Oct. 12, 1965 J. L. FAHLBERG 3,211,439

FORCED AIR HEATER

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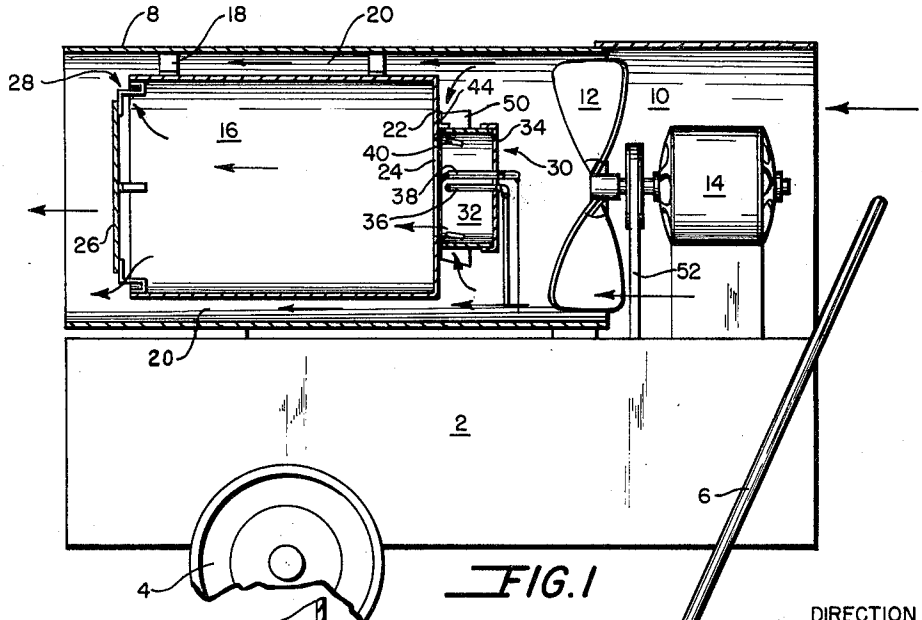

FIG. 1

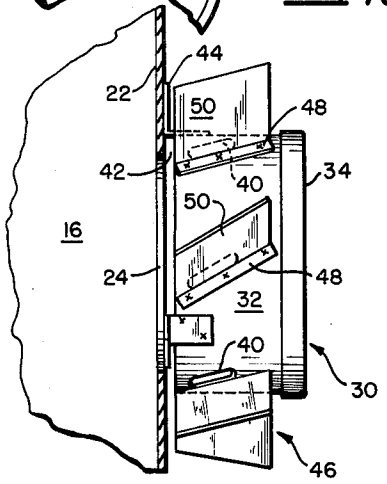

FIG. 2

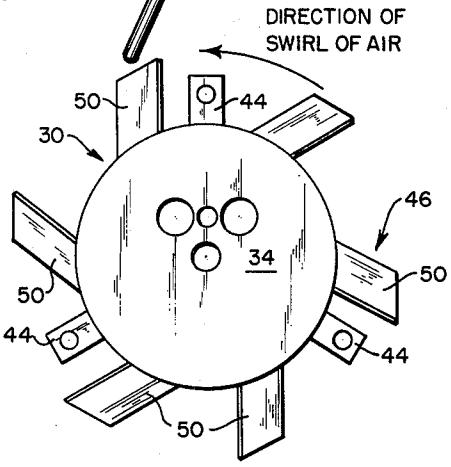

FIG. 3

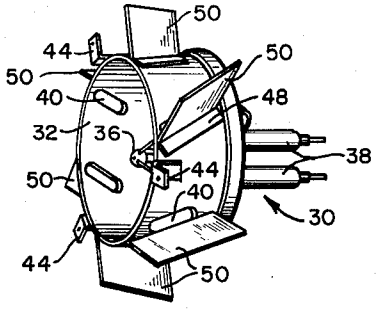

FIG. 4

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FORCED AIR HEATER

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This invention relates to improvements in fluid fuel burning forced air heaters.

One common construction of forced air heaters of the direct fired type includes: an outer casing, usually of cylindrical form, defining an air passage for the flow of air to be heated; a somewhat shorter and diametrically smaller inner cylindrical drum serving as a combustion chamber, the drum being open in part on each end so that fuel and air may be delivered into its inlet end and combustion gases be delivered out of its outlet end for mixing with additional air which flows along the periphery of the drum; means for mounting a fuel nozzle and ignition electrodes on the inlet end of the combustion chamber; burner shell means forming an inlet for combustion air adjacent the fuel nozzle and electrodes; and a propeller fan at the inlet end of the outer casing for forcing air through the casing. This invention is concerned with a heater of this general character and in particular with the arrangement for admitting combustion air to the inlet end of the combustion drum.

Thus one object of this invention is to provide a direct fired forced air heater having an improved arrangement for the admission of combustion air to the combustion drum.

A more specific object is the provision of a burner shell so constructed, and incorporating means for admitting combustion air to the combustion drum, that advantage is taken of the particular air flow pattern normally encountered in forced air heaters of the general character described.

In accordance with the invention, a cup-shaped burner shell in mounted on the upstream end of the combustion drum with the open downstream end or rim of the shell being spaced slightly away from the upstream end wall of the combustion drum to provide an annular gap therebetween for the admission of a part of the combustion air. The upstream end wall of the combustion drum is provided with a central opening of a diameter less than the diameter of the burner shell. Thus with the drum and shell in axially aligned relation the downstream rim of the shell circumscribes the periphery of the central opening. The upstream end of the shell is substantially closed to air flow and the openings for the admission of primary combustion air to the shell and drum are provided in the circumferential wall of the shell. In the presently preferred construction, the openings are in the form of slots spaced from each other around the circumferential wall and pitched or angled in the same direction as the direction of swirl imparted to the air by the propeller fan, but to a greater degree than the angle of swirl. The presently preferred construction also includes an outwardly projecting vane associated with each slot and disposed with its root or base extending along one edge of the slot and parallel thereto, on the downstream side of the slot relative to direction of rotation of the swirling air, and with its projecting portion inclined or tilted in opposition to the direction of rotation of the swirling air.

With such an arrangement, the air flow pattern occurring with a propeller fan forcing air through the heater is utilized to good advantage in that the tendency for

reverse flow of air generally inwardly along the upstream end wall of the combustion drum and then back toward the hub of the propeller fan is used to obtain combustion air having a proper volume and advantageous flow characteristics. Described somewhat more specifically, that air which flows inwardly along the upstream end wall of the drum, and which retains a rotational component of velocity, is directed into the shell by flowing along the windward side of the vanes (relative to the air swirl direction). With the vanes and slots pitched to a degree exceeding the degree of swirl of the air, the capture of this inwardly flowing air is facilitated. The inclination of the vanes in opposition to the swirl direction of the air enhances the smooth flow of the combustion air into the slots with a resultant retention of the swirling pattern of air in the burner shell and combustion drum. This swirling pattern within the shell and drum is advantageous from the standpoint of good mixing of combustion air and fuel, and also from the standpoint of avoiding the problem of flames licking out of the outlet end of the drum. The latter condition is commonly encountered with burner shells in the form of open-ended blast tubes.

A preferred embodiment of the invention by way of example is illustrated in the accompanying drawing wherein:

FIGURE 1 is a side view of an air heater incorporating the invention, with the outer casing, combustion drum and burner shell being shown in vertical section;

FIGURE 2 is an enlarged view of the burner shell shown in mounted relation on the upstream end wall of the combustion drum;

FIGURE 3 is an upstream end view of the burner shell of FIGURE 2; and

FIGURE 4 is an isometric view of the burner shell with the fuel nozzle and electrodes in mounted position.

The forced air heater of the direct fired type shown in FIGURE 1 includes a base portion **2** which also serves as a fuel tank and is normally supported in a horizontal position by a pair of wheels **4** and a handle **6**. An outer cylindrical casing **8**, open at both ends, is mounted upon the base **2** and has its upstream end joined to a motor cowl **10** of generally semi-cylindrical shape. Air flow through the heater is in the direction indicated by the arrows, the air flow being created by propeller fan **12** driven by motor **14**.

A cylindrical combustion chamber or drum **16** of shorter length and lesser diameter than casing **8** is coaxially disposed therewithin by means of spacer elements **18** so that the circumferential walls of the outer casing and drum form an annular passage **20** for the flow of air to be heated. The upstream end wall **22** of the combustion drum has a central opening **24** therein for the admission of combustion air. On the downstream or outlet end of the drum a diffuser plate **26** of lesser diameter than the drum is coaxially positioned to form a peripheral outlet **28** through which combustion gases leave the drum and mix with the uncontaminated air leaving the annular passage **20**.

A burner shell generally designated **30** is mounted on the upstream end wall **22** of the drum and supports the fuel nozzle and ignition electrodes and provides a structure through which combustion air is admitted to the drum. The shell is generally cup-shaped, has a diameter considerably less than the drum but slightly larger than the diameter of the central opening **24**, and is disposed in axially aligned relation with the drum. Thus the downstream rim of the burner shell circumferential wall **32** is in encircling relation to the drum end wall central

opening **24**. The upstream end wall **34** of the shell has suitable openings through which the fuel nozzle **36** and ignition electrodes **38** project into the shell interior. Except for the openings which accommodate the nozzle and electrodes and their mounting structure, the shell end wall **34** is imperforate.

Referring now to FIGURES 2–4 as well as FIGURE 1, the circumferential wall **32** of the burner shell is provided with circumferentially spaced slots **40** which admit most of the combustion air into the shell and drum. Additional or secondary combustion air is admitted slightly downstream of the slots through the annular inlet **42** formed between the downstream rim of the shell circumferential wall and the end wall **22** of the combustion drum. Angle brackets **44** are used to mount the shell to the end wall with the proper space therebetween as illustrated in FIGURE 2. An outwardly projecting vane **46** is secured to the circumferential wall **32** of the shell adjacent each of the slots **40**.

Details of the burner shell structure and the combustion air inlet arrangement will be described as embodied in one particular heater for example, it being understood that the principles of the invention are applicable to heaters of other sizes and having certain structural differences. Six slots **40** are spaced equally about the circumference of the shell. In a shell which has an axial dimension of about 2⅜" and an outside diameter of 5", slots ½" wide by 1¼" long and having their longitudinal axes lying at an angle of about 30° from the axis of the shell have been found to give excellent results in practice. The slots are preferably positioned closer to the downstream rim of the shell than to the upstream imperforate end wall **34**, but a strip of at least ⅛" wide is left between the downstream edge of the slots and the annular gap **42**. With a drum diameter of about 10", a central opening **24** of 3¼" is provided with a 5" diameter burner shell, and the shell is positioned relative to the drum end wall to form an annular gap having a width of ⅛". The vanes **46** may be about 2" long and about 1½" high and each vane is disposed with its base parallel to and closely adjacent the edge of a slot.

Each vane **46** includes a base **48** which may be secured by spot welding to the burner shell circumferential wall **32**, and an outwardly projecting portion **50**. The vanes are formed with an angle of about 120° between the base and projecting portion so that in mounted position the projecting portions **50** are inclined at an angle of about 30° from respective radial lines passing through the bases **48** and the axis of the shell.

In connection with the angular disposition of the slots and vanes, certain relationships provide superior results. First, while the slots are angled or pitched in the same direction as the direction of swirl of the air delivered by the propeller fan, the pitch of the slots is greater than the angle of swirl imparted to the air by the fan. Second, the vanes are pitched at the same angle as the slots and are positioned on the downstream side (relative to air swirl direction) of the slots and closely adjacent that edge of the slot. Third, the projecting portions of the vanes are inclined in opposition to the direction of air swirl. This latter relationship is illustrated in FIGURE 3 wherein the counterclockwise swirl direction of the air is indicated by the so-identified arrow, and the vanes are oppositely inclined, i.e., in a clockwise direction. Of course, the exact angles at which the slots and vanes should be disposed to yield the best performance will depend in part at least upon the particular propeller fan used, and in that connection it is noted that the tangential or swirl velocity component of the propeller fan of the example is in the order of 15°.

In operation of the air heater, fuel is furnished to the nozzle by a pump (not shown) driven by the motor **14** through belt **52**. Ignition cables deliver electrical power to the electrodes for igniting the atomized fuel issuing from the nozzle. The motor **14** drives the propeller fan in a counterclockwise direction (as viewed from the air inlet end of the heater) so that air is forced through the heater with a counterclockwise swirl. Part of the air passes through the annular passage **20** around the combustion drum, and the remainder of the air enters the drum through slots **40** and annular gap **42** for mixing with the fuel as combustion air.

Based in part on observation, the combustion air flow is theorized to be generally as follows. The propeller fan in the described environment has a tendency to cause part of the air striking the upstream end wall **22** of the combustion drum to flow inwardly and back toward the hub of the fan for recirculation. This air, as it starts on that path, strikes the tilted vanes and is directed into the pitched slots in a relatively smooth flow pattern which does not destroy the swirl component of the air as it enters the shell and then the drum. Additional air enters the drum through the annular gap **42**, probably in part at least by aspiration of the primary air entering the shell by way of the slots and then passing into the drum.

Thus, with the described arrangement, a relatively low pressure propeller fan providing its characteristic air flow pattern provides adequate combustion air with a flow pattern facilitating efficient combustion.

Having described my invention, I claim:

1. An air heater including:

(a) an outer casing;

(b) an axial flow fan in said casing for forcing air through said casing, said fan having blades pitched in one direction;

(c) a combustion drum in said casing downstream from said fan in substantial axial alignment therewith and having an upstream end wall provided with a central opening therein;

(d) a substantially right cylindrical burner shell, of greater diameter than said opening and in substantial axial alignment therewith, projecting upstream from said end wall, said shell having a closed upstream end to prevent the admission of air into said shell in an axial direction and having a substantially open downstream end;

(e) means defining a series of air inlets in the circumferential wall of said shell; and

(f) vane means extending in a generally longitudinal fashion along and projecting outwardly from the circumferential wall of said shell adjacent said air inlets and pitched in a direction opposite to said fan blades for directing a portion of said air into said shell and drum by way of said inlets.

2. An air heater including:

(a) an outer cylindrical casing;

(b) an axial flow fan in said casing for forcing air through said casing, said fan having blades pitched in one direction;

(c) a cylindrical combustion drum in said casing downstream from said fan in substantial axial alignment therewith and having an upstream end wall provided with a central opening therein;

(d) a substantially right cylindrical burner shell, of greater diameter than said opening and in substantial axial alignment therewith, projecting upstream from said end wall, said shell having a closed upstream end to prevent the admission of air into said shell in an axial direction and having a substantially open downstream end;

(e) means mounting said shell on said upstream wall to form an annular gap between said downstream end of said shell and said wall;

(f) means defining a series of air inlets in the circumferential wall of said shell; and

(g) a generally outwardly projecting vane associated with each of said air inlets, each vane being disposed to extend in a generally longitudinal fashion along said circumferential wall closely adjacent an air inlet

and on the same side thereof as are the advancing faces of said fan blades on said blades.

3. An air heater according to claim 2 wherein:

(a) said air inlets are in the form of slots pitched in a direction opposite to the direction of the pitch of said fan blades; and,

(b) said vanes extend generally parallel to said slots,

4. An air heater according to claim 3 wherein:

(a) said vanes are inclined, with respect to their radial dimensions, so that their outer portions overlie said slots.

5. An air heater including:

(a) an outer cylindrical casing;

(b) a propeller fan in said casing for forcing air through said casing, said fan having blades pitched in one direction;

(c) a cylindrical combustion drum in said casing downstream from said fan in substantial axial alignment therewith and having an upstream end wall provided with a central opening therein;

(d) a substantially right cylindrical burner shell, having a downstream open end and an upstream closed end, mounted on said drum end wall to define an annular space between said drum end wall and the downstream rim of said shell for the admission of secondary combustion air, the circumferential wall of said shell having a series of circumferentially spaced slots therein for the admission of primary combustion air; and,

(e) vane means extending in a generally longitudinal fashion along and projecting outwardly from said circumferential wall adjacent said slots, and pitched in a direction opposite to the direction in which said fan blades are pitched, to direct said primary combustion air into said slots.

6. An air heater according to claim 5 wherein:

(a) said slots are pitched in the same direction as said vane means.

7. The air heater of claim 6 wherein:

(a) said vane means are inclined, with respect to their radial dimensions, so that their outer portions overlie said slots.

8. An air heater including:

(a) an outer cylindrical casing;

(b) a propeller fan in said casing for forcing air through said casing, said fan having blades pitched in one direction;

(c) a cylindrical combustion drum in said casing downstream from said fan in substantial axial alignment therewith and having an upstream end wall provided with a central opening therein;

(d) a substantially right cylinder cup-shaped burner shell having an upstream closed end, and its downstream open end mounted in circumscribing axial relation to said central opening and spaced upstream from said drum end wall, the circumferential wall of said shell having a series of circumferentially spaced openings therein for the admission of primary combustion air; and,

(e) a corresponding series of outwardly projecting vanes mounted on said circumferential wall to extend in generally longitudinal fashion therealong and pitched in a direction opposite to said blades, each vane having its root adjacent a corresponding opening and on the same side of said opening as are the advancing faces of said fan blades on said blades.

9. An air heater according to claim 8 wherein:

(a) said primary air openings are in the form of slots having their longitudinal axes pitched in a direction opposite to the direction of pitch of said fan blades;

(b) the root of each vane extends substantially parallel to the longitudinal axis of its respective slot; and,

(c) each vane is tilted to define, between its face on the side of said slot and a line tangent to said shell at its root, an acute angle.

10. An air heater including:

(a) an outer cylindrical casing;

(b) a propeller fan in said casing for forcing air through said casing, said propeller fan having blades pitched in one direction;

(c) a cylindrical combustion drum in said casing downstream from said fan in substantially axial alignment therewith and having an upstream end wall provided with a central opening therein;

(d) a right cylindrical burner shell of substantially smaller diameter than said drum and of greater diameter than said central opening, and having an open downstream end and a closed upstream end, mounted with said downstream end circumscribing said central opening and in substantial axial alignment therewith and spaced from said drum wall, the circumferential wall of said shell having a series of circumferentially spaced slots therein to admit primary combustion air; and,

(e) vane means extending in a generally longitudinal fashion along and projecting outwardly from said circumferential wall adjacent said slots and pitched in a direction opposite to the direction of pitch of said fan blades to direct said primary combustion air into said slots.

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