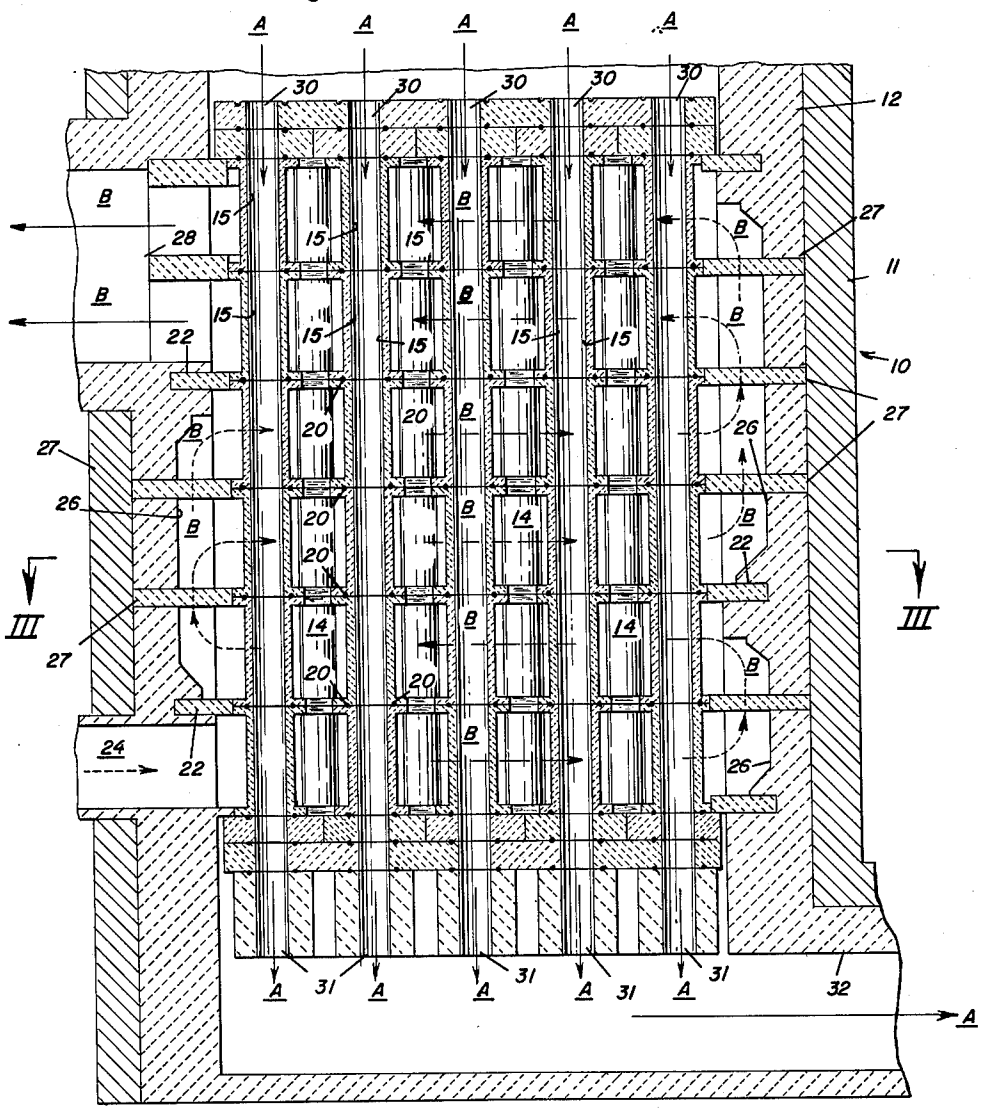
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RECUPERATORS

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Fig. 1



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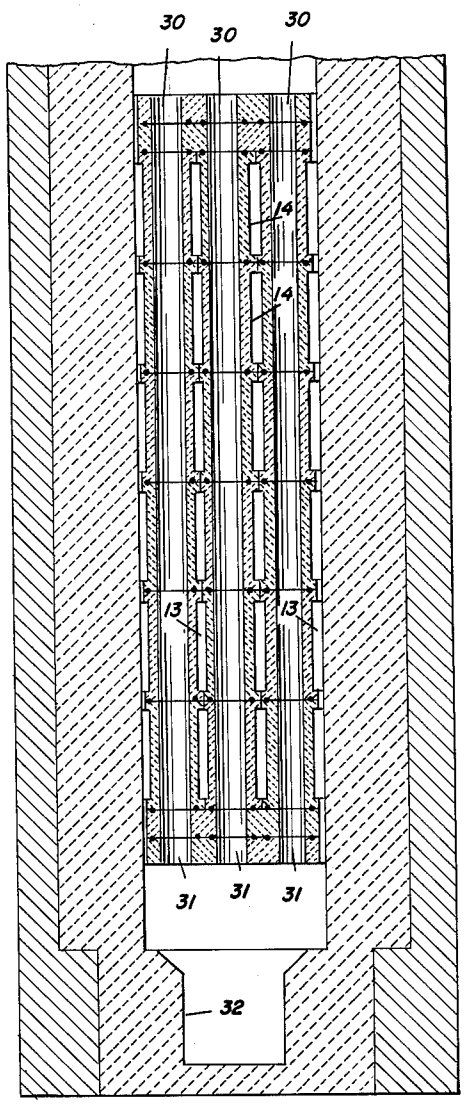


Fig. 2

Fig. 4

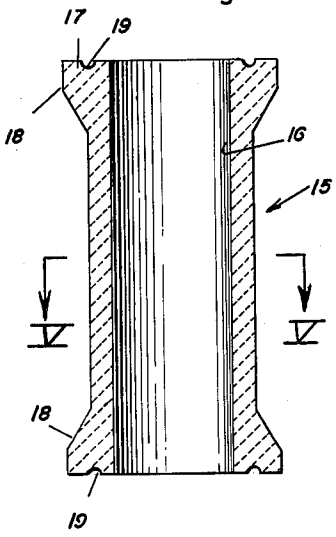
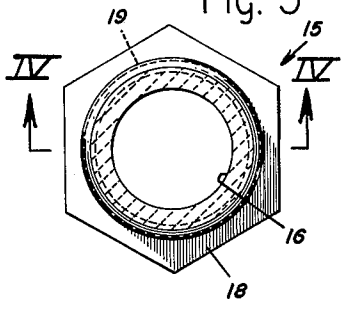


Fig. 5



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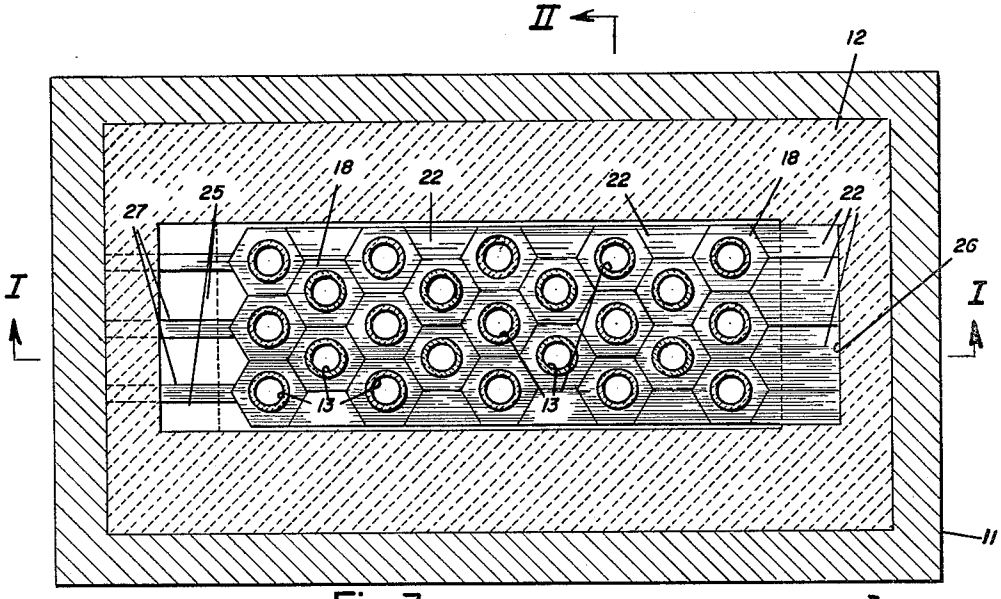


Fig. 3

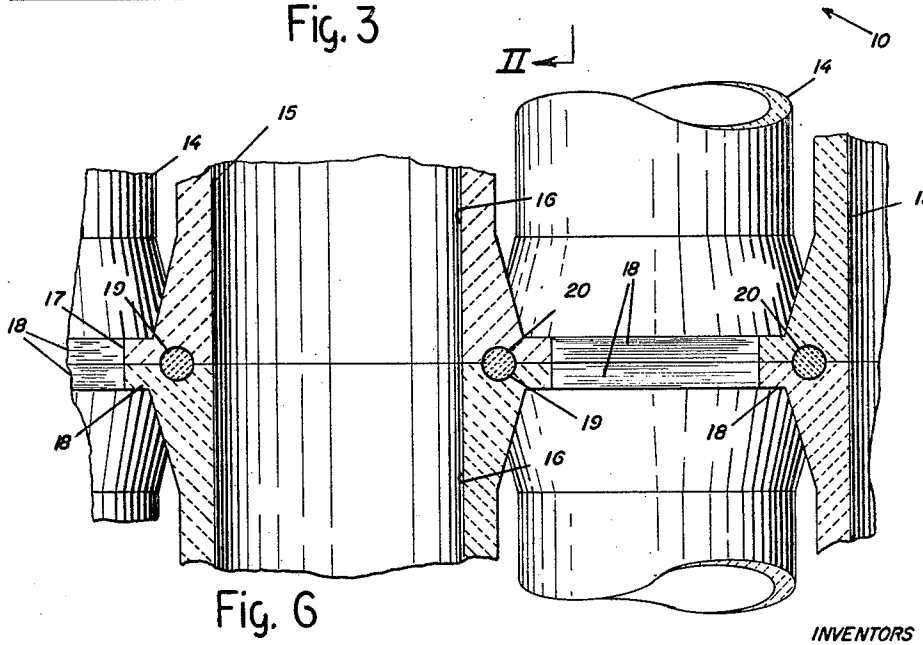


Fig. 6

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This invention relates to heat exchangers of the type known as recuperators, in which one fluid medium is passed through spaced vertical tubes and a second fluid medium flows in the spaces between the tubes, and is particularly although not exclusively applicable to recuperators for use in combination with industrial furnaces, for example open-hearth furnaces, whereby combustion air is preheated by waste gases carrying ash.

It has previously been known to construct the vertical tubes in recuperators from tubular bricks or members of square external cross-section, each brick being formed with a socket at one end for receiving the plain end of the brick immediately above it. Horizontally extending plates are arranged to bear on the protruding parts of the sockets and hold the tubes in spaced relationship. The sizes of the sockets and the plates determine the cross-section of the passages between the tubes, and the horizontal plates guide the heat-receiving medium through the recuperator.

In such a prior arrangement, the sockets which serve as the joining means for the tubular bricks, and which directly or indirectly act as spacers between the vertical tubes, have a number of disadvantages with regard to the construction and efficiency of the recuperators. The large number of separate components, such as bricks and spacers makes the construction of the recuperator difficult and reduces its stability, and in particular the sockets do not ensure absolute tightness of the vertical tubes. The sockets provide a horizontal and a vertical joint at each junction, and of these two joints only the horizontal joint, which corresponds to the thickness of the wall of the tube, is of practical use for sealing purposes because of the weight of the bricks or of the tube. In service the mortar seal in the vertical joints loosens, and therefore leaks, when shrinkages occur in the material because of temperature effects or when the refractory brick material is otherwise displaced. The mortar drops prematurely out of the vertical joints which are open at one end, and therefore fails to provide permanent sealing. In addition the socket ends must have sufficient wall thickness to prevent lateral breakage of the sockets. Thus the sockets must have a considerable periphery and as this determines the minimum spacing and flow cross-section between the vertical tubes, excessive flow cross-sections are usually produced for the fluid medium and consequently heat transfer is reduced.

An object of the present invention is to provide a recuperator of the type comprising a group of laterally spaced vertical tubes through the bores of which one fluid medium flows, the spaces between the tubes affording transverse passages through which a second fluid medium flows in heat exchange relationship with the outer surfaces of the tubes, and in which each tube comprises a stack of tubular sections superimposed one upon another end to end, each section being formed at each extreme end with a transversely projecting peripheral flange one surface of which constitutes the horizontal end surface of the section, which end surface is formed with a continuous annular groove extending around the bore of the section to receive a packing ring.

A further object of the recuperator is to position the sections in columns within an outer casing, with the flanges of the sections in adjacent columns arranged to

be in abutting relationship with each other in both vertical and horizontal planes, which gives the tubes stability.

Preferably the flanges are of identical external profile, for example of hexagonal profile, the tubes being arranged with the flat edges of the flanges of the sections of adjacent tubes in abutting relationship so that the abutting flanges constitute horizontal partitions defining the transverse passages.

The end surface of each flange provides a wide sealing surface, several times greater than the cross-sectional area of the section, and is subjected to the weight of the tube column, as is the resilient packing material placed in the groove. Displacement of the sections during operation of the recupertor will not loosen the packings nor cause them to fall out.

The transverse passages between the vertical tubes for the second fluid medium are defined at top and bottom by the abutted flanges. The intermediate portion of each tubular section between its end flanges may be of external cylindrical form and is in contact with the second fluid medium.

According to a further aspect of the present invention a tubular section for constructing a recuperator is formed with a transversely projecting peripheral flange at each end, the end surface of each flange having a continuous annular groove extending around the bore of the section to receive a packing ring.

The invention may be carried into practice in various ways but one specific embodiment will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a vertical section of a recuperator on the line I—I of FIGURE 3,

FIGURE 2 is a vertical section on the line II—II of FIGURE 3,

FIGURE 3 is a horizontal section on the line III—III of FIGURE 1.

FIGURE 4 is a section of a tubular brick included in the recuperator on the line IV—IV of FIGURE 5,

FIGURE 5 is a section on the line V—V of FIGURE 4, and

FIGURE 6 is a cross-sectional view of the abutting ends of two sections showing particularly the annular groove and packing material therein.

In the embodiment illustrated, a recuperator **10** comprises an outer masonry shell **11**, an inner masonry shell **12** and a number of spaced vertical tubes **13** which convey hot waste gases and ash downwardly from a furnace (not shown) in a direction indicated by the arrows A in FIGURE 1. Combustion air for the furnace which is circulated in horizontally extending passages **14** in the direction indicated by the arrows B is preheated by the waste gases, before being passed to the furnace.

Each tube **13** is constructed entirely from tubular bricks or sections **15** shown in FIGURES 4 and 5 as having a bore **16** and enlarged end surfaces **17** formed by integral flanges **18** of hexagonal cross-section. The bricks **15** are stacked within the inner shell **12**, the flanges **18** of horizontally adjacent bricks in abutting relationship with each other and the side walls of the recuperator as shown in FIGURE 3. The tubes **13** are built up from layers of the bricks, the enlarged end surfaces **17** constituting a sealing surface between vertically adjacent bricks. The end surfaces **17** of each brick are formed with annular groove **19** coaxial with the bore **16** so that there is an annular channel between vertically adjacent bricks in which is placed resilient packing material **20**, for example asbestos string. The weight of the bricks bears on each surface **17** and provides an effective seal in addition to the packing ring **20** as shown in FIG. 6.

The abutting flanges **18** form horizontal walls surrounding the tubes **13** at the level of the ends of each layer of

bricks and these together with cooperatingly shaped side pieces 22 define the passages 14 for the combustion air.

The combustion air enters the recuperator through an inlet 24 at the level of the lowest layer of bricks 15 and is deflected into the upper layers through apertures 25 in the horizontal walls. Recesses 26 in the inner shell deflect the air through the apertures 25 and baffle plates 27 distribute the air around the tubes and also serve to hold the tubes within the inner shell 12. The air is passed to the furnace through a port 28 at the upper end of the recuperator. Hot waste gases from the furnace enter the upper ends 30 of the tubes 13 and at the lower ends 31 of the tubes are led into a horizontally extending discharge duct 32.

In FIGURES 4 and 5 the bricks or sections are shown with a bore of circular cross-section and a hexagonal flange although these may have any convenient shape for example square configuration. The size of the flange controls the size of the passages 14 and because of the integral construction of the flange and the honeycomb construction of the recuperator these passages may have a smaller cross-sectional area than in previously known constructions. Thus the rate of flow of air may have to be increased to provide the required amount to the furnace and this increase in the rate of flow improves the efficiency of the recuperator by extracting more heat from the waste gases. The rate of flow of air and the amount supplied to the furnace may be suitably controlled by adjusting the pressure of the air at the inlet to the recuperator.

The honeycomb construction and the small flange size also has the advantage that the vertical tubes can be placed closer together and that more tubes can be accommodated per unit area compared with known constructions.

It is thought that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the form,

construction and arangement of the parts without departing from the spirit and scope of the invention or sacrificing its material advantages, the form hereinbefore described and illustrated in the drawings being merely a preferred embodiment thereof.

We claim:

1. A ceramic recuperator comprising tube columns spaced at a distance from one another for one flow medium, each of said columns comprising individual superimposed tubular bricks, passageways located between the external surfaces of said tubular bricks for conveying the other flow medium, protruding flanges arranged at the ends of said bricks forming hexagons which impinge similar flanges upon the bricks in adjacent columns to form said passageways, the end faces located at the ends of said tubular bricks having their entire width plane to form plane surfaces upon the outer faces of said hexagon flanges and said plane surfaces having a central groove and an elastic tightening medium in said grooves of contacting superposed bricks.

2. A ceramic recuperator according to claim 1 wherein said tubular bricks have a tube wall and have adjacent said flanges an increase in tube wall cross section extending toward said flanges.

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