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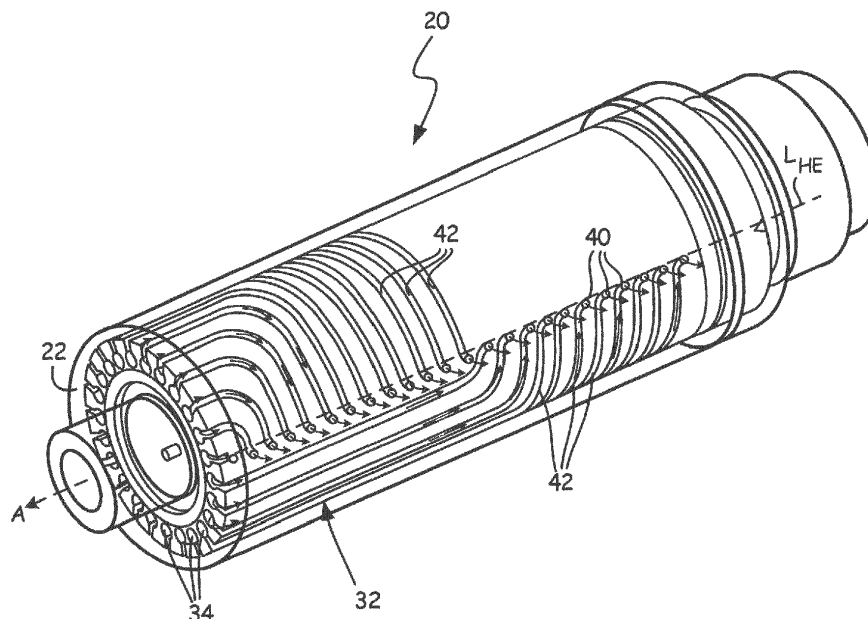
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(54) HEAT EXCHANGER DISTRIBUTOR SWIRL VANE

(57) A vapor cycle heat exchanger has a plurality of heat exchanger lines 38 and a distributor. The distributor comprises a distributor housing 23, a swirl vane, an atomizing nozzle, a plurality of nozzles, and a fluid line intersection. The distributor housing defines a main distributor line 24 configured to receive a non-homogenous flow of the two-phase refrigerant fluid. The swirl vane is disposed within the main distributor line and configured

to distribute the non-homogeneous flow into a symmetric fluid distribution. The atomizing nozzle 28 is disposed downstream of the swirl vane. The routing lines 32 each lead to one of the plurality of heat exchanger lines. The main distributor line branches into the routing lines at the fluid line intersection, which is situated downstream of the nozzle.

**FIG. 2****EP 3 070 419 A1**

Description

BACKGROUND

[0001] The present invention relates generally to heat exchangers, and more particularly to a swirl vane for a heat exchanger distributor.

[0002] Heat exchangers are used in a variety of applications to transfer and transport heat, and often include a plurality of separate fluid lines through fins or planes that increase surface area for thermal transfer. Heat exchangers commonly use distributors to evenly distribute coolant from a single inlet line across these separate heat exchanger lines. To ensure efficient heat transfer, distributors must distribute fluid volume from inlet lines substantially evenly across heat exchanger lines.

[0003] Vapor cycle heat exchangers are often used to cool electronics and other components with high thermal loads. As used in the present application, the term "vapor cycle heat exchanger" is defined as a closed system heat exchanger that transfers heat via cyclical phase changes of flowing refrigerant fluid. Many stages of vapor cycle heat exchangers carry refrigerant in non-homogeneous state mixtures of liquid and gas.

[0004] It is desired to ensure efficient heat transfer distributors in vapor cycle heat exchangers by providing equal refrigerant mass down each heat exchanger line, and substantially the same proportion of liquid to gas down each heat exchanger line.

SUMMARY

[0005] The present invention is directed toward a vapor cycle heat exchanger with a plurality of heat exchanger lines and a distributor. The distributor comprises a distributor housing, a swirl vane, an atomizing nozzle, a plurality of nozzles, and a fluid line intersection. The distributor housing defines a main distributor line configured to receive a non-homogenous flow of the two-phase coolant fluid. The swirl vane is disposed within the main distributor line and configured to distribute the non-homogeneous flow into a symmetric fluid distribution. The atomizing nozzle is disposed downstream of the swirl vane. The routing lines each lead to one of the plurality of heat exchanger lines. The main distributor line branches into the routing lines at the fluid line intersection, which is situated downstream of the nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a simplified cross-sectional view of a heat exchanger system.

FIG. 2 is a perspective view of a distributor of the heat exchanger system of FIG. 1.

FIG. 3a is a perspective view of a swirl vane in the distributor of FIG. 2.

FIG. 3b is a cross-sectional view of the swirl vane of FIG. 3a.

FIG. 4 is a schematic view of the distributor of FIG. 2.

[0007] While the above-identified figures set forth one or more embodiments of the present disclosure, other embodiments are also contemplated, as noted in the discussion. In all cases, this disclosure presents the invention by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the invention. The figures may not be drawn to scale, and applications and embodiments of the present invention may include features and components not specifically shown in the drawings.

DETAILED DESCRIPTION

[0008] The present invention concerns a swirl vane disposed in a main distributor line of a distributor for a vapor cycle heat exchanger with a plurality of heat exchanger lines. The swirl vane distributes non-homogeneous mixtures of gas and liquid refrigerant into a rotationally symmetric fluid distribution. A nozzle is located downstream of the swirl vane. The swirl vane ensures that liquid refrigerant entering the nozzle is substantially evenly distributed across a plurality of routing lines, and that the proportion of liquid to gas in each routine line is substantially the same.

[0009] FIG. 1 is a simplified cross-sectional view of heat exchanger system 10, comprising expansion valve 12, refrigerant inlet 14, expansion chamber 16, distributor inlet 18, distributor 20 (with distributor housing 22, main distributor line 24, swirl vane assembly 26, nozzle 28, fluid intersection 30, routing lines 32, and branch sections 34), and heat exchanger 36 (with heat exchanger lines 38, heat exchanger inlets 40).

[0010] Heat exchanger system 10 is portion of a vapor cycle heat exchanger. Heat exchanger 10 can, for example, carry refrigerants fluids such as Freon, CO₂, R134 refrigerants, or other refrigerants. Heat exchanger system 10 can be used in a wide variety of applications, including but not limited to air and electronics cooling. Expansion valve 12 receives liquid or mostly-liquid refrigerant via refrigerant inlet 14. Refrigerant is allowed to expand and evaporate in expansion chamber 16, producing a mixture of liquid and gas that distributor inlet 18 carries to distributor 20. Distributor 20 distributes refrigerant substantially uniformly between a multitude of heat exchanger lines 38 of heat exchanger 36. Each heat exchanger line 38 receives refrigerant from distributor 20 at a corresponding heat exchanger inlet 40.

[0011] Distributor 20 includes distributor housing 22, a rigid structure that extends axially along distributor axis A and forms the structure of distributor 20. Distributor housing 20 can, in some embodiments, be a rigid metal structure formed, for example, of cast aluminum. In other

embodiments, distributor housing 20 can be an injection molded polymer structure. Distributor housing 20 defines main distributor line 24, a substantially axial fluid flow path that carries refrigerant fluid flow F_c . Refrigerant fluid flow F_c contains a mixture of liquid and gas refrigerant, and is initially non-homogeneously distributed within main distributor line 24. The particular proportions of refrigerant fluid in liquid and gas states can vary based on application and refrigerant fluid selection. The initial non-homogeneous distribution of refrigerant fluid flow F_c can, for example, take the form of heavier liquid refrigerant pooling along a bottom portion of main distributor line 24, while coolant gas is correspondingly forced upwards. Swirl vane assembly 26, a flow directing member within main distributor line 24, redistributes the non-homogeneous fluid of refrigerant fluid flow F_c into a substantially symmetric distribution. In at least some embodiments, swirl vane assembly 26 is a rotationally symmetric fan-, helix-, or propeller-shaped guide vane that redistributes refrigerant fluid flow F_c into a rotationally symmetric distribution, as described with respect to FIGs. 3a and 3b. Distributions of refrigerant fluid flow F_c are discussed in greater detail below with respect to FIG. 4. In some embodiments, swirl vane assembly 26 can be formed as an integral part of distributor housing 20. In other embodiments, swirl vane assembly 26 can be an insert that is installed within distributor housing 20, or an overmolded piece about which distributor housing 20 is formed.

[0012] Swirl vane assembly 26 preconditions the non-homogeneous mixture of liquid and gas refrigerant in fluid flow F_c to be substantially symmetrically distributed about axis A. Downstream of swirl vane assembly 26, this preconditioned refrigerant fluid flow F_c passes through nozzle 28. Nozzle 28 is a narrow aperture that forms a neck in main distributor line 24. Refrigerant fluid flow F_c passes through the constrained aperture of nozzle 28 at high speeds, and is thereby atomized. This atomization of refrigerant flow F_c substantially homogenizes liquid and gas distribution immediately downstream of nozzle 28, where main distributor line 24 branches at fluid intersection 30 into a plurality of routing lines 32. Intersection 30 acts as a flow divider, separating refrigerant fluid flow F_c into a plurality of secondary refrigerant flows F_s , one down each routing line 32. Each routing line 32 extends from fluid intersection 30 to a heat exchanger inlet 40 for one of the plurality of heat exchanger lines 38. Further details of the routing path of routing lines 32 are described below with respect to FIG. 2. Routing lines 32 include branch sections 34, which extend axially and radially from fluid intersection 30. Branch sections 34 are circumferentially distributed about axis A at fluid intersection 30. Refrigerant fluid flow F_c is substantially homogeneously distributed at fluid intersection 30: the atomized, symmetrical distribution of refrigerant fluid flow F_c at fluid intersection 30 ensures that substantially equal refrigerant volumes with substantially identical distributions of liquid and gas refrigerant enter each routing line 32 via corresponding branch sections 34. Consequently, all second-

ary refrigerant flows F_s have substantially equal volume, and share substantially the same proportion of liquid to gas as refrigerant fluid flow F_c . Secondary refrigerant flows F_s can subsequently separate (i.e. into liquid and gas layers) downstream of fluid intersection 30, without any impact on the uniformity of fluid distribution across heat exchanger lines 38, or the overall efficiency of heat exchanger 36.

[0013] FIG. 2 is a perspective view of distributor 20, described above with respect to FIG. 1. FIG. 2 illustrates distributor housing 22, routing lines 32, branch sections 34, heat exchanger inlets 40, secondary distribution sections 42, distributor axis A. Distributor housing 20 is transparently to allow routing lines 32 to be seen.

[0014] Distributor 20 operates as described above with respect to FIG. 1, with swirl vane assembly 26 and nozzle 28 ensuring substantially uniform refrigerant distribution across all routing lines 32. Routing lines 32 comprise branch sections 34 and secondary distribution sections 42. In the depicted embodiment, branch sections 32 are distributed circumferentially about axis A, and extend axially and radially from fluid intersection 30 to an axially rear-most portion of distributor housing 22. Secondary distribution sections 42 extend from branch sections 34 to heat exchanger inlets 40. In the depicted embodiment, all heat exchanger inlets 40 are aligned along a heat exchanger line L_{HE} . This embodiment corresponds to an arrangement of heat exchanger lines 38 (e.g. for each vane or fin of heat exchanger 36) along a single plane intersecting distributor housing 22 at heat exchanger line L_{HE} . In alternative embodiments, heat exchanger inlets 40 can be distributed across several locations on distributor housing 22, e.g. where heat exchanger 36 comprises multiple planes of heat exchanger lines. In the illustrated embodiment, secondary distribution sections 42 extend axially and circumferentially from branch sections 34 to heat exchanger inlets 40.

[0015] FIGs 3a and 3b are perspective and cross-sectional views, respectively, of one possible embodiment of swirl vane assembly 26. FIGs. 3a and 3b illustrate flow guide vanes 44 and vane connection 46. In the depicted embodiment, swirl vane assembly 26 comprises two flow guide vanes 44 joined at vane connection 46, and each swirl vane assembly 26 comprises a bent half-moon shape. As shown in FIGs. 3a and 3b, flow guide vanes 44 are bent sections of substantially uniform thickness, and vane connection 46 is a chamfered connection between flow guide vanes 44. In this embodiment, parallel surfaces of flow guide vanes 44 are separated by an axial distance D. Axial distance D is also the spanwise diameter of a circular region R_C of each fluid guide vane 44 conforming to a circular shape, and each fluid guide vane 44 comprises two opposite symmetrically controlled circular and/or oval regions, each covering an angular sweep θ from the center cross-section line. Angular sweep θ can, for example, be 30-60°. More generally, the shape of swirl vane assembly 26 is selected such that refrigerant fluid flow F_c impinging on swirl vane as-

sembly 26 is constrained by fluid guide vanes 44 and by cylindrical walls of distributor housing 22 to conform to a swirling or vortex pattern. Alternative embodiments of swirl vane assembly 26 can, for example, be helical or propeller-shaped. As described above with respect to FIG. 1, the vortex imparted on coolant fluid flow F_c by swirl vane assembly 26 serves to rearrange the asymmetric distribution of non-homogeneous coolant fluid flow F_c upstream of swirl vane assembly 26 into a rotationally symmetric distribution that preconditions refrigerant for increased homogeneity after passing through nozzle 28. In some embodiments, swirl vane assembly 26 can be cast or molded as a single piece, and/or machined into a desired shape. In other embodiments, swirl vane assembly 26 can be formed from multiple pieces (e.g. as separate flow guide vanes 46) welded or otherwise joined together during manufacturing. The particular geometry of swirl vane assembly 26 illustrated in FIGs. 3a and 3b comprises only one possible embodiment, but provides desirable flow characteristics.

[0016] FIG. 4 is a schematic view of distributor 20 illustrating the distribution of refrigerant fluid by swirl vane assembly 26. FIG. 4 also depicts distributor housing 22, main distribution line 24, and distributor axis A. FIG. 4 illustrates the transition of refrigerant fluid flow from a first, asymmetric distribution $Dist_A$ to a second, rotationally symmetrical distribution $Dist_S$. As shown in FIGs. 1 and 4, distributor housing 22 defines a predominantly axial main distributor line 24. Swirl vane assembly 26 is interposed within main distributor line 24, upstream of nozzle 28. Swirl vane assembly 26 imparts a rotational component about axis A on fluid velocity within main distributor line 24, preventing asymmetric pooling of denser liquid or lighter gas in nozzle 28 and fluid intersection 30. Swirl vane assembly 26 and nozzle 28 cooperate to ensure that fluid distribution is uniform across all routing lines 32 branching off of fluid intersection 30. This uniformity takes two forms. First, distributor 20 helps ensure that substantially equal volumes of refrigerant fluid reach each routing line 32. Second, distributor 20 helps ensure that the proportion of liquid to gas is substantially identical in refrigerant reaching each routing line 32. This uniformity promotes efficient operation of heat exchanger 36.

Discussion of Possible Embodiments

[0017] The following are non-exclusive descriptions of possible embodiments of the present invention.

[0018] A distributor for a two-phase refrigerant fluid of a vapor cycle heat exchanger having a plurality of heat exchanger lines, the distributor comprising: a distributor housing defining a main distributor line configured to receive a non-homogeneous flow of the two-phase coolant fluid; a swirl vane disposed within the main distributor line and configured to distribute the non-homogeneous flow into a symmetric fluid distribution; an atomizing nozzle disposed downstream of the swirl vane; a plurality of routing lines, each leading to one of the plurality of heat

exchanger lines; and a fluid line intersection situated downstream of the nozzle, and where the main distributor line branches into the plurality of routing lines.

[0019] The distributor of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

[0020] A further embodiment of the foregoing distributor, wherein the main distributor line is a cylindrical passage extending along a distributor axis.

[0021] A further embodiment of the foregoing distributor, wherein the symmetric fluid distribution is a substantially rotationally symmetric distribution of the two-phase fluid about the distributor axis.

[0022] A further embodiment of the foregoing distributor, wherein the rotationally symmetric distribution comprises a radially outer layer of liquid, and a radially inner core of gas.

[0023] A further embodiment of the foregoing distributor, wherein the routing lines extend axially and radially with respect to the distributor axis, away from the fluid line intersection, and wherein the routing lines are evenly circumferentially distributed about the distributor axis at the fluid line intersection.

[0024] A further embodiment of the foregoing distributor, wherein each routing line extends from the fluid line intersection to a line inlet into one of the plurality of heat exchanger lines, and wherein the line inlets are arranged in a line parallel to the distributor axis.

[0025] A further embodiment of the foregoing distributor, wherein the swirl vane is a helical or propeller-shaped vane.

[0026] A further embodiment of the foregoing distributor, wherein the swirl vane is an integral part of the distributor housing.

[0027] A further embodiment of the foregoing distributor, wherein the swirl vane is a separate component installed within the distributor housing.

[0028] A heat exchanger system comprises: a heat exchanger with a plurality of parallel heat exchanger lines, arranged along a common heat exchanger plane, each heat exchanger line having a line inlet; a distributor housing defining a main distributor line oriented along a distributor axis, and configured to receive a non-homogeneous flow of the two-phase coolant fluid; a swirl vane disposed within the main distributor line and configured to distribute the non-homogeneous flow into a rotationally symmetric fluid distribution about the distributor axis; an atomizing nozzle disposed downstream of the swirl vane; a plurality of routing lines, each leading to one of the line inlets; and a rotationally symmetric fluid line intersection situated downstream of the nozzle, and where the main distributor line branches into the plurality of routing lines.

[0029] The heat exchanger system of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

[0030] A further embodiment of the foregoing heat ex-

changer system, wherein the swirl vane is a helical or propeller-shaped vane.

[0031] A further embodiment of the foregoing heat exchanger system, wherein the line inlets are arranged in a line formed by the intersection of the heat exchanger plane with the heat exchanger housing.

[0032] A further embodiment of the foregoing heat exchanger system, wherein at least one of the distributor housing and the swirl vane is formed of aluminum.

Summation

[0033] Any relative terms or terms of degree used herein, such as "substantially", "essentially", "generally", "approximately" and the like, should be interpreted in accordance with and subject to any applicable definitions or limits expressly stated herein. In all instances, any relative terms or terms of degree used herein should be interpreted to broadly encompass any relevant disclosed embodiments as well as such ranges or variations as would be understood by a person of ordinary skill in the art in view of the entirety of the present disclosure, such as to encompass ordinary manufacturing tolerance variations, incidental alignment variations, alignment or shape variations induced by thermal, rotational or vibrational operational conditions, and the like.

[0034] While the invention has been described with reference to an exemplary embodiment(s), 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 of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. A distributor for a two-phase refrigerant fluid of a vapor cycle heat exchanger having a plurality of heat exchanger lines (38), the distributor comprising:

a distributor housing (22) defining a main distributor line (24) configured to receive a non-homogenous flow of the two-phase coolant fluid;
a swirl vane disposed within the main distributor line (24) and configured to distribute the non-homogeneous flow into a symmetric fluid distribution;
an atomizing nozzle (28) disposed downstream of the swirl vane;
a plurality of routing lines (32), each leading to one of the plurality of heat exchanger lines (38);
and

a fluid line intersection situated downstream of the nozzle, and where the main distributor line branches into the plurality of routing lines.

2. The distributor of claim 1, wherein the main distributor line (24) is a cylindrical passage extending along a distributor axis.
3. The distributor of claim 2, wherein the symmetric fluid distribution is a substantially rotationally symmetric distribution of the two-phase fluid about the distributor axis.
4. The distributor of claim 3, wherein the rotationally symmetric distribution comprises a radially outer layer of liquid, and a radially inner core of gas.
5. The distributor of claim 2, wherein the routing lines (32) extend axially and radially with respect to the distributor axis, away from the fluid line intersection, and wherein the routing lines are evenly circumferentially distributed about the distributor axis at the fluid line intersection.
6. The distributor of claim 2, wherein each routing line extends from the fluid line intersection to a line inlet into one of the plurality of heat exchanger lines (38), and wherein the line inlets are arranged in a line parallel to the distributor axis.
7. The distributor of any preceding claim, wherein the swirl vane is a helical or propeller-shaped vane.
8. The distributor of any preceding claim, wherein the swirl vane is an integral part of the distributor housing.
9. The distributor of any of claims 1 to 7, wherein the swirl vane is a separate component installed within the distributor housing.
10. A heat exchanger system (10) comprises:

a heat exchanger with a plurality of parallel heat exchanger lines (38), arranged along a common heat exchanger plane, each heat exchanger line (38) having a line inlet;
the distributor of any preceding claim, the main distributor line oriented along a distributor axis;
said swirl vane disposed within the main distributor line and configured to distribute the non-homogeneous flow into a rotationally symmetric fluid distribution about the distributor axis;
said plurality of routing lines, each leading to one of the line inlets; and
said fluid line intersection being a rotationally symmetric fluid line intersection situated downstream of the nozzle, and where the main dis-

tributor line branches into the plurality of routing lines.

11. The heat exchanger system of claim 10, wherein the swirl vane is a helical or propeller-shaped vane. 5
12. The heat exchanger system of claim 10 or 11, wherein the line inlets are arranged in a line formed by the intersection of the heat exchanger plane with the heat exchanger housing. 10
13. The heat exchanger system of any of claims 10 to 12, wherein at least one of the distributor housing (22) and the swirl vane is formed of aluminum. 15

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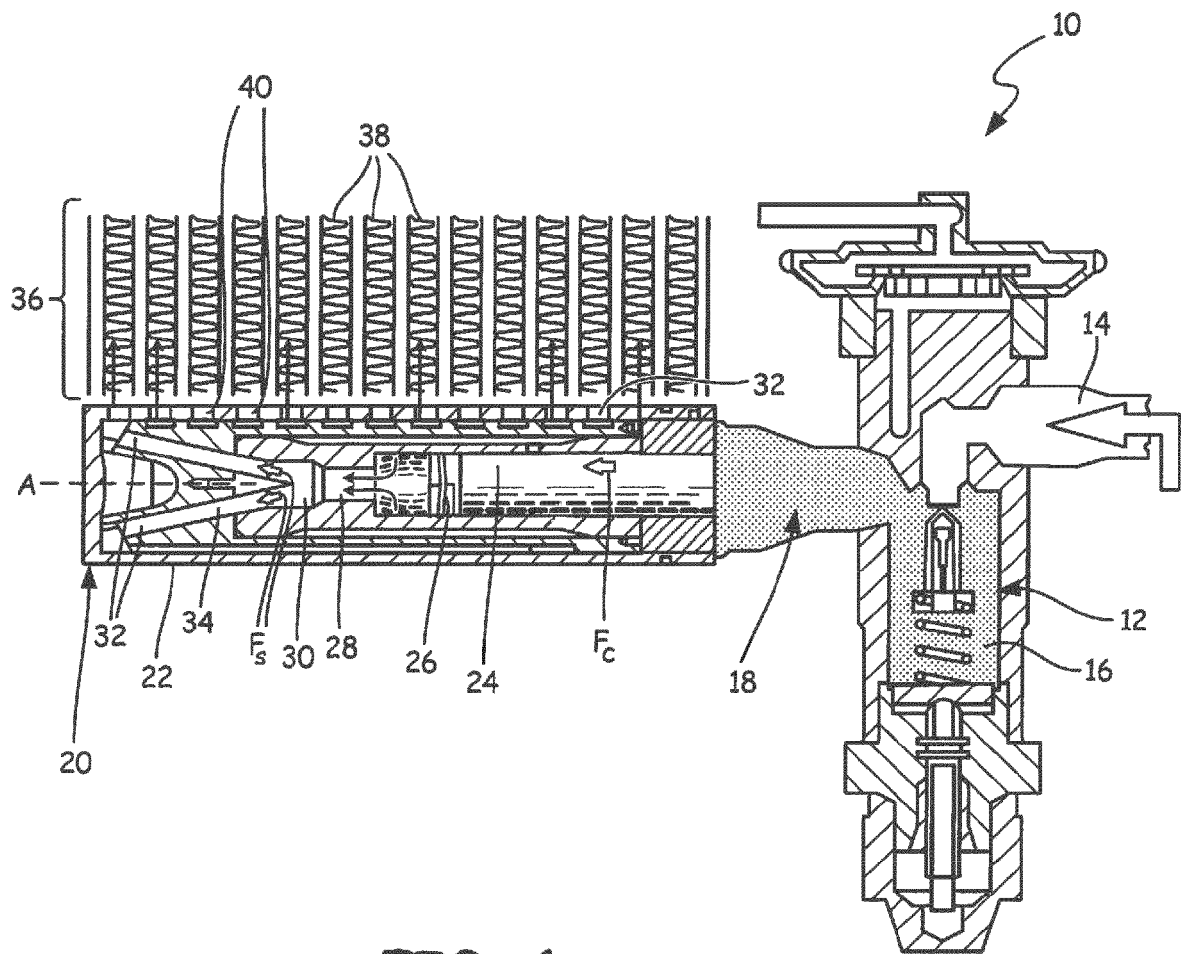


FIG. 1

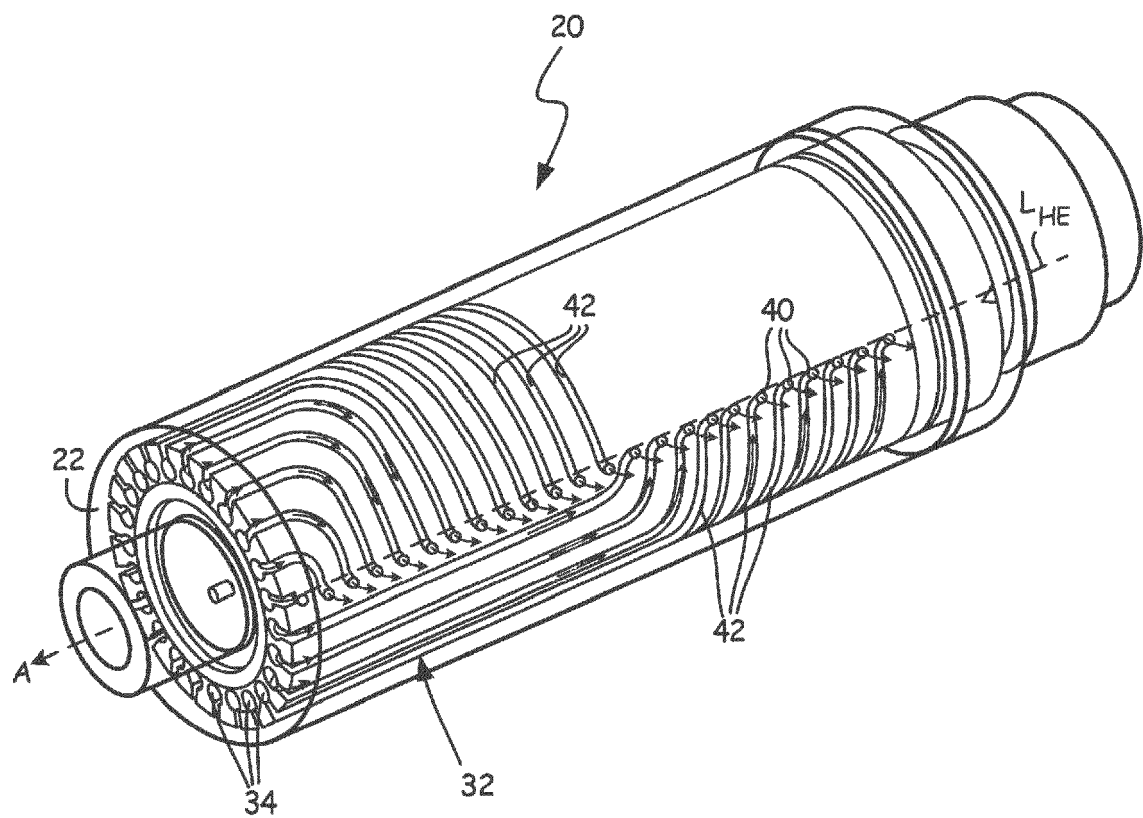


FIG. 2

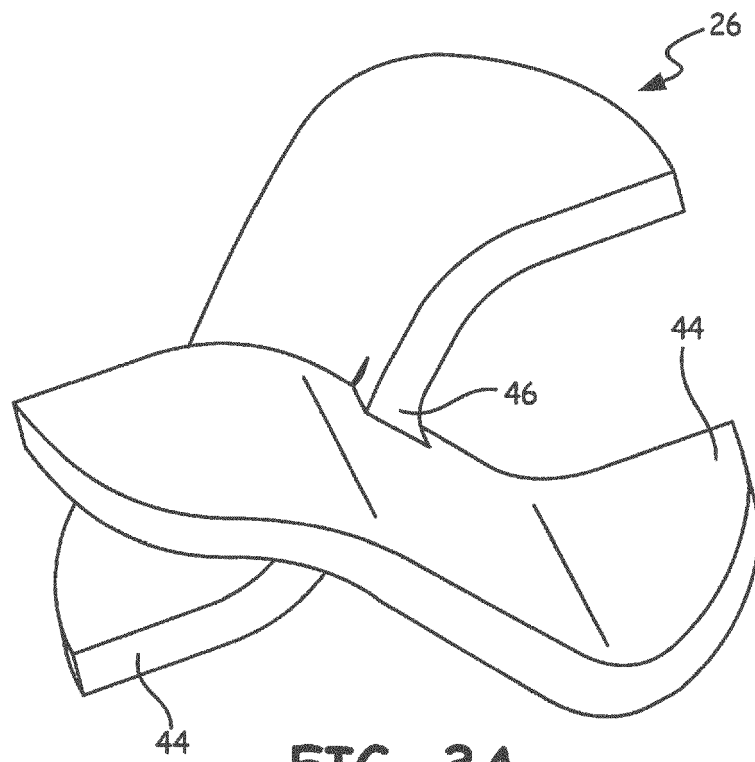


FIG. 3A

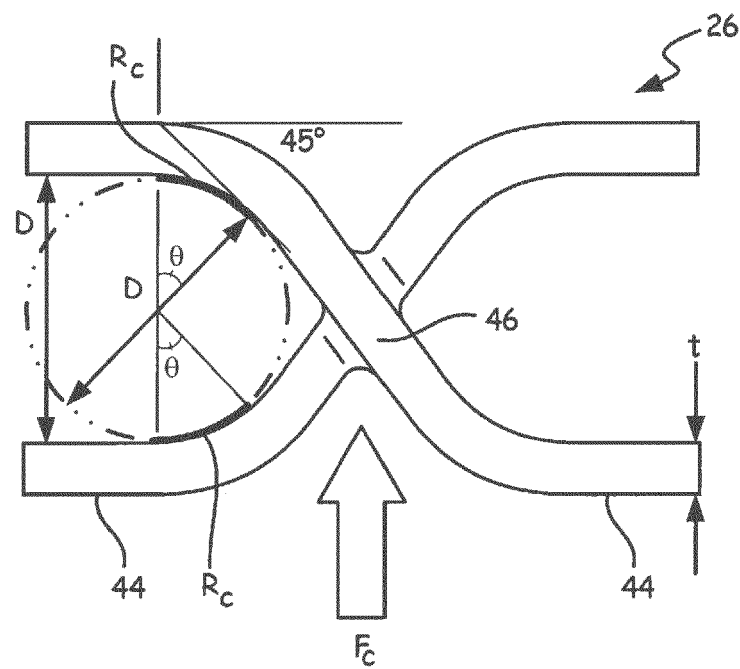


FIG. 3B

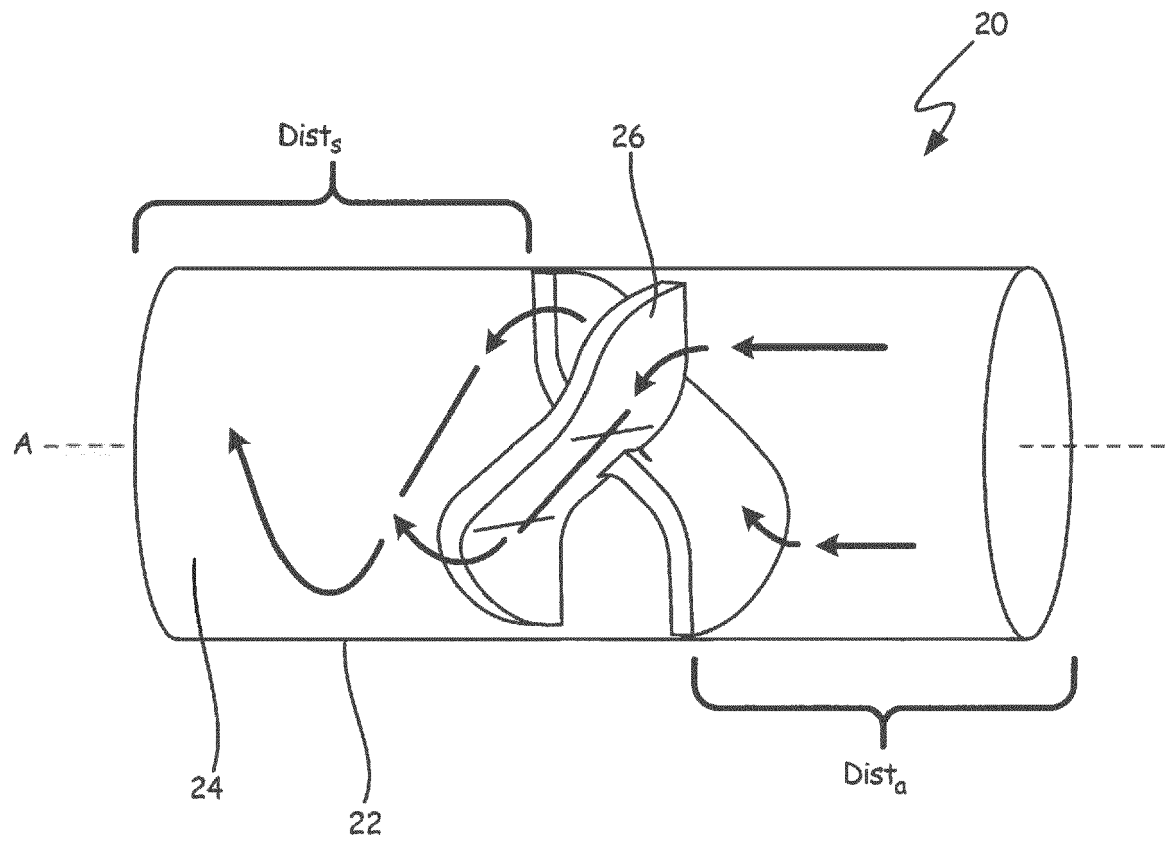


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
EP 16 16 1418

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 August 2016	Examiner Ritter, Christoph
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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