A variety of polymer manifolds and associated fabrication methods are described. The described manifolds can be used in heat exchangers and a variety of other applications. In one aspect, a polymer manifold is formed by welding distal tips of a multiplicity of polymer tubes to a polymer retainer. The tubes pass through guide passages that extend between opposing faces of the retainer and the distal tip of each tube is welded to a manifold face of the retainer. The welds between the tubes and the manifold face form sealed connections between the tubes and the manifold face. In some embodiments, a locking plate is positioned adjacent the retainer. The tubes also pass through the locking plate such that during assembly, the locking plate and/or the retainer can be translated or otherwise moved slightly relative to the other to hold the tubes in place during welding to the retainer.
START

510 INSERT TUBE INTO PERFORATED RETAINER

520 ALIGN TUBE TO PROVIDE DESIRED PROTRUSION PAST MANIFOLD FACE

530 LOCK TUBE IN PLACE

540 WELD DISTAL TIPS OF TUBES TO MANIFOLD FACE

550 INTEGRATE MANIFOLD STRUCTURE WITH COUPLING ARRANGEMENT

DONE

FIG. 5
POLYMER MANIFOLD AND METHODS OF FABRICATION

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to manifolds and heat exchangers formed from polymer materials and associated fabrication techniques.

[0002] Heat exchangers are used in a wide variety of applications and have a wide variety of geometries and designs for specific applications. Most often, heat exchangers are formed from metal materials such as copper, aluminum or stainless steel due to the favorable heat transfer characteristics that are displayed by such materials. Although metal heat exchanger designs work well for many applications, metals tend to be more expensive and/or more subject to corrosion than certain other materials such as plastics. Therefore, there are some applications where it is desirable to form a heat exchanger from lower cost polymer materials.

[0003] One class of heat exchangers uses a flow of a heat exchange fluid (heat exchange medium) through a heat transfer medium to affect heat exchange. For example, a feed stream can be supplied to a heat exchange device and divided into multiple streams that pass through the heat transfer medium. Such a heat exchanger typically employs inlet and outlet manifolds to divide and reunite the feed stream into/from a number of relatively narrow tubes that pass through the heat transfer medium. The fabrication of such manifolds can be difficult when the tubes and/or manifolds are formed from a plastic (or other polymer) material. Co-owned U.S. patent application Ser. No. 13/071,322 describes a few methods of manufacturing polymer manifolds and polymer heat exchangers. Although the described polymer manifold and polymer heat exchanger designs work well, there are continuing efforts to provide improved manifold and heat exchanger designs. The present application describes a low cost polymer manifold design that is well suited for use in a variety of heat exchanger designs. The polymer manifold may also have extensive applications outside of the heat exchanger field.

SUMMARY OF THE INVENTION

[0004] A variety of polymer manifold structures and methods of forming polymer manifolds are described. In one aspect a polymer manifold is formed by welding distal tips of a multiplicity of polymer tubes to a polymer retainer. The tubes pass through guide passages that are arranged to oppose facing of the retainer and the distal tip of each tube is welded to a manifold face of the retainer. The welds between the tubes and the manifold face form sealed connections between the tubes and the manifold face.

[0005] In some embodiments a locking plate is positioned adjacent the retainer. The locking plate also includes a multiplicity of guide passages, with each locking plate guide passage being aligned with an associated retainer guide passage and receiving an associate one of the tubes therethrough. During assembly, the locking plate and/or the retainer can be moved slightly relative to each other to hold the tubes in place during welding to the retainer.

[0006] The manifold may also include a coupling member that facilitates connection to complementary devices. In some embodiments, the coupling member includes a cap that covers the manifold face and forms a manifold plenum adjacent the manifold face.

[0007] In some embodiments, such polymer manifolds are provided on both ends of the tubes.

[0008] In a method aspect, the tubes are positioned in the retainer such that distal tips of the tubes extend slightly beyond the manifold face of the retainer. These protruding portions of the tubes are then welded to the manifold face of the retainer. In some embodiment, a heated platen is used to melt the tube tips and heat fuse the tubes to the manifold face of the retainer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention and the advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

[0010] FIG. 1 is a diagramatic perspective illustration of a polymer heat exchanger incorporating manifolds in accordance with the present invention.

[0011] FIG. 2 is a diagramatic perspective illustration of a polymer manifold in accordance with one embodiment of the present invention.

[0012] FIGS. 3(a) & 3(b) are respectively perspective and cross section side views of an embodiment of a retainer suitable for use in the polymer manifold illustrated in FIG. 2.

[0013] FIG. 4 is a cross section view of a locking plate embodiment suitable for use in the polymer manifold of FIG. 2.

[0014] FIG. 5 is a flow chart illustrating one method of fabricating a polymer manifold in accordance with some embodiments of the invention.

[0015] FIGS. 6(a)-6(f) are a series of diagrammatic side sectional views that illustrate various steps in a process of fabricating a manifold in accordance with a process embodiment of the invention.

[0016] In the drawings, like reference numerals are sometimes used to designate like structural elements. It should also be appreciated that the depictions in the figures are diagrammatic and not to scale.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] The present invention relates generally to polymer heat exchangers. In general, polymer materials may be used to form a low cost heat exchanger that can perform well in a variety of applications.

[0018] Referring initially to FIG. 1, a polymer heat exchanger in accordance with one embodiment will be described. In the illustrated embodiment, the heat exchanger 100 includes a multiplicity of plastic tubes 110 and a pair of manifold assemblies 200. The manifold assemblies 200 are positioned on opposing ends of tube 110 to facilitate connection to larger diameter input and output lines or other component such as plenums, etc.

[0019] The diameter and length of the tubes 110 may be widely varied to meet the needs of any particular application. Preferrably, the tubes will have small diameters and relatively thin walls. By way of example, polymer tubes having an outer diameter in the range of approximately 0.08 to 0.25 inches work well for many applications, although both larger and smaller tube diameters may be used in particular applications. Inner tube diameters may also vary widely although it should be appreciated that thin walls are generally preferred since
thin walls will generally improve the heat exchangers thermal performance by decreasing the temperature drop across the tube walls.

[0020] The tubes 110 and various components of the manifold assemblies 200 may be formed from a wide variety of plastics and other polymers. By way of example, Polyethylene, Polypropylenene, Polyamide, Polysulfone, and Polyphenylene Sulfide work well for both the tubes and the manifold assemblies. Of course, in other embodiments, a wide variety of other plastics and polymers may be used. The tubes and components of the manifold assemblies may be formed from the same materials, substantially the same materials or different materials depending on the requirements of any particular application.

[0021] A representative manifold assembly 200 is illustrated in the partially cut-away, perspective, cross-sectional view of FIG. 2. Each manifold assembly 200 includes a perforated retainer plate 202 that serves as a manifold plate, a locking plate 209 and a manifold cap 205. The cap 205 defines an internal chamber 207 that serves as a manifold plenum and integrates a tube stub 208 suitable for coupling to a feed or drain line. The tubes 100 pass through the locking plate 209 and the perforated retainer 202. Distal ends of the tubes are welded to the exterior face 213 of the perforated retainer plate 202 in a manner that seals the retainer plate openings. Thus, face 213 effectively serves a manifold surface. This structure is described in more detail below.

[0022] Although a particular cap geometry is shown, it should be appreciated that the actual geometry of both the manifold cap 205 and its associated chamber 207 may be widely varied. In the illustrated embodiment, the cap 205 is butted welded to the retainer plate 202. Of course, in other embodiments, a variety of alternative coupling structures can be used to connect the manifold cap to the tube assembly. By way of example, other welding techniques (e.g., socket welding), threaded connections, and or other conventional coupling techniques can be used to secure the tube assembly to the manifold cap.

[0023] FIGS. 3(a) and 3(b) illustrate a representative embodiment of a perforated retainer 202 in more detail. The perforated retainer 202 has a generally cylindrical or puck like geometry although a variety of other shapes and sizes can be used. In the illustrated embodiment, selected peripheral segments 327 of the perforated retainer puck are flattened to facilitate handling. The retainer is formed of a polymer or plastic material. Examples of suitable materials include, but are not limited to, polyethylene, polypropylene, polyamide, polysulfone, and polyphenylene sulfide materials. The perforated retainer 202 includes a first face that serves as manifold surface 213, an opposing second face 305, and a plurality of guide passages 307 that extend therebetween. The passages 307 are sized, spaced, and arranged such that a plurality of tubes 110 can be inserted into the guide passages 307 and then affixed in place.

[0024] The diameter of the guide passages 307, like the diameter of the associated tubes, can be varied. The actual number of guide passages 307 in any particular implementation is variable and generally determined by the size of the retainer, the arrangement of the passages, the desired fluid flow, and the diameter of the tubes 110 associated with the manifold 100. By way of example, in some implementations, on the order of 40 to 70 guide passages 307 are formed in the perforated retainer 202 to accommodate a like number of tubes 110. The guide passages 307 can be arranged in a wide variety of configurations and arrays in accordance with the needs of any particular application. In general, the tolerances between the diameter of the passages and the outer diameter of the tubes are such that the tubes can be readily inserted into the guide passages without undue difficulty. In one specific example, the perforated retainer 202a has a diameter of about 3 inches and a thickness of about ½ of an inch, with sixty (60) guide passages 307 each having a diameter of approximately ¼ inch. Other retainer embodiments can assume a wide variety of sizes, shapes, and thicknesses as well as support a wide range of guide passages (sizes, shapes, and passage arrangements).

[0025] The locking plate 209 may have a geometry that is generally similar to the perforated retainer 202—although its thickness may vary as discussed below. Typically, the guide passage pattern of the locking plate 209 will match that of the perforated retainer. In some embodiments, at least a portion of the guide passages in the locking plate may be tapered somewhat to facilitate insertion of the tubes 110. Once such geometry is illustrated in FIG. 4. In the illustrated embodiment the guide passages 337 in locking plate 209 include a short tapered portion 337a and a narrower cylindrical portion 337b. In other embodiments, the guide passages may be tapered along their entire length. The openings on the face abutting the retainer plate are slightly narrower than the openings on the opposing proximal face. Such a taper can make it easier to insert the tubes 110 during assembly of the manifold. When such a taper is used, the actual taper angle may vary widely. By way of example, a taper angle of approximately 45 degrees works well for many applications.

[0026] The thickness of the locking plate may be widely varied. In many embodiments, the locking plate 209 is formed from a polymer material similar to the retainer 202 and/or the tubes 110. An advantage of using a polymer material for the locking plate is that after attachment of the tubes, the locking plate can optionally be welded to the retainer to provide additional strength which is particularly useful in higher pressure applications.

[0027] Referring next to FIG. 5 a process suitable for fabricating a manifold assembly 200 using the locking plate approach will be described. Initially a perforated retainer and a locking plate are positioned adjacent one another and oriented such that their respective openings are aligned. Thereafter, tubes 110 are inserted into each of the aligned passages 307, 317—typically from the tapered end of the locking plate 209. (Step 510 as illustrated in FIG. 6(a)). Preferably the tubes are inserted such that their distal ends protrude slightly from past the manifold face 213. The tubes can be inserted manually or in an automated fashion. For example, a jig can be used assist in the insertion of the tubes.

[0028] The inserted tubes are aligned such that each of the tubes extends a predetermined distance past the manifold face 213. The alignment of the tubes can be accomplished in any suitable manner such as by using a registration block during or after insertion. (Step 520).

[0029] The distance 112 that the distal lips 118 of tubes 110 protrude past the manifold face 213 is selected to provide the proper amount of material for welding as will be described in more detail below. The appropriate protrusion distance will vary somewhat based on a number of factors, but generally tends to be dependent on the size of the tubes (e.g., diameter and wall thickness), the materials used and the spacing between the guide passages.
Once the tubes are properly positioned, they are locked in place. In the illustrated embodiment, the locking of the tubes is accomplished by translating or otherwise moving the locking plate 209 relative to the retainer (step 530) which exerts a force on the tubes thereby holding them in place for the subsequent welding operation. In other embodiments the locking plate can be rotated relative to the retainer to hold the tubes in place (although this approach does not work well for centrally located tubes) or other mechanisms can be used to hold the tube in place.

Once the tubes are properly positioned and locked in place, the distal tips 118 of tubes 110 are welded (or otherwise affixed) to the perforated retainer 202. (Step 540). In one embodiment, this can be achieved by melting the tips 118 of the tubes 110 and welding the melted tips to the first surface of the retainer 202. This approach forming a high quality seal that affixes the tubes 110 to the retainer 202.

In one approach, the tubes are affixed by applying a heated platen 601 against the extended distal tips 118 of the tubes 110 and gently pushing the platen 601 against the tubes in the direction of the manifold face 213 of the perforated retainer 202. (FIG. 6(c)). In this way the heated platen 601 melts the distal tips of tubes 110. As the tips melt, the protruding portion of the tubes “collapse” allowing the platen 601 to move towards the manifold face until the platen is only separated from the manifold face by the molten plastic. As the platen moves towards the retainer, the melted plastic spreads out on the manifold face—preferably away from the open entrances to the tubes. In this position, the platen heats the manifold face which effectively welds the tips of the tubes to the manifold face 213 of retainer 202.

The platen may be formed from a variety of different materials that facilitate good weld formation. By way of example the platen may be formed from a material having good heat conduction properties such as aluminum and may be covered with a thin coat of a material such as Teflon or other suitable fluoropolymer to prevent sticking. The results can be high quality bonds that affix the tubes 110 to the retainer 202 and seal the connections. When polypropylene is used as the material for both tubes 110 and the retainer 202, heating a platen 601 to a temperature in the range of 250-400°F is suitable to facilitate the melting/welding of the tube tips.

It should be appreciated that the amount of plastic material that is used in the weld is most directly controlled by the distance that the tube tips 118 protrude beyond the manifold face 213. It has been found that by controlling the amount of material melted (i.e., the tube tip protrusion) and the pressure applied by the platen 601 during welding, good welds can be formed that do not unduly occlude the tubes. If the tube tips extend too far (resulting in too much material being melted) or too much pressure is used during the welding operation, then larger amounts of plastic will flow into the distal ends of the tubes, thereby clogging the tubes and/or good welds between the tubes and the retainer will not be formed. Conversely, if the tips do not extend out far enough or too little pressure is used during the welding operation, then poor welds will form and the resulting manifold structure will not be strong. In some embodiments, the movement of the platen can be controlled to provide a designated standoff distance from the manifold face to help maintain weld quality.

As suggested above, a number of factors will influence the quality of the welds and the optimal protrusion of the tube tips will vary with factors such as the diameter of the tubes, the wall thickness of the tubes, the materials used to form the tubes, etc. In one particular embodiment, polypropylene tubes having a ¼ inch outer diameter with a 0.018 inch (18 mil) wall thickness, the distal tips 118 of the tubes 110 protrude a specified distance 112 that is about ¼ of an inch beyond the manifold face 213. Additionally, the spacing between guide passages 307 should be selected such that there is room for the melted plastic from the protruding tube tips 118 to spread sufficiently to avoid blocking the adjacent tubes. In this embodiment, the spacing distance (between guide passages) is at least ¼ of an inch, edge-to-edge. It should be noted that the distance that the tips protrude and the spacing between adjacent tubes is subject to a wide range of variability depending on the specific design. The appropriate tip protrusion and tube spacing for any particular design can be determined experimentally.

The bonds between the tubes 110 and the retainer 202 is diagrammatically illustrated in FIG. 6(e). As seen therein, when the appropriate volume of plastic material is provided and the appropriate pressure is used, the melted plastic material will primarily spread outward from the openings 114 of the tubes 110. Thus, the melted portion of the plastic 115 does not noticeably occlude the openings 114. However, it should be appreciated that if the protruding tube segments are too long, bulges of plastic material (not shown) may form adjacent the distal end of the tube which extend into the tube opening 114, thereby partially or fully occluding the tubes.

FIG. 6(f) is a more detailed frontal view of a portion of the perforated retainer 202 showing the tubes 110 secured thereto. As discussed above, the melted tube ends 113 are not intended to substantially occlude the tube opening 114. The separation 116 between the guide passages 307 is chosen such that the melted plastic from one of the tubes does not interact with the melted plastic from adjacent tubes in a manner that can cause undue blockage of an adjacent tube. Often the skirts 119 of plastic formed around adjacent tubes will merge together in places, although often not to the extent that the entire surface of the retainer is covered. In other implementations, the guide passages can be located far enough apart such that the skirts 119 associated with adjacent tubes generally do not touch.

A significant advantage of the described approach is that when controlled properly, the tube openings are not significantly occluded during the welding operation. Thus, there is no need to machine out, or otherwise enhance or form openings in the tube channels after the welding operation which can significantly reduce production costs. Of course, the openings could be drilled out, routed or otherwise machined if necessary or desired—however, it is believed that the elimination of the need for such steps will be highly desirable in most applications.

Since control of the weld volume is desirable, it is helpful to hold the tubes and retainer firmly in place relative to each other during the welding operation. When desired, this can be done using a jig or other suitable fixture. Although such arrangements work well, they can be a bit expensive—particularly in low volume manufacturing environments. Therefore, in the embodiments shown above, the locking plate 209 is used to hold the tubes in place during the welding operations. As mentioned above, this can be done by simply translating or otherwise moving at least one of the retainer 202 and the locking plate 209 relative to the other. This movement binds the tubes, thereby immobilizing the tubes, which are effectively locked into place. After the welding has
been completed, the locking translation may be released, thereby freeing the tubes. If desired, the locking plate can be removed and potentially reused. However, that is not always appropriate (as for example when manifolds are provided at both ends of the tubes.) Therefore, it is often easiest to form the locking plates from the same plastic material as the retainer and to use the locking plate as additional reinforcement for the manifold.

In an alternative embodiment having manifolds provided at both ends of the tubes 110, a single locking plate can potentially be used in conjunction with the formation of both manifolds with the locking plate being slid along the tubes from adjacent the first retainer to a position adjacent the second retainer.

Although only a few embodiments of the invention have been described in detail, it should be appreciated that the invention may be implemented in many other forms without departing from the spirit or scope of the invention. For example, although the manifold formation has been described primarily in the context of a heat exchanger manifold, it should be appreciated that the described polymer manifold may be used in a wide variety of applications and its uses are not in any way limited to heat exchanger manifolds.

In the primary described embodiments, the polymer tubes are plated welded to the polymer retainer. Although platen welding works well and has been specifically described, it should be appreciated that there are a number of other plastic welding techniques that may be suitable including, for example, ultrasonic bonding, thermosonic bonding, infrared welding, laser welding, hot gas welding, and a variety of other heat welding techniques and any of these may be used in other embodiments. All of these techniques are considered plastic “welding” or “fusing” within the context of this application.

The process of forming a manifold has been described in the context of a particular sequence of steps. It should be appreciated that in alternative embodiments, the sequence of the steps can sometimes be altered and some of the steps may be skipped, while others may be added. For example, the tubes may be inserted into the retainer in and aligned in a single operation or the distal tips of the tubes may be gradually egressed out of the retainer during the welding operation rather than using fixed protrusions. In other examples, the locking plate can be eliminated in some embodiments and/or the manifold housing may be assembled in a wide variety of manners.

The method of forming a manifold has been described primarily in the context of forming a heat exchanger manifold. However, it should be appreciated that the described approach to may be used to attach a plurality of tubes to a variety of structures. For example, U.S. Pat. Nos. 3,934,323 and 6,038,768 describe approaches for attaching riser tubes to a header in a solar collector application. It should be appreciated that the approach described herein is well suited for use as an alternative approach to forming such header manifolds. Therefore, the present embodiments should be considered illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

1. A device comprising:
   a multiplicity of polymer tubes, each of the polymer tubes including first and second ends and a passage having first and second openings; and
   first and second retainers, each retainer having a substantially planar polymer manifold face, an opposing second face and a multiplicity of guide passages that extend between the opposing faces; and
   wherein each tube passes through an associated guide passage in both the first and second retainers and the first end of each tube has a first skirt portion that has a wider diameter than the associated first retainer guide passage and is fused to the manifold face of the first retainer outside of the associated first retainer guide passage in a manner that encircles the associated first retainer guide passage and the second end of each tube has a second skirt portion that has a wider diameter than the associated second retainer guide passage and is fused to the
manifold face of the second retainer outside of the associated second retainer guide passage in a manner that encircles the associated second retainer guide passage.

2. A device as recited in claim 1 wherein each guide passage receives a single associated tube and the fusing of the tubes to the manifold faces form sealed connections between the tubes and the manifold faces.

3. A device as recited in claim 2 wherein the first retainer is formed entirely of a polymer material.

4. A device as recited in claim 2 wherein the first retainer further comprises a metal backing plate.

5. A device as recited in claim 2 further comprising a locking plate positioned adjacent the second face of the first retainer, wherein the locking plate includes a multiplicity of guide passages, each locking plate guide passage being aligned with an associated retainer guide passage and receiving an associate one of the tubes therethrough such that the tubes pass entirely through the locking plate.

6. A device as recited in claim 5 further comprising a manifold cap butt welded to the first retainer, wherein the manifold cap encloses the manifold face and forms a manifold plenum adjacent the manifold face.

7. A device as recited in claim 5 wherein both the first retainer and the locking plate are formed from plastic and the locking plate is welded to the first retainer.

8. A device as recited in claim 5 wherein the locking plate is formed from metal and has a larger diameter or size than the first retainer and includes an exposed coupling surface that extends radially beyond the first retainer to facilitate attachment of the device to other devices.

9. A device as recited in claim 5 wherein the locking plate abuts against the first retainer and the guide passages in the locking plate include tapered portions having wide ends that open on a surface facing away from the first retainer.

10. (canceled)

11. (canceled)

12. A device as recited in claim 1 wherein the plurality of tubes and the first retainer are formed from a material selected from the group consisting of Polyethylene, Polypropylene, Polyamide, Polysulfone, and Polyphenylene Sulfide.

13. (canceled)

14. A device as recited in claim 1 wherein the first retainer has a substantially cylindrical or puck shaped geometry.

15. A device as recited in claim 1 wherein the number of tubes passing through and fused to the first retainer is in the range of 20 to 250 tubes.

16. A device as recited in claim 1 wherein the guide passages include tapered portions having wide ends that open on the second face.

17. A method of forming a manifold, comprising:

   inserting a multiplicity of polymer tubes into guide passages in a retainer having a substantially planar polymer manifold face and positioning distal tips of first ends of the tubes such that they extend outward from the manifold face, wherein the distal tip of each tube that extends outward from the manifold face has substantially the same diameter and cross sectional geometry as the portion of such tube that passes through the associated guide passage; and

   fusing the distal tips of the tubes to the manifold face to form a sealed connection between the tubes and the retainer to thereby form a manifold, wherein the fusing of the distal tips of the tubes to the manifold face is accomplished by melting the distal tips of the tubes that extend outward from the manifold face and pressing the melted material against the manifold face to form polymer skirts around the guide passages that are fused to the manifold face, the polymer skirts being integral extensions of the tubes.

18. A method as recited in claim 17 wherein the multiplicity of tubes are also inserted through a locking plate positioned adjacent the retainer, the method further comprising moving at least one of the locking plate and the manifold relative to the other to thereby apply a force to the tubes to hold the tubes in place during the fusing of the distal tips of the tubes to the substantially planar polymer manifold face.

19. A method as recited in claim 17 wherein the fusing of the distal tips of the tubes to the retainer is accomplished using a substantially planar heated platen that melts the distal tips of the tubes that extend outward from the manifold face and moves towards the substantially planar polymer manifold face as the distal tips of the tubes melt to facilitate fusing the tubes to the retainer.

20. A method as recited in claim 17 further comprising attaching a manifold cap to the retainer in a manner that forms a manifold plenum adjacent the substantially planar polymer manifold face.

21. A method as recited in claim 17 further comprising forming a second manifold at a second end of the multiplicity of polymer tubes.

22. A method of forming a manifold, comprising:

   inserting a multiplicity of polymer tubes into guide passages in a retainer having a polymer manifold face and positioning distal tips of first ends of the tubes such that they extend outward from the manifold face, wherein the distal tip of each tube that extends outward from the manifold face has substantially the same diameter and cross sectional geometry as the portion of such tube that passes through the associated guide passage; and

   fusing the distal tips of the tubes to the manifold face to form a sealed connection between the tubes and the retainer to thereby form a manifold, wherein the fusing of the distal tips of the tubes to the manifold face is accomplished by melting the distal tips of the tubes that extend outward from the manifold face and pressing the melted material against the manifold face to form polymer skirts around the guide passages that are fused to the manifold face, the polymer skirts being integral extensions of the tube;

   wherein the multiplicity of tubes are also inserted through a locking plate positioned adjacent the retainer, the method further comprising moving at least one of the locking plate and the manifold relative to the other to thereby apply a force to the tubes to hold the tubes in place during the fusing of the distal tips of the tubes to the manifold face;

   wherein the retainer and the locking plate are both formed from polymer materials, the method further comprising: after the fusing, moving at least one of the locking plate and the manifold relative to the other a second time to release the hold; and

   welding the locking plate to the retainer after the hold has been released.

23. A method of forming a manifold, the comprising:

   aligning a retainer having a multiplicity of retainer guide passages and a substantially planar polymer manifold face with a locking plate having a multiplicity of locking
plate guide passages such that each retainer guide passage plate longitudinally aligns with an associated locking plate guide passage; inserting a multiplicity of polymer tubes into the aligned guide passages in the locking plate and retainer such that each polymer tube passes through a single associated guide passage in the locking plate and a single associated guide passage in the retainer, and positioning distal tips of first ends of the tubes such that they extend outward from the manifold face; locking the tubes in place at least in part by moving at least one of the locking plate and the retainer relative to the other to thereby apply a force to the tubes to hold the tubes in place; fusing the distal tips of the tubes to the manifold face with the tubes locked in place to form a sealed connection between the tubes and the retainer to thereby form a manifold, wherein the fusing of the distal tips of the tubes to the manifold face is accomplished by melting the distal tips of the tubes that extend outward from the manifold face and pressing the melted material against the manifold face to form polymer skirts around the guide passages that are fused to the manifold face, the polymer skirts being integral extensions of the tubes.

24. A polymer manifold comprising:

a retainer having a substantially planar polymer manifold face, an opposing second face and a multiplicity of guide passages that extend between the opposing faces, each guide passage being arranged to receive a single associated tube;
a multiplicity of polymer tubes, each of the polymer tubes including first and second ends and a passage having first and second openings, wherein each tube passes through an associated guide passage and the first end of each tube has a skirt portion that has a wider diameter than the associated guide passage and is fused to the manifold face of the retainer outside of the associated guide passage in a manner that encircles the associated guide passage, and wherein the fusing of the tubes to the manifold face forms sealed connections between the tubes and the manifold face and each guide passage receives a single associated tube;
a manifold cap secured to the retainer, wherein the manifold cap encloses the manifold face and forms a manifold plenum adjacent the manifold face; and a locking plate that abuts the second face of the retainer, wherein the locking plate includes a multiplicity of guide passages, each locking plate guide passage being aligned with an associated retainer guide passage and receiving an associate one of the tubes therethrough such that the tubes pass entirely through the locking plate; and wherein the plurality of tubes and the retainer are formed from a material selected from the group consisting of Polyethylene, Polypropylene, Polyamide, Polysulfone, and Polyphenylene Sulfide.

25. A device as recited in claim 1 wherein:

the retainer has a substantially cylindrical or puck shaped geometry;
the number of tubes passing through and fused to the retainer is in the range of 20 to 250 tubes; and the guide passages in the locking plate include tapered portions having wide ends that open on a surface facing away from the retainer; and wherein the locking plate is permanently affixed to the retainer.

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