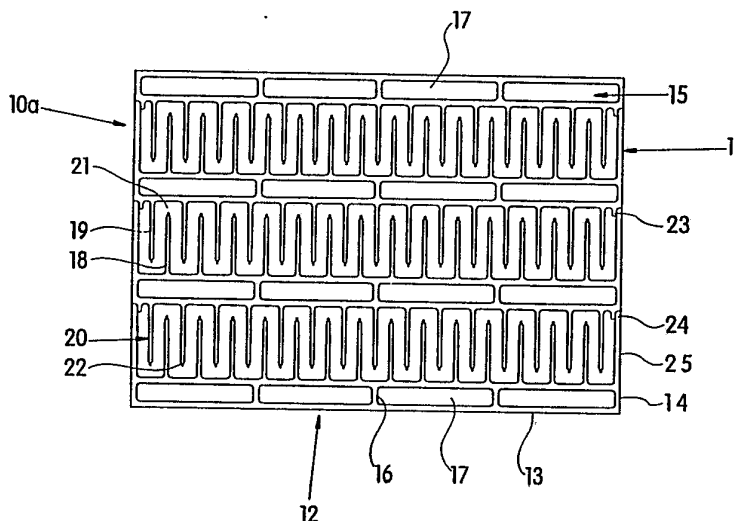




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<p>(21) International Application Number: PCT/AU93/00085 (22) International Filing Date: 1 March 1993 (01.03.93) (30) Priority data: PL 1129 28 February 1992 (28.02.92) AU (71) Applicant (for all designated States except US): MELANESIA INTERNATIONAL TRUST COMPANY LIMITED [VU/VU]; The International Building, Kumil Highway, Port Vila (VU). (72) Inventor; and (75) Inventor/Applicant (for US only) : JURISICH, Milne [AU/AU]; Unit 204, 3575 Main Beach Parade, Main Beach, QLD 4217 (AU). (74) Agent: KELLY, Robin, T.; Fisher &amp; Kelly, Level One, 349 Coronation Drive, Milton, QLD 4064 (AU).</p>		<p>(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, SN, TD, TG).</p> <p>Published With international search report.</p>

## (54) Title: HEAT EXCHANGER ASSEMBLY



## (57) Abstract

A heat exchanger has a core assembled of integrally formed modules (11). Each module encloses channels (17) separated by strengthening webs (16) and its large, flat, external faces carry respective arrays of fins (18, 19). By stacking the modules, with facing arrays of fins interleaving, further channels (20) are formed. The enlarged surface area of channels (20) compared with channels (15) (preferably these surface areas are in a ratio of over 7:1) makes the stack of modules suitable for heat exchange between parallel counterflows of fluids of differing heat capacities. Preferred apparatus has air fan-forced, via straight manifolds, through channels (20) - the interleaved fins serving to even out air temperatures and speeds across the channels' widths - whilst the ends of channels (17) are closed and a liquid (or liquids) enters and leaves channels (17) at right angles thereto although once in the channels (17) the liquid flows in parallel counterflow to the air flow.

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TITLE

## HEAT EXCHANGER ASSEMBLY

FIELD OF INVENTION

This invention relates to improved heat exchanger  
5 cores and in particular heat exchanger cores which  
incorporates a plurality of heat exchanger elements or  
modules which may be utilised in applications where heat  
energy is to be transferred from one fluid to another.

BACKGROUND ART

10 There are many types of heat exchangers known. These  
can be generally divided into two main groups, the first  
being shell-and-tube heat exchangers and the second being  
plate heat exchangers. One example of a shell and tube  
heat exchanger comprises an array or bundle of tubes and a  
15 surrounding for external shell. Plate heat exchangers may  
have plate-fin arrangements such as described in U.S.A.  
Patent 4,282,927 or a series of rectangular stacked plates  
creating flow channels from two or more fluids when the  
plates are sealingly stacked upon one another as described  
20 for example in U.S. Patent 4,823,867.

In each of the two groups, in order to manufacture the  
heat exchanger, a number of parts are usually fabricated  
and joined together. In shell and tube heat exchangers,  
for example, a number of tubes are assembled into a bundle,  
25 and prior to having the ends of each tube sealed into  
corresponding apertures of a pair of tube sheets, baffles  
are installed along the length of the bundle. The bundle  
of tubes, baffles and tube sheets are then placed inside a  
pressure vessel which seals a pair of end zones around the  
30 tube sheets so that there are two fluid flow paths defined,  
the first being around the outside of the tubes and between  
the tube sheets, and the second being inside the tubes and  
in end chambers of the pressure vessel. In both the shell  
and tube configuration and the plate type heat exchanger,  
35 there is a large amount of material dedicated to defining  
and sealing fluid flow paths, and since the flow paths are  
defined by joining fabricated parts, there is always the

danger of one fluid leaking into another.

In addition, fabricated heat exchangers suffer from inefficiency brought about by a plurality of boundaries constituted by welds, joins or parts interconnecting adjacent components of the heat exchangers, the boundaries providing zones of resistance to the conduction of heat to heat transmission surfaces of the exchanger. An integral part of heat exchangers formed by processes such as extrusion or casting are known as "primary structure" and must be differentiated from components welded or otherwise attached to the primary structure wherein such components including the boundaries are termed "secondary" structure. In a similar fashion surface(s) of primary structure are known as "primary" surface(s) and surface(s) of "secondary" structure known as "secondary" surface(s).

This disadvantage is particularly detrimental where liquid to air heat exchange through a plate exchanger is required. The generally low thermal capacity of the air cooling medium coupling with the inherent inefficiency of the prior art exchangers result in the requirement for very large exchangers relative to the respective liquid and cooling or heat air flows.

Reference may be made to U.S. specification 3,202,212 forming one example of prior art. This specification refers to a heat exchange element formed of extruded aluminium having a plurality of first fluid passages located in a body part thereof and a multiplicity of spines extending outwardly from opposed broad surfaces of the body part. Each spine was thin and comparatively small in cross section to thereby provide a high ratio of exposed surface to the mass of the spines for maximum thermal transfer efficiency from the body part. However each spine was spaced from each other in such a manner so as to form a number of separate rows arranged transversely across the body part so that transverse channels were formed between adjacent rows. There were also formed longitudinal channels so that while the heat exchanger was mainly formed

to promote crossflow of a second fluid relative to the flow of first fluid parallel flow could also occur. This arrangement did not provide an efficient rate of heat transfer because of the crossflow of second fluid was not as efficient as a parallel flow system which enables heat to be removed and dissipated at any required rate. This occurs because crossflow heat exchange systems are not as well suited to external ducting as parallel flow systems. Also parallel flow systems achieve a more efficient arrangement in relation to being more compact and thus being more suited to stackable or modular arrangements. This has particular reference to engines which may be used in vehicles or in stationary applications and also for heat exchangers utilised in air conditioning.

Also the spines which were formed in a subsequent process to the initial production of the extrusion by cutting or gouging the spines from precursor ribs formed on the extrusion was inefficient because of the necessity of the subsequent cutting or gouging process which added materially to the cost of production of the heat exchanger.

Reference may also be made to Australian Specification 85777/75 and U.S. Specification 4,565,244 which show heat exchangers having a similar construction to U.S. Specification 3,202,212 and thus subject to the disadvantages described above.

Reference may also be made to U.S. Patents 3,743,252; 4,352,008; 3,566,959, 4,567,074; 3,137,785 as well as U.S. Patent 3,467,190 which all refer to useful background prior art in relation to this invention. These references show that formation of one piece extrusions are not new and thus U.S. Patent 3,137,785 shows a one piece extrusion for use as a component in an electric heater comprising a body with longitudinally extending fins on each side of the body. Within the body are a plurality of extruded passages. However these internal passages are for receiving and containing tubular heating elements or thermally sensitive control elements and are not fluid passages.

U.S. Patent 3,566,959 concerns an aluminium extrusion for use as a heat sink in semi conductor rectifiers.

U.S. Patent 4,657,074 refers to a one piece aluminium extrusion tubular heat exchanger element which has a tubular body and a number of interior and exterior fins projecting integrally radially from the tubular body. However this reference is not considered relevant to this invention.

Reference may also be made to U.K. Patent 2 142 129 which describes a radiator formed from a rectangular elongate hollow body which is provided on each of two opposite sides with a plurality of spaced heat radiating fins to thus form a plurality of air channels located intermediate mutually adjacent fins. A cover plate extends across outer edges of each set of fins to form with said fins a plurality of open ended channels through which can flow air which is heated by a transfer of heat from a hot fluid flowing through the elongate hollow body.

While this reference shows a parallel flow situation and thus may overcome the problems of a cross flow aluminium extrusion discussed above in relation to U.S. Patent 3,202,212 problems still occurred in operation because of the fact that such an extrusion is basically inefficient in operation because air in passing through the heat exchanger adjacent tips of the fins has substantially the same temperature and has a different temperature to air which is passing through the heat exchanger adjacent base areas of each air channel. In this regard it will be appreciated that the air passing through the heat exchanger adjacent the base areas will be substantially hotter or at a higher temperature than the air passing through the heat exchanger adjacent the tips of the fins which will be substantially cooler. This is because the tips of the fins are located substantially further away from the elongate hollow body than the base areas of each channel which are located immediately adjacent the elongate hollow body. Thus the efficiency of the heat exchanger which will

require a uniform rate of heat transfer will be impaired because of the resultant heat gradient which will ensue wherein the hottest part of the exchanger through which air flow will occur is located in the base areas of each channel and the coolest part of the exchanger through which air flow will occur is located adjacent the tips of the fins. Also this problem of lack of heat exchange efficiency will be exacerbated because the volume of air passing through the heat exchanger adjacent the tips will be greater than the volume of air passing through the base areas of the air channels.

Reference may also be made to similar heat exchangers such as radiators which are described in U.S. Patent 4,341,346 which have a central tubular duct for passage of hot water and a pair of webs extending on opposite sides of the central tubular duct with oppositely located fins being provided on each side of the webs and extending normal thereto. The conclusions which are expressed above in relation to U.K. Patent 2,142,129 also apply to this prior art reference. Similar conclusions also apply to U.S. Patent 3,147,802, U.K. Patent 1,411,162 and U.S. Patent 4,296,539.

U.S. Patent 4,401,155 relates to a heat exchanger constructed from a plurality of stacked modules wherein each module has closed channels for high pressure flow and fins extending vertically up and/or down from the channels which form open channels suitable for low pressure flow when the modules are stacked parallel to each other along their length. It is specified that each fin be of uniform thickness and have an identical dimension perpendicular to the channels. Each module is generally formed from an aluminium extrusion. The heat exchanger of U.S. Patent 4,401,155 is particularly directed at high pressure applications and especially where one heat exchange stream is at high pressure and another is at low pressure. This has particular reference to cryogenic processes.

In U.S. Patent 4,401,155 it is noted in regard to a first embodiment (i.e. FIGS 1, 3 and 4) that there are provided as many channels as there are fins while in another second embodiment (i.e. in FIGS 2, 6, 7 and 8) there are provided two channels for every fin.

In the first embodiment the heat exchanger assembly would not be efficient in relation to effective heat transfer because of the fact that the channel surface area is substantially the same as the fin surface area and in this regard it has been ascertained as described in more detail hereinafter that for efficient heat transfer to take place the surface area of the fins should be substantially greater than the surface area of the channels. This is important in a situation wherein the density of one fluid which may pass through the fins (e.g. air) is significantly different to the density of the fluid passing through the channels (eg water). In this situation air has a density much less than water and this means that air will have a much less effective heat storage capacity than water. This therefore means that an effective heat transfer from the water channels through the walls of the heat exchanger to the fins will only take place when the surface area of the fins is much greater than the surface area of the channels. This occurs because the greater surface area of the fins will facilitate effective absorption of heat to be passed through the walls of the heat exchanger from the channels to the fins whereby such heat may be transferred to the air passing through the fins. Simultaneously, the air must be able to satisfactorily absorb heat from the fins so that the heat may be transported away from the heat exchanger. In this regard the volume of air passing through the fins should be considerably in excess of the volume of water passing through the channels.

In regard to the second embodiment referred to above such embodiment does not provide an arrangement whereby uniform heat transfer in regard to a heat exchange core formed from a series of stacked modules could be obtained

at least in relation to outwardly directed fins extending from peripheral modules are concerned. This is also a problem of other heat exchanger cores formed from extrusions as discussed in detail above concerning U.S. Patent 3,202,212. It is relevant to note however that U.S. patent 4 401 155 describes a stacked arrangement of modules whereby outwardly directed fins from one module may extend into channels formed by adjacent fins of an adjoining module to achieve an interleaved arrangement. A similar interleaved stacked arrangement is shown in U.S. patent 3 476 179 and the same conclusions expressed herein in relation to the first embodiment of U.S. patent 4 401 155 also apply to this reference.

It is also considered that the heat exchangers shown in German patent 3 011 011 and Japanese patent 55-152 397 will also not provide efficient heat transfer for substantially the same reasons as expressed above in relation to U.S. patent 4 401 155.

It will also be appreciated that heat exchangers formed as one piece extrusions having a plurality of fins generally will also be subject to the same disadvantages as described and thus references such as U.S. Patent 3,202,212, Australian Patent 85777/75, U.S. Patents 4,565,244; 3,743,252; 4,352,008; 3,566,959; 4,567,074; 3,137,785 and 3,467,180 will also be subject to these disadvantages.

Reference may also be made to U.S. Patent 5,042,247 which relates to a thermoelectric cooler wherein semiconductor materials with dissimilar characteristics are connected electrically in series and thermally in parallel so that two junctions are created. The semiconductor materials are N and P-type. In a typical thermoelectrical cooler (TEC), alternative columns of these N-type and P-type semiconductor materials have their ends connected in a serpentine fashion by electrical conductors. These electrical conductors typically are metallisations formed on insulating or ceramic plates. With the application of

direct current to the TEC, heat is absorbed on the cold side ceramic, passes through the semiconductor material and is dissipated at the hot side ceramic. A heat sink must be attached to the hot side ceramic for dissipating the heat from the TEC to the surrounding environment. Without a heat sink the TEC would overheat and fail within seconds.

In fact a heat sink is a device that is generally associated with machines or apparatus which generates substantial amounts of heat such as a TEC, or a computer so that the heat may be rapidly dissipated. Therefore a heat sink is more effective when it may dissipate heat at greater rates. U.S. Patent 5,042,257 therefore describes a heat sink for a TEC which includes a pair of opposed plates which have a plurality of fins on each of opposed faces wherein one array of fins on one face may be accommodated or interleaved between another array of fins on the other face whereby one array of fins may be retained in desired position by suitable retaining means such as a pair of relatively short fins which constitute thermal surface area contacts for sufficient exchange of heat. However it will be appreciated that the relevant factors that must be taken into account when a heat sink is being designed for effective use are not relevant when one is considered the relevant parameters that are essential to design of a heat exchanger. This applies in particular to the design of a heat exchanger core comprising a stacked array of heat exchanger modules having channels or passages for two fluids which will flow in heat exchange relationship through the core. It will also be appreciated that heat sink considerations will be far removed from other heat exchanger considerations which will include relevant ducting requirements to achieve maximum heat exchange efficiency.

It therefore is an object of the invention to provide a heat exchanger assembly which will be relatively efficient and may reduce the problems of the prior art discussed above.

The heat exchanger assembly of the invention is formed from primary structure comprises a core comprising a multiplicity of primary fluid sections and a plurality of secondary fluid sections wherein a respective primary fluid section is located adjacent to a respective secondary fluid section wherein each primary fluid section is substantially parallel to each secondary fluid section characterised in that each primary fluid section is bounded by a peripheral wall and that each secondary fluid section include a first array of fins extending away from the peripheral wall of one adjoining primary fluid section and a second array of fins extending away from the peripheral wall of another adjoining fluid section wherein an individual first fin may extend between each adjacent second fin in interleaved relationship wherein the surface area of each secondary fluid section is substantially greater than the surface area of each primary fluid section.

Preferably the primary fluid sections are provided with a plurality of webs wherein each web extends from opposed faces of the peripheral wall to thereby provide a number of parallel primary fluid passages. The webs are useful for strengthening and reinforcement purposes to maintain the structural integrity of the core.

Suitably the tips of the first array of fins abut or are attached to an adjacent surface of the peripheral wall of said another adjoining fluid section. Alternatively and more preferably the tips of the first array of fins are spaced from the adjacent surface. In similar manner the tips of the second array of fins may abut or be attached to an adjacent surface of the said one adjoining fluid section but more preferably are spaced therefrom.

It will of course be appreciated that when the tips of the first and/or second array of fins abut or are attached to a mating surface of an associated peripheral wall that separate flow passages for secondary fluid may be provided. When the tips of the first and/or the second array of fins are spaced from an adjacent surface of an associated

peripheral wall then each secondary fluid section may correspond to a single flow passage for secondary fluid.

It is within the scope of the invention to provide a heat exchanger core which may be formed in one piece such as an extrusion formed from aluminium or other suitable metal. However it is preferred that the core be formed from a plurality of separate modules. Suitably a particular module may include the peripheral wall which bounds the flow passages for primary fluid and both the first and second array of fins which extend away from external or outer surfaces of opposed parts of the peripheral wall respectively.

It is an important feature of the present invention that the peripheral wall and the elongate fins of each module are each formed simultaneously in formation of the one piece extrusion or casting so that the heat exchanger module is formed from primary structure. In other words no secondary structure is present which can lead to disadvantages as discussed above. Also the primary fluid passages and the secondary fluid passages are substantially parallel to each other to form a parallel flow heat exchanger core which has advantages over cross flow heat exchangers of the type described previously. These advantages include the following -

- (i) with the secondary fluid comprising a cooling medium such as air, the parallel flow arrangement facilitates ducting of air both to and from the heat exchanger core. A fan may then be used to draw the air through and the hot air away from the heat exchanger core. This means that the heat exchange core of the invention does not have to rely upon ambient air passing through when used for example as a radiator in a motor vehicle. Therefore the heat exchanger core of the invention need not be located in front of the vehicle.

- (ii) when used as a radiator, the heat exchanger core of the invention need not have a large flat surface as is the case with a conventional radiator. Therefore it can be designed in a far more compact configuration. This means that the shape of the vehicle may be changed to permit reduced wind resistance in the case of a truck or increased usage of the interior in the case of a coach or bus.
- 5
- (iii) the ducting of the hot air away from the heat exchanger core of the invention also facilitates the use of the hot air for other purposes such as for the supply of heat or as a power source.
- 10
- (iv) because the fluid passages are parallel this means that the heat exchanger element of the invention may be manufactured as a one piece extrusion. An extrusion could not be satisfactorily produced in the case of a crossflow arrangement. This also means that the fins form an integral part of the heat exchanger core of the invention rather than being crimped, welded or soldered to the part. This avoidance of secondary structure maximises conductivity of the heat from the fluid to be cooled to the other fluid.
- 15
- 20
- 25
- (v) as a consequence of (iv) above the one piece extrusion may be cut to any desired length and may be designed to be releasably attached to other heat exchanger elements or modules to produce a core of the invention. Not only length but height and width are all flexible and may be varied to suit the particular application desired.
- 30
- (vi) the heat exchanger core of the invention when compared to the prior art is far more efficient and also lighter. It also requires less power from the main power sources (e.g. an engine or
- 35

motor) for operational purposes.

The core of the heat exchanger apparatus may take any form consistent with the function of providing definition for flow of both primary and secondary fluids. For example, the core may comprise a continuous cross section of indefinite length with the flow passages being disposed in the direction of the indefinite length. Such a configuration has proved to be particularly amenable to continuous casting or extrusion.

Preferably the peripheral wall of each module is substantially rectangular having a pair of opposed substantially horizontal parts in use which are joined by a pair of opposed vertical parts. The abovementioned webs of the primary fluid section formed by the peripheral wall are preferably substantially parallel to the vertical parts.

However it will also be appreciated that the peripheral wall may have any other suitable shape such as being circular in cross section or triangular in cross section or polygonal in cross section.

The primary flow passages of the primary fluid section may have any suitable shape or configuration and thus may be round, rectangular or polygonal in cross section.

It will be appreciated that the configuration of the flow passage or passages will depend upon the application of the heat exchanger and will also significantly depend upon the material of manufacture of the heat exchanger core.

It will also be appreciated that the elongate fins may have any suitable shape. Preferably however each fin is of constant height and width although this is not absolutely essential. Thus for example each elongate fin is of constant height and width although this is not absolutely essential. Thus for example each elongate fin may taper in width from one end to the other if required if the heat exchange element of the invention is produced as a casting. The elongate fins may also have projections or ribs on an outer surface to increase their surface area if required.

It is also within the scope of the invention to have internal fins located in the flow passages of the body part if such is considered appropriate.

5 The heat exchanger cores of the invention may be provided with manifolding means adapted to supply the primary and secondary fluids to their respective flow sections and such manifolding means may take any appropriate form. Thus an inlet manifold and an outlet manifold may be provided which enable primary fluid to  
10 communicate with the primary fluid section and secondary fluid to communicate with the secondary fluid section. Alternatively separate primary fluid and secondary fluid manifolds may be provided at inlet and outlet.

15 It is preferred however that the entry and exit of primary fluid and secondary fluid from the core occur at right angles to each other and thus it is desirable that suitable manifolding means be chosen so as to accomplish this objective.

20 In this regard therefore the flow of primary fluid and secondary fluid through their respective manifolds may also be normal to each other although this is not essential and the respective manifolds may be constructed so that the primary and/or the secondary fluid may flow at an acute angle to their respective core entry and core exit flow  
25 directions.

30 The primary fluid is suitably an "operating fluid" i.e. a fluid which is being processed by the heat exchanger and which is to be recirculated through a suitable flow system to which the heat exchanger of the invention is being applied. For vehicle radiators for example such a fluid is suitably water.

35 The secondary fluid is preferably "an active fluid" which functions as a coolant for the operating fluid and which absorbs heat from the operating fluid after passage through the heat exchanger core. Such a fluid for vehicle radiators for example may comprise air.

However it will also be appreciated that the above is not essential and the "active fluid" in accordance with this invention may become the "operating fluid" if necessary.

5           The heat exchange modules for use in the invention may be adapted for vertical stacking or horizontal stacking as may be required. In particular, each module may be provided with connection means for this purpose. In a preferred embodiment of the present invention the  
10 connection means may be such that interconnection of the adjacent modules defines a suitable flow passage for secondary fluid.

          Preferably, each module has integrally extruded therewith connection means to enable adjacent modules of  
15 the invention to be assembled together. The connection means may be of any suitable type and thus comprise for example male members or projections engageable with female members or sockets in snap fit or interference fit relationship. Suitably each module includes a top  
20 connection member and bottom connection member which may engage with corresponding top and bottom connection members of an adjacent module.

          Preferably the top or bottom connection member may comprise a panel rib or flange which may engage with a  
25 corresponding ratchet rib or flange of a mating top or bottom connection member of an adjacent module.

          The number of modules or heat exchange elements utilised in a horizontal or vertical stacking arrangement may then depend upon the particular application desired.

30           Heat exchanger cores in accordance with the present invention may be used in gas/gas, liquid/gas or liquid/liquid application and are particularly suited to gas/air and liquid/air applications using impelled ambient air as the heat transfer fluid. Alternatively, the cores  
35 can be placed in an enclosure suitable for natural or draft convection of air. Of course, heat transfer fluids other than air may be employed, such as water, ethylene glycol,

ammonia, fluorocarbon compounds, silicone compounds, mineral oils and the like.

When the flow channels are manifolded in series, it is preferred to direct the flow of the first fluid counter-currently to the heat transfer fluid so as to obtain the maximum log mean temperature differential between the two fluids, and thus the most efficient heat transfer. Alternatively, where the first or heat transfer fluids are sensitive to rapid temperature changes, or have an upper or lower temperature limit, co-current flow may be utilised.

The heat exchanger cores of the present invention may be of any suitable material, the suitability of a material being generally determined with reference to the application to which it is to be put. For example, use in extreme high temperature applications may dictate that a ceramic material be used for its high temperature properties, whereas for lower temperature applications it has been found that aluminium or its alloys or other metals are suitable for their relatively high thermal conductivities, permitting thicker wall sections per unit efficiency and thus increasing mechanical strength.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Reference may now be made to a preferred embodiment of the invention as shown in the attached drawings wherein:

FIG 1 is an end view of a stack of four modules in regard to providing a heat exchanger core constructed in accordance with the invention;

FIG 2 is a similar view of the core as shown in FIG 1 with external fins removed;

FIG 3 is a perspective view of a heat exchanger module constructed in accordance with the invention;

FIG 4 shows heat exchanger apparatus constructed in accordance with the invention with appropriate manifolds and using the core of FIG 2;

FIG 5 is a view of the heat exchanger assembly of the invention when used in vehicle engines.

FIG 6 is a detailed view of a fin of the module of FIG 3 showing the temperature distribution in use of not only the fin but also the spaces between adjacent fins.

BEST METHOD FOR CARRYING OUT THE INVENTION

5 In FIG 1 there is shown heat exchanger core 10 in accordance with the invention including a vertical stack of modules 11. Each module 11 includes a peripheral wall 12 of shallow rectangular configuration having opposed horizontal parts 13 and opposed vertical parts 14. The peripheral wall 12 which is of a continuous nature defines a primary fluid section 15. Webs 16 are included to define separate primary flow passages 17.

15 There are also included a first array of fins 18 extending away from one horizontal part 13 and a second array of fins 19 extending away from the opposed horizontal part 13 of peripheral wall 12.

20 A section 20 for passage of secondary fluid is therefore defined by fins 18 extending between adjacent fins 19 and terminating short of an adjacent horizontal section 13 of wall 12 to define a space 21 and fins 19 extending between adjacent ribs 18 and terminating short of an adjacent horizontal section 13 of wall 12 to define a space 21. There is also shown spaces 22 between adjacent fins 18 or 19. Each adjacent module 11 is attached by ribs 23 of one module engaging with the ends 24 of vertical extensions 25A of terminal vertical parts 14 of each peripheral wall 12.

30 It is important to realise that the effective fluid passages of heat exchanger core 10 are primary fluid section(s) 15 and secondary fluid section(s) 17. Therefore ducts or manifolds communicating with sections 15 and 17 do so in the area between dotted lines AA and BB. This of course means that the external fins 18A and 19A have no function in regard to heat exchanger apparatus of the invention 10 and may be omitted or cut off. The same applies to outer extensions 25A. This will mean that the effective core of the heat exchanger apparatus of the

invention is as shown in FIG 2. Ribs 23A may also be omitted. FIG 2 therefore defines a core 10A which has been constructed in accordance with the invention. This of course does not mean that core 10 cannot be utilised. It is just more convenient to use core 10A because of the saving in space or storage capacity within a heat exchanger system which also incorporates appropriate inlet and outlet manifolds.

FIG 3 shows a perspective view of an individual module for use in the core 10 and 10A shown in FIGS 1-2. Each of fins 18 and 19 may be provided with peripheral ribs 18B and 19B of relatively thin cross section.

In FIG 4 there is shown heat exchanger apparatus 26 in accordance with the invention which includes a gas or air inlet duct or manifold 27 having inlet 28, core 10A constructed of five modules 11, assembled as shown in FIGS 1-2, an air or gas outlet duct or manifold 28 with outlet 29, gas or air sections 20 including fins 18 and 19, liquid sections 15, welded areas 32 of liquid sections 15 which function as a plug or cover to prevent air or gas gaining access to sections 20, and liquid inlet manifold 33 with inlet conduits 34, 35, 36 and 37 and liquid outlet manifold 38 with associated outlet conduits 39, 40, 41 and 42. The inlet manifold 33 has respective compartments 34A, 35A, 36A and 37A which register with inlet slots 34B (i.e. there are two of these slots), 35B, 36B and 37B respectively. In a similar manner outlet manifold 38 has outlet compartments 39A, 40A, 41A and 42A which register with outlet slots 39B (i.e. there are two of these slots), 40B, 41B and 42B respectively.

In a variation of the heat exchanger apparatus shown in FIG 4 it will be appreciated that it is not necessary to use a pair of air manifolds 27 at each end of core 10A. Thus one manifold 27 may be utilised adjacent the inlet end of core 10A whereby forced air (e.g. by use of an air blower or air compressor) may be forced through core 10A or alternatively only one manifold 27 may be utilised adjacent

the outlet end of core 10A whereby air may be forced through core 10A by use of an exhaust fan.

The heat exchanger apparatus 26 is used for gas and liquid heat transfer. In such an arrangement it is preferred that gas inlet and outlet manifolds are located at opposed ends of the core and liquid inlet and outlet manifolds are located on the same side or on different sides if appropriate or even on top and/or bottom of the core if appropriate. The gas therefore may make one pass through the core and the liquid may also make a single pass through the core. Each of the liquid manifolds may have a single inlet and single outlet if the same fluid is being processed or different inlets and outlets as shown in FIG 4 if different liquids are being processed by core 10A. Thus for example apparatus 10A may be used for a vehicle and thus conduit 34 may be used for engine cooling water, conduit 35 used for engine oil, conduit 36 used for transmission oil, and conduit 37 used for condensing liquid for air conditioning. Conduits 39, 40, 41 and 42 have the same functions as an outlet conduit.

In FIG 5 reference is shown to truck or vehicle 63 wherein fuel from engine 64 is passed through line 65 to a heat exchanger assembly 66 constructed in accordance with the invention. The fuel tank 67 may also be utilised which then passes the fuel back to the engine 64 through line 68.

It therefore will be appreciated from the above discussion of the preferred embodiment shown in FIGS 1 to 4 that a heat exchanger core constructed in accordance with the invention will overcome the disadvantages of the prior art discussed in detail above because a uniform heat distribution will be obtained throughout the core by the location of fins 18 and 19 as illustrated whereby the tips of the fins 18 and 19 which are normally the coolest part of a conventional heat exchanger core are placed in close proximity to the hottest part of a conventional heat exchanger core which is the peripheral wall 12. It therefore follows that the temperature of the core at the

tips of the fins 18 and 19 will be substantially the same or slightly less than the temperature of the peripheral wall 12. This will mean that a uniform heat distribution or temperature distribution will be obtained in each of the liquid sections 20 and this will bring about substantially improved heat exchanger efficiency. Heat exchanger efficiency will also be improved by the manufacture of core 10 or 10A as a single piece aluminium extrusion or alternatively being comprised of a stack of modular aluminium extrusions 10 or 10A.

The abovementioned effect is shown in FIG 6 which shows the temperature distribution through an individual fin 18 or 19 and adjacent spaces 22A in relation to a conventional heat exchanger. It will therefore be appreciated that by adopting an interleaved arrangement as shown in FIGS 1-2 a uniform heat or temperature distribution will be obtained as described above because the hot areas will be cancelled out by the cold areas.

It will also be appreciated from the foregoing that the heat exchanger apparatus of the invention will be most useful in regard to function as a vehicle radiator but this does not preclude its use as a heat exchanger in relation to processing of gas to gas or liquid to liquid applications as discussed above. Preferably the thickness of peripheral wall 12 and also of vertical extensions 25 is substantially the same and is of relatively narrow thickness e.g., about 3 mm or less and more suitably 2 mm or less and of the order of 1.5 mm or 1.0 mm or less.

Preferably also the surface area of the secondary flow sections 20 is at least twice the surface area and more preferably is at least 7 times the area of primary fluid sections 15.

It will also be appreciated that spaces 21 should be substantially uniform and this also applies to the spaces 22 between adjacent fins 18 or 19. Naturally each fluid channel 17 should also be substantially of the same volume.

CLAIMS

1. A heat exchanger assembly formed from primary structure comprising -

5 a core comprising a multiplicity of primary fluid sections and a plurality of secondary fluid sections wherein a respective primary fluid section is located adjacent to a respective secondary fluid section with each primary fluid section being substantially parallel to each secondary fluid section characterised in that each primary fluid section is bounded by a peripheral wall and that each secondary fluid section include a first array of fins extending away from the peripheral wall of one adjoining primary fluid section and a second array of fins extending away from the peripheral wall of another adjoining fluid section wherein an individual first fin may extend between each adjacent second fin in interleaved relationship wherein the surface area of each secondary fluid section is substantially greater than the surface area of each primary fluid section.

20 2. A heat exchanger assembly as claimed in claim 1 wherein each primary fluid section is provided with one or more webs extending from opposed faces of the peripheral wall.

25 3. A heat exchanger assembly as claimed in claim 1 wherein the first array of fins each has a free end or tip spaced from an adjacent surface of the peripheral wall of said another adjoining fluid section.

30 4. A heat exchanger assembly as claimed in claim 1 wherein the second array of fins each has a free end or tip spaced from an adjacent surface of the peripheral wall of said one adjoining fluid section.

35 5. A heat exchanger assembly as claimed in claim 1 wherein the core comprises a plurality of modules wherein each module includes said peripheral wall and said first array of fins and said second array of fins.

6. A heat exchanger assembly as claimed in claim 5 wherein the peripheral wall of each module is substantially rectangular.

5 7. A heat exchanger assembly as claimed in claim 1 provided with manifolding means adapted to supply primary and secondary fluids to the respective primary fluid section and secondary fluid section wherein entry and exit of primary fluid and secondary fluid from the core occurs at right angles to each other.

10 8. A heat exchanger assembly as claimed in claim 7 wherein said manifolding means includes an inlet manifold and an outlet manifold which enable primary fluid to communicate with the primary fluid sections and secondary fluid to communicate with the secondary fluid sections.

15 9. A heat exchanger assembly as claimed in claim 7 wherein separate primary fluid manifolds and secondary fluid manifolds are utilised at inlet and outlet.

20 10. A heat exchanger assembly as claimed in claim 1 wherein the secondary fluid sections at each end of the core are blocked or closed while primary flow sections are open providing primary fluid access slots to facilitate entry into and exit from the core of primary fluid.

25 11. A heat exchanger assembly as claimed in claim 10 wherein secondary fluid access slots are located in the core in a side, top or bottom of the core to facilitate entry into and exit of secondary fluid from the core.

12. A heat exchanger assembly as claimed in claim 11 wherein secondary fluid access slots are provided in a side of the core adjacent each end.

30 13. A heat exchanger assembly as claimed in claim 5 wherein each module has connection means integral therewith to enable adjacent modules to be connected to each other.

35 14. A heat exchanger assembly as claimed in claim 1 wherein the surface area of secondary flow sections are at least seven times the surface area of each primary fluid section.

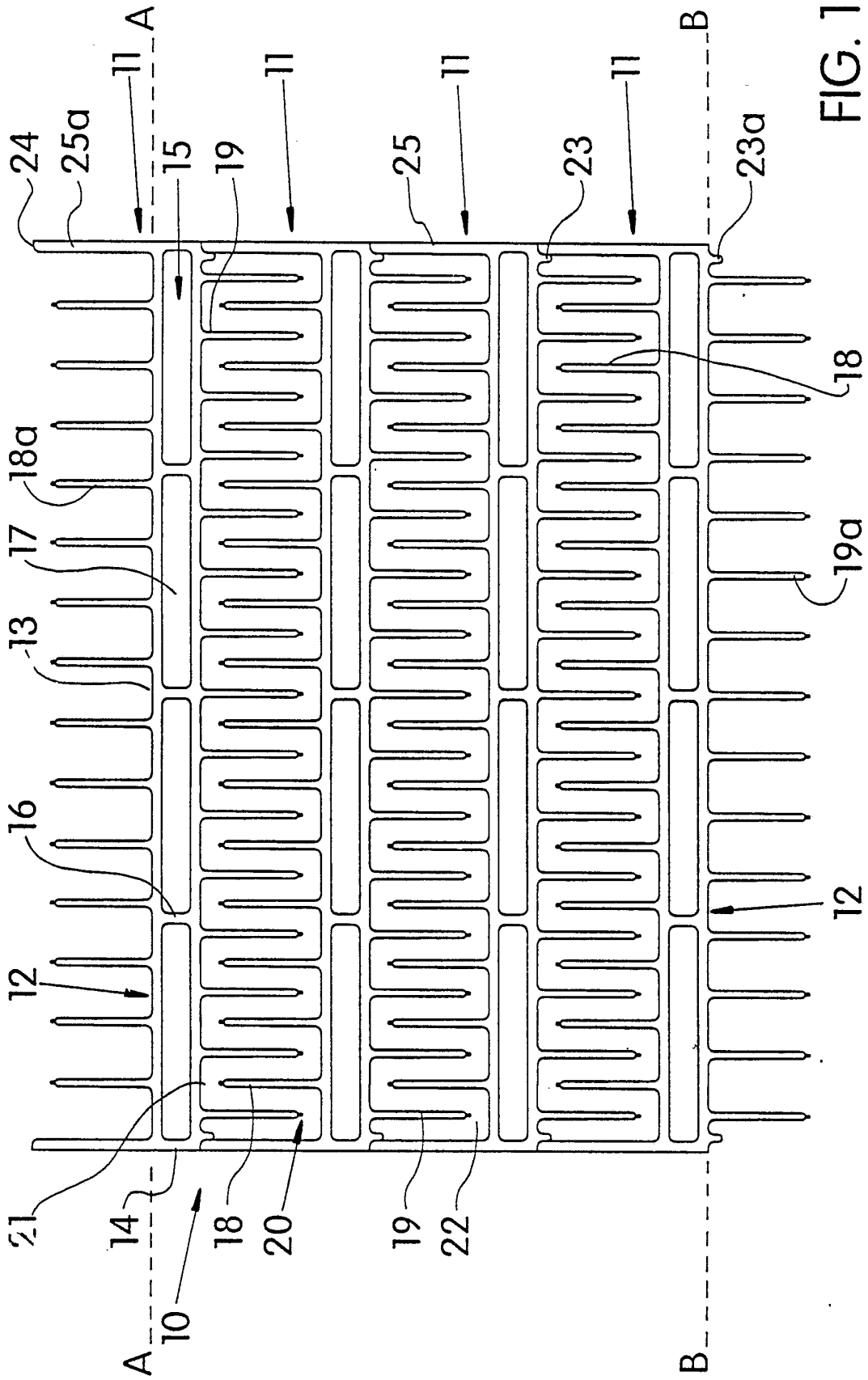


FIG. 1

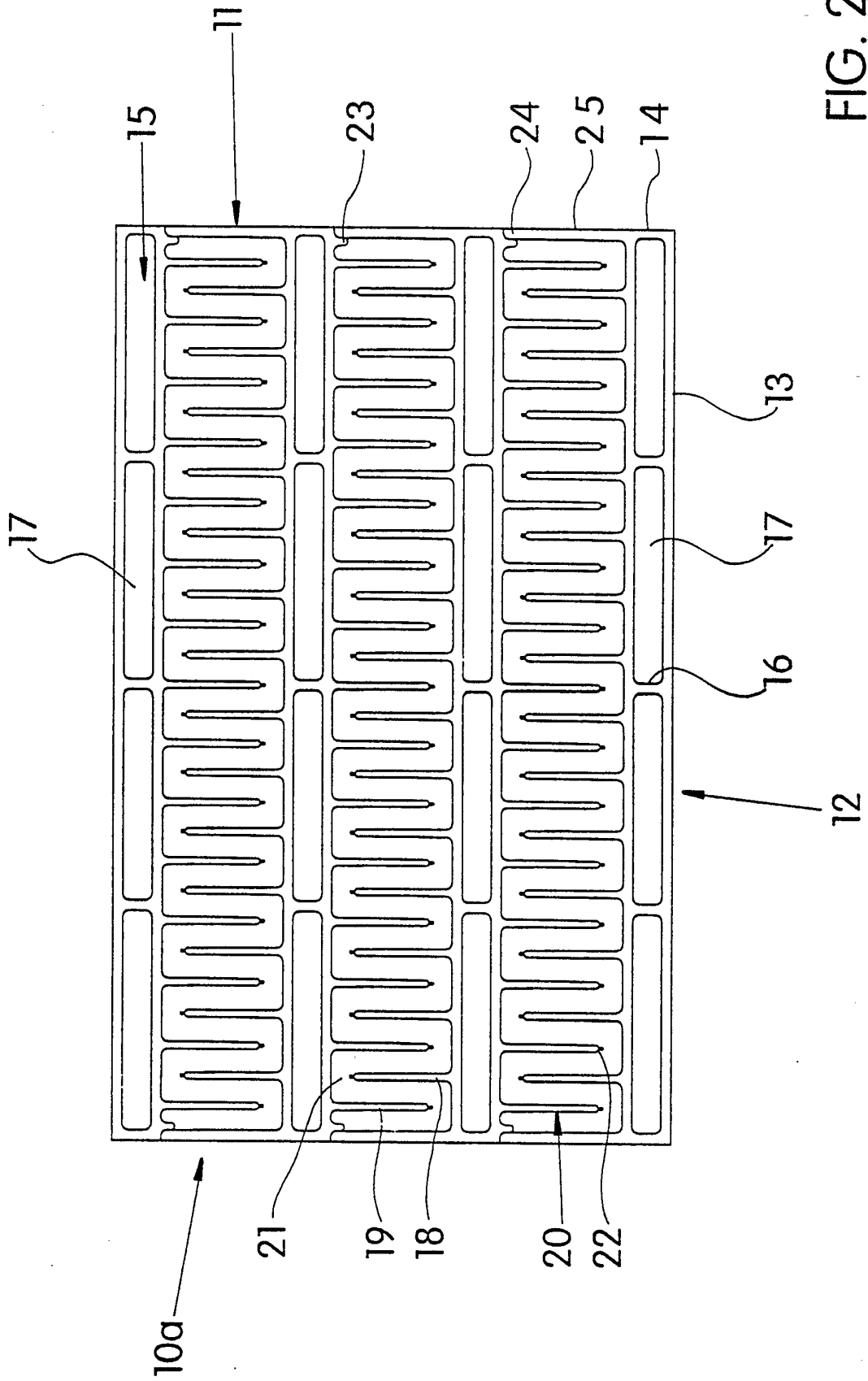


FIG. 2

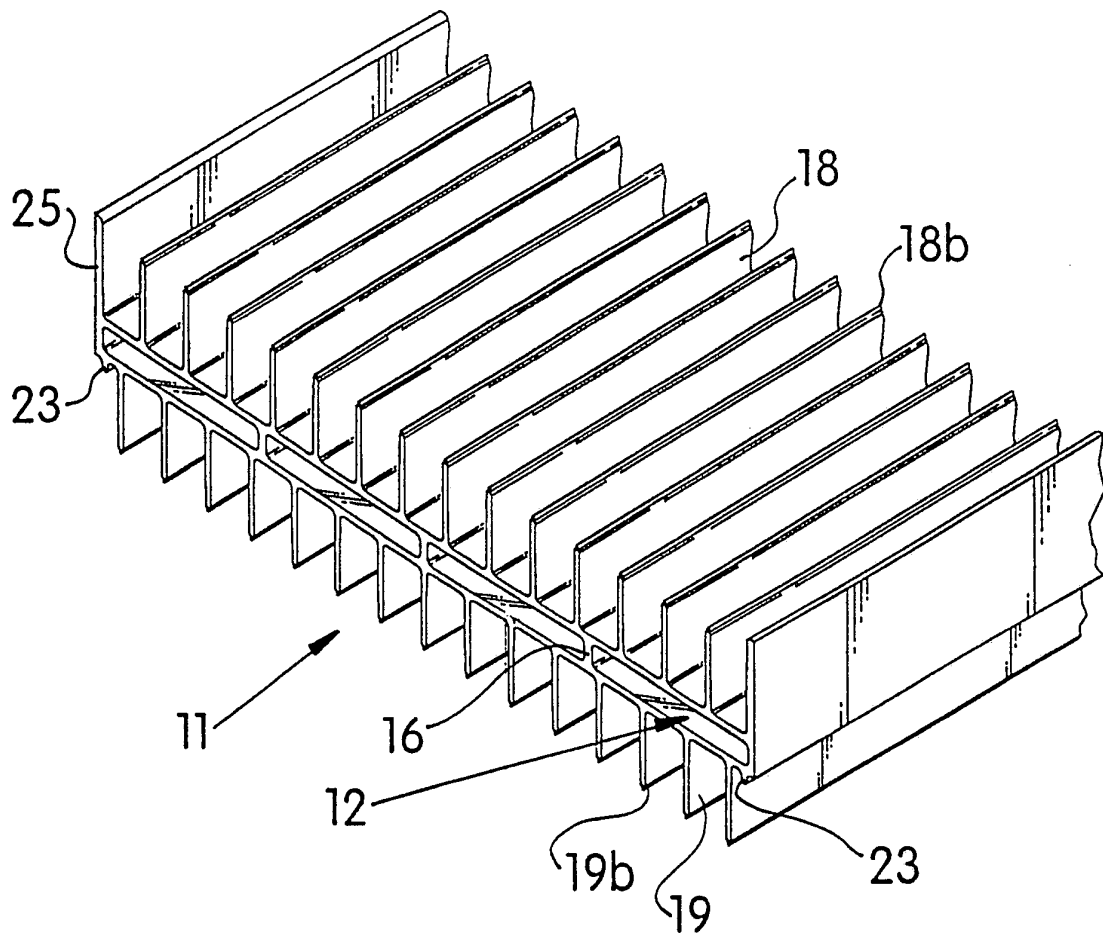


FIG. 3

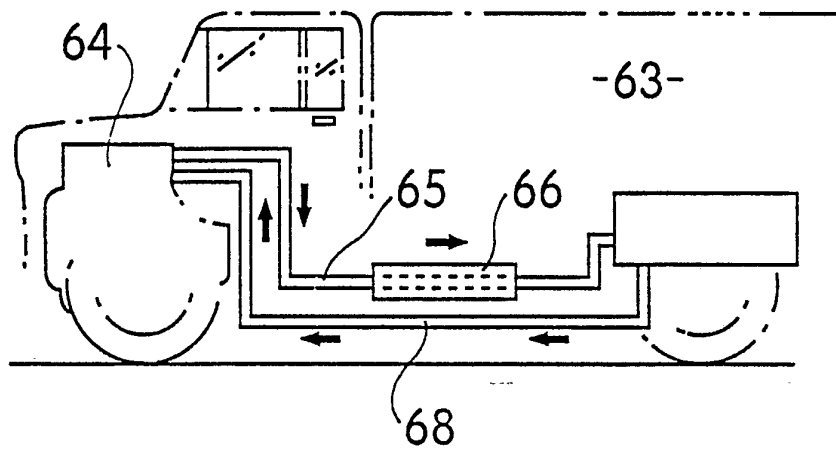


FIG. 5

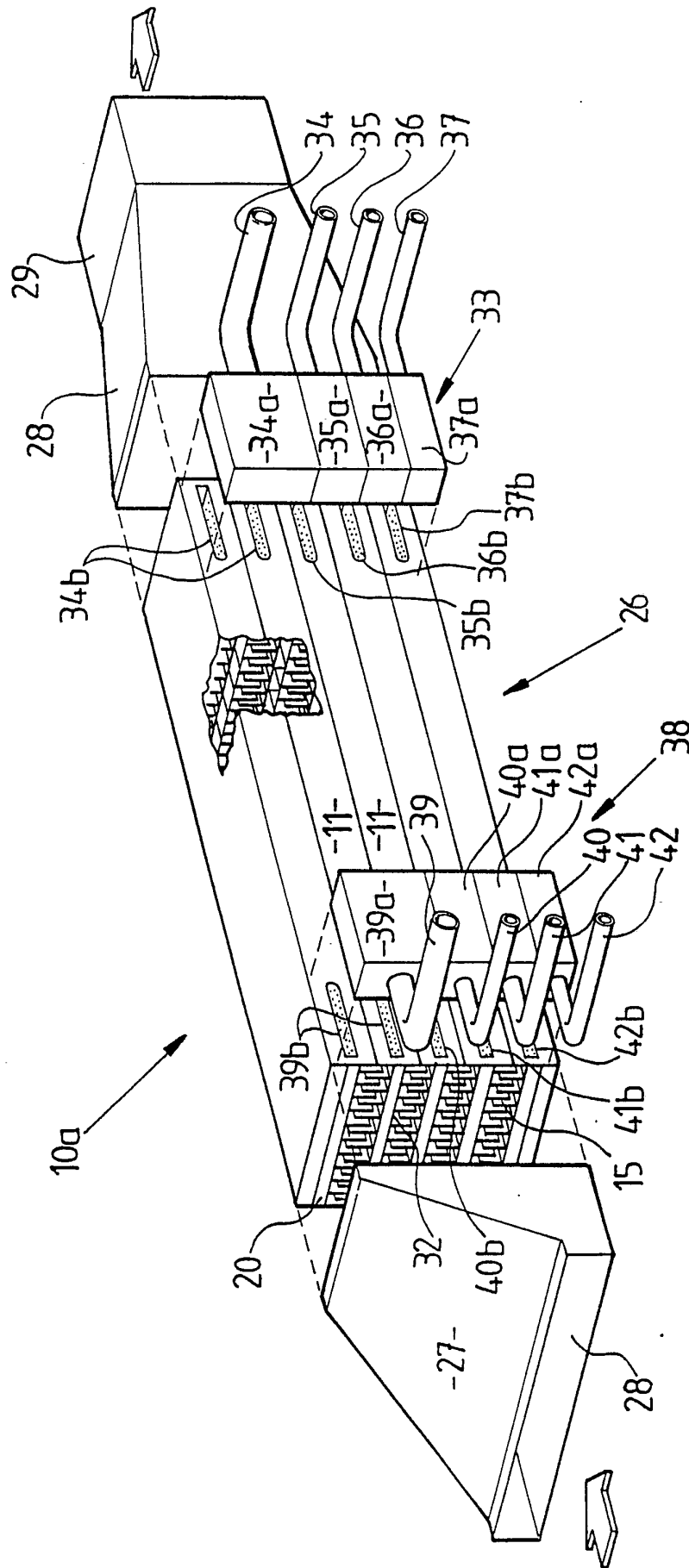
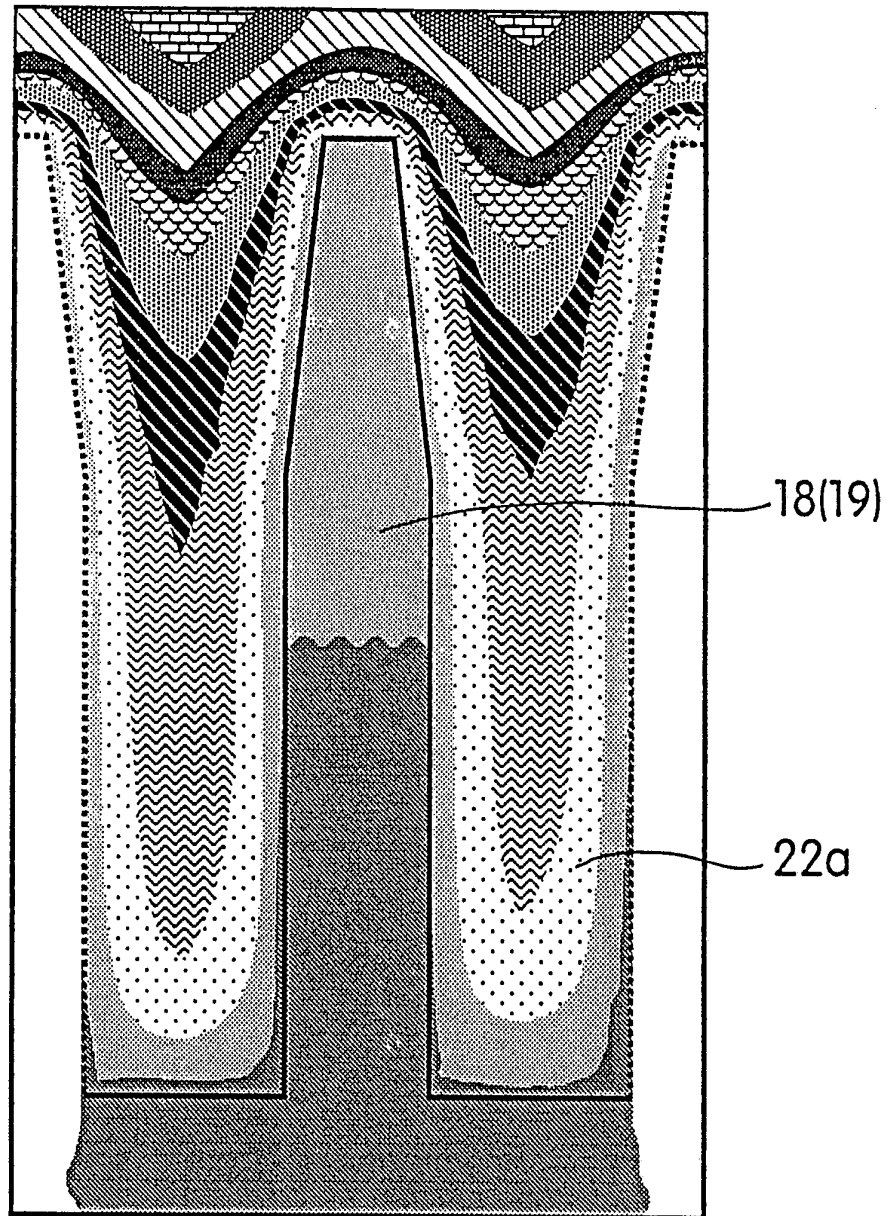


FIG. 4



TEMPERATURES IN CELSIUS



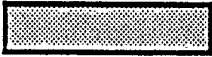
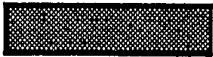







77.5° - 76.5°			71.5° - 70.5°
76.5° - 75.5°			70.5° - 69.5°
75.5° - 74.5°			69.5° - 68.5°
74.5° - 73.5°			68.5° - 67.5°
73.5° - 72.5°			67.5° - 66.5°
72.5° - 71.5°			

FIG. 6

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int. Cl. <sup>5</sup> F28D 9/00, F28F 3/04, 1/16  According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>  Minimum documentation searched (classification system followed by classification symbols) IPC F28D 9/00, F28F 1/16, 1/22, 3/04  Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU : IPC as above  Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	DE,C, 1021553 (S.I.R.T.A. SOCIETA ITALIANA RADIATORI TIRAGGIO	1-6
Y	ATTIVATO, BUSTO ARSIZIO (ITALIEN)) 27 December 1957 (27.12.57)	7-14
	AU,B, 45112/79 (526929) (SULZER BROTHERS LTD) 20 September 1979 (20.09.79)	
X	See Figures 1-8 and the associated description	1,3-9,13,14
X	US,A, 4089302 (ENSINK) 16 May 1978 (16.05.78)	1-4,7,10-12,14
	See Figures 1-2 and the associated description	(continued)
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier document but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search 25 May 1993 (25.05.93)		Date of mailing of the international search report 31 MAY 1993 (31.05.93)
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA  Facsimile No. 06 2853929		Authorized officer  I.A. KILBEY  Telephone No. (06) 2832115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	EP,A, 183211 (NORSK HYDRO A/S) 4 June 1986 (04.06.86) See whole document	1,5
Y	DE,A, 3011011 (HITACHI LTD) 25 September 1980 (25.09.80) See, in particular, Figs 10-14 and the associated description	7-14
X	EP,A, 461781 (SERVOTOMIC LTD) 18 December 1991 (18.12.91) See whole document	1-4,14
A	FR,A, 2553503 (DE DIETRICH S.A.) 19 April 1985 (19.04.85)	
A	US,A, 4401155 (ROYAL) 30 August 1983 (30.08.83)	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
DE	1021553	NONE					
AU	45112/79	BR WO	7907427 7900766	CH ZA	625611 7901190	EP	15915
US	4089302	BE DK IT	841897 2117/76 1060589	CH FR LU	611999 2311269 74922	DE GB	2620515 1553287
EP	183211	JP	61193733				
DE	3011011	JP	55152397				
EP	461781	NONE					
FR	2553503	NONE					
US	4401155	NONE					
END OF ANNEX							