March 5, 1957 C. D. MacCRACKEN 2,783,755

FORCED AIR HEATING APPARATUS

Filed May 16, 1952 2 Sheets-Sheet 1

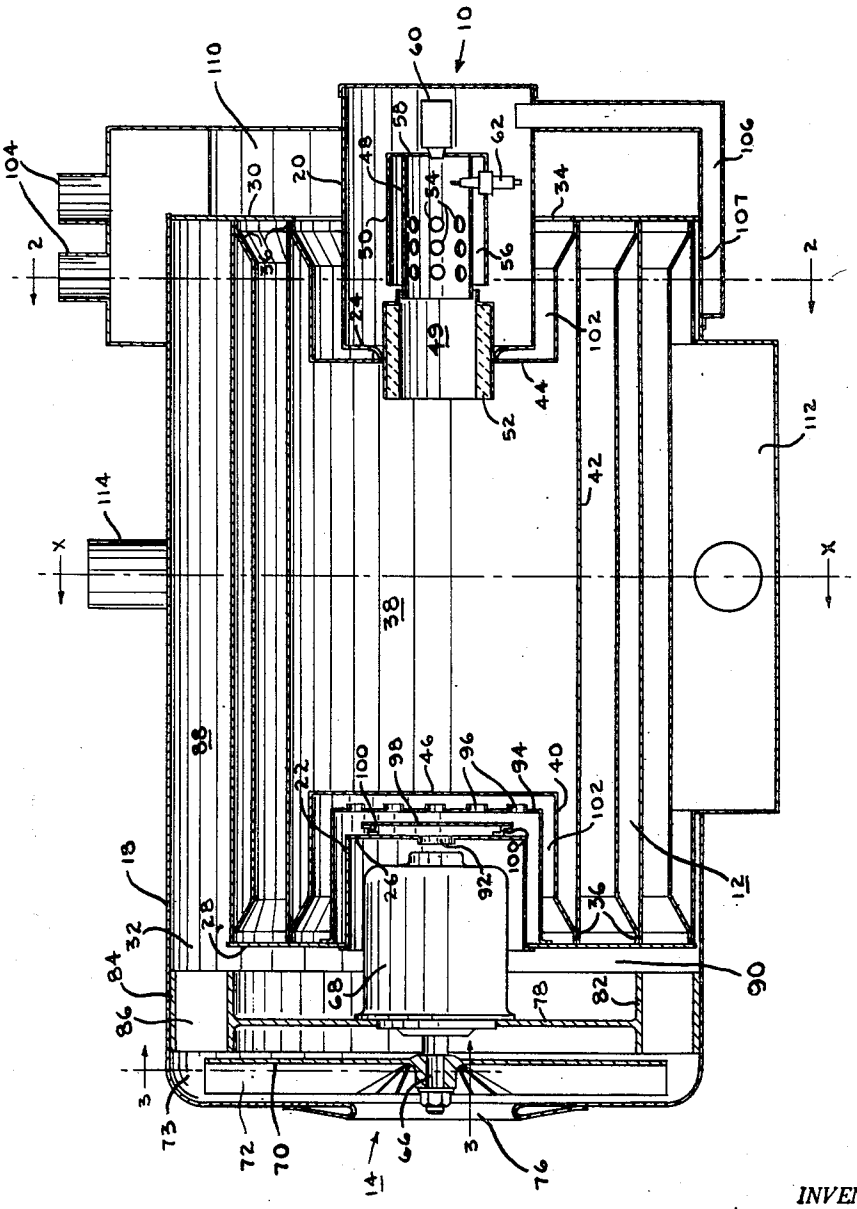


Fig. 1.

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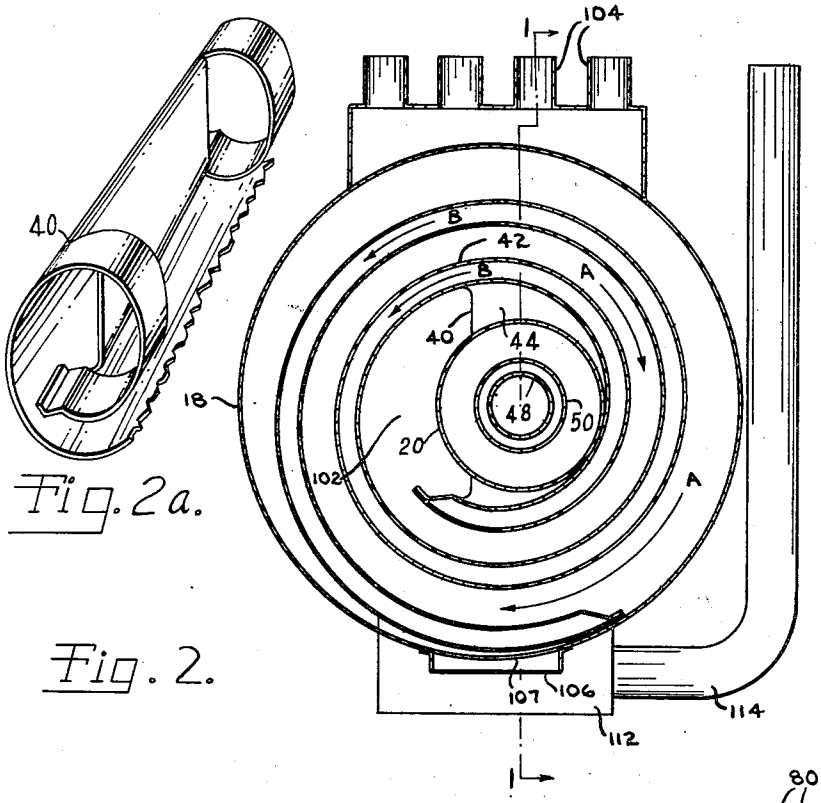


Fig. 2a.

Fig. 2.

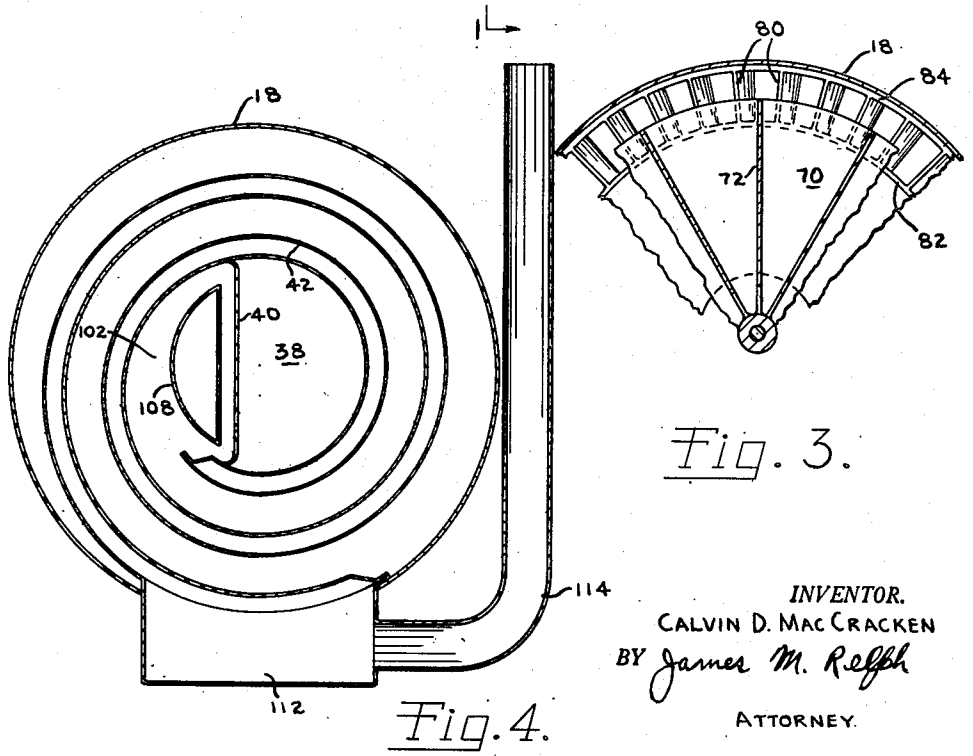


Fig. 4.

Fig. 3.

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FORCED AIR HEATING APPARATUS

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Application May 16, 1952, Serial No. 288,187

9 Claims. (Cl. 126—110)

This invention relates to improvements in heating apparatus, and particularly to an improved forced-air heating apparatus of the general type described in U. S. Patent No. 2,488,548 to MacCracken.

In the apparatus described in the above-mentioned MacCracken patent, a pair of substantially cylindrical shells are concentrically arranged to provide therebetween a hollow annular space within which is placed a spiral heat exchanger element. Inside the inner shell, a fuel burner is mounted to discharge hot gaseous combustion products, in a direction at right angles to the shell axes, directly into an opening in the inner turn of the spiral heat exchanger. An air compressor at one end of the shells supplies air both to the fuel burner and to the space between the shells to flow in heat exchange relationship over the spiral surfaces of the heat exchanger, thereby providing for heating of the air.

While the apparatus just described has many advantages over other previously known heating systems, it has been found that the orientation of the fuel burner and the air flow arrangement has certain shortcomings. The location of the fuel burner at right angles to the shell axes results in a concentrated discharge of hot gaseous combustion products directly onto a limited surface area portion of the innermost turn of the heat exchanger. Even though the metal utilized in the heat exchanger be fully capable of withstanding the relatively high temperatures encountered, the impingement of hot gases on a localized portion of the heat exchanger wall may create a condition of uneven expansion and contraction thereof, eventually causing failure due to bending of the metal. Furthermore, it is not entirely practical to direct cooling air onto this localized area which is subject to wide temperature changes because the area in question is at the end of the path through which air to be heated flows.

It is, therefore, a general object of the present invention to provide an improved air-heating apparatus, wherein the problems just mentioned are overcome while retaining all of the advantages of the apparatus described in the above-mentioned patent. In accordance with the present invention, the foregoing and other related objects and advantages are obtained by reorienting the burner to expose a different and much greater area portion of the heat exchanger structure to the initial high temperature combustion products, thereby eliminating the localized expansion and contraction problem. Provision also is made to insure a flow of cooling air directly onto a surface that is or may be the target of flame from the burner, thereby limiting temperature variations of this target surface.

A more complete understanding of the invention can be had by reference to the following description of an illustrative embodiment thereof, when considered in connection with the accompanying drawing, wherein

Fig. 1 is a longitudinal sectional elevation of an air heating device embodying the invention, taken on the line 1—1 of Figure 2,

Fig. 2 is a cross-sectional view, taken on the line 2—2, of the apparatus shown in Fig. 1,

Fig. 2*a* is a perspective view of the innermost wall of the innermost turn of the heat exchanger,

Fig. 3 is a partial sectional view of the compressor portion of the apparatus of Fig. 1, taken on the line 3—3 of Fig. 1, and

Fig. 4 is a cross-sectional view of a modified form of heating apparatus embodying the invention.

In Fig. 1 of the drawing, the principal elements of a heating apparatus arranged in accordance with the invention are shown to comprise a fuel burner 10 for supplying hot gaseous combustion products to a heat exchanger 12, and a compressor 14 for supplying air both to the burner 10 and to the heat exchanger 12. The elements 10—14 are housed in a substantially cylindrical casing 18.

In place of the unitary inner casing shown in the above-mentioned patent, in the present apparatus there are provided two "bucket" shaped inner casing elements 20, 22, disposed in opposite ends of the outer casing 18. These bucket elements 20, 22 thus form a partial inner casing, dividing the space inside the outer casing 18 into annular spaces at each end thereof joined by a substantially cylindrical space at the mid-portion of the casing 18. The outer ends of the annular spaces are substantially closed by walls 28, 30. One of these walls, 28, has an opening 32 near its outer edge. The other wall, 30, has an opening 34 near its inner edge, for a purpose explained hereinafter.

The heat exchanger 12 is a hollow spiral element, the sealed edges 36 of which extend into the annular spaces between the inner and outer casing element and terminate adjacent the walls 28, 30.

In accordance with one important feature of the present invention, the central portion of the walls 40, 42 forming the innermost turn of the heat exchanger 12 open out to define a chamber 38 encompassing a substantial part of the space between the inner bucket ends 24, 26. In other words, the central section of the sheet 40 that forms the innermost wall is bent away sharply (see Figure 2*a*) from its companion wall 42 (see Fig. 2) to extend across the space at the center of the unit. The ends of the chamber 38 thus defined are closed by a pair of end walls 44, 46 adjacent the inner end walls 24, 26 of the buckets 20, 22.

One of the bucket shaped casing elements, 20, constitutes a housing for the fuel burner 10. The burner 10 comprises a pair of concentrically disposed metal sleeves 48, 50. The inner one (48) of these sleeves surrounds and defines a combustion space 49 which is extended into the chamber 38 by a sleeve 52 of refractory material forming a continuation of the inner sleeve 48. The refractory sleeve 52 extends through a central opening in the end wall 24 of the element 20 and the chamber end wall 44, the two end walls 24, 44 being sealed together about this opening.

The inner sleeve 48 is provided with a plurality of laterally aligned holes 54 through which combustion air can enter the combustion space 49 from the space 56 between the sleeves 48, 50. The sleeves 48, 50 are closed by an end wall 58 at the end remote from the refractory sleeve 52, and a fuel supply means, such as an atomizing fuel nozzle 60, is mounted to discharge fuel into the combustion space 49. Ignition means, such as a spark plug 62 or the like, projects through the sleeves 48, 50 into the combustion space 49 to ignite the fuel which enters through the supply means 60. It will be understood that the burner 10 can as well be arranged to burn gaseous fuel.

It can be seen that the burner 10 is arranged to discharge combustion gases axially or endwise into the

chamber 38, so that the entire inner surface of the chamber defining walls 40, 42, 44, 46 will be exposed to the radiant heat from the flame. The flame itself may impinge on the end wall 46 facing the refractory sleeve 52 from which the combustion gases issue.

The air compressor 14, disposed at the other end of the assembly, is driven by a motor 68 which is housed in the casing element 22. A more detailed description of the compressor is given in MacCracken Patent No. Re. 23,126. Briefly, the compressor rotor comprises a disc or plate 70, in the center of which is a splined hole fitting over the motor shaft 66. Radially arranged blades or vanes 72 are provided on the disc 70, and these blades 72 and the disc 70 terminate a short distance from the outer casing 18, leaving an annular space 73 between the casing 18 and the outer periphery of the rotor.

The end wall of the casing 18 has a central opening 76 providing an air inlet to the compressor 14.

The compressor stator comprises a second disc 78, fixed to the shaft end of the motor housing and carrying a plurality of curved vanes 80 (see Fig. 3) on a ring 82 at the outer edge of the disc 78. An outer ring 84 surrounding the vanes 80 cooperates with the inner ring 82 to define an annular space 86 communicating between the space 72 at the outer edge of the rotor and the space 88 between the casing 18 and the heat exchanger outer turn. This annular space 86 thus is segmented by the vanes 80, which serve to convert the rotational velocity components of the moving air flowing from the rotor into axial components at lower velocity and higher static pressure.

In the apparatus described in MacCracken Patent No. 2,488,548 a single air compressor supplies both combustion and ventilating air, and the flow of combustion air is directed over the compressor motor for cooling purposes.

In the apparatus presently being described, the single compressor 14 is arranged to serve the several useful functions stated above, with the further feature that provision is made for directing a cooling flow of air against the central chamber end wall 46 on which hot gaseous combustion products from the burner 10 may impinge. The manner in which the parts are arranged to obtain these various deliveries of air will now be described.

The outer periphery of the end wall 28 at the compressor end of the apparatus is shaped to conform generally to the outer turn of the heat exchanger spiral, so as to present to the compressed air leaving the stator vanes 80 an opening 32 of diminishing width through which a portion of hte air can flow into the space 88 between the heat exchanger and the casing. The air flowing into this space 88 constitutes the principal supply of ventilating air to be heated in the apparatus. It may also provide the air for combustion, as hereinafter explained.

As the width of the opening 32 diminishes, the end wall 28 presents a surface of increasing width to divert more and more of the compressed air to flow radially inwardly along the wall 28 through the space 90 between the wall 28 and the back side of the stator disc 78. It can be seen that the air flowing along this space 90 will flow into the bucket 22 over the compressor motor 68 to cool the compressor motor.

The end wall 26 of the bucket 22 in which the motor 68 is located is provided with a central opening 92 through which air can leave the bucket 22. This air leaving the bucket 22 then is available for cooling the chamber end wall 46.

Preferably, the motor housing bucket 22 is surrounded by a third bucket 94 to aid in shielding the motor 68 from radiant heat. This second bucket 94 has a plurality of holes 96 in the end wall thereof through which jets of cooling air can flow onto the chamber end wall 46. As these holes 96 would expose the motor 68 (particularly, the motor bearing) to radiant heat, a shield plate 98 preferably is mounted between the inner and

outer buckets 22, 94 on spacers 100 secured to the end wall 26 of the inner bucket.

With the arrangement just described, cooling air will flow radially inwardly along the heat exchanger end wall 28, around the compressor motor 68 and through the inner bucket opening 92, then around the edges of the shield plate 98 past the spacers 100. The air then will flow through the ports 96 in the outer bucket end wall 94 to impinge on and cool the chamber end wall 46, and then will pass into the space 102 between the bucket 94 and the heat exchanger inner turn to mix with the heated ventilating air going to the outlet pipes 104 through the opening 34 at the inner edge of the opposite end wall 30.

To provide combustion air for the burner 10, two alternative arrangements are shown. The first, shown in Fig. 1, comprises a duct 106 extending from an opening 107 in the shell 18 to the burner housing bucket 20. Alternatively, as shown in Fig. 4 (which is an end section view taken on a plane corresponding to the line X—X of Fig. 1), a duct 108 can be placed alongside the chamber 38 to communicate from the compressor motor bucket 22 to the burner housing bucket 20. Both arrangements have proved satisfactory in operation, although a modification such as shown in Fig. 1 is somewhat preferable for assembly.

In operation, the apparatus of Figs. 1–3 will draw in air through the inlet opening 76 to the compressor 14, and the air thus received will be forced radially outwardly on the rotor of the compressor. The air then will flow axially into the spaces 86 between the stator vanes, and from those vanes will be directed into the spaces 88 and 90 as already described.

The major part of the compressed air will pass around between the turns of the heat exchanger as indicated by the arrows A (Fig. 2), in counterflow relation to the combustion products flowing inside the exchanger, as indicated by the arrows B. The air thus heated will pass out of the heat exchanger 12 through the opening 34 in the end wall 30 into a duct 110 leading to the distributing pipes 104. The exhaust gases will be discharged through a cleanout box 112 and exhaust stack 114.

It can be seen that the present invention provides a unique arrangement for equalizing the heating of the heat exchanger inner turn, not only by exposing a much greater portion of the heat exchanger walls 40, 42 to the initial high temperature combustion products, but also by directing a cooling flow of air onto the surface (the end wall 46) most likely to be heated excessively. Such an arrangement is not feasible in the apparatus disclosed in the above-mentioned patent if the advantageous feature of counterflow between heating and heated gases is to be maintained. In other words, in the counterflow arrangement as disclosed in said patent, the ventilating air flowing over the heat exchanger surfaces has reached its highest temperature at the time it reaches the highest temperature portion of the heat exchanger surfaces. Therefore, it is not in a condition to supply the cooling effect that is found to be advantageous in the apparatus as described in the present application nor can the velocity and direction of flow be so well controlled.

I claim:

1. In a heating apparatus, in combination, an outer casing, a pair of inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end chambers joined by a substantially cylindrical central chamber, a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls forming continuations of the walls of the innermost turn of said heat exchanger and end walls adjacent

the innermost ends of said inner casing elements, a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in the other end of said outer casing adjacent the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor and said other inner casing element to direct air from said compressor into cooling engagement with the compressor motor and thence against the inner chamber end wall that faces said combustion-space-defining means, means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

2. In a heating apparatus, in combination, an outer casing, a pair of inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end chambers joined by a central chamber, a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls forming continuations of the walls of the innermost turn of said heat exchanger and end walls adjacent the innermost ends of said inner casing elements, a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in the other end of said outer casing, adjacent the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor to direct air from said compressor against the inner chamber end wall that faces said combustion-space-defining means, means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

3. In a heating apparatus, in combination, an outer casing, a pair of inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end chambers joined by a substantially cylindrical central chamber, a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls forming continuations of the walls of the innermost turn of said heat exchanger and end walls adjacent the innermost ends of said inner casing elements,

a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in the other end of said outer casing, adjacent the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor and said other inner casing element to direct air from said compressor into cooling engagement with the compressor motor means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

4. In a heating apparatus, in combination, an outer casing, a pair of inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end chambers joined by a substantially cylindrical central chamber, a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls forming continuations of the walls of the innermost turn of said heat exchanger and end walls adjacent the innermost ends of said inner casing elements, a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in said outer casing with the compressor motor disposed in the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor and said other inner casing element to direct air from said compressor into said motor-containing inner casing element to pass over and in cooling engagement with the compressor motor and thence against the inner chamber end wall that faces said combustion-space-defining means, means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

5. In a heating apparatus, in combination, an outer casing, a pair of bucket-shaped inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end chambers joined by a substantially cylindrical central chamber, a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls forming continuations of the walls of the innermost turn of said heat exchanger and end walls adjacent the innermost ends of said inner casing

elements, a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in said outer casing with the compressor motor disposed in the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor and said other inner casing element to direct air from said compressor into cooling engagement with the compressor motor and thence against the inner chamber end wall that faces said combustion-space-defining means, means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

6. A heating apparatus as defined in claim 5, including a third bucket shaped element surrounding and spaced from said motor-containing bucket shaped element to protect said motor from radiant heat, and a shield plate disposed between the inner ends of said motor-containing and third buckets.

7. A heating apparatus as defined in claim 5, wherein said means for conducting air to said fuel burner comprises a duct extending from said motor-containing casing element to said burner-containing casing element alongside said central chamber.

8. A heating apparatus as defined in claim 5, wherein said means to conduct air to said fuel burner comprises a duct communicating from the annular end chamber which is adjacent said other inner casing element to said burner-containing casing element.

9. In a heating apparatus, in combination, a substantially cylindrical outer casing, a pair of bucket-shaped inner casing elements disposed concentrically in opposite ends of said outer casing, end walls cooperating with said inner and outer casings to define within said outer casing and outside of said inner casings a pair of annular end

chambers joined by a substantially cylindrical central chamber, one of said end walls having an opening near its outer edge; a hollow spiral heat exchanger disposed within said outer casing in said central chamber and with its edges extending into said annular end chambers, wall means defining an inner chamber within said central chamber and encompassing a substantial portion of said central chamber, said wall means including side walls formed by the walls of the innermost turn of said heat exchanger and end walls adjacent the innermost ends of said inner casing elements, a fuel burner disposed at one end of said outer casing within one of said inner casing elements, said fuel burner including means defining a combustion space extending axially into said inner chamber through an opening in the adjacent inner chamber end wall, a motor-driven compressor in said outer casing with the compressor motor being disposed in the other of said inner casing elements, means cooperating with said compressor and said outer casing to direct air from said compressor through said end wall edge opening to the space between said outer casing and the outermost turn of said heat exchanger, means cooperating with said compressor and said other inner casing element to direct air from said compressor into said motor-containing casing element and thence against the inner chamber end wall that faces said combustion-space-defining means, means cooperating with said compressor to conduct air from said compressor to said fuel burner to supply combustion air thereto, duct means communicating with the space inside said outermost turn of said heat exchanger to conduct combustion gases out of said apparatus, and duct means communicating with the space between said one inner casing element and said innermost turn of said heat exchanger to conduct heated air out of said apparatus.

References Cited in the file of this patent

UNITED STATES PATENTS

2,410,547	McCollum	Nov. 5, 1946
2,447,373	Smoot	Aug. 17, 1948
2,454,511	Heyman	Nov. 23, 1948
2,488,548	McCracken	Nov. 22, 1949
2,517,446	Ryder	Aug. 1, 1950
2,579,507	McCracken	Dec. 25, 1951
2,600,020	Pietsch	June 10, 1952