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(54) **Manifold with multiple passages and crosscounterflow heat exchanger incorporating the same**

(57) A manifold (22) having multiple chambers for use in a cross-counterflow heat exchanger assembly (20) includes a first member (24) having arms (26) extending from a base (28) to arm ends (30). A second member (42) is secured to the first member to define the manifold. The second member includes an inner plate edge (50) that defines a first mating surface (54) that extends inwardly along the inner plate edge from each of the plate ends to mate with the arm ends (30). A wall (46) extends transversely to the inner plate edge to a wall end (56). The wall end mates with an inner base surface (34) to divide the interior of the manifold into a plurality of chambers (58,60). At least one lip (64) extends transversely to the inner plate edge to define a second mating surface that extends perpendicularly from the first mating surface and mates with an inner arm surface of the arms.

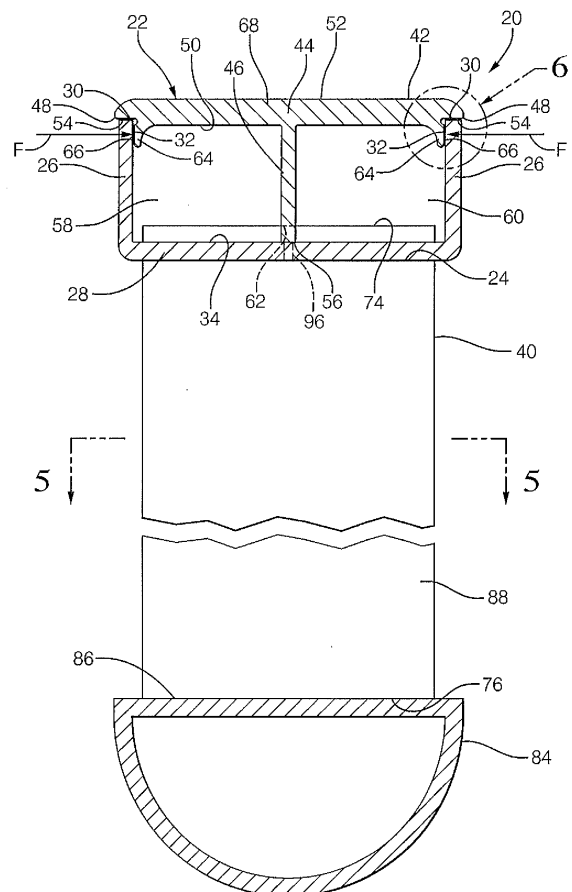


FIG. 2

Description

TECHNICAL FIELD

[0001] The invention relates to manifolds having multiple chambers. More specifically, the invention relates to extruded manifolds with multiple chambers 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, 1999 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 having multiple chambers for use in a cross-counterflow heat exchanger assembly. The manifold includes a first member having arms extending from a base to arm ends. A second member is secured to the first member to define the manifold. The second member includes an inner plate edge that defines a first mating surface that extends inwardly along the inner plate edge from each of the plate ends to mate with arm ends. A wall extends transversely to the inner plate edge to a wall end. The wall end mates with an inner base surface to divide the interior of the manifold into a plurality of chambers. At least one lip extends transversely to the inner plate edge to define a second mating surface that extends perpendicularly from the first mating surface and mates with an inner arm surface of the arms.

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 partial view of the exemplary embodiment of the invention;

[0007] Figure 2 is a cross-sectional view of the manifold, return manifold and the tubes taken along line 2-2 of Figure 1;

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

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

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

[0011] Figure 6 is an enlarged view of the lip taken from section 6 of Figure 2; and

[0012] Figure 7 is a perspective view of the manifold of the exemplary embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an exemplary heat exchanger assembly **20** is generally shown.

[0014] The exemplary heat exchanger assembly **20** includes a manifold **22** generally indicated having a first member **24** at least partially defining an interior. Referring to Figure 3, in an exemplary embodiment, the first member **24** is a longitudinally extending channel having a cross-section defining a U-shape and presenting arms **26** integrally connected to a base **28** and extending forwardly to arm ends **30**. Each of the arms **26** include an inner arm surface **32** and an outer arm surface. Each of the arms **26** include a stress therein to cant the arm ends **30** toward one another.

[0015] Referring to Figures 1 and 3, the base **28** of the first member **24** includes an inner base surface **34** and the base **28** presents a plurality of first tube slots **36** longitudinally spaced from one another. The base **28** further defines at least one opening **38** that is disposed between adjacent first tube slots **36**. The opening **38** is generally circular in cross section but may be any shape known in art. Additionally, while the exemplary embodiment shows the opening **38** being disposed between adjacent first tubes **40** slot, the opening **38** may be disposed in the area between the first tube slot **36** and the end of the first member **24**. The first tube slots **36** and at least one opening **38** may be formed by conventional machining methods including stamping, grinding, or milling.

[0016] Referring to Figure 2, the assembly includes a second member **42** having a plate **44** and a wall **46** extending transversely to the plate **44**. The second member **42** has a cross section that defines a T-shape. The plate **44** extends between plate ends **48**, and transversely between an inner plate edge **50** and an outer plate edge **52**. The inner plate edge **50** defines a first mating surface

54 that extends inwardly along the inner plate edge **50** from each of the plate ends **48** to mate with arm ends **30**. The wall **46** extends transversely to the inner plate edge **50** of the plate **44** to a wall end **56**. The wall end **56** is contoured to conform with the inner base surface **34** for positioning the wall end **56** against the inner base surface **34** and the first tube slots **36** to divide the interior of the manifold **22** into a plurality of chambers **58, 60**. The wall end **56** of the second member **42** defines a plurality of notches **62** being spaced to correspond with the first tube slots **36** of the first member **24**.

[0017] The wall **46** includes at least one locking arm **96** that extends outwardly from the wall end **56** to mate with at least one opening **38**. The locking arm **96** secures the second member **42** to the first member **24**. The locking arm **96** is generally circular in cross section, but may be any shape known in the art.

[0018] The subject invention is distinguished by at least one lip **64** that extends transversely to the inner plate edge **50** to define a second mating surface **66**, and thus creating a boot shape as seen in Figure 4. The second mating surface **66** extends perpendicularly from the first mating surface **54** and mates with the inner arm surface **32** of the arms **26**. The canted arms **26** of the first member **24** create a clamping force **F** on the second mating surface **66** of the lip **64** to temporally securing the second member **42** to the first member **24** before brazing the first and second members **24, 42** together. The second member **42** is then permanently fixed to the first member **24** to form the manifold **22**. In the exemplary embodiment, the second member **42** is brazed to the first member **24**, but any other method of permanently fixing the first and second members **24, 42** may also be used. The manifold **22** extends longitudinally between first and second manifold ends **68, 70**. The second member **42** defines a longitudinally extending groove **72** that extends between the first and second mating surfaces **54, 66** for accommodating a burr between the first and second members **24, 42**.

[0019] Prior to brazing the first member **24** to the second member **42** to a cap **98** is disposed on each of the first and second manifold ends **68, 70** of the manifold **22**. In addition to the clamping force **F** of the first member **24** on the second member **42**, the cap **98** temporally secures the manifold **22** prior to being permanently secured.

[0020] The heat exchanger assembly **20** further includes a plurality of tubes **40** extending between first and second tube ends **74, 76**. The first tube end **74** of each tube **40** is disposed in one of the first tube slots **36** of the manifold **22**. Referring to Figure 5, each tube **40** defines at least one tube divider **78** disposed in the tube **40** and extending between the first and second tube ends **74, 76** to define a first passage **80** in fluid communication with one of the chambers **58, 60** of the manifold **22** and a second passage **82** in fluid communication with the other of the chambers **58, 60** of the manifold **22**. The tube divider **78** at the first tube end **74** abuts and is permanently fixed to the notches **62** in the wall end **56** of the

second member **42**.

[0021] The assembly further includes a return manifold **84** extending in spaced and parallel relationship with the manifold **22**. The return manifold **84** presents a plurality of second tube slots **86** longitudinally spaced from each other to correspond with the spacing of the first tube slots **36** of the manifold **22**. The second tube end **76** of each tube **40** extends into and engages the corresponding second tube slot **86** to establish fluid communication between the tubes **40** and the return manifold **84**. The return manifold **84** directs the flow of coolant from one of the passages of the tubes **40** to the other of the passages to define a two-pass cross-counterflow heat exchanger assembly **20**. In an exemplary embodiment, the return manifold **84** is D-shaped to direct the flow of coolant from the one passages of the tubes **40** to the other passage of the passages, but the return manifold **84** may be any shape known in the art.

[0022] In the exemplary embodiment, the tubes **40** and the first and second tube slots **36, 86** each have a cross-section presenting parallel flat sides **88** that extend between round ends. However, the tubes **40** may be have any shape capable of transmitting a fluid between the first and second manifold **22**. The flat sides **88** of adjacent tubes **40** are spaced from one another to define a plurality of air passages for the flow of air therebetween. A corrugated air fin **90** is disposed between and brazed to the parallel flat sides **88** of adjacent tubes **40** and extends between the first and return manifolds **22, 84** for dissipating heat from the tubes **40**.

[0023] One of the chambers **58, 60** of the manifold **22** includes an input **92** in communication with an input chamber **58** for receiving a fluid, and an output **94** in communication with an output chamber **60** for dispensing the coolant after it has passed through the heat exchanger assembly **20**. In an exemplary embodiment, the input **92** is disposed on the input chamber **58** that is downstream of the direction of the flow of air and the output **94** is disposed on the output chamber **60** upstream of the input chamber **58**. The input **92** and output **94** may have any shape capable of delivering a fluid to the input chamber **58** and output chamber **60** of the manifold **22**.

[0024] 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 return 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 manifold into two chambers, the return manifold has one wall, and each tube has two tube dividers.

[0025] The invention also includes a method of forming a manifold **22** for use in a heat exchanger assembly **20**. The method starts with the step of separately forming a first member **24** at least partially defining an interior and a second member **42**. The first member **24** has a spaced set of first tube slots **36** and the second member **42** has

a wall **46** that is positioned against the first tube slots **36** to divide the interior into a plurality of chambers **58, 60**.

[0026] Next, the first member **24** is temporally secured to the second member **42**. The arm ends **30** of the first member **24** are rolled to be canted toward one another. This creates a stress in the arms **26** of the first member **24** so that when the inner arm surface **32** of the first member **24** is brought into contact with the second mating surface **66** of the lip **64** of the second member **42**, the first member **24** will be secured to the second member **42**.
[0027] The method may further include the step of placing a cap **98** on each of the first and second manifold ends **68, 70**. The shape of the cap **98** is contoured to mate with the outer periphery of the first and second manifold ends **68, 70**. The cap **98** temporally secures the first member **24** to the second member **42** by the clamping force **F**.

[0028] The method continues with the step of permanently fixing the first member **24** to the second member **42** to define a manifold **22** after the temporally securing step. The second member **42** 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 **24** 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 **28** and arms **26** extending forwardly to arm ends **30**. Rolling the first member **24** 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 **24** to the second member **42**.

[0029] The method proceeds with the step of forming a plurality of tubes **40** extending between first and second tube ends **74, 76**. The method then continues with the step of forming a tube divider **78** extending between the first and second tube ends **74, 76** in each of the tubes **40** to separate each tube **40** into a first passage **80** and a second passage **82**. Referring to Figure 5, in one embodiment, the forming each tube **40** is further defined by rolling a flat sheet of material into a tube **40** defining a tube divider **78**. Rolling each tube **40** 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 brazing material may then later be used for the step of fixing and sealing the tube ends **74, 76** to the first and second tube slots **36, 86** of the manifolds **22, 84**. However, any other method of forming the tube divider **78** may also be used.

[0030] The method continues with the step of inserting the first tube end **74** of each tube **40** into one of the first tube slots **36** of the manifold **22** and abutting the divider of each tube **40** against the wall **46** of the second member **42** to establish fluid communication between the first passage **80** of the tubes **40** and one of the chambers **58, 60** of the manifold **22** and to establish fluid communication between the second passage **82** of the tubes **40** and the

other of the chambers **58, 60** of the manifold **22**. The first tube end **74** of each tube **40** is then permanently fixed to the associated first tube slot **36** manifold **22**.

[0031] The method further continues with the step of forming a return manifold **84** having a set of second tube slots **86** being spaced from each other to correspond with the set of first tube slots **36** of the manifold **22**. The method proceeds with the step of inserting the second tube end **76** of each of the tubes **40** into the corresponding second tube slot **86** of the return manifold **84** to establish fluid communication between the first and second passages **80, 82** of each tube **40** and the return manifold **84**.

[0032] The method is finished with the steps of forming a plurality of air fins **90** and inserting one of the air fins **90** between adjacent tubes **40** to dissipate heat from the tubes **40**. In the exemplary embodiment, the tubes **40**, manifold **22**, and air fins **90** are all brazed together to define a unified heat exchanger assembly **20**.

[0033] 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. Additionally, the exemplary embodiment provides a more sturdy structure prior to and following brazing. Many of the traditional methods for forming the tube slots in the manifold of the Gowan '303 patent must be abandoned in order to avoid interfering with the dividing wall of the 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 **36** of the present invention may be formed in the first member **24** using a variety of manufacturing methods including stamping before the step of permanently fixing the first and second members **24, 42** together. This leads to significantly greater manufacturing efficiency, thereby reducing the cost and time to assemble the manifold **22** and of the heat exchanger assembly **20**.

[0034] 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 manifold (**22**) for use in a heat exchanger assembly (**20**) comprising:

a first member (**24**) presenting arms (**26**) integrally connected to a base (**28**) having an inner

- base surface (34), each of said arms (26) having an inner arm surface (32) and extending from said base (28) to an arm end (30);
a second member (42) secured to said first member (24) to define said manifold (22), said second member (42) having a plate (44) extending between plate ends (48) and between an inner plate edge (50) and an outer plate edge (52), and said inner plate edge (50) defining a first mating surface (54) extending inwardly along said inner plate edge (50) from each of said plate ends (48) to mate with arm ends (30);
a wall (46) extending transversely to said inner plate edge (50) of said plate (44) to a wall end (56), said wall end (56) mating with said inner base surface (34) to divide the interior of said manifold (22) into a plurality of chambers (58, 60); and
at least one lip (64) extending transversely to said inner plate edge (50) of said second member (42) to define a second mating surface (66) that extends perpendicularly from said first mating surface (54) and mates with said inner arm surface (32) of said arms (26).
2. The manifold (22) as set forth in claim 1 wherein each of said arms (26) includes a stress therein to cant said arm ends (30) toward one another and wherein said canted arms (26) create a clamping force (F) on said second mating surface (66) of said lip (64) for temporally securing said second member (42) to said first member (24).
 3. The manifold (22) as set forth in claim 1 wherein said base (28) defines a plurality of longitudinally spaced first tube slots (36) and at least one opening (38) disposed between adjacent ones of said first tube slots (36).
 4. The manifold (22) as set forth in claim 3 wherein said wall end (56) is contoured to conform with said inner base surface (34) for positioning said wall end (56) against said inner base surface (34) and said first tube slots (36).
 5. The manifold (22) as set forth in claim 4 wherein said wall end (56) of the second member (42) defines a plurality of notches (62) being spaced to correspond with said first tube slots (36) of said first member (24).
 6. The manifold (22) as set forth in claim 3 wherein said wall (46) includes at least one locking arm (96) extending from said wall end (56) to mate with said at least one opening (38) to secure said second member (42) to said first member (24).
 7. The manifold (22) as set forth in claim 1 wherein said manifold (22) extends longitudinally between first and second manifold ends (68, 70), and wherein said manifold includes a cap (98) disposed at each of said first and second manifold ends (68, 70).
 8. The manifold (22) as set forth in claim 1 wherein said second member (42) defines a longitudinally extending groove (72) between said first and second mating surfaces (54, 66) for accommodating a burr between said first and second members (24, 42).
 9. A cross-counterflow heat exchanger assembly (20) comprising:
 - a first member (24) presenting arms (26) integrally connected to a base (28) having an inner base surface (34), each of said arms (26) having an inner arm surface (32) and extending from said base (28) to an arm end (30), said base (28) defining a plurality of longitudinally spaced first tube slots (36);
 - a second member (42) secured to said first member (24) to define a manifold (22), said second member (42) having a plate (44) extending between plate ends (48) and between an inner plate edge (50) and an outer plate edge (52), and said inner plate edge (50) defining a first mating surface (54) extending inwardly along said inner plate edge (50) from each of said plate ends (48) to mate with arm ends (30);
 - a wall (46) extending transversely to said inner plate edge (50) of said plate (44) to a wall end (56), said wall end (56) mating with said inner base surface (34) to divide the interior of said manifold (22) into a plurality of chambers (58, 60);
 - at least one lip (64) extending transversely to said inner plate edge (50) of said second member (42) to define a second mating surface (66) that extends perpendicularly from said first mating surface (54) and mates with said inner arm surface (32) of said arms (26);
 - a return manifold (84) extending in spaced and parallel relationship with said manifold (22) and defining a plurality of longitudinally spaced second tube slots (86) to correspond with said first tube slots (36) of said manifold (22);
 - a plurality of tubes (40) extending between first and second tube ends (74, 76), each of said first tube ends (74) engaging each of said first tube slots (36) and each of said second tube ends (76) engaging each of said second tube slots (86) to establish fluid communication between said manifold (22) and said return manifold (84), and wherein adjacent tubes (40) are spaced from one another to define a plurality of air passages for the flow of air between said adjacent tubes (40); and
 - an air fin (90) disposed between and brazed to

said tubes (40) and extending between said manifold (22) and said return manifold (84) for dissipating heat from said tubes (40).

10. The assembly as set forth in claim 9 wherein each of said tubes (40) define a tube divider (78) extending between said first and second tube ends (74, 76) to define a first passage (80) in fluid communication with one of said chambers (58, 60) of said manifold (22) and a second passage (82) in fluid communication with the other of said chambers (58, 60) of said manifold (22). 5 10
11. The assembly as set forth in claim 9 wherein said wall end (56) of the second member (42) defines a plurality of notches (62) being spaced to correspond with said first tube slots (36) of said first member (24) and wherein said tube divider (78) at said first tube end (74) abuts said notches (62) of said wall end (56) of said second member (42). 15 20
12. A method of forming a manifold (22) for use in a heat exchanger assembly (20) including the steps of:

separately forming a first member (24) at least partially defining an interior and having a spaced set of first tube slots (36) and a second member (42) having a wall (46) positioned against the first tube slots (36) and dividing the interior into a plurality of chambers (58, 60); 25 30
temporarily fixing the first member (24) to the second member (42) to define a manifold (22) extending between first and second manifold ends (68, 70) after the separately forming step; and 35
permanently fixing the first member (24) to the second member (42).

13. The method as set forth in claim 12 wherein the temporarily fixing step is further defined as canting arms (26) of the first member (24) inwardly to create a stress therein and on a second mating surface (66) defined by a lip (64) on said second member (42). 40

14. The method as set forth in claim 12 further including the step of: 45

placing a cap (98) on the first and second manifold ends (68, 70) prior to the permanently fixing step. 50

15. The method as set forth in claim 12 wherein the forming the first member (24) is further defined as rolling a flat sheet of material into a channel having a cross-section presenting a U-shape presenting a base (28) and arms (26) extending forwardly to arm ends (30). 55

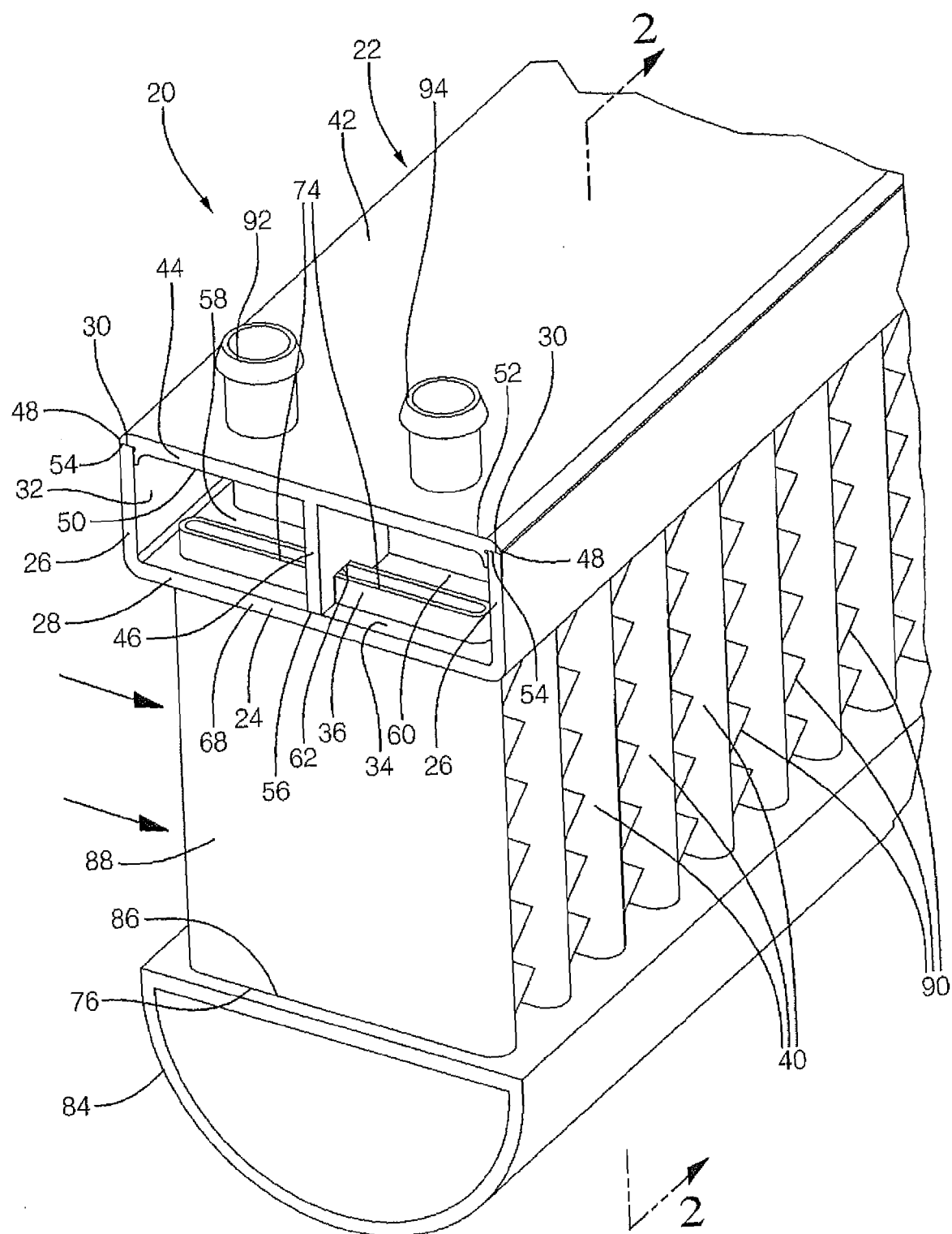


FIG. 1

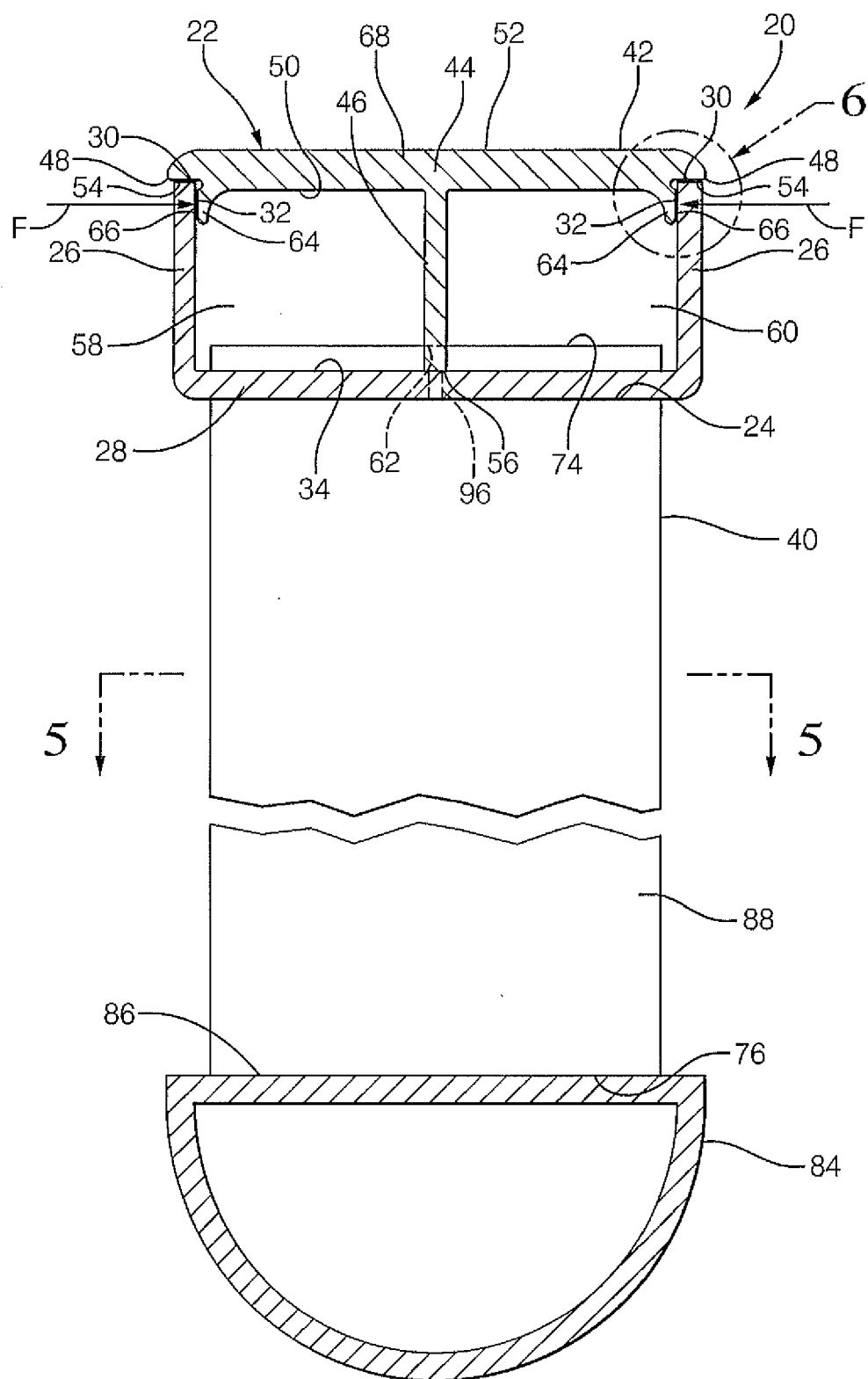


FIG. 2

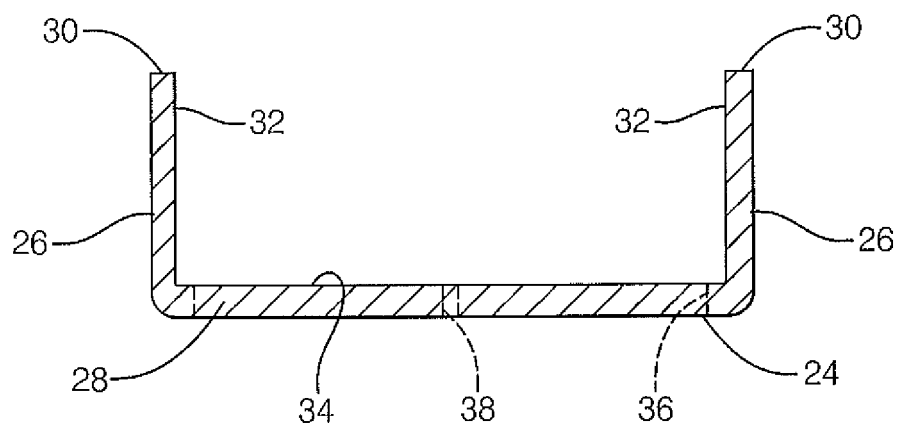


FIG. 3

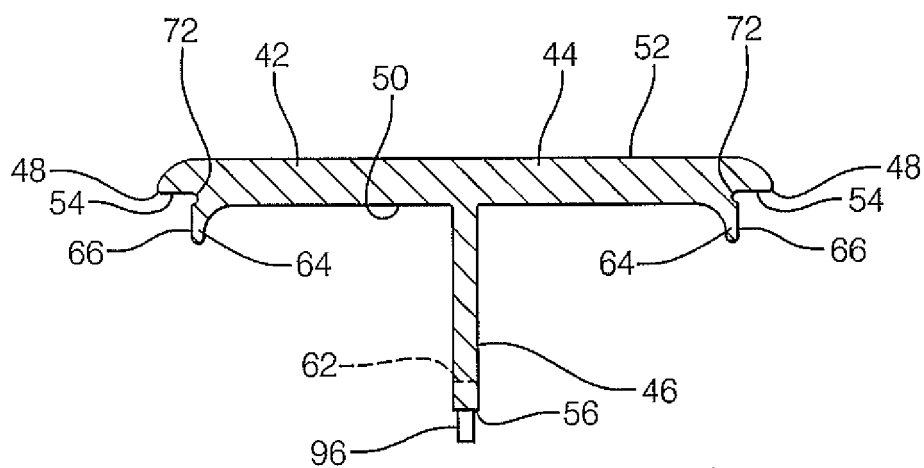


FIG. 4

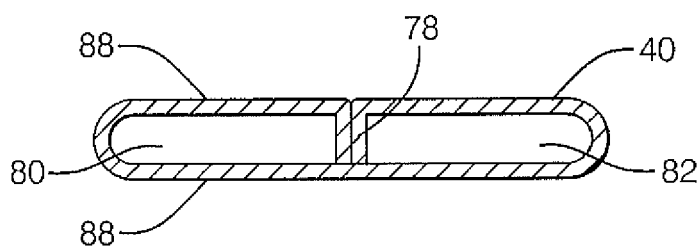


FIG. 5

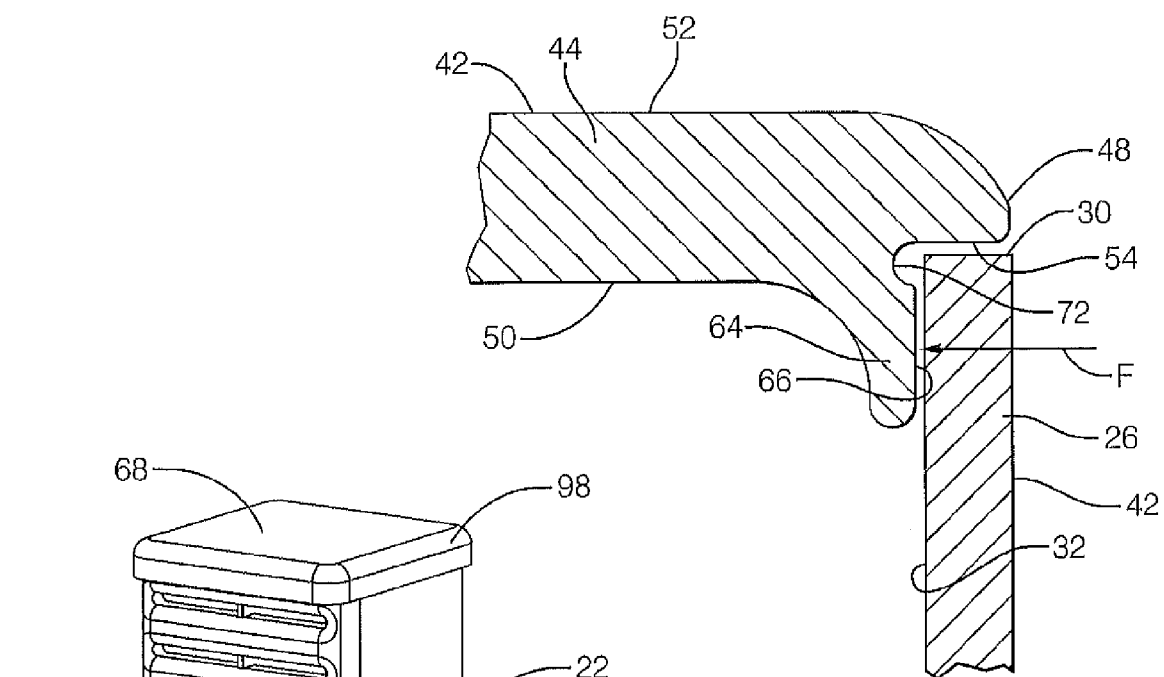


FIG. 6

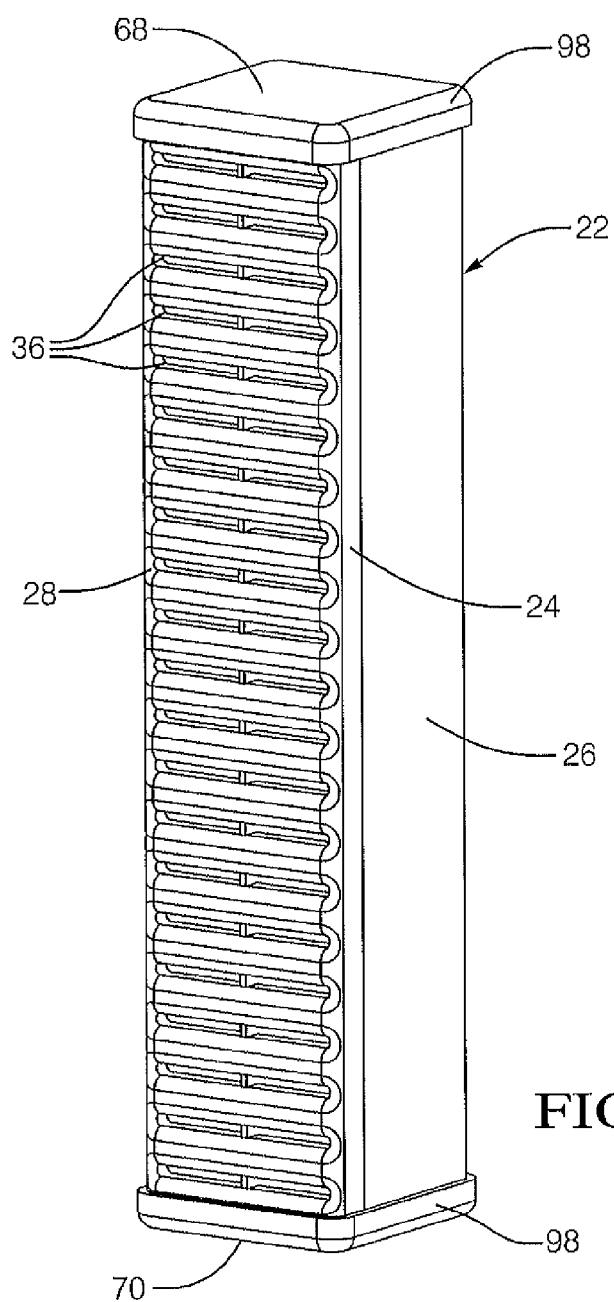


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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