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(54) **HOLLOW DEVICE AND MANUFACTURING METHOD THEREOF**

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(57) **ABSTRACT**

A hollow device includes: a hollow fiber that has a micro channel; and a device body forming portion that is disposed around a periphery of the hollow fiber.

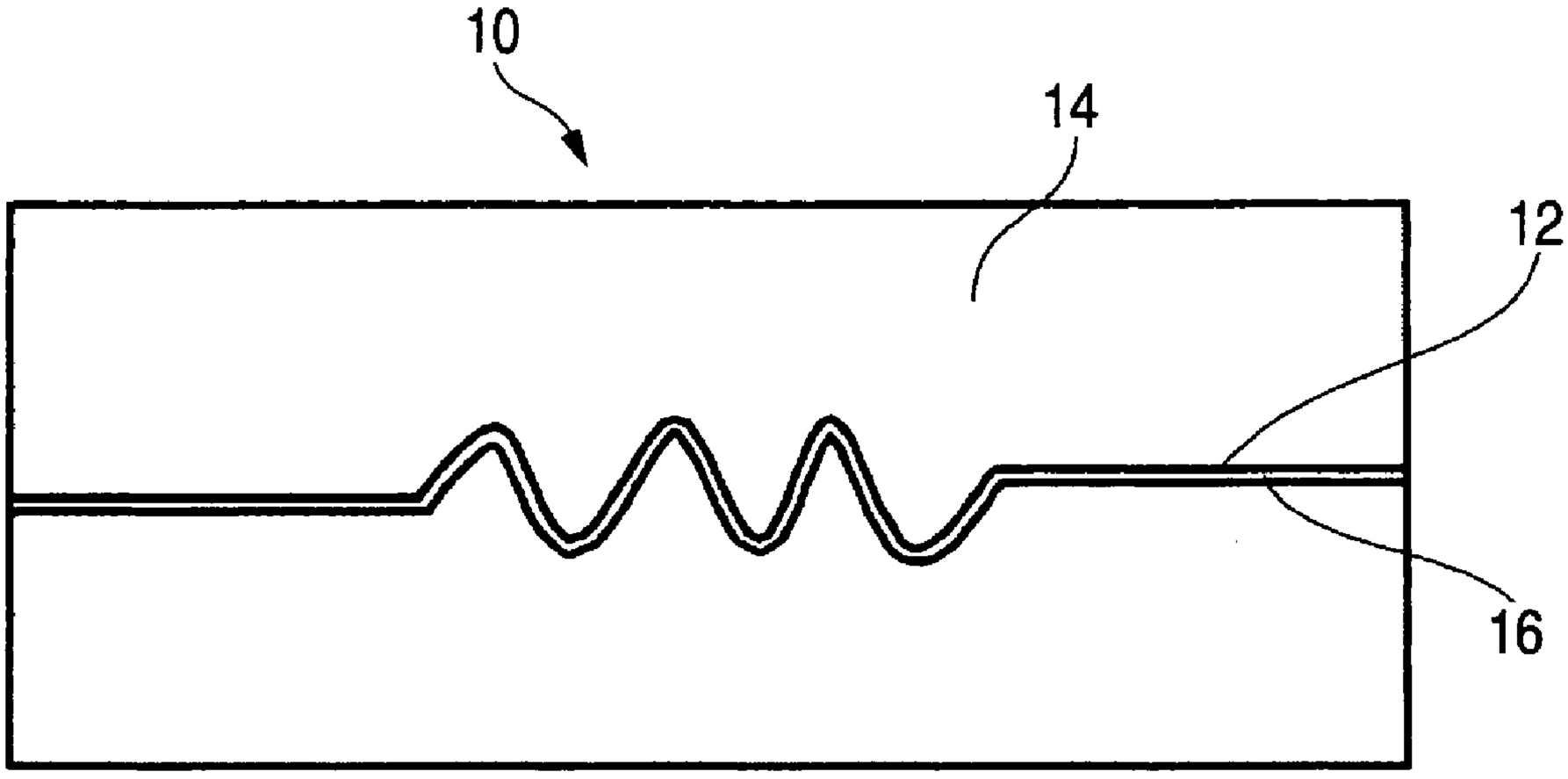


FIG. 1

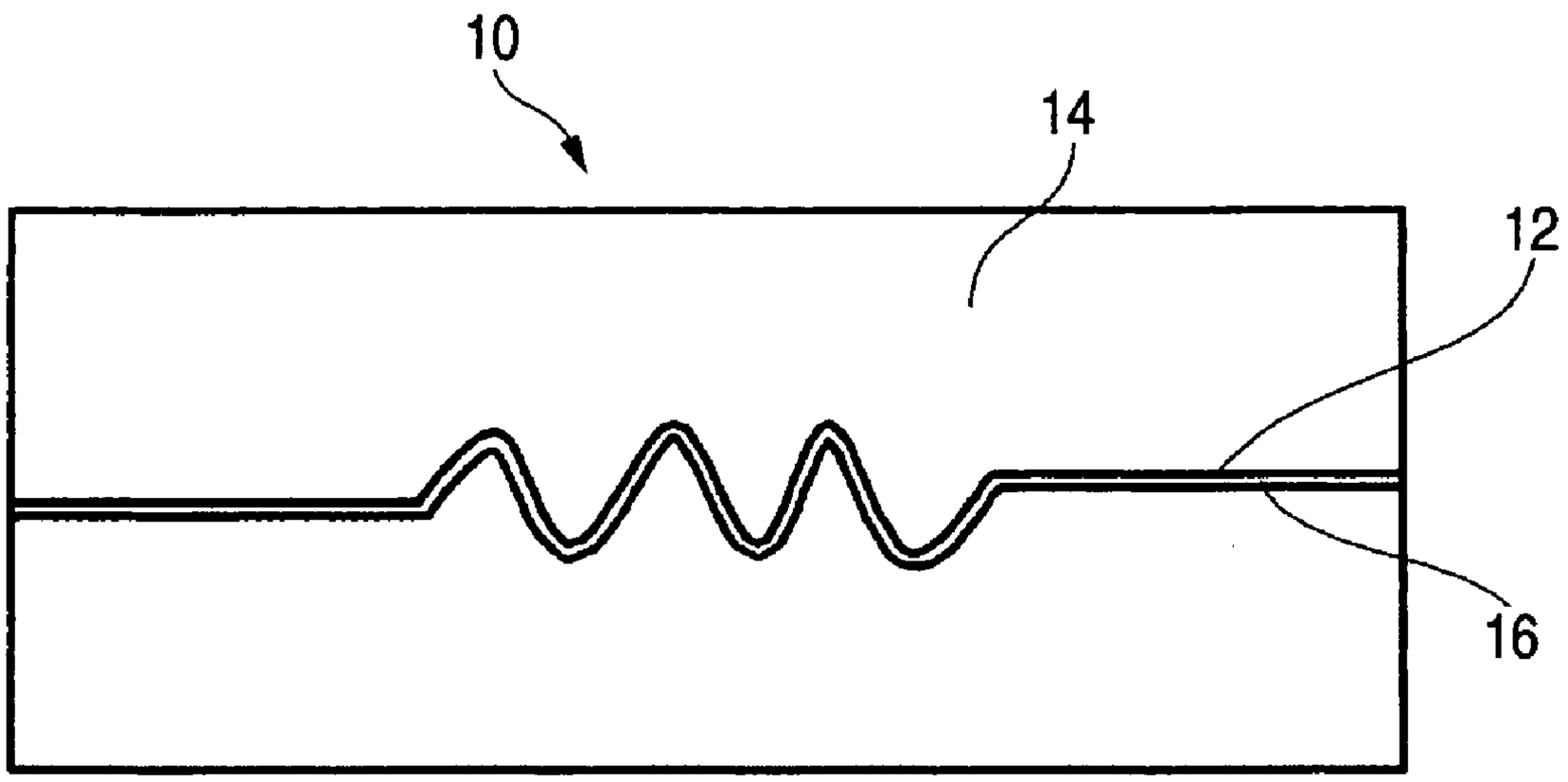


FIG. 2A

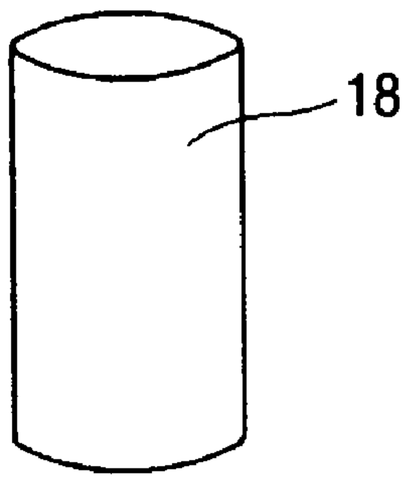
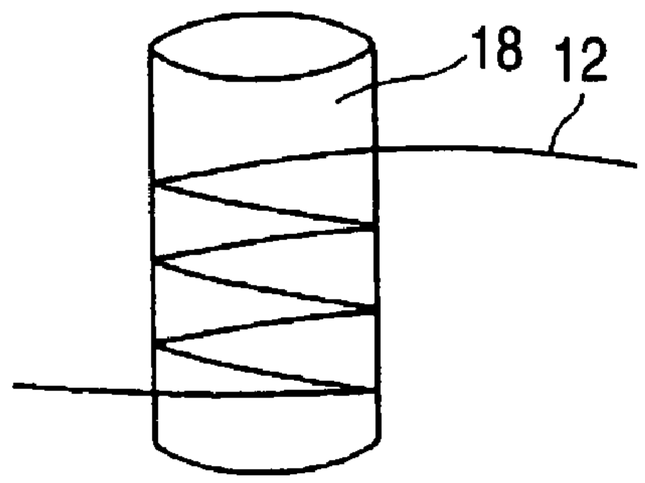


FIG. 2B



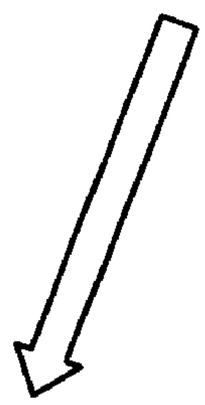


FIG. 2C

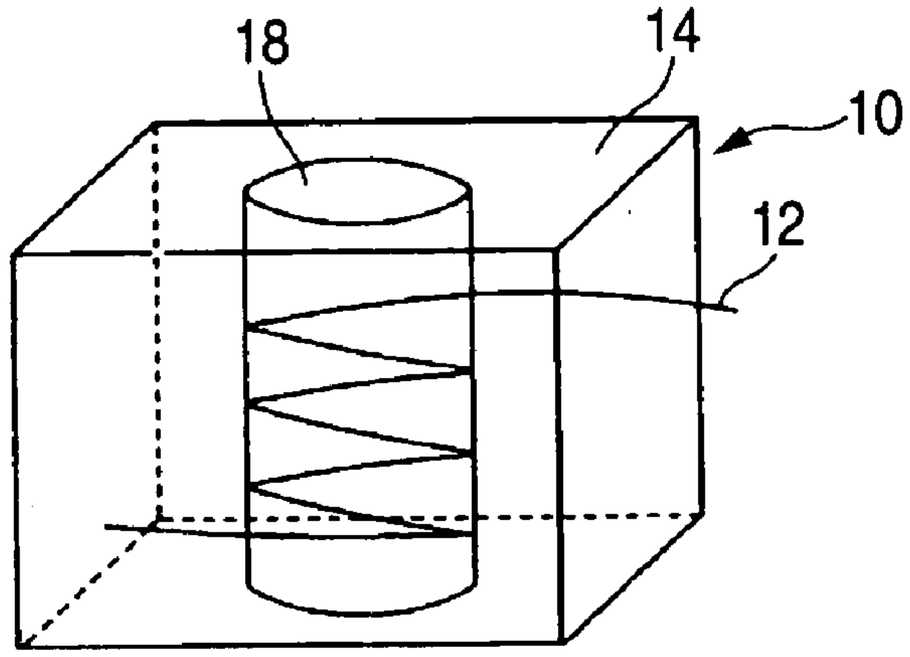


FIG. 3

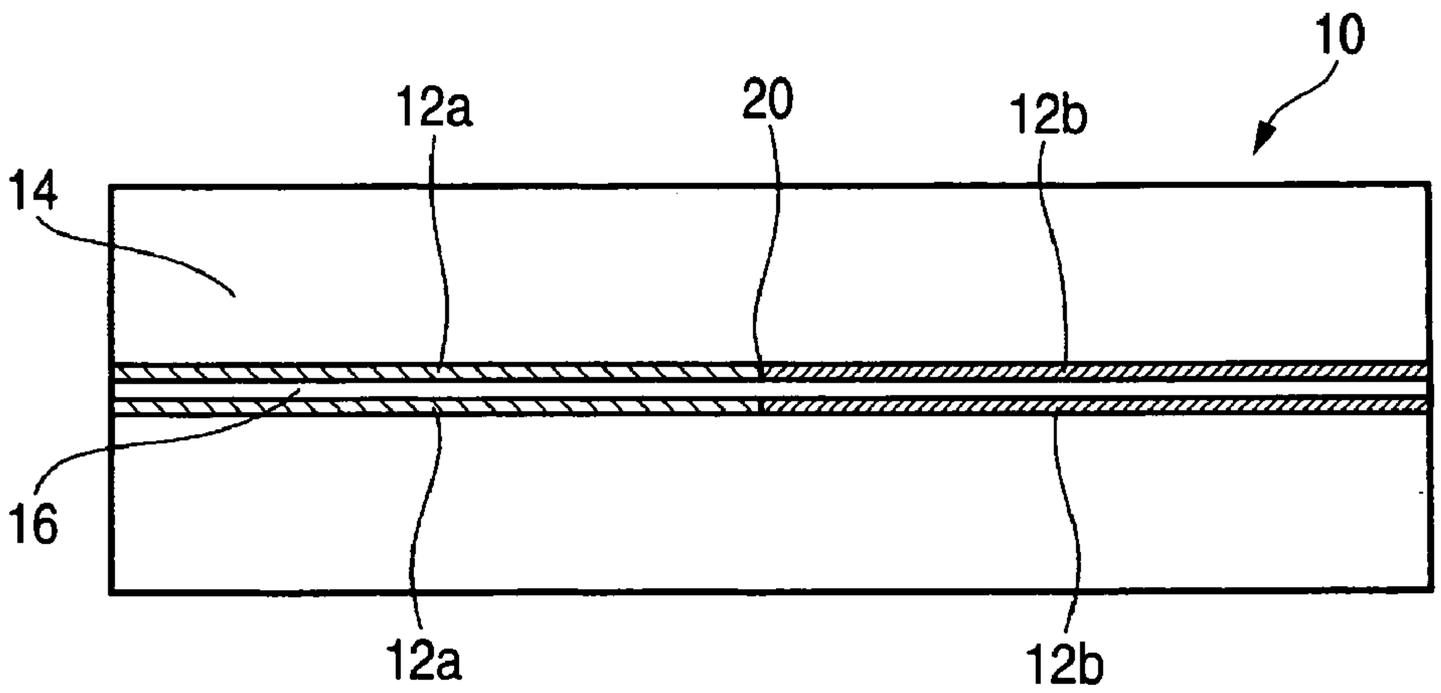
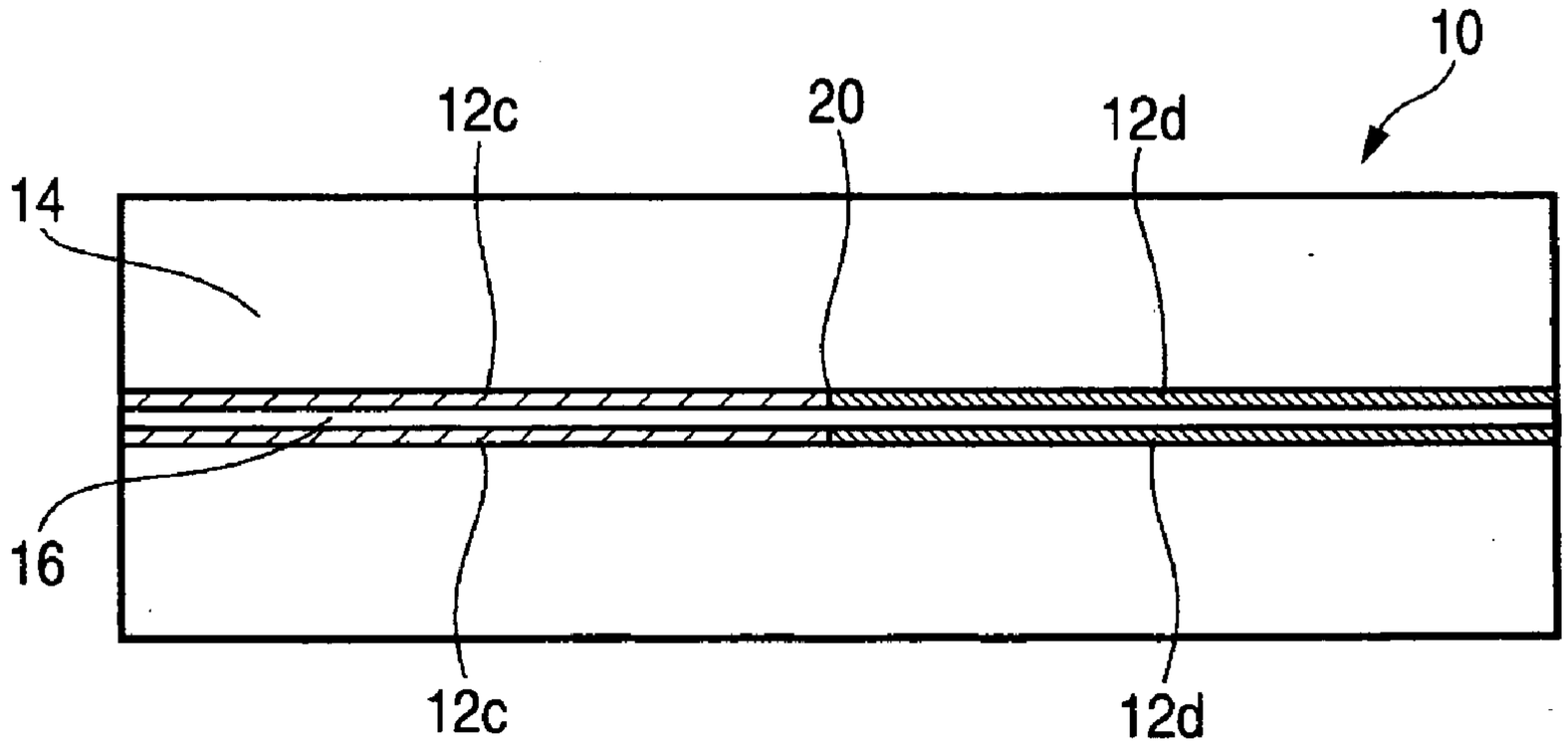


FIG. 4



HOLLOW DEVICE AND MANUFACTURING METHOD THEREOF

BACKGROUND

[0001] 1. Technical Field

[0002] The present invention relates to a hollow device and a manufacturing method thereof.

[0003] 2. Related Art

[0004] Conventionally, hollow devices are mainly formed of metallic materials such as stainless steel. In this case, since the metallic materials have extremely high melting temperatures, depending on casting into a mold, it has been difficult to mold the hollow device so as to have a hollow portion, particularly a micro channel whose diameter is in micron units. For this reason, conventionally, after capillary grooves are respectively formed in surfaces of two parts of the metallic material by etching treatment, these two parts are joined by welding or the like to form a tubular channel, or a short tubular passage is formed in a metallic material by laser processing, and these short tubular passages are joined to form a channel.

[0005] In addition, in a conventional method of manufacturing a hollow device using a high molecular resin, a high molecular resin in a molten state is caused to flow into a mold having a convex shape corresponding to a micro channel by injection molding to mold a member (one resin-made member) having a groove corresponding to the micro channel. A member (another resin-made member) separately molded of a high polymer is joined to the surface with the groove formed thereon, thereby molding a hollow device.

SUMMARY

[0006] According to a first aspect of the present invention, a hollow device includes: a hollow fiber that has a micro channel; and a device body forming portion that is disposed around a periphery of the hollow fiber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Exemplary embodiment of the present invention will be described in detail based on the following figures, wherein:

[0008] FIG. **1** is a schematic cross-sectional view, taken along an axially central portion of a hollow fiber, of an example of a hollow device in accordance with the invention;

[0009] FIGS. **2**A to **2**C are schematic diagrams that illustrate an example of the hollow device and a manufacturing process thereof in accordance with the invention;

[0010] FIG. **3** is a schematic cross-sectional view, taken along the axially central portion of the hollow fiber, of another example of the hollow device in accordance with the invention; and

[0011] FIG. **4** is a schematic cross-sectional view, taken along the axially central portion of the hollow fiber, of still another example of the hollow device in accordance with the invention.

DETAILED DESCRIPTION

[0012] A hollow device in accordance with the invention is characterized by comprising: a hollow fiber having a micro channel; and a device body forming portion disposed around a periphery of the hollow fiber.

[0013] In addition, a method of manufacturing a hollow device in accordance with the invention is characterized by comprising the steps of; disposing a hollow fiber having a micro channel in a desired shape; introducing a device body forming material to around a periphery of the hollow fiber; and curing or solidifying the device body forming material.

[0014] Hereafter, a detailed description will be given of the invention with reference to the drawings.

[0015] In a conventional method of manufacturing a hollow device, as in the invention described in the above-described patent document 1, for instance, a method has been proposed in which a fibrous hollow portion forming member, such as a metallic yarn, a resinous yarn, a glass-made yarn, or a carbon-made yarn, is stretched in a mold in a predetermined shape, a thermosetting resin or a thermoplastic resin such as an epoxy resin is then filled into the mold and is allowed to cure, and the fibrous hollow portion forming member is removed after the formation of the device body. Although the formation of a loop-like channel, a curved channel, a channel in which a straight channel and a curved channel are combined, and a channel in which a straight channel and a loop-like channel are combined has been proposed in this method, the manufacturing process is not easy, and it is difficult to process and design the functions of the interior of the channel for the purpose of high performance.

[0016] With the method described in the patent document 1, the fibrous member is removed; however, in the hollow device and the manufacturing method thereof in accordance with the invention, the hollow fiber is used, and the hollow portion of the interior of the hollow fiber is used as the micro channel. Therefore, the material and structure of the hollow fiber can be selected from various kinds, and the channel for imparting high performance can be designed easily. In addition, since the channel is formed by the hollow fiber, it is possible to obtain by batch molding a device having a micro channel formed by designing an arbitrary hollow fiber into a desired shape, such as a straight shape, a loop-like shape, a curved shape, and a complex shape.

[0017] In the conventional method of manufacturing a device having a micro channel, after capillary grooves are respectively formed in surfaces of two parts of a metallic material by etching treatment, these two parts are joined by welding or the like to form a tubular channel. In another method, a short tubular passage is formed in a metallic material by laser processing, and these short tubular passages are joined to form a channel. In such methods and in the manufacturing method using a high molecular resin, it is possible to cite a method in which a high molecular resin in a molten state is caused to flow into a mold having a convex shape corresponding to a micro channel by injection molding to mold a member (one resin-made member) having a groove corresponding to the micro channel. A member (another resin-made member) separately molded of a high polymer is joined to the surface with the groove formed thereon, thereby molding a hollow device. However, with these conventional methods, the process has been complex in that the interior of the micro channel is coated with a high molecular material after the formation of the channel for the purpose of high performance.

[0018] On the other hand, in the invention, since the channel is formed by the hollow fiber, by selecting the material and structure of the hollow fiber, it is possible to easily obtain by batch molding devices having micro chan-

nels of desired properties such as, for example, a hydrophilic channel, a hydrophobic channel, a combination of a hydrophilic channel and a hydrophobic channel, a combination of channels which are selectively gas permeable, a channel having a sea-island structure of an organic material and an inorganic material, and so on.

(Hollow Device)

[0019] The hollow device in accordance with the invention is characterized by comprising: a hollow fiber having a micro channel; and a device body forming portion disposed around a periphery of the hollow fiber.

[0020] In addition, the hollow device in accordance with the invention should preferably be manufactured by the below-described method of manufacturing a hollow device in accordance with the invention.

[0021] As the hollow device in accordance with the invention, it is possible to specifically cite the shapes such as those shown in FIGS. **1** to **4**, but the invention is not limited to the same.

[0022] FIG. **1** is a schematic cross-sectional view, taken along an axially central portion of a hollow fiber, of the hollow device in accordance with the invention.

[0023] A hollow device **10** shown in FIG. **1** is formed by a hollow fiber **12**, and a device body forming portion **14**, and a micro channel **16** is formed in the interior of the hollow fiber **12**. As the hollow device is formed by disposing the hollow fiber **12** in a desired shape at the time of the manufacture of the hollow device such that, in FIG. **1**, the micro channel **16** assumes a corrugated shape in the vicinity of the center of the device, it is possible to easily form a hollow device having a micro channel of an arbitrary shape.

[0024] FIGS. **2**A to **2**C are schematic diagrams that illustrate an example of the hollow device and a manufacturing process thereof in accordance with the invention.

[0025] The hollow device **10** shown in FIG. **2** is a hollow device **10** (FIG. **2**C) in which the micro channel **16** is formed spirally in the central portion of the device. As a manufacturing method thereof, a portion of the hollow fiber **12** is first wound spirally around a cylindrical member **18** shown in FIG. **2**A, and the device body forming portion **14** is then formed while maintaining the shape of the hollow fiber **12**, thereby making it possible to easily manufacture the hollow device **10**.

(Hollow Fiber)

[0026] The hollow fiber which can be used in the invention is not particularly limited insofar as the hollow fiber has a hollow portion in the interior of the fiber, and the hollow portion of the hollow fiber is capable of forming a micro channel when the hollow device is manufactured. In addition, as the number of the hollow fibers used in the hollow device in accordance with the invention, one or two or more hollow fibers may be used.

[0027] The shape of the hollow fiber which can be used in the invention is not particularly limited, and it is possible to cite a shape in which a cross-sectional shape of the outer periphery of the hollow fiber is, for example, a circle, an ellipse, a polygon, a shape consisting of one or more arbitrary curves, a shape consisting of one or more arbitrary straight lines and one or more arbitrary curves, and the like. In addition, the shape of the micro channel in the interior of the hollow fiber is similarly not particularly limited, and it is possible to cite a shape in which a cross-sectional shape of the outer periphery of the hollow fiber is, for example, a circle, an ellipse, a polygon, a shape consisting of one or more arbitrary curves, a shape consisting of one or more arbitrary straight lines and one or more arbitrary curves, and the like.

[0028] In addition, the hollow fiber which can be used in the invention may have in the interior of one hollow fiber only one micro channel or two or more micro channels, as required.

[0029] In the hollow device in accordance with the invention, the length of the hollow fiber, i.e., the length of the micro channel, is not particularly limited, and the hollow device can be formed by using a desired length.

[0030] In addition, the above-described hollow fiber may not have a uniform shape or channel diameter in the overall hollow fiber, and it is sufficient if the hollow fiber has a desired shape and fiber diameter.

[0031] The micro channel which is formed by the above-described hollow fiber is sufficient if it is a channel of a micro scale in at least its portion. Namely, the width of the portion where the width (channel diameter) of the channel is the narrowest in the hollow device in accordance with the invention is 5,000 μm, preferably in a range of 10 to 1,000 μm, and more preferably in a range of 30 to 500 μm. Further, the depth of the channel is preferably in a range of 10 to 1,000 μm.

[0032] In addition, the fiber diameter of the above-described hollow fiber is not particularly limited, and the hollow fiber should preferably be such that the one or more micro channels formed in the hollow fiber are formed with the above-described channel diameter. The fiber diameter of the above-described hollow fiber is preferably in a range of 10 to 2,000 μm, more preferably in a range of 30 to 1,000 μm.

[0033] In addition, the micro channel formed by the above-described hollow fiber may not have a uniform shape or channel diameter in the overall hollow fiber, and it is sufficient if the micro channel has a desired shape and channel diameter.

[0034] As the hollow fiber which can be used in the invention, it is possible to suitably use, for instance, commercially available hollow fibers. Owing to the development of fiber forming technology in recent years, hollow fibers of various materials have been fabricated. In particular, hollow fibers made of such resins as polyethylene, polypropylene, polyimide, fluororesin, and polyester have been marketed by fiber manufacturers. As for these hollow fibers, various materials, functions, and shapes have been designed in tune with the objectives. As compared with conventionally fabricated devices having micro channels, the use of these hollow fibers as micro channels makes it possible to easily impart to channels functions including a multiplicity of kinds of materials, shapes, and surface characteristics through the combination of hollow fibers.

[0035] In addition, since the hollow fibers are fibrous, it is easily possible to form various channels including loop-like channels, curved channels, and straight channels, or combinations thereof; In addition, it is readily possible to form these channels in one device by using one hollow fiber.

[0036] As the material of the hollow fiber, it is possible to use any materials such as a resin (high molecular compound), a carbon fiber, a composite material of a resin and an inorganic material such as silica particles and clay, glass,

and a metal insofar as they are capable of forming hollow fibers. Among these, because of ease of the fabrication of a hollow fiber and in light of the selectivity and high performance of the material, a resin, a carbon fiber, a composite material of a resin and an inorganic material, or glass is preferable, and a resin is particularly preferable.

[0037] As for the hollow fiber which can be used in the invention, it is preferable to use two or more kinds of hollow fibers by connecting and combining them. The method of connecting the hollow fibers is not particularly limited, and it suffices if an end of one hollow fiber, an end of another hollow fiber, and an end of still another fiber are connected by a known method. As specific methods of connecting the hollow fibers, it is possible to cite by way of example a method of connecting an end of a hollow fiber and an end of another hollow fiber by an adhesive or the like, a method of thermally fusing ends, a method of connecting two hollow fibers at their ends by a joint member, and so on.

[0038] In addition, in the manufacture of the hollow fiber, one hollow fiber having two or more portions whose properties are different may be manufactured and may be used as the hollow device in accordance with the invention.

[0039] In the conventional micro channel devices, it has been difficult to modify the inner wall of the micro channel and impart specific properties and functions thereto.

[0040] In the hollow device in accordance with the invention, since the micro channel is formed by the hollow fiber, the inner wall portion of the micro channel can be easily functionalized only by using a hollow fiber having desired properties and functions.

[0041] As for the hollow fibers which can be used in the invention, in light of imparting specific properties and functions, it is preferable to use hollow fibers which have such properties and functions as the hydrophilic property, the hydrophobic property, selective gas permeability, selective liquid permeability, reactivity, compound selective reactivity, and/or a filtering function, a dialyzing function, and the like.

[0042] In addition, in the hollow device in accordance with the invention, since the channel is formed by the hollow fiber, by selecting the material and structure of the hollow fiber, it is possible to easily obtain micro channels of desired properties such as, for example, a combination of a hydrophilic channel and a hydrophobic channel, a combination of channels which are selectively gas permeable, a channel having a sea-island structure of an organic material and an inorganic material, and so on.

[0043] As the combination of a hydrophilic channel and a hydrophobic channel, it is possible to cite by way of example the hollow device of the invention such as the one shown in FIG. **3**.

[0044] FIG. **3** is a schematic cross-sectional view, taken along the axially central portion of the hollow fiber, of the hollow device in accordance with the invention.

[0045] The hollow device **10** shown in FIG. **3** is a device in which the hollow fiber **12** is formed by a hydrophilic hollow fiber **12***a* and a hydrophobic hollow fiber **12***b*, and the property of the inner wall portion of the micro channel changes between the hydrophilic property and the hydrophobic property at a joint portion **20** serving as a boundary.

[0046] As the combination of channels which are selectively gas permeable, it is possible to cite by way of example the hollow device of the invention such as the one shown in FIG. **4**.

[0047] FIG. **4** is a schematic cross-sectional view, taken along the axially central portion of the hollow fiber, of the hollow device in accordance with the invention.

[0048] The hollow device **10** shown in FIG. **4** is a device in which the hollow fiber **12** is formed by a hollow fiber **12***c* having a deoxidizing property and a hollow fiber **12***d* having a water vapor permeation property, and the property of the inner wall portion of the micro channel changes between the deoxidizing property and the water vapor permeation property at the joint portion **20** serving as a boundary.

[0049] In addition, the hollow fiber which can be used in the invention may have a bifurcation or branches. Namely, the micro channel in the hollow device in accordance with the invention may have a bifurcation or branches.

[0050] In addition, a plurality of hollow fibers may be connected by a joint member provided with a micro channel having a bifurcation or branches, thereby forming bifurcated or branched micro channel portions in the hollow device.

[0051] Specifically, it is possible cite a method in which grooves of a desired bifurcation or branches are formed in a substrate which forms a part of the device body forming portion, and hollow fibers are disposed and fixed in these portion, and are subjected to molding with a device body forming material, as well as a method in which hollow fibers are connected by using a commercially available joint or an epoxy resin-made joint fabricated by a laser molding method, so as to obtain a molded body having a bifurcation or branches.

(Device Body Forming Portion)

[0052] As the material of the device body forming portion in the hollow device in accordance with the invention, it is possible to cite by way of example a metal, a ceramic, glass, silicon, and a resin. In light of ease of molding, glass, silicon, or a resin is preferable, and it is more preferable to use a high molecular material such as a reactive resin having a thermosetting property or a photo-curing property, a thermoplastic resin, and the like.

[0053] In addition, in the hollow device in accordance with the invention, the material of the device body forming portion and the material of the hollow fiber should preferably be different materials.

[0054] In the case where a thermosetting resin or a thermoplastic resin is used, it is preferable to select such a material that the melting point of the material of the hollow fiber is higher than that of the material of the device body forming portion. In addition, in a case where a material which has been fused by a solvent is used, it is preferable to select such a material that the material of the hollow fiber has resistance against the solvent fusing the material.

[0055] In addition, as the resin which is used as the material of the device body forming portion, the resin should preferably be such a resin that the shock resistance, the heat resistance, the chemical resistance, the transparency, and the like are suitable for the reaction or the unit operation which is performed. Specifically, as preferred resins it is possible to cite by way of illustration a polyester resin, a styrene resin, an acrylic resin, a styrene-acrylic resin, a silicone resin, an epoxy resin, a diene-based resin, a phenolic resin, a terpene resin, a coumarin resin, an amide resin, an amide-imide resin, a butyral resin, a urethane resin, an ethylene-vinyl acetate resin, and the like. However, an epoxy resin is more preferable.

[0056] In addition, as the aforementioned thermosetting resin, photo-curing resin, and thermoplastic resin, it is possible to suitably use those described in "*Koubunshi Jiten* (Concise Encyclopedia of Polymer Science and Engineering)" (**1994**, published by Maruzen Company, Limited), as required.

[0057] The size of the hollow device in accordance with the invention can be set appropriately in tune with the objective of use, as required, but a range of 1 to 100 cm^2 is preferable, and a range of 10 to 40 cm^2 is more preferable. In addition, the thickness of the hollow device is preferably in a range of 2 to 30 mm, more preferably in a range of 3 to 15 mm.

[0058] The hollow device in accordance with the invention may have, in addition to the micro channel formed by the hollow fiber, another micro channel and portions having the functions of reaction, mixing, separation, refining, analyzing, cleaning, and the like in correspondence with its applications.

[0059] Further, the hollow device in accordance with the invention may be provided with, for example, a liquid feeding port for feeding a liquid to the hollow device and a collection port for collecting a liquid from the hollow device, as required.

[0060] In addition, the hollow device in accordance with the invention may be combined with devices having the functions of reaction, mixing, separation, refining, analyzing, cleaning, and the like, as well as a liquid feeding device, a collecting device, another micro channel device, and the like in correspondence with its applications, thereby making it possible to suitably construct a micro chemical system.

(Method of Manufacturing Hollow Device)

[0061] The method of manufacturing a hollow device in accordance with the invention is characterized by including a step of disposing a hollow fiber having a micro channel in a desired shape (hereafter also referred to as the "disposing step"), a step of introducing a device body forming material to around a periphery of the hollow fiber (hereafter also referred to as the "introducing step"), and a step of curing or solidifying the device body forming material (hereafter also referred to as the "fixing step").

[0062] The disposing step is one in which, in tune with the objective of use, a suitable hollow fiber having a micro channel is selected, and the hollow fiber is disposed in a desired shape in tune with the design of the channel. As preferred methods of disposing the hollow fiber in a desired shape, it is possible to cite by way of illustration a method in which the hollow fiber is disposed in a mold which is used at the time of forming the device body forming portion or in a substrate fabricated of a device body forming material, and a method in which the hollow fiber is disposed in a desired shape by using an auxiliary member such as the cylindrical member shown in FIG. **2**, as described before,

[0063] The introducing step is one in which the device body forming material is introduced to around the hollow fiber in conformity with the shape of the hollow fiber. The device body forming material which is introduced should preferably be a fluid when introduced, and may be used in a state in which it is dissolved or dispersed in a solvent.

[0064] In addition, as for the method of manufacturing a hollow device in accordance with the invention, after the device body forming material is introduced to around the hollow fiber, the hollow fiber may be disposed in a desired shape, or may be disposed in a desired shape while the device body forming material is being introduced to around the hollow fiber. Namely, in the method of manufacturing a hollow device in accordance with the invention, the introducing step may be performed after the disposing step is effected, the disposing step may be performed after the introducing step is effected, or the disposing step and the introducing step may be performed simultaneously.

[0065] The fixing step is one in which the device body forming material is cured or solidified by an appropriate means such as heating, cooling, application of light, drying, desolventing, compression, and the like. In addition, the "curing" or "solidification" is sufficient if the disposition of the hollow fiber disposed inside the device does not change, and the device body forming material is cured or solidified to hardness which does not present a problem when the hollow device is used. The hollow device itself may be deformable by a stress as in the case of rubber or the like.

[0066] As preferred specific methods of manufacturing a hollow device in accordance with the invention, it is possible to cite by way of example a method in which a suitable hollow fiber is selected in tune with the objective of use of the hollow device, the hollow fiber is fixed in a substrate which forms a part of the device body forming portion in tune with the design of the channel, and a device body forming material is introduced into a mold and is solidified to thereby obtain a molded body, and a method in which a suitable hollow fiber is selected in tune with the objective of use of the hollow device, the hollow fiber is fixed in a mold in tune with the design of the channel, and a device body forming material is introduced into the mold and is solidified to thereby obtain a molded body.

EXAMPLES

[0067] Hereafter, a detailed description will be given of the invention by citing examples, but the invention is not limited to the same.

First Example

[0068] After a polyethylene-made hollow fiber (made by Mitsubishi Rayon Co. Ltd.) was disposed in a mold such that a central portion was set in a corrugated shape and the remaining portions were set in a straight shape, as shown in FIG. **1**, an epoxy resin in a state of a solution (made by Japan Epoxy Resins Co., Ltd.; liquid grade: 821, curing agent grade: 3019) was allowed to flow into the mold, and was subjected to heat treatment at 80° C. for 3 hours to solidify the high molecular resin, thereby fabricating a hollow device having a micro channel

Second Example

[0069] After a hydrophobic polyethylene-made hollow fiber (made by Mitsubishi Rayon Co. Ltd.) and a hydrophilic ethylene-vinyl alcohol copolymer-made hollow fiber (made by Kawasumi Laboratories, Inc.) were combined and were disposed in a mold, as shown in FIG. **3**, the epoxy resin in a state of a solution (made by Japan Epoxy Resins Co., Ltd.; liquid grade: 821, curing agent grade: 3019) was allowed to flow into the mold, and was subjected to heat treatment at

80° C. for 3 hours to solidify the high molecular resin, thereby fabricating a hollow device having a micro channel.

Third Example

[0070] A polytetrafluoroethylene-made hollow fiber having a deoxidizing property (SEPAREL/PF-F made by Dainippon Ink and Chemicals Incorporated) and a polyimide-made hollow fiber having a water vapor permeation property (made by UBE INDUSTRIES, LTD. were combined and disposed, an epoxy resin in a molten state (made by Japan Epoxy Resins Co., Ltd.; liquid grade: 821, curing agent grade: 3019) was allowed to flow into the mold, and was subjected to heat treatment at 80° C. for 3 hours to solidity the high molecular resin, thereby fabricating a hollow device having a micro channel. Pumps were respectively installed at a channel inlet port and an outlet port of the fabricated hollow device, the flow rate was adjusted to regulate the internal pressure, and an ethanol in which oxygen and water were dissolved was allowed to flow. As a result of the measurement of the amount of oxygen and the amount of water dissolved in the ethanol which passed through the channel, both the amount of dissolved oxygen and the amount of dissolved water were observed to have dropped in comparison with the state before the flow through the channel.

What is claimed is:

1. A hollow device comprising:

a hollow fiber that has a micro channel; and

a device body forming portion that is disposed around a periphery of the hollow fiber.

2. The hollow device as claimed in claim **1**, wherein a cross-sectional shape of an outer periphery of the hollow fiber is one of a circle, an ellipse, a polygon, a shape consisting of one or more arbitrary curves, a shape consisting of one or more arbitrary straight lines and one or more arbitrary curves.

3. The hollow device as claimed in claim **1**, wherein a material of the hollow fiber comprises a resin.

4. The hollow device as claimed in claim **1**, wherein the material of the hollow fiber comprises a carbon fiber.

5. The hollow device as claimed in claim **1**, wherein the material of the hollow fiber comprises a composite material of the resin and an inorganic material.

6. The hollow device as claimed in claim **1**, wherein the material of the hollow fiber comprises a glass.

7. The hollow device as claimed in claim **1**, wherein the material of the hollow fiber comprises:

a portion that has hydrophobic property; and

a portion that has hydrophilic property.

8. The hollow device as claimed in claim **1**, wherein the material of the hollow fiber comprises:

a first permeable portion that gas is able to permeate; and

a second permeable portion that gas different from the gas is able to permeate.

9. A method of manufacturing a hollow device, which comprises:

disposing a hollow fiber in a desired shape, the hollow fiber having a micro channel;

introducing a device body forming material to around a periphery of the hollow fiber; and

one of curing and solidifying the device body forming material.

10. The method of manufacturing the hollow device as claimed in claim **9**, wherein a cross-sectional shape of an outer periphery of the hollow fiber is one of a circle, an ellipse, a polygon, a shape consisting of one or more arbitrary curves, a shape consisting of one or more arbitrary straight lines and one or more arbitrary curves.

11. The method of manufacturing the hollow device as claimed in claim **9**, wherein a material of the hollow fiber comprises a resin.

12. The method of manufacturing the hollow device as claimed in claim **9**, wherein the material of the hollow fiber comprises a carbon fiber.

13. The method of manufacturing the hollow device as claimed in claim **9**, wherein the material of the hollow fiber comprises a composite material of the resin and an inorganic material.

14. The method of manufacturing the hollow device as claimed in claim **9**, wherein the material of the hollow fiber comprises a glass.

15. The method of manufacturing the hollow device as claimed in claim **9**, wherein the material of the hollow fiber comprises:

a portion that has hydrophobic property and

a portion that has hydrophilic property.

16. The method of manufacturing the hollow device as claimed in claim **9**, wherein the material of the hollow fiber comprises:

a first permeable portion that gas is able to permeate; and

a second permeable portion that gas different from the gas is able to permeate.

* * * * *