Oct. 25, 1966 N. LAING 3,280,901

FAN HEATER UNIT

Original Filed Sept. 5, 1962 2 Sheets-Sheet 1

FIG. 1a.

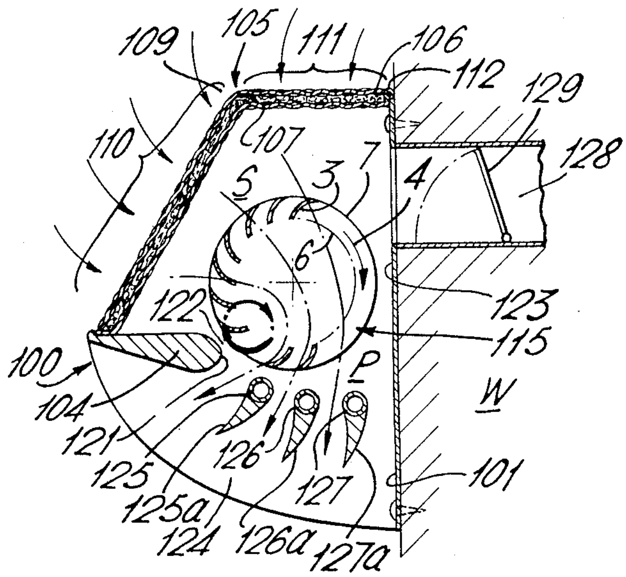

FIG. 1b.

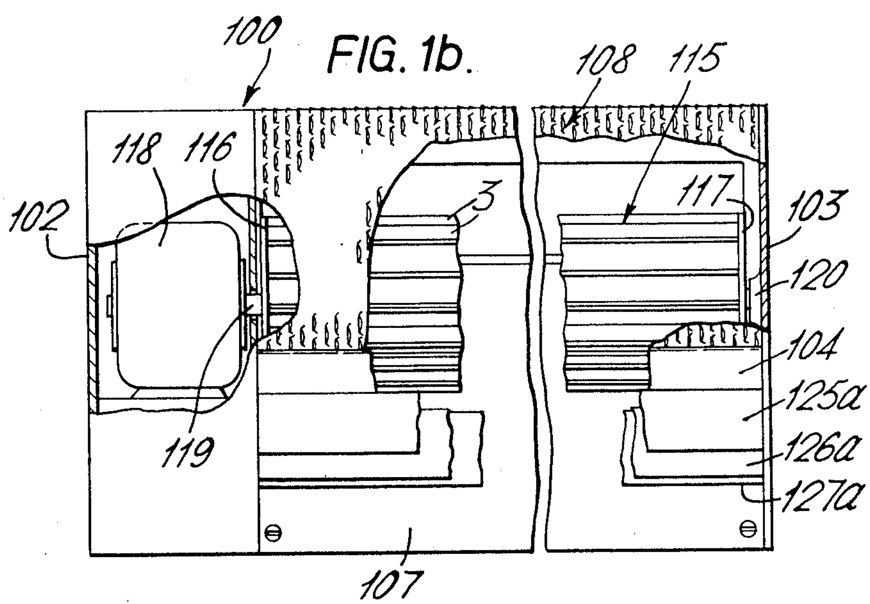

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FIG. 2.

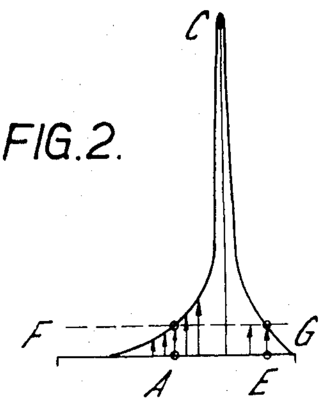


FIG. 3.

FIG. 4.

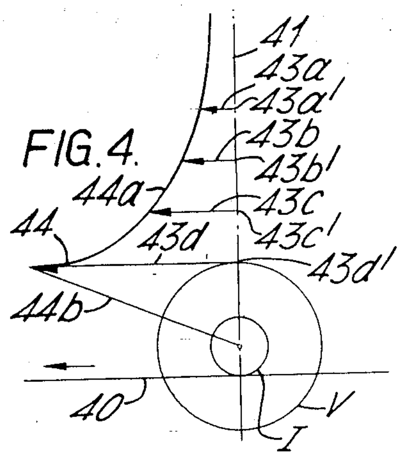


FIG. 5.

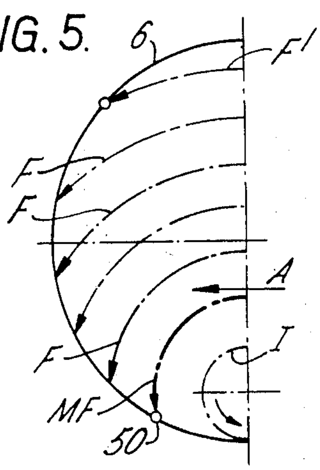
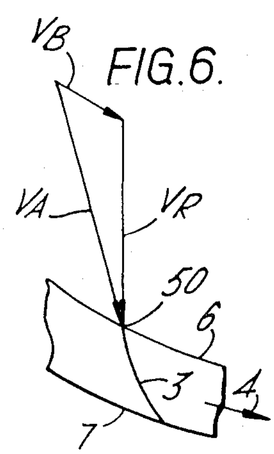


FIG. 6.



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3,280,901
FAN HEATER UNIT

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Original application Sept. 5, 1962, Ser. No. 221,621, now Patent No. 3,232,522, dated Feb. 1, 1966. Divided and this application Aug. 3, 1965, Ser. No. 476,825
Claims priority, application Germany, Dec. 31, 1956, L 26,542
6 Claims. (Cl. 165—122)

This invention relates to fan assisted space heaters, more particularly though not exclusively for the domestic field: this application is a division of application Serial No. 221,621 filed September 5, 1962, now Patent No. 3,232,522 granted February 1, 1966, itself a continuation-in-part of application Serial No. 671,114 filed July 5, 1957, now abandoned.

The invention is more particularly but not exclusively concerned with space heaters for mounting in or on a wall, whether using centrally heated water or steam or other means for producing heat, e.g., electric heater elements. It is a prime requirement for wall mounted space heaters that they should be compact and a main object of the invention is to satisfy this requirement. Further objects of the invention are to provide a wall-mounted space heater which can produce an evenly heated and uniform flow of air, more especially a flat jet directed downwardly away from the wall.

With these objects in view the invention provides a space heater comprising a casing having an inlet and an outlet on the same side of the casing, bladed cylindrical rotor means mounted horizontally within the casing for rotation about its axis and defining an interior space, a motor for rotation of said rotor in a predetermined direction, guide means within the casing defining with the rotor means a suction region communicating with the inlet a pressure region communicating with the outlet, heating means mounted within the casing and extending the length of the rotor means on the pressure side thereof, the guide means and rotor cooperating on rotation of the latter by said motor in said predetermined direction to induce a flow of air through the inlet to the suction region and thence through the path of the rotating blades of the rotor to the interior space and thence again through the path of the rotating blades of the rotor to the pressure region and past the heating means to the outlet. The casing preferably includes a mounting plate for securing to a wall, the inlet and outlet being provided on the same side of the mounting plate and facing outwardly of the wall. The inlet may be above the outlet, with the latter angled for discharge downward and outwardly from the wall: however the space heater according to the invention could readily be designed for horizontal discharge if desired. Inlet and outlet may be aligned one above the other as seen facing the unit, if desired.

The rotor and guide means combination above defined has the important property that flow conditions are more or less uniform at any point along the length of the rotor, since flow takes place substantially in planes transverse to the rotor axis. Because of this, the air flow is substantially uniform, and therefore uniformly heated over the length of the rotor. Possibly more important, the dimensions of rotor and guide means perpendicular to the wall can be quite small: to achieve a required air flow without exceeding given dimensions it suffices to extend the rotor lengthwise as may be expedient and units of different heat capacities can be designed with changes only in the lengthwise dimensions. It will be understood that a comparable arrangement is impossible with an axial or centrifugal unit.

It is preferred to design the rotor and guide means, as will be described in more detail later, so that a vortex of Rankine type is formed within the rotor and having its core eccentric of the rotor axis: such a vortex gives rise to a flow through the rotor which, as seen in planes transverse to the axis thereof, is strongly curved about the vortex core; correct positioning of the guide means, as will be explained later, allows the required turning of flow between inlet and outlet to be achieved in flow through the rotor and substantially without ducting losses. Of course, the invention contemplates that ducting could be included if desired.

The space heater according to the invention can be mounted as desired on the wall of a room, taking up negligible space. It will be appreciated that an equally compact arrangement is impossible with the conventional axial or centrifugal fans. To achieve with such fans an arrangement having inlet and outlet on the same side of a casing would mean that the casing would have to be large to accommodate the changes of flow direction which these fans by their nature require: moreover design and manufacture become distinctly more complicated since axial and centrifugal fans are not susceptible to indefinite lengthwise extension.

One preferred embodiment of the invention will now be described by way of example and reference to the accompanying diagrammatic drawings in which;

FIGURE 1*a* is a transverse section through a wall-mounted space heater which according to the invention provides for inlet and outlet on the same side of a casing;

FIGURE 1*b* is a frontal elevation of the FIGURE 1*a* space heater with parts cut away;

FIGURE 2 is a graph illustrating air velocity at the outlet of a blower such as that incorporated in the heater of FIGURE 1;

FIGURE 3 is a graph illustrating air velocity at the outlet of a conventional blower;

FIGURE 4 is a graph illustrating the velocity of air flow within the field and core of a Rankine vortex;

FIGURE 5 illustrates the ideal flow occurring in one half the cross-sectional area of a rotor such as shown in FIGURE 1; and

FIGURE 6 is a vector diagram illustrating the flow of air over a blade of the FIGURE 1 rotor from the interior of the rotor to the exit side thereof.

Referring first to FIGURES 1*a* and 1*b*, the space heater there shown comprises a casing designated generally **100** and having a vertical mounting plate **101** whereby it is secured on a wall indicated at W so as in this embodiment to project therefrom into the room. The casing has end walls **102**, **103** and a member **104** extends between them at the front of the casing. A major part of the casing **100** is provided by an inlet assembly **105** comprising a pair of interconnected perforated supporting elements **106**, **107** sandwiching a filter **108**, the whole providing a large-area inlet designated generally **109** made up of a major frontal area **110** and a minor top area **111**. The inlet assembly **105** is hinged along one long edge at **112** to the mounting plate **101** so as to be pivotable upward from the operative position shown, where the other long edge of the assembly rests on the member **104**, for access to the interior of the casing **100**.

Within the casing **100** a cylindrical rotor **115** is mounted for rotation about a horizontal axis parallel to the mounting plate **101**, the rotor having a series of similar forwardly curved blades **3** mounted between supporting end discs **116**, **117** and disposed in a ring about the rotor axis so that their inner and outer edges lie on coaxial cylindrical envelopes **6**, **7**. A driving motor **118** is provided within the casing **100** adjacent one end wall **102** thereof to drive the rotor **115** in the direction of the arrow **4**. In the embodiment illustrated the rotor end disc

116 is mounted on the motor shaft 119, and the other end disc 117 is journalled at 120 on the end wall 103.

The member 104 presents to the rotor 115 a rounded surface 121 which is well spaced from the rotor at its line 122 of nearest approach thereto. Approximately opposite the member 104, the mounting plate 101 has its line 123 of nearest approach to the rotor 115 also well spaced from the rotor. Because of this spacing, which may be half the radial blade depth, close manufacturing tolerances are not required and the apparatus lends itself to commercial manufacture. The member 104 and mounting plate 101 define with the rotor 115 a suction region 5 between the inlet 109 and a pressure region P between the rotor and the outlet 124 which may be here regarded as defined by the end walls 102, 103 and the extremities of the member 104 and mounting plate remote from the rotor within the pressure region P, three steam pipes 125, 126, 127 run parallel to the rotor axis and carry fairings 125*a*, 126*a*, 127*a*. The steam pipes are connected to a central steam source by conventional means not shown.

A subsidiary inlet 128 provided with a flap 129 for controlling air flow therein leads from the outside through the wall into the suction region.

The member 104 and the interior surface of the mounting plate 101 provide guide means cooperating with the rotor 115 on rotation thereof to induce a flow of fluid through the inlet 109 into the suction region S, through the path of the rotating blades 3 to the interior of the rotor and thence again through the path of the rotating blades to the pressure region and thence to the outlet 124 past the steam pipes 125, 126, 127.

The rotor 115 and guide means 104, 101 are designed as will be explained whereby in operation to set up a vortex of Rankine type having a core indicated schematically at V and positioned eccentrically with respect to the rotor axis and interpenetrating the path of the rotating blades 3 of the rotor adjacent the member 104. The whole throughput of the machine flows twice through the blade envelope in a direction perpendicular to the rotor axis and as indicated by the flow lines F, MF.

FIGURE 4 illustrates an ideal relation of the vortex to the rotor 2 and the distribution of flow velocity in the vortex and in the field of the vortex. The line 40 represents a part of the inner envelope 6 of the rotor blades 3 projected onto a straight line while the line 41 represents a radius of the rotor taken through the axis of the vortex core V. Velocity of fluid at points on the line 41 by reason of the vortex is indicated by the horizontal lines 43*a*, 43*b*, 43*c* and 43*d*, the length of these lines being the measure of the velocity at the points $43a^1$, $43b^1$, $43c^1$ and $43d^1$. The envelope of these lines is shown by the curve 44 which has two portions, portion 44*a* being approximately a rectangular hyperbola and the other portion, 44*b*, being a straight line. Line 44*a* relates to the field region of the vortex and the curve 44*b* to the core. It will be understood that the curve shown in FIGURE 4 represents the velocity of fluid where an ideal or "mathematical" vortex is formed, and that in actual practice, flow conditions will only approximate these curves.

The core of the vortex is a whirling mass of fluid with no translational movement as a whole and the velocity diminishes from the periphery of the core to the axis 42. The core of the vortex intersects the blade envelope as indicated at 40 and an isotach I within the vortex having the same velocity as the inner envelope contacts the envelope. The vortex core V is a region of low pressure and the location of the core in a machine constructed according to the invention can be determined by measurement of the pressure distribution within the rotor.

The velocity profile of the fluid where it leaves the rotor and passes through the path of the rotating blades will be that of the vortex. In the ideal case of FIGURE 4, this profile will be that of the Rankine vortex there shown by curves 43*a* and 43*b*, and in actual practice, the profile will still be substantially that shown in FIGURE 4 so that there will be in the region of the periphery of the core V shown in FIGURE 1 a flow tube MF of high velocity and the velocity profile taken at the exit of the rotor will be similar to that shown in FIGURE 2 where the line FG represents the exit of the rotor and the ordinates represent velocity. The curve shown exhibits a pronounced maximum point C which is much higher than the average velocity represented by the dotted line.

It will be appreciated that much the greater amount of fluid flows in the flow tubes in the region of maximum velocity. It has been found that approximately 80% of the flow is concentrated in the portion of the output represented by the line AE which is less than 30% of the total exit of the rotor. A conventional velocity profile for fluid flow in a defined passage is illustrated by way of contrast in FIGURE 3 where the average velocity of flow is represented by the dotted line. Those skilled in the art regard this profile as being approximately a rectangular profile which following the principle generally adhered to is the sort of profile heretofore sought in the outlet of a flow machine.

The maximum velocity C shown in FIGURE 2 appertains to the maximum velocity flow tube indicated as MF in FIGURE 1. With a given construction the physical location of the flow tube MF may be closely defined. The relative velocity between the blades and fluid in the restricted zone of the rotor blades 3 through which the flow tube MF passes is much higher than it would be if a flow machine were designed following the conditions adhered to heretofore in the art respecting the desirability of a rectangular velocity profile at the exit arc and even loading of the blades.

Under low Reynolds number conditions, this unevenness of the velocity profile leads to beneficial results in that there will be less separation and energy loss in the restricted zone through which the flow tube MF passes than if that flow tube had the average velocity of throughput taken over the whole exit of the rotor. There is a more efficient transfer of momentum to the fluid by the blades in this restricted zone and while the transfer of momentum in the flow tubes travelling below the average velocity will be less efficient, nevertheless when all of the flow tubes are considered, there is a substantial gain in efficiency.

FIGURE 5 illustrates the ideal distribution of flow tubes F occurring within one half the rotor area defined by the inner envelope 6, it being understood that the flow tubes in the other half of the rotor are similar. The maximum velocity flow tube MF is shown intersecting the envelope 6 at point 50 and the isotach I as being circular when the whole rotor is considered. It is seen that ideally the maximum velocity flow tube MF undergoes a change of direction of substantially 180° from the suction to the pressure sides when the flow in the whole rotor is considered. It is also to be noted that the major part of throughput, represented by the flow tube MF, passes through the rotor blades where they have a component of velocity in a direction opposite to the main direction of flow within the rotor indicated by the arrow A.

FIGURE 6 is a diagram showing the relative velocities of flow with respect to a blade at the point 50 referred to in FIGURE 5. In this figure V_B represents the velocity of the inner edge of the blade 3 at the point 50, V_A the absolute velocity of the air in the flow tube MF at the point 50, and V_R the velocity of that air relative to the blade as determined by completing the triangle. The direction of the vector V_R coincides with that of the blade at its inner edge so that fluid flows by the blade substantially without shock.

The character of a vortex is considered as being determined largely by the blade angles and curvatures. The position of the vortex, on the other hand, is considered as being largely determined by the configuration of the vortex forming means which forms and stabilizes a vortex in co-operation with the bladed rotor. The particular angles and curvatures in any given case depend upon the following parameters: the diameter of the rotor, the depth of a blade in a radial direction, the density and viscosity of the fluid, the disposition of the vortex forming means and the rotational speed of the rotor, as well as the ratio between over-all pressure and back pressure. These parameters must be adapted to correspond to the operating conditions in a given situation. Whether or not the angle and shape of the blades have been fixed at optimum values is to be judged by the criterion that the flow tubes close to the vortex core are to be deflected substantially greater than 90°.

It is to be appreciated that the flow lines of FIGURE 1 do not correspond exactly to the position of the vortex core V as illustrated in FIGURES 4 and 5 which represent the theoretical or mathematical flow. These latter figures show that it is desirable to have the axis of the core of the vortex within the inner blade envelope 6 so that the isotach within the core osculates that envelope. Although this position is achieved in certain constructions hereinafter described, it is not essential, and in fact, is not achieved in the structure shown in FIGURE 1.

It is to be further appreciated that despite the divergence of the flow in FIGURE 1 from the ideal, the maximum velocity flow tube MF with which is associated the major part of the throughput is nevertheless turned through an angle of substantially 180° in passing from the suction to the pressure side of the rotor and that this maximum flow tube passes through the rotor blades where the blades have a velocity with a component opposite to the main direction of flow through the rotor as indicated by the arrow A.

It will be seen that the construction illustrated has a dimension perpendicular to the wall that is small, as is most desirable for a space heater to be secured on or built into a wall of a room. The air throughput requirement does not directly determine or affect this dimension, since extra throughput can be achieved simply by lengthening the rotor without changing its diameter. As explained, the air flows in planes perpendicular to the rotor axis and, by reason of the vortex, in paths curved about the member 14. Thus, the air tends to enter at the front and leave at the front without requiring any ducting or other guidance other than provided by the rotor and guide means themselves, which simplifies the construction, saves space and avoids the energy loss which is inseparable from changes of flow direction by ducts and the like. Of course, ducting could be provided if required. A uniform flat jet of warm air is directed forwardly and downwardly from the rotor; other discharge directions could readily be achieved: this forward and downward jet will often be preferred since it provides optimum room heating since it counteracts the effect of natural convection which is to bring the heated air adjacent the ceiling. The main flow through the space heater will be of air already in the room: however a regulable proportion of air from outside can be brought in.

I claim:

1. A space heater comprising a casing having an inlet and an outlet on the same side of the casing, bladed cylindrical rotor means mounted horizontally within the casing for rotation about its axis and defining an interior space, a motor for rotation of said rotor in a predetermined direction, guide means within the casing defining with the rotor means a suction region communicating with the inlet and a pressure region communicating with the outlet, heating means mounted within the casing and extending the length of the rotor means on the pressure side thereof, the guide means and rotor cooperating on rotation of the latter by said motor in said predetermined direction to induce a flow of air through the inlet to the suction region and thence through the path of the rotating blades of the rotor to the interior space and thence again through the path of the rotating blades of the rotor to the pressure region and past the heating means to the outlet.

2. A space heater comprising a casing having a mounting plate for secural to a wall and defining an inlet and an outlet on the same side of the mounting plate to face outwardly of the wall, bladed cylindrical rotor means mounted horizontally within the casing for rotation about its axis and defining an interior space, a motor for rotation of said rotor in a predetermined direction, guide means within the casing defining with the rotor means a suction region communicating with the inlet and a pressure region communicating with the outlet, heating means mounted within the casing and extending the length of the rotor means on the pressure side thereof, the guide means and rotor cooperating on rotation of the latter by said motor in said predetermined direction to induce a flow of air through the inlet to the suction region and thence through the path of the rotating blades of the rotor to the interior space and thence again through the path of the rotating blades of the rotor to the pressure region past the heating means to the outlet.

3. A space heater as claimed in claim 2, having a second inlet on the wall side of the mounting plate to lead fresh air into the casing, and a controllable throttle in said second inlet.

4. A space heater as claimed in claim 2, wherein said heating means comprise at least one pipe for circulation of hot fluid therethrough and extending the length of the rotor parallel thereto.

5. A space heater as claimed in claim 2, wherein said heating means comprise at least a pair of pipes for circulation of hot fluid therethrough and extending the length of the rotor parallel thereto, the pipes carrying fairings defining a plurality of diffusing ducts in said outlet.

6. A space heater as claimed in claim 2, wherein the inlet extends over the major part of the area of said casing facing away from the mounting plate and the outlet is beneath it for discharge of air downwardly and away from the mounting plate.

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