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(54) **Burner for solid fuel, and furnace**

(57) The invention relates to a burner for solid fuel, particularly for pellets, the burner comprising a body (3') and a grate (4'). To enable burning of pellets with a clam flame and yet at low emissions, the grate (4') comprises an oblique grate surface (16a', 16b') defining an underlying air flow space (20') and an overlying fuel space (19') extending all the way to the top end of the body (3'), the grate (4') extending from a first end wall of the body (3') to a second end wall opposite to the first one, the top end (10') of the grate comprising first air openings (13a', 13b') arranged to extend in the longitudinal direction of the grate (4') from the first end of the grate to the second end opposite to the first one, the air openings being formed so as to allow flow of air from the air flow space (20') to the top end of the fuel space (19'), and the grate (4') comprising second air openings (14a', 14b') arranged to extend underneath the first air openings (13a', 13b') in the longitudinal direction of the grate (4') from a first end of the bottom end (15') of the grate to a second end opposite to the first one. The invention also relates to a furnace.

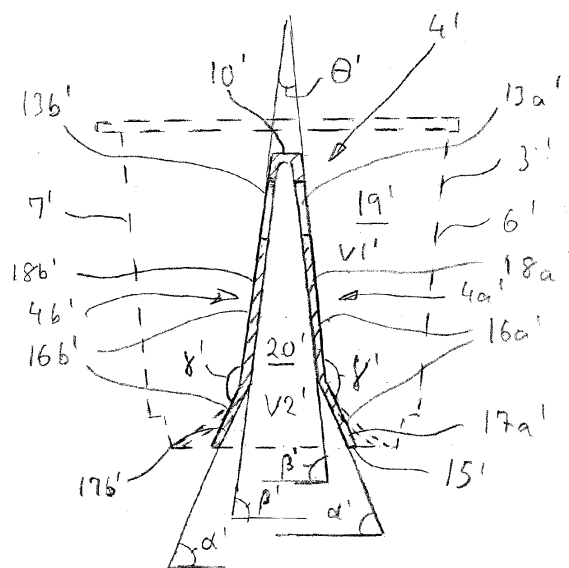


Fig. 7

Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a burner for solid fuel, particularly for pieces of fuel, such as pellets, the burner comprising a body and a grate. The body is defined by a wall structure and the grate is arranged inside the body. The invention also relates to a furnace comprising a burner like the one mentioned above.

[0002] EP publication 1402217 B1 discloses a burner of this type that may be placed into a furnace. A problem with this prior art burner is that it causes pellets to burn very intensively, which is seen in the flame: it is extremely restless and has an unpleasantly bright colour. In other words, the burner is not suitable for creating a calm flame pattern producing a nice ambience as is conventionally associated with burning wood. Another drawback of the burner is that the intensive burning locally heats up and thus causes stress to the structures where it is installed in, such as the surrounding furnace. A further problem is that the burner is not well-suited for burning wood, because it comprises a cylindrical body which is difficult to charge.

BRIEF DISCLOSURE OF THE INVENTION

[0003] An object of the invention is to eliminate the disadvantages of the prior art burner. A burner of the invention is characterized in that its body is longitudinal and its wall structure comprises a longitudinal side wall and end walls, that the grate comprises an oblique grate surface, which extends between the top end and the bottom end of the grate and defines an underlying air flow space and an overlying fuel space, which substantially extends all the way to the top end of the body, that the grate extends from the bottom end of the body to the top end thereof and substantially from a first end wall of the body to a second end wall opposite to the first end wall, that the top end of the grate comprises first air openings arranged to extend in the longitudinal direction of the grate substantially from the first end of the top end of the grate to the second end opposite to the first end, the air openings being defined so as to allow flow of air from the air flow space to the top end of the fuel space, and that the grate comprises second air openings arranged underneath the first air openings to extend in the longitudinal direction of the grate substantially from the first end of the bottom end of the grate to the second end opposite to the first end.

[0004] An essential aspect of the invention is that the grate guides the combustion air to the top part of the fuel space and the body, thus producing a clean, uniform and wide flame.

[0005] Preferred embodiments of the burner of the invention are disclosed in the accompanying claims 2 to 15.

[0006] The major advantage of the burner of the invention is that it enables pellets to be burned with a calm

flame creating an ambience of tranquillity, which is aesthetically pleasant and does not cause significant stress to structures close by the flame. The burner allows burning with low CO and OGC emissions and high efficiency to be achieved. Because of the oblique grate pellets (or other solid fuel) can be efficiently burned completely. A further essential advantage of the burner of the invention is that it provides a suitable alternative for burning wood without any modifications being required. Yet another advantage is that because of its body structure the burner is suitable for retrofitting to fireplaces using wood as fuel and provided with a suitable recess for the burner, or the burner grate may be placed into furnaces provided with a grate funnel. From the manufacturing point of view, the burner structure is easy to accomplish.

[0007] A further object of the invention is to provide a furnace suitable for burning pellets without the burning being associated with a restless flame and local overheating of the furnace or with other drawbacks common in the burning of pellets. The furnace of the invention is characterized by what is stated in the characterizing part of the accompanying claim 16.

[0008] The wall structure of the fire chamber above the burner is preferably provided with air supply conduits for supplying secondary air above the fuel space of the burner. The air supply conduits ensure efficient and clean total burning of the fuel gases. Alternatively, or in addition, clean and efficient burning is ensured by air supply means associated with the door structure of the furnace fire chamber for supplying secondary air above the fuel space of the burner.

[0009] The major advantages of the furnace of the invention are that although pellets are burned in the furnace, it provides a calm and beautiful flame pattern and its structures are not subjected to high thermal stresses. Moreover, the furnace is free of disadvantages usually associated with pellet solutions, such as ailing and poor burning and dirty flame pattern. The furnace produces burning with low CO and OGC emissions and high efficiency. Because the grate is oblique, pellets (or other solid fuel) can be efficiently burned completely. In addition, pellets are burned more rapidly and thus through-flow of air cooling the furnace remains low. The furnace provides a suitable alternative for burning wood without the need to make any changes to it.

BRIEF DISCLOSURE OF THE FIGURES

[0010] In the following the invention will be disclosed with reference to two embodiments and the accompanying drawing, in which

Figure 1 is a perspective view of a furnace of the invention;

Figure 2 shows a first embodiment of a burner of the invention that may be used in the furnace of Figure 1; Figure 3 shows a second embodiment of the burner of the invention that may be used in the furnace of

Figure 1;
 Figure 4 is a side view of a grate used in the burner of Figure 2;
 Figure 5 shows a section along line V - V in Figure 4;
 Figure 6 is a side and, correspondingly, an end view of the grate to be used in the burner of Figure 3; and
 Figure 7 shows a section along line VII - VII in Figure 6.

DETAILED DISCLOSURE OF THE INVENTION

[0011] Figure 1 shows a furnace comprising a fire chamber 1 and a burner 2 for solid fuel in the lower part of the fire chamber. The upper level of the burner 2 is located at the height of the bottom level of the fire chamber 1 of the furnace.

[0012] Figure 2 illustrates a first embodiment of the burner 2. The burner 1 comprises a body 3 in the form of a receptacle and a plate-like grate 4 arranged inside the body. The Figure only shows the top part of the grate 4; Figures 4 and 5 show the grate 4 as a whole.

[0013] The body 3 of the burner 2 is longitudinal and its wall structure comprises two longitudinal opposite side walls 6, 7 and opposite end walls 8, 9. The longitudinal side walls 6, 7 are towards the door opening of the furnace, i.e. facing the door opening, and the person looking at the flame, which makes the flame well visible. The wall structure is substantially airtight. The shape of the body 3 is downward tapering and can therefore be called funnel-like. In geometric terms the shape of the body may be referred to as a polyhedron without a bottom and top surface, i.e. an open polyhedron. The top end 10 of the grate 4 is located at the top part of the body 3 and the bottom end 15 at the bottom part of the body. The top end 10 of the grate has a first end which is designated by reference numeral 11 and a second end, opposite to the first one, designated by reference numeral 12. The top end 10 of the grate 4 comprises first air openings 13 in the form of grooves extending from the end 11 of the grate to the opposite end 12 thereof. The air openings 13 provide the top end 10 of the grate 4 with a toothed structure.

[0014] Figures 2 and 4 show that the grate 4 also comprises three rows of second air openings 14 below the first openings 13 and extending horizontally from one end of the grate to the other. The number of the air opening rows and the number of openings 14 in them and their shape may deviate from those shown in the figure. The second air openings 14 extend from the first openings 13 substantially all the way to the bottom end 15 of the grate and from a first end 22 of the bottom end 15 of the grate to an opposite end 23 thereof.

[0015] In Figure 4 the body 3 of the burner is depicted with a broken line.

[0016] Figure 5 shows that the grate 4 is a plate-like piece arranged obliquely inside the body 3 of the burner so that the grate comprises an oblique grate surface 16. The grate 4 comprises two wall portions 17, 18 at an

angle γ in relation to each other, these portions forming the grate surface 16. The lower wall portion 17 is at an angle α to the horizontal and the upper wall portion 18 at an angle β to the horizontal. In the embodiment of Figure 5 angle γ is roughly 160 degrees, angle α about 30 degrees and angle β about 55 degrees. The angles are chosen to allow downward flow of the fuel. Angle α is preferably at least 20 degrees and angle β at least 50 degrees. Yet more preferably angle α is at least 30 degrees and angle β at least 60 degrees. Angle γ is 130 to 180 degrees. When installed into the burner, the grate 4 defines an overlying fuel space 19 and an underlying air flow space 20. The fuel space 19 has a volume V_1 which is greater than volume V_2 of the air flow space 20. Due to this the amount of pellets or other fuel the burner is capable of receiving is relatively large in relation to its size. If angles α and β are too big, the fuel space 19 becomes small. It is very difficult to define an upper limit for angles α and β , because the upper limit depends on the shape of the body and on how the lengths of the wall portions 17, 18 relate to each other.

[0017] The first air openings 13 at the top end 10 of the grate 4 form a passage for air located high in the body 3 from the air flow space 20 to the top end of the fuel space 19. The air openings 13 are crucial for the use of the burner. The air openings 13 allow air to flow well to the top end of the fuel space 19 also at the beginning of combustion, when the fuel space 19 is full of fuel, which complicates the entry of air from the air flow space 20 to the top end of the fuel space 19 and to the top end of the body 3 through another way. The burning requires air at the top end of the fuel space 19 right after the fire is lit. If the burner is used in a furnace and the grate 4 is filled with fuel well over its top end 10, air may be supplied at the beginning onto the fuel cushion through air supply channels, such as door openings and/or air supply gaps provided in the furnace (see the air supply openings 21 in Figure 1). The top end 10 of the grate 4 and the air openings 13 are at a height of at least 80%, preferably at least 90%, of the height of the body 3. Because the air openings 13 also extend across the entire length of the grate 4 (horizontally from end 11 to end 12 of the grate), air is obtained to the top end of the fuel space 19 or above the fuel space as a whole, which produces a uniform flame pattern soon after the burner has been lit.

[0018] In the case of Figures 2, 4 and 5 the grate 4 is formed by a plate piece comprising two straight oblique wall portions 17, 18. Alternatively the grate may consist of a concave plate piece with a concave top part, i.e. the grate angle in relation to the horizontal (i.e. tangent angle β) becomes greater in the upward direction.

[0019] Figures 3, 6 and 7 show an alternative implementation of a burner 2'. Like reference numerals for like structures are used in the Figure as in Figures 2, 4 and 5. In Figures 3, 6 and 7 the burner 2' has a grate 4' which is formed of two plate-like pieces 4a' and 4b', both of which define a lower wall portion 17a' and 17b' and an upper wall portion 18a' and 18b'. The plate-like pieces

4a', 4b' are at an angle θ' with respect to each other. The size of the angle θ' is roughly 10 degrees. The plate-like pieces 4a', 4b' open towards the bottom of the body 3' and form oblique grate surfaces 16a', 16b'. The plate-like pieces 4a', 4b' provide the grate 4' with an upside down V shape (an A shape in a way). The lower wall portions 17a', 17b' of the plate-like pieces 4a', 4b' are at an acute angle α' to the horizontal and the upper wall portions 18a', 18b' at an angle β' to the horizontal. Angle α' is greater than angle β' . Angle α' is about 65 degrees and angle β' is about 85 degrees. Angle α' is preferably at least 40 degrees and angle β' is at least 70 degrees. When angle β' is big, the fuel space 19' can be made large. The plate-like pieces 4a', 4b' form a symmetrical grate 4'. Unlike shown in the figure, the wall portions 17a', 18a', 17b', 18b' may form a uniform curve without angles γ' , α' , β' , θ' , the tangent angle increasing in the upward direction of the body 3'. The top end of the grate 4' is not necessarily provided with a steep corner, but the grate may have a rounded top end.

[0020] In Figures 3, 6 and 7 the top end of the grate 4' comprises two series of first openings 13a', 13b'. The openings 13a', 13b' are upward tapering.

[0021] The top end 10' of the grate 4' is air impermeable at its highest point. Unlike in the figures, the top end 10' and its air openings 13a', 13b' may even be located above the top end of the body 3'. The latter implementation allows a maximum fuel space to be provided.

[0022] The burner 2 in Figures 3, 6 and 7 differs from the burner 2' in Figures 2, 4 and 5 in that the shape of the grate is different. In Figures 3, 6 and 7 the burner 2' comprises a larger grate surface than the burner 2 in Figures 2, 4 and 5. Moreover, the burner 2' is in a way divided in two compartments with air openings 13a', 13b' of their own, whereas the burner 2 only has one compartment and air openings 13 associated with it.

[0023] The lower wall portions 17a', 17b' of the plate-like pieces 4a', 4b' may be shaped to form a concave grate surface with a tangent angle (α') to the horizontal that increases in the upward direction of the body 3', i.e. the lower part of the grate 4' depicted with a broken line.

[0024] The burner of the invention is used by filling the fuel space 19, 19' with pellets so that they possibly cover the grate and then lighting the pellets. Flow of air from the air flow space 20, 20' to the top end 10, 10' of the grate and possibly - when the burner has been installed into a furnace - also secondary air flow (caused by gaps in the doors of the furnace and/or the wall structure of the fire chamber) cause the flame to spread rapidly across the entire length of the grate 4, 4a', 4b'. When the amount of pellets decreases during combustion, the pellets originally lower in the combustion space 19, 19' start to burn. The lower pellets receive the air needed for combustion from the second air openings 14, 14a', 14b'. The secondary air in the furnace takes care of end burning of fuel gases.

[0025] When the surface of the air openings 13, 14, 13a', 13b', 14a', 14b' is at least about 30% of the surface

of the grate 4, 4a', 4b' sufficient flow of air from the air flow space 20, 20' to the combustion space 19, 19' is ensured.

[0026] If the burners 2, 2' of Figures 2 to 7 are placed into the furnace of Figure 1, where one or more of the walls in the fire chamber 1, preferably made of panels, comprise an air supply gap 21 for the supply of secondary air, combustion air is obtained above the pellets or other fuel. The air supply gap 21 guides air above the pellets across the entire pellet cushion, ensuring that air is available also when the fire chamber 1 is filled with pellets to the extent that they cover the top end of the body 3, 3' of the burner 2, 2'. The air supply gap 21 contributes to the formation of a calm flame when pellets are burned. Instead of the air supply gap 21, or in addition to it, air may be guided into the fire chamber 1 through air gaps 25 in the door 24 of the furnace or the frame 24 of the door. Presumably fire chamber walls made of ceramic material, such as ceramic plates, which are recommended, also contribute to the clean burning. The temperature of walls made of ceramic material rises high during use because ceramic material has a low thermal conductivity.

[0027] Instead of pellets, wood may be burned in the furnace of Figure 1. The furnace as such, when equipped with the burners 2', 2' of Figures 2 or 3, is suitable for burning wood. Alternatively, when wood is burned, the grate 4, 4' can be replaced by a more conventional grate, which is planar and entirely located at the bottom of the burner body 3, 3'. In other words, the grate 4, 4' is detachable from the body 3, 3'. The detachability of the grate 4, 4' is important also because it allows the grate 4, 4' to be replaced by a new one when it is worn out.

[0028] The invention has been described above with reference to two examples and for this reason it is to be noted that the details of the invention may be implemented in various ways within the scope of the accompanying claims. Therefore the shape of the grate and the shape and number of air openings provided in it may vary from those disclosed here. The longitudinal wall 7 in the body 3 of the embodiment of Figures 2, 4 and 5 is not indispensable.

Claims

1. A burner for solid fuel, particularly for pieces of fuel, such as pellets, the burner comprising a body (3, 3') and a grate (4, 4'), the body being defined by a wall structure and the grate being arranged inside the body (3, 3'), **characterized in that** the body (3, 3') is longitudinal and its wall structure comprises a longitudinal side wall (6, 6') and end walls (8, 9, 8', 9'), that the grate (4, 4') comprises an oblique grate surface (16, 16a', 16b'), which extends between the top end (10, 10') and the bottom end (15, 15') of the grate and defines an underlying air flow space (20, 20') and an overlying fuel space (19, 19'), which substantially extends all the way to the top end of the body

- (3, 3'), that the grate (4, 4') extends from the bottom end of the body (3, 3') to the top end thereof and substantially from a first end wall (8, 8') of the body (3, 3') to a second end wall (9, 9') opposite to the first end wall, that the top end (10, 10') of the grate comprises first air openings (13, 13a', 13b') arranged to extend in the longitudinal direction of the grate (4, 4') substantially from a first end (11, 11') of the top end (10, 10') of the grate to a second end (12, 12') opposite to the first end, the air openings being defined so as to allow flow of air from the air flow space (20, 20') to the top end of the fuel space (19, 19'), and that the grate (4, 4') comprises second air openings (14, 14a', 14b') arranged underneath the first air openings (13, 13a', 13b') so as to extend in the longitudinal direction of the grate (4, 4') substantially from a first end (22, 22') of the bottom end (15, 15') of the grate to a second end (23, 23') opposite to the first end.
2. A burner according to claim 1, **characterized in that** the body (3, 3') is in the form of a receptacle and comprises a longitudinal wall (7, 7') opposite to the longitudinal side wall (6, 6').
 3. A burner according to claim 1 or 2, **characterized in that** the grate is a plate-like piece forming the oblique grate surface (16), the plate-like piece comprising two wall portions (17, 18) at an angle (γ) to each other and at different heights on the body (3), the upper wall portion (18) being at an acute angle (β) to the horizontal and the lower wall portion (17) at an angle (α) to the horizontal, this angle being smaller than the acute angle (β).
 4. A burner according to claim 1, 2 or 3, **characterized in that** the angle (β) of the upper wall portion (18) to the horizontal is at least 50 degrees and that the angle (α) of the lower wall portion (17) to the horizontal is at least 20 degrees.
 5. A burner according to claim 4, **characterized in that** the angle (β) of upper wall portion (18) to the horizontal is at least 60 degrees and that the angle (α) of the lower wall portion (17) to the horizontal is at least 30 degrees.
 6. A burner according to claim 1 or 2, **characterized in that** the grate (4) is a concave plate-like piece and forms a concave grate surface having a tangent angle (α) to the horizontal that increases in the upward direction of the body (3).
 7. A burner according to any one of the preceding claims 1 to 6, **characterized in that** the top end (10) of the grate (4) comprises a tooth-like structure comprising a plurality of grooves, the grooves forming the first openings (13) and the tooth-like structure being arranged to rest on the body (3).
 8. A burner according to claim 1 or 2, **characterized in that** the grate (4') comprises a first plate-like piece (4a') and a second plate-like piece (4b') which are at an acute angle (θ) to each other, the plate-like pieces forming two oblique grate surfaces (16a', 16b') and opening towards the bottom of the body (3').
 9. A burner according to claim 8, **characterized in that** at least the first plate-like piece (4a') of the grate (4') comprises two wall portions (17a' and 18a') at an angle (γ') to each other and located at different heights, the upper wall portion (18a') being at an acute angle (β') to the horizontal and the lower wall portion (17a') at an angle (α') to the horizontal, this angle being smaller than the acute angle (β').
 10. A burner according to claim 9, **characterized in that** the angle (β') of the upper wall portion (18a') to the horizontal is at least 70 degrees and that the angle (α') of the lower wall portion (17a') to the horizontal is at least 40 degrees.
 11. A burner according to claim 8, **characterized in that** at least the first one (4a') of the plate-like pieces (4a', 4b') forms a concave grate surface having a tangent angle (α') to the horizontal that increases in the upward direction of the body (3').
 12. A burner according to claim 1 or 2, **characterized in that** the first air openings (13, 13a', 13b') and the second air openings (14, 14a', 14b') are longitudinal openings extending substantially perpendicularly to the longitudinal direction of the grate (4, 4').
 13. A burner according to claim 1 or 2, **characterized in that** the first air openings (13, 13a', 13b') and the second air openings (14, 14a', 14b') have a surface that is at least 30% of the surface of the grate (4, 4').
 14. A burner according to any one of the preceding claims 2 to 13, **characterized in that** the fuel space (19, 19') has a volume (V_1 , V_2) that is greater than the volume of the air flow space (20, 20').
 15. A burner according to any one of the preceding claims, **characterized in that** the side walls (6, 7, 8, 9, 6', 7', 8', 9') of the wall structure of the body (3, 3') are substantially airtight.
 16. A furnace comprising a burner for solid fuel, particularly for pieces of fuel, such as pellets, the burner comprising a body (3, 3') and a grate (4, 4'), the body being defined by a wall structure and the grate (4, 4') being arranged inside the body (3, 3'), **characterized in that** the body (3, 3') of the burner is lon-

gitudinal and its wall structure comprises a longitudinal side wall (6, 7, 6', 7') and end walls (8, 9, 8', 9'), that the grate (4, 4') is detachable from the body (3, 3') and comprises an oblique grate surface (16, 16a', 16b'), which extends between the top end (10, 10') and the bottom end (15, 15') of the grate and defines an underlying air flow space (20, 20') and an overlying fuel space (19, 19'), which substantially extends all the way to the top end of the body (3, 3'), that the grate (4, 4') extends from the bottom end of the body (3, 3') to the top end thereof and substantially from a first end wall (8, 8') of the body (3, 3') to a second end wall (9, 9') opposite to the first end wall, that the top end (10, 10') of the grate comprises first air openings (13, 13a', 13b') arranged to extend in the longitudinal direction of the grate substantially from a first end (11, 11') of the top end (10, 10') of the grate to a second end (12, 12') opposite to the first end, the air openings being formed so as to allow flow of air from the air flow space (20, 20') to the top end of the fuel space (19, 19'), and that the grate comprises second air openings (14, 14a', 14b') arranged underneath the first air openings (13, 13a', 13b') so as to extend in the longitudinal direction of the grate (4, 4') substantially from a first end (22, 22') of the bottom end (15, 15') of the grate to a second end (23, 23') opposite to the first end.

17. A furnace according to claim 16, **characterized in that** the wall structure of the fire chamber (1) above the burner (2, 2') has air supply conduits (21) for supplying secondary air above the fuel space (19, 19') of the burner (2, 2').
18. A furnace according to claim 16 or 17, **characterized in that** the door structure (24) of the fire chamber (1) of the furnace is provided with air supply means (25) for supplying secondary air above the fuel space (19, 19') of the burner.

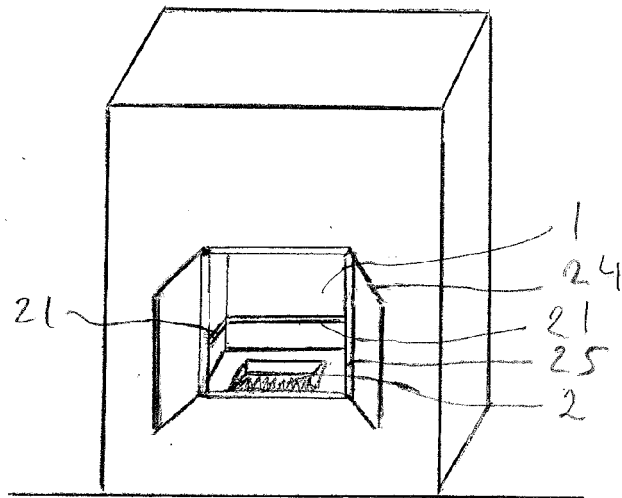


Fig. 1

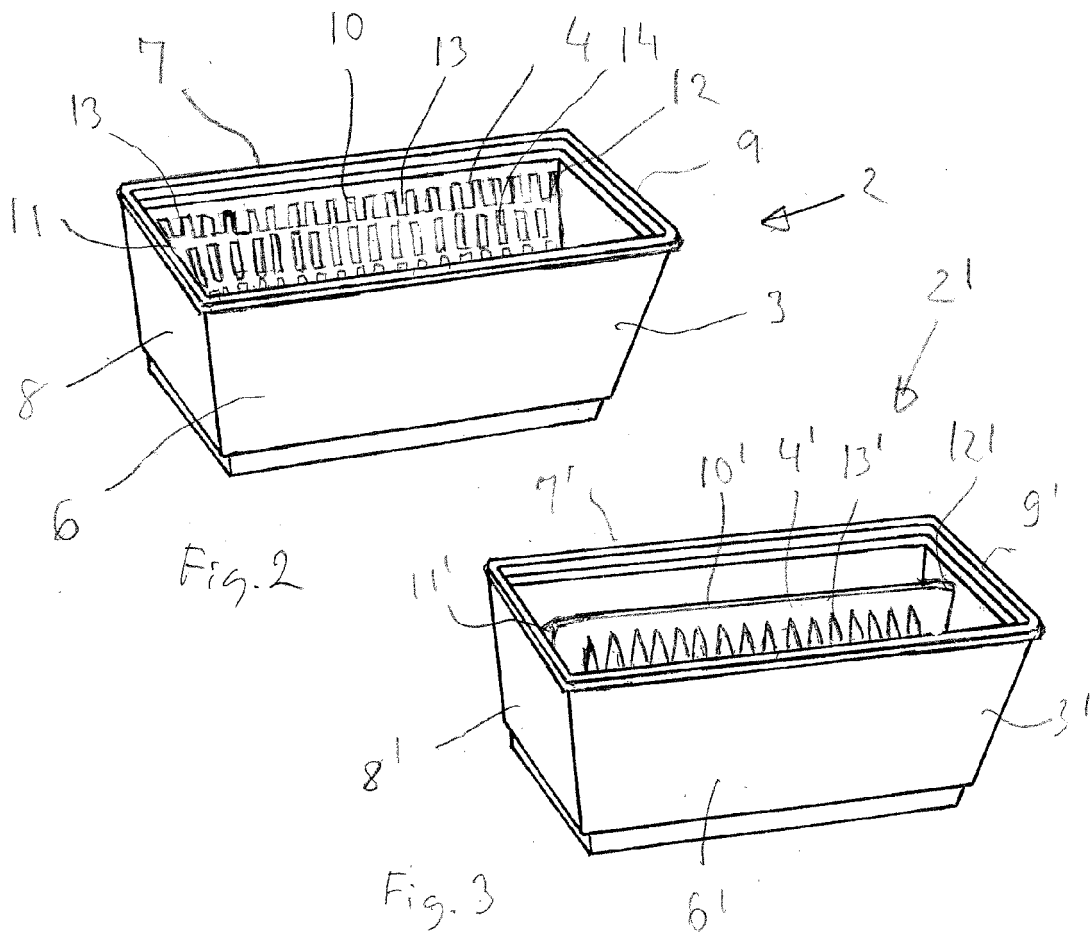


Fig. 2

Fig. 3

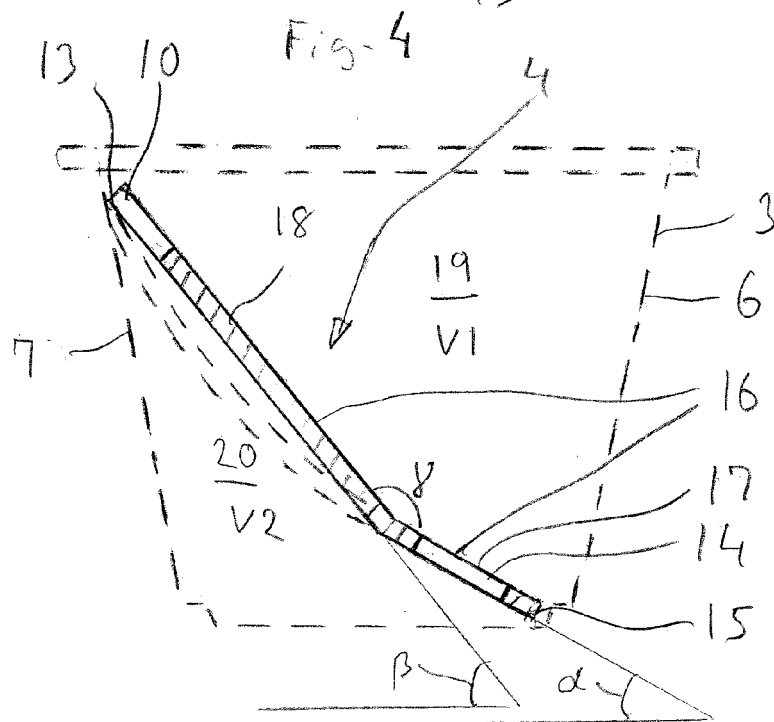
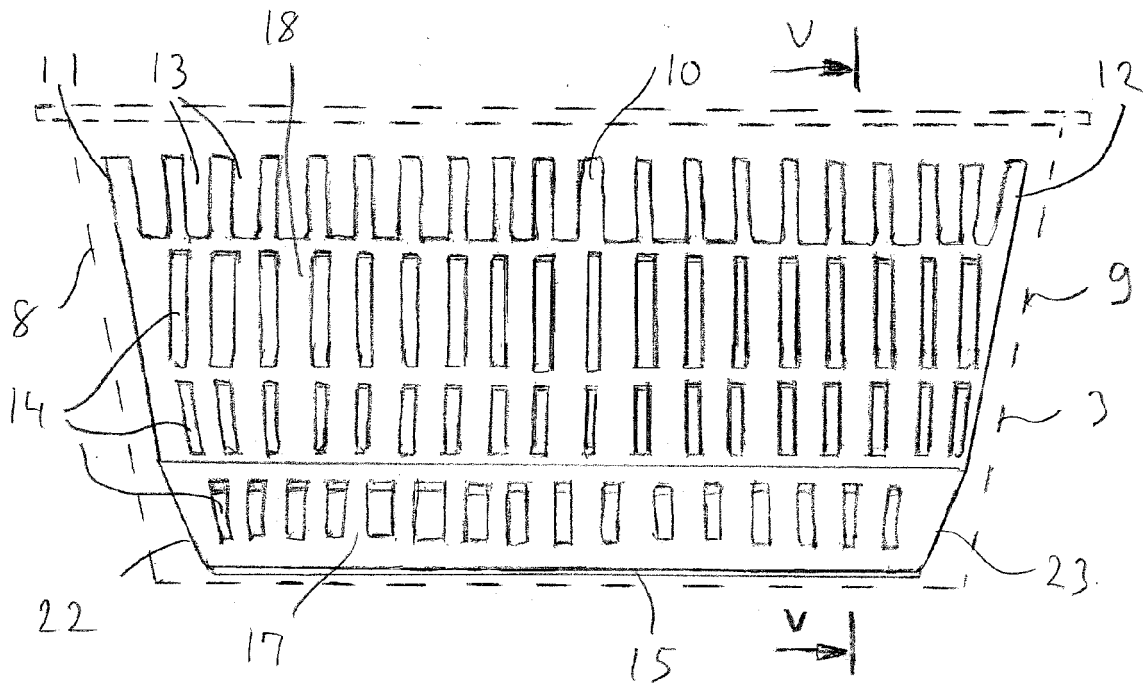


Fig. 5

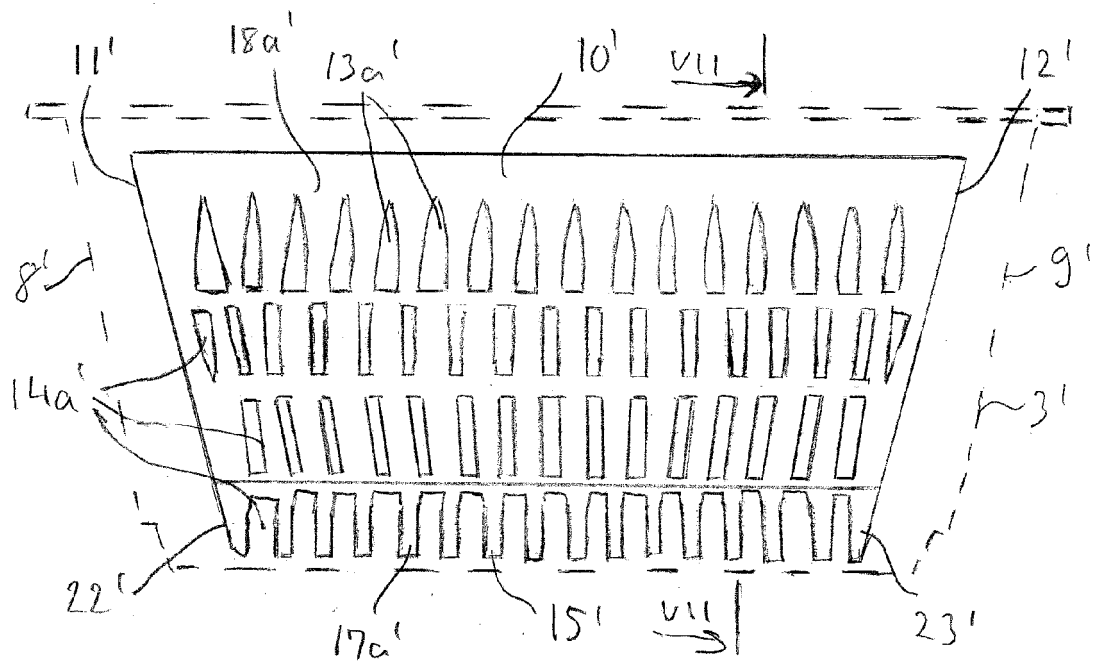


Fig. 6

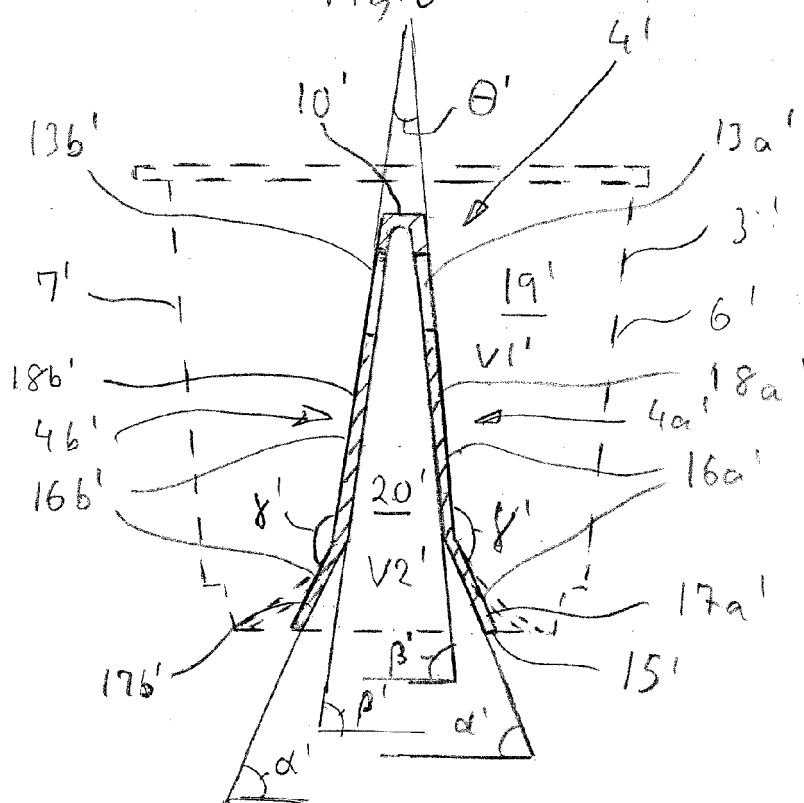


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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