July 3, 1951 S. HOLM 2,558,752

REGENERATIVE HEAT EXCHANGER

Filed July 9, 1948 2 Sheets-Sheet 1

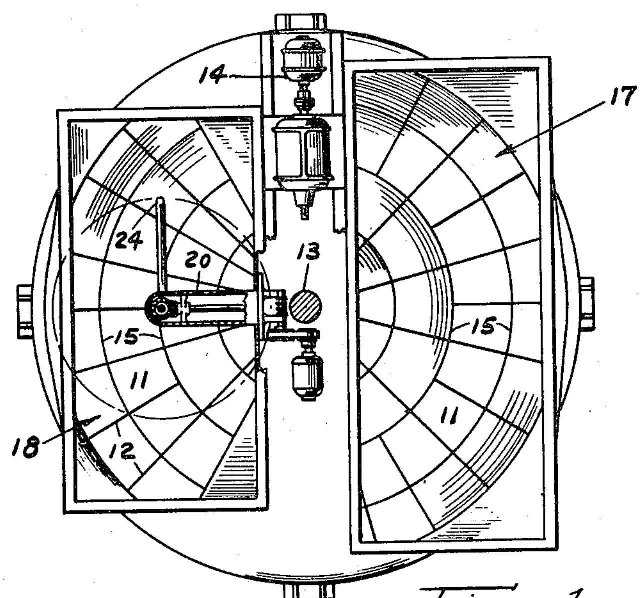

Fig. 1.

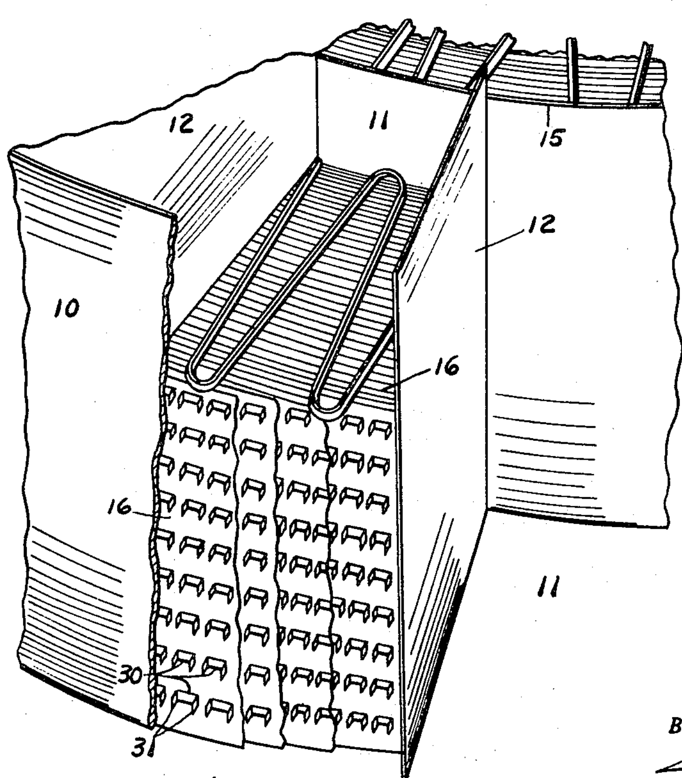

Fig. 2.

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Filed July 9, 1948 2 Sheets-Sheet 2

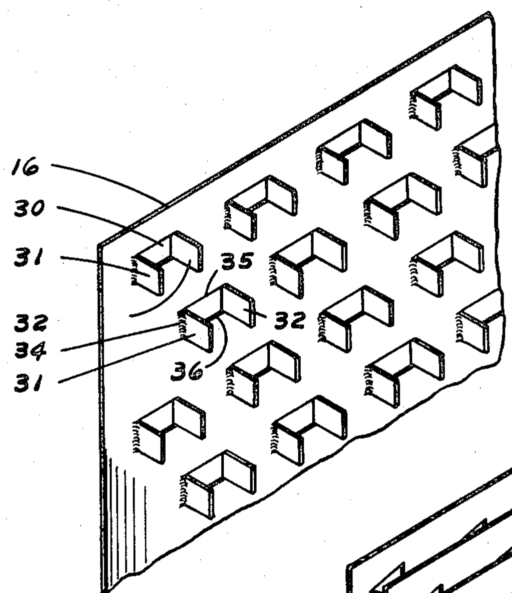

Fig. 3.

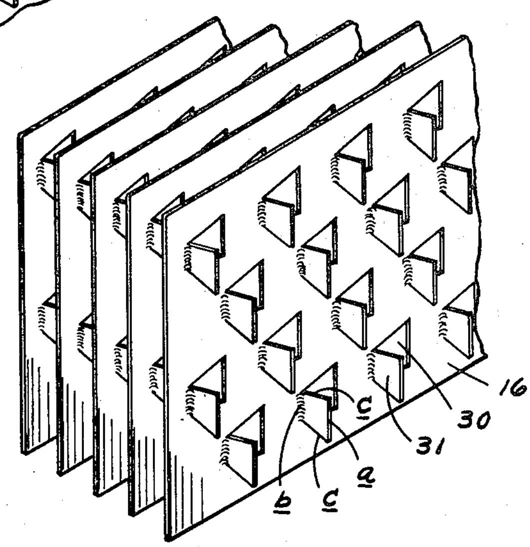

Fig. 4.

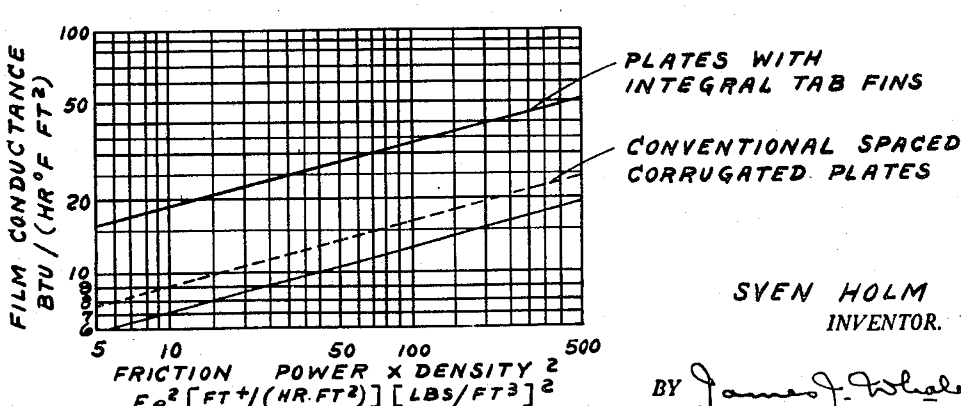

Fig. 5.

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REGENERATIVE HEAT EXCHANGER

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4 Claims. (Cl. 257—6)

1

The present invention relates to heat exchange apparatus and particularly to improvements in the heat absorbing surface of regenerative air preheaters.

A conventional regenerative air preheater of the Ljungstrom type includes a rotor carrying heat absorbing surface in the form of metallic plates that are first positioned in a gas passage to absorb heat and then upon turning of the rotor become disposed in the air passage to impart heat to air flowing therethrough. Such heat absorbing surface requires periodical cleaning to remove ash and other impurities deposited thereon by the gases and for this purpose it is customary to use cleaning nozzles that provide streams of compressed air or high pressure steam jets. It has been noted that the elements, particularly at the hot end of the preheater, sometimes rupture and break and it has been discovered that this breakage is due to the force imposed by the high pressure streams of cleaning fluid, particularly when utilizing steam which, upon entering the channels between the plates expands and creates a separating force on the plates thereby causing stresses which, in combination with shock and vibrations imparted to the plates, results in their rupture. An object of the present invention is to overcome this disadvantageous condition and the manner in which it is carried out will be best understood upon consideration of the following detailed description when read in conjunction with the accompanying drawings in which:

Figure 1 is a plan view of a regenerative type air preheater equipped with washing nozzles.

Figure 2 is a fragmentary perspective view on an enlarged scale of part of the heater shown in Fig. 1 illustrating the novel heat absorbing surface embodying the present invention;

Figure 3 is a further enlarged fragmentary perspective view showing an alternative form for the heat exchange plates;

Figure 4 illustrates a monolithic heat exchange mass made up of heat exchange plates embodying the invention; and

Figure 5 is a diagram illustrating the heat exchange efficiency of the present plates as compared with conventional corrugated or undulated plates.

In the drawings, the numeral 10 designates the cylindrical shell of a rotor which is divided into sector shaped compartments 11 by radial partitions 12 connecting it with the rotor post 13. A motor and reduction gearing 14 connected to the rotor post turn the rotor slowly about its axis. The rotor compartments 11 which may be further

2

subdivided by a circumferential partition 15 contain regenerative heat transfer material in the form of metallic plates 16 which are spaced apart to form narrow passages parallel to the rotor axis. The plates 16 first absorb heat from hot gases flowing through the gas passage 17 of the preheater and, as the rotor turns slowly about its axis, the heated plates 16 are moved into the stream of air flowing through the air passage 18 to which a forced draft fan (not shown) is connected. After passing over the plates 16 and absorbing heat therefrom the stream of air is conveyed to a boiler furnace or other place of use. A soot blower 20 has one or more rotary nozzles 24 disposed above the rotor so that jets of cleaning fluid under pressure may be directed into the passages between the plates for cleaning them as disclosed in the patent to Waitkus, 2,355,021, issued August 1, 1944.

In accordance with the present invention the heat exchange plates 16 are each formed, preferably over their entire area, with a plurality of relatively small perforations 30 shown as arranged in parallel rows. These perforations are illustrated as of rectangular shape and are created by cutting through the plate material along opposite edges of the apertures and bending up the plate material so that the rectangular tab portions 31 which formerly filled the apertured portions of the plates project at right angles from the plate surface. In the form shown in Figs. 2 and 3 two tabs 31, 32 are created adjacent each aperture by slitting the mid-portion of the material from the aperture parallel to its side edges 34 as well as along its top and bottom edges 35, 36 thus dividing the tab into two parts hinged at opposite edges of the perforation. In Fig. 4 the tabs 31 are connected to the body of the plate 16 only at one side edge 34 of the aperture 30.

When mounted in the compartments of a rotary regenerative air preheater, either throughout the height of the latter or, alternatively, only in the hot end section heat exchange plates embodying the present invention provide a heat absorbing surface which eliminates the stresses and shocks imposed on the plate material due to entry of high pressure steam into the passages between the plates as has been experienced heretofore because with the present plates the apertures 30 permit the steam to expand and pass through the plates instead of becoming confined and exerting a pressure on the surface of plates which strains them, subjects them to shock and vibration and eventually disrupts them. In addition to this, the tabs 31, 32 extending from the surfaces of the plates 16 serve useful functions, one being to act as spacers for holding the plates in properly spaced relation to form passages through the heat exchange mass without the use of specially provided separators.

A further important function performed by the tabs 31, 32 is to increase the effectiveness of the heat exchange surfaces because they act as integral extensions of the plates and a greater efficiency is obtainable than when the heat is exchanged merely by contact with the streams of fluid flowing in film contact with the plate surface itself. The fact that the planar surface is interrupted at intervals by the tabs maintains a thin boundary layer that does not impede heat transfer. In this form also more of the plate material is actually disposed in the stream of gases and by staggering the tabs projecting from the apertures as illustrated in Fig. 3 further efficiency is attainable because the streams of gases and air are continually interrupted and divided by contact with the staggered tabs in their passage through the rotor. The fin-like tabs 31, 32 which are in alinement form interrupted strip fins in two planes extending both in the direction of gas flow and transversely thereof, considering the wider faces of the tabs as cross-sectional portions of transverse fins. To function effectively as heat transfer surface the tabs should extend in closely spaced relation parallel to the direction of flow to provide free lanes therebetween for the flow of gases without producing an undesirable draft loss or causing useless turbulence since this is not desired.

A comparison of the heat exchange efficiency of the present plates as compared with conventional Ljungstrom undulated plates is shown in Fig. 5 wherein "film conductance" is plotted against the product of "friction power" by the gas "density" squared. A concomitant advantage of this marked increase in heat transfer efficiency is that for a given recovery the amount of plate surface of like gauge material required in a preheater is reduced by approximately fifty per cent (50%). This permits the height of the preheater rotor to be reduced (about 20%) or its diameter correspondingly lessened and its volume decreased (to about 68%). At the "cold end" greater heat transfer may be attained by increasing the gauge of the plates while at the same time reducing their height. In addition to the saving in cost of plate material the weight of the preheater assembly is less with the result that a saving may also be effected in the structural steel supporting the unit. Less power also is required to operate the unit for driving it. In operation the power for the requisite fans would not be appreciably greater because the increase in heat transfer efficiency is effected without producing a greater resistance through the heat transfer surface or greater draft loss.

By stacking in contact with each other a number of plates 16 sufficient to fill one of the rotor compartments 11 or a sub-division thereof and then bonding them together, as by dipping in a brazing bath etc. a unitary heat exchange mass may be produced. This mass would be a unitary structure having a series of passages for gas flow parallel to the axis of the rotor which passages would be created by the spacing function of the tabs 31, 32 and would be cross-connected by the plate perforations 30. In addition to its heat exchange qualities such masses would have the considerable advantage of greatly reducing the time of erection of a preheater because a single block would be quickly deposited in each rotor section instead of a large number of separate plates that require individual handling or special bundling.

Figure 4 also illustrates a fin construction in which the metallic tab 31 is trapezoidal in form, having tapered and divergent side edges *c* which made the distal end *a* wider than the hinged end *b*. This facilitates the stacking of a number of plates since the distal ends *a* being wider than the major part of the perforation prevent the tabs or fins 31 from slipping inadvertently through perforations in adjacent plates.

Another advantage is presented by this form of surface. In a counterflow heat exchanger, heat always flows from the hot end of the heating surface to the cold end of the surface. This condition lowers the effectiveness of the heat exchanger and the amount of heat flowing this way is a function of the length of the path of flow. It is therefore evident that with the present surface the heat flow path for a given depth of surface is longer. Due to the surface being interrupted by the perforations the possible path for flow of conducted heat is not direct but because of the perforations becomes tortuous and therefore considerably longer. The cross-sectional area for conducted heat flow is also reduced. Hence less heat flows uselessly along plates and the heat flow area is also restricted between the perforations.

What I claim is:

1. In a regenerative air preheater or the like having a cylindrical rotor divided by partitions into compartments that carry heat transfer material; a pressurized fluid jet apparatus disposed and arranged for cleaning said material; heat transfer plates disposed in said compartments parallel to the direction of fluid flow and closely spaced to form narrow fluid passages therebetween axially of the rotor, each plate being formed over substantially its entire area with a myriad of perforations uniformly distributed over the plate area in parallel rows permitting passage of fluid between said passages laterally through the plates for minimizing pressure effects on the plates caused by the cleaning jets.

2. In a regenerative air preheater or the like having a cylindrical rotor divided by partitions into compartments that carry heat transfer material; heat transfer plates serving as primary surface disposed in said compartments parallel to the direction of fluid flow and closely spaced to form narrow fluid passages, each plate being formed over substantially its entire area with a myraid of closely spaced perforations arranged in parallel rows and the plate material from the perforations remaining to constitute tabs attached to the body of the plate along at least one edge of each aperture and being bent to extend therefrom into the passages provided between the plates for fluid flow and lie in planes parallel to the direction of fluid flow.

3. A monolithic primary heat exchange mass comprising a plurality of metallic plates each formed over substantially its entire area with relatively small apertures uniformly distributed in parallel rows the material from which remains as tabs attached at one edge of the apertures to the plates and is bent out perpendicular to the surface thereof to contact an adjacent plate for spacing adjacent plates to form fluid passages therebetween, the plates being bonded, as by brazing, into a unitary mass.

4. In a regenerative air preheater or the like

having a cylindrical rotor divided by partitions into compartments that carry heat transfer material; heat transfer plates disposed in said compartments parallel to the direction of fluid flow and closely spaced to form narrow fluid passages therebetween axially of the rotor, each plate being formed over substantially its entire area with a myraid of perforations uniformly distributed in parallel rows over the plate area permitting passage of fluid between said passages laterally through the plates; and spacer means extending axially of the rotor between said plates for separating the latter to form said fluid passages.

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