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(71) Applicant: NORTH AMERICAN MANUFACTURING COMPANY [US/US]; 4455 East 71st Street, Cleveland, OH 44105 (US).

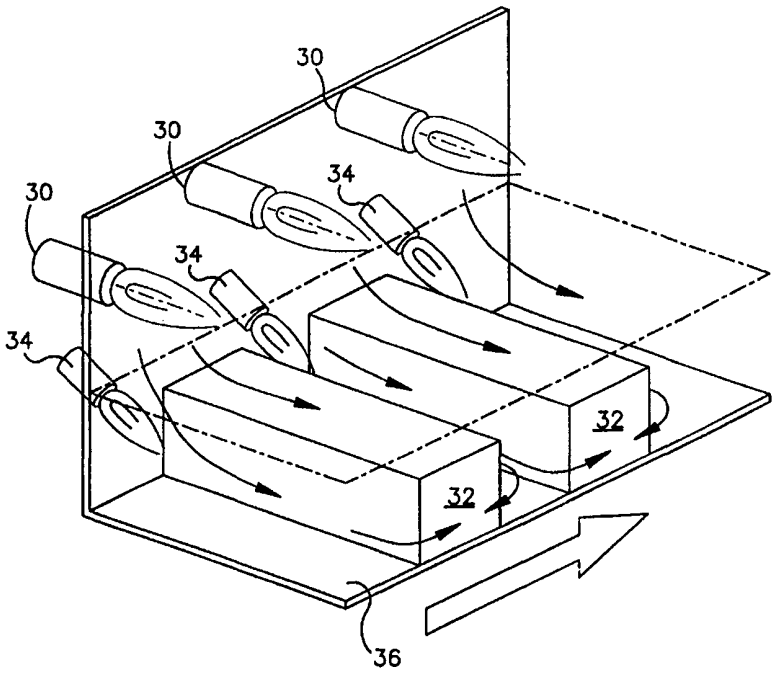
(72) Inventors: SHANNON, Robert, A.; 32546 Electric Boulevard, Avon Lake, OH 44012 (US). RICH, Lawrence, V.; 2006 Broadhills Farm, Caraopolis, PA 15108 (US). GILBERT, Frank, Christian; 6927 Woodwalk Road, Brecksville, OH 44141 (US).

(74) Agents: SCANLON, Stephen, D. et al.; Jones, Day, Reavis & Pogue, North Point, 901 Lakeside Avenue, Cleveland, OH 44114 (US).

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(54) Title: METHOD AND APPARATUS FOR UNIFORMLY HEATING A FURNACE



(57) Abstract

A method and apparatus is disclosed for heating metal billets or other separate pieces of metal in a continuous furnace using two different burner systems. The primary burner system provides the majority of available heat at relatively high flame temperatures. The secondary high velocity burner system entrains hot flame products of combustion that impinge around on the load. Thus, heat transfer and temperature uniformity is improved by forcing hot gases between the metal pieces.

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METHOD AND APPARATUS FOR UNIFORMLY HEATING A FURNACE

BACKGROUND OF THE INVENTION

The present invention is directed to the field of continuous industrial furnaces used to heat metal billets or other separate pieces. A standard production furnace 10 is shown in Figs. 1A and 1B. Units of product 12 are advanced through the furnace 10 along a movable hearth or beam 14. Burners 16 are fired into the furnace 10 so as to heat the product 12.

In a standard metal reheating application, it is typically desirable to heat a load to 2000-2400°F. This heating is achieved by firing burners 16 sufficient in size and number to establish a furnace thermal environment having products of combustion (POC's) at a temperature of 2000-2500°F. Burner flame temperatures are typically above 3000°F. Thus, care must be taken to insure that the burner flame does not directly impinge upon the product 12, which affects grain growth, surface properties and creates excessive "scaling" which reduces the quality and quantity of useful product output. To this end, it is common to install burners 16 near the top of the furnace walls so that they fire horizontally, i.e. parallel to the top of the product 12, or mount radiant flat flame burners in the roof of the furnace 10, so as to preclude flame impingement. In some furnace configurations, the burners 16 can be placed to fire below the load.

There are drawbacks associated with the standard furnace design. Since burner firing occurs above and/or below the load, there tends to be an uneven thermal distribution within the furnace chamber. A boundary layer 18 exists which separates the load from a region 20 of the hot, radiant POC's exiting the burners 16. The spaces between and around the billets of product 12 tend to retain pockets 22 of stagnant furnace gas that are much cooler than the hot POC's in hot region 20. Thus, most of the heat is transferred to the product 12 by radiation from above to the top surface and fractional areas between pieces of the product 12, thereby limiting the rates of heat

transfer to the product 12. Thus, the product 12 must spend a longer time in the furnace 10 in order to obtain the desired heating effect, resulting in reduced throughput productivity and greater energy consumption.

BRIEF DESCRIPTION OF THE INVENTION

In view of the drawbacks and disadvantages associated with previous systems, there is a need for a furnace heating system that provides a more uniform thermal distribution within a furnace chamber.

There is also a need for a furnace heating system that reduces pockets of colder, stagnant furnace gases.

There is also a need for a furnace heating system that compensates for hearth losses without over heating the product and/or damaging the working layer of a refractory hearth.

There is also a need for a furnace heating system with reduced product resident time and increased throughput.

There is also a need for a furnace heating system with increased fuel efficiency.

These needs and others are satisfied by the method and apparatus of the present invention in which a furnace heating system includes both a primary and a secondary burner system. The secondary burner system is designed to impinge upon and between the load, to provide increased rates of heat transfer to the load.

As will be appreciated, the invention is capable of other and different embodiments, and its several details are capable of modifications in various respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B illustrate a previous type industrial furnace.

Figs. 2A and 2B illustrate a possible furnace configuration that incorporates the heating system of the present invention.

Fig. 3 is a graph illustrating the improvement in thermal distribution for a furnace provided by the present invention.

Figs. 4A and 4B are respective graphs comparing improvements in fuel rate and product quality to production using the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a furnace and method of heating where the hot POC's are circulated around the product so as to promote high rates of heat transfer to the furnace load along all its exposed surfaces. As shown in Figs. 2A and 2B, a primary burner arrangement 30 is used as a heating source for the furnace 10. The primary burners 30 preferably operate substantially at a stoichiometric fuel-to-air ratio, i.e. where oxidant (e.g. air) is supplied in the minimum proportion for complete oxidation of the fuel, which is the most fuel-efficient firing since maximum heat is released. However, as a practical consideration, it is understood that as much as 10% excess air (or its equivalent in O_2) can be supplied to insure complete combustion and provide better control of the burner operation without losing much of the benefits of stoichiometric firing. The primary burners 30 create POC's that establish the desired furnace environment, e.g. between 1500-2500°F.

The present invention includes a secondary burner system 34 to disturb the boundary layer adjacent to the product and circulate the hot POC's around the product 32. The secondary burners can be mounted in the side walls or the roof. The preferred embodiment shown in Figs. 2A and 2B uses a secondary burner arrangement 34, including high velocity, low capacity burners, to produce the necessary circulation. The secondary burners 34 are mounted in the side of the furnace wall at a position close to the product 32. In order to increase circulation to all exposed surfaces of the load, the burners 34 are preferably mounted at an angle above or below horizontal, e.g. plus or minus 45 degrees from horizontal. In the preferred embodiment, the secondary burners 34 are preferably mounted at a depressed angle below horizontal so that they fire generally toward the furnace hearth 36. Burner angle will vary according to the specific requirements of each particular furnace. In this way, a circulation flow pattern is created

within the furnace that entrains the hot POC's of the furnace environment to impinge upon the product 32, and in between individual loads of product 32 thereby promoting uniform heating of the product 32 at a higher rate along all its exposed exterior surfaces.

In the preferred embodiment, the secondary burner is fired with a controlled fuel-to-air ratio of the input, resulting in a desired amount of excess air which adds thermal load to the burner, thereby suppressing the flame temperature of the secondary burners 34. The fuel/air input is added in such a proportion that the flame temperature of the secondary burners 34 preferably matches that of the furnace environment, e.g. 2500°F (as compared with the 3400°F flame temperature of the primary burners 30). Operated in this manner, the secondary burners 34 release minimal additional heat into the furnace environment. In this way, the secondary burner flame can impinge directly onto the product 32 for an extended period of time without excessive oxidation or overheating, and thereby entrain a large volume of hot POC's to wash over all the exposed exterior surfaces of the product 32, providing increased rates of heating of the product. Fig. 3 shows potential temperature curves indicating the drop between the roof and the hearth of a furnace. The curve 50 for a conventionally fired furnace shows a significant temperature differential between the roof and the hearth. The curve 52 for the invention shows a minimal temperature differential between the roof and hearth which improves heat transfer and uniformity. Thus, with the present invention the product throughput is greatly increased with reduced furnace residence time. Also, heating of the exposed product surfaces is more uniform, resulting in improved product quality.

As indicated in Fig. 2B, the invention can include a dedicated control system 40 for controlling the temperature of the circulating POC's in and around the product 32 by controlling the fuel input to the secondary burners 34. As an example, the control system 40 receives temperature data from a sensor arrangement including a primary thermocouple 42 that measures the temperature within a zone near the top of the furnace and varies fuel input to the primary burners 30. A secondary thermocouple 34 is placed closer to the bottom of the furnace, near the product 32, and is used to detect a setpoint temperature higher than the zone temperature but lower than the

material tolerance temperature of the product 32. In the event that setpoint temperature is exceeded in a normal heating operation, a secondary temperature control 54 will vary the position of a secondary fuel valve 56, which will reduce the fuel input to the secondary burner 34, thereby reducing temperature below the setpoint.

The secondary temperature control loop 54 can also operate in an emergency mode if there is a delay in the advancement of product 32 through the furnace. In this instance, impingement of the secondary burner's POC on the product 32 can be prolonged, typically resulting in overheating of the product. In this event, the control system 54 cuts back the fuel input to the secondary burner 34, or increases the excess air to cool the burner exhaust, precluding product overheating during the delay interval.

With the invention's control system 40, the excess air in the secondary burners 34 can be varied to the most effective ratio to effect optimum heat transfer to the product 32. In this way, the wasted heat carried up the stack by the flue gas is minimized. This degree of control provides several correlated benefits. By improving heat transfer, total production can be increased along with production per unit of fuel, or total fuel consumption can be reduced while maintaining production (as indicated in Fig. 4A, where the dashed line indicates performance of the present invention). Alternatively, by providing greater uniformity, an improvement in product quality is realized for any production rate (as indicated in Fig. 4B, where the dashed line again indicates performance of the present invention.

As described hereinabove, the present invention solves many problems associated with previous systems, and increases productivity and efficiency. However, it will be appreciated that various changes in the details, materials and/or arrangements of parts herein described and illustrated may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

We Claim:

1. A continuous furnace system for heating separate pieces comprising:

a primary burner system for establishing a thermal environment having a predetermined temperature within a furnace containing a load;

a secondary burner system for entraining the thermal environment into impingement with the load, to provide rapid and uniform heating of the load, wherein the secondary burner system operates with sufficient excess air to avoid overheating and damaging the product.

2. The furnace heating system of claim 1 wherein the secondary burner system entrains the thermal environment at a predetermined angle to horizontal.

3. The furnace heating system of claim 2 wherein the predetermined angle is a depressed angle between 0 and 45 degrees.

4. The furnace heating system of claim 1 wherein:

the heating means comprises at least one primary burner firing and attaining a temperature that releases heat in the furnace to establishing a thermal environment having a predetermined temperature; and

the circulating means comprises at least one secondary burner firing at a second flame temperature lower than said first temperature, so as to create a circulation flow pattern within the furnace that entrains said thermal environment into impingement with the load without substantially releasing additional heat into the thermal environment.

5. The furnace heating system of claim 4 wherein the at least one primary burner fires at a substantially stoichiometric fuel-to-air ratio, wherein the at least one secondary burner fires with a predetermined proportion of excess air, so that

the second flame temperature is substantially approximate to the predetermined temperature of the furnace environment.

6. The furnace heating system of claim 5 wherein at least one primary burner is mounted near at least one of a top side and/or bottom side of the furnace, and at least one secondary burner is mounted on a vertical side of the furnace.

7. The furnace heating system of claim 6 comprising a plurality of secondary burners mounted on opposite sides of the furnace.

8. The furnace heating system of claim 4 wherein the at least one primary burner is mounted in a furnace roof and the at least one secondary burner is mounted in one of the furnace's roof, floor or sidewall.

9. The furnace heating system of claim 4 wherein the at least one secondary burner fires at a predetermined angle to horizontal.

10. The furnace heating system of claim 9 wherein the predetermined angle is a depressed angle between 0 and 45 degrees.

11. The furnace heating system of claim 4 further comprising a control system for varying fuel flow to the secondary burner, in order to vary the temperature of the secondary burner.

12. The furnace heating system of claim 11 wherein the control system includes a critically placed sensor means for measuring temperature within a furnace zone.

13. The furnace heating system of claim 12 wherein the sensor means includes a primary thermocouple for measuring zone temperature, and a secondary thermocouple for measuring a temperature near the load, wherein the control system reduces fuel flow to the secondary burner when the temperature set point is exceeded.

14. A method of uniformly heating a furnace comprising the steps of:

heating a furnace containing a load to establish a thermal environment having a predetermined temperature;

circulating the thermal environment into the load to provide uniform heating of the load; and

controlling the temperature of the thermal environment near the load to avoid overheating and damage.

15. The method of claim 14 wherein the step of circulating products of combustion comprises entraining the thermal environment in order to impinge upon and around the load, so as to reduce thermal gradients within the furnace's chamber.

16. The method of claim 15 wherein the step of circulating comprises entraining the thermal environment at a predetermined angle to horizontal.

17. The method of claim 16 wherein the predetermined angle is a depressed angle between 0 and 45 degrees.

18. The method of claim 17 wherein:

the step of heating comprises firing at least one primary burner to establish the predetermined temperature of the thermal environment; and wherein

the step of circulating comprises firing at least one secondary burner so as to create a flow pattern within the furnace that entrains the thermal environment to impingement upon the load.

19. The method of claim 18 wherein at least one primary burner is firing and attaining a first flame temperature that releases heat into the furnace, and wherein the at least one secondary burner fires at a second flame temperature lower than said first temperature, so as to circulate the thermal environment without substantially releasing additional heat into the thermal environment.

20. The method of claim 19 wherein the step of circulating comprises firing the at least one secondary burner at a predetermined angle to horizontal.

21. The method of claim 20 wherein the predetermined angle is a depressed angle between 0 and 45 degrees.

22. The method of claim 19 wherein the at least one primary burner fires at a substantially stoichiometric fuel-to-air ratio, wherein the at least one secondary burner fires with a predetermined proportion of excess air, so that the second temperature is substantially approximate to the predetermined temperature of the thermal environment.

23. The method of claim 18 further comprising the step of varying the fuel flow to the secondary burner, in order to vary the flame temperature of the secondary burner.

24. The method of claim 23 further comprising the step of accurately measuring temperature within a furnace zone.

25. The method of claim 24 wherein the step of measuring temperature includes measuring zone temperature and measuring a temperature near the load, wherein fuel flow to the secondary burner is reduced when the temperature is exceeded.

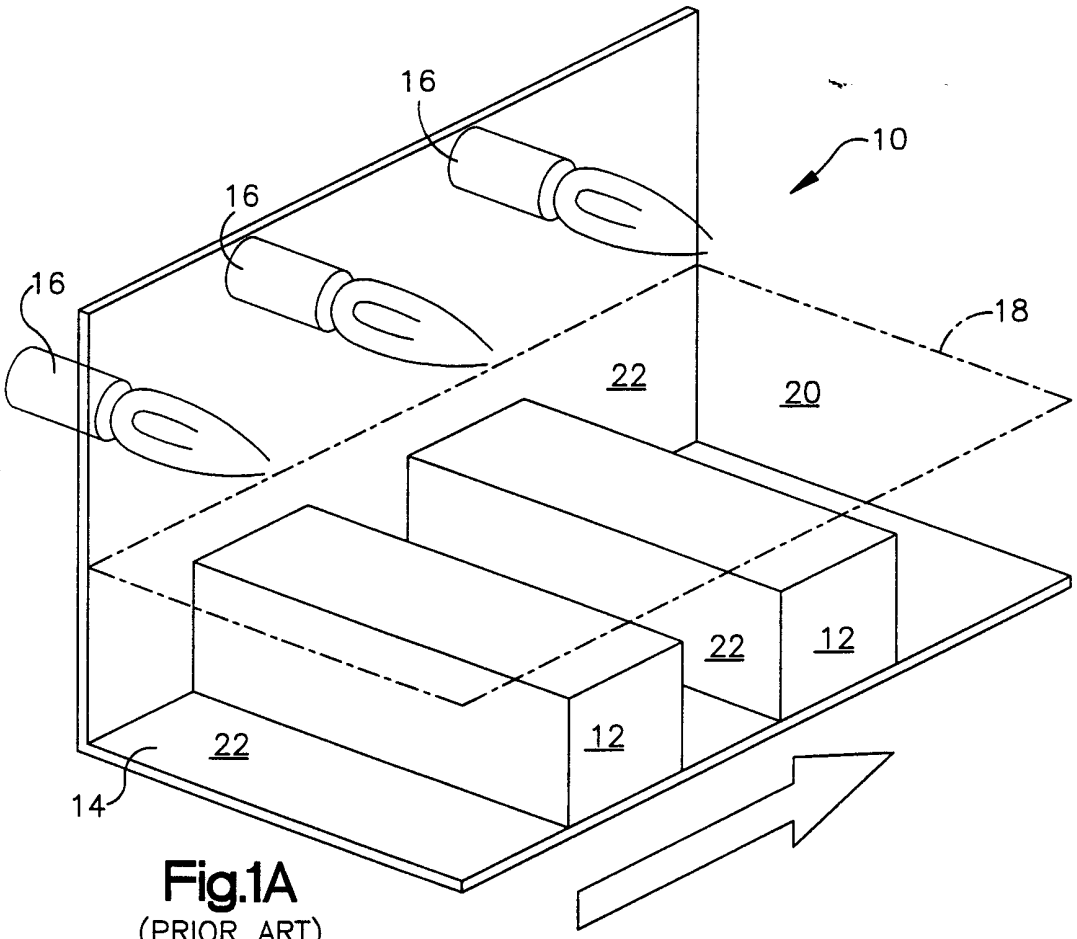


Fig.1A
(PRIOR ART)

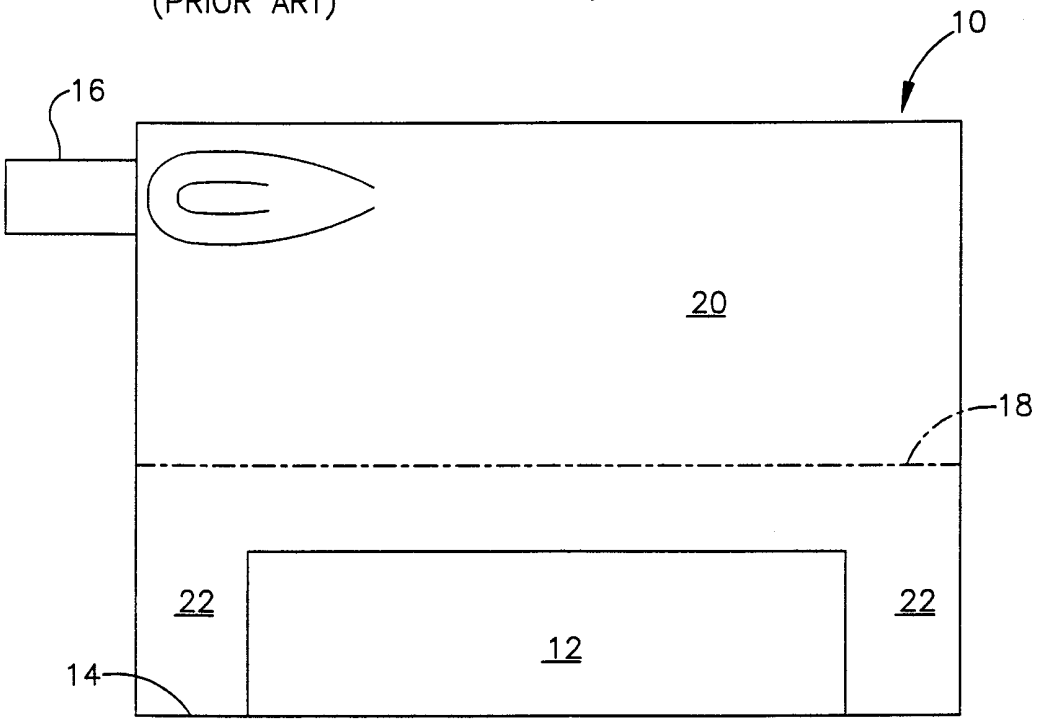


Fig.1B
(PRIOR ART)

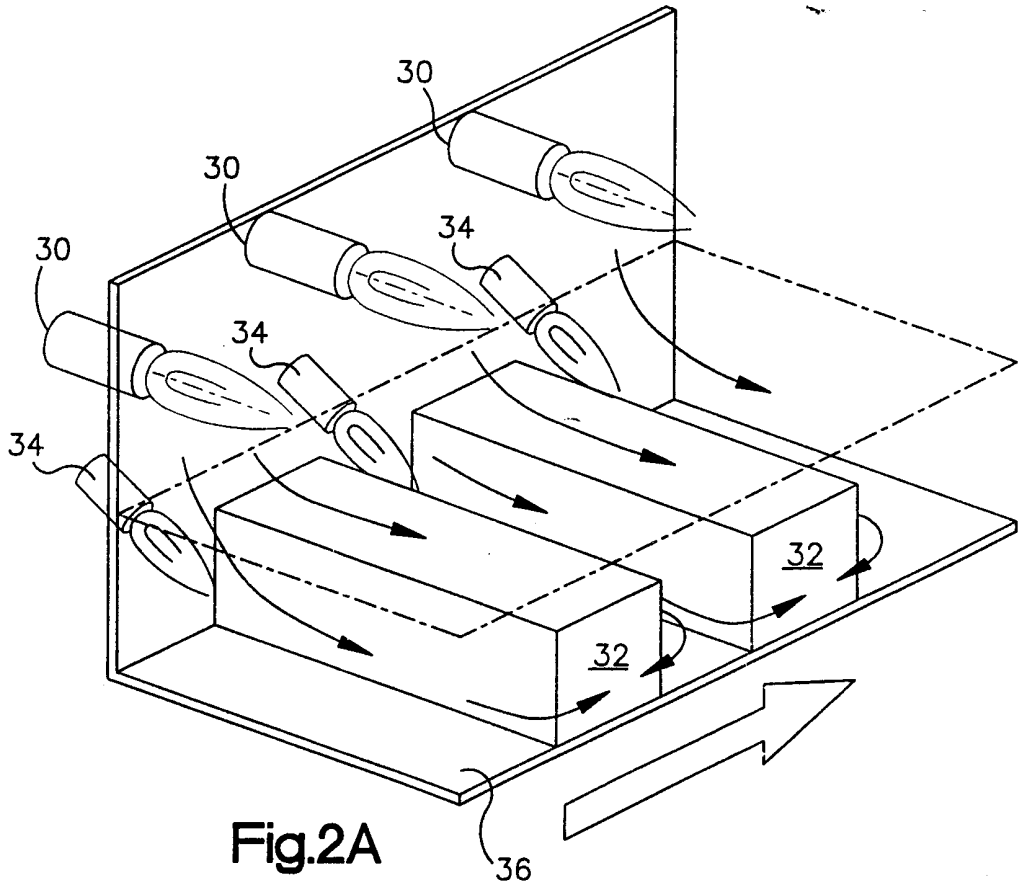

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Fig.2A

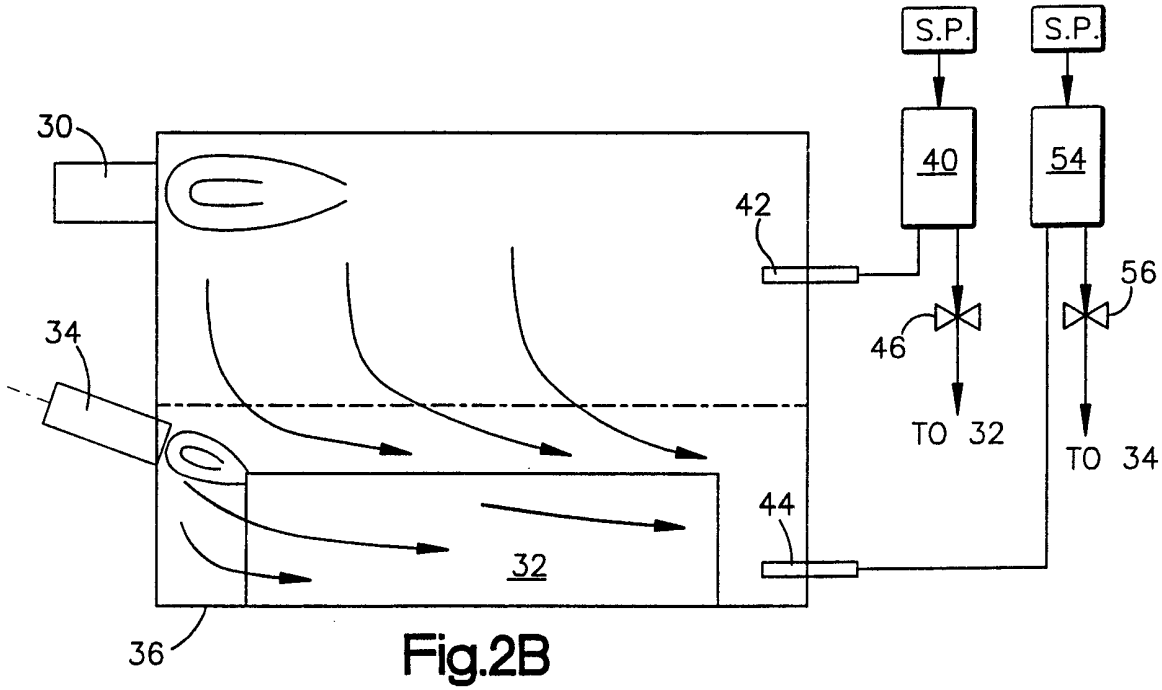

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S.P.
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Fig.2B

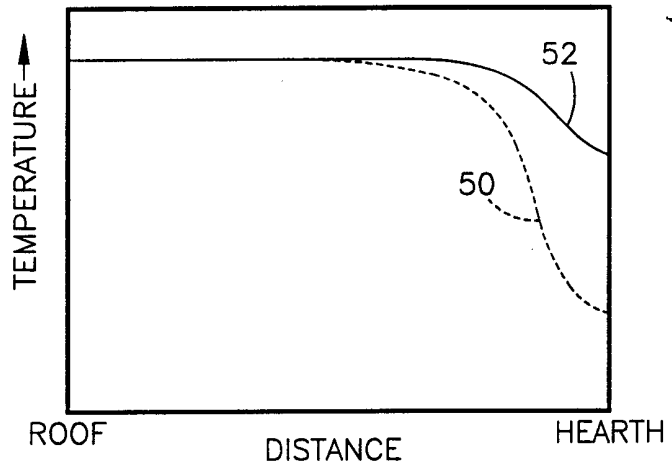


Fig.3

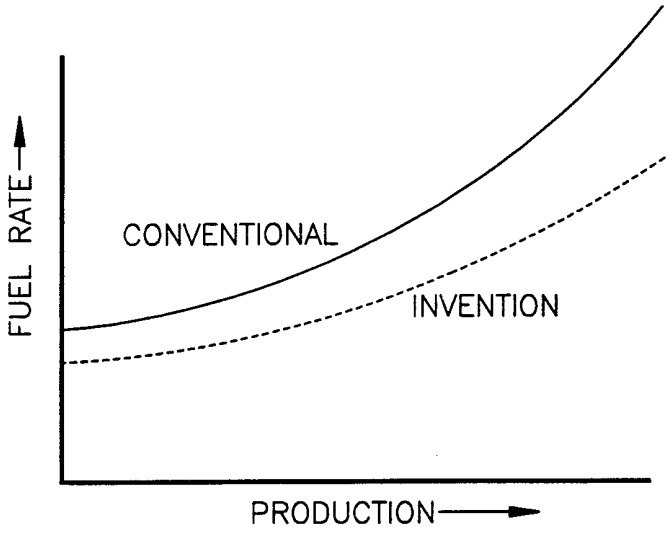


Fig.4A

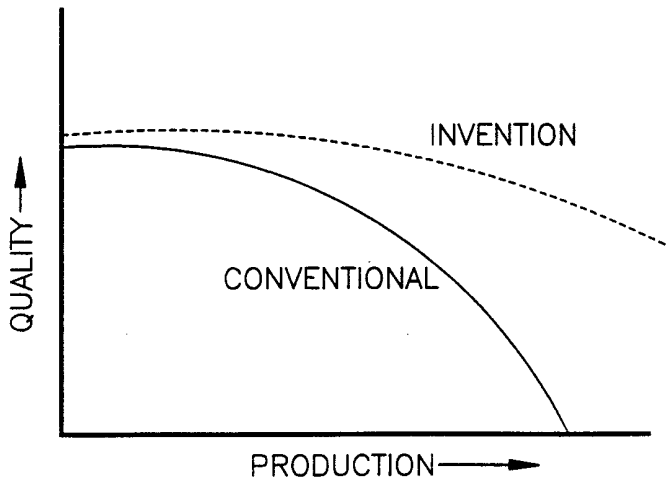


Fig.4B

INTERNATIONAL SEARCH REPORT

Inter ɔnal Application No
PCT/US 99/23348

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F27B3/20 F27B9/36 C21D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F27B C21D F27D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	DE 25 32 922 A (BRITISH STEEL CORP) 5 February 1976 (1976-02-05) claims 1,7	1,4,5, 14,15
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 January 2000	01/02/2000

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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