Feb. 26, 1929. 1,703,793

C. M. STEIN

HEAT REGENERATOR WITH LARGE SURFACE

Filed Aug. 8, 1924

Fig 1

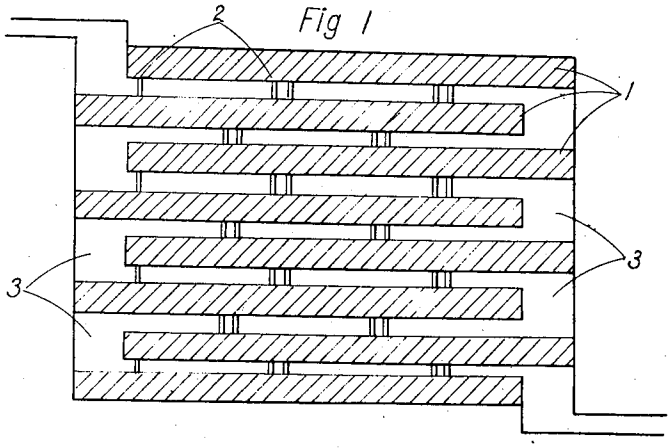


Fig 2

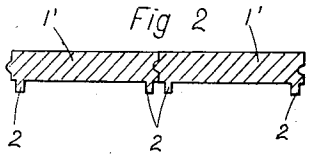


Fig 3

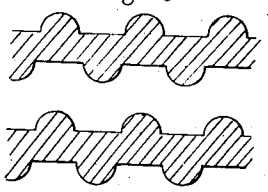


Fig. 4

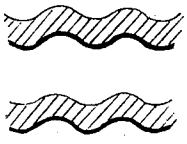
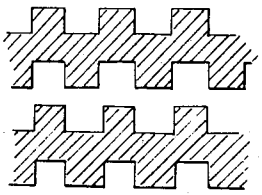


Fig. 5



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UNITED STATES PATENT OFFICE.

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HEAT REGENERATOR WITH LARGE SURFACE.

Application filed August 8, 1924, Serial No. 730,998, and in France August 31, 1923.

This invention relates to improvements in the construction of heat regenerators for the purpose of providing them with a very large heating surface and a high velocity of circulation of the fluids passing through them. As is known it is necessary to provide a certain heating surface in order to obtain satisfactory recuperation of the calories contained in the flue gases.

The extent of this heating surface obviously depends, for a given set of conditions, on the value of the coefficient of transmission of heat between the gaseous fluids and the refractory brickwork forming the regenerator chamber. It is known that this coefficient of transmission increases with the speed of circulation of the gaseous fluids. It is therefore advantageous to increase the speed of circulation so as to reduce the heating surface required to obtain a predetermined degree of recuperation.

But on the other hand in order to increase this velocity it becomes necessary to reduce the surface of the section of the passage for the gaseous fluids which entails a reduction of the perimeter.

If, therefore, the velocity is increased it will be necessary on the one hand to reduce the length of the heating surface since the said heating surface is decreased, whilst on the other hand the length should be increased, since the width of the heating surface (represented by the perimeter of the section of the passage) is reduced. Now, the coefficient of transmission and consequently the heating surface is less than proportionate to the square root of the velocity, whilst the perimeter of the section and consequently the length of the heating surface is in inverse ratio to that square root. It follows that the effect of reducing the perimeter is contrary to that required and that the result obtained leads to a variation in the length of the heating surface in the same sense as that of the velocity.

When, therefore, the velocity of the gaseous fluids circulating in an apparatus for the recuperation of heat is increased a reduction of the required heating surface is certainly obtained, but at the same time it will be found necessary to increase the length of the passage of the gaseous fluids which will involve in general an increase in the bulk of the apparatus and will consequently lead to an effect exactly opposite to that in view by increasing the velocity.

It is for this reason in conjunction with a consideration of the increase in the losses of the charge with the velocity that in recuperating apparatus as hitherto constructed only a low velocity of circulation of the gaseous fluids is employed (as a rule 1 to 2 metres per second).

The object of the present invention consists substantially in providing an apparatus which enables a considerably higher velocity of circulation to be obtained (6 to 12 metres per second) in combination with a reduction in the total bulk of the recuperator.

This arrangement is such that for a given velocity, that is to say for a given section of the passage for the gaseous fluids, the perimeter is a maximum with the object of reducing to a minimum the length of the passage of the said fluids. This result is obtained in practice by the employment of very flat sections for the passage which has the additional advantage that all the thin streams of fluid, laminated in this manner, are in contact with the heat transfer surface.

The characteristic feature of the system is therefore the provision of a large surface for the recuperation of the heat combined with a small volume owing to the method of arranging the refractory walls that serve for the transfer of heat.

These walls are arranged parallel one to another and very close together so that a very thin stream of fluid passes between them which has the advantage of facilitating the transfer of heat in all the gaseous filaments of the said stream.

The several passages are arranged in a zigzag manner and the gaseous fluids flow through them in succession so that a considerable length of passage is obtained although the distance between the two ends of the circuit is a minimum.

The accompanying Figures 1 to 5 show the various methods of carrying out the invention. In these figures:

Figure 1 shows in section one method of carrying out the invention, in which the walls are horizontal as well as the gaseous circuits passing between them.

Figure 2 is a section of the elements constituting the recuperator, showing the joints thereof.

Figures 3, 4 and 5 show examples of elements with corrugated walls.

Referring to Figure 1, it must, of course, be understood that the elements, which are supposed to be horizontal in this case, may be vertical or inclined without changing in any way the statements mentioned above.

As an example of construction, the refractory walls, Figure 1, consist of plates 1, of which the thickness is twice that of the space separating them. These plates are of the same length as the brick chamber containing them, but are not quite so wide, so as to leave a vertical passage 3 between one of their extremities and the corresponding face of the said chamber. The vertical passages 3—3 are staggered in order to obtain the desired zig-zag circulation.

The plates shown in Figure 1 have plane faces but several other methods of construction of these plates constitute also the object of the invention. Thus, for example, with the object of increasing the perimeter of the section of the passage (and consequently reducing the length of the passage of the fluids) one may use plates provided with alternate projections on both faces of rectangular or square section, Figure 5, or even hemispherical, Figure 3. Finally, plates having both faces of wavy outline, Figure 4, may be used with the same object in view.

The method of constructing the plates is one of the characteristic features of the invention. For example, if the arrangement according to Figure 1 with horizontal walls is adopted, each plate consists of a series of elements 11, Figure 2, of the required thickness and provided with four feet 2—2 of a height equal to the space required between the successive plates.

For the purpose of making a tight joint between two adjacent elements the four vertical faces of these elements are formed midway of the thickness with a feather on two of the adjacent faces so that when two elements of the same plate are in contact the feathers of the one will engage in the grooves of the other and vice versa.

The elements are therefore all interchangeable which enables any desired plate to be constructed, very rapidly, and the plates to be built one above the other, as shown in Figure 1.

It may be added that the increase in the resistance owing to the restricted passage provided for the gaseous fluids will be compensated by employing mechanical blowing of the air and mechanical extraction of the gases, which in this case has no disadvantage since we are dealing with a heat recuperator and there is no fear of mixing owing to the difference in pressure between the two circuits of air and gases.

In comparison with standard regenerators, which are normally built of bricks 22 x 11 x 16 cm., arranged to provide passageways about 5 cm. wide, the number of passageways and the length thereof depending on the volume of gases and the amount of heat transfer desired, a regenerator according to applicant's invention would have a passageway approximately 40 x 3 cm., the length being designed in accordance with the heat exchange requirements.

Experience has shown that a decrease in one of the flow area dimensions to produce an increase in speed of 6 meters per second in applicant's regenerator, as compared to the normal speed of 1 meter per second in the usual types of standard regenerators, increases the heating surface and destroys the film of hot gases normally clinging to the heating surfaces, thus facilitating the heat exchange between the gas and the surface.

Claim:

In a regenerator, uniform gas passageways highly restricted in cross-sectional area as compared to the standard, in order to induce an increased velocity of gas flow over the normal of at least two to one, the walls of such passageways having alternate projections and depressions to provide an enlargement of the heating area.

In testimony whereof I affix my signature.

CHARLES M. STEIN.