Aug. 25, 1964 C. G. TOLSON 3,145,978

AIR HEATERS

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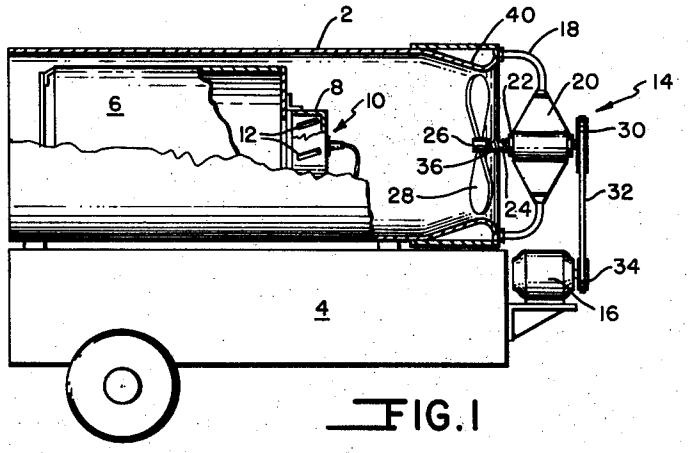


FIG. 1

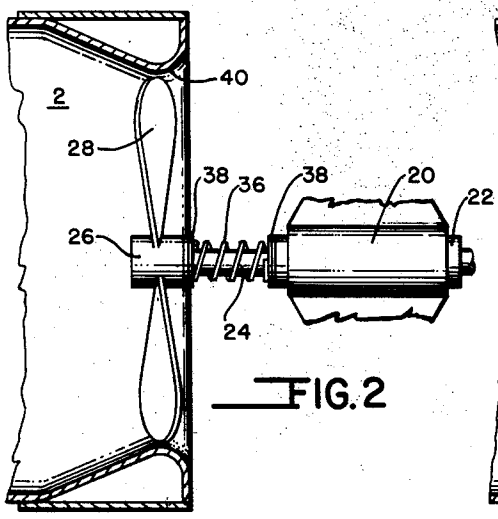


FIG. 2

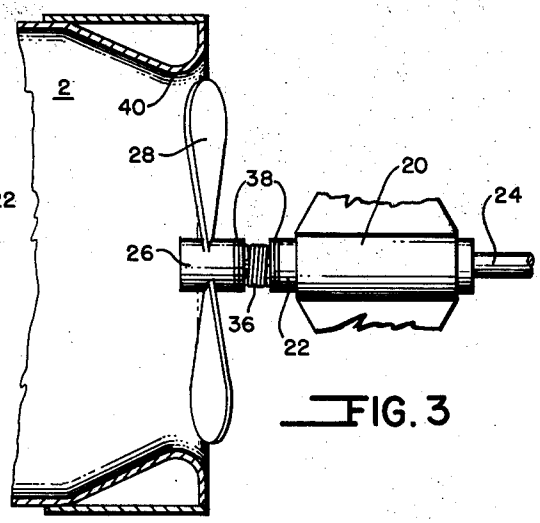


FIG. 3

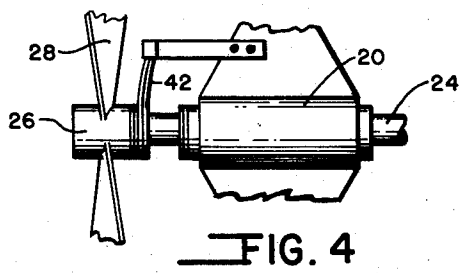


FIG. 4

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AIR HEATERS

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This invention relates generally to air heaters and particularly to means for reducing variations in the weight of combustion air delivered to the air heater combustor under conditions of varying air density.

One type of heater to which the invention is applicable is the relatively simple, inexpensive direct-fired portable heater which uses a propeller fan for creating the flow of combustion air and space heating air. In such heaters, the propeller fan is usually mounted at the air inlet end of an open-ended outer casing which contains a gun-type combustor and a combustion drum downstream of the fan and co-axially disposed within the casing. The air flow produced by the fan includes a combustion air component which enters the combustor for mixing with the sprayed fuel which ignites and burns in the combustion drum. The products of combustion issuing from the outlet end of the drum join the main air stream which is discharged out of the open downstream end of the casing into the space to be heated.

One aspect of these heaters which I consider subject to improvement is the usual provision of an arrangement which results in a constant fuel volume to air volume ratio over the range of operating temperatures. The trouble with this arrangement is that with a variation in air density the weight ratio between fuel and combustion air correspondingly changes. It will be appreciated that such variations do not promote uniformly efficient combustion.

The aim of this invention is not only to reduce such variations, but to accomplish this in a commercially feasible way (i.e., at a minimal cost).

According to the invention, the propeller fan is mounted in a manner which permits its axial displacement relative to the orifice ring associated with it in accordance with variations in density of the air that the fan is handling. Yieldable means urge the propeller fan into a maximum volume position when the fan is operated in the upper range of temperatures under which the heater operates. With lower temperatures (and consequently higher densities), the axial thrust of the fan opposing the yieldable means increases, and the fan will be displaced relative to its ring. Accordingly, a reduced volume of air is handled at such lower temperatures with the result that the weight of air handled does not increase in proportion to the temperature decrease.

The invention will be explained in connection with the accompanying drawing wherein:

FIGURE 1 is a partly broken side view of one type of direct-fired air heater incorporating the invention;

FIGURE 2 is a fragmentary, enlarged side view in the nature of a vertical section of the fan and ring showing the fan's position relative to the ring under an air density condition wherein a maximum volume of air flow is produced;

FIGURE 3 is a view similar to FIGURE 2, but with the fan displaced relative to the ring in response to a higher air density condition; and

FIGURE 4 is a fragmentary view illustrating a modification of the invention.

The principal elements of the portable air heater of FIGURE 1 include: a cylindrical outer casing 2 mounted upon a fuel tank base 4; a somewhat shorter and diametrically smaller combustion drum 6 having suitable openings on each end for combustion air to enter and

leave, the drum being co-axially disposed within the outer casing to permit some air flow through the annular space formed between the circumferential walls of the drum and casing; the burner shell or combustor 8 mounted over the opening on the upstream end of the drum 6, the combustor supporting a fuel nozzle and an ignition electrode assembly 10 on its upstream wall and including suitable openings 12 for the admission of combustion air into the combustor and drum; a propeller fan assembly 14 mounted at the upstream open end of the casing 2; and an electric motor 16 for driving the fan, and for driving other elements such as a fuel pump through means not shown.

The propeller fan assembly 14 in the illustrated embodiment includes a support arrangement of a plurality of converging arms 18 having their outer ends secured to the structure defining the open upstream end of the casing, and their inner ends supporting a bearing housing 20. A sleeve bearing 22 is secured within the bearing housing with opposite ends projecting out of the ends of the housing. One end of the fan shaft 24, which is journalled in the bearing to permit axial displacement of the shaft relative to the bearing, supports the fan hub 26 carrying the fan blades 28, and the other end of the shaft has a driven sheave 30 secured to it. The sheave 30 is driven by belt 32 and sheave 34 from the motor 16.

Turning now to FIGS. 2 and 3, the expanse of shaft 24 between the fan hub 26 and the projecting end of the bearing 22 has a helical spring 36 mounted thereon. Preferably means are provided to reduce friction between the ends of the helical spring and the end portions of the hub 26 and bearing 22 which engage the ends of the spring. In an elementary (and inexpensive) form, these means may be simple washers 38. It will be appreciated that ball bearings or other friction reducing means may be used where the operating improvement justifies the cost.

The interior surface of the upstream end of the outer casing which forms the orifice ring for the fan is provided with a Venturi shape 40 for reducing air flow losses. The fan assembly 14 as a whole is mounted so that when the heater is operating in the upper range of operating temperatures expected (say 50° to 60° F.), the fan will be substantially in the FIG. 2 position relative the ring 40, this fan position producing a maximum volume of air flow. When the heater is operating in an extremely low ambient temperature, the fan will be in an extreme shifted position relative to the ring as generally illustrated in FIGURE 3, and the fan will be producing a reduced volume of air flow as compared to the FIG. 2 position. It will be appreciated that while in both cases the axial thrust of the fan is in a direction tending to move it out of the ring 40, the magnitude of the thrust in the FIG. 2 case is such that the helical spring 36 in its substantially extended position balances this axial thrust. In the FIG. 3 case however, the axial thrust of the fan has increased sufficiently that it shifts out of the ring by progressively compressing the spring 36 until the spring force equals the axial thrust.

It will be appreciated that this axial displacement of the shaft and fan is due to variations in the axial thrust of the fan at different air densities; which are usually due to different air temperatures, although air density also changes with elevation. The axial thrust developed by a propeller fan is approximately equal to the rise in total pressure across the fan multiplied by the area of the orifice in which the fan is operating. With a constant system having a constant fan speed the air volume will be constant, but the pressure will vary as the density of the air being handled. Thus it will be seen that with a rise in density of the air, due to a lower air temperature for example, the total pressure will rise and this results in

the increased axial thrust which opposes the force of the spring 36. By shifting the fan away from the maximum volume position in the ring 40, a reduced volume and a reduced weight of air results. It is in this way that the invention accomplishes the reduction in variations of the fuel-to-air weight ratio in such a heater.

The inventive concept here involved does not necessarily require that the ring have a Venturi shape. For example, the ring may simply constitute the open upstream end of a uniform diameter cylinder serving as the outer casing, and in this case the fan is arranged to be shifted to a greater or lesser degree out of the end of the casing. The character of the ring shape is, it will be appreciated, a matter which is interrelated with the pitch of the fan blades, the force of the spring or other yieldable means employed, and other factors which are well known to those conversant in this art.

In the case of the relatively small propeller fans producing a rather low volume (in the order of 1100 c.f.m.) of air flow for the direct-fired portable heaters of the herein contemplated example, the increase in axial thrust due to the rise in pressure occasioned by increased air density at lowered temperatures does not amount to a great deal, and for this reason the spring 36 for such a heater must be relatively light and easily compressible. In some cases the change in axial thrust may be of a degree that superior results would be obtained by use of spring means of a character wherein the spring force is directly responsive to temperature changes. Such an arrangement is illustrated in FIG. 4 which shows a bi-metal leaf element 42 supported from the fan assembly mounting means to bear against the hub 26. In this arrangement, as with a simple helical spring, the axial thrust of the fan opposes the spring force of the leaf 42, but the spring force is a function of both the degree to which it is stressed and to its temperature. The direction of force applied by the bi-metal leaf 42 with an increase in temperature is to the left as viewed in FIGURE 4, with a decrease in temperature resulting in a reduction of force to the left by the leaf.

The invention claimed is:

1. In an air heater:
(*a*) a casing including a propeller fan orifice ring;
(*b*) a combustor within said casing adapted to receive combustion air admitted through said ring;
(*c*) a propeller fan supplying combustion air to said combustor, said fan being mounted for operation in said ring on an axially displaceable shaft; and
(*d*) spring means on said shaft urging said fan into an operating position relative to said ring yielding a maximum volume of air flow, and being compressible in accordance with the axial thrust developed by said fan to permit axial displacement of said fan out of said maximum volume position and to a reduced volume position.

2. In an air heater as specified in claim 1:
(*a*) said spring means includes bi-metallic means providing variations in spring force in accordance with temperature variations.

3. In an air heater:
(*a*) a casing including a shaped propeller fan ring;
(*b*) a combustor within said casing;
(*c*) a propeller fan mounted in said ring on an axially displaceable shaft;
(*d*) spring means urging said fan into an operating position relative to said ring creating a maximum volume of air flow and opposing the axial thrust of said fan in operation, said spring means being yieldable in response to increasing axial thrust of said fan arising from increasing air densities to permit progressive axial displacement of said fan out of said maximum volume position and to progressively reduced volume positions.

4. In an air heater:
(*a*) an outer casing including a shaped air inlet;
(*b*) a combustor in said casing;
(*c*) a propeller fan mounted in said inlet upon an axially displaceable shaft for supplying combustion air to said combustor; and
(*d*) yieldable means urging said shaft in a direction opposing the axial thrust of said fan for positioning said fan in a maximum volume position relative to said inlet under a condition of low axial thrust, and permitting displacement of said shaft and fan away from said maximum volume position and to a reduced volume position in response to an increased axial thrust arising from an increased density of air handled by said fan.

5. In an air heater as specified in claim 4:
(*a*) said yieldable means comprise a helical spring upon said shaft.

6. Axial flow fan apparatus for supplying combustion air to an air heater, comprising:
(*a*) an air inlet ring and a propeller fan therein for causing air flow through said ring;
(*b*) means supporting said fan for axial movement relative to said ring;
(*c*) means urging said fan in opposition to the axial thrust developed by said fan toward a maximum volume position of said fan relative to said ring under a low density of air condition;
(*d*) said last-mentioned means being yieldable in response to an increased axial thrust developed by said fan arising from an increased air density condition for permitting displacement of said fan away from said maximum volume position and to a reduced volume position.

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