(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 151 650 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.02.2010 Bulletin 2010/06

(51) Int Cl.:
F28D 1/053 *(2006.01)* ***F28F 9/02*** *(2006.01)*

(21) Application number: **09166888.9**

(22) Date of filing: **30.07.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

(30) Priority: **06.08.2008 US 221703**

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(54) Cross-counterflow heat exchanger assembly

(57) A manifold for use in a heat exchanger assembly **(20)** and a method of forming the manifold is disclosed herein. The method starts with the step of separately forming a first member **(22)** at least partially defining an interior and having a spaced set of first tube slots **(30)** and a second member **(32)** having a wall **(36)** positioned against the first tube slots **(30)** and dividing the interior into a plurality of chambers **(38, 40).** The method is finalized with the step of permanently fixing the first member **(22)** to the second member **(32)** to define an first manifold **(42)** after the separately forming step.

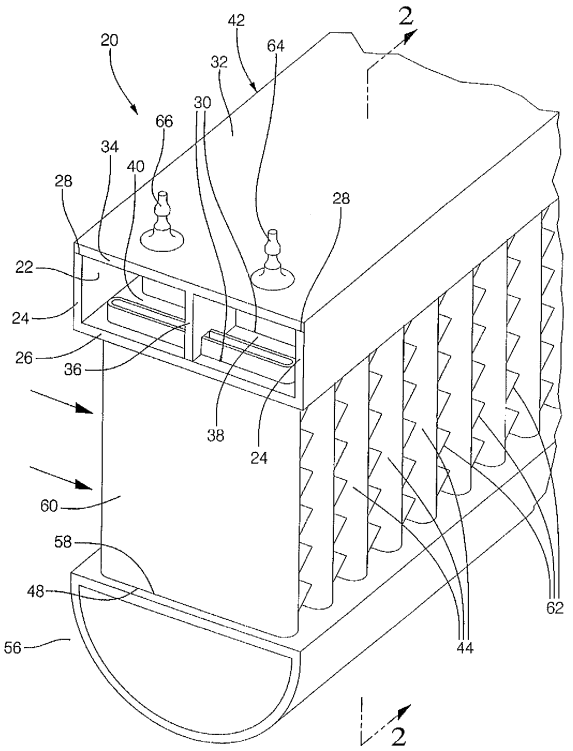

FIG. 1

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Description

Technical Field

[0001] The invention relates to manifolds having multiple passages. More specifically, the invention relates to extruded manifolds with multiple passages and cross-counterflow heat exchangers incorporating such manifolds.

Background of the Invention

[0002] Air-cooling (or heating) cross-counterflow heat exchangers are often used in applications where space limitations restrict the surface area of the heat exchanger. Cross-counterflow heat exchangers typically include a plurality of stacked, assembled modules, with each module including a pair of spaced manifolds interconnected by a plurality of spaced and parallel tubes. The modules are stacked such that air flows in a direction perpendicular to the face of the heat exchanger, and air fins are disposed between adjacent pairs of tubes for transferring heat from the tubes to the passing air.

[0003] Another type of cross-counterflow heat exchanger assembly is shown in US Patent No. 5,941,303, issued to James D. Gowan on August 24, 1998 and hereinafter referred to as Gowan '303. Gowan '303 discloses a cross-counterflow heat exchanger comprising a pair of spaced and continually extruded manifolds. Each of the manifolds includes an interior, and each of the manifolds includes at least one dividing wall to divide the interior into a plurality of flow paths. A plurality of tubes extends and establishes fluid communication between the pair of manifolds. Each of the tubes includes at least one tube divider to separate it into a plurality of passages.

Summary of the Invention

[0004] In summary, the invention provides a manifold for use in a heat exchanger assembly and a method of forming the manifold. The method starts with the step of separately forming a first member at least partially defining an interior and having a spaced set of first tube slots and a second member having a wall positioned against the first tube slots and dividing the interior into a plurality of chambers. The method is finalized with the step of permanently fixing the first member to the second member to define a first manifold after the separately forming step.

Brief Description of the Drawings

[0005] Advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0006] Figure 1 is a perspective and exploded view of the exemplary embodiment of the invention;

[0007] Figure 2 is a cross-sectional view of the first and second manifolds and the tubes taken along line 2-2 of Figure 1;

[0008] Figure 3 is a front view of the first member of the exemplary embodiment of the invention;

[0009] Figure 4 is a front view of the second member of the exemplary embodiment of the invention; and

[0010] Figure 5 is a cross-sectional view of one of the tubes taken along line 5-5 of Figure 2.

Description of the preferred embodiment

[0011] Referring to Figure 1, a heat exchanger assembly **20** is generally shown and includes a first member **22** at least partially defining an interior. Referring to Figure 3, in the exemplary embodiment, the first member **22** is a channel having a cross-section defining a U-shape and presenting arms **24** integrally connected to a base **26** and extending forwardly to arm ends **28.** Referring again to Figure 1, the base **26** of the first member **22** presents a plurality of first tube slots **30** longitudinally spaced from one another. The first tube slots **30** can be formed by conventional machining methods including stamping, grinding, or milling.

[0012] Referring to Figure 2, the assembly **20** includes a second member **32** comprising a plate **34** and a wall **36** extending transversly to the plate **34.** The plate **34** extends between and engages the arm ends **28** of the first member **22** and the wall **36** engages the base **26** of the first member **22** to divide the interior into a plurality of chambers **38, 40.** Referring again to Figure 1, the second member **32** includes a plurality of notches being spaced to correspond with the first tube slots **30** of the first member **22.** The second member **32** is permanently fixed to the first member **22** to define an first manifold **42,** which is generally indicated. In the exemplary embodiment, the second member **32** is brazed to the first member **22,** but any other method of permanently fixing the first and second members **22, 32** may also be used.

[0013] Other geometries for the first and second members **22, 32** may be used and are meant to be included in the scope of the invention. For example, the first member may be a flat shield presenting a plurality of first tube slots, and the second member may include a flat plate extending in spaced and parallel relationship with the first member and having a plurality of arms extending transversely therebetween to define an interior divided into a plurality of chambers. The first member may also be cylindrically shaped and present a unified interior defining a plurality of first tube slots. The second member would then be inserted into the first member to divide the unified interior into a plurality of chambers.

[0014] The assembly **20** also includes a plurality of tubes **44** extending between first and second tube ends **46, 48.** The first tube end **46** of each tube **44** is disposed in one of the first tube slots **30** of the first manifold **42.** Referring to Figure 5, each tube **44** defines at least one

tube divider **50** disposed in the tube **44** and extending between the first and second tube ends **46, 48** to define a first passage **52** in fluid communication with one of the chambers **38, 40** and a second passage **54** in fluid communication with the other of the chambers **38, 40.** The tube divider **50** at the first tube end **46** abuts and is permanently fixed to the wall **36** of the second member **32.**

[0015] The assembly **20** further includes a second manifold **56** extending in spaced and parallel relationship with the first manifold **42.** The second manifold **56** presents a plurality of second tube slots **58** spaced from each other to correspond with the spacing of the first tube slots **30** of the first manifold **42.** The second tube end **48** of each tube **44** extends into and engages the corresponding second tube slot **58** to establish fluid communication between the tubes **44** and the second manifold **56.** The second manifold **56** directs the flow of coolant from one of the passages **52, 54** of the tubes **44** to the other to define a two-pass cross-counterflow heat exchanger assembly **20.**

[0016] In the exemplary embodiment, the tubes **44** and the first and second tube slots **30, 58** each have a cross-section presenting flat sides **60** and round ends. However, the tubes **44** may be have any shape capable of transmitting a fluid between the first and second manifolds **42, 56.** The flat sides **60** of adjacent tubes **44** are spaced from one another to define a plurality of air passages for the flow of air therebetween. A corrugated air fin **62** is disposed between and brazed to the parallel flat sides **60** of adjacent tubes **44** and extends between the first and second manifolds **42, 56.**

[0017] One of the chambers **38, 40** of the first manifold **42** includes an input **64** to define an input chamber **38** for receiving a fluid, and the other of the chambers **38, 40** includes an output **66** to define an output chamber **40** for dispensing the coolant after it has passed through the heat exchanger assembly **20.** In the preferred embodiment, the input **64** is disposed on the chamber that is downstream of the direction of the flow of air and the output **66** is disposed on the chamber upstream of the input chamber **38.** The input **64** and output **66** may have any shape capable of delivering a fluid to the input and output chambers **38, 40** of the first manifold **42.**

[0018] The embodiment shown in the drawings is for a two-pass counter crossflow heat exchanger assembly. However, the manifolds and tubes may be designed to allow for more than two passes by inserting walls in either or both of the first and second manifolds and including a plurality of tube dividers in each tube. For example, in a three-pass heat exchanger assembly, the second member has one wall to divide the first manifold into two chambers, the second manifold has one wall, and each tube has two tube dividers.

[0019] The invention also includes a method of forming a first manifold **42** for use in a heat exchanger assembly **20.** The method starts with the step of separately forming a first member **22** at least partially defining an interior and a second member **32.** The first member **22** has a spaced set of first tube slots **30** and the second member **32** has a wall **36** that is positioned against the first tube slots **30** to divide the interior into a plurality of chambers **38, 40.** The method continues with the step of permanently fixing the first member **22** to the second member **32** to define a first manifold **42** after the separately forming step. The second member **32** is preferably extruded and then cut to size, but may also be formed by other methods including casting and machining. In one embodiment, the forming the first member **22** is further defined as rolling a flat sheet of material into a channel having a cross-section presenting a U-shape and having a base **26** and arms **24** extending forwardly to arm ends **28.** Rolling the first member **22** from a flat sheet provides advantages because the flat sheet can be a stock sheet of metal with a brazing material pre-disposed on either side of it. The brazing material then may be used for the step of permanently fixing the first member **22** to the second member **32.**

[0020] The method proceeds with the step of forming a plurality of tubes **44** extending between first and second tube ends **46, 48.** The method then continues with the step of forming a tube divider **50** extending between the first and second tube ends **46, 48** in each of the tubes **44** to separate each tube **44** into a first passage **52** and a second passage **54.** Referring to Figure 5, in one embodiment, the forming each tube **44** is further defined by rolling a flat sheet of material into a tube **44** defining a tube divider **50.** Rolling each tube **44** from a flat sheet provides advantages because the flat sheet can be a stock sheet of metal having a pre-disposed brazing material on either side of it. The bazing material may then later be used for the step of fixing and sealing the tube ends **46, 48** to the first and second tube slots **30, 58** of the manifolds **42, 56.** However, any other method of forming the tube divider **50** may also be used.

[0021] The method continues with the step of inserting the first tube end **46** of each tube **44** into one of the first tube slots **30** of the first manifold **42** and abutting the divider of each tube **44** against the wall 36 of the second member **32** to establish fluid communication between the first passage **52** of the tubes **44** and one of the chambers **38, 40** of the first manifold **42** and to establish fluid communication between the second passage **54** of the tubes **44** and the other of the chambers **38, 40** of the first manifold **42.** The first tube end **46** of each tube **44** is then permanently fixed to the associated first tube slot **30** first manifold **42.**

[0022] The method further continues with the step of forming a second manifold **56** having a set of second tube slots **58** being spaced from each other to correspond with the set of first tube slots **30** of the first manifold **42.** The method proceeds with the step of inserting the second tube end **48** of each of the tubes **44** into the corresponding second tube slot **58** of the second manifold **56** to establish fluid communication between the first and second passages **52, 54** of each tube **44** and the second manifold **56.**

[0023] The method is finished with the steps of forming a plurality of air fins **62** and inserting one of the air fins **62** between adjacent tubes **44** to dissipate heat from the tubes **44.** In the exemplary embodiment, the tubes **44,** manifold, and air fins **62** are all brazed together to define a unified heat exchanger assembly **20.**

[0024] The subject invention provides for a manifold and a cross-counterflow heat exchanger assembly **20** that is both cheaper and quicker to manufacture than those of the prior art. Many of the traditional methods for forming the tube slots in the first manifold of the Gowan '303 patent must be abandoned in order to avoid interfering with the dividing wall of the first manifold. The first tube slots of the Gowan '303 patent must be milled or grinded, either of which is a very time consuming and costly process. The first tube slots **30** of the present invention may be formed in the first member **22** using a variety of manufacturing methods including stamping before the step of permanently fixing the first and second members **22, 32** together. This leads to significantly greater manufacturing efficiency, thereby reducing the cost and time to assemble the first manifold **42** and of the heat exchanger assembly **20.**

[0025] While the invention has been described with reference to an exemplary embodiment, 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 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 appended claims.

Claims

1. A method of forming a manifold for use in a heat exchanger assembly **(20)** including the steps of:

separately forming a first member **(22)** at least partially defining an interior and having a spaced set of first tube slots **(30)** and a second member **(32)** having a wall **(36)** positioned against the first tube slots **(30)** and dividing the interior into a plurality of chambers **(38, 40);** and
permanently fixing the first member **(22)** to the second member **(32)** to define a first manifold **(42)** after the separately forming step.

2. The method as set forth in claim 1 wherein the forming the first member **(22)** is further defined as rolling a flat sheet of material into a channel having a cross-section presenting a U-shape presenting a base **(26)** and arms **(24)** extending forwardly to arm ends **(28).**

3. The method as set forth in claim 1 further including the steps of:

forming a plurality of tubes **(44)** extending between first and second tube ends **(46, 48),** wherein the forming each tube **(44)** is further defined by rolling a flat sheet of material into a tube **(44)** defining a tube divider **(50),**
forming a tube divider **(50)** extending between the first and second tube ends **(46, 48)** in each of the tubes **(44)** to separate each tube **(44)** into a first passage **(52)** and a second passage **(54),**
inserting the first tube end **(46)** of each tube **(44)** into one of the first tube slots **(30)** of the first manifold **(42)** and abutting the tube divider **(50)** of each tube **(44)** against the wall **(36)** to establish fluid communication between the first passage **(52)** of the tubes **(44)** and one of the chambers **(38, 40)** of the first manifold **(42)** and to establish fluid communication between the second passage **(54)** of the tubes **(44)** and the other of the chambers **(38, 40)** of the first manifold **(42).**

4. The method as set forth in claim 3 further including the steps of:

forming a second manifold **(56)** having a set of spaced second tube slots **(58)** to correspond with the set up first tube slots **(30)** of the first manifold **(42).**
inserting the second tube end **(48)** of each of the tubes **(44)** into the corresponding second tube slot **(58)** of the second manifold **(56)** to establish fluid communication between the first and second passages **(52, 54)** of each tube **(44)** and the second manifold **(56).**

5. An assembly **(20)** manufactured according to the method of claim 1.

6. The assembly **(20)** as set forth in claim 5 wherein said first member **(22)** extends longitudinally and said first tube slots **(30)** are longitudinally spaced from each other.

7. The assembly **(20)** as set forth in claim 5 wherein said first member **(22)** is a channel having a cross-section defining a U-shape and presenting arms **(24)** integrally connected to a base **(26)** and extending forwardly to arm ends **(28).**

8. The assembly **(20)** as set forth in claim 7 wherein said second member **(32)** includes a plate **(34)** extending between said arm ends **(28)** of said channel and said wall **(36)** extends transversely from said plate **(34)** to said tube slots **(30, 58)** of said channel.

9. The assembly **(20)** as set forth in claim 5 further comprising:

an input **(64)** disposed on one of said chambers **(38, 40)** to receive a fluid and to define an input chamber **(38)** and an output **(66)** disposed on the other of said chambers **(38, 40)** to dispense the fluid and to define an output chamber **(40).**

10. The assembly **(20)** as set forth in claim 11 further comprising:

a plurality of tubes **(44)** extending between first and second tube ends **(46, 48);**
said first tube end **(46)** of each of said tubes **(44)** is disposed in one of said first tube slots **(30)** of said first manifold **(42),**
wherein each of said tubes (44) defines a tube divider (50) extending between said first and second tube ends (46, 48) to define a first passage (52) in fluid communication with one of said chambers (38, 40) of said first manifold (42) and a second passage (54) in fluid communication with the other of said chambers (38, 40); and
said tube divider **(50)** at said first tube end **(46)** abuts said wall **(36)** of said second member **(32).**

11. The assembly **(20)** as set forth in claim 10 further comprising:

a second manifold **(56)** extending in spaced and parallel relationship with said first manifold **(42)** and end engaging said second tube ends **(48)** of said plurality of tubes **(44)** to establish fluid communication between said first and second passages **(52, 54)** of said tubes **(44)** and said second manifold **(56).**

12. The assembly **(20)** as set forth in claim 11 wherein said second manifold **(56)** defines a plurality of second tube slots **(58)** spaced from each other to correspond with said first tube slots **(30)** of said first manifold **(42),** and
said second end of each of said tubes **(44)** extends into said corresponding second tube slot **(58).**

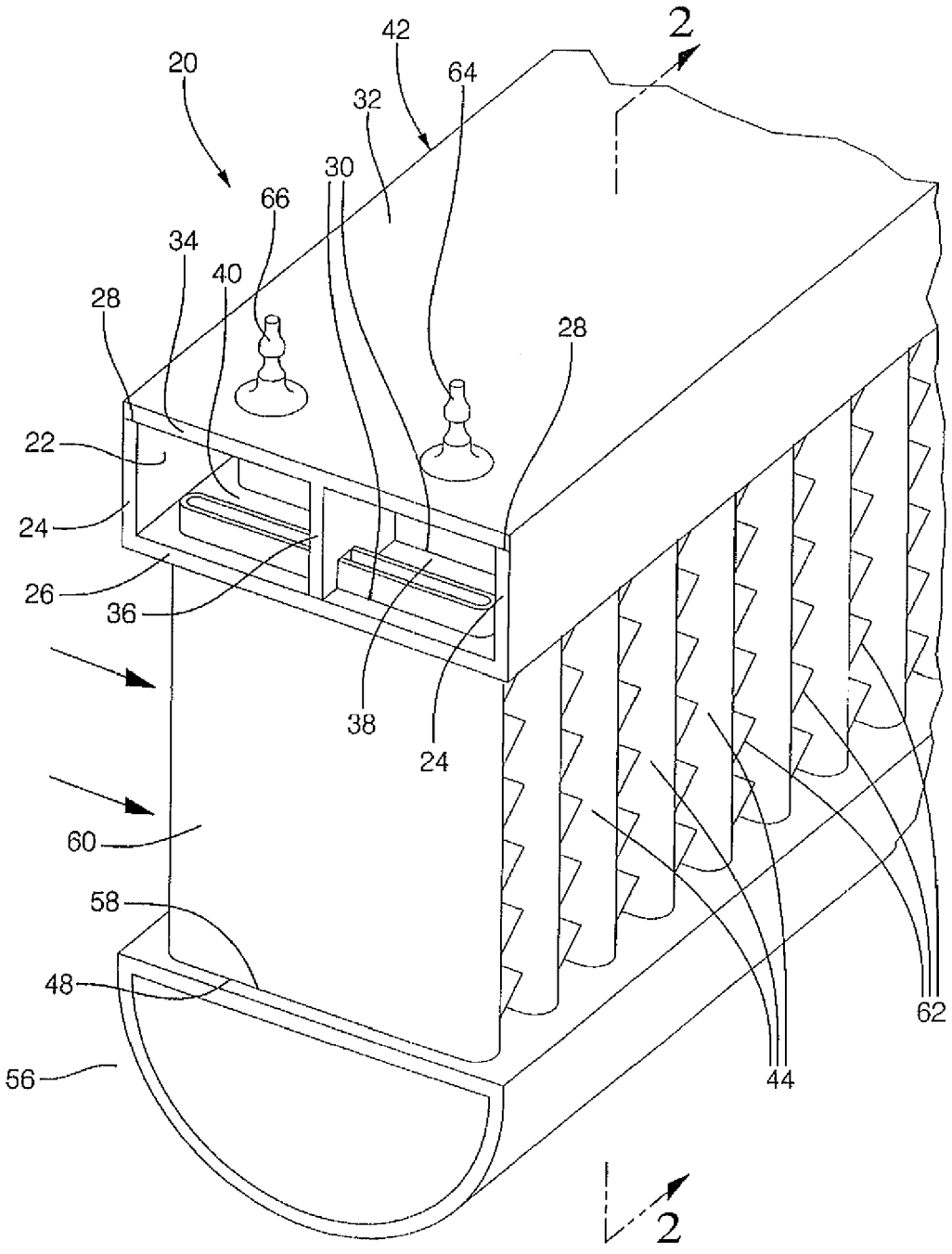

FIG. 1

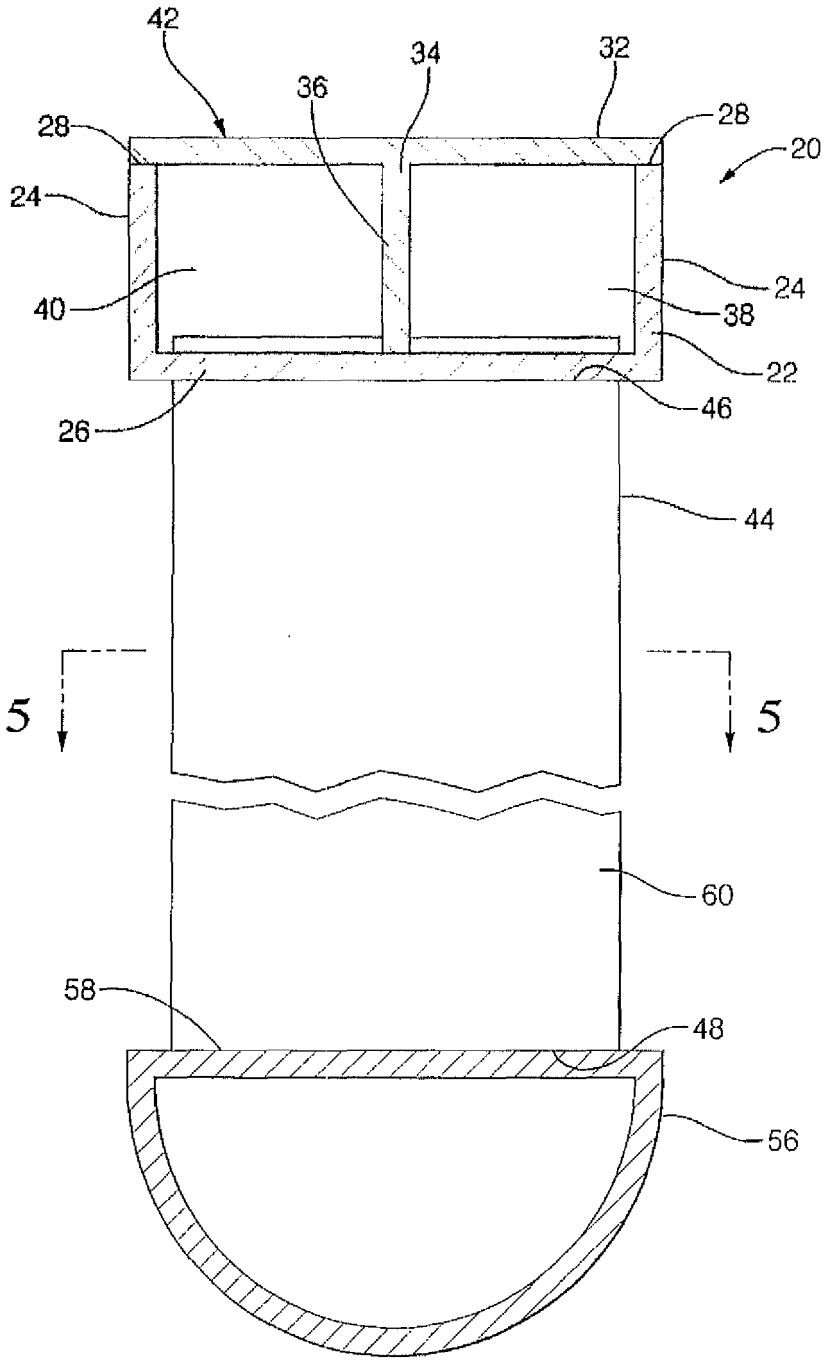

FIG. 2

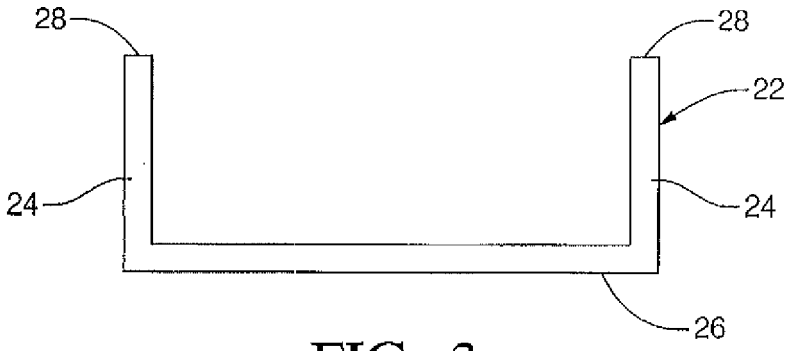

FIG. 3

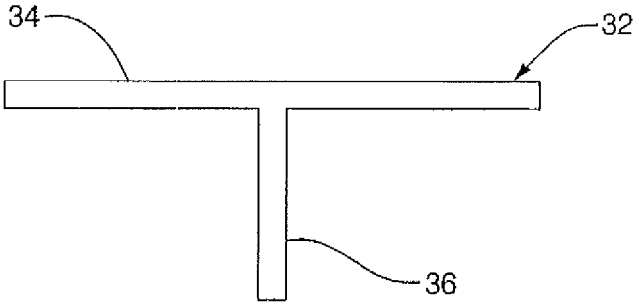

FIG. 4

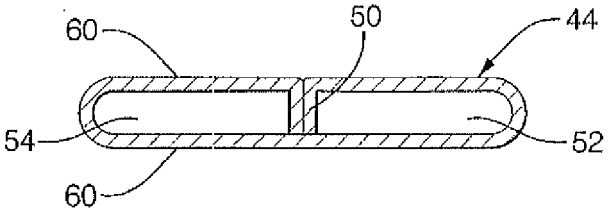

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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