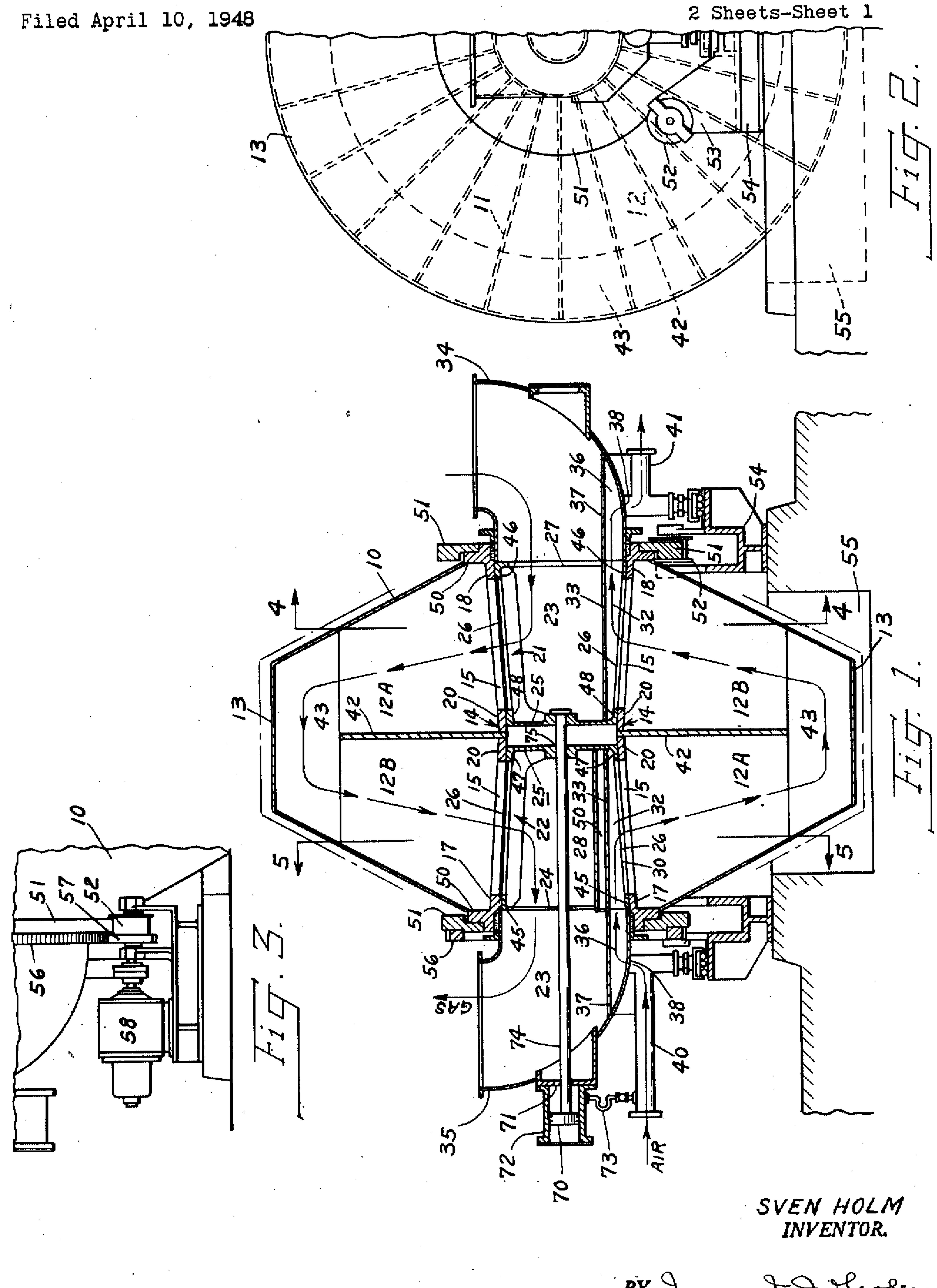
Feb. 6, 1951 S. HOLM **2,540,733**

RECOVERY OF PRESSURE FLUID IN HEAT EXCHANGERS

Filed April 10, 1948 2 Sheets-Sheet 1



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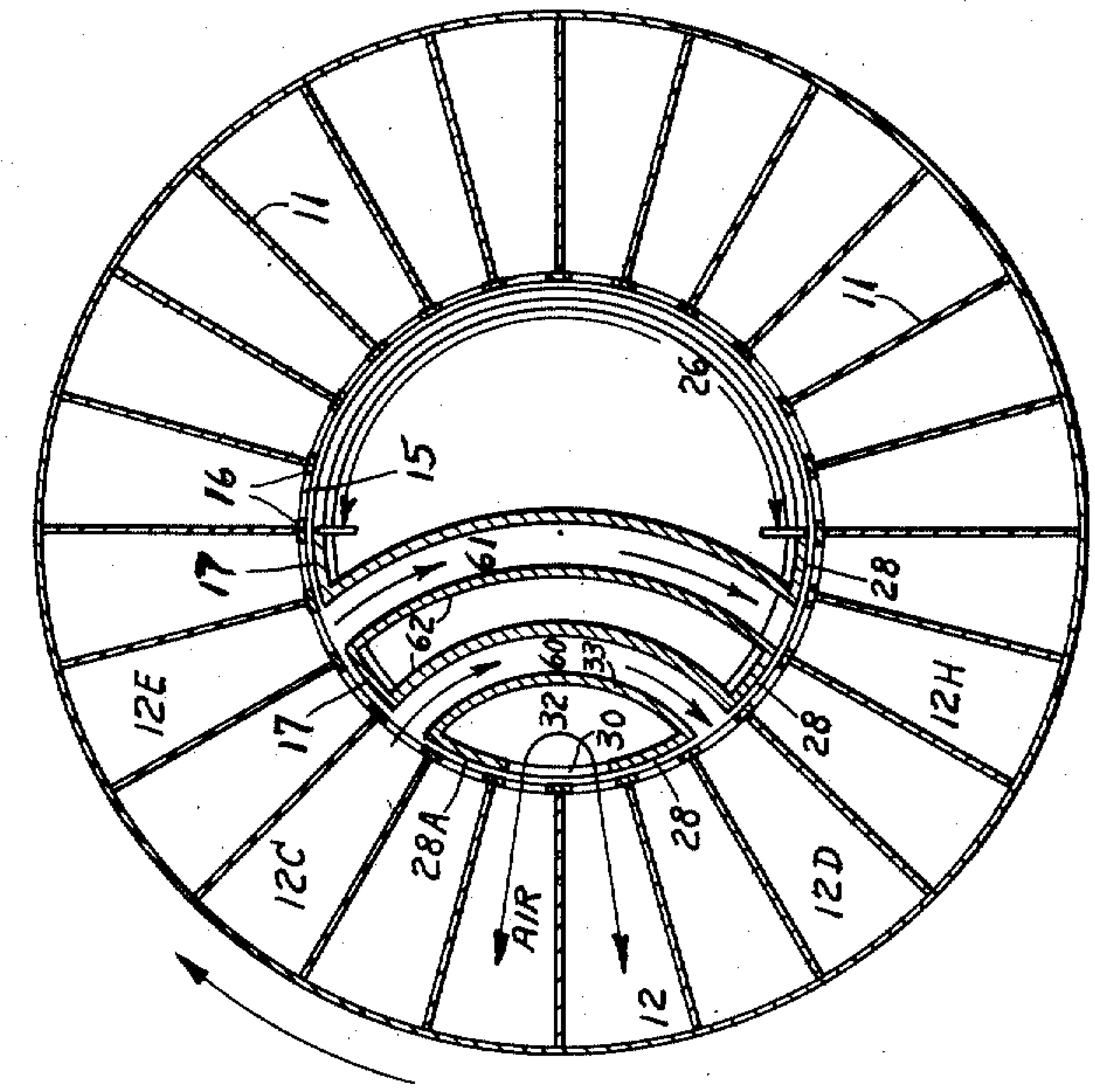

Fig. 5.

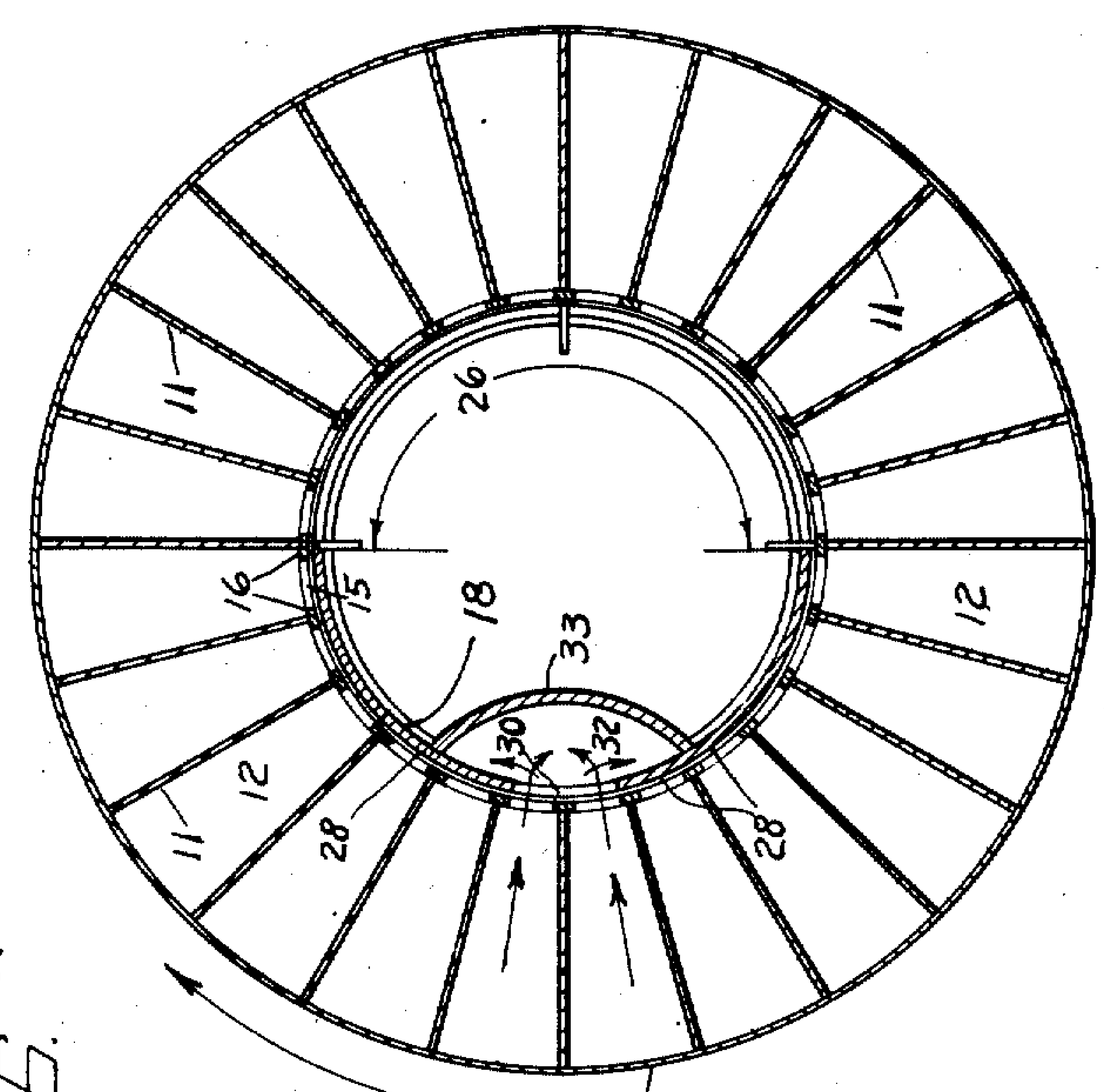

Fig. 4.

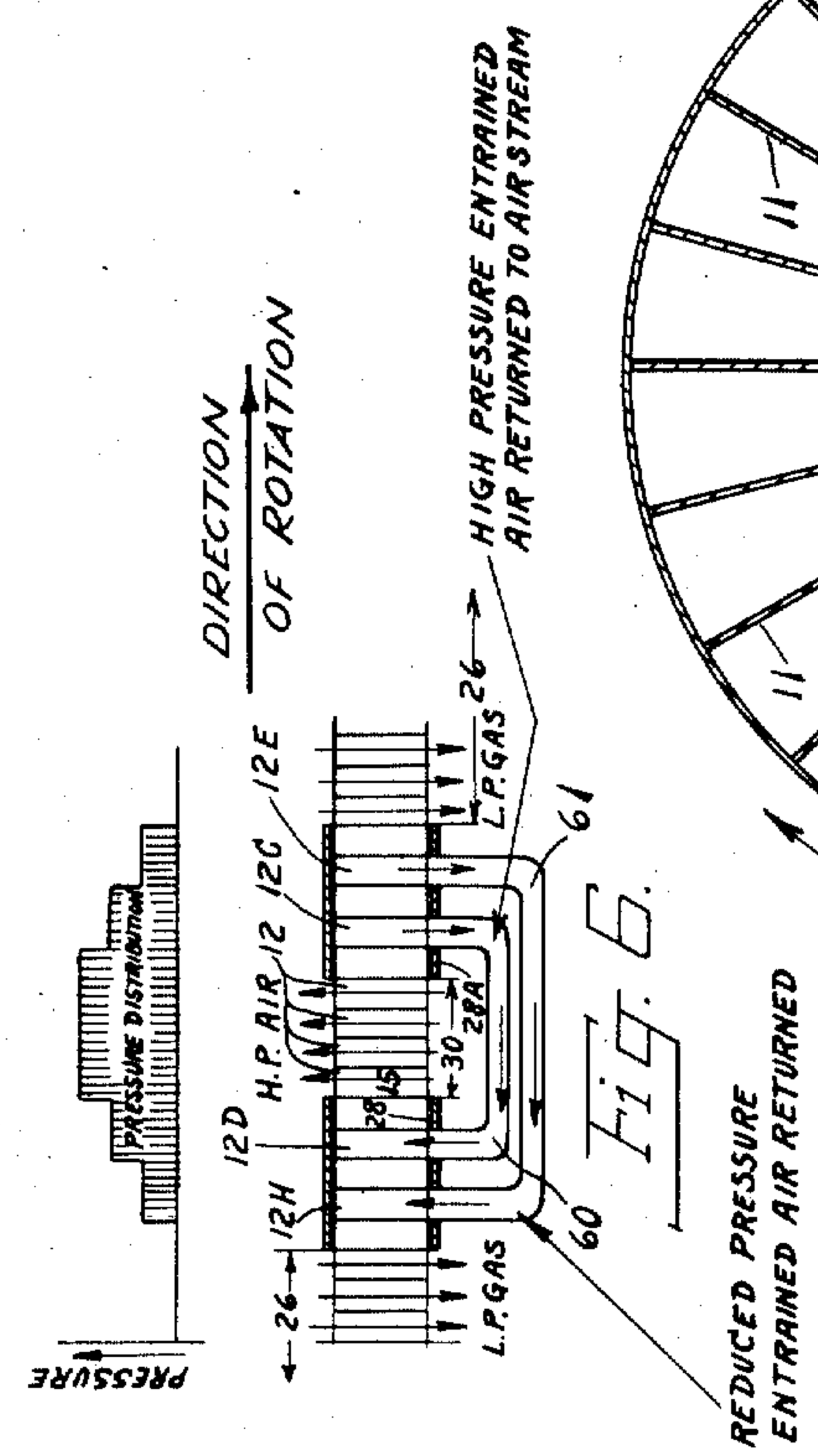

Fig. 6.

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RECOVERY OF PRESSURE FLUID IN HEAT EXCHANGERS

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3 Claims. (Cl. 257—6)

1

The present invention relates to heat exchange apparatus and particularly to improvements in apparatus such as regenerators for exchanging heat between the working medium and waste gases in a gas turbine cycle.

One form of heat exchange apparatus that may be employed in gas turbine cycles is the familiar rotary regenerative heat exchanger wherein a mass of heat storing material is carried in a rotor and first exposed to hot gases directed through the latter and then subsequently positioned in the path of the stream of air or other medium to be heated. However, because the medium to be heated in a gas turbine cycle is compressed air, the rotor of a regenerative heat exchanger entrains part of the high pressure air when the rotor leaves the air passages, and upon entering the low pressure gas compartment the trapped air expands into the gas. This results in losing a large portion of the work required to compress the air because one rotor full of compressed air is lost for each turn of the rotor.

It is the object of the present invention to provide means for substantially reducing the amount of compressed air lost due to entrapment in the rotor and at the same time reducing the direct leakage between the high pressure air stream and the low pressure gas stream by providing zones of intermediate pressure between the two streams.

The invention will be best understood upon consideration of the following detailed description of an illustrative embodiment thereof when read in conjunction with the accompanying drawing in which:

Figure 1 is a sectional elevational view taken along the axis of a rotary heat exchanger embodying the present invention;

Figure 2 is a partial end view of the apparatus shown in Figure 1;

Figure 3 is a fragmentary elevational view illustrating the means for turning the rotor;

Figures 4 and 5 are transverse sectional views through the rotor on the correspondingly designated section lines in Fig. 1; and

Figure 6 is a schematic view showing the relation between the rotor and return ducts for air and also illustrating the formation of zones of intermediate pressure between the high pressure air stream and the low pressure gas stream.

The apparatus embodies a rotor 10 of generally cylindrical exterior form which is interiorally divided by radially extending partition plates 11 (Figs. 2, 4, 5) into a plurality of compartments 12 that extend from the outside circular wall 13 of the rotor which is annular in cross-section to

2

the centrally located circular wall 14. In wall 14 there are formed ports 15 individual to each of the compartments 12 for admitting and discharging the air to be heated as well as the heating gas. In fact the "wall" 14 is made up mainly of webs 16 (Figs. 4, 5) located between the ports 15 and extending between the circular bands 17, 18 (Fig. 1) near the ends and the band 20 at the center of the rotor. Located in the space defined centrally of the rotor by the ported "wall" 14 are a pair of distributing valves 21, 22 which resemble plug valves in that each is formed with a passage 23 extending axially from the open outer end 24 of the core to near the inner imperforate end 25. A large port 26 (Figs. 3, 4) in the side wall of the core is of great enough circumferential extent to simultaneously be in communication with a majority of the rotor compartments 12 for the admission or discharge of heating medium.

Spaced circumferentially from either edge of the gas orifice 26 in the valves 21, 22 by the imperforate ligaments 28 of the side wall of the core is an air port 30 opening into the lune shaped passage 32 formed by the axially extending arched partition 33 located in the valve at the side of its axis opposite the gas port 26. At opposite ends of the rotor axis the two distributing valves 21, 22 are in direct communication with the inlet and outlet ducts 34 and 35 for gas. The air passages 30 in the distributing valves extend axially of the valves and are continued beyond the ends of the rotor as passages 36 formed within the ducts 34 and 35 at one side of their axes by the partitions 37. The air is supplied to and taken from the passages 36 through ports 38 in the outer walls of the ducts 34, 35 which are in communication with the air inlet and outlet pipes 40 and 41 respectively. The circular bands 17, 18 forming either end of the central wall 14 of the rotor and its middle band 20 bear against flanges 45—48 on the plug valves which serve as sealing surfaces between the rotor and the distributing valves.

The end plates 50 of the rotor have mounted thereon discs 51 which ride upon the rotor supporting rollers 52 that are journalled in brackets 53 mounted on the supporting beams 54 that extend parallelly along opposite sides of a pit 55 that receives the lower portion of the rotor 10. At one end of the rotor the supporting disc 51 (Fig. 3) has attached thereto a gear 56 meshing with a drive gear 57 driven by a motor 58.

The various compartments 12 of the rotor are divided into two parts designated 12A and 12B in Fig. 1 by the annular plate 42 attached to the inner wall 14 of the annular rotor and extending in the plane of its central axis outwardly to a point short of the outer wall 13 of the rotor so that a passage 43 is provided placing the two parts 12A and 12B of the compartments 12 in communication. With this arrangement, gas entering the central passage 23 in the valve 21 from the inlet duct 34 at the right flows laterally through the large port 26 into the compartment sections 12A then in alinement therewith, these constituting the greater portion circumferentially of the rotor. The heating gas flows outwardly in a radial direction through the compartments 12A and then through the end passage 43 and in a radially inward direction through the compartment section 12B and through the port 26 of the valve 22 into its central passage and axially of the latter to the outlet duct 35. The compartments 12 contain heat storing material which may be in the form of metal plates or any other appropriate type spaced to permit fluid flow and capable of picking of heat from hot gases and storing it temporarily so that it may be imparted to the air or other fluid. The air to be heated compressed to say, 60 lbs. passes from the supply duct pipe 40 at the lower left of Fig. 1 through the stationary passage 36 in duct 35 into the alined lune shaped passage 32 of the valve 22 and through its side wall port 30 into the parts 12A of the several compartments 12 that are in alinement therewith. In the same manner as the gas, the compressed air flows in a radially outward direction through the compartment section 12A and in a radial inward direction through the compartment section 12B, being discharged into the passage 32 of the other valves 21 and flowing axially through the alined passage 36 in duct 34 to be discharged finally through the outlet pipe 41. Instead of being actually cylindrical the rotor has tapered ends so as to provide a constantly proportional cross-sectional area to the volume of flow in sections 12A and also to provide a large frontal area for minimum pressure loss as the gas and air enter the rotor.

As mentioned previously, the air which remains in any of the compartments 12 of the rotor as they pass from communication with the air ports 30 in the distributing valves across the imperforate portions 28A of these valves is trapped and when the compartments become alined with the gas port 26 the air expands into the stream of gas with resultant loss of the work required for air compression. To avoid this loss of compressed air the distributing valve 22 at the high pressure end of the exchanger (left in Fig. 1) is formed with one or more passages (two being shown in Fig. 5) which extend back from a position on the valve 22 beyond the leading imperforate portion 28A to compartments 12 which have not yet come into registration with the air port 30 in the valve. These passages 60 and 61 are formed by arced plates 62 extending axially of the valve 22 between the side edges of imperforate portions 28, 28A of the valve located at either side of the air port 30. Thus while several compartments 12 (two as shown in Figs. 4 and 5) are in communication with the air supply port 30 in the valve 22, a compartment circumferentially spaced from this group in the direction of rotation and designated 12C in Fig. 5 is in direct communication through the passage 60 with another compartment 12D which has not yet moved into registration with the air port 30. When more than one return flow passage is provided, other compartments such as 12E still further forwardly of the air port 30 and one 12H rearwardly thereof are in communication with each other through the passage 61.

Thus, as the rotor turns, hot gas first flows through the greater number of compartments 12 in the rotor and imparts heat to the heat storing material therein. Compressed air flows over already heated material in the lesser number of compartments 12 then in registration with the ports 30 of the valves 22 and 21 and picks up heat from the packing. As each compartment leaves the air stream, compressed air is trapped therein as its port 15 is closed off by the imperforate portion 28A located on the valve forwardly of its air port 30. As the rotor turns further the compartments in which air has been trapped then register one by one with the passage 60 and the air which is at high pressure flows through the latter as from the compartment 12C into the compartments 12D until pressure is equalized. Further turning of the rotor brings these partly evacuated compartments into the position designated 12E in Fig. 5 and places each in turn in communication through the passage 61 with the compartment 12H located further rearwardly beyond the compartment 12D and therefore at a lower pressure. This compartment 12H is at relatively low pressure since it has just moved from communication with the gas port 26 in which the pressure may be of the range of 15 lbs. Here also pressure equalization takes place between the two sectors 12E and 12H and a gradual decrease in pressure is obtained as shown diagrammatically in Fig. 6. It will also be apparent that direct leakage between the air side of the heat exchanger and the gas side is reduced because the air volumes returned to compartments 12D and 12H are at pressures somewhat higher than in compartments rearwardly thereof. Thus, each forms a pressure zone creating a fluid seal between the high pressure air stream and the lower pressure gas stream. A substantial portion of the air carried beyond the air port 30 is returned to sectorial compartments in which a lower pressure exists since they have just moved from the gas stream and thus this amount of air is carried back into the main air stream. The heat imparted into this volume of air is recovered as is the work of compression.

The distributing valves 21, 22 have their sealing surfaces 46, 48 and 45, 47 urged into contact with the sealing surfaces 18, 20 and 17, 20 on the rotary casing 10 by air pressure acting against the piston 70 and end wall 71 of a piston cylinder 72 which is connected by a pipe 73 with the pressure air inlet duct 40. Force applied against the piston 70 draws the valve 21 to the left by means of the rod 74 which extends freely through the orifice 75 in the end wall 25 of the valve 22. It will be noted that the cylinder 72 is integral with the gas outlet duct 35 and hence the reaction of the air under pressure in the cylinder 22 against the end wall 71 forces the outlet pipe 35 to the right and the latter, engaging the outer end of the valve 22, presses the surfaces 45 and 47 thereof into contact with the sealing surfaces 17, 20 on the inner circular wall of the annular casing.

What is claimed is:

1. In heat exchange apparatus having a cylindrical casing divided by radial partitions into circumferentially spaced sector shaped compartments having inlet and outlet means for admis-

sion and discharge of fluids to flow over heat exchange material contained in said compartments; fluid distributing means having fluid admission and discharge ports in communication with a group of contiguous compartments for flow of a heating fluid therethrough and other ports circumferentially spaced and separated from the ports for said first fluid for flow of a fluid to be heated in communication with another group of adjacent compartments that are spaced circumferentially of said casing and separated from said first group of compartments; means for rotating said casing and fluid distributing means relatively to each other for passing said two fluids in succession through each of said compartments; and means forming a passage disposed between said two sets of ports adapted to register with said compartments for placing a compartment circumferentially located beyond the admission port for said fluid to be heated, in the direction of rotation, in communication with a compartment circumferentially located in advance of said port for returning volumes of the fluid to be heated from said first compartment to said other compartment upon movement of said one compartment from registration with the port for said fluid to be heated into registration with said passage.

2. In heat exchange apparatus; an annular casing formed by spaced circular wall members bridged by end closures; radial partitions dividing the interior of said casing into sector shaped compartments; inlet and outlet means for fluid admission formed in the inner circular wall of said casing for the flow of fluids over heat exchange material contained in said compartments; fluid distributing valve means fitting the central space of said annular casing having a fluid distributing inlet and outlet ports for a heating fluid in simultaneous communication with a group of contiguous compartments and other ports spaced circumferentially from said first ports for a fluid to be heated in communication with another group of adjacent compartments that are spaced circumferentially and separated in said casing from said first group of compartments; means for rotating said casing and valve means relatively to each other for passing said two fluids in succession through each of said compartments; and means forming a passage located in said valve means between said ports for placing a pair of compartments respectively located at opposite sides of said second group and disposed intermediate said two groups at either side of said second mentioned ports in communication with each other for returning volumes of said fluid to be heated from one compartment of said pair to the other compartment upon movement of said one compartment from registration with said other port of said valve means.

3. In heat exchange apparatus having a casing divided internally by partitions into compartments having inlet and outlet means for admission and discharge of fluids that flow over heat exchange material contained in said compartments, fluid distributing means movable relatively to said compartments having fluid admission and discharge ports in communication with a group of contiguous compartments for flow of a heating fluid therethrough and other ports spaced and separated from ports for said first fluid for flow of a fluid to be heated in communication with another group of adjacent compartments that are spaced in said casing and separated from said first group of compartments; means for moving said casing and fluid distributing means relatively to each other for passing said two fluids in succession through each of said compartments; and means forming a passage disposed between said two sets of ports adapted to register with said compartments for placing a compartment located beyond the admission port for said fluid to be heated, in the direction of movement, in communication with a compartment located in advance of said port for returning volumes of the fluid to be heated from said first compartment to said other compartment upon relative movement of said one compartment from registration with the port for said fluid to be heated into registration with said passage.

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