



(51) International Patent Classification:

B01F 3/08 (2006.01) **B01F 13/10** (2006.01)
B01F 13/00 (2006.01) **B01F 15/02** (2006.01)

(21) International Application Number:

PCT/EP2009/056091

(22) International Filing Date:

19 May 2009 (19.05.2009)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

08158692.7 20 June 2008 (20.06.2008) EP

(71) **Applicant** (for AE, AG, AU, BB, BH, BW, BZ, CA, CY, EG, GB, GD, GH, GM, IE, IL, KE, KN, LC, LK, LS, MT, MW, MY, NA, NG, NZ, OM, PG, SC, SD, SG, SL, SZ, TT, TZ, UG, VC, ZA, ZM, ZW only): **UNILEVER PLC** [GB/GB]; a company registered in England and Wales under company no. 41424, Unilever House, 100 Victoria Embankment, London Greater London EC4P 4BQ (GB).

(71) **Applicant** (for all designated States except AE, AG, AU, BB, BH, BW, BZ, CA, CY, EG, GB, GD, GH, GM, IE, IL, IN, KE, KN, LC, LK, LS, MT, MW, MY, NA, NG, NZ, OM, PG, SC, SD, SG, SL, SZ, TT, TZ, UG, US, VC, ZA, ZM, ZW): **UNILEVER N.V.** [NL/NL]; Weena 455, NL-3013 AL Rotterdam (NL).

(71) **Applicant** (for IN only): **HINDUSTAN UNILEVER LIMITED** [IN/IN]; Hindustan Lever House, 165/166 Backbay Reclamation, Maharashtra, Mumbai 400 020 (IN).

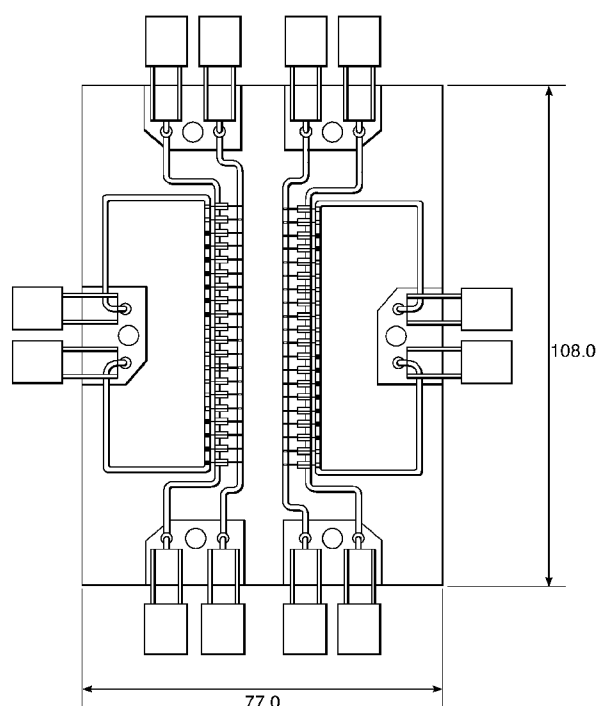
(72) Inventors; and

(75) **Inventors/Applicants** (for US only): **JOUSSE, Fabien, Frederic, Raymond, Marie** [FR/FR]; Unilever France, 48 quai Nicolas Rolin, F-21000 Dijon (FR). **ROSSETTI, Damiano** [IT/GB]; Unilever R&D Colworth, Sharnbrook, Bedford Bedfordshire MK44 1LQ (GB). **TETRADIS-MAIRIS, Georgios** [GR/GB]; Unilever R&D Colworth, Sharnbrook, Bedford Bedfordshire MK44 1LQ (GB).

[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR EMULSION MANUFACTURE

Fig.1a.



(57) **Abstract:** The drawbacks with existing commercial emulsion manufacture technology "are the lack of control over emulsion droplet size and the tendency towards poly-disperse emulsion droplet size distributions. It is also very difficult to produce well-defined multiple emulsions. An apparatus is provided for manufacturing an emulsion product which overcomes, amongst other things, these problems comprising: (a) a plurality of elements (201), wherein each element (201) comprises a first microfluidic conduit (202) for carrying a first liquid stream and a second microfluidic conduit (203) for carrying a second liquid stream, the first microfluidic conduit (202) and second microfluidic conduit (203) intersecting at a junction (204) thereby to produce an emulsion product stream from the first liquid stream and the second liquid stream, and a microfluidic emulsion product conduit (205) for carrying the emulsion product stream away from the junction (204); (b) a non-microfluidic first manifold (301) in fluid communication with the plurality of first microfluidic conduits (202); and (c) a non-microfluidic second manifold (302) in fluid communication with the plurality of second microfluidic conduits (203); wherein the non-microfluidic first manifold (301) and the non-microfluidic second manifold (302) are in fluid communication with respectively a first closeable manifold drain (304) and a second closeable manifold drain (305). A method for manufacturing an emulsion product using the aforementioned apparatus is also provided.



(74) **Agent:** ACHAM, Nicholas, Clive; Unilever PLC, Unilever Patent Group, Colworth House, Sharnbrook, Bedford Bedfordshire MK44 1LQ (GB).

(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

APPARATUS AND METHOD FOR EMULSION MANUFACTURE

Emulsion technology is a key technology utilised in a variety of industrial products such as food, home care, personal care and laundry products. On a commercial scale, emulsions can be prepared by mixing all the required ingredients in a large, for example 10 ton, reactor fitted with an agitator thereby to produce a mixture and then passing the mixture through a homogeniser. The drawbacks with this method of manufacture are the lack of control over emulsion droplet size and the tendency towards polydisperse emulsion droplet size distributions. It is also very difficult to produce well-defined multiple emulsions.

The aforementioned drawbacks can be overcome by scaling down the manufacturing apparatus such that at least one of the dimensions of the apparatus is no more than 250 microns, preferably no more than 100 microns. The reason for this is that at this scale, it is possible to control the formation of each emulsion droplet in succession. The obvious drawback to operating manufacturing apparatus of this scale is that only small, non-commercial, quantities of product can be manufactured.

EP 1 810 746 A1 discloses a microscopic flow passage structure for generating microscopic liquid droplets, the microscopic flow passage comprising fluid introduction flow passages, a merged flow passage and a common outlet.

SUMMARY OF THE INVENTION

A solution to the foregoing problem, amongst others, is provided in a first aspect of the invention by an apparatus for manufacturing an emulsion product comprising:

- (a) a plurality of elements, wherein each element comprises a first microfluidic conduit for carrying a first liquid stream and a second microfluidic conduit for carrying a second liquid stream, the first microfluidic conduit and second microfluidic conduit intersecting at a junction thereby to produce an emulsion product stream from the first liquid stream and the second liquid stream, and a microfluidic emulsion product conduit for carrying the emulsion product stream away from the junction;
- (b) a non-microfluidic first manifold in fluid communication with the plurality of first microfluidic conduits; and
- (c) a non-microfluidic second manifold in fluid communication with the plurality of second microfluidic conduits;

wherein the non-microfluidic first manifold and the non-microfluidic second manifold are in fluid communication with respectively a first manifold drain and a second manifold drain.

For the purposes of this invention, by conduit is meant any pipe, tube and/or open gutter.

5

For the purposes of this invention, by microfluidic conduit is meant any conduit wherein at least one dimension is no more than 250 microns, preferably no more than 100 microns, more preferably no more than 50 microns, most desirably no more than 10 microns. Preferably the at least one dimension is greater than 5 microns.

10

For the purposes of this invention, by non-microfluidic manifold is meant any manifold wherein the smallest dimension is no smaller than 500 microns, preferably no smaller than 1000 microns, even more preferably no smaller than 2000 microns, most preferably no smaller than 5000 microns. Preferably the smallest dimension is no greater than 20 000 microns.

15

For the purposes of this invention, by emulsion is meant any emulsion whether is be oil-in-water or water-in-oil, or multiple emulsions such as oil-in-water-in-oil or water-in-oil-in-water.

20

For the purposes of this invention, by manifold is meant a conduit with at least three or more outlets.

It has been observed that simple parallelisation of the aforementioned elements results in an apparatus which, at best, takes a very long time to start producing an emulsion product stream with a monodisperse emulsion droplet size distribution, and at worst, may never produce an emulsion product stream with a monodisperse emulsion droplet size distribution. This is because of the issue of cross-contamination of the elements. Specifically, after use the elements must be cleaned with an appropriate solvent otherwise the elements may become permanently blocked by the residue of, for example, the oil and/or aqueous phase. However traces of the solvent are also then left within the elements. Difficulties with flushing of these traces from the elements when the elements are next used can lead to the aforementioned problems of producing an emulsion product stream with a monodisperse emulsion droplet size distribution. These problems are solved through employing the first manifold drain and the second manifold drain.

25

30

35

Preferably the apparatus for manufacturing an emulsion product comprises at least 10, preferably at least 100 elements and most preferably at least 500 elements.

5 Preferably the non-microfluidic first manifold has a smallest dimension which is at least five times greater than the at least one dimension of the first microfluidic conduit and the non-microfluidic second manifold has a smallest dimension which is at least five times greater than the smallest dimension of the second microfluidic conduit. More preferably, the non-microfluidic first manifold has a smallest dimension which is at least ten times greater than the smallest dimension of the first microfluidic conduit and the non-
10 microfluidic second manifold has a smallest dimension which is at least ten times greater than the smallest dimension of the second microfluidic conduit.

In a second aspect of the invention, a method for manufacturing an emulsion product is provided, the method comprising the steps of:

- 15 (a) providing an apparatus according to the first aspect of this invention; then
(b) passing the first liquid stream along the non-microfluidic first manifold and through the first manifold drain at a first pressure and then closing the first manifold drain; and either simultaneously or sequentially
passing the second liquid stream along the non-microfluidic second manifold and
20 through the second manifold drain at a second pressure and then closing the second manifold drain; and then
(c) passing the first liquid stream along the first microfluidic conduit at a third pressure; and either simultaneously or sequentially
passing the second liquid stream along the second microfluidic conduit at a fourth
25 pressure;

wherein the first liquid stream is at least partially immiscible in the second liquid stream;
wherein the first pressure is lower than the third pressure; and
wherein the second pressure is lower than the fourth pressure.

30 For the purposes of this invention, by partially immiscible is meant that the degree of immiscibility is sufficient to produce an emulsion from mixing of the first liquid stream and the second liquid stream.

The advantage of this two-step method is that it allows the non-microfluidic first manifold
35 and the non-microfluidic second manifold to fill with reduced loss of the first liquid stream and the second liquid stream through the first manifold drain and the second manifold

drain respectively before the pressure is raised to pump the first liquid stream and the second liquid stream at an appropriate rate through the microfluidic part of the apparatus.

An alternative arrangement to the inventive apparatus includes recycling of the waste first liquid stream and the second liquid stream from the first manifold drain and the second manifold drain back to the non-microfluidic first manifold and the non-microfluidic second manifold respectively. This would then mean that the apparatus could be operated at the pressures required to pump the first liquid stream and the second liquid stream at an appropriate rate through the microfluidic part of the apparatus from the start of operation.

Thus in a second embodiment of the inventive method, a method for manufacturing an emulsion product is provided, the method comprising the steps of:

- (a) providing an apparatus according to the first aspect of this invention; then
- (b) passing the first liquid stream along the non-microfluidic first manifold and through the first manifold drain and along the first microfluidic conduit at a fifth pressure; and either simultaneously or sequentially passing the second liquid stream along the non-microfluidic second manifold and through the second manifold drain and along the second microfluidic conduit at a sixth pressure;

wherein the first liquid stream is at least partially immiscible in the second liquid stream.

DESCRIPTION OF THE FIGURES

The invention is now exemplified with reference to the figures which show in:

Figure 1(a) a plan view of an apparatus according to the invention;

Figure 1(b) a cross-section of the apparatus of figure 1(a) illustrating that the apparatus comprises a 2mm wafer of SU8 photoresist (102) sandwiched by first (101) and second (103) 2mm poly(methyl methacrylate) wafers;

Figure 2 a plan view of the 2mm wafer of SU8 photoresist; and

Figure 3 a plan view of the second (103) 2mm poly(methyl methacrylate) wafer.

DETAILED DESCRIPTION OF THE INVENTION

Apparatus

Figure 1(a) shows a plan view of an apparatus according to the invention. As shown in figure 1(b), the apparatus comprises a 2mm wafer of SU8 (102) (an epoxy-based negative photoresist available from Microchem Corporation) sandwiched by first (101) and second (103) 2mm poly(methyl methacrylate) wafers. Figure 1(b) also shows inlet/outlet ports (104) mounted on the upper surface of the first 2mm poly(methyl methacrylate) wafer.

Figure 2 shows a plan view of the 2mm wafer of SU8 photoresist (102) illustrating a plurality of (forty) elements (201) arranged according to the invention. Each element (201) comprises a first microfluidic conduit (202) for carrying a first liquid stream and a pair of second microfluidic conduits (203) for carrying a second liquid stream, the first microfluidic conduit (202) and the pair of second microfluidic conduits (203) intersecting at a junction (204) thereby to produce an emulsion product stream from the first liquid stream and the second liquid stream, and a microfluidic emulsion product conduit (205) for carrying the emulsion product stream away from the junction (204). This arrangement is characterised by opposing second microfluidic conduits (203). The microfluidic conduits are all 20 microns in diameter and prepared by ultra-violet etching of the surface of the SU8 wafer using techniques known in the art of photoresists.

Figure 3 shows a plan view of the second (103) 2mm poly(methyl methacrylate) wafer illustrating the routes of the non-microfluidic first manifold (301) and the first manifold drain (304), the non-microfluidic second manifold (302) and the second manifold drain (305), and a non-microfluidic third manifold (303) for carrying away the emulsion product stream. The non-microfluidic manifolds are all 500 microns in diameter and prepared by mechanical drilling.

Fluid communication between the microfluidic conduits of the SU8 photoresist wafer, the non-microfluidic manifolds of the second 2mm poly(methyl methacrylate) wafer and the inlet/outlet ports (104) mounted on the upper surface of the first 2mm poly(methyl methacrylate) wafer is accomplished by mechanically drilling holes through the wafers prior to assembly of the apparatus. The apparatus is assembled by adhesives and/or thermobonding techniques known in the art.

Such apparatus may be manufactured to order by Epigem Limited.

Method and Results

In use, an aqueous solution of 7% w/w pullulan (a polysaccharide consisting of maltotriose units) (viscosity 40 mPas) was treated as the first liquid stream and a 4% w/w solution of Admul Wol (polyglycerol polyricinoleate available from Quest International) in sunflower oil (viscosity 63 mPas) was treated as the second liquid stream.

5

The viscosities of the first liquid stream and the second liquid stream were determined on a ThermoHaake RheoStress 1 rheometer operated at 20 degree Celsius with a cone (60mm diameter; 1 degree cone angle) and plate geometry in a controlled shear stress mode wherein the shear stress rose from 0.01 to 10 Pa in 0.345 Pa steps over four
10 minutes.

Fouling of second liquid stream:

In order to mimic a potential mix up of the first and second liquid streams during use of the apparatus of the invention and to evaluate the ability of the apparatus illustrated in th
15 figures to recover to normal operating conditions, the following protocol was adopted starting with a previously unused apparatus:

a) The first liquid stream was pumped along the non-microfluidic first manifold (301) and through the first manifold drain (304) at which point the first manifold drain
20 (304) was closed; then

b) The second liquid stream was pumped along the non-microfluidic second manifold (302) and through the second manifold drain (305) at which point the second manifold drain (305) was closed; then
25

c) The apparatus was operated at higher pressures of for the first liquid stream of 41.3 kPa (6 psi) and for the second liquid stream of 82.7 kPa (12 psi) for 30 minutes whereupon droplets of the first liquid stream in the second liquid stream were formed at the junctions (204); then
30

d) The second manifold drain (305) was opened and the first liquid stream pumped along the non-microfluidic second manifold (302) and through the second manifold drain (305) at which point the second manifold drain (305) was closed; then

35 e) The pressure of the first liquid stream in the non-microfluidic second manifold (302) was increased to 344.7 kPa (50 psi) and maintained for 2.5 minutes at

which point the first liquid stream had passed through the pair of second microfluidic conduits (203); then

- 5 f) The second liquid stream was pumped along the non-microfluidic second manifold (302) at a pressure of 82.7 kPa (12 psi) with the second manifold drain (305) remaining closed from step (d) and with the first liquid stream being pumped through the non-microfluidic first manifold (301) at 41.3 kPa (6 psi) with the first manifold drain (304) remaining closed from step (a); and then
- 10 g) The time was taken for droplet formation to resume from the moment step (f) was initiated using a camera and stop watch.

In order to evaluate the effects of the first manifold drain (304) and the second manifold drain (305), a second experiment was conducted repeating the above-mentioned steps (a) to (f) but wherein step (f) was replaced by repeating steps (b) and (c). The time taken for droplet formation to resume was determined from the moment that the second manifold drain (305) was closed in the repeat step (b) using a camera and stop watch. The results are summarised in table 1.

20 Table 1: Time taken for droplet formation after fouling of second liquid stream

Element number	Time (minutes) without using second manifold drain	Time (minutes) using second manifold drain	Ratio
10	10.5	2.5	4.2
20	48	3.5	13.7

The time taken for the resumption of droplet formation is considerably lower when using the second manifold drain (305). It is also believed that when using the second manifold drain (305), resumption of droplet formation starts simultaneously from all the elements (201) because the one minute difference between observation of droplet formation at the 10th and 20th elements reported in table 1 can be attributed to the time taken to move and refocus the camera from element 10 to element 20 rather than to a physical delay in droplet formation.

Fouling of first liquid stream:

The following protocol was adopted starting with a previously unused apparatus:

- 5 a) The first liquid stream was pumped along the non-microfluidic first manifold (301) and through the first manifold drain (304) at which point the first manifold drain (304) was closed; then
- 10 b) The second liquid stream was pumped along the non-microfluidic second manifold (302) and through the second manifold drain (305) at which point the second manifold drain (305) was closed; then
- 15 c) The apparatus was operated at higher pressures of for the first liquid stream of 41.3 kPa (6 psi) and for the second liquid stream of 82.7 kPa (12 psi) for 30 minutes whereupon droplets of the first liquid stream in the second liquid stream were formed at the junctions (204); then
- 20 d) The first manifold drain (304) was opened and the second liquid stream pumped along the non-microfluidic first manifold (301) and through the first manifold drain (304) at which point the first manifold drain (304) was closed; then
- 25 e) The pressure of the second liquid stream in the non-microfluidic first manifold (301) was increased to 344.7 kPa (50 psi) and maintained for 2.5 minutes at which point the second liquid stream had passed through the first microfluidic conduit (202); then
- 30 f) The first liquid stream was pumped along the non-microfluidic first manifold (301) at a pressure of 41.3 kPa (6 psi) with the first manifold drain (304) remaining closed from step (d) and with the second liquid stream being pumped through the non-microfluidic second manifold (302) at 82.7 kPa (12 psi) with the second manifold drain (305) remaining closed from step (b); and then
- 35 g) The time was taken for droplet formation to resume from the moment step (f) was initiated using a camera and stop watch.

In order to evaluate the effects of the first manifold drain (304) and the second manifold drain (305), a second experiment was conducted repeating the above-mentioned steps (a) to (f) but wherein step (f) was replaced by repeating steps (a) and (c). The time taken for droplet formation to resume was determined from the moment that the first manifold drain (304) was closed in the repeat step (a) using a camera and stop watch. The results are summarised in table 2.

Table 2: Time taken for droplet formation after fouling of first liquid stream

Element number	Time (minutes) without using first manifold drain	Time (minutes) using first manifold drain
1	>30	<5
5	>30	<8
10	>30	<17
15	>30	<13
20	>30	17 (all working)

The time taken for the resumption of droplet formation is considerably lower when using the first manifold drain (304). It is believed that the resumption of droplet formation when the apparatus was operated without using the first manifold drain (304) not being observed after more than 30 minutes is due to the fact that the pressure of the first liquid stream was low and thus takes a lot of time to push the second liquid stream from the first microfluidic conduit (202).

CLAIMS

1. An apparatus for manufacturing an emulsion product comprising:

- 5 (a) a plurality of elements (201), wherein each element (201) comprises a first microfluidic conduit (202) for carrying a first liquid stream and a second microfluidic conduit (203) for carrying a second liquid stream, the first microfluidic conduit (202) and second microfluidic conduit (203) intersecting at a junction (204) thereby to produce an emulsion product stream from the first liquid stream and the second liquid stream, and a
- 10 microfluidic emulsion product conduit (205) for carrying the emulsion product stream away from the junction (204);
- (b) a non-microfluidic first manifold (301) in fluid communication with the plurality of first microfluidic conduits(202); and
- (c) a non-microfluidic second manifold (302) in fluid communication with the
- 15 plurality of second microfluidic conduits (203);

wherein the non-microfluidic first manifold (301) and the non-microfluidic second manifold (302) are in fluid communication with respectively a first closeable manifold drain (304) and a second closeable manifold drain (305).

20 2. An apparatus for manufacturing an emulsion product according to claim 1 additionally comprising a first recycling conduit providing fluid communication with the closeable first manifold drain (301) and the non-microfluidic first manifold (301), and a second recycling conduit providing fluid communication with the closeable second manifold drain (305) and the non-microfluidic second manifold

25 (302).

3. An apparatus for manufacturing an emulsion product according to claim 1 or claim 2 wherein the non-microfluidic first manifold (301) has a smallest dimension which is at least five times greater than an at least one dimension of the first microfluidic

30 conduit (202) and the non-microfluidic second manifold (302) has a smallest dimension which is at least five times greater than an at least one dimension of the second microfluidic conduit (203).

4. A method for manufacturing an emulsion product, the method comprising the steps of:

35

- (a) providing an apparatus according to any one of the preceding claims; then

(b) passing the first liquid stream along the non-microfluidic first manifold (301) and through the closeable first manifold drain (304) at a first pressure thereby to fill the first manifold (301) with the first liquid stream and then closing the closeable first manifold drain (304); and either simultaneously or sequentially

passing the second liquid stream along the non-microfluidic second manifold (302) and through the closeable second manifold drain (305) at a second pressure thereby to fill the second manifold (302) with the second liquid stream and then closing the closeable second manifold drain (305); and then

(c) passing the first liquid stream along the first microfluidic conduit (202) at a third pressure thereby to fill the first microfluidic conduit (202) with the first liquid stream; and either simultaneously or sequentially

passing the second liquid stream along the second microfluidic conduit (203) at a fourth pressure thereby to fill the second microfluidic conduit (203) with the second liquid stream;

wherein the first liquid stream is at least partially immiscible in the second liquid stream;

wherein the first pressure is lower than the third pressure; and

wherein the second pressure is lower than the fourth pressure.

5. A method for manufacturing an emulsion product, the method comprising the steps of:

(d) providing an apparatus according to any one of claims 1 to 3; then

(e) passing the first liquid stream along the non-microfluidic first manifold (301) and through the first closeable manifold drain (304) and along the first microfluidic conduit (202) at a fifth pressure thereby to fill the first manifold (301) and the first microfluidic conduit (202); and either simultaneously or sequentially

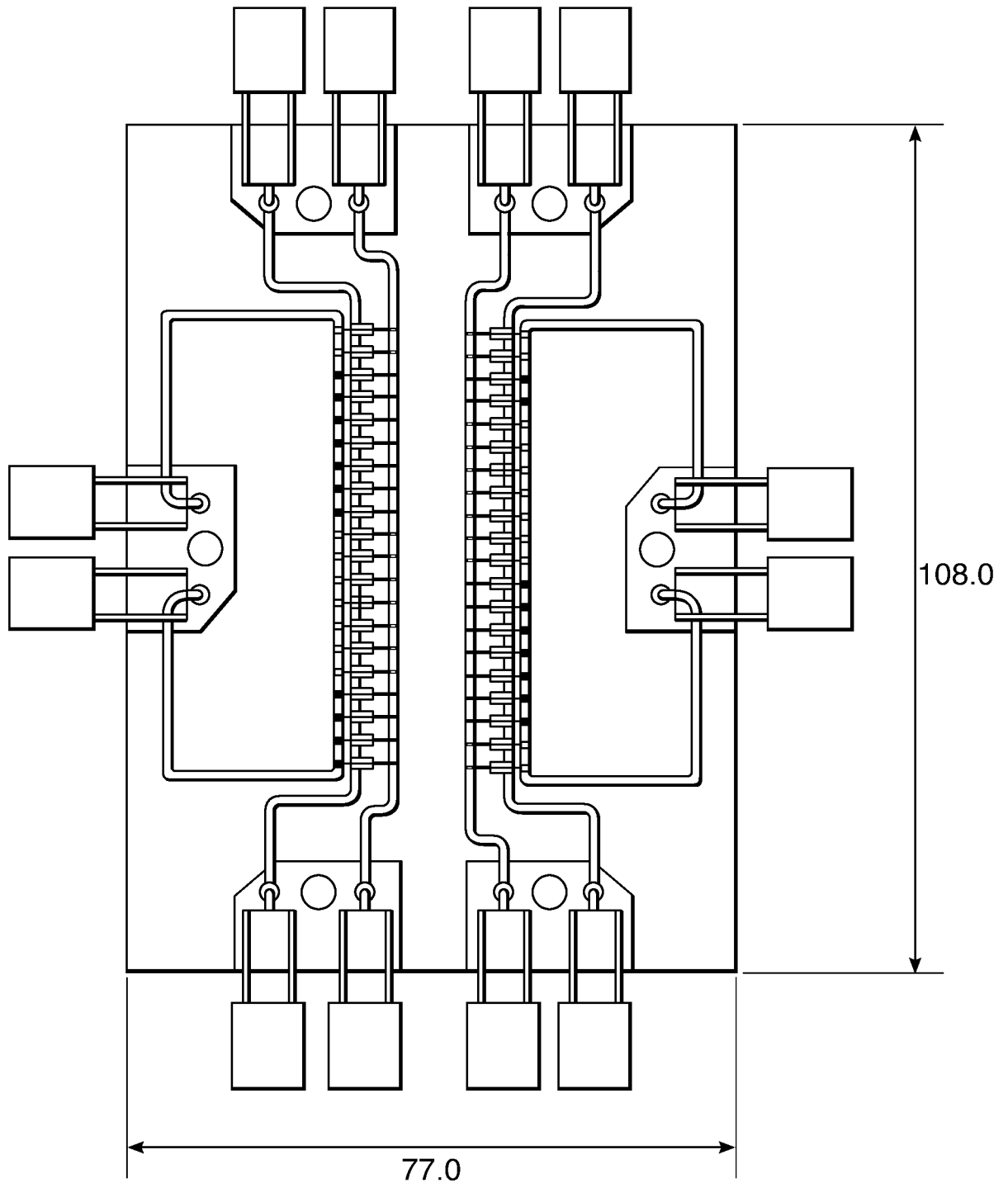
passing the second liquid stream along the non-microfluidic second manifold (302) and through the closeable second manifold drain (305) and along the second microfluidic conduit (203) at a sixth pressure thereby to fill the second manifold (302) and the second microfluidic conduit (203);

wherein the first liquid stream is at least partially immiscible in the second liquid stream.

6. A method for manufacturing an emulsion product according to claims 5, the method composing the additional steps of recycling the first liquid stream from the closeable first manifold drain (302) to the non-microfluidic first manifold (301), and recycling the second liquid stream from the closeable second manifold drain (305) to the non-microfluidic second manifold (302).
- 5

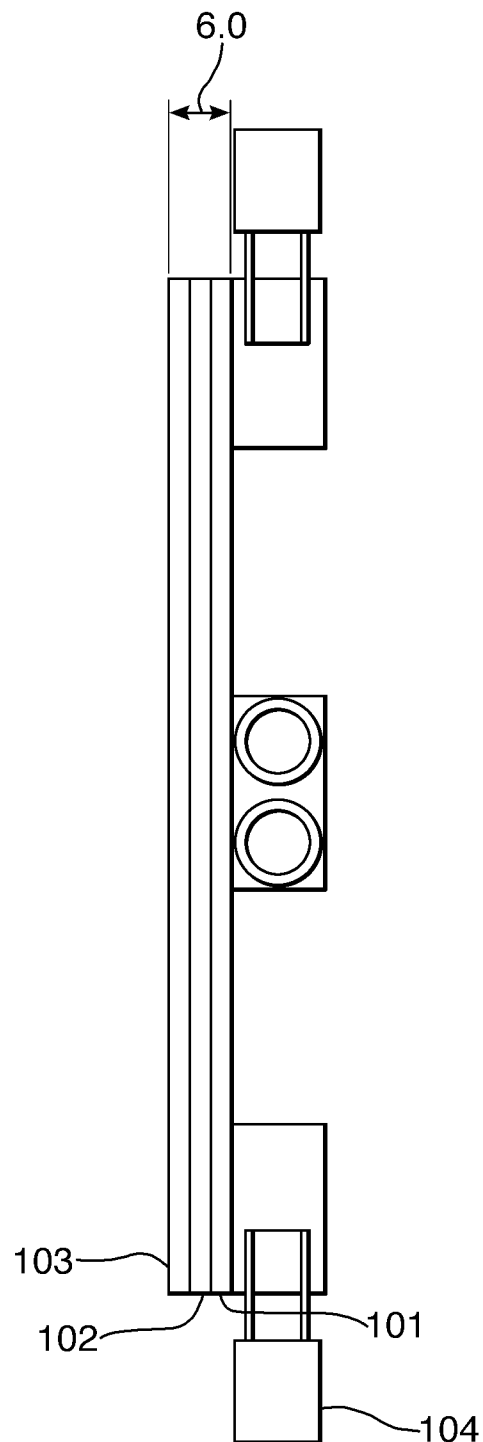
1/4

Fig.1a.



2/4

Fig.1b.



3/4

Fig.2.

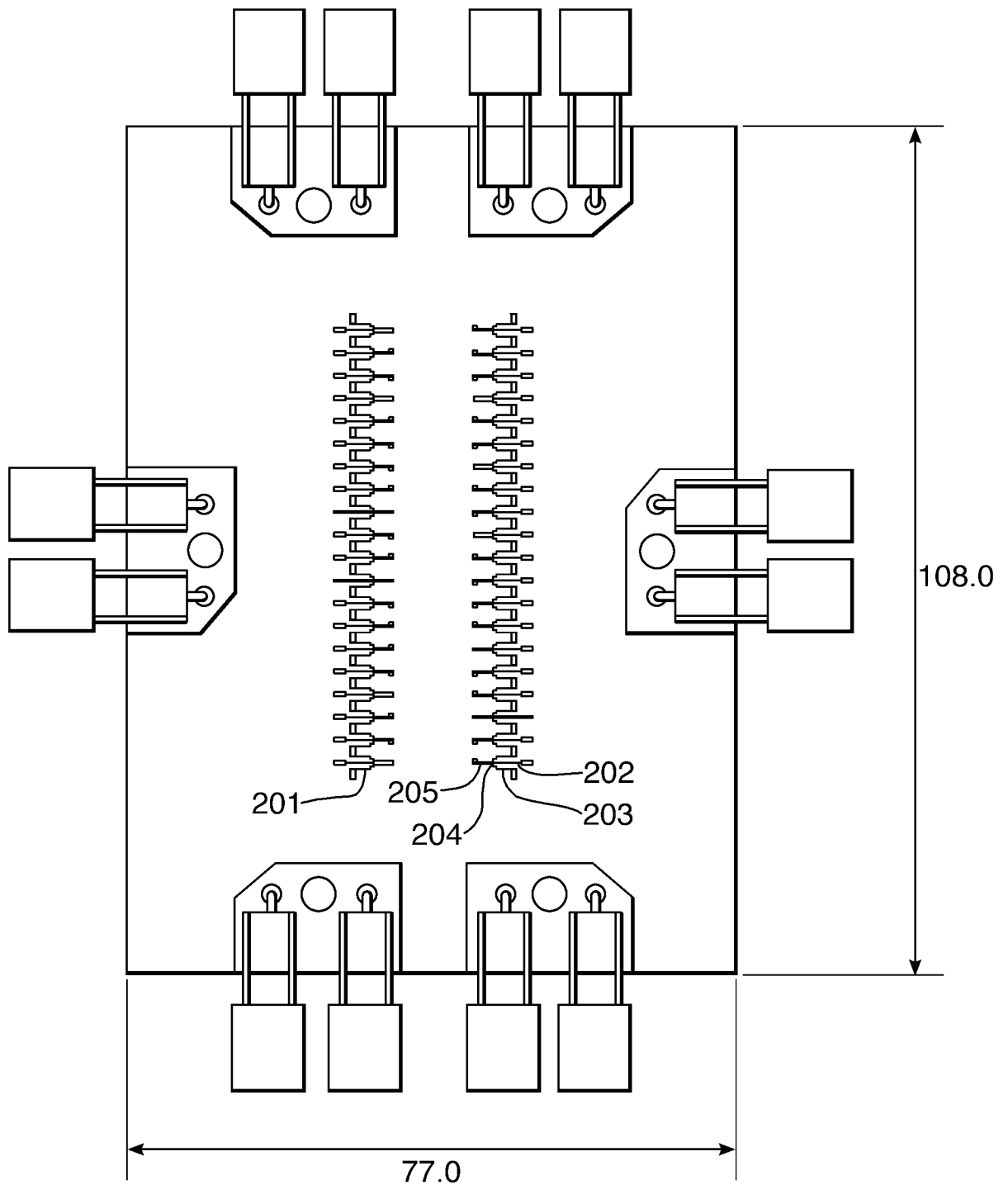
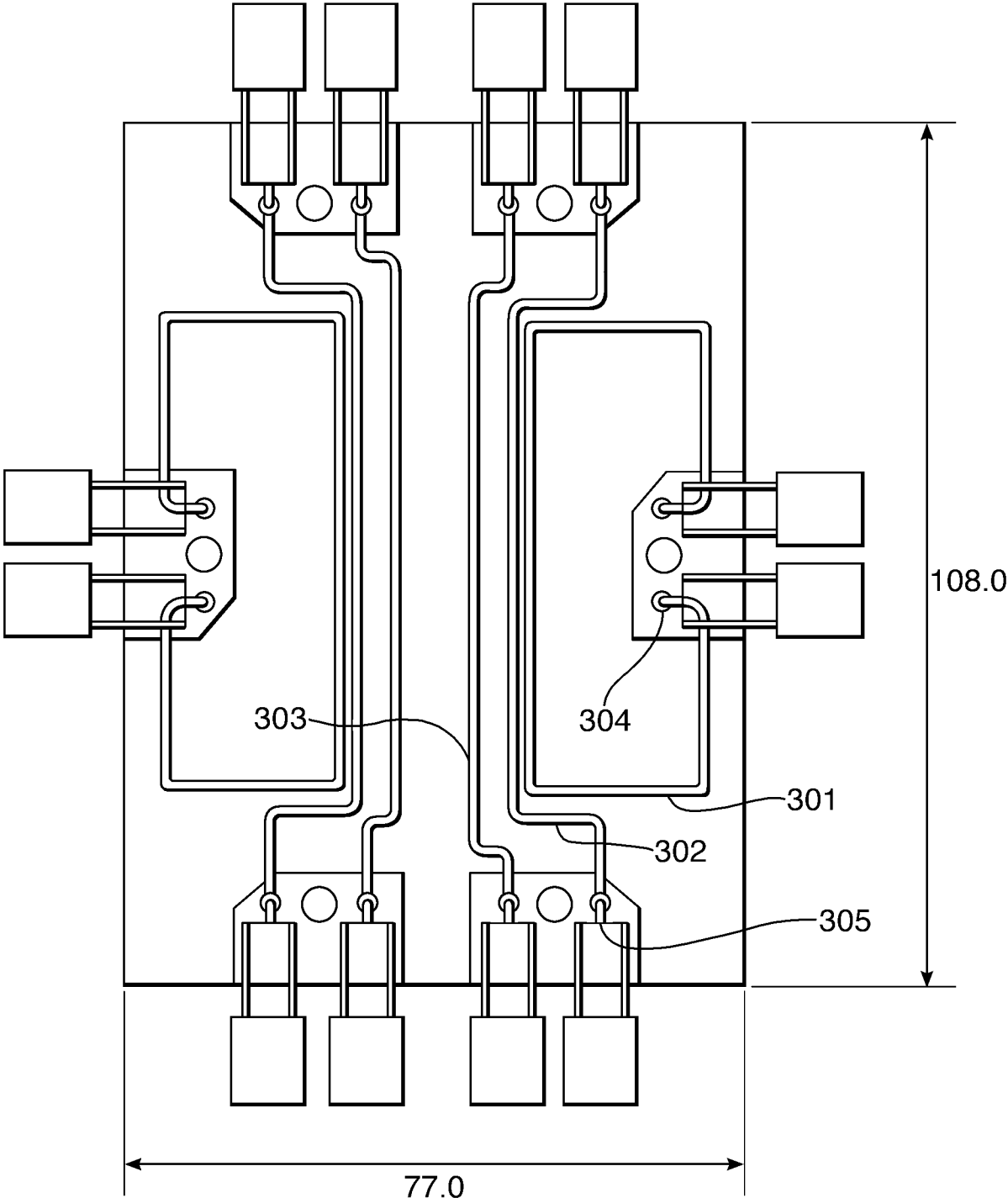


Fig.3.



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/056091

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01F3/08 B01F13/00 B01F13/10 B01F15/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 810 746 A (RICOH KK [JP]) 25 July 2007 (2007-07-25) paragraph [0001] - paragraph [0002] paragraph [0013] paragraph [0084] figures 1,3,17 -----	1-6

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

31 August 2009

Date of mailing of the international search report

04/09/2009

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Real Cabrera, Rafael

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/056091

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 1810746	A	25-07-2007	JP	2007216206 A	30-08-2007
			US	2007242560 A1	18-10-2007