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83490 Nunnanlahti (FI)(54) **Combustion air duct system**

(57) Combustion air duct system for supplying combustion air into the combustion space of a fireplace, said combustion air duct system comprising an air inlet (1), a heat exchanger (2) for heating the air flowing from the

air inlet through the combustion air duct system, and an outlet (3) for passing the heated air into the combustion space (4). The heat exchanger (2) is in direct heat transfer contact with the flue gas flow after combustion.

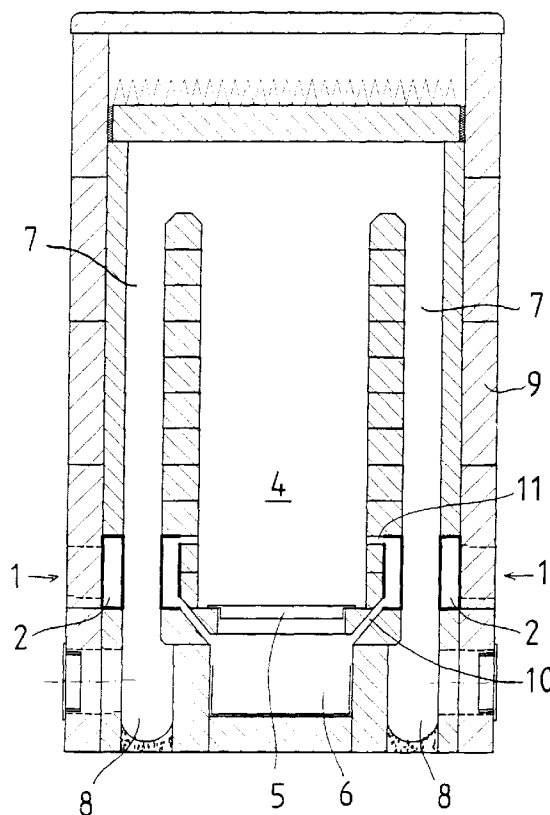


Fig 1

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Description

The present invention relates to a combustion air duct system as defined in the preamble of claim 1.

The way combustion air is supplied into a fireplace is of great importance for combustion. In most cases, the primary combustion air is passed via an ash scuttle and a grate into the combustion process directly from indoor or outdoor air. There are also other ways to supply primary air into the combustion process.

Supplying secondary air to a combustion process is of great importance in respect of cleanness of combustion. Secondary air can be passed to the space above the burning material through scuttles or via separate ducts or even into a separate upper secondary combustion space.

In known structures, combustion air is passed into the combustion process either directly at ambient temperature or after preheating. In prior-art solutions, preheating takes place in the combustion chamber, in other words, generally the combustion chamber is provided with heating channels or pipes in which air is heated and is then discharged at a suitable point into the combustion process.

However, prior-art preheating arrangements have significant drawbacks. The cold air flowing into the system cools down the combustion chamber, thus lowering the combustion temperature and leading to imperfect combustion and impure flue gases. In certain preheating applications, part of the burning gases is cooled down so that the gases are passed unburnt into the exit flue. Thus, because of imperfect combustion, more fuel is needed, use of the furnace becomes more expensive and requires more maintenance, such as chimney sweeping.

The object of the invention is to eliminate the aforementioned drawbacks. A specific object of the invention is to produce a new type of combustion air duct system structure, allowing the preheating of the combustion air in a fireplace to be so implemented that it does not interfere with the combustion process in the furnace and that the combustion will be as efficient and perfect as possible. As for the features characteristic of the invention, reference is made to the claims.

The air duct system of the invention has been mainly developed for soapstone furnaces, but the invention is not restricted to soapstone structures alone; instead, it can be used in furnaces made of other fireplace materials as well, such as brick. In addition, the invention is intended for use in batch furnaces, fireplaces with a heat storage capacity in which the storage mass consists of a solid material capable of storing and delivering heat. Thus, in the applicable fireplaces or furnaces, the structural material as well as the heat storing material may consist of metal, soapstone or other stone material, brick or other burnt mass or equivalent.

The combustion air duct system of the invention for supplying combustion air into the combustion space of

a furnace comprises one or more air inlets, a heat exchanger for heating the air flowing from the air inlet through the supply air duct system, and one or more outlets through which the heated air is passed to a suitable point or suitable points in the combustion space. According to the invention, the heat exchanger is in direct heat transfer contact with the flue gas flow after combustion. In other words, the heat exchanger is placed in the flow of flue gases flowing out of the combustion space. Thus, an essential feature of the invention is that the combustion air is heated, i.e. the energy for its heating is taken from the flue gas flow at a sufficient distance from the combustion process so that at this point all combustion has already taken place and the transfer of heat from the flue gas flow does not interfere with the combustion process.

Thus, the thermal energy used to heat the combustion air is taken from those areas of the duct system or those parts of the furnace structures whose cooling does not reduce the temperature of the combustion process, preferably from a point as close to the flue gas exit flue as possible.

In a furnace with a heat storage capacity, the heat exchanger is preferably placed in a cheek duct, e.g. in its lower part. It may also be placed in the bottom duct after a cheek duct, before the flue. In certain applications, the heat exchanger can also be partially or completely placed in the first part of the flue.

According to the invention, the combustion air duct system may be designed only for the preheating of primary air, in which case the outlet of the duct system preferably opens into the space below the grate. In another embodiment of the invention, the duct system is designed only for the heating of secondary air, in which case the outlets direct the preheated combustion air into the upper part of the combustion chamber or into a secondary combustion space. In a third embodiment of the invention, the combustion air duct system branches after the heat exchanger, directing one portion of the preheated air for use as primary combustion air and another portion for use as secondary combustion air. It is naturally also possible within the scope of the inventive idea to use separate heat exchangers for the preheating of primary air and secondary air.

The air inlet of the combustion air duct system of the invention may be placed freely as appropriate for each furnace either in the top, bottom, front, back or side part of the furnace. The air inlet can be provided with a separate shutter to enable the inlet opening to be closed and the air flow rate to be adjusted.

Especially when only secondary air is preheated, the air inlet can be placed in a coal box or ash box below the combustion chamber, in which case it will be unnecessary to provide a separate shutter or regulator in the structure because the adjustment can be done simultaneously with the primary air adjustment performed via the ash box. In this case, a correct ratio between primary air supplied via the grate and preheated secondary air

supplied into the combustion chamber can be implemented via correct design of the secondary air duct system.

In an embodiment of the invention, the heat exchanger is placed in a cheek duct of the fireplace so that it is surrounded by hot flue gases. It is also possible to place the heat exchanger in the immediate vicinity of a cheek duct, i.e. at the edge of a cheek duct or in contact with the edge so that the heat of the flue gases is effectively transferred to the combustion air to be heated.

In an embodiment of the invention, the heat exchanger is so constructed that the combustion air to be heated is separated from a suitable part of the flue gas channel with a material having a good heat conductivity, such as a relatively thin soapstone sheet or a wall of steel, cast iron or other fire-resistant material with good heat conduction properties. Thus, as the wall between the air duct and the cheek duct is thin and capable of fast and effective conduction of heat, the temperature of the air in the combustion air duct rises rapidly right at the beginning of combustion and the heated primary or secondary air supplied into the combustion reaction has the effect that more perfect combustion is achieved than in conventional structures.

In an embodiment of the invention, the heat exchanger consists of separate, possibly ribbed heat exchanger elements of e.g. cast iron placed in the flue gas channel. Such elements may comprise tubular, platelike or other suitable structures.

It is further possible to form the heat exchanger by machining grooves, holes, cavities or canals in the massive stone structures of a stone furnace. In this case, these structures are disposed near the surface of the flue gas channel, i.e. on the other surface of the massive stone used, so that they effectively heat the combustion air flow.

The combustion air duct system of the invention provides significant advantages as compared with prior art:

- cleaner combustion is achieved than in currently known corresponding furnaces,
- efficiency is improved due to cleaner combustion,
- the structure is cheap and simple to implement,
- cleaner and more perfect combustion is more environment-friendly and saves wood.

In addition, when only secondary air preheating is used, it can be made easily adjustable by placing the air inlet in the coal space, permitting the adjustment to be performed simultaneously with primary air adjustment. On the other hand, when both primary air and secondary air are heated, they can easily be regulated by means of a single adjustable scuttle while the relative air quantities are regulated via design of the ducts.

Moreover, by supplying secondary air preheated according to the invention into the front part of the combustion chamber, to a point right over the door, a solution

is achieved that provides the following advantages:

- the door of the combustion chamber becomes simpler and cheaper because the controls can be omitted
- use of the fireplace is easier because the adjustments can be made from one location, and
- advantageous solutions for sealing the doors are available because the combustion chamber doors need not be provided with air regulation ports.

In the following, the invention is described in detail by referring to the attached drawings, in which

Fig. 1 presents a sectional view of a fireplace with a heat storage capacity and a combustion air duct system as provided by the invention,

Fig. 2 presents a sectional top view of the structure in Fig. 1,

Fig. 3 presents a horizontal section of another structure according to the invention,

Fig. 4 presents a sectional view of a third structure according to the invention,

Fig. 5 presents a fourth fireplace according to the invention in front view,

Fig. 6 presents the fireplace in Fig. 5 in lateral view,

Fig. 7 presents a sectional front view of a fifth embodiment of the invention,

Fig. 8 presents a sectional front view of a sixth embodiment of the invention,

Fig. 9 presents a sectional front view of a seventh embodiment of the invention, and

Fig. 10 presents a sectional front view of an eighth embodiment of the invention.

The fireplace with a heat storage capacity as illustrated by Fig. 1 and 2 comprises an ash box 6 under the grate 5 and a combustion space 4 above the grate, from where the flue gases ascend and, having reached the top part of the combustion chamber, turn downward into the cheek ducts 7, flowing down toward the bottom ducts at the bottom of the fireplace, from where the flue gases pass further into the flue, which is not shown in the figure. The whole structure is surrounded by a massive envelope 9 with a good heat storage capacity.

The envelope 9 is provided with air inlets 1 placed on either side of the envelope and going through it. The air inlets lead to ring-shaped heat exchangers 2 surrounding the cheek ducts 7 at the lower part of the cheek ducts, roughly at the level of the grate or combustion chamber. The ring-shaped heat exchanger, made of cast iron or steel, is so embedded in the massive structures of the fireplace that it does not reduce the cross-sectional flow area of the cheek ducts 7. The ring-shaped heat exchanger 2 opens downward into the ash box 6 via a primary air duct 10 and upward via a secondary air duct 11 above the fuel material in the combustion chamber 4. In this way, both primary air and sec-

ondary air in the fireplace is preheated before entering into the combustion process. The heat for the preheating of the air is taken from the flue gases in the cheek duct 7 at a point far enough from the combustion chamber to ensure that this heat transfer will not interfere with or deteriorate the combustion process in any way.

Fig. 3 presents another embodiment of the invention, in which the heat exchanger 2 is also placed in the lower part of the cheek ducts, but only at one edge of the cheek ducts, i.e. at the rear edge. The air inlets 1 are located on the rear side of the fireplace while the outlets 3 are placed in the back wall of the combustion chamber and likewise in the back wall of the ash chest.

Fig. 4 presents a third embodiment of the invention, in which a corner fireplace has an exit flue 12 in the rear corner, with a ring-shaped heat exchanger 2 disposed around the exit flue. In this case, the flue gases flow up from the combustion space 4 and down through the cheek ducts on either side of the fireplace and further via the bottom ducts into the flue, where the heat exchanger 2 recovers some of the heat and passes it into the combustion air. The air inlet 1 is located in the rear part of the fireplace and the primary air duct 13 runs in a substantially horizontal direction through the bottom structures 15 of the combustion chamber 2 to a point under the grate 16. The secondary air duct 17 goes through the back wall 18 of the combustion chamber 4, opening into the combustion chamber at a point clearly above the grate 16.

Fig. 5 and 6 present an embodiment of the invention in which a soapstone fireplace with a heat storage capacity is only provided with a secondary air duct system according to the invention. The air inlets 1 of the duct system are located on the front side of the fireplace at the level of the lower edge of the door, on either side of it. The air inlets 1 open inwards into the fireplace, where they expand to form a sheetlike heat exchanger 2, which forms in the cheek ducts on either side of the combustion chamber, at the level of the combustion chamber of the fireplace, an air space of a width substantially equal to the width of the cheek ducts and a height substantially equal to the height of the combustion chamber. In the upper part of these air spaces there are a number of outlets 3 which lead through the thick side walls 20 of the combustion chamber into the combustion chamber, passing the air heated by the flue gases in the heat exchanger 2 into the combustion chamber 19. It is to be noted that it would be possible in this embodiment, too, to use primary air ducts to pass part of the preheated air as primary air e.g. via the ash chest and grate.

Fig. 7 shows an embodiment of the invention in which spaces disposed in the outer surfaces of the side stones 21 of the combustion chamber act as a heat exchanger 2. There are air inlets 1 leading from the ash chest 23 of the fireplace into the heat exchangers. In addition, outlets 3 go through the side stones 21 in the upper heat exchanger area into the combustion space 4. Thus, the hot flue gases flowing downward in the

cheek ducts 22 flow past the relatively thin casing 24 of the heat exchanger, thereby heating the secondary combustion air flowing in the opposite direction on the other side of the casing wall.

Fig. 8 presents alternative structures for implementing the heat exchanger 2 of the invention. The cheek ducts 25 are located on either side of the combustion space or combustion chamber 4, and the relatively thick mass with a good heat storage capacity between the combustion chamber and the cheek ducts is provided with outlets 3, through which warm secondary combustion air can be discharged into the combustion space. The heat exchanger 2a is placed behind the cheek duct 25, with a relatively thin casing 26 with a good thermal conductivity between them. Another possibility is to place the heat transfer component 2c in front of the cheek duct, separated from the latter by a corresponding thin casing 27. A third application is a heat exchanger 2b placed beside the cheek duct on the opposite side relative to the combustion space 4, with a corresponding, relatively thin casing 28 with a good thermal conductivity separating the heat exchanger from the cheek duct.

It is further possible in the structure of the invention, as illustrated by Fig. 9, to have outlets 3 placed above the door of the combustion chamber in the front part of the fireplace as well, in addition to the outlets 3 on either side of the combustion chamber 4. In this case, the heat exchangers 2 are preferably placed on either side of the combustion chamber near the cheek ducts 29, with a suitable channel 30 to pass heated secondary air into the combustion space through the front outlets as well.

Fig. 10 presents an embodiment in which the structure of the invention is applied in a corner fireplace. The cheek ducts are now at right angles to each other, with a tubular, vertical heat exchanger 32 disposed at the juncture between them, i.e. in the corner area. At the lower end of the heat exchanger 32 there is an air inlet (not visible in the figure), while its upper end opens into the combustion space 4 via outlets 3.

As can be seen from the embodiments described above, the combustion air duct system of the invention can be implemented in several different ways and the heat exchanger of the invention can be disposed in several different locations in fireplaces of different forms, made of soapstone or other fireplace materials and designed to be used for different purposes or in different modes.

Claims

1. Combustion air duct system for supplying combustion air into the combustion space of a fireplace, said combustion air duct system comprising an air inlet (1), a heat exchanger (2) for heating the air flowing from the air inlet through the combustion air duct system, and an outlet (3) for passing the heat-

ed air into the combustion space (4), **characterized** in that the heat exchanger (2) is in direct heat transfer contact with the flue gas flow after combustion.

2. Combustion air duct system as defined in claim 1, **characterized** in that the heat exchanger is placed in a cheek duct (7,22,25,29,31) in a fireplace with a heat storage capacity. 5
3. Combustion air duct system as defined in claim 1, **characterized** in that the heat exchanger is placed in a bottom duct between a cheek duct and the flue in a fireplace with a heat storage capacity. 10
4. Combustion air duct system as defined in claim 1, **characterized** in that the heat exchanger (2) is placed in the first part of the flue (12). 15
5. Combustion air duct system as defined in any one of claims 1-4, **characterized** in that the heat exchanger is a ring-shaped structure, through which the flue gas flow passes. 20
6. Combustion air duct system as defined in any one of claims 1-4, **characterized** in that the heat exchanger is a sheetlike structure in the flue gas flow. 25
7. Combustion air duct system as defined in any one of claims 1-4, **characterized** in that the heat exchanger is a structure forming part of the flow channel of the flue gas flow. 30
8. Combustion air duct system as defined in any one of claims 1-7, **characterized** in that the air inlet (1) is placed in the top, bottom, front, back or side part of the fireplace and/or in the ash chest. 35
9. Combustion air duct system as defined in any one of claims 1-8, **characterized** in that the outlet (3) is a primary air outlet for passing heated primary air into the combustion chamber. 40
10. Combustion air duct system as defined in any one of claims 1-8, **characterized** in that the outlet (3) is a secondary air outlet for passing heated secondary air into the upper part of the combustion chamber or into a secondary combustion space. 45
11. Combustion air duct system as defined in any one of claims 1-10, **characterized** in that the combustion air duct system is divided after the heat exchanger into a primary air duct (10) and a secondary air duct (11). 50

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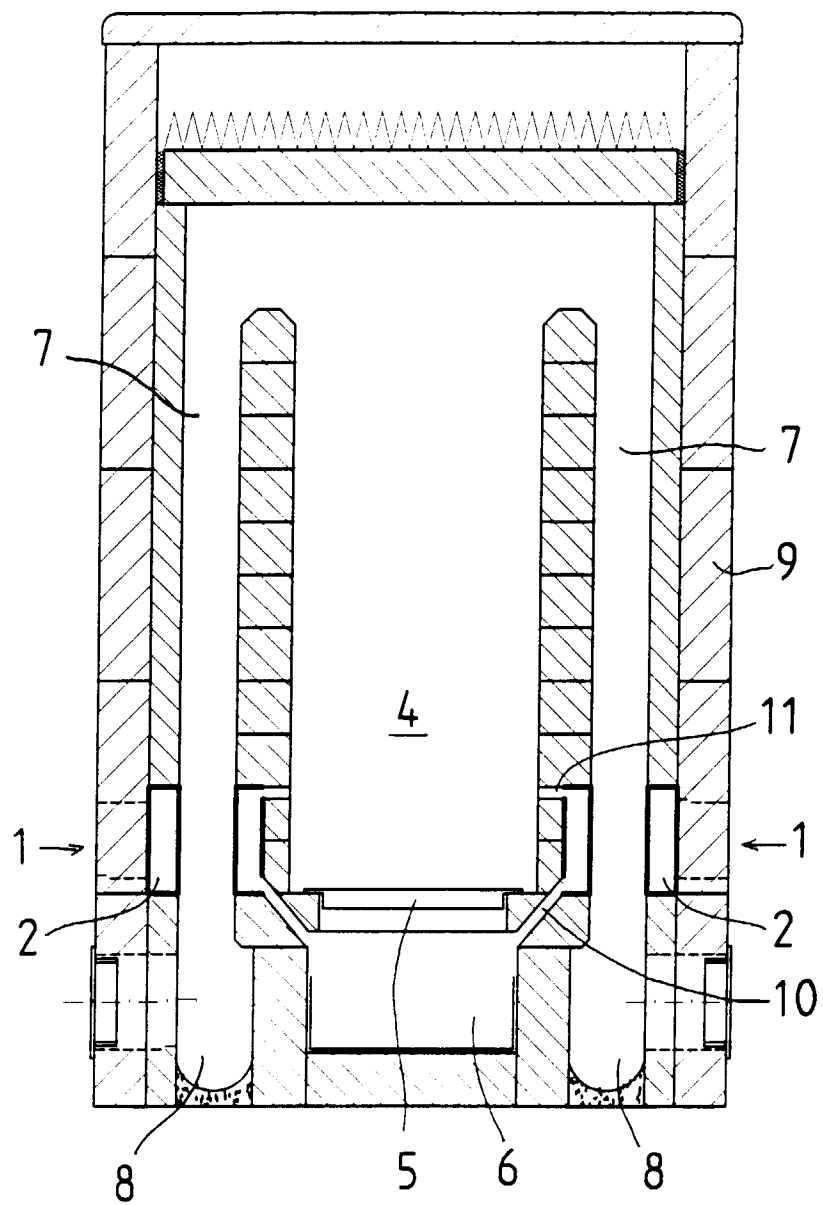


Fig 1

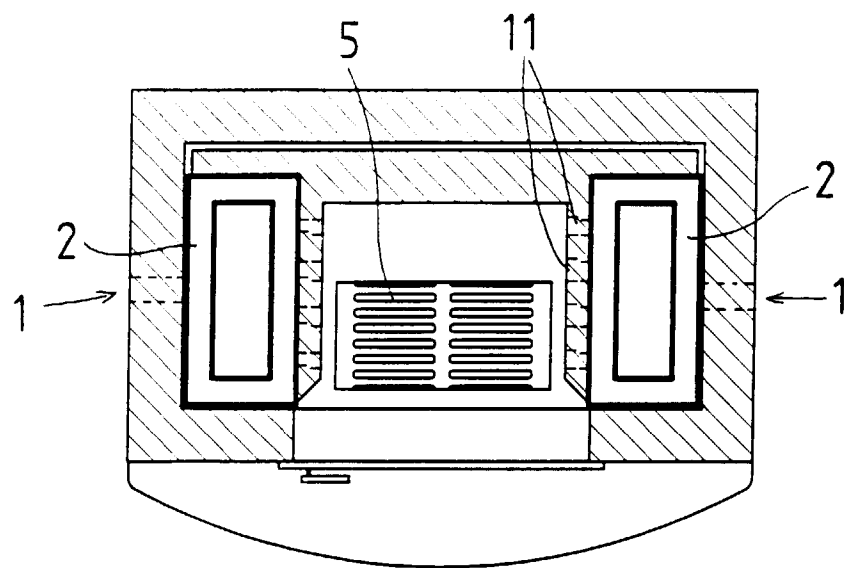


Fig 2

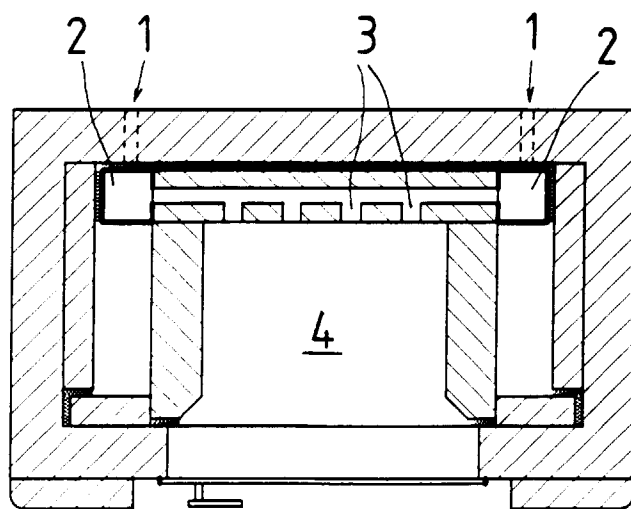


Fig 3

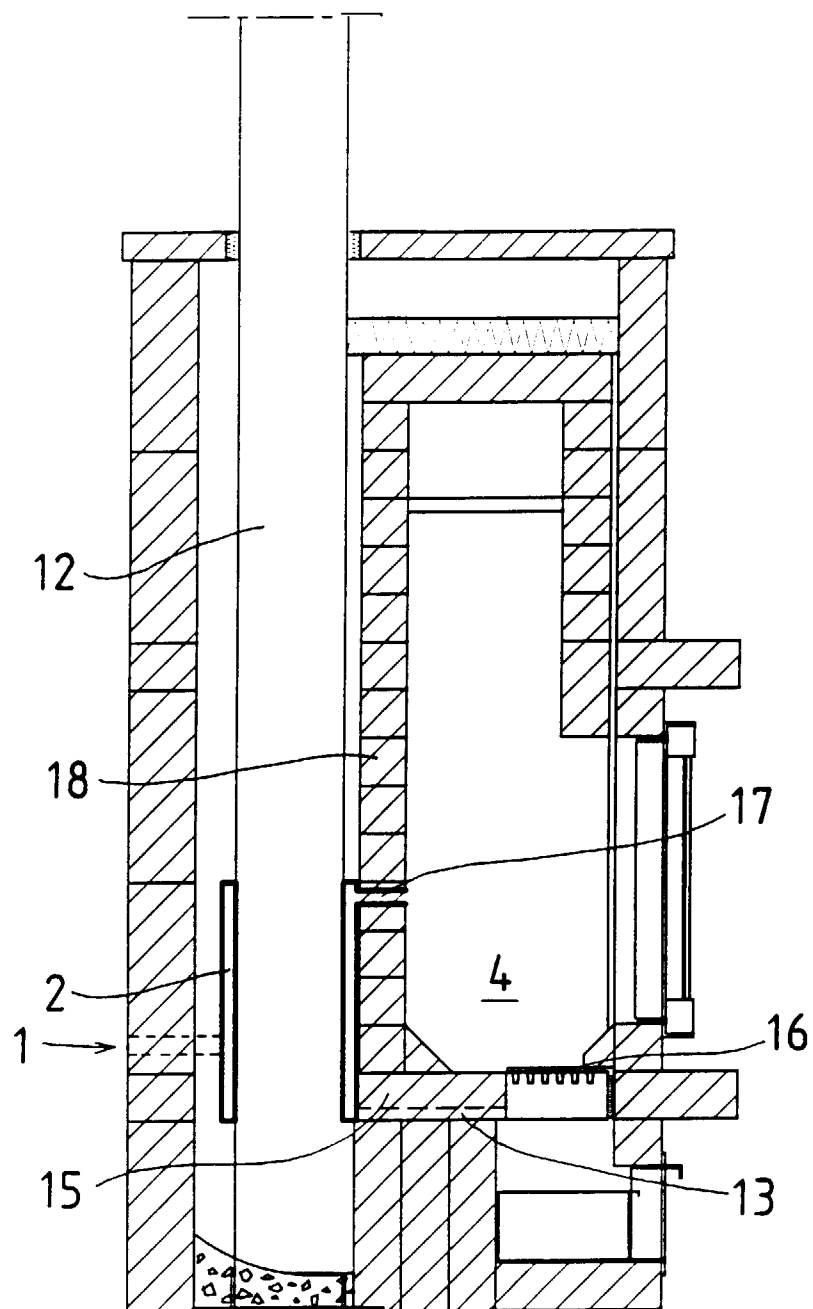
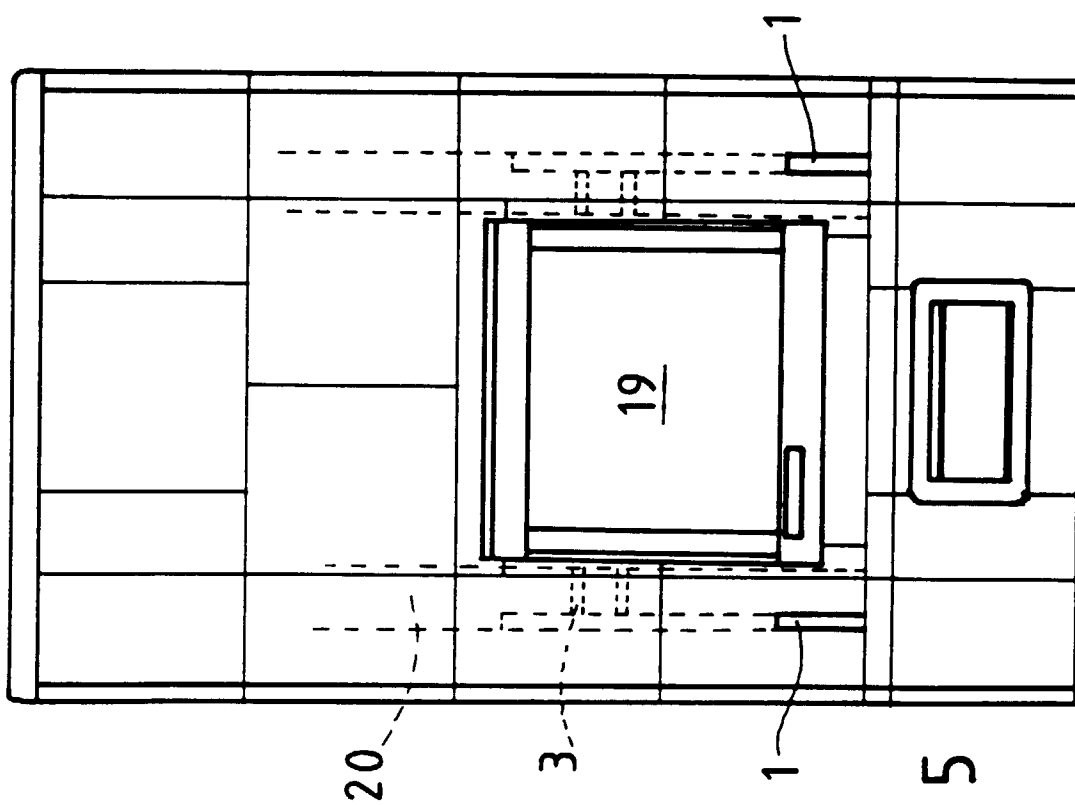
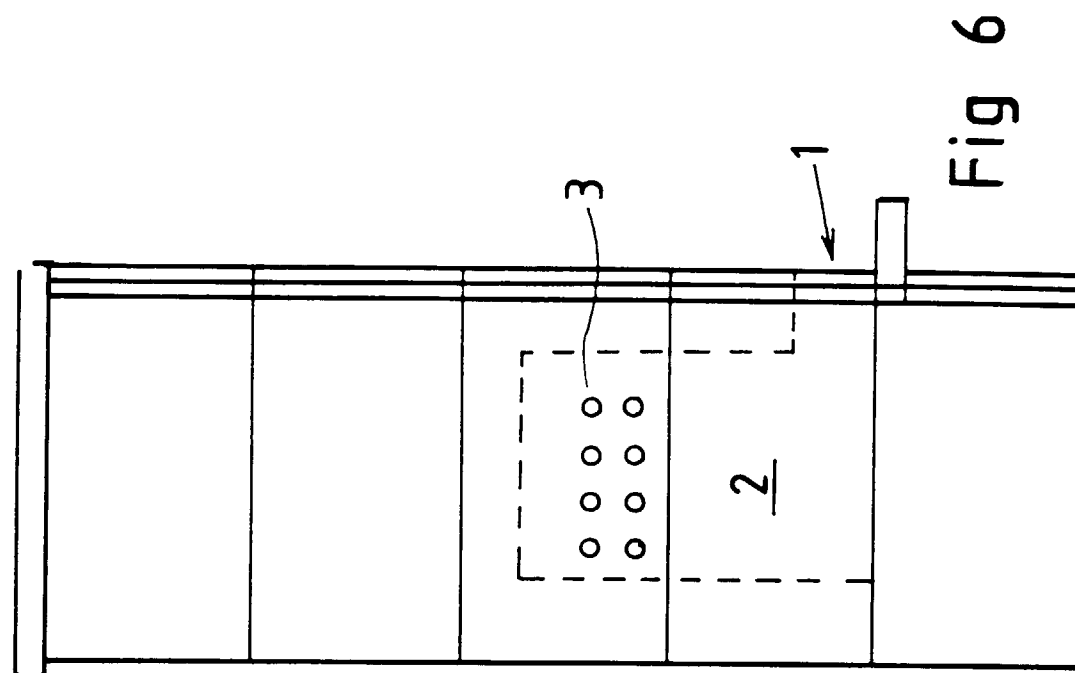


Fig 4



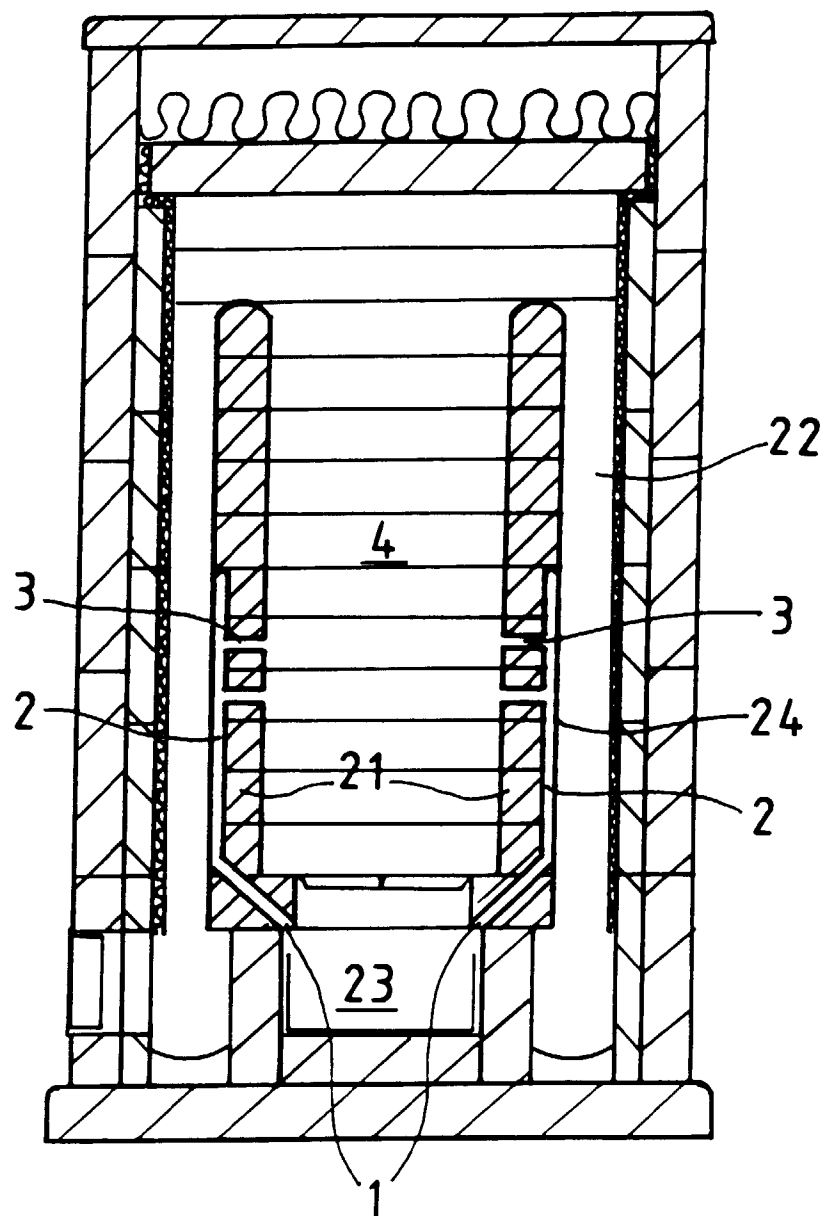


Fig 7

