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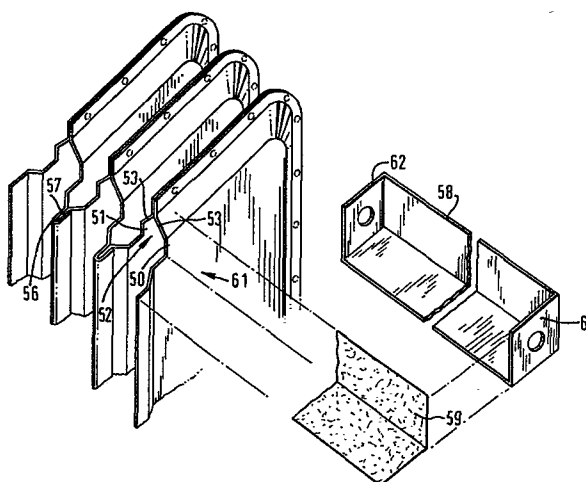
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Heat exchangers.

1. A heat exchanger comprising a casing (1), means (33) in the casing defining first and second fluid flowpaths, and a fluid inlet (42) and a fluid outlet (10, 31) associated with each of the said flowpaths, the said flowpath-defining means including a plurality of substantially parallel flat plates (50, 51), each of the said plurality of plates having a portion of its periphery (53) bent towards a first side of the plate, and an adjacent portion (55) of its periphery bent towards an opposite side of the said plate, the said peripheral portions of the plates serving to connect the plates to at least one adjacent plate (57), each of the said plates including a notch (61) intermediate the said peripheral portions, and the heat exchanger including a sealing bar (58) accommodated in the notches (61) of the said plates for preventing mixing of the said first and second fluid flowpaths.



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HEAT EXCHANGERS

This invention relates to heat exchangers, and in particular air-to-air heat exchangers of the kind used in domestic and commercial heating installations and
05 of the kind used for tumbler driers as used for drying articles of laundry. It has particular application to heat exchangers for use with such driers when used in conjunction with washing machines in launderette installations.

10 Tumbler driers of the aforementioned kind commonly employ a gas fired heater located at the top of a cabinet which contains a tumbler cylinder. The tumbler cylinder takes the form of a perforated sheet metal cage which is rotated at about 50 r.p.m. on a
15 horizontal axis. At the bottom of the cabinet there is provided a fan which draws a current of air through air inlets provided at the top of the cabinet down through a duct past the tumbler cylinder through a filter screen and exhausts it to atmosphere. This air
20 is drawn through the heater compartment so that a copious supply of hot air is drawn through the tumbler cylinder so as to heat and dry the laundry articles and expel moist air and the products of combustion to the atmosphere. The system tends to be wasteful of
25 fuel since in order to achieve the rapid heating of the air flow a high capacity burner is needed and of necessity much hot air leaves the machine and much heat is lost in this way. For example, it is common

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to use about 100 cubic feet of gas per hour (about
100,000 BTU per hour) and the air through-put is of
the order of 500 cubic feet per minute. Much of this
loss could be avoided if use could be made of the heat
05 normally lost to atmosphere in the exhaust air. The
present invention is directed to the achievement of
these savings.

According to a first aspect of this invention
there is provided a heat exchanger comprising a
10 casing, means in the casing defining first and second
fluid flowpaths, and a fluid inlet and a fluid outlet
associated with each of the said flow paths, the said
flowpath-defining means including a plurality of
substantially parallel flat plates, each of the said
15 plurality of plates having a portion of its periphery
bent towards a first side of the plate, and an
adjacent portion of its periphery, bent towards an
opposite side of the said plate, the said peripheral
portions of the plates serving to connect the plates
20 to at least one adjacent plate, each of the said
plates including a notch intermediate the said
peripheral portions, and the heat exchanger including
a sealing bar accommodated in the notches of the said
plates for preventing mixing of the said first and
25 second fluid flow paths.

Plates are preferably joined in pairs to form
discrete and removable elements which can be connected

together in a casing either by longitudinal clips, or by folding over a peripheral portion of one of the plates to accommodate an edge portion of an adjacent plate and thereby form a seal.

05 According to an alternative aspect of the invention there is therefore provided a heat exchanger comprising a casing, means in the casing defining first and second fluid flowpaths, and a fluid inlet and a fluid outlet associated with each of the said
10 flowpaths, the said flowpath-defining means including a plurality of discrete heat exchanger elements, each element comprising a pair of plates, the said plates being substantially parallel so as to define a space therebetween, the space being a part of the said first
15 flow path, a first portion of the periphery of each plate being bent outwardly of the said space to define an inlet thereto, and a second portion of the periphery of each plate being bent outwardly of the said space to define an outlet therefrom, the first
20 and second said portions each being juxtaposed opposite a similar portion bent outwardly of the said space on the periphery of the other said plate, and a third portion of the periphery of the said plates being bent inwardly of the said space and being
25 connected to a corresponding peripheral portion of the other said plates to constitute the said element.

The outwardly bent peripheral portions are preferably provided at opposite ends of a substantially straight edge of one of the elements, the greater part of the remainder of the periphery of the plates being joined to define effectively a pocket-like structure, with inlet and outlet at opposite ends of the same straight side. This enables a particularly advantageous and simple construction to be produced, in which the elements are generally rectangular, and closed around three sides, the edges along the fourth side being bent outwardly of the space along substantially all of the fourth side. Adjacent free edges are then joined together along the fourth side, for example by means of removable clips, and a sealing plate is provided in the central portion of the said fourth side between the inlet and the outlet.

As an alternative to providing removable clips, part of the peripheral portion of the plates may be folded over to accommodate an edge portion of an adjacent plate, and thereby form a seal.

A major advantage of the heat exchanger according to the invention is that heat exchanger elements may be formed very simply, using conventional press or swaging tools. Because, in the preferred embodiments of the invention, substantially all of the periphery

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of each plate is bent towards an adjacent plate in one direction or the other, notches are preferably provided in each plate intermediate the peripheral portions bent in opposite directions, to enable the
05 desired bending to take place. Such notches may preferably be provided at corner parts of the heat exchanger elements, and may serve to accommodate bars which simultaneously support the heat exchanger elements, and seal the two flowpaths from each other.
10 The two plates of an element may be stamped from separate sheets of material, and clipped or welded together around their edges, or, in an alternative embodiment may be stamped from a single sheet of material, the sheet being folded along its length to
15 form a deep channel.

Thus, according to a further embodiment of the invention there is provided a duct and a divider within said duct said divider comprising an array of plates of heat conductive sheet material each said
20 plate being folded along its length to form a deep channel, said plates being arranged in side by side and edge to edge relation the adjacent free edges of successive plates being connected together by removable clips to form a continuous undulation
25 reaching across said duct said array being closed at its ends.

Both the inlet and outlet for the said first flowpath may preferably be provided on the same wall of the heat-exchanger casing, and sealing means are preferably provided between the said divider and the
05 said wall to enclose the said space.

When the heat exchanger of the kind described above is used in a tumbler drier installation, it is preferred that, during the warm-up phase of the tumbler drier cycle, a proportion of the exhaust air
10 from the tumbler drier passing through one side of the heat exchanger (the second flowpath) is allowed to mix with fresh air passing into the tumbler drier through the first flowpath. Because such exhaust air is moisture-laden, it is preferable to provide a flap or
15 similar valve to enable the degree of mixing to be cut down after the tumbler drier has reached a desired temperature. Such a flap or valve may preferably be automatically operated by means of a thermostat.

When the heat exchanger is used in conjunction
20 with a tumbler drier, a second discharge path may be provided, otherwise than through the tumbler drier, adapted to provide alternative ingress for heated air from the tumbler drier should the path through the heat exchanger become blocked. It has however been
25 found that heat exchangers according to the invention are not only readily disassembled for easy cleaning,

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but also are less inclined to become blocked than conventional heat exchangers.

A number of preferred embodiments of the invention will now be described with reference to the
05 accompanying drawings in which:-

Fig. 1 is a side view of a tumbler drier fitted with a heat exchanger according to the invention,

Fig. 2 is a side elevation, partly in section, and

10 Fig. 3 is a front elevation of the heat exchanger shown in Figure 1,

Fig. 4 is a vertical cross-section of the heat exchanger shown in Figures 2 and 3,

Fig. 5 shows the upper end of three alternative
15 forms of heat exchanger element,

Fig. 6 illustrates the use of support/sealing bars with such elements,

Fig. 7 represents an alternative heat exchanger element configuration, and

20 Fig. 8 shows 4 further alternative configurations of the heat exchanger element.

Referring first to Figure 1, a conventional tumbler drier 1 has a heater compartment 2 at the top, containing gas burners 3. In the centre of the
25 machine is a tumbler cylinder 5 shown in dotted outline. At the bottom of the cabinet is a fan 6 for

drawing air through the heater compartment 2, and
thence through the compartment containing the drum 5.
The burners 3 are located to one side of a partition
wall 7 to the other side of which is a downwardly
05 directed duct 8 which leads past the tumbler cylinder
5 to the fan unit 6. A lint screen or filter 9
intercepts lint shed from the articles being dried so
that this contamination is kept away from fan 6. When
the burners 3 are alight and the fan 6 is operating
10 air is drawn in through inlets 10 and heated by the
flames of burners 3. The air drawn in through inlet
10 and the flames from burners 3 are drawn over the
top of the upstanding partition 7. Further air may be
drawn in through an additional inlet (not shown).

15 The exhaust from fan 6 will typically consist of a
considerable volume, typically up to about 500 cubic
feet per minute, of hot moist air. In the heat
exchanger 30, some of this heat is recovered and used
to preheat the air supplied to the heater compartment
20 2. The air-to-air heat exchanger 30 is connected to
receive the exhaust from fan 6, the cooled air passing
to atmosphere through discharge pipe 31. The heat
exchanger 30 is shown in more detail in Figures 2, 3
and 4. It comprises a duct or casing 32 within which
25 is located a divider 33 which divides the duct 32 into
two interleaved air flowpaths. The exhaust air from

fan 6 is likely to contain particles of lint from the laundry articles and the construction of the heat exchanger is particularly advantageous in that it can be readily cleaned. It may also be desirable for
05 provision to be made for condensed moisture condensing inside the heat exchanger to be drawn off. For this reason also the material of which the heat exchanger is made should be resistant to corrosion and of good thermal conductivity. Black matt painted galvanised
10 mild steel or aluminium sheet are suitable materials.

In the construction shown the divider 33 for defining the first and second fluid flowpaths is made up of a number of elements 20, 21, 22, each comprising two substantially parallel plates 21a, 21b etc. each
15 plate is formed, in this embodiment, from a single sheet of material, bent to a deep channel configuration. The cross-section of Figure 4 shows six such elements.

The elements are substantially identical, and the
20 characteristic features of the elements will therefore be described simply with reference to the endmost element. The two plates, 21a and 21b of the endmost element 21 define between them a space 24 comprising a part of the flowpath for the influent air for the
25 tumbler drier. The peripheral portion 25 of each plate 21a, 21b along the rear vertical edge of the element is bent outwardly of the space 24 for a first

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portion of its length in the region of the inlet 42, and a second portion of its length in a region of the outlet 10. For convenience, the peripheral portion of the plates along the edge intermediate the inlet 42 and the outlet 10 is also bent outwardly of the space 24 in the same way, but in this region, the rear panel, 26 of the casing effectively seals the space 24 so as to form a closed duct.

Along the opposite vertical edge of the plates 21a, 21b a peripheral portion 26 is bent inwardly of the space and is connected to the corresponding peripheral portion of the other plate. Thus, the plates may be mounted in a substantially parallel spaced fashion, with each element forming a readily demountable unit. The free peripheral edges 25 of the plates 21a, and 21b are held in close contact with the casing 32 or the adjacent plate 20a respectively by means of spring clips 34 along their free edges.

On its rear wall the casing 32 carries two projecting ribs 38 and 39. These serve as an abutment against which the divider 33 rests and are slotted to offer location of the elements. They also deflect the air-flow through the duct 32 causing turbulence and increasing the contact of the rising air stream with the outer surfaces of the plates of the divider 33.

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At the top and bottom ends of the plates 21a, 21b of the element, each fold is bent inwardly of the space and joined to the other plate to maintain the space between the plates of each element inaccessible to the rising air stream. At the top and bottom ends of the divider 33 sealing pads 40 and 41, which may be made of felt, are provided to seal the divider against the front wall of duct 32. Thus the space on the right hand side of the divider 33 as seen in Figure 4 (i.e. the space between the two plates of each element) is completely sealed from the duct 32. Access to this space is via an inlet port 42 at its bottom end and the duct 10 at its upper end. The duct 10 as will be seen from Figure 2 connects to the air inlet of the heater compartment 2. A drain plug 43 is provided at the bottom of the duct 32 to enable condensed moisture to be drawn off.

The heat exchanger above described can be designed to provide something of the order of 100 square feet of heat exchange surface between the two currents of air in a typical installation. It should preferably be of such cross-section that at least 50 square inches of cross-section is available for each of the air paths through the exchanger. Having regard to the normal temperature of the air exhausted from a tumbler drier and the normal temperatures of the intake air a

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gain of some 60°-70°F can be achieved so that the heater compartment 2 is supplied with input air already at a temperature of around 150°F.

It will moreover be seen that the construction of heat exchanger above described lends itself to easy dismantlement and therefore easy cleaning. Thus, to dismantle the heat exchanger for heating purposes, the rear sealing plate 26 may be removed complete with flexible inlet and outlet pipes, if fitted. The clips 34 are then removed, and individual elements removed, cleaned by a simple sweeping operation, and replaced. Because only clean air circulates in the space between the plates of each element, only the outside of each element is liable to require cleaning.

Emergency air flaps may be provided for affording alternative air paths for air to be admitted to the heater compartment in the event that clogging of either of the air flowpaths takes place or that the fan should fail to run. These emergency provisions (which have not been illustrated in the drawings) may comprise, an entry port communicating with the heater compartment and covered by a hinged flap. This flap is hinged at either its top or its bottom edge to open inwardly but is normally held shut by a detent.

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In the event that the normal air inlet should become blocked the suction of fan 6 will override the restraint of the detent and allow the flap to open and admit air. To cover the possibility that the fan 6
05 may stall or that the air flow should be otherwise interfered with air must be admitted to the burner compartment to enable the burner to continue to burn. For this purpose a second entry port is provided covered by a flap which in this case opens outwardly.
10 When the fan 6 is running the suction keeps this second flap shut but if this suction should cease the flap will fall open to admit air to the burner compartment. Shutting of this flap under the action of air drawn in by fan 6 can be accelerated and
15 ensured by a pressure plate supported from the inner side of the flap on a stem which passes through the entry port. Air drawn in through the port will bear on this plate to help pull the flap shut to the point when external pressure on the flap itself completes
20 the closure. Both flaps are fitted with counterpoise weights to ensure that they operate under the action of relatively light air flow. The second flap is preferably caused to operate a micro-switch controlling a valve which shuts off the gas supply to
25 the burner so that the burner will be shut down if the fan 6 should fail.

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Figures 5 and 6 shows a particularly preferred form of heat exchanger element which may be used in the heat exchanger shown in Figures 1 to 4. The upper ends only of the elements are shown in Figure 6, the
05 lowers ends being substantially identical. Each of the elements comprises two plates 50, 51, which are substantially flat and parallel over a greater part of their area. the plates define between them a space 52, and the peripheral portions 53 of the plates are
10 bent inwardly around three sides thereof. These peripheral portions are spot-welded to each other in the embodiment shown, although seam-welding could equally well be used. The corner portion 54 of the plates 51 is rounded, and this is particularly
15 advantageous as it enables the corner portion of the plates to be formed in a simple pressing or swaging operation without the need to cut material from the corner portions. It also lessens fluff deposition.

Along the fourth side 55, the plates are bent
20 outwardly of the space 52, the right-hand edge 56 as shown in Figure 5 of the said peripheral portion being folded to accommodate a left hand edge 57 of the adjacent element. A sealing mastic or the like may be incorporated in the folded portion 56 to enhance the
25 sealing effect.

Notches 60, 61, are formed in each end of the element, to enable the edge portions 53 and 55 to be bent in opposite directions. These notches

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accommodate a sealing bar 58, which also serves to support the elements in the casing. The bar 58 is formed from a right-angle or square section having end lugs 62 welded thereto. A sealing strip of felt-like material or the like 59 is accommodated intermediate the bar 58 and the elements to seal the flowpaths from each other in the region of the notches.

Figure 7 shows an alternative configuration of heat exchanger element, in which first portions 70, 71 of each plate are bent outwardly of the space between the plates to form a fluid inlet, and a second portion 72 of the peripheral portion of the plates which is bent outwardly of the space to form a fluid outlet is situated on a different edge of the heat exchanger element. In this case, the notch 73 intermediate inwardly bent and outwardly bent portions of the periphery is similar to that shown in Figure 5, in being formed at a corner of the element, but a second notch 74 is necessary intermediate outwardly bent peripheral portions 70 and 71 and inwardly bent peripheral portions 75. Thus it is necessary for notch 74 to have three sides, since it is not at the corner of the elements.

Alternative configurations of heat exchanger elements are shown in Figures 8(i) to (iv). In Figure 8, edges designated "a" are formed generally as shown

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in Figure 8(v), and that is designated "b" as shown in Figure 8(vi). It can be readily seen from Figure 8 that any desired heat exchanger configuration can be achieved using the elements according to the
05 invention, for example a conventional cross-flow as shown in Figure 8(ii).

A particular advantage of a heat exchanger according to the invention is that a heat exchanger of any width may be formed by simply varying the size of
10 the casing, and utilizing a greater number of standard off-the-shelf elements. The casing, must, of course, incorporate the necessary inlets and outlets in the appropriate position. In each case, the elements may be readily removed for cleaning purposes, although it
15 has been found in practice that the low cross sectional area presented to the oncoming air flow by virtue of the welded edges of the elements means that cleaning is less likely to be necessary than with a conventional heat exchanger.

20 In a further preferred embodiment (not shown) two banks of elements having a configuration as illustrated in Figure 6 are utilised, with their outwardly bent edges 55 facing each other. A common inlet feeds a manifold at one end of the edge 55, and
25 heated air from the the internal space of each element of the two banks is fed to a common outlet manifold.

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This arrangement is particularly advantageous as it can be used where vertical space is at a premium with the elements orientated in the horizontal plane.

It is a particular advantage of the embodiments
05 disclosed above that the elements are elongate, and
the two air flowpaths are generally longitudinally of
the elements in contra-flow fashion, since this gives
maximum heat transfer. Although the invention has
been particularly described with reference to heat
10 exchangers for tumbler drier applications, it should
be understood that the invention is by no means
limited to such applications and may, for example, be
used in commercial and domestic heating, ventilation
and air conditioning applications, and any other
15 industrial application. Clearly a wide variety of
configurations and applications are possible in
addition to those specifically described above.

CLAIMS

1. A heat exchanger comprising a casing (1), means
(33) in the casing defining first and second fluid
flowpaths, and a fluid inlet (42) and a fluid outlet
05 (10,31) associated with each of the said flowpaths,
the said flowpath-defining means including a plurality
of substantially parallel flat plates (50,51), each of
the said plurality of plates having a portion of its
periphery (53) bent towards a first side of the plate,
10 and an adjacent portion (55) of its periphery bent
towards an opposite side of the said plate, the said
peripheral portions of the plates serving to connect
the plates to at least one adjacent plate (57), each
of the said plates including a notch (61) intermediate
15 the said peripheral portions, and the heat exchanger
including a sealing bar (58) accommodated in the
notches (61) of the said plates for preventing mixing
of the said first and second fluid flowpaths.

2. A heat exchanger comprising a casing (1), means
20 (33) in the casing defining first and second fluid
flowpaths, and a fluid inlet (42) and a fluid outlet
(10,31) associated with each of the said flowpaths,
the said flowpath-defining means including a plurality
of discrete heat exchanger elements, each element
25 comprising a pair of plates (50,51), the said plates
being substantially parallel so as to define a

space (52) therebetween, the space (52) being a part of the said first flow path, a first portion (55) of the periphery of each plate being bent outwardly of the said space to define an inlet thereto, and a
05 second portion (55) of the periphery of each plate being bent outwardly of the said space to define an outlet therefrom, the first and second said portions each being juxtaposed opposite a similar portion bent outwardly of the said space on the periphery of the
10 other said plate, and a third portion (53) of the periphery of the said plates being bent inwardly of the said space and being connected to a corresponding peripheral portion (53) of the other said plates to constitute the said element.

15 3. A heat exchanger as claimed in Claim 2, wherein the said first and second peripheral portions are positioned at opposite ends of a substantially straight edge (55) of the element.

4. A heat exchanger as claimed in Claim 3, wherein
20 the peripheral portion of the said plates in the region between the said first and second peripheral portions is folded outwardly of the space, adjacent peripheral portions (56,57) of the said straight edge being joined to thereby connect adjacent elements, and
25 substantially all the remainder of the peripheral portion of the said plates being connected to the other said plate of the element.

5. A heat exchanger as claimed in Claim 4, wherein the said elements are elongate and generally rectangular in shape, closed around their two short sides and one long side, the edge portion of each plate
05 along the other side of the plate being bent outwardly of the space, and a notch being provided at each end of the last-mentioned side to accommodate a sealing bar.

6. A heat exchanger as claimed in any one of Claims
10 2 to 5, wherein the periphery of each plate includes at least one notch in a region thereof intermediate an outwardly bent and an inwardly bent portion, the said notch accommodating a sealing bar.

7. A heat exchanger as claimed in Claim 1 or Claim
15 6, wherein the said sealing bar serves to support the said elements in the casing.

8. A heat exchanger as claimed in Claim 7, wherein sealing bars are provided to support the said elements at at least two of their corners.

20 9. A heat exchanger as claimed in any one of the preceding Claims, wherein at least part of the peripheral portion of one or more of the plates is folded over to accommodate an edge portion of an adjacent plate, and thereby form a seal with the said
25 adjacent plate.

10. A heat exchanger as claimed in any one of the preceding Claims, wherein the two said plates are joined together by welding at the said inwardly bent peripheral portions.

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FIG. 1.

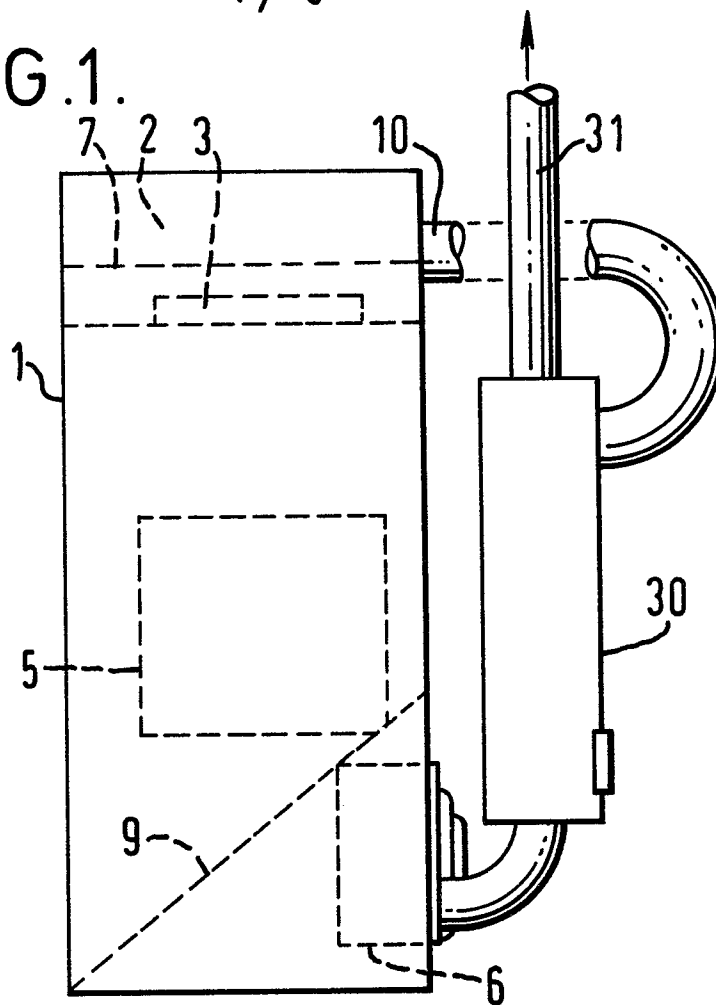
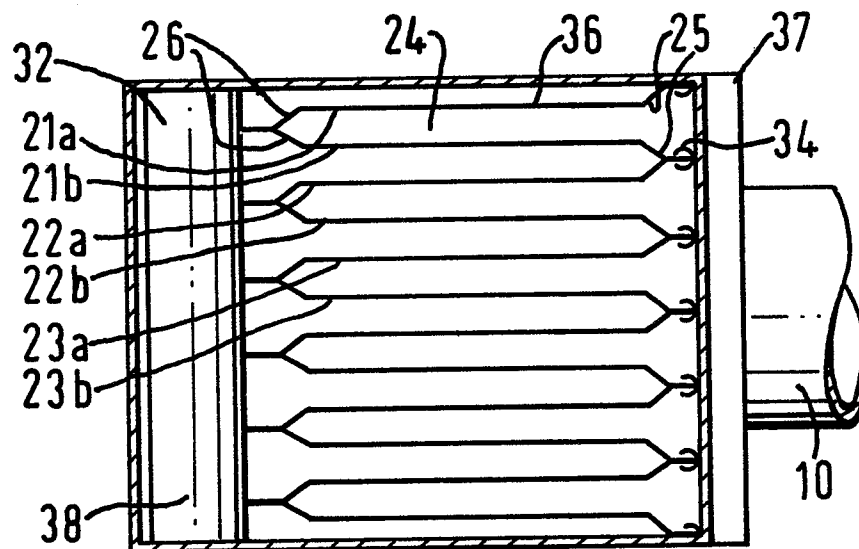


FIG. 4.



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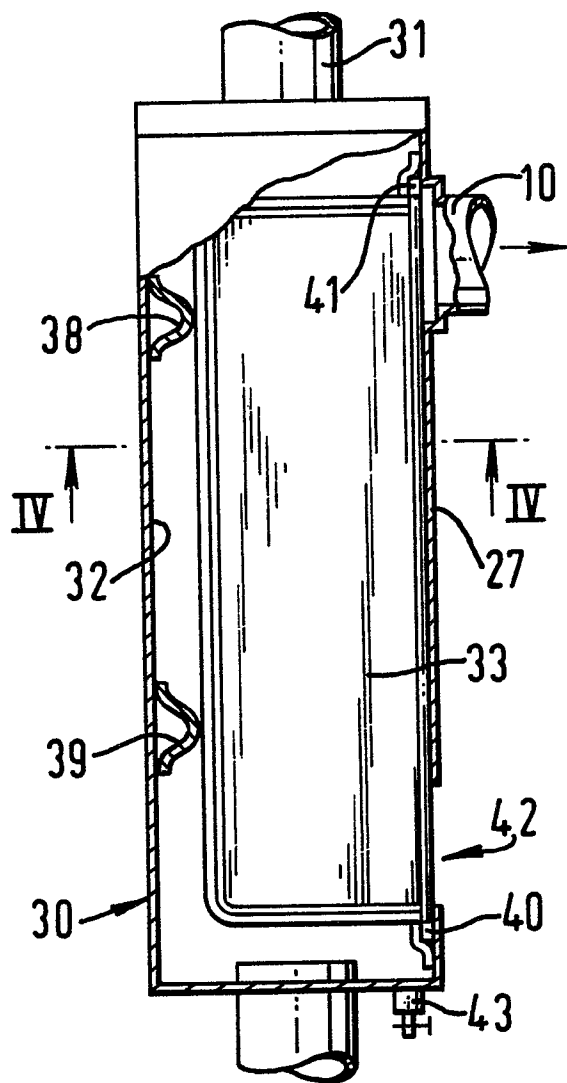


FIG. 2.

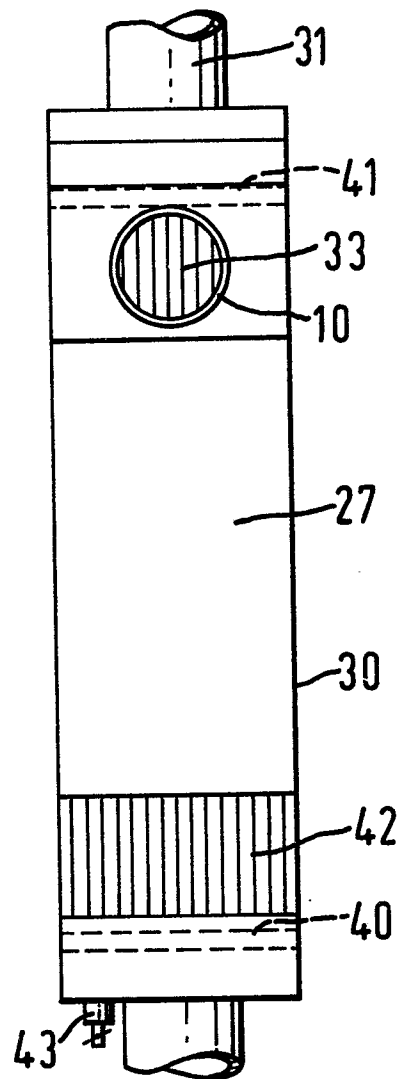
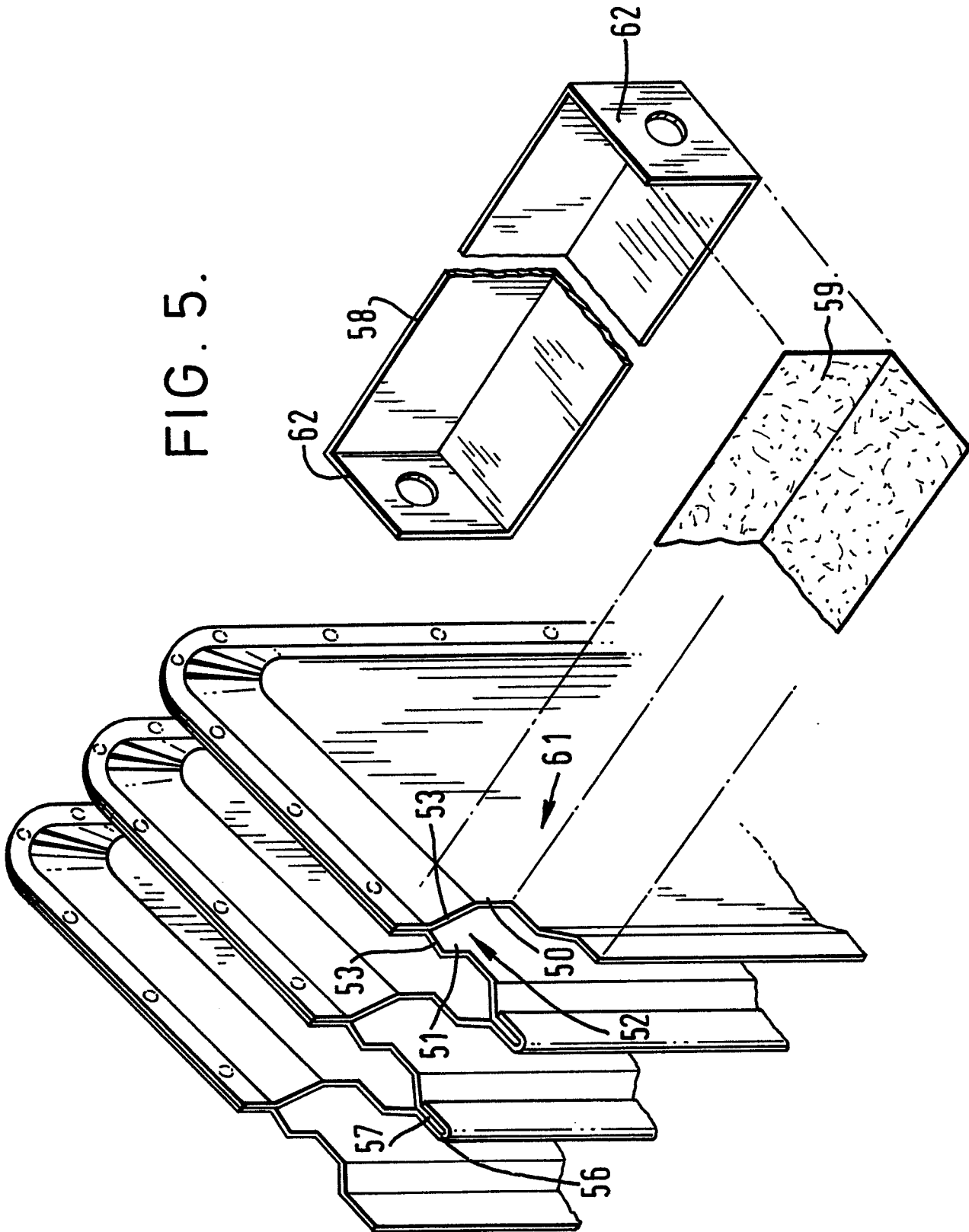


FIG. 3.

FIG. 5.



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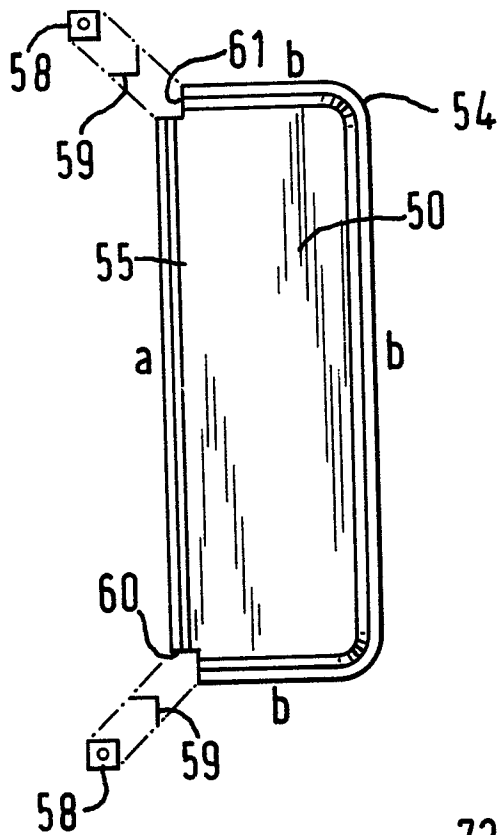


FIG. 6.

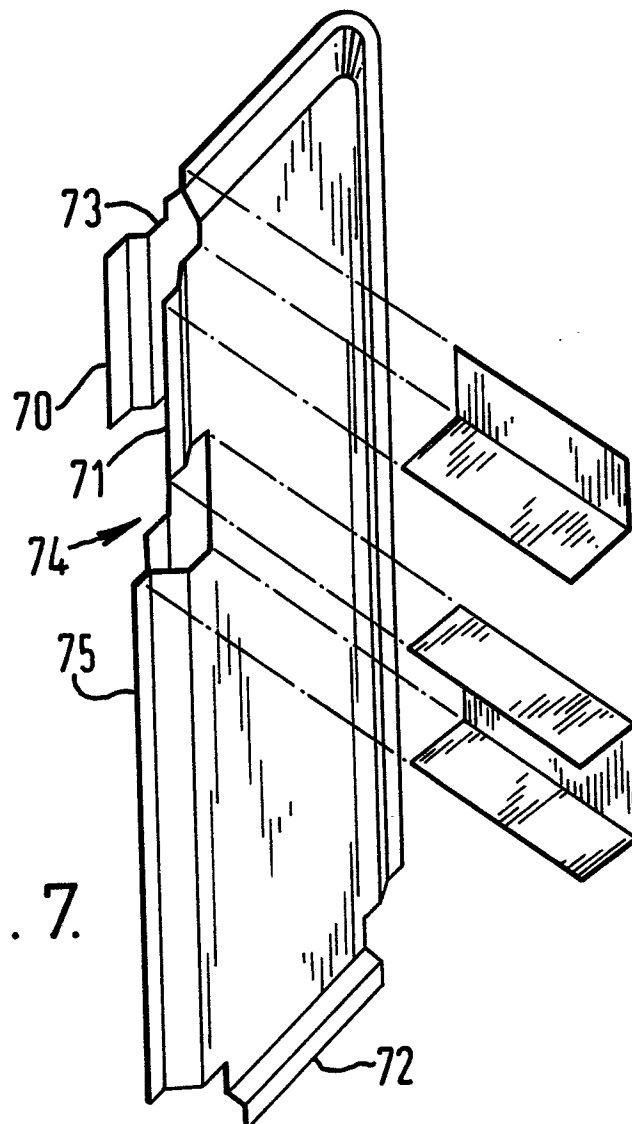


FIG. 7.

