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FAN ENCLOSURE

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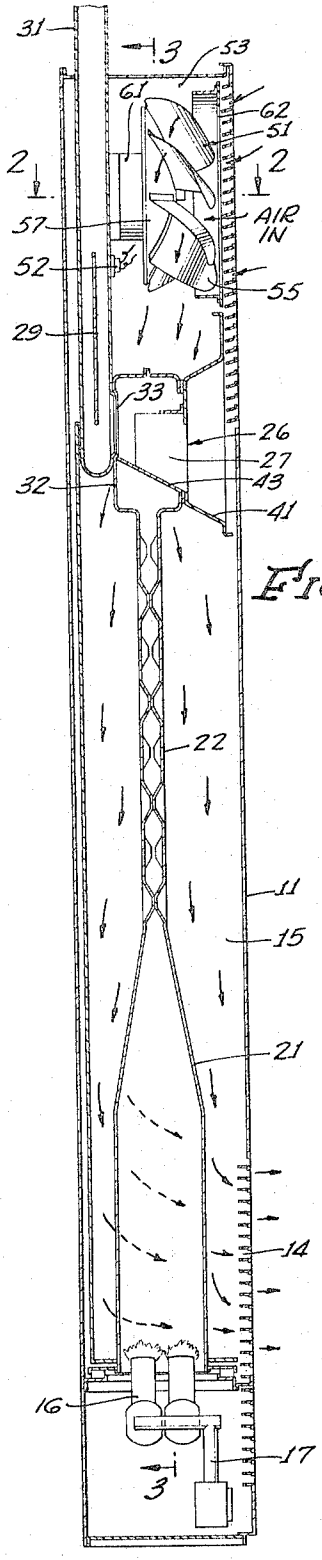


FIG. 1.

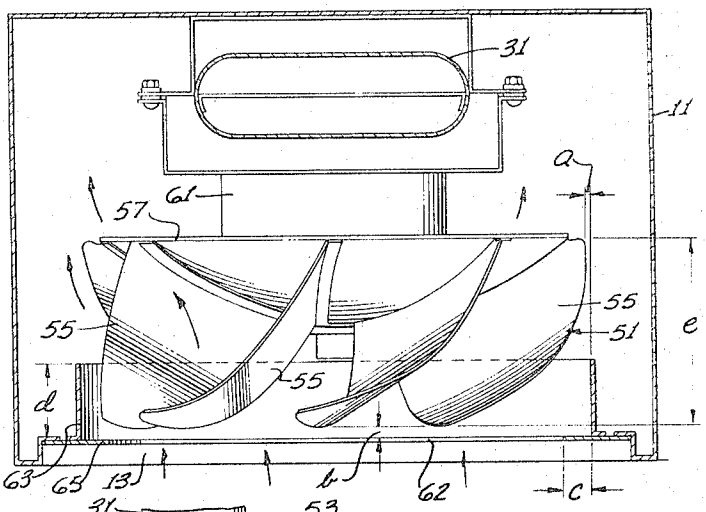


FIG. 2.

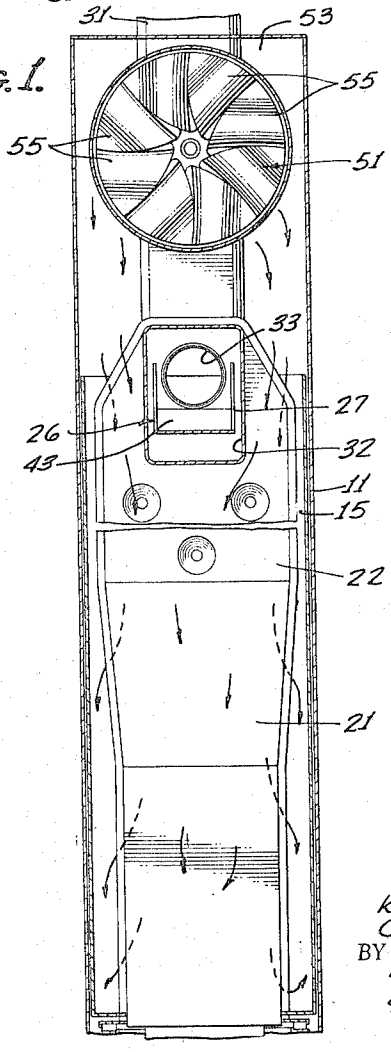


FIG. 3.

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FAN ENCLOSURE

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This invention relates to forced air heating and ventilating systems, and, more particularly, to low noise enclosing means for fans used in conjunction with such systems.

In most comfort heating systems, air is employed to transfer heat from a high temperature sink to the area being serviced by the system or, in the case of a cooling system, to absorb heat in the serviced area which is thereafter removed by a low temperature sink. These forced air systems normally utilize one or more fans to circulate the heated or cooled air between the controlled space and their sinks.

While fans and blowers do not present any particular problem in many applications, in comfort air conditioning systems particular attention must be given to noise levels. The wide variations in load that such systems encounter do not help. They require designs that will meet all demands, including peak demands—a situation which is not conducive to efficient operation. Moreover, changes in loads and operating efficiencies degrade the noise level performance of even the most carefully engineered systems.

While the ducts used in forced air systems create their own special noise problems and there are a number of non-aerodynamic sources of fan noise as well, given the existing noise level of a heating or cooling system, it is important that the system have a relatively fixed operating point or that means be provided to minimize increases in the noise level resulting from adjustments to compensate for changing parameters. The system resistance and the density of the carrier air are the parameters most frequently changing, and variations in the operating characteristics of the fan are the easiest way to introduce the compensation needed.

A carefully designed fan can hold down the quantum of aerodynamic noise generated by blade rotation and vortex phenomenon to some extent, yet it cannot provide the entire solution. The multi-bladed fan exemplarily disclosed herein is a well designed fan patterned after the fan disclosed in Patent No. 3,131,236 issued April 28, 1964 to Beehler et al. It uses forwardly curved, air foil shaped blades and hemispherical back plate to improve air distribution across the blade face and to eliminate minimum flow sections that generate eddies and other turbulent pockets. However, this design does not reduce the overall noise level as much as is desired for living and working spaces when load variations are encountered. Other means are needed to avoid sound levels that are annoying to occupants of the conditioned spaces.

Therefore, the principal object of the present invention is to provide improved means in forced air systems to minimize objectionable fan noise.

Another object of the present invention is to provide a quiet fan system for wall heaters and the like that is also simple to fabricate and economical to operate.

In many installations, centrifugal fan noise can be kept low by paying careful attention to the shape of the casing and scroll and the cutoff point for the fan, but in installations for wall heaters and the like, the fan is normally arranged to "dump" air into the heater enclosure or casing—converting the centrifugal fan into a sort of right-angle axial flow fan. Such conversion is exemplarily disclosed in Patent No. 3,131,236 issued April 28, 1964

to Richard F. Beehler et al., referred to hereinbefore. As pointed out in that patent, such fans are neither pure axial flow nor pure centrifugal flow fans. Instead, they are a sort of mixed flow or hybrid axial-centrifugal fan in which the air enters the blades from the front in substantially the direction of the fan axis and leaves the blades at their periphery in a direction generally along the surface of the hemispherical back-plate. Not only is the throttling of the air into the wall heater enclosure inefficient, but it aggravates the noise problem—even when the system encounters a constant resistance and moves standard air. When variations in load and air density must also be taken into account, matters become even worse.

The present invention provides an improved fan enclosure which reduces the throttling of the air at the inlet port and is also relatively unaffected by high system resistances or changes therein. It accomplishes this by controlling the magnitude of the inset of the fan in the wall heater enclosure, the degree of inlet port overlap of the fan blades and the ratio of the areas of the outlet and inlet ports for the fan.

Broadly speaking, the present invention provides an enclosure for a hybrid or mixed flow fan including a member having an inlet port formed in it, a multibladed fan having a diameter larger than that of the inlet port mounted for rotation behind the inlet port, and a cowl of a preselected depth attached to the fan side of the member and encircling the forward part of the fan to define the peripheral outlet area for the fan.

In a more restricted sense, the present invention is a low noise enclosure for a hybrid or mixed flow fan utilizing a plurality of forwardly curved blades affixed to a hemispherical backplate combining an enclosure having an inlet port formed in its front surface; a multibladed fan having a diameter larger than the diameter of the inlet port inset in the enclosure behind the port for rotation about its axis, with the difference in the diameters being approximately equivalent to the degree of inset of the fan; and a cowl attached to the front surface around the periphery of the fan blades to provide a channel for the passage of air between the axial fan input and the peripheral fan output.

These and other objects, features and advantages of the present fan enclosure for maintaining a low noise level will be more fully understood when the following detailed description is read with reference to the drawing, in which:

FIG. 1 is side section view of an exemplary gas burning wall heater utilizing the fan enclosure constituting the present invention;

FIG. 2 is a top section view taken along line 2—2 of FIG. 1; and,

FIG. 3 is a front section view of the exemplary wall heater using the improved fan enclosure means.

The improved enclosure for hybrid fans forming the present invention is illustrated in connection with an exemplary wall heater as shown in FIGS. 1–3. Looking to these figures, the exemplary wall heater **10** can be seen to include a rectangularly-shaped elongated outer shell or enclosure **11** having upper and lower grills **13** and **14** in its front wall or surface member **15** and a plurality of gas burners **16** attached to a cross plate in its lower end. The burners **16** are supplied gas from a source (not shown) and can be lighted and adjusted by automatic means **17**. The burners and ignition system can be any kind conventionally used in gas heaters.

The burners **16** have a primary heat exchanger hood **21** disposed thereover. The primary hood **21** is reduced in cross-section at its upper end to connect to the secondary heat exchanger hood **22**, which in turn is of a flat rectangular shape and is connected to the bottom of the

generally rectangularly-shaped diverter chamber 26. The diverter chamber 26 surrounds diverter box 27.

The flue 31 of the wall heater 10, which includes a splitter plate 29, is offset horizontally from the upper hood 22 and is attached to the rear wall of the diverter chamber 26 but it is in open communication with the diverter chamber 26, and the heat exchanger hoods 22 and 21.

The rear wall 32 of the diverter chamber 26 defines a circular aperture 33 between the flue 31 and the chamber 26 and the bottom of a splitter plate 29 is adjacent thereto. The diverter chamber 26 has an outer trapezoidal-shaped hood or open box 41 affixed to its forward edge. The diverter box 27 is roughly square in cross section and includes a lower baffle plate 43 which extends across diverter chamber 26.

In operation, the combustion gases from the primary heat exchanger hood of the exemplary wall heater 10 move through the secondary heat exchanger hood 22 and into the lower part of the chamber 26. Under normal operating conditions, the combustion gases are diverted by the baffle plates of the diverter box 27, including baffle plate 43, and flow around it and into the flue 31. The particular way in which the combustion gases and the diverter chamber operate is described in more detail in our co-pending application for an Improvement in Gas Burning Wall Heater, Ser. No. 368,062, filed on May 18, 1964.

In the exemplary embodiment of the present invention, a circulating fan 51 is provided adjacent the incoming air vent 13 to pull air into the heater, heat it by the heat exchanger hoods 21 and 22 and flow it out of exhaust grill 14. In many cases, this fan 51 is operated by a thermally sensitive switch, such as 52 when the temperature of the flue wall reaches a certain value.

Looking more particularly to the invention claimed herein, attention must be directed to fan 51 and its enclosure indicated generally as 53. The fan 51 is of a hybrid axial-centrifugal type employing eight forwardly curved blades 55 equally spaced about and attached to a hemispherical back-plate or disc 57. Technically, the fan is identified as a clockwise down blast type because the fan is rotated clockwise when viewed from the driving side of the fan and it discharges air primarily downwardly interior of the enclosure 11. As shown by the arrows in the drawings, the air enters the blades from the front generally in the direction of the rotary axis and leaves the blades at the periphery in a direction generally along the surface of the hemispherical back-plate. These types of fans are high capacity since they handle a maximum volume of air without materially sacrificing speed, efficiency or pressure. In most applications of forwardly curved centrifugal fans, of course, there is provided a casing immediately about the fan to permit a gradual buildup of static pressure and a relatively narrow direction of discharge.

Looking to the form of the blades 55, they can be seen to be air foil shaped to equalize the pressure gradient between the blades. Since the blades 55 are approximately parallel to each other from the tips to base, there are fewer vortices or eddies formed intermediate the blades. This reduces fan noise.

The fan 51 is rotatably supported by the shaft of the motor 61 which is attached, by way of example, to the forward part of the flue 31 for rotation in response to a source of power (not shown). In its supported position, the fan 51 can be seen inset behind the air inlet grill 13 a preselected distance designated *b* (see FIG. 2). It is desirable to inset centrifugal fans to some extent from an inlet surface 62 to avoid uneven distribution of air along the length of the blades 55 in all events but here it serves another important function as well.

A circular cowl or ring 63 is affixed to the inner surface of the front wall 11 of the wall heater 10, adjacent the edges defining the circular air inlet port 13. The cowl 63 extends rearwardly covering the forward axial part of the fan 51. The rearwardly extending distance of the cowl 63 is designated *d*. The spacing between the outer tips of the fan blades 55 and the inner surface of the cowl 63 is designated *a*, and the depth of the fan blades 55 is designated *e*. It will also be observed that the surfaces defining the port 13 terminate radially inwardly from the position of the cowl 63 a distance designated *c*, or what is the same thing, the radius of fan 51 exceeds the radius of the inlet port 13 by the value of $c-a$.

It has been found that a careful proportioning of the various distances and dimensions provides a significantly superior fan enclosure from the standpoint of the level of noise. The minimum separation *a* between the tips of the fan blades 55 and the inner surface of the cowl 63 is dictated by the disk diameter, the rated speed of the fan and the noise level that is acceptable for the space in which the fan enclosure and heater are to be used. This distance *a* must be small to contain the air flow in the air channels and yet minimize slippage between the input and output areas. If *a* is made too small, it will cause the input air to be modulated by the fan blades. This results in high frequency noise or whistling—something which is also disturbing and annoying to occupants of conditioned spaces.

With the separation *a* fixed, it has been found that maximum performance can be obtained from the present arrangement if the inset distance *b* for the fan 51 is made approximately equal to the distance of overlap provided by the edges 65 defining the inlet port 13. Thus, the distance $c-a$ should be approximately equal to *b*. These dimensions prevent recirculation or spilling of the air off the blade tips. The result is a reduced noise level even under varying load conditions. If any degree of recirculation around the blade tips occurs, the noise level is substantially increased. As near as can be understood, the overlap provided by *c* and the inset distance *b*, provide a channel between the inlet and outlet areas for the fan which acts to minimize the generation of noise by preventing air from spilling into the inlet opening 13 after being recirculated about the tips of the blades. This is helped with the inset of the fan blades approximately twice the radial spacing between the cowl and the blade tips, i.e. *b* is approximately equal to twice *a*.

Not only is the noise level of the present forced air system kept low by properly shaping the channel area to prevent recirculation and slippage but by proportioning the width of the cowl to control the ratio of the outlet to inlet areas, throttling of air is kept to a minimum. Thus, the noise normally generated by the turbulence created when air is throttled through a restricted opening is avoided.

In the exemplary embodiment, it has been found that if the width or depth of the ring *d* is maintained at approximately 40 to 50 percent of the depth of the fan *e*, the generation of noise will be minimized. This means, in effect, that the ratio of the outlet area to the inlet area for the fan should vary between approximately 0.9 and 1.1, the outlet area being defined by the hemispherical back-plate 57 and the edge of the cowl 63. Therefore, the throttling or expansion from inlet to outlet for the fan enclosure does not vary over approximately $\pm 10\%$. The enclosure provided by such an arrangement is relatively insensitive to changes in system resistance or air density and it operates quite efficiently over a wide range of conditions. The importance of this desensitivity can be appreciated by remembering that the overall sound power level varies as $50 \log_{10} (\text{r.p.m.}_2/\text{r.p.m.}_1)$ or $10 \log_{10} (\text{capac.}_2/\text{capac.}_1) + 20 \log_{10} (\text{pressure}_2/\text{pressure}_1)$.

If the depth of the cowl 63 is increased much beyond the 40 to 50 percent of the blade depth *e*, it seriously affects the capacity of the forced air system by reducing the effective air outlet area. On the other hand, if the depth of the cowl 63 is reduced too much, it reduces the static

pressure against which the fan or wheel operates at a given volume or rated r.p.m.

While the present invention has been described with respect to an exemplary wall heater using a fan having air foil shaped, forwardly curved blades, it should be apparent to those skilled in the art that variations are possible without departing from the spirit and scope of this invention. This being the case, the invention should be limited only to the extent of the claims.

What is claimed is:

1. In combination with a multibladed fan having an axial input to the blades and a peripheral output from the blades, a low noise enclosure comprising:

(a) a wall heater enclosure having a circular inlet port formed in its front surface;

(b) means rotatably mounting said fan interior of said enclosure facing said inlet port with the frontmost edges of the fan blades lying in a plane parallel to said front surface and a preselected linear distance therebehind;

(c) the tips of said blades radially spaced apart from the edges of the circular inlet port a preselected distance approximately equal to said preselected linear distance; and,

(d) a circular cowl disposed around the outside of said fan and affixed to the interior of said enclosure at a radially spaced apart distance from the tips of said fan blades approximately equal to one-half of either of said preselected distances;

(e) said cowl extending rearwardly alongside the tips of said fan blades for approximately 40–50% of the depth of said fan to optimize the inlet and outlet areas for said fan.

2. In combination with a hybrid fan employing forwardly curved blades affixed to a hemispherical backplate, a low noise enclosure comprising:

(a) a front surface having an inlet port spaced forwardly from the fan blades a preselected distance;

(b) the radius of said inlet port being less than the radius to the outer tips of the fan blades by an amount approximately the same as said preselected distance; and,

(c) a cowl disposed around the periphery of said fan and attached to said front surface to provide a channel for the passage of air between the axial input to said fan blades and the peripheral output therefrom, the depth of said cowl being selected to maintain the ratio of the fan outlet area to inlet area between approximately 0.9 and 1.1.

3. In combination, a mixed flow centrifugal fan and enclosure thereabout, said fan having forwardly curved blades supported on a hemispherical back-plate, said blades extending axially on said hemispherical back-plate and having free outer tips, said enclosure including a front plate having a substantially flat surface normal to said fan and radially overlapping the outer tips of said blade, said surface being spaced axially forward of said blades a preselected distance and terminating in an inner edge defining an inlet to said fan of lesser radius than the radius to said fan outer tips by an amount substantially equal to said preselected distance, an annular ring secured to said plate, said annular ring being disposed about the outer tips of said blades and spaced radially outward thereof, said annular ring having axial depth extending rearward from the front plate a substantial distance over said blades and terminating in a free annular edge intermediate the depth of the fan blades, said preselected distance and said axial depth of said annular ring cooperating with said mixed flow fan whereby the noise of the fluid flowing through said enclosure is materially reduced.

4. The combination of a mixed flow fan and enclosure in accordance with claim 3, wherein the depth of said annular ring is approximately 40–50% of the depth of the fan blades.

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