(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 December 2010 (16.12.2010)

PCT

(10) International Publication Number
WO 2010/142012 Al

(51) International Patent Classification:
F25B 39/02 (2006.01) *E03B 3/28* (2006.01)
BOlD 5/00 (2006.01) *F25D 21/00* (2006.01)
BOlD 53/26 (2006.01) *F25D 21/14* (2006.01)

(21) International Application Number: PCT/CA2009/000780

(22) International Filing Date: 8 June 2009 (08.06.2009)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR),

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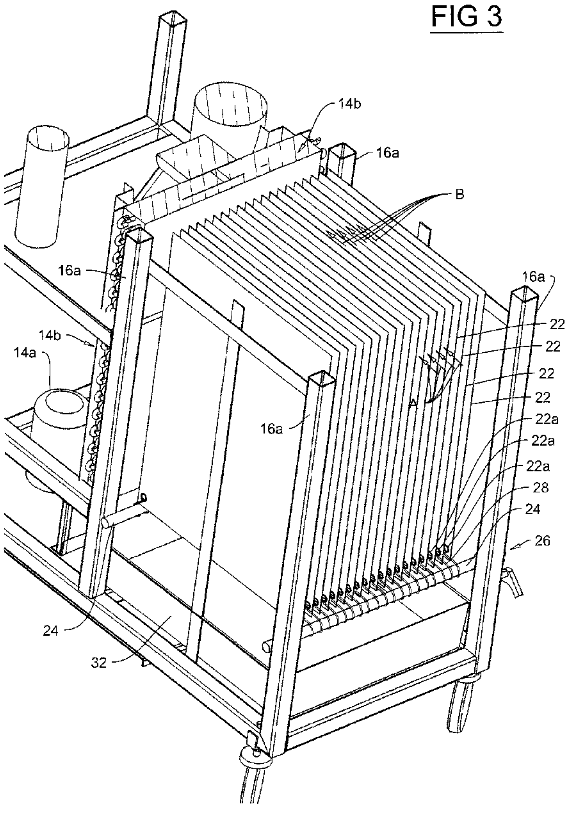
(54) Title: ATMOSPHERIC WATER GENERATOR

FIG 3



(57) Abstract: An atmospheric water generator includes a ref igeration system. The evaporators may be roll-bond evaporators. Fans cooperate with a radiator and the evaporators to induce an in-flow stream of air from ambient air into and through, firstly, the condenser, and secondly, the radiator. The in-flow stream of air is cooled by the evaporator as the in-flow stream passes through the evaporator. The cooled stream of air then passes through a heated dissipating section of the radiator. The airways between the evaporators in the array are sufficiently long so that the streams of air become turbulently mixed. The evaporators may be planar. Opposed facing surfaces of adjacent evaporators may include turbulent flow trippers to change laminar flow in the airways to turbulent flow. The turbulent flow trippers may include protrusions formed on the opposed facing surfaces or metallic mesh interleaved in the airways between the evaporators.

WO 2010/142012 A1

OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

ATMOSPHERIC WATER GENERATOR

Field of the Invention

This invention relates to the field of atmospheric water generators, and in particular to a water generator system employing a synergistic relationship between the radiator and condenser in the refrigeration thereof wherein cooling of parallel roll-bond evaporator plates increases the efficiency of the radiator, reducing power consumption while the roll-bond evaporator plates increase water recovery from airflow from a single set of fans stationed to sequentially urge the airflow through the gaps between the roll-bond evaporator plates and through the heat radiating core of the radiator.

Background of the Invention

Generally, natural freshwater resources are scarce or limited in many areas of the world, including areas such as, for example, deserts and arid lands, due to low precipitation and high salinity of surface and underground water. Shortage in supply of potable water and fresh water is increasing at a vast rate, as deserts expand and overtake fertile land, and as many of the natural ground water resources are being depleted. Furthermore, shifts in patterns of the global climate over time have resulted in a drop in the rate of rainfall in many areas. For example, hunger and starvation is spreading in areas such as, for example, Africa, because of shortage of fresh water to raise domestic animals and crops for food.

Sparse population and scattered population pockets in many areas make the application of water desalination and other water treatment technologies uneconomical due to the low demand and the high cost of water distribution from a central system over a wide stretch of land. For example, such methods of supplying potable water may be inaccessible to remote and/or impoverished areas of the world due to lack of natural resources, wealth, infrastructure and technical expertise. Alternatively, transportation of loads of fresh water is costly and exposes water to contamination en route and during handling and storage. For example, remote areas of the world may lack the necessary transportation infrastructure to allow transportation of potable water to these remote areas.

Accordingly, there is a need for localized production of fresh water to provide water for human drinking, and fresh water for raising animals and for irrigation as well as other human uses, that is reliable, affordable and produces little or no industrial pollution. Additionally, there is a need that the system may be transported and assembled in a number of remote areas inhabited by humans where little or no natural resources are available for providing potable water. The apparatus should be accessible to individuals with limited technical expertise and be available in a range of sizes so that it maybe used in areas that lack abundant space.

In the prior art applicant is aware of the following United States Patents:

United States Patent No. 3,675,442 which issued July 11, 1972 to Swanson discloses a mechanical refrigeration means which intermittently cools a fresh water bath. Water from the bath is conducted to vertically aligned condenser filaments by conduit means. The condenser filaments provide condensing surfaces at a temperature below the dew point of the air. A distributing means directs condensed water, depending on its temperature, to either the bath or from the apparatus as output water.

United States Patent No. 4,812,132 which issued to Nasser et al. on January 8, 1980 describes a tower having a pair of vertically aligned spaced apart air guides wherein the lower air guide includes a cooler which can simultaneously condense moisture from the air and wherein the upper air guide includes a heat dissipater of a refrigeration cycle. Air guides are associated with respective blowers and induce ambient air into the air guide at a location between the blowers. Air is displaced through the air guides into a heat exchanging relationship. The tower may be used to collect drinking water by condensation from the atmosphere.

United States Patent No. 4,255,937 which issued March 17, 1981, to Ehriich discloses a dehumidifier in an upper compartment of a cabinet, and a water collecting tank in a lower compartment of the cabinet. Oppositely perforated walls in the cabinet provide access of moisture carrying air to the dehumidifier. A water feed conduit leads from the dehumidifier to the water collecting tank. The water collecting tank is cooled by a refrigerator.

United States Patent No. 4,433,552 which issued February 28, 1984, to Smith discloses a refrigeration system including an evaporator positioned in an atmospheric duct whereon water vapour is then condensed and collected.

United States Patent No. 4,892,570 which issued to Littrell on January 9, 1990 discloses a water precipitator which provides a water supply over an extended surface area of land in a high temperature region by condensing water on piping chilled by a refrigerant circulating within the piping.

United States Patent Nos. 4,891,952 and 5,033,272 which issued respectively January 9, 1990, and July 23, 1991, to Yoshikawa et al. disclose a refrigerator having a refrigeration cycle which is applied alternatively to first and second coolers so as to provide for quick freezing of the second cooler by the refrigerant pressure being reduced in two steps by corresponding first and second capillary tubes corresponding to the first and second coolers. For quick freezing the coolant is evaporated in the second cooler only, and during usual operation no refrigerant flows into the second cooler whereby the second cooler remains substantially free of frost.

United States Patent No. 4,933,046 which issued June 12, 1990, to May discloses a water purifying system having a condenser made of two superposed sheets of hydrophobic plastic film bonded together to form a steam path through the condenser so that as steam entering the condenser is cooled by ambient air it condenses into water which is then removed from the condenser.

United States Patent Nos. 5,106,512, 5,149,446, and 5,203,989, which issued, respectively, April 21,1992, September 22, 1992, and April 20 1993, to Reidy disclose a water generating device for obtaining potable water from ambient air wherein a condenser is provided for extracting water vapour.

United States Patent Nos. 5,259,203 and 6,755,037 which issued November 9, 1993, and June 29, 2004, respectively, to Engel et al. disclose using a refrigeration system which includes a compressor, evaporator, fan, condenser, and reservoir to extract drinking water from the air.

United States Patent No. 5,469,915 which issued November 28, 1995, to Cesaroni discloses a panel heat exchanger having a plurality of parallel tubes located between two plastic sheets that envelope and conform to the shape of the tubes, wherein the sheets are bonded together between the tubes.

United States Patent No. 5,555,732 which September 17, 1996 to Whiticar discloses a portable dehumidirler wherein a blower fan causes humid air to come into contact with a cold plate causing water vapour to condense from the air. The condensate drips from the cold plate into a trap.

United States Patent Nos. 5,669,221 and 5,845,504 which issued to LeBleu on, respectively, September 23, 1997 and December 8, 1998, disclose a portable, potable-water generator for producing water by condensation of dew from ambient air wherein an enclosed heat absorber cools air to its dew point and collects droplets of condensate into a closed system.

United States Patent Nos. 6,289,689 and 6,779,358 which issued, respectively, September 18, 2001, and August 24, 2004, to Zakryk et al. disclose a water collection machine having an evaporator coil structured to cycle a cold refrigerant liquid therethrough wherein the coil is disposed in line in an air inlet so that moisture condenses on the coil and may be collected in the form of water droplets.

United States Patent No. 6,397,619 which issued to Cheng et al. on June 4, 2002, discloses a dehydrating device which includes an electrode member mounted under the lower end of the assembly. Positive and negative voltage sources are connected to the electrode member and the lower end of the assembly so as to form an electric field therebetween. Water condensed on the assembly is pulled and removed from the surface of the assembly by means of periodical change of the electric field.

United States Patent No. 7,140,425 which issued to Romero-Beltran on November 28, 2006, discloses a plate-tube type heat exchanger having a plate with a plurality of channels running parallel there along and a plurality of tubes housed and secured to the channels thus forming a circuit for circulation of a heating fluid, a cooling fluid or a means of heating.

United States Patent No. 7,269,967 which issued September 18, 2007 to Cole discloses removing excess moisture from the evaporator coils of an air-conditioning system by vibrating the coils, wherein the coils may be vibrated by mechanical or acoustic devices such as solenoid plungers or acoustic transducers.

United States Patent No. 7,272,947 which issued September 25, 2007, to Anderson et al. discloses a water producing system for condensing water from air and for collecting the condensed water in a storage tank. In a duct fluid circuit, an operating fluid dumps heat to a second circuit such as refrigeration cycle and the cooled operating fluid lowers the temperature of a water condensation member.

In my co-pending United States patent applications filed, respectively, September 27, 2004, and December 22, 2004 and published March 30, 2006 under respectively, publication Nos. 20060065001 and 20060065002, I describe a system for producing potable water from the atmosphere wherein the system includes a plurality of panels arranged within an enclosure substantially parallel to each other along a central access, and wherein each of the panels is made of a material on which water condensate from the atmosphere forms in response to a temperature differential between the material and the atmosphere passed through the panels. Cooling fluid cools the panels so as to form water condensate on the surface of the panels. The panels are rotated about the central axis within the enclosure to remove the water condensate from the surfaces of the panels.

Summary of the Invention

In summary, the atmospheric water generator according to the present invention may be characterized as including a refrigeration system including a motor, compressor, radiator, evaporator, and at least one fan, wherein the evaporator includes a spaced apart array of roll-bond evaporators. The radiator and the array of evaporators are adjacent one another and arranged in fluid communication therebetween. The fan or fans cooperate with the radiator and the evaporators to induce an in-flow stream of air from ambient air into and through, firstly, the condenser, and secondly, the radiator. Consequently, the in-flow stream of air is cooled by the evaporator as the in-flow stream passes through the evaporator as a through-flow stream of air. The cooled through-flow stream of air then passes through a heat dissipating section of the radiator so as to optimize functioning of the radiator in the refrigeration system.

Advantageously the roll-bond evaporators are each made of unitary planar aluminium sheet having refrigeration conduits formed therein. They may have a thickness of substantially 1.5mm. In one preferred embodiment all of the evaporators in the array of evaporators are roll-bond evaporators.

Preferably the array of evaporators are spaced apart by a through-flow spacing of substantially between one half inch and one inch. In one embodiment the through-flow spacing is substantially constant. The through-flow spacing form airways extending the length of a first dimension of the array of evaporators corresponding to the direction of the through-flow stream of air. The first dimension may be horizontal. The second dimension of the array of evaporators corresponds to the width of the spacing of the through-flow spacings, and is orthogonal to the first dimension. The through-flow spacings also extend in a third dimension orthogonal to the first and second dimensions. That is, where the first dimension is horizontal and the second dimension is also horizontal the third dimension is vertical, hi a preferred embodiment the airways are sufficiently long along the first dimension so that the through-flow stream of air becomes turbulent.

For one embodiment the airways are also sufficiently long so that airstream boundary layers of the through-flow stream of air form turbulent boundary layers along the airway on opposed facing surfaces of adjacent evaporators in the spaced apart array of evaporators. The second dimension may be sufficiently small so that the turbulent boundary layers on the opposed facing surfaces extend substantially fully across the second dimension.

In a further embodiment the opposed facing surfaces of adjacent evaporators further include turbulent flow trippers to trip laminar flow components and laminar boundary layer components of the through-flow stream of air into downstream turbulent flow and turbulent boundary layer components. For example, the turbulent flow trippers may include protrusions formed on the opposed facing surfaces.

Advantageously, the third dimension extends substantially the full height of the evaporators, and water droplets condensing on the surfaces of the evaporators descend downwardly along the third dimension by force of gravity. A fluid source may be provided so as to project a film of fluid onto the surfaces of the evaporators to urge the droplets into and along their cascading descent. For example, the fluid source may include at least one apertured sprayer mounted at an upper end of the array of evaporators. The fluid may be water, and the apparatus may further comprise a water collector positioned under the array of evaporators. The water collected in the collector may be re-cycled to the water source by a water re-cycler such as a pump. The fluid may also be air, and the apparatus may further comprise a motivator for urging a downward flow of air along the first dimension.

hi one embodiment a fill of elongate strands may be positioned in-between adjacent evaporators in the array of evaporators. The fill may be a mesh of sufficient volume to be partially in contact with, or suspended between, so as to be interleavered between, opposed facing surfaces of the adjacent evaporators. The fill may be a metallic such as aluminium mesh.

Brief Description of the Drawings

Figure 1 is, in right side perspective view, the atmospheric water generator unit according to one embodiment of the present invention.

Figure 2 is, in left side partially exploded perspective view, the water generator of Figure 1.

Figure 2a is in side elevation view, one of the roll-bond evaporators of Figure 2.

Figure 2b is a section view along line A-A in Figure 2a.

Figure 2c is a section view along line B-B in Figure 2a.

Figure 2d is a section view along line C-C in Figure 2a.

Figure 3 is, in right side perspective view, a horizontal cross-section on line 3-3 in Figure 2 illustrating the water generator with the cowlings removed.

Figure 4 is, in plan view, the evaporator, radiator, and fan sections of a second embodiment of the water generator according to present invention.

Figure 5 is the partially cutaway view of Figure 4 with the evaporator plate vibrator and part of the chassis removed.

Figure 6 is, in right side perspective view, the chassis of the water generator according to the present invention.

Figure 7 is, in right side perspective view, the second embodiment of the water generator according to the present invention, with the cowlings removed.

Figure 8 is, in left side perspective view, the water generator of Figure 7.

Figure 9 is, in right side perspective view, the water generator of Figure 7 showing the evaporator unit, the radiator, the fans, a chassis, a vibrator, and a water collection tray.

Figure 10 is an enlarged view of the water generator of Figure 7.

Figure 11 is a further enlarged view of Figure 10 with the cross-bar over the vibrator removed.

Figure 12 is the water generator of Figure 11 with the chassis, cross-members, and vibrator of Figure 11 removed-

Figure 13 is, in perspective view, a pair of roll-bond evaporators sandwiching an aluminium mesh therebetween.

Figure 13a is, and enlarged view with the roll-bond evaporators cutaway, of the aluminium mesh of Figure 13.

Figure 14 is, in elevation view, an alternative embodiment of a roll-bond evaporator according to one aspect of the present invention, wherein the surfaces of the evaporator have sharp-sided scales punched therein.

Figure 14a is an enlarged perspective view of a portion of Figure 14.

Figure 14b is an enlarged view of a portion of Figure 14a.

Figure 15 is, in perspective view, the water condenser section of the water extractor according to the present invention, with a fluid sprayer mounted between the upper ends of the roll-bond evaporators.

Figure 15a is an enlarged view of a portion of Figure 15.

Figure 16 is, in perspective view, the water extractor according to the present invention with a water ionizer mounted to the chassis.

Figure 16a is, in elevation view, one of the water ionizing bars of Figure 16.

Detailed Description of Embodiments of the Invention

In the drawings wherein similar characters of reference denote corresponding parts in each view, atmospheric water generator 10 includes an evaporator unit 12 cooperating with refrigeration components 14 mounted adjacently within rigid chassis 16 and housed within cowlings 18.

One aspect of the present invention is the synergy and increased efficiency gained by the use of only a single set of fans 20 which function both as cooling fans for the refrigeration cycle and also to draw moisture laden air in in-flow direction A through a parallel, spaced-apart array of roll-bond evaporators 22. A single roll-bond evaporator is shown in Figure 2a showing the arrangement in one preferred embodiment of liquid coolant conduits 22a. Conduits 22a may thus in one embodiment be arranged so as to extend vertically along substantially the entire height dimension of the roll-bond evaporator 20. In one embodiment, not intending to limiting, as illustrated by the downward arrows in Figure 2a, the liquid refrigerant enters conduits 22a from the top of roll-bond evaporator 20 and as illustrated by the upward arrows, also exit from the top of roll-bond evaporator 2O.The in-flow pipes (not shown) and out-flow pipes (not shown) transfer liquid coolant to each conduit 22a in each roll-bond evaporator 20. The in-flow and out-flow pipes may for example be mounted in the relatively easy to access space directly above chassis 16 so as to be contained between the top of the array of roll-bond evaporators 22 and the interior of the top of cowlings 18. As would be known to one skilled in the art the array of pipes are in fluid communication with corresponding in-flow and out-flow manifolds (not shown) which are themselves connected by further conduits to compressor 14a.

Advantageously, the vertical array of fans 20 may in one embodiment not intending to be limiting include three five-bladed fans. Inducted airflow in direction A is drawn horizontally along a first dimension in direction B through the array of roll-bond evaporators 22 substantially along the entire vertical height of the array. The compressor and other corresponding conventional refrigeration components, cool the liquid refrigerant, which is then pumped through conduits 22a simultaneously in all of the roll-bond evaporators 22 so that air drawn in the spacing have a second dimensional or width between the evaporators is cooled so as to condense water droplets onto the exterior surfaces 22b of the evaporators without freezing. The resulting cooled through-flow air is then drawn through fans 20 so as to exit in direction C. The cooled through-flow air is also forced through the core of radiator 14b of refrigeration assembly 14 so that the through-flow of already cooled air from the roll-bond evaporators provides for increased cooling of radiator 14b and thus more efficient operation of the refrigeration cycle. Increased efficiency has also been gained by using more than one radiator 14b, for example two radiators 14b, stacked vertically so as to lie in the same plane facing and parallel to the vertically stacked set of fans. Thus in the illustrated embodiment, the set of three fans would have for example two separate radiators 14b, one on top of the other. In applicant's experience the use of stacked radiators reduced the power consumption by the compressor.

In applicant's experience, this increased cooling of the radiator has resulted in reducing the required power consumption of compressor 14a thereby reducing the- power consumption of the apparatus overall. The present invention thus differs in one respect from the prior art in that whereas in the prior art separate fans are provided to draw air through radiator-style water-condenser units and separate fans are provided for the condenser/radiator of the refrigeration system, in the present invention applicant realized space and energy savings by housing the refrigeration assembly and the water condensing assembly adjacent to one another so as to share the operation of a single fan or set of fans, thereby resulting in increased synergistic efficiency of the system.

Moisture laden air entering in direction A into the planar spaces 22c interleaved between roll-bond evaporators 22 passes through the spaces in direction B, and exits from spaces 22c as cooled air the cooled air the enters the heated air spaces within the core of radiator 14c wherein the air is warmed as the core is cooled. The air passes from radiator 14c as hot air exiting fans 20 in direction C. Again, it is significant to note that fans 20 draw air in the through-flow in horizontal direction B across substantially the entire height of evaporators 22, Le. along a third dimension of the apparatus which is for example approximately 5 feet high in one commercial embodiment.

Thus for the embodiment illustrated, which is not intended to be limiting, chassis 16 may have approximate dimensions of two meters (91 inches) in height, 1.7 meters (77 inches) in width, 0.9 (41 inches) in depth thus making for a relatively compact water generator. As may be seen, chassis 16 thus provides a rigid frame supporting the refrigeration components including the parallel array of roll-bond evaporators 22 held suspended substantially vertically, and the substantially vertical array of fans mounted adjacent the evaporators.

Sheet-like roll bond evaporators 22 are mounted suspended within chassis 16 parallel to one another. Without intending to be limiting, in the embodiment of Figures 2-4 horizontal rotatable shafts 24 are rotatably mounted to corresponding vertical uprights 16a of chassis 16. One rotatable shaft 24 is provided for each corner of the array of roll-bond evaporators 22. A racheting winch mechanism 26 may be provided for releasable uni¬ directional rotation of shafts 24 so that they may be simultaneously or individually rotated. Rotating shafts 24 in one direction winds a length of flexible line 28 onto shaft 24. Flexible line 28 is secured to each corner of each roll-bond evaporator 22 through corresponding eyelets 22a.

Each ratchet and pawl mechanism 26 includes a toothed ratchet. The tensioning of lines 28 is controlled by rotation of the ratchet and the operation of a ratchet-engaging pawl.

Mechanism 26 together comprise an intermittent rotation controller wherein motion from a handle or for example motorized device is converted into intermittent circular motion having a constant rotational direction. Mechanism 26 may be released so as to unwind shafts 24 thereby releasing tension on lines 28 by the release of the pawl from the teeth of the ratchet.

In the embodiment of Figure 5, 7, and 9-12, instead of using flexible line 28 wound onto shafts 24 to suspend and tension roll-bond evaporators 22, springs 36 are mounted through eyelets 38 in the corners of evaporators 22 so as to tension the evaporators between cross-members 16c of chassis 16.

Chassis 16 may be mounted on casters 30 or other wheeled or tracked or skid assemblies to allow for ease of positioning.

Roll-bond evaporators are known in the prior art for use in for example domestic refrigerators. In such refrigerators the sheet of the roll-bond evaporator is typically bent into a U-shape to form a cooling box. Thus the conduits formed in conventional roll-bond evaporators are directed in such a way to allow for bending of the sheet along where the corners of the box are to be formed. Roll-bond evaporators are formed by bonding together two thin sheets of aluminium so that the two sheets become a single unitary sheet of aluminium. The conduits are formed by masking the desired conduit paths before the two thin sheets are formed together so that, once the two sheets are formed into a single unitary sheet the masked path remains thereby separating the two sheets along the length of the masking. The remaining separated sheets along the masked path are then further separated so as to define the elongate cavities of the continuous conduits through which refrigerant such as Freon™ may be passed. Roll-bond evaporators are thus very efficient as they only present a thin aluminium layer between the refrigerant within the conduits and the air passing over the outer surface of the roll-bond evaporators.

In the present invention, the roll-bond evaporators are, at least in the illustrated embodiment which is not intended to be limiting, used in a planar form. Thus the conduits may be advantageously run the entire length of the sheets without having to worry about where the sheet will be bent.

Two further factors in maximizing the production of water by atmospheric water extraction are also dealt with in the present invention; namely, maximizing the number of water droplets and consequently the volume of water condensing on the surfaces of the roll-bond evaporators, and, secondly, maximizing the rate of removal and completeness of removal of the water droplets once condensed onto the surfaces of the roll-bond evaporators.

With respect to the former factor, applicant determined that if the spacing between the roll-bond evaporators is too large then a large percentage of the through-flow of air in direction B will likely never come into contact with the surface of a roll-bond evaporator and instead will continue straight through and into the core of the radiator, from there passing out in direction C through the fans. Consequently, applicant adjusted the spacing between the evaporators so as to be in the range between approximately one half inch and one inch. In this fashion applicant attempted to better mix the air-flow to increase contact of moist air with the surfaces of the evaporators which had been cooled below the dew point. Although not wishing to be bound by any particular theory of physical operation of the mixing, applicant sought to trigger turbulent mixing of the laminar air-flow B1 as it travelled along the spacing between the roll-bond evaporators. Applicant thought that turbulent rather than laminar boundary layers in the relatively long narrow planar passages between the roll-bond evaporators where the air-flow was moving at relatively low velocity, approximately in the order of 3000-3500 CFM per fan, allowed the build-up of the boundary layer and in particular a turbulent boundary layer until substantially all of the flow in the spacing between the roll-bond evaporators was turbulent flow B2. This turbulently mixed incoming moisture laden air-flow so as to expose as much as possible of the volume of air-flow to the chilled surfaces of the roll-bond evaporators. Thus in the present invention and in particular in the illustrated embodiment which is not intended to be limiting but rather merely illustrative, each of the roll-bond evaporators has a dimension of approximately 2 V2 feet wide by approximately 5-6 feet high. The array of roll-bond evaporators, again without intending to be limiting, may contain as illustrated at least nineteen roll-bond evaporators, although fewer will work but with reduced efficiency, each having a spacing therebetween of in the order of A inch to 1 inch spacing. In one embodiment, the array of roll-bond evaporators when viewed in plan view, that is, from above when seen in horizontal section, forms an array which is approximately square in dimension for example approximately 2'A feet square.

Another factor in the operation of the atmospheric water generator according to the present invention is controlling the frosting of the roll-bond evaporators so as to minimize and advantageously avoid, the build-up of frost or ice on the surfaces of the roll-bond evaporators. One method by which this is accomplished is running the refrigeration assembly at a lower capacity, for example, by reducing the available power from the motor. Thus although likely not sufficient for refrigerating roll-bond evaporators for use in for example a refrigerator for keeping food products stored at a safe temperature slightly above freezing, applicant has found that providing a motor which only delivers approximately 1/16th of a horsepower per roll-bond evaporator minimizes the formation of frost or ice so as to maximize the formation of moisture droplets on the surfaces of the roll-bond evaporators. In applicant's experience, providing 1/16th of a horsepower per roll-bond evaporator reduces the power requirement, as compared to a conventional refrigeration use of the roll-bond evaporator by approximately one half. hi operation during experiments on a prototype applicant has observed that the atmospheric water generator may consume approximately 6.5 kilowatts (28 amps at 20 volts) using a 6 horsepower motor to generate approximately 20 litres of captured water per hour during an experiment conducted in Lima, Peru, on a day during which the atmospheric humidity was approximately 68%, at 30 degrees Celsius.

hi a further experiment to increase the efficiency of condensing water droplets onto the chilled surfaces within the water condensing section 12, applicant inserted sheets of aluminium mesh 40 so as to substantially fill the volume in the spacing between the roll-bond evaporators. This experiment resulted in an increase in approximately 24 litres per day of recovered water. Although not wishing to be limited to any particular theory of operation, applicant believes that the aluminium mesh assists in increasing the turbulence of the airflow of the through-flow air moving in direction B in the spacing between the roll-bond evaporators and also provides substantially chilled surfaces in the mesh because the roll-bond evaporators are in contact with the aluminium mesh and have thus also chilled the aluminium mesh, at least in proximity to the roll-bond evaporators. This may result in a temperature gradient with slightly increasing temperature in the aluminium mesh further away from the contact with the roll-bond evaporator surface. Although it might have been thought placing such obstacles into the airflow path might decrease the efficiency by choking the air-flow, therefore by reducing the volumetric quantity of airflow moving through the array of roll-bond evaporators and possibly also adversely affecting the operation of the radiator in the refrigeration system so as to decrease the efficiency of the refrigerator and therefore increase the power consumption, applicant did not notice any substantial increase in the amperage required by the fans to maintain an approximately constant airflow rate in the refrigeration system, instead, as noted above, realizing an increased volumetric recovery of water into tray 32 underneath the array of roll-bond evaporators.

In keeping with applicants experience in optimizing the volumetric recovery of water by the use of turbulence in the through-flow in direction B of the moisture laden air arriving in direction A, in a further alternative embodiment, the surfaces 22b of roll-bond evaporators 22 may be formed with protrusions, or "scales" 42 or other flow-tripping devices such as would be known to those skilled in the art of fluid mechanics, which would rapidly trip a laminar flow into a turbulent one. Applicant has also noticed that water condensation in the form of droplets more readily form where sharp surfaces or sharp intersections of surfaces are formed. Thus, advantageously the flow-tripping devices might beneficially be in the shape of sharp edged scales or breaks in the otherwise smooth surfaces 22b of the roll-bond evaporators

22. The edges of the aluminium mesh would also provide relatively sharp edges along the aluminium threads or strips forming the mesh.

Addressing now the second factor in optimizing the volumetric recovery of water from the atmospheric water generator according to the present invention; namely, optimizing the method of removal of water drops from the surfaces of the roll-bond evaporators, in addition to merely relying on gravity to disrupt the surface tension holding a water droplet adhered to the side of a roll-bond evaporator, applicant has devised several means for accomplishing improved detachment of the water droplets from the surfaces of the roll-bond evaporators. Firstly, the roll-bond evaporators themselves are not coated with any paint or like finish but rather are coated with Teflon™ or like low surface friction coatings or polymers. Secondly, or alternatively, the water droplets may be ionized as better described below. Lastly, mechanical means may be provided to assist for example by the use of a mechanical resilient wiper (not shown) being translated relative to, while in contact with, the surfaces of the roll-bond evaporators, or for example the use of a mechanical shaker as better described below to vibrate each of the roll-bond evaporators in the array of roll-bond evaporators, or the use of a water spray recycling water from tray 32 and sprayed by spray-bars 46 via apertures 46a onto the surfaces 22b of the roll-bond evaporators 22 so as to provide wetted surfaces to which the water droplets will only adhere with reduced viscosity, or alternately the use of jets of air from aperture 46a for example directed downwardly onto the surfaces of the roll-bond evaporators from a linearly perforated s such as may be used to spray water onto the roll-bond evaporators so as to wet the surfaces. In the case of spraying air, the air spray provides a downwardly moving boundary layer airflow comingling with the through-flow of air travelling in direction B in the spacing between the roll-bond evaporators. Advantageously the spray-bars 46 are provided in parallel spaced apart array interleaved between the upper ends of evaporators 22 so that opposed facing arrays of apertures 46a formed an opposite sides of spray-bars 46 spray both sides of each evaporator 22. Spray-bars 46 may be supplied by a manifold 46b which itself is pressurized by pump 48 via feed-line 50.

In yet a further embodiment (not shown), the roll-bond evaporators may be replaced with cooling pipes embedded in a large volume of aluminium mesh, for example sufficient volume so as to fill the inside of chassis 16 encasing water condenser 12, where the cooling pipes may be of a serpentine shape through the volume of aluminium mesh so as to attempt to equally chill the aluminium mesh. Fans 20 thus draw air in direction A into the pores of the mesh and the through-flow then diffuses its way through the porous mesh from the in-flow side to the out-flow side from which the airflow, as before, flows through the core of radiator 14b and then through fans 20 so as to be expelled in direction C.

In a further embodiment (not shown), instead of the use of aluminium mesh, a bristled member, or a plurality of bristled members having bristles of for example aluminium filaments or spikes or needles, are mounted in the spacing between the roll-bond evaporators. The bristled members are advantageously chilled for example by reason of being in thermal contact with roll-bond evaporators 22 or for example by reason of chilled pipes being run in the spacing between the roll-bond evaporators, the bristles being mounted to the chilled pipes.

In yet a further embodiment, additional fans 20 may be added to extract a larger volume of air through the evaporators of the water condenser section 12 at the coldest end of the roll-bond evaporator plates, typically, at the end of the plates adjacent the in-flow of the refrigerant.

In one embodiment, a perforated plate 44 is mounted across the inlet side of the array of roll-bond evaporators 22, for example mounted in the inlet opening to the housing formed by cowlings 18, so that incoming air in direction A has to pass through the perforations in the plate. In applicant's experience, the use of such a perforated plate 44 may drop the air temperature of the incoming flow in direction A while the humidity in the air remains constant. Thus, the use of such a perforated plate mechanically lowers the air temperature thereby better matching the temperature of the incoming airflow to that of the chilled surfaces 22b of roll-bond evaporators 22. In applicant's experience the closer matching of temperatures in this manner increases production volume of recovered water per the amount of power used to generate the water.

As described above, one of the mechanical methods for breaking the adherence of the water droplets to the surfaces 22b of roll-bond evaporators 22 is to mechanically shake the array of roll-bond evaporators. In the illustrated embodiment which is not intended to be limiting, a vibrator 34 is mounted on plates 34a, themselves mounted to cross-members 16d, so as to be centered above the array of roll-bond evaporators on a cross bar 16b. Thus vibration of cross bar 16b by the operation of vibrator 34, shakes chassis 16 thereby transmitting the vibration via shafts 24 or springs 36 (or other suspension means) to the corners of the roll-bond evaporators 22. Vibrator 34 may in one embodiment be an electrically driven device, for example a conductive wire winding through which when a current is pulsed the induced electric fields operate on an offset metallic object (not shown) so as to vibrate the metallic object within the housing of the vibrator. Other means for inducing a vibration in chassis 16 would be well known to those skilled in the art.

With respect to the above mentioned ionizing method, to decrease the adherence of water droplets to the surfaces of the roll-bond evaporators applicant has determined that pulsing electricity in the approximately 15 kilovolt range at a low amperage, for example as would be obtained by running 12 volts through an inverter as from an automobile, and running the pulse electricity through pointed electrodes 52 on internally-wired conduit 54, or through the above mentioned perforated plate 44 for example mounted just upstream and adjacent the in-flow side of the array of roll-bond evaporators, decreases the droplet adherence to surfaces 22b. Alternatively, pulsing the electricity through a screen mounted between an air filter and chassis 16, or through perforated plate 44 using a pulse generator which feeds for example in the range of 15,000 kilovolts which might be obtained from an automobile coil into the metal of the screen, or a mesh, or the plate, may increase the droplet flow rate down surfaces 22b. The ionizing in applicant's experience so as to oxygenates the water droplets as they are borne therethrough in the moisture laden airflow. In applicant's opinion, and to which applicant does not wish to be bound, the water droplets become negatively charged thereby attracting the droplets to the grounded surfaces of the roll-bond evaporators. In applicant's experience, the result is an oxygenated supply of water scavenged from the incoming airflow and which provides the resulting water with a light-blue appearance. The light-blue water provides an aesthetically appealing look to the water which may then simply be bottled and sold to the consuming public who will perceive the difference between ordinary tap water and the oxygenated water for at least the reason of the difference in color as between the two.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

WHAT IS CLAIMED IS:

1. An atmospheric water generator comprising:

a refrigeration system including a motor, compressor, radiator, evaporator, and at least one fan,

wherein said radiator and said evaporator are adjacent one another and arranged in fluid communication therebetween, and wherein said at least one fan cooperates with said radiator and said evaporator to induce an in-flow stream of air from ambient air into and through, firstly, said condenser, and secondly, said radiator, wherein said in-flow stream of air is cooled by said evaporator as said in-flow stream passes through said evaporator as a cooled through-flow stream of air, and wherein said cooled through-flow stream of air then passes through a heated dissipating section of said radiator so as to optimize functioning of said radiator in said refrigeration system,

and wherein said evaporator is a spaced apart array of evaporators.

2. The water generator of claim 1 wherein the evaporators in said array of evaporators include roll-bond evaporators.

3. The water generators of claim 2 wherein said roll-bond evaporators are unitary aluminium sheet having refrigeration conduits formed therein.

4. The water generator of claim 3 wherein said roll-bond evaporators have a thickness of substantially 1.5mm.

5. The water generator of claim 2 wherein all of said evaporators in said array of evaporators are roll-bond evaporators.

6. The water generator of claim 2 wherein said evaporators in said array are substantially planar.

7. The water generator of claim 6 wherein said array of evaporators are spaced apart by a through-flow spacing of substantially between one half inch and one inch.

8. The water generator of claim 6 wherein said array of evaporators are spaced apart by substantially constant through-flow spacing

9. The water generator of claim 1 wherein said array of evaporators are spaced apart by through-flow spacings, and wherein said through-flow spacing form airways extending the length of a first dimension of said array of evaporators corresponding to the direction of said through-flow stream of air, and wherein a second dimension of said array of evaporators corresponds to the width of the spacing of said through-flow spacings, orthogonal to said first dimension, and wherein said through-flow spacings also extend in a third dimension orthogonal to said first and second dimensions, and wherein said airways are sufficiently long along said first dimension so that said through-flow stream of air becomes turbulent

10. The water generator of claim 9 wherein said airways are also sufficiently long so that airstream boundary layers of said through-flow stream of air forms turbulent boundary layers along said airway on opposed facing surfaces of adjacent evaporators in said spaced apart array of evaporators.

11. The water generator of claim 10 wherein said second dimension is sufficiently small so that said turbulent boundary layers on said opposed facing surfaces extend substantially fully across said second dimension.

12. The water generator of claim 11 wherein said evaporators are planar.

13. The water generator of claim 9 wherein said opposed facing surfaces of said adjacent evaporators further comprise turbulent flow trippers to trip laminar flow components and laminar boundary layer components of said through-flow stream of air into downstream turbulent flow and turbulent boundary layer components.

14. The water generator of claim 13 wherein said turbulent flow trippers include protrusions formed on said opposed facing surfaces.

15. The water generator of claim 14 wherein said evaporators are planar.

16. The water generator of claim 15 wherein said evaporators are mounted substantially vertically, wherein said second dimension is substantially horizontal.

17. The water evaporator of claim 16 wherein said first dimension is substantially horizontal.

18. The water generator of claim 17 wherein a third dimension is substantially vertical and extends substantially the full height of said evaporators, and wherein water droplets condensing on said surfaces of said evaporators descend downwardly along said third dimension by force of gravity.

19. The water generator of claim 11 further comprising a fluid source providing at least a film of said fluid onto said surfaces of said evaporators to urge said droplets into and along said descent.

20. The water generator of claim 19 wherein said fluid source includes at least one apertured sprayer mounted at an upper end of said array of evaporators.

21. The water generator of claim 20 wherein said fluid is water, and further comprising a water collector positioned under said array of condensers, and wherein water collected in said collector is recycled to said water source by a water re-cycler.

22. The water generator of claim 21 wherein said re-cycler is a pump.

23. The water generator of claim 20 wherein said fluid is air, and further comprising a motivator for urging a downward flow of air along said first dimension.

24. The water generator of claims 1-23 further comprising a fill of elongate strands positioned in-between adjacent evaporators in said array of evaporators.

25. The water generator of claim 24 wherein said fill is a mesh of sufficient volume to be in contact with, and interleavered between, opposed facing surfaces of said adjacent evaporators.

26. The water generator of claim 25 wherein said fill is an aluminium mesh.

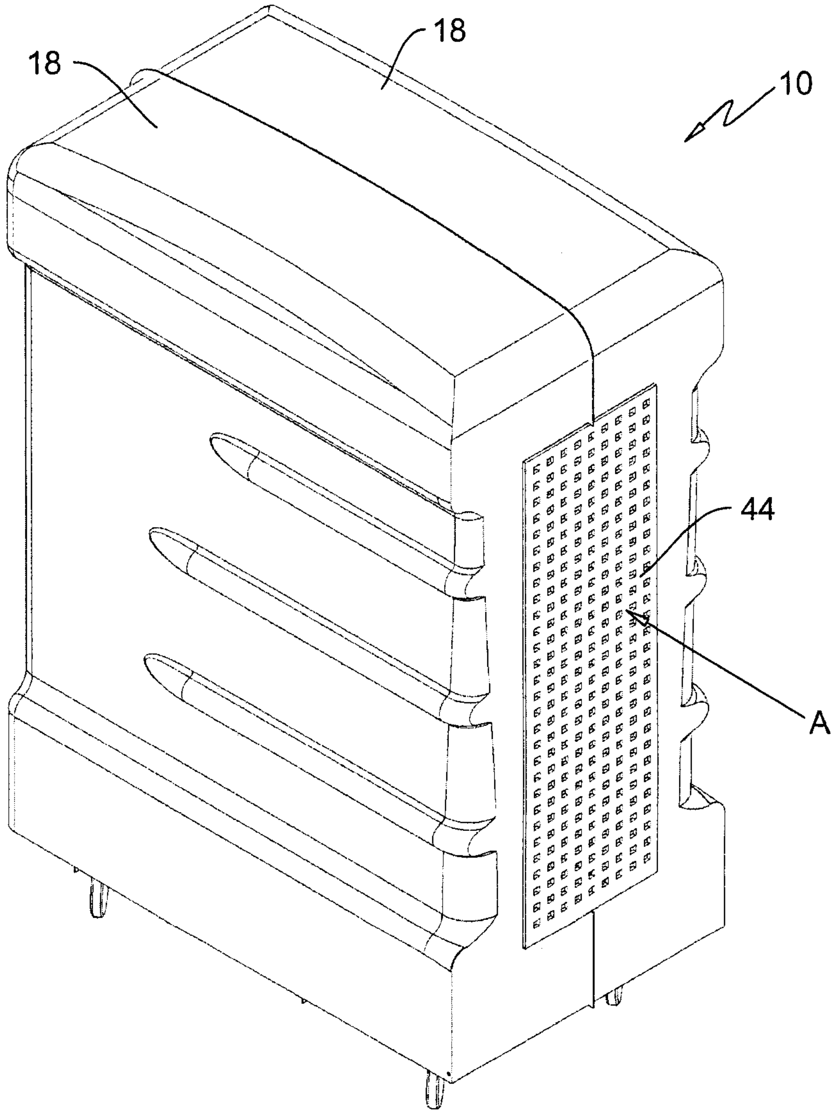
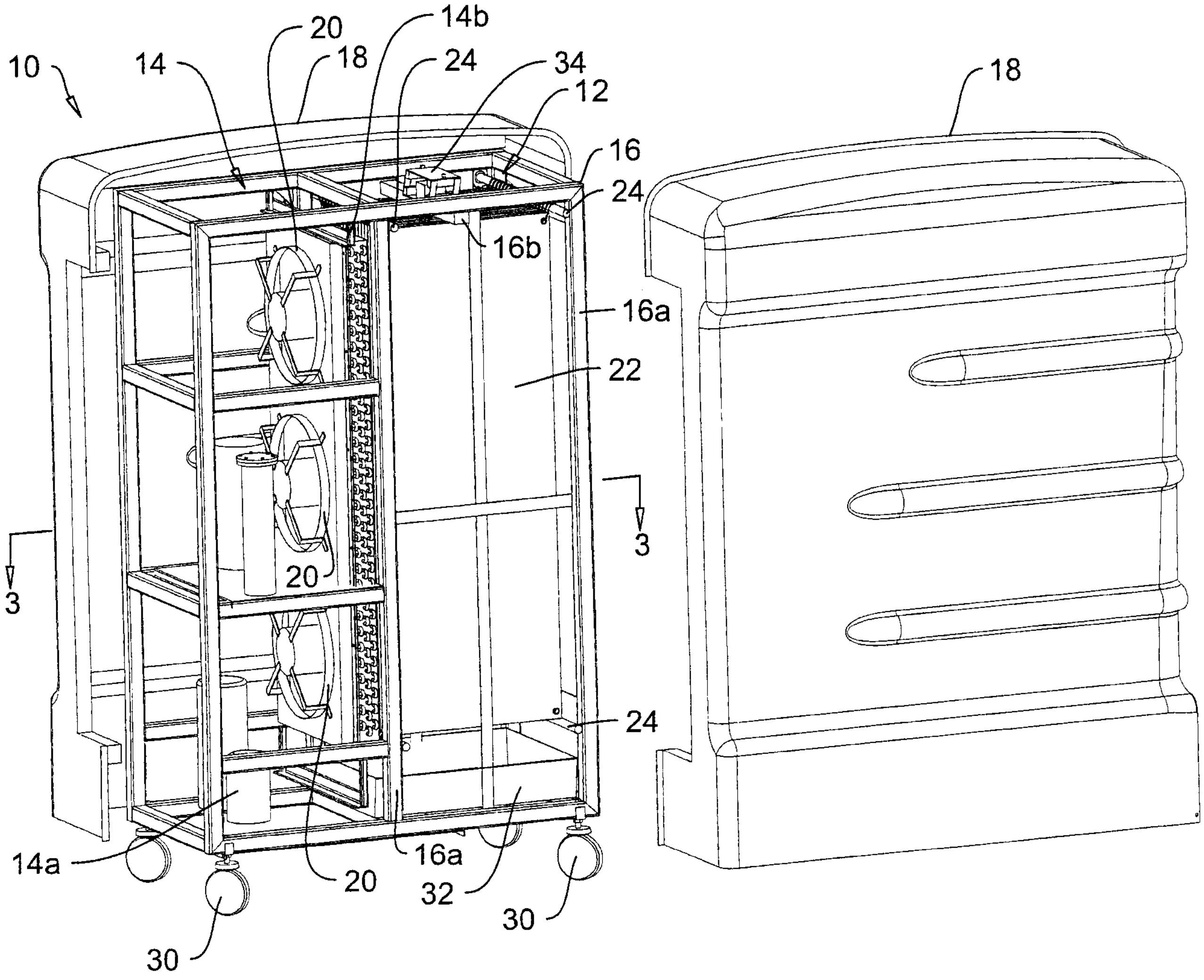


FIG 1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20
18
14b
24
34
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16
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16b
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16a
32
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30
18

FIG 2

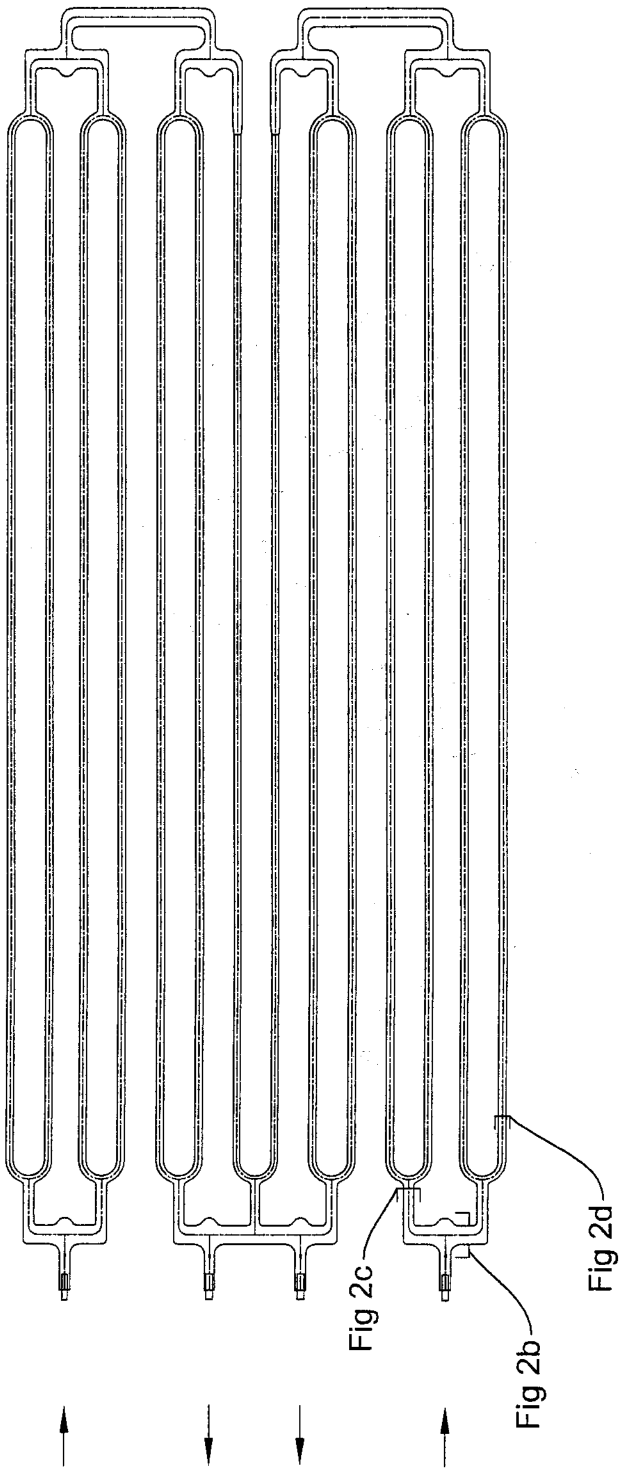


FIG 2a

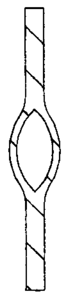


FIG 2d

FIG 2c

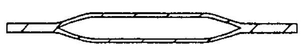
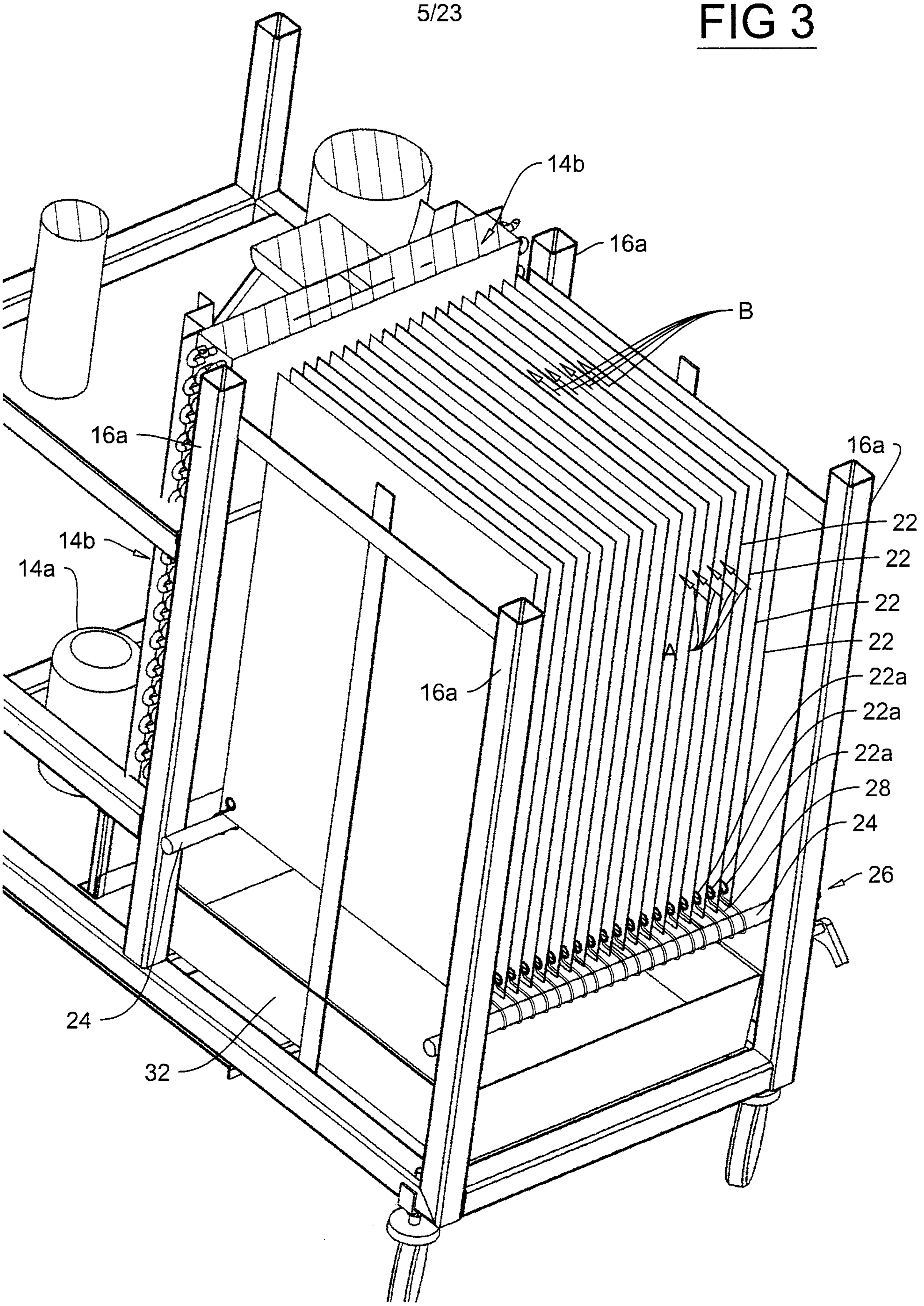


FIG 2b

FIG 3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B
16a
16a
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26
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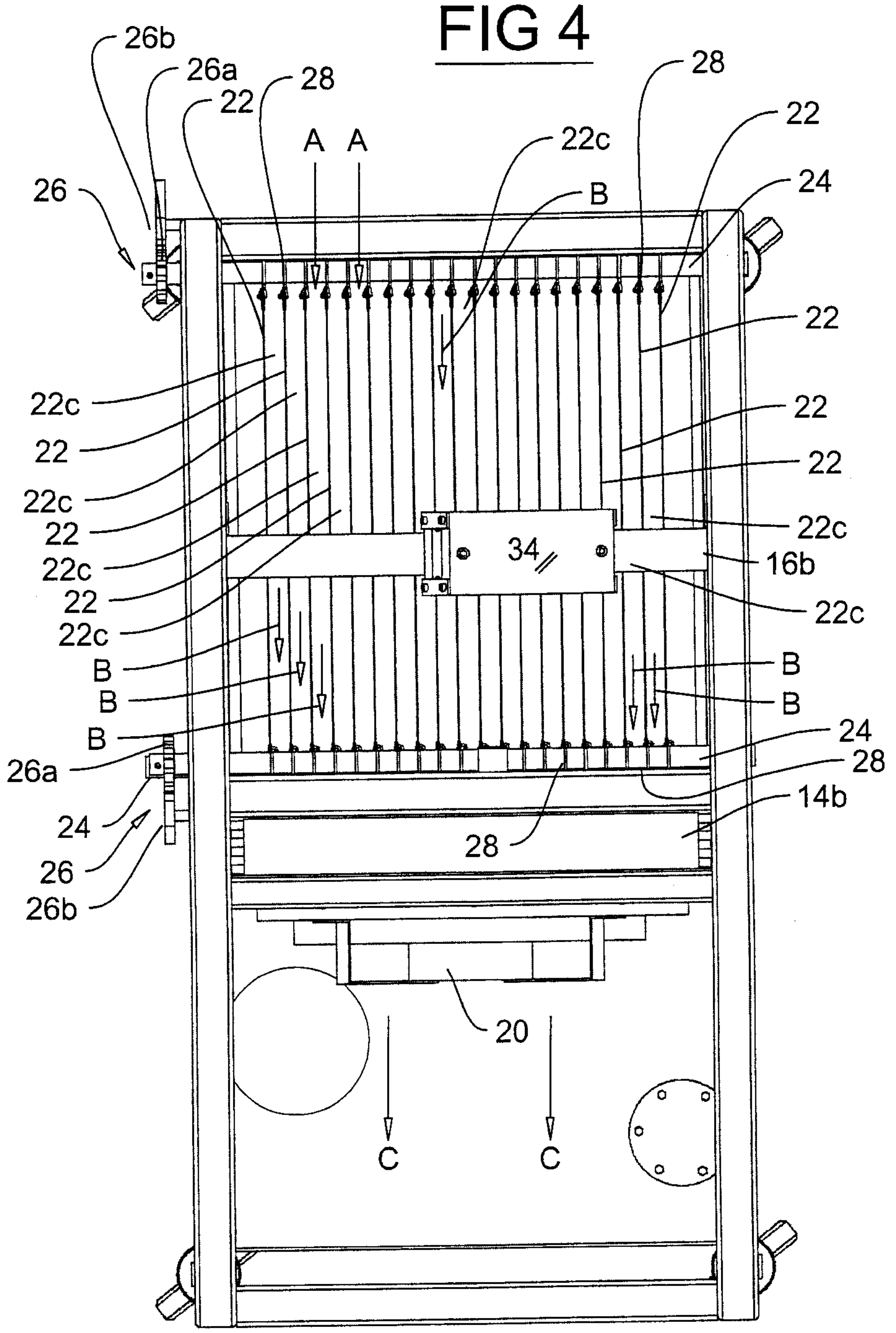
32

FIG 4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22c
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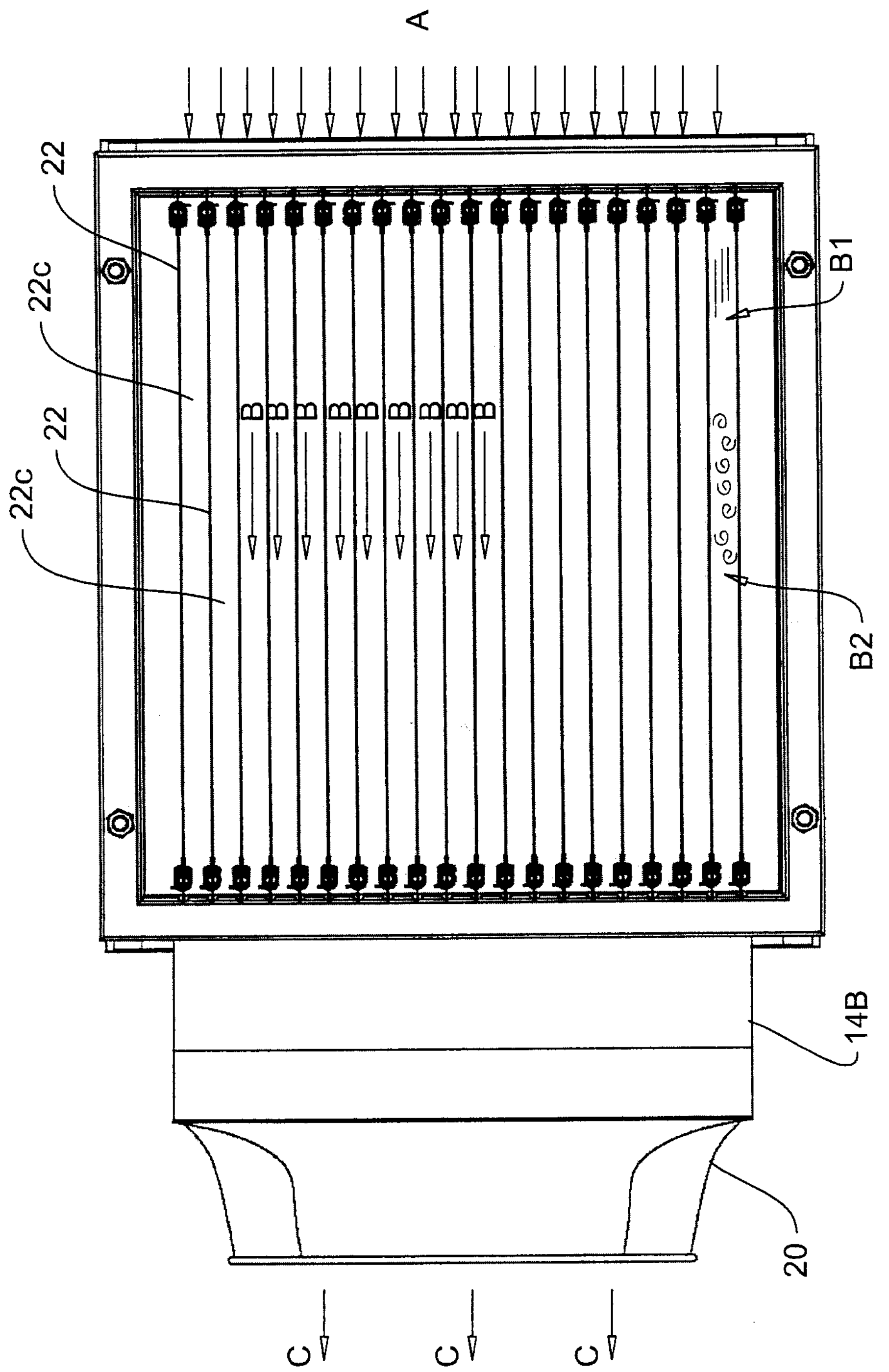


FIG 5

FIG 6

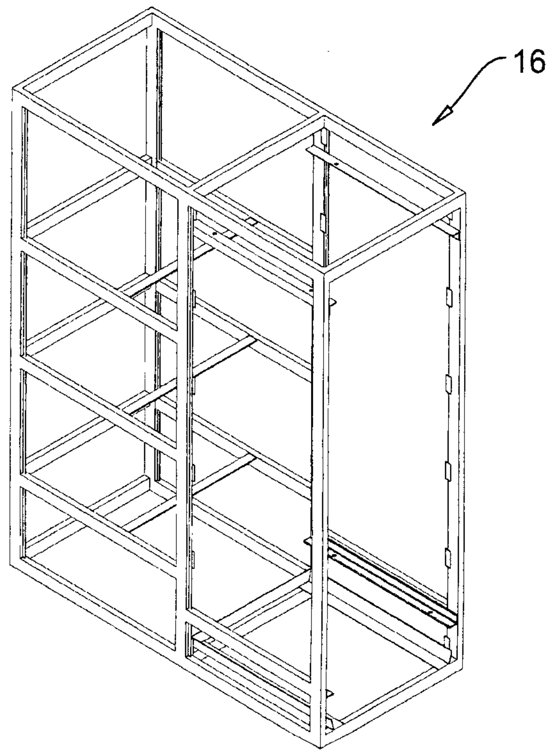
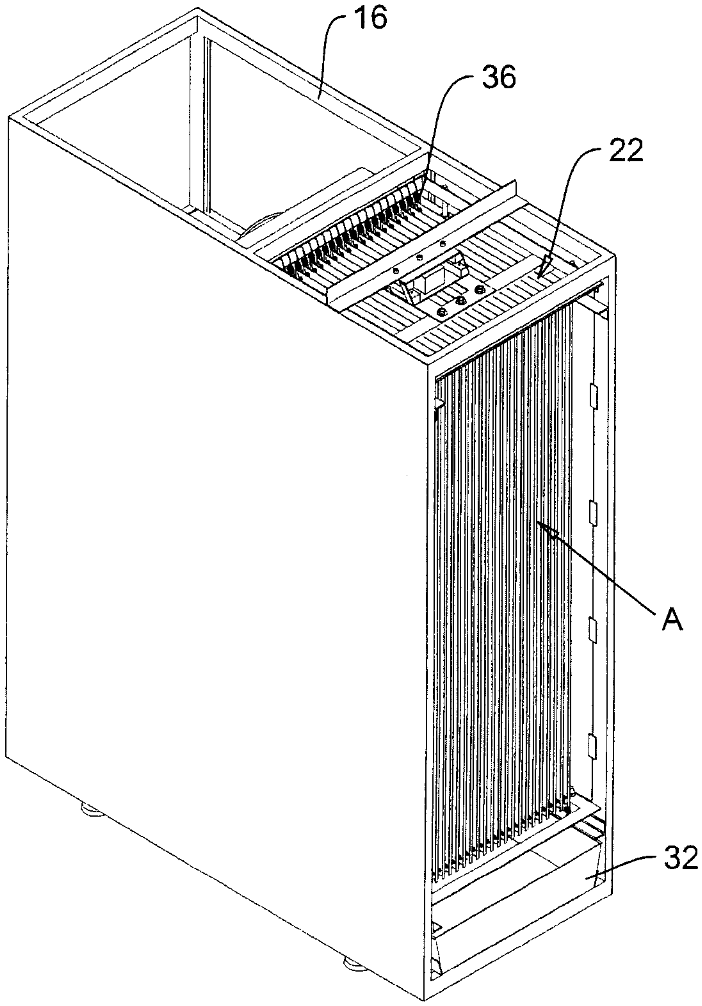


FIG 7



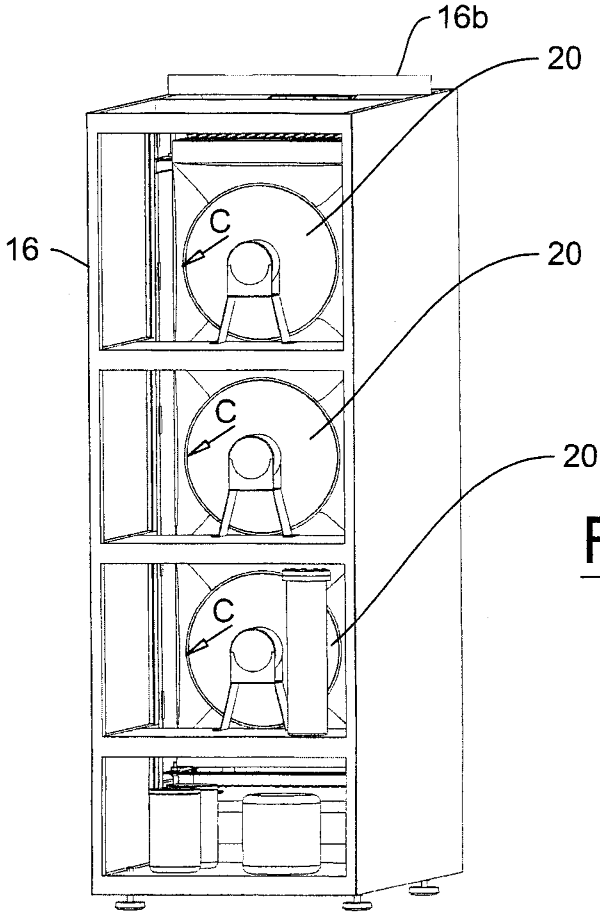


FIG 8

FIG 9

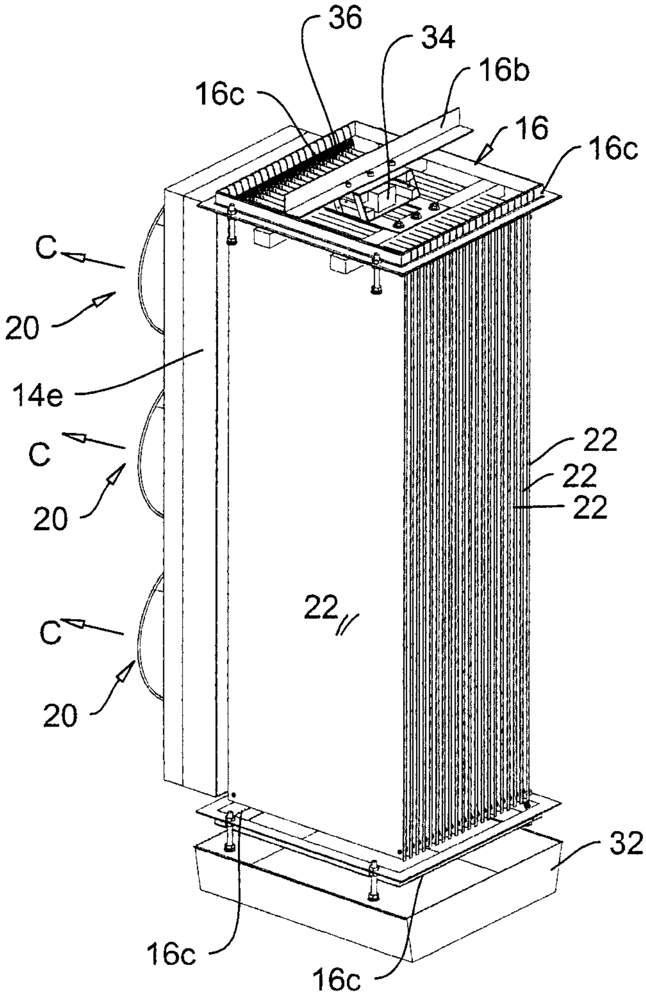


FIG 10

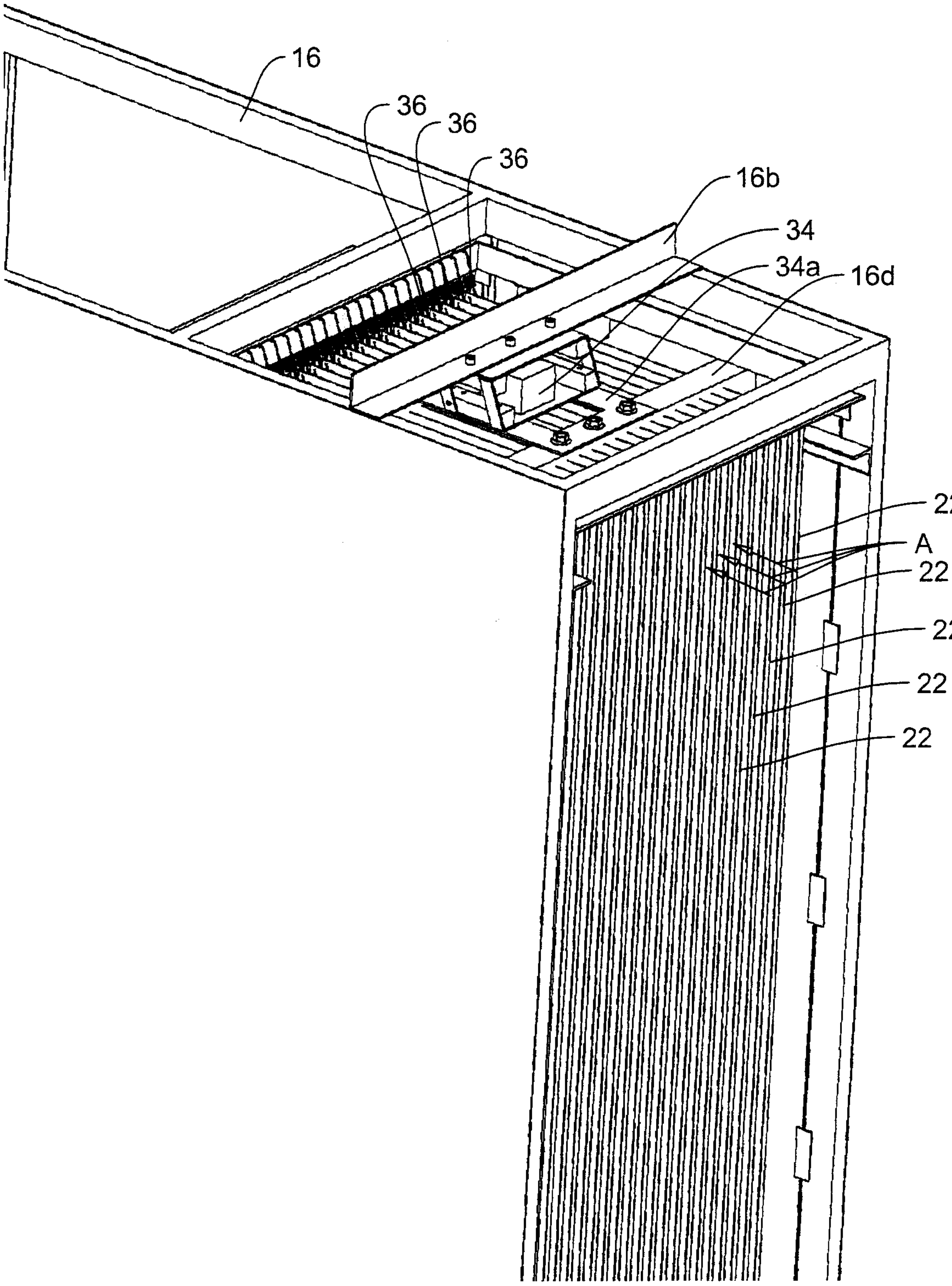


FIG 11

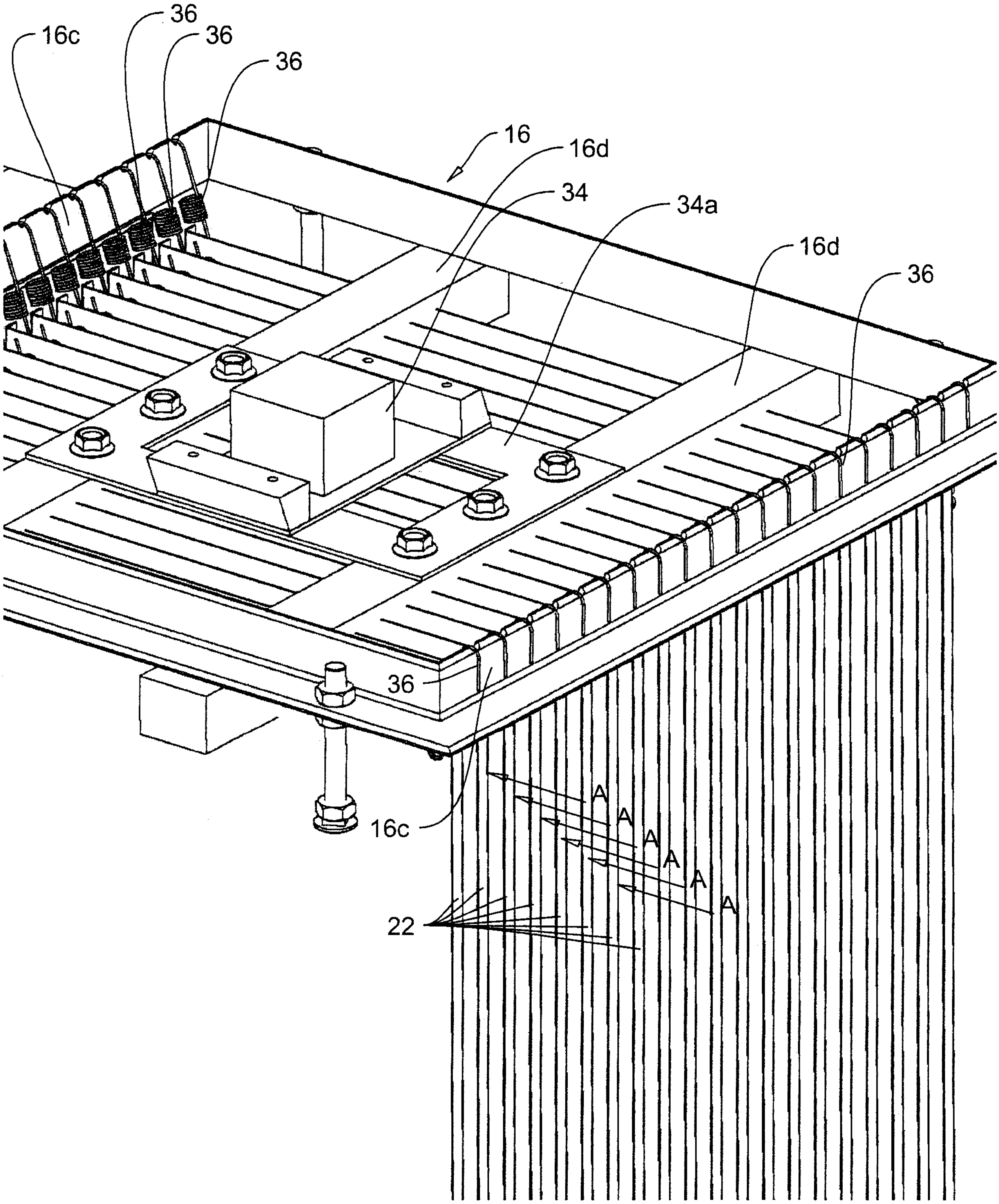
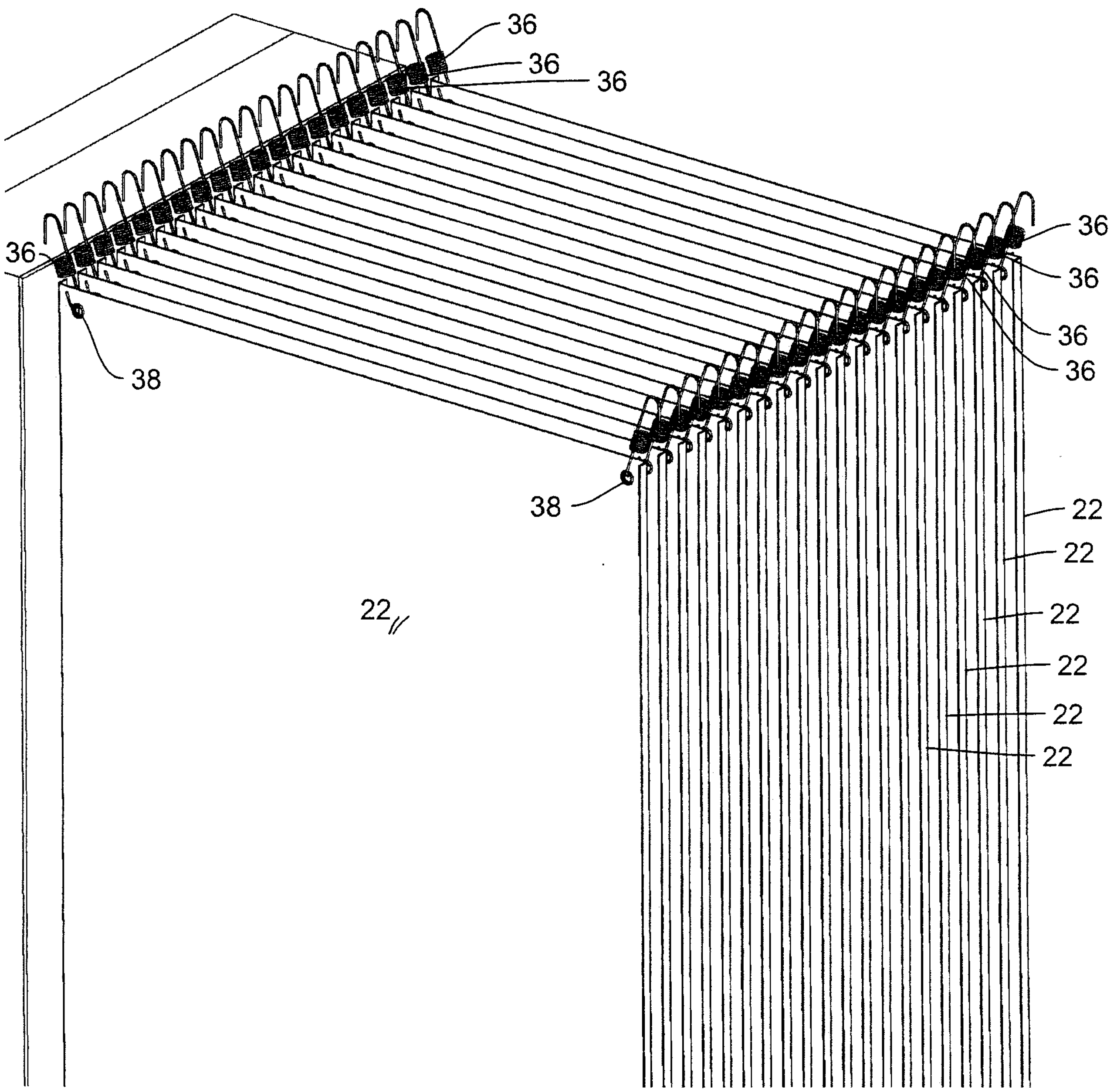


FIG 12



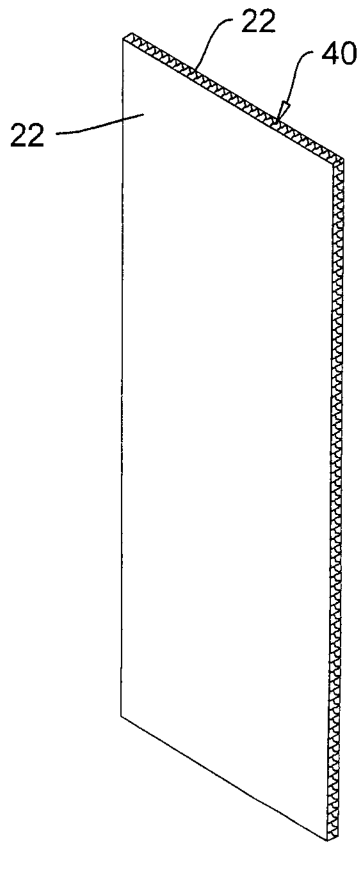


FIG 13

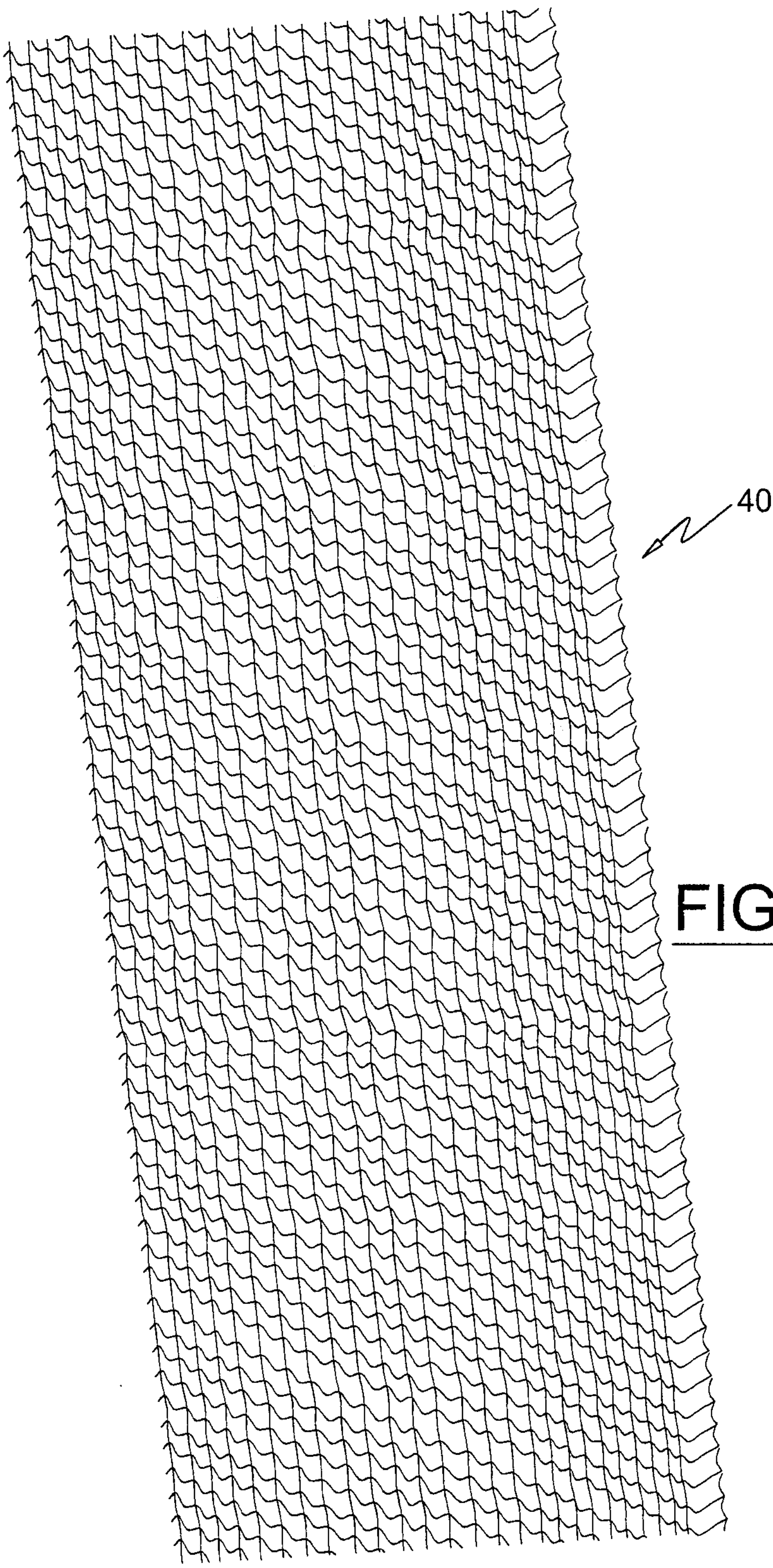


FIG 13a

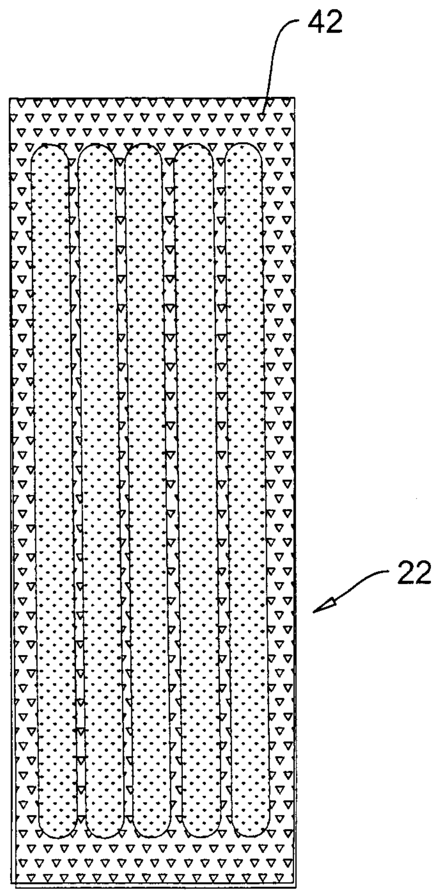


FIG 14

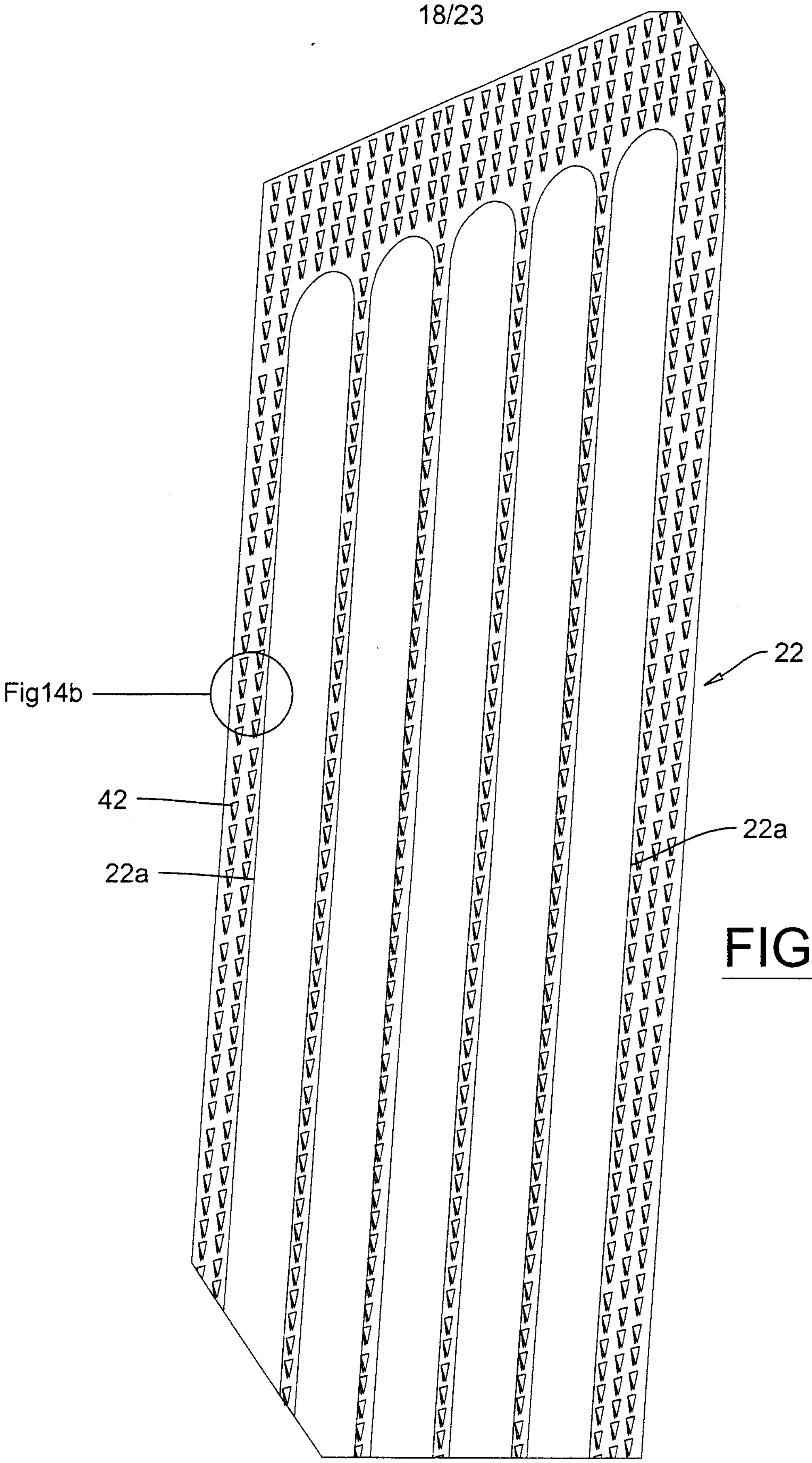


FIG 14a

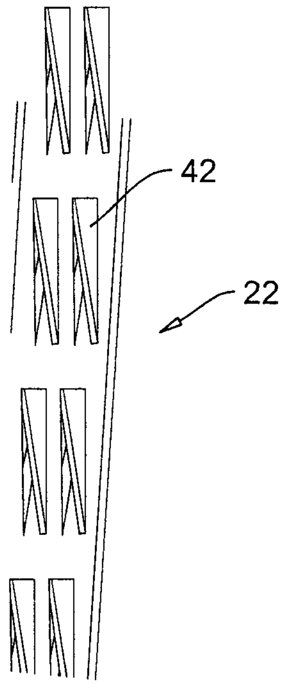


FIG 14b

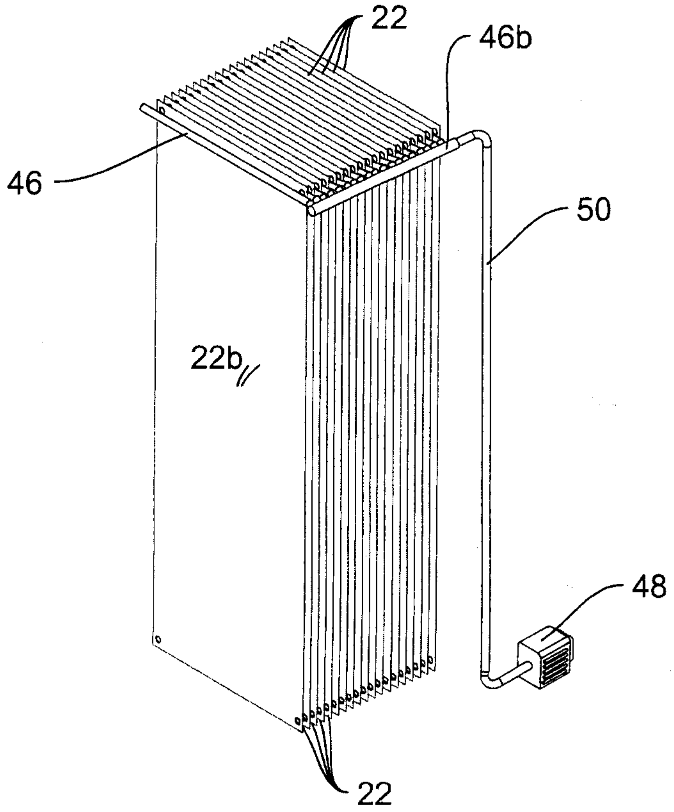


FIG 15

FIG 15a

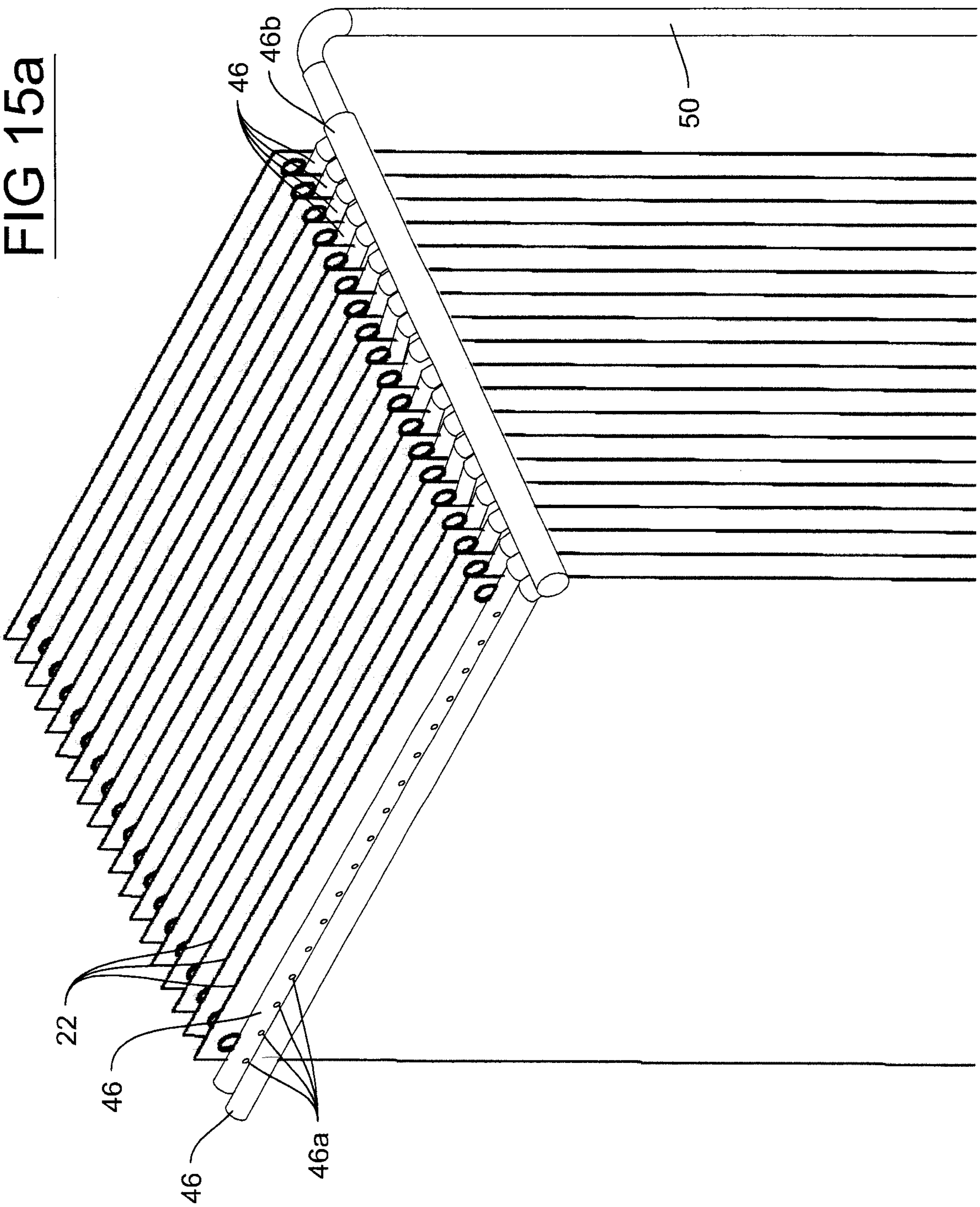


FIG 16

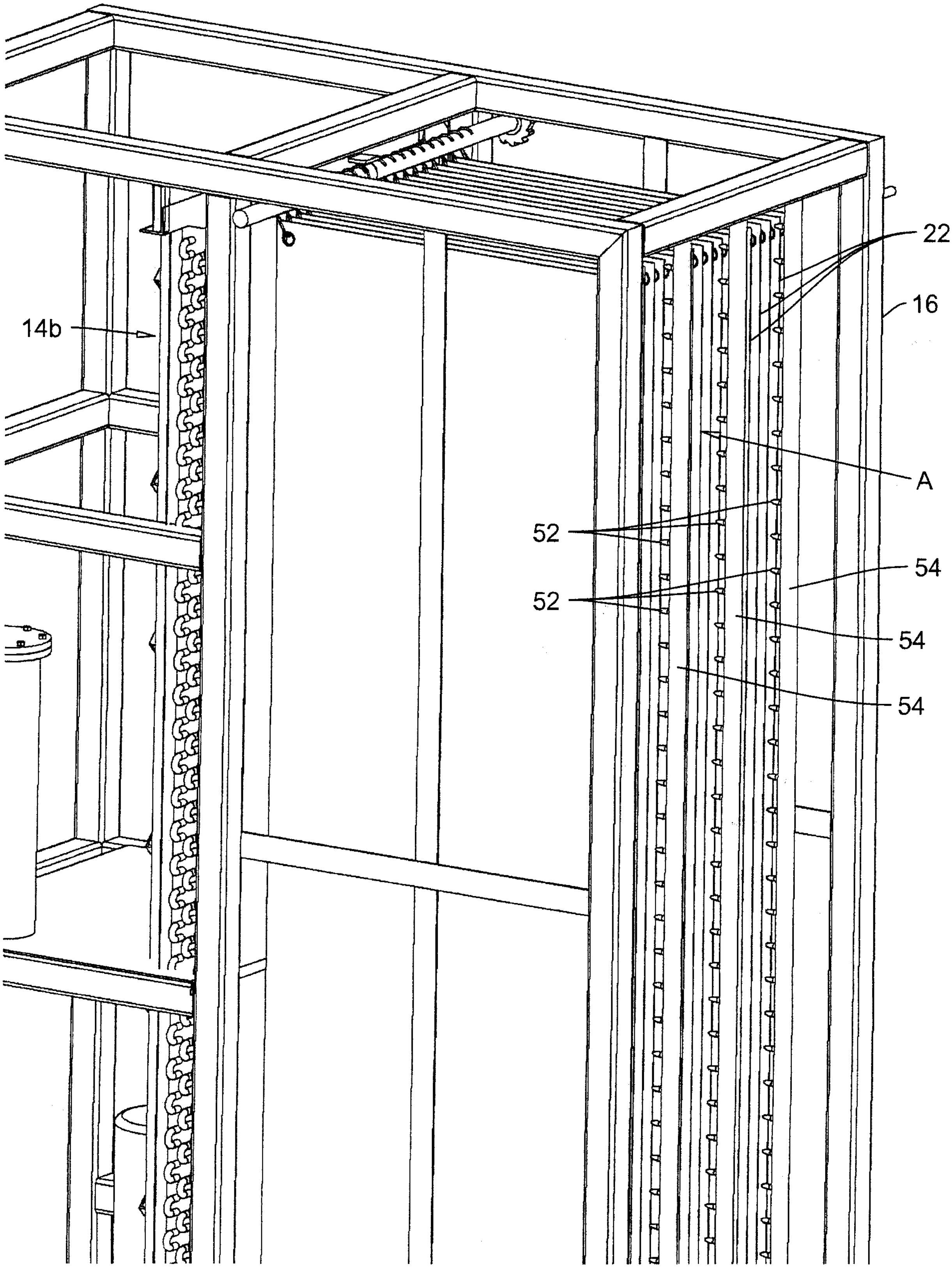
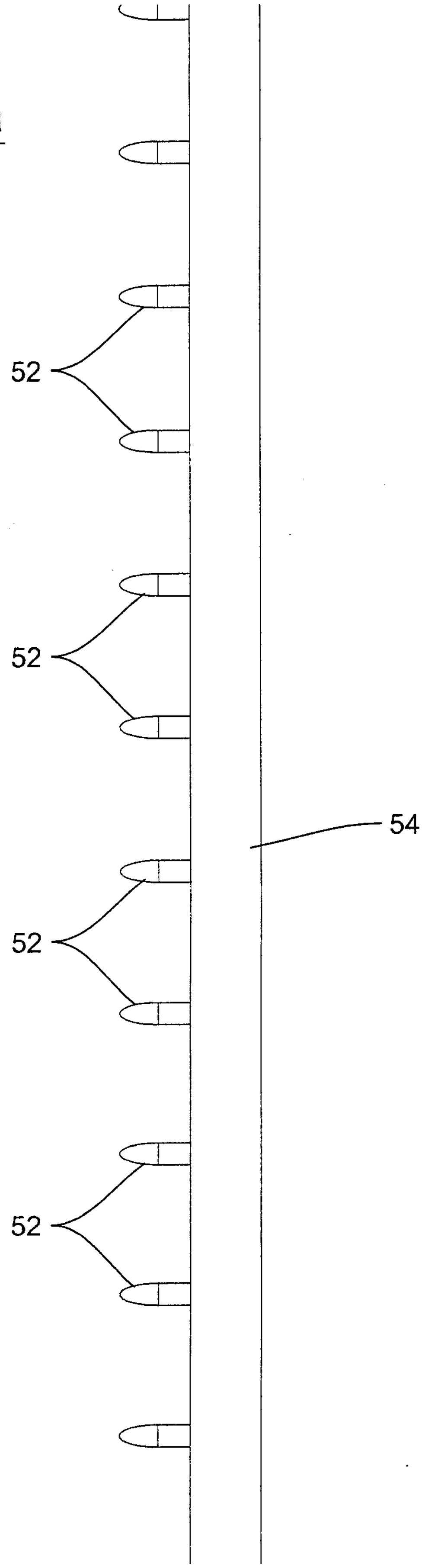


FIG 16a



INTERNATIONAL SEARCH REPORT

International application No
PCT/CA2009/000780

A CLASSIFICATION OF SUBJECT MATTER
IPC ***F25B 39/02*** (2006 **01)** , ***BOlD 5/00*** (2006 01) , ***BOlD 53/26*** (2006 **01)** , ***E03B 3/28*** (2006 01) , ***F25D 21/00*** (2006 01) , ***F25D 21/14*** (2006 **01)**
According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B 39/02 (2006 01) , ***BOlD 5/00*** (2006 01) , ***BOlD 53/26*** (2006 **01)** , ***E03B 3/28*** (2006 01) , ***F25D 21/00*** (2006 01) , ***F25D 21/14*** (2006 **01)**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Epoque, Delphion, Intellect
water, generator, condenser, array, evaporator, recovery, collection, atmosphere and combinations thereof

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
Y	US 5,259,203 A (Engel et al) 9 November 1993 (09-1 1-1993) Cited by applicant	1, 6, 12, 13, 14 and 15
Y	US 6,289,689 Bl (Zakryk) 18 September 2001 (18-9-2001) Cited by applicant	1, 6, 12, 13, 14 and 15
Y	US 5,507,340 A (Alston) 16 April 1996 (16-04-1996)	1, 6, 12 and 15
Y	CA 2,169,230 Al (Sirovich et al) 14 August 1996 (14-08-1996)	13, 14

[ ] Further documents are listed m the continuation of Box C [X] 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
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- O document referring to an oral disclosure use exhibition or other means
- P document published prior to the international filing date but later than the priority date claimed
- T later document published after the international films date or priority date and not m conflict with the application but citedto understand the principle or theory underlying the invention
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- & document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2010 (16-02-2010)	5 March 2010 (05-03-2010)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, Cl 14 - 1st Floor, Box PCT 50 Victoria Street Gatmeau, Quebec KlA 0C9 Facsimile No 001-819-953-2476	Sam Abounehme (819) 997-2773

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No
PCT/CA2009/000780

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US5259203A	09-1 1-1993	US5259203A	09-1 1-1993
US6289689B1	18-09-2001	AU2704999A	07-06-1999
		US5701749A	30-12-1997
		US6029461A	29-02-2000
		US6289689B1	18-09-2001
		US200309401 1A1	22-05-2003
		US6779358B2	24-08-2004
		WO9926030A1	27-05-1999
US5507340A	16-04-1996	US5507340A	16-04-1996
CA2169230A1	14-08-1996	CA2169230A1	14-08-1996
		DE69616103D1	29-1 1-2001
		DE69616103T2	06-06-2002
		EP0726398A1	14-08-1996
		EP0726398B1	24-10-2001
		IL1 171 19D0	18-06-1996
		IL1 171 19A	01-06-2004
		IN186816A1	17-1 1-2001
		RU2159363C2	20-1 1-2000
		US5797414A	25-08-1998