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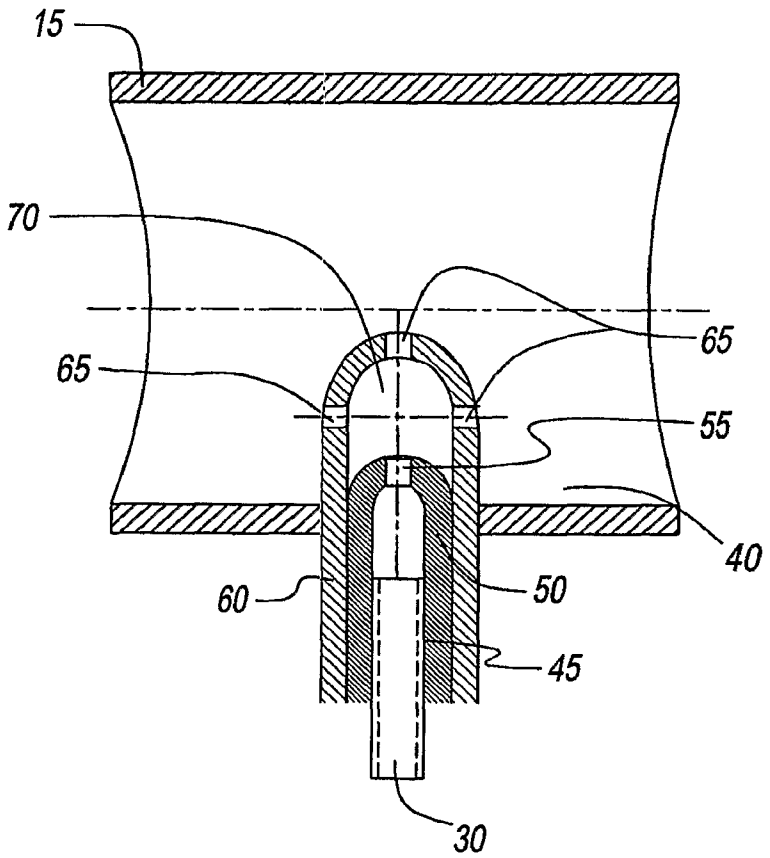
(54) Title: MULTI-CHANNEL HEAT EXCHANGER WITH MULTI-STAGE EXPANSION DEVICE



(57) Abstract: An expansion device for a heat exchanger having a manifold and a plurality of mini-and or micro-channels. The expansion device has an outer element having a plurality of orifices therethrough that is received in the manifold, and an inner element telescopically received in the outer element having at least one orifice therethrough and being in fluid communication with the plurality of orifices. Fluid passing through the at least one orifice and through the plurality of orifices is expanded and reduced in pressure prior to entering the manifold.

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MULTI-CHANNEL HEAT EXCHANGER WITH MULTI-STAGE EXPANSION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an expansion device for heat exchangers. More particularly, the present invention relates to an expansion device for mini- or micro-channel heat exchangers (MCHX) that provide pressure reductions and mixing through multiple orifices to improve heat exchanger efficiency.

2. Description of Prior Art

Refrigeration systems are well known in the art and ubiquitous in such industries as food service industry, chemical and automotive industry. On a larger scale, heat exchangers are required for office buildings and for residential purposes. Failure or more commonly, lack of efficiency is a great concern with such systems.

Traditional refrigeration cycles, or air conditioners, include a compressor, a condenser, an expansion valve, an evaporator and a refrigerant whose evaporation creates the cool temperature. In some refrigeration systems, the evaporator is a series of parallel narrow tubes. When the refrigerant fluid passes from the condenser through the evaporator, a pressure and temperature drop occurs thus achieving the cooler temperature.

Cooling systems can use either a single or a two-phase coolant throughout the circuit. When the refrigerant is a single phase cooling fluid, such as the water in an automotive radiator, there is no concern that the fluid will be in two phases during and after expansion. However, in many refrigerant vapor

compression systems as the fluid passes from the condenser to the evaporator a portion of the fluid expands to vapor. Consequently, a portion of the fluid entering the evaporator is a vapor, resulting in poor heat exchanger efficiency. This vapor problem is called maldistribution and is a common problem of heat exchangers that use parallel refrigerant paths. Gravity and the difference in density of the vapor and liquid phases cause this problem..

In mini or micro-channel heat exchangers (MCHX), the concern is even greater because the flow of refrigerant is divided into many small tubes where every tube and mini-channel is to receive just a small and equal fraction of the total refrigerant flow. With the maldistribution, certain tubes receive more liquid while the remaining tubes receive more vapor. Various methods, such as expanding and distributing the refrigerant into one or a few mini-channel tubes can be used to prevent maldistribution and to achieve a pressure drop.

Therefore, there exists a need for a multi-stage expansion device for mini-channel heat exchangers that is capable of creating pressure drops during the expansion phase using multiple larger orifices arranged in series to properly mix the refrigeration fluid to avoid the aforementioned problems that are a cause of heat exchanger inefficiency.

SUMMARY OF THE INVENTION

It is an object of the present invention to reduce maldistribution of refrigerant in heat exchangers in MCHX, thereby increasing single and multiple pass heat exchanger efficiency.

It is also an object of the present invention to reduce maldistribution of two-phase flow in MCHX, by facilitating pressure drops in heat exchanger manifolds.

It is a further object of the present invention to provide a coupling device inserted in the heat exchanger manifold that enables pressure drops using several larger orifices instead of one small orifice.

It is yet a further object of the present invention to provide a pair of mating coupling tubes that interface to provide a multi expansion device that is inserted into a manifold pipe to minimize maldistribution of refrigerant.

It is still yet a further object of the present invention to provide multi-expansion device having large orifices that can achieve a substantial pressure drop and mixture of refrigerant and feed refrigerant to mini- and mirco-channel evaporator.

It is yet still a further object of the present invention to provide shaped and perforate a heat exchanger manifold that receives at least one expansion device to further enhance pressure reductions and mixing of refrigerant prior to entering mini-and mirco-channel tubes of heat exhanger.

It is still yet a further object of the present invention to provide a manifold having a plurality of openings into which an expansion device is inserted or received.

These and other objects and advantages are provided by an expansion device for a heat exchanger having a manifold and a plurality of mini-and or micro-channels. The expansion device has an outer element having a plurality of orifices therethrough that is received in the manifold, and an inner element telescopically received in the outer element having at least one orifice therethrough and being in fluid communication with the plurality of orifices. Fluid passing through the at least one orifice and through the plurality of orifices is expanded and reduced in pressure prior to entering the manifold.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the present invention will be more apparent from the followed detailed description of the present invention, in conjunction with the accompanying drawings wherein:

Fig. 1 illustrates a heat exchanger having several mini-channel tubes incorporating an expansion according to the first embodiment of the present invention;

Fig 2 illustrates an expansion device according to a first embodiment of the present invention that is inserted in a heat exchanger manifold of Fig. 1;

Fig. 3 illustrates a side view of a second configuration of the expansion device of the present invention inserted into a shaped manifold for further pressure reduction; and

Fig. 4 illustrates a bottom view of the perforate manifold of Fig. 3 having openings for expansion devices of Fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 illustrates a mini-channel heat exchanger generally represented by reference numeral 10. Heat exchanger 10 has an inlet mainifold 15 and an outlet manifold 20. Connecting manifolds 15 and 20 are a series or plurality of mini- or micro-channel tubes 25 that form the main body of heat exchanger 10. Each mini- or micro-channel tube 25 is a very narrow tube that with other tubes form the main body of the heat exchanger 10 and transport refrigerant 30 during evaporation.

Inlet manifold 15 receives a refrigerant 30 that can be either a single or a two-phase refrigerant that flows through mini- or micro-channel tubes 25. Inlet manifold receives multi-expansion device 40 of the present invention. At least one or more multi-expansion devices 40 of the present invention can be inserted into manifold 15 to enhance pressure drop of refrigerant 30 to ensure an even distribuiton of refrigerant for mini-channel tubes 25. While Fig. 1 shows a single-pass configuration of a heat exchanger, a two or a multi-pass heat exchanger could also be used.

Referring to Fig. 2, a detailed view of expansion device 40, is shown. Expansion device 40 has a feeder tube 45 that receives refrigerant 30 from an earlier circuit. Fitted to feeder tube 45 is a first coupler 50 having an orifice 55 at its upper most point or apex. Coupled to first coupler 50 is a second coupler 60. Coupler 60 has a series or plurality of orifices 65 around a top portion thereof at its apex and at points peripheral or a 90° angles to the apex.

As refrigerant 30 flows from feeder tube to into expansion device 40, it is received in first coupler 50. When refrigerant 30 flows through orifice 55 is experiences a pressure drop and an expansion and is mixed in space 70. When refrigerant 30 is released through orifices 65, refrigerant 30 is further reduced in pressure and again expanded. When refrigerant passes again through orifices 65 of second coupler 60, the pressure of refrigerant 30 is reduced even further and refrigerant 30 expands and is redistributed in manifold 15, prior to entering mini-channel tubes 25 of heat exchanger 10.

Were expansion device 40 not inserted into manifold, the refrigerant entering the manifold from feeder tubes and entering mini channels would be a two phase fluid as opposed to a single phase. Further, by passing through multiple larger orifices 65 in series the desired overall pressure drop is achieved. While Fig. 1 shows two expansion devices 40 being used more expansion devices could be used depending upon system requirements. Further, Fig. 2

shows two couplers 50 and 60 having orifices 55 and 65, respectively, in series, other orifice or coupler configurations could also be used to achieve double expansion of refrigerant 30.

Referring to Figs. 3 and 4, a second configuration of the expansion system inserted in to a shaped manifold is shown, generally referred by reference numeral 70. In this configuration the expansion device 40 of the first embodiment is inserted into a shaped manifold 85 at multiple apertures, 90 and 95. Shaped manifold 85 has a circular cross-section that is divided into two chambers, a receiving chamber 100 and an outlet chamber 105, by divider 102. Receiving chamber 100 receives an expansion device 40 in each of apertures 90 and 95. Divider 102 has a series of apertures 110 that permits an additional degree of expansion even after refrigerant 30 has been expanded and depressurized twice in expansion device 40.

While manifold 85 is shown as having a circular cross-section other cross-sections could also be used to offer the same pressure reduction and expansion benefits. Further more apertures 90 could be located in manifold 85 for a greater expansion and mixing of refrigerant.

While the instant disclosure has been described with reference to one or more exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope thereof. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the scope thereof. Therefore, it is intended that the disclosure not be limited to the particular embodiment(s) disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the disclosure.

We Claim:

1. An expansion device for a heat exchanger having a manifold and a plurality of channels comprising:

an outer element having a plurality of orifices therethrough, said outer element received in the manifold; and

an inner element telescopically received in said outer element, said inner element having at least one orifice therethrough and being in fluid communication with said plurality of orifices,

wherein a fluid passing through said at least one orifice and through said plurality of orifices is expanded and reduced in pressure prior to entering said manifold.

2. The expansion device of claim 1, wherein said outer element is a tubular element.

3. The expansion device of claim 1, wherein said inner element is a tubular element.

4. The expansion device of claim 1, wherein said outer element has a rounded end and an opened end opposite said rounded end, said plurality of orifices extending through said rounded end, said inner element being received in said opened end.

5. The expansion device of claim 1, wherein said inner element has an opened end and a rounded end opposite said opened end, a feeder tube transporting said refrigerant being received in said opened end and said at least one orifice extending through said rounded end.

6. The expansion device of claim 1, wherein said fluid is a refrigerant that is received into said inner element by a feeder tube.

7. The expansion device of claim 1, wherein said fluid passing through said at least one orifice and through said plurality of orifices is expanded and reduce in pressure at least twice.

8. An expansion device for a heat exchanger, the heat exchanger having manifolds and a plurality of mini- or micro-channels connecting said manifolds, the expansion device comprising:

an outer expansion tube having a plurality of orifices; and

an inner expansion tube received in said outer expansion tube,

wherein refrigerant exiting said inner expansion tube and exiting said outer expansion tube into the manifold, has been reduced in pressure and expanded at least twice thereby mixing said refrigerant before entering said plurality of mini-and or micro-expansion channels.

9. The expansion device of claim 8, wherein said outer expansion tube has a rounded end and an opened end opposite said rounded end, said plurality of orifices extending through said rounded end, said inner expansion tube being received in said opened end.

10. The expansion device of claim 8, wherein said inner expansion tube has an opened end and a rounded end, said opened end opposite said rounded end, a feeder tube transporting said refrigerant being received in said opened end and at least one orifice extending through said rounded end.

11. An expansion system for a heat exchanger having a plurality of mini-micro expansion channels for expansion comprising:

a manifold having two chambers and a divider between said two chambers, said divider having a series of apertures therethrough; one of said two chambers capable of receiving said plurality of mini and micro-expansion channels;

at least one outer element received in the other of said two chambers, said at least one outer element having a plurality of orifices therethrough;

an inner element received in said at least one outer element, said inner element having at least one orifice therethrough,

wherein refrigerant entering said inner element and expanding through said at least one orifice, said plurality of orifices and said series of apertures, has been reduced in pressure and expanded thereby mixing said refrigerant before entering said plurality of expansion channels.

12. The expansion system of claim 11, wherein said at least one outer element is a plurality of outer elements.

13. The expansion system of claim 11, wherein said at least one outer element is a tubular element.

14. The expansion system of claim 11, wherein said inner element is a tubular element.

15. The expansion system of claim 11, wherein said at least one outer element having a rounded end and an opened end opposite said rounded end, said plurality of orifices extending through said rounded end, said inner element being received in said opened end of said at least one outer element.

16. The expansion device of claim 11, wherein said inner element has an opened end and a rounded end opposite said opened end, a feeder tube

transporting said refrigerant being received in said opened end and said at least one orifice extending through said rounded end.

17. The expansion system of claim 11, wherein said fluid is a refrigerant that is received into said inner element by a feeder tube.

18. The expansion system of claim 11, wherein said fluid passing through said at least one orifice, through said plurality of orifices and said plurality of apertures is expanded and reduce in pressure at least three times.

19. A device for expanding refrigerant in a manifold according and enhancing efficiency of a heat exchanger as herein before described with reference to any one of Figures 1, 2, 3 and 4.

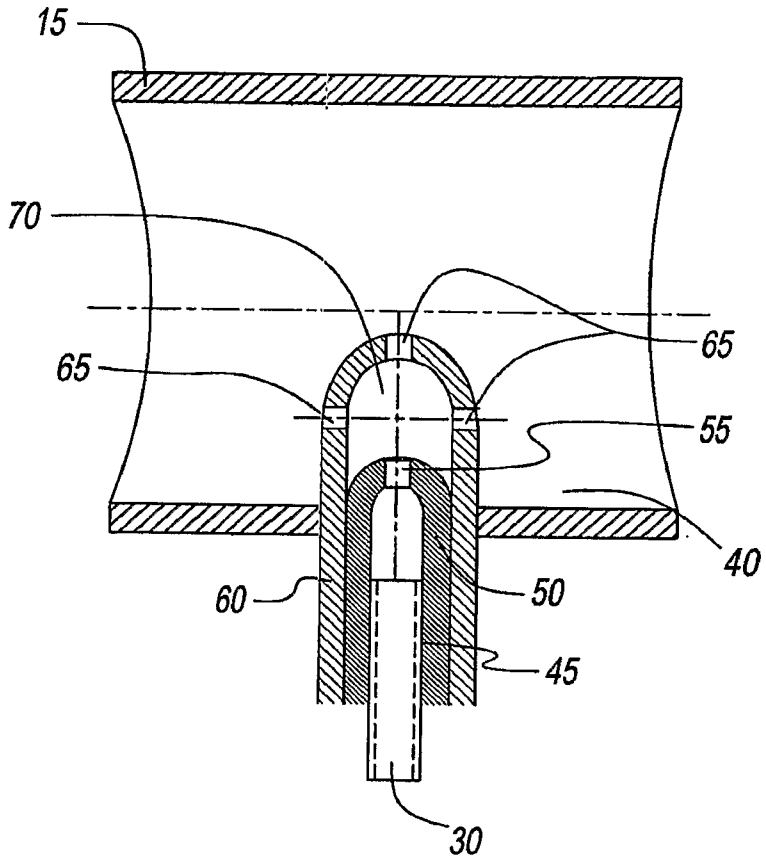

Fig. 2

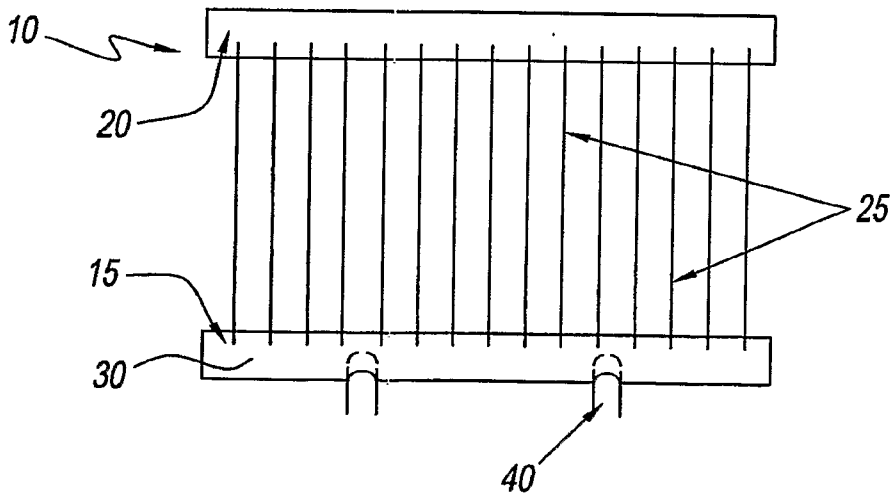

Fig. 1

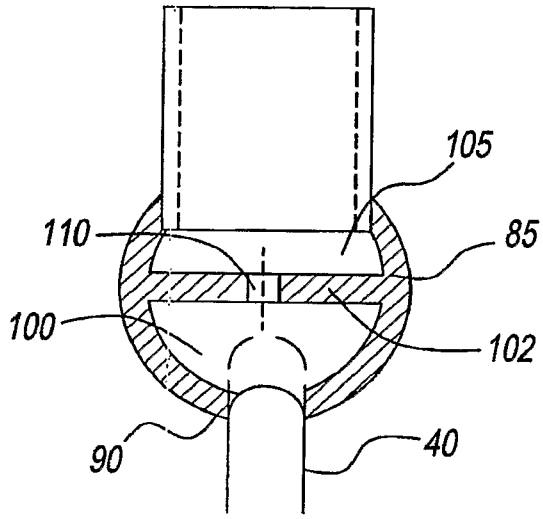

Fig. 3

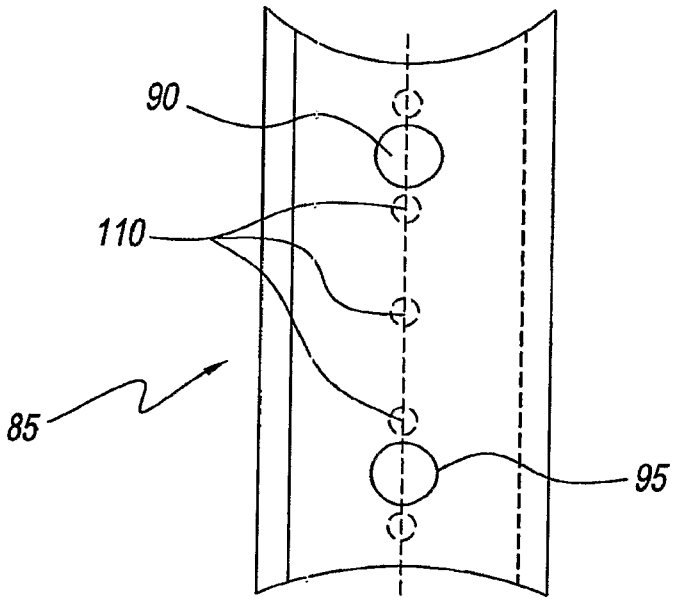

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/48347

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F25B 41/06; F28F 9/02 (2007.10)
USPC - 62/511; 165/175
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)
IPC(8) - F25B 41/06; F28F 9/02 (2007.10)
USPC - 62/222, 504, 511, 515, 527, 528; 165/172, 173, 174, 175, 908

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO EAST System (US, USPG-PUB, EPO, DERWENT), MicroPatent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,910,167 A (REINKE et al) 08 June 1999 (08.06.1999) entire document	1-4, 6-9, 11-15, 17-19
Y	US 6,289,924 B1 (KOZINSKI) 18 September 2001 (18.09.2001) entire document	1-4, 6-9, 11-15, 17-19
Y	US 2004/0159121 A1 (HORIUCHI et al) 19 August 2004 (19.08.2004) entire document	11-15, 17, 18
A	US 2005/0006069 A1 (KAMIYAMA et al) 13 January 2005 (13.01.2005) entire document	1-19
A	US 5,862,676 A (KIM et al) 26 January 1999 (26.01.1999) entire document	1-19
A	WO 2006/083448 A1 (GORBOUNOV et al) 10 August 2006 (10.08.2006) entire document	1-19

☐ Further documents are listed in the continuation of Box C. ☐

* 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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 October 2007	20 NOV 2007
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774