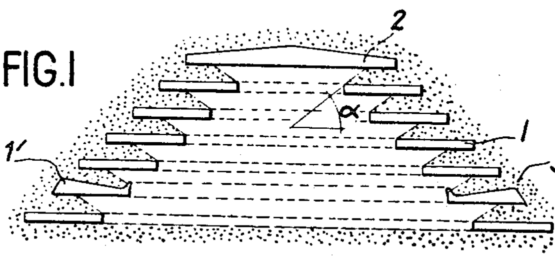
Sept. 17, 1968 J. COMTE 3,401,921

GASEOUS HEAT EXCHANGER

Filed Oct. 3, 1966

FIG.1



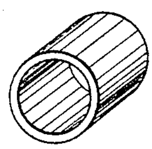


FIG.2

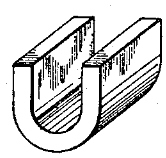


FIG.3

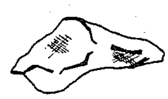


FIG.4

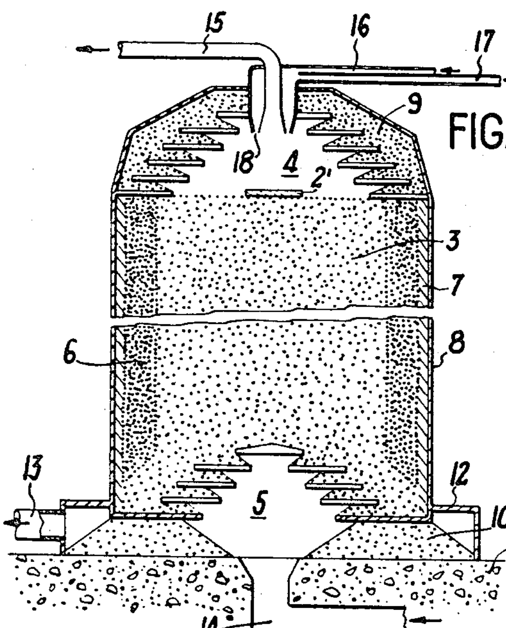
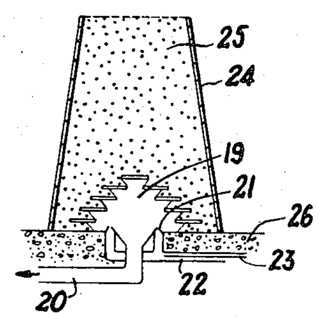


FIG.5

FIG.6



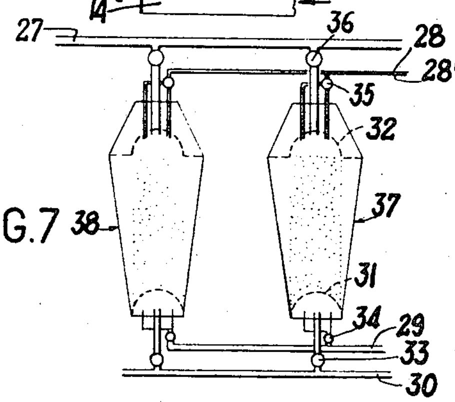


FIG.7

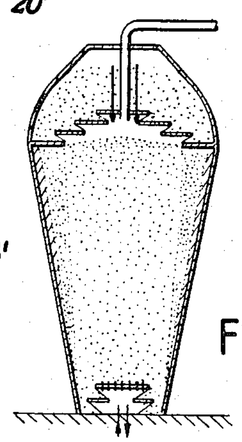


FIG.8

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GASEOUS HEAT EXCHANGER
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7 Claims. (Cl. 263—19)

ABSTRACT OF THE DISCLOSURE

A heat exchanger of Cowper type with a tubular envelope containing a filling of fragmentary material permeable to gaseous currents. The filling material has at least one free space adjacent one of the ends of the casing which communicates with an external conduit. The free space is of sawtooth shape as formed by vertically superimposed coaxial rings separated from one another by layers of the fragmentary material.

This invention relates to heat-exchanging, especially, but not exclusively of the Cowper type, which are simple in construction, robust, capable of withstanding cycles of heating and cooling without detriment, and designed particularly to mitigate the effects of expansion. Moreover, these heat exchangers can be made to much smaller dimensions than those of the known Cowper arrangements, but produce the same results.

The present invention is a heat exchanger of the Cowper type comprising a tubular envelope or casing enclosing solid material in loose form constituting an insulating wall contiguous with the said envelope and an axial fireproof mass permeable to gaseous currents, with at least one free space at the opening of at least one nozzle, situated below an axial arch, saw-toothed in section, formed by annular elements in rising stages of dimensions decreasing from the bottom towards the top of said arch, freely supported and separated by the said materials which rest in a free pile on the elements, the lower annular element likewise freely resting on a bed of said materials.

A burner may open axially into the free space. The envelope may have a generally conical form, the wide part being at the level of the burner. The envelope may be closed at the top, save for the entry for at least one nozzle at the apex of an axial arch which supports the insulating wall of the top of the envelope. The envelope may be closed, a least at one end, by a part having the geometrical shape of a truncated cone or a spherical cap. Preferably an axial arch is located at the base of the heat exchanger, and the envelope may be closed from top to bottom except for the entries for opposed co-axial nozzles. In a modification, the open base of the envelope rests on an annular bed of freely-heaped materials on a plane pedestal, the said heap likewise supporting the lower flat annular element of an axial arch centred on a nozzle opening through the pedestal. The envelope may be open at the top.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

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FIG. 1 is a schematic view in axial section of an arch in a heat exchanger according to the invention;

FIGS. 2, 3 and 4 are views in perspective of solid materials which can be used for the loose filling of the heat exchanger;

FIG. 5 is a schematic view, in axial section, of a heat exchanger according to the invention;

FIG. 6 is a schematic view in axial section of a modified heat exchanger of simplified construction;

FIG. 7 is a schematic elevation in partial section of a battery of Cowper type heat exchangers according to the invention,

FIG. 8 is a schematic view in axial section of a particularly functional Cowper type heat exchanger according to the invention.

The construction of the arches shown in FIG. 1 has as its main advantage the fact that it can be made of simple and inexpensive materials, and in such a way that it is practically insensitive to the results of expansion, which, therefore, mitigates the main disadvantages met in the normal Cowper construction. As shown in FIG. 1, such an arch is formed of substantially flat annular elements **1**, the dimensions of which decrease from the base towards the top of the arch. These elements **1** can be made, for example, of concrete, an agglomerate or metal and their manufacture from one or more ring-shaped elements of the required dimensions presents no difficulty. It is possible to mould them from a cement-based material, in a single piece. Their section can be slightly tapered, such as the element indicated by **1'** in FIG. 1, to attain advantages such as robustness, balance and retention of material **3** as will be hereinafter described. The upper element **2** can be a disc made in the same way as the annular elements **1**. All these elements are separated one from another by the material **3** which is loose and fragmented and allows free passage of gaseous currents between the elements. This material **3** rests freely on each element with its natural angle α. The lower annular elements rest on a bed of the material **3**. The thus formed arch has free play under the effects of expansion without risk of fracture to the supporting elements. By means of an appropriate choice of dimensions of the annular elements, the general shape of the desired form of arch is obtained.

FIG. 2 shows a Raschig ring widely used for filling cooling towers, and which can serve as loose material for filling a heat exchanger of the invention. Such rings are substantially in the form of a cylinder which can be inscribed within a cube. FIG. 3 shows another form of material which can be used. The element shown is in the form of a U which can be inscribed in a cube, and it has the particular property of constituting in a loose form, a material of regulable homogeneity, controllable by the choice of dimensions of the elements. It has an excellent mechanical structure and affords high degree of permeability to gases, good convection, and a good apparent specific mass comprising innumerable channels. The specific contact surface can be adjusted to between 80 and 200 $m.^2/m.^3$ by the choice of dimensions (thickness and bulk) of the U-shaped elements. It is practically impossible to choke the apparatus as a result of accidental waste matter, and no disadvantage can arise from variations in expansion.

The U-shaped elements, as well as the Raschig rings of

FIG. 2 can be made with advantage from silicate-clay products, even of second class quality, and can be reproduced in large quantities according to methods of manufacture already known for the fabrication of similar products, such as drains used for soil-drainage, as made by a draw-press. Such elements can advantageously have a thickness of between 3 and 15 mm., their bulk being that of a cube with sides from 10 to 100 mm.

Likewise, for the supply of heat exchangers according to the invention, crushed quarry products screened to size can be used, for example quartzite 16/22, porphytite 33/50 and the like. These products have the advantage of being resistant to deterioration, low in price, and easily available on the market.

The heat exchanger shown in FIG. 5 is an example of adaptation of the invention to a heat regulator, which functions cyclically, with descending combustion. The arrangement, in whole and in detail, of such a device is capable of a wide range of modifications, which gives this embodiment a flexible range of adaptability.

This heat exchanger comprises in its upper part a hollow space **4** in the form of an arch, formed as shown in FIG. 1, which arch serves alternately as a combustion chamber and a collector of hot air. At the bottom of the heat exchanger, another hollow space **5**, similar to that at the top, serves alternately as a collector of fumes and a distributor of cold air. The annular elements which form these two arches can, if necessary, be perforated to assist the passage of gaseous currents, and it may be of advantage if space **4** is of a greater diameter than space **5** in order to give the active part of the heat exchanger the shape of an upturned cone. This presents numerous advantages from the point of view of distribution of heat and the circulation of fluids. The chamber **3'** of the heat exchanger is filled with fireproof material such as those shown in FIGS. 2, 3 and 4, in which the bulk and thickness of the component elements can be greater at the bottom than at the top, as the surface is of less importance than the solidity at the base, whereas the lower flat annular element of the upper arch **4** describes a vertical cylindrical zone **6** which escapes the gaseous currents and serves as an insulating layer against a brick wall **7** contiguous with an external casing **8** made of sheet metal. Zone **6** can be made up of materials similar to those making up the central part of chamber **3'**, or of insulating materials made up of screened fireproof material, or crushed flint of small calibre, gravel, small grit, sand or the like. Such insulating material can likewise be used for packing **9** located in the upper arch **4**. The base of the heat exchanger rests by means of the lower annular element of the lower arch on a pile **10** which is also made up of insulating fireproof materials, permeable to gaseous currents, and set directly on the ground **11**. The pile **10** is surrounded by an annular sealed casing **12** connected to a collector **13**. A tubular cold air feed **14** opens axially into the heat exchanger at the base of the lower arch **5**. The collector **13** serves for the evacuation of fumes. At the top of the upper arch **4**, one or more hot air outlets open axially into the heat exchanger, concentric with one or more combustible gas feeds **16** and one or more oxygen-containing feeds **17** of an annular burner **18** which opens into the top of the arch **4**. This arrangement has a favorable effect on the equal distribution of the fluids in the mass of materials in the central chamber **3**. To supplement this effect a circular protective element **2'** may be placed in the exchanger or the upper surface of the mass may be shaped as shown in FIG. 8.

In the embodiment shown in FIG. 5, the envelope is closed at the top by a part in the shape of multiple truncated cones, simple in construction.

The functioning of such a heat exchanger is that of a normal Cowper. In the first part of the cycle, the mass of materials **3** is heated by the burner **18**, while the fumes escape through the collector **13**, and in the second part of the cycle, cold air is introduced through the tube **14**,

while hot air is collected in the tube **15**. When the mass has cooled, heating is recommenced, and the cycle repeated.

A simplified embodiment shown in FIG. 6 utilizes ascending combustion, and is used when the hot air can circulate by suction. In this embodiment, the evacuation of fumes is carried out by natural draught of the cooler surrounding air.

Such a simplified heat exchanger comprises at the bottom a hollow space **19** situated below an arch similar to that shown in FIG. 1. A hot-air suction tube **20** opens axially into the lower part of this hollow space as does an annular burner **21** similar to the burner **18** of FIG. 5, fed with combustible material and with burning-air by two channels **22** and **23**. The heat exchanger has an external casing in the form of a truncated cone **24** open at the top, filled with fireproof material **25** in loose form and resting to form a seal on the ground **26**.

The plant shown in FIG. 7 is an example of the application of the heat exchanger to blast-furnaces. The adoption of paired hot-air generators of alternating cycle, equipping each nozzle of the blast-furnace individually, or again, to groups of two or three nozzles symmetrically distributed, presents numerous advantages, notably a strictly equal distribution of the hot air and a considerable reduction in dimensions, due to systematic functioning with very short duration of phase. With such arrangement, 400 tons of cheap fireproof material suffice to heat to 1,200 degrees C. a discharge of hot air which considerably exceeds 100,000 m^3/h. (volume proportional to normal environmental conditions). This arrangement allows practically complete suppression of thermal inertia, with very small variations in the temperatures of hot air. All security measures are thereby alleviated. There is, however, no limit to the combustion temperature in the burner. It is possible to make systematic use of automation, as there is no problem to provide a regulable automatic cyclic programmed functioning of the tap-system, given the numerous embodiments of similar arrangements which are known. Such an embodiment allows the reduction in the diameter of the different pipes, and the adoption of a sealed-valve system currently used at high temperatures in other industries, which has the additional advantages of reduction of weight, price, bulk and losses, as well as the possibility of manufacture of the elements entirely in the workshop, the only operations necessary on the site being the filling of the device with loose fireproof materials, and linking up.

In the plant shown in FIG. 7, the channel **27** serves to evacuate hot air, while channels **28** and **28'** feed the burners at the top of the Cowpers. Channel **29** evacuates fumes and tube **30** feeds in cold air. Two arches **31** and **32** are arranged at the base and top of each heat exchanger as in the example shown in FIG. 5, while a set of valves **33**, **34**, **35** and **36** allows the making and breaking of a circuit of the different channels with one or the other of the heat exchangers **37** and **38**, which function in the normal alternating fashion, one discharging hot air while the other is in the heating phase, both arrangements, moreover, being essentially identical.

A modification of the embodiment of the heat exchangers shown in FIGS. 5 and 7 is shown in FIG. 8. Its upper part, more or less hemispherical in form, instead of in the form of a truncated cone as in FIG. 7, or as multiple truncated cones superimposed on one another as in FIG. 5, can present certain advantages in manufacture, namely, those of robustness, expansion, access and liaison, for certain applications. In FIG. 8 it appears that such a form presents the maximum number of advantages from the point of view of shape and the utilization of the volumes of the different active or insulating zones of the filling materials taking into account the differences in volume of the gases at the different levels of such a heat exchanger as a result of the differences in temperature at these levels.

The following table gives varied practical data in two embodiments of Cowper type heat exchangers of blast-furnaces for unitary discharge of hot air of 6,000 and 4,000 $m.^3/h.$ (volumes proportional to normal environmental conditions). In this table, all data in $m.^3$ is proportional in volume to normal environmental conditions.

	Discharge of Hot Air ($m.^3/h.$)	
	6,000	4,000
Filling Body:		
Bulk	30 x 30mm	30 x 30mm.
Thickness	6mm	6mm.
Temperature of hot air:		
At start of phase	{1,140° C. / 1,060° C.} 1,100±40	{1,212° C. / 1,188° C.} 1,200±1%.
Temperature at burner	1,300 C	1,300 C.
Temperature of environment.	0 deg. C	0 deg. C.
Proportion of duration of phase.	1	1.
Production:		
Calories hot air / Calories burner	90%	90%.
Useful zone of exchange:		
Diameter	1.46m	1.13m.
Height	6m	5.5m.
Loose weight	8.5 T	7.6 T.
Duration of each of phases.	5 min. 30	2 min.
Temperature of fumes, at:		
Start of phase	96 C	125 C.
End of phase	184 C	155 C.
Discharge of combustible gas:	3,000 $m.^3/h$	2,000 $m.^3/h.$
Air	2,400 $m.^3/h$	1,650 $m.^3/h.$
Fumes	4,930 $m.^3/h$	3,600 $m.^3/h.$
Max. diameter of pipes:		
Cold air	200mm	200mm.
Fumes	200mm	200mm.
Gas	180mm	180mm.
Air	180mm	180mm.
Hot air	400mm	400mm.

What I claim is:

1. A device for heating gases, comprising an erect tubular casing enclosing a filling of fireproof fragmentary material permeable to gaseous currents, at least one free space being defined coaxially in said filling material adjacent at least one of the ends of said casing, said free space communicating with at least one orifice of a conduit means extending from said casing externally thereof, said free space having an axial cross-section of sawtoothed shape defining vertically superimposed portions of said free space, each one of said portions having a diameter smaller than that of the adjacent lower portion, said free space portions being formed by substantially flat annular elements disposed coaxially with respect to each other and to said casing and separated from each other by respective annular layers of said filling material, each annular element resting freely on one annular filling material layer and supporting another one of said annular filling material layers thereabove.

2. A device according to claim **1**, wherein a first free space is provided adjacent the bottom end of said casing and communicates with a conduit adapted to feed gas to be heated into said first free space, a second free space being provided adjacent the top end of said casing and communicating with conduits adapted, respectively, to evacuate heated gas from said second free space and to feed a combustion gas and an oxygen-containing gas to at least one burner arranged inside said second free space.

3. The device of claim **2** comprising a flange-like annular wall extending radially inwardly from the bottom end of said casing, the annular filling material layer which supports the lowermost annular element of said first free space resting upon said flange-like annular wall and an annular bed of filling material resting on the floor and supporting said annular wall.

4. A device according to claim **1**, wherein one free space is provided adjacent the bottom end of said casing and is selectively connectable to at least one conduit for evacuating heated air, and to conduit means for feeding combustible and oxygen-containing gases to burner means arranged within said free space, said casing having an open top end.

5. A device according to claim **1**, wherein said filling material comprises an annular layer of fragmentary heat insulating material disposed adjacent the inner surface of said casing.

6. A device according to claim **1**, wherein said fireproof material is constituted by tubular or U-shaped fragments of Raschig ring type.

7. A device according to claim **1**, wherein said fireproof material is constituted by crushed quartzite or similar quarry product fragments.

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