEL INJECTION FOR AN INDURATING FURNACE

NOX-ARME BRENNSTOFFEINSPRITZUNG FÜR EINEN AUSHÄRTUNGSOFEN

INJECTION DE COMBUSTIBLE À FAIBLE TENEUR EN NO× POUR UN FOUR DE CONSOLIDATION

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Description

TECHNICAL FIELD

[0001] This technology relates to a heating system in which combustion produces oxides of nitrogen (NO_x), and specifically relates to a method and apparatus for suppressing the production of NO_x in an indurating furnace.

BACKGROUND

[0002] Certain industrial processes, such as heating a load in a furnace, rely on heat produced by the combustion of fuel and oxidant. The fuel is typically natural gas. The oxidant is typically air, vitiated air, oxygen, or air enriched with oxygen. Combustion of the fuel and oxidant causes NO_x to result from the combination of oxygen and nitrogen.

[0003] An indurating furnace is a particular type of furnace that is known to produce high levels of NO_x. Large quantities of pelletized material, such as pellets of iron ore, are advanced through an indurating process in which they are dried, heated to an elevated temperature, and then cooled. The elevated temperature induces an oxidizing reaction that hardens the material. When cooled, the indurated pellets are better able to withstand subsequent handling in storage and transportation.

[0004] The indurating furnace has sequential stations for the drying, heating, and cooling steps. Pelletized material is conveyed into the furnace, through the sequential stations, and outward from the furnace. Air shafts known as downcomers deliver downdrafts of preheated air to the heating stations. Burners at the downdrafts provide heat for the reaction that hardens the pelletized material.

[0005] An example of a pelletizing plant 10 with an indurating furnace 20 is shown schematically in Fig. 1. A movable grate 24 conveys loads of pelletized material 26 into the furnace 20, through various processing stations within the furnace 20, and then outward from the furnace 20. The processing stations include drying, heating, and cooling stations. In this particular example, the drying stations include an updraft drying station 30 and a downdraft drying station 32. The heating stations include preheat stations 34 and firing stations 36. First and second cooling stations 38 and 40 are located between the firing stations 36 and the furnace exit 42. Burners 44 are arranged at the preheating and firing stations 34 and 36.

[0006] A blower system 50 drives air to circulate through the furnace 20 along the flow paths indicated by the arrows shown in Fig. 1. As the pelletized material 26 advances from the firing stations 36 toward the exit 42, it is cooled by the incoming air at the first and second cooling stations 38 and 40. This causes the incoming air to become heated before it reaches the burners 44. The preheated air at the second cooling station 40 is directed through a duct system 52 to the updraft drying station 30 to begin drying the material 26 entering the furnace 20. The preheated air at the first cooling station 38, which is hotter, is directed to the firing and preheat stations 36 and 34 through a header 54 and downcomers 56 that descend from the header 52. Some of that preheated air, along with products of combustion from the firing stations 36, is circulated through the downdraft drying station 32 before passing through a gas cleaning station 58 and onward to an exhaust stack 60.

[0007] As shown for example in Fig. 2, each downcomer 54 defines a vertical passage 61 for directing a downdraft 63 from the header 52 to an adjacent heating station 36. Each burner 44 is arranged to project a flame 65 into a downcomer 54. Specifically, each burner 44 is mounted on a downcomer wall 66 in a position to project the flame 65 in a direction extending across the vertical passage 61 toward the heating station 36 to provide heat for the reaction that hardens the pelletized material 26.

[0008] The burner 44 of Fig. 2 is an inspirating burner, which injects fuel and ambient temperature primary air. Some of the preheated air from the downdraft 63 is inspirated by the fuel and primary air through an inspirator 68. The fuel, primary air, and inspirated air form a fuel-rich diffusion-type flame which propagates into the downdraft 63, where the large excess of air in the downdraft 63 results in an overall ratio that is highly fuel lean, and thus high in oxygen content. This propagation of a fuel-rich diffusion-type flame into a highly preheated excess of combustion air produces high levels of interaction NOx as the unmixed or poorly mixed fuel interacts with the high temperature downdraft air in a fuel-lean atmosphere with a large excess of oxygen. US 2010/244,337 discloses a method and apparatus for achieving low NOx combustion,

[0009] US 2010/0244337 A1 discloses a method and apparatus for achieving low NOx combustion in accordance with the preamble of claims 1 and 4.

SUMMARY

[0010] A method in accordance with claim 1 and an apparatus in accordance with claim 4 to achieve a low NOx combustion of fuel gas in a furnace combustion chamber is is provided.In preferred embodiments, the furnace combustion chamber is a downcomer passage in an indurating furnace.

[0011] The method delivers fuel gas to the furnace combustion chamber from a premix burner having a reaction zone with an outlet to the furnace combustion chamber. This includes the steps of injecting a premix of primary fuel gas and combustion air into the reaction zone, preferably injecting radial fuel gas into the reaction zone in a direction radially outward from an axis, and combusting those reactants to provide combustion products including vitiated combustion air in the reaction zone. Further steps include separately injecting staged fuel gas into the vitiated combustion air in the reaction zone, discharging the staged fuel gas and vitiated combustion air from the reaction zone through the outlet to the furnace combustion chamber, and combusting the staged fuel gas and vitiated combustion air in the furnace combustion chamber. This enables low NOx combustion in the furnace combustion chamber to be achieved as a result of interacting the staged fuel gas with the vitiated combustion air in the reaction zone.

[0012] The apparatus includes a burner structure defining a reaction zone with an outlet to the furnace combustion chamber. A mixer tube has an inlet connected to sources of primary fuel gas and combustion air, and has an outlet to the reaction zone. The apparatus preferably further includes a radial flame burner connected to sources of radial fuel gas and combustion air, and arranged to fire into the reaction zone. A staged fuel injector is connected to a source of staged fuel gas, and is arranged to inject the staged fuel gas into the reaction zone separately from the other injected reactants. The staged fuel gas can thus interact with vitiated combustion air in the reaction zone to produce low NOx combustion in the furnace combustion chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a schematic view of a pelletizing plant including an indurating furnace known in the prior art.
Fig. 2 is an enlarged partial view of parts of the prior art indurating furnace of Fig. 1.
Figs. 3 and 4 are schematic views similar to Fig. 2, but show embodiments of an indurating furnace that are not known in the prior art.
Figs. 5-8 are similar to Figs. 3 and 4, showing alternative embodiments of an indurating furnace.
Figs. 9-12 show other alternative embodiments of an indurating furnace with elements of the present invention.

DETAILED DESCRIPTION

[0014] As shown partially in Fig. 3, an indurating furnace 100 is equipped with burners 102, one of which is shown in the drawing. The furnace 100 also has a reactant supply and control system 104 for operating the burners 102. The furnace 100 is thus configured according to the invention disclosed and claimed in copending U. S. Patent Application 12/555,515 (US 2010/0244337 A1), filed 09/02/2009, which is commonly owned by the Assignee of the present application. The furnace 100 may otherwise be the same as the furnace 20 described above, with downcomers 110 defining vertical passages 111 for directing downdrafts 113 from a header to adjacent heating stations 114. As set forth in the copending application, each burner 102 is mounted on a corresponding downcomer wall 116 in a position to project a premix flame 119 into the downdraft 113 in a direction toward the heating station 114. This provides heat for a reaction that hardens pelletized material 124 on a movable grate 126 at the heating station 114.

[0015] In the illustrated embodiment, the flame 119 is projected across the downcomer 110 toward a toward a horizontal lower end section 125 of the vertical passage 111 that terminates adjacent to the heating station 114. Although the illustrated downcomer 110 has a predominantly vertical passage 111, any suitable arrangement or combination of differently oriented passages for conveying a preheated recirculation air draft to an indurating heating station may be utilized.

[0016] The burners 102 are preferably configured as premix burners with the structure shown in the drawing. This burner structure has a rear portion 140 defining an oxidant plenum 141 and a fuel plenum 143. The oxidant plenum 141 receives a stream of unheated atmospheric air from a blower system 144. The fuel plenum 143 receives a stream of fuel from the plant supply of natural gas 146.

[0017] Mixer tubes 148 are located within the oxidant plenum 141. The mixer tubes 148 are preferably arranged in a circular array centered on a longitudinal axis 149. Each mixer tube 148 has an open inner end that receives a stream of combustion air directly from within the oxidant plenum 141. Each mixer tube 148 also receives streams of fuel from fuel conduits 150 that extend from the fuel plenum 143 into the mixer tube 148. These streams of fuel and combustion air flow through the mixer tubes 148 to form a combustible mixture known as premix.

[0018] An outer portion 160 of the burner 102 defines a reaction zone 161 with an outlet port 163. The premix is ignited in the reaction zone 161 upon emerging from the open outer ends of the mixer tubes 148. Ignition is initially accomplished by use of an igniter before the reaction zone 161 reaches the auto-ignition temperature of the premix. Combustion proceeds as the premix is injected from the outlet port 163 into the downcomer 110 to mix with the downdraft 113. The fuel in the premix is then burned in a combustible mixture with both premix air and downdraft air. By mixing the fuel with combustion air to form premix, the burner 102 avoids the production of interaction NO_x that would occur if the fuel were unmixed or only partially mixed with combustion air before mixing into the downdraft air.

[0019] As further shown in Fig. 3, the reactant supply and control system 104 includes a duct 180 through which the blower system 144 receives unheated air from the ambient atmosphere. Another duct 182 extends from the blower system 144 to the oxidant plenum 141 at the burner 102. A fuel line 184 communicates the fuel source 146 with the fuel plenum 143 at the burner 102. Other parts of the system 104 include a controller 186, oxidant control valves 188, and fuel control valves 190.

[0020] The controller 186 has hardware and/or software that is configured for operation of the burner 102, and may comprise any suitable programmable logic controller or other controlled device, or combination of controlled devices, that is programmed or otherwise configured to perform as described and claimed. As the controller 186 carries out those instructions, it operates the valves 188 and 190 to initiate, regulate, and terminate flows of reactant streams that cause the burner 102 to fire the premix flame 119 into the downcomer 110. The controller 186 is preferably configured to operate the valves 188 and 190 such that the fuel and combustion air are delivered to the burner 102 in amounts that form premix having a lean fuel-to-oxidant ratio. The fuel-lean composition of the premix helps to avoid the production of interaction NO_x in the downdraft 113.

[0021] Although the premix produces less interaction NO_x upon combustion of the fuel-air mixture in the high temperature downdraft 113, this has an efficiency penalty because it requires more fuel to heat the cold atmospheric air in the premix. The efficiency penalty is greater if the premix has excess air to establish a lean fuel-to-oxidant ratio. However, the efficiency penalty can be reduced or avoided by using an embodiment of the invention that includes preheated air in the premix. For example, in the embodiment shown in Fig. 4, the reactant supply and control system 104 includes a duct 200 for supplying the burner 102 with preheated downdraft air from the downcomer 110. As in the embodiment of Fig. 3, the controller 186 in the embodiment of Fig. 4 is preferably configured to operate the valves 188 and 190 such that the fuel gas, the unheated air, and the preheated air are delivered to the burner 102 in amounts that form premix having a lean fuel-to-oxidant ratio.

[0022] The embodiment of Fig. 5 also reduces the efficiency penalty caused by the premix in the embodiment of Fig. 3. In this embodiment, the reactant supply and control system 104 includes a fuel branch line 206 with a control valve 208. As shown schematically, the branch line 206 terminates at a fuel injection port 210 that is spaced axially downstream from the burner 102. The reactant supply and control system 104 is thus configured to supply primary fuel gas and combustion air to the premix burner 102, and to separately inject second stage fuel gas into the downcomer 110 without combustion air. The controller 186 is preferably configured to operate the valves 188, 190 and 208 such that primary fuel and combustion air are delivered to the burner 102 in amounts that form premix having a lean fuel-to-oxidant ratio, while simultaneously providing the branch line 206 with second stage fuel in an amount that is stoichiometric with the premix supplied to the burner 102. Since the premix in this embodiment includes less than the total target rate of fuel, it can include a correspondingly lesser amount of unheated air to establish a lean fuel-to-oxidant ratio. The lesser amount of unheated air in the premix causes a lower efficiency penalty.

[0023] An additional NO_x suppression feature of the invention appears in Fig. 5 where the downcomer 110 is shown to have a recessed wall portion 220. This portion 220 of the downcomer 110 defines a combustion zone 221 that is recessed from the vertical passage 111. The burner 102 is mounted on the recessed wall portion 220 of the downcomer 110 so as to inject premix directly into the combustion zone 221 rather than directly into the vertical passage 111.

[0024] In the embodiment of Fig. 5, the premix flame 119 projects fully through the combustion zone 221 and into the vertical passage 111. The controller 186 could provide the burner 102 with fuel and combustion air at lower flow rates to cause the premix flame 119 to project only partially through the combustion zone 221 and thereby to produce less interaction NO_x in the vertical passage 111. As shown in Fig. 6, a deeper combustion zone 225 could have the same effect without reducing the reactant flow rates.

[0025] Additional suppression of interaction NO_x can be achieved with differently staged fuel injection ports along with a recessed combustion zone. As shown for example in Fig. 7, these may include a port 230 for injecting staged fuel directly into the recessed combustion zone 225, a port 232 for injecting staged fuel directly into the vertical passage 111 upstream of the recessed combustion zone 225, and a port 234 for injecting staged fuel into the vertical passage 111 at a location downstream of the recessed combustion zone 225.

[0026] The embodiment of Fig. 8 has another alternative arrangement of staged fuel injector ports 236. These ports 236 are all arranged on the downcomer wall 116 in positions spaced radially from the burner port 163, and are preferably arranged in a circular array centered on the burner axis 149. The reactant supply and control system 104 includes a staged fuel control valve 238 for diverting fuel to a manifold 240 that distributes the diverted fuel to each port 236 equally. The ports 236 together inject that fuel into the downcomer 110 in a circular array of second stage streams. The ports 236 may be configured to inject the second stage fuel streams in directions that are parallel to and/or inclined toward the axis 149.

[0027] The temperature of the preheated air in the downdraft 113 is typically expected to be in the range of 815 to 1093 degrees C (1,500 to 2,000 degrees F), which is above the auto-ignition temperature of the fuel gas. For natural gas, the auto-ignition temperature is typically in the range of 538 to 649 degrees C (1,000 to 1,200 degrees F).

[0028] Therefore, in the embodiments of Figs. 4-7, which use preheated downdraft air along with ambient air to form premix with the fuel gas, the downdraft air is mixed with the ambient air before being mixed with the fuel gas. This cools the downdraft air to a temperature below the auto-ignition temperature to prevent the fuel from igniting inside the mixer tubes 146 before the premix enters the downcomer 110.

[0029] The pelletizing process typically requires temperatures approaching 1316 to 1371 degrees C (2,400-2,500 degrees F).

[0030] These processing temperatures at the heating stations 114 could be provided by combustion with peak flame temperatures of 1371 to 1538 degrees C

(2,500-2,800 degrees F) in the adjacent downcomers 110. These peak flame temperatures could be maintained by combustion of natural gas and preheated air of 815 to 1093 degrees C (1,500-2,000 degrees F) and 200%-600% excess air. Preheated air of that temperature and amount is available in the downdrafts 113. However, since the downdraft air temperature of 815 to 1093 degrees C (1,500-2,000 degrees F) is higher than the auto-ignition temperature, the downdraft air can not form an unignited premix in the burners 102 if it is not first mixed with cooler air as noted above regarding Figs. 4-7.

[0031] In the embodiment shown in Fig. 9, the furnace 100 includes an alternative premix burner 300. This burner 300 has many parts that are the same or substantially the same as corresponding parts of the burner 102 described above, and such parts arc indicated by the same reference numbers in the drawings. The burner 300 thus has a rear portion 140 defining an oxidant plenum 141 and a fuel plenum 143. The oxidant plenum 141 receives combustion air from the oxidant duct 182. The fuel plenum 143 receives fuel gas from the fuel line 184.

[0032] Like the burner 102, the burner 300 has mixer tubes 148 that are preferably arranged in a circular array centered on a longitudinal axis 149. The mixer tubes 148 receive streams of combustion air from the oxidant plenum 141 and streams of fuel from fuel conduits 150 reaching from the fuel plenum 143. An outer portion 160 of the burner 300 defines a reaction zone 161 with an outlet port 163 to the downcomer passage 111. The premix is injected from the open outer ends of the mixer tubes 148 into the reaction zone 161.

[0033] The burner 300 of Fig. 9 also includes a secondary fuel line 310 with an outlet port 311 centered on the axis 149. The outlet port 311 is preferably provided as a high pressure nozzle, which may have any suitable configuration known in the art. The controller 186 is configured to operate a fuel supply valve 314 for the secondary fuel line 310 as described above.

[0034] The burner 300 further includes a radial flame burner 320 that is located concentrically between the secondary fuel outlet port 311 and the surrounding array of mixer tubes 148. The radial flame burner 320 can function as a combustion anchor structure as described in U.S. Patent No. 6,672,862.

[0035] The radial flame burner 320 has a radial fuel line 322 reaching concentrically over the secondary fuel line 310. A valve 324 supplies the radial fuel line 322 with fuel gas under the influence of the controller 186. As shown in enlarged detail in Fig. 9A, the outer end portion of the radial fuel line 322 has fuel ports 325 that face radially outward. A radial combustion air passage 327 reaches concentrically over the radial fuel line 322. A spin plate 328 is located at the outer end of the passage 327, and a surrounding refractory surface 330 is tapered outwardly from the passage 327.

[0036] In operation of the embodiment of Fig. 9, a premix of primary fuel and primary combustion air is injected from the mixer tubes 148 into the reaction zone 161. Radial fuel is injected from the ports 325 into the reaction zone 161 in radially outward directions. Radial combustion air is injected from the passage 327 into the reaction zone 161 through the spin plate 328, which induces a swirl that carries the radial fuel and combustion air radially outward across the tapered refractory surface 330 toward the injected streams of premix. Combustion of those reactants in the reaction zone 161 then provides combustion products including vitiated combustion air.

[0037] Secondary fuel is injected from the secondary fuel outlet port 311 in a jet reaching axially across the reaction zone 161. The secondary fuel mixes with the vitiated combustion air in the reaction zone 161. Combustion then proceeds as the contents of the reaction zone 161 move toward and through the outlet port 163 to the downcomer passage 111. Because the secondary fuel mixes with vitiated combustion air in the reaction zone 161 before interacting with the downdraft 113, further combustion of secondary fuel in the downdraft 113 produces less NOx than it would if the secondary fuel were injected directly into the downdraft 113 as described above with reference to the embodiments of Figs. 1-8.

[0038] The radial flame burner 320 typically will account for 1% to 3% of the total fuel supplied to the burner 300 except when the burner 300 is firing at high turndown (typically 25% or less of maximum firing rate), in which case the proportion of the total fuel supplied by the radial flame burner 320 can be higher. In the best mode of operation, the proportion of the total fuel supplied in premix, or primary, fuel will be in a fuel-lean ratio with the combustion air, and will result in a calculated premix adiabatic flame temperature in the range of 2600 to 3200° F. The balance of the fuel, which will typically be sufficient, when added to the primary and radial fuel as secondary fuel, to provide a stoichiometric ratio between the total fuel and the air supplied to the burner 10.

[0039] The controller 186 can be further configured to operate the burner 300 of Fig. 9 in a mode in which some of the secondary fuel is supplied at the radial flame burner 320 instead of the secondary fuel line 310. The reaction zone 161 would then be supplied with a total amount of fuel in four portions including a portion of primary fuel at the mixer tubes 148, a portion of fuel sufficient to perform the anchoring function at the radial flame burner 320, a portion of secondary fuel that also is injected radially from the radial flame burner 320, and the remaining balance of the total amount as a portion of secondary fuel that is injected axially from the port 311.

[0040] In the embodiment of Fig. 10, the indurating furnace 100 is equipped with a premix burner 400 that differs from the premix burner 300 of Fig. 9 by having a reaction zone 401 that is tapered radially outward, whereas the reaction zone 161 is tapered radially inward.

[0041] In the embodiment of Fig. 11, the indurating furnace 100 is equipped with a premix burner 600 that differs from the premix burner 300 of Fig. 9 by having multiple secondary fuel injectors 602, each of which is located concentrically within a respective mixer tube 148. Each mixer tube 148 is supplied with primary fuel by the premix fuel conduits 150 reaching from the premix fuel plenum 143. In the illustrated embodiment, the secondary fuel injectors 602 are supplied with fuel from a separate fuel plenum 604. A secondary fuel valve 606 is operated by the controller 186 to supply the separate plenum 604 with secondary fuel separately from the primary fuel supplied to the premix fuel plenum 143. Alternatively, the secondary fuel injectors 602 could be supplied with fuel from the premix fuel plenum 143.

[0042] The premix burner 700 of Figure 12 differs from the premix burner 600 of Figure 11 by having a reaction zone 705 that is tapered radially outward, whereas the reaction zone 161 in the burner 600 is tapered radially inward.

Claims

1. A method for achieving low NOx combustion of fuel gas in heated pelletizing process air, comprising:

conveying pelletized material (26) through an indurating furnace (20), (100) having a heating station (36) and a passage (61) that directs heated process air to the heating station;
driving heated process air through the passage toward the heating station (36); and
operating a premix burner (102) having a reaction zone (161) with an outlet to the passage (61), including the steps of:

injecting a premix of primary fuel gas and combustion air into the reaction zone (161);
combusting the premix to provide combustion products including vitiated combustion air in the reaction zone (161);
injecting staged fuel gas into the reaction zone (161) separately from the premix;
discharging the staged fuel gas and vitiated combustion air from the reaction zone (161) through the outlet to the passage; and
combusting the staged fuel gas and vitiated combustion air in the heated process air in the passage (61), whereby low NOx combustion in the heated process air is achieved as a result of interacting the staged fuel gas with the vitiated combustion air in the reaction zone (161),

characterized in that
the reaction zone (161) has a central axis (149), and staged fuel gas is injected into the reaction zone (161) as a jet centered on the axis (149), or that the premix is injected into the reaction zone (161) from a mixer tube (148), and the staged fuel gas is injected into the reaction zone (161) from a staged fuel injector (602), located within the mixer tube (148).

2. A method as defined in claim 1 wherein the premix is injected into the reaction zone (161) in a fuel lean condition, whereby excess combustion air in the premix is available for vitiation in the reaction zone (161).

3. A method as defined in claim 1 wherein the staged fuel gas is injected into the reaction zone (161) from a high pressure nozzle.

4. An apparatus for achieving low NOx combustion in heated pelletizing process air, comprising:

an indurating furnace (20), (100) structure defining a heating station, a conveyor that conveys pelletized material to the heating station, and a passage (61) that directs heated pelletizing process air to the heating station (36);
sources of primary fuel gas, combustion air, and staged fuel gas; and
a premix burner (102) having:

a structure defining a reaction zone (161) with an outlet to the passage (61);
a mixer tube (148) having an inlet that receives primary fuel gas and combustion air from the respective sources, and having an outlet that discharges a premix of the primary fuel gas and combustion air into the reaction zone (161); and
a staged fuel injector (602), (830) that receives staged fuel gas from the respective source, and that injects the staged fuel gas into the reaction zone (161) separately from the premix, whereby the staged fuel gas can interact with vitiated combustion air in the reaction zone (161) to produce low NOx combustion in heated process air in the passage,

characterized in that
the reaction zone (161) has a central axis (149), and the staged fuel injector (602) is centered on the axis, or that the staged fuel injector (602) is located within the mixer tube (148).

5. An apparatus as defined in claim 4 wherein the staged fuel injector (602) has a high pressure nozzle.

Patentansprüche

1. Verfahren zum Erzielen einer Verbrennung von Brenngas mit einem niedrigen NOx-Ausstoß in einer aufgeheizten Pelletisierprozessluft, wobei das Verfahren aufweist:

ein Fördern von granuliertem Material (26) durch einen Härtungsofen (20), (100), der eine Heizstation (36) und einen Durchgang (61) aufweist, der die aufgeheizte Prozessluft an die Heizstation leitet,
ein Treiben der aufgeheizten Prozessluft durch den Durchgang in Richtung auf die Heizstation (36) und ein Betreiben eines Vormischbrenners (102), der eine Reaktionszone (161) mit einem Auslass an den Durchgang (61) aufweist, wobei dies die Schritte aufweist:

ein Einspritzen einer Vormischung aus einem primären Brenngas und einer Verbrennungsluft in die Reaktionszone (161),
ein Verbrennen der Vormischung, um Verbrennungsprodukte einschließlich einer verunreinigten Verbrennungsluft in der Reaktionszone (161) bereitzustellen,
ein Einspritzen eines Stufen aufweisenden Brenngases in die Reaktionszone (161) getrennt von der Vormischung,
ein Ausstoßen des Stufen aufweisenden Brenngases und der verunreinigten Verbrennungsluft von der Reaktionszone (161) durch den Auslass an Durchgang und
ein Verbrennen des Stufen aufweisenden Brenngases und der verunreinigten Verbrennungsluft in der aufgeheizten Prozessluft in dem Durchgang (61), wodurch eine Verbrennung mit einem niedrigen NOx-Ausstoß in der aufgeheizten Prozessluft als ein Ergebnis der Wechselwirkung des Stufen aufweisenden Brenngases mit der in der Reaktionszone (161) enthaltenen Verbrennungsluft erreicht wird,

dadurch gekennzeichnet, dass die Reaktionszone (161) eine zentrale Achse (149) aufweist und dass das Stufen aufweisende Brenngas in die Reaktionszone (161) als ein auf die Achse (149) zentrierter Strahl eingespritzt wird, oder dass die Vormischung in die Reaktionszone (161) aus einem Mischrohr (148) eingespritzt wird, und dass das Stufen aufweisende Brenngas in die Reaktionszone (161) von einer Stufen aufweisenden Brennstoffeinspritzvorrichtung (602) (830) eingespritzt wird, die in dem Mischrohr (148) angeordnet ist.

2. Verfahren nach Anspruch 1, wobei die Vormischung in einem kraftstoffarmen Zustand in die Reaktionszone (161) eingespritzt wird, wodurch überschüssige Verbrennungsluft in der Vormischung für die Verunreinigungen in der Reaktionszone (161) verfügbar ist.

3. Verfahren nach Anspruch 1, wobei das Stufen aufweisende Brenngas von einer Hochdruckdüse in die Reaktionszone (161) eingespritzt wird.

4. Vorrichtung zum Erzielen einer Verbrennung mit einem niedrigen NOx-Ausstoß in einer aufgeheizten Pelletisierprozessluft, wobei die Vorrichtung aufweist:

einen Härtungsofen (20), (100) mit einer Struktur, die eine Heizstation, eine Fördereinrichtung, die ein pelletiertes Material an die Heizstation befördert, und einen Durchgang (61) bestimmt, der die aufgeheizte Prozessluft an die Heizstation leitet,
Quellen eines primären Brenngases, einer Verbrennungsluft und eines Stufen aufweisenden Brenngases und
ein Vormischbrenner (102), welcher aufweist:

eine Struktur, die eine Reaktionszone (161) mit einem Auslass an den Durchgang (61) bestimmt,
ein Mischrohr (148), das einen Einlass, der von den jeweiligen Quellen das primäre Brenngas und die Verbrennungsluft empfängt, und einen Auslass aufweist, der eine Vormischung des primären Brenngases und der Verbrennungsluft in die Reaktionszone (161) auslässt, und
einen Stufen aufweisenden Brennstoffeinspritzer (602), (830), der das Stufen aufweisende Brenngas von der jeweiligen Quelle empfängt und der das Stufen aufweisende Brenngas getrennt von der Vormischung in die Reaktionszone (161) einspritzt, wodurch das Stufen aufweisende Brenngas mit einer verunreinigten Verbrennungsluft in der Reaktionszone (161) wechselwirken kann, um die Verbrennung mit einem niedrigen NOx-Ausstoß in der aufgeheizten Prozessluft in dem Durchgang zu erzeugen,

dadurch gekennzeichnet, dass die Reaktionszone (161) eine zentrale Achse (149) aufweist und der Stufen aufweisende Brennstoffeinspritzer (602) auf der Achse zentriert ist, oder dass der Stufen aufweisende Brennstoffeinspritzer (602) innerhalb des Mischrohres (148) angeordnet ist.

5. Vorrichtung nach Anspruch 4, wobei die Einspritzdüse für den Stufen aufweisenden Kraftstoff (602) eine Hochdruckdüse aufweist.

Revendications

1. Procédé permettant d'obtenir une combustion de

gaz combustible à faibles émissions de NOx dans un air de procédé de granulation chauffé, comprenant :

le transport du matériau en granules (26) dans un four de durcissement (20), (100) comportant une station de chauffage (36) et un passage (61) qui dirige l'air de procédé chauffé vers la station de chauffage ;
la conduite de l'air de procédé chauffé dans le passage en direction de la station de chauffage (36) ; et l'activation d'un brûleur de prémélange (102) comportant une zone de réaction (161) pourvue d'un orifice d'évacuation débouchant dans le passage (61), comprenant les étapes suivantes :

l'injection d'un prémélange de gaz combustible primaire et d'air de combustion dans la zone de réaction (161) ;
la combustion du prémélange pour obtenir des produits de combustion contenant de l'air de combustion vicié dans la zone de réaction (161) ;
l'injection de gaz combustible étagé dans la zone de réaction (161) séparément du prémélange ;
la décharge du gaz combustible étagé et de l'air de combustion vicié de la zone de réaction (161) par l'orifice d'évacuation débouchant dans le passage ; et
la combustion du gaz combustible étagé et de l'air de combustion vicié dans l'air de procédé chauffé dans le passage (61), de sorte qu'une combustion à faibles émissions de NOx dans l'air de procédé chauffé est obtenue suite à l'interaction du gaz combustible étagé avec l'air de combustion vicié dans la zone de réaction (161),

caractérisé en ce que
la zone de réaction (161) a un axe central (149), et le gaz combustible étagé est injecté dans la zone de réaction (161) sous la forme d'un jet centré sur l'axe (149), ou **en ce que** le prémélange est injecté dans la zone de réaction (161) à partir d'un tube mélangeur (148), et le gaz combustible étagé est injecté dans la zone de réaction (161) à partir d'un injecteur de combustible étagé (602), qui se trouve dans le tube mélangeur (148).

2. Procédé selon la revendication 1 dans lequel le prémélange est injecté dans la zone de réaction (161) sous une condition de mélange pauvre en combustible, de sorte que l'air de combustion en excédent dans le prémélange est disponible pour la viciation dans la zone de réaction (161).

3. Procédé selon la revendication 1 dans lequel le gaz combustible étagé est injecté dans la zone de réaction (161) à partir d'une buse à haute pression.

4. Appareil permettant d'obtenir une combustion à faibles émissions de NOx dans un air de procédé de granulation chauffé, comprenant :
une structure de four de durcissement (20), (100) définissant une station de chauffage, un convoyeur qui transporte le matériau en granules jusqu'à la station de chauffage, et un passage (61) qui dirige l'air de procédé de granulation chauffé jusqu'à la station de chauffage (36) ;
des sources de gaz combustible primaire, d'air de combustion, et de gaz combustible étagé ; et
un brûleur (102) de prémélange ayant :

une structure définissant une zone de réaction (161) pourvue d'un orifice d'évacuation débouchant dans le passage (61) ;
un tube mélangeur (148) pourvu d'un orifice d'admission qui reçoit le gaz combustible primaire et l'air de combustion de leurs sources respectives, et d'un orifice d'évacuation qui décharge un prémélange du gaz combustible primaire et de l'air de combustion dans la zone de réaction (161) ; et
un injecteur de combustible étagé (602), (830) qui reçoit le gaz combustible étagé de sa source respective, et qui injecte le gaz combustible étagé dans la zone de réaction (161) séparément du prémélange, de sorte que le gaz combustible étagé peut interagir avec l'air de combustion vicié dans la zone de réaction (161) pour produire une combustion à faibles émissions de NOx dans l'air de procédé chauffé dans le passage,

caractérisé en ce que
la zone de réaction (161) a un axe central (149), et l'injecteur de combustible étagé (602) est centré sur l'axe, ou **en ce que** l'injecteur de combustible étagé (602) se trouve dans le tube mélangeur (148).

5. Appareil selon la revendication 4 dans lequel l'injecteur de combustible étagé (602) a une buse à haute pression.

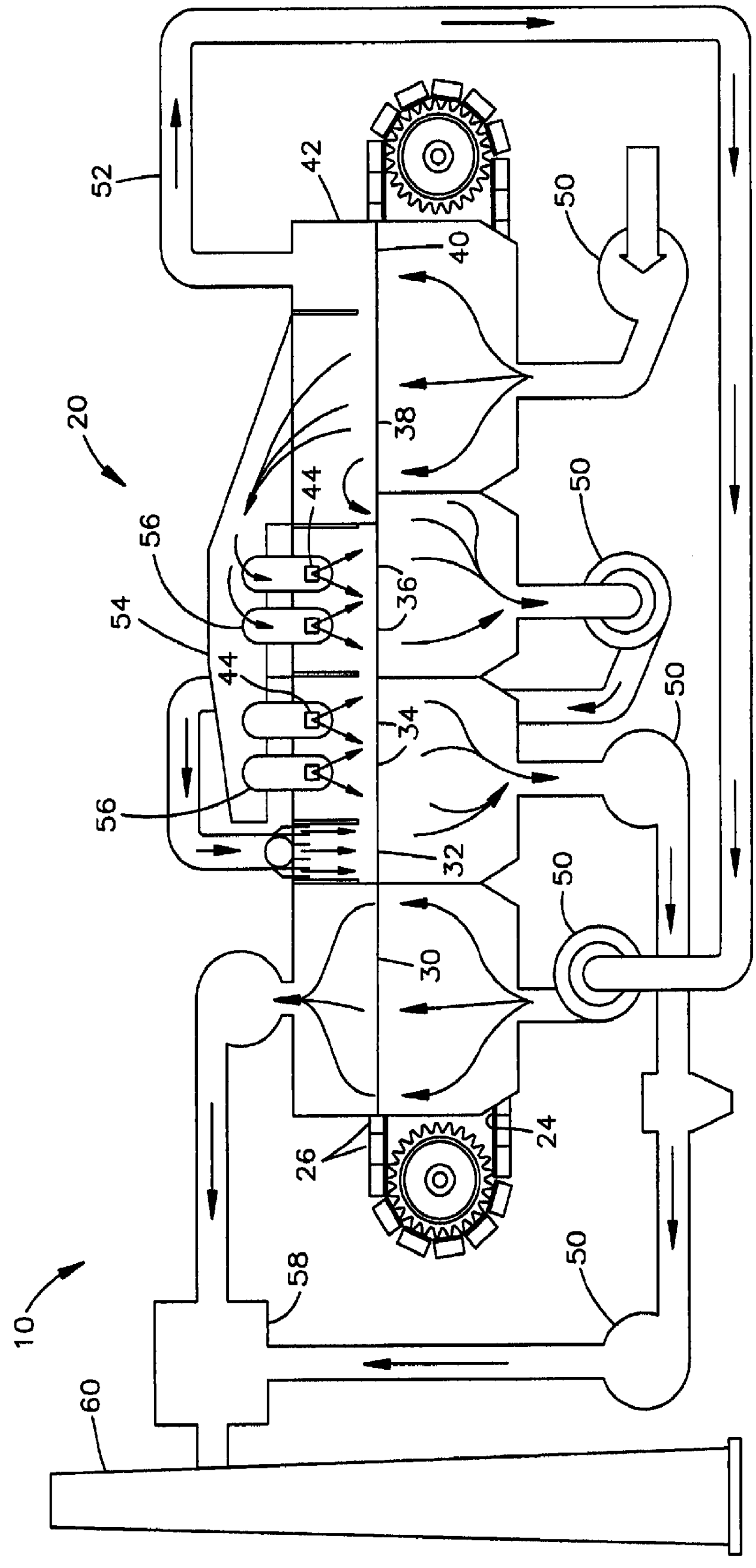

Fig.1
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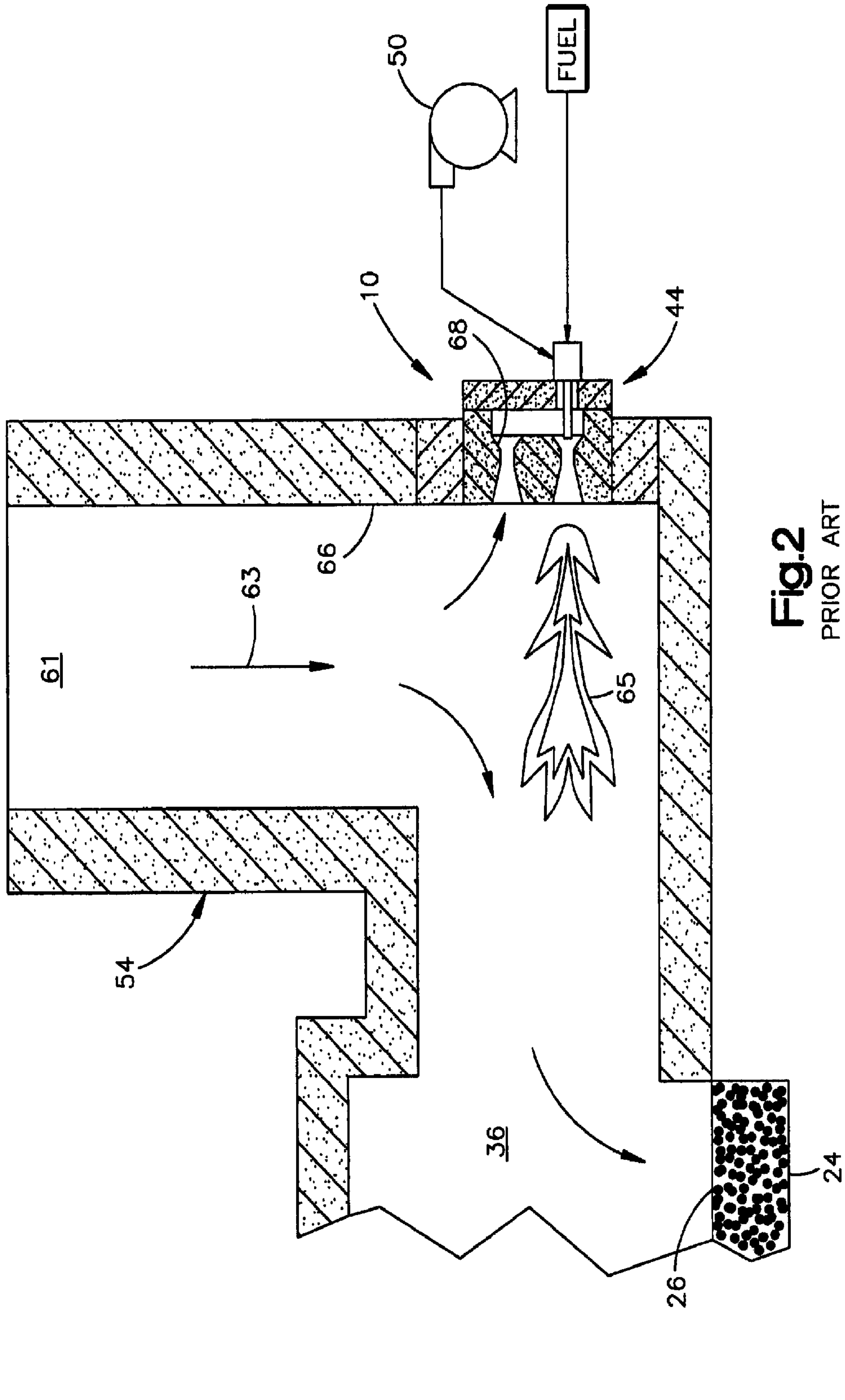

Fig.2
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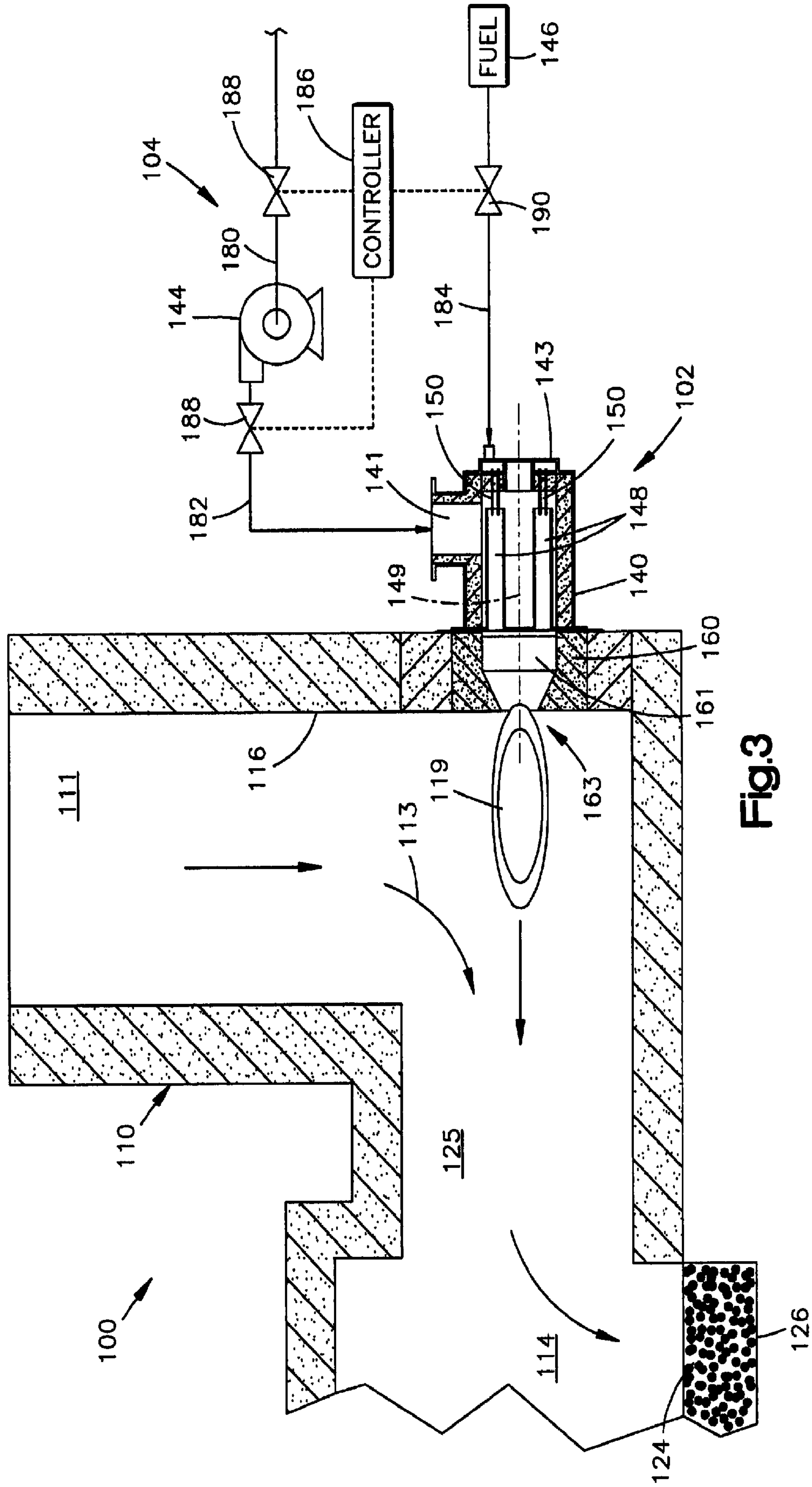
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Fig.3

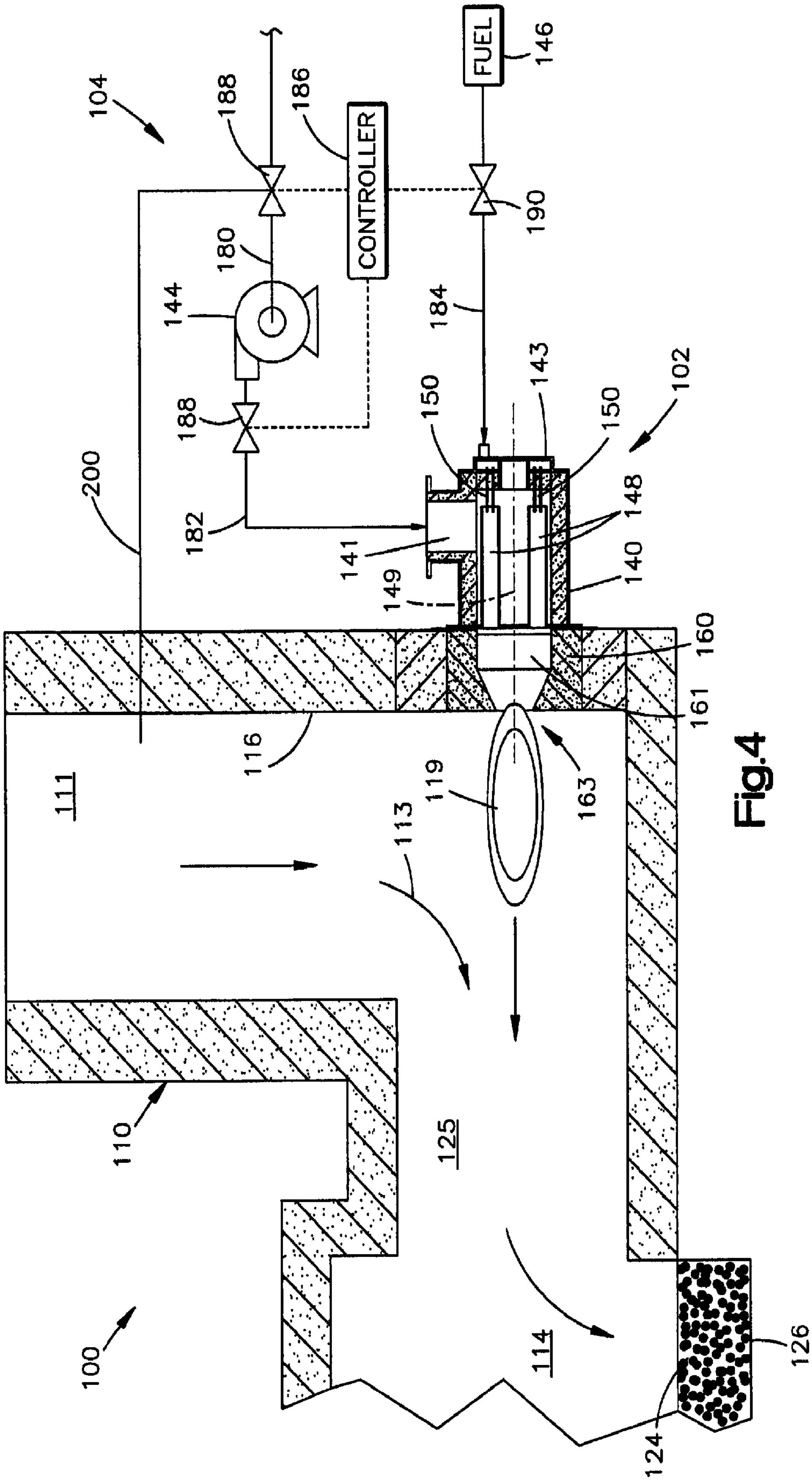
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Fig.4

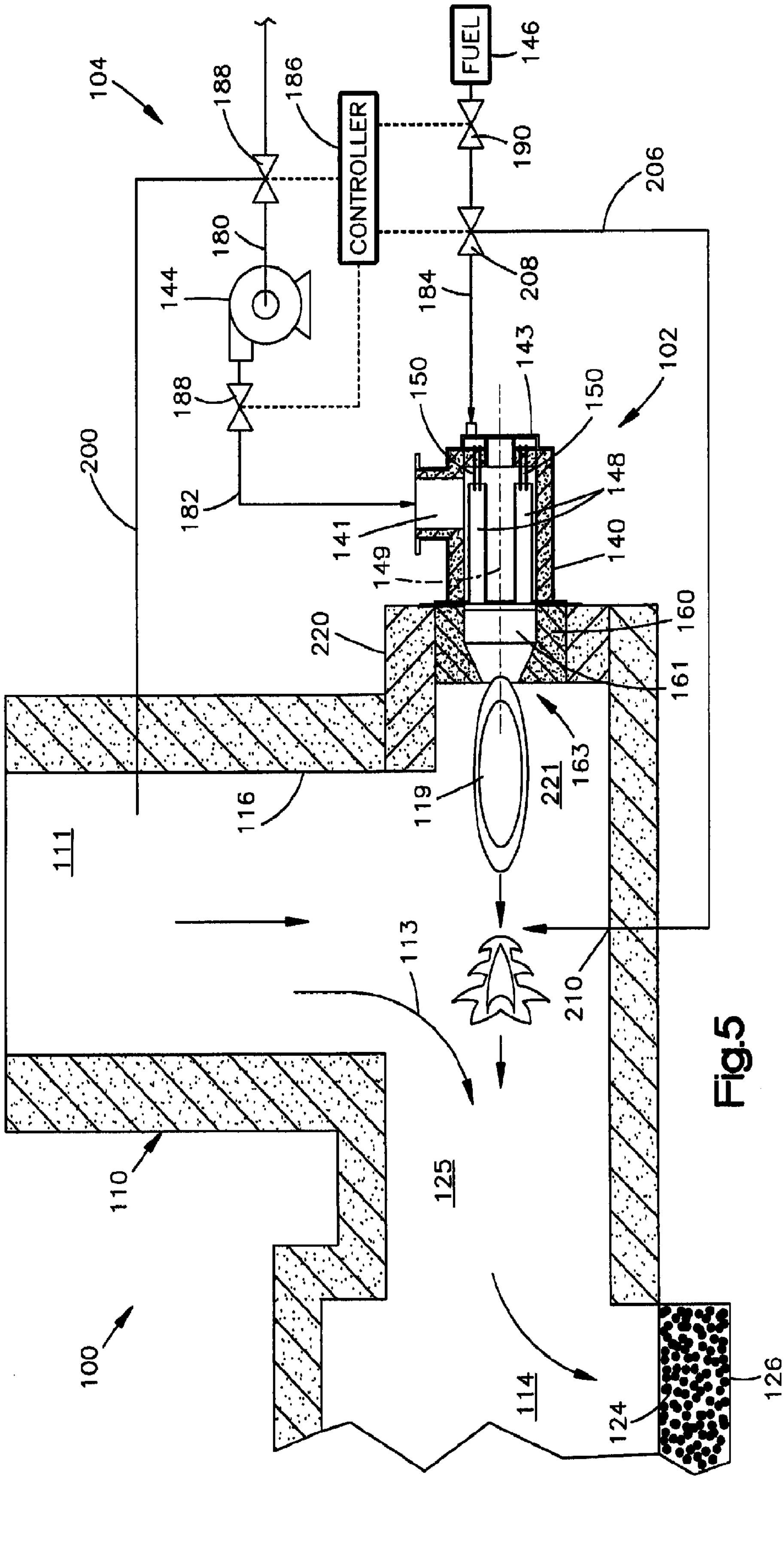
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Fig.5

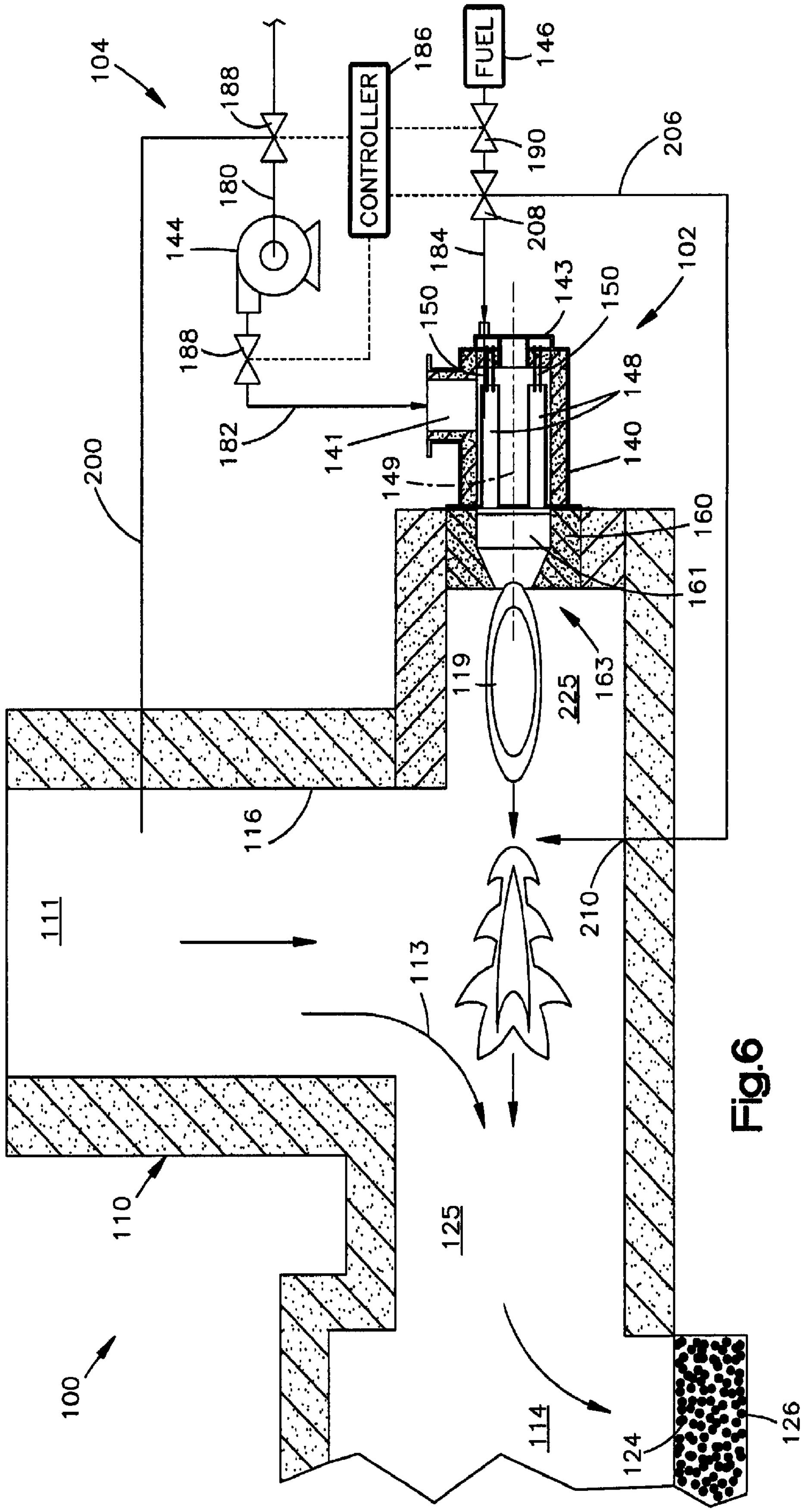
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Fig.6

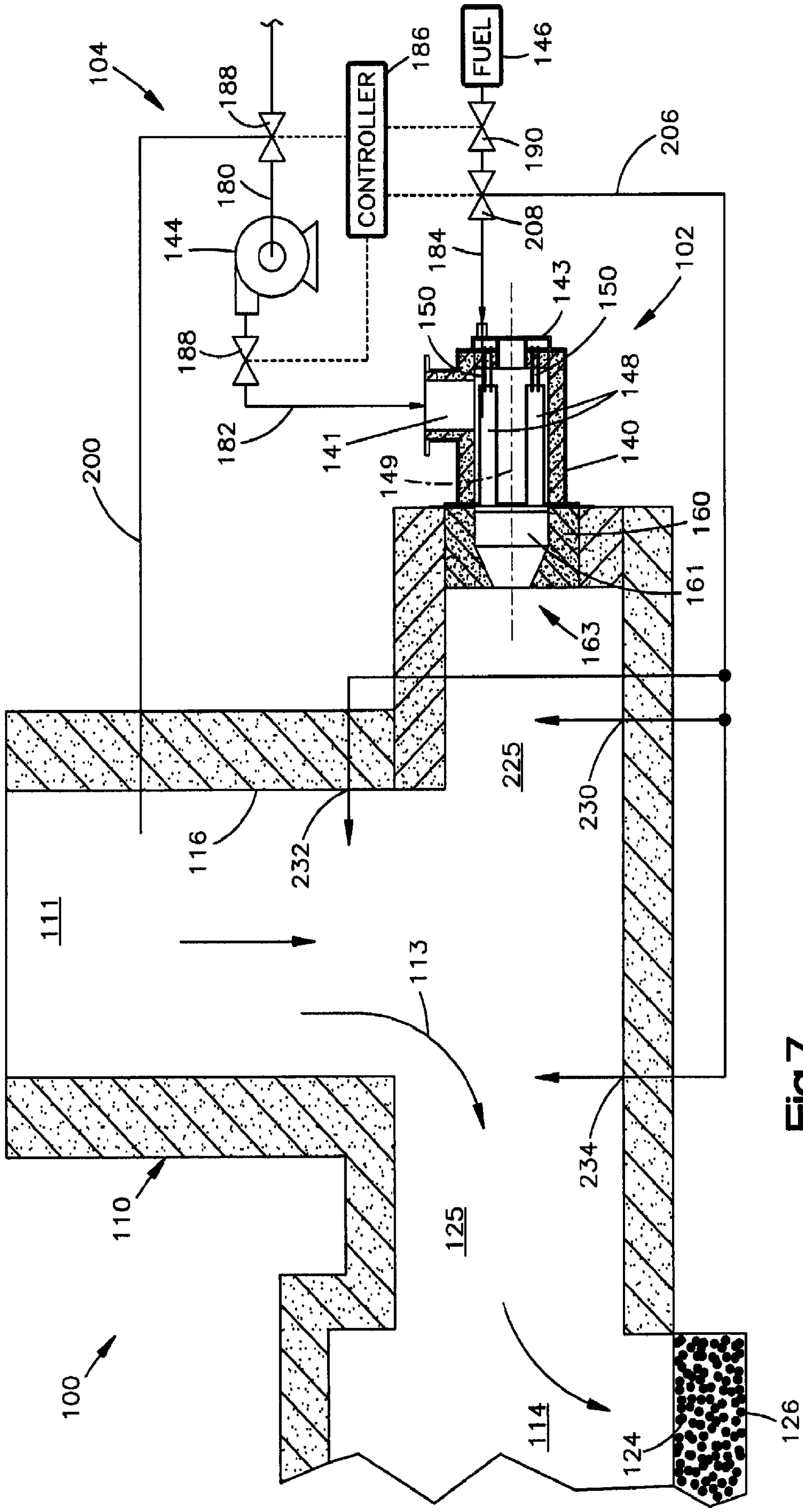
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Fig.7

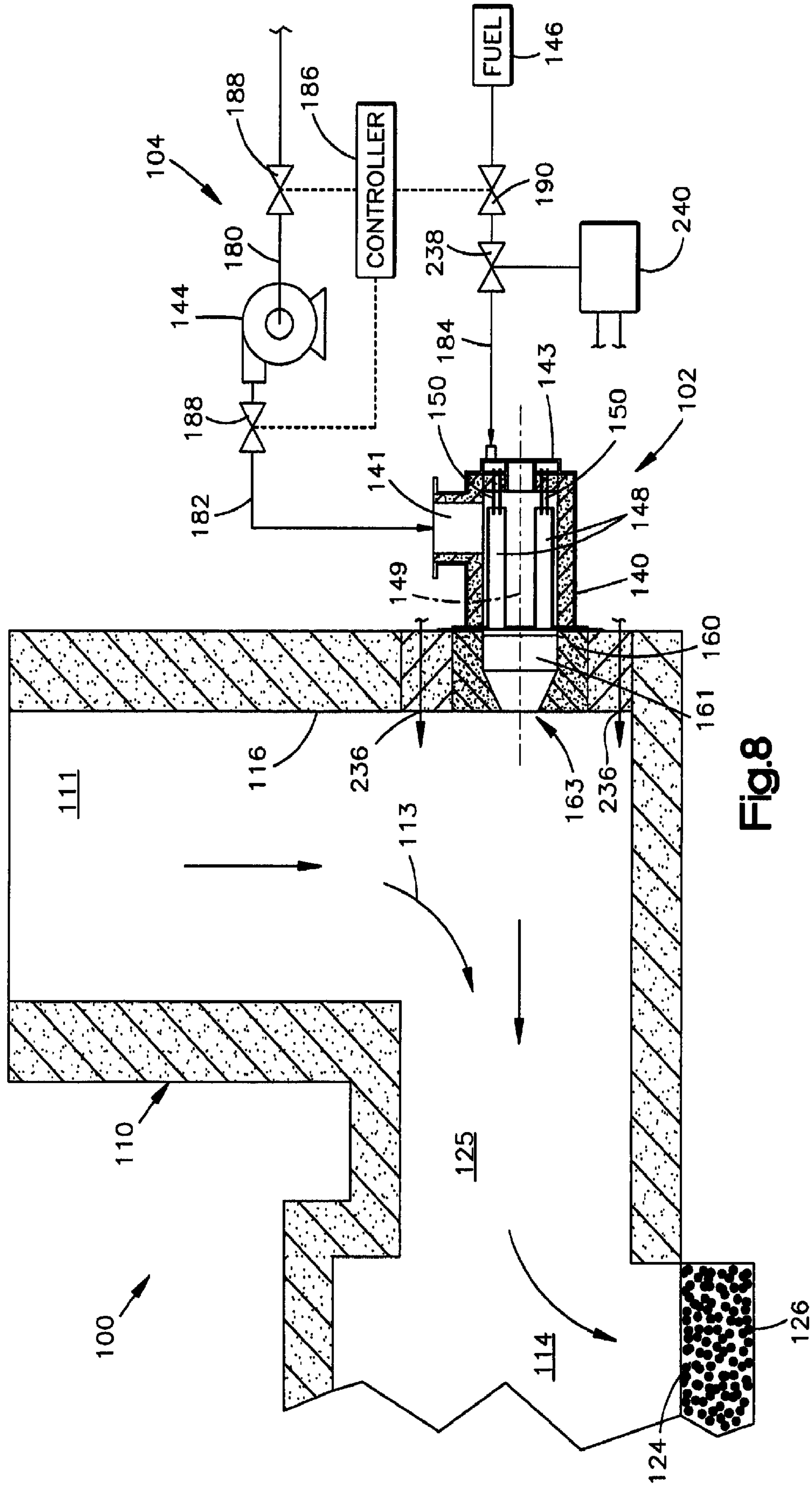
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Fig.8

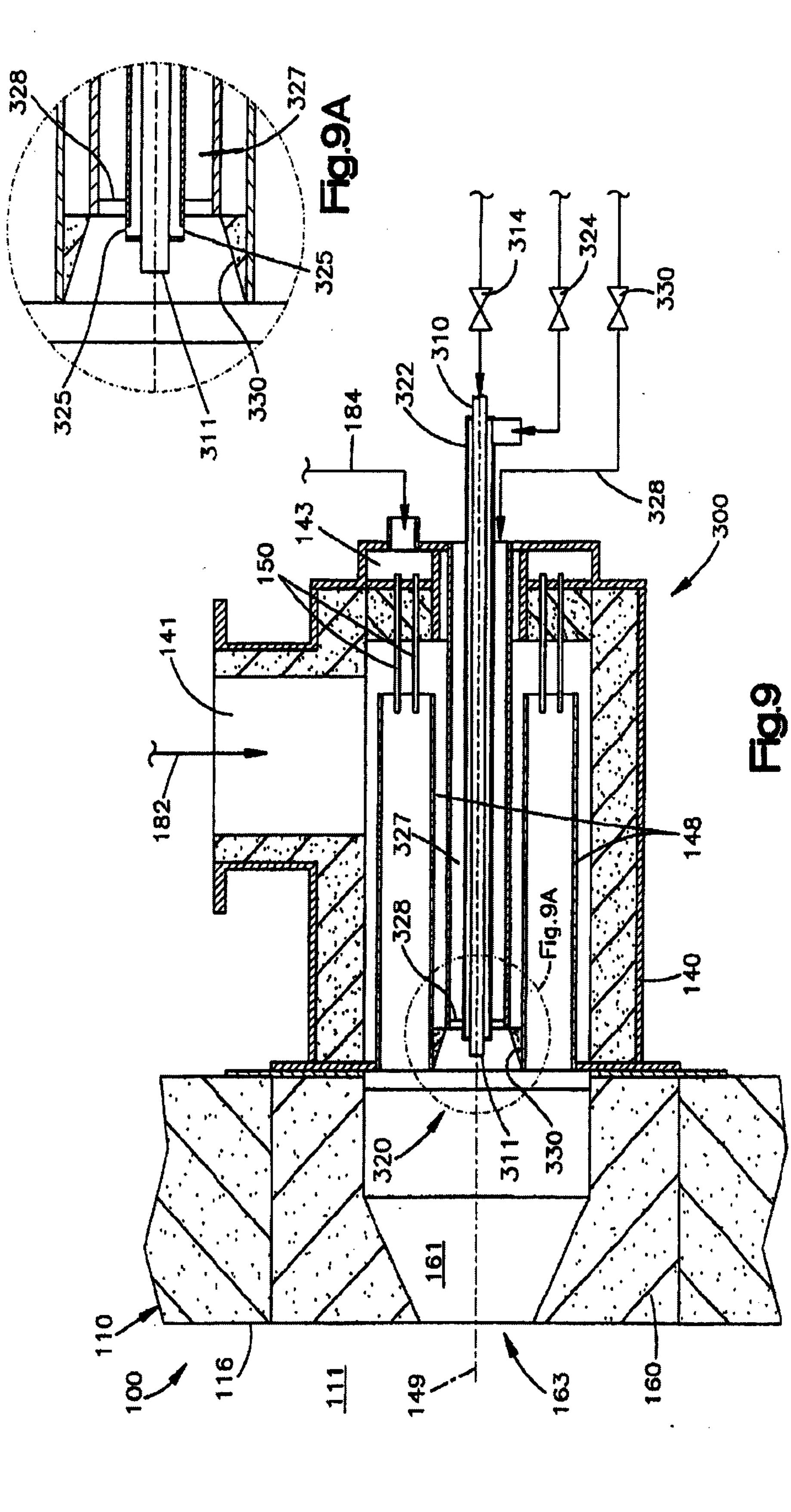
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Fig.9A
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Fig.9A

Fig.9

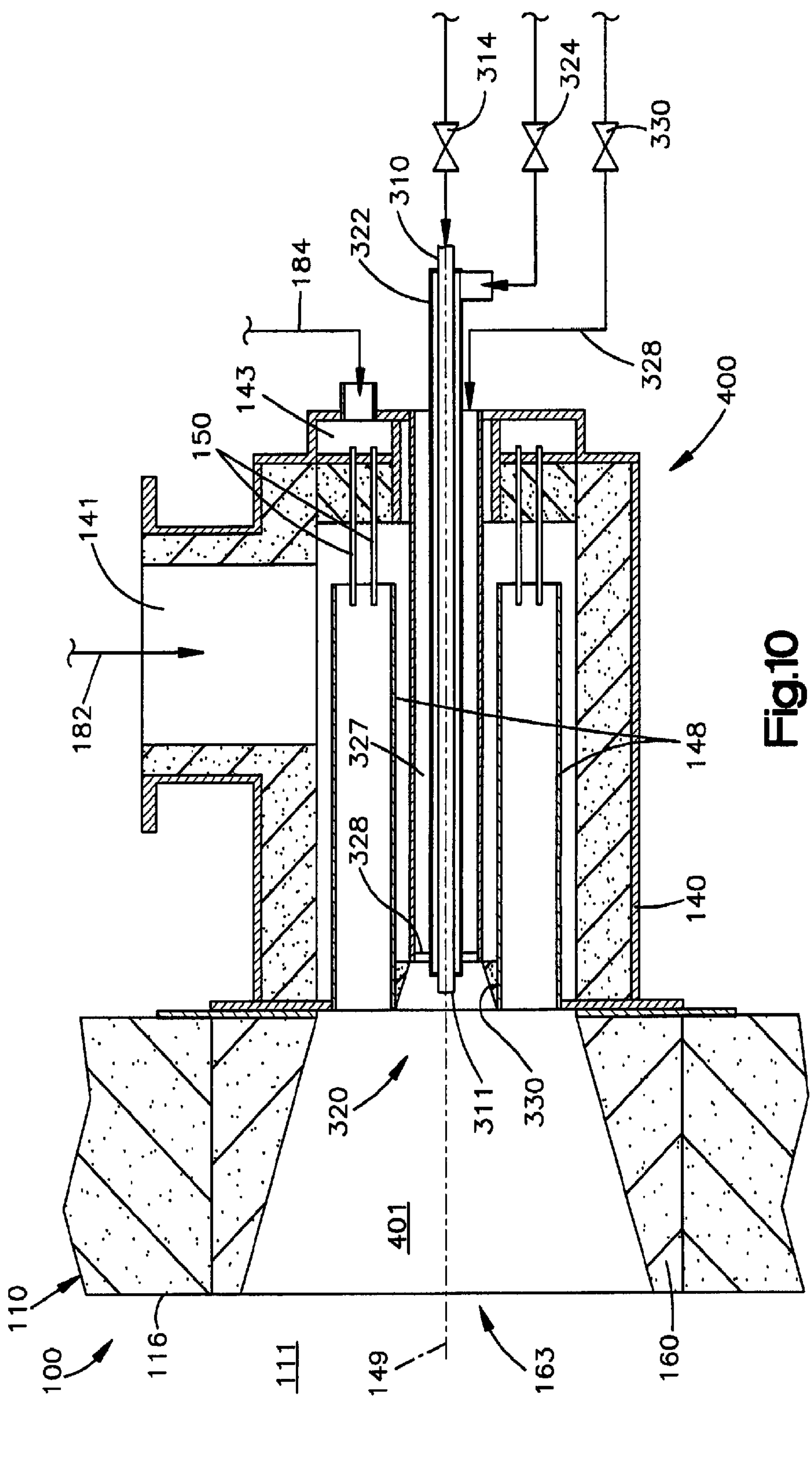
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Fig.10

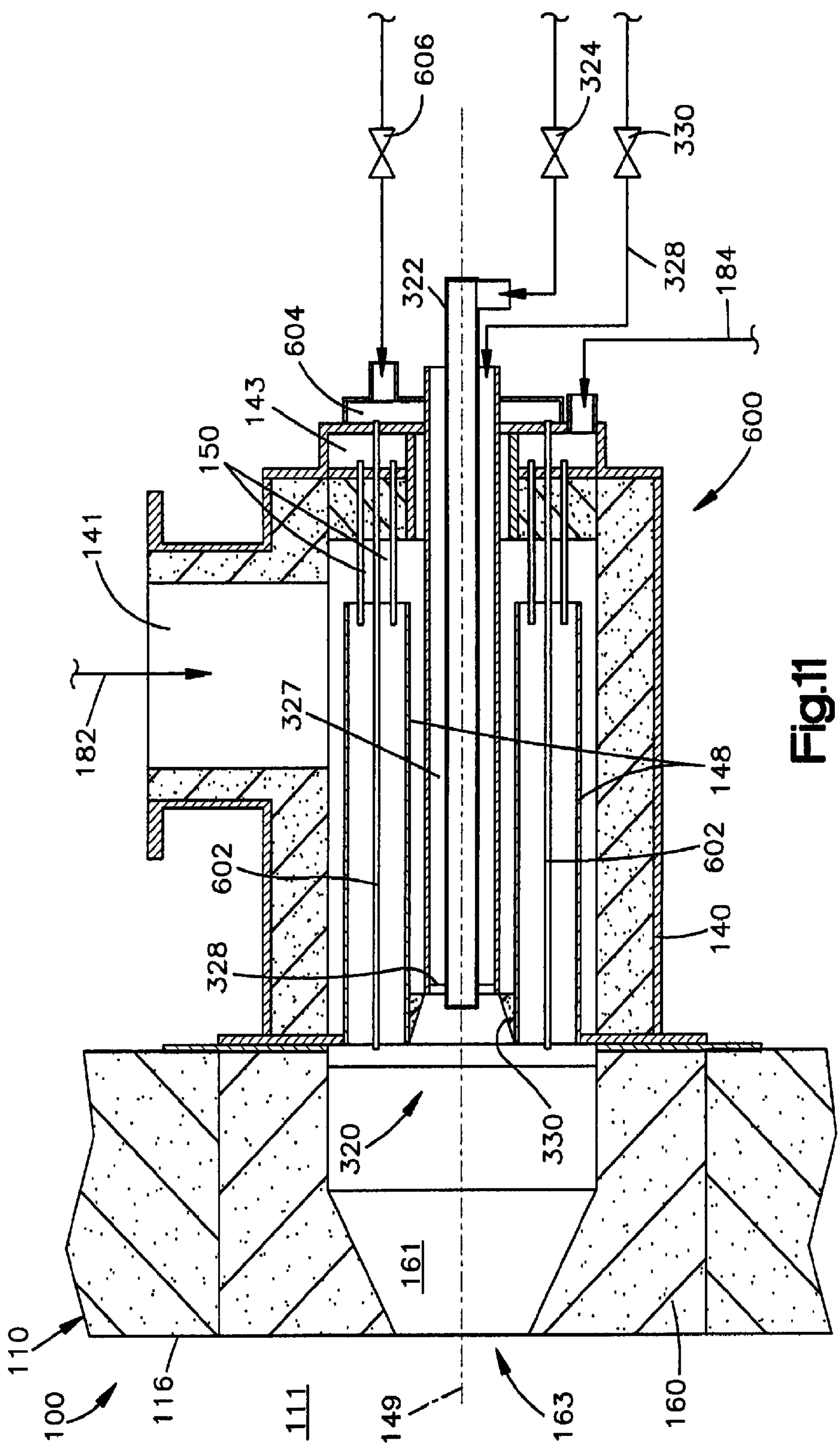
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Fig.11

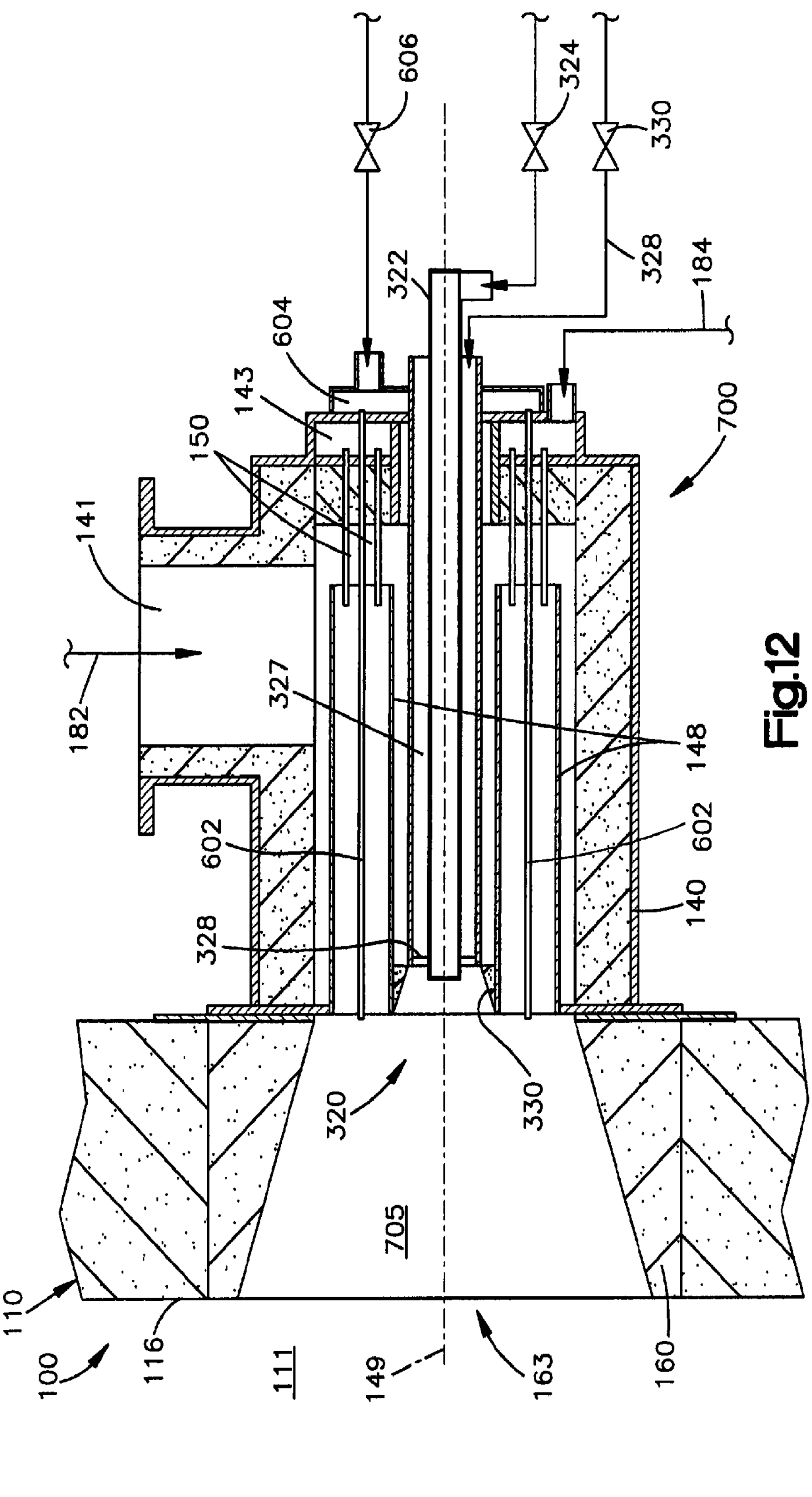
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Fig.12

REFERENCES CITED IN THE DESCRIPTION

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