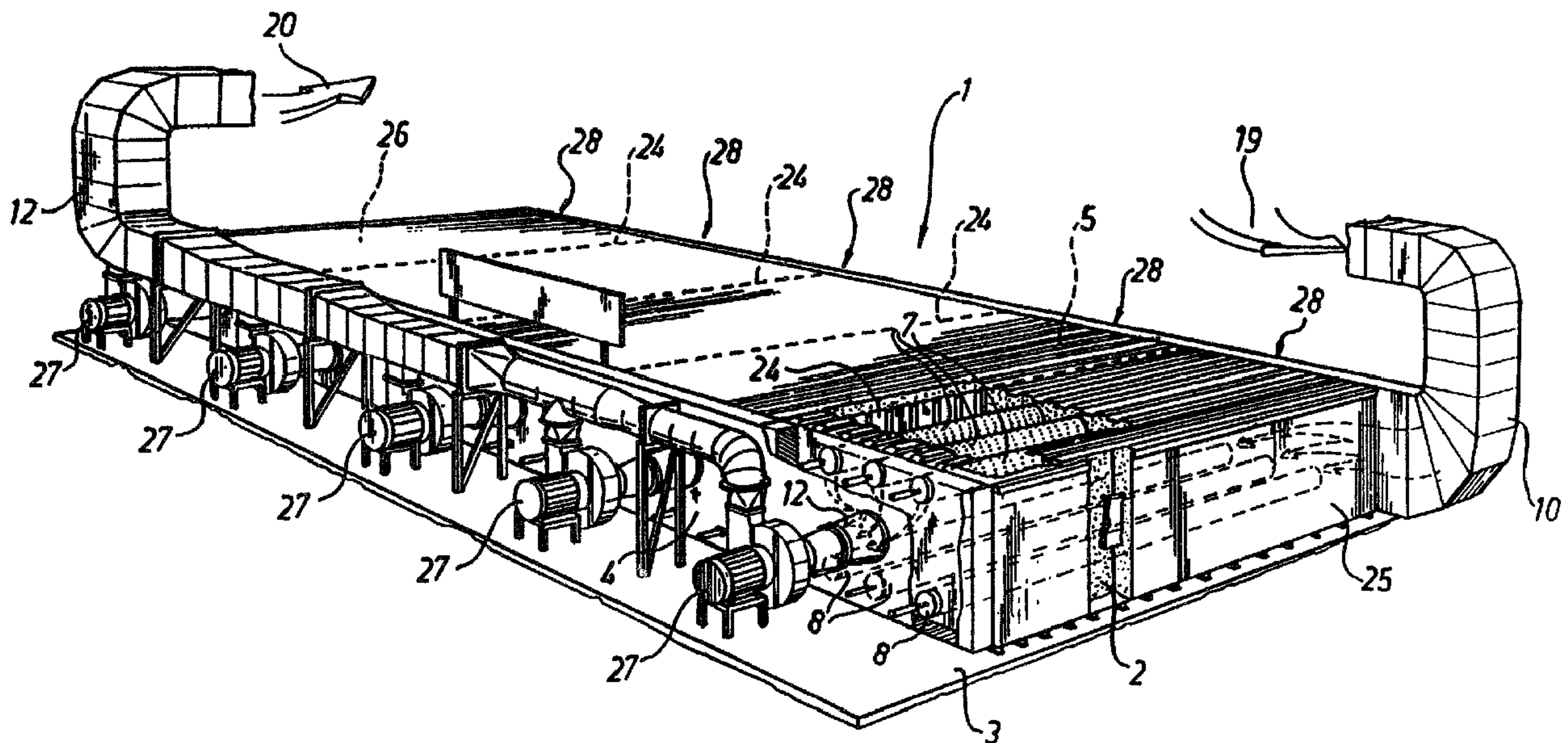




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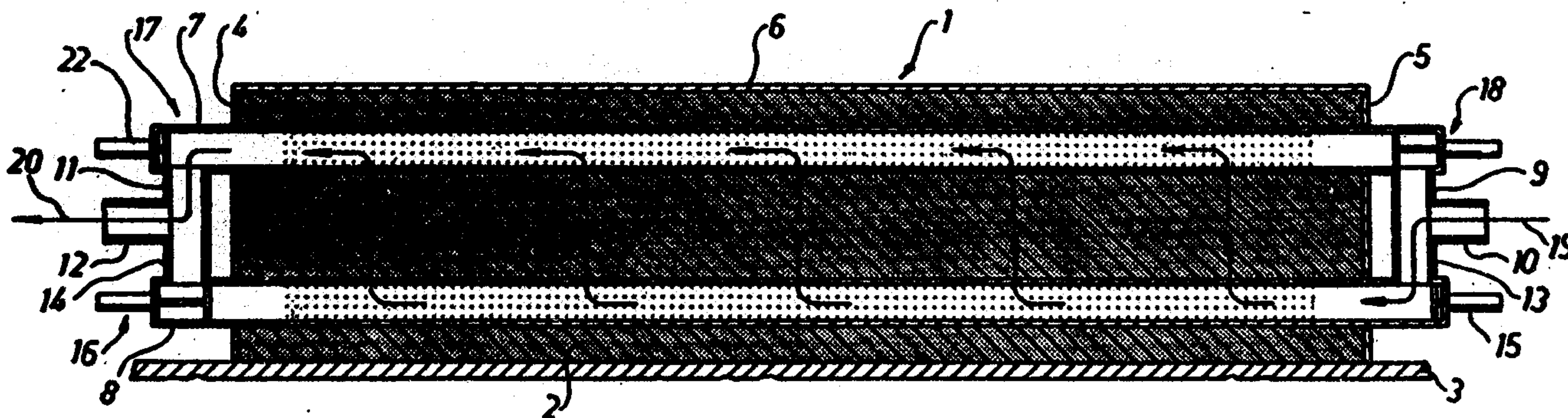
A combustion device (1) incorporated in an apparatus for combustion and/or decomposition of pollutants in air or other gases. The device has a stationary bed of e.g. sand having heat-accumulating and heat-exchanging properties. The bed is provided with heating means to heat a central part of the bed to the self-decomposition and/or the self-combustion temperature of the medium to be treated. The stationary bed (2) is placed on an essentially horizontal support (3), and at the remaining sides it is enclosed by side elements (4, 5) and a roof element (6), the latter resting directly on the upper face of the bed (2) so that the bed supports the roof element (6) and the loads to which the latter is exposed. Inside the bed upper, essentially horizontal tubes (7) are arranged as well as lower, essentially horizontal tubes (8), all said tubes being provided with valve systems at their ends. In this manner a stream of air or gas may be directed from one (8) of the perforated tubes, through the bed (2) and into the other (7) perforated tube in accordance with a first mode of operation. Combustion or decomposition of the pollutants is effected inside the bed. In accordance with a second mode of operation, the direction of flow through the bed may be reversed.





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(54) Title: A COMBUSTION DEVICE**(57) Abstract**

A combustion device (1) incorporated in an apparatus for combustion and/or decomposition of pollutants in air or other gases. The device has a stationary bed of e.g. sand having heat-accumulating and heat-exchanging properties. The bed is provided with heating means to heat a central part of the bed to the self-decomposition and/or the self-combustion temperature of the medium to be treated. The stationary bed (2) is placed on an essentially horizontal support (3), and at the remaining sides it is enclosed by side elements (4, 5) and a roof element (6), the latter resting directly on the upper face of the bed (2) so that the bed supports the roof element (6) and the loads to which the latter is exposed. Inside the bed upper, essentially horizontal tubes (7) are arranged as well as lower, essentially horizontal tubes (8), all said tubes being provided with valve systems at their ends. In this manner a stream of air or gas may be directed from one (8) of the perforated tubes, through the bed (2) and into the other (7) perforated tube in accordance with a first mode of operation. Combustion or decomposition of the pollutants is effected inside the bed. In accordance with a second mode of operation, the direction of flow through the bed may be reversed.

A COMBUSTION DEVICETECHNICAL FIELD OF THE INVENTION

The subject invention concerns a combustion device
5 incorporated in an apparatus for combustion and/or
decomposition of pollutants in gaseous form, in the form
of droplets or other particles that are carried by the air
or other gases. The combustion device has a stationary bed
of sand, rock or other materials having heat-accumulating
10 and heat-exchanging properties, and means for heating a
central part of said bed to the self-decomposition and/or
the self-combustion temperature of the medium to be
treated. The combustion device is of the type known as
regenerative and is arranged to receive flows of said
15 pollutants alternately from different directions.

BACKGROUND OF THE INVENTION

In order to decompose pollutants through combustion
in a device known as a combustion exchanger (see US-A-
20 4,741,690), a structure having one upper and one lower air
distributing duct is often used. The polluted air passes
through the layer of bed material positioned between said
ducts, and the bed material often consists of sand which
has been pre-heated to an elevated temperature of about
25 1000°C.

The capacity expressed as quantity of air flow per
time unit is determined by the parameters pressure drop
and temperature of the bed. The pressure drop is a
function of the thickness of the bed, the composition of
30 the material of the bed, the surface structure, the
granular size and the compaction degree of the material of
the bed, and so on. To obtain a satisfactory degree of
purification, expressed as the proportion of pollutants
remaining in the exhaust in relation to the amount of
35 pollutants in the incoming gas, a certain dwelling time in
the hot zone is required. Each bed layer therefore
provides a specific degree of purification for a given

flow capacity, depending on the composition and thickness of the bed material. When the velocity of the air passing through the bed is high, the pressure drop becomes considerable. The area of the bed in a combustion exchanger
5 therefore determines the dimensions of the total flow.

Because of the restrictions laid down by the road traffic rules and regulations concerning transports, units manufactured in one place for installation elsewhere, must not exceed certain limits as to their area and as a
10 result they have a restricted flow capacity.

If the combustion exchanging technology is to be used to treat flows larger than those for which the largest units allowable on public roads are intended, larger units, built in situ, may be used as an alternative to
15 pre-fabricated units. This alternative provides economical advantages as the costs per flow unit become smaller.

Large flows require large bed areas. In one combustion exchanger of conventional construction the polluted air is distributed across a horizontal bed
20 area through an air gap above and below the bed area.

In large-size plants, this construction embodying an air gap would necessitate large spans in the structure forming the roof of the sealed air gap.

Large spans in roofs that are exposed to positive or
25 negative pressures necessitate complicated and thus expensive structures. In addition, the air gap underneath the bed also is a complication in large installations from a maintenance point of view.

30 PURPOSE OF THE INVENTION

The purpose of the invention is to considerably reduce the above problems by providing a combustion exchanger designed in such a manner that the air gap above and underneath the bed becomes superfluous. As a result,
35 the bed material may be deposited directly on a hard support and the roof structure may be supported by the bed material on the upper face thereof.

SUMMARY OF THE INVENTION

The above purpose is achieved in a combustion device in accordance with the invention, possessing the characteristics set forth in the appended claims.

5 The combustion device in accordance with the invention thus is essentially characterized in that the air to and from the bed is distributed in the bed material by means of horizontal, perforated tubes which extend for instance in parallel with the shortest dimension of the
10 bed. The tubes may be positioned in pairs, one upper and one lower. A valve mechanism positioned at either end of each tube determines the direction of flow inside the tube. By opening or closing selected valves, the air flow may be made to flow from the lower to the upper tube in
15 a first operative phase and in the reverse direction in a second operative phase. Usually, the tubes have a round cross-sectional shape but other suitable cross sections are possible. The polluted air thus flows in an essentially vertical direction between the tubes and it is
20 heated in the bed layer in such a manner that combustion and/or decomposition of pollutants take place and the air thus is purified.

The bed is pre-heated by means of a heater. The principles of cleaning and heating appear from US-A-
25 4,741,690. The roof, which should be sealed air-tight from the exterior, may rest on the bed material except at the edges, where sealing is required. By installing a suction fan on the inlet side of the combustion device a negative pressure is created in the plant, with the result that on
30 the one hand the roof and the side walls will bulge inwards so as to rest on the bed, and on the other that the sealing effect at the edges of the roof will be improved. In other words, the bed supports the roof and the loads to which it is exposed, which is a definite
35 advantage, since the installation costs may be reduced considerably. On account of the weight of the bed material a pressure is created inside the bed. The horizontal tubes

must be able to resist this pressure. Normally, they have a circular cross-sectional shape, which is a section well capable of resisting bulging inwards. This means that tubes having a comparatively small wall thickness may be
5 used both for air supply and air evacuation purposes in the bed. This is an economical solution.

It is also possible to use other cross-sectional configurations than the circular one for the tubes, provided the latter are dimensioned accordingly.

10 Furthermore, a blower fan may be used on the inlet side, provided that the dimensions of the roof and the side walls are adapted accordingly. By means of partition walls directed in parallel with the tubes the installation may be divided into sections. These can be individually
15 connected and disconnected from the system independently of one another, which facilitates servicing and also increases the possibilities to adapt the capacity to the actual flows. Additionally, the bed material in one section may be replaced without affecting the rest of the
20 installation.

The valve system may be such that each tube is provided at one of its ends with a valve means comprising a sealing body having a cross-sectional configuration corresponding to the internal cross-sectional configura-
25 tion of the associated tube, said sealing body being arranged for movement in the axial direction of the tube. In an outer position, the sealing body interrupts the communication between the tube and the associated inlet or outlet while in its inner position it does not
30 significantly disturb the communication.

In accordance with a further development of the invention modular units of the combustion device are arranged in superposed relationship. They may be separated by horizontal divisioning means delimiting separate
35 sections. They could also be designed so as to make the divisioning means superfluous. In this case, simultaneous supply of polluted gas and simultaneous evacuation of

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purified gas, respectively, are effected in the upper horizontal tubes in one modular unit and in the lower horizontal tubes in the modular unit above. Said tubes may then also be united into one common tube. In either case, the result is a double section. In similar ways two or more "double modular units" may be positioned in superposed relationship and may have tubes in common. By "section" should be understood in this context a unit which is delimited by partition wall whereas as a modular unit has no partition wall.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in closer detail in the following with reference to some embodiments thereof and to the accompanying drawings wherein the same reference numerals have been used in all drawing figures to indicate corresponding components and wherein

Fig. 1 is a perspective view of a combustion device for purification of gases,

Fig. 2 is a schematic cross-sectional view of a part of a combustion device corresponding to the device in Fig. 1 in its first mode of operation, and

Fig. 3 is a cross-sectional view corresponding to that of Fig. 2 but with the device in a second mode of operation.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In Fig. 1 reference numeral 1 is used to designate a combustion device for purification of air or other gases. On a floor 3 is supported a stationary bed 2 of sand, rock or other material having heat accumulating and heat-exchanging properties. The bed is enclosed by side elements 4, 5, a roof element 6, and end elements 25, 26. The roof element 6 rests in direct contact with the upper face of the bed 2 in such a manner that the bed supports the roof element 6 as well as the loads to which the latter is exposed.

A number of tubes 7, 8 extend across the bed 2. The tubes are all arranged in parallel and spaced-apart relationship. Usually, their cross-section shape is circular but also other cross-sectional configurations are possible. The tubes are arranged in one upper row 7 of tubes and one lower row 8. The polluted air 19 is admitted into the combustion device 1 through one of several inlets 10. Purified air 20 is evacuated from the combustion device 1 via one or several outlets 12.

As a rule, a number of fans 27 are connected to the outlet part to ensure that the air is sucked through the combustion device 1. Mostly it is an advantage if a negative pressure is created in the combustion device so that the walls of the device will bulge inwards, into contact with the bed 2, to be supported thereby. However, it is likewise possible to position a number of fans on the inlet side to create a positive pressure in the combustion device. In this case the enclosure means 3, 4, 5, 25 and 26 must be reinforced in some other way to withstand the positive pressure inside the combustion device.

Fig. 1 also show vertical partition walls 24 delimiting various sections 28 of the combustion device. As a result of this arrangement, the bed material, for instance, could be replaced in one section of the combustion device while simultaneously the rest of the sections are in operation. In accordance with the embodiment illustrated, each section comprises three pairs of upper and lower tubes 7, 8 and is served by one fan 27. The combustion devices comprises a total of five sections.

Figs. 2 and 3 illustrate the structure and function of the combustion device in closer detail. These drawing figures are cross-sectional views taken vertically through an upper tube 7, a lower tube 8 and the inlet 10 and the outlet 12 associated with these tubes. The two horizontal tubes 7 and 8 are perforated, i.e. a large number of holes are pierced through them, the size of which depends on the

particular bed material that is used. At the tube ends valve means 15 - 18 are provided. By means of connective pieces the ends of the tubes are coupled to the inlet and the outlet. For instance, an upper inlet connection 9 connects the upper tube 7 to the inlet 10 and an upper outlet connection 11 connects the tube to the outlet 12. A lower inlet connection 13 connects the lower tube 8 to the inlet and a lower outlet connection 14 connects it to the outlet 12. The connections could be designed in various ways. For instance, the upper inlet connections 9 and the lower inlet connections 13 could consist of a pipe having a circular or other cross-sectional configuration. The pipe is connected to the horizontal tubes 7, 8 and to the inlet 10. The connective pieces could also have box shape. The "box" thus formed is connected to several horizontal tubes and to one or several inlets or outlets. The horizontal tubes 7, 8 usually have a circular cross-sectional shape but also other cross-sectional configurations are possible. The connection pieces could be different at the two ends of the combustion device. Since the outlet side normally is coupled to a suction fan, it is exposed to a stronger negative pressure and consequently it might need to be of sturdier construction.

According to the valve system 15-18 one valve means is inserted at each end of each tube. A sealing body 21 the section of which corresponds to the internal cross-section of the tubes 7, 8, is arranged to move in the axial direction of the tube between an outer position, in which the body blocks the communication between the tube and the corresponding inlet or outlet, and an inner position, in which it does not significantly interfere with the communication. The sealing body 21 is attached to a piston rod 23 of a cylinder 22, the latter being mounted and operative in the axial direction of the tube. The cylinder is operated by pressurized air or by hydraulic means. The valve system 15-18 could also be such that the sealing body 21 seals axially against the end of the

horizontal tube 7, 8, for example when the inlet or outlet is box-shaped. In this case, the cylinder is attached to the box.

Fig. 2 illustrates the function of the combustion device 1 in accordance with the first mode of operation and Fig. 3 the function according to the second mode of operation. At change-overs from one mode to the other, the direction of flow of the air in the stationary bed 2 is reversed.

10 In accordance with the first mode of operation illustrated in Fig. 2, the lower inlet connection 13 is open, allowing polluted air 19 to flow from the inlet 10 through the inlet connection 13 down into the lower horizontal tube 8. Holes dimensioned as a function of the material of the bed 2 perforate the lower tube 8. The valve positioned at the remote end 16 of the tube is closed. The polluted air thus will flow into the bed, through the perforations in the tube 8. The bed, which often consists of sand, is heated to an elevated temperature. The temperature is sufficiently high to cause self-destruction and/or ignition of the pollutants in the air at this temperature. This means temperature levels of about 1000°C, normally, a level at which polluted air from car paint spraying booths is to be purified. In order for the bed 2 to reach this elevated temperature before the polluted air is supplied to the combustion device, a heater, positioned inside the bed, is used for heating. The heater may be an electric heater or may be heated by gas, oil or some other suitable fuel. The pollutants may be in the form of gas, droplets or other air-borne or gas-borne particles. As they are combusted or decomposed, heat is generated, generally, and this heat is supplied to the bed material. Owing to this heating of the bed, the hot zone thereof will move slowly in the direction of flow through the bed. When the hot zone begins to reach the upper horizontal tube 7, it is time to change over to the other mode of operation. Normally, each mode of operation

lasts one or a few minutes, depending on the size of the installation, the pollutants, the material in the bed, and so on.

Upon change-over to the mode of operation 2, the
5 valves 15-18 are re-set to the positions appearing from Fig. 3. As a result, the polluted air 19 will flow from the inlet 10 and the upper inlet connection 9 into the upper horizontal tube 7 and pass through the holes therein and into the stationary bed 2, wherein the air is purified
10 and enters into the lower tube 8, from which it exits through the outlet 12 by way of the lower outlet connection 14.

One consequence of the change of the mode of operation is that some air present in the stationary bed 2 but
15 not yet completely purified will be entrained in the clean air to the outlet. This insufficiently purified air will be dealt with by an external filter, such as a carbon filter. This method, like the heater device in the stationary bed, are described in detail in Applicant's
20 previous patent US-A-4,741,690. When the direction of flow is reversed, the hot zone will now travel from the area adjacent the horizontal tube 7 towards the area adjacent the lower horizontal tube 8. When this has happened, there is again a change-over to mode of operation 1, as
25 illustrated in Fig. 2, and the sequence is repeated.

When there is a change of mode of operation all valves 15 - 18 thus are displaced more or less simultaneously in the upper tube 7 and the lower tube 8. On the other hand, change-overs in neighbouring pairs of
30 tubes 7, 8 or in juxtaposed sections of the combustion device 1 could be arranged to take place with a certain delay in order to avoid pressure peaks which might arise, should a change-over take place in all pairs of tubes simultaneously.

35 The embodiment illustrated in the drawings is a typical example of the invention. But also other arrangements and designs of the sections of the combustion

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device or of the horizontal tubes are possible. For example, the sections which in accordance with Fig. 1 are separated by partition walls 24, may be stacked one on top of the other, instead of being position side by side. Such an arrangement may be suitable for instance if the available space is very limited. In this case horizontal partition walls between the sections or the modular units need not necessarily be used. If two modular units are positioned one on top of the other and without horizontal partition walls, and assuming that the two neighbouring tubes in the two modular units, i.e. the uppermost ones in one unit and the lowermost ones in the other, are respectively supplied simultaneously with polluted air and connected simultaneously to the outlet, the arrangement will operate well without partition walls. The two neighbouring tubes then may be assembled into one larger tube. This embodiment reduces the costs while at the same time it allows the sand bed to be utilized more efficiently. The bed therefore could have a reduced volume compared with the varieties described earlier. In the "double section" thus formed, an upper row of tubes, for instance three, and a lower row of tubes, for instance three, therefore will sandwich between them a central row of larger tubes, for instance three. The upper row and the lower row are supplied with polluted air simultaneously or are connected to the outlet simultaneously. A number of such double sections or double modular units may be placed in superposed positions. They may have a horizontal partition wall that extends between them but this is not necessary, since the upper and lower tubes of each double section or double modular unit are supplied with polluted air or are evacuated simultaneously.

What is claimed is:

1. A combustion device for treating pollutants, comprising:
 - a bed of material having heat-accumulating and heat-exchanging properties;
 - means for heating a central part of the bed during operation;
 - at least one lower tube horizontally provided to a lower side of the bed, the lower tube having at least one first hole;
 - at least one upper tube horizontally provided to an upper side of the bed, the lower tube having at least one second hole;
 - an inlet,
 - an outlet; and
 - means for providing a communication path from the inlet to the outlet through the lower tube, the bed and the upper tube during operation which includes a first mode and a second mode;
 - in the first mode, the means for providing a communication path coupling the pollutants from the inlet through the lower tube to the upper tube, which is connected to the outlet, via the first hole, the bed and the second hole,
 - in the second mode, the means for providing a communication path coupling the pollutants from the inlet through the upper tube to the lower tube, which is connected to the outlet, via the second hole, the bed and the first hole.
2. The combustion device according to claim 1, wherein the means includes inlet communication means and outlet communication means,
 - the inlet communication means including lower inlet valve means for providing a communication path between the inlet and the lower tube, and upper inlet valve means for providing a communication path between the inlet and the upper tube,
 - the outlet communication means including lower outlet valve means for providing a communication path between the outlet and the lower tube, and upper outlet valve means for providing a communication path between the outlet and the upper tube.

3. The combustion device according to claim 2, wherein the lower inlet valve means includes a first cylinder having a first piston rod, which is actuated by a pressure medium, and a first sealing body attached to the first piston rod, which is arranged at a first side of the lower tube, the first piston rod and the first sealing body moving within the lower tube in an axial direction of the lower tube,

the upper inlet valve means including a second cylinder having a second piston rod, which is actuated by a pressure medium, and a second sealing body attached to the second piston rod, which is arranged at a first side of the upper tube, the second piston rod and the second sealing body moving the upper tube in an axial direction of the upper tube,

the lower outlet valve means including a third cylinder having a third piston rod, which is actuated by a pressure medium, and a third sealing body attached to the third piston rod, which is arranged at a second side of the lower tube, the third piston rod and the third sealing body moving within the lower tube in the axial direction of the lower tube,

the upper outlet valve means includes a fourth cylinder having a fourth piston rod, which is actuated by a pressure medium, and a fourth sealing body attached to the fourth piston rod, which is arranged at a second side of the upper tube, the fourth piston rod and the fourth sealing body moving within the upper tube in the axial direction of the upper tube.

4. The combustion device according to claim 3, wherein in the first mode, the second sealing body interrupts the connection between the upper tube and the inlet and the third sealing body interrupting the connection between the lower tube and the outlet.

5. The combustion device according to claim 3, wherein in the second mode, the first sealing body interrupts the connection between the lower tube and the inlet and the fourth sealing body interrupting the connection between the upper tube and the outlet.

6. The combustion device according to claim 3, wherein the inlet communication means further includes an inlet connection for connecting the inlet to the upper tube and the lower tube, and an outlet connection for connecting the outlet to the upper tube and the lower tube.
7. The combustion device according to claim 6, wherein the first sealing body interrupts a communication path between the lower tube and the inlet connection, the second sealing body interrupting a communication path between the upper tube and the inlet connection, the third sealing body interrupting a communication path between the lower tube and the outlet connection, the fourth sealing body interrupting a communication path between the upper tube and the outlet connection.
8. The combustion device according to claim 1, wherein during the operation, the first mode and the second mode are alternatively performed.
9. The combustion device according to claim 6, wherein at least one of the inlet, the outlet, the inlet connection and the outlet connection is configured as a box.
10. The combustion device according to claim 1, wherein the device comprises more than one pair of the upper tube and the lower tube, the pairs being positioned laterally to each other and being separated from each other.
11. The combustion device according to any one of claims 1-10, further comprising means for creating a negative pressure through the upper tube or the lower tube in the device.
12. The combustion device according to any one of claims 1-11, further comprising means for creating a positive pressure through the upper tube or the lower tube in the device.

13. The combustion device according to any one of claims 1-10, wherein the device is divided at least two units, each unit having the bed, the upper tube and the lower tube.
14. The combustion device according to claim 13, wherein the units are superposed vertically.
15. The combustion device according to claim 14, wherein the units communicate with each other through the beds of the units.
16. The combustion device according to any one of claims 14-15, wherein the lower tube in the unit provided to an upper side and the upper tube in the unit provided to a lower side are simultaneously connected to the outlet, and the upper tube in the unit provided to the upper side and the lower tube in the unit provided to the lower side are simultaneously connected to the inlet.
17. The combustion device according to claim 1, further comprising a middle tube having a third hole, the middle tube horizontally provided to a middle side of the bed, so as to form a first communication path from the inlet to the outlet through the middle tube, the bed and the upper tube, and form a second communication path through the inlet to the outlet through the middle tube, the bed and the lower tube.
18. The combustion device according to any one of claims 1-12, further comprising a housing for enclosing the bed, the upper tube and the lower tube, the housing including a roof element which directly contact with an upper surface of the bed.
19. The combustion device according to claim 18, wherein the bed supports the roof element and the loads to which the roof element is exposed.
20. The combustion device according to claim 13, wherein during the operation, each unit changes a mode such that the first mode and the second mode are alternatively performed.

21. The combustion device according to claim 20, wherein a timing of changing a mode in one unit is different from a timing of changing a mode in another unit.

22. The combustion device according to claim 1, wherein the device includes more than one pair of the upper tube and the lower tube, each pair of the upper tube and the lower tube changing a mode during the operation such that the first mode and the second mode are alternatively performed.

23. The combustion device according to claim 22, wherein a timing of changing a mode in one pair of the upper tube and the lower tube is different from a timing of changing a mode in another pair of the upper tube and the lower tube.

24. The combustion device according to claim 1, wherein the means for heating a central part of the bed is positioned inside the bed.

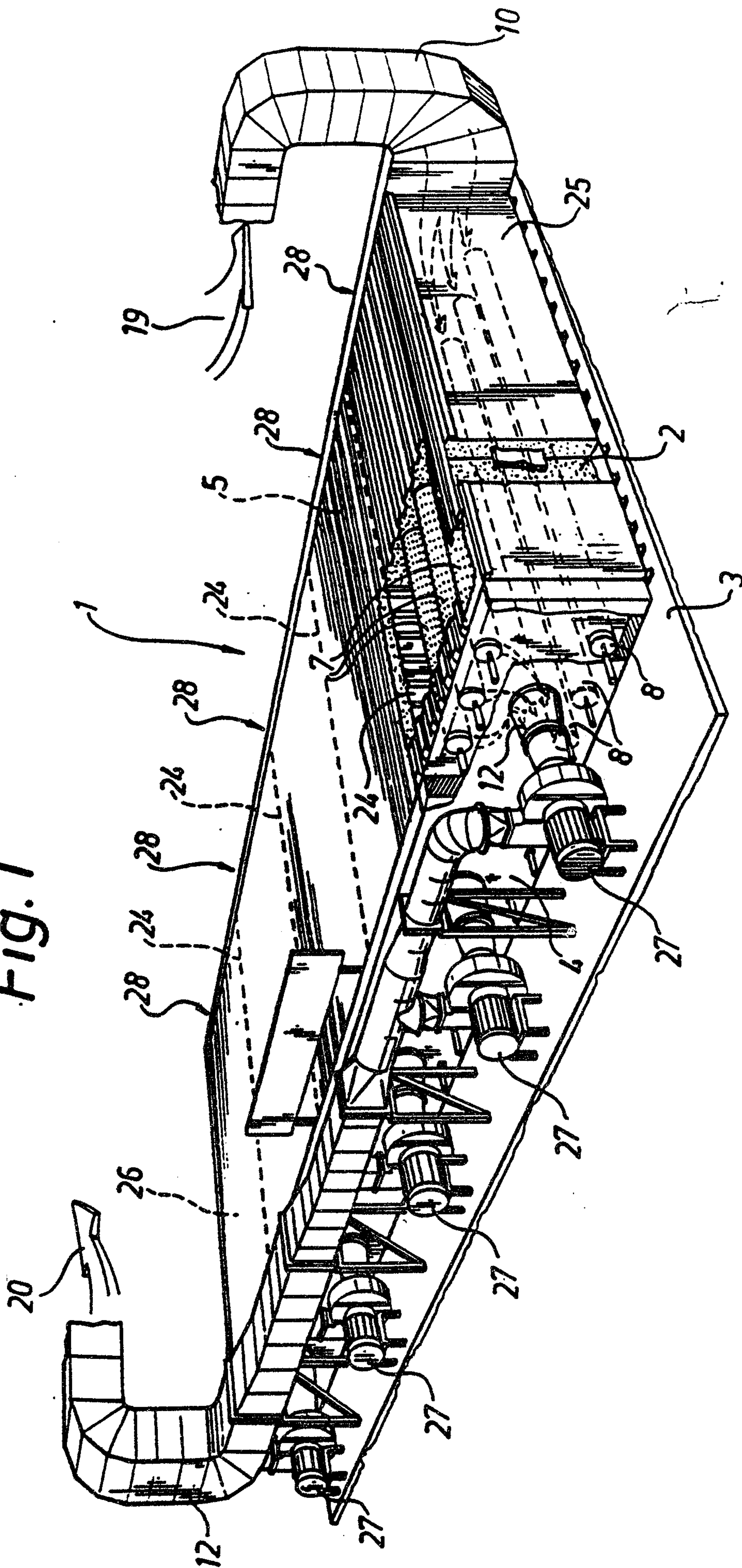
25. The combustion device according to claim 13, further comprising a housing for enclosing the units, the housing including a roof element which directly contact with an upper surface of the bed of each unit.

26. The combustion device according to any one of claims 14-16, further comprising a housing for enclosing the units, the housing including a roof element which directly contact with an upper surface of the bed on top of the units.

27. The combustion device according to claim 2, wherein at least one of the inlet, the outlet, the communication path between the inlet and the lower tube, the communication path between the inlet and the upper tube, the communication path between the outlet and the lower tube, and the communication path between the outlet and the upper tube is configured as a box which is common to the tubes.

28. The combustion device according to claim 13, wherein each unit is separated by means for delimiting the unit.
29. The combustion device according to claim 1, wherein the means for providing provides a communication path from the inlet to the upper tube or the lower tube for coupling the pollutants in gaseous, droplet, or particulate form carried by air or gases.
30. The combustion device according to claim 2, wherein a change between the first mode and the second mode is performed through a resetting of the lower inlet valve means, the upper inlet valve means, the lower outlet valve means, and the upper outlet valve means so as to avoid pressure peaks.
31. The combustion device according to claim 1, wherein the device has a plurality of a pair of the lower tube and the upper tube, each pair has a mode change between the first mode and the second mode, the mode change in one pair took place with a certain delay after the mode change in another pair to avoid pressure peaks.

Fig. 1



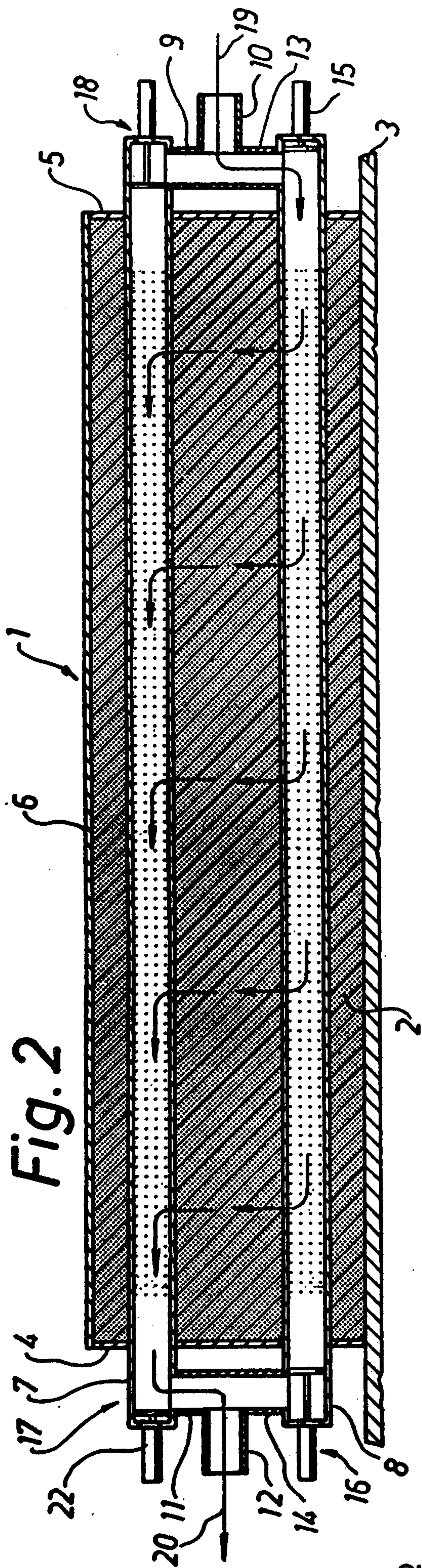


Fig. 2

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Fig. 3

