June 20, 1950 R. M. RUSH 2,512,384

DIRECT-FIRED HOT AIR HEATING APPARATUS

Filed Sept. 4, 1945 3 Sheets-Sheet 1

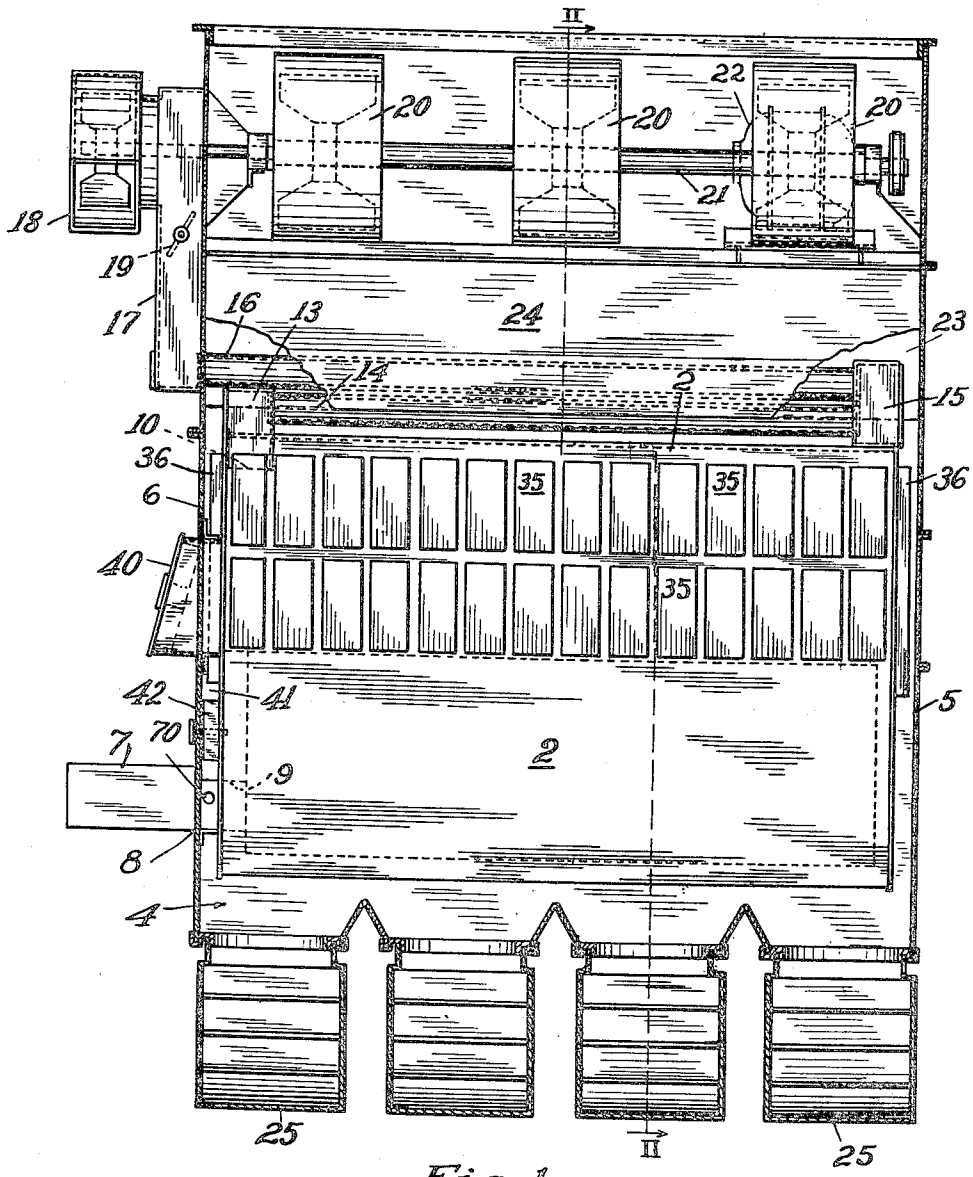


Fig. 1

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3 Sheets-Sheet 2

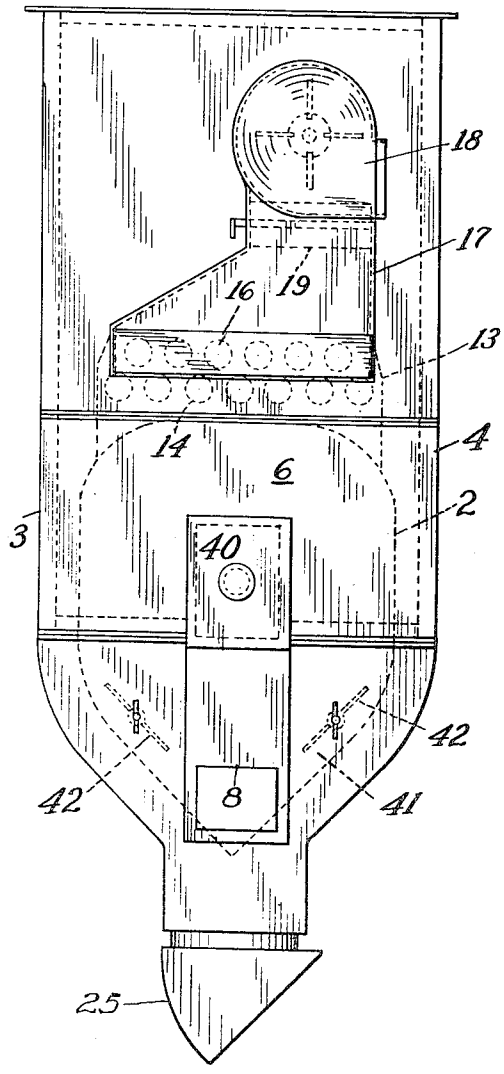


Fig. 3.

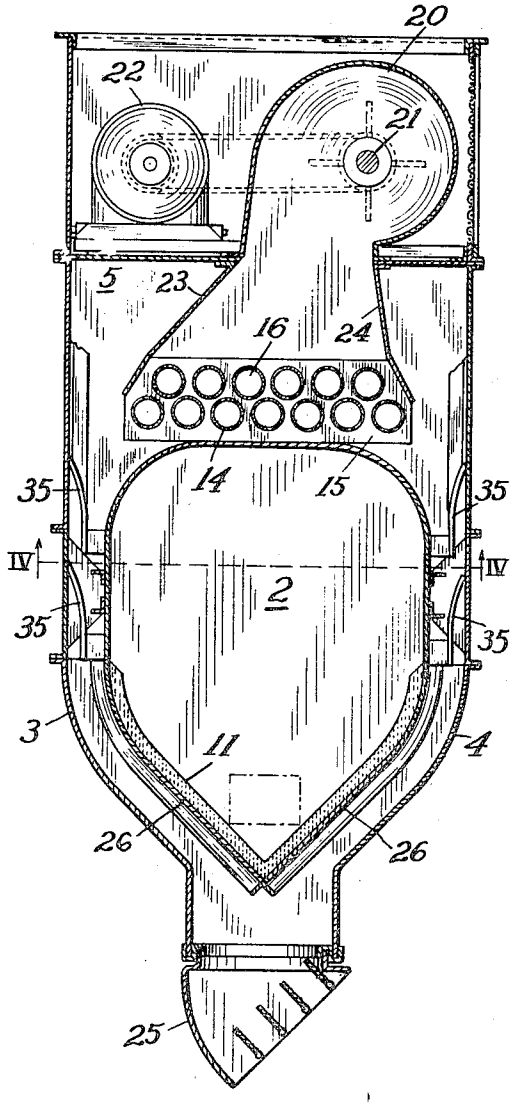


Fig. 2.

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3 Sheets-Sheet 3

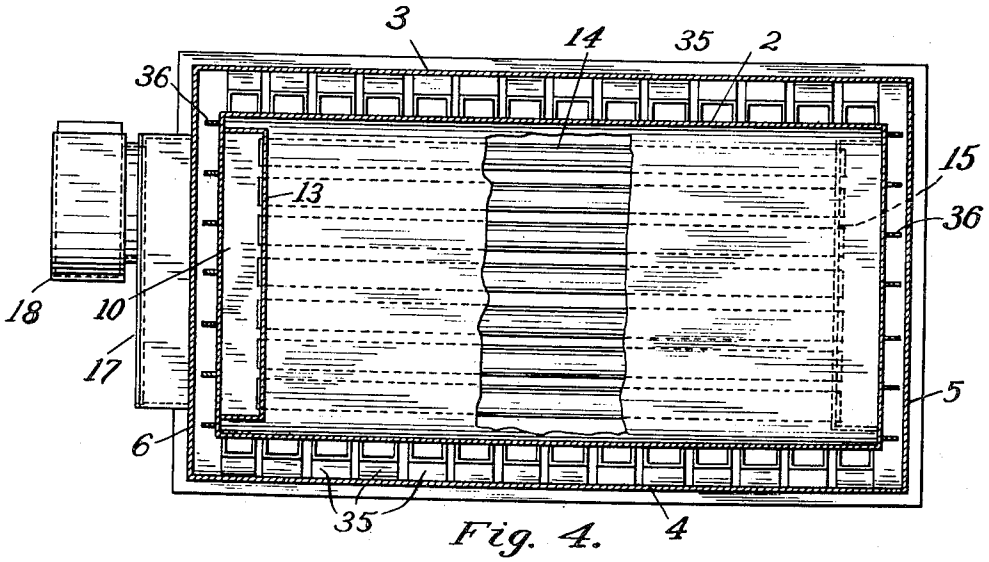


Fig. 4.

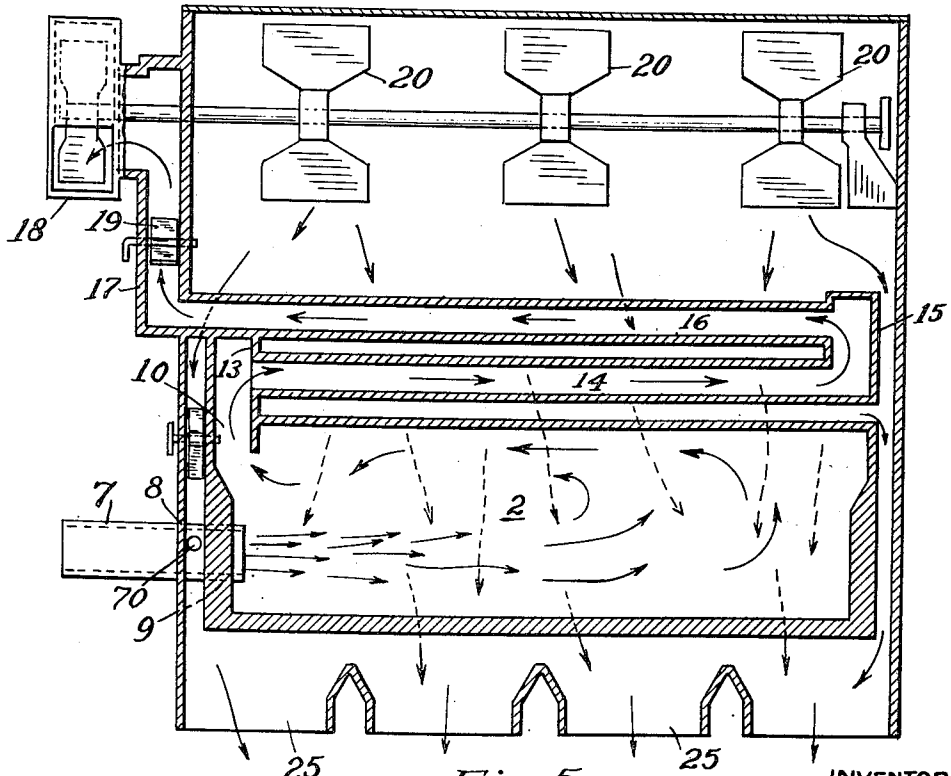


Fig. 5.

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UNITED STATES PATENT OFFICE

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DIRECT-FIRED HOT-AIR HEATING APPARATUS

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Application September 4, 1945, Serial No. 614,313

4 Claims. (Cl. 126—110)

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My invention relates to direct-fired unit heaters of the type adapted primarily, but not exclusively, for the heating of industrial plants and factories.

In United States Letters Patent No. 2,376,140, granted May 15, 1945, and owned in common with the invention hereof, a heater is disclosed of the general type to which my present invention relates. Such heater comprises a combustion chamber arranged within and spaced from the walls of outer housing or casing. Fuel is burned in the combustion chamber, and the products of combustion flow from the chamber through the passages of a bank of heat-exchange tubes to an exhaust. The heat-exchange tubes, communicating at one end with the interior of the combustion chamber and at opposite end with the exhaust, are arranged in the space between the walls of the combustion chamber and the outer casing, and fans are arranged to impel air through the spaces between the tubes and between the walls of the combustion chamber and outer casing to and through discharge outlets. The streams of air, flowing over the hot external surfaces of said heat-exchange tubes and combustion chamber, are heated to desired degree, and emerge through said outlets to heat the room within the factory, or other room or space to be heated.

In the further development of the patented heater certain valuable improvements were made in the mechanical structure of the combustion chamber, and, additionally, certain advantages were discovered in a new and particularly effective arrangement of a plurality of banks or passes of heat-exchange tubes and headers externally of the combustion chamber, but within the outer casing of the heater, in conjunction with a flue-box and exhaust fan in compact unit assembly upon the outer wall of the casing. The improvements in the novel structural features of the combustion chamber and the new and useful arrangement of the heat-exchange tubes, headers and exhaust fan has been made the subject-matter of a patent application, Serial No. 614,312, filed by me on even date herewith.

In my above-noted copending application Serial No. 614,312 the heaters are shown to be of the upright type which are adapted to be supported upon a floor, foundation, or other support, in such position that the hot-air discharge outlets are arranged at the tops of the heater structures. It is possible, and, indeed, in some cases it is practically essential, to employ heaters that are suspended overhead in the room to be heated, such overhead or suspended heaters

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having their hot-air discharge outlets arranged at the bottom or lower side portions of the heater bodies. While the improvements of my prior and copending applications are in certain instances readily applicable to the overhead or suspended type of heaters, the improvements of this, my present disclosure, are directed to certain new and useful features of construction, by virtue of which greater economy in manufacture, and superiority in service are realized, particularly, if not exclusively, in an overhead or suspended heater.

The invention will be understood upon reference to the accompanying drawings, in which a heater including an exemplary and presently preferred embodiment of the invention is illustrated:

Figure 1 is a view of the heater in side elevation, with the adjacent side wall of the outer casing removed, to reveal details of internal construction;

Figure 2 is a view of the heater in cross section, as seen on the plane II—II of Figure 1;

Figure 3 is a view of the heater structure in end elevation, as seen from the right of Figure 1, but with a certain burner omitted, and the firing port in which the burner is mounted appearing in elevation;

Figure 4 is a horizontal sectional view, showing the structure as seen looking upward on the plane IV—IV of Figure 2; and

Figure 5 is a diagrammatic sectional view of the heater structure, illustrating the courses of flow of the flames and hot waste gases, and of the air heated within the structure.

Referring to the drawings the reference numeral 2 indicates the combustion chamber arranged within and spaced from the side walls 3 and 4 and end walls 5 and 6 of the outer casing or housing. Other than as described herein, the heater may be understood to be constructed in accordance with the teaching of Letters Patent No. 2,376,140, and application Serial No. 614,312, above mentioned. In Figure 1 the side wall 3 is removed to reveal the combustion chamber and other structure within the casing.

In this case the heater may be understood to be oil fired or gas fired, a suitable burner 7 being arranged to direct through a port 8 in the end wall 6 of the outer casing and a port 9 in the adjacent end wall of the combustion chamber a combustible mixture of fuel and air. The combustion chamber is of the cross sectional shape shown in Figure 2. The bottom of the combustion chamber is made in the form of a V-shaped trough, having a refractory lining 11, and

into such trough the burning column of fuel and air is directed longitudinally of the chamber. As the burning column of fuel and air approaches the end wall of the chamber opposite to the burner end wall, the flames and hot products of combustion loop upward and flow in reverse direction along the upper walls of the chamber, and then sweep upward through a passage 10 formed in the top of the combustion chamber at the firing end. The passage 10 forms the entrance to a header 13, and upon entering such header the hot waste gases stream through a lower bank or pass of heat-exchange tubes 14, a header 15, an upper bank or pass of heat-exchange tubes 16, and a flue-box 17 to an exhaust fan 18, which delivers the waste gases into the open atmosphere, or into a suitable stack (not shown). The flue-box contains a damper 19, by means of which the effect of the fan may be regulated as and if need be.

Within the top of the outer casing of the heater structure a fan is provided; in this case three fans 20 are provided, whose impellers are mounted on a common shaft 21 driven by an electric motor 22. The fans draw air from the outer atmosphere into the top of the casing, and direct streams of air downward through the banks of heat-exchange tubes 16 and 14. Metal plates 23 and 24, forming a breeching of inverted funnel shape in cross section, confine the streams of air until they pass between and over the hot surfaces of the heat-exchange tubes, it being noted that in Figure 1 parts of the plate 24 are shown broken away for purposes of illustration.

Upon emerging downward through the heat-exchange tubes, the streams of air strike the top of the combustion chamber 2, and, spreading outward in contact therewith, descend through the vertical passages formed by and between the hot walls of the combustion chamber and the walls 3, 4, 5 and 6 of the outer casing. At the bottom of the structure the side walls of the combustion chamber and outer casing converge in parallelism, and the heated air flowing downward therebetween is discharged through louvered cowls 25 into the space or room to be heated.

The V-shaped bottom, side walls, end walls and top wall of the combustion chamber 2 may be formed of flat sheet or plate steel, cut to pattern, shaped and united, as by welding. Alternately, the combustion chamber may be formed partly of corrugated sheet metal and partly of plain or flat sheet metal, as disclosed in my copending application Serial No. 614,312 it being noted that the combustion chamber 2 herein illustrated may consist of the identical combustion chamber structure shown in said copending application, with the qualifications that the combustion chamber is inverted; that is, the V-shaped top of the combustion chamber of said copending application becomes herein the trough shaped bottom of the combustion chamber; the rounded bottom becomes the top, with the headers 13 and 15 and heat-exchange tubes positioned above the chamber, and the passage 10 opening upwardly rather than downwardly into the header 13. The refractory lining 11 herein is applied to the V-shaped trough or bottom of the combustion chamber, while the side walls and rounded top wall may remain without any lining. Indeed, in some cases the V-shaped trough portion, whether of corrugated construction or not, may be formed of refractory metal sheets, and the need for the lining 11 eliminated.

The walls of the outer casing may be formed of metal sheets, or of sheets of refractory composition, or of metal sheets lined with refractory material.

The end walls and side walls of the combustion chamber are equipped with deflector plates 35 and 36, to give turbulence to the streams of air that sweep downward over the hot external surfaces of the chamber, and to insure more intimate contact of the air with the hot surfaces and effect better heat transfer. The structure and arrangement of such deflectors are dealt with in Letters Patent No. 2,115,057, granted April 26, 1938, to Harold C. Anderson.

It will be understood that the heater structure illustrated herein is designed to be suspended or otherwise sustained in such position that the air intake is at the top of the structure and the air outlets at the bottom, ordinarily the heater being installed with the outlet cowls 25 located over the heads of the occupants of the room or space to be heated. The particular features of structural organization that have resulted in high thermal efficiency of such an overhead heater provide important aspects of my present invention.

It is to be noted that a plurality (two) of banks or passes of heat-exchange tubes 14 and 16 are arranged above the combustion chamber but within the outer casing of the heater structure, together with the headers 13 and 15. The flue-box 17 and exhaust fan 18 are arranged as a unit on the external wall of the casing, adjacent to the top thereof. The flue-box 17 provides a header for the delivery end of the upper or secondary bank of heat-exchange tubes 16. The exhaust fan 18 is mounted immediately upon the wall of this combination header and flue-box 17, and is positioned with its impeller in axial alignment with the shaft 21 that carries the impellers of the air fans 20 within the outer casing of the heater. The shaft 21 is continued in a portion of reduced diameter outwardly through the wall of the outer casing and mounts the impeller of the exhaust fan 18. Thus, all of the fans of the heater, the air fans and the waste gas exhaust fan, are driven by a single shaft 21 geared or belted to a single motor 22. Accordingly, the great practical advantages of the unit assembly of the exhaust fan upon the wall of the combined header and flue-box 17 will be appreciated, and such advantages are realized not only in heater structures that have their air-delivering cowls positioned at the bottom of the heater, but in various other heater structures, say in a heater structure such as that disclosed in my said copending application Serial No. 614,312.

It will be noted that the V-shaped bridge wall that is arranged across the remote end of the combustion chamber to receive impingement of the flames jetted by the burner in the heater of Patent No. 2,376,140 is eliminated in the heater structure herein described. Additionally, the usual explosion and access door 40 is advantageously arranged in the front rather than the back wall of the heater.

As indicated by full-line arrows in Figure 5, the travel of the flames and hot products of combustion, first through a double, looped course within the combustion chamber, and then through two successive passes of heat-exchange tubes, is promotive of the high thermal efficiency of the heater described. More particularly, the burner 7 directs a column of burning fuel and combustion air longitudinally of the refractory V-shaped trough portion of the combustion

chamber, and it is to be here repeated that the refractory trough portion of the combustion chamber may be formed of a heat resistant metal without the need of the plastic refractory lining 11. Upon approaching the remote end of the lower refractory fire-box portion of the combustion chamber, the flames and hot gases loop upward and flow in reverse direction, in intimate contact with the upper heat-conducting walls of the combustion chamber, and, reaching the firing end of the combustion chamber, the flames and gases sweep upward in a stream of substantially the breadth of the combustion chamber into the port 10 above the line of delivery of the burner 7. From the port 10 the residual flames and the products of combustion enter the header 13 and flow through the lower bank or pass of heat-exchange tubes 14 into the header 15, whence they flow through the upper bank or pass of tubes 16 into the combination header and flue-box 17. This flow or travel of the flames and hot gases is induced by the action of the exhaust fan 18, whose draft effect is subject to accurate regulation by means of the manual setting of the damper 19. Thus, it will be perceived that flames and/or hot waste gases proceed through two generally horizontal courses of flow within the combustion chamber 2 and then flow above the combustion chamber first in one horizontal direction and then through opposite horizontal direction through succeeding banks or passes of heat exchange tubes into a flue-box and exhaust fan unit. This cycle of flow of the flames and hot waste gases in the combustion chamber and through the several passes of heat-exchange tubes establishes, in conjunction with the passage of the air (note the dotted-line arrows in Figure 5) first over the external surfaces of the several banks of tubes and then over the external surfaces of the combustion chamber walls, provides a heat transfer efficiency that approaches the practical ideal, it being noted that the flow of air is in a direction extending transversely or vertically of the successive horizontal courses of flow of the flames and hot waste gases.

The primary air for combustion is admitted with the fuel through the burner 7, while the secondary air for combustion is drawn from the space 41 between the end wall 6 of the outer casing and the adjacent end wall of the combustion chamber 2 into the column of fuel and air delivered by the burner, ports or passages 70 adjacent to the delivery end of the burner serving as entrances for the admission of this secondary combustion air to the mixture of fuel and primary air. The secondary air, drawn from between the outer casing and the hot walls of the combustion chamber, is hot, whereby certain advantages of the use of preheated combustion air are realized. Above and on opposite sides of the burner 7 dampers or butterfly valves 42 are arranged in the space 41, and by the manual setting of these dampers the flow of the heated combustion air to the burner may set at optimum value. Exceeding efficient combustion may be maintained in the heater.

Air has been described as the fluid to be heated in its passage over the walls of the heat-exchange tubes and the combustion chamber, but other fluids than air are held in contemplation, and within the terms of the appended claims other variations and modifications of the invention are permissible.

I claim:

1. A unit heater comprising heat-conducting walls forming an internally fired horizontally extending combustion chamber, a casing having walls spaced from said heat-conducting walls and forming passageways for air to be heated, a pass of horizontal heat-exchange tubes arranged above the combustion chamber, the walls of said combustion chamber including an outlet located in the top and adjacent to one end of the chamber, a header at the top of said chamber into which said outlet opens, said pass of tubes at one end communicating with said header, a flue-box communicating with the opposite end of said pass of tubes, a motor-driven exhaust fan mounted in position above said combustion chamber upon the wall of said flue-box, with the fan intake opening through the wall of the flue-box, a burner opening through the wall of the combustion chamber at the end thereof where said outlet is located, said burner being directed to deliver a burning column of fuel and air longitudinally into the lower portion of said combustion chamber and cooperating with said exhaust fan to effect the sweep of flames and hot products of combustion through a succession of horizontal courses of flow, one of which extends in horizontal direction along the lower portion of said combustion chamber away from said outlet, another of which extends in horizontal direction above the first course and along the upper portion of said combustion chamber to said outlet, and another of which extends in horizontal direction above said first two courses and through said outlet and header and pass of heat-exchange tubes into said flue-box and exhaust fan, a motor-driven fan above said heat-exchange tubes for driving air downwardly through said passageways over the hot external surfaces of said heat-exchange tubes and said combustion chamber, and air-delivering cowls opening from said casing at the bottoms of said passageways.

2. The structure of the next-preceding claim, a single electric motor connected to drive both of said fans arranged above said pass of heat-exchange tubes.

3. A unit heater comprising heat-conducting walls forming an internally fired horizontally extending combustion chamber, a casing having walls spaced from said heat-conducting walls and forming passageways for air to be heated, a pass of horizontal heat-exchange tubes arranged above the combustion chamber, the walls of said combustion chamber including an outlet located in the top and adjacent to one end of the chamber, a header at the top of said chamber into which said outlet opens, said pass of tubes at one end communicating with said header, a flue-box communicating with the opposite end of said pass of tubes, a motor-driven exhaust fan mounted in position above said combustion chamber upon the wall of said flue-box, with the fan intake opening through the wall of the flue-box, a burner opening through the wall of the combustion chamber at the end thereof where said outlet is located, said burner being directed to deliver a burning column of fuel and air longitudinally into the lower portion of said combustion chamber and cooperating with said exhaust fan to effect the sweep of flames and hot products of combustion through a succession of horizontal courses of flow, one of which extends in horizontal direction along the lower portion of

said combustion chamber away from said outlet, another of which extends in horizontal direction above the first course and along the upper portion of said combustion chamber to said outlet, and another of which extends in horizontal direction above said first two courses and through said outlet and header and pass of heat-exchange tubes into said flue-box and exhaust fan, a plurality of motor-driven air fans arranged in axial alignment above said pass of heat-exchange tubes, a breeching in said casing for directing the air delivered by said fan downward upon and between said tubes and thence through said passageways, and air-delivering means arranged at the bottoms of said passageways.

4. A unit fired heater comprising an internally fired horizontally extending combustion chamber having heat-conducting walls arranged within and spaced from an outer casing and providing between the chamber and casing walls passageways for air to be heated, air-delivering outlets opening from said casing below said combustion chamber, a burner for delivering a burning column of fuel and air into one end of said combustion chamber, a flue-box, two headers arranged immediately above said combustion chamber, one of said headers communicating with the interior of said combustion chamber adjacent to and above said burner, and the second header being located adjacent to the end of said combustion chamber opposite to that through which said burner delivers, two passes of heat-exchange tubes arranged immediately above said combustion chamber, one of said passes of heat-exchange tubes extending from the header which communicates with the interior of said combustion chamber to the second header, and the other pass of said heat-exchange tubes extending from said second header to said flue-box, an exhaust fan for drawing the products of combustion from said combustion chamber through said headers, heat-exchange tubes and flue-box, and a fan for driving air downwardly through said passageways, over the external surfaces of said tubes and combustion chamber and through said air-delivering outlets.

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