

Description

Field of the Invention

[0001] The present invention relates to a burner unit comprising a solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel into a vertically open bowl burner from below.

[0002] The present invention also relates to a radiant heater for indoor use as a pellet stove or outdoor use, such as on balconies, patios, terraces, yards or in gardens.

Background of the Invention

[0003] Radiant heaters provide heat to the surroundings by means of radiating heat, e.g. as infrared radiation to the surrounding area.

[0004] Radiant heaters are widely used in outdoor areas where additional heat is desired in order to be able to stay outdoor instead of going inside., e.g. in the evening or during the night when having a barbeque or enjoying dinner. Thus radiant heaters are used in gardens, patios or on balconies etc. in private homes to enjoy staying outside without becoming cold or without the need for additional sweaters.

[0005] For example, radiant heaters are provided at outdoor serving areas of hotels, bars, cafes, restaurants etc. to extend the time in which the costumers enjoy their servings outdoor. In addition, many restaurants extend their season with outdoor seats during spring or autumn by providing radiant heaters near the outdoor tables.

[0006] Such radiant heaters are usually electrical heaters connected to the power supply by an electrical cable or cord. Such power cords limit the area in which the radiant heater may be used to a certain radius from the power source.

[0007] In addition it may be dangerous to have power cords ling on the ground/floor as people, e.g. restaurant guests or staff members may trip over the cable and become injured.

[0008] Alternatively, the radiant heaters use gas for heating by combustion of the gas to provide heat. The gas fuelled radiant heaters typically produce heat by combusting the heat in a burner arranged in a top with a circular reflector. Usually gas is delivered in pressurized containers comprising approx. 10-12 kg gas. The lower part thus comprises a cover for arranging the gas container inside the radiant heater. The gas is, however, usually of fossil origin and is thus a non-renewable source of energy.

[0009] Such gas fired radiant heaters are inefficient because they provide the heat from the top and downwards by means of an inefficient reflector and usually provide heat in any direction. In addition the combustion gas, including carbon monoxide and carbon dioxide and maybe combustion residue particles, is exhausted directly into the surrounding area where people stay to enjoy the

heat from the gas burners.

[0010] When a restaurant uses several gas fired radiant heaters, there is a need for storing a relatively large number of pressurized gas containers in storage in order to be able to provide exchange gas containers at least a few days. Restaurants are usually situated in central areas with a relatively large density in population and storing large amounts of gas in such an area may cause a risk of the pressurized gas containers explode in case of fire. Thus several cities have introduced regulations in respect of the number of pressurized gas containers each restaurant may keep in storage.

[0011] In addition, the reflection of heat from the burners and heat transfer from the burner area is rather inefficient, as most of the heat is directed upwards by convection. Instead of being distributed in the surroundings as desired. The result is that a radiant heat based on combustion of gas may consume the content of one or more pressurized gas containers during an evening.

[0012] Radiant heaters for combustion of solid particulate fuel, such as wood chips, pellets, sawdust or the like are disclosed in DE102013100971A1 or DE202011001786 U1. The bottom part of the radiant heaters disclosed herein comprises a combustion chamber and a chimney pipe is arranged on top of the combustion chamber. A combustion flame extends into the chimney pipe and may provide a spectacular flame since the chimney pipe is made of glass. Exhaust and heat is distributed to the surrounding area by convection, e.g. from the chimney pipe, and by the combustion air leaving the chimney pipe below a reflector at the top end of the chimney pipe.

[0013] These radiant heaters use low cost fuel, such as wood pellets or wood chips and increase the transfer of heat to the surrounding, by increasing the effective area of heat transfer, at least by means of the chimney pipe. Hot exhaust gas is also directed into the surroundings by being expelled under the reflector mounted on top of the chimney pipe.

[0014] When solid fuel, e.g. wood pellets, is combusted, there is a risk of exposing the surroundings to smoke and malodorous smells emitted in the exhaust gas. Small particulate combustion particles, e.g. soot, may be also exhausted in the combustion gas, and it is thus highly inconvenient to direct the exhaust into the near surroundings or the neighbourhood.

[0015] In addition, when feeding solid particulate fuel into a burner bowl from below by a screw conveyor, whereby the solid creates a molehill of particulate fuel burning at the top surface thereof, there is a risk of igniting the solid particulate fuel present in the screw conveyor.

[0016] Thus there is a need for further improving radiant heaters in respect of fuel economy as well as reducing the emission of smoke in the near surroundings of the radiant heater. In addition there is a need for decreasing the risk of emission of smell in the neighbourhood due to combustion gasses emitted from the radiant heaters.

Object of the Invention

[0017] It is an object of the present invention to effectively prevent any backfire into solid particulate fuel in a screw conveyor feeding solid particulate fuel into a burner bowl from below.

[0018] It is also an object of the present invention to provide a burner unit where the flames can be viewed from the entire circumference, and where the flames hide the fuel dispensing means.

[0019] Thus it is an object of the present invention to provide an improved radiant heater for indoor or use as a pellet stove or outdoor use such as on balconies, terraces, patios or in gardens, which is based on combustion of particulate solid fuel, in particular solid particulate bio-fuel such as pellets, wood chips, grains corn etc. etc. which improves the transfer of heat to the surroundings.

[0020] It is also an object of the present invention to provide a radiant heater based on solid particulate fuel which reduces the exposure to smells and malodorous exhaust in the vicinity of the radiant heater as well as reduces the exposure to smells and malodorous exhaust in the surrounding neighbourhood during emission of smoke from the radiant heater.

[0021] It is also an object of the present invention to improve control of the combustion process in relation to the need for heat in the vicinity of the radiant heater, which in turn improves the overall economy of the radiant heater according to the present invention when in use.

[0022] Likewise, it is an object of the present invention to provide an improved radiant heater for indoor or outdoor use such as on balconies, terraces, patios or in gardens, which provide improved directional reflection of the convection heat and in turn overall increases the efficiency of the radiant heater as well as improves the fuel economy.

Description of the Invention

[0023] The present invention relates to a special burner unit construction. The burner unit comprises a solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel, such as pelletized wood, into a vertically open bowl burner from below, such as in a radiant heater. The dispensing device comprises a vertical dispensing tube arranged vertically through the centre of the burner bowl. Said dispensing tube is arranged in extension of an outer sheath of a vertical or inclined screw conveyor, which extends vertically or inclined downwards into a solid fuel storage, where the screw of the screw conveyor extends below the sheath in order to allow the solid particulate to enter the screw conveyor for transport upwards into the dispenser tube, wherein a collar is arranged at the upper end of the dispenser tube, said collar being provided with an inclined or a rounded or semi circular upper surface and where the lower surface of the collar is generally rounded or cone-shaped.

[0024] The circular pile of solid particulate fuel created

by the dispenser in the burner bowl ensures that flames do not come into direct contact with the outlet of the dispenser.

[0025] In addition a ring shaped pile of burning solid fuel is created in the burner bowl. The flames thus surround the fuel dispenser outlet and "hide" it behind the flames. Thus, the fuel dispensing means are not visible or at least reduced visible, because they are surrounded by flames.

[0026] This burner construction further enables that the combustion chamber can be provided with glass walls around the entire periphery, whereby the flames become visible at 360 degrees.

[0027] The inclined or rounded shape of the lower surface of the collar results in that the flames are directed outwards and thus away from the dispenser opening. This further reduces the risk of flames entering the outlet of the dispenser tube.

[0028] The collar is preferably made of ceramic material, cast iron or steel. The interior of the body of the collar is preferably filled with an flameproof insulating material, e.g. hard mineral wool, glass foam or the like.

[0029] The dispenser tube is preferably surrounded by an insulation layer in at least part of its length in order to reduce transfer of heat through the wall of the dispenser tube. This reduces the risk of heating the solid fuel above the ignition point, while the solid fuel are inside the dispenser tube.

[0030] Said dispensing tube is preferably divided in a lower stationary part and an upper end part, which is arranged in rotatable manner. The upper rotating part of the dispenser tube is preferably attached to the auger to provide a rotating dispenser tube outlet. This provides a very even distribution of the solid fuel in the burner bowl in the entire circumference thereof. Thereby the burning solid fuel in the burner bowl result in that the dispenser tube is surrounded by flames and thus appears less visible when the burner is in operation.

[0031] The dispensing tube is preferably attached to the screw conveyor by means of an elongated rod or bolt which is attached to a universal joint or a ball joint connected to the upper end of the auger. These types of joints have proven to be stable under elevated temperatures which may exist at the area where the rotating dispenser tube and the screw conveyor are connected.

[0032] In the upper end of the dispenser tube, a heat resistant bearing ensures alignment of the rod or bolt and the upper rotating part of the dispenser tube in relation to the auger and the stationary lower part of the dispensing tube.

[0033] The rotating part of the dispensing tube is preferably provided with a radial outlet opening which further improves even distribution of the solid fuel to the burner bowl in the entire circumference thereof.

[0034] The outlet opening of the dispenser tube may be provided with a baffle plate or a hinged flap, which reduces the risk of flames entering into the dispenser tube opening and igniting the solid fuel present in the

dispenser tube.

[0035] The bottom of the burner bowl is preferably inclined downwards in a radially outward direction. This causes the solid fuel particulates to concentrate in the outer circumference of the bottom of the burner bowl when dispensed into the burner bowl. This increases the distance from the burning solid fuel to the dispenser tube, which reduces the risk of overheating the solid fuel present inside the dispenser tube. In addition, the solid fuel will be concentrated at the lowermost area of the burner bowl, which further improves the combustion of the solid fuel and thus also improves generation of heat. In addition, the burner may work effectively even if with less solid fuel are distributed to the dispenser tube.

[0036] The bottom of the burner bowl comprises a number of directional air nozzles which provide the combustion air through the bottom of the burner bowl in a vortex flow-like manner. This causes the air to circulate inside the burner bowl and lead combustion air from the electric igniter and around the entire burner bowl. This also ensures that the solid fuel is ignited around the entire area of the (circular) bowl. Further the air flow creates a kind of vortex whereby the flame spreads around the entire burner bowl, such as in an even manner.

[0037] As mentioned below, the burner may also comprise a cone-shaped top baffle, which is preferably mounted above the top edge of the dispenser tube with its pointed end towards the opening in the dispenser tube for creating a circular dispenser outlet between the lower conical surface of the baffle and the upper end of the dispenser tube,

[0038] An air flow pipe is preferably arranged parallel to or coaxially around at least a part of the screw conveyor sheath and/or a lower part of the dispenser tube, for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and the dispenser opening.

[0039] Alternatively, or in addition to this, the burner bowl is provided with legs, to lift the burner bowl from the bottom wall of the combustion chamber. This enables primary air to enter the burner bowl through apertures in the bottom thereof and allow an air flow from below the burner bowl.

[0040] Other details of the burner unit, e.g. the burner bowl, combustion air inflow means, the screw conveyor etc., are also discussed further below in connection with other embodiments of the burner unit as well as in connection with the radiant heater.

[0041] The objects of the present invention mentioned above are met by a solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel into a vertically open bowl burner from below, such as in a radiant heater. The dispensing device comprises a vertical dispensing tube arranged vertically through the centre of the burner bowl, said dispensing tube is arranged in extension of an outer sheath of a vertical or inclined screw conveyor, which extends vertically or inclined

downwards into a solid fuel storage, where the screw of the screw conveyor extends below the sheath in order to allow the solid particulate to enter the screw conveyor for transport upwards into the dispenser tube. A cone-shaped top baffle is mounted above the top edge of the dispenser tube with its pointed end towards the opening in the dispenser tube for creating a circular dispenser outlet between the lower conical surface of the baffle and the upper end of the dispenser tube.

[0042] An air flow pipe is arranged coaxially around at least a part of the screw conveyor sheath and/or a lower part of the dispenser tube, for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and across the dispenser opening. The cone-shaped baffle mentioned above assists in directing the air flow across the dispenser opening as it provides a lower pressure on the upper side of the cone, thus creating an ejector-like effect. This further assists in directing the airflow upwards across the dispenser opening.

[0043] This construction is very compact. Further it enables an accurate amount of solid particulate fuel to be dosed and fed to the burner bowl from below, which results in low fuel consumption and thus improved fuel economy in relation to the amount of KW of heat delivered to the surroundings. In addition the risk of any backfire into the dispenser tube and/or the screw conveyor is prevented. Backfire from the burner bowl and into the screw conveyor may ignite solid particulate fuel present in the screw conveyor and eventually also the solid fuel in the solid fuel storage. In a conventional "molehill" burner construction in which the fuel is fed to the burner bowl from below through a horizontal screw conveyor, the tip of the auger in the screw conveyor will in time be worn due to being repeatedly calcined. The wear will shorten the overall length and over time increase the risk of backfire into the fuel storage as the length of the auger decreases over time. This problem is elegantly avoided in the present construction of the dispenser and its position in relation to the burner bowl.

[0044] This burner and dispenser construction further enables that the combustion chamber can be provided with glass walls around the entire periphery, whereby the flames become visible at 360 degrees.

[0045] The solid fuel dispenser according to the invention is preferably used in a radiant heater, a stove or a fireplace where the combustion chamber is arranged on top of the solid fuel storage. A horizontal wall divides the combustion chamber from the solid fuel storage. The horizontal wall is e.g. made of metal, such as stainless steel with thermal insulation on the back. The horizontal wall provides the bottom of the combustion chamber.

[0046] A sloping bottom in the solid fuel storage ensures that the solid particulate fuel collects at the bottom leading the particulate fuel to the lower part of the spiral auger of the screw conveyor.

[0047] A vertical or inclined screw conveyor feeds the

solid particulate fuel to the burner bowl from below above and thus creating a molehill-like construction as discussed below. A vertical or inclined screw conveyor feeds the solid particulate fuel into a vertical dispenser tube as described in more detail below.

[0048] The geared electrical motor coupled to the shaft of the screw conveyor conveying solid particulate fuel into a circular burner bowl from below.

[0049] The lower part of the screw conveyor is open towards the outside, and thus pulls solid particulate fuel into the tube surrounding the auger whereby the solid particulate fuel is lifted up from the solid fuel storage and into a dispenser tube. A least the lower third to the lower half of the auger is preferably provided with means for retaining the solid particulate fuel on the while rotating. The retaining means comprise a concave auger surface (when seen in the radial direction) so that the circumference of the helical transport surface is levelled above the middle of the helical transport surface when seen in the radial direction) or upright sidewalls along the periphery of the auger and/or radially positioned ribs on the upper and/or lower transport surface of the auger. The radially positioned ribs prevent backflow of the solid particulate fuel during transport on the vertical or inclined screw conveyor. The upright sidewalls or concave helical transport surface prevents or reduces the risk of solid particulate fuel dropping from the circumference of the auger and back into the solid fuel storage.

[0050] The dispenser tube is provided as an upper end extension of the tube surrounding the auger.

[0051] The auger presses the solid particulate fuel upwards and into the dispenser tube which ends at a certain height, such as e.g. 1-25 cm, or preferably 3-25 cm above the burner bowl above the bottom from where the particulate fuel drops into the burner bowl in a circular pile around the dispenser tube.

[0052] The circular pile of solid particulate fuel ensures that flames do not come into direct contact with the outlet of the dispenser.

[0053] A cone-shaped top is mounted on the top of the dispenser tube with its pointed end towards the opening in the dispenser tube thus creating a circular dispenser opening and assists in guiding the solid particulate fuel out of the dispenser tube.

[0054] A blower or a suction fan supplies combustion air to the burner bowl from an air inlet, such as via air supply tube and through a coaxial air supply pipe provided around the screw conveyor pipe and/or at least a part of the dispenser pipe.

[0055] A flow of cold primary combustion air is thus passed up along the outside surface of the dispenser tube and screw conveyor tube through the coaxial opening. A part of the air flow of the primary combustion air is then guided into the burner bowl through openings in the bottom of the burner bowl. A second flow of air exits at the upper end of the coaxial air pipe. This air flow cools the dispenser tube and guides air upwards along the outer surface of the dispenser tube and past the dispenser

opening. The design of the cone top causes an ejector like effect around the feeding dispenser opening and prevents flames from the burner bowl to enter into the dispenser tube.

5 **[0056]** Thus ignition of the solid particulate fuel inside the dispenser tube or the screw conveyor is avoided.

[0057] The combination of dispensing the solid particulate fuel in a circular pile around the dispenser tube in the burner bowl and providing the airflow around the circumference of the effectively prevents any flames from backfiring into the screw conveyor.

10 **[0058]** A collar is preferably arranged at the upper end of the dispenser tube. This allows the solid particulate fuel to be spread out evenly before being dispensed into the burner bowl.

15 **[0059]** The dispenser tube extends vertically up through the bottom of the burner bowl through a central opening with an inner vertical wall extending around the dispenser tube, thus creating a ring shaped burner bowl.

20 **[0060]** The flange or collar extends in radial direction at a distance which is larger than the distance between the vertical inner wall of the burner bowl and the outer surface of the dispenser tube, so as to prevent any solid fuel from being positioned in the burner bowl and directly

25 against the outer surface of the dispenser tube. **[0061]** The upper surface of the flange or collar is preferably inclined in radial direction so that the outer circumference of the flange or collar is lower than the end of the dispenser tube from the end of the dispenser tube.

30 **[0062]** The lower surface of collar or flange extends upwardly inclined in radial direction, which assists the airflow from the coaxial opening to pass upwards and outwards to provide a protective "air curtain" in front of the dispenser opening. This further reduces the risk of flames entering into the dispenser tube and causing inflammation of solid fuel present in the dispenser tube.

35 **[0063]** A temperature sensor is preferably arranged on the dispenser tube. The temperature sensor detects the temperature of the feeding dispenser tube and provides control signals to the control unit. The suction fan or the blower starts when radiant heater is started in order to provide combustion air to the burner bowl and to ensure that the solid particulate fuel is not ignited in the dispenser tube when burning solid particulate fuel in the burner

40 bowl. When the temperature detected by the sensor on the dispenser falls below for example 50 °C the blower stops. This also ensures that the blower or suction fan is running until all solid fuel present in the burner bowl is burnt, where by the burner bowl will be empty and ready

45 to fill when restarting the radiant heater. The objects of the present invention are also met by means of a radiant heater for indoor or use as a pellet stove or outdoor use, such as on balconies, patios, terraces or in gardens, comprising a combustion chamber for combustion of solid

50 particulate fuel, said combustion chamber is arranged in the lower part of the radiant heater and a chimney pipe arranged with its first end above the combustion chamber to lead flue gas from the combustion chamber for emis-

sion to the atmosphere in a height h above the combustion chamber through a second end of the chimney pipe.

[0064] The radiant heater according to the present invention is special in that it further comprises storage means for storing the solid fuel which storage means are arranged beside the combustion chamber in the lower part of the radiant heater, and means for transferring the solid fuel from the storage means to the combustion chamber. The radiant heater further comprises a burner unit and/or a solid particulate fuel feeding and dispensing device as described above.

[0065] When used as an indoor pellet stove, the ejector at the top of the chimney pipe is not used. Instead the upper end of the chimney pipe of the radiant heater is attached to a conventional chimney, e.g. a steel chimney, arranged in a building.

[0066] The combustion chamber is placed in the lower end of the radiant heater near ground level. Thus heat radiation from the combustion chamber is radiated into the surroundings at a level above ground in which it efficiently heats the air around the radiant heater. The solid fuel based combustion chamber is thereby heating the surroundings in a more energy efficient manner, as the heat is transferred to the surroundings at a level above ground in which people effectively benefit from radiated heat as the heated air gradually raises upwards from a level of around the knees or legs of the people who are in the vicinity of the radiant heater according to the present invention.

[0067] In addition, the chimney pipe emits heat from the flue gas passing through the chimney pipe to the surroundings at a level above ground corresponding to the area of the body of people who are near the radiant heater.

[0068] The result is an effective transfer of heat from the radiant heater to the surroundings resulting in an overall effective fuel economy. When using solid particulate fuel from renewable sources, such as wood pellets, wood chips, saw dust, grain/corn of various crops, and/or kernels of fruits, nuts or vegetables etc. a very low fuel cost is a reality when compared to gas of fossil origin. One traditionally gas fired radiant heater typically uses around the content of one pressurized container per night, i.e. around six hours, corresponding to a gas cost of up to 250-350 DKK in retail prices. In comparison, the radiant heater will typically use around 10-12 kg of wood pellets corresponding to a retail price of approx. 30 DKK per night.

[0069] The radiant heater comprises a lower body in which the combustion chamber and solid fuel storage means are provided. The lower body may be circular, oval or polygonal, e.g. square, rectangular, pentagon, hexagon etc. in cross shape. The cross section may be constant in area throughout the height of the lower body or the cross section area may be reduced throughout the height of the body part resulting in e.g. a cone-shaped or a pyramid shaped body part.

[0070] The combustion chamber and the solid fuel stor-

age means are separated by a wall made of heat and flame proof material such as stone, ceramics or the like to protect the stored solid fuel from heat from the combustion chamber. If necessary, the wall may also comprise a layer of insulation material, e.g. mineral wool or glass wool if additional insulation of the solid fuel storage means is preferred to protect the solid fuel storage from heat from the combustion chamber. The solid fuel storage means may be arranged above, besides or below the combustion chamber or a combination thereof.

[0071] The solid fuel storage means comprises a hatch through which the solid fuel can be fed to the storage in the body part. The hatch is e.g. hinged along a lower horizontal side of the hatch and may comprise side walls along two opposing more or less vertical sides whereby the hatch acts as a hopper when feeding the solid particulate fuel to the storage means.

[0072] The bottom of the body of the radiant heater comprises a bottom frame. The bottom frame is preferably provided with feet or wheels or a combination thereof for lifting the bottom frame from the ground in order to enable air being sucked into the combustion chamber from below.

[0073] In addition, the bottom frame, which may comprise ballast material, e.g. a concrete slab, to provide stability and reduce or eliminate the risk of the radiant being knocked over, e.g. when moved or by the wind.

[0074] The wheels on the bottom frame enable that the radiant heater may be moved. The wheels may comprise a lock to prevent the radiant heater from moving or being moved unintentionally after being placed at a desired position. If a combination of wheels and feet are provided the ambient air body may comprise a handle on the lower body for lifting the feet from the ground while moving the radiant heater.

[0075] A chimney pipe is arranged on top of the lower body of the radiant heater to guide smoke or waste gas from the combustion chamber to the atmosphere. The chimney pipe ends at a height of e.g. approx. 1.8-2.5 meters above ground level in a chimney top from which waste gas is directed upward and thus away from the persons occupying the area around the radiant heater.

[0076] The radiant heater according to the present invention is also special in that it comprises an ejector arranged at the upper end of the chimney pipe, said ejector being provided to mix ambient air into the flue gas prior to or in connection with the flue gas being emitted to the atmosphere or the upper end of the chimney pipe of the radiant heater is attached to a conventional chimney arranged in a building.

[0077] The ejector is provided to mix ambient air into the flue gas prior to or in connection with the flue gas being emitted to the atmosphere by blowing or suction of the flue gas through the ejector means. This results in that the flue gas is diluted when emitted to the atmosphere. The dilution of the flue gas prior to emission to the atmosphere results in a less malodourous flue gas and thus reduces or even eliminates spreading odorous

smoke in the neighbourhood.

[0078] The ejector comprises one or more slits and/or openings in the upper end of the chimney pipe through which the ambient air is sucked into the flue gas due to the flow velocity of the flue gas in the chimney pipe. The flow velocity of the flue gas necessary for providing the ejector effect is preferably obtained by the flue gas being sucked through the chimney pipe or alternatively by being blown through chimney pipe as described in more detail below. Preferably a decrease in the diameter of the chimney pipe in connection with the slits and/or openings for ambient air may be combined with the flue gas suction or blowing means.

[0079] The radiant heater comprises a combustion chamber arranged in the lower body part. The combustion chamber comprises a burner bowl into which the solid material is fed for combustion and generation of heat. The burner bowl is vertically upward open into the combustion chamber. The burner bowl may be circular, oval square or rectangular. The burner bowl is preferably provided with perforations which enable combustion air to enter the burner bowl from below and/or the sides of the burner bowl and enables ashes to fall into a collection tray arranged below the burner bowl.

[0080] The ash collection tray for collecting and removing ashes may be inserted in the lower body below the burner bowl. The collection tray can be drawn from the body and reinserted after emptying the ashes from the tray.

[0081] Solid fuel is fed from the storage means to the burner bowl by means of a screw conveyor driven by a geared motor.

[0082] In one embodiment the screw conveyor is inclined and feeds solid particulate fuel from the solid fuel storage means to the burner bowl from above, e.g. by dispensing the solid particulate fuel directly into the burner bowl or by feeding the solid particulate fuel onto a chute or similar dispensing means, which then direct the solid particulate fuel into the burner bowl. Thus the solid particulate fuel is dispensed into the burner bowl at the instant it leaves the screw conveyor and is fed to the chute dispenser. This construction prevents flames from the burner bowl from igniting solid particulate fuel present in the screw conveyor.

[0083] Alternatively the solid particulate fuel is fed to the burner bowl from below by the screw conveyor, e.g. form a substantially horizontal screw.

[0084] The screw conveyor feeds the solid particulate fuel to a bottom opening in the burner bowl, which is connected with the outlet from the screw conveyor. The solid particulate fuel thus creates a "molehill" in the burner bowl. The solid particulate fuel is continuously burnt from the top of the molehill while fresh solid particulate fuel is fed from below the burning particulate fuel, which provides an inexpensive construction.

[0085] Alternatively, the combustion chamber is arranged on top of the solid fuel storage and a vertical or inclined screw conveyor feeds the solid particulate to the

burner bowl from below and thus creating a molehill as discussed above. Hereby it becomes possible to provide view to the flames in the combustion chamber at a 360 degrees angle because it becomes possible to provide the combustion chamber with walls or wall parts of heat resistant glass around substantially the entire periphery wall and to provide excellent heat radiation at low height. The wall at the periphery of the combustion chamber may comprise one or more wall parts having one or more doors or removable wall parts, to allow access to the combustion chamber, e.g. for cleaning. The wall parts of heat resistant glass are preferably separated by rods, e.g. three, four or six rods, to support a flange at the upper end of the lower body onto which the chimney pipe is attached to the lower body.

[0086] Combustion air is supplied to the combustion chamber through one or more openings in the bottom of the lower body into the combustion chamber. The one or more openings may be closed by draught control means, e.g. a sliding draught or a swiveling draught control to stop any air from entering the combustion chamber.

[0087] Preferably, a suction fan is arranged in the chimney, such as in the upper end thereof, more preferred in connection with the ejector, such as downstream to the ejector for introducing primary and/or secondary combustion air to the combustion chamber by suction through one or more openings in the bottom part of the combustion chamber. A suction fan is provided in the upper end of the chimney pipe reduces pressure in the combustion chamber whereby the risk of escape of potentially hazardous gases from the combustion chamber, e.g. through leaks in the construction of the radiant heater, is reduced significantly or even eliminated. In addition, the amount of ashes, particles and/or soot particles which escapes the combustion chamber in the flue gas is reduced because the suction fan in the upper end of the chimney is less likely to fluidize any particulate matter which rests on surfaces in the combustion chamber or in the collection tray. When the suction fan is arranged in connection with the ejector, in particular upstream to the ejector, the suction fan controls the flow velocity of the flue gas and thus assists in mixing ambient air into the flue gas in the ejector for diluting the flue gas before emitting the flue gas to the atmosphere.

[0088] Alternatively combustion air is provided to the burner bowl one or more blowers arranged below the combustion chamber, e.g. in the one or more openings in the bottom of the combustion chamber for blowing combustion air into the combustion chamber from below.

[0089] Preferably the radiant heater according to the present invention comprises means for controlling the feed of solid particulate fuel to the combustion chamber and/or for controlling the speed of the suction fan or blower.

[0090] The size of the flame can be increased or decreased by varying the feed rate of the solid particulate fuel. A large flame increases the amount of heat which can be transferred to the surroundings while a smaller

flame reduces the heat transferred to the surroundings.

[0091] The temperature in the combustion chamber may be up to around 1100 °C during effective combustion of the solid particulate fuel.

[0092] The combustion chamber preferably comprises one or more wall parts and/or one or more doors made of heat resistant glass to provide a view to the flames at a large angle and to provide excellent heat radiation at low height, e.g. below tables, where the need is greatest. The wall part of glass or one or more glass doors extend preferably at a majority of the height and/ at the majority of the outer circumference, e.g. at an angle of up to 120-180 degrees, of the wall surrounding the combustion chamber in the lower body part of the radiant heater.

[0093] Alternatively the wall part at the majority of the outer circumference of the wall surrounding the combustion chamber in the lower body part of the radiant heater is made of metal, such as steel, in particular stainless steel, heat and flame resistant ceramics, stone or similar materials which do not deteriorate from the heat from the combustion chamber. Hereby the circumferential wall of the combustion chamber provides infrared radiation to the surroundings whereby heat may be distributed effectively to a large radius surrounding the lower body part.

[0094] The outer surface of the combustion chamber wall may be provided with fins, ribs or similar means to increase the surface available for transfer of heat from the combustion chamber, whereby transfer of heat to the surroundings is further improved at low height above ground.

[0095] In another alternative, there is no outer wall surrounding the combustion chamber whereby the radiant heater may resemble an open fireplace. If necessary a wire mesh may be provided to cover the opening in the combustion wall chamber.

[0096] The feed rate of the solid particulate matter can be varied by varying the rotational speed of the screw conveyor and/or duration of the feed from the screw conveyor.

[0097] The speed of the suction fan or the blower, which controls the air supply, is then adjusted according to the feed rate of the solid fuel in order to ensure optimal supply of combustion air to ensure full combustion of the solid particulate fuel fed to the combustion chamber. Control of the air supply in relation to feed rate of the solid particulate fuel also reduces the risk of emitting soot particles, as formation of soot particles may occur during combustion with insufficient air supply.

[0098] The heating effect from the radiant heater can be controlled from a minimum to a maximum by controlling the feed rate of the solid fuel. The heating effect is controlled within a minimum of e.g. 0.5kW to a maximum of e.g. 10kW, or preferably e.g. 1.5kW to 8 W. The feed rate of the solid fuel may e.g. be controlled from a minimum of e.g. 10-20 % of the maximal rotational speed of the feed screw rate. The feed rate can be controlled up to a maximum feed rate at maximal screw rotational speed.

[0099] Alternatively, or in addition to controlling the rotational speed of the screw, the feed rate may be controlled by controlling duration of feeding by the screw conveyor by reducing or increasing, respectively, the time intervals in which the gear motor of the screw conveyor is activated. For example the screw rotation is activated intermittently to control duration of feed from the screw from e.g. 3-60 seconds, such as 3-30 or preferably 5-15 seconds in minimum feed mode and up to constant feed, depending also on the load capacity of the burner bowl and/or the screw.

[0100] The desired temperature may e.g. be used as a set point by the user providing an input to the control unit.

[0101] The user may control the settings in the control unit from a control panel mounted on the radiant heater, e.g. on the lower body. Alternatively a remote control unit may be used to control the settings.

[0102] Alternatively a control program, e.g. an app, may be installed on a computer, such as a laptop, a smart phone, a tablet computer, a PDA etc., with one or more standardized wireless communication ports, e.g. wireless network, internet, Bluetooth, radio frequency communication, infra-red communication etc. The settings may then be remote controlled from the computer interface, e.g. the touchscreen of the tablet or smart phone, via wireless communication between the remote control and the radiant heater control unit.

[0103] A temperature sensor is preferably connected to the control unit to detect the temperature at a distance from the radiant heater. The temperature sensor may be connected to the control unit by a cord or preferably by means of wireless communication technology, e.g. as mentioned above. When a wireless temperature sensor is used, the user may place the sensor at a certain position in which he or she desires a certain temperature.

[0104] The temperature sensor provides a control signal to the control unit based on the actual temperature detected by the temperature sensor. The control unit compares the input from the temperature sensor with the input temperature set point stored in the control unit (as by input from the user), and increases or decreases or interrupts the feed rate of solid fuel respectively.

[0105] Alternatively, the temperature sensor is not installed or not used. The feed rate of solid fuel is then controlled by selecting a feed rate using a switch on the control panel. The feed rate is e.g. controlled stepwise by the switch by the user selecting a fixed feed rate between the minimum and maximum feed rates, e.g. with one or more additional feed rate steps between the minimum and maximum feed rates, e.g. minimum-medium-maximum or minimum-low-high-maximum or minimum-low-medium-high-maximum. Alternatively, the feed rate switch on the control panel is steplessly adjustable between a minimum and a maximum value.

[0106] The solid fuel storage preferably comprises a level sensor for detecting low levels of solid particulate fuel in the fuel storage, so that the user can react and fill

solid fuel into the fuel storage means. The level sensor provides a control signal to the control unit which indicates a low level alarm, e.g. on the control display or on the remote control means, e.g. by a message on a display and/or by a visual alarm, e.g. a flashing light, and/or by means of an acoustic alarm signal.

[0107] The radiant heater according to the present invention preferably comprises a cyclone for separating particles from the flue gas is arranged at the upper end part of the chimney pipe, preferably upstream to the suction fan, preferably upstream to the ejector.

[0108] Hereby is achieved that particles, e.g. ashes, soot and/or uncombusted solid fuel particles are separated from the flue gas prior to emission to the atmosphere.

[0109] The ejector is preferably arranged in the chimney top, and flue gas from the flue pipe enters the cyclone from the chimney pipe via slits in an outwards direction and at an angle that creates a vortex flow inside the cyclone body. The particles are collected at the bottom wall of the cyclone.

[0110] The particles collected in the bottom part of the cyclone may be collected at regular intervals depending on the amount of collected particles, e.g. by collecting the particles in a tray, which can be drawn for the bottom part of the ejector and reinserted after being emptied or by separating the chimney top for gaining access to the interior of the cyclone. Alternatively a hatch may be provided through which the nozzle of a suction cleaner can be inserted for cleaning out ashes by suction.

[0111] The flue gas exits the cyclone at the top via a central outlet. The reduced diameter of the cyclone outlet in relation to the diameter of the cyclone increases the flow velocity in the flue gas at the inlet of the ejector.

[0112] The chimney pipe transfers the flue gas from the combustion chamber in the lower body to the chimney top for emission to the atmosphere. When the radiant heater is in use, the chimney pipe becomes hot and transfers heat to the surrounding by heat convection and/or infra-red radiation.

[0113] The chimney pipe is preferably made of heat resistant glass or steel, in particular stainless steel, as these materials provide excellent transfer of heat to the surroundings by heat radiation and/or infra-red radiation.

[0114] The chimney pipe may comprise one or more interior baffle means, such as a helical baffle, a screw shaped baffle or a twisted baffle plate, which increases the retention time of the flue gas in the chimney pipe, which improves heat transfer to the surroundings even further and thus even further improve efficiency of the radiant heater in terms of kW/kg solid particulate fuel.

[0115] The chimney pipe is preferably surrounded by a protective grille wire mesh or a similar construction at a distance which prevents any direct contact with the exterior surface of the chimney pipe and reduces the risk of injury by contact with the hot chimney pipe.

[0116] The exterior surface of the chimney pipe is preferably provided with heat distributing means, such as

parallel vertical or horizontal ribs or fins or helical ribs or fins or rods extending from the outer surface. The fins, ribs or rods increase the contact surface with between the chimney pipe and the surrounding air whereby the flue gas is cooled and transfer of heat to the surrounding air and/or emission of infra-red radiation to the surroundings in a large radius surrounding the radiant heater is further optimized. This also improves the overall efficiency of the radiant heater improves the fuel economy of the radiant heater.

[0117] The chimney pipe is preferably provided with a reflector extending around a part of the periphery of the chimney pipe, whereby infra-red radiation may be directed in a certain direction for improving heat transfer to the desired area surrounding the radiant heater. The reflector may also protect inflammable or heat sensitive items, e.g. vegetation, building construction parts, parts of umbrellas, tents or pavilions etc., nearby from heat radiation from heat radiation from the chimney pipe.

[0118] The reflector is preferably mounted so it can be rotated around the chimney pipe for adjusting the direction in which infra-red radiation is to be reflected to the surroundings. The reflector may e.g. be attached to the wire mesh or alternatively to the body part by means of an upper and a lower ring member or circular track on/in which the reflector is slidable for rotating the reflector around the chimney pipe. Alternatively, the reflector is mounted on a rod, extending substantially vertically from a sliding member in a (semi) circular track in the upper surface of the lower body part, preferably at the outside of the wire mesh. The reflector is then rotated around the chimney pipe by moving the sliding member in the track to either side. The reflector may be moved manually or automatically by means of an electrically driven actuator.

[0119] The chimney pipe may be extended with one or more rotatable and/or detachable extensions. Said rotatable and/or detachable extensions each comprises a chimney pipe part, which is arranged to extend upward in a direction of up to 45 degrees in relation to horizontal position, said detachable and/or rotatable extension is further provided with reflector means for downwards reflection of heat radiation and/or infra-red radiation from the chimney pipe.

[0120] The extended chimney pipe further cools the flue gas and the reflectors direct the heat downwards towards the surroundings, e.g. toward a number of tables at an outdoor serving area in a hotel or restaurant. The extensions may be rotatable in order to be able to adjust the position according to a desired position at which the heat should be directed to e.g. tables placed near the radiant heater.

[0121] Alternatively, or in combination with the above mentioned chimney pipe extensions, a flexible pipe or hose may be attached to the chimney top to guide the flue gas round and over any parasols or awnings used in the area.

[0122] The combustion chamber may be provided with automatic ignition means which may be activated from

the control panel and/or the remote control means as discussed above. The automatic ignition means may e.g. comprise an electrically driven ignition tube through which hot air is expelled into the burner cup. The hot air ignites the solid particulate fuel which is dispensed into the burner cup upon start-up of the radiant heater.

[0123] The chimney pipe with the chimney top is preferably detachable, whereby the lower body part comprising the combustion chamber can be used as an open fire place without a chimney and the above mentioned chimney top. The lower end of chimney pipe is e.g. attached to upper edge of the lower body by a flange connection.

[0124] Energy supply to the control unit, the suction fan or blower and the motor for the screw conveyor is provided by a 12 V power supply, e.g. 12V battery arranged in the lower body part, e.g. in connection with the control circuit, such as in an enclosure, which is protected from heat from the combustion chamber. Alternatively the power supply may be provided by a 230 V to 12 V transformer connected to the electrical energy supply. The transformer may be incorporated into the lower body of the radiant heater or it may be provided at the electrical cord connected to the energy supply.

[0125] The use of a 12V electrical system reduces the risk of accidents in relation to the power supply, e.g. caused by defect electrical cables etc.

[0126] The battery may be charged or recharged by means of a charger which is connected to the energy supply when needed.

[0127] Alternatively, the battery may be recharged using solar cells mounted on the radiant heater, e.g. in the chimney top. Alternatively the battery may be charged by means of a thermoelectrical element which transforms heat from the combustion chamber into electrical power, (e.g. as supplied by Alpcorn A/S in Denmark).

Description of the Drawing

[0128] The present invention will be described in the following paragraphs with reference to the drawings in which

- Fig. 1 shows a vertical cross section of the radiant heater according to the present invention
- Fig. 2 shows a horizontal cross sectional view through the chimney pipe area at A-A in fig. 1
- Fig. 3 shows a horizontal cross sectional view through the lower body area at B-B in fig. 1
- Fig. 4 shows a vertical cross sectional view through a detachable chimney pipe extension with reflector means
- Fig. 5 shows a vertical cross sectional view through the detachable chimney pipe at C-C in fig. 4 of the detachable extension with reflector means.

Fig. 6 shows a vertical cross section view through the chimney top comprising a suction fan, an ejector and a cyclone.

Fig. 7 shows a cross sectional view through the lower body of an embodiment with a vertical screw conveyor and the combustion chamber positioned above the solid fuel storage.

Fig. 8 shows a cross sectional view through the burner bowl and the vertical dispenser tube in detail.

Fig. 9 shows a cross sectional view of a variant similar to fig. 7, with an alternative burner bowl as well as an alternatively shaped collar.

Figs. 10-11b show a variant of a radiant heater having a rotating fuel dispenser and alternative burner bowl as well as an alternatively shaped collar.

Fig. 12 shows a top view of the burner bowl and the dispenser tube in cross section above the collar.

Detailed Description of the Invention

[0129] A radiant heater 1 for indoor or use as a pellet stove or outdoor use is shown in cross sectional view in fig. 1. The radiant heater comprises lower body part 2 in which a combustion chamber 3 for combustion of solid particulate fuel is provided next to a solid fuel storage chamber 4.

[0130] The combustion chamber and the solid fuel storage means are separated by a wall 5 made of heat and flame proof material as discussed above.

[0131] The solid fuel storage means 4 comprises a hatch 12 through which the solid fuel 8 can be fed to the storage 4 as discussed above, whereby by the hatch can act as a hopper when feeding the solid particulate fuel 8 into the storage means 4.

[0132] The bottom of the lower body 2 of the radiant heater comprises a bottom frame. The bottom frame is preferably provided with feet and/or wheels 6 moving the radiant heater and for lifting the bottom frame from the ground in order to enable air being sucked into the combustion chamber from below through not shown apertures or channels into the combustion chamber 3.

[0133] In addition, the bottom frame may comprise ballast material, e.g. a concrete slab 7.

[0134] The combustion chamber 3 comprises a burner bowl 7 into which the solid particulate fuel 8 is fed for combustion and generation of heat. An automatic igniter 44 (as discussed above) may be provided in connection with the burner bowl 7 to ignite the solid particulate fuel present in the burner bowl 7. The burner bowl 7 is vertically upward open into the combustion chamber 3. The burner bowl 7 is preferably provided with perforations 45 which enable combustion air to enter the burner bowl from below and/or the sides of the burner bowl and en-

ables ashes to fall into a collection tray (not shown) arranged below the burner bowl.

[0135] Solid fuel 8 is fed from the storage means 4 to the burner bowl 7 by means of a screw conveyor 9 driven by a geared electrically driven motor 10. In fig. 1 the screw conveyor 9 is inclined and feeds solid particulate fuel 8 from the solid fuel storage means 4 to the burner bowl 7 by feeding the solid particulate fuel onto a chute 11 which then directs the solid particulate fuel 8 into the burner bowl 3.

[0136] In a not shown embodiment the solid particulate fuel 8 is fed to the burner bowl 7 from below by the screw conveyor 9, e.g. form a substantially horizontal screw as discussed above and thus creating a molehill as discussed above.

[0137] As can be seen in fig. 3, the combustion chamber 3 preferably comprises one or more wall parts and/or one or more doors 15 made of heat resistant glass to provide a view to the flames at a large angle and to provide excellent heat radiation at low height, e.g. at an angle of up to 120-180 degrees, of the wall surrounding the combustion chamber 3.

[0138] In a not shown alternative the wall part at the majority of the outer circumference surrounding the combustion chamber 3 is made of metal, such as steel, in particular stainless steel, heat and flame resistant ceramics, stone or similar materials, optionally provided with fins or ribs, whereby circumferential wall of the combustion chamber provides infra-red radiation to the surroundings whereby heat may be distributed effectively to a large radius surrounding the lower body part.

[0139] A chimney pipe 13 is attached to the top area of the combustion chamber 3 to emit flue gas to the atmosphere in a height h, e.g. 1.8-2.5 m or more above ground level. The chimney pipe 13 leads the flue gas through the chimney top 14 at the upper end of the chimney pipe 13.

[0140] The chimney pipe transfers the flue gas from the combustion chamber in the lower body to the chimney top for emission to the atmosphere. When the radiant heater is in use, the chimney pipe becomes hot and transfers heat to the surrounding by heat convection and/or infra-red radiation.

[0141] The chimney pipe may comprise one or more interior baffle means (not shown) such as a helical baffle or a twisted baffle plate which increases the retention time of the flue gas in the chimney pipe and which improves heat transfer to the surroundings.

[0142] The chimney pipe 13 is preferably surrounded by a protective wire mesh 16 or a similar construction at a distance which prevents any direct contact with the exterior surface of the chimney pipe 13 and reduces the risk of injury by contact with the hot chimney pipe 13.

[0143] The exterior surface of the chimney pipe is preferably provided with heat distributing means 17. In fig. 1 and 6 the heat distributing means are exemplified as parallel or horizontal ribs 17 extending from the outer surface of the chimney pipe. The ribs or increase the contact

surface with between the chimney pipe and the surrounding air whereby the flue gas is cooled and transfer of heat to the surrounding air. Emission of infra-red radiation to the surroundings is provided in a large radius surrounding the radiant heater whereby the effect of the radiant heater is further optimized.

[0144] When used as an indoor pellet stove, the ejector at the top of the chimney pipe is not used. Instead the upper end of the chimney pipe of the radiant heater is attached to a conventional chimney, e.g. a steel chimney, arranged in a building.

[0145] The chimney pipe is preferably provided with a reflector 18 extending around a part of the periphery of the chimney pipe 13, for reflecting infra-red radiation in a certain direction.

[0146] The reflector 18 is preferably mounted so it can be rotated around the chimney pipe for adjusting the direction in which infra-red radiation is to be reflected to the surroundings as discussed above (not shown in the drawings).

[0147] The radiant heater 1 comprises an ejector 19 arranged in the chimney top 14 as shown in fig. 6. The ejector is provided to mix ambient air into the flue gas prior to or in connection with the flue gas being emitted to the atmosphere. The ejector sucks ambient air into the ejector through a first slit 20 in the chimney top and through one or more second 21 slits and/or openings in the upper end of the chimney pipe 13 through which the ambient air is sucked into the flue gas due to the flow velocity of the flue gas in the chimney pipe 13.

[0148] Combustion air is supplied to the combustion chamber through one or more openings in the bottom of the lower body into the combustion chamber.

[0149] Preferably, a suction fan 22 is arranged in the chimney pipe 13, such as in the upper end thereof, more preferred in connection with the ejector 19, such as downstream to the ejector 19.

[0150] Alternatively combustion air is provided to the burner bowl 7 by one or more blowers arranged below the combustion chamber e.g. in the one or more openings (not shown) in the bottom of the combustion chamber for blowing combustion air into the combustion chamber from below.

[0151] Flue gas from the flue pipe enters the cyclone 26 from the chimney pipe 13 via a third set of slits in an outwards radial direction and at an angle in relation to the radial direction that creates a vortex flow inside the cyclone body 26. The particles are collected at the bottom 27 of the cyclone.

[0152] The flue gas exits the cyclone 26 at the top via a central outlet 28. The reduced diameter of the cyclone outlet 28 in relation to the diameter of the cyclone 26 increases the flow velocity in the flue gas at the inlet of the ejector 19.

[0153] The chimney pipe 13 may be extended with one or more rotatable and/or detachable extensions 23 which is shown in figs. 4-5. The rotatable and/or detachable extensions each comprises a chimney pipe part 24,

which is arranged to extend upward in a direction of up to 45 degrees in relation to horizontal position. The detachable and/or rotatable extension 23 is further provided with second reflector 25 means for downwards reflection of heat radiation and/or infra-red radiation from the second detachable chimney pipe part 24.

[0154] The extended chimney pipe 24 further cools the flue gas and the second reflectors 25 direct the heat downwards towards the surroundings, e.g. toward a number of tables at an outdoor serving area in a restaurant.

[0155] Alternatively, or in combination with the above mentioned chimney pipe extensions 23, a flexible pipe or hose (not shown) may be attached to the chimney top to guide the flue gas round and over any parasols or awnings used in the area.

[0156] Energy supply to the control unit, the suction fan or blower and the motor for the screw conveyor is provided by a 12 V power supply, e.g. 12V battery arranged in the lower body part, e.g. in connection with the control circuit, such as in an enclosure 2, see fig. 1 or 7.

[0157] The chimney pipe 13 with the chimney top 14 is preferably detachable, whereby the lower body part comprising the combustion chamber can be used as an open fire place, e.g. as illustrated in fig. 7. The lower end of chimney pipe 13 is e.g. attached to upper edge of the lower body 2 by a flange connection, e.g. by bolts and nuts or snap lock connections in which a spring member or a spring actuated latch on one part grips into a hole or a groove on the second part, e.g. on a flange or in a circumferential groove on the lower end of the chimney pipe 13.

[0158] In another embodiment as shown in fig. 7 the combustion chamber 3 is arranged on top of the solid fuel storage 4. A horizontal wall 5' divides the combustion chamber from the solid fuel storage. The horizontal wall 5' is e.g. made of metal, such as stainless steel with thermal insulation on the back. The horizontal wall 5' provides the bottom of the combustion chamber 3.

[0159] A sloping bottom in the solid fuel storage 4 ensures that the solid particulate fuel 8 collects at the bottom leading the particulate fuel to the lower part of the spiral auger 9" of the screw conveyor 9.

[0160] A vertical or inclined screw conveyor 9 feeds the solid particulate 8 to the burner bowl 7 from below above and thus creating a molehill as discussed above.

[0161] The geared electrical motor 10 coupled to the shaft of the screw conveyor 9 conveying solid particulate fuel into a circular burner bowl 7 from below.

[0162] The lower part of the screw conveyor 9 is open towards the outside, and thus pulls solid particulate fuel 8 into the tube 9' surrounding the auger 9" whereby the solid particulate fuel 8 is lifted up from the solid fuel storage 4 and into a dispenser tube 31. The dispenser tube 31 is e.g. an upper end extension of the tube 9' surrounding the auger 9".

[0163] The auger 9" presses the solid particulate fuel 8 upwards in the dispenser tube 31 which ends at a cer-

tain height of 3-25 cm or preferably 3-15 cm above the bottom from where the particulate fuel drops into the burner bowl 7.

[0164] The bottom of the burner bowl preferably comprises a number of directional air nozzles 43, as shown in fig. 12. The directional air nozzles 43 provide the combustion air through the bottom of the burner bowl 7 in a vortex flow-like manner.

[0165] An air flow pipe 37, 38 is preferably arranged parallel to or coaxially around at least a part of the screw conveyor 9 sheath and/or a lower part of the dispenser tube, for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and the dispenser opening.

[0166] Alternatively, or in addition to this, the burner bowl is provided with legs 45 (see figs 10, 11a), to lift the burner bowl from the bottom wall of the combustion chamber. This enables primary air to enter the burner bowl through apertures in the bottom thereof and allow an air flow from below the burner bowl.

[0167] The bottom of the burner bowl 7 is preferably inclined downwards in a radially outward direction as shown in figs. 9-11a. This causes the solid fuel particulates to concentrate in the outer circumference of the bottom of the burner bowl 7 when dispensed.

[0168] A flange or collar 32 around the dispenser tube end causes the pellets are spread out before they fall into the burner bowl. The dispenser tube 31 extends up through the bottom of the burner bowl 7 through a central opening with an inner vertical wall 40 extending around the dispenser tube, thus creating a ring shaped burner bowl.

[0169] The flange or collar 32 extends in radial direction at a distance which is larger than the distance between the vertical inner wall 40 of the burner bowl 7 and the outer surface of the dispenser tube 31 so as to prevent any solid fuel from being positioned in the burner bowl 7 and directly against the outer surface of the dispenser tube 31.

[0170] The upper surface 41 of the flange or collar 32 is preferably inclined in radial direction so that the outer circumference of the flange or collar 32 is lower than the end of the dispenser tube from the end of the dispenser tube 31, thereby forming a chute for the solid particulate fuel exiting the dispenser opening 33.

[0171] The lower surface 42 of collar or flange 32 extends upwardly inclined in radial direction, which assists the airflow from the coaxial opening 39 to pass upwards and outwards to provide a protective "air curtain" in front of the dispenser opening 33 as shown by the dashed arrows in fig. 8. This further reduces the risk of flames entering into the dispenser tube and causing inflammation of solid fuel 8 present in the dispenser tube 31.

[0172] Alternatively, the flange or collar 32 is generally rounded, i.e. having a generally circular cross section as shown in figs. 9 or the upper surface 41 of the collar 32

is inclined as discussed above while the lower surface 42 is rounded and may represent semi circular cross sectional view (when seen in a vertical cross section through the collar 32) as shown in figs. 10-11.

[0173] The inclined or rounded shape of the lower surface 42 of the collar 32 results in that the flames are directed outwards and thus away from the dispenser opening 33. This further reduces the risk of flames entering the outlet of the dispenser tube.

[0174] The collar 32 is preferably made of ceramic material, cast iron or steel. The interior of the body of the collar is preferably filled with an flameproof insulating material 46, e.g. hard mineral wool, glass foam or the like.

[0175] The dispenser tube 33 is preferably also surrounded by an a layer of flameproof insulation material 47 in at least part of its length in order to reduce transfer of heat through the wall of the dispenser tube 33.

[0176] A cone-shaped top 34 is optionally mounted on the top of the dispenser tube 31 with its pointed end towards the opening in the dispenser tube 31 thus creating a circular dispenser opening 33 and assists in guiding the solid particulate fuel 8 out of the dispenser tube 31. The cone top 34 also creates an ejector- like effect on the airflow thus further assisting in providing the above mentioned "air curtain" in front of the dispenser opening 33 as shown by the dashed arrows in fig. 8.

[0177] A blower 35 supplies combustion air to the burner bowl 7 from an air inlet 36 via air supply tube 37 and through a coaxial pipe 38 provided around the screw conveyor pipe 9' and at least a part of the dispenser pipe 31.

[0178] A flow of cold primary combustion air thus passes upwards through the coaxial opening 39 between the outside surface of the screw conveyor tube 9' and/or a part of the outside surface of the dispenser tube 31 and the coaxial pipe 38. A part of the air flow of the combustion air is then guided into the burner bowl 7 through (not shown) openings in the bottom of the burner bowl 7. A second flow of air exits at the upper end of the coaxial air pipe 38. This air flow cools the dispenser tube and guides air upwards along the outer surface of the dispenser tube and past the dispenser opening 33. The design of the cone top 34 causes an ejector like effect around the feeding dispenser opening 33 and prevents flames from the burner bowl 7 to enter into the dispenser tube 31. Thus ignition of the solid particulate fuel 8 inside the dispenser tube 31 or the screw conveyor 9 is avoided.

[0179] The suction fan 22 or the blower 35 is automatically started when the radiant heater is turned on. During start-up the blower 35 or suction fan 22 may run at increased speed for a few seconds, e.g. 5-30 seconds, to blow out any ashes present in the burner bowl prior to dispensing new solid particulate fuel into the burner bowl and subsequent ignition hereof. A temperature sensor 29 may be provided to detect the temperature of the feeding dispenser tube 31. When the temperature of the dispenser falls below for example 50 °C the blower 35 or suction fan stops as discussed above.

[0180] The shaft of the auger 9' of the screw conveyor

9 may comprise a support bearing to ensure correct position in relation to the tube and an opening in the bottom of the solid fuel storage.

[0181] Said dispensing tube 31 is preferably provided with a separate upper end part 31' which is attached to the auger to provide a rotating dispenser tube 31' outlet 33.

[0182] The rotating part of the dispensing tube 31' is preferably attached to the auger by means of an elongated rod or bolt 48 which is attached to a joint 49, such as a universal joint or a ball joint connected to the upper end of the auger of the screw conveyor 9..

[0183] In the lower end of the rotating part 31' of the dispenser tube 31, a heat resistant bearing 50 ensures alignment of the rod or bolt and the rotating part 31' of the dispenser tube 31 in relation to the auger and the lower stationary part of the dispenser tube 31.. The upper rotating end part of the dispensing tube 31' is preferably provided with a radial outlet opening 33.

[0184] The outlet opening 33 of the rotating part of the dispenser tube 31' may be provided with a baffle plate 51, see fig. 11a or a hinged flap (not shown), which reduces the risk of flames entering into the dispenser tube opening and igniting the solid fuel present in the dispenser tube.

[0185] In a not shown variant of the radiant heater, the combustion chamber is provided with a longitudinal, e.g. rectangular burner bowl 7 resembling a traditional open fireplace. In this embodiment there are no glass walls in the combustion chamber 3 and the combustion chamber is thus open to the surroundings.

Claims

1. A burner unit comprising a solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel into a vertically open bowl burner from below, such as in a radiant heater, wherein

- the dispensing device comprises a vertical dispensing tube arranged vertically through the centre of the burner bowl,

- said dispensing tube is arranged in extension of an outer sheath of a vertical or inclined screw conveyor, which extends vertically or inclined downwards into a solid fuel storage, where the screw of the screw conveyor extends below the sheath in order to allow the solid particulate to enter the screw conveyor for transport upwards into the dispenser tube, wherein a collar is arranged at the upper end of the dispenser tube, said collar being provided with an inclined or a rounded or semi circular upper surface and where the lower surface of the collar is generally rounded or cone-shaped.

2. A burner unit according to claim 1, **characterized**

- in, **that** a separate upper part of said dispensing tube is attached to the auger to provide a rotating dispenser outlet.
3. A burner unit according to claim 1 or 2, **characterized in, that** the bottom of the burner bowl is inclined downwards in a radially outward direction.
 4. A burner unit according to any of the claims 1-3, **characterized in, that** a cone-shaped top baffle is mounted above the top edge of the dispenser tube with its pointed end towards the opening in the dispenser tube for creating a circular dispenser outlet between the lower conical surface of the baffle and the upper end of the dispenser tube,
 5. A burner unit according to any of the claims 1-4 **characterized in, that** an air flow pipe is arranged coaxially around at least a part of the screw conveyor sheath and/or a lower part of the dispenser tube, for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and the dispenser opening.
 6. A solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel into a vertically open bowl burner from below, such as in a radiant heater, wherein
 - the dispensing device comprises a vertical dispensing tube arranged vertically through the centre of the burner bowl,
 - said dispensing tube is arranged in extension of an outer sheath of a vertical or inclined screw conveyor, which extends vertically or inclined downwards into a solid fuel storage, where the screw of the screw conveyor extends below the sheath in order to allow the solid particulate to enter the screw conveyor for transport upwards into the dispenser tube,
 - where a cone-shaped top baffle is mounted above the top edge of the dispenser tube with its pointed end towards the opening in the dispenser tube for creating a circular dispenser outlet between the lower conical surface of the baffle and the upper end of the dispenser tube,
 - where an air flow pipe is arranged coaxially around at least a part of the screw conveyor sheath and/or a lower part of the dispenser tube for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and the dispenser opening.
 7. A solid particulate fuel feeding and dispensing device according to claim 6, **characterized in, that** a collar is arranged at the upper end of the dispenser tube.
 8. A burner unit comprising a solid particulate fuel feeding and dispensing device for dispensing solid particulate fuel into a vertically open bowl burner from below, such as in a radiant heater, wherein
 - the dispensing device comprises a vertical dispensing tube arranged vertically through the centre of the burner bowl,
 - said dispensing tube is arranged in extension of an outer sheath of a vertical or inclined screw conveyor, which extends vertically or inclined downwards into a solid fuel storage, where the screw of the screw conveyor extends below the sheath in order to allow the solid particulate to enter the screw conveyor for transport upwards into the dispenser tube,
 wherein the bottom of the burner bowl is inclined downwards in a radially outward direction.
 9. A burner unit according to claim 8, **characterized in, that** a separate upper part of said dispensing tube is attached to the auger to provide a rotating dispenser outlet.
 10. A solid particulate fuel feeding and dispensing device according to claim 9, **characterized in, that** a cone-shaped top baffle is mounted above the top edge of the dispenser tube with its pointed end towards the opening in the dispenser tube for creating a circular dispenser outlet between the lower conical surface of the baffle and the upper end of the dispenser tube,
 11. A solid particulate fuel feeding and dispensing device according to claim 8, 9 or 10, **characterized in, that** an air flow pipe is arranged coaxially around at least a part of the screw conveyor sheath and/or a lower part of the dispenser tube for introducing at least a partial airflow at an air outlet arranged in the bowl burner and coaxially around the dispenser tube for creating a vertical protective air flow upwards along the dispenser tube and the dispenser opening.
 12. Radiant heater for indoor use or use as a pellet stove or outdoor use, such as on balconies, terraces, patios or in gardens, comprising a combustion chamber for combustion of solid particulate fuel, said combustion chamber is arranged in the lower part of the radiant heater and a chimney pipe arranged with its first end above the combustion chamber to lead flue gas from the combustion chamber for emission to the atmosphere in a height h above the combustion chamber through a second end of the chimney pipe, wherein the radiant heater further comprises storage means for storing the solid fuel which storage means are arranged next to the combustion

chamber in the lower part of the radiant heater, means for transferring the solid fuel from the storage means to the combustion chamber, and wherein the radiant heater comprises a burner unit and/or a solid particulate fuel feeding and dispensing device according to any of the preceding claims 1- 11.

- 13. Radiant heater according to claim 12, **characterized in**, an ejector arranged at the upper end of the chimney pipe, said ejector being provided to mix ambient air into the flue gas prior to or in connection with the flue gas being emitted to the atmosphere or that the upper end of the chimney pipe is attached to a conventional chimney arranged in a building. 5
- 14. Radiant heater according to claim 12 or 13, **characterized in, that** a suction fan arranged in the chimney, preferably in the upper end thereof, more preferred in connection with the ejector means, for introducing primary and/or secondary combustion air to the combustion chamber by suction through one or more openings in the bottom part of the combustion chamber or alternatively by a fan arranged below the combustion chamber for blowing combustion air into the combustion chamber from below. 10
- 15. Radiant heater according to claim 12, 13 or 14, **characterized in, that** control means are arranged for controlling the feed of solid particulate fuel to the combustion chamber and/or for controlling the speed of the fan. 15
- 16. Radiant heater according to any of the preceding claims 12-15, **characterized in, that** a cyclone for separating particles from the flue gas is arranged at the upper end part of the chimney pipe, preferably upstream to the suction fan, or preferably upstream to the ejector. 20
- 17. Radiant heater according to any of the preceding claims 12-16, **characterized in, that** the exterior surface of the chimney pipe is provided with heat distributing means, such as parallel or helical ribs, fins or rods extending from the outer surface. 25
- 18. Radiant heater according to any of the preceding claims 12-17, **characterized in, that** the chimney pipe comprises one or more rotatable and/or detachable extensions, said rotatable and/or detachable extensions each comprises a chimney pipe part, which is arranged to extend upward in a direction of up to 45 degrees in relation to horizontal position, said detachable and/or rotatable extension is further provided with reflector means for downwards reflection of heat radiation from the chimney pipe. 30
- 19. Radiant heater according to any of the preceding claims 12-18, **characterized in, that** the combustion 35

chamber comprises one or more wall parts and/or one or more doors made of heat resistant glass.

- 20. Radiant heater according to any of the preceding claims 12-19, **characterized in, that** the chimney pipe with the chimney top is detachable. 40
- 21. Radiant heater according to any of the preceding claims 12-19, **characterized in, that** the means for transferring the solid fuel from the storage means to the combustion chamber comprises an inclined screw conveyor for feeding solid particulate fuel from the solid fuel storage means to the burner bowl from above, optionally via a chute or similar dispensing means directing the solid particulate fuel into the burner bowl. 45

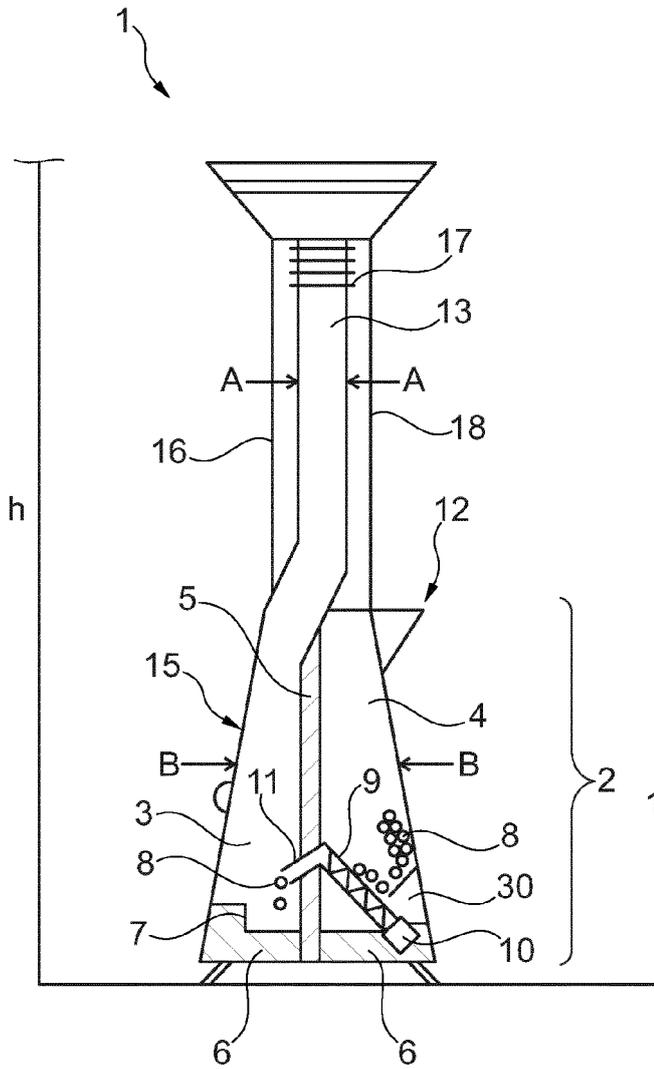


Fig. 1

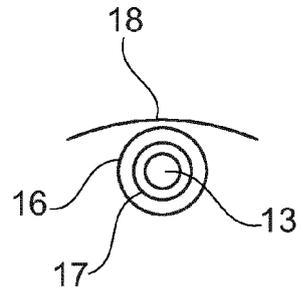


Fig. 2

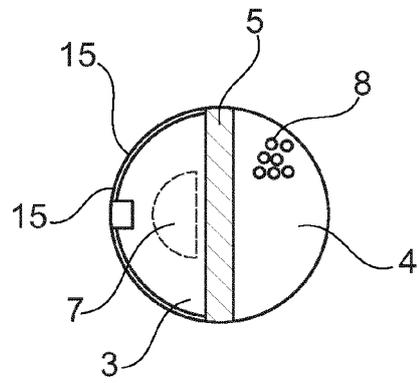


Fig. 3

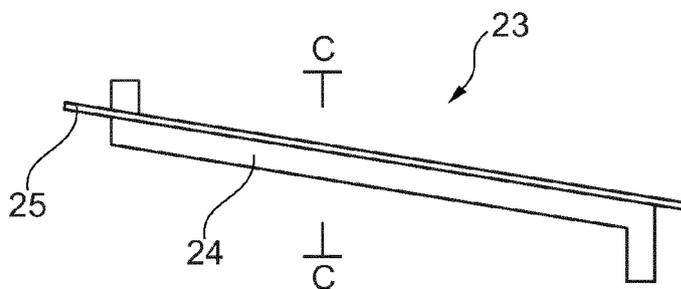


Fig. 4

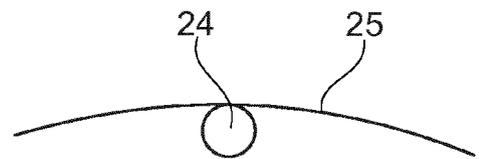


Fig. 5

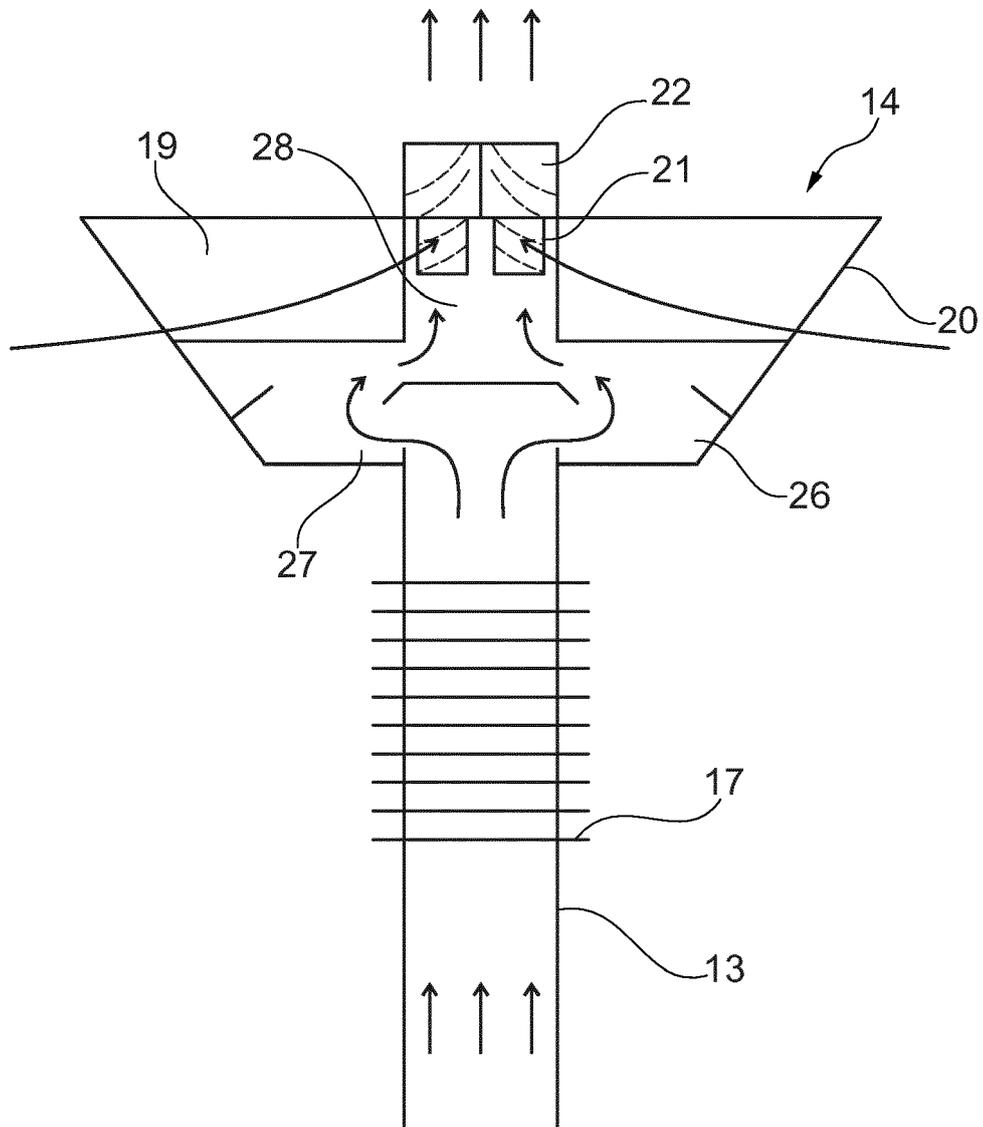


Fig. 6

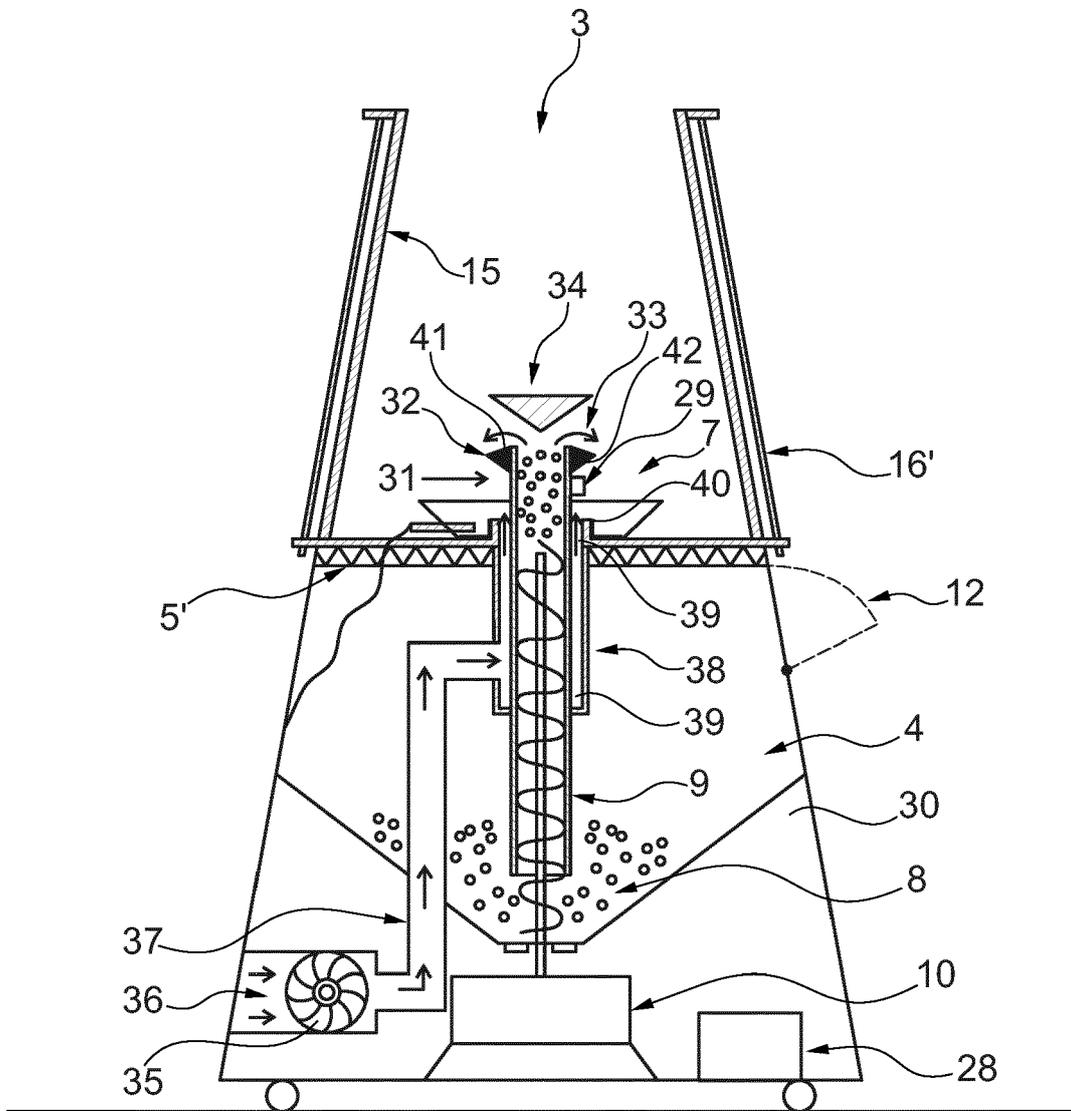


Fig. 7

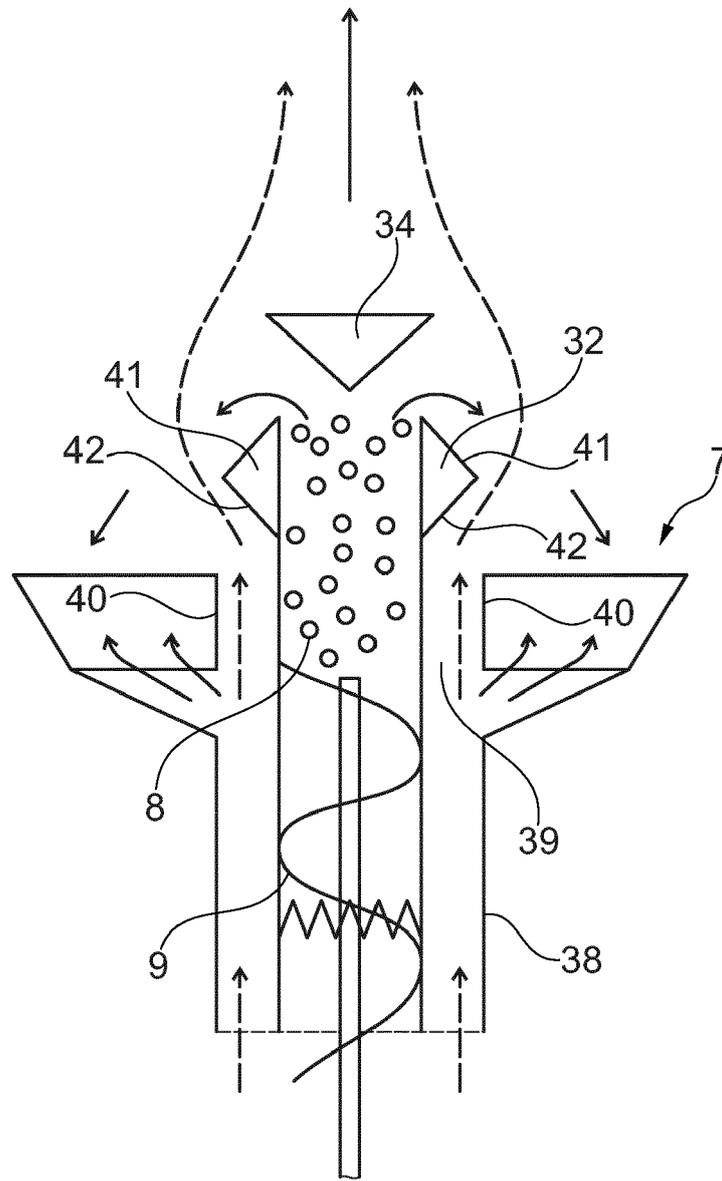


Fig. 8

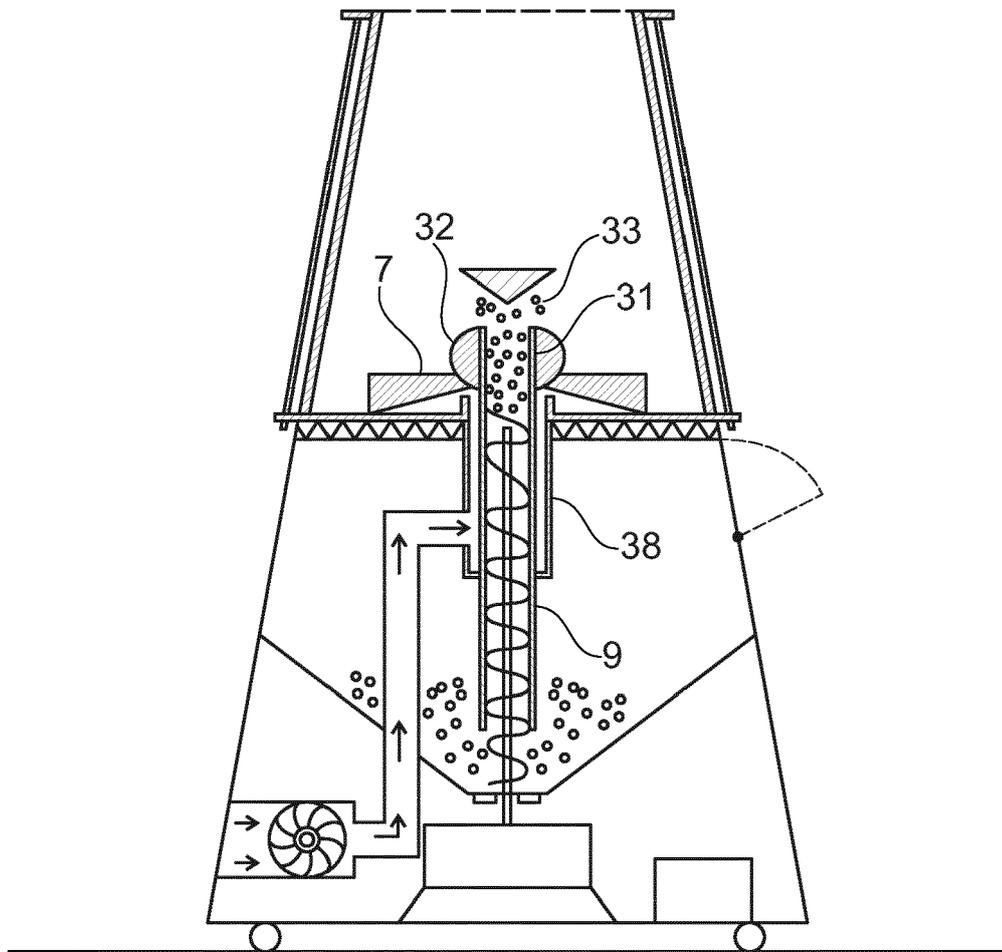


Fig. 9

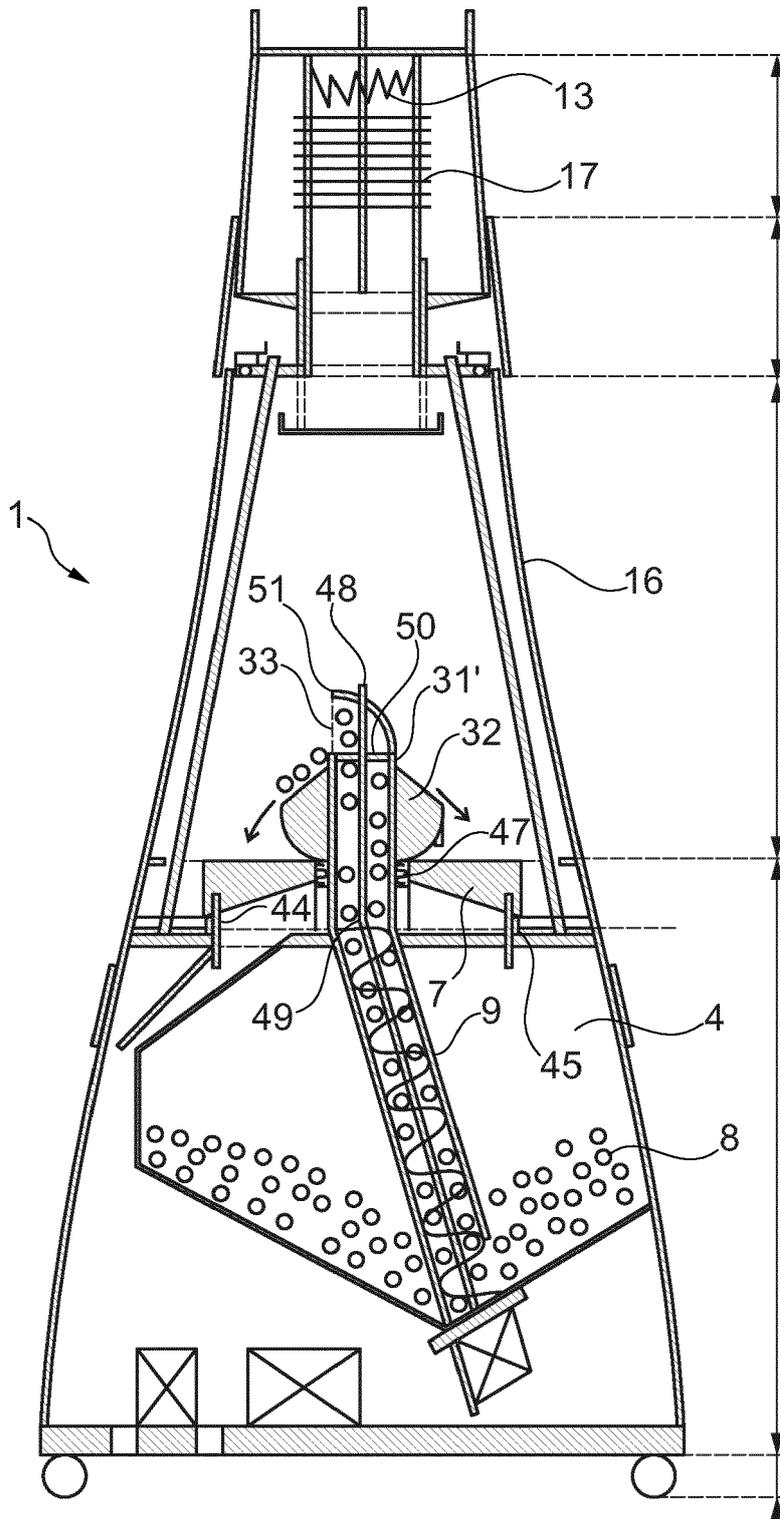


Fig. 10

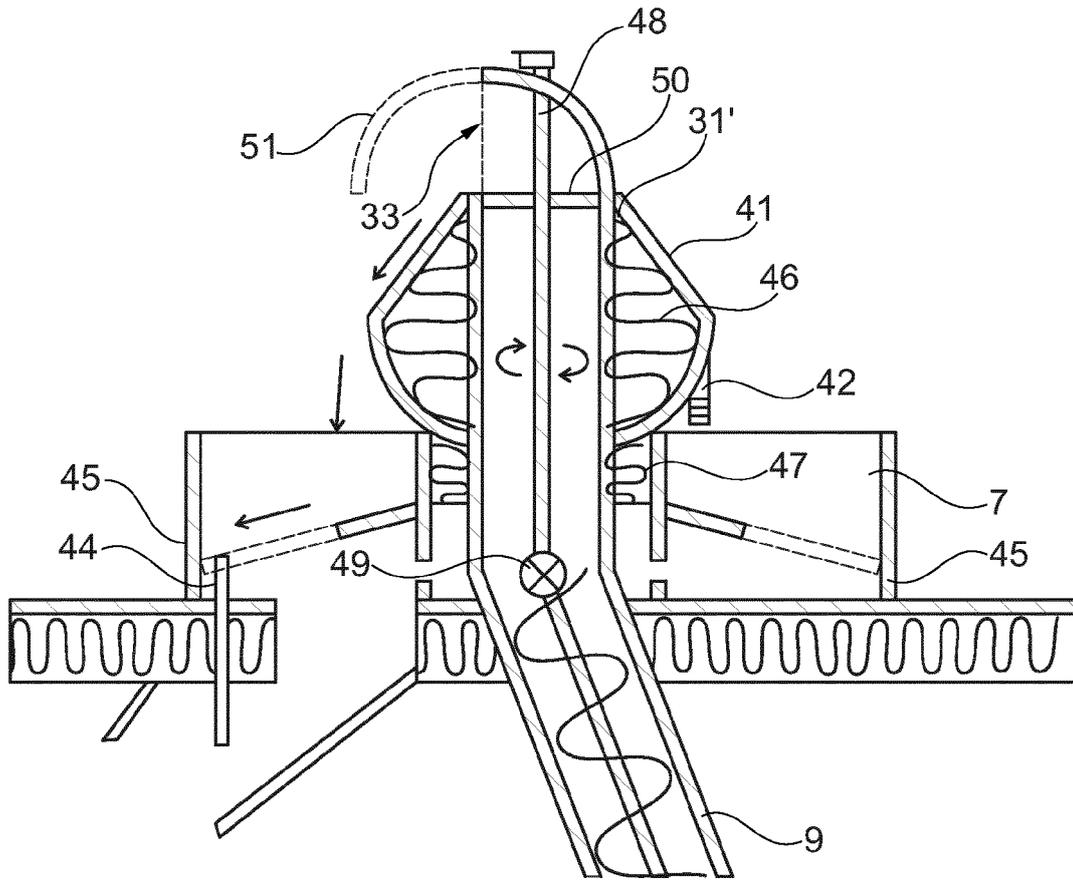


Fig. 11a

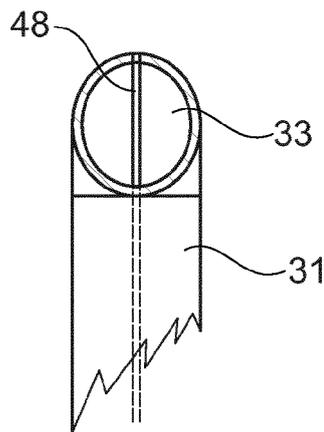


Fig. 11b

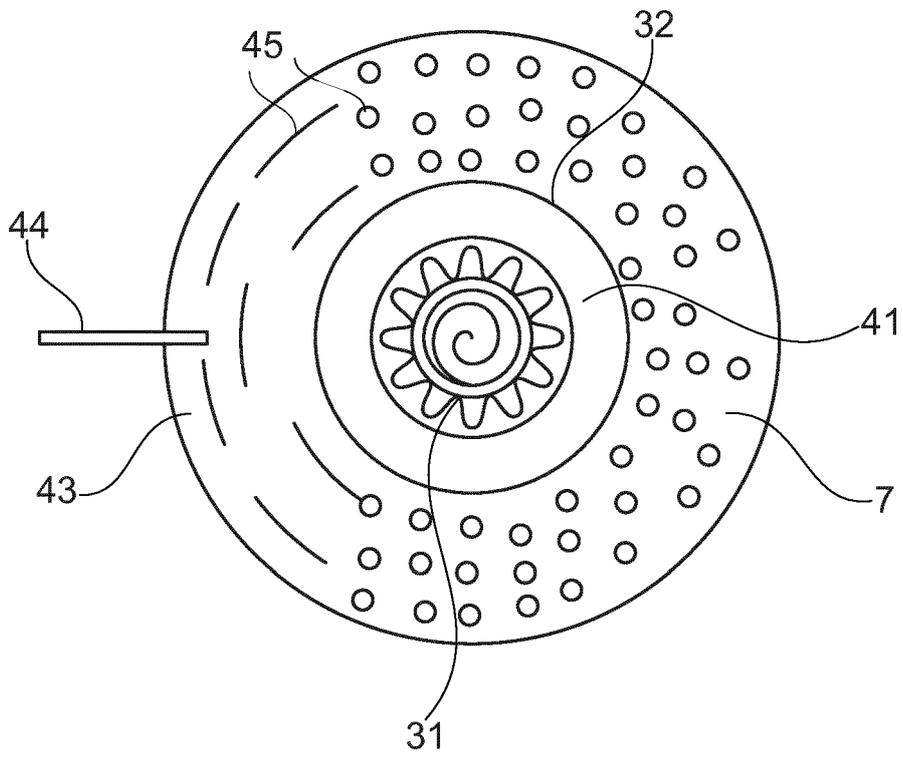


Fig. 12



EUROPEAN SEARCH REPORT

Application Number
EP 16 17 7171

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	BE 362 609 A (UNREADABEL)	1-11	INV. F24B1/08 F23B50/12 F24B1/199 F24B13/04 F24C1/14 F23K3/14
A	31 August 1929 (1929-08-31) * the whole document * -----	12-21	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F24B F23B F24C F23K
Place of search		Date of completion of the search	Examiner
The Hague		15 September 2016	Makúch, Milan
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EP 16 17 7171

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15-09-2016

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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