603510

COMMONWEALTH OF AUSTRALIA

Form 1
Regulation 9

Patents Act 1952

APPLICATION FOR PATENT OF ADDITION

WE, SIDDONS RAMSET LIMITED, formerly Siddons Industries Limited of 58 Dougharty Road, West Heidelberg, Victoria 3081, Australia hereby apply for the grant of a patent of addition for an invention entitled **WATER HEATER** which is described in the accompanying complete specification.

The actual inventors of the said invention are: Lockwood DeFOREST, Ian D. ROBERTS and Christopher W.S. DIXON

OUR address for service is SMITH SHELSTON BEADLE, 207 Riversdale Road (P.O. Box 410), Hawthorn, Victoria, 3122 (Attorney Code SA)

Details of Basic Application:-

Number of Basic Application:	179,450
Convention Country in which Basic Appliction was filed :	United States of America
Date of Basic Application:	8th April, 1988
ISO Code	US

Patent of Addition

WE request that the patent may be granted as a Patent of Addition to the patent applied for on

M007998 07/04/89

Application No.:	67436/87
Patent No.:	582,291
In the Name of:	Siddons Industries Limited

APPLICATION ACCEPTED AND AMENDMENTS

ALLOWED 22-3-90

We ~~I~~ request that the term of the Patent of Addition be the same as that for the main invention or so much of the term of the patent for the main invention as is unexpired.

DATED THIS 7th DAY OF April, 1989.

SMITH SHELSTON BEADLE
Patent Attorneys for the Applicant

To: The Commissioner of Patents
Our Ref: #2850 TNB:WB 15sid

FORM 7 & 8

AUSTRALIA

PATENTS ACT 1952

SMITH SHELSTON BEADLE
PATENT ATTORNEYS

PATENT DECLARATION FORM
(CONVENTION OR NON-CONVENTION)

DECLARATION IN SUPPORT OF APPLICATION FOR A PATENT

Insert name of applicant.

In support of the application made by SIDDONS RAMSET LIMITED formerly Siddons Industries Limited

Insert title of invention.

for a patent for an invention entitled: WATER HEATER

Insert full name(s) and address(es) of person(s) making declaration. If applicant a company person must be authorised to make declaration.

I/We ALFRED ROBERT CARTER
2 YARRABEE COURT
MOUNT WAVERLEY 3149
VICTORIA

do solemnly and sincerely declare as follows:

* Delete alternatives which do not apply

* 1. ~~(a) I am/We are the applicant(s) for the patent.~~

* OR (b) I am authorized by the abovementioned applicant to make this declaration on its behalf.

* 2. ~~(a) I am/We are the actual inventor(s) of the invention.~~

Insert name(s) and address(es) of actual inventor(s).

* OR (b) Lockwood DeFOREST of 5A Cyprian Street, Mosman, New South Wales 2088, Australia, Ian D. ROBERTS of 6 Lynette Street, Nunawading, Victoria 3131, Australia and Christopher W.S. DIXON of 1 Farleigh Grove, Brighton, Victoria 3186, Australia.

Insert details of entitlement to apply, e.g. Applicant is assignee of inventor(s)

~~is~~/are the actual inventor(s) of the invention and the facts upon which the applicant~~(s)~~ is/~~are~~ entitled to make the application are as follows:—
Applicants are assignees of the inventors

Delete 3 and 4 if application non-convention. Otherwise insert details of basic application(s).

3. The basic application~~(s)~~ as defined by Section 141 of the Act was/~~were~~ made in the following country or countries on the following date~~(s)~~ by the following applicant~~(s)~~ s
in United States of America on 8th April, 19 88
by Lockwood DeForest, Ian D. Roberts and Christopher W.S. Dixon.
in ____ on ____ 19 ____
by ____
in ____ on ____ 19 ____
by ____
in ____ on ____ 19 ____
by ____

4. The basic application~~(s)~~ referred to in paragraph 3 of this Declaration was/~~were~~ the first application~~(s)~~ made in a Convention country in respect of the invention the subject of the application.

Place and date of Signature.

Declared at Heidelberg West this 19th day of April 19 89

SIDDONS RAMSET LIMITED

NO ATTESTATION OR SEAL

ALFRED ROBERT CARTER.

Signature(s) of declarant(s).

To: The Commissioner of Patents, Australia

SSB10

(12) PATENT ABRIDGMENT (11) Document No. AU-B-32581/89
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 603510

(54) Title
WATER HEATER

International Patent Classification(s)
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(56) Prior Art Documents
AU 582291 67436/87 F24J
AU 538313 70043/81 F16B, F28F, F25D
AU 296189 61275/65 06.7, 24.5

(57) Claim

1. A water heater comprising:

a water tank having a wall formed from material having heat transfer properties;

a cold water inlet adjacent one end of the tank;

a hot water inlet adjacent the other end of the tank;

a tube adapted to carry a refrigerant fluid secured externally about said tank wall;

heat-conductive bonding material substantially coextensive with the length of said tube securing said tube and said tank wall substantially continuously one to the other with the tube and heat-conductive bonding material in heat-conductive contact with the external surface of said wall of said tank to transfer heat from condensation of refrigerant fluid in said tube through said wall to the water contained in the tank, said tube about said tank being under tension to reduce the likelihood of the heat-conductive bonding material breaking during expansion and contraction of the tube and tank during use.

.../2

an evaporator positioned to be exposed to ambient conditions for absorbing heat energy from said ambient conditions, and having a passage for carrying the refrigerant fluid whereby said fluid may be heated by said ambient conditions; and

a compressor connected to said passage and to said tube to circulate refrigerant fluid through said tube and to said evaporator.

603510

COMPLETE SPECIFICATION

FOR OFFICE USE

Application Number: Class Int. Class
Lodged:

Complete Specification -- Lodged:
Accepted:
Published:

Priority:

This document contains the amendments made under Section 49 and is correct for printing.

Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: SIDDONS RAMSET LIMITED

Address of Applicant: 58 Dougharty Road, West Heidelberg, Victoria 3081, Australia.

Actual Inventors: Lockwood DeFOREST, Ian D. ROBERTS and Christopher W.S. DIXON

Address for Service: SMITH SHELSTON BEADLE
207 Riversdale Road (P.O. Box 410)
Hawthorn, Victoria, Australia

Complete Specification for the invention entitled:

WATER HEATER

The following statement is a full description of this invention, including the best method of performing it known to us:

Our Ref: #2850 TNB:WB 15sid

This invention relates to improvements in water heaters, and more particularly solar boosted heat pump water heaters having an improved heat exchanger arrangement.

Background of the Invention

The use of solar energy to supplement water heating systems is becoming increasingly practical with developments in technology. In Australian patent number 509901 there is described a solar boosted heat pump system which converts solar energy particularly efficiently and transfers that energy by the use of a refrigerant heat pump.

In developing a solar boosted heat pump system for the heating of domestic water, the inventors tested various heat exchange systems for transferring the heat from the refrigerant circulated by the heat pump to the water to be heated. One such arrangement included the immersion of a finned tube carrying the refrigerant in a tank containing the water to be heated. This arrangement was thought to provide the most efficient means of transferring heat from the refrigerant to the water to be heated even though the system was expensive to manufacture. However, testing of the system showed that it was impractical due to the fact that the spaces between the fins tended to fill with the sediments commonly found in some domestic water supplies. Although attempts were made to redesign the finned tube to avoid the collection of sediments, the problem could not be overcome.

A number of attempts to provide heat pump water heaters may be found in the patent literature. For example, United States Patents 2,716,866 Silva and 4,452,050 Pierce, and United Kingdom Patent 1,466,980 Cromarty, each show water heaters having a refrigerant carrying tube surrounding a heat exchanger tank containing water to be heated. In each of the above examples, the heat exchange system is both complex and expensive due to the use of a number of separate windings (or winding sections, in the case of Cromarty) aimed at extracting the higher temperature superheat from the refrigerant fluid carried by the tubes. The use of separate windings or winding sections increases the material and manufacturing costs of the heat exchanger, and the inventors believe that these costs are not justified by the benefit which may be achieved by extracting the superheat from the refrigerant fluid. Furthermore, none of the systems described in the above literature envisages use of the system in association with a solar evaporator.

Of course water heating systems utilising solar energy are known, and one such system is described in United States Patent 4,282,861 Roark. However, this system uses the water to be heated as the heat transfer medium and such a system does not have the required efficiency to function adequately as a domestic or industrial water heating system.

The patent literature also contains numerous examples of heat exchange systems in which pipes are attached to tanks, such as United Kingdom Patent 377398 Bishop et al and German Patent Application No. P3325137 Knabben et al, but these disclosures are not directed toward heat pump systems in which the heat transfer fluid is a refrigerant or the like. For example, the Bishop et al patent pipes steam around a cooking pan and as such is impractical for application to a domestic water heater, In the case of Knabben, the invention is concerned with the shaping of the tube to maximize contact between the tube and the heat exchange tank, and the heat exchange medium is not even discussed. Thus, while patents such as the above disclose the attachment of heat exchange tubing to the lower portion of a liquid containing tank, the earlier mentioned patents directed to systems using refrigerant as the heat transfer medium would suggest that such a limited use of exchange tubing would not be satisfactory for a system using a heat pump.

In our earlier Patent AU-B 67430/87 (582291) we describe a water heater in which any of the above shortcomings are addressed. However, such water heaters still suffer from the potential disadvantage that the expansion and contraction of the tubing and/or the tank may cause breaking of the heat-conductive bonding.

Brief Summary of the Invention and Objects

It is an object of the present invention to provide a water heater, and a method of constructing a water tank therefor, which does not suffer from the above disadvantage and which nevertheless provides efficient transfer of heat contained in a heating medium to water containing in a tank.

The invention therefore provides *

By holding the tube under tension while it is bonded to the tank, the likelihood of the conductive bonding being broken by expansion or contraction is significantly reduced.

In a preferred embodiment of the invention, the tank is a vertically standing cylindrical tank and the tube extends from a position adjacent the bottom of the tank to a position approximately 50% to 70% of the height of the tank. It will be appreciated that although this arrangement is presently preferred, other arrangements in which the tube extends to a position from 50% to 75% of the height of the tank may be satisfactory. Similarly, while the use of a vertically standing cylindrical tank is presently preferred, the invention is equally applicable to a horizontally disposed tank of cylindrical or other suitable shape with the turns of said tube attached to the lower or downwardly inclined surface of the tank.

The turns in the tube conductively contacting the wall of the tank are preferably spaced by a distance which optimizes the heat transfer between the heat transfer medium and the water to be heated and at least one turn of the tube is preferably located under the cold water inlet.

The tube may be attached to the external surface of the wall of the tank by means of a heat transfering bonding material such as solder.

The water tank wall is preferably of cylindrical metallic (e.g. steel) construction having a concave bottom wall and a convex top wall and the tube is preferably made of the same material to reduce the likelihood of heat transfering contact being lost due to the different coefficients of expansion of the tank and tube.

Brief Description of the Drawings

One presently preferred embodiment of the invention is shown in the accompanying drawings in which:

Figure 1 is a fragmentary sectional elevation of a water tank incorporating a heat exchanger suitable for use with the water heater embodying the invention;

Figure 1A is an enlarged fragmentary sectional elevation of portion of the tank showing the attachment of the tube thereto;

Figure 2A is a schematic elevation of mechanism for applying the tube to the tank;

Figure 2B is an enlarged schematic elevation of the tube deforming rollers shown in Figure 2A;

Figure 3 is a schematic diagram showing the layout of a solar boosted heat pump water heating system embodying the invention;

Figure 4 is a schematic diagram showing an arrangement for cooling the compressor used in the system of Figure 3;

Figure 5 is a schematic diagram showing one layout of the refrigerant passages in the solar collector used in the system of Figure 3; and

Figure 6 is a sectional side elevation of one of the solar evaporator/collectors used in the system of Figure 3.

Description of Preferred Embodiment

Referring to the drawings, the heat exchange system will be seen to comprise a water tank 1 having a cylindrical wall 2, a bottom wall 3, a convex top wall 4, a cold water inlet 5 adjacent the bottom wall 3 incorporating a diffuser or diverter 6 and a hot water outlet 7 adjacent the top wall 4. While the bottom wall 3 is shown to be concave, it may be convex if desired. A tube 8 carrying a refrigerant, such as refrigerant R12, is wrapped around the external surface of the tank wall 2. The tube 8 is preferably flattened as shown in figure 1A, so that it is D-shaped in cross-section, and the flattened portion is heat conductively bonded to the surface of the wall 2 by means of a thin film of solder 9 or the like between the outer surface of the wall 2 of the tank 1 and the flat face of the tube 8. To ensure the best possible contact during soldering and during expansion and contraction of the tube and tank wall 2 in use, the tube 8 is wound around the tank 1 under an applied tension of the order of 1,286 N, and is secured to the tank 1 while under tension. This may be achieved in the manner shown schematically in figure 2A of the drawings.

As shown in figure 2A, the tank 1 is supported on a rotating table 20, which is rotatably driven by a motor 21 through a gear box 22 and chain drive 23. A suitable length of tube 8 is fed by feed rollers 24 and deformed into the D-shape shown in figure 1A by deforming rollers 25. The feed rollers 24 and the deforming rollers 25 form part of an assembly including a nut engaging a feed screw 26 which is rotatably driven by a motor 27 to move the assembly up the tank 1 at the required rate relative to rotation of the table 20 so that the tube 8 is wound around the tank with the required spacing between adjacent turns.

As shown in greater detail in figure 2B, the deforming rollers 25 include a knurled roller 28 and a grooved support roller 29. The rollers 28 and 29 are driven by gears 30,31 which are driven at the same speed as the pinch rollers 24 to ensure that the tube 8 is fed and deformed at the same rate. The pinch rollers 24 and the rollers 28 and 29 are restrained against free rotation by means of brake pads, such as those shown in figure 2B at 32. The tension applied to the tube may be adjusted by clamping the brake pads 32 into engagement with the roller 29 and gear 30 under the influence of a spring 33 which is adjustably compressed by means of a tension nut 34.

In the present embodiment, the part of the tank 1 to which the tube 8 is to be fixed is cleaned and a copper flash is applied in a known manner. The tube 8 is then fixed by spot welding to the bottom of the tank wall 2 and the tube 8 is then wound around the tank using the mechanism shown in figure 2A of the drawings. A tin/lead solder paste is applied to the flat portion of the tube 8 as it is wound onto the tank 1 and once the tube has been completely wound, the upper end thereof is fixed to the wall 2 of the tank 1 by spot welding to maintain the tube 8 under tension. The tank 1 with an attached tube 8 is then heated in an oven to melt the solder and complete the formation of the heat transfer bond between the tube 8 and the wall 2 of the tank 1.

The tube 8 extends from the position adjacent the bottom wall 3 to a position approximately two thirds of the overall height of the tank 1 and defines a heat exchange surface S on the wall 2. The lowermost turn 8A of tube 8 is located under the cold water inlet 5, which is usually cold, and this causes sub-cooling of the refrigerant whereby it is rendered stable enough for transportation. The tube 8 is connected to a solar boosted heat pump (Figure 3 as described below) of the general type described in Australian patent number 509901, although it will be noted that modifications to that system have been made in the system described further below. Other forms of heat pump may also be used and the heat exchange medium carried by the tube 8 may be varied as desired.

It will be appreciated that by attaching the refrigerant carrying tube 8 to the external surface of the tank 1, a double-wall effect is automatically achieved and the protection required by the relevant water authorities, which stipulates a double walled tube where a refrigerant carrying tube is associated with water, is satisfied. Both the tube 8 and the tank 1 are preferably made from a similar material, or at least from materials having similar coefficients of thermal expansion.

In the present case, the tube 8 and the tank 1 are fabricated from steel or stainless steel. For example, the tube may be Bundyweld steel tubing while the tank 1 may be made from mild steel. As mentioned above, the thermal bond between the tube 8 and the tank 1 is maintained by the winding of the tube 8 around the tank 1 under tension. Where materials having slightly different coefficients of thermal expansion are used, the different rates of expansion and contraction of the materials may be compensated for by increasing the winding tension of the tube 8 in the manner described above. In any event, the winding of the tube under tension ensures that the thermal bond is maintained notwithstanding the flexing of the materials caused by expansion and contraction in use.

Furthermore, the described heat exchange arrangement is eminently suitable for use with a fluid A, such as water which is likely to contain precipitatable contaminants since a major portion of the heat exchanger surface S is vertical whereby the accumulation of precipitates on the heat exchanger surface is discouraged. Still further, the heat exchanger surface S is sufficiently enlarged to allow for the application of coatings, such as vitreous enamel, while still maintaining the product of heat transfer coefficient and surface area at an efficient level and minimizing the temperature difference between the fluid to be heated A and the heat exchanger surface S.

The area of the heat exchange surface S is selected so as to give the best compromise between the following conflicting requirements:

(a) The requirement that the heat exchanger surface be substantially vertical, downwardly facing or downwardly sloping as discussed above;

(b) The requirement that the heat flux density within the fluid A to be heated should be low enough to prevent de-stabilization of unstable components within the fluid whereby the maximum temperature difference between the heat exchanger surface S and the fluid A is limited so that fluids in contact with the surface are not locally heated to a point where the fluid A reaches some critical de-stabilization temperature, and

(c) The requirement that the heat exchanger surface S should be as compact as possible so that it is in the coldest region of the vessel.

Requirement (c) minimizes the irreversibility of the system of which the heat exchanger is a part which implies that the temperature at which heat is being transferred between the refrigerant B and the fluid A to be heated is as close as possible to the coldest sink temperature of fluid A. By making the heat exchanger compact the passive volume of the vessel is increased. This volume acts as a stored volume of fluid ready for delivery to the end user of the fluid A.

To enable the heat exchanger to be both compact and efficient, the spacing between the turns of tubing 8 and the flow rate of the refrigerant or other heat transfer fluid B must be optimized so as to give adequate fluid side surface area S, heat transfer medium side surface area T, heat transfer coefficients, heat exchanger fin efficiency and adequate passive storage if required. The requirements of this optimization is always a compromise and depends largely on the size of the system and the fluids in use. For the system shown in the preferred embodiment, having a vessel height of the order of 1520 mm, a surface height S of 1000 mm, and a turn spacing of 55 mm has been selected.

In general terms the design procedure for the above preferred embodiment can be summarised as follows:

Considering the passive storage volume requirement and the stratification of fluid A, the surface area S is made as compact as possible until the benefits outlined above are negated by the increase in heat transfer temperature difference across surface S caused by the reduction in area available to transmit the desired total heat flux.

The spacing and sizing of the tubes on the outside face of the heat exchanger surface S is then determined by established engineering design procedures involving consideration of internal tube heat transfer, tube to wall bond conduction and fin efficiency.

Reconsideration of the surface area S determined may then be necessary if the tube spacing computations reveal that further optimisation of the design is possible through some compromise with surface area S.

To avoid degradation of the stored volume of the fluid through mixing with fluid which has yet to be fully heated or cooled, stratification of fluids which are at different temperatures should be promoted as far as possible. To this end the entry and exit conduits are arranged so as not to promote mixing by stirring up the fluid A. Also the cold conduit 5 is positioned at the bottom of the tank and the hot conduit 7 at the top of the tank. To achieve a reduction in stirring, it will be noted that the axis of the entry conduit 5 is perpendicular to the axis of stratification. In addition a downwardly facing diffuser-deflector 6 is used at the cold water inlet 5 while an upwardly facing diffuser-deflector 6a is used at the hot water outlet 7 to further reduce mixing and stirring.

The heat exchanger should preferably be arranged so that the counter-flow principle is embodied as this further improves heat transfer. In the embodiment shown, it will be noted that the refrigerant B flows from the top of the coiled tube 8 to the bottom.

A preferred solar boosted heat pump water heating system is shown schematically in Figure 3 of the drawings and will be seen to include a heat exchange system embodying the invention in which the tank 1 and refrigerant carrying tube 8 is enclosed in a housing 10 containing insulating foam 11. For convenience, the compressor 12 and receiver/filter/drier 13 of the heat pump system are mounted on a refrigeration chassis 14 located on top of the tank housing 10. This arrangement avoids the need for the housing 10 to be supported at an elevated position to allow location of the compressor and receiver under the tank housing as is usual, thereby reducing construction costs.

The compressor 12 is preferably a rotary compressor, although other forms of refrigerant compressors may be used without materially detracting from the efficiency of the system. A rotary compressor is preferred because of its relatively smooth quieter operation. Furthermore, a rotary compressor is able to accept slugs of liquid on the suction side of the compressor whereas other types of compressors have greater difficulty accepting such slugs. These slugs may occur in a solar boosted heat pump due to the rapid variations in temperature which may be experienced as a result of changing weather conditions.

To reduce heat losses from the system to a minimum, the compressor 12 is preferably externally insulated. To compensate for the heat build up caused by such external insulation, the compressor is cooled by bleeding refrigerant from the outlet of the condenser or receiver directly into the inlet suction line or into the "suction side" of the cylinder through a bypass line which is preferably controlled by a control valve, capilliary tubing or fixed orifice (not shown). One arrangement for achieving this is shown schematically in Figure 4 of the drawings and will be seen to comprise a cylinder 12A enclosed within an insulating casing 12B and containing a rolling piston 12C and vane 12D. A liquid injection tube 12E is connected from the refrigerant liquid line to the suction line 12G into the compressor 12. By this arrangement, heat which would normally have been wasted to the air is passed to the water in the tank through the condenser. It has been found that the arrangement shown in Figure 4 works more reliably than injection directly into the cylinder as used in commercially available compressors.

The system includes a thermostat control system including a thermostat T,

More complex thermostat variations are possible, including:

a) a variable or dual thermostat setting which depends on the level of sunlight, or

b) sensing evaporation temperature when the unit is running and using this as an indication of the potential performance which in turn increases or decreases the thermostat set point.

The overall aim of the above described systems is to bias the system towards running during the day by making it raise the water to a higher temperature during daylight hours than during the night. Further sophistications are possible by making the set point of the thermostat a function of solar radiation and ambient air temperature although control "intelligence" is required in this case so that adequate water temperatures are reached during the winter. Similarly, biassing the system to operate primarily during a low tariff (off-peak) period is possible.

The compressor 12 and the receiver 13 are connected to a series of solar evaporator plates 15 which are located in a position exposed to the sun. Each evaporator plate contains a number of refrigerant passages 16 which are preferably arranged in the configuration shown in Figure 5 of the drawings. Each evaporator plate 15 is made from two sheets of metal which are bonded together, except in the regions of the passages 16, by the so-called Roll-Bond (Trade Mark) process, which is well-known in the art. Since the evaporator plates are formed from thin sheet metal, each evaporator plate is supported in an outwardly curved profile as shown in the sectional elevation of Figure 6 of the drawings. The outwardly curved profile is maintained by the positioning of a molded insulating foam former 17 behind each plate 15, the assembly being supported by two bearers as shown in Figures 3 and 6 of the drawings. Each evaporator plate 15 is further strengthened by the formation of an angle section 18 along each longitudinal edge of the plate 15. The evaporator plate arrangement described above has been found to perform well in wind tests conducted to assess its ability to withstand wind forces of the type encountered when the evaporator plate is mounted on the roof of a dwelling.

As will be appreciated from Figure 5 of the drawings, each evaporator plate is formed with three separate parallel refrigerant passages 16 connected at either end by a manifold 19 to which the refrigerant lines (not shown) are connected. The plates 15 are, as shown in Figure 3 of the drawings, connected in series so that the outlet manifold of the first plate is connected to the inlet manifold of the second plate and so on. As will be further seen from Figure 5 of the drawings, the first passage connected to a manifold at one end of the plate is the last passage connected to the manifold at the other end of the plate to assist in equalising the flow of refrigerant in the parallel passage 16. The cross sectional area of the manifold is reduced after each junction to further assist in flow equalisation. The arrangement minimises the cross sectional area of the manifold and its junctions for a given design pressure drop across the manifold. This results in an improved burst pressure for a given refrigerant pressure drop compared with the performance of the typical "waffle" type distributor used in other "Roll Bond" evaporators.

As a result of these features the evaporator plate can be used with high evaporation pressure refrigerants such as R22 without incurring a high pressure drop across the evaporator. Furthermore the evaporator may be mounted at downward sloping angles, as is usually desired, as flow equalisation between passages 16 is relatively unaffected by the forces of gravity which usually cause the lower-most passage to be favoured. Refrigerant fluid is delivered to the top of each plate 15 rather than to the bottom, as is usually the case, and this allows the use of less refrigerant since the plates do not need to be flooded as is the case with bottom entry. An additional advantage is that positive oil return is achieved since the oil does not tend to accumulate at the bottom of the plates as it does with bottom entry. Top entry of the refrigerant in combination with high velocity refrigerant circulation causes annular flow of wet fluid in the passages 16 which improves the heat transfer from the plates to the fluid. In this mode of operation refrigerant gas flows within the wet fluid annulus.

A liquid trap is provided prior to returning the refrigerant to the compressor suction to prevent any accumulation of liquid in the plates 15 while the system is off from flowing by gravity down into the compressor suction. The trap must be sized such that oil is carried over with the refrigerant gas during operation.

It will be noted from Figure 3 of the drawings that the TX valve in the liquid line is located inside the refrigeration chassis 14 rather than at the evaporator plates 15 as is usually the case. Although compensation must be allowed for the location of the TX valve in this position, it has been found that valve performs in a superior manner in this location and manufacture of the system is simplified by the location of the valve in this position. The TX valve is preferably internally equalised and biased to give an appropriate superheat by setting to a negative superheat setting.

While the evaporator plates are shown in the above embodiment as being mounted in a position exposed to the sun, the plates may be mounted on the outside of the housing 10, as shown in broken outline in Figure 3, in a wrap around configuration in areas where the ambient temperature is high or where the tank is able to be mounted on a roof or in another position which is at least partly exposed to the sun. In such a situation, the heat pump operates at least partly as an air source heat pump.

In tests conducted by the Solar Energy Laboratory of the University of New South Wales, the performance of a solar boosted heat pump water heater having a heater arrangement according to the above described preferred embodiment was compared with a solar boosted heat pump water heater having a finned heat exchanger arrangement of the type described above and it was found that the average coefficient of performance of the water heater incorporating the heat exchanger embodying the present invention was approximately 11.2% better than that of the prior art arrangement for virtually identical test conditions. The test result may be summarised as follows:

<u>Old Style Unit</u> (Inserted finned tube condenser)

Test Period: 3-31 May 1985 (29 days)

Average Ambient Temperature: 15.8^{o}C

Average Solar Irradiation: 12.7 MJ/m^2/day

Average Overall System Coefficient of Performance: 2.48

<u>New Style Unit</u> (condenser coil wrapped around cylinder)

Test Period: 3-31 July 1985 (29 days)

Average Ambient Temperature: 12.4^{o}C

Average Solar Irradiation: 13.7 MJ/m^2/day

Average Overall System Coefficient of Performance: 2.76

Both periods provided virtually identical test conditions for solar heat pump operation. In July slightly lower average ambient temperature combined with slightly higher average solar irradiation to balance out and produce almost the same climatic conditions.

The COP achieved in July was however approximately an 11.2% improvement on the May figure.

In both cases the average water discharge temperature on the same load pattern approximated 57°C.

The claims form part of the disclosure of this specification.

1. A water heater comprising:

a water tank having a wall formed from material having heat transfer properties;

a cold water inlet adjacent one end of the tank;

a hot water inlet adjacent the other end of the tank;

a tube adapted to carry a refrigerant fluid secured externally about said tank wall;

heat-conductive bonding material substantially coextensive with the length of said tube securing said tube and said tank wall substantially continuously one to the other with the tube and heat-conductive bonding material in heat-conductive contact with the external surface of said wall of said tank to transfer heat from condensation of refrigerant fluid in said tube through said wall to the water contained in the tank, said tube about said tank being under tension to reduce the likelihood of the heat-conductive bonding material breaking during expansion and contraction of the tube and tank during use.

an evaporator positioned to be exposed to ambient conditions for absorbing heat energy from said ambient conditions, and having a passage for carrying the refrigerant fluid whereby said fluid may be heated by said ambient conditions; and

a compressor connected to said passage and to said tube to circulate refrigerant fluid through said tube and to said evaporator.

2. The water heater of claim 1, wherein said tank wall is metallic and said tube is made from material having a substantially similar coefficient of thermal expansion as said tank wall.

3. The water heater of claim 1 or 2 wherein said tank is a vertically standing cylindrical tank and the tube extends from a position adjacent the bottom of the tank to a position approximately 50% to 70% of the height of the tank.

4. The water heater of claim 3, wherein said tube extends to a position approximately 66% of the height of the tank.

5. The water heater of any preceding claim wherein at least one turn of said tube is located below said cold water inlet.

6. The water heater according to any preceding claim, wherein

said evaporator comprises flat, heat-conductive, sheet material forming a panel having a plurality of passages through which the refrigerant fluid is circulated in a heat conductive relation with said panel, means defining a manifold passage at each of the opposite ends of said passages said connecting one to the other, the passage which is first connected to said manifold passage at one end of said panel being last connected to said manifold passage at the opposite end of said panel.

7. The water heater according to any one of claims 1 to 5, wherein said evaporator comprises a solar collector panel having said passage through which the refrigerant fluid is circulated in heat-conductive relationship with said panel, means defining an inlet to said collector for flowing the fluid into the collector passage, said panel being secured to a support which holds the panel in an outwardly bowed configuration to thereby increase the effective strength of the panel.

8. The water heater according to claim 6 or 7 wherein said collector is disposed with one end elevated with respect to the other end, said refrigerant fluid inlet to the collector being positioned at said elevated end, said panel being formed of heat-conductive, sheet material.

9. The water heater according to any preceding claim including an insulating casing surrounding said tank, said compressor being positioned on top of said casing, and means for externally insulating said compressor.

10. A method of making a heat exchanger for a water heater comprising the step of attaching one end of a tube to the external surface of a metallic water tank, winding the tube around the external surface of said tank while applying a predetermined tension to said tube, attaching the other end of said tube to said tank to keep the tube in tension, and heat conductively bonding said tube to said tank.

11. The method of claim 10 further comprising the step of forming a flat area on said tube prior to said winding step and winding the tube around said tank with said flattened area in contact with said tank.

12. The method of claim 10 or 11, further comprising applying a

heat conductive bonding material to that part of said tube which will be in contact with the tank when wound around the tank prior to contact with said tank, and heating the material to form a thin bonding film between said tube and said tank.

13. The method of any preceding claim, wherein the tension applied to said tube is about 1286 N.

14. A water heater of any one of claims 1 to 9 substantially as hereinbefore described with reference to the accompanying drawings.

15. The method of claims 10, 11, 12 or 13 substantially as hereinbefore described with reference to Figures 1A, 2A and 2B of the accompanying drawings.

6 August 1990
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Fellows Institute of Patent Attorneys of Australia
Patent Attorneys for the Applicant:
SIDDONS RAMSET LIMITED

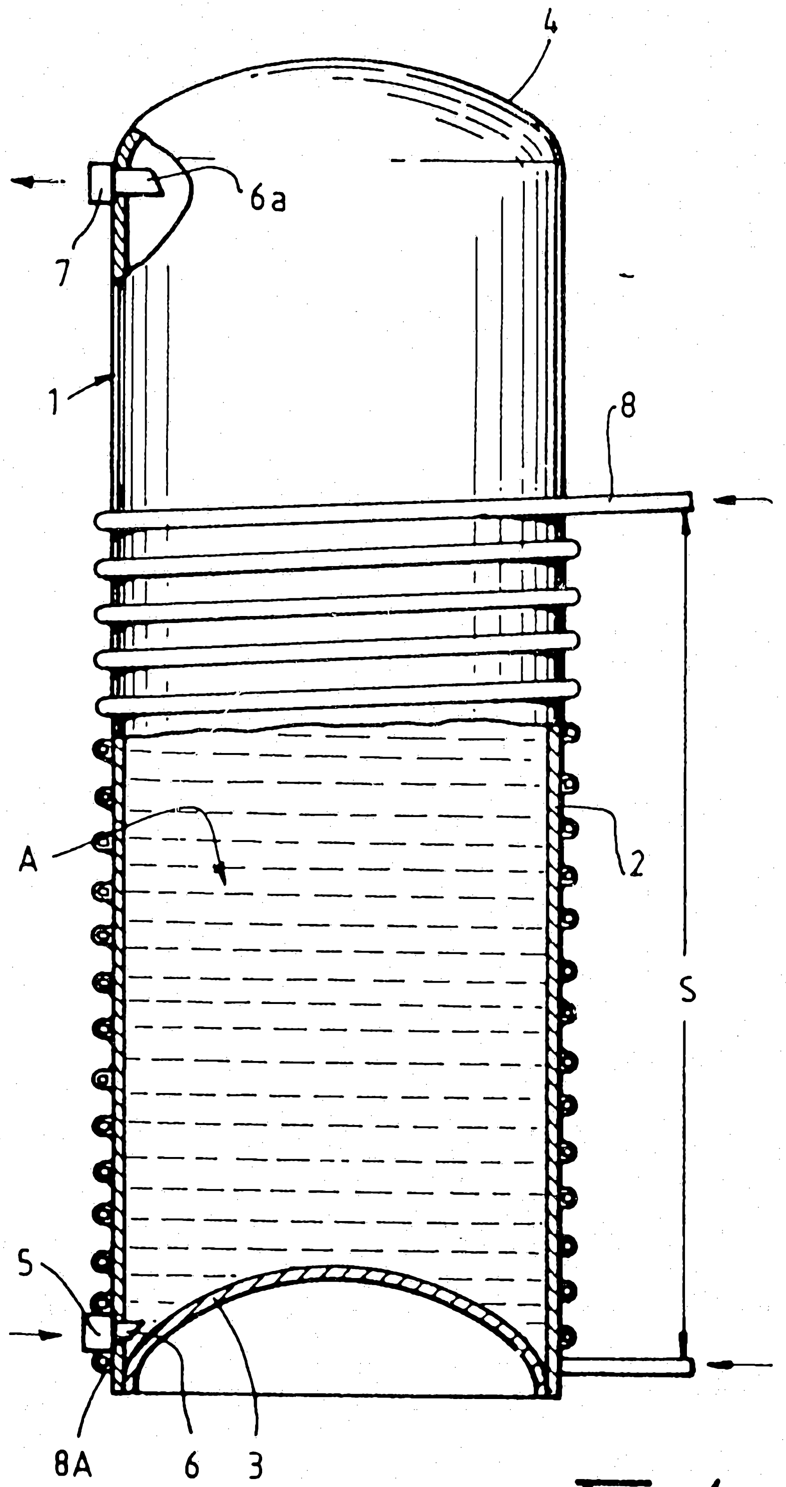

FIG. 1.

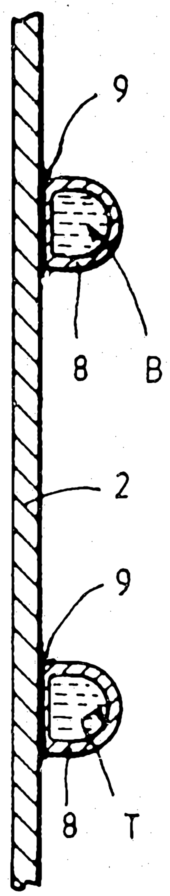

FIG. 1A.

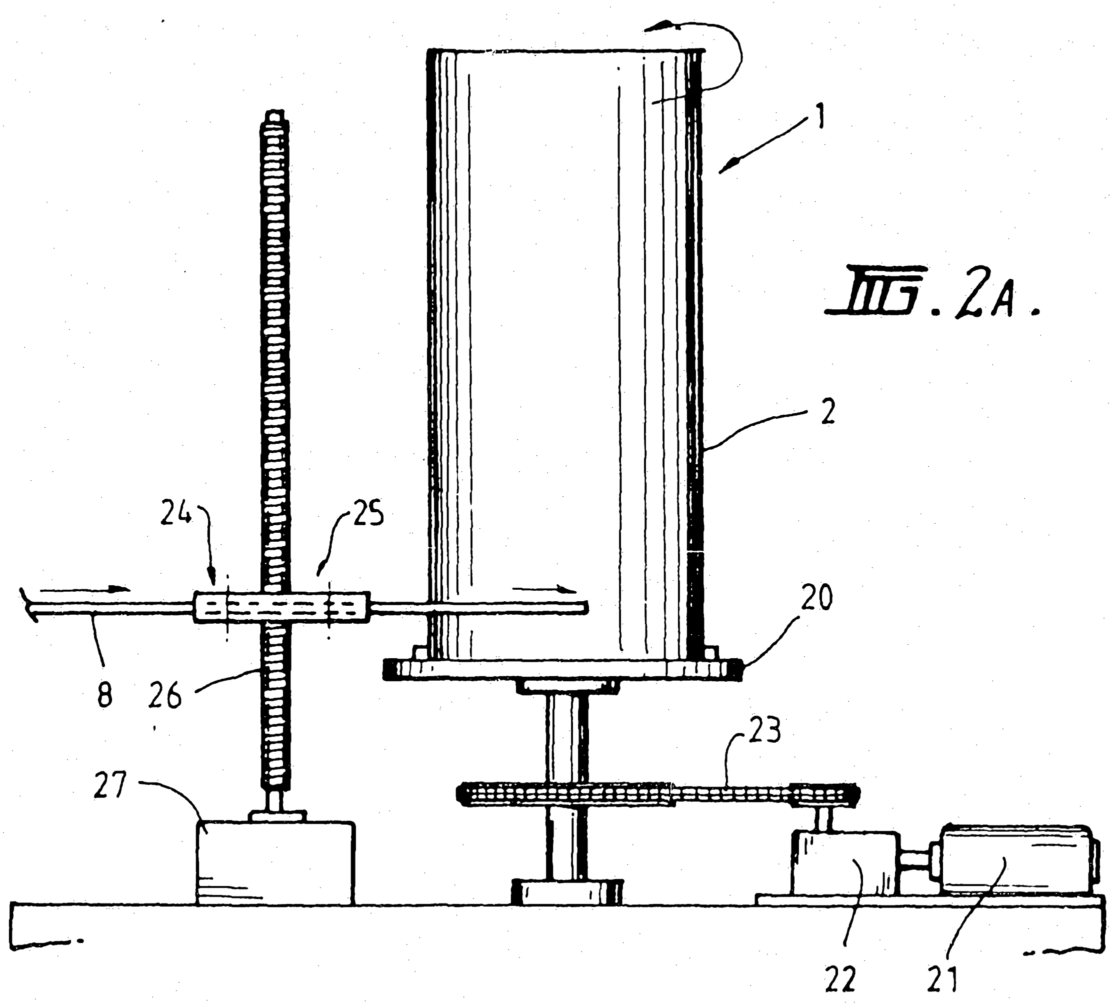

FIG. 2A.

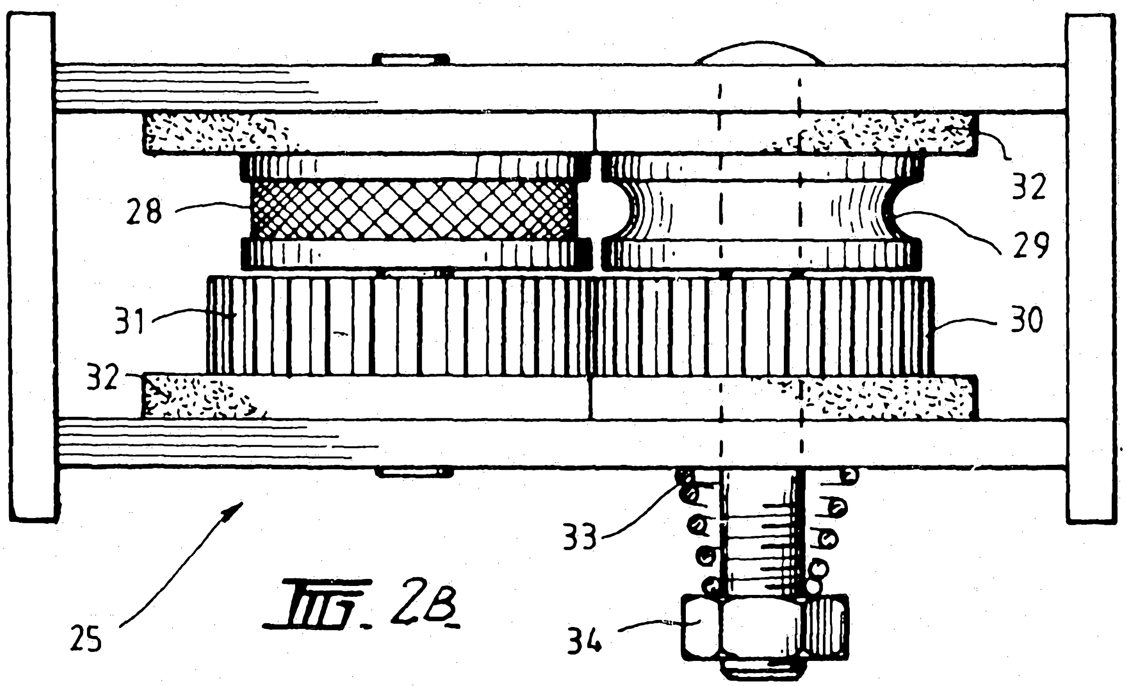

FIG. 2B.

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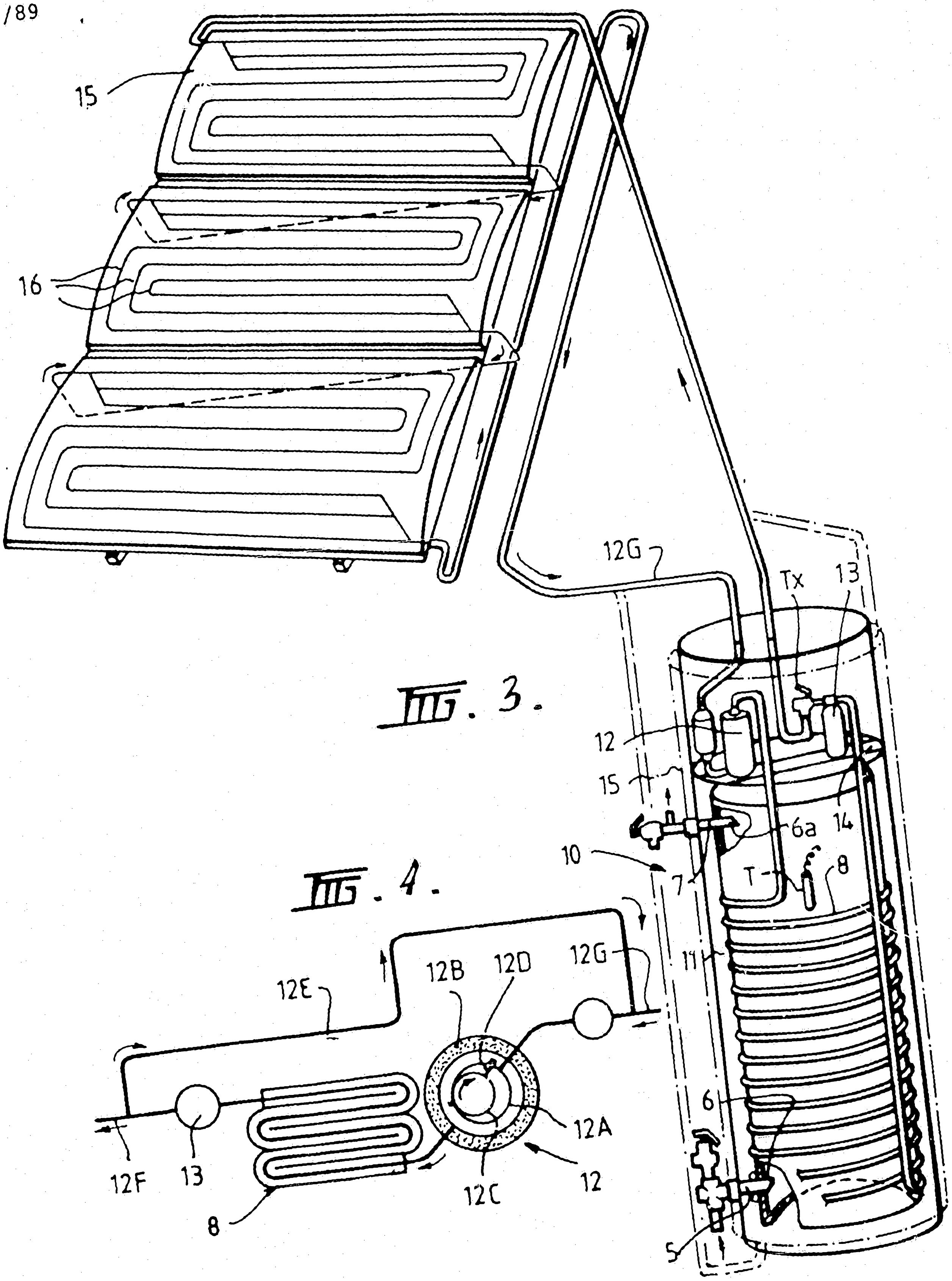

FIG. 3.

FIG. 4.

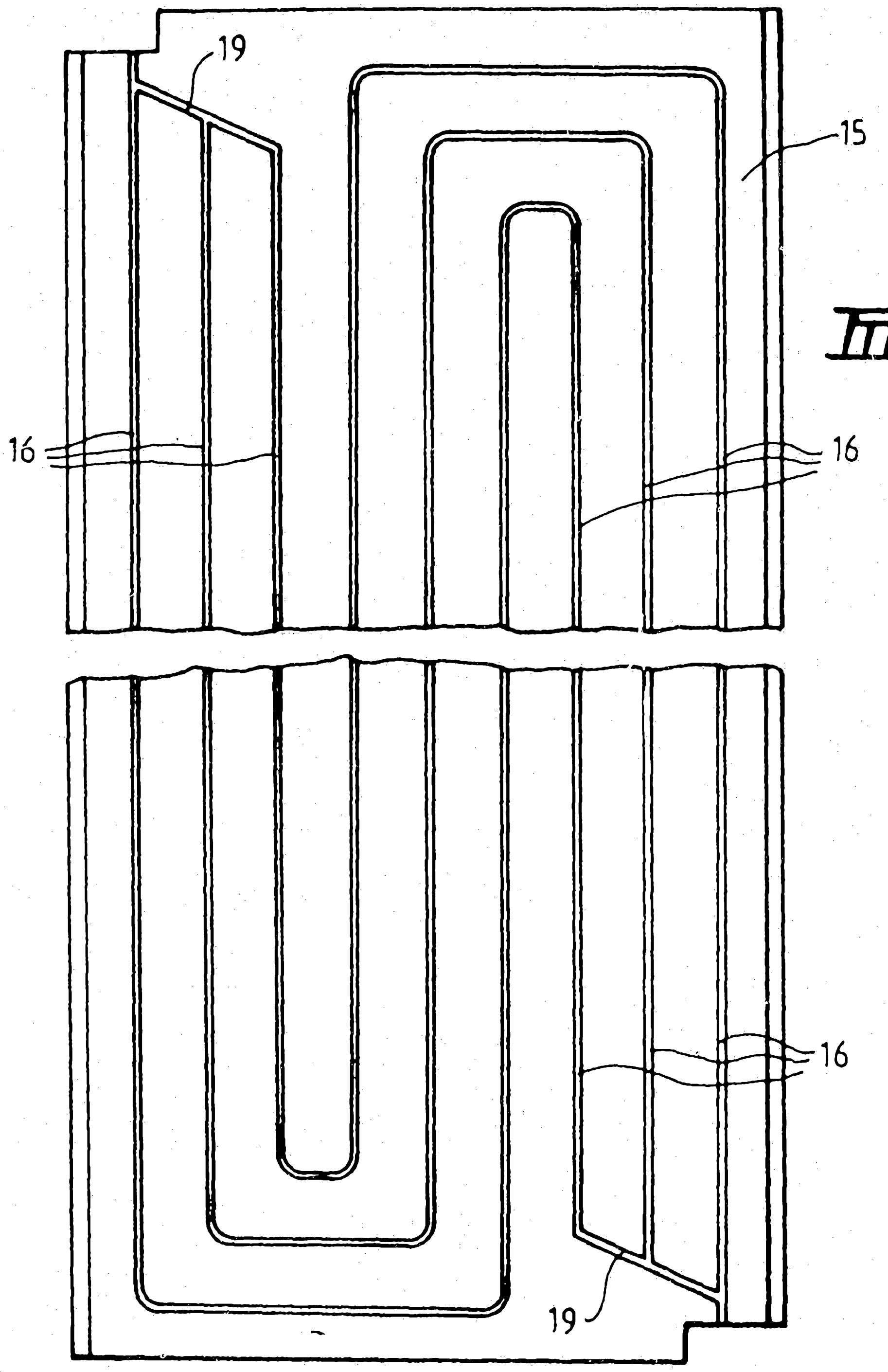

FIG. 5.

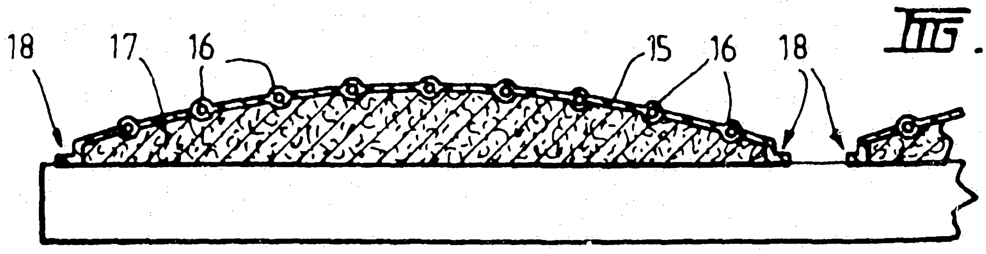

FIG. 6.