(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 098 296 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.09.2009 Bulletin 2009/37

(51) Int Cl.:
B01L 9/06 *(2006.01)*

(21) Application number: **08003329.3**

(22) Date of filing: **25.02.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicants:
- **F. Hoffmann-La Roche AG**
  4070 Basel (CH)
  Designated Contracting States:
  AT BE BG CH CY CZ DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
- **Roche Diagnostics GmbH**
  68305 Mannheim (DE)
  Designated Contracting States:
  DE

(72) Inventor: **Stettler, Ueli**
6330 Cham (CH)

(74) Representative: **Ventocilla, Abraham et al**
Ventocilla Patent AG
Burgstrasse 8
4107 Ettingen (CH)

(54) Sample tube rack, sample tube positioning assembly comprising such a rack, and analyzer comprising such an assembly

(57) A sample tube rack (11) for holding and positioning a plurality of sample tubes (12, 13). The rack (11) comprises an array of receptacles (14) which have a chamber (44) with side walls (18), openings (16) at the upper end, a bottom wall (17) and a length axis (15) and a bottom wall (20). The chambers (44) of the receptacles (14) are adapted for receiving and positioning sample tubes (12, 13) of different diameters. The bottom wall (20) of the rack (11) comprises channels (24) which extend from openings (25) in the bottom wall (20). The channels (24) extend adjacent to side walls (18) and communicate via lateral openings (22) with chambers (44).

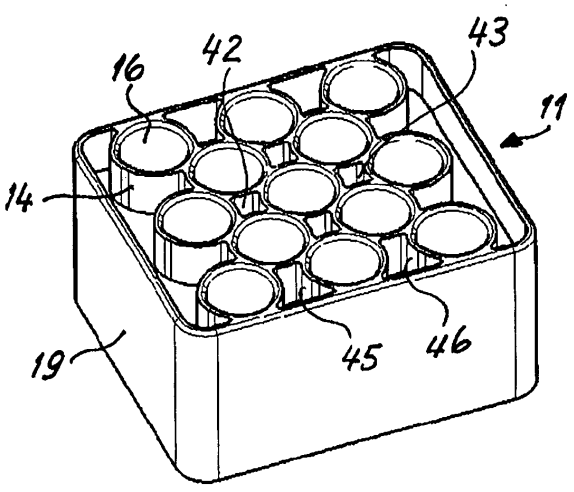

Fig. 1

EP 2 098 296 A1

Description

Field of the invention

[0001] The invention concerns a sample tube rack 11 for holding a plurality of sample tubes 12, 13, the tubes having outer diameters which lie within a predetermined diameter range.

[0002] The invention also concerns a sample tube rack assembly for holding and positioning a plurality of sample tubes, the tubes having outer diameters which lie within a predetermined diameter range.

[0003] The invention further concerns an analyzer for performing medical diagnostic analysis of biological samples, the analyzer including a sample tube rack assembly for holding and positioning a plurality of sample tubes, the tubes having outer diameters which lie within a predetermined diameter range.

Background

[0004] Analyzer systems for performing medical diagnostic analysis of biological samples use sample tubes for receiving the samples to be analyzed. Sample tubes of different sizes are commercially available. There are sample tubes with an outer diameter which lies within a predetermined range, e.g. between 11.5 and 16.5 millimeter.

[0005] There are various known types of sample tube racks which have a plurality of receptacles for holding and positioning tubes.

[0006] In a first type of sample tube rack, the size of each rack receptacle corresponds closely to the specific outer diameter of a sample tube of a particular size. The disadvantage of this first type of rack is that a large number of rack types are needed for holding the sample tubes to be processed in the analyzer system, because the sample tubes received by the system have a plurality of different outer diameters.

[0007] In a second type of sample tube rack, described e.g. in U.S. Patent Specification No. 5,378,433 the size of each rack receptacle is slightly larger than the largest outer diameter of a sample tube to be processed in the analyzer system. Adapter members inserted in the rack receptacles are used for receiving therein sample tubes which have smaller outer diameters. The disadvantage of this solution is on the one hand that adapter members with different inner diameters are required which correspond to the various outer diameters of the sample tubes received by the system, and on the other hand there is the risk of mistakes when selecting the adapter member for a specific sample tube, i.e. an adapter of the wrong size may be inserted by mistake in a receptacle of a rack.

[0008] In a third type of sample tube rack, described e.g. in U.S. Patent Specification No. 5,700,429, the size of each rack receptacle is slightly larger than the largest outer diameter of a sample tube to be processed in the analyzer system and a leaf spring or a flexible tongue attached to the side wall of each receptacle makes it possible that sample tubes having different outer diameters which lie within a certain range can be held and positioned in each rack receptacle. The disadvantages of this third type of rack are that it is on the one hand more expensive, and on the other hand less reliable in holding a sample tube in the desired position due to the flexibility and possible failure of the integrated leaf springs or tongues used.

[0009] A first aim of the present invention is to provide a sample tube rack of the above mentioned kind which makes possible to avoid the above mentioned disadvantages of known sample tube rack types.

[0010] According to a first aspect of the invention the above mentioned first aim is achieved by means of a sample tube rack defined by claim 1 and 14 respectively. Claims 2 to 6 define preferred embodiments of the rack defined by claim 1.

[0011] A second aim of the invention is to provide a sample tube rack assembly which makes possible to avoid the above mentioned disadvantages of known sample tube rack types with regard to the desired accurate and reliable positioning of the sample tubes on a rack.

[0012] According to a second aspect of the invention the above mentioned second aim is achieved by means of a sample tube rack assembly defined by claim 7. Claims 8 to 11 define preferred embodiments of this sample tube rack assembly.

[0013] A third aim of the invention is to provide a medical diagnostic analyzer which advantageously uses a sample tube rack assembly according to the invention.

[0014] According to a third aspect of the invention the above mentioned third aim is achieved by means of an analyzer defined by claim 13.

[0015] The main advantages obtained with a sample tube rack, and with a sample tube rack assembly respectively according to the invention are the following:

i) The number of different rack types needed is substantially reduced.

ii) A single solution is provided for correctly holding and positioning sample tubes having outer diameters which lie within a predetermined diameter range regardless of the specific diameter within this range, wherein correct positioning allows correct automatic pipetting and/or handling.

iii) The positioning function is performed by a tube positioning device which is part of the assembly thus enabling simpler and cheaper manufacturing of the sample rack as well as more robust and reliable positioning of the sample tubes.

Description of the invention

[0016] The present invention refers to a sample tube rack for holding and positioning a plurality of sample tubes, and this rack comprises

a) an array of receptacles having a chamber with side walls, openings at the upper end, a bottom wall and a length axis, adapted for receiving and positioning sample tubes of different diameters, and
b) a bottom wall comprising channels extending from openings in the bottom wall,

wherein the channels extend adjacent to the side walls and communicate via lateral openings with the chambers.

[0017] According to a preferred embodiment, the chambers have approximately a cylindrical shape, the side wall of the chambers having a first portion comprising the lateral opening and a second portion. Both first and second portions might be portions of a cylinder so that cross-sectional area seen from the top through the upper opening looks circular.

[0018] According to a preferred embodiment, the first portion of the side wall is a portion of a cylinder the length axis of which is the length axis of the receptacle, while the second portion of the side wall is a portion of a deformed cylinder comprising a concave or conical section parallel to the length axis of the receptacle and preferably extending from the bottom to the upper end of the receptacle. The concave or conical section has the function to assist and improve the correct positioning and holding of the sample tubes.

[0019] The lateral opening in the side wall of the receptacle is a slit the length axis of which is preferably parallel to the length axis of the receptacle and is preferably located opposite to the concave section comprised within the second portion of the side wall.

[0020] According to a preferred embodiment, the bottom wall of the receptacle has a slit the length axis of which extends in a plane which in a top plan view passes through the center of the first portion of the side wall comprising the lateral opening and the center of the second portion of the side wall comprising the concave section.

[0021] According to a preferred embodiment, the rack has side walls which are part of a frame of approximately rectangular shape and the receptacles are arranged in ordered arrays.

[0022] The present invention also refers to a sample tube rack assembly for holding and positioning a plurality of sample tubes, the assembly comprising

(a) a rack, the rack comprising

- an array of receptacles having a chamber with side walls, openings at the upper end, a bottom wall and a length axis, adapted for receiving and positioning sample tubes of different diameters, and
- a bottom wall comprising channels extending from openings in the bottom wall, wherein the channels extend adjacent to the side walls and communicate via lateral openings with the chambers, and

(b) a tube positioning device which is adapted for cooperating with the rack for positioning sample tubes in the chambers of the receptacles in a well defined position, the tube positioning device comprising a plurality of movable elongated levers, the levers having an upper portion and a lower portion.

[0023] According to a preferred embodiment the sample tube rack assembly further comprises a drive mechanism for imparting to the plurality of levers a first movement, by which movement the upper portion of the levers is introduced through the openings in the bottom wall of the rack, along the channels corresponding to the openings.

[0024] According to a preferred embodiment the drive mechanism is adapted for imparting to the plurality of levers a second movement through the lateral openings adjacent to the channels pushing the tubes against the inner surface of the second portion of the side wall of the respective receptacles, thus bringing the tubes to an upright position at which the length symmetry axis of the tubes is parallel to the length axis of the receptacles.

[0025] According to a preferred embodiment the second movement is an angular displacement of the levers, by which the upper portion of the levers is tilted through the lateral opening of the receptacles and towards sample tubes contained therein.

[0026] According to another embodiment, the second movement is a linear displacement of the levers, by which the upper portion of the levers is linearly displaced through the lateral opening of the receptacles and towards sample tubes contained therein.

[0027] According to another embodiment, the upper portions of the levers are protruding outwards so as to enter into channels when the rack is disposed on the sample tube rack assembly and wherein a drive mechanism is adapted for imparting to the levers a movement, which causes the upper portion of the levers to move through the lateral opening of the receptacles and towards sample tubes contained therein.

[0028] The present invention also refers to an analyzer system for performing medical diagnostic analysis of biological samples, the analyzer including a sample tube rack assembly for holding and positioning a plurality of sample tubes, the analyzer comprising

(a) a sample tube rack assembly according to a preferred embodiment,
(b) automatic pipetting means which comprise transport means for bringing a pipetting tip to a pipetting position which is aligned with the center of a sample tube held by a receptacle of a sample tube rack of the sample tube rack assembly, and
(c) control means for controlling the operation of the pipetting means and the transport means thereof.

[0029] The present invention also provides a sample tube rack for holding a plurality of sample tubes having

at least two different diameters, the rack comprising an array of tube holding elements formed by

- a first plurality of subsets of uniformly spaced pillars, for holding tubes having a first diameter, and
- a second plurality of subsets of uniformly spaced pillars, for holding tubes having a second diameter which is different from the first diameter.

Brief description of the drawings

[0030] The subject invention will now be described in terms of its preferred embodiments with reference to the accompanying drawings. These embodiments are set forth to aid the understanding of the invention, but are not to be construed as limiting.

Fig. 1 shows a perspective view of a first embodiment of a sample tube rack 11 according to the invention.

Fig. 2 shows a perspective upside-down view of the sample tube rack 11 represented in Fig. 1.

Fig. 3 shows a top plan view of the sample tube rack 11 represented in Fig. 1.

Fig. 4 shows a cross-sectional view taken along a plane A-A in Fig. 3.

Fig. 5 shows a cross-sectional view similar to Fig. 4 and shows in addition sample tubes inserted in receptacles of sample tube rack 11 and a gripper 28 used for transporting a sample tube.

Fig. 6 shows a cross-sectional view similar to Fig. 5 and shows gripper 28 in a different position.

Fig. 7 shows a perspective view of a first embodiment of a sample tube rack assembly according to the invention.

Fig. 8 shows a perspective view of the sample tube rack 11 and sample tubes represented in Fig. 7.

Fig. 9 shows a schematic cross-sectional view taken along a vertical plane which passes through the axis of motor 53 in Fig. 7. This figure shows the components of tube positioning device 31 when crank pin 54 is in a first angular position.

Fig. 10 shows a schematic cross-sectional view similar to Fig. 9. This figure shows the components of tube positioning device 31 when crank pin 54 is in a second angular position.

Fig. 11 shows a schematic cross-sectional view similar to Fig. 9. This figure shows the components of tube positioning device 31 when crank pin 54 is in a third angular position.

Fig. 12 shows a top plan view of sample tube rack 11 represented in Fig. 1 and holding sample tubes positioned by the clamping levers 32 of tube positioning device 31 represented in Figures 7 and 9-11.

Fig. 13 shows a perspective view of a sample tube rack assembly similar to the one represented in Fig. 7, but for a larger rack 11a.

Fig. 14 shows a first perspective view of a second embodiment of a sample tube rack 61 according to the invention.

Fig. 15 shows an enlarged view of a portion of Fig. 14.

Fig. 16 shows a portion of a second perspective view of the sample tube rack 61 represented in Fig. 14.

Fig. 17 shows a top plan view of the sample tube rack 61 represented in Fig. 14.

Fig. 18 shows a cross-sectional view taken along a plane B-B in Fig. 17.

Fig. 19 shows a cross-sectional view taken along a plane A-A in Fig. 17.

Fig. 20 shows an enlarged portion of the top plan view represented in Fig. 17.

Fig. 21 shows an enlarged portion of a perspective view of the sample tube rack 61 represented in Fig. 14 and of two sample tubes positioned therein.

Fig. 22 shows a perspective view of sample tube rack 61 represented in Fig. 14 and of two sets of sample tubes of different sizes positioned in this rack.

Fig. 23 shows a top plan view of sample tube rack 61 and sample tubes represented in Fig. 22.

Fig. 24 shows a portion of the top plan view represented in Fig. 23.

Fig. 25 shows a cross-sectional view taken along planes E-E in Fig. 24.

Fig. 26 shows a cross-sectional view similar to Fig. 25 and showing in addition sample tubes in-

serted in receptacles of sample tube rack 11 and a gripper 28 used for transporting a sample tube.

Fig. 27 shows a cross-sectional view similar to Fig. 5 and showing gripper 28 in a different position.

Reference numerals used in drawings

[0031]

11 rack
11a rack
12 tube having a diameter of e.g. 16 millimeter
13 tube having a diameter of e.g. 13 millimeter
14 receptacle
15 length axis of receptacle 14
16 opening at upper end of receptacle 14
17 bottom wall of receptacle 14
18 side wall of receptacle 14
19 frame of rack 11
20 bottom wall of rack 11
21 first portion of side wall 18
22 lateral opening of receptacle 14 / slit
23 second portion of side wall 18
24 channel
25 opening in the bottom wall of rack 11
26 edge
27 slit in the bottom wall 17 of receptacle 14
28 two-hand gripper
29 gripper clamp
30 gripper clamp
31 tube positioning device
32 clamping lever
33 upper portion of lever 32
34 lower portion of lever 32
35 rotation axis of lever 32
41 drive mechanism of tube positioning device
42 space between receptacles 14
43 space between receptacles 14
44 tube receiving chamber of receptacle 14
45 space between receptacles 14
46 space between receptacles 14
48 recess of frame 52
49 clamping unit
50 rotation axis of motor 53
51 frame of tube positioning device 31
52 frame of clamping unit 49
53 motor
54 crank pin
55 guide plate
56 spring
57 stop which is part of frame 52
58 stop which is part of frame 51
59 spring
60 spring
61 sample tube rack
62 frame of rack 61
63 bottom wall of rack 61
71 pillar
72 pillar
73 pillar
74 pillar
75 tube holding element formed by pillars 71-74
81 pillar
82 pillar
83 pillar
84 pillar
85 tube holding element formed by pillars 81-84
91 group of tubes 12
92 group of tubes 13

EXAMPLES

EXAMPLE 1:

FIRST EMBODIMENT OF A SAMPLE TUBE RACK

[0032] Figures 1 to 12 show a rack 11 which is a first embodiment of a sample tube rack according to the invention. Rack 11 is preferably made by injection molding of a suitable plastic material. Rack 11 is in particular suitable for being used with the assembly described hereinafter as Example 2 for accurately positioning sample tubes held by rack 11.

[0033] Figures 1 to 12 show a sample tube rack 11 for holding and positioning a plurality of sample tubes 12, 13 of the type used in medical diagnostic analyzers for performing medical diagnostic analysis of biological samples. Tubes 12, 13 have outer diameters which lie within a predetermined diameter range. As shown by Figures 1-4, rack 11 comprises an array of elongated receptacles 14 that are tube holding elements adapted for holding and positioning sample tubes 12 or 13 having different diameters, and each of those receptacles 14 is adapted for holding a single sample tube 12 or 13. Fig. 8 shows sample tubes 12 or 13 the lower parts of which are inserted in respective receptacles 14 of rack 11.

[0034] Fig. 2 shows a perspective upside-down view of the sample tube rack 11 represented in Fig. 1. Fig. 3 shows a top plan view of the sample tube rack 11 represented in Fig. 1. Fig. 4 shows a cross-sectional view taken along a plane A-A in Fig. 3.

[0035] As shown by the above mentioned Figures 1 to 4, rack 11 comprises an array of elongated receptacles 14. As shown by Figures 1, 3 and 4, there are hollow spaces 42, 43, 45, 46 between the upper portions of neighbor receptacles 14. These hollow spaces are advantageous for the manufacturing of rack 11.

[0036] Receptacle 14 has a chamber 44 adapted for receiving a sample tube. Chamber 44 is dimensioned for receiving a sample tube having an outer diameter which lies within a predetermined diameter range, e.g. a diameter range going from 11.5 to 16.5 millimeter. Chamber 44 has approximately a cylindrical shape, a length axis 15, and an opening 16 at its upper end. The cross-section

of chamber 44 is larger than the largest sample tube outer diameter within a predetermined diameter range.

[0037] Receptacle 14 has a bottom wall 17 and a side wall 18. A first portion 21 of side wall 18 is a portion of a cylinder which has length axis 15 as axis of symmetry. The first portion 21 of side wall 18 has a lateral opening 22 of receptacle 14. The side wall 18 has a second portion 23, the center of which is diametrically opposite to the center of the first portion 21 of side wall 18.

[0038] Rack 11 has a bottom wall 20 and comprises channels 24, which are adjacent to the outer wall of receptacles 14 and extend parallel to the length axis 15 thereof. Channel 24 communicates with the lateral openings 22 of receptacle 14 with an opening 25 in the bottom wall 20 of rack 11.

[0039] In a preferred embodiment of rack 11 and as shown by Fig. 3, the second portion 23 of the side wall 18 of receptacle 14 is a portion of a deformed cylinder. The second portion 23 of side wall 18 has approximately a prismatic shape and comprises a concave section having an edge 26, which is parallel to the length axis 15 of the receptacle 14. Seen in a top plan, edge 26 is located at the center of the second portion 23 of the side wall 18 of the receptacle 14. The concave section of the second portion 23 of side wall 18 helps to hold sample tube 12, 13 in the desired position.

[0040] The second portion 23 of the side wall 18 might be however also cylindrical like the first portion 21 and both portions 21, 23 might have different geometrical shapes including a rectangular shape.

[0041] In a preferred embodiment of rack 11 and as shown by Figures 2 to 4, the bottom wall 17 of each receptacle 14 has a slit 27. The length axis of slit 27 extends in a plane which in a top plan view passes through the center of the first portion 21 of the side wall 18 and the center of the second portion 23 of the side wall 18. Slit 27 is preferably a portion of the opening 25 in the bottom wall 20 of rack 11.

[0042] In a preferred embodiment of rack 11 and as shown by Fig. 4, the lateral opening 22 in the side wall 18 of receptacle 14 is a slit the length axis of which is parallel to the length axis 15 of the receptacle 14. The lower end of slit 22 preferably opens up in opening 25 in the bottom wall 20 of rack 11.

[0043] In a preferred embodiment of rack 11 and as shown by Figures 5 and 6, the length of chamber 44 of receptacle 14 is shorter than the length of the shortest sample tube 13 to be inserted in the rack. The length of such sample tubes lies within a predetermined length range.

[0044] As shown by Figures 1 and 3, a preferred embodiment of rack 11 has side walls which are part of a frame 19 which has approximately a rectangular shape, and the receptacles 14 are arranged within frame 19 in ordered arrays, e.g. in uniformly spaced rows which are parallel to each other, and which in a top plan view extend in a direction which is parallel to a diagonal of frame 19. The receptacles 14 in each of those rows are uniformly spaced from each other.

[0045] Fig. 5 shows a cross-sectional view similar to Fig. 4 and shows in addition sample tubes 13 inserted in receptacles of sample tube rack 11 and a gripper 28 used for transporting one of the sample tubes. Gripper 28 has gripper clamps 29 and 30. Fig. 6 shows a cross-sectional view similar to Fig. 5 and shows gripper 28 in a different position. Gripper 28 is part of an automatically controlled transport system for introducing individual sample tubes into chambers 44 of receptacles 14 and for removing individual sample tubes held in those chambers and bringing them to another position within an analyzer system.

EXAMPLE 2:

FIRST EMBODIMENT OF A SAMPLE TUBE RACK ASSEMBLY

[0046] Figures 7 to 12 show a first embodiment of a sample tube rack assembly according to the invention, i.e. a sample tube rack assembly for holding and positioning a plurality of sample tubes which have outer diameters which lie within a predetermined diameter range.

[0047] As shown by Fig. 7, a sample tube rack assembly according to the invention comprises a rack 11 having the features described above with reference to Figures 1 to 6, a tube positioning device 31 which comprises a plurality of simultaneously movable elongated levers 32, and a drive mechanism 41 for moving the levers 32 of tube positioning device 31.

[0048] The clamping levers 32 of tube positioning device 31 are adapted for cooperating with rack 11 for positioning the lower portion of tubes 12, 13 in chambers 44 of receptacles 14 of rack 11 in a well defined upright position.

[0049] As shown by Figures 9 to 11, tube positioning device 31 comprises a frame 51 and this frame comprises an upper plate having a portion adapted for receiving a rack 11.

[0050] As shown by Figures 9 to 11, drive mechanism 41 comprises a clamping unit 49 and a motor 53 which rotates a crank pin 54 along a circular path.

[0051] Clamping unit 49 comprises a frame 52 and this frame is arranged within the frame 51 of tube positioning device 31. Crank pin 54 is inserted in a recess 48 of frame 52. Frame 52 of clamping unit 49 is movable in vertical direction, relative to frame 51, by rotating crank pin 54 by means of a motor 53.

[0052] Clamping unit 49 further comprises a guide plate 55 which is arranged within frame 52 and which as shown by Fig. 9 is held in position by springs 56 and 59 which press guide plate 55 against stops 57 of frame 52 when crank pin 54 is in the positions shown in Figures 9 and 10.

[0053] As shown in Figures 9 to 11, frame 51 has stops 58 which stop the movement of guide plate 55 as the frame 52 of clamping unit 49 is moved upwards by rota-

tion of crank pin 54.

[0054] The above mentioned plurality of clamping levers 32 are mounted on frame 52 of clamping unit 49. Each of clamping levers 32 has an upper portion 33 and a lower portion 34 and is rotatably mounted on frame 52. Clamping levers 32 are rotatable about an axis of rotation 35.

[0055] Drive mechanism 41 is adapted for simultaneously moving the plurality of clamping levers 32 and thereby introducing the upper portion 33 of the levers 32 through the openings 25 in the bottom wall 20 of the rack 11, along channels 24 corresponding to those openings 25, and through lateral openings 22 which are adjacent to those channels 24. The upper portion 33 of levers 32 thereby pushes the tube 12,13 against the inner surface of the second portion 23 of the side wall of the respective receptacle 14 and brings tubes 12, 13 to an upright position at which the length symmetry axis of tubes 12, 13 is parallel to the length axis 15 of receptacle 14.

[0056] In a preferred embodiment of the above described sample tube rack assembly, drive mechanism 41 is adapted for imparting to each of the levers 32 a first movement along one of the channels 24, and a second movement which follows the first movement and which causes an angular displacement of each lever 32, and thereby moves the upper portion 33 of lever 32 thorough the lateral opening 22 of the receptacles 14 and towards sample tube 12, 13 contained therein.

[0057] In an alternative embodiment (not shown) the second movement might be a linear displacement of lever 32 caused e.g. by an horizontal linear displacement of frame 52. According to another embodiment (not shown) the upper portions 33 of the levers 32 are protruding out of frame 51 so as to enter into the channels 24 already at the time when the sample rack 11 is disposed onto frame 51. Therefore the drive mechanism 41 needs to be adapted to conduct only one movement.

[0058] Fig. 8 shows a perspective view of the sample tube rack 11 and sample tubes 12, 13 represented in Fig. 7.

[0059] In Figures 7 and 8 the sample tubes 12, 13 are represented in their upright positions achieved by the operation of tube positioning device 31.

[0060] Figures 9 to 11 illustrate the operation of the tube positioning device 31 shown in Fig. 7.

[0061] The operation of tube positioning device 31 is as follows:

Fig. 9 shows the initial position of frame 52 of clamping unit 49, the corresponding angular position of crank pin 54 and the initial position of guide plate 55. In these positions of frame 52 and guide plate 55 levers 32 are held in vertical position, each lever 32 being aligned with one of the channels 24 of rack 11, while springs 60 press the lower portion 34 of levers 32 against guide plate 55.

[0062] A first rotation step of motor 53 and of crank pin 54 brings crank pin to the angular position shown by Fig. 10 and thereby moves frame 52 upwards up to the position shown by Fig. 10. At this position guide plate 55 just contacts stops 58 of frame 51 and the levers 32 are still in vertical position. It should be noted that the upward movement of frame 52 just mentioned introduces levers 32 in corresponding channels 24 of rack 11.

[0063] A further rotation step of motor 53 and of crank pin 54 brings crank pin 54 to the angular position shown by Fig. 11 and thereby moves frame 52 further upwards up to the position shown by Fig. 11. During this latter movement of frame 52, the stops 58 of frame 51 press guide plate 55 downwards and springs 60 press the corresponding lower portion 34 of levers 32 against guide plate 55 and thereby cause an angular movement of each lever 32 about its rotation axis. This angular movement of levers 32 introduces the upper portion 33 of levers 32 through lateral openings 22 of receptacles 14 of rack 11 and thereby the upper portions 33 of levers 32 press the lower portion of tubes 12, 13 inserted in a receptacle 14 against the side wall portion 23 which has the section 26 and which lies in front of lateral opening 22. Section 26 and slit 27 of chamber 44 contribute to the positioning of a sample tube 12 or 13 in the above mentioned upright position as the tube is pressed by the upper portion of a lever 32 against side wall portion 23. The result of this operation is that tubes 12, 13 inserted in receptacles 14 of rack 11 are held there in a well defined upright position. These positions of the tubes 12 respectively 13 are represented in Figures 7, 8, 11 and 12.

[0064] As can be appreciated in particular from Fig. 12, the coordinates Xt, Yt of the center of the cross-section of each of the tubes 12 or 13 held by rack 11 and positioned therein by the above described tube positioning operation can be calculated taking into account the coordinates Xr, Yr of the center of the cross-section of the receptacle 14 where the tube 12 or 13 is inserted, the diameter of the chamber 44 of that receptacle and the diameter of the tube 12 or 13. Since the center of the cross-section of each of the tubes 12 or 13 held by rack 11 defines a desired pipetting position, i.e. the position of a pipetting tip for performing a pipetting operation, calculation of the coordinates Xt, Yt of the center of the cross-section of each of the tubes 12 or 13 provides the coordinates of the corresponding pipetting position.

EXAMPLE 3:

SECOND EMBODIMENT OF A SAMPLE TUBE RACK ASSEMBLY

[0065] Figure 13 shows a second embodiment of a sample tube rack assembly according to the invention. This assembly is similar to the one represented in Fig. 7, but comprises a rectangular rack 11a which is larger than rack 11 shown by Figures 1-6. Rack comprises a higher number of receptacles 14, but the array of receptacles 14 of rack 11a has the same or similar basic struc-

ture as the array of receptacles 14 of rack 11.

[0066] As shown by Figure 13, the rack assembly represented therein includes a tube positioning device 31 and a drive mechanism 41 which have similar structure and operation as the tube positioning device 31 and a drive mechanism 41 described above with reference to Figures 9-12.

Example 4:

EMBODIMENT OF AN ANALYZER COMPRISING A RACK ACCORDING TO THE INVENTION

[0067] A sample tube rack 11 having the features described above with reference to Figures 1 to 6 and a sample tube rack assembly having the features described above with reference to Figures 7 to 13 are preferably used as components of an analyzer system for performing medical diagnostic analysis of biological samples. Such an analyzer system comprises:

(a) a sample tube rack assembly of the above described kind for holding and positioning a plurality of sample tubes which have outer diameters which lie within a predetermined diameter range,
(b) automatic pipetting means which comprise transport means for bringing a pipetting tip to a pipetting position which is aligned with the center of a sample tube 12 or 13 held by a receptacle 14 of a sample tube rack 11 of the sample tube rack assembly, and
(c) control means for controlling the operation of the pipetting means and the transport means thereof.

[0068] The control means comprise storage means for storing data corresponding to:

- the position of the center of each receptacle 14 of rack 11,
- the diameter of the chamber 44 of the receptacle 14,
- the diameter of each sample tube 12 or 13 carried by the sample tube rack 11, and
- means for processing the above mentioned data for calculating the coordinates of the pipetting position.

[0069] The coordinates of the pipetting position are calculated e.g. as described above in the description of Example 2.

EXAMPLE 5:

SECOND EMBODIMENT OF A SAMPLE TUBE RACK

[0070] Figures 14 to 27 show a rack 61 which is a second embodiment of a sample tube rack according to the invention. Rack 61 is preferably made by injection molding of a suitable plastic material. Rack 61 is in particular suitable for the storage of sample tubes having two different specific diameters. Particular advantages of rack 61 are that it holds and positions the sample tubes by itself in a well defined upright position, i.e. without need of any auxiliary means, and that it does not include any flexible or deformable parts whose performance becomes less reliable due e.g. to aging of the rack material.

[0071] Figures 14 to 27 show a sample tube rack 61 for holding and positioning a plurality of sample tubes 12, 13 of the type used in medical diagnostic analyzers for performing medical diagnostic analysis of biological samples. Tubes 12, 13 have different specific outer diameters which lie within a predetermined diameter range. Rack 61 comprises an array of tube holding elements 75, 85 and that array includes tube holding elements adapted for holding and positioning sample tubes 13 respectively 12 having different specific diameters. Tube holding elements 75 are adapted for holding a single sample tube 13 of a first diameter, and tube holding elements 85 are adapted for holding a single sample tube 12 of a second diameter.

[0072] As shown in particular by Figures 17 to 20, tube holding elements 75 are formed by a subset 71-74 of an array of rigid pillars, and tube holding elements 85 are formed by a subset 81-84 of an array of rigid pillars.

[0073] The pillars of rack 61 are rigid and have preferably the same shape and dimensions. These pillars have approximately a rectangular cross-section which has a first side which is longer than and perpendicular to a second side, and the rectangular cross-section of the pillars has a symmetry axis which is parallel to the first side of the cross-section of the pillar. In another preferred embodiment the cross-section of the pillar has however a different shape, and is e.g. circular.

[0074] As shown in particular by Figures 17, 20 and 23, the pillars of rack 61 are arranged in uniformly spaced rows which are parallel to each other, and which in a top plan view extend in a direction which forms an angle of 45 degrees with the symmetry axis of the cross-section of any of the pillars, the symmetry axis of neighbor pillars in the same row forming an angle of 90 degrees.

[0075] As shown in particular by Figures 14, 17 and 20 to 23, sample tube rack 61 has side walls which are part of a frame 62 of approximately rectangular shape and the above mentioned rows of pillars are arranged within frame 62,
wherein each of the rows extends in a top plan view in a direction which is parallel to a diagonal of frame 62.

[0076] As shown in particular by Figures 17 to 21, sample tube rack 61 comprises
a first plurality of subsets of pillars, like subset of pillars 71, 72, 73, 74, and each subset of the first plurality of subsets defines a first tube holding element 75 for holding a single tube 13 having a first diameter, and
a second plurality of subsets of pillars, like subset of pillars 81, 82, 83, 84, and each subset of the second plurality of subsets defines a second tube holding element 85 for holding a tube 12 having a second diameter.

[0077] Tube holding element 75 is suitable for holding tubes 13 having a diameter of e.g. 13 millimeter, whereas

tube holding element 85 is suitable for holding tubes 12 having a diameter of e.g. 16 millimeter. Rack 61 is thus suitable for holding sample tubes having two different specific diameters, e.g. 13 millimeter and 16 millimeter.

[0078] As shown by Figures 22-25 rack 61 can hold a first group 91 of tubes 12 having a first diameter, e.g. 16 millimeter, and a second group 92 of tubes 13 having a second diameter, e.g. 13 millimeter. Rack 61 can of course hold sample tubes having all the same diameter. For instance tubes 13 held by tube holding elements 75 or tubes 12 held by tube holding elements 85.

[0079] Fig. 26 shows a cross-sectional view similar to Fig. 25 and shows in addition sample tubes 13 inserted in tube holding elements 75 of sample tube rack 61 and a gripper 28 used for transporting one of the sample tubes. Gripper 28 has gripper clamps 29 and 30.

[0080] Fig. 27 shows a cross-sectional view similar to Fig. 26 and shows gripper 28 in a different position. Gripper 28 is part of an automatically controlled transport system for introducing individual sample tubes into tube holding elements 75 respectively 85 of sample tube rack 61, and for removing individual sample tubes held in those tube holding elements and bringing them to another position within an analyzer system.

Claims

1. A sample tube rack (11) for holding and positioning a plurality of sample tubes (12, 13), said rack (11) comprising

   a) an array of receptacles (14)having a chamber (44) with side walls (18), openings (16) at the upper end, a bottom wall (17) and a length axis (15), adapted for receiving and positioning sample tubes (12, 13) of different diameters, and
   b) a bottom wall (20) comprising channels (24) extending from openings (25) in said bottom wall (20),

   wherein said channels (24) extend adjacent to side walls (18) and communicate via lateral openings (22) with chambers (44).

2. A sample tube rack according to claim 1 wherein said chamber (44) has approximately a cylindrical shape,
   the side wall (18) of said chamber (44) having a first portion (21) comprising the lateral opening (22) of the receptacle (14) and a second portion (23).

3. A sample tube rack according to claim 2 wherein the first portion (21) of the side wall (18) is a portion of a cylinder with length axis (15),
   and wherein the second portion (23) of the side wall (18) is a portion of a deformed cylinder comprising a concave section (26) parallel to the length axis (15) of the receptacle (14).

4. A sample tube rack according to claim 2 or 3, wherein said bottom wall (17) of receptacle (14) has a slit (27) the length axis of which extends in a plane which in a top plan view passes through the center of said first portion (21) of the side wall (18) comprising the lateral opening (22) and the center of said second portion (23) of the side wall (18) comprising the concave section (26).

5. A sample tube rack according to any of the preceding claims, wherein said lateral opening (22) in the side wall (18) of receptacle (14) is a slit the length axis of which is parallel to the length axis (15) of the receptacle (14).

6. A sample tube rack according to any of the preceding claims, wherein said rack has side walls which are part of a frame (19) of approximately rectangular shape and said receptacles (14) are arranged in ordered arrays.

7. A sample tube rack assembly for holding and positioning a plurality of sample tubes (12, 13), said assembly comprising

   (a) a rack (11), said rack (11) comprising

   - an array of receptacles (14)having a chamber (44) with side walls (18), openings (16) at the upper end, a bottom wall (17) and a length axis (15), adapted for receiving and positioning sample tubes (12, 13) of different diameters, and
   - a bottom wall (20) comprising channels (24) extending from openings (25) in said bottom wall (20), wherein said channels (24) extend adjacent to side walls (18) and communicate via lateral openings (22) with chambers (44), and

   (b) a tube positioning device (31) which is adapted for cooperating with said rack (11) for positioning tubes (12, 13) in chambers (44) of said receptacles (14) in a well defined position,

   said tube positioning device (31, 41) comprising a plurality of movable elongated levers (32), said levers having an upper portion (33) and a lower portion (34).

8. A sample tube rack assembly according to claim 7 further comprising a drive mechanism (41) for imparting to said plurality of levers (32) a first movement, by which movement the upper portion (33) of said levers (32) is introduced through said openings (25) in the bottom wall (20) of said rack (11), along

channels (24) corresponding to openings (25).

9. A sample tube rack assembly according to claim 8 wherein said drive mechanism (41) is adapted for imparting to said plurality of levers (32) a second movement through the lateral openings (22) adjacent to channels (24) pushing tubes (12, 13) against the inner surface of said second portion (23) of the side wall (18) of the respective receptacles (14), thus bringing tubes (12, 13) to an upright position at which the length symmetry axis of the tube (12, 13) is parallel to the length axis (15) of the receptacle 14.

10. A sample tube rack assembly according to claim 9, wherein said second movement is an angular displacement of said levers (32), by which the upper portion (33) of said levers (32) is tilted through the lateral opening (22) of said receptacles (14) and towards sample tubes (12, 13) contained therein.

11. A sample tube rack assembly according to claim 9, wherein said second movement is a linear displacement of said levers (32), by which the upper portion (33) of said levers (32) is displaced through the lateral opening (22) of said receptacles (14) and towards sample tubes (12, 13) contained therein.

12. A sample tube rack assembly according to claim 7, wherein the upper portions (33) of said levers (32) are protruding outwards so as to enter into channels (24) when rack (11) is disposed on the sample tube rack assembly and
wherein a drive mechanism (41) is adapted for imparting to said levers (32) a movement, which causes the upper portion (33) of said levers (32) to move through the lateral opening (22) of said receptacles (14) and towards sample tubes (12, 13) contained therein.

13. An analyzer system for performing medical diagnostic analysis of biological samples, said analyzer including a sample tube rack assembly for holding and positioning a plurality of sample tubes, said analyzer comprising

(a) a sample tube rack assembly according to any of claims 7 to 12,
(b) automatic pipetting means which comprise transport means for bringing a pipetting tip to a pipetting position which is aligned with the center of a sample tube (12, 13) held by a receptacle (14) of a sample tube rack (11) of said sample tube rack assembly, and
(c) control means for controlling the operation of said pipetting means and said transport means thereof.

14. A sample tube rack (61) for holding a plurality of sample tubes (12, 13) having at least two different diameters, said rack (61) comprising
an array of tube holding elements (75, 85) formed by

- a first plurality of subsets (71, 72, 73, 74) of uniformly spaced pillars, for holding tubes (13) having a first diameter, and
- a second plurality of subsets (81, 82, 83, 84) of uniformly spaced pillars, for holding tubes (12) having a second diameter which is different from said first diameter.

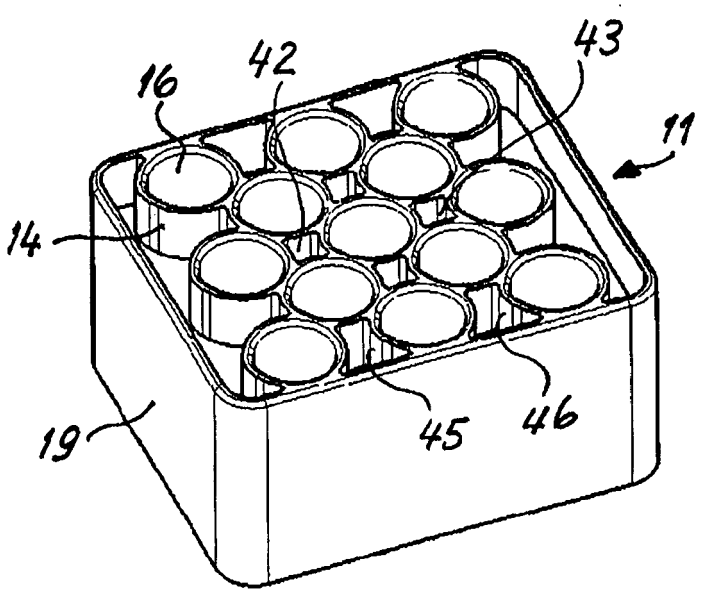

Fig. 1

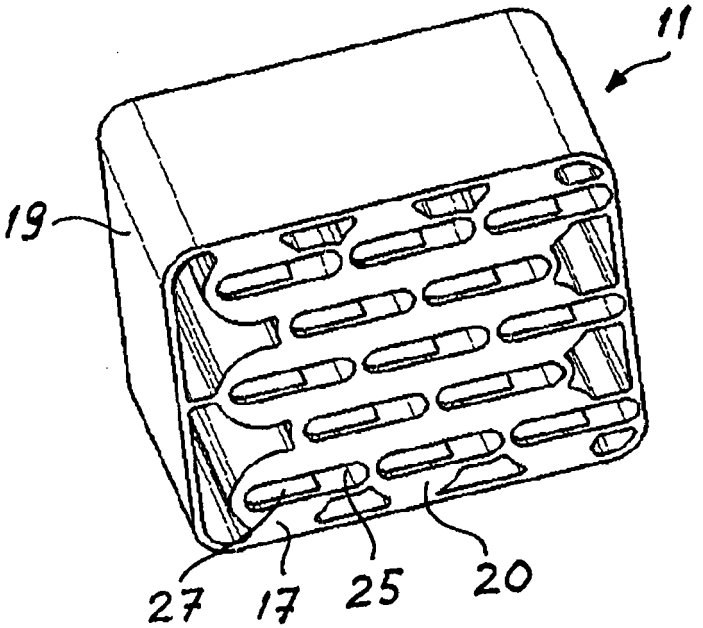

Fig. 2

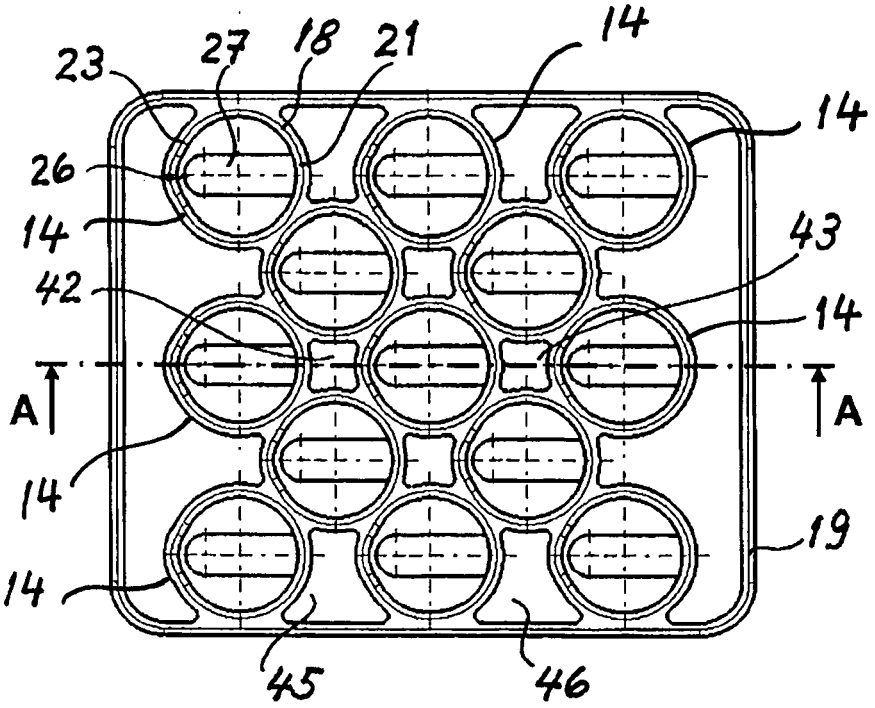
23
27
18
21
14
14
26
14
43
42
14
A
A
14
19
14
45
46

Fig. 3

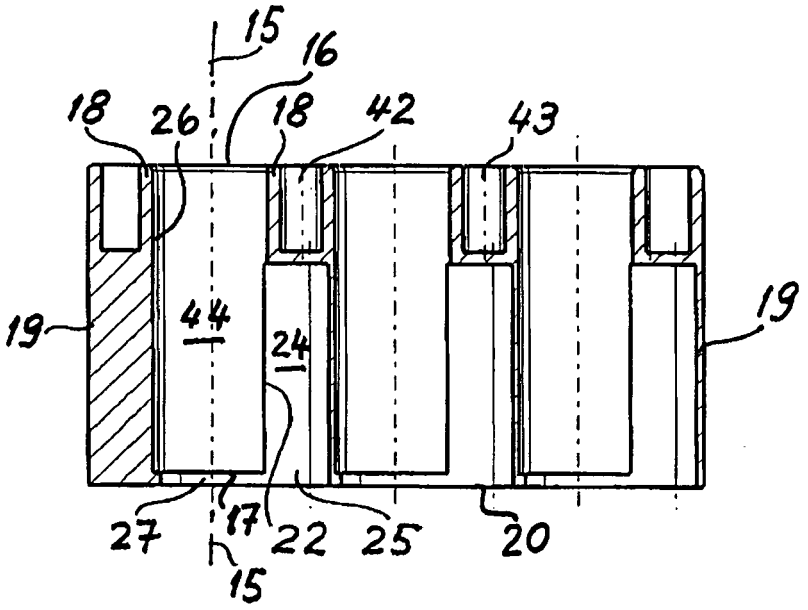
15
16
18
26
18
42
43
19
44
24
19
27
17
22
25
20
15

Fig. 4

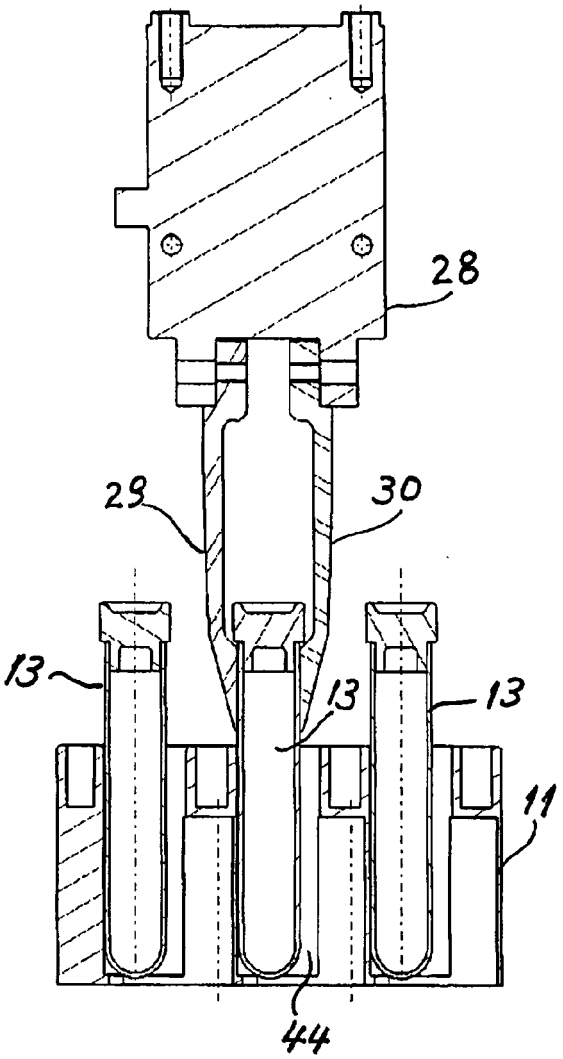

Fig. 5

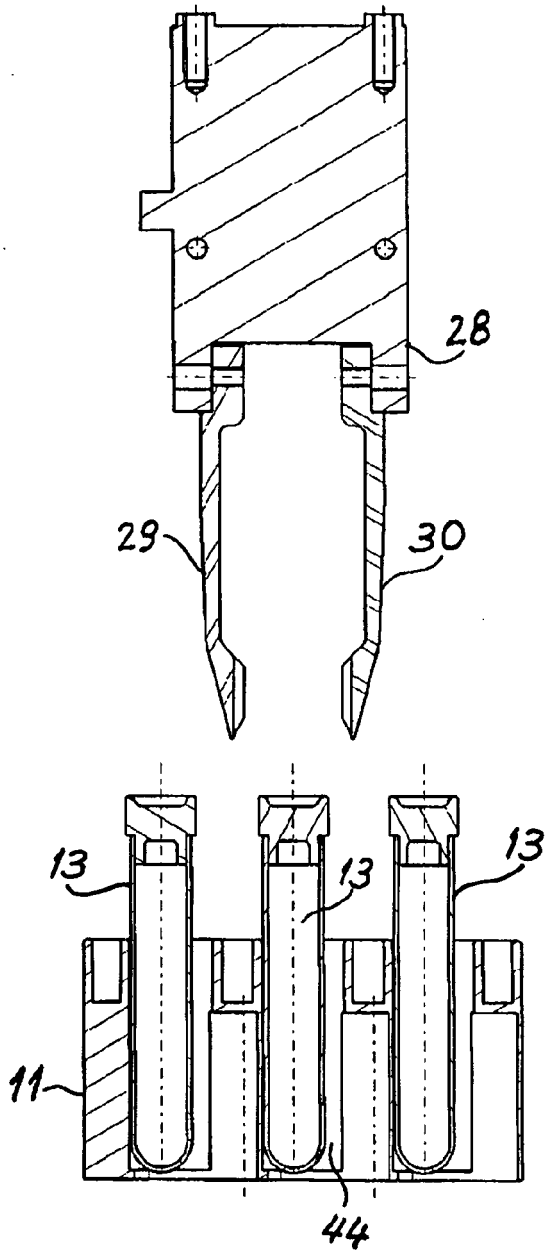

Fig. 6

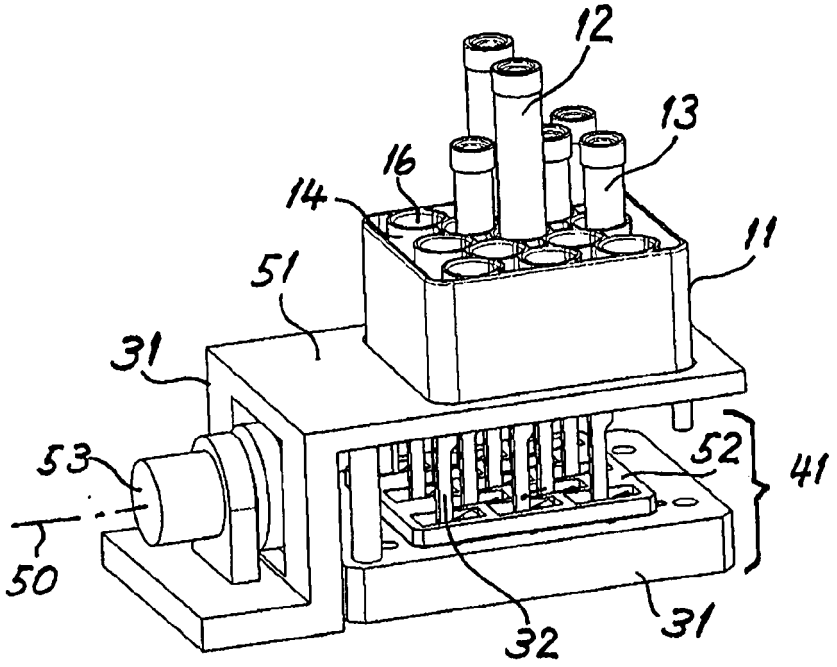

Fig. 7

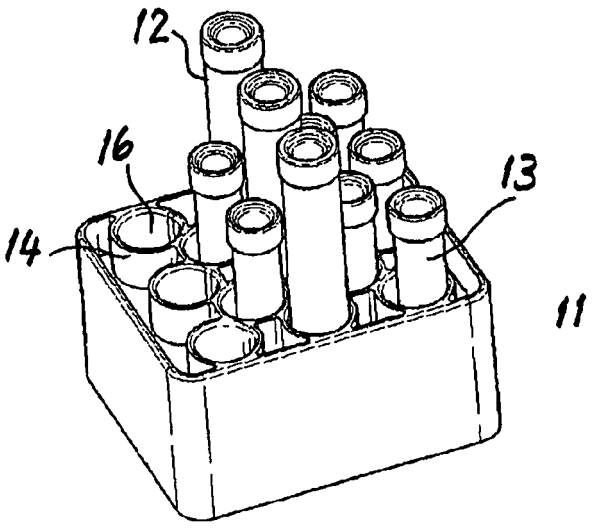

Fig. 8

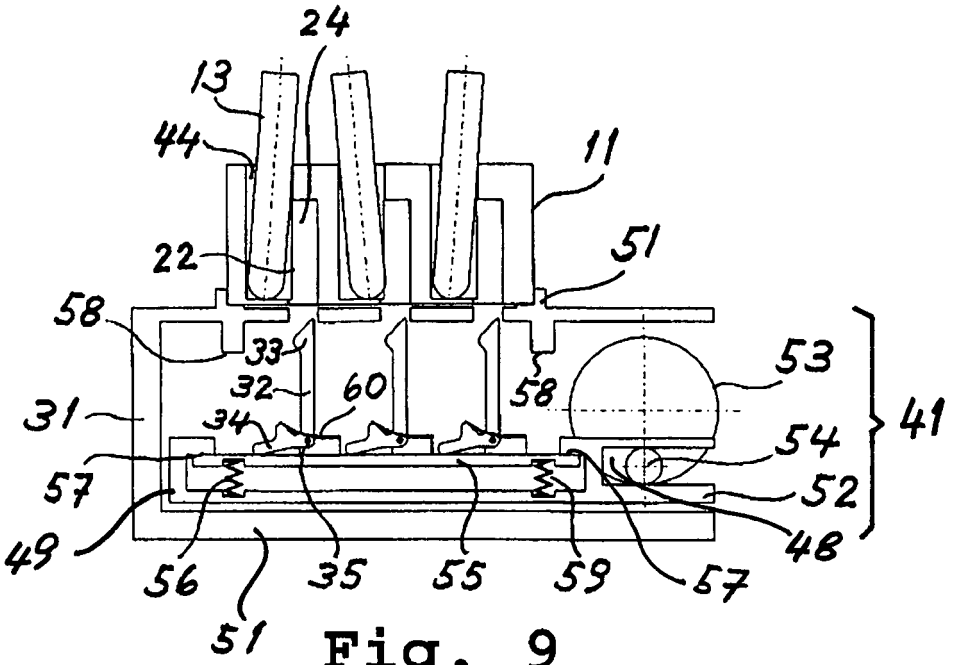
24
13
44
11
22
51
58
33
58
53
32
60
31
34
54
41
57
52
49
48
56
35
55
59
57
51

Fig. 9

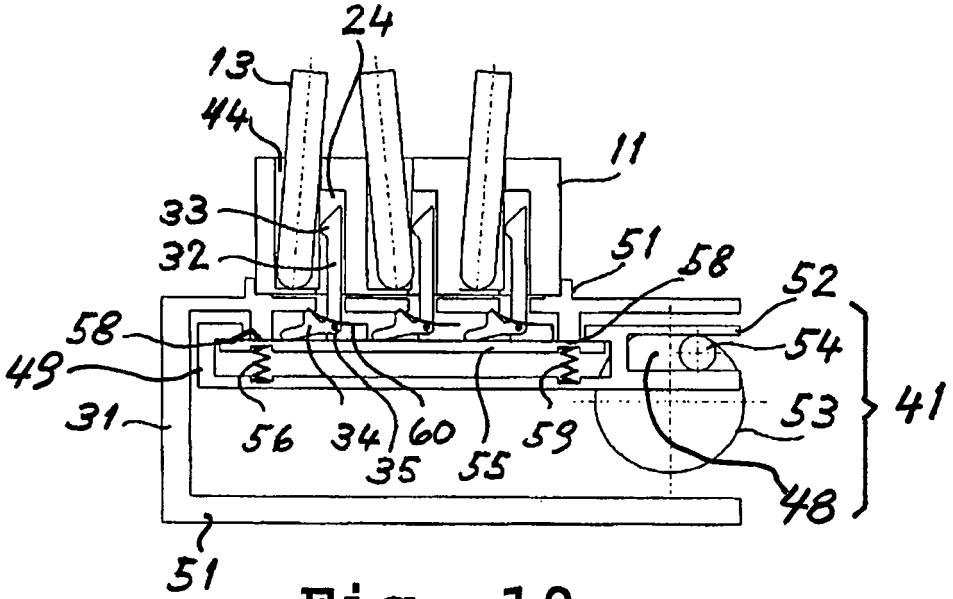
24
13
44
11
33
32
51
58
52
58
54
49
53
41
31
56
34
60
59
35
55
48
51

Fig. 10

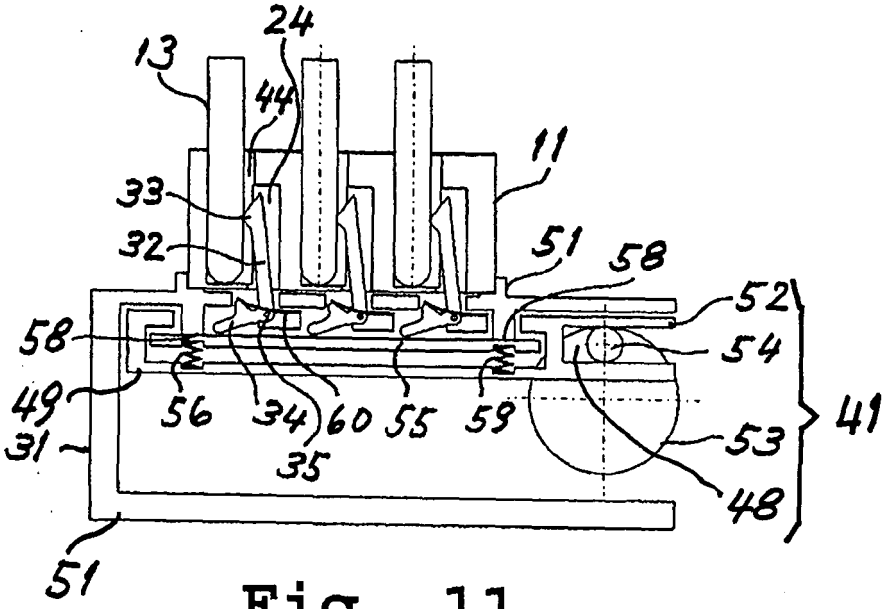
24
13
44
11
33
32
51
58
52
58
54
49
56
34
60
55
59
41
31
53
35
48
51

Fig. 11

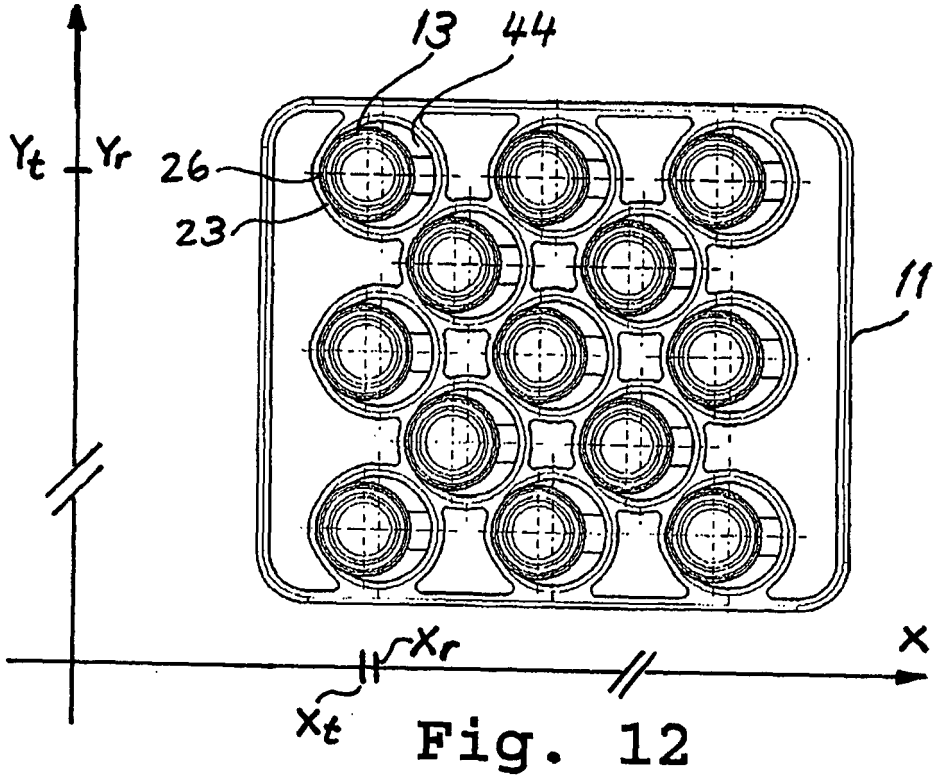
13
44
Yt
Yr
26
23
11
Xr
X
Xt

Fig. 12

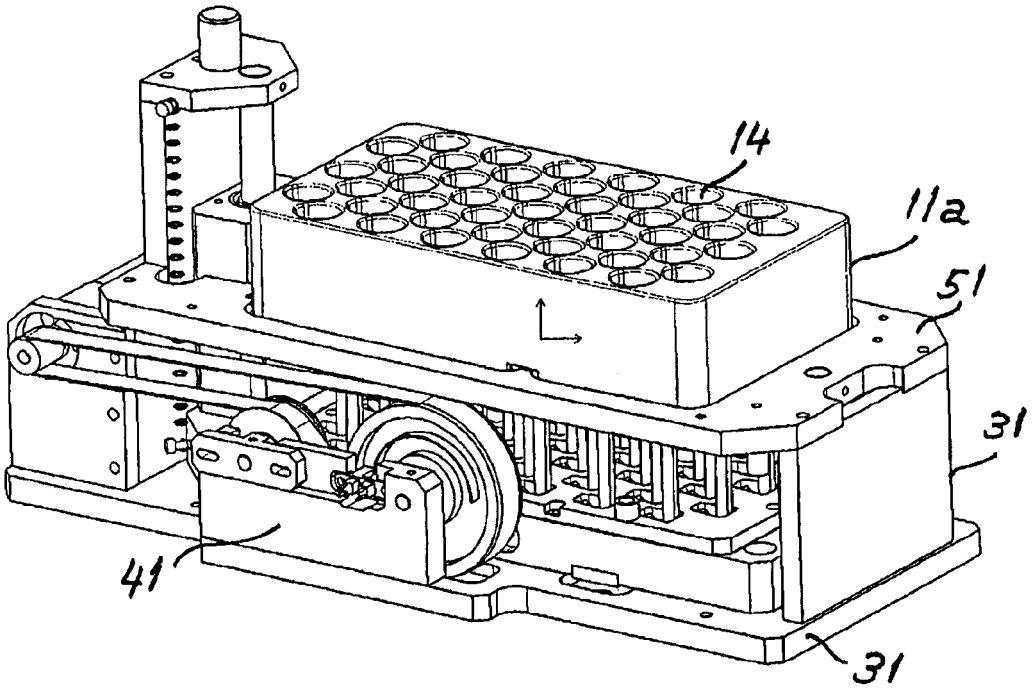

Fig. 13

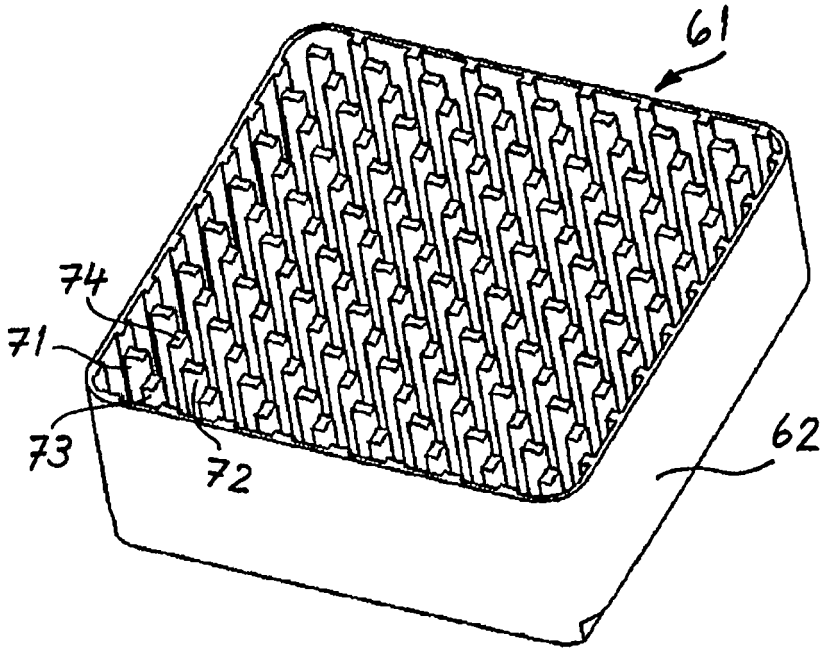

Fig. 14

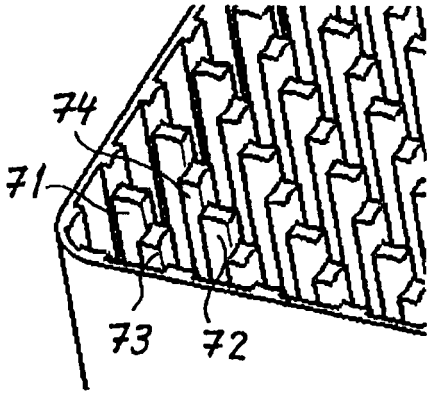

Fig. 15

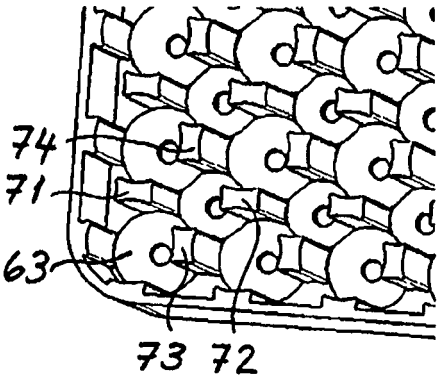

Fig. 16

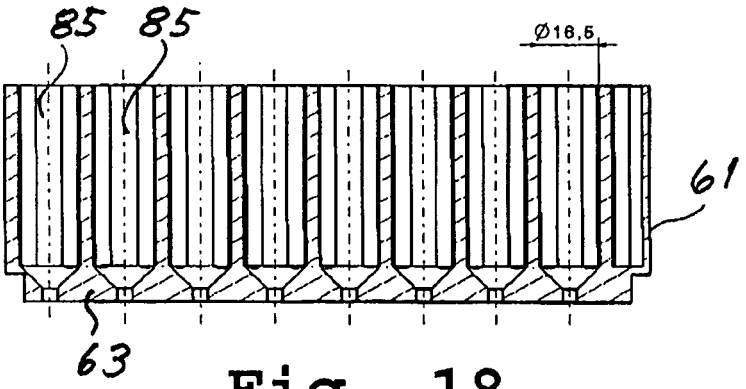

Fig. 18

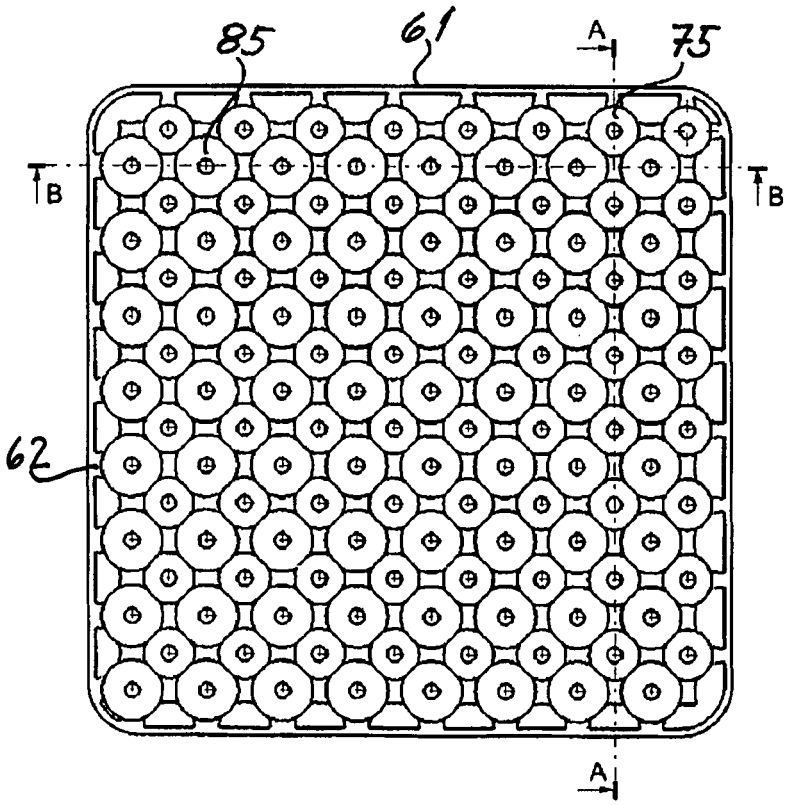

Fig. 17

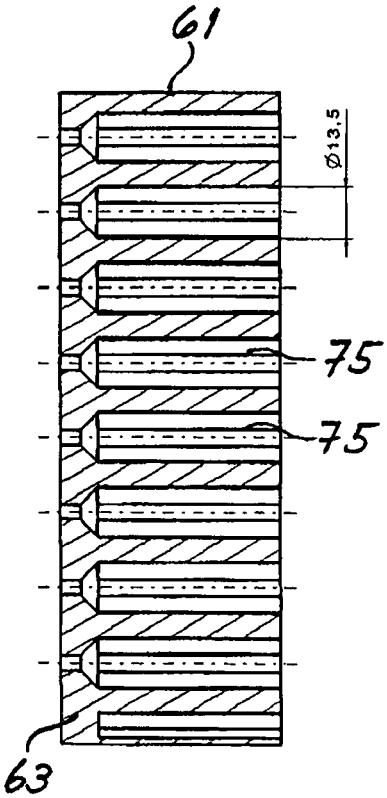

Fig. 19

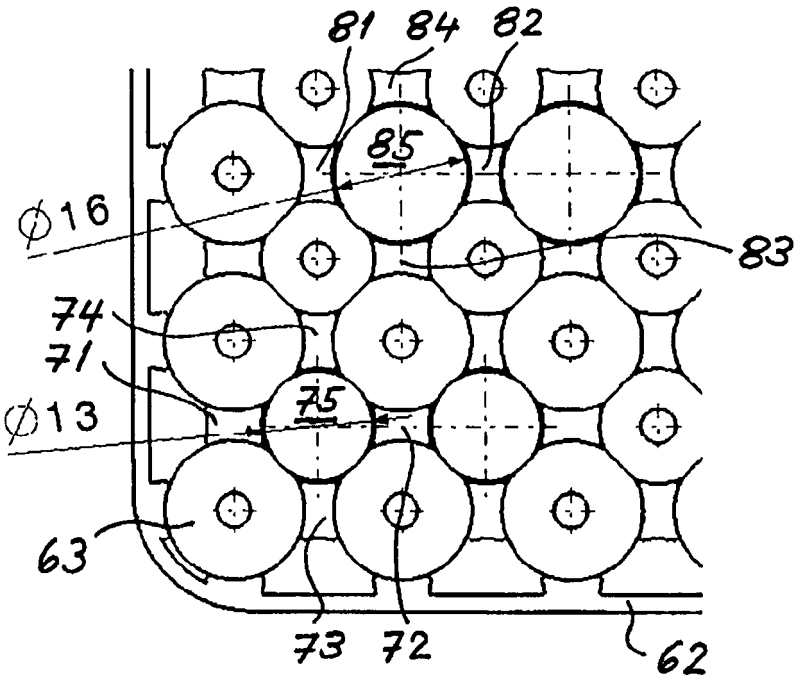
81
84
82
85
Ø16
83
74
71
75
Ø13
63
73
72
62

Fig. 20

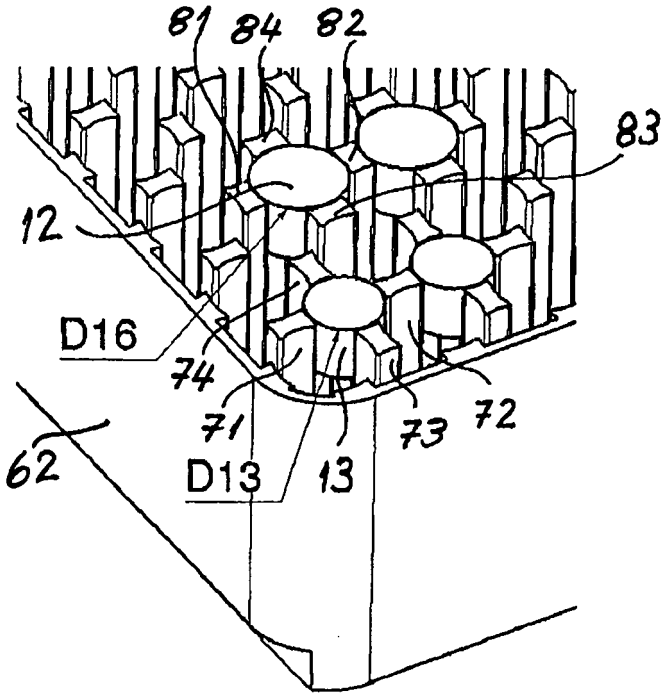
81
84
82
83
12
D16
74
71
73
72
62
D13
13

Fig. 21

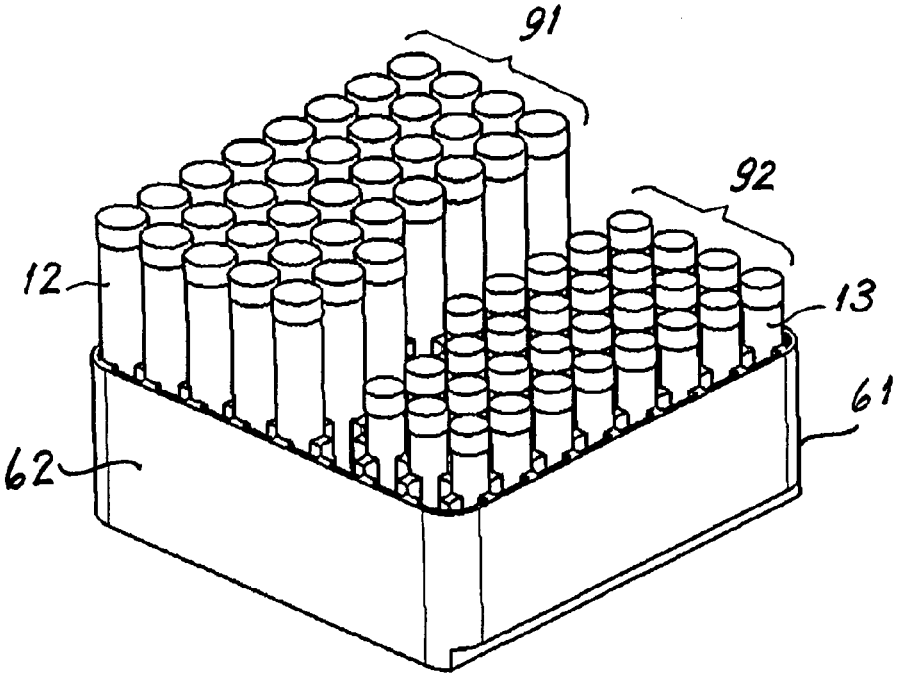

Fig. 22

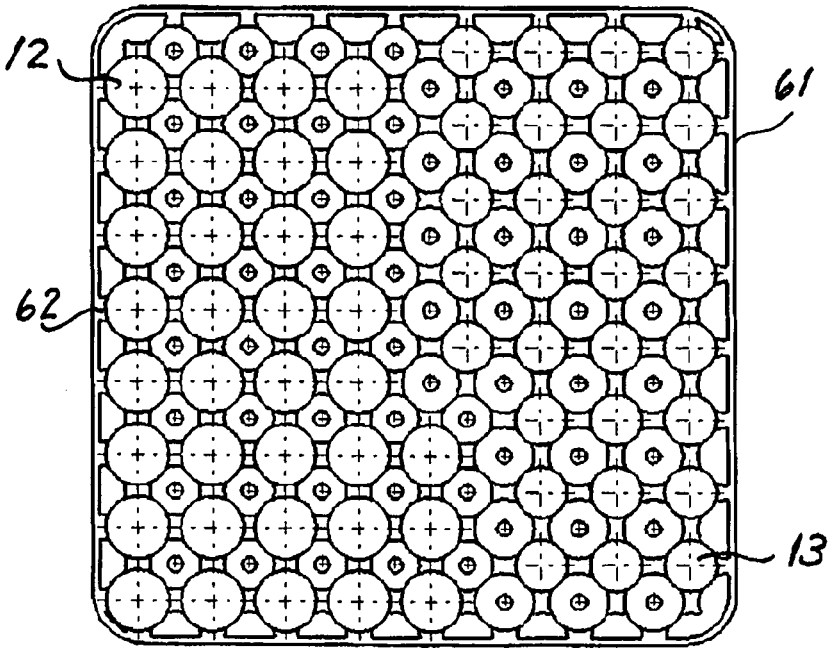

Fig. 23

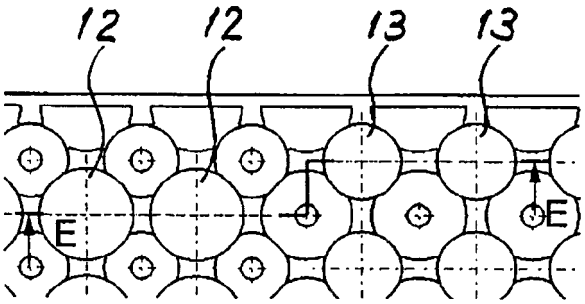

Fig. 24

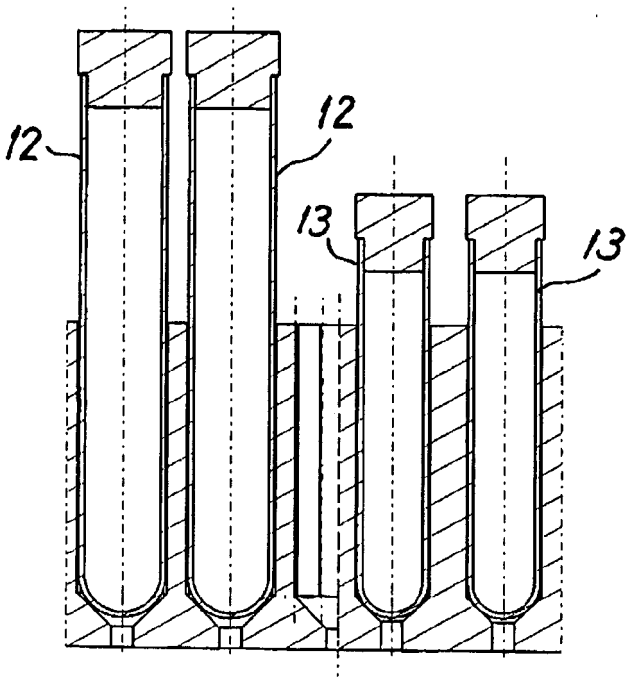

Fig. 25

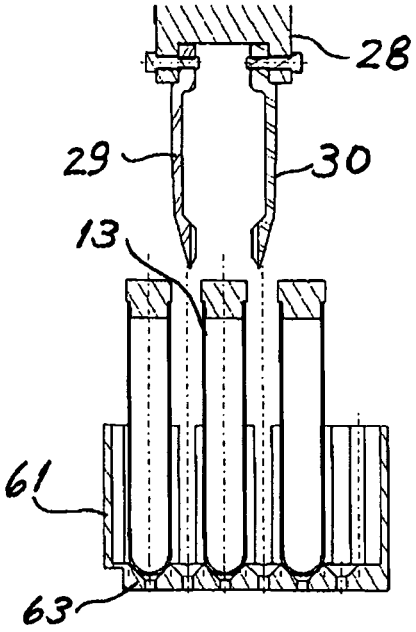

Fig. 26

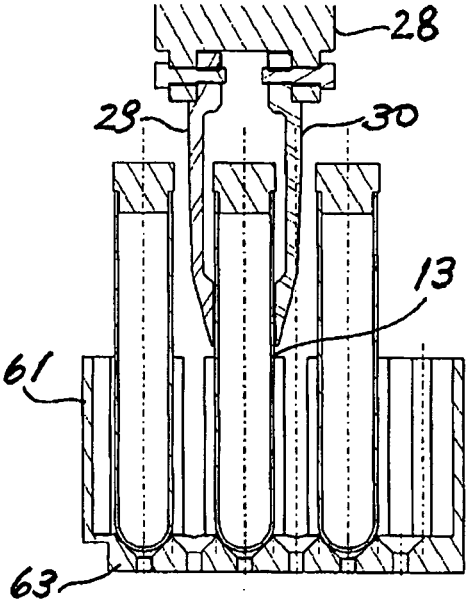

Fig. 27

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 3329

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 03/097239 A (GEN PROBE INC [US]) 27 November 2003 (2003-11-27) * figures 6B,7B *	1-13	INV. B01L9/06
A	US 6 156 275 A (DUMITRESCU NICOLAE [US] ET AL) 5 December 2000 (2000-12-05) * the whole document *	1-13	
A	WO 96/36437 A (SMITHKLINE BEECHAM CORP [US]; UNIVERSAL MACHINE COMPANY [US]; BRYAN DA) 21 November 1996 (1996-11-21) * the whole document *	1-13	
A	EP 0 467 301 A (EASTMAN KODAK CO [US]; KODAK AG [DE] JOHNSON & JOHNSON CLIN DIAG [US];) 22 January 1992 (1992-01-22) * the whole document *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

B01L

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
Munich	15 April 2008	Skowronski, Maik

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

Application Number
EP 08 00 3329

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

see additional sheet

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 08 00 3329

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-13

A sample tube rack with a bottom wall comprising channels extending into the side walls for a tube positioning device

---

2. claim: 14

A sample tube rack with first and second pillars for creating a space for two different tube diameters

---

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 00 3329

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-04-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03097239 A	27-11-2003	AT 375823 T	15-11-2007
		AU 2003234594 A1	02-12-2003
		CA 2480530 A1	27-11-2003
		DE 60316938 T2	17-07-2008
		EP 1507593 A1	23-02-2005
		JP 2005526242 T	02-09-2005
US 6156275 A	05-12-2000	AT 271921 T	15-08-2004
		DE 69825238 D1	02-09-2004
		DE 69825238 T2	28-07-2005
		EP 0919281 A2	02-06-1999
		JP 11230969 A	27-08-1999
		US 6123205 A	26-09-2000
WO 9636437 A	21-11-1996	AT 244606 T	15-07-2003
		AU 712957 B2	18-11-1999
		AU 5750696 A	29-11-1996
		CA 2220981 A1	21-11-1996
		DE 69629025 D1	14-08-2003
		DE 69629025 T2	15-04-2004
		DK 825898 T3	06-10-2003
		EP 0825898 A1	04-03-1998
		IL 118232 A	24-07-2001
		JP 11505920 T	25-05-1999
		NZ 307989 A	30-08-1999
EP 0467301 A	22-01-1992	CA 2047069 A1	21-01-1992
		DE 4023194 A1	23-01-1992
		JP 3187456 B2	11-07-2001
		JP 4232867 A	21-08-1992
		US 5186339 A	16-02-1993

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5378433 A **[0007]**
- US 5700429 A **[0008]**