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(54) MICROCHANNEL HEAT EXCHANGER WITH ENHANCED REFRIGERANT DISTRIBUTION

MIKROKANAL-WÄRMETAUSCHER MIT VERBESSERTER KÄLTEMITTELVERTEILUNG

ÉCHANGEUR DE CHALEUR À MICROCANAUX A DISTRIBUTION AMÉLIORÉ DU RÉFRIGÉRANT

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(56) References cited:
JP-A- 6 159 983 **JP-A- 8 086 591**
JP-A- 9 166 368 **JP-A- 2007 178 048**

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Description

BACKGROUND OF THE INVENTION

[0001] This application relates to microchannels heat exchangers of refrigerant systems that utilize a distributor insert mounted within a manifold, and more particularly to heat exchangers incorporating dividing elements separating the manifold into a plurality of chambers, each associated with at least one heat exchange tube. JP-6-159983 discloses a heat exchanger as defined in the preamble of claim 1.

[0002] In recent years, much interest and design effort has been focuse on the efficient operation of heat exchangers (and condensers and evaporators in particular) of refrigerant systems. One relatively recent advancement in the heat exchanger technology is the development and application of parallel flow, or so-called microchannel or minichannel, heat exchangers (these two terms will be used interchangeably throughout the text), as the condensers and evaporators. Also, throughout the text, the reference will be made to a heat rejection heat exchanger as a condenser, with the understanding that the heat rejection heat exchanger may operate as a gas cooler, at least for a portion of the time.

[0003] Such microchannel heat exchangers are provided with a plurality of parallel heat exchange tubes, among which refrigerant is distributed and flown in a parallel manner. The heat exchange tubes are orientated generally substantially perpendicular to a refrigerant flow direction in the inlet, intermediate and outlet manifolds that are in flow communication with the heat exchange tubes. When utilized in condenser and evaporator applications, these heat exchangers may be designed in multi-pass configuration, typically with a plurality of parallel heat exchange tubes within each refrigerant pass, in order to obtain superior performance by balancing and optimizing heat transfer and pressure drop characteristics. Single-pass configurations are typically more desirable in the evaporator applications, since the refrigerant pressure drop plays a dominant role in the evaporator performance.

[0004] However, there have been some obstacles to the use of the microchannel heat exchangers within a refrigerant system. In particular, a problem, known as refrigerant maldistribution, typically occurs in the microchannel heat exchanger manifolds when the two-phase flow enters the manifold. A vapor phase of the two-phase flow has significantly different properties, moves at different velocities and is subjected to different effects of internal and external forces than a liquid phase. This causes the vapor phase to separate from the liquid phase and to flow independently. The separation of the vapor phase from the liquid phase has raised challenges, such as refrigerant maldistribution in parallel flow heat exchangers.

[0005] It is known in certain refrigerant systems to utilize a distributor insert for delivering refrigerant into an evaporator manifold (see, for example, JP 6-159983). Such systems have been employed in refrigerated merchandisers, such as refrigeration display cases. The proposed inlet distributor insert utilized in refrigerant display cases would not solve the problem of refrigerant maldistribution mentioned above.

[0006] Another proposed heat exchanger is constructed of a plurality of plates. The heat exchange refrigerant channels are formed of spaced plates, and remote ends of those spaced plates provide inlet plenums for each refrigerant channel. The plates separate adjacent plenums, and an insert tube extends through the plates and into the plenums. This tube includes a plurality of orifices which direct refrigerant into the individual plenums. This arrangement would not be practical for microchannel heat exchangers, and would only be a practical construction for the one type of heat exchanger formed of the spaced plates.

SUMMARY OF THE INVENTION

[0007] The present invention provides a microchannel heat exchanger comprising: a plurality of heat transfer tubes; a manifold for communicating refrigerant into said plurality of heat transfer tubes; and a distributor insert connectable to a source of refrigerant and having a plurality of orifices in an outer periphery of said distributor insert, characterised by dividing elements on an outer wall of said distributor insert such that a plurality of distribution chambers are defined and associated with said plurality of heat transfer tubes, wherein the plurality of orifices are arranged to uniformly direct the refrigerant into the plurality of distribution chambers.

[0008] In one embodiment, the heat exchanger manifold is an inlet manifold of an evaporator and, in another embodiment, the heat exchanger manifold is an intermediate manifold of a condenser or an evaporator.

[0009] While all separation chambers may be of an identical size and the distributor dividing elements uniformly spaced, in one embodiment, they are of a variable size to further fine tune refrigerant distribution. Although the invention is disclosed in relation to a two-phase refrigerant, it is also applicable to a single-phase refrigerant and refrigerant-oil mixtures.

[0010] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Figure 1 schematically shows a basic exemplary refrigerant system.

Figure 2 shows a portion of an inlet manifold of an inventive heat exchanger.

Figure 3 shows a portion of an intermediate manifold

of an inventive heat exchanger.

Figure 4 shows an exemplary design of a distributor insert.

Figure 5A shows a cross-sectional view of an exemplary heat transfer tube.

Figure 5B shows a cross-sectional view of an exemplary dividing element.

Figure 5C shows a side view of an exemplary dividing element of Figure 5B.

Figure 5D shows a cross-sectional view of another exemplary dividing element.

Figure 5E shows a side view of an exemplary dividing element of Figure 5D.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0012] A basic exemplary refrigerant system 20 is illustrated in Figure 1 including a compressor 22 compressing a refrigerant and delivering it downstream into a condenser 24. From the condenser 24 the refrigerant passes through an expansion device 26 into an inlet refrigerant pipe 28 leading into an evaporator 30. From the evaporator 30, the refrigerant is returned to the compressor 22 to complete the closed-loop refrigerant circuit.

[0013] A portion of the evaporator 30, that includes an inlet refrigerant manifold 34 incorporating the present invention, is illustrated in Figure 2. The evaporator 30 is a microchannel heat exchanger, such heat exchangers particularly benefit from this inventive design and construction. The benefits of this invention can extend to other applications, such as, for instance, condenser applications.

[0014] Although the benefits of the invention will be disclosed in reference to a two-phase refrigerant flow passing through the heat exchanger, single-phase refrigerant flows and refrigerant-oil mixtures are also within the scope and can benefit from the invention.

[0015] As shown in Figure 2, the inlet refrigerant pipe 28 fluidly communicates with a distributor insert 32, which provides a refrigerant flow path along its longitudinal axis. An inlet manifold 34 of the evaporator 30 receives the distributor insert 32, and in turn fluidly communicates with a plurality of heat exchange tubes 36 positioned generally perpendicular to and downstream, with respect to the direction of refrigerant flow, of the inlet manifold 34. The inlet refrigerant pipe 28 may be positioned at the end of the inlet manifold 34, in the middle of the inlet manifold 34 or at any intermediate location in-between. Further, the inlet refrigerant pipe 28 may comprise two inlet refrigerant pipes connected at the opposite ends of the inlet manifold 34 or at any intermediate locations. Obviously, more than two inlet refrigerant pipes can be utilized, but all of them need to be fluidly connected and provide refrigerant paths into the distributor insert 32.

[0016] As known, a plurality of heat transfer fins 38 may be disposed between and rigidly attached, usually by a furnace braze process, to the heat exchange tubes 36, in order to enhance external heat transfer and provide structural rigidity for the heat exchanger 30. Also, as known, each heat exchange tube 36 of a microchannel heat exchanger (evaporator) 30 typically has a plurality of small internal channels 41 providing multiple parallel refrigerant flow paths along longitudinal axis of each heat exchange tube 36 (see Figure 5A). The internal channels 41 enhance internal heat transfer and also provide structural rigidity for the heat exchanger 30.

[0017] As also illustrated in Figure 2, a plurality of refrigerant distribution orifices 42 of a small size are formed to protrude through the walls of the distributor insert 32 and to provide the refrigerant paths from an internal cavity of the distributor insert 32 into the inlet manifold 34. The distribution orifices 42 can be, for instance, of a round shape, rectangular shape, oval shape or any other shape. Furthermore, the distributor insert 32 has dividing elements 44 located on its periphery and rigidly attached to the outside walls of the distributor insert 32. Upon positioning the distributor insert 32 within the inlet manifold 34 of the evaporator 30, the dividing elements 44 form refrigerant separation chambers 46 within the internal cavity of the inlet manifold 34, with each chamber communicating refrigerant downstream to at least one heat exchange tube 36. Typically, each separation chamber would be fluidly connected to several refrigerant distribution orifices 42 and several heat exchange tubes 46.

[0018] As mentioned above, a plurality of small refrigerant distribution orifices 42 is provided to direct the refrigerant from the distributor insert 34 into a plurality of separation chambers 46 defined by adjacent dividing elements 44 of the distributor insert 32 within the cavity of the inlet manifold 34. The distance between the dividing elements 44 can be uniform or can be adjusted to control the ultimate size of the separation chambers 46 associated with any particular cluster of heat transfer tubes 36. This distance between the dividing elements 44 may vary from one cluster of heat transfer tubes 36 to another, or in an extreme case, from one heat transfer tube 36 to another. As an example, for a single inlet refrigerant pipe 28 located at the end of the inlet manifold 34, the size of the chambers 46 may be uniform along the longitudinal axis of the manifold 34 or, for instance, may decrease from the manifold inlet end to its remote end, where refrigerant velocity is expected to be lower. Any particular configuration of the dividing elements 44 could depend on operational parameters and particular application.

[0019] The distributor insert 32 receives the two-phase refrigerant from the inlet refrigerant pipe 28 and delivers this refrigerant, through a plurality of small distribution orifices 42, into the heat exchanger manifold 34 that has been divided into the separation chambers 46 by the dividing elements 44 of the distributor insert 32. A relatively small size of the distributor insert 32 provides significant momentum for the refrigerant flow preventing the phase separation of the two-phase refrigerant. The plurality of the distribution orifices 42 uniformly directs the two-phase refrigerant into the plurality of separation cham-

bers 46 of the manifold 34 defined by the spaced dividing elements 44 of the distributor insert 34. Since the size of the separation chambers 46 is relatively small, the refrigerant liquid and vapor phases do not have conditions and time to separate, as in the prior art, when the two-phase refrigerant was expanded into the entire inlet manifold cavity. Even in cases where some separation of the refrigerant phases occurs, it would be within a relatively small manifold chamber 46, and on average, the refrigerant distribution would be still predominantly uniform across the entire heat exchanger 30. Therefore, the inventive distributor concept having a plurality of small distribution orifices 42 and dividing elements 44 prevents refrigerant maldistribution and assures uniform refrigerant distribution into the heat exchange tubes 36. In this manner, the refrigerant being delivered into the heat exchange tubes 36 through the distributor insert orifices 42 and separation chambers 46 of the inlet manifold 34 will not have different quantities of vapor and liquid phases flowing through different heat exchange tubes and heat exchanger tube clusters.

[0020] An outer periphery of the dividing elements 44 is tightly received within an inner wall of the inlet manifold 34. Similarly, an inner periphery of the dividing elements 44 is closely received on an outer wall of the insert 32. In this manner, adjacent separation chambers 46 are maintained predominantly isolated from each other preventing refrigerant migration from one separation chamber 46 to another. Therefore, the overall characteristics of the refrigerant flow into the heat exchange tubes 36 can be controlled such that the effects of phase separation and/or refrigerant migration can be eliminated or minimized.

[0021] Figure 3 shows another embodiment 300, wherein the manifold 301 is an intermediate manifold, downstream of heat exchange tubes 302, and feeding the refrigerant into heat exchange tubes 312. As shown, the distributor insert 306 has orifices 308, a top separator plate 304, and intermediate separator plates 310. This embodiment functions as in the prior embodiment to reduce refrigerant phase separation and maldistribution. In this embodiment, the heat exchanger could be a condenser, or an evaporator.

[0022] The dividing elements 44 can be of any shape and form, such as, for instance, flat plates (see Figure 5B), as long as they do not drastically block refrigerant flow into the heat exchange tubes 36 and isolate one separation chamber 46 from another (e.g. by a small clearance or mechanical/chemical bonding). Furthermore, dividing elements 44 may have cutouts 200, in case the heat exchange tubes 36 penetrate inside the inlet manifold 34 (see Figures 5B and 5C). The dividing elements 44 may be attached to the distributor insert 32 mechanically (e.g. snapped into place into small groves manufactured on the outer wall of the distributor insert 32), or by brazing, welding or soldering. The dividing elements 44 may be also attached to the inner wall of the inlet manifold 34 (e.g. by furnace brazing). Both attachment processes can be performed, for instance, during furnace brazing of the entire heat exchanger 30.

[0023] Figures 5D and 5E show another embodiment, wherein the dividing elements 44 do not include the cutout 200, but do include a groove or indentation 202. The purpose of this indentation is to provide a holding cavity for brazing flux such that the distributor insert can be inserted into a manifold and brazed upon construction of the overall heat exchanger

[0024] In general, each of the disclosed embodiments teaches a distributor insert which will receive refrigerant, and distribute refrigerant through a plurality of orifices into separation chambers defined between dividing elements. Since the insert and the dividing elements are attached to each other as a rigid sub-assembly, the entire assembly can be inserted into a manifold. This will allow the use of this feature without requiring any specific heat exchanger design, as has been the case in the prior art.

[0025] Although an embodiment of this invention has been disclosed, a worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention, which is defined by the claims. For that reason, the following claims should be studied to determine the scope of the invention.

Claims

1. A microchannel heat exchanger (30) comprising:

   a plurality of heat transfer tubes (36);
   a manifold (34) for communicating refrigerant into said plurality of heat transfer tubes; and
   a distributor insert (32) connectable to a source of refrigerant and having a plurality of orifices (42) in an outer periphery of said distributor insert,
   characterised by dividing elements (44) on an outer wall of said distributor insert such that a plurality of distribution chambers (46) are defined and associated with said plurality of heat transfer tubes, wherein the plurality of orifices are arranged to uniformly distribute the two-phase refrigerant into the plurality of distribution chambers.

2. The heat exchanger as set forth in Claim 1, wherein said distributor insert and said dividing elements improve refrigerant distribution in said heat exchanger.

3. The heat exchanger as set forth in Claim 1, wherein said dividing elements are spaced uniformly along a length of said distributor insert.

4. The heat exchanger as set forth in Claim 1, wherein said dividing elements are attached to said distributor insert by one of mechanical attachment and chemical bonding.

5. The heat exchanger as set forth in Claim 1, wherein the distributor insert has a round cross-sectional shape.

6. The heat exchanger as set forth in Claim 1, wherein said manifold has an internal bore of a round cross-sectional shape.

7. The heat exchanger as set forth in Claim 1, wherein the refrigerant passing through said distributor insert is a two-phase refrigerant.

8. A refrigerant system comprising:

a compressor, said compressor for compressing a refrigerant and delivering it said refrigerant downstream into a condenser, refrigerant from said condenser passing through an expansion device and then into an evaporator, at least one of said condenser and said evaporator being a heat exchanger as set forth in Claim 1.

9. The refrigerant system as set forth in Claim 8, wherein said distributor insert extends from an upstream end of said manifold toward a downstream end of said manifold, and the size of said separation chambers defined between adjacent ones of said dividing elements is determined to optimize the flow of refrigerant within the plurality of heat transfer tubes.

10. The refrigerant system as set forth in Claim 8, wherein said plurality of heat transfer tubes, each including a plurality of channels, are spaced generally perpendicularly to an upstream to downstream direction of said distributor insert.

11. The heat exchanger or refrigerant system as set forth in Claim 1 or 8, wherein the heat exchanger is an evaporator, and said manifold is an inlet manifold.

12. The heat exchanger or refrigerant system as set forth in Claim 1 or 8, wherein said manifold is an intermediate manifold.

13. The heat exchanger or refrigerant system as set forth in Claim 1 or 12, wherein said distributor insert extends along only a portion of said manifold, and is not aligned with heat transfer tubes communicating into said manifold, but is aligned with heat transfer tubes communicating out of said manifold.

14. The heat exchanger or refrigerant system as set forth in Claim 1 or 8, wherein said dividing elements are flat plates having a cutout portion at an outer periphery to provide clearance for said heat transfer tubes.

Patentansprüche

1. Mikrokanalwärmetauscher (30), umfassend:

eine Mehrzahl von Wärmeübertragungsröhren (36);
einen Verteiler (34) zum Leiten von Kältemittel in die Mehrzahl von Wärmeübertragungs-röhren; und
einen Verteilungseinsatz (32), der mit einer Quelle von Kältemittel verbindbar ist und eine Mehrzahl von Mündungen (42) an einem Außenumfang des Verteilungseinsatzes aufweist, **gekennzeichnet durch** Teilungselemente (44) an einer Außenwand des Verteilungseinsatzes, derart, dass eine Mehrzahl von Verteilungskammern (46) definiert wird und der Mehrzahl von Wärmeübertragungsröhren zugeordnet wird, wobei die Mehrzahl von Mündungen derart angeordnet ist, dass sie das zweiphasige Kältemittel gleichmäßig in der Mehrzahl von Verteilungskammern verteilt.

2. Wärmetauscher nach Anspruch 1, wobei der Verteilungseinsatz und die Teilungselemente die Kältemittelverteilung in dem Wärmetauscher verbessern.

3. Wärmetauscher nach Anspruch 1, wobei die Teilungselemente entlang einer Längserstreckung des Verteilungseinsatzes gleichmäßig beabstandet sind.

4. Wärmetauscher nach Anspruch 1, wobei die Teilungselemente durch eine von einer mechanischen Anbringung und chemischer Bindung an dem Verteilungseinsatz angebracht sind.

5. Wärmetauscher nach Anspruch 1, wobei der Verteilungseinsatz eine runde Querschnittform aufweist.

6. Wärmetauscher nach Anspruch 1, wobei der Verteiler eine Innenbohrung mit einer runden Querschnittform aufweist.

7. Wärmetauscher nach Anspruch 1, wobei das Kältemittel, das durch den Verteilungseinsatz gelangt, ein zweiphasiges Kältemittel ist.

8. Kältesystem, umfassend:

einen Kompressor, wobei der Kompressor zum Verdichten eines Kältemittels und zum Leiten des Kältemittels stromabwärts in einen Kondensator dient, wobei Kältemittel von dem Kondensator durch eine Ausdehnungsvorrichtung und dann in einen Verdampfer gelangt, wobei wenigstens einer von dem Kondensator und dem Verdampfer ein Wärmetauscher nach Anspruch

1 ist.

9. Kältesystem nach Anspruch 8, wobei sich der Verteilungseinsatz von einem Stromaufwärtsende des Verteilers zu einem Stromabwärtsende des Verteilers erstreckt und die Größe der Trennungskammern, die zwischen benachbarten der Teilungselemente definiert sind, festgelegt ist, um den Fluss von Kältemittel innerhalb der Mehrzahl von Wärmeübertragungsröhren zu optimieren.

10. Kältesystem nach Anspruch 8, wobei die Mehrzahl von Wärmeübertragungsröhren, die jeweils eine Mehrzahl von Kanälen aufweisen, allgemein senkrecht zu einer Stromaufwärtsstromabwärts-Richtung des Verteilungseinsatzes beabstandet ist.

11. Wärmetauscher oder Kältesystem nach Anspruch 1 oder 8, wobei der Wärmetauscher ein Verdampfer ist und der Verteiler ein Einlassverteiler ist.

12. Wärmetauscher oder Kältesystem nach Anspruch 1 oder 8, wobei der Verteiler ein Zwischenverteiler ist.

13. Wärmetauscher oder Kältesystem nach Anspruch 1 oder 12, wobei der Verteilungseinsatz sich nur an einem Teil des Verteilers entlang erstreckt und nicht an den Wärmeübertragungsröhren ausgerichtet ist, die in den Verteiler eingehen, sondern an den Wärmeübertragungsröhren ausgerichtet ist, die aus dem Verteiler austreten.

14. Wärmetauscher oder Kältesystem nach Anspruch 1 oder 8, wobei die Teilungselemente flache Platten sind, die an einem Außenumfang einen Aussparungsabschnitt aufweisen, um Platz für die Wärmeübertragungsröhren zu schaffen.

Revendications

1. Échangeur (30) de chaleur à microcanaux comprenant :

une pluralité de tubes (36) de transfert de chaleur ;
un collecteur (34) servant à mettre le réfrigérant en communication avec ladite pluralité de tubes de transfert de chaleur ; et
un insert (32) de distribution pouvant être relié à la source d'un réfrigérant et ayant une pluralité d'orifices (42) sur une périphérie extérieure dudit insert de distribution,
caractérisé par des éléments diviseurs (44) situés sur une paroi extérieure dudit insert de distribution de telle sorte qu'une pluralité de chambres (46) de distribution sont définies et associées à ladite pluralité de tubes de transfert de chaleur, la pluralité d'orifices étant conçue pour distribuer uniformément le réfrigérant diphasique dans la pluralité de chambres de distribution.

2. Échangeur de chaleur selon la revendication 1, dans lequel ledit insert de distribution et lesdits éléments diviseurs améliorent la distribution du réfrigérant dans ledit échangeur de chaleur.

3. Échangeur de chaleur selon la revendication 1, dans lequel lesdits éléments diviseurs sont espacés uniformément sur une longueur dudit insert de distribution.

4. Échangeur de chaleur selon la revendication 1, dans lequel lesdits éléments diviseurs sont fixés audit insert de distribution soit par fixation mécanique soit par liaison chimique.

5. Échangeur de chaleur selon la revendication 1, dans lequel l'insert de distribution a une section transversale de forme arrondie.

6. Échangeur de chaleur selon la revendication 1, dans lequel le collecteur a un trou intérieur dont la section transversale est de forme arrondie.

7. Échangeur de chaleur selon la revendication 1, dans lequel le réfrigérant traversant ledit insert de distribution est un réfrigérant diphasique.

8. Système réfrigérant comprenant :

un compresseur, ledit compresseur servant à compresser un réfrigérant et à fournir ledit réfrigérant en aval à un condensateur, le réfrigérant dudit condensateur traversant un dispositif d'expansion puis arrivant dans un évaporateur, au moins l'un desdits condensateur et évaporateur étant un échangeur de chaleur selon la revendication 1.

9. Système réfrigérant selon la revendication 8, dans lequel ledit insert de distribution s'étend d'une extrémité amont dudit collecteur vers une extrémité aval dudit collecteur, et la taille desdites chambres de séparation définies entre des éléments diviseurs adjacents desdits éléments diviseurs est définie de sorte à optimiser le flux de réfrigérant à l'intérieur de la pluralité de tubes de transfert de chaleur.

10. Système réfrigérant selon la revendication 8, dans lequel ladite pluralité de tubes de transfert de chaleur, comprenant chacun une pluralité de canaux, est espacée généralement perpendiculairement à une direction d'amont en aval dudit insert de distribution.

11. Échangeur de chaleur ou système réfrigérant selon la revendication 1 ou la revendication 8, dans lesquels l'échangeur de chaleur est un évaporateur, et ledit collecteur est un collecteur d'entrée.

12. Échangeur de chaleur ou système réfrigérant selon la revendication 1 ou la revendication 8, dans lesquels ledit collecteur est un collecteur intermédiaire.

13. Échangeur de chaleur ou système réfrigérant selon la revendication 1 ou la revendication 12, dans lesquels l'insert de distribution s'étend le long d'une partie dudit collecteur seulement, et n'est pas aligné avec les tubes de transfert de chaleur mis en communication à l'intérieur dudit collecteur, mais est aligné avec les tubes de transfert de chaleur mis en communication à l'extérieur dudit collecteur.

14. Échangeur de chaleur ou système réfrigérant selon la revendication 1 ou la revendication 8, dans lesquels lesdits éléments diviseurs sont des plaques planes dont une partie est découpée sur une périphérie extérieure pour laisser de l'espace pour lesdits tubes de transfert de chaleur.

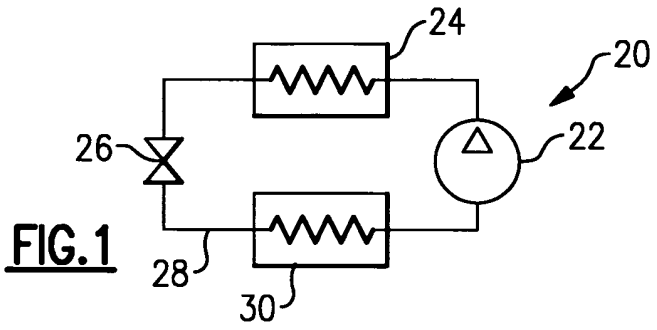


FIG.1

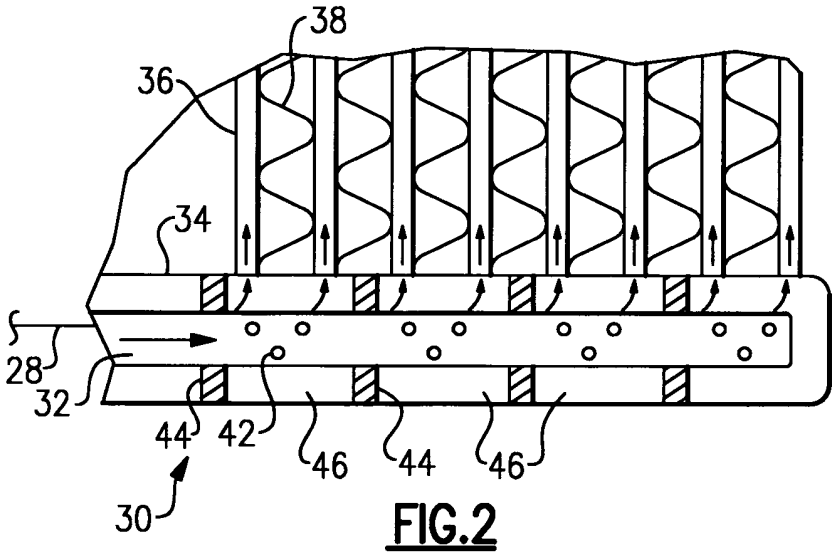


FIG.2

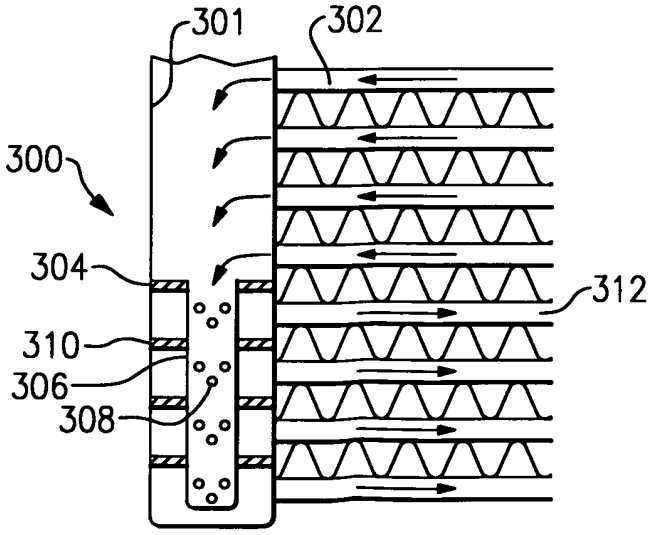


FIG.3

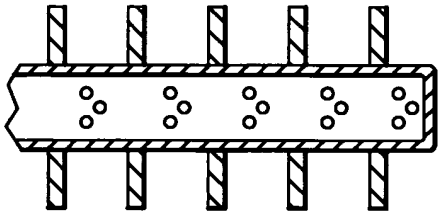


FIG.4

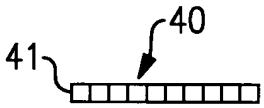


FIG.5A

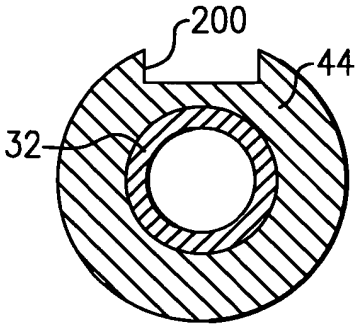


FIG.5B

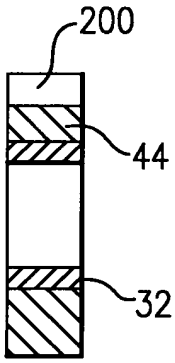


FIG.5C

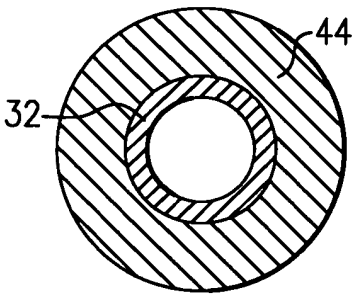


FIG.5D

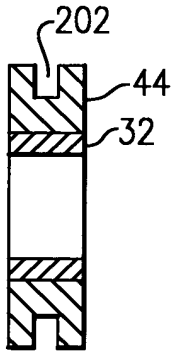


FIG.5E

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6159983 A **[0001] [0005]**