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Beebe et al.

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(54) **METHOD AND DEVICE FOR CONTROLLED LAMINAR FLOW PATTERNING WITHIN A CHANNEL**

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F16L 41/00	(2006.01)
B01L 3/00	(2006.01)

(52) **U.S. Cl.**

CPC ***F17D 3/00*** (2013.01); *B01L 3/5027* (2013.01); *B01L 3/50273* (2013.01); *B01L 3/502715* (2013.01); *B01L 3/502776* (2013.01); *B01L 2200/0605* (2013.01); *B01L 2200/10* (2013.01); *B01L 2300/087* (2013.01); *B01L 2300/0816* (2013.01); *B01L 2300/0867* (2013.01); *B01L 2400/084* (2013.01); *Y10T 137/0318* (2015.04); *Y10T 137/85938* (2015.04)

(58) **Field of Classification Search**

USPC 422/68.1, 502–507
See application file for complete search history.

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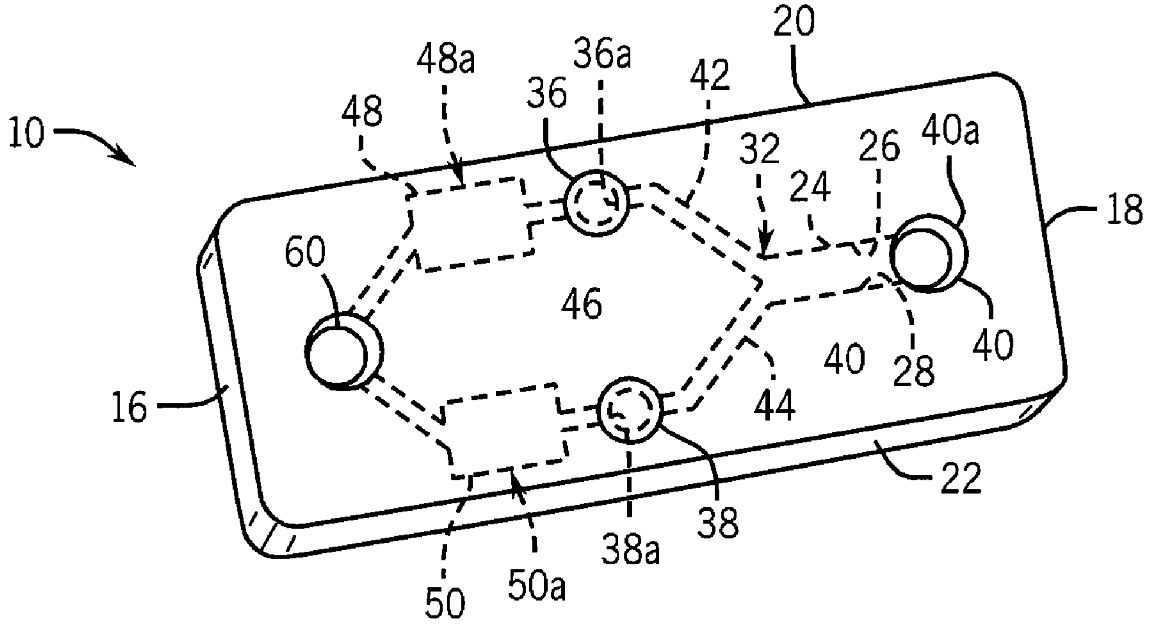
(57) **ABSTRACT**

A device and method of laminar flow patterning of at least one sample fluid in a main channel in a microfluidic device are provided. A first input channel is provided in the microfluidic device. The first input channel has an output end communicating with the first end of the main channel and an input end communicating with a first input port. A buffer fluid is deposited in the main channel and the first input channel and a first sample fluid is deposited in the first input port. A first pressure is generated in response to the depositing of the first sample fluid in the first input port so as to cause laminar flow of the first sample fluid in the main channel.

8 Claims, 5 Drawing Sheets



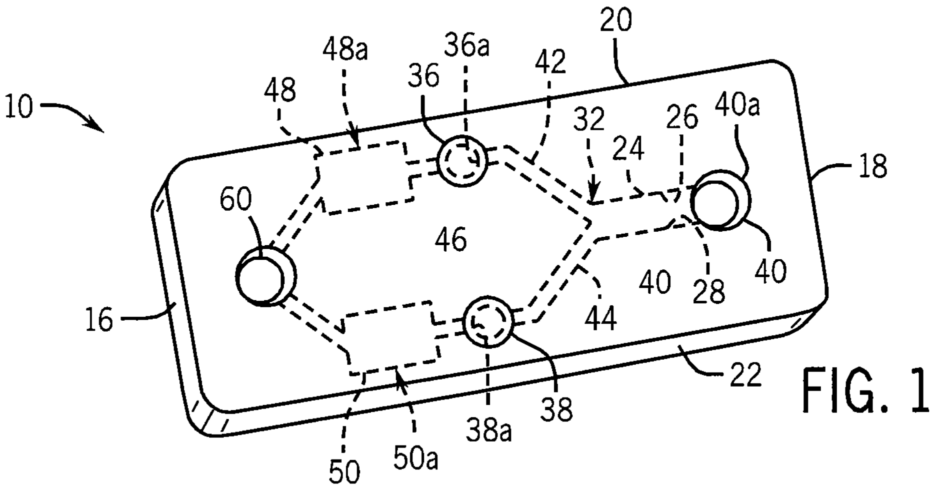


FIG. 1

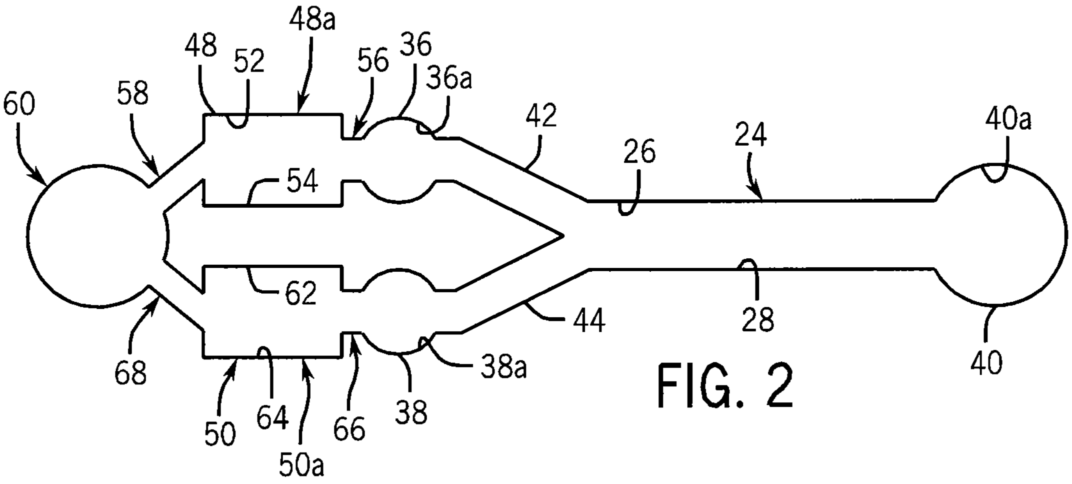


FIG. 2

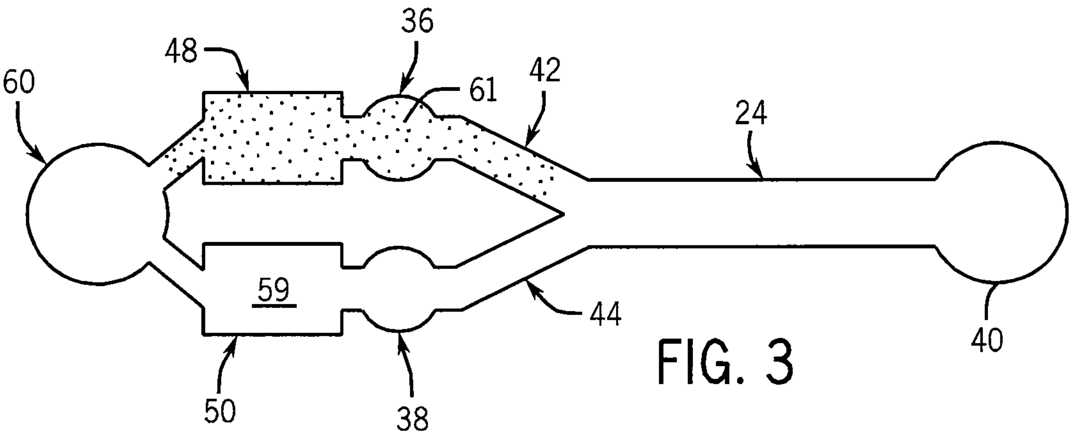
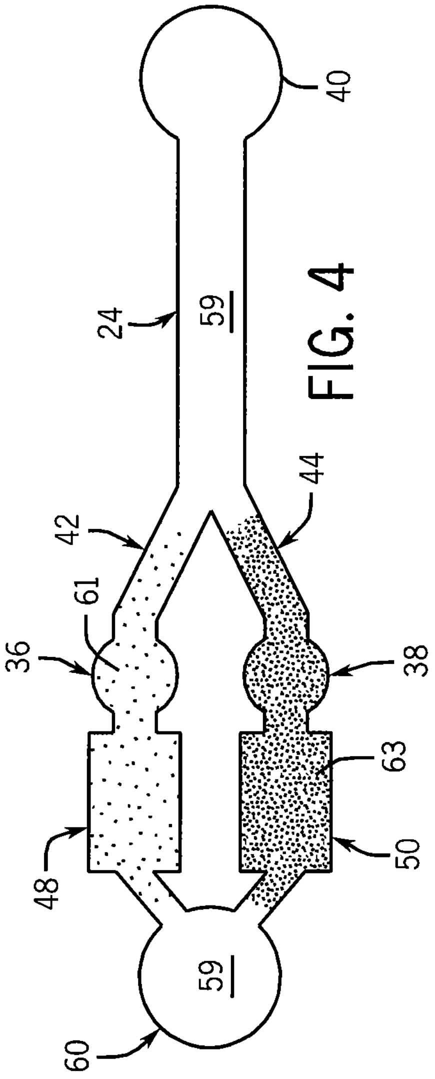


FIG. 3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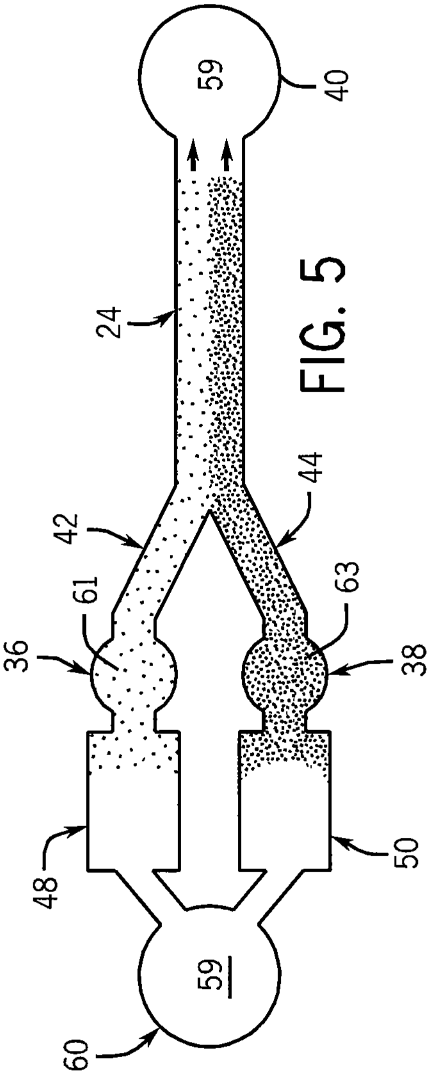
24
59
44
42
61
36
38
63
50
48
59
60

FIG. 4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48
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60

FIG. 5

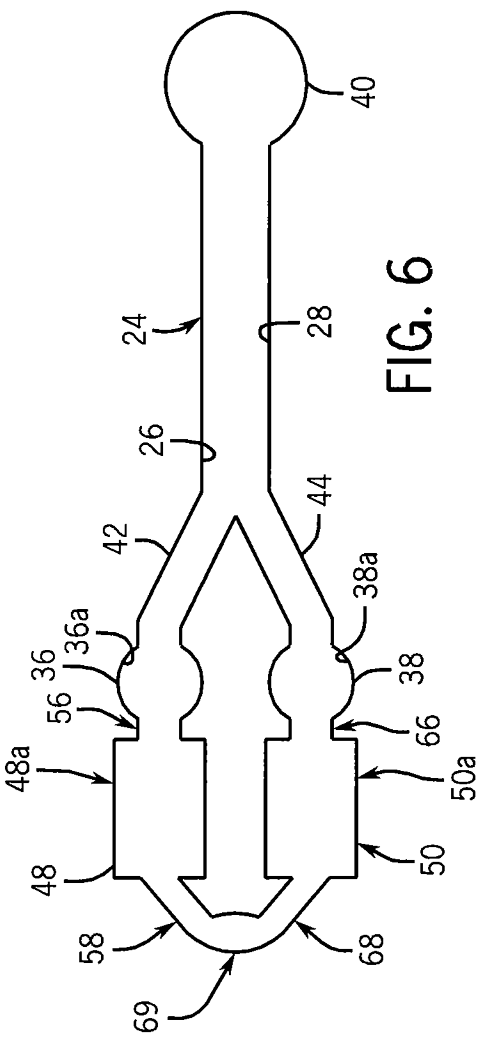
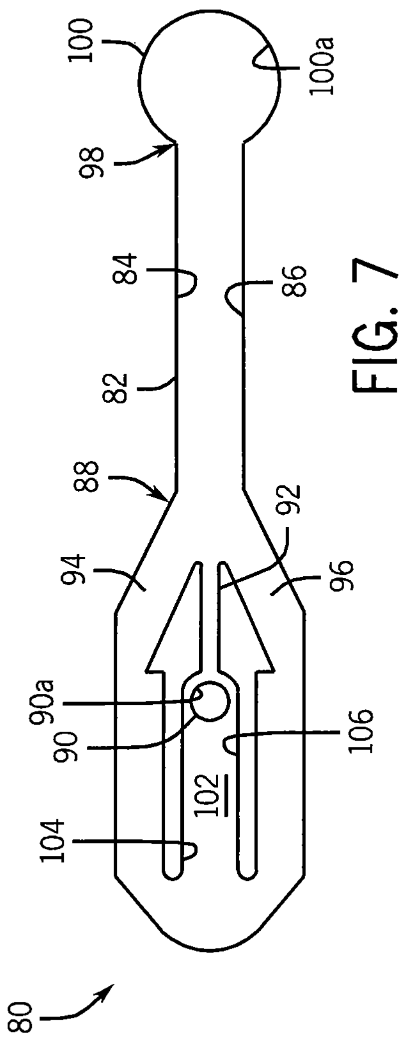

40
24
28
26
44
42
38a
36a
36
38
56
66
48a
50a
48
50
58
68
69

FIG. 6


100
100a
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84
86
82
88
92
94
96
90a
90
106
102
104
80

FIG. 7

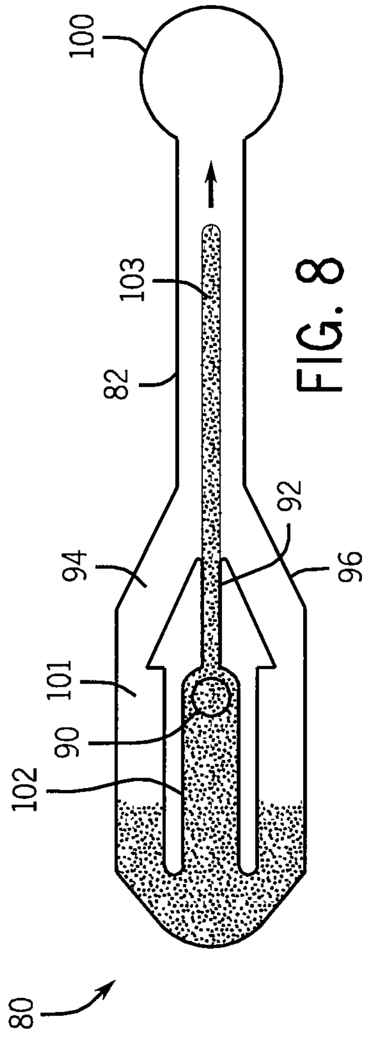
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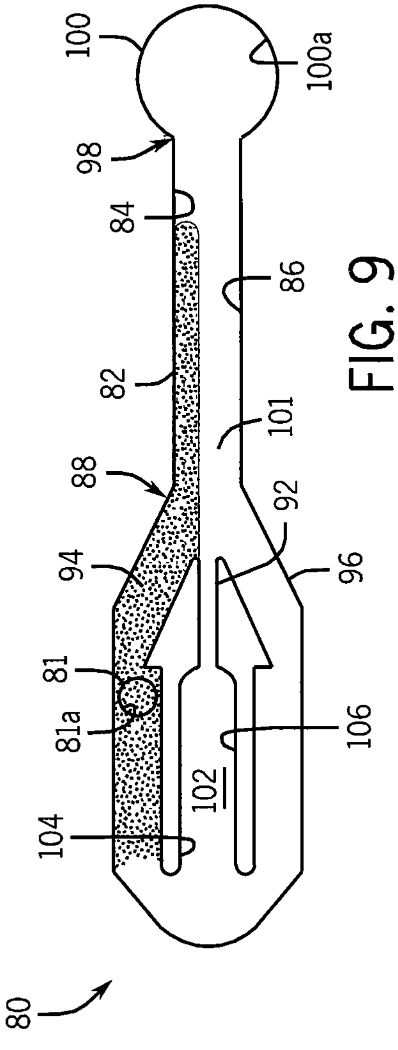
FIG. 8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81a
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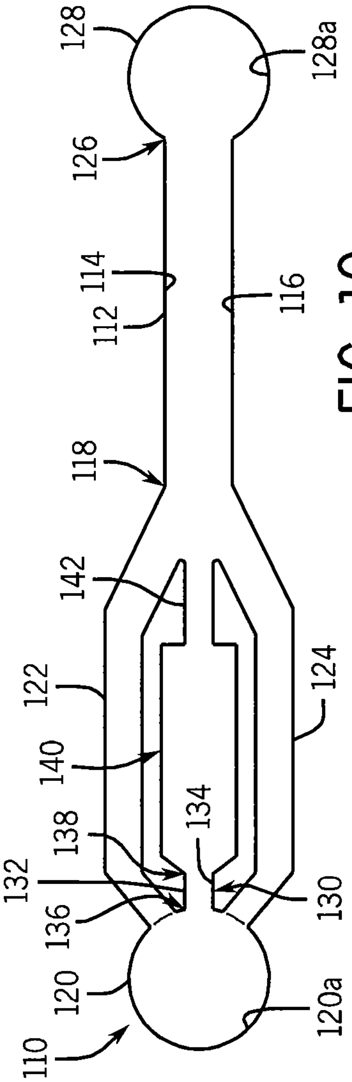
FIG. 9


128
128a
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132
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130
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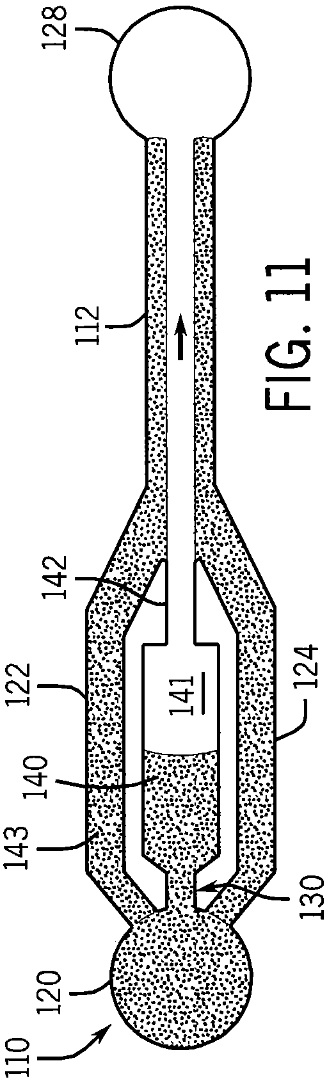
120a
110

FIG. 10


128
112
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122
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110

FIG. 11

METHOD AND DEVICE FOR CONTROLLED LAMINAR FLOW PATTERNING WITHIN A CHANNEL

REFERENCE TO GOVERNMENT GRANT

This invention was made with government support under W81XWH-09-1-0192 awarded by the ARMY/MRMC. The government has certain rights in the invention.

FIELD OF THE INVENTION

This invention relates generally to microfluidic devices, and in particular, to a method and a device for controlled laminar flow patterning within a channel of a microfluidic device.

BACKGROUND AND SUMMARY OF THE INVENTION

An increasing number of biological studies reveal the strong interaction between different cellular compartments in vivo. To accurately study and model these phenomena in vitro, traditional cell-biology platforms have been used on the periphery of their designed use. Microfluidic and microfabricated platforms are a natural fit for these applications as they provide unique capabilities to controllably place different cellular compartments in two-dimensional (2D) or three-dimensional (3D) matrices. Two main fluidic approaches have been demonstrated to achieve this task. The first fluidic approach segregates liquid compartments by providing a highly resistive fluidic path, such as a diffusion channel or a membrane, thereby allowing a user to load in contiguous chambers multiple cell types. This approach has proven to enable multi-culture of up to 5 cell types, as well as, increase the sensitivity as compared to traditional transwell dishes. The second fluidic approach leverages laminar (i.e. not turbulent) flow properties to fluidically pattern the different cell types in a channel. Laminar flow is employed by flowing two streams, side-by-side, within a channel in order to pattern cells, particles, and treatments. Laminar flow may also be used for developing gradients, where one chemical diffuses laterally from one stream into the other. It can be appreciated that this method maximizes the efficiency of the soluble factor signaling as the exchange of soluble factors is highest, while the volume per cell ratio is low.

Currently, there are no methods for reproducibly controlling laminar flow in a practical way. Hence, this fluidic approach remains seriously underutilized. Further, traditional microfluidic methods for reproducibly controlling laminar flow are not readily amendable to biological studies due to limitations such as connectivity problems (tubing, dead volumes, air bubbles, etc.). Recently, microdevices have been developed to alleviate these issues by integrating seamlessly with traditional equipment from the biology lab. These microdevices utilize surface tension-driven pumping or gravity pumping with a simple micropipette. In cell-based applications, the loading volumes are finite, usually from 1 to 10 μL, and the process is sequential. Therefore, flow patterning methods are more difficult to achieve as the flow varies over time. In particular, since the flow is limited in time, any differences in pressures occurring at the end of the motion will induce large changes in patterning. Further, the use syringe pumps to achieve laminar flow requires exact timing to achieve desirable results. This is due to the need to synchronize flows to avoid causing one stream to flow into the region of another, thereby disturbing the pattern.

Therefore, it is a primary object and feature of the present invention to provide a device for controlled laminar flow patterning of at least one sample fluid in a channel of a microfluidic device.

It is a further object and feature of the present invention to provide a method of laminar flow patterning of at least one sample fluid in a main channel in a microfluidic device.

It is a still further object and feature of the present invention to provide a device and a method of laminar flow patterning of at least one sample fluid in a main channel in a microfluidic device that is simple and inexpensive to implement.

In accordance with the present invention, a device is provided for controlled laminar flow patterning of at least one sample fluid. The device includes a body defining a channel network. The channel network includes a main channel extending along a longitudinal axis and having a first end and a second end defining an output port. A first input channel has an output end communicating with the first end of the main channel and an input end communicating with a first input port. The first input channel has a fluidic resistance. The channel network further includes a fluidic capacitor and a first buffering channel. The first buffering channel has a first end communicating with the first input channel and the first input port and a second end communicating with the fluidic capacitor. The first buffering channel has a fluidic resistance less than the fluidic resistance of the first input channel.

The channel network in the body of the device further includes a second input channel having an output end communicating with the first end of the main channel and an input end communicating with either the first input port or, alternatively, with a second input port. The second input channel having fluidic resistance. In the alternate embodiment, a second buffering channel has a first end communicating with the second input channel and the second input port and a second end communicating with the fluidic capacitor. The second buffering channel has a fluidic resistance less than the fluidic resistance of the second input channel.

A buffering fluid may be provided within the channel network and the at least one sample fluid may include a first sample fluid and a second sample fluid. It is intended for the fluidic capacitor to urge laminar flow of the first and second sample fluids in the main channel in response to the asynchronous depositing of the first sample fluid in the first input port and the second sample fluid in the second input port. Further, it is contemplated for the first and second input channels to have cross sectional areas and for the first and second buffering channels to have cross sectional areas. The cross sectional area of the first buffering channel is greater than the cross sectional area of the first input channel and the cross sectional area of the second buffering channel is greater than the cross sectional area of the second input channel. Similarly, the fluid capacitor, the first input port and the second input port have cross sectional areas. The cross sectional area of the fluid capacitor is greater than the cross sectional areas of the first and second input ports.

In accordance with a further aspect of the present invention, a method is provided of laminar flow patterning of at least one sample fluid in a main channel in a microfluidic device. The method includes the step of providing a first input channel in the microfluidic device. The first input channel has an output end communicating with the first end of the main channel and an input end communicating with a first input port. A buffer fluid is deposited in the main channel and in the first input channel. A first sample fluid is deposited in the first input port and a first pressure is generated in response to the depositing of the first sample fluid in the first input port. The first pressure causes laminar flow of the first sample fluid in the main channel.

A fluidic capacitor may be provided in communication with the first input channel and the buffer fluid being received in the fluidic capacitor. The buffer fluid in the fluidic capacitor has a surface tension pressure and the pressure causing laminar flow of the first sample fluid in the main channel is the surface tension pressure of the buffer fluid in the fluidic capacitor.

The method may include the additional step of providing a second input channel in the microfluidic device. The second input channel has an output end communicating with the first end of the main channel and an input end communicating with a second input port. The buffer fluid is deposited in the second input channel and a second sample fluid is deposited in the second input port. A second pressure is generated in response to the depositing of the second sample fluid in the second input port. The second pressure combines with the first pressure to provide a total pressure for causing laminar flow of the first and second sample fluids in the main channel along corresponding flow paths. In addition, the flow paths of the first and second sample fluids have corresponding widths. The widths of the flow paths are proportional to the fluidic resistances of the flow paths.

The method may also include the additional step of providing a fluidic capacitor in communication with the first and second input channels. The buffer fluid is received in the fluidic capacitor. The buffer fluid in the fluidic capacitor has a surface tension pressure and the total pressure causing laminar flow of the first and second sample fluids in the main channel is the surface tension pressure of the buffer fluid in the fluidic capacitor.

A second input channel may be provided in the microfluidic device. The second input channel has an output end communicating with the first end of the main channel and an input end communicating with a first input port. The buffer fluid is deposited in the second input channel. A first portion of the first sample fluid flows along a first flow path in the main channel and a second portion of the first sample fluid flows along a second flow path in the main channel.

In accordance with a still further aspect of the present invention, a method is provided of laminar flow patterning of at least one sample fluid in a flow channel in a microfluidic device. The method includes the step of providing a first input flow path between a first input port and the flow channel. The first flow path has a fluidic resistance. A first sample fluid is deposited in the first input port and a first pressure in response to the depositing of the first sample fluid in the first input port. The first pressure causes laminar flow of the first sample fluid in the fluid channel.

A fluidic capacitor may be provided in communication with the first input flow path and the first input port through a first buffering flow path. The first buffering flow path has a fluidic resistance less than the fluidic resistance of the first input flow path. The step of generating the first pressure includes the additional step of depositing a buffer fluid in the fluidic capacitor. The buffer fluid has a surface tension pressure and the pressure causing laminar flow of the first sample fluid in the flow channel is the surface tension pressure of the buffer fluid in the fluidic capacitor.

A second input flow path is provided between a second input port and the flow channel. The second flow path has a fluidic resistance. A second sample fluid is deposited in the second input port and a second pressure is generated in response to the depositing of the second sample fluid in the second input port. The second pressure combines with the first pressure to provide a total pressure for causing laminar flow of the first and second sample fluids in the flow channel along corresponding flow paths. The flow paths of the first and second sample fluids within the flow channel have corresponding widths. The widths of the flow paths in the flow channel are proportional to the fluidic resistances of the flow paths.

Alternatively, the second input flow path may communicates with flow channel and the first input port. As such, the first pressure causes laminar flow of a first portion of the first sample fluid along a first flow path in the flow channel and laminar flow of a second portion of the first sample fluid along a second flow path in the flow channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings furnished herewith illustrate a preferred construction of the present invention in which the above advantages and features are clearly disclosed as well as others which will be readily understood from the following description of the illustrated embodiment.

In the drawings:

FIG. **1** is an isometric view of a device for effectuating a methodology in accordance with the present invention;

FIG. **2** is a schematic, top plan view of a channel network for the device of FIG. **1**;

FIG. **3** is a schematic, top plan view of the channel network of FIG. **2** after a first sample fluid is loaded;

FIG. **4** is a schematic, top plan view of the channel network of FIG. **2** after a second sample fluid is loaded;

FIG. **5** is a schematic, top plan view of the channel network of FIG. **2** depicting laminar flow of the first and second sample fluids in a main channel;

FIG. **6** is a schematic, top plan view of an alternate embodiment of a channel network of a device for effectuating the methodology of the present invention;

FIG. **7** is a schematic, top plan view of a still further embodiment of a channel network of a device for effectuating the methodology of the present invention;

FIG. **8** is a schematic, top plan view of the channel network of FIG. **7** after loading;

FIG. **9** is a schematic, top plan view of a channel network, similar to FIG. **7**, after loading;

FIG. **10** is a schematic, top plan view of a still further embodiment of a channel network of a device for effectuating the methodology of the present invention; and

FIG. **11** is a schematic, top plan view of the channel network of FIG. **9** after loading.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIGS. **1-5**, an exemplary device for effectuating the methodology of the present invention is generally designated by the reference numeral **10**. Device **10** includes first and second ends **16** and **18**, respectively, and first and second sides **20** and **22**, respectively. Main channel **24** extends through device **10** along a longitudinal axis and is defined by first and second spaced sidewalls **26** and **28**, respectively. Main channel **24** further includes first end **32** that communicates with first and second input ports **36** and **38**, respectively, through first and second diverging input channels **42** and **44**, respectively, and second end **34** the communicates with output port **40**. First and second input ports **36** and **38**, respectively, and output port **40** communicate with upper surface **46** of device **10**.

It is contemplated for output port **40** of main channel **24** to have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette of a robotic micropipetting station. In addition, a portion of upper surface **46** of device **10** about outlet port **40** or inner surface **40***a* defining outlet port **40** may be physically or structurally patterned to contain fluid droplets within/adjacent outlet port **40**. It is further contemplated for the portions of upper surface **46** about first and second input ports **36** and **38**, respectively, and for the inner surfaces **36***a* and **38***a*, respectively, defining first and second input ports **36** and **38**, respectively, to be physically, chemically or structurally patterned to contain fluid drops therein and prevent cross channel contamination. Similarly, each input port **36** and **38** may have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette.

Device **10** includes further includes first and second reservoir channels **48** and **50**, respectively. First reservoir channel **48** is defined by first and second spaced sidewalls **52** and **54**, respectively, and includes first end **56** that communicates with first input port **36** and second end **58** that communicates with buffering reservoir **60**. Buffering reservoir **60** communicates with upper surface **46** of device **10**. First reservoir channel **48** includes a wide diameter portion **48***a*, for reasons hereinafter described. Second reservoir channel **50** is defined by first and second spaced sidewalls **62** and **64**, respectively, and includes first end **66** that communicates with second input port **38** and second end **68** that communicates with reservoir port **60**. Second reservoir channel **50** includes a wide diameter portion **50***a*, for reasons hereinafter described. It is contemplated for buffering reservoir **60** to have a generally cylindrical configuration with an open upper end that communicates with upper surface **46** of device **10**.

As hereinafter described, laminar flow synchronization of first and second fluidic samples in main channel **24** is achieved by providing wide diameter portions **48***a* and **50***a* in first and second reservoir channels **48** and **50**, respectively, in fluid communication with first and second input ports **36** and **38**, respectively, and by providing a common buffering reservoir **60** which acts as a fluidic capacitor, as hereinafter described. More specifically, in operation, device **10** is filled with a buffer fluid **59**. First and second fluidic samples, **61** and **63**, respectively, are deposited in corresponding first and second input ports **36** and **38**, respectively. The surface tension-generated pressures provided by first and second fluidic samples **61** and **63**, respectively, in first and second input ports **36** and **38**, respectively, and by the buffer fluid **59** in buffering reservoir **60** act as fluid capacitors with capacitances related to the corresponding radii of first and second input ports **36** and **38**, respectively, and buffering reservoir **60**. For example, a large port, such as buffering reservoir **60**, is able to contain a large volume of fluid, and as such, acts as a weak capacitor. Alternatively, a small port, such as input ports **36** and **38**, acts as a stiffer capacitor thereby generating larger pressures when fluid is added. When first fluidic sample **61** is added to first input port **36**, a relatively large pressure is generated, causing flow of the first fluidic sample **61** into first reservoir channel **48** towards buffering reservoir **60**, FIG. **3**. Subsequently, the surface tension-generated pressure provided by the buffer fluid **59** in buffering reservoir **60** urges the buffer fluid **59** from buffering reservoir **60**, thereby urging the first fluidic sample **61** from first reservoir channel **48**, through first input channel **42** and into main channel **24**. Similarly, when the second fluidic sample **63** is added to second input port **38**, FIG. **4**, a relatively large pressure is generated, causing flow of the second fluidic sample **63** into second reservoir channel **50** towards buffering reservoir **60**. Subsequently, the surface tension-generated pressure provided by the buffer fluid **59** in buffering reservoir **60** urges the buffer fluid **59** from buffering reservoir **60**, thereby urging the second fluidic sample **63** from second reservoir channel **50**, through second input channel **44** and into main channel **24**, FIG. **5**.

It is noted that other configurations of the buffering reservoir are contemplated as being within the scope of the present invention. By way of example, referring to FIG. **6**, second end **58** of first reservoir channel **48** and second end **68** of second reservoir channel **50** are interconnected by a buffering reservoir such as enlarged reservoir channel **69**. As such, when first fluidic sample **61** is added to first input port **36**, a relatively large pressure is generated, causing flow of the first fluidic sample into first reservoir channel **48** towards reservoir channel **69**. Subsequently, the pressure provided by the buffer fluid in reservoir channel **69** urges the buffer fluid from reservoir channel **69**, thereby urging the first fluidic sample **61** from first reservoir channel **48**, through first input channel **42** and into main channel **24**. Similarly, when the second fluidic sample **63** is added to second input port **38**, a relatively large pressure is generated, causing flow of the second fluidic sample **63** into second reservoir channel **50** towards reservoir channel **69**. Subsequently, the pressure provided by the buffer fluid in reservoir channel **69** urges the buffer fluid from reservoir channel **69**, thereby urging the second fluidic sample **63** from second reservoir channel **50**, through second input channel **44** and main channel **24**.

As described, the loading of fluidic samples in either the first or second input ports **36** and **38**, respectively, charges the common capacitor, e.g. buffering reservoir **60** or reservoir channel **69**, so as to trigger flow in first and second reservoir channels **48** and **50**, respectively, and hence, into main channel **24**. Therefore, it can be appreciated that the first and second fluidic samples **61** and **63**, respectively, can be added asynchronously to first and second input ports **36** and **38**, respectively, without variation of the relative flow rates in first and second reservoir channels **48** and **50**, respectively, and first and second diverging input channels **42** and **44**, respectively.

It has been found that synchronization of the flows from first and second input channels **42** and **44**, respectively, into main channel **24** occurs rapidly (e.g., within 15 ms). However, thereafter, the flows from first and second input channels **42** and **44**, respectively, into main channel **24** closely match each other. As such, synchronization occurs on the time scale required to flow the entire fluidic sample towards from buffering reservoir **60**. Therefore, to achieve the best results this time should be minimized. This can be achieved by reducing radius of first and second input ports **36** and **38**, respectively; decreasing the volume of the fluidic samples supplied at first and second input ports **36** and **38**, respectively; and reducing the resistance between first and second input ports **36** and **38**, respectively, and buffering reservoir **60**.

Before synchronization, the flow rate in the first input channel **42** corresponding to the first input port **36** wherein the first fluidic sample **61** was initially supplied is higher than the flow rate in the second input channel **44** wherein the second fluidic sample had yet to be supplied. To ensure proper fluidic patterning in main channel **24**, it is important to prevent the first fluidic sample **61** initially supplied at first input port **36** from entering main channel **24** prior to the loading of the second fluidic sample **63** in second input port **24**. It has been found that the time it takes for a volume of fluid added to a first side of a channel to reach the other side of the channel is a factor of the volume of the channel and the aspect ratio of the channel. In the device **10**, it is contemplated for the aspect factor of the first and second input channels **42** and **44**, respectively, to be always greater than 0.48. Hence, the maximum volume of fluid that is allowed to flow into first input channel

42 prior to synchronization is roughly half of the volume of first input channel **42**. The volume of the fluidic sample **61** that flows into first input channel **42** prior to synchronization can be minimized by reducing the flow rate of the fluidic sample **61** into first input channel **42**. This may be accomplished by increasing the fluidic resistance of first input channel **42** or by increasing the length of first and second input channels **42** and **44**, respectively.

In order to prevent contamination of buffering reservoir **60**, the volume of the fluidic samples loaded into first and second input ports **36** and **38**, respectively, must be small enough such that fluidic samples do not flow into buffering reservoir **60**. Furthermore, the ratio of the fluidic resistance of first input channel **42** to the fluidic resistance of second input channel **44** should be equal to the desired ratio of the width patterning of the first and second fluidic samples in main channel **24**. For example, the fluidic resistance of first input channel **42** and the fluidic resistance of second input channel **44** should be generally equal for the width patterning of the first and second fluidic samples in main channel **24** to be generally equal.

Alternatively, other ratios of the width patterning of the first and second fluidic samples **61** and **63**, respectively, in main channel **24** are possible without varying the scope of the present invention. For example, in order for the width patterning of the first and second fluidic samples **61** and **63**, respectively, in main channel **24** to have a ratio of 2/3 of the first sample fluid **61** to 1/3 of the second sample fluid **63**, the ratio of the fluidic resistances of first and second diverging input channels **42** and **44**, respectively, must be adjusted accordingly.

It is also noted that the timing of the loading of the first and second fluidic samples **61** and **63**, respectively, in main channel **24** is not an important factor in generating laminar flow in main channel **24**. Even if the second fluidic sample **63** is loaded in second input port **38** after the first fluidic sample **61** loaded in first input port **36** has entirely flown into the main channel **24**, the loading of the second fluidic sample **63** in second input port **38** will "re-load" the pressure generated by the fluidic capacitor such that the fluidic capacitor urges the second fluidic sample **63** from second reservoir channel **50**, through second input channel **44** and into main channel **24**.

Referring to FIGS. **7**-**8**, an alternate channel network for device **10** is generally designated by the reference numeral **80**. Channel network **80** includes main channel **82** extending along a longitudinal axis and is defined by first and second spaced sidewalls **84** and **86**, respectively. Main channel **82** further includes first end **88** that communicates with input port **90** through input channel **92** and with first and second diverging reservoir channels **94** and **96**, respectively, and second end **98** that communicates with output port **100**. Input port **90** and output port **100** communicate with upper surface **46** of device **10**.

It is contemplated for output port **100** of main channel **82** to have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette of a robotic micropipetting station. In addition, a portion of upper surface **46** of device **10** about outlet port **100** or inner surface **100***a* defining outlet port **100** may be physically or structurally patterned to contain fluid droplets within/adjacent outlet port **100**. It is further contemplated for the portions of upper surface **46** about input port **90** and for the inner surface **90***a* defining input port **90** to be physically, chemically or structurally patterned to contain fluid drops therein and prevent cross channel contamination. Similarly, input port **90** may have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette.

Channel network **80** of device **10** further includes third reservoir channel **102** defined by first and second spaced sidewalls **104** and **106**, respectively, and includes first end **108** that communicates with first input port **90** and second end **110** that communicates with first and second diverging reservoir channels **94** and **96**, respectively. Third reservoir channel **102** has a diameter greater the input channel **92** such that third reservoir channel **102** has less fluidic resistance than input channel **92**. As hereinafter described, it is intended for first, second and third reservoir channels **94**, **96** and **102**, respectively, act as a fluidic capacitor so as to urge a fluidic sample loaded at input port **90** through input channel **92** and main channel **82**.

Referring to FIG. **8**, in operation, channel network **80** of device **10** is filled with a buffer fluid **101**. A fluidic sample **103** is deposited in input port **90** such that a surface tension-generated pressure is provided by the fluidic sample **103** in input port **90**. As previously described, a relatively large pressure is generated, causing flow of the fluidic sample **103** into third reservoir channel **102**. Subsequently, the surface tension-generated pressure provided by first, second and third reservoir channels **94**, **96** and **102**, respectively, urge the fluidic sample **103** from third reservoir channel **102**, through input channel **92** and into main channel **82**, thereby allowing for laminar flow and patterning of the fluidic sample through main channel **82**.

Alternatively, as best seen in FIG. **9**, an input port **81** may be provided in either first and second diverging reservoir channels **94** and **96**, respectively, instead of third reservoir channel **102**. By way of example, input port **81** is provided in first reservoir channel **94** and communicates with upper surface **46** of device **10**. It is contemplated for the portions of upper surface **46** about input port **81** and for the inner surface **81***a* defining input port **81***a* to be physically, chemically or structurally patterned to contain fluid drops therein and prevent cross channel contamination. Similarly, input port **81** may have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette.

In operation, channel network **80** of device **10** is filled with a buffer fluid **101**. A fluidic sample **103** is deposited in input port **81** such that a surface tension-generated pressure is provided by the fluidic sample **103** in input port **81**. A relatively large pressure is generated, causing flow of the fluidic sample **103** into first reservoir channel **94**. Subsequently, the surface tension-generated pressure provided by first, second and third reservoir channels **94**, **96** and **102**, respectively, urge the fluidic sample **103** from first reservoir channel **94** and into main channel **82**, thereby allowing for laminar flow and patterning of the fluidic sample through main channel **82**.

Referring to FIGS. **10**-**11**, a still further embodiment of a channel network for device **10** is generally designated by the reference numeral **110**. Channel network **110** includes main channel **112** extending along a longitudinal axis and is defined by first and second spaced sidewalls **114** and **116**, respectively. Main channel **112** further includes first end **118** that communicates with input port **120** through first and second diverging input channels **122** and **124**, respectively, and second end **126** that communicates with output port **128**. Input port **120** and output port **128** communicate with upper surface **46** of device **10**.

It is contemplated for output port **128** of main channel **112** to have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette of a robotic micropipetting station. In addition, a portion of upper surface **46** of device **10** about outlet port **128** or inner surface **128***a* defining outlet port **128** may be physically or structurally patterned to contain fluid droplets within/adjacent outlet port **128**. It is further contemplated for the portions of upper surface **46** about input port **120** and for the inner surface **120***a* defining input port **120** to be physically, chemically or structurally patterned to contain fluid drops therein and prevent cross channel contamination. Similarly, input port **120** may have a generally cylindrical shape to allow for robust and easy access via droplet touch off using a micropipette.

Channel network **110** of device **10** further includes reservoir channel **130** defined by first and second spaced sidewalls **132** and **134**, respectively, and includes first end **136** that communicates with input port **120** and second end **138** that communicates with buffering reservoir **140**. Buffering reservoir **140** communicates with upper surface **46** of device **10** and is in fluid communication with main channel **112** through buffering channel **142**.

Referring to FIG. **11**, in operation, channel network **110** of device **10** is filled with a buffer fluid **141**. A fluidic sample **143** is deposited in input port **120** such that surface tension-generated pressure is provided by the fluidic sample **143** in input port **120**. As previously described, the relatively large pressure generated at input port **120** causes flow of the fluidic sample **143** into buffering reservoir **140**. Subsequently, the surface tension-generated pressure provided by buffering reservoir **140** urges the fluidic sample **143** through first and second input channels **122** and **124**, respectively, and into main channel **24**, thereby allowing for laminar flow and patterning of the fluidic sample **143** through main channel **82**.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

We claim:

1. A device for controlled laminar flow patterning of at least one sample fluid, comprising:

a body defining a channel network, the channel network including:

a main channel extending along a longitudinal axis and having a first end and a second end defining an output port;

a first input port, the first input port adapted for receiving a first sample fluid of the of at least one sample fluid and for introducing the first sample fluid into the channel network;

a first input channel having an output end interconnected to and communicating with the first end of the main channel and an input end interconnected to and communicating with the first input port, the first input channel having a fluidic resistance;

a fluidic capacitor for receiving a buffer find having a surface tension therein; and

a first buffering channel having a first end directly interconnected to and communicating with the first input port and a second end interconnected to and communicating with the fluidic capacitor, the first buffering channel configured to have a fluidic resistance less than the fluidic resistance of the first input channel such that the first sample fluid received at the first input port initially flows into the first buffering channel;

wherein the surface tension of the buffer fluid in the fluidic capacitor causes the first sample fluid in the first buffering channel to flow through the first input channel and laminarly in the main channel; and the main channel is free of diffusion ports between the first and second ends of thereof.

2. The device of claim **1** wherein the body further includes a second input channel having an output end communicating with the first end of the main channel and an input end communicating with the first input port, the second input channel having fluidic resistance.

3. The device of claim **1** wherein the body further includes a second input channel having an output end communicating with the first end of the main channel and an input end communicating with a second input port, the second input channel having fluidic resistance.

4. The device of claim **3** wherein the fluid capacitor, the first input port and the second input port have cross sectional areas, and wherein the cross sectional area of the fluid capacitor is greater than the cross sectional areas of the first and second input ports.

5. The device of claim **1** wherein the first input channel has a cross sectional area, and wherein the first buffering channel has a cross sectional area greater than the cross sectional area of the first input channel.

6. A device for controlled laminar flow patterning of at least one sample fluid, comprising:

a body defining a channel network, the channel network including:

a main channel extending along a longitudinal axis and having a first end and a second end defining an output port;

a first input channel having an output end interconnected to and communicating with the first end of the main channel and an input end interconnected to and communicating with a first input port, the first input channel having a fluidic resistance;

a fluidic capacitor;

a first buffering channel having a first end directly interconnected to and communicating with the first input port and a second end interconnected to and communicating with the fluidic capacitor, the first buffering channel configured to have a fluidic resistance less than the fluidic resistance of the first input channel;

a second input channel having an output end interconnected to and communicating with the first end of the main channel and an input end interconnected to and communicating with a second input port, the second input channel having fluidic resistance; and

a second buffering channel having a first end directly interconnected to and communicating with the second input port and a second end interconnected to and communicating with the fluidic capacitor, the first buffering channel configured to have a fluidic resistance less than the fluidic resistance of the first input channel.

7. The device of claim **6** further comprising a buffering solution within the channel network and wherein:

the at least one sample fluid includes a first sample fluid and a second sample fluid; and

the fluidic capacitor urges laminar flow of the first and second sample fluids in the main channel in response to the asynchronous depositing of the first sample fluid in the first input port and the second sample fluid in the second input port.

8. The device of claim **7** wherein:

the first and second input channels have cross sectional areas;

the first and second buffering channels have cross sectional areas;

the cross sectional area of the first buffering channel is greater than the cross sectional area of the first input channel; and the cross sectional area of the second buffering channel is greater than the cross sectional area of the second input channel.

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