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2,742,269

RECUPERATOR

Filed Aug. 12, 1952

2 Sheets-Sheet 1

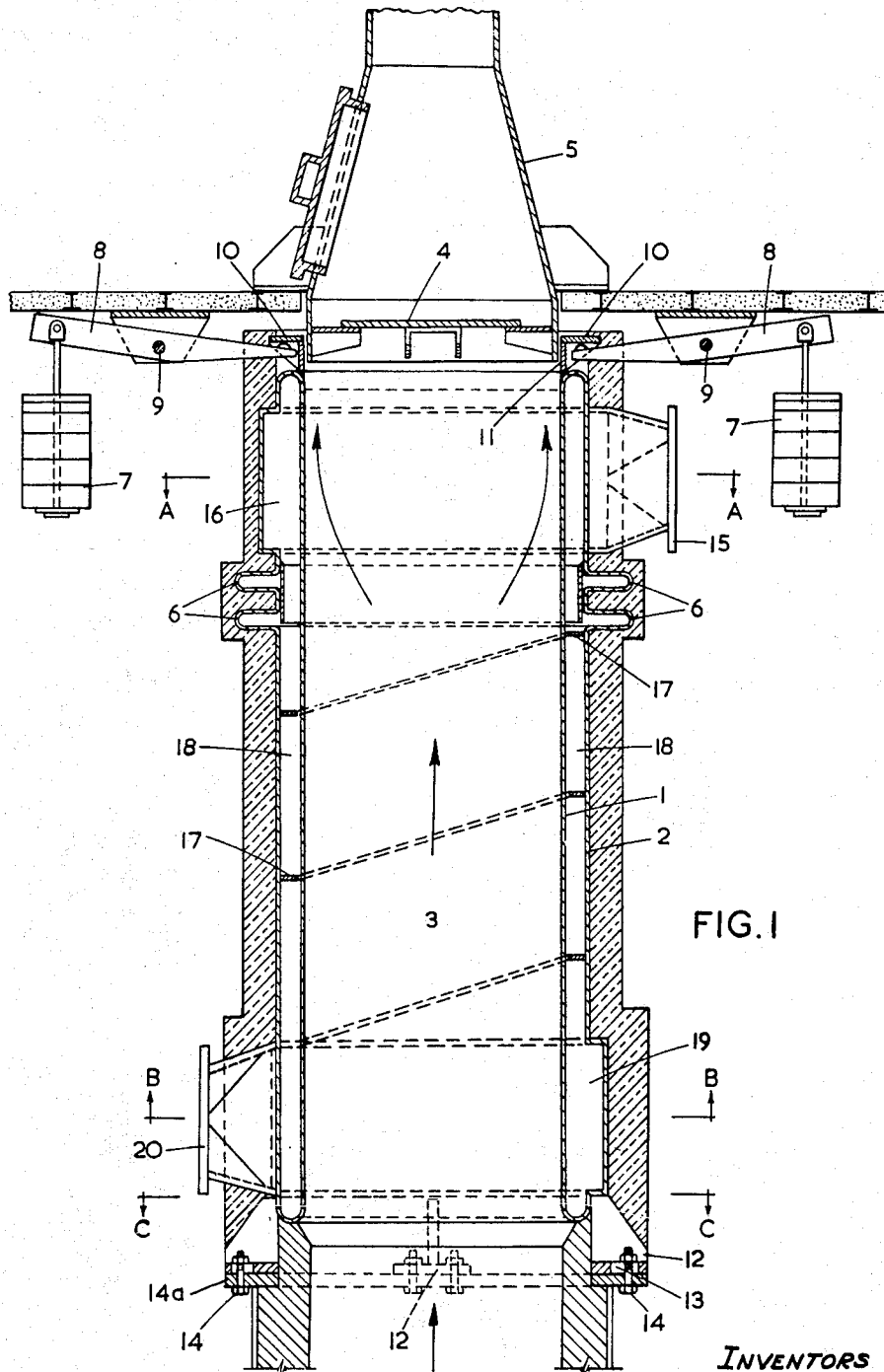


FIG. 1

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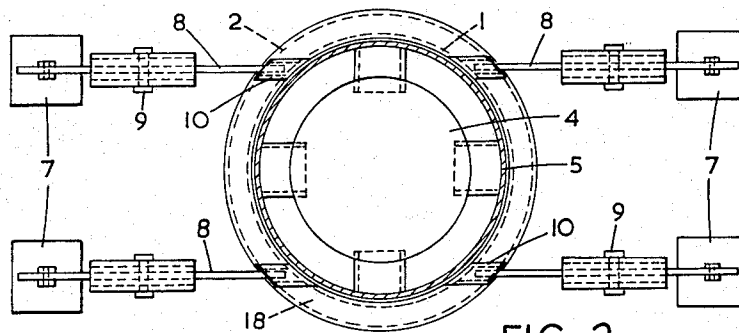


FIG. 2

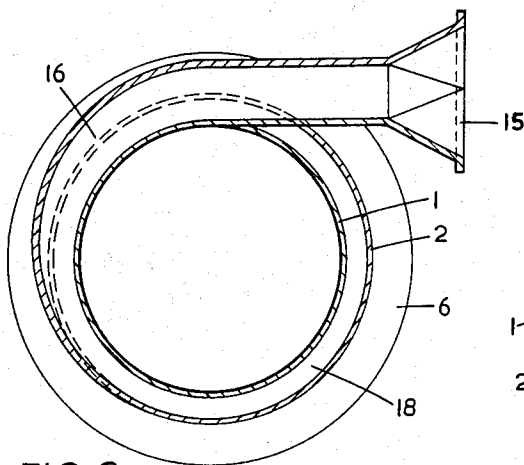


FIG. 3

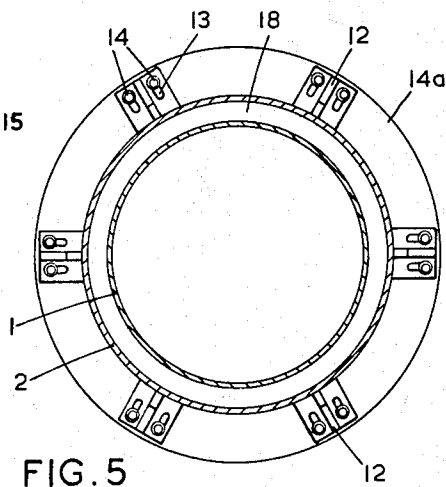


FIG. 5

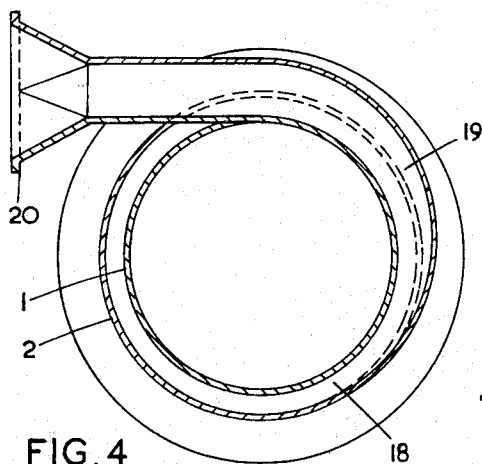


FIG. 4

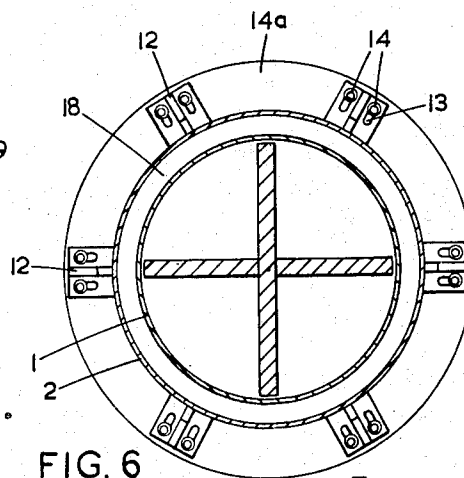


FIG. 6

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RECUPERATOR

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Claims priority, application Germany August 17, 1951

6 Claims. (Cl. 257—172)

The invention relates to a recuperator, in which hot gases, for example the waste-gases of coal-dust firing, cupola furnaces, and the like, are passed at a relatively low speed, though at high temperature, through a cylinder having a large diameter, while the gases to be heated are conducted at a speed several times as great, that is to say ten to thirty times as great, through a narrow annular space surrounding the cylinder. Recuperators of this type, which are primarily radiation recuperators, have hitherto been so constructed as a cast-iron cylinder having a large number of longitudinal ribs and surrounded at a small distance by a sheet-metal casing. The gases to be heated flowed in the axial direction through the narrow annular space left between the cylinder and casing. Such recuperators are only adapted to be used as small recuperators, because the ribbed casing must be made substantially wholly of cast-iron.

It has previously been proposed to provide a fundamentally new design according to which the inner cylinder is formed of sheet-metal, in given cases even of soft steel, a helical member, guiding the gases to be heated helically through the annular space, being welded in the annular space to the inner cylinder. This construction may be used wherever the cast-iron recuperator fails. Such a construction may also be used in combination with a convection recuperator, which is placed to the rear of the radiation recuperator and is operated with passages of smaller cross-section for the heating gas, so that the velocities of the heating gas are higher.

However, it has been found that in spite of these fundamental advantages, this design can also only be used to a limited extent, and that in recuperators through which large amounts of gas are passed at high temperatures, numerous disadvantages, particularly distortions and cracks occur to a considerable extent.

According to the invention, it has been found that these disadvantages can be overcome by relatively simple means, the effects of which complement each other. These means consist in introducing the gases to be heated tangentially into an annular and gradually narrowing channel and then passing them helically through guide-members which are loosely inserted, or loosely attached within the annular space, to escape finally through a gradually widening channel. At the bottom, and in some cases also at the top, the double-walled cylinder formed by two concentric outer and inner cylinders is received in supporting members, which are secured to the colder parts by means of resilient members; this may be effected by means of horizontally displaceable supporting frames. The outer casing is provided with a compensator, above which engages a counter-weight which counterbalances the adjusting forces of the compensator and subjects the inner cylinder to light tensile stresses.

The advantageous effect of this design is due to the fact that all these means relieve the inner cylinder of additional thermal stresses and of the harmful effects of

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these thermal stresses in the radial and axial directions throughout its entire length.

At the position at which the gases to be heated enter, by means of the annular channel and particularly by reason of the tapered part, care is taken that the increase in height of the channel caused by the starting pitch of the plates forming a helix, is wholly or partly compensated by the reduced width of the channel, so that reduction in velocity, which would involve a correspondingly poor heat transmission, is avoided and thus also local excess temperature in the inner cylinder. Furthermore, dead spaces are in this way avoided. In this manner it is even possible to accelerate the flow of gases to be heated by reducing the cross-section, so that it is possible to force the gases flowing in the inner cylinder automatically into the boundary zone, that is to say, against the cylinder wall, by inserting a central cover-plate, so that at the same time hot gases are prevented from escaping through the core of the inner cylinder, in which case they would not give out sufficient heat. Tests made in a large plant have shown that the total heat-transmission by the recuperator is considerably increased, to an extent of more than 10%.

The middle part of the inner cylinder remains undistorted and free from cracks, because it is no longer constricted by the helical guide-plates, which are loosely inserted, or loosely attached, at a corresponding clearance, so that the considerably hotter cylinder is allowed to expand in the radial direction without becoming dented or otherwise distorted. Expansion is also possible at the bottom, because the double cylinder is mounted resiliently, for example so as to be slidable.

When the radial stresses of the cylinder are in this way overcome by the interengaging means, which compensate each other, as hereinbefore described, the recuperator would nevertheless not be able to meet high requirements in all cases, were it not possible according to the invention, for axial expansions to occur without danger being involved. For this purpose, the compensator is mounted in the outer cylinder. However, this compensator as a rule requires considerable adjusting forces. These adjusting forces are compensated in that a counter-weight engages the double-walled cylinder above the compensator, so that the inner cylinder does not utilise the adjusting forces when it expands axially. It may even be subjected to light tensile stresses by the counter-weight, or forces, such as the forces of springs, replacing the counter-weight, so that it is possible to use heat-resistant steel, which has little hardness at the temperatures existing.

It is also possible to use special steels, such as high-melting point chromium steel alloys or chromium nickel-steel alloys, using, according to the invention furthermore, these steels at temperatures exceeding the so-called "temperature of embrittlement." In some cases, it is advantageous to cause an increase in the wall-temperature in these zones, that is to say in those cases in which danger would be involved in using low-melting point and non-embrittling steel alloys at these positions, at which overheating is unavoidable. According to the invention, at these positions, the temperature of which is, however, generally within the embrittling range, the wall-temperature must be increased so as to exceed this temperature (for example to above 475°–500° with 13%–24% Cr and to above 700°–750° with above 24% Cr), by reducing the speed and the coefficient of heat transmission of the heat-absorbing means. According to the invention, at those temperature ranges in the recuperator which are outside the embrittlement range, the velocity of the airstream, and thus its coefficient of heat transmission, must be made as high as corresponds to the thermodynamic optimum.

The recuperator according to the invention affords the advantage that the part, which is particularly exposed to danger, namely the inner cylinder, is largely relieved of any additional stresses and distortions resulting therefrom. The so-called "spiral recuperator" thus conquers the fields of application, into which hitherto a steel-recuperator could not penetrate.

One example of a recuperator constructed according to the invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a longitudinal section of a recuperator according to the invention;

Figure 2 is a corresponding plan view;

Figure 3 is a section on the line A—A of Figure 1;

Figure 4 is a section on the line B—B of Figure 1;

Figure 5 is a section on the line C—C of Figure 1;

Figure 6 is a sectional plan showing the sheet metal plates serving as secondary heating surfaces.

The recuperator is provided with an inner cylinder 1 and an outer cylinder 2, which are connected together at the top and at the bottom to form an enclosed space. The heat-radiating gases flow upwardly through the interior space 3 of the cylinder 1, in the upper part of which they are conducted towards the outer walls by the central plate 4, as indicated by the arrows. The gases are then passed into the vent 5. In the outer cylinder 2, is provided a bellows type compensator 6, which allows axial thermal expansion of the inner cylinder. The adjusting forces of the compensator 6 are generated by a counter-weight 7 mounted on a lever-arm 8, which is pivotable on a spindle 9, and the other end of which engages beneath claws 10, which are connected to the inner cylinder 1 by means of metal plates 11. A number of counter-weights 7 are provided together with corresponding lever arms so as to encircle the central axis of the recuperator. The function of the counter-weights is to support the inner cylinder 1 which has little resistance to axial collapse at high temperatures because it is made from high heat resistant nickel chrome steel.

At the bottom, the double-cylinder 1, 2 is supported on frame members or brackets 12, which are connected to the colder portion of the frame, floor or the like, by means of screw bolts 14 secured in a member 14a and passing through slots 13 provided in the brackets 12. The screw bolts are tightened only to an extent sufficient to secure the general vertical position of the recuperator, yielding however, to any thermal radial expansions by sliding in the slots 13.

The gases to be heated flowing in at an inlet 15 pass into an annular space 16, the width of which decreases gradually, as may be seen clearly in Figure 2. The annular space 16 merges into narrow and high helical paths 18 formed by metal plates 17 loosely mounted between the cylinders, along which paths the gases to be heated flow at a relatively high velocity thus exerting a considerable cooling effect on the cylinder-wall 1, so that the temperature of the cylinder-wall is considerably lower than that of the waste-gases in the space 3. The metal plates 17 are loosely mounted in order to enable the cylinder 1 to expand under the action of heat. The gases, heated in the meantime, then pass at the bottom into another annular space 19, which widens with decreasing height, and from which the gases escape through an outlet 20.

In the illustrated example, the building material used for the bottom part of the inner cylinder 1 of the recuperator is chromium steel or chromium-nickel steel, whereas ordinary soft steel may be used at the top, if cold gas, and not pre-heated gas is passed in at 15. The two types of steel are so distributed that the heat-resistant steel containing more than 13% Cr is used only at those positions in the recuperator at which its temperature is above approximately 475° C., which is the embrittlement temperature. While it was hitherto the object of the efforts made to avoid reaching this limit,

it is intentionally exceeded in the new recuperator, so that there is no danger of embrittlement of the metal and fracture of the inner cylinder is thus avoided.

In those cases, in which the temperature of the entering gases to be heated falls substantially below 1000°, the gas-radiation and the heat transmitted by the recuperator are much reduced. In this case gas-radiation may be considerably improved by providing secondary heating surfaces, for example in the form of a cross (Figure 3a), which may be made of brickwork or of metal plates 21. The surfaces thus added absorb heat from the gas stream both by radiation and by convection, and radiate the heat thus absorbed on to the actual heating surface, namely the cylinder 1. At first, no substantial results were obtained in this manner, due to the fact that the thickness of the layer of radiating gas is excessively reduced by this installation. According to the invention, therefore, when secondary heating surfaces are installed, the diameter of the recuperator is provided to be considerably larger than that of similar recuperators having no secondary heating surfaces.

When the diameter of the inner hollow cylinder is thus increased, the secondary heating surface serves also to guide the flow of gases, and to prevent reversing movements. These reversing movements occur in large cross-sections when the heat-radiating gas flows slowly upwardly. The gas masses, which on their path are cooled by the wall, fall back downwardly in the middle of the wide hollow cylinder and mix at the bottom with the freshly arriving masses of hot gas. Obviously, a circulation of this type would considerably impair the heat-transmission.

The invention can be modified in various ways. In recuperators, to which maximum requirements are made in respect of quantities and temperatures of the gas, it is advantageous to use all the means hereinbefore described simultaneously. When the requirements are not so exacting, one or the other means may be dispensed with.

The term "gases" is to be understood in a general sense, so that both individual gases and also gas-mixtures (such as air) and finally also vapours are included in this term. The recuperator is particularly useful for the utilization of dust-containing gases, which deposit only to a slight extent and cannot thus substantially impair the heat-transmission, quite apart from the fact that the recuperator can be cleaned conveniently through appropriate cleaning openings during operation.

The recuperator may be provided in a vertical; in an inclined, or in a horizontal position. It may also be used in combination with a convection recuperator.

We claim:

1. A recuperator formed as a double-walled cylinder closed at top and bottom, a passage for the upward flow of heating gas provided centrally of the recuperator, a tangential inlet progressively decreasing in cross-section at the upper end of said cylinder to increase the velocity of the gas passing through the inlet and into the annulus between the walls of the cylinder where it is heated, means mounted in said annulus to cause the gas to be heated to follow a helical path from the top of said cylinder to the bottom and an outlet at the bottom of said cylinder for said heated gas, said outlet being of gradually increasing cross-section to decrease the velocity of the gas, and means for supporting the inner wall of said cylinder during the axial thermal expansion thereof to prevent said inner wall of said cylinder from being subjected to stresses normally encountered in expansion.

2. A recuperator according to claim 1, including compensator means for supporting the inner wall of said cylinder during axial thermal expansion of the inner wall of said cylinder, said compensator means comprising counter-weights secured to the ends of pivoted levers having their opposite ends in engagement with claw members secured by plates to the inner of the walls of said cylinder.

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3. A recuperator according to claim 1, in which the cylinder is mounted on frame members secured to the fixed parts of the furnace in such manner as to provide for thermal radial expansion.

4. A recuperator according to claim 1, in which the cylinder is mounted on frame members secured to the fixed parts of the furnace by means of screw bolts secured in slots.

5. A recuperator according to claim 1, in which the upper part of the recuperator is formed of soft steel and the lower part of chromium or chromium-nickel steel.

6. A recuperator according to claim 1, in which means are provided to increase gas radiation including secondary heating surfaces and in which the diameter of the recuperator is increased to compensate for the reduction in thickness of the layer of radiating gas.

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