HEAT EXCHANGER AND METHOD OF MANUFACTURING THE SAME

Inventors: Helmut Roll, Bad Urach (DE); Ramez Abdulnour, Racine, WI (US); Thomas M. Shields, Racine, WI (US); Robert J. Barfknecht, Waterford, WI (US); Erwin Schnell, Racine, WI (US)

Correspondence Address:
MICHAEL BEST & FRIEDRICH LLP
100 E WISCONSIN AVENUE, Suite 3300
MILWAUKEE, WI 53202 (US)

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ABSTRACT
The present invention provides, among other things, a heat exchanger including a plurality of tubes providing a flow path for a first fluid, a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid. Together, the fin and the plurality of tubes at least partially define a heat exchanger core. The heat exchanger can also include first and second tanks positioned adjacent to opposite ends of the plurality of tubes and an elastically deformable side part extending across the heat exchanger core and including a pair of integrally formed caps for closing openings in the first and second tanks.
FIG. 2

Prior Art
HEAT EXCHANGER AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

[0002] The present invention relates to heat exchangers and a method of manufacturing the same.

SUMMARY

[0003] Figs. 1 and 2 disclose a conventional heat exchanger including elements of the heat exchanger described in International Patent Application No. PCT/EP2006/001487. The illustrated heat exchanger of Figs. 1 and 2 is a soldered structure composed entirely of metal. Therefore, it is desirable to manufacture the entire heat exchanger using a single soldering process. Accordingly, the heat exchanger can be preassembled to facilitate subsequent soldering. This entails difficulties with heat exchanger designs, in particular because the tubes have length tolerances which may lead to inadequate soldered connections at the lateral closures of the tanks. In addition, conventional manufacturing and assembly methods can be disadvantageous when used in motor vehicle applications because such methods do not provide proper tolerances and/or compensate for thermal expansions.

[0004] A further heat exchanger having at least some of these features is known from European Patent Application No. EP 0 656 517 B1. In this document, in contrast to the first-mentioned reference, the openings are located in the header, and the projections are arranged on a longitudinal partitioning wall in the tank.

[0005] Some embodiments of the present invention provide a simplified method for manufacturing and/or assembling a heat exchanger in such a way that a pre-mounting or pre-assemblability of the heat exchanger is more easily soldered, welded, or brazed.

[0006] Some embodiments of the present invention provide side parts, which are deformable in their longitudinal direction in order to compensate for fabrication tolerances. The side parts can be compressed, and projections can penetrate somewhat further into the tube ends in order to compensate for changes in the length of the flat tubes. As a result, when the heat exchanger is manufactured, the prefabricated side parts can be more easily secured to the heat exchanger. The closure caps can be soldered, welded, or brazed to the lateral ends of the tanks in a positively engaging and fluid tight manner. The inventive solution of the present invention can be used in motor vehicles, and, in some such applications, can compensate for thermal expansions which occur during operation of the motor vehicle.

[0007] It is advantageous that the side parts have at least one elastic region which can be compressed or expanded according to specific requirements. The region can be in the form of at least one expansion gap with at least one expansion web. The width of the expansion gap can have a different dimension before the deformation than after the deformation. In some embodiments, if the side part is compressed, the gap width is correspondingly reduced in size.

[0008] In some embodiments, the present invention provides for each side part to have at least two expansion gaps, which are arranged approximately at the junction between a closure cap and a central part. The deformability of the side parts can be made more easily if the expansion gap or gaps extend transversely or obliquely with respect to the longitudinal direction of the side parts.

[0009] The elastic region of the present invention can have, for example, a compressible or stretchable bead or the like instead of or in addition to the expansion gaps. In some embodiments, the side parts can bear against the outer fin or directly against the outer flat tube of the heat exchanger core.

[0010] Consideration has also been given to the situation in which the closure caps seal the front ends of tanks. Alternatively or in addition, it is possible to attach the closure caps to only one of the headers or to the tanks, as has been provided, for example, in EP 656 517 B1. The closure caps have tabs, which are inserted into holes in the headers and can be soldered, welded, or brazed thereto. In such a construction, separate closure lids can be inserted into the ends of the tanks.

[0011] The present invention also provides a method for manufacturing a heat exchanger wherein flat tubes and fins are fitted together to form a heat exchanger core, and wherein headers and/or tanks are secured to one or both of the ends of the flat tubes. Projections can be plugged into openings in the tubes and side parts can be secured onto the core. The side parts can be expanded or compressed in the longitudinal direction of the side parts in order to be able to compensate for fabrication tolerances and thermal expansion.

[0012] In some embodiments, the present invention provides a heat exchanger including a number of tubes providing a flow path for a first fluid. A fin can be supported between two of the tubes and positioned along a flow path for a second fluid. Together, the fin and the plurality of tubes can at least partially define a heat exchanger core. First and second tanks can be positioned adjacent to opposite ends of the tubes. An elastically deformable side part can extend across the heat exchanger core and can include a pair of integrally formed caps for closing openings in the first and second tanks.

[0013] The present invention also provides a heat exchanger as a soldered, brazed, or welded structure, which includes flat tubes having narrow sides and broad sides, corrugated fins, and tanks formed from two clamshell members. The two tank members can be joined together along a longitudinal plane of the heat exchanger, or alternatively, in a plane which is parallel thereto.

[0014] EP 864 839 B1 discloses a conventional heat exchanger, which does not include tanks. The heat exchanger of EP 864 839 B1 does include widened tube ends which are joined to one another to form a heat exchanger core. The terminating edge of each member of the tanks extends around the heat exchanger core and is flush against the tube ends. Conventional heat exchangers have the advantage that less material, such as, for example, sheet aluminum, can be used because, as mentioned above, there are no tanks. However, the weight of the materials used for the heat exchanger is reduced only to an insignificant degree because the widening of the tube ends requires comparatively larger wall thicknesses of the flat tubes, as a result of which the aforemen-
tioned savings are at least partially cancelled out. In addition, a considerable degree of extra expenditure is produced during the shaping process being carried out at each individual tube end. It is also possible to assume that the known structures present technical soldering problems which result in excessively high rejection rates or post processing rates unless particularly careful preparations are followed during and prior to soldering. In addition, it is desirable to improve the distribution of the fluid flowing through the tanks between the individual flat tubes.

[0015] One object of the present invention is to make available a heat exchanger which permits flat tubes with relatively thin wall thicknesses to be used and/or which can at least partially alleviate one or more of the above-mentioned disadvantages.

[0016] Because the two clamshell tank members are equipped with projections which are arranged at intervals and which engage in the ends of the flat tubes in the region of the narrow sides, tubes with relatively thin wall thicknesses can be used because it is not necessary to widen the tube ends. In addition, the present invention includes easily accessible connecting points, which are critical in terms of soldering, brazing, and welding technology. The readily accessible connecting points can be post treated if necessary. In a second soldering, welding, or brazing operation, leaks can be eliminated. However, it has also been found in numerous trials that the soldering, welding, or brazing results are comparatively outstanding so that the need for post treatment is very small. In the functional respect, the heat exchanger according to the present invention has a decidedly advantageous ratio between its overall cross sectional area and the effective heat exchanging area. The available installation space can therefore be utilized satisfactorily.

[0017] The ends of the flat tubes can be plugged into openings in headers, and the tube ends can have a protruding portion on each side of the tanks. In contrast to the openings in known tanks, the ends of the flat tubes in the openings of the headers are not embraced around the entire circumference of the opening edge.

[0018] It is particularly advantageous here that the clamshell members bear against the edges of the header, that the projections engage in the ends of the flat tubes in the region of the protruding portions, and that they bear on the inside in the narrow sides of the flat tubes.

[0019] It is possible that one clamshell tank member is constructed so as to be identical to the other clamshell tank member, and that the connection between the two clamshell tank members is made approximately along the central longitudinal plane of the heat exchanger. This does not take into account the fact that a connector or the like can be formed on one of the clamshell tank members and to this extent the tank members could be different.

[0020] One clamshell tank member can have an open shell or cup configuration and the other clamshell tank member can have a substantially planar configuration. The connection between the two parts can be made along a plane which is parallel to the central longitudinal plane. In the present invention, essentially planar parts can therefore also be considered clamshell parts. In the present invention, the central longitudinal plane or a plane which is parallel thereto does not have to be actually planar or entirely planar. As used herein, the term "planar" merely indicates an orientation which extends transversely through the broad sides of the flat tubes. The parts could, for example, be connected along a corrugated portion of the connecting edges of the clamshell tank members.

[0021] The present invention also provides clamshell tank members, which are held together in a manner suitable for soldering, brazing, or welding. The connecting structure can include tabs and/or notches or the like, which are arranged along the edge of the clamshell tank members and which engage one another when the clamshell tank members are connected.

[0022] The connecting structure of the present invention can also or alternatively include contoured portions which are formed integrally with at least one of the clamshell tank members and are directed inwardly into an interior of the tank. The contoured portions can be constructed in such a way that the clamshell tank members can be connected, for example, by plugging the clamshell tank members together to pre-connect the two clamshell tank members.

[0023] The inwardly-directed contoured portions can be constructed in such a way that they have flow directing properties which promote uniform distribution of a working fluid flowing through the flat tubes.

[0024] The present invention also provides clamshell tank members which can be joined together to have openings which point toward the ends of the heat exchanger. The heat exchanger of the present invention can also include side parts or caps which close off the openings of the clamshell tank members. Alternatively or in addition, at least one of the clamshell tank members can be shaped in such a way that the parts can be joined together without requiring openings. This eliminates the need to provide side parts or closures.

[0025] In some embodiment, the present invention provides a heat exchanger including a number of tubes providing a flow path for a first fluid. The tubes can have narrow sides and broad sides. The heat exchanger can also include a fin supported between two of the tubes and positioned along a flow path for a second fluid and a tank positioned adjacent to ends of the tubes and including first and second tank members joined together along a connection plate. The tank can have outwardly-extending projections engageable in the ends of the tubes adjacent to the narrow sides to secure the tank to the tubes.

[0026] The present invention also provides a welded, brazed, or soldered heat exchanger including flat tubes having narrow sides and broad sides, corrugated fins and tanks, and a partitioning wall or the like in at least one of the tanks in order to configure the internal throughflow characteristic of the heat exchanger.

[0027] EP 864 840 B1 describes a conventional heat exchanger which does not have any tanks but rather includes widened tube ends which are joined to one another to form a heat exchanger core. The terminating edge of each tank engages around the block of tube ends, in a way which terminates in a flush position. The heat exchanger of EP 864 840 B1 has the apparent advantage of including relatively less material (e.g., sheet aluminum) because the tanks are not included. However, the weight of the materials used for the heat exchanger is reduced only to an insignificant degree because the widening of the tube ends requires comparatively larger wall thicknesses of the flat tubes, as a result of which the aforementioned savings are at least partially cancelled out. In addition, a considerable degree of extra expenditure is produced during the shaping process being carried out at each individual tube end. It is also possible to assume that the
known structures present technical soldering problems which result in excessively high rejection rates or post processing rates unless particularly careful preparations are followed during and prior to soldering.

[0028] In EP 864 840 B, a partitioning wall is advantageously inserted into one of the tanks in the transverse direction or depth direction of the heat exchanger. The partitioning wall permits a U-shaped flow through the heat exchanger, which is desired for some applications. The embodiment of the partitioning wall with a securing foot plugged onto adjacent flat tube walls proposed in EP 864 840 B1 appears possible but relatively costly.

[0029] One object of the invention is to make available a heat exchanger which permits flat tubes with relatively thin wall thicknesses to be used and/or which can at least partially alleviate one of the above-mentioned disadvantages.

[0030] In some embodiments of the present invention, it is possible to use tubes with relatively thin wall thicknesses because it is not necessary to widen the tube ends and because the tanks are equipped with projections which are arranged at intervals and which engage in the ends of the flat tubes in the region of the narrow sides. In some embodiments, a partitioning wall extends either transversely or longitudinally between at least two rows of projections. It is to be understood that the terms “transversely” or “longitudinally” also include, for example, “obliquely.”

[0031] In addition, the connecting points which are critical in terms of soldering, welding, and brazing technology are easily accessible, and therefore can be post-treated if necessary. In a second soldering, brazing, or welding operation, leakages can be eliminated. However, it has also been found in numerous trials that the soldering, welding, or brazing results are comparatively outstanding so that the need for post-treatment is very limited. In the functional respect, the heat exchanger according to the present invention can have an advantageous ratio between its overall cross sectional area and the effective heat exchanging area. The available installation space can therefore be utilized satisfactorily.

[0032] In some embodiments, the present invention provides tubes having a protruding portion on each side of spaced apart headers. In contrast to the openings in conventional heat exchanger tanks, the ends of the flat tubes in the openings of the headers are not embraced around the entire circumference of the opening edge.

[0033] It is particularly advantageous here that the tanks bear against the edges of the headers and that the projections engage in the ends of the flat tubes in the region of the protruding portions. It is also advantageous that they bear on the inside in the narrow sides of the flat tubes.

[0034] In some embodiments of the present invention, each tank can be composed of two clamshell tank members, which are connected to one another in a central longitudinal plane of the heat exchanger or in a plane which is parallel thereto. Additionally, at least one partitioning wall can be inserted between the two clamshell tank members.

[0035] In some embodiments, the present invention provides a header formed of a single part including two edge portions and being open toward the sides of the heat exchanger. The header can include side openings.

[0036] In some embodiments, the present invention provides for one clamshell tank member to be identical to the other clamshell member, with the connection between the two clamshell tank members being arranged approximately in the central longitudinal plane of the heat exchanger. In addition, at least one of the clamshell tank members can include a connector.

[0037] The invention also provides one clamshell tank member being configured in the manner of a shell, and the other clamshell tank member being configured in an approximately planar fashion such that the connection between the two clamshell tank members is in a plane parallel to the central longitudinal plane of the heat exchanger. The partitioning wall between the clamshell tank members can be planar or be formed with one or more edge portions. This ensures that the connection between the partitioning wall and the header is not in the same plane as the connection between the partitioning wall and the clamshell tank members. Accordingly, the invention provides that planar parts are essentially also clamshell tank members and that the central longitudinal plane or a plane parallel thereto, does not actually have to be planar. The term merely indicates an orientation which extends transversely through the broad sides of the flat tubes. The connection between the parts could, for example, be along a corrugated connecting edge of the parts.

[0038] The clamshell tank members have means with which they are held together in a manner which is suitable for soldering, brazing, or welding, with the partitioning wall also being held in a provisional fashion therewith. The means can be embodied as tabs or notches or the like which are arranged at the edge of one of the clamshell tank members and engage the other clamshell tank member. The means can also be configured as shaped portions which are formed on at least one of the clamshell tank members and are directed inwardly such that the clamshell tank members can be connected together. For example, the clamshell tank members can be plugged together for pre-securing them by joining the clamshell tank members also to the partitioning wall. The partitioning walls can be supported on the surface of the headers. The partitioning walls can also include projections which engage in the flat tubes. The partitioning wall can also be plugged into slits in the edge of the headers.

[0039] The present invention also provides an all metal heat exchanger, composed of flat tubes having two narrow sides and two broad sides, and fins which together with the flat tubes form a heat exchanger core such that tanks and projections extending outwardly from the tanks engage in the ends of the flat tubes.

[0040] International patent application PCT/EP 2006/001487, which is incorporated herein by reference, describes a heat exchanger embodied as a cooler such that cooling air flows freely through the fins of the heat exchanger core and in doing so cools a working fluid in the flat tubes. Such heat exchangers have proven to be advantageous in terms of their manufacturability and effectiveness. It is possible to achieve comparatively outstanding soldering, welding, or brazing results with heat exchangers which are constructed in such a manner. Furthermore, these heat exchangers are rather compact and thus require relatively little space.

[0041] One independent object of the present invention is to provide a heat exchanger that can maintain two different working fluids in separate circuits.

[0042] The present invention provides, among other things, an all metal heat exchanger including flat tubes having two narrow sides and two broad sides, and fins which together with the flat tubes form a heat exchanger core such that tanks located at the ends of flat tubes and projections extending from these first tanks engage the ends of the flat tubes. The
he heat exchanger of the present invention can also include second tanks which extend in the longitudinal direction of the flat tubes and are fluidly separated from the first tanks.

[0043] As a result of the aforesaid features, the present embodiment of the heat exchanger does not provide free flow of working fluids therethrough but rather both working fluids are conducted in separate circuits through the heat exchanger. In one example, the heat exchanger can include a charge air cooler, cooled with coolant, for motor vehicles or any other application for motor vehicles or can be outside this field.

[0044] According to some embodiments of the present invention, the second tanks include projections and are preferably formed of at least two side parts. It is also preferable that the first tanks include openings for receiving the ends of the flat tubes such that the openings do not completely engage around the ends of the flat tubes. This feature causes the ends of the flat tubes to have a protruding portion beyond the first tanks for the projections of the second tanks to engage the ends of the flat tubes in the region of the protruding portion. The projections can bear in the narrow sides of the flat tubes. It is provided that the two parts of the second tanks can be assembled together. Accordingly, the distance defined by the depth which can be plugged together corresponds approximately to the plug-in depth for the projections. The distances between the projections correspond to the distances between the flat tubes allowing the projections to be inserted in the flat tubes.

[0045] A serpentine throughflow path through the heat exchanger is provided by means of the seams between the two parts in order to exert a positive influence on the efficiency of the heat exchange. The seams which are present on opposite sides of the heat exchanger are then arranged offset with respect to one another.

[0046] Other embodiments of the present invention can include projections arranged on first tanks and for second tanks to be connected to the first tanks but to be fluidly separated therefrom. The connection between the first and second tanks can be configured in different ways. In yet other embodiments, both the first and second tanks can include projections which engage in the ends of the flat tubes. However, it is provided that the first tanks and second tanks do not have a fluid connection with one another.

[0047] In some embodiments, the present invention provides a heat exchanger including a number of tubes providing a flow path for a first fluid and a fin supported between two of the tubes and positioned along a flow path for a second fluid. Together, the fin and the tubes can at least partially defining a core. The heat exchanger can also include first and second tanks positioned adjacent to opposite ends of the tubes and a side part extending across the core between the first and second tanks and including outwardly extending projections engageable in the ends of the tubes.

[0048] In some embodiments, the present invention provides a heat exchanger including a number of tubes providing a flow path for a first fluid, a fin supported between two of the tubes and positioned along a flow path for a second fluid, and a tank secured to and in fluid communication with the ends of the tubes and including first and second tank members at least partially defining an interior space. A portion of an outer wall of the first tank member can extend inwardly through the interior space and engage a portion of an outer wall of the second tank member.

[0049] The present invention also provides a method of assembling a heat exchanger including the acts of stamping a first tank member and depressing a portion of an outer wall of the first tank member, stamping a second tank member and depressing a portion of an outer wall of the second tank member, connecting the first tank member to the second tank member such that the depressed portion of the first tank member extends through an interior space at least partially enclosed by the first and second tank members toward the depressed portion of the second tank member to direct a first fluid through the interior space, and connecting a heat exchanger core to the first and second tank members, the heat exchanger core including a number of tubes providing a flow path for the first fluid and a fin supported between two of the tubes and positioned along a flow path for a second fluid.

[0050] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] FIG. 1 is an exploded perspective view of a prior art heat exchanger;

[0052] FIG. 2 is a partially exploded perspective view of another prior art heat exchanger;

[0053] FIG. 3 is a perspective view of a portion of a heat exchanger according to a first exemplary embodiment of the present invention;

[0054] FIG. 4 is a side view of a portion of the heat exchanger shown in FIG. 3;

[0055] FIG. 5 is a perspective view of a portion of a heat exchanger according to a second exemplary embodiment of the present invention;

[0056] FIG. 6 shows a first mounting step performed during the assembly of the heat exchanger shown in FIG. 5;

[0057] FIG. 7 shows a further mounting step performed during the assembly of the heat exchanger shown in FIG. 5;

[0058] FIG. 8 is a side view of a side part of the heat exchanger shown in FIG. 5;

[0059] FIG. 9 is a perspective view of the side part shown in FIG. 8;

[0060] FIG. 10 is a perspective view of a heat exchanger according to a third exemplary embodiment of the present invention;

[0061] FIG. 11 shows a mounting step performed during assembly of the heat exchanger shown in FIG. 10;

[0062] FIG. 12 is a perspective view of a portion of the heat exchanger shown FIG. 10 rotated 180° with respect to the orientation shown in FIG. 10;

[0063] FIG. 13 is a perspective view of two side parts of the heat exchanger shown in FIG. 10;

[0064] FIG. 14 is a perspective view of a portion of a heat exchanger according to a fourth exemplary embodiment of the present invention;

[0065] FIG. 15 is a side view of the heat exchanger shown in FIG. 14;

[0066] FIG. 16 is a perspective view of a portion of a heat exchanger according to a fifth exemplary embodiment of the present invention;

[0067] FIG. 17 shows another perspective view of the portion of the heat exchanger shown in FIG. 16;

[0068] FIG. 18 is a perspective view of a heat exchanger according to a sixth embodiment of the present invention;

[0069] FIG. 19 is an enlarged perspective view of a portion of the heat exchanger shown in FIG. 18;
FIG. 20 is an exploded perspective view of a portion of the heat exchanger shown in FIG. 18;

FIG. 21 is a sectional view of a portion of a heat exchanger according to a seventh embodiment of the present invention;

FIG. 22 is another sectional view of a portion of the heat exchanger shown in FIG. 21;

FIG. 23 is an exploded perspective view of a portion of the heat exchanger shown in FIG. 21;

FIG. 24 is another exploded perspective view of a portion of the heat exchanger shown in FIG. 21;

FIG. 25 is a perspective view of a heat exchanger according to an eighth embodiment of the present invention;

FIG. 26 is an exploded perspective view of the heat exchanger shown in FIG. 25;

FIG. 27 is a partially exploded cross-sectional view of the heat exchanger shown in FIG. 25;

FIG. 28 is a perspective view of a heat exchanger according to a ninth embodiment of the present invention;

FIG. 29 is a perspective view of an interior portion of the heat exchanger shown in FIG. 28;

FIG. 30 is an exploded perspective view of the heat exchanger shown in FIG. 28;

FIG. 31 is a perspective view of a heat exchanger including a first clamshell member and a second clamshell member according to a tenth embodiment of the present invention;

FIG. 32 is an exploded perspective view of the heat exchanger shown in FIG. 31;

FIG. 33 is a perspective view of the second clamshell tank member of the heat exchanger shown in FIG. 31;

FIG. 34 is a side view of the second clamshell tank member shown in FIG. 33;

FIG. 35 is a perspective view of the first clamshell tank member of the heat exchanger shown in FIG. 31;

FIG. 36 is a side view of the first clamshell tank member shown in FIG. 35;

FIG. 37 is a perspective view of a heat exchanger according to an eleventh embodiment of the present invention;

FIG. 38 is an enlarged perspective view of a portion of the heat exchanger shown in FIG. 37;

FIG. 39 is an exploded perspective view of the heat exchanger shown in FIG. 37;

FIG. 40 is another exploded perspective view of the heat exchanger shown in FIG. 37;

FIG. 41 is an enlarged perspective view of a portion of the heat exchanger shown in FIG. 37; and

FIG. 42 is a perspective view of a heat exchanger according to a twelfth embodiment.

DEDICATED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

As shown in FIGS. 1 and 2, prior art heat exchangers can be assembled in the following way: Flat tubes 1 with fins 2 are alternately stacked to form a heat exchanger core. While the heat exchanger is operating, one fluid can flow through the flat tubes 1, and another fluid (e.g., air) can flow across the fins 2. Headers 3 and tanks 4 with projections 10 are secured to opposite ends of the flat tubes 1. In the illustrated embodiment of FIGS. 1 and 2, the tanks 4 are substantially box shaped and the headers 3 are substantially rectangularly shaped, but, in other embodiments the headers 3 and/or the tanks 4 can also or alternatively have other shapes and configurations.

When they are assembled, outwardly-extending projections 10, which are arranged on the tanks 4 in the illustrated exemplary embodiment, move past the headers 3 and engage directly in the ends 11 of the flat tubes 1. In order to close the tanks 4 laterally in a fluid tight manner, closure caps 21 are provided at opposite ends of side parts 20. Conventional side parts 20 are in need of improvement because they are each commonly formed of one part, including a central part 22 and two integral closure caps 21. These conventional side parts are therefore relatively rigid and have little or no flexibility to compensate for fabrication tolerances.

FIG. 3 shows a first exemplary embodiment of the present invention. Here too, the side part 20 is formed as a single part with a central part 22 and two closure caps 21 (only one is shown in FIG. 3). In a heat exchanger which is constructed differently, it is also possible to provide just one closure cap 21 because the heat exchanger can include a single tank 4 and/or a single header 3. As shown in the illustrated embodiment, a generally rectangular expansion gap or expansion slot 23 can be located in an elastic region between the central part 22 and the closure caps 21. In other embodiments, the expansion gap 23 can have other shapes and configurations, such as, for example, oval or irregular.

In the illustrated embodiment of FIG. 3, the expansion gaps 23 are located in the vicinity of the tanks 4. However, in other embodiments, the expansion gaps 23 can also or alternatively be provided at some other location along the side parts 20. Alternatively or in addition, the side parts 20 can include more than two expansion gaps 23 located in a common elastic region or at least partially defining separate elastic regions. By virtue of the positions selected for the illustrated embodiment of FIG. 3, the expansion gaps 23 can compensate for fabrication tolerances when the heat exchanger is mounted and can also or alternatively compensate for thermal expansion caused during operation in a motor vehicle.

FIG. 4 shows a top view of a portion of a side part 20. Expansion webs 25 located on opposite sides of the expansion gaps 23 connect the closure caps 21 to the central part 22. In addition to the webs 25, cutouts or recesses 24 are present in order to permit the webs 25 to be compressed during assembly of the heat exchanger. In the illustrated embodiment, the web 25 is formed to be as thin as possible so that unnecessarily high forces are not required to compensate for fabrica-
tion tolerances. During operation in a motor vehicle, the webs 25 can then also tear, which can be permitted in a controlled manner.

[0099] The shapes and positions of the webs 25 can be selected as desired. For example, in some embodiments, a single web 25 can be positioned in the approximate center of the expansion gap 23 to divide the expansion gap 23. In still other embodiments, one or more webs 25 can be positioned on one or both sides of a center of an expansion gap 23.

[0100] Each expansion gap 23 can have a width b and a length L. In the illustrated embodiment of FIG. 3, the width b can be between about 1 and 20 mm, and the length L can depend on the depth T of the heat exchanger. The length L can be at least twice the thickness D of the webs 25 and can be smaller than the depth T of the heat exchanger (L ≤ T - 2D). The thickness D of the webs 25 can be approximately 2 to 5 mm. If the expansion gap 25 is oval or elliptical, b is the maximum diameter and L is the maximum diameter transversely with respect to it.

[0101] A second exemplary embodiment of the heat exchanger of the present invention is shown in FIGS. 5-9. Here too, there is again an expansion gap 23 between the central part 22 and closure caps 21 of the side part 20. However, in this exemplary embodiment, a clamped connection is also provided. The clamped connection between the closure cap 21 and the tank 4 is provided by the clamps or connectors 27, 28 located at opposite ends of the closure cap 21. These clamps 27, 28 can also be located at other positions on the closure cap 21. Alternatively or in addition, similarly configured clamps (not shown) can be located on the tank 4.

[0102] FIGS. 6 and 7 show a method of assembling the heat exchanger. As first, as shown in FIG. 6, the flat tubes 1 and the fins 2 are stacked alternately one on the other in order to form the heat exchanger core, and the headers 3 are then pushed onto the ends of the flat tubes (see above). During a subsequent step, the projections 10 of the tanks 4 are inserted into the protruding ends 11 of the flat tubes 1. The heat exchanger which is mounted in this way can be stable by itself. A clamping aid can be positioned transversely with respect to the longitudinal direction of the flat tubes 1 so that the fins 2 and/or the flat tubes 1 do not flex outwardly and so that the fins 2 and/or the flat tubes 1 retain their intended shape during soldering, brazing, or welding. A side part 20 can be used to prevent this clamping aid (not shown) from crushing the outermost fin 2. The side part 20 can be fitted on before the clamping aid is attached.

[0103] The closure caps 21 of the side parts 20 close the lateral openings in the tanks 4. In this exemplary embodiment, the closure caps 21 are attached to the tanks 4 by the clamps 27, 28 so that they cannot slip. During assembly and when the side parts 20 are secured to the heat exchanger core, the expansion gaps 23 compensate for potent fabrication tolerances by either compressing or expanding the webs 25.

[0104] To conclude the operation, the entire heat exchanger or substantially the entire heat exchanger can be soldered, welded, and/or brazed. In some embodiments, the side parts 20 and then the tanks 4 are first fitted onto the heat exchanger core and the entire structure or substantially the entire structure is then pressed together and/or compressed in order to compensate for fabrication tolerances. More specifically, the upper clamp 28 can be configured in such a way that this second manufacturing method can be applied. The two manufacturing methods can be the same for all of the exemplary embodiments.

[0105] Two detailed views of the side part 20 are also shown in FIGS. 8 and 9. The closure cap 21 has a surface 26 which is curved towards an interior of the tanks 4 but is planar in the main region, and includes an edge 29 with a bent collar 29a. This collar 29a bears against the tank 4 and is soldered, welded, or brazed to it. Clamps 27, 28 can be integrally formed on this collar 29a. The shape of the expansion gap 23 can be selected such that two clamps 27 can be integrally formed across the expansion gap 23. The expansion gap 23 can have the shape shown in the figures or any other appropriate shape, and it can also be made significantly larger. As a result of the shape selected here, two webs 25 are present. It is important that the thickness D is not too large, so as to facilitate the compression or expansion. The shape of the webs 25 is also achieved by the cutouts 24 at the lateral edge of the central part 22 of the side part 20.

[0106] A third exemplary embodiment is shown in FIGS. 10-13. A detailed view of a portion of a finished heat exchanger can be seen in FIG. 10. Here, the side part 20 is shaped differently. The outermost flat tube 1 is positioned more closely to an outer edge of the tank 4 and the header 3 than in the preceding exemplary embodiments. However, because a fin 10 bears against the outermost flat tube 1, the outermost fin 2 protrudes beyond the tank 4. The illustrated configuration of the side part 20 compensates for the protruding portion of the fin 2.

[0107] As shown in FIGS. 10-13, the central part 22 of the side part 20 is removed from the plane of the closure caps 21 and follows the outermost fin 2 so that the central part 22 and the closure caps 21 are arranged offset with respect to one another by a few millimeters. As can be seen, the closure cap 21 bears with its section 37 directly against the flat tube 1. In addition it has an edge 29 which is bent inwardly toward the tank 4 and can be soldered, welded, or brazed to the tank 4. The central part 22 and the closure caps 21 are connected to one another by the webs 25. The outermost flat tube 1 is arranged directly on the edge of the header 3 so that the section 37 of the closure cap 21 is not soldered, welded, or brazed in a seal forming manner. As shown in FIGS. 10-13, the section 37 of the closure cap 21 does not include a bent edge 29.

[0108] FIG. 12 shows an interior of the tank 4 of the heat exchanger. The edge 29 of the closure cap 21 bears against the wall of the tank 4. In the section 37, the edge 29 of the closure cap 21 is removed so that the header 3 has an open interior space. Here, the edge 29 of the closure cap 21 and the header 3 abut one another and are soldered, welded, or brazed to one another. As a result, the tank 4 is fluid tight.

[0109] FIG. 13 shows a detail of the side part 20 in two orientations. The shape of the webs 25 and of the expansion gap 23 can be adapted to the shape of the side part 20. The shape of the expansion gap 23 and the number of the webs 25 can also or alternatively be selected as desired.

[0110] A fourth exemplary embodiment is shown in FIGS. 14 and 15. Here, the side part 20 has only closure caps 21. The central part 22 is omitted, as a result of which material is saved. However, the closure cap 21 is sufficiently long to bear with the section 39 against the outermost flat tube 1. Also, the outermost fin 2 has been eliminated. In this exemplary embodiment, the edge 29 of the closure cap 21 engages the outside of the tank 4. A latchingly aid can retain the closure cap 21 in its position.

[0111] A fifth exemplary embodiment is shown in FIGS. 16 and 17. Here too, the side part 20 has only closure caps 21.
without a central part 22. The closure cap 21 is sufficiently long to bear with the section 47 of the outermost flat tube 1. The edge 29 of the closure cap 21 is bent outward so that the closure cap 21 bears against the inside of the tank 4. Latching aids or clamps can additionally be provided on the closure cap 21.

Depending on the requirements, it is, however, also possible to select a reduced central part 22 which does not have any connections to the closure caps 21. However, it is also possible to use a side part 20 as is known from the other exemplary embodiments, but with the proviso that the outermost fin 2 is eliminated. With very thin walled flat tubes 1, it may be the case that such a side part 20 is required because the clamping aid, which is used during the soldering, brazing, or welding process in order to obtain an optimum connection of the fins 2 to the flat tubes 1, could then damage the outermost flat tubes 1. In this case, the central parts 22 can be positioned precisely at the points at which the clamping aid engages.

FIGS. 18-20 illustrate an alternate embodiment of a heat exchanger according to the present invention. The heat exchanger shown in FIGS. 18-20 is similar in many ways to the illustrated embodiments of FIGS. 1-17 described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. 18-20 and the embodiments of FIGS. 1-17, reference is hereby made to the description above accompanying the embodiments of FIGS. 1-17 for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. 18-20. Features and elements in the embodiment of FIGS. 18-20 corresponding to features and elements in the embodiments of FIGS. 1-17 are numbered in the 100 series.

The heat exchanger which is illustrated in FIGS. 18-20 is a charge air cooler for motor vehicle applications and is cooled by cooling air. In other embodiments, the heat exchanger of the present invention can be used in other applications and can have other configurations.

The heat exchanger includes an inlet opening 146 located in one of the tanks 104 for receiving charge air to be cooled, and an outlet opening 143 for directing cooled charge air outwardly from the other tank 104. The cooling air flows in the direction of the block arrow through the corrugated fins 102, which are arranged between broad sides 112 of the flat tubes 101. Furthermore, the direction of air flow through the heat exchanger and the air flow referenced herein is presented by way of example only and is not intended to limit the scope of the heat exchanger of the present invention in any manner. As such, the heat exchanger of the present invention can have a number of different configurations and orientations.

The heat exchanger shown in FIGS. 18-20 can be assembled, for example, as follows. The flat tubes 101 can be alternately stacked with the corrugated fins 102 to form a stack or heat exchanger core. Headers 103 can then be connected to opposite ends of the flat tubes 101 (FIG. 20). The headers 103 can include openings 140 which extend toward the outer edges 141 of the headers 103. In some embodiments, the openings 140 can include collars or flanges which open toward the corrugated fins 102 in order to improve the soldering, welding, and/or brazing to the ends of the flat tubes 101.

In some embodiments, the heat exchanger of the present invention can be assembled such that the ends of the flat tubes 101 do not protrude inwardly towards the tank 104. The headers 103 can be fitted in such a way that the headers 103 are pushed onto the ends of the flat tubes 101 transversely with respect to the longitudinal extent of the headers 103. Alternatively or in addition, the tubes 101 can be inserted transversely into the openings 140 in the headers 103.

In the illustrated embodiment of FIGS. 18-20, the flat tubes 101 include a relatively small protruding portion 105 (shown in FIG. 20), which extends outwardly beyond the two longitudinal edges 141 of the header 103. The tanks 104 can then be fitted onto the headers 103 adjacent to opposite ends of the flat tubes 101. Finally, side parts 120, which are provided in this exemplary embodiment can be connected, as shown in FIGS. 18-20.

The tanks 104 can include two clamshell tank members 131 and 132. A first tank member 131 can have an "open" shell or cup configuration and the second tank member 132 can have a substantially planar or flat configuration. In the illustrated embodiment of FIGS. 18-20, closure caps 171 are integrally formed as portions of the side parts 120 and are secured to openings 133 in the tanks 104. In other embodiments, the side parts 120 and the caps 171 can be separately formed. In still other embodiments, the heat exchanger can be constructed without closure caps 171 and/or without side parts 120. In the illustrated embodiment, the side parts 120 define an expansion slot or expansion gap 123, which permits operational expansions and contractions caused by temperature changes.

The tank members 131 and 132 are provisionally connected around their circumference before being subsequently connected by tabs 161 and notches 162. Projections 130 can be arranged at intervals along and can extend outwardly from the two tank members 131, 132. The projections 130 can be connected to and engage in the ends of the flat tubes 101 adjacent to the narrow sides 113 of the flat tubes 101. The intervals between the projections 130 can correspond precisely to the intervals between the flat tubes 101 so that the tanks 104 can be pushed in the longitudinal direction of the flat tubes 101 onto their ends, and so that each projection 130 is received in and engages an end of a flat tube 101. More specifically, the projections 130 can be received in and engage the protruding portions 105 of the tubes 102.

As shown in FIG. 19, four projections 130 are seated in the flat tube ends 101. As is apparent in particular from FIG. 20, the projections 130 can have a tapered or slightly conical shape, so that, on the one hand, they can slide more easily into the ends of the flat tubes 101 and, on the other hand, so that they can also abut in a seal forming fashion so that good soldering, brazing, or welding is also achieved.

In the illustrated embodiment of FIGS. 18-20, the edges of the projections 130 are extremely sharp because it has been found that existing length tolerances of the flat tubes 101 can be satisfactorily compensated for by the sharp edges of the projections 130 cutting into the tube wall of the somewhat longer flat tubes 101, which can contribute to the aforementioned compensation of the tolerances. Furthermore, it has been found that the projections 130 hold the tube walls under tension, as a result of which what is referred to as the "collapsing" of the flat tubes 101 during the soldering, brazing, or welding process can be prevented. The "collapsing" can lead to faulty soldered, brazed, or welded connections. It is apparent that in each end of a flat tube 101 there are two projections 130 which fit snugly against the two narrow sides 113 and produce the aforementioned tensile stress in the tube wall.
In addition, in the illustrated embodiment of FIGS. 18-20, the heat exchanger can include a connector 180 which can be secured, for example, to hooks 181 or the like, which are located on the member 132. In some embodiments, the connector 180 can also be made of plastic.

Furthermore, the applicant would like to direct the readers’ attention to international patent application PCT/EP 2006/001487 which is incorporated herein by reference.

Bumps or contoured portions 165 are formed along the relatively thin outer walls of the first and second members 131, 132 by pressing or deforming the outer walls inward to improve the stability and strength of the tanks 104. These inwardly directed bumps 165 can also or alternatively influence the flow distribution of fluid flowing through the tanks 104. The central pipes of a heat exchanger are often known to have a better flow through them than those which lie at the outer ends of the heat exchanger. As a result, an undesired temperature gradient is caused and the maximum possible cooling power is often not achieved. The bumps 165 of the present invention operate to at least partially counteract these and other disadvantages. The bumps 165 can, as is shown, be located on both tank members 131, 132, or alternatively, can be located on just one of the tank members 131, 132.

FIGS. 21-24 show a modified embodiment which also counteracts the aspect last mentioned and which furthermore permits the provisional connection of the two tank members 131, 132, making it possible to dispense with the tabs 161 and notches 162 of the embodiment shown in FIGS. 17-20. As shown in FIGS. 17-20, an extension 166 can be formed into the shaped portion 165 of one of the tank members 131, 132, and the extension 166 can be pressed into an opening 167 or into another shaped element 165, corresponding to the extension 166 located on another of the members tank 131, 132. The illustrated heat exchanger and tanks 104 of FIGS. 21-24 are self-explanatory and do not require any further explanation in the applicant’s view. It should be noted that element 167 does not necessarily need to be an opening. The tank members 131, 132, bumps 165, extensions 166, and openings 167 should correspond so as to secure the tank members 131, 132 together and influence the flow, as described above with respect to FIGS. 18-20.

FIGS. 25-30 illustrate an alternate embodiment of a heat exchanger according to the present invention. The heat exchanger shown in FIGS. 25-30 is similar in many ways to the illustrated embodiments of FIGS. 1-24 described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. 25-30 and the embodiments of FIGS. 1-24, reference is hereby made to the description above accompanying the embodiments of FIGS. 1-24 for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. 25-30. Features and elements in the embodiment of FIGS. 25-30 corresponding to features and elements in the embodiments of FIGS. 1-24 are numbered in the 200 series.

The heat exchanger illustrated in FIGS. 25-30 is a charge air cooler for motor vehicle applications and is cooled by cooling air. Other embodiments of the heat exchanger are also expressly provided, but not shown in the figures. For example, the heat exchanger can include a coolant cooler for motor vehicle applications to perform specific throughput characteristics achieved by means of a partitioning wall or walls. Accordingly, coolers are often mentioned, and this is meant to refer to heat exchangers in the broadest sense, even when referring to heat exchangers which are configured for different media which flow through flat tubes 201.

The heat exchanger includes a tank 204 with two inlet/outlet openings 235 for charge air to be cooled. In other embodiments, the tank 204 can include one or more inlet/outlet openings 235. Cooling air flows in the direction of the block arrow through the fins 202 which are arranged between broad sides 212 of the flat tubes 201. Inlet/outlet openings 235 are referred to because very different internal throughput patterns of the cooler can be set, as is desirable for specific applications, by using one or even more partitioning walls 210 in one or in both tanks 204 to determine whether the openings 235 are either inlet or outlet openings.

Only a few different exemplary throughput patterns are shown in FIG. 25 by means of arrows 229. Internal throughput patterns are formed by coolant which flows in the flat tubes 201. The flat tubes 201 are not specified in more detail below. However, the flat tubes 201 can preferably include separate internal flow ducts 208 (FIG. 30), also referred to as multichamber tubes, in which the chambers can be formed using an internal insert in the flat tube 201 or even using fixed partitioning walls in the flat tube 201, such as can be found, for example, in extruded flat tubes. In the preferred embodiments, the heat exchanger includes one row of flat tubes 201, irrespective of the depth of the cooling network formed from flat tubes 201 and fins 202. However, other preferred embodiments can include more than one row of flat tubes 201 in a heat exchanger.

The heat exchangers shown in FIGS. 25-30 can be assembled as follows. The flat tubes 201 are alternately fitted together with the corrugated fins 202 (see FIG. 28) to form a stack. Headers 203 are then fitted onto the ends of the flat tubes 201. The headers 203 have openings 240 which extend as far as the edge 241 of the headers 203. As a result, the headers 203 differ from otherwise customary tanks. The openings 240 include a collar-like passage which opens toward the corrugated fins 202, in order to improve the soldering, welding, or brazing to the ends of the flat tubes 201. As a result, the ends of the flat tubes 201 do not protrude inward toward the tank 204 when the stack of flat tubes 201 and fins 202 is assembled with the headers 203. The headers 203 are fitted such that the headers 203 are pushed transversely to their longitudinal direction onto the ends of the flat tubes 201. Each of the flat tubes 201 includes a protruding portion 205, which is relatively small in size but functionally important and which extends beyond the two longitudinal edges 241 of the header 203. The tanks 204 with the partitioning walls 210 are then joined to the headers 203 on the two opposite ends of the flat tubes 201.

The tanks 204 include, according to the exemplary embodiment shown in FIGS. 25-27, two clamshell tank members 231 and 232. The clamshell tank members 231, 232 are formed with a substantially identical shell shape. However, it is envisioned that an approximately planar housing part can alternatively be used to form the tank 204.

In the illustrated embodiment, two side openings 233 are formed after the two clamshell tank members 231, 232 have been coupled to each other, thus closure caps or the like (not shown) can be used. The two clamshell tank members 231, 232 forming the tank 204 include projections 230 arranged at intervals and engaging the ends of the flat tubes 201 in the region of the narrow sides 211. The distances between the projections 230 correspond substantially to the distances between the flat tubes 201 such that the tanks 204
can be pushed onto the ends of the flat tubes 201 in their longitudinal direction. Each projection 230 engages an end of a flat tube 201, precisely in the respective protruding portion 205. The projections 230 are present in two rows of projections 230 which have been characterized by A and B (see FIGS. 26 and 30).

[0134] A partitioning wall or a longitudinal partitioning wall 210 can be positioned between the two clamshell tank members 231, 232. The partitioning wall 210 can include projections 215 arranged at intervals as a suitable means for holding the longitudinal partitioning wall 210 to the tank members 231, 232 before the heat exchanger is soldered, welded, or brazed (FIGS. 26-27). The projections 215 are intended to be plugged into the flat tubes 201 approximately in the center between the two narrow sides 211 of the flat tubes 201. Other embodiments however do not necessarily include the partitioning wall 210 in the center between the two narrow sides 211.

[0135] As illustrated in FIG. 30, the flat tubes 201 include flow ducts 208 extending in the longitudinal direction such that the projections 215 of the partitioning wall 210 can bring about flow in the same direction or in opposite directions in the selected regions of the cross sections of the flat tubes 201.

[0136] As illustrated in FIGS. 26 and 30, the projections 230 are formed on the tank 204 with a corresponding, slightly conical or tapered shape such that the projections 230 can, on the one hand, more easily slide in the ends of the flat tubes 201 and, on the other hand, also bear in a seal-forming fashion so that good soldering, brazing, or welding results are achieved. The projections 230 also include sharp edges because it has been found that existing length tolerances of the flat tubes 201 can be satisfactorily compensated for by virtue of the fact that the sharp edges of the projections 230 cut into the tube wall of the somewhat longer flat tubes 201, which brings about the aforementioned compensation of the tolerances. Furthermore, it has been found that the projections 230 on the tank 204 keep the tube walls under tension. As a result of which, “collapsing” of the flat tubes 201 during the soldering, welding, or brazing process is prevented. The “collapsing” can lead to faulty soldered, welded, or brazed connections. It is apparent that in each end of a flat tube 201 there are two projections 230 each fitted snugly on the inside of the two narrow sides 211 and causing the aforementioned tensile stress in the tube wall.

[0137] Furthermore, the applicant would like to draw the reader’s attention to the international patent application PCT/EP 2006/001487, which is incorporated herein by reference.

[0138] Inwardly directed shaped portions or bumps 265 have been formed in the two clamshell tank members 231, 232. The shaped portions 265 provide, on the one hand, improved stability of the heat exchanger. Accordingly, the clamshell tank members 231, 232 can be constructed with extremely thin walls. On the other hand, the shaped portions 265 can influence the flow distribution. The central tubes of a heat exchanger are known often to have a better flow through them than those which lie at the edge of the heat exchanger. As a result, an undesired temperature gradient is caused and the maximum possible cooling power often cannot be achieved. A selective geometry of the shaped portions 265 is intended to counter these disadvantages. The shaped portions 265 further provide provisional securing of the partitioning wall 210 between the clamshell members 231, 232 as shown in FIGS. 26-27. Accordingly, the partitioning wall 210 has been provided with an aperture 216. It is envisioned that the clamshell tank members 231, 232 and/or the partitioning wall 210 can include other coupling means, such as, for example, bendable tabs or the like to secure the partitioning wall 210.

[0139] The heat exchanger illustrated in FIGS. 28-30 includes a partitioning wall 210 which extends approximately transversely between the two rows A and B of projections 230. The partitioning wall 210 is relatively easy to manufacture. However, it is to be understood that the tanks 204 do not require a transverse partitioning wall 210 or a longitudinal partitioning wall 210. Moreover, the partitioning wall 210 may be formed in other orientations within the tanks 204 and can contribute with the clamshell tank members 231, 232 to form the tanks 204. Space for modifications is available as a result of including the partitioning wall 210. Two slits 242 are formed opposite to one another at the edge 241 of the header 203 such that the partitioning wall 210 can be inserted into the slits 242. The slits 242 and consequently the position of the transverse partitioning wall 210 are preferably between two flat tubes 201. It is envisioned however that the latter are arranged in the region of a cross section of a flat tube 201.

[0140] FIGS. 31-36 illustrate an alternate embodiment of a heat exchanger according to the present invention. The heat exchanger shown in FIGS. 31-36 is similar in many ways to the illustrated embodiments of FIGS. 1-30 described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. 31-36 and the embodiments of FIGS. 1-30, reference is hereby made to the description above accompanying the embodiments of FIGS. 1-30 for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. 31-36. Features and elements in the embodiment of FIGS. 31-36 corresponding to features and elements in the embodiments of FIGS. 1-30 are numbered in the 300 series.

[0141] A tank 304 for a heat exchanger, such as for example, a charge air cooler is illustrated in FIGS. 31-36. The tank 304 includes a first tank member 331 and a second tank member 332 secured to the first tank member 331 to at least partially define an interior space. In some embodiments, for example, each of the first tank member 331 and second tank member 332 can be stamped from a single sheet of material (e.g., metal), as described below in more detail.

[0142] The first tank member 331 illustrated in FIGS. 32 and 35-36 includes an exterior wall 372 having an elongated base 373, a first receiving portion 374, and a first connecting flange 375. The first tank member 331 also includes a first bump or contoured portion 377 extending inwardly from the exterior wall 372 into the interior space and, when the heat exchanger is assembled, toward the second tank member 332.

[0143] In the illustrated embodiment of FIGS. 31-36, the bump 377 includes a substantially elliptical profile and includes a first contact surface 378. The bump 377 provides structural support to the tank 304 so that the tank 304 can be constructed without or with only minimal braces, studs, brackets, or other structural support devices for providing stability. The bump 377 can be welded, brazed, or soldered to the second tank member 332 to provide additional structural support to the tank 304 and can also provide improved flow distribution within the tank 304, as described below in more detail.

[0144] The second tank member 332 is substantially similar to and can be a mirror image of the first tank member 331. In the illustrated embodiment of FIGS. 32-34, the second tank member 332 includes a second exterior wall 382 with a rela-
tively elongated base 383, a second receiving portion 384, and a second connecting flange 385. The first connecting flange 375 and the second connecting flange 385 are secured together during a soldering, welding, or brazing process to at least partially form the tank 304 and to at least partially enclose the inner space within the first and second walls 372, 382.

[0145] As shown in FIGS. 34-36, the second tank member 332 can also include a second bump or contoured portion 387 extending inwardly from the exterior wall 382 into the interior space and, when the heat exchanger is assembled, toward the first tank member 331. The bump 387 can have a substantially circular profile (with respect to FIG. 34) and can include a second contact surface 388. When the tank 304 is assembled, the bump 387 can provide additional structural support to the tank 304 so that interior braces, studs, brackets and/or other structural support devices are unnecessary. The bump 387 of the second tank member 332 can be welded, brazed, or soldered to the first bump 377 of the first tank member 331 to provide additional structural support to the tank 304 and to provide improved flow distribution within the interior space of the tank 304.

[0146] In the illustrated embodiment of FIGS. 31-36, the second tank member 332 also includes an inlet aperture 335 for receiving a working fluid and for distributing the working fluid through the interior space of the tank 304 and into the tubes of the heat exchanger core. When the tank 304 is assembled, the inlet aperture 335 can be positioned adjacent to or substantially in line with the first bump 377 such that working fluid flowing into the aperture 335 contacts the first bump 377 and flows around the welded first and second bumps 377, 387, thus providing improved distribution through the interior space of the tank 304 and into the tubes of the heat exchanger core.

[0147] As mentioned above, the first tank member 331 and the second tank member 332 are preferable each manufactured from a single piece of sheet metal. However, in some embodiments, the first tank member 331 and/or the second tank member 332 can also include welded baffles 379, 389 to add additional structural support and/or improve fluid distribution through the heat exchanger.

[0148] FIGS. 37-42 illustrate an alternate embodiment of a heat exchanger according to the present invention. The heat exchanger shown in FIGS. 37-42 is similar in many ways to the illustrated embodiments of FIGS. 1-36 described above. Accordingly, with the exception of mutually inconsistent features and elements between the embodiment of FIGS. 37-42 and the embodiments of FIGS. 1-36, reference is hereby made to the description above accompanying the embodiments of FIGS. 1-36 for a more complete description of the features and elements (and the alternatives to the features and elements) of the embodiment of FIGS. 37-42. Features and elements in the embodiment of FIGS. 37-42 corresponding to features and elements in the embodiments of FIGS. 1-36 are numbered in the 400 series.

[0149] The heat exchanger illustrated in FIGS. 37-42 is an all metal heat exchanger including a soldered, welded, or brazed structure, which can be manufactured in a CAB oven preferably in a single soldering, welding, or brazing operation providing a more economic manufacture in comparison to known, conventional welded structures. In the illustrated construction, aluminum sheets expeditiously coated with solder generally represent a preferred material for the manufacture of the heat exchanger. However, other materials fall within the scope of the present invention.

[0150] With reference to FIGS. 37-41, the illustrated embodiment of the heat exchanger includes flat tubes 401 with two broad sides and two narrow sides, and fins 402 which together with the flat tubes 402 form a heat exchanger core 413. The heat exchanger includes first tanks 451 at the ends of the flat tubes 401. Second tanks 452 are formed, at least in part, by side parts and extend in the longitudinal direction of the flat tubes 401. Two housing parts 420 cooperate with the second tanks 452 to close off from the outside a space in which a coolant flows, for example. The housing parts 420 also extend in the longitudinal direction of the flat tubes 401 on opposite sides of the heat exchanger. Thus, the coolant flows through an inlet 455 and then flows in the aforesaid space through the fins 402, arranged between the flat tubes 401, to an outlet 456.

[0151] In the illustrated embodiment, projections 430 are located at the edge of the second tanks 452, as best shown in FIGS. 39-41. The second tanks 452 include first and second side parts 491, 492, with the aforementioned projections 430 extending from the edge of first part 491 and from the edge of the second part 492. The first tanks 451 can include a one-piece construction with the base section having a series of openings 440 (see FIG. 39). It is thus possible, for example, for charge air which is to be cooled to enter the first tank 451 and flow through the flat tubes 401 to the other first tank 451, during which time the air exchanges heat with the coolant flowing through the heat exchanger, as further described below. Some constructions of the heat exchanger can include flat tubes 401 having turbulators, inserts or the like, as illustrated in FIG. 39.

[0152] In some embodiments of the present invention, the mounting sequence of the heat exchanger can be as follows. The core 413 is first formed by stacking flat tubes 401 and fins 402. The core 413 with protruding flat tube ends is then introduced into the openings 440 of the first tanks 451. The broad sides of the flat tubes 401 are relatively wider than the tanks 451 such that the openings 440 do not completely surround the ends of the flat tubes 401. For example, FIG. 41 illustrates a protruding portion 405 on both sides of the tanks 451 (only one side of the tank 451 shown in FIG. 41). The protruding portion 405 receives the projections 430 of the first and second parts 491, 492. Accordingly, the projections 430 are formed narrower at the ends such that the projections 430 can engage in the protruding portions 405. In the course of the fitting on and insertion of first part 491 and the subsequent fitting on and insertion of the second part 492, the projections 430 are pushed into the protruding portions 405. In the process, the projections 430 also have direct contact with the wall of the first tank 451 such that the fluid separation of the two tanks 451, 452 and a sealed and stable soldered, brazed, or welded connection are ensured.

[0153] Concurrently with the projections 430 being inserted, the first and second parts 491, 492 are also pushed together at their seam 498. The insertion depth of the projections 430 into the ends of the tubes 401 corresponds approximately to the depth of the seam 498 (FIG. 38). The configuration of the seam 498, or of the seams 498 because one seam 498 is present on each of the two parts 491, 492, is not restricted to the illustrated embodiment. The seams 498 are formed such that the seams 498 force the coolant to flow in a serpentine profile, as partially illustrated in FIGS. 39 and 40. Also shown in the illustrated embodiment are the seams 498
offset on opposite sides of the heat exchanger, due to the fact that the first and second parts 491, 492 include different lengths.

[0154] A heat exchanger according to another embodiment of the present invention is illustrated in FIG. 42. Some aspects of the illustrated heat exchanger are described in PCT/EP 2006/001487, which is incorporated herein by reference. Two second tanks 452 on opposite sides of the heat exchanger extend in the longitudinal direction of the flat tubes 401. The projections 430 are located on the first tanks 451. The projections 430 are not visible in FIG. 42 as the projections 430 have already been plugged into the ends of the flat tubes 401. The end sides of the second tanks 452 are correspondingly closed.

The second tanks 452 with inlets 455 and outlets 456 are shown schematically in FIG. 42. The second tank 452 is located on the front and rear sides of the heat exchanger and has only been indicated at the lower edge to permit viewing of the core 413 of the heat exchanger.

[0155] The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes are possible.

What is claimed is:

1. A heat exchanger comprising:
   a plurality of tubes providing a flow path for a first fluid;
   a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid, together, the fin and the plurality of tubes at least partially defining a core;
   first and second tanks positioned adjacent to opposite ends of the plurality of tubes; and
   an elastically deformable side part extending across the heat exchanger core and including a pair of integrally formed caps for closing openings in the first and second tanks.

2. The heat exchanger of claim 1, wherein one of the pair of caps contacts the heat exchanger core.

3. The heat exchanger of claim 1, wherein the side part includes a rigid central part arranged between the caps and contacting an outermost tube of the heat exchanger core.

4. The heat exchanger of claim 1, wherein the side part is elastically deformable in a direction generally parallel to a length between the opposite ends of one of the plurality of tubes.

5. The heat exchanger of claim 1, wherein the side part includes at least one elastic region having an elliptically-shaped expansion gap, and wherein webs extend across the gap between the caps and a central part of the side part.

6. The heat exchanger of claim 1, wherein the side part includes at least one elastic region having an expansion web extending between a central part and one of the pair of caps.

7. The heat exchanger of claim 1, wherein the first tank includes outwardly extending protrusions engageable in one of the ends of the plurality of tubes.

8. The heat exchanger of claim 1, wherein the side part includes an expansion gap, and wherein a connector extends outwardly from the side part through the expansion gap for engaging the first tank.

9. A heat exchanger comprising:
   a plurality of tubes providing a flow path for a first fluid, the plurality of tubes having narrow sides and broad sides;
   a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid; and
   a tank positioned adjacent to ends of the plurality of tubes and including first and second tank members joined together along a connection plane, the tank having outwardly-extending projections engageable in the ends of the tubes adjacent to the narrow sides to secure the tank to the tubes.

10. The heat exchanger of claim 9, wherein the ends of the tubes are received in openings in headers positioned adjacent to the first tank, and wherein portions of the tubes protrude outwardly beyond side edges of the headers, the side edges being transverse to the ends of the tubes.

11. The heat exchanger of claim 10, wherein the projections are received in the protruding portions of the ends of the tubes and engage interior sides of the narrow sides of the tubes.

12. The heat exchanger of claim 9, wherein the first and second members at least partially define an interior space, and wherein a portion of an outer wall of the first member extends inwardly through the interior space engaging a portion of an outer wall of the second member.

13. The heat exchanger of claim 9, wherein the projections extend outwardly from each of the first and second members, and wherein projections from the first member and projections from the second member are engageable in the ends of the tubes adjacent to the narrow sides.

14. The heat exchanger of claim 9, further comprising a partitioning wall extending through an interior of the tank in a direction substantially parallel to a longitudinal extent of the projections to at least partially define the flow path of the first fluid through the tank.

15. The heat exchanger of claim 14, wherein the partitioning wall includes projections engageable in the ends of the plurality of tubes.

16. The heat exchanger of claim 14, wherein the ends of the tubes are received in openings in a header, and wherein the partitioning wall is engageable in a slit formed in the header.

17. A heat exchanger comprising:
   a plurality of tubes providing a flow path for a first fluid;
   a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid, together, the fin and the plurality of tubes at least partially defining a core;
   first and second tanks positioned adjacent to opposite ends of the plurality of tubes; and
   a side part extending across the core between the first and second tanks and including outwardly extending projections engageable in the ends of the tubes.

18. The heat exchanger of claim 17, wherein the side part includes a first member secured to a second member, the first member being adjacent to the first tank and including projections engageable with first ends of the tubes and the second member being adjacent to the second tank and including projections engageable with second ends of the tubes.

19. The heat exchanger of claim 18, wherein one of the first member and the second member defines a recess and an other of the first member and the second member includes a protrusion moveable through the recess a distance to connect the first member to the second member during movement of the first member with respect to the second member, and wherein the distance corresponds to a length of the projections.

20. The heat exchanger of claim 18, wherein the first member is connected to the second member along a seam, and
wherein the seam directs the second fluid along a substantially serpentine path through the heat exchanger.

21. The heat exchanger of claim 17, wherein the first tank includes openings for receiving the ends of the tubes, and wherein sides of the tubes extend outwardly beyond outer edges of the first tank.

22. The heat exchanger of claim 17, wherein the portions of the ends of the tubes engaged with the projections extend outwardly beyond outer edges of the first tank.

23. The heat exchanger of claim 17, wherein the side part is a first side part, further comprising a second side part extending across the heat exchanger core between the first and second tanks and including outwardly extending projections engageable in the ends of the tubes, and wherein the first and second side parts at least partially enclose the heat exchanger core.

24. A heat exchanger comprising:
   a plurality of tubes providing a flow path for a first fluid;
   a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid; and
   a tank secured to and in fluid communication with the ends of the plurality of tubes and including first and second tank members at least partially defining an interior space, a portion of an outer wall of the first tank member extending inwardly through the interior space and engaging a portion of an outer wall of the second tank member.

25. The heat exchanger of claim 24, wherein the first tank member and the second tank member are stamped parts.

26. The heat exchanger of claim 24, wherein the portion of the outer wall of the first tank member directs the flow of the first fluid through the interior space and distributes the first fluid among the tubes.

27. The heat exchanger of claim 24, wherein the portion of the outer wall of the first tank member has a substantially convex shape.

28. The heat exchanger of claim 27, wherein the tank includes in an inlet for receiving the first fluid, the inlet being oriented to direct the first fluid onto the convex portion of the outer wall of the first tank member to distribute the first fluid through the interior space.

29. A method of assembling a heat exchanger, the method comprising the acts of:
   stamping a first tank member and depressing a portion of an outer wall of the first tank member;
   stamping a second tank member and depressing a portion of an outer wall of the second tank member;
   connecting the first tank member to the second tank member such that the depressed portion of the first tank member extends through an interior space at least partially enclosed by the first and second tank members toward the depressed portion of the second tank member to direct a first fluid through the interior space; and
   connecting a heat exchanger core to the first and second tank members, the heat exchanger core including a plurality of tubes providing a flow path for the first fluid and a fin supported between two of the plurality of tubes and positioned along a flow path for a second fluid.

30. The method of claim 29, wherein connecting the first tank member to the second tank member includes securing the depressed portion of the first tank member to the depressed portion of the second tank member.

31. The method of claim 29, wherein depressing the portion of the outer wall of the first tank member includes forming a first convex protrusion, and wherein depressing the portion of the outer wall of the second tank member includes forming a second convex protrusion.

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