(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 008 808 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.06.2000 Bulletin 2000/24

(51) Int Cl.[7]: **F23L 1/02**, F23L 9/00

(21) Application number: **99660185.2**

(22) Date of filing: **03.12.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **11.12.1998 FI 982692**

(71) Applicant: **Nunnanlahden Uuni Oy**
83940 Nunnanlahti (FI)

(72) Inventor: **Lehikoinen, Juhani**
83940 Nunnanlahti (FI)

(74) Representative: **Helino, Timo Kalervo et al**
Papula Rein Lahtela Oy,
P.O. Box 981
00101 Helsinki (FI)

(54) Method for the regulation of combustion air and a corresponding regulation arrangement

(57) A method for the regulation of combustion air when wood is burned in a heat-storing fireplace in which all combustion air (1) is supplied from below a grate (2) into a firebox. When a wood charge (4) is being ignited, a substantial proportion of the combustion air (1) is supplied as auxiliary primary air (5) through the middle area of the grate (2) under the wood charge and some of the combustion air is supplied into the firebox as secondary air (6). After the wood charge has been kindled or when more wood (7) is added on top of glowing embers (8), the amount of auxiliary primary air is limited, some of the combustion air is directed as main primary air (9) under the wood charge mainly to the edge areas of the wood charge while most of the combustion air is supplied as secondary air (10) into the firebox.

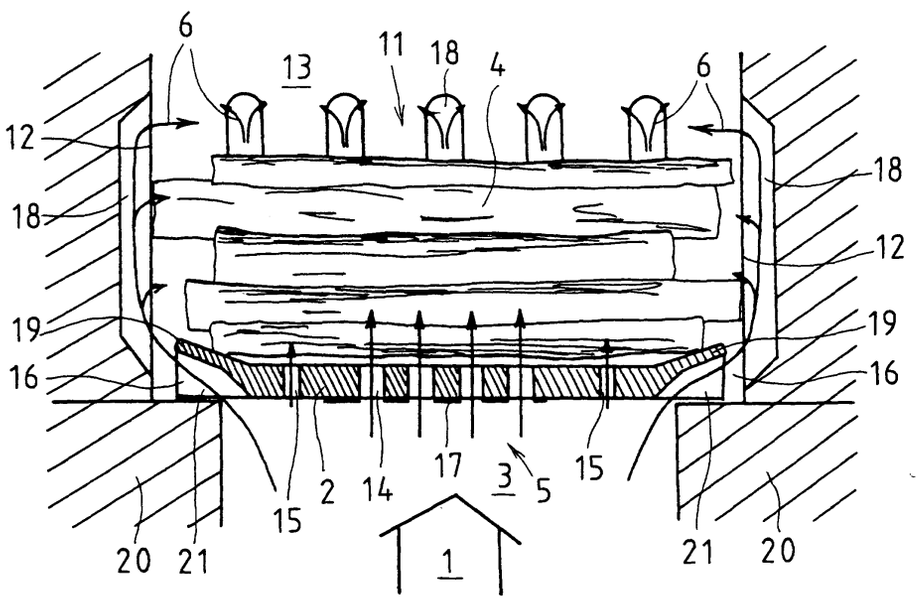

Fig 1

EP 1 008 808 A2

Description

[0001] The present invention relates to a method as defined in the preamble of claim 1 and to a regulation arrangement as defined in the preamble of claim 9 for regulating combustion air in conjunction with the combustion of wood in a heat-storing fireplace.

[0002] For burning wood in heat-storing fireplaces, generally a fire grate is used and the wood charge to be burned is placed on the grate. For fast and efficient ignition, the wood needs plenty of combustion air, which is mainly supplied through the grate as primary air flowing into the wood charge. In this way, the wood charge is effectively ignited and its gasification is started quickly. In addition, many fireplaces use secondary air, which is supplied to the space above the wood charge, which generally is not the hottest point in the combustion process, where the combustible gases released from the wood are burned with the aid of secondary air. Without secondary air, a considerable portion of the gases would flow out through the smoke flue, unburned due to an insufficient supply of oxygen.

[0003] When fresh fuel wood is added on top of hot embers in prior-art fireplaces, problems arise. Very intensive reduction into gas of the wood charge begins immediately because the primary air flowing through the embers makes the embers glow too hot. As a consequence of this, there arises an excessively large flow of unburned gases released from the wood charge, which would require plenty of secondary air to allow complete combustion of all the gases. Such a large amount of secondary would cool down the combustion process and be an impediment to good combustion, because the secondary air could not be heated due to the large amount of energy it would require. Moreover, in prior-art methods, a separate method for regulation of secondary air would have to provided because the need for secondary air varies greatly from moment to moment. If a large amount of secondary air were to be supplied and preheated to make the combustion process work, this would result in large heat peaks. It would not be possible to store a sufficient proportion of the energy of these heat peaks in the mass but the combustion gases would be passed too hot into the chimney.

[0004] Supplying such a large amount of secondary air into the space above the wood charge would require exceptionally large secondary air ducts whose construction would be difficult to implement, and therefore no such structures have been implemented. For these reasons, when fuel wood is added into the furnace in prior-art solutions, part of the combustible gases contained in the wood is passed unburned into the chimney flue, which significantly increases the emissions from the combustion process. Similar intensive gas formation occurs even after the first wood charge has been properly kindled. In this case, too, a significant proportion of the combustion gases is passed unburned into the chimney flue because of an insufficient oxygen supply.

[0005] The object of the invention is to eliminate the drawbacks referred to above. A specific object of the invention is to disclose a new type of method and a corresponding regulation arrangement which will allow wood to be burned in a heat-storing fireplace as effectively as possible and so that over-gasification of the fuel wood is prevented.

[0006] As for the features characteristic of the invention, reference is made to the claims.

[0007] In the method of the invention for the regulation of combustion air, when wood is burned in a heat-storing fireplace, a substantial proportion of the combustion air is passed as auxiliary primary air through the central area of the grate under the wood charge so that ignition takes place promptly and effectively and the wood charge begins to be reduced into gas. This is also essential in respect of draught in the fireplace and the maintenance of cleanness of the smoke flues. In addition, some of the combustion air is passed into the firebox, suitably as secondary air into the burning gas flow around and above the wood charge to induce combustion of unburned gases in the firebox of the heat-storing fireplace. Thus, the secondary air is also effectively heated and therefore it maintains the combustion process well. After the wood has been properly kindled, the amount of auxiliary primary air flowing through the grate is limited and at the same time some of the combustion air is directed as main primary air under the wood charge mainly to the edge areas of the wood charge so that the gasification of the wood charge will go on and is maintained, yet limited and regulated. In addition, most of the combustion air is passed as secondary air into the firebox, suitably around and above the wood charge, so that the gases flowing up from the wood charge immediately mingle with a sufficient amount of preheated oxygen and are completely burned in the firebox of the fireplace before reaching the chimney flue. Another possible alternative is that the limitation of the amount of auxiliary primary air according to the invention is only effected after the first refueling, in other words, the first wood charge is allowed to burn with ignition adjustments, and when more wood is added on top of the hot embers, the combustion air flows are readjusted.

[0008] The main primary air can be supplied from under the wood charge through the grate so that it flows from the central part of the grate, increasing towards the edges. However, the primary air is preferably caused to flow under the wood charge only in the edge areas of the wood charge or alternatively only in the edge areas of the grate. This means that s new wood charge placed upon hot embers will not be gasified in an explosive manner but in an appropriate and controlled manner in respect of clean combustion of the gases with secondary air. Thus, the gases released from the wood charge will be completely burned in the abundant secondary air flow which, being preheated, is immediately available around the wood charge for combustion.

[0009] The primary air flow through the grate mainly

in its edge areas is preferably kept continuous even during ignition, but the auxiliary primary air flows in the middle part of the grate are appropriately throttled after the charge has been ignited or in conjunction with the first addition of a wood charge. In a preferred embodiment, the openings for auxiliary primary air flow are closed completely after the wood has been ignited or in conjunction with the first addition of wood into the firebox, the primary air for the gasification of the wood being supplied under the wood charge as a main primary air flow directed to the edge areas of the charge.

[0010] The secondary air is preferably supplied into the firebox around the wood charge as an air flow as smooth as possible and surrounding the wood charge on all sides except the under side. Thus, secondary air may be flowing on both sides of the wood charge, behind the wood charge, in front of and/or above the wood charge.

[0011] The heat-storing fireplace used in the arrangement of the invention for the regulation of combustion air comprises a firebox horizontally delimited by side walls and a back wall and a door, a grate forming the bottom of the firebox and a space under the grate, often an ash box, through which combustion air can be passed into the firebox. Other ways of supplying combustion air from below the grate into the firebox may also be used. According to the invention, the middle area of the grate is provided with holes for auxiliary primary air whereas the holes for main primary air are disposed in the edge areas of the grate. Disposed at the edges of the grate are also ducts for passing secondary air from below the grate around the firebox on all four sides of the wood charge so that the secondary air will surround the entire fuel wood charge. Moreover, the auxiliary primary air holes are provided with adjusting elements allowing regulation for the flow of auxiliary primary air.

[0012] The main primary air holes are preferably disposed around or outside the auxiliary primary air holes, i.e. farther away from the centre of the grate, and the auxiliary primary air holes are disposed mainly in the middle area of the grate. In this way, definite zones or areas are formed where the air flow through the grate can be controlled or even stopped altogether.

[0013] The total maximum cross-sectional area of the auxiliary primary air holes is many times larger than the total cross-sectional area of the main primary air holes. Therefore, when the fuel wood is being ignited, a large primary air flow can be supplied from under the wood, but on the other hand, at a later stage during the combustion of the wood, the primary air flow can be adjusted to a suitable level with respect to the secondary air flow and the combustion.

[0014] The side walls and/or back wall of the firebox are preferably provided with vertical grooves with their open sides facing toward the firebox, said grooves directing the secondary air flowing along the air ducts at the edges of the grate into the firebox, around and above the fuel wood. The secondary air is effectively heated in the grooves and at the same time the secondary air flow prevents overheating of the walls of the firebox. The grooves form a rising channel through which secondary combustion air can effectively flow around and above the wood in the firebox regardless of how far the firebox is filled with wood. The grooves may be made directly in the stone walls of the firebox or they may be implemented using separate elements placed at the edges of the firebox. In prior-art solutions comprising vertical grooves in firebox walls, the function of the grooves is to allow the combustion gases to flow past the wood charge in a fully loaded firebox, whereas in the present invention the grooves expressly function as a channel for passing combustion air from below the wood charge to its sides and above it.

[0015] Instead of grooves, it is also possible to use various flow channels placed at the edges of the firebox. The flow channels may be disposed inside the firebox side walls or on their surface, and the channels may consist of a stone or metal structure or a suitable cast structure or suitable masonry. The channels may serve to supply secondary air above the wood charge and also to its sides. Therefore, the implementation of the vertical secondary air flows is not defined in more definite terms, but the essential point is that sufficiently ample amounts of secondary air can be supplied from below the grate and passed around and above the burning wood charge.

[0016] The method of the invention and the corresponding regulation arrangement have significant advantages as compared with prior art. The invention allows considerably more efficient combustion of wood than is possible in currently used heat-storing fireplaces. The invention effectively prevents excessive and sudden gasification of wood already ignited or wood added into a hot furnace, and thus is allows the combustion of all combustible gases in the firebox, thereby preventing unburned gases from getting into the chimney flue. The temperature variations of the combustion gases remain at a minimum. The temperatures remain at a steady high level all the time during heating, so the storage performance of the fireplace is also at a maximum. Thus, the invention significantly improves the final result of combustion, which also means substantially cleaner combustion gases. Moreover, with the regulation arrangement of the invention, uniform combustion in the fireplace is achieved and excessive temperatures are prevented, thereby increasing the durability of the structures and prolonging their service life.

[0017] In the following, the invention will be described in detail with reference to the attached drawings, wherein

Fig. 1 presents a diagram illustrating a first stage in the method and regulation arrangement of the invention, and Fig. 2 correspondingly illustrates a second stage,

Fig. 3 presents a firebox structure according to the

invention in top view,

Fig. 4 presents the firebox in the previous figure when filled with wood, and

Fig. 5 presents another firebox structure according to the invention in top view.

[0018] The heat-storing fireplace as presented in Fig. 1 and 2 comprises a firebox 11, which again comprises side walls 12 and a back wall 13 and a door in the front, which is not shown in the drawings. The bottom of the firebox is formed by a grate 2 and an ash box 3 below the grate. In this embodiment, all combustion air 1 is supplied into the firebox 11 exclusively through the ash box 3.

[0019] In its middle area, the grate 2 is provided with a number of auxiliary primary air holes 14, and on the lower surface of the grate in the region of the holes there are regulating elements 17, i.e. a suitable slidable damper or shutter, by means of which the auxiliary primary air holes can be closed and opened as desired. Around or outside the auxiliary primary air holes 14, i.e. in the edge areas of the grate 2, there are smaller holes going through the grate, i.e. main primary air holes 15, which are always open and are therefore not provided with any regulating elements. In addition, the edge of the grate consists of a flange 19 pointing in an oblique upward direction, the grate being only supported by ribs 21 on the edges 20 of the ash box. Thus, flow channels 16 are formed below the flanges 19 of the grate, through which channels the secondary air portion of the combustion air 1 can flow near both the side walls and back wall of the firebox and via the front edge into the front part of the firebox. In this way, the wood charge is surrounded by a rising flow of secondary air 6.

[0020] The walls of the firebox are provided with upright grooves 18 laid vertically, with their open sides facing toward the firebox, the flow of secondary combustion air being guided into these grooves by the flow channels 16. The grooves 18 pass the secondary combustion air further up around and above the wood charge burning in the firebox.

[0021] The regulation arrangement of the invention presented in Fig. 1 and 2 works as follows. In the case of Fig. 1, when a wood charge is to be kindled, the wood charge 4 is placed on the grate 2 and ignited, keeping the auxiliary primary air holes 14 fully open. Thus, a maximum amount of primary air is supplied to the wood charge, so it will start burning rapidly. In this way, the gasification of the wood is started quickly, combustion is accelerated fast and the entire fireplace and chimney flue are warmed up, so a natural draught is set up in the flue. During the ignition phase, the auxiliary primary air holes, main primary air holes and the secondary air flow channels are all fully open and the combustion air 1 is divided roughly equally between the primary air and secondary air flows. The auxiliary secondary air flow is about 4-6 times as large as the main primary air flow.

[0022] As illustrated in Fig. 2, when a new wood charge 7 is added into the firebox onto full-hot embers 8, the following changes are made in the regulation of combustion air 1. The corresponding changes can also be made already after the first wood charge has properly caught fire and intensive gasification of charge is taking place. By means of the regulating elements 17, the auxiliary primary air holes 14 are preferably closed completely, but they can also be left slightly open. When the auxiliary primary air holes are closed completely, the combustion air 1 is only divided between the main primary air holes 15 and the secondary air flow. In this case, only 15-20 % of the total combustion air 1 is passed through the main primary air holes 15 under the hot embers 8 and the wood charge 7. The remaining portion of the combustion air is supplied as a secondary air flow 10 to the front, lateral, back and top sides of the wood charge.

[0023] As the main primary air flow 9 is relatively limited, gasification of the wood charge 7 at first mainly takes place only above the main primary air holes 15, i. e. in the edge areas of the wood charge, and further as the combustion advances slowly toward the middle region of the wood charge. Therefore, at first there is an insufficient oxygen supply in the middle of the wood charge 7, so in that part the temperature falls and gasification is slowed down or is not started rapidly. In this way, the gasification of the wood charge can be regulated and limited, in other words, the rate of gasification of the wood charge is limited to a level such that a significant amount of secondary combustion air can be supplied around and above the wood charge so as to cause all the combustible gases to burn already in the firebox, thus preventing unburned gases from getting into the chimney flue.

[0024] The combustion efficiency is also increased by the fact that a large secondary air flow is flowing in the firebox near its walls, this air flow being thus heated by the intensive radiated heat from the embers 8 and the combustion process before the secondary combustion. In addition, the secondary combustion air flow keeps the temperature of the firebox walls relatively low, thus prolonging their service life and increasing their durability in spite of the high temperature, which may reach a level as high as 1200°C.

[0025] Figures 3 and 4 present a firebox structure corresponding to figures 1 and 2 as seen from above. The grate 2 forms the bottom of the firebox. In the middle area of the grate there are number of auxiliary primary air holes 14, and around these, i.e. on both sides of this group of holes, there are three main primary air holes 15 arranged in a line. At the front edge of the grate, behind the door 22, there is a transverse slit 23 leading from below the edge flange 19 of the grate into the ash box. Moreover, both side walls 12 and the back wall 13 are provided with a number of vertical grooves 18 open toward the firebox. The grooves extend from below the grate 2, i.e. from the region of the flow channel 16 below the grate 2, up to the upper part of the firebox, to a level

above the wood charge. As shown in Fig. 4, the firebox can be completely filled with wood right to the walls 12 and 13. In spite of this, an effective secondary air flow via the channels 18 is formed around the wood charge.

[0026] Fig. 3 also presents a possible additional embodiment in which the side walls 12 and the back wall 13 of the firebox are provided with flow channels 27 placed between the grooves 18 and supplying secondary air from below the grate to the upper part of the firebox, either only above the wood charge or also partly to the level of the wood charge. The secondary air rising in the flow channels effectively cools the stone structure between the grooves, preventing overheating of the stones. These channels can also be used to supply unburned air with a high oxygen content to a desired point in the upper part of the firebox.

[0027] Fig. 5 presents another embodiment of the invention, in which, as in Fig. 3, the grate 2 is provided with auxiliary primary air holes 14 and main primary air holes 15 as well as a slit 23 at the front edge of the grate behind the door 22. The side walls 12 and the back wall 13 of the firebox have smooth surfaces, and the firebox is provided with vertical bars or ribs 24 placed in direct contact with the walls. The vertical bars or ribs are connected to each other in a suitable manner, e.g. by their upper and lower edges via intermediate brackets 25. As the grate 2 does not extend right up to the walls 12 and 13, there are passages 26 formed between the grate edge, the walls 12 and 13 and the ribs 24, allowing secondary air to rise from below the grate and get around and above the wood charge on the grate. The bars or ribs may form a frame which is only placed loose on the grate against the walls of the firebox. This structure and the intensive air flow rising in it give an effective protection against overheating of the firebox.

[0028] In the foregoing, the invention has been described by way of example with reference to the attached drawing while different embodiments of the invention are possible within the scope of the inventive idea defined in the claims.

Claims

1. Method for the regulation of combustion air when wood is burned in a heat-storing fireplace in which all combustion air (1) is supplied from below a grate (2) into a firebox, **characterized** in that, when a wood charge (4) is being ignited, a substantial proportion of the combustion air (1) is supplied as auxiliary primary air (5) through the middle area of the grate (2) under the wood charge and some of the combustion air is supplied into the firebox as secondary air (6), and that after the wood charge has been properly kindled, the amount of auxiliary primary air is limited, some of the combustion air is directed as main primary air (9) under the wood charge mainly to the edge areas of the wood charge while most of the combustion air is supplied as secondary air (10) into the firebox.

2. Method as defined in claim 1, **characterized** in that the main primary air flow (9) is supplied under the wood charge (4) so that it increases from the middle towards the edges.

3. Method as defined in claim 1, **characterized** in that the main primary air (9) is supplied from under the wood charge (4) only in the edge areas of the wood charge.

4. Method as defined in claim 1, **characterized** in that the main primary air (9) is supplied from under the wood charge only in the edge areas of the grate (2).

5. Method as defined in any one of claims 1-4, **characterized** in that the openings in the middle area of the grate (2) for the flow of auxiliary primary air (5) are throttled.

6. Method as defined in any one of claims 1 - 4, **characterized** in that the openings for the flow of auxiliary primary air in the middle area of the grate (2) are closed.

7. Method as defined in any one of claims 1 - 6, **characterized** in that the main primary air (9) is passed through the grate via separate individual discharge holes, so that the main primary air flow forms intensive, sharp primary air jets in the edge areas of the wood charge.

8. Method as defined in any one of claims 1 - 7, **characterized** in that the secondary air is supplied into the firebox so that it forms an air envelope substantially surrounding the wood charge.

9. Arrangement for the regulation of combustion air when wood is burned in a heat-storing fireplace comprising

- a firebox (11) delimited horizontally by side walls (12) and a back wall (13) and a door,
- a grate (2) forming the bottom of the firebox, and
- an ash box (3) below the grate, **characterized** in that
- the middle area of the grate (2) is provided with auxiliary primary air holes (14),
- the edge areas of the grate are provided with main primary air holes (15),
- flow channels (16) are provided at the edges of the grate for passing secondary air from below the grate to the vicinity of the firebox walls, and
- regulating elements (17) are provided in conjunction with the auxiliary primary air holes (14)

to allow regulation of air flow passing through them.

10. Regulation arrangement as defined in claim 9, **characterized** in that the main primary air holes (15) are disposed around the auxiliary primary air holes (14).

11. Regulation arrangement as defined in claim 9, **characterized** in that the total maximum cross-sectional area of auxiliary primary air holes (14) is multiple times as large as the total cross-sectional area of the main primary air holes (15).

12. Regulation arrangement as defined in any one of claims 9 - 11, **characterized** in that the side walls and/or back wall of the firebox are provided with grooves (18) with their open sides facing toward the firebox, said grooves directing the secondary air flowing via flow channels at the edges of the grate to the upper part of the firebox, around and above the burning wood.

13. Regulation arrangement as defined in any one of claims 9 - 11, **characterized** in that the firebox comprises flow channels only open at their ends and disposed in the side walls and/or back wall of the firebox or in their vicinity, said channels directing the secondary air flowing through the flow channels at the edges of the grate to the upper part of the firebox, around and above the wood being burned and gasified.

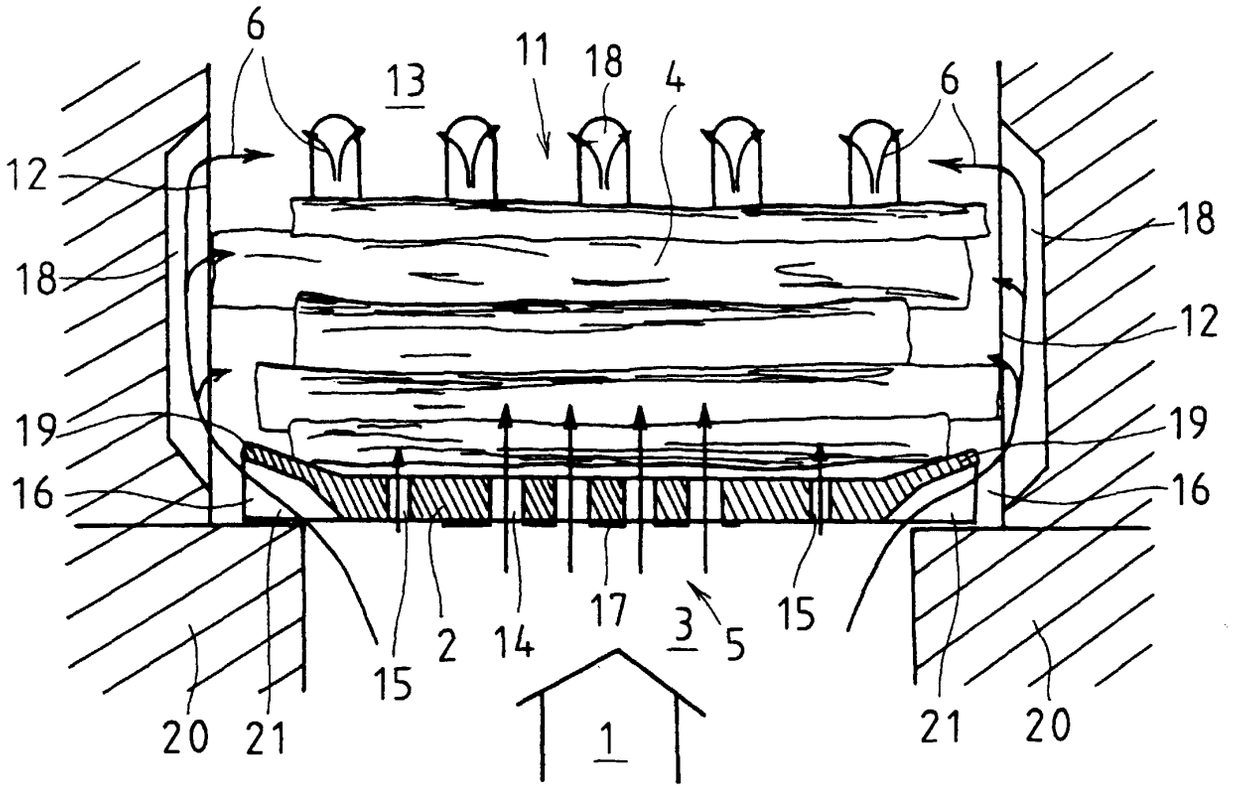

Fig 1

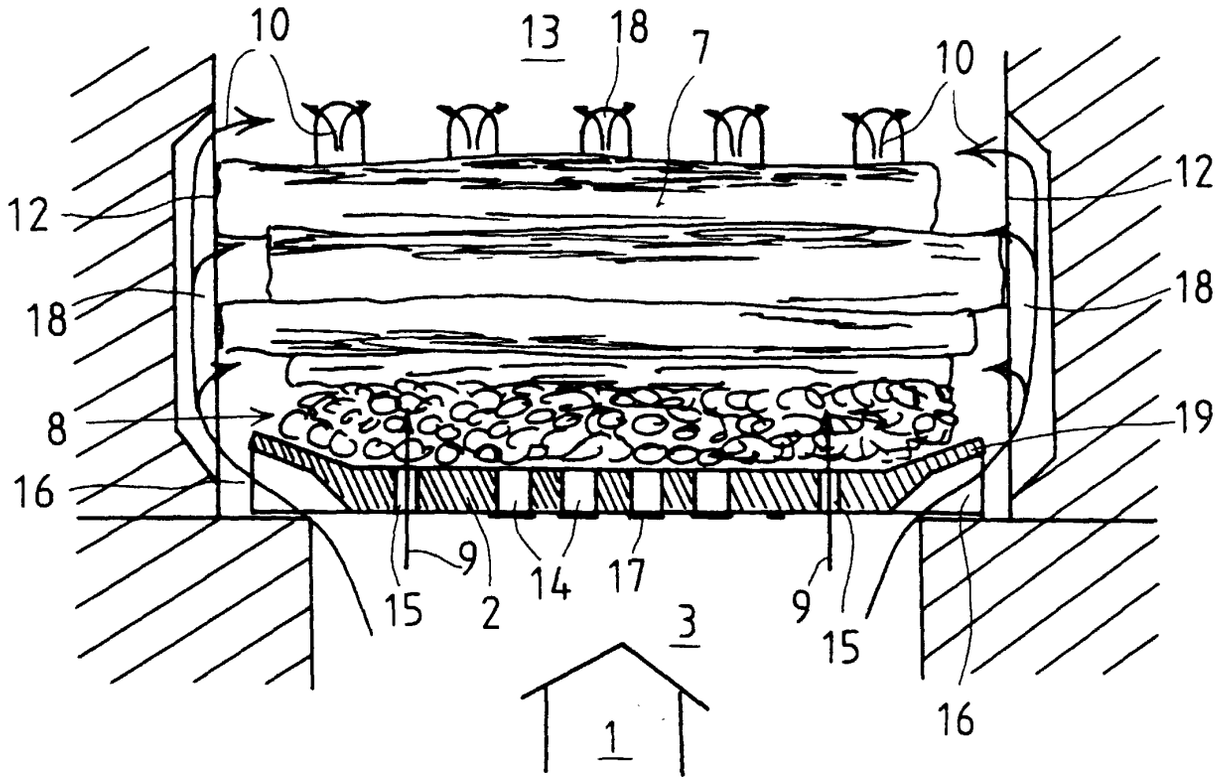

Fig 2

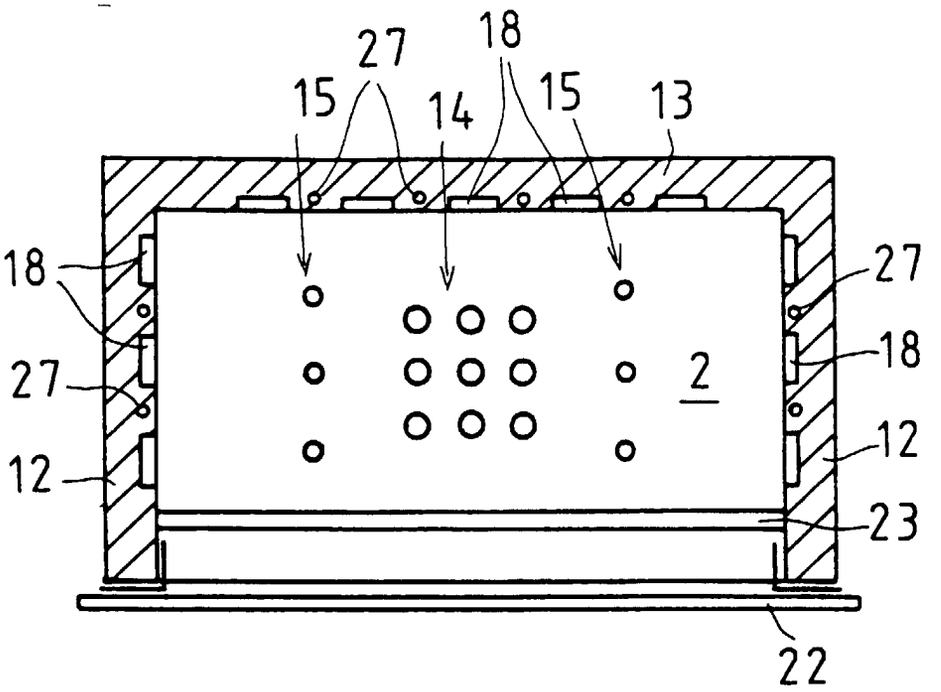

Fig 3

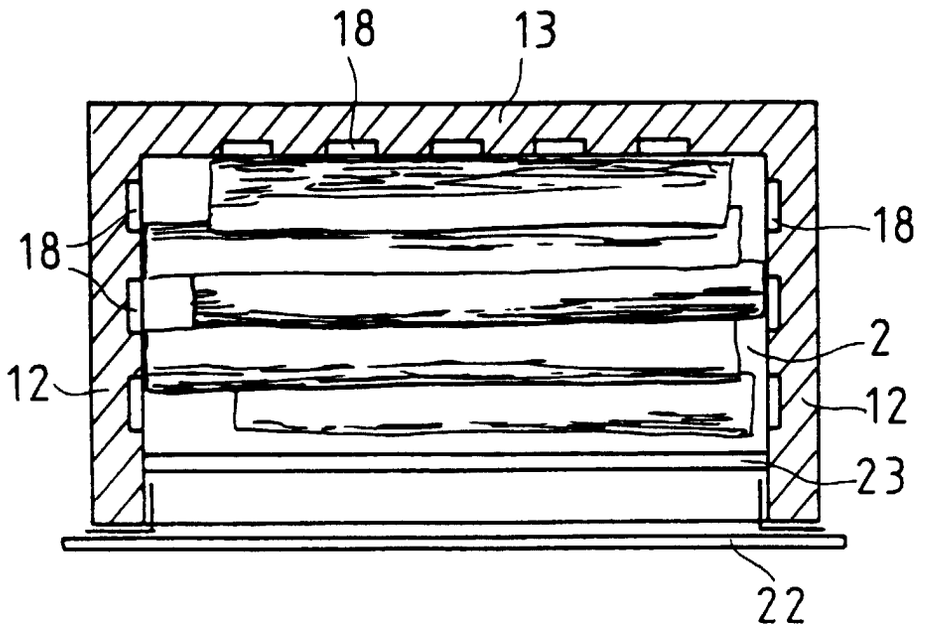

Fig 4

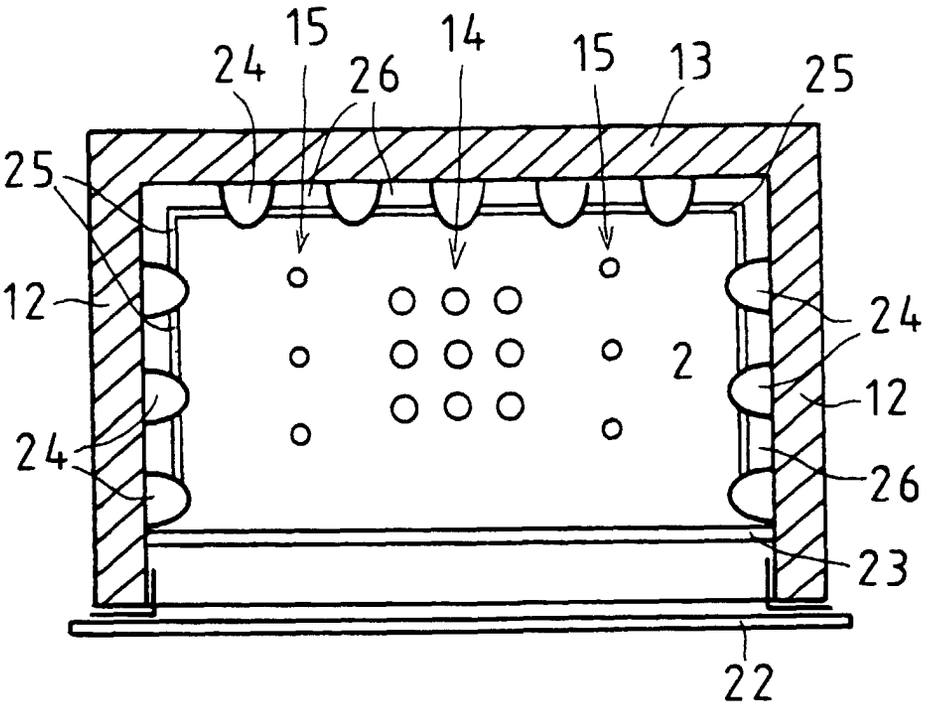

Fig 5