Aug. 30, 1949. W. D. YERRICK 2,480,277

TWO-PASS REGENERATIVE AIR PREHEATER

Filed Aug. 22, 1946

Fig. 2

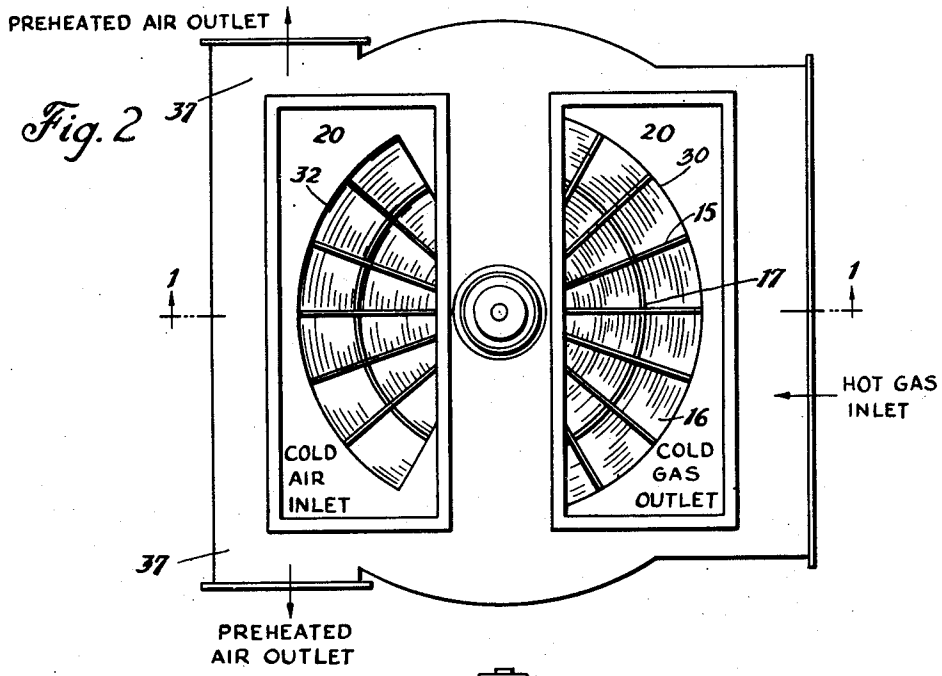


Fig. 1

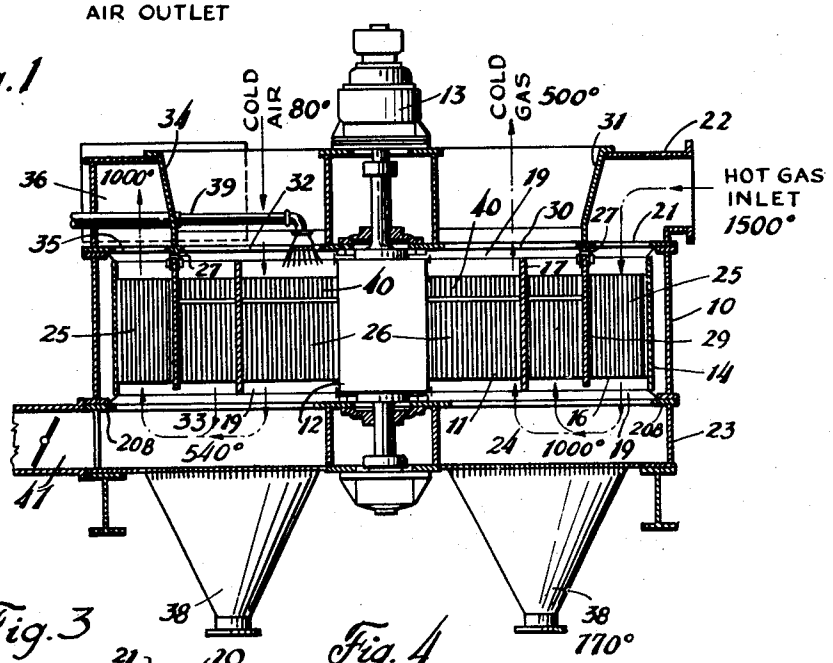


Fig. 3

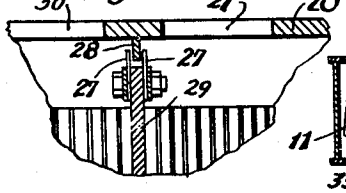
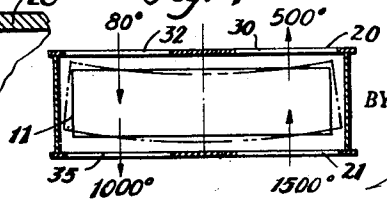


Fig. 4



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TWO-PASS REGENERATIVE AIR PREHEATER

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4 Claims. (Cl. 257—6)

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The present invention relates to heat exchange apparatus and particularly to improvements in a regenerative heater of the rotary type.

Rotary regenerative heaters such as those of the Ljungstrom type comprise a rotor carrying heat transfer material which is first moved through a gas passage to absorb heat and then moves through an air passage to impart heat to the air which flows through the preheater in counterflow with respect to the heating medium. The gas and air ducts in such a preheater are in communication to openings in sector plates at the opposite ends of the rotor and the latter is divided by radial partitions into a plurality of wedge-shaped compartments in which the heat transfer material in the form of plates are mounted. To prevent mingling of the streams of gas and air the partitions are conventionally provided with sealing members which bear against the opposing faces of the sector plates to seal the gas and air passages from each other. However, because the rotor turns at relatively slow speed it becomes unequally heated since it is exposed on one side of its axis of rotation to the heating gases and on the other to cold air or other fluid to be heated, and further the heat exchange process necessarily entails a considerable differential between the temperatures of the entering and leaving gas and air streams at the inlet and outlet ends of the rotor. All of this has the effect of causing a bulging or distortion of the rotor which displaces the sealing members from good sealing contact with the sector plates.

An object of the present invention is to provide an improved preheater construction in which distortion of the rotor due to temperature differentials is minimized with resulting improvement in the effectiveness of the sealing members.

Another feature of the present invention is a heat exchanger construction in which the effects of corrosion on the certain sections of the heat transfer plates due to cooling by the gases is minimized.

Other features and advantages of the present invention will become apparent 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 elevation of a Ljungstrom type preheater embodying the present invention;

Figure 2 is a plan view corresponding to Figure 1;

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Figure 3 is a fragmentary view on an enlarged scale illustrating a sealing device; and

Figure 4 is a diagrammatic view illustrating the distortion of a preheater rotor due to temperature differentials between its inlet and outlet ends.

In the drawings the numeral 10 designates the preheater housing within which is mounted a rotor designated as a whole by the numeral 11 adapted to be slowly rotated within the housing on its axis 12 by a motor 13 operating through reduction gearing. Conventionally the rotor 11 consists of a cylindrical shell 14 connected by radial partition plates 15 to the rotor post 12. The radial partitions divide the interior of the rotor into wedge-shaped compartments each of which contains a multiplicity of spaced metallic plates 16 which absorb heat from hot gases passed thereover and then impart it to air or other fluid to be heated. Usually the wedge-shaped compartments are subdivided by circumferential diaphragms 17.

Conventionally the heating gases and the air to be heated flow countercurrent to each other at opposite sides of the axis 12 of the rotor, being admitted to and taken from the housing 10 through ducts connected into openings in the sector plates 20 mounted on the housing 10 at opposite ends of the rotor as indicated in Figure 4. With heating gas entering at say 1500° F. and being discharged at 500° F. while air enters at 80° F. and is heated to 1000° F. it will be seen that there is a temperature differential of 1000° between the gas inlet and discharge ends of the rotor and nearly as great a difference between the air inlet and outlet sides of the rotor. As a result, the rotor is hot at one end and cool at the other so that unequal expansion takes place causing a distortion of the rotor as a mass, which dishes it somewhat as indicated in Figure 4. A consequence of this is that the parts of the radial seal members 19 on the radial partitions 15 are withdrawn from proper wiping contact or like cooperation with the imperforate portions of the sector plates 20 and the gases may leak into the air stream by crossing over in the space between the ends of the rotor and the opposed faces of the sector plates.

According to the present invention the rotor 11 is provided at a point inwardly of the shell 14 with a circular partition 29 which divides the rotor into inner and outer annular sections 25, 26 radially spaced from each other. Partition 29 is positioned at a radial location such that the flow area is substantially the same in the inner

and outer sections, or somewhat greater in the latter to accommodate larger volumes of hot gas and heated air. On the upper end edge of this circular partition there are mounted circular sealing strips 27 which cooperate with a similar strip 28 (Figure 3) depending from the under side of the sector plate opposite the top end of the rotor. A special end plate 20 takes the place of the usual sector plate at the upper end of the rotor, being formed with an aperture 21 at the outer side of partition 27 and above section 25 of the rotor to provide for the admission at the upper end of the rotor of hot gases supplied through a duct 22 connected to the upper end of the housing 10. Beneath the rotor 11 an extension 23 of the housing 10 forms a chamber 24 so that gas flowing downwardly over the heat exchange plates 16 in the outer section 25 of the rotor may pass around the lower end of the circular partition 29 and reversing its direction flow upwardly over the heat exchange plates in the section 26 of the rotor to be discharged through an opening 30 in the end plate 20 into a gas outlet duct 31 suitably connected to the upper end of the housing inwardly of the gas inlet duct 22 and between the latter and the rotor post 12.

The air side of the heat exchanger is of generally similar construction, the cold air being admitted however to the inner section 26 of the rotor on the opposite side of the rotor post through an inlet duct 34. The air flows through sector opening 32 and downwardly through section 26 to reverse its direction in a chamber 33 on the opposite side of the rotor post from the chamber 24 and then flows upwardly over the heat exchange plates in the outer section 25 of the rotor through sector opening 35 into a chamber 36 located on the top of the housing 10. In the arrangement shown the heated air is taken from the chamber 36 through the dual outlet ducts 37 connecting into the ends of chamber 34.

The sector plate 20B opposite the lower end of the rotor has only a pair of apertures, one each on the gas and air sides and separated by the usual imperforate portion against which the radial seals 19 bear.

An auxiliary offtake duct 41 connected to chamber 33 permits heated air to be taken from this chamber of the preheater for uses requiring a temperature less than the maximum afforded by passage of air through section 25 as well as section 26.

Hoppers 38 are provided on the underside of the housing in communication with the chambers 24 and 33 to receive fly ash, dust and other material that may be separated out in the reversal of direction of flow of the gas and air and also to receive soot and other impurities cleaned from the rotor by a cleaning apparatus 39 on the air side.

The construction above described minimizes distortion of the rotor as a consequence of temperature differentials between the upper and lower sides thereof. This is due to the fact that the streams of gas and air by flowing in two passes over the heating elements 16 in the rotor produce more equalized temperatures at opposite ends of the rotor 11 than is the case where the stream of gas, with counter-current air, is admitted, for example, at the under side of the rotor and after passing over the heat exchange material is discharged at the upper end thereof as shown in Figure 4. Herein for example, gas admitted to the inlet 22 at say 1500 degrees F.

could be reduced to 1000° F. in the chamber 24 as a result of passing over the heat exchange plates 16 in the outer section 25 of the rotor. Then in passing through the inner section 26 of the rotor the temperature of the gases would be further reduced to say 500° F. with the result that the mean temperature of the rotor both on the upper and lower sides thereof would be approximately 1000° F. Likewise on the air side of the rotor air entering at a temperature of 80° F. would be heated to say 540° F. in passing through the inner section 26 of the rotor and further heated to 1000° F. in passing upwardly over outer section 25 of the rotor. Here also a mean temperature of approximately 540° F. would exist both on the upper and lower sides of the rotor on the air side thereof. As a consequence of this, distortion of the rotor due to extreme temperature differences between its upper and lower sides is considerably reduced.

Another advantage of the invention is that cleaning of the heat exchange plates 16 is facilitated since it is necessary to wash or blow air or steam through a relatively short distance that amounts to only one half or less of the depth of heating surface that would be required in a conventional type heater where fluids are admitted to one end of the rotor and passing once therethrough are discharged from the opposite end. A concomitant advantage is that the cleaning of the rotor may ordinarily be limited to its inner section 26. This is the section of the rotor containing the so-called cold end elements, i. e., those contacted by the coolest gases and the colder air. The construction described also localizes in the center section of the rotor those heat exchange plates 40 which may be subjected to the greatest cooling action and thereby reach a temperature below the dew point of the gases so that corrosion takes place. Thus, a further advantage is that if the heat exchange plates do become clogged and corroded the amount of surface that need be replaced is minimized and substantially less than would be the case in the conventional heater because the upper ends of the outer sections 25 are no longer involved. Inasmuch as the depth of the surface to be replaced or cleaned is reduced by one half compared with that of the conventional heater, it is possible to obtain higher heat recovery from the gases and risk cooling them to a temperature below the dew point because although condensation and resultant deposits of corrosive elements may possibly occur, the damage is minimized since the amount of surface that need be replaced is substantially less than in previous constructions.

What is claimed is:

1. In apparatus of the type described having a housing containing a rotor turning about a vertical axis; partition means dividing said rotor and housing into inner and outer annular sections; inlet and outlet ducts for one fluid connected to said housing at the upper end thereof at one side of said rotor axis and communicating respectively with the outer and inner sections of said rotor; means forming a chamber in said housing below said rotor in communication with both the inner and outer sections of said rotor at said one side of said axis so said one fluid may flow in series through said sections via said chamber; inlet and outlet ducts for another fluid connected to said housing at the upper end thereof at the opposite side of said rotor axis; means forming a second chamber interconnecting the

lower ends of the sections of said rotor at the opposite side of said axis for series flow of said second fluid therethrough; fluid sealing means associated with said housing and said rotor located between said fluid inlets and related outlets; and means maintaining the streams of fluid separated.

2. In a rotary regenerative heat exchanger having a housing containing a rotor carrying heat transfer material; partition means in said rotor sub-dividing it into a pair of parallelly arranged sections for fluid flow therethrough; fluid sealing means associated with said housing and said rotor located between said parallel flow sections at one end of the rotor; inlet and outlet ducts for a heating gas so connected to said housing at one end of the rotor as to communicate with corresponding ends of said sections; means forming separate stationary chambers at opposite sides of the rotor axis at the opposite end of said rotor for placing said parallel rotor sections in fluid communication with each other at their opposite ends whereby fluid flows through said rotor sections in series; inlet and outlet ducts for air or other fluid to be heated both connected to said housing at one end thereof for passing air through said sections in series; and cooperating sealing means on the rotor and housing for maintaining the streams of heating fluid separated from the stream of fluid to be heated.

3. In a rotary regenerative heat exchanger having a housing containing a rotor carrying heat exchange material; a circular partition dividing the rotor into inner and outer annular sections; cooperative fluid sealing means between said partition and said housing at one end of the rotor; gas inlet and outlet ducts connected at one side of the rotor axis to said housing at one end of the rotor for admitting a heating gas to one of said sections and for withdrawing it from the other; inlet and outlet ducts spaced circumferentially of said housing from said first ducts and connected to said housing at the opposite side of said axis for admitting and withdrawing air or other fluid to be heated; means forming separated chambers positioned at opposite sides

of said rotor axis at the opposite end of the rotor in communication with both annular sections of the rotor so that fluid flowing through one annular section passes through the adjacent chamber to flow in series through the other annular section of said rotor; and means maintaining the gas stream separated from the air stream.

4. In apparatus of the type described having a housing containing a rotor turning about a vertical axis; circular partition means dividing said rotor and housing into inner and outer annular sections; cooperative fluid seals between the upper end of said partition and said housing; inlet and outlet ducts for a heating gas connected to said housing at the upper end thereof at one side of said rotor axis and communicating respectively with the outer and inner sections of said rotor; means forming a chamber in said housing below said rotor in communication with both inner and outer sections of said rotor so said gas may flow in series through said sections via said chamber; inlet and outlet ducts for air connected to said housing at the opposite side of said rotor axis; means forming a second chamber interconnecting the lower ends of the sections of said rotor for series flow of said air therethrough; means maintaining the streams of gas and air separated; and hoppers connected to the bottoms of said chambers for receiving material separated from said streams of gas and air as the streams flowing downwardly through the outer sections of said rotor change direction in said chamber to flow upwardly through the inner sections of said rotor.

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