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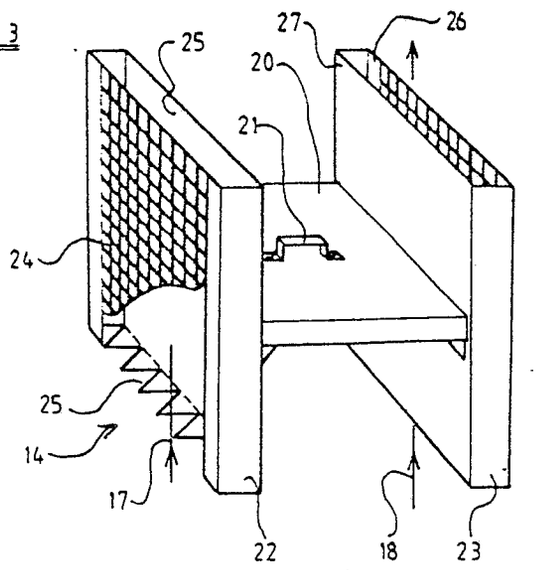
(54) A heat exchanger.

(57) A heat exchanger comprises means defining a flow passage (4) for a first fluid medium, such as heated gas from a burner, and means defining a flow passage (3) for a second fluid medium, such as water to be heated. The two flow passages are separated by a thermally conductive wall. A cartridge (14) is inserted into one of the flow passages. The cartridge (14) presents means to make the flow of fluid through the flow passage a turbulent flow. Also the cartridge establishes thermal contact with the thermally conductive wall so that the fluid medium flows in a turbulent manner past the cartridge, thus transferring heat to the material of the cartridge, that heat then being transferred to the thermally conductive wall and thus to the other fluid medium.

FIG 3



EP 0 356 735 A1

A heat exchanger

A typical heat exchanger comprises a flow passage for a first fluid medium and a flow passage for a second fluid medium, the flow passages being separated by a thermally conductive wall structure. It is common to employ in heat exchangers some method of increasing the effective surface area of the wall structure, in at least one of the flow passages, in order to obtain a high rate of transfer of heat energy between the media. For example, in a typical boiler in which water is to be heated, fins or baffles may be provided on the inside of a generally tubular water jacket, in the region which is exposed to the product of combustion of a liquid, solid or gaseous fuel, thus effectively increasing the surface area of the water jacket exposed to the combustion products and, in turn, transferring heat energy in an efficient manner to water within the water jacket. The fins or baffles may also create turbulence in the flow of combustion products. However, the provision of such fins is relatively expensive, and demands complex and accurate assembly procedures, while baffles produce a high gas flow resistance or low efficiency.

It has also been proposed previously to provide a number of loose elements which are located within a passage through which the combustion products flow. One wall of the passage is defined by a wall of the water jacket, and the elements are thermally conductive. The elements establish a turbulent flow within the passage, which tends to assure that there is a good transfer of heat from the combustion products to the elements. The elements are in thermal contact with each other and are also in thermal contact with the wall of the water jacket, so that there is a very efficient transfer of heat from the combustion products to water within the water jacket. An arrangement of this type is disclosed in GB 2199647-A.

One disadvantage of this prior art arrangement is that the elements are made of metal, in the form of short lengths of tube, and are thus subject to thermal expansion when exposed to high temperature combustion products. As the elements cool, when the boiler is switched off, for example, the elements contract thus enabling the elements to settle. On subsequent expansion of the elements very severe forces are applied to the walls of the passage in which the elements are held. This cycle of events can repeat until the walls of the passage are significantly damaged.

A further problem that exists with the prior art arrangement is that if the passage through which the combustion products flow has to be cleaned, the elements must be separately removed from the passage prior to the cleaning operation, and must then be separately replaced within the passage. This is time-consuming and inconvenient.

The present invention seeks to provide an improved heat exchanger in which the draw-backs and dis advantages of the prior art are obviated or reduced.

According to this invention there is provided a heat exchanger comprising means defining a flow passage for a first fluid medium, means defining a flow passage for a second fluid medium, a thermally conductive wall structure separating the said flow passages and, in at least one of said flow passages, a cartridge, the cartridge presenting means to make the flow of fluid through the flow passage a turbulent flow, and the cartridge establishing thermal contact with said thermally conductive wall.

The cartridge may contain a plurality of thermally conductive turbulators, and at least some of the turbulators may contact the thermally conductive wall through apertures formed in a side wall of the cartridge.

Preferably the apertures formed in the side wall of the cartridge are constituted by apertures formed in a mesh which forms the side wall of the cartridge.

Conveniently the turbulators are thermally conductive ring or tubular elements.

Advantageously the cartridge supports one or more elements formed of conductive material which present an irregular or discontinuous surface to the medium flowing in the flow passage in which the cartridge is located, to constitute the means to make the flow of fluid a turbulent flow and which also make thermal contact with said thermally conductive wall.

Preferably the cartridge supports panels which are provided with metallic sheets which are slit and de formed, constituting said elements.

Conveniently the sheets comprise sheets of expanded metal.

Preferably the cartridge supports one or more bats or mats of metal wire or fibre, the metal being deformed or crushed, parts of the or each metal bat or mat establishing thermal contact with the thermally conductive wall.

Advantageously the cartridge is readily removable from the flow passage for the relevant medium.

Preferably the cartridge includes a portion adapted to substantially seal the flow passage, apart from one or more predetermined flow paths, the means to make the flow of fluid through the flow passage a turbulent flow being located within the region of said flow path or flow paths.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which

FIGURE 1 is a vertical sectional view through a boiler incorporating the present invention,

FIGURE 2 is a horizontal sectional view of the boiler of Figure 1,

FIGURE 3 is an enlarged view of a cartridge inserted in the boiler of Figure 1,

FIGURE 4 is an enlarged sectional view through part of the cartridge of Figure 3 when in position,

FIGURE 5 is a view corresponding to Figure 4 showing a modified form of cartridge,

FIGURE 6 is an exploded perspective view illustrating a heat exchanger for a motor vehicle incorporating two cartridges in accordance with the invention,

FIGURE 7 is an exploded perspective view of a further form of cartridge for use in a heat exchanger in accordance with the invention,

FIGURE 8 is a perspective view illustrating a further form of cartridge for use in a boiler such as that illustrated in Figure 1,

FIGURE 9 is a part-sectional view of another form of domestic boiler in accordance with the invention, and

FIGURE 10 is a part-sectional view of another embodiment of the invention.

Referring initially to Figures 1 and 2 of the accompanying drawings a boiler 1 is in the form of a domestic hot water boiler. The boiler has an outer casing 2. Contained within the casing is a water jacket 3 having an open hollow interior 4, whioh is square in horizontal cross-section. A water inlet connection 5 is provided at the bottom of the water jacket, the water outlet connection 6 is provided at the top of the water jacket. The lower open end of the water jacket is sealed by means of a ceramic felt pad 7. The upper end of the water jacket 4 is substantially closed by means of a cover 8 which has a removable inspection hatch 9 and which has a gas outlet 10 which can extend to a flue connection 11.

A fuel burner assembly 12 is provided adapted to direct a flame 13 into the hollow interior 4 of the water jacket. A cartridge 14, as illustrated in Figure 3, is inserted within the water jacket.

The cartridge 14, when in position, defines two flow passages 15,16 adjacent the inner wall of the water jacket, and the products of combustion flow through these flow passages 15,16 as indicated by the arrow 17,18 and then pass to the chimney 11.

Mounting brackets 19 are provided within the interior of the boiler upon which the cartridge 14 rests to locate the cartridge in position.

As can be seen more clearly in Figure 3 the cartridge 14 comprises a central substantially rectangular plate 20 provided with a handle 21, opposed side edges of the plate supporting two substantially vertical tubular elements 22,23 each of generally rectangular form when viewed from above, each having an outer face 24 formed of a mesh or the like. The lower end of each tubular element is effectively closed by a mesh 25 or the like, the tops of the tubular elements 22,23, as indicated at 25,26 being open. The walls 27 of the tubular elements 22,23 secured to the central plate 20 are substantially solid.

It will be appreciated, from Figure 2, that the cartridge 14 is adapted to be snuggly received within the water jacket 3, with the outer mesh faces 24 thereof located adjacent two opposed inner walls of the water jacket 3. The overall cross-section of the cartridge 14, when viewed from above, is the same as the cross-section of the hollow interior 4 of the water jacket 3. The plate 20 substantially seals the interior 4 of the water jacket 3, thus causing combustion products from the flame 13 to flow through the flow passages 15,16 which are defined by the tubular elements 22,23.

Contained within the tubular elements 22,23 are a plurality of turbulators comprising elements formed of a material having a good thermal conductivity, such as metal. The turbulators may comprise ring-like elements or may be formed from shapes other than rings, for example spheres, hollow extrusions, springs, spirals, apertured tubes or other non-settling loose elements. The arrangement is such that when the cartridge is inserted in the boiler the elements project through the mesh face 24 to contact the interior wall of the water jacket 3. While the elements may be loosely packed in position, they may alternatively be in a random position but be fixed in position, for example by solder or the like. The elements may be soldered in position by a hot dip process.

From the above description it will be appreciated that the water jacket 3 forms a flow passage for a first fluid medium, in the form of the combustion products generated by the flame 13, and a flow passage for a second fluid medium, in the form of water, constituted by the parts of the water jacket interconnected by the water inlet 5 and the water outlet 6. The material of the inner face of the water jacket 3 constitutes a thermally conductive wall structure of the heat exchanger.

Whilst the described embodiment shows only two tubular elements 22,23 adjacent two of the four internal faces of the heat exchanger as defined by the water jacket 3, in a higher efficiency embodiment, four tubular elements (or even an annular sleeve of appropriate cross-section)-are provided to contact each of the four faces of the heat ex-

changer.

Figure 4 is an enlarged view illustrating a plurality of tubular turbulator elements 28, (as present within the cartridge 14) which may be formed from copper tube. Preferably the turbulator elements have a length which is substantially equal to their diameter. It can be seen that the turbulator elements are in a random disposition and thus form a convoluted flow path for the combustion products. Combustion products flowing through the tubular portions 22,23 of the cartridge 14 are thus constrained to flow in a turbulent and non-linear manner. It can be seen that some of the turbulators 28 project through the mesh 24 and contact the wall 29 of the water jacket 3 thus ensuring that heat is firstly absorbed by the turbulators 28 from the combustion products, and is then transferred by conduction to the wall 29 of the water jacket.

It will be appreciated that, when the interior of the boiler is to be serviced or cleaned, the entire cartridge 14 can readily be removed from the boiler in a simple operation. The turbulator elements, if loose, are retained within the cartridge, which can thus be handled as a single entity in an easy and straight forward manner.

In an alternative embodiment of the invention the turbulator elements are replaced by a bat or mat of metal wires or fibres, which may be deformed or crushed to be in a totally random array. Alternatively, again, in a modified cartridge a plate corresponding to the plate 20 exerts outward pressure against vertically extending elements which contact the inner walls of the water jacket, the elements each being formed of one or more sheets of metal which are bent, dimpled, folded, and/or slit to form a convoluted flow path for the combustion products generated by the flame, whilst being of such a form that the sheet or sheets each contact the water jacket at a plurality of spaced apart points.

Figure 5 illustrates a modified embodiment of the invention wherein not only the outer face 24 of the tubular element 22 or 23 of the cartridge is formed of a mesh, but also the inner face 27. The turbulator elements 28, however, perform the same function as described above. Whilst this arrangement may be used in a boiler as described above, the arrangement may also be used in other forms of heat exchanger, such as a motor vehicle heat exchanger.

Figure 6 illustrates, schematically, such a motor vehicle heat exchanger in the form of a so-called radiator. The radiator includes an assembly 30, formed of tubes, through which water from an internal combustion engine cooling system flows. Two cartridges 31 are illustrated each effectively comprising a cage formed of mesh, to be mounted one on each side of the tubular assembly 30. Each cartridge is to contain a plurality of turbulators of the type described above, and it will be appreciated that the turbulators will project through the mesh into contact with the tubular assembly 30. Air may flow through the entire radiator as indicated by the arrow 32. It will be appreciated, therefore, that in use of this arrangement, heat from hot water present within the tubular assembly 30 will pass, by virtue of conduction, to turbulator elements in contact with the tubular assembly 30. The heat will then be passed to the entire assembly of turbulator elements in each cartridge 31 and will then be dissipated by air flowing through the cartridges as indicated by the arrow 32. The flow of air will be turbulent by virtue of the nature of the turbulator elements present within the cartridges 31.

Figure 7 is an exploded view illustrating two further cartridges 33 each of generally semi-circular form and each formed of mesh, which can be located to surround a cylinder of an internal combustion engine which is to be air-cooled. It is to be appreciated that the cartridges 33 will again be filled with turbulator elements as described above which may project through the inner mesh wall of the cartridge in order to contact an external surface of the wall defining the cylinder to be cooled. Again air will flow through the cartridges, in a turbulent manner, extracting heat from the turbulator elements.

While the invention has been described above with reference to embodiments in which loose turbulator elements are utilised, it is to be appreciated that such loose turbulator elements may suffer from the disadvantage described above, namely that on successive thermal expansion and contraction the turbular elements may settle, and may then effect damage to the walls which serve to retain turbulator elements in position. Thus, in each of the embodiments described above, the turbulator elements may be fixed in position, by soldering or some other convenient way. However, the embodiments of the invention to be described with reference to Figures 8 and 9 of the invention do not suffer from this particular disadvantage.

Figure 8 illustrates a cartridge 34 which is intended for use in a manner similar to that described in connection with the cartridge 14. The cartridge 34 comprises a central sheet 35 adapted substantially to seal the hollow interior 4 of a water jacket 3 within a domestic boiler 1. Mounted at two opposed side edges of the central sheet 35 are two upstanding panels 36. At their upper edges the upstanding panels 36 are interconnected by resilient elements 37 which serve to bias the panels apart. Each panel 36 has an exterior face which is formed from a metal sheet 38 which is deformed to provide a convoluted flow path for combustion products, and which also provides a plurality of projec-

ting points or surfaces which can contact an interior wall 29 of a water jacket 3. Thus, for example, the exterior of each panel 36 may be formed from a sheet of expanded metal, or metal which has been otherwise slit and deformed to provide a plurality of discrete areas at different relative angular positions, the sheet also presenting a plurality of points or edges which are directed outwardly so as to be able to come into contact with the wall 29 of a water jacket 3.

It is to be appreciated that when the cartridge 34 has been mounted in position within a boiler, such as the boiler 1, when the boiler is operational combustion products will be caused to flow, as indicated by the arrows 39 through flow paths effectively defined by the material comprising the outer face 38 of each of the panels 36. The combustion products will flow in a turbulent manner, thus efficiently transferring heat to the material forming the outer face 38 of each of the panels 36. This heat is then transferred by conduction to the wall 29 of the water jacket 3.

As in the embodiment described with reference to Figures 1 to 4 of the accompanying drawings the cartridge 34 can easily be lifted out of the boiler when it is desired to service or clean the boiler.

Figure 9 illustrates a further form of water heater 40 having an outer casing 41 of generally rect angular form. Within the centre of the casing is a core 42 which is hollow and which is adapted to receive a flow of water. A water inlet 43 is provided on the exterior of the casing leading to an injector tube 44 within the hollow core 42. A water outlet 45 is also present on the exterior of the casing and the arrangement is such that water injected through the water inlet 43 passes through the injector tube 44 into the hollow interior of a core 42 and then leaves the core through the outlet 45.

Contained within the casing 41 beneath the core 42 is a burner tube 46 which is supplied with gas, which burns as flames 47. Located above the burner tube 46, between the core 42 and one wall of the casing 41 is a cartridge 47 having an operative part formed from two superimposed sheets of expanded metal. In alternative embodiments a single sheet of expanded metal may be used, or three or more superimposed sheets. Portions of the expanded metal are deflected outwardly, so that these portions engage the interior of the casing 41 and also engage the exterior of the core 42. Thus the exterior of the cartridge 47 is forced into contact with the exterior of the core 42. There is a space between the top of the core 42 and the top of the casing, and in a space between the other side of the core and the other side of the casing a further cartridge 48 of a similar design is provided.

It is to be appreciated that combustion products from the flame 47 pass upwardly past the first cartridge 47 across the top of the core and then downwardly past the second cartridge 48 before emerging through a flue gas outlet 49 as indicated by the arrows 50. A condensate outlet 51 may be provided communicating with the interior of the casing 41 at a position beneath the second cartridge 48.

It will be appreciated that in use of the heat exchanger as illustrated in Figure 8 heat will be absorbed by both cartridges from the flue gas. The heat absorbed from the second cartridge 48 may consist at least partly of the latent heat of any moisture present initially in the flue gases in the form of steam. It is for this reason that the condensate outlet 51 is provided. If this latent heat can be retrieved, the boiler will operate in a very efficient manner.

The cartridges may be removed from the boiler in an easy way when the boiler is to be serviced or cleaned. Also the cartridges may be easily manufactured.

Figure 10 illustrates another embodiment of the invention in the form of a heat exchanger which may be used for a gas fired boiler or a car radiator. In this embodiment of the invention the first flow passage comprises a plurality of portions of conduit 60,61,62. The first flow passage may carry water which, in the case of a boiler is to be heated and in the case of a vehicle radiator is to be cooled. A plurality of sheets of expanded metal 63 are provided which are adapted to be located on either side of the lengths of conduit 60,61,62. The sheets 63 are intended to "sandwich" the portions of conduit and thus the sheets 63 are provided with arcuate deformed regions 64 having radiuses of curvature broadly equivalent to the radius of each of the conduits 60,61,62. The sheets of expanded metal may be mechanically pressed into engagement with the conduit portion 60,61,62 and may be clamped or even soldered into position. The elements of expanded metal 63 provide a convoluted flow path for any gas passing through the sheets of expanded metal. In the case of a motor vehicle radiator the gas may pass through the expanded metal in the direction indicated by the arrows 65 where as in the case of a gas boiler the gas may flow in the direction indicated by the arrow 66. In either case the flow of fluid through the conduits 60,61,62 is indicated by the arrows 67.

Whilst the invention has been described with reference to cartridges made from expanded metal, it is to be appreciated that cartridges, especially for use in the embodiment of Figure 9, may simply be formed from sheets of metal which are dimpled or otherwise deformed to provide at least point contact with the exterior of the core 42 and to provide means projecting into the flow path of combustion

products in order to cause the combustion products to flow in a turbulent manner, rather than in a linear or laminar-type flow. Alternatively, the cartridges may carry panels which support bats or mats of metal wire or fibres, which may be deformed or crumpled.

Claims

1. A heat exchanger comprising means defining a flow passage for a first fluid medium, means defining a flow passage for a second fluid medium, a thermally conductive wall structure separating the said flow passages and, in at least one of said flow passages, a cartridge, the cartridge presenting means to make the flow of fluid through the flow passage a turbulent flow, and the cartridge establishing thermal contact with said thermally conductive wall.

2. A heat exchanger according to Claim 1 wherein the cartridge contains a plurality of thermally conductive loose turbulators.

3. A heat exchanger according to Claim 2 wherein at least some of the turbulators contact the thermally conductive wall through apertures formed in a side wall of the cartridge.

4. A heat exchanger according to Claim 2 wherein the apertures formed in the side wall of the cartridge are constituted by apertures formed in a mesh which forms the side wall of the cartridge.

5. A heat exchanger according to any one of the preceding Claims wherein the turbulators are thermally conductive ring or tubular elements.

6. A heat exchanger according to Claim 1 wherein the cartridge supports one or more elements formed of conductive material which present an irregular or discontinuous surface to the medium flowing in the flow passage in which the cartridge is located, to constitute the means to make the flow of fluid a turbulent flow and which also make thermal contact with said thermally conductive wall.

7. A heat exchanger according to Claim 6 wherein the cartridge supports panels which are provided with metallic sheets which are slit and deformed, constituting said elements.

8. A heat exchanger according to Claim 1 wherein the cartridge supports one or more bats or mats of metal wire or fibre, the metal being deformed or crushed, parts of the or each metal bat or mat establishing thermal contact with the thermally conductive wall.

9. A heat exchanger according to any one of the preceding Claims wherein the cartridge is readily removable from the flow passage for the relevant medium.

10. A heat exchanger according to Claim 9 wherein the cartridge includes a portion adapted to substantially seal the flow passage, apart from one or more predetermined flow paths, the means to make the flow of fluid through the flow passage a turbulent flow being located within the region of said flow path or flow paths.

FIG 1

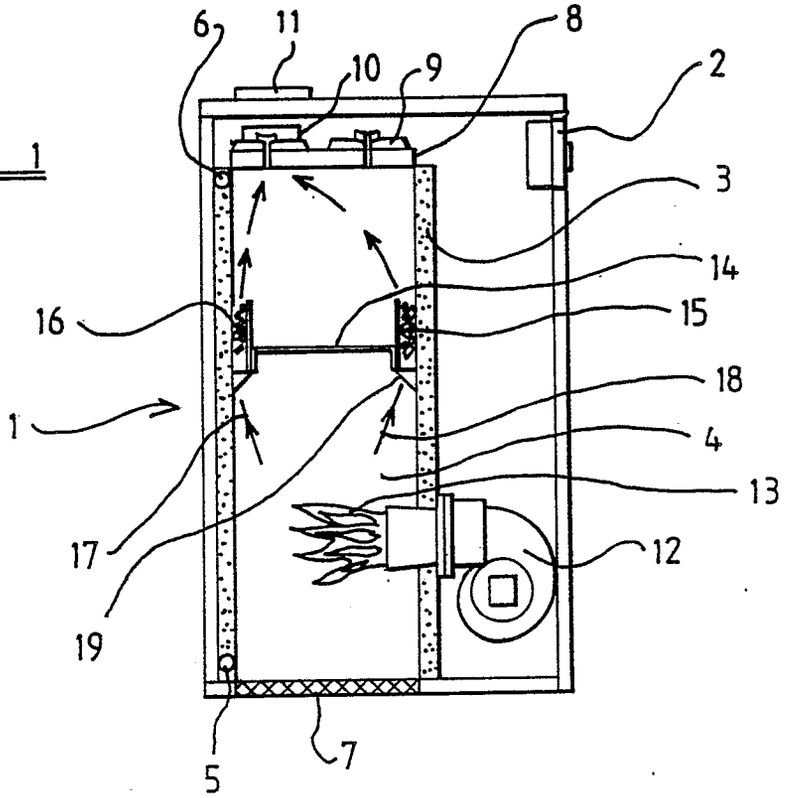


FIG 2

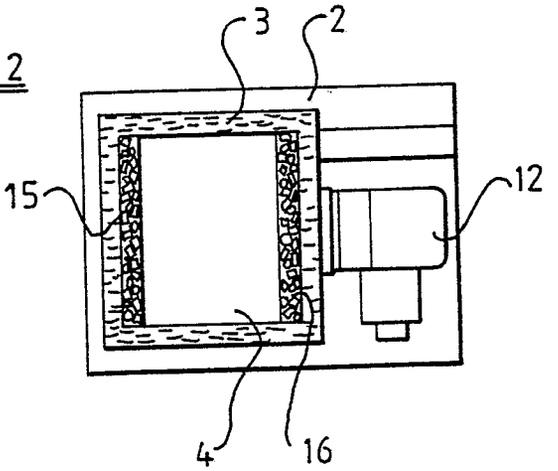
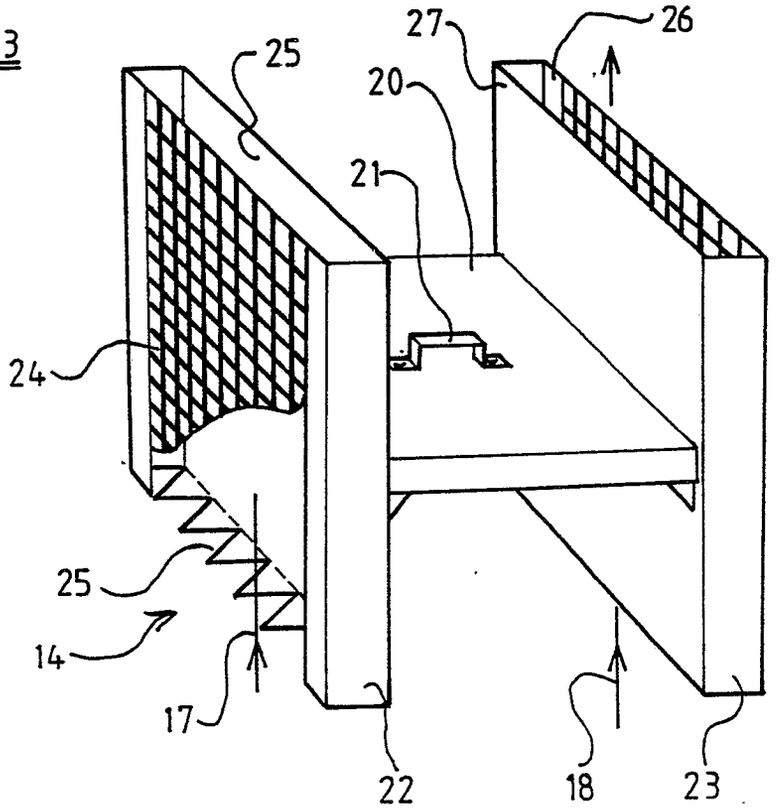


FIG 3



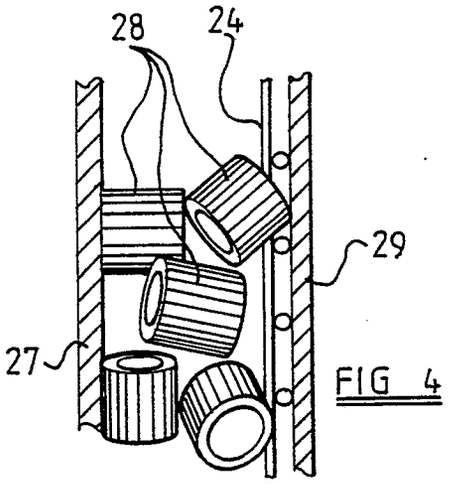


FIG 4

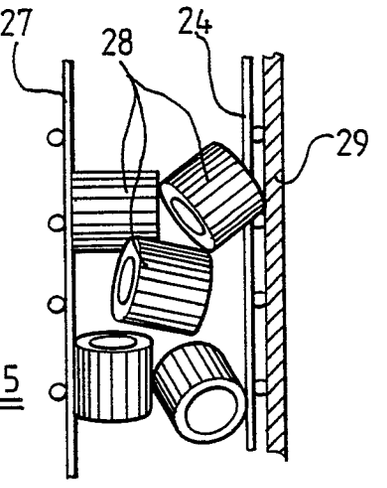


FIG 5

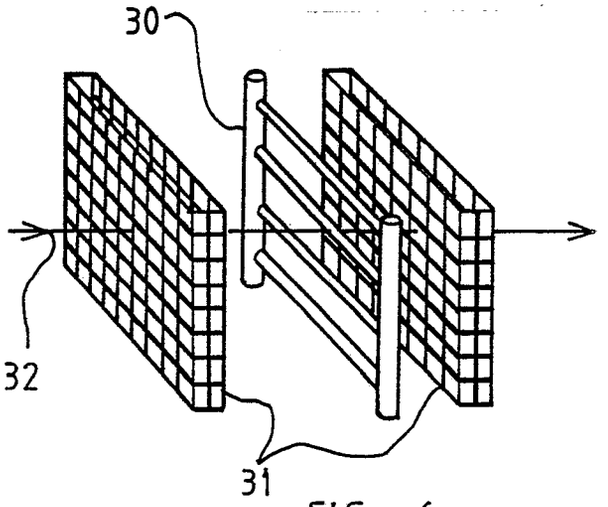


FIG 6

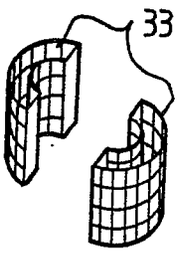


FIG 7

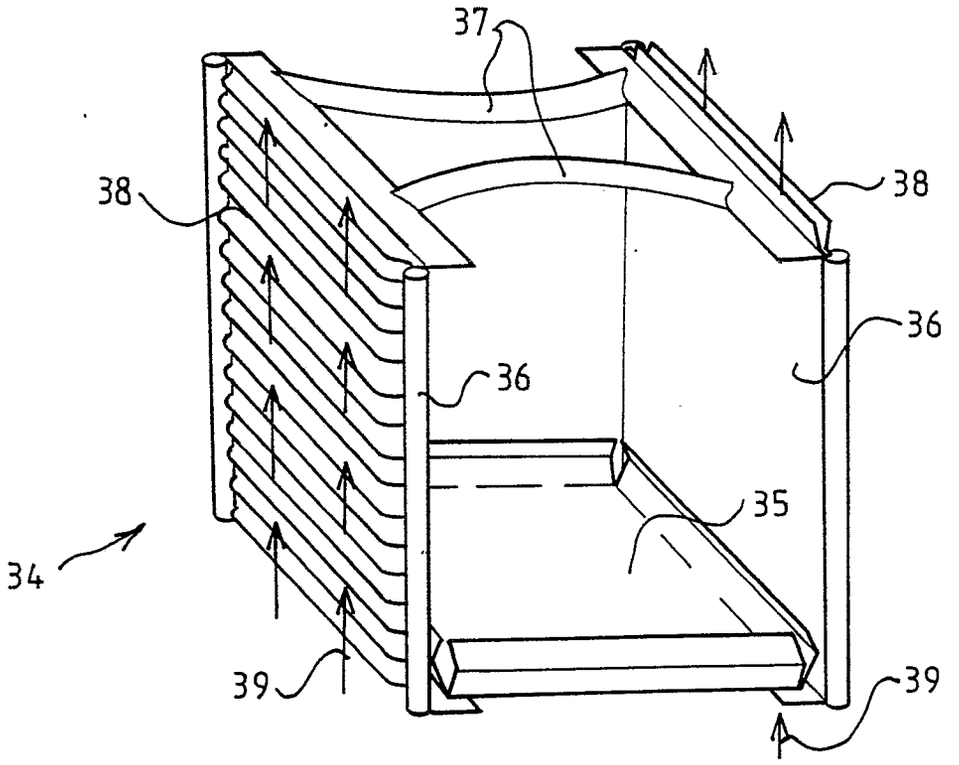


FIG 8

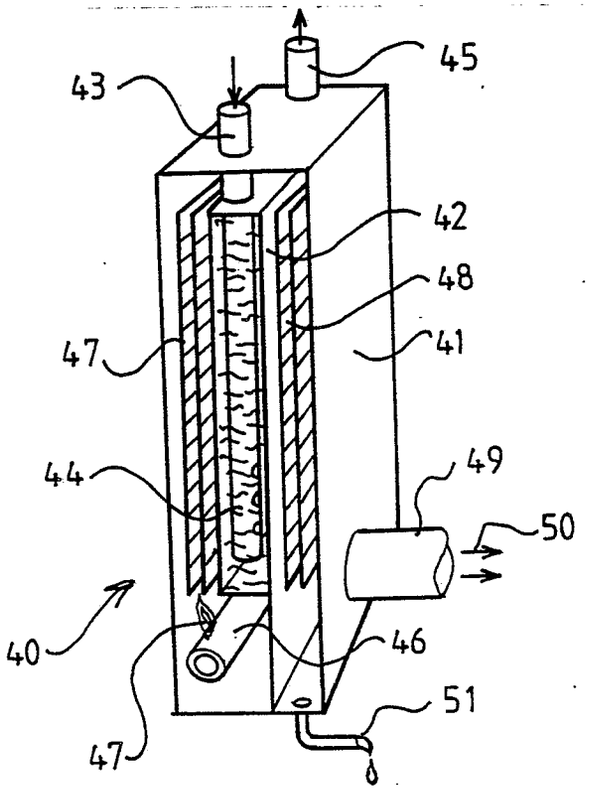


FIG 9

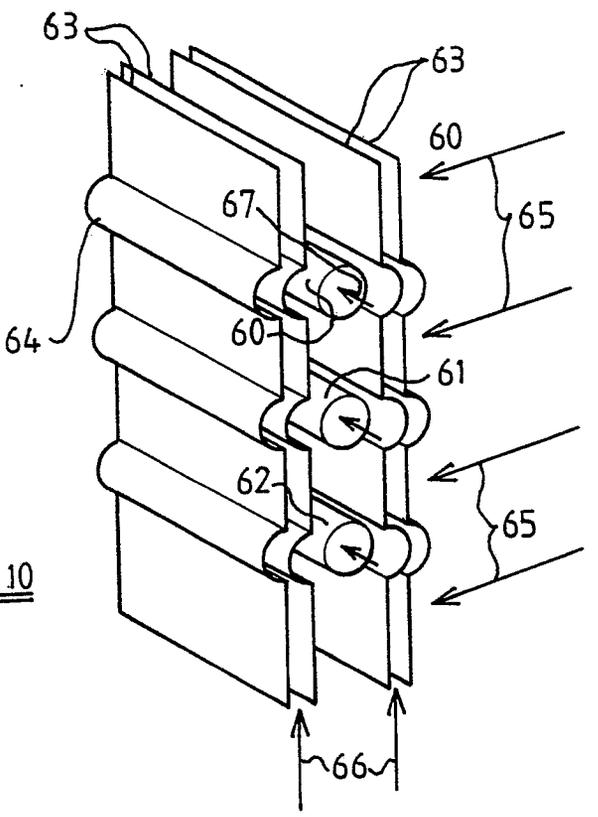


FIG 10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 11 4127

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-A-1 551 512 (SÖLCH) * Whole document *	1,6-8	F 28 F 13/12 F 24 H 9/00
A	GB-A-2 165 349 (BRITISH GAS CORP.) * Abstract *	1,6,7	
A	GB-A-2 065 288 (MIDLAND WIRE CORDAGE CO. LTD) * Abstract *	1,8	
A	FR-A-2 238 909 (PERTSEV) * Figures *	1	
A	US-A-3 921 711 (AMERICAN STANDARD) * Abstract; column 2, line 60 - column 3, line 9 *	1,2	
A	FR-A-2 514 475 (BONNET) * Whole document *	1	
A,D	GB-A-2 199 647 (MacPHAIL)		TECHNICAL FIELDS SEARCHED (Int. Cl.5) F 24 H F 28 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-11-1989	VAN GESTEL H.M.

CATEGORY OF CITED DOCUMENTS

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