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(54) **Flow splitter and reaction assembly.**

- (57) The invention pertains to a flow splitter for splitting a primary fluid flow into a plurality of secondary fluid flows for performing experiments, comprising:
- a manifold, which has a manifold inlet for receiving the primary fluid flow, and a plurality of manifold outlets for releasing the plurality of secondary fluid flows,
 - a plurality of capillary units, each comprising:
 - a unit inlet for receiving a secondary fluid flow from a manifold outlet,
 - a unit outlet for releasing said secondary fluid flow,
 - a capillary, which is arranged between the unit inlet and the unit outlet such that said secondary fluid flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the secondary fluid flow passing through said capillary,
 - a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary,
 - a flow sensor for measuring the flow rate of the secondary fluid flow through the capillary unit, which flow sensor can be arranged either inside or outside the housing,
 - a flow adjustment unit for adjusting the flow rates of the secondary fluid flows, which comprises a temperature control device for individually controlling the heater and/or cooler of each capillary unit in response to the flow rate that is measured by the flow sensor of that capillary unit

Flow splitter and reaction assembly

The invention pertains to a flow splitter for splitting a primary fluid flow into a plurality of secondary fluid flows for performing experiments. The invention also pertains to a reaction
5 system.

When experiments are performed in parallel, often the reactors in which the experiments take place receive their feed from a single source. The reactor feed comes from this single source in a single, primary fluid flow which is then split into a plurality of secondary fluid flows. Each of the secondary fluid flows is then fed to a reactor in which a reaction can
10 take place.

Often it is desirable that all secondary fluid flows have the same flow rate, as this contributes to creating the same reaction circumstances in all reactors. WO99/64160 discloses that a substantially equal flow distribution over all reactors can be obtained by arranging capillaries upstream of the reaction vessels. WO99/64160 also discloses that by
15 heating a capillary, the viscosity of the fluid flowing through the capillary can be influenced, and thereby the flow rate of the fluid through the capillary can be influenced.

In practice, it has turned out that the system known from WO99/64160 is not suitable for experiments in which the flow rate of the secondary fluid flows and/or the ratio between the flow rates of the secondary fluid flows has to be controlled accurately, especially when small
20 scale experiments are performed, for example experiments with flow rates below 2 ml/min. For example, the dimensions of individual capillaries vary due to manufacturing tolerances. This results in a variation in flow resistance between individual capillaries, and therewith in a variation in flow rates of the secondary fluid flows. Obtaining substantially equal flow rates for all secondary fluid flows is a cumbersome process, as it requires calibration and adaptation of
25 all capillaries. This is worsened by the fact that when the flow resistance of one capillary in the system is changed, this affects the flow rates in the other capillaries of the system as well, because the ratio between the flow resistance of the different capillaries determines the distribution of the primary flow over the secondary flows. Also, in practice it has turned out that even with very accurately calibrated capillaries, it is not possible to obtain a reliable and
30 accurate splitting of the primary fluid flow in secondary fluid flows with equal flow rates or any other predetermined ratio of flow rates.

The object of the invention is to provide an improved flow splitter and an improved reaction system.

This object is achieved with a flow splitter according to claim 1.

The flow splitter according to claim 1 is a flow splitter for splitting a primary fluid flow into a plurality of secondary fluid flows for performing experiments, which flow splitter comprises:

- a manifold, which manifold has a manifold inlet for receiving the primary fluid flow, and a plurality of manifold outlets for releasing the plurality of secondary fluid flows,
- a plurality of capillary units, each of the capillary units comprising:
 - a unit inlet for receiving a secondary fluid flow from a manifold outlet,
 - a unit outlet for releasing said secondary fluid flow,
 - a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said secondary fluid flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the secondary fluid flow passing through said capillary,
 - a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary,
 - a flow sensor for measuring the flow rate of the secondary fluid flow through the capillary unit, which flow sensor can be arranged either inside or outside the housing,
- a flow adjustment unit for adjusting the flow rates of the secondary fluid flows, which flow adjustment unit comprises a temperature control device for individually controlling the heater and/or cooler of each capillary unit in response to the flow rate that is measured by the flow sensor of that capillary unit.

In this flow splitter, the flow adjustment unit of the flow splitter determines the flow rate of the fluid flow, which can be a gas flow, a liquid flow or a combined gas/liquid flow. The flow adjustment unit then determines the deviation of the flow rate of the fluid flow from a desired flow rate, and adjusts the flow rate by controlling the heater and/or cooler of the capillary unit. The heater and/or cooler changes the temperature of the capillary of the capillary unit and therewith influences the flow rate of the fluid flow through that capillary. The temperature of the capillary affects the flow rate through that capillary in several ways: the viscosity of the fluid in the capillary depends from the temperature, the fluid expands when it is heated and maybe the inner dimensions of the capillary change a bit too because of thermal expansion effects. Both the viscosity of the fluid and the dimensions of the capillary are parameters that determine the flow resistance of the capillary, and therewith the flow rate of the fluid flow through that capillary.

Each capillary unit can have its own flow adjustment unit, or a plurality of capillary units can be controlled by a single flow adjustment unit. The flow adjustment unit can be connected to or be part of an overall control system controlling the splitter, or when the splitter is used in

a reaction system, of a reaction system control unit that controls the whole reaction system or a part thereof.

The applicant has found that by providing the capillaries with thermal insulation, the flow rate in the capillary can be controlled more accurately. Probably, this is because flow rate through the capillaries appears to be very sensitive to temperature differences, as the applicant established in his research. Even a difference of 0.1°C turned out to make a noticeable difference in flow rate when small scale experiments (for example with flow rates of about 2 ml/min or lower) or even very small scale experiments (with flow rates of in particular liquids of 1-10 microliters per minute or lower) are performed. This may explain why even accurately calibrated capillaries show varying flow rates, for example at different times of the day (daytime/nighttime) or when they are used at different locations (middle of a room or close to a wall or ventilation unit of the lab). By arranging the capillary within a housing that is provided with thermal insulation, the influence of the temperature of the direct environment of the capillary on the flow rate of the flow through that capillary is decreased. Furthermore, by providing a heater and/or a cooler within said housing, the temperature of the capillary can be controlled more directly, which makes that the desired flow rate of the fluid flow can be obtained rapidly.

It has turned out that when a flow splitter according to the invention is used, it is no longer necessary to calibrate the capillaries themselves very accurately any more. Using the flow splitter according to the invention helps to accurately obtain the desired flow rate of the fluid flow of the secondary fluid flows.

In an advantageous embodiment, the capillary unit is at least partly accommodated in a cassette, so that it can be easily connected to other elements of a reaction system, such as a fluid source and/or a reactor. It is possible that the entire capillary unit is enclosed in the cassette, but it is also possible that for example the flow sensor is arranged outside of the cassette.

In an advantageous embodiment, the heater comprises a wire having an electrical resistance, which wire is wound around the capillary for supplying heat to said capillary.

In an advantageous embodiment, the capillary is arranged, for example wound, around a core, which core is provided with heating and/or cooling means.

The flow splitter according to the invention can be used for gases, liquids, gels, and/or combinations thereof. It is in particular suitable to be used for controlling flows having small flow rates, such as between 1 microliters and 2 ml per minute for the secondary fluid flow.

The flow splitter according to the invention comprises a manifold, which manifold has a manifold inlet for receiving the primary fluid flow, and a plurality of manifold outlets for releasing the plurality of secondary fluid flows. The flow splitter further comprises a plurality of capillary units, each of the capillary units comprising a unit inlet for receiving a secondary fluid

flow from a manifold outlet, a unit outlet for releasing said secondary fluid flow, a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said secondary fluid flow passes through the capillary, a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the secondary fluid flow passing through said capillary and a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary. The capillary unit further comprises a flow sensor that is adapted to measure the flow rate of the fluid flow through the capillary unit. The flow splitter further comprises a flow adjustment unit for adjusting the flow rates of the secondary fluid flows, which flow adjustment unit comprises a temperature control device for individually controlling each of the heaters and/or coolers of the capillary units.

In this flow splitter, the flow rate of each secondary fluid flow is measured by a flow sensor, and based on the measured flow rate, the temperature control unit makes that the heater and/or cooler in the housing of capillary unit to which the measured flow rate pertains heat or cool the capillary in that housing. By changing the capillary temperature, the flow rate of the fluid flow through the capillary is adjusted.

The thermally insulated housing of the capillary of each capillary unit prevents that the temperature of one capillary influences the temperature of an other capillary that is arranged nearby. This allows accurate control of the temperature of each individual capillary, and therewith accurate control of the flow rate of each individual second fluid flow. Of course too, by arranging the capillary within a housing that is provided with thermal insulation, the influence of the temperature of the direct environment of the capillary on the flow rate of the flow through that capillary is decreased. Furthermore, by providing a heater and/or a cooler within said housing, the temperature of the capillary can be controlled more directly, which makes that the desired flow rate of the fluid flow can be obtained rapidly.

The flow splitter according to the invention is suitable for obtaining a distribution of the primary fluid flow into secondary fluid flows which have equal flow rates. However, it is also possible to obtain any other desired distribution of flow rates of the secondary fluid flows.

In an advantageous embodiment at least one unit outlet is connected to a reaction vessel. This way, the fluid flow supplied to that reaction vessel can be controlled.

In an advantageous embodiment, one or more capillary units are accommodated in a cassette.

In an advantageous embodiment, the heater comprises a wire having an electrical resistance, which wire is wound around the capillary for supplying heat to said capillary.

In an advantageous embodiment, the capillary is arranged, preferably wound, around a core, which core is provided with heating and/or cooling means.

In a particularly advantageous embodiment, the flow splitter further comprises an auxiliary channel, which has a resistance to fluid flow that is considerably lower than the resistance to fluid flow in the secondary channels. The auxiliary channel is connected to the manifold, which has the effect that the main part of the fluid that enters the manifold leaves the manifold via the auxiliary channel. The auxiliary channel can for example take the fluid back to the source from which it came before entering the manifold inlet, to waste or to a separate discharge.

The effect of the auxiliary channel is that, especially as long as the pressure at the manifold inlet is kept steady, a change in flow rate through one of the capillary units does not or hardly not influence the flow rate through the other capillary units.

The invention further pertains to a reaction system for performing parallel experiments, which reaction system comprises a fluid supply unit for supplying a primary fluid flow, a flow splitter according to the invention, wherein the manifold inlet is connected to the fluid supply unit for receiving the primary fluid flow from the fluid supply unit and a plurality of reaction vessels, wherein each reaction vessel comprises at least one reaction vessel inlet, wherein a reaction vessel inlet of each reaction vessel is connected to an associated capillary unit outlet for receiving a secondary fluid flow from the flow splitter.

In an advantageous embodiment, the reaction system further comprises a reaction block for accommodating the reaction vessels, one or more cassettes, each cassette accommodating at least one of the plurality of capillary units of the flow splitter and an enclosure for receiving at least the reaction block and the one or more cassettes.

In an advantageous embodiment, the reactors are flow through reactors.

The invention further pertains to a reaction system for performing parallel experiments, wherein the fluids come from different fluid sources. The fluid sources can for example supply different fluids and/or fluids at a different pressure. This reaction system comprises a first fluid supply unit for supplying a first primary fluid flow at a first pressure, and a second fluid supply unit for supplying a second primary fluid flow at a second pressure. Further it comprises a first capillary unit, which is a capillary unit of the same kind as used in the flow splitter according to the invention, which first capillary unit is adapted to receive the first primary fluid flow from the first fluid supply unit. There is also a second capillary unit, which is a capillary unit of the same kind as used in the flow splitter according to the invention, which second capillary unit is adapted to receive the second primary fluid flow from the second fluid supply unit. Furthermore, there is provided a first reactor, which is in fluid communication with the first capillary unit and a second reactor, which is in fluid communication with the second capillary

unit. The first capillary unit comprises a flow adjustment unit that is adapted to adjust the flow rate of the first primary fluid flow through the first capillary unit. The second capillary unit comprises a flow adjustment unit that is adapted to adjust the flow rate of the second primary fluid flow through the second capillary unit such that a predetermined distribution of flow rates of the first and the second primary fluid flow is obtained.

It is possible that the flow adjustment unit of the first capillary unit and the flow adjustment unit of the second capillary unit are separate entities, but it is also possible that they are integrated into a single flow adjustment unit. They can be part of an overall reaction system control unit.

This reaction system is in particular suitable to obtain a first flow rate (of the first primary fluid flow) and a second flow rate (of the second primary fluid flow) that are in a predetermined proportion to each other, independent of the pressure. For example, despite different pressures, a first and second flow rate that are equal to each other can be obtained.

In an advantageous embodiment, the reaction system further comprises a reaction block for accommodating the reaction vessels, one or more cassettes, each cassette accommodating at least one of the plurality of capillary units of the flow splitter and an enclosure for receiving at least the reaction block and the one or more cassettes.

In an advantageous embodiment, the reactors are flow through reactors.

The principle of the flow splitter according to the invention can also be used in a back pressure control system for controlling the pressure downstream of a reaction vessel outlet. The invention provides a reaction system for performing experiments, which reaction system comprises:

- a reaction vessel, wherein said reaction vessel comprises at least one reaction vessel inlet, which reaction vessel inlet is connectable to a fluid supply unit for receiving a fluid flow, wherein each reaction vessel further comprises at least one reaction vessel outlet for releasing an effluent flow,
- a reaction vessel effluent line for receiving the effluent flow from the reaction vessel, which effluent line is in fluid communication with at least one reaction vessel outlet, which reaction vessel effluent line is provided with a aperture for releasing a pressure control flow,
- a back pressure control system comprising a capillary unit, which capillary unit comprises
 - a unit inlet for receiving the pressure control flow from the aperture in the reaction vessel effluent line,
 - a unit outlet for releasing said pressure control flow from the capillary unit,

- a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said pressure control flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of pressure control flow passing through said capillary,
 - 5 - a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary,
- wherein the back pressure control system further comprises a flow adjustment unit for adjusting the flow rates of the pressure control flow,
- which flow adjustment unit comprises:

- 10 - a flow sensor which is arranged to measure the flow rate of said pressure control flow,
- a temperature control device for controlling the heater and/or cooler of the capillary unit.

In such a reaction system according to the invention the principle of the flow splitter
15 according to the invention is used in a back pressure control system for controlling the pressure in a reaction vessel. It is known that the pressure inside a reaction vessel can be controlled by controlling the pressure downstream of the reaction vessel, advantageously close to the reaction vessel outlet. In a reaction system having a backpressure controller according to the invention, the reaction vessel effluent line is provided with a aperture,
20 through which a portion of the reaction vessel effluent can escape. The portion of the reaction vessel effluent that escapes is called the pressure control flow. By controlling the flow rate of the pressure control flow, the pressure just downstream of the reaction vessel can be controlled, and therewith the pressure in the vessel. The flow rate of each of the pressure control flows is controlled using the principle of the capillary unit as used in the flow splitter
25 according to the invention.

In an advantageous embodiment, a reactor system for performing parallel experiments is provided. This reaction system comprises a plurality of reaction vessels, each of them being connected to an associated effluent line. Each of the effluent lines is provided with an aperture, for releasing a pressure control flow. The flow rate of each of the pressure control
30 flows is controlled using the principle of the capillary unit as used in the flow splitter according to the invention.

The invention will be explained in more detail under referral to the drawing, in which non-limiting embodiments of the invention are shown. The drawing shows in:

- 35 Fig. 1: an embodiment of a capillary unit according to the invention,
- Fig. 2: a further embodiment of a capillary unit as applied in the invention,
- Fig. 3: an embodiment of a flow splitter according to the invention,

Fig. 4: a first embodiment of a reaction system according to the invention,

Fig. 5: a second embodiment of a reaction system according to the invention,

Fig. 6: a third embodiment of a reaction system according to the invention,

Fig. 7: a variant of the embodiment of a flow splitter according to fig. 3.

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Fig. 1 shows an embodiment of a capillary unit according to the invention. In this embodiment, fluid is supplied to a capillary unit 1 by a supply line 10. The fluid, which can be a gas, a liquid or a combination thereof, enters the capillary unit by the capillary unit inlet 2. Through capillary 4, the fluid flows to capillary unit outlet 3, where it leaves the capillary unit.

10 In this embodiment, the capillary 4 extends all the way from the capillary unit inlet 2 to the capillary unit outlet 3, but this is not necessary for its functioning. The fluid flows away from the capillary unit 1 by discharge line 11. Flow sensor 7 measures the flow rate of the fluid flow downstream of the capillary 4. The flow sensor 7 can be arranged either outside or inside the housing 6.

15 The capillary 4 is arranged in housing 6, which is provided with thermal insulation. Inside the housing a heater and/or cooler 5 is arranged. With this heater and/or cooler 5, the temperature of the capillary can be influenced. The thermal insulation of the housing 6 makes that the temperature of the capillary 4 can be controlled effectively and accurately, because the capillary is shielded from outside thermal influences. In addition, and in case the capillary
20 heated, less heat leaks away from the capillary. The heater/cooler 5 is controlled by a temperature control device 8, which can be arranged inside the housing 6, outside the housing 6 or partially inside and partially outside the housing 6. For example, POM is a suitable material to be used for the thermal insulation, as it has good thermal insulating properties and is easy to process.

25 By changing the temperature of the capillary 4, the flow rate of the fluid flow through the capillary 4 also changes. This is due to a combination of effects. When the temperature of the capillary 4 rises, so does the temperature of the fluid in the capillary 4. This lowers the viscosity of the fluid and therewith the flow resistance that the fluid flow experiences in the capillary 4. Also, it makes the fluid expand in volume. Both effects make the flow rate
30 downstream of the capillary 4 go up. It is also possible that thermal expansion changes the internal dimensions of the capillary 4, which also changes the flow resistance of the capillary 4.

In general, the flow rate of the fluid flow through the capillary 4 goes up when the temperature of the capillary 4 is increased.

35 In a preferred embodiment, a desired flow rate is set by the flow adjustment unit. Preferably, around the desired flow rate, an accepted band width is determined. The flow sensor 7 then measures the flow rate of the fluid flow leaving the capillary 4. If the flow rate is

within the accepted band width, the temperature of the capillary is not changed. If the flow rate is outside the accepted band width, the temperature control device comes into action. If the measured flow rate is lower than the lowest limit of the accepted band width, the temperature control device makes the heater 5 heat up the capillary, for example by raising the temperature by 0.5 °C. After a little while, when the system has had the time to react, the flow sensor 7 again measures the flow rate of the fluid flow. Then again it is determined whether the flow rate is within the accepted band width or not. If the flow rate is still too low, the temperature of the capillary is increased by another step of for example 0.5°C.

If the flow sensor 7 measures a flow rate that is higher than the highest limit of the accepted band width, the heater/cooler 5 is controlled by the temperature control device in such a way that the temperature of the capillary is reduced, for example by reducing the temperature by a step of 0.5°C. After a little while, when the system has had the time to react, the flow sensor 7 again measures the flow rate of the fluid flow. Then again it is determined whether the flow rate is within the accepted band width or not. If the flow rate is still too high, the temperature of the capillary is reduced by another step of for example 0.5°C.

This way, the desired flow rate is obtained by iterative, stepwise changes of the temperature of the capillary 4.

The heater/cooler 5 can be realised in many forms. In some embodiments, just a heater of just a cooler suffices. For example, if the capillary is always used at temperatures above room temperature, using only a heater can be fine. In those cases, if the flow rate of the flow through the capillary has to be decreased, the heater 5 just heats the capillary a little less. For example, if the capillary is operated at 80 °C and the flow rate is too high, the heater 5 is then set by the temperature control device to a temperature of 79.5 °C. If the capillary 4 always is cooled, the same principle is used and just a cooler can be applied to obtain the desired effect. So, the heater/cooler 5 can be either a heater or a cooler or a combination of a heater and a cooler.

The heater/cooler 5 can take many forms. It can be an electrical resistance wire, which produces heat when an electrical current flows through. Such a wire can for example be wound around the capillary. The housing 6 can be provided with a heater/cooler channel, through which channel a heated or cooled medium flows. Also, it is possible that the capillary 4 is wound around a core, which core is heated and/or cooled, and which core then in turn heats and/or cools the capillary 4. This is shown in fig. 2

Fig. 2 shows a further possible embodiment of a capillary unit 1. A supply line 10 supplies fluid flow F to the unit inlet 2, and then the fluid flows through capillary 4 to unit outlet 3, where it enters the discharge line 11. The capillary 4 is arranged in thermally insulated housing 6. In this embodiment, the capillary 4 is wound around a core 9. In the example of fig. 2, the core is cylindrical, but this is not necessary. The core 9 is provided with heating means

and/or cooling means. For example, the core 9 can be provided with a channel that is or can be brought into fluid communication with an external source of a cooling and/or heating medium, such as water. In an other embodiment, the core can be provided with an electrical resistance wire or any other form of heat tracing.

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The principle of the flow splitter according to the invention can be used in many ways when performing chemical reactions.

Fig. 3 shows an embodiment of a flow splitter according to the invention. In this flow splitter, the same principle is used as in the capillary unit according to fig. 1.

10 In the flow splitter of fig. 3, a primary flow P of fluid is supplied to a manifold inlet 21 of a manifold 20. In the manifold 20, primary fluid flow P is divided over two secondary fluid flows S1,S2. After passing through the flow splitter, each secondary fluid flow S1,S2 will be directed to a device in which it is used, such as a reaction vessel. In the example of fig. 3, the
15 secondary fluid flows S1,S2 can be supplied to two parallel reaction vessels for performing parallel chemical tests. It is possible of course that the manifold has more than two manifold outlets, so that more than two secondary flows are created. This does however not alter the technical principle of the flow splitter.

When parallel tests are carried out, it is often desired that the secondary fluid flows
20 have flow rates that are in a predetermined proportion to each other. For example, the flow rates of all fluid flows are desired to be equal, or the flow rate of S1 has to be twice the flow rate of S2. This can be achieved with the flow splitter according to the invention.

The flow splitter of fig. 3 comprises two capillary units 1, which are similar to the capillary unit according to fig. 1. Each capillary unit 1 of the flow splitter receives a secondary
25 fluid flow from an associated manifold outlet 22 at capillary unit inlet 2. In the capillary unit 1, the secondary fluid flows are adjusted in the same way as the fluid flow through the capillary in to fig. 1. So, the flow rate of each secondary fluid flow is measured by a flow sensor 7, and based on the measured flow rate, the temperature control unit 8 makes that the heater and/or cooler 5 in the housing 6 of capillary unit 1 to which the measured flow rate pertains heat or
30 cool the capillary 4 in that housing 6. By changing the capillary temperature, the flow rate of the fluid flow through the capillary is adjusted.

The thermally insulated housing 6 of the capillary 4 of each capillary unit 1 prevents that the temperature of one capillary 4 influences the temperature of an other capillary 4 that is arranged nearby. Also, other thermal influences from the environment are reduced, as well as
35 heat loss to the environment from the heater/cooler 5. This allows accurate control of the temperature of each individual capillary 4, and therewith accurate control of the flow rate of each individual second fluid flow.

The flow sensor 7 and the temperature control device 8 of related to each capillary unit 1 form part of the flow adjustment unit for the associated secondary fluid flow. With this flow rate adjustment unit, each the flow rate of each secondary fluid flow can be controlled individually. In an advantageous embodiment, the flow splitter further comprises a flow distribution controller, which communicates with the individual flow adjustment units (preferably directly with the temperature control devices of the individual flow adjustment devices) of the flow splitter.

The function of the flow distribution controller is to make sure that the flow rates of the secondary fluid flows are in the desired proportion relative to each other (for example: first secondary flow rate: second secondary flow rate: third secondary flow rate: fourth secondary flow rate = 1:1:1:1 or 1:2:3:4). To that end, the flow distribution controller receives the measured flow rates from all flow sensors 7 of the flow splitter. It compares the flow rates of the individual secondary fluid flows with each other, and determines whether the flow rates are in the desired proportions to each other. If this is not the case, then the flow distribution controller activates one or more of the individual flow adjusting units, preferably directly the temperature control devices, to adjust the flow rate of the associated secondary fluid flow.

In general, if the primary fluid flow has a constant flow rate and the flow rate of one of the secondary fluid flows is changed, then the flow rates of the other secondary fluid flows will change somewhat too. This means that in general, obtaining the desired relative proportions of the flow rates of the secondary fluid flows, that is: the desired distribution of the primary fluid flow over the secondary fluid flows, will require some iterations. It is however also possible that the flow rate of the primary fluid flow is allowed to vary. In that case, it will usually be easier to obtain the desired relative proportions of the flow rates of the secondary fluid flows. In such a case for example, the pressure in the fluid supply unit may be kept constant while the flow rate of the primary fluid flow is allowed to vary.

Fig. 4 shows a first embodiment of a reaction system according to the invention. This reaction system comprises a fluid supply unit 31 for supplying a primary fluid flow P. The reaction system further comprises in this example two flow splitters 30 according to the invention. The skilled person will understand that any other number of flow splitters is also possible. Connection lines 12 connect the fluid supply unit 31 to the manifold 20 of each of the flow splitters 30. The primary fluid flow P is first divided into flows SA and SB. The first flow splitter divides flow SA into secondary fluid flows SA1, SA2, SA3 and SA4. The second flow splitter divides flow SB into secondary fluid flows SB1, SB2, SB3 and SB4.

In the embodiment of fig. 4, the housings 6 of the capillary units 1 of the same flow splitter 30 are arranged together in a cassette. This allows easy mounting into a reaction system setup, for example in a rack. It also allows a fast exchange of flow splitters and an

easy connection to other parts of the reaction system, for example if quick catch couplings are used for connecting different flow lines to each other, for example the connection line 12 to the manifold inlets 21. The cassette itself can be thermally insulated, but this is not necessary. In this embodiment, it is advantageous if the reaction vessels 32 are arranged in a reaction block that can be arranged in the rack as well.

In the reaction system of fig. 4, a plurality of reaction vessels 32 is present. To each capillary unit outlet 3, a reaction vessel 32 is connected. The flow splitters 30 provide the distribution of the primary fluid flow over the individual reactors with the secondary fluid flows having the desired relative proportions in respect of the flow rates. For example, a flow rate distribution could be that the flow rate of flows SA1, SA2, SA3 and SA4 is twice the flow rate of flows SB1, SB2, SB3 and SB4, while the flow rates of flows SA1, SA2, SA3 and SA4 are equal to one another and the flow rates of flows SB1, SB2, SB3 and SB4 are equal to one another as well.

The control of the flow rates of the individual secondary fluid flows SA1, SA2, SA3, SA4, SB1, SB2, SB3 and SB4 takes place in the same way as described above in relation to the flow splitter according to the invention.

In general, if the primary fluid flow has a constant flow rate and the flow rate of one of the secondary fluid flows is changed, then the flow rates of the other secondary fluid flows will change somewhat too. This means that in general, obtaining the desired relative proportions of the flow rates of the secondary fluid flows, that is: the desired distribution of the primary fluid flow over the secondary fluid flows, will require some iterations. It is however also possible that the flow rate of the primary fluid flow is allowed to vary. In that case for example, it will usually be easier to obtain the desired relative proportions of the flow rates of the secondary fluid flows. In such a case, the pressure in the fluid supply unit may be kept constant while the flow rate of the primary fluid flow is allowed to vary.

Fig. 5 shows a second embodiment of a reaction system according to the invention. In this embodiment, the reaction system comprises a first fluid supply unit 41 and a second fluid supply unit 42. The first fluid supply unit 41 delivers a first primary fluid flow F1 at a first pressure p1. The second fluid supply unit 42 delivers a second primary fluid flow F2 at a second pressure p2. It is possible that p1 is equal to p2, but the system is in particular suitable for situations in which p1 and p2 are different. It is also suitable for a system in which parallel reactions are carried out using different fluids.

Downstream of first fluid supply unit 41, first capillary unit 40* is arranged. First capillary unit 40* is a capillary unit according to the invention, for example a first capillary unit according to fig. 1. The first fluid supply unit 41 is connected to first capillary unit 40* by supply line 10*. Downstream of the first capillary unit 40*, discharge line 11* is arranged for

supplying first fluid flow F1 to first reactor 32*. In this example, reactor 32* is a flow through reactor.

Downstream of second fluid supply unit 42, second capillary unit 40' is arranged. Second capillary unit 40' is a capillary unit according to the invention, for example a capillary unit according to fig. 1. The second fluid supply unit 42 is connected to second capillary unit 40' by supply line 10'. Downstream of the second capillary unit 40', discharge line 11' is arranged for supplying second fluid flow F1 to second reactor 32'. In this example, reactor 32' is a flow through reactor.

The reaction system of fig. 5 further comprises a flow distribution controller 43 for ensuring that the flow rates of the first primary fluid flow F1 and the second primary fluid flow F2 are in a desired proportion relative to each other, for example that the flow rate is the same for both primary fluid flows.

The function of the flow distribution controller is to make sure that the flow rates of the first and second primary fluid flows F1, F2 are in the desired proportion relative to each other (for example flow rate F1: flow rate F2 = 1:1 or 1:2). To that end, the flow distribution controller receives the measured flow rates from both flow sensors 7. It compares the flow rates of the individual primary fluid flows with each other, and determines whether the flow rates are in the desired proportion to each other. If this is not the case, then the flow distribution controller activates one or more of the individual temperature control devices 8 to adjust the flow rate of the associated primary fluid flow.

With this embodiment of the invention, it is possible to for example carry out parallel reactions at different pressures or with different fluids, but at the same flow rate.

Fig. 6 shows a third embodiment of a reaction system according to the invention. In this embodiment, capillary units according to the invention are used as part of a back pressure control system.

In the reaction system according to fig. 6, a plurality of reaction vessels 32 is provided. Each reaction vessel 32 is provided with at least one reaction vessel inlet 34 and at least one reaction vessel outlet 35. A primary fluid flow P is supplied to the system, which is then in this example split up into secondary fluid flows S1, S2 and S3. For this flow splitting, a flow splitter according to the invention, for example a flow splitter according to fig. 3, can be used, but this is not necessary. In the reaction system of fig. 6, each of the reaction vessels 32 is provided with a reaction vessel effluent line 50 for discharging the reaction effluent from that particular reaction vessel 32. The reaction vessel effluent line 50 is connected to the reaction vessel outlet 35 of the associated reaction vessel 32.

In the reaction system according to fig. 6 the principle of the capillary unit according to the invention is used in a back pressure control system for controlling the pressure in the

reaction vessels 32. It is known that the pressure inside a reaction vessel can be controlled by controlling the pressure downstream of that reaction vessel, advantageously close to the reaction vessel outlet.

To that end, each of the reaction vessel effluent lines 50 is provided with an aperture, through which a portion of the reaction vessel effluent can escape. The portion of the reaction vessel effluent that escapes is called the pressure control flow. By controlling the flow rate of the pressure control flow, the pressure just downstream of the reaction vessel can be controlled, and therewith the pressure in the vessel. If for example the pressure has to be reduced in order to obtain the desired pressure in the reaction vessel, the flow rate of the pressure control flow has to be increased. In the reaction system of fig. 6, a capillary unit according to the invention is used for controlling the flow rate of the pressure control flow, and therewith the pressure in the associated reactor 32.

In fig. 6, a plurality of reaction vessels 32 is provided. However, a back pressure control system like the one of fig. 6 can also be used in combination with a single reaction vessel.

Fig. 7 shows a variant of the embodiment of a flow splitter according to fig. 3. In this variant, auxiliary channel 23 is provided, through which a tertiary fluid flow TF can pass. The resistance to fluid flow of the auxiliary channel is much less than the resistance to fluid flow in the capillaries of the capillary units 1. As a result of that, most of the primary fluid flow P leaves the flow splitter via the auxiliary channel 23.

Due to this, a change in resistance to fluid flow in one of the capillaries 4 of the capillary units 1 has far less effect on the flow rate of the fluid flow through the other capillaries in the flow splitter.

As an example, say that in the flow splitter of fig. 3 the primary fluid flow is 10 microliter per minute, the secondary fluid flow through the first capillary unit is 6 microliter per minute and the secondary fluid flow through the second capillary unit is 4 microliter per minute. Then, the capillary of the second capillary unit is heated, and the flow rate through the second capillary unit changes to 4.5 microliter per minute. If the flow rate of the primary fluid flow is kept constant, the fluid flow through the first capillary unit as a consequence changes to 5.5 microliter per minute.

For comparison, if in the flow splitter of fig. 7 the primary fluid flow is 10 microliter per minute, the tertiary fluid flow through the auxiliary channel 23 is 8 microliter per minute, the secondary fluid flow through the first capillary unit is 1 microliter per minute and the secondary fluid flow through the second capillary unit is also 1 microliter per minute. Then, the capillary of the second capillary unit is heated, and the flow rate through the second capillary unit changes to 1.5 microliter per minute. If the flow rate of the primary fluid flow is kept constant, the fluid flow through the auxiliary channel as a consequence changes to 7.56

microliter per minute and the fluid flow through the first capillary unit as a consequence changes to 0.94 microliter per minute.

The flow rate values and ratios as mentioned above are merely an example to illustrate the effect of the auxiliary channel. In general, the flow rate through the auxiliary channel can be for example 10 to 50 to 100 times, or even more, than the flow rate through each of the capillaries.

In a typical embodiment, it could be that 90% of the fluid of the primary fluid flow goes through the auxiliary channel, while only 10% is distributed over the capillary units. If there are 16 capillary units in the splitter, and the desired flow rates are set such that there is an equal distribution of the fluid flow over the capillary units, each capillary unit only receives 0,625% of the fluid of the primary fluid flow.

The auxiliary channel can take the fluid back to the source from which it came before entering the manifold inlet, to waste or to a separate discharge.

A flow splitter as shown in fig. 7 can be used in combination with any of the reaction systems according to the invention.

Clauses:

1. Flow splitter for splitting a primary fluid flow into a plurality of secondary fluid flows for performing experiments,

which flow splitter comprises:

- a manifold, which manifold has a manifold inlet for receiving the primary fluid flow, and a plurality of manifold outlets for releasing the plurality of secondary fluid flows,
- a plurality of capillary units, each of the capillary units comprising:
 - a unit inlet for receiving a secondary fluid flow from a manifold outlet,
 - a unit outlet for releasing said secondary fluid flow,
 - a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said secondary fluid flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the secondary fluid flow passing through said capillary,
 - a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary,
 - a flow sensor for measuring the flow rate of the secondary fluid flow through the capillary unit, which flow sensor can be arranged either inside or outside the housing,
- a flow adjustment unit for adjusting the flow rates of the secondary fluid flows, which flow adjustment unit comprises a temperature control device for individually

controlling the heater and/or cooler of each capillary unit in response to the flow rate that is measured by the flow sensor of that capillary unit.

2. Flow splitter according to any of the preceding clauses,
5 wherein the flow splitter further comprises a flow distribution controller for ensuring that the flow rates of the secondary fluid flows are in a desired proportion relative to each other, for example that the flow rate is the same for all secondary fluid flows.
3. Flow splitter according to any of the preceding clauses,
10 wherein at least one unit outlet is connected to a reaction vessel.
4. Flow splitter according to any of the preceding clauses,
wherein one or more capillary units are at least partly accommodated in a cassette.
- 15 5. Flow splitter according to any of the preceding clauses,
wherein the heater comprises a wire having an electrical resistance, which wire is wound around the capillary for supplying heat to said capillary.
6. Flow splitter according to any of the preceding clauses,
20 wherein the capillary is wound around a core, which core is provided with heating and/or cooling means.
7. Flow splitter according to any of the preceding claims,
Wherein the flow splitter further comprises an auxiliary channel that is connected to the
25 manifold, which auxiliary channel has a resistance to fluid flow that is lower than the resistance to fluid flow of the capillaries of the capillary units.
8. Reaction system for performing parallel experiments,
which reaction system comprises:
30
 - a fluid supply unit for supplying a primary fluid flow,
 - a flow splitter according to clause 1, wherein the manifold inlet is connected to the fluid supply unit for receiving the primary fluid flow from the fluid supply unit,
 - a plurality of reaction vessels, wherein each reaction vessel comprises at least one
reaction vessel inlet, wherein a reaction vessel inlet of each reaction vessel is connected
35 to an associated capillary unit outlet for receiving a secondary fluid flow from the flow splitter.

9. Reaction system according to clause 8,
wherein the reaction system further comprises:

- a reaction block for accommodating the reaction vessels,
- one or more cassettes, each cassette accommodating at least part of at least one of the plurality of capillary units of the flow splitter,
- an enclosure for receiving at least the reaction block and the one or more cassettes.

10. Reaction system for performing parallel experiments,
which reaction system comprises:

- a first fluid supply unit for supplying a first primary fluid flow at a first pressure,
- a second fluid supply unit for supplying a second primary fluid flow at a second pressure,
- a first capillary unit, which first capillary unit is adapted to receive the first primary fluid flow from the first fluid supply unit, the first capillary unit comprising:
 - a unit inlet for receiving the first primary fluid flow from the first fluid supply unit,
 - a unit outlet for releasing said first primary fluid flow,
 - a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said first primary fluid flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the first primary fluid flow passing through said capillary,
 - a housing for accommodating at least the capillary and heater and/or cooler of the first capillary unit, which housing provides thermal insulation of the capillary,
 - a flow sensor for measuring the flow rate of the first primary fluid flow through the first capillary unit, which flow sensor can be arranged either inside or outside the housing,
 - a flow adjustment unit for adjusting the flow rate of the first primary fluid flow through the first capillary unit,
which flow adjustment unit comprises a temperature control device for controlling the heater and/or cooler of the first capillary unit in response to the flow rate that is measured by the flow sensor of the first capillary unit,
- a second capillary unit, which second capillary unit is adapted to receive the second primary fluid flow from the second fluid supply unit, the second capillary unit comprising:
 - a unit inlet for receiving the second primary fluid flow from the second fluid supply unit,
 - a unit outlet for releasing said second primary fluid flow,
 - a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said second primary fluid flow passes through the capillary,
 - a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of the second primary fluid flow passing through said capillary,

- a housing for accommodating at least the capillary and heater and/or cooler of the second capillary unit, which housing provides thermal insulation of the capillary,
- a flow sensor for measuring the flow rate of the second primary fluid flow through the second capillary unit, which flow sensor can be arranged either inside or outside the housing,
- a flow adjustment unit for adjusting the flow rate of the second primary fluid flow through the second capillary unit, which flow adjustment unit comprises a temperature control device for controlling the heater and/or cooler of the second capillary unit in response to the flow rate that is measured by the flow sensor of the second capillary unit,

wherein the flow adjustment unit of the first capillary unit is adapted to adjust the flow rate of the first primary fluid flow and the flow adjustment unit of the second capillary unit is adapted to adjust the flow rate of the second primary fluid flow, and wherein the reaction system further comprises a flow distribution controller for ensuring that the flow rates of the first and second primary fluid flows are in a desired proportion relative to each other, for example that the flow rate is the same for the first and the second primary fluid flow.

11. Reaction system according to any of the clauses 8-10, wherein the reactors are flow through reactors.

12. Reaction system for performing experiments,

which reaction system comprises:

- a reaction vessel, wherein said reaction vessel comprises at least one reaction vessel inlet, which reaction vessel inlet is connectable to a fluid supply unit for receiving a fluid flow, wherein each reaction vessel further comprises at least one reaction vessel outlet for releasing an effluent flow,
- a reaction vessel effluent line for receiving the effluent flow from the reaction vessel, which effluent line is in fluid communication with at least one reaction vessel outlet, which reaction vessel effluent line is provided with a aperture for releasing a pressure control flow,
- a back pressure control system comprising a capillary unit, which capillary unit comprises
 - a unit inlet for receiving the pressure control flow from the aperture in the reaction vessel effluent line,

- a unit outlet for releasing said pressure control flow from the capillary unit,
- a capillary, which capillary is arranged between the unit inlet and the unit outlet such that said pressure control flow passes through the capillary,
- a heater and/or a cooler for adjusting the temperature of the capillary and therewith influencing the flow rate of pressure control flow passing through said capillary,
- a housing for accommodating at least the capillary and heater and/or cooler of said capillary unit, which housing provides thermal insulation of the capillary,
- a flow sensor which is adapted to measure the flow rate of the pressure control flow through the capillary unit,

5

10

wherein the back pressure control system further comprises a flow adjustment unit for adjusting the flow rates of the pressure control flow,
which flow adjustment unit comprise a temperature control device for controlling the heater and/or cooler of the capillary unit.

15

13. Reaction system for performing parallel experiments,
which reaction system comprises:

- a fluid supply unit for supplying a primary fluid flow,
- a manifold, which manifold has a manifold inlet for receiving the primary fluid flow, and a plurality of manifold outlets for releasing a plurality of secondary fluid flows,
- a plurality of reaction systems according to clause 11, wherein each of the manifold outlets is connected to a reaction vessel inlet.

20

CONCLUSIES

1. Stroomsplitser voor het opsplitsen van een primaire fluïdumstroom in meerdere secundaire fluïdumstromen voor het uitvoeren van experimenten,

5 welke stroomsplitser omvat:

- een verdeelstuk, welk verdeelstuk een verdeelstukinlaat heeft voor het ontvangen van de primaire fluïdumstroom, en meerdere verdeelstukuitlaten voor het afgeven van de meerdere secundaire fluïdumstromen,
- meerdere capillaireenheden, waarbij elke capillaireenheid omvat:
 - 10 ○ een eenheidinlaat voor het ontvangen van een secundaire fluïdumstroom van een verdeelstukuitlaat,
 - een eenheiduitlaat voor het afgeven van de secundaire fluïdumstroom,
 - een capillair, welke is aangebracht tussen de eenheidinlaat en de eenheiduitlaat zodat de fluïdumstroom door het capillair gaat,
 - 15 ○ een verwarmers en/of een koeler voor het aanpassen van de temperatuur van het capillair en daarmee het beïnvloeden van het debiet van de fluïdumstroom die door het capillair gaat,
 - een behuizing voor het opnemen van ten minste het capillair en de verwarmers en/of koeler van de capillaireenheid, welke behuizing thermische isolatie van het capillair verschaft,
 - 20 ○ een debietsensor, die is ingericht om het debiet van de secundaire fluïdumstroom te meten, welke debietsensor binnen of buiten de behuizing opgesteld kan zijn,
- een debietaanpaseenheid voor het aanpassen van het debiet van de secundaire fluïdumstromen, welke debietaanpaseenheid een temperatuurregelinrichting omvat voor het individueel regelen van elk van de verwarmers en/of koelers van de capillaire eenheden.
- 25

2. Stroomsplitser volgens conclusie 1, waarbij de stroomsplitser verder een stroomverdelingsregelaar omvat voor het zekerstellen dat de debieten van de secundaire fluïdumstromen de gewenste verhoudingen tot elkaar hebben, bijvoorbeeld dat het debiet hetzelfde is voor alle secundaire fluïdumstromen.

30

3. Stroomsplitser volgens één van de voorgaande conclusies, waarin tenminste één eenheiduitlaat verbonden is met een reactievat.

35

4. Stroomsplitser volgens één van de voorgaande conclusies, waarin één of meer capillaireenheden zijn ondergebracht in een cassette.

5. Stroomsplitser volgens één van de voorgaande conclusies, waarin de verwarmers
5 een draad omvat die een elektrische weerstand heeft, welke draad om het capillair
gewonden is voor het toevoeren van warmte aan het capillair.

6. Stroomsplitser volgens één van de voorgaande conclusies, waarin het capillair
10 rond een kern gewonden is, welke kern voorzien is van verwarmings- en/of
koelingsmiddelen.

7. Stroomsplitser volgens één van de voorgaande conclusies, waarin de
stroomsplitser verder een hulpkanaal omvat dat verbonden is met het verdeelstuk, welk
15 hulpkanaal een stromingsweerstand heeft die lager ligt dan de stromingsweerstand in de
capillairen van de capillarieenheden.

8. Reactiesysteem voor het uitvoeren van parallelle experimenten, welk
reactiesysteem omvat:

- een fluïdumtoevoereenheid voor het toevoeren van een primaire fluïdumstroom,
- 20 – een stroomsplitser volgens conclusie 1, waarbij de inlaat van het verdeelstuk
verbonden is met de fluïdumtoevoereenheid voor het ontvangen van de primaire
fluïdumstroom van de fluïdumtoevoereenheid,
- meerdere reactievaten, waarbij elk reactievat tenminste één reactievatinlaat
25 omvat, waarbij een reactievatinlaat van elk reactievat verbonden is met een
bijbehorende capillaireenheiduitlaat voor het ontvangen van een secundaire
fluïdumstroom van de stroomsplitser.

9. Reactiesysteem volgens conclusie 8, waarbij het reactiesysteem verder omvat:

- een reactieblok voor het onderbrengen van de reactievaten,
- 30 – één of meer cassettes, waarbij elke cassette tenminste een deel van één van de
meerdere capillaireenheden van de stroomsplitser opneemt,
- een behuizing voor het ontvangen van tenminste het reactieblok en de één of
meer cassettes.

10. Reactiesysteem voor het uitvoeren van parallelle experimenten, welk reactiesysteem
35 omvat:

- een eerste fluïdumtoevoereenheid voor het toevoeren van een eerste primaire fluïdumstroom op een eerste druk,
- een tweede fluïdumtoevoereenheid voor het toevoeren van een tweede primaire fluïdumstroom op een tweede druk,
- 5 – een eerste capillaireenheid die is ingericht om de eerste primaire fluïdumstroom van de eerste fluïdumtoevoereenheid te ontvangen, welke capillarieenheid omvat:
 - een eenheidinlaat voor het ontvangen van de eerste primaire fluïdumstroom van de eerste fluïdumtoevoereenheid,
 - een eenheiduitlaat voor het afgeven van de eerste primaire
 - 10 fluïdumstroom,
 - een capillair, welke is aangebracht tussen de eenheidinlaat en de eenheiduitlaat zodat de eerste primaire fluïdumstroom door het capillair gaat,
 - een verwarmers en/of een koeler voor het aanpassen van de temperatuur
 - 15 van het capillair en daarmee het beïnvloeden van het debiet van de eerste primaire fluïdumstroom die door het capillair gaat,
 - een behuizing voor het opnemen van ten minste het capillair en de verwarmers en/of koeler van de capillaireenheid, welke behuizing thermische isolatie van het capillair verschaft,
 - 20 ○ een debietsensor, die is ingericht om het debiet van de eerste primaire fluïdumstroom te meten, welke debietsensor binnen of buiten de behuizing opgesteld kan zijn,
 - een debietaanpaseenheid voor het aanpassen van het debiet van de eerste primaire fluïdumstroom door de eerste capillaireenheid, welke
 - 25 debietaanpaseenheid een temperatuurregelinrichting omvat voor het individueel regelen van elk van de verwarmers en/of koeler van de eerste capillaireenheid,
 - een tweede capillaireenheid die is ingericht om de tweede primaire fluïdumstroom van de tweede fluïdumtoevoereenheid te ontvangen, welke capillarieenheid
 - 30 omvat:
 - een eenheidinlaat voor het ontvangen van de tweede primaire fluïdumstroom van de tweede fluïdumtoevoereenheid,
 - een eenheiduitlaat voor het afgeven van de tweede primaire fluïdumstroom,
 - 35 ○ een capillair, welke is aangebracht tussen de eenheidinlaat en de eenheiduitlaat zodat de tweede primaire fluïdumstroom door het capillair gaat,

- een warmer en/of een koeler voor het aanpassen van de temperatuur van het capillair en daarmee het beïnvloeden van het debiet van de tweede primaire fluïdumstroom die door het capillair gaat,
 - een behuizing voor het opnemen van ten minste het capillair en de warmer en/of koeler van de capillaireenheid, welke behuizing thermische isolatie van het capillair verschaft,
 - een debietsensor, die is ingericht om het debiet van de tweede primaire fluïdumstroom te meten, welke debietsensor binnen of buiten de behuizing opgesteld kan zijn,
 - een debietaanpaseenheid voor het aanpassen van het debiet van de tweede primaire fluïdumstroom door de tweede capillaireenheid, welke debietaanpaseenheid een temperatuurregelinrichting omvat voor het individueel regelen van elk van de warmer en/of koeler van de tweede capillaireenheid,
 - een eerste reactor die in fluïde verbinding staat met de eerste capillaireenheid,
 - een tweede reactor die in fluïde verbinding staat met de tweede capillaireenheid, waarbij de debietaanpaseenheid van de eerste capillaireenheid is ingericht om het debiet van de eerste primaire fluïdumstroom aan te passen en de debietaanpaseenheid van de tweede capillaireenheid is ingericht om het debiet van de tweede primaire fluïdumstroom aan te passen, en waarbij het reactiesysteem verder een stroomverdelingsregelaar omvat voor het verzekeren dat de debieten van de eerste en tweede primaire fluïdumstromen in een gewenste verhouding tot elkaar zijn, bijvoorbeeld dat het debiet hetzelfde is voor de eerste en tweede fluïdumstroom.
11. Reactiesysteem volgens één van de conclusies 8-11, waarin de reactoren doorstroomreactoren zijn.
12. Reactiesysteem voor het uitvoeren van experimenten, welk reactiesysteem omvat:
- een reactievat, waarbij het reactievat tenminste één reactievatinlaat omvat, welke reactievatinlaat te verbinden is met een fluïdumtoevoereenheid voor het ontvangen van een fluïdumstroom, waarbij elk reactievat verder tenminste één reactievatuitlaat omvat voor het afgeven van een uitgaande stroom,
 - een reactievatafvoerleiding voor het ontvangen van de uitgaande stroom van het reactievat, welke afvoerleiding in fluïde verbinding staat met tenminste één reactievatuitlaat, welke reactievatafvoerleiding voorzien is van een opening voor het afgeven van een drukregelstroom,

- een achterdrukregelsysteem dat een capillaireenheid omvat, welke capillaireenheid omvat:

- een eenheidinlaat voor het ontvangen van de drukregelstroom van de opening in de reactievat uitgaande lijn,
 - 5 ○ een eenheiduitlaat voor het afgeven van de drukregelstroom van de capillaireenheid,
 - een capillair, welk capillair is aangebracht tussen de eenheidinlaat en de eenheiduitlaat zodanig dat de drukregelstroom door het capillair gaat,
 - 10 ○ een verwarmers en/of koeler voor het aanpassen van de temperatuur van het capillair en daarmee het beïnvloeden van het debiet van de drukregelstroom die door het capillair gaat,
 - een behuizing voor het opnemen van tenminste het capillair en de verwarmers en/of koeler van de capillaireenheid, welke behuizing thermische isolatie van het capillair verschaft,
 - 15 ○ een debietsensor welke debietsensor is ingericht om het debiet van de drukregelstroom te meten
- waarbij het achterdrukregelsysteem verder een debietaanpassingseenheid omvat voor het aanpassen van het debiet van de drukregelstroom, welke debietaanpassingseenheid een temperatuurregelinrichting omvat voor het
- 20 regelen van de verwarmers en/of koeler van de capillaireenheid.

13. Reactiesysteem voor het uitvoeren van parallelle experimenten, welk reactiesysteem omvat:

- een fluïdumtoevoereenheid voor het toevoeren van een primaire fluïdumstroom,
- 25 – een verdeelstuk, welk verdeelstuk een verdeelstukinlaat heeft voor het ontvangen van de primaire fluïdumstroom en meerdere verdeelstukuitlaten voor het afgeven van meerdere secundaire fluïdumstromen,
- meerdere reactiesystemen volgens conclusie 12, waarbij elk van de verdeelstukuitlaten verbonden is met een reactievatinlaat.

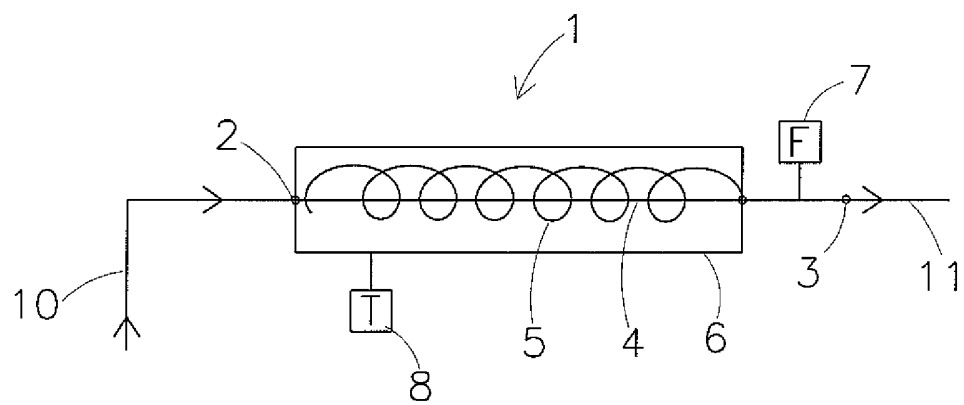


Fig 1

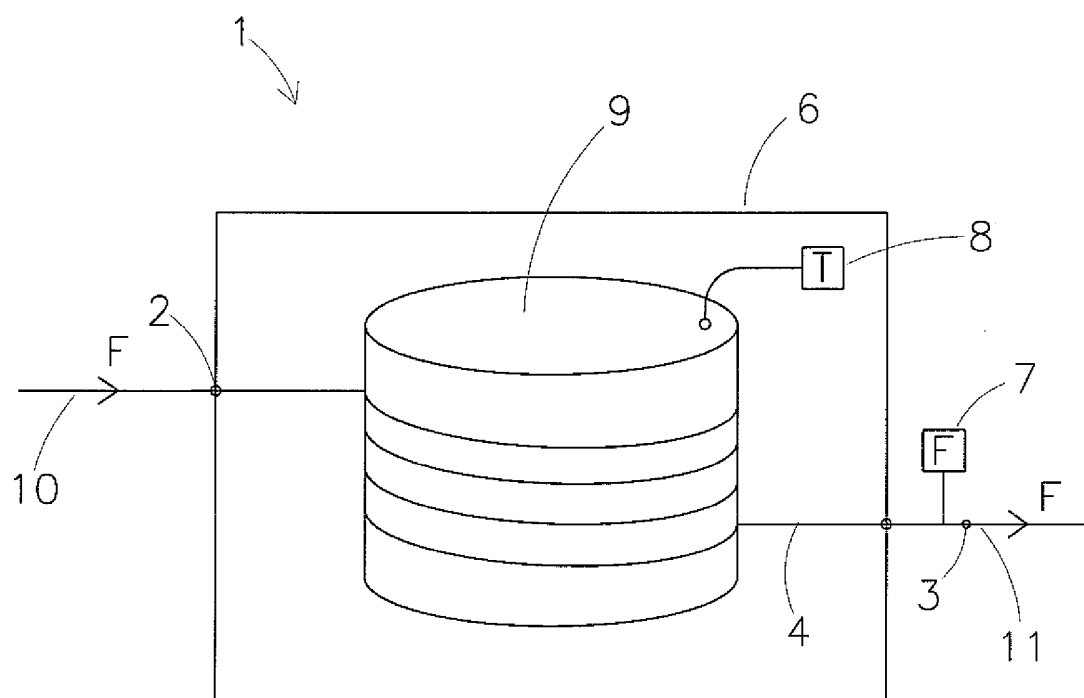


Fig 2

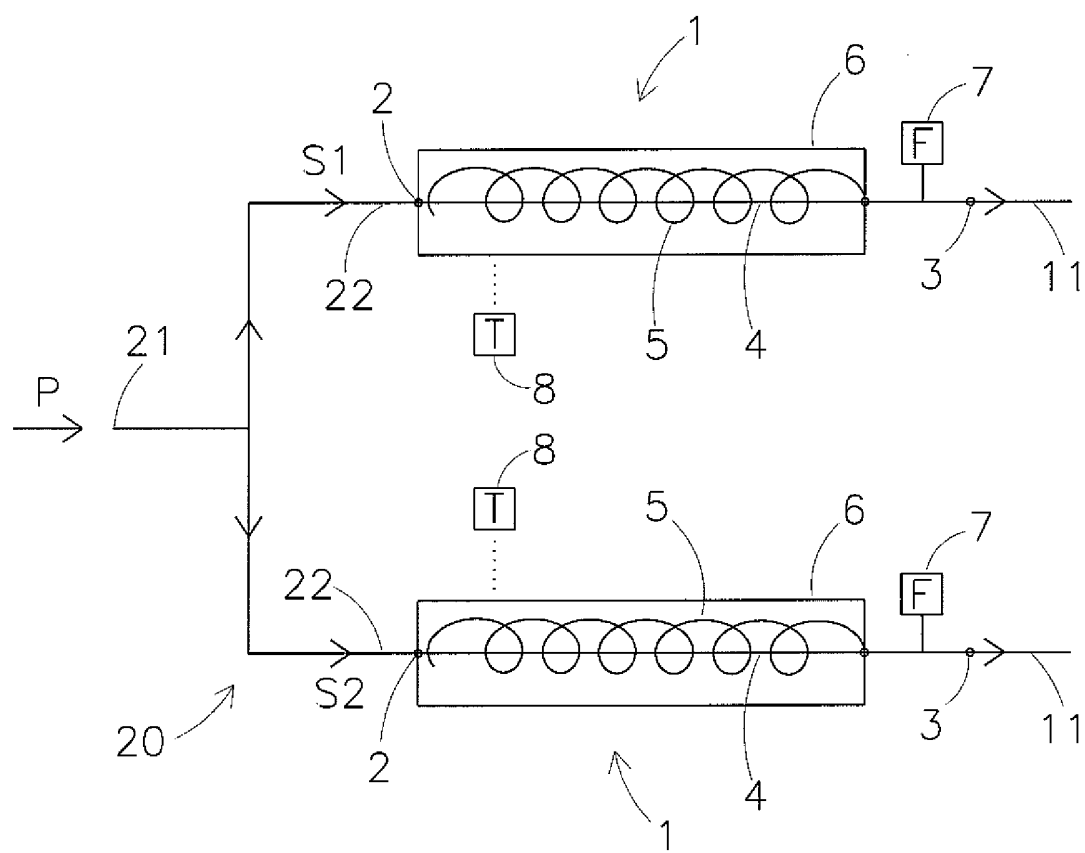


Fig 3

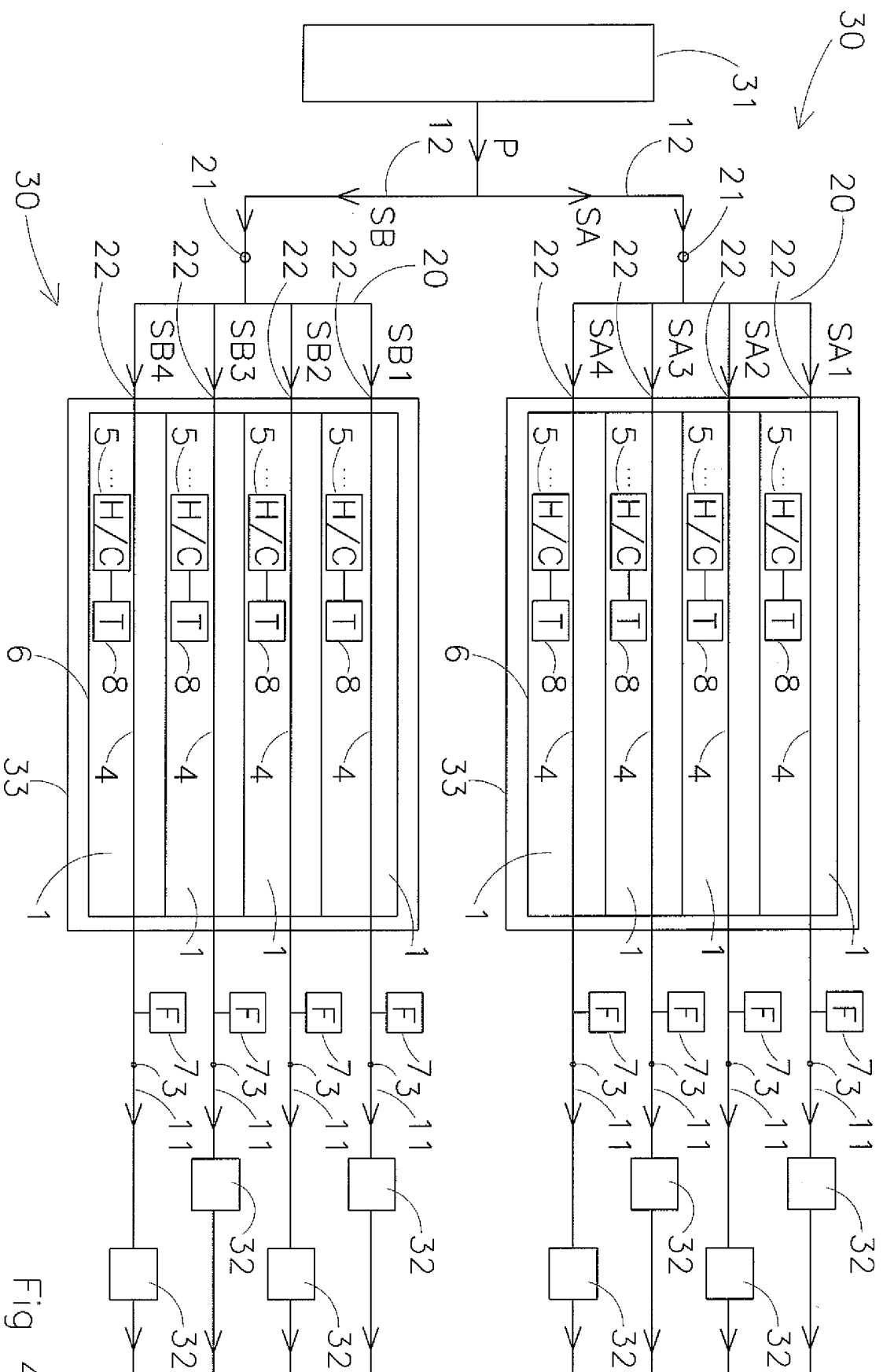


Fig 4

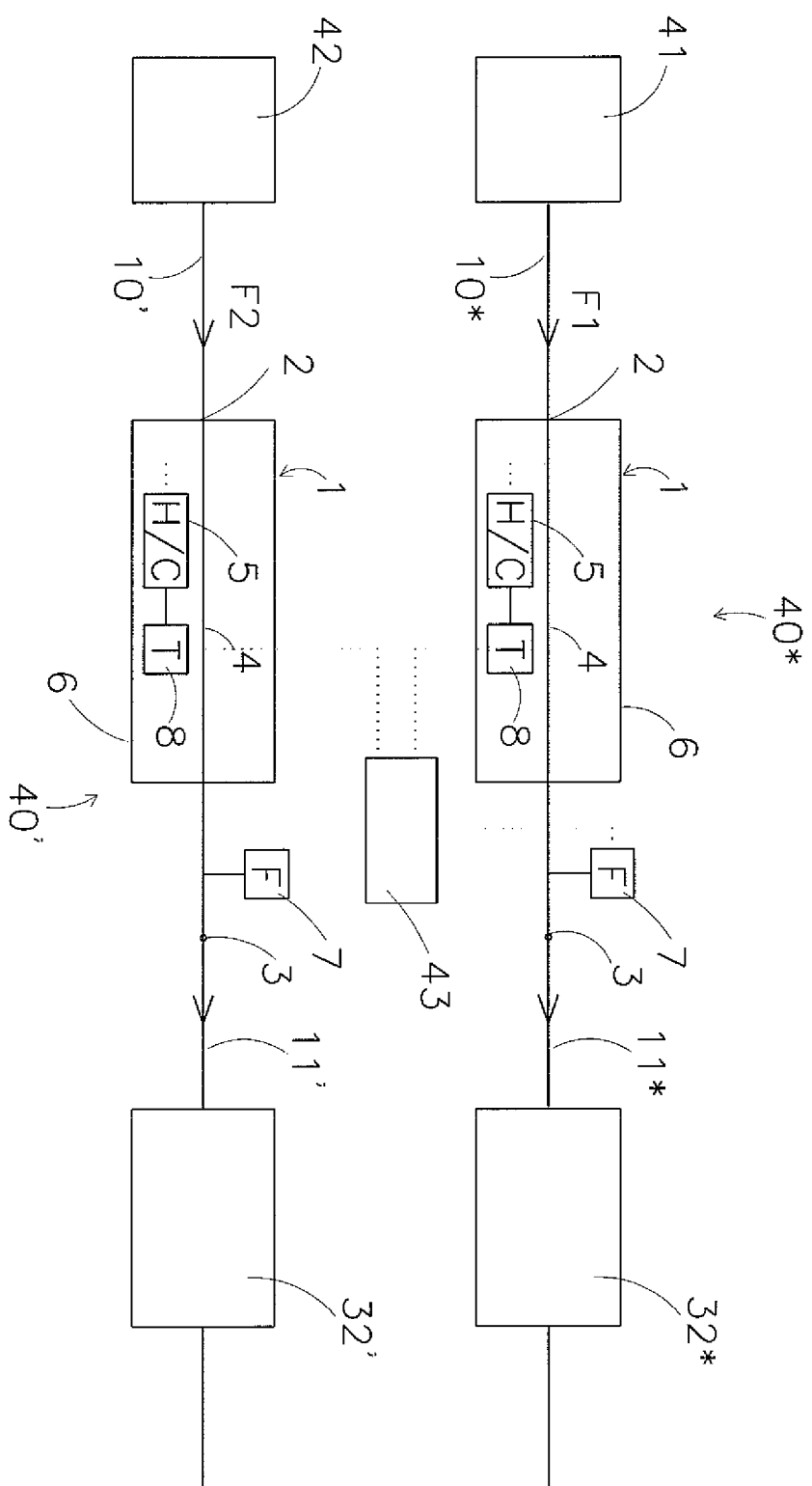


Fig 5

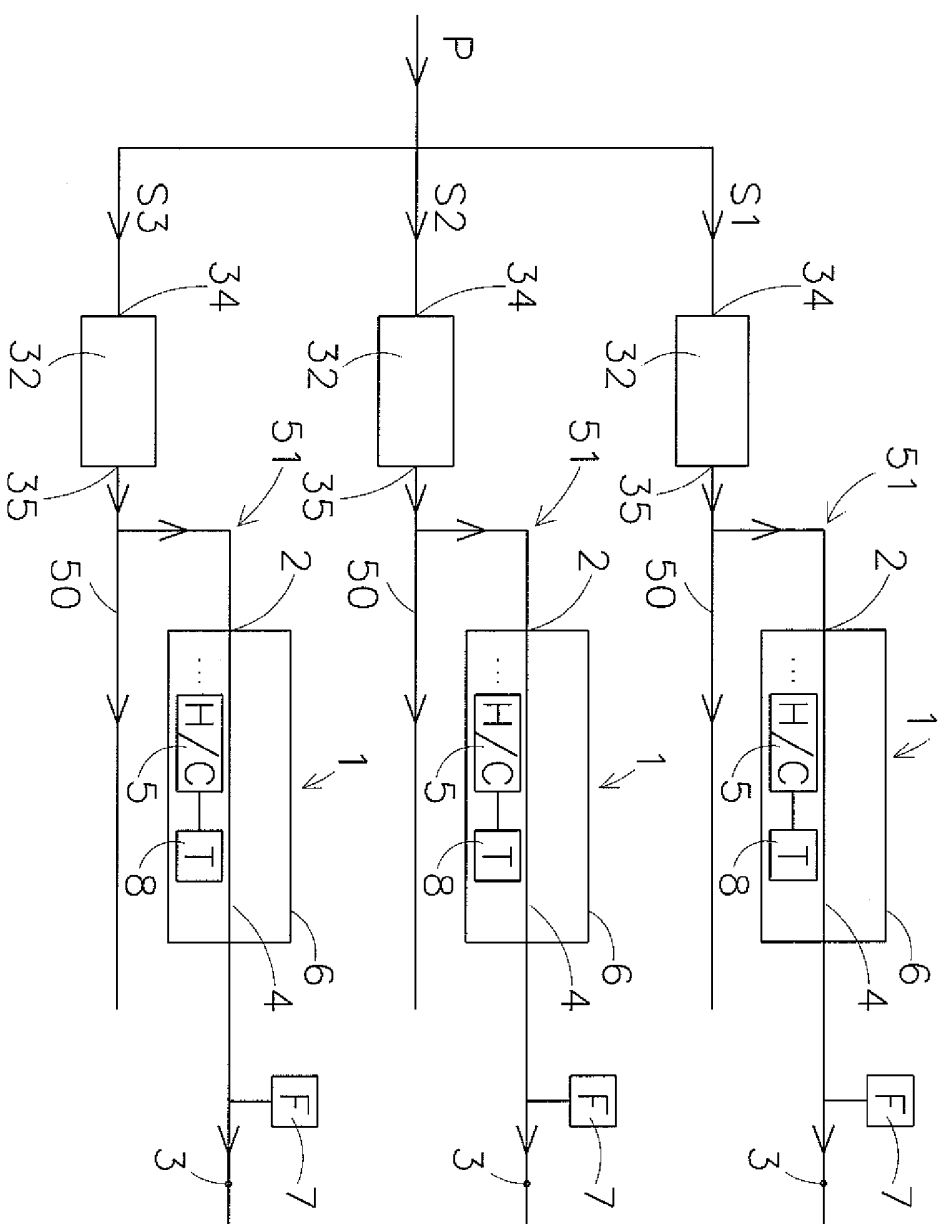


Fig 6

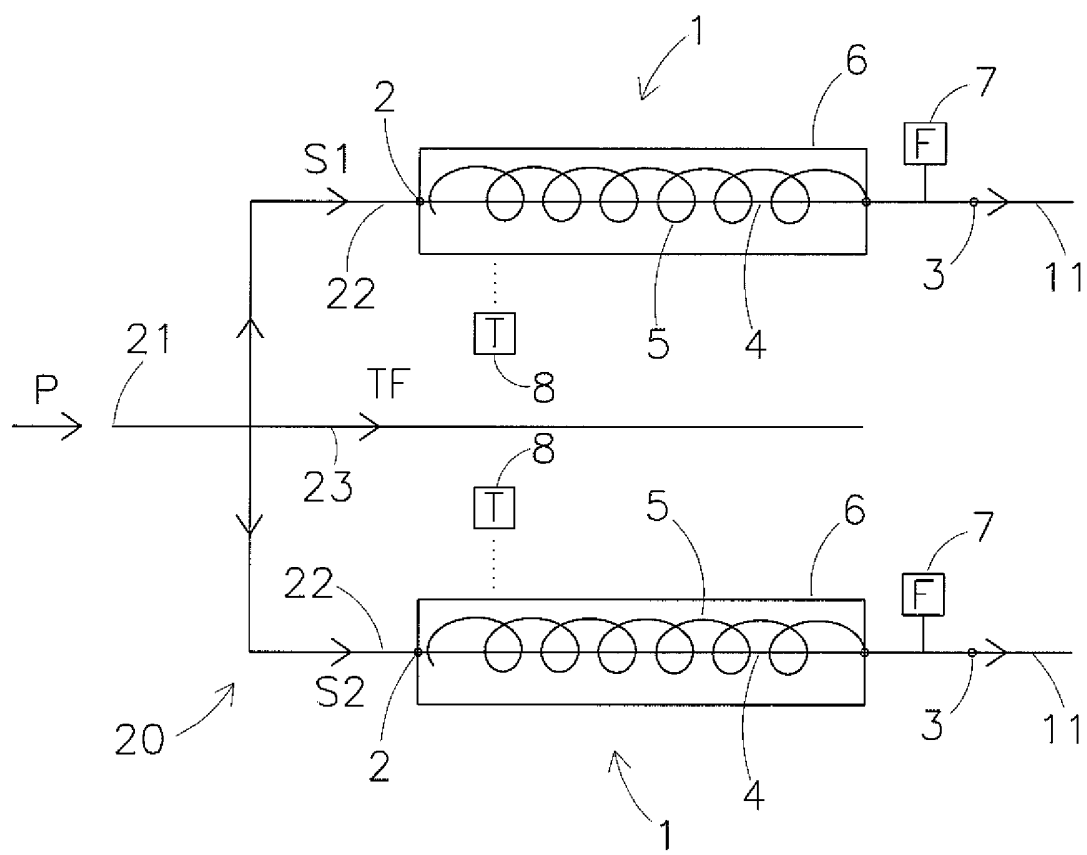
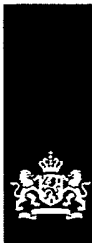


Fig 7



RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

Octrooiaanvraag 2002365

Classificatie van het onderwerp ¹ : G05D7/06, G05D11/13	Onderzochte gebieden van de techniek ¹ : G05D, B01L
Computerbestanden: EPODOC, WPI	Omvang van het onderzoek: Niet volledig
Indien gewijzigde conclusies; indieningsdatum van deze conclusies:	Niet onderzochte conclusies ² : 9-13 wegens niet-eenheid van uitvinding

Van belang zijnde literatuur

Categorie ³	Vermelding van literatuur met aanduiding, voor zover nodig, van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr.:
X, D Y	WO 99/64160 A (SYMYX TECHNOLOGIES) 16 december 1999 *; blz. 11 regels 8-23; blz. 13 regel 22 - blz. 15 regel 19 * * figuren 1, 7, 9 *	1-5, 8 6, 7
Y	--- US 2006/0213256 A (TRAINOFF), 28 september 2006 * figuur 2; par.[0016] *	6
Y	--- GB 2381589 A (CYBER INSTR TECHNOLOGY) 7 mei 2003 * figuur 1, blz. 1 regel 26 - blz. 2 regel 24 *	7
A	--- US 2002/157951 A (FORET ET AL), 31 oktober 2002 * abstract *	1

Datum waarop het onderzoek werd voltooid: 24 januari 2011		De bevoegde ambtenaar: Dr. M.W. de Lange NL Octrooiencentrum

>> Als het gaat om octrooien

¹ Gedefinieerd volgens International Patent Classification (IPC).

² Voor motivering zie toelichting in de schriftelijke opinie.

³ Verklaring van de categorie-aanduiding: zie apart blad.

Categorie van de vermelde literatuur:

- X: op zichzelf van bijzonder belang zijnde stand van de techniek
- Y: in samenhang met andere geciteerde literatuur van bijzonder belang zijnde stand van de techniek
- A: niet tot de categorie X of Y behorende van belang zijnde stand van de techniek
- O: verwijzend naar niet op schrift gestelde stand van de techniek
- P: literatuur gepubliceerd tussen voorrangs- en indieningsdatum
- T: niet tijdig gepubliceerde literatuur over theorie of principe ten grondslag liggend aan de uitvinding
- E: octrooiliteratuur gepubliceerd op of na de indieningsdatum van de onderhavige aanvraag en waarvan de indieningsdatum of de voorrangsdatum ligt voor de indieningsdatum van de onderhavige aanvraag.
- D: in de aanvraag genoemd
- L: om andere redenen vermelde literatuur
- &: lid van dezelfde octrooifamilie; corresponderende literatuur

AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK, UITGEVOERD IN OCTROOIAANVRAGE NR. 2002365

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooigeschriften genoemd in het rapport. De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per **3 februari 2011**

De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door NL Octrooiencentrum gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

In het rapport genoemd octrooi- geschrift		datum van publicatie	overeenkomend(e) geschrift(en)	datum van publicatie
WO9964160	A	1999-12-16	CA2297725 AC	1999-12-16
			AU4228999 A	1999-12-30
			EP1001846 AB	2000-05-24
			DE1001846T T	2000-09-14
			US6149882 A	2000-11-21
			US6395552 B	2002-05-28
			JP2002517735T T	2002-06-18
			AT219968T T	2002-07-15
			DE69901996T T	2002-10-31
			ES2178442T T	2002-12-16
			US6869799 B	2005-03-22
			DE29924905U U	2006-06-22
			AT372829T T	2007-09-15
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US2006213256	A	2006-09-28	EP1707941 A	2006-10-04
			JP2006276018 A	2006-10-12
			CN1847823 A	2006-10-18
GB2381589	AB	2003-05-07	GB2373054 AB	2002-09-11
US2002157951	A	2002-10-31		

SCHRIFTELIJKE OPINIE
Octrooiaanvraag 2002365

Indieningsdatum: 23 december 2008	Vorrangsdatum: 26 mei 2008
Classificatie van het onderwerp ¹ : G05D7/06, G05D11/13	Aanvrager: Avantium Holding B.V.

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- | | |
|--|--|
| ☒ Onderdeel I | Basis van de schriftelijke opinie |
| ☒ Onderdeel II | Vorrang |
| ☐ Onderdeel III | Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk |
| ☒ Onderdeel IV | De aanvraag heeft betrekking op meer dan één uitvinding |
| ☒ Onderdeel V | Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid |
| ☐ Onderdeel VI | Andere geciteerde documenten |
| ☐ Onderdeel VII | Overige gebreken |
| ☐ Onderdeel VIII | Overige opmerkingen |

De bevoegde ambtenaar:

Dr. M.W. de Lange

NL Octrooiencentrum

¹ Gedefinieerd volgens International Patent Classification (IPC).

Onderdeel I Basis van de schriftelijke opinie

Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.

Onderdeel II Voorrang

Deze schriftelijke opinie is opgesteld onder de aanname dat eventueel ingeroepen voorrang geldig is, tenzij hieronder anders is aangegeven. Controleren van de voorrang maakt geen deel uit van het reguliere onderzoek naar de stand van de techniek.

Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding

Vastgesteld is dat de octrooiaanvraag betrekking heeft op meer dan één uitvinding.

De materie van conclusies 1 en 8 is niet nieuw, zie de toelichting in onderdeel V. Daarom vallen de conclusies uiteen in ten minste de volgende mogelijke uitvindingen:

- Een stroomsplitser omvattende een stroomverdelingsregelaar volgens conclusies 1 en 2, en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een stroomsplitser waarin tenminste één eenheid uitlaat dat verbonden is met een reactievat volgens conclusies 1 en 3, en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een stroomsplitser waarin één of meer capillaireenheden zijn ondergebracht in een cassette volgens conclusies 1 en 4, en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een stroomsplitser waarin de verwarmer een draad omvat die een elektrische weerstand heeft, welke draad om het capillair gewonden is voor het toevoeren van warmte aan het capillair volgens conclusies 1 en 5 en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een stroomsplitser waarin het capillair rond een kern gewonden is, welke kern voorzien is van verwarmings- en/of koelingsmiddelen volgens conclusies 1 en 6 en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een stroomsplitser waarin de stroomsplitser verder een hulpkanaal omvat dat verbonden is met het verdeelstuk, welk hulpkanaal een stromingsweerstand heeft die lager ligt dan de stromingsweerstand in de capillairen van de capillaireenheden volgens conclusies 1 en 7 en een reactiesysteem omvattende zo'n stroomsplitser volgens conclusie 8;
- Een reactiesysteem omvattende een eerste en een tweede capillaireenheid volgens conclusie 10;
- Een reactiesysteem omvattende doorstroomreactoren volgens conclusie 11;
- Een reactiesysteem omvattende een achterdrukregelsysteem volgens conclusie 12 en een reactiesysteem omvattende meerdere reactiesystemen omvattende een achterdrukregelsysteem volgens conclusie 13;

Het onderzoek naar de stand van de techniek is beperkt tot conclusies 1-8.

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja:	Conclusies	6, 7
	Nee:	Conclusies	1-5, 8
Inventiviteit	Ja:	Conclusies	
	Nee:	Conclusies	6, 7
Industriële toepasbaarheid	Ja:	Conclusies	1-8
	Nee:	Conclusies	

2. Literatuur en toelichting

De volgende documenten genoemd in de tabel op de voorste bladzijde worden besproken:

D1 = WO 99/64160 A

D2 = US 2006/0213256 A

D3 = GB 2381589 A

Zoals in de onderhavige aanvraag wordt onderkend is uit D1 bekend een stroomsplitser voor het opsplitsen van een primaire fluïdumstroom in meerdere secundaire fluïdumstromen als onderdeel van een reactiesysteem voor het uitvoeren van parallelle experimenten.

Deze stroomsplitser blijkt de volgende onderdelen te omvatten:

- een verdeelstuk (verwijzingcijfer 14 in figuur 1), welk verdeelstuk een verdeelstukinlaat heeft voor het ontvangen van de primaire fluïdumstroom, en meerdere verdeelstukuitlaten voor het afgeven van de meerdere secundaire fluïdumstromen,
- meerdere capillaireenheden ('flow restrictors' 18), waarbij elke capillaireenheid omvat (zie figuur 7):

- een eenheidinlaat voor het ontvangen van een secundaire fluïdumstroom van een verdeelstukuitlaat (linkerzijde van capillair 122),
- een eenheiduitlaat voor het afgeven van de secundaire fluïdumstroom (rechterzijde van capillair 122),
- een capillair (122), welke is aangebracht tussen de eenheidinlaat en de eenheiduitlaat zodat de fluïdumstroom door het capillair gaat,
- een verwarmers (140) voor het aanpassen van de temperatuur van het capillair en daarmee het beïnvloeden van het debiet van de fluïdumstroom die door het capillair gaat (zie blz. 13 regel 18 - blz. 14 regel 24),
- een behuizing (182) voor het opnemen van ten minste het capillair en de verwarmers van de capillaireenheid, welke behuizing thermische isolatie van het capillair verschaft (zie fig. 9, blz. 15 regels 14-19).

- een debietsensor (124), die is ingericht om het debiet van de secundaire fluïdumstroom te meten, welke debietsensor binnen of buiten de behuizing opgesteld kan zijn,
- een debietaanpaseenheid (126) voor het aanpassen van het debiet van de secundaire fluïdumstromen, welke debietaanpaseenheid een temperatuurregelinrichting omvat voor het individueel regelen van elk van de verwarmers en/of koelers van de capillaire eenheden.

Conclusie 1 is daarom niet nieuw.

Verder is uit D1 ook bekend dat het reactiesysteem omvat een fluïdumtoevoereenheid (22) voor het toevoeren van een primaire fluïdumstroom en meerdere reactievaten (12), waarbij elk reactievat tenminste één reactievatinlaat omvat, waarbij een reactievatinlaat van elk reactievat verbonden is met een bijbehorende capillaireenheiduitlaat voor het ontvangen van een secundaire fluïdumstroom van de stroomsplitser. Conclusie 8 is daarom evenmin nieuw in het licht van D1.

De maatregelen van volgconclusies 2 tot en met 5 zijn eveneens bekend uit D1: Zie de microprocessor 136, het reactievat 12, de cassette bestaande uit 'base block' 160 en 'cover block' 162 en draden 130. Ze zijn dus niet nieuw.

Volgconclusies 6 en 7 zijn om de volgende redenen niet inventief:

De maatregel van volgconclusie 6 is bekend uit D2, zie figuur 2, par.[0016]. Het ligt voor de vakman voor de hand dit als alternatief voor de uit D1 bekende constructie te gebruiken.

De maatregel van volgconclusie 7 is bekend uit D3, zie figuur 1, blz. 1 regel 26 - blz. 2 regel 24. Het ligt voor de vakman voor de hand deze maatregel toe te passen bij de uit D1 bekende constructie teneinde het effect van de stroom door een capillaireenheid t.o.v. de stroom door het gehele systeem te minimaliseren.