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

(11) EP 2 503 255 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.09.2012 Bulletin 2012/39

(51) Int Cl.:
***F24F 13/068** (2006.01)* ***F24F 13/062** (2006.01)*

(21) Application number: **12160313.8**

(22) Date of filing: **20.03.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **21.03.2011 DK 201100193**
31.10.2011 DK 201100841

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(54) **A system including a building ceiling having one or more integrated air inlet diffuser devices, and a metal ceiling plate for a suspended ceiling**

(57) The invention relates to an air inlet diffuser device (1) comprising a) an outer cylindrical tubular part (5) having an inside surface (5') and an upper free edge (8) and b) an inner elongated air guiding part (20) which is symmetrical about an axis of rotation (25).

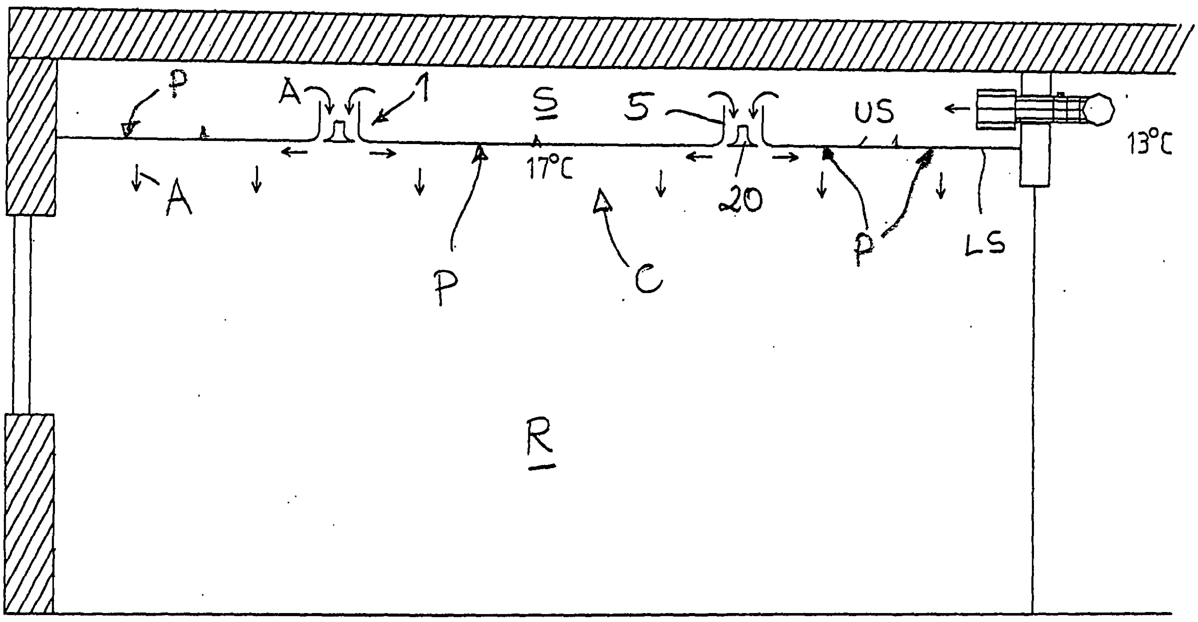

Fig. 1

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Description

[0001] The present invention relates to a system including a building ceiling having one or more integrated air inlet diffuser devices, as defined in the preamble of claim 1, and a metal ceiling plate or panel for a suspended ceiling as defined in the preamble of claims 8 and 9. Air is blown into the room below the ceiling through the air inlet diffusor devices, preferably without any ducts in the plenum above the suspended ceiling leading the air to the air inlet diffusor devices.

[0002] Ventilation of office buildings etc. is normally performed to ensure a desired indoor climate in summer- and wintertime.

[0003] Examples of known air inlet diffuser devices and suspended building ceiling systems with air inlet diffuser devices are disclosed in W098/51 978 and US 3 403 614.

[0004] It is an object of the present invention to provide an improved building ceiling system which may be manufactured at a low cost and which provides for a highly efficient through-flow of air that gives an excellent cooling or heating of the building room. The air diffuser device of the invention does not project from the lower side of the ceiling to any large extend. The temperature gradient in the aforementioned plenum allows for air to be blown into the room at the highest possible temperature difference relative to the temperature in the room.

[0005] The present invention provides a low resistance to the air flow through the diffusor devices with a consequential reduction in noise and energy consumption. The k_r value of the air inlet diffuser device resulting from the design of the device may be in the order of 3.72, yielding a long throw length as determined by formulae $l_{0,2} \approx k_r \cdot v_o \cdot \sqrt{A_o} \approx k_r \cdot \sqrt{(v_o \cdot q_v)}$, where v_o is the effective inflow velocity, A_o is the effective inflow area, and q_v is the volume flow. Traditional air inlet diffuser devices have a k_r value of less than half that. The design of the diffusor device ensures that air driven through the device will flow very closely against the lower side of the suspended ceiling to a relatively large distance from the diffuser device, before losing energy leading to a downward flow of the air.

[0006] The number and size of air inlet diffuser devices is selected in accordance with the heat load, i.e. the amount of heat energy supplied as sunlight, by machinery, computers, people or lighting equipment to the building room or inside space or room R below the suspended ceiling. Based on the total heat load an amount of cooling air to be supplied to the building room can be calculated using a PC-program. The arrangement, dimensions and number of the air inlet diffuser devices may be calculated using this PC-program. In addition it is possible to integrate into the ceiling system any type of lighting fixture (not shown). The ceiling system may be used in any type of building where ventilation is required or desired.

[0007] In a cooling operation, the air may be subcooled to 12-13°C. This sub-cooled air will spread out on the ceiling plates, being heavier than the surrounding air. This leads to a significant cooling of the (metal/aluminium) ceiling plates which cools the room through radiation; hence, the entire ceiling will act as a cooling surface. The integrated diffusor devices provide a flow of cub-cooled air which contributes further to the cooling. The combined effect may be 100 W/m^2 floor area.

[0008] Further advantages and benefits of the invention will appear in the following description wherein reference is made to embodiments shown on the drawings wherein

Fig. 1 is an example of a system including a suspended ceiling according to the present invention, and

Fig. 2-4 show different embodiments of air diffuser devices for use in the suspended ceiling of fig. 1.

[0009] Fig. 1 shows schematically a ceiling system having no installations such as ventilating air ducts or cooling or heating pipes, the ceiling system having integrated air inlet diffuser devices 1. The ceiling system is normally formed as a suspended ceiling C comprised by a plurality of individual four-sided metal plates or panels P, such as aluminium plates, each having an upper side US and a lower side LS. The size of the plates P is selected according to the builder's specifications to obtain a desired visual appearance of the ceiling C; the plates P may, by way of example, be square with dimensions in the order of 1m x 1m.

[0010] The suspended ceiling may be mounted in a conventional manner, such as supported by hangers (not shown), below a fixed ceiling forming part of a building structure, to define a plenum or space S, and a fan drives air at a given temperature into this space S. The plates P are delivered in standard sizes, and the suspended ceiling is constructed as a sealed structure such that air A will primarily flow from the space S through air inlet diffuser devices 1 to be discussed in further details below.

[0011] Some of the plates P of the ceiling have an integral tubular part 5 of a respective air inlet diffuser device 1, the part 5 preferably being pressed out from the metal plates by a local deformation of a peripheral edge or rim of a through-going aperture previously made in the plate. The tubular part 5 extends into the space S. The number and size of air inlet diffuser devices 1 is selected in accordance with the heat load, i.e. the amount of heat energy supplied as sunlight, by machinery, computers, people or lighting equipment to the building room or inside space R below the suspended ceiling.

[0012] The design or configuration of the air inlet diffuser device 1 is such that is may carry through large variations in the through-flow of air while still ensuring that the air exiting the device will "stick" to the lower side LS of the ceiling C; it will be understood that it is important to ensure that the air A flows as far as possible along and close to the lower side LS of the plates after exiting the device 1.

[0013] By the present invention it is possible to obtain the aforementioned desirable flow without the need for any regulating devices, i.e. without the need for any movable parts for setting and varying the size of the flow passage of the air inlet diffuser device 1, in that the device provides for a minimum flow resistance and, hence, provides a minimum noise and energy requirement while at the same time complying with current building codes. The device factor k_r may be in the order of 3.72, while traditional air inlet diffuser devices have a device factor k_r of less than half.

[0014] The air inlet diffuser device 1 will in the following be discussed in further details, a part 5 thereof being a raised portion of the plates P, which has been pressed transversally out from the plates P by a local deformation, such as by using a punching tool, of a peripheral edge or rim of a through-going aperture previously made in the plate.

[0015] The air inlet diffuser device 1 comprises as shown in fig. 2-4 a) an outer cylindrical tubular part 5 having an inside surface 5' and an upper free edge 8 to located above the upper side US of the plates P and b) an inner elongated air guiding part 20 which preferably is symmetrical about an axis of rotation 25, i.e. which may eg. have a conical shape with the axis 25 parallel with the longitudinal axis of the tubular part 5. The tubular part 5 has at the lowermost extremity thereof a first circumferential flange 12 with a lower surface 12' and being defined by a portion of the plate P in that the lower surface 12' of the part 5 is an area of the lower surface LS of the plate P. An even or uniform transition between the inner surface 5' of the tubular part 5 and the lower surface 12' is defined by a curved transition face 7. The air guiding part 20 is mounted centrally within the cylindrical tubular part 5 such that the distance d2 to the tubular part 5 measured perpendicularly to the axis of rotation 25 decreases uniformly in the direction from the upper free edge 8. This forms a converging flow passage 3 between the tubular part 5 and the air guiding part 20. The air guiding part 20 extends farthest from the upper free edge 8 into a second circumferential flange 22 which together with the lower surface 12' forms a circumferential and horizontal air exit passage 2 for orienting air perpendicularly to the axis of rotation 25, i.e. parallel with or essentially parallel with the lower surface LS of the plate P. The air guiding part 20 is preferably fixed to the tubular part 5 so as to be immovable during use of the device 1 in the building. Preferably, the apex T of the air guiding part 20 is maintained located at a distance d4 below the edge 8 corresponding to 25%-75%, or 40% - 60%, of a distance d3 between the first circumferential flange 12 and the upper free edge 8.

[0016] As shown the circumferential passage 2 has no air flow restrictions and the tubular part 5 preferably has a circular cross-section of constant diameter. As also shown the air guiding part 20 is located in its entirety below the free edge 8, giving rise to a very compact construction, while at the same time the tubular part 5 projects by a distance d3 into the space S above the upper side US of the plates P, to provide for a "bathtub-effect" where cold air at the upper side US of the plates P is heated, thereby rising upwards, after which this heated air passes through the air inlet diffuser device 1, as shown by the arrows in fig. 1. Figs. 2-4 show different designs of a transition area 20" between the air guiding part 20 and the circumferential flange 22, and of the air guiding part 20 as such.

[0017] In use the system preferably drives - essentially without any installations in the space or plenum S - the desired heating or cooling air to the room R. The sub-cooled air having a temperature of eg. 13°C is - due to the temperature gradient - distributed across the upper side US of the plates P, and thereby brings about a cooling of the lower side LS of the plates P to a temperature of eg. 17°C, generating cooling radiation towards the room R. The air inlet diffuser devices 1 of the invention establish a through flow of the sub-cooled air, the air flowing horizontally along the lower side LS of the plates, contributing to a further cooling of the room R. The total cooling effect may eg. reach 100 W/m^2 floor area, which cannot be obtained with the devices currently on the market. A high level of comfort in the room R below the suspended ceiling is maintained.

[0018] The ceiling system may be used in all types of buildings with a need for ventilation.

[0019] It is noted that the shown solution where the part 5 is integral with the plates 5 is highly compact, allowing for the air to exit and flow very closely to the lower side LS of the plates 5.

[0020] By way of example the apertures formed in the plates 5 may have a diameter configured such that the diameter of the tubular part 5 is 160 mm when the raised portions are formed. The plates 5 may be 0.5 mm aluminium plates, and distance d3 and d4 may be 200 mm and 80 mm, respectively. A desired increased length d4 of the tubular part 5 may be obtained by placing an extension collar on top of the raised portion, the collar then defining the upper free edge of the tubular part 5.

Claims

1. A ceiling system for advancing heating or cooling air to a building space (R), comprising a suspended ceiling (C) defined by a plurality of metal ceiling plates (P) having an upper side (US) and a lower side (LS), wherein air (A) is driven to a plenum (S) above the suspended ceiling (C) and from this plenum (S) is directed onto said lower side (LS) of said ceiling plates (P) by air inlet diffuser devices (1), **characterised in that** a part (5) of said diffusor devices is defined by a pressed-out portion of the ceiling plates (P), said part (5) projecting upwards into said plenum (S).

2. The ceiling system of claim 1, **characterised in** an

even or uniform transition between the inner surface (5') of said part (5) and the lower surface (LS, 12') of said plates P being defined by a curved transition face (7).

3. The ceiling system of claim 1 or 2, said portion defining a tubular part (5) with an upper free edge (8) located in said plenum (S).

4. The ceiling system of the preceding claim, said tubular part (5) having a circular or square cross-section.

5. The ceiling system according to any of the preceding claims, an elongated air guiding part (20) being fixed inside said part (5) and forming together with said lower surface (12') a circumferential air exit passage (2) for orienting said air along said lower side (LS) of said plates (P).

6. The ceiling system according to the preceding claim, said air guiding part (20) being immovably fixedly mounted centrally within said part (5).

7. The ceiling system according to any of claims 5 or 6 when dependent on claim 3, said air guiding part (5) being symmetrical about an axis of rotation (25), the distance (d2) to said part (5) measured perpendicular to said axis of rotation (25) decreasing uniformly in the direction from said upper free edge (8) for forming a converging flow passage (3) between said tubular part (5) and said air guiding part (20), and in that said air guiding part (20) farthest from said upper free edge (8) extends into a circumferential flange (22).

8. The ceiling system according to any of claims 5-7, said air guiding part (20) being located in its entirety below said upper free edge (8).

9. A metal ceiling plate (P) for a suspended ceiling, integral with a part (5) of an air inlet diffusor device (1) for inflow of air to a room (R) below said suspended ceiling, **characterised in** said integral part (5) being tubular with a square of circular cross-section and being a pressed-out portion of said plate (P) such that an end edge (8) of said tubular part (5) is located facing away from a lower side (LS) of said plate (P), an even or uniform transition between said tubular part (5) and said lower side (LS) being defined by a curved transition face (7), said tubular part (5) being on the inside configured for securing an air guiding part (20) which together with said lower side (LS) forms an air exit passage (2).

10. A metal ceiling plate (P) for a suspended ceiling, integral with a part (5) of an air inlet diffusor device (1) for inflow of air to a room (R) below said suspended ceiling, **characterised in** said integral part being tubular with a square of circular cross-section and being a pressed-out portion of said plate (P) such that an end edge (8) of said tubular part (5) is located facing away from a lower side (LS) of said plate (P), an even or uniform transition between said tubular part (5) and said lower side (LS) being defined by a curved transition face (7), said tubular part (5) having on the inside an air guiding part (20) which together with said lower side (LS) forms an air exit passage (2).

11. A method for making the ceiling plate according to any of claims 9 or 10, comprising forming said part (5) by a local deformation, such as by using a punching tool, of a peripheral edge or rim of a throughgoing aperture previously made in the metal plate (P).

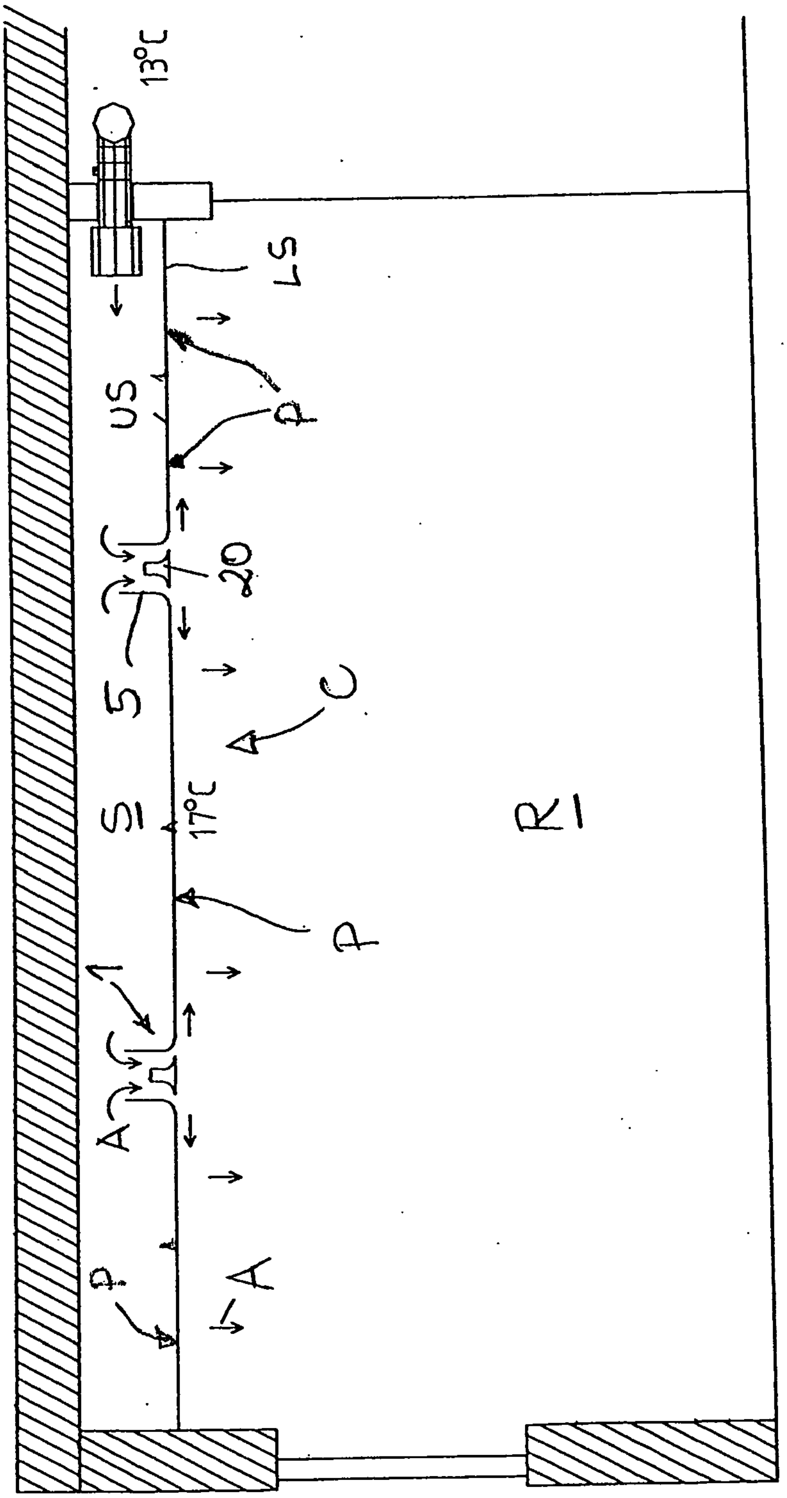

Fig. 1

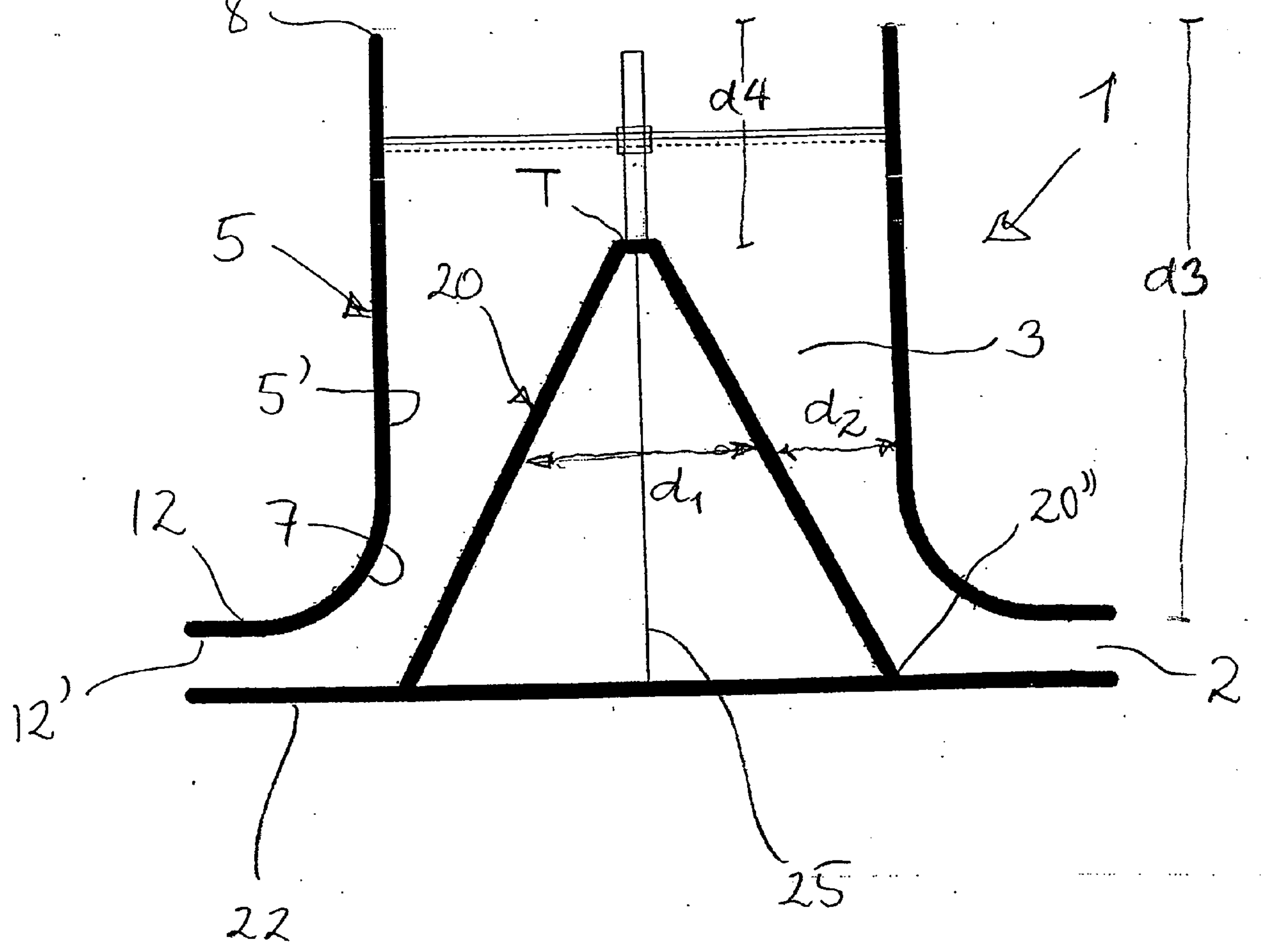

Fig. 2

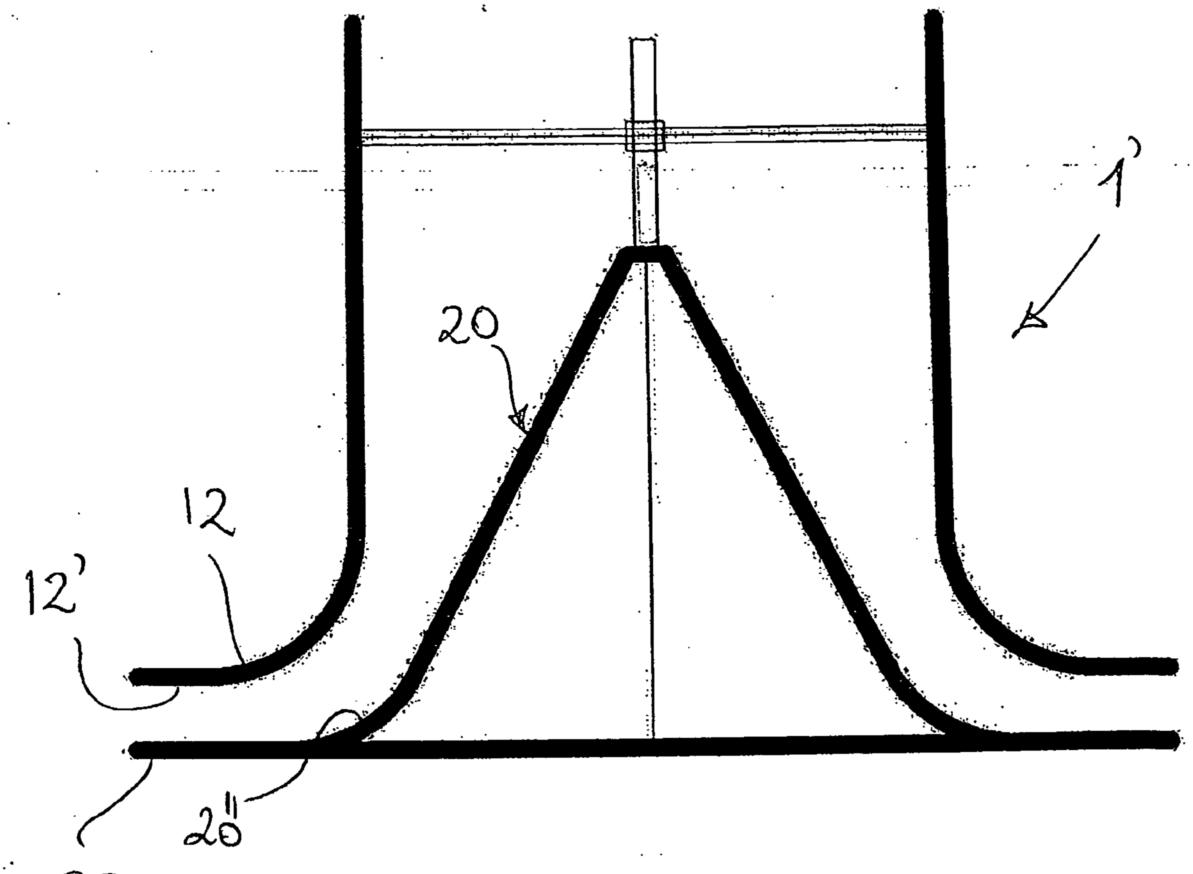

Fig. 3

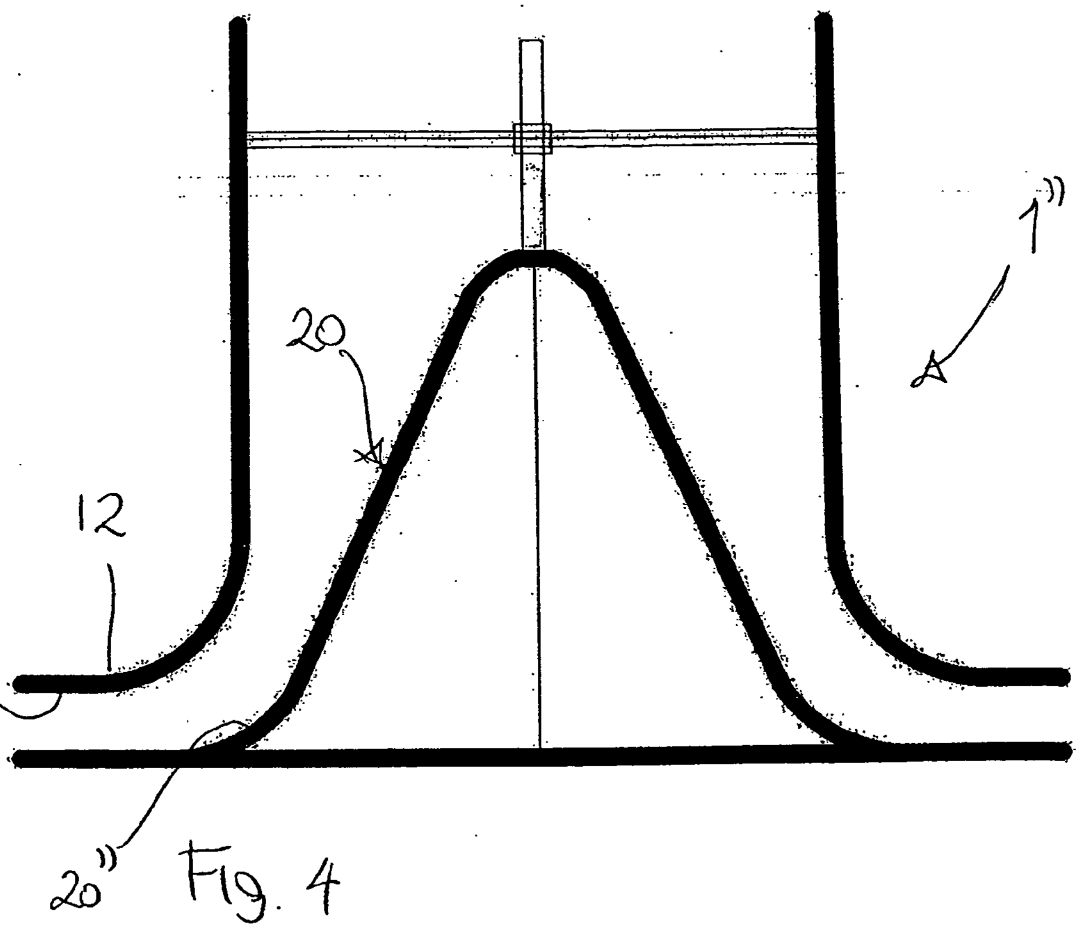

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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