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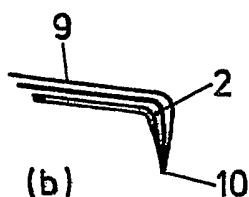
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(54) Title: BENT MICROSTRUCTURES



(57) Abstract: A device for sampling, transporting and/or disposal of fluid media in the nl and µl-range comprises a substrate with an open or closed capillary-like groove or channel respectively, the substrate with the open or closed groove or capillary respectively is bent or arcuated at least at one location. The substrate comprises at least one end into which the open or closed capillary-like groove or channel respectively is extended, which end is shaped according to its application or use as e.g. needle-like, straight-lined cut, tip-like, at least most half circle-shape, rounded, etc.



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**Bent microstructures**

The present invention refers to a device or an instrument  
5 respectively for sampling, transporting or dispensing of  
fluid media according the introduction of claim 1, a  
microstructure comprising at least a device or facility,  
the use of the device or the structure as well as a method  
for the production of a device or structure respectively.

10 For sampling or dispensing respectively of fluid samples,  
such as in particular of fluids in the analytical field  
such as in particular medical or pharmaceutical field among  
others so called pipettes or capillaries or multiple  
pipette microstructures are used. In the course of  
15 increasing the efficiency in analytical laboratories, the  
economization and due to smaller sample amounts in this  
field also the used instruments such as in particular  
pipettes or multiple pipette structures are getting finer  
and more complex. For this purpose e.g. from the firms  
20 Zymark or Caliper multiple pipette structures are offered  
comprising up to 384 so called pipette tips for sampling  
amounts in the range of 2 to 100 nl.

In the EP 1 388 369 micro fluidic systems are proposed,  
which can be used in micro array systems including channel  
25 spring probes, that include at least one capillary channel.  
The proposed spring beams with incooperated channels as  
e.g. stressy metal beams curve away from a substrate when  
released. The channel spring probes are arranged onto a

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substrate by using specific production steps by covering the substrate with a plurality of layer coatings, so that the spring properties are achieved.

The subject of the present invention consists in proposing  
5 further refinement or increase of capacity and the possibility of increased automation in micro-technical process steps by using Nano- or Microsystems as in particular in analyses, the execution of test series, sampling, sample dispensing, at capillary-electro phoresis,  
10 capillary-chromatography, etc., etc.

According the present invention it is proposed, that instead of a "straight" device, a planar 2D-structure or channel spring probes arranged onto a substrate as proposed within the EP 1 388 369, in the nl or  $\mu$ l-range, a bent or  
15 arcuate fluidic device or a corresponding fluidic instrument respectively or a 3D-structure is used. E.g. an out of plane sampling device for sampling, transporting and/or disposal of fluid media is proposed, comprising within a substrate plane at least one longitudinal  
20 extending strip like portion, comprising a liquid channel, such as a pipette or a capillary tube or needle respectively for sampling or dispensing, which is bent or arcuate designed at least at one location extending out of the plane of the substrate.

25 "Bent" in the sense of the present invention means that out of an initially, essentially plane substrate, e.g. a substrate pre-structured by etching a three-dimensional structure has been produced by a specific bending action, the bent parts of the initially plane substrate project out

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of the plane of the substrate. In particular capillary channels or grooves can be produced which either are running into the substrate plane or also out of the substrate plane.

- 5 Surprisingly and against any assumption it could be proved in experiments that the flow in e.g. so called capillary grooves and in particular in open fluid channels also works "around the corner" in the  $\mu$ l and nano litre range. The open channel or the open channels can be inside as well as  
10 outside of the radius of curvature at the location of the bending.

The same of course is valid for structures, which consist of a plurality of devices or instruments respectively including liquid channels in the micro litre or nano litre  
15 range comprising at least one bent location or structure respectively as proposed above.

It goes without saying that the flow characteristic of the fluid within the capillary grooves or fluid channels is dependent on the geometry and the surface finish or coating  
20 of the inner wall surface. In case of a water based solution or a fluid the surface is preferably hydrophilic and case of a more oily fluid the surface characteristic is preferably more hydrophobic like. As a general comment, one can say, that the contact angle between the fluid and the  
25 surface should be small.

Within the prior art so called 3D-structures are known, where capillaries for sampling are bonded into and/or arranged onto a so called "out-of-plane" structure as e.g. the channel spring probes as proposed in the EP 1 388 369.

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For these structures the production costs are very high and also the production method is complicated and error-prone. In addition with some of such structures closed liquid channels have to be used which means within the prior art often so called closed capillaries are proposed. In addition for the spring probes as proposed within the EP 1 388 369 multi structures have to be applied onto a substrate to achieve the spring properties.

In contrast to the today usually used materials for the production of pipettes or capillaries i.e. for the production of the devices proposed according the present invention or structures comprising a plurality of devices or instruments respectively preferably plastically formable material as metals, at least partially plastic polymers and the same are used usually comprising only one layer.

On one side the production of the inventively proposed elements or instruments such as pipettes and capillaries or of whole structures is very simple, as the elements or instruments comprising the fluid channels usually consist only of one layer and can be bent in a simple manner. In addition a metal band can be used as a basis, which can be treated by using well-known lithography processes such as e.g. by means of etching to produce the liquid channels. It is possible e.g. to produce open channels on one side or both sides of a small metal band and further more closed channels can be produced by covering the open channels using a film. The possible production processes for the production of the inventive elements or devices respectively like i.e. etching, punching, bending, etc.

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shall be explained later on with reference to the attached drawings.

The advantage of the instruments or devices proposed according the present invention is, that sampling or  
5 dispensing of a sample is far easier by using a bent or arcuated element, such as a pipette or a capillary including instrument, as it does not have to be moved against the substrate surface in a more or less perpendicularly manner, from which substrate a sample has  
10 to be removed. It is e.g. possible to move the pipette or capillary including device from one side more or less in a parallel manner over the surface of the substrate for removing a sample. By using an inventive structure also at limited dimensional conditions at the same time a plurality  
15 of samples can be removed or dispensed in a simple manner. The various advantages of the inventively proposed devices or elements respectively as well as the structures shall be explained in more details later on with reference to the attached drawings.

20 Furthermore a process is described for sampling, transporting and/or dispensing of fluid media in particular by using the above mentioned devices or the above mentioned structures. According to the inventive process a pipette or capillary such as a needle or a structure, comprising a  
25 plurality of pipettes or capillaries is used and the fluid is transported along a location at sampling or dispensing a sample, which is arcuated or bent respectively.

Further preferred aspects or embodiments of the elements, devices as well as of the structures and the processes respectively are characterized in dependent claims.

The devices, instruments or structures respectively

5 according the present invention are suitable in particular for diagnostic or analytical processes in the field of chemistry, medicine, microbiology, pharmaceuticals, etc. The invention shall be explained in more details with reference to the attached drawings.

10

In the drawings:

Fig. 1a - 1c show in perspective view embodiments of a bent fluidic channel,

Fig. 2a and 2b show in perspective view bent elements  
15 comprising a needle shaped tip-end,

Fig. 3a and 3b show in perspective view a bent element, comprising a tip-like end,

Fig. 4a and b      liquid reservoirs in perspective view as  
well as fluidic elements for sampling,

20      Fig. 4c                shows a section along line I-I of fig.  
4 a and b,

Fig. 5a and 5b show in perspective view the simple immersion of a bent fluidic element into a fleece or non woven element,

25     Fig. 6a and 6b     show schematically in perspective view  
the dispense of a fluid from a bent

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fluidic element in accordance with the principal of a fountain pen,

Fig. 7 shows schematically a so-called multiplex array with mixing zones, produced by the use of fountain pen like fluidic elements,

Fig. 8a and 8b show the sample transfer from fluidic device to fluidic device by overlapping contact of capillaries,

Fig. 9 shows schematically in perspective view the transfer of a fluid between two fluidic elements by use of additional positioning elements,

Fig. 10 shows in view from the top an example of a steel CD, etched on both sides, out of which for the production of an inventive structure needle shaped fluidic elements can be bent,

Fig. 11 shows the structure produced out of the CD of fig. 10 from a side in perspective view,

Fig. 12 shows a further structure similar to the one shown in fig. 11

Fig. 13a - 13d show an elastic flat spring like fluidic element arranged on a CD in view from the top, in a sectional view seen from the side as well as actuated by use of an



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actuating element for the dispense of samples,

5 Fig. 14a and 14b show an example of a mechanical transmission at flat springs for the production of a structure according the present invention,

Fig. 15a and 15b show a planar micro-structure produced in conventional manner as well as a bent "out-of-plane" micro-structure,

10 Fig. 16a to 16f show a possible version for the production of fluidic channels in inventive fluidic elements,

Fig. 17a shows a micro fluidic-device with bent distance elements, and

15 Fig. 17b a stack of a plurality of micro fluidic-devices as shown in fig. 17a.

In the fig. 1a to 1c schematically and in perspective view three embodiments are shown, how a fluidic channel can be arranged on an individual fluidic element "around-the-  
20 corner" of an inventive fluidic structure. Fig. 1a shows a bent element 1 comprising two layers with a closed channel, comprising a bend 2.

Fig. 1b shows a one layer bent element 3 comprising an open "inner" channel with a bend of e.g. approximately 90  
25 degrees.

Fig. 1c finally shows a one layer bent element 5, comprising an "outer" open channel and a bend 2.

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Fig. 2a and 2b show each a bent element, which is needle-like shaped. Fig. 2a shows a bent needle-shaped element 7 with an inner open channel and a needle-shaped tip 6. Fig. 2b shows a bent needle-shaped element 9 with an outer open channel and a needle-shaped tip 10. The bent fluidic elements shaped as a needle can be used for sampling from a well-plate or for the direct sampling of body fluids or the dispense of a fluid into a human or animal body by piercing.

10 The bent or arcuate fluidic element can also be shaped as a tip end, as shown in the fig. 3a and 3b. Fig. 3a again shows a bent tip 11 with an inner open channel and an even cut tip end 12 while fig. 3b shows a bent tip 13 with an outer open channel comprising an even cut tip end 14. Again  
15 the tip-like element can be used for sampling from a well-plate. The tip end has only to be dipped into a fluid and the capillary is filled automatically. Of course other forms or designs of a tip or needle-like element are possible such as e.g. elements comprising a semi-circle  
20 shaped end, comprising ends with a wave-structure, the end-areas of the elements may comprise a capillary or a plurality of capillaries which may be closed or open, as described above.

With the use of experiments it could be shown, that the  
25 flow "around the corner" in particular also with use of open fluid channels works perfectly. It is irrelevant, if the open channel (capillary) is on the inner or the outer surface of the bent radius.

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In Fig. 4a schematically and in perspective view a well-plate disk 21 as liquid source is shown with open grooves 23 arranged corresponding to the circle-round disk as closed circles. The open grooves 23 are fed through so-called well-reservoirs 25. The sampling or disposal of samples by use of the fluidic elements as shown e.g. in fig. 1 to 3 can happen in the following manner: a flat disk, as the well-plate-disk 21 with open grooves 23, as shown in fig. 4 serves as a liquid source for the fluidic devices. The sampling can happen via dipping of the fluidic elements 9 (only one element is shown) within the grooves (contact with the fluid). In doing so the capillarity (capillary force) of the bent elements has to be bigger than the one of the grooves, which are arranged on the disk. This may happen e.g. by using smaller capillary dimensions or bigger capillary aspect proportions.

To ensure, that the disk or the CD grooves are always filled with fluid, it is preferred to arrange etched well reservoirs 25. These wells may be filled with conventional methods, e.g. by using pipettes. The disk can be kept static or can be rotated so that sampling is possible at any location around the circular-like grooves.

In fig. 4b a similar panel-like well plate 21' is shown which in contrast to fig. 4a does have straight-lined grooves 23' which are connected to edged well reservoirs 25. Again the collection of fluid samples can be executed by using fluidic elements 9 (only one element is shown) which are dipping into the grooves 23'. Similar to the disk-like plate 21 of fig. 4a the panel-like plate 21' of

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fig. 4b can be moved in longitudinal direction, so that sampling can be executed along the full length of the grooves 23`.

Fig. 4c shows a cross-sectional view along the line I`I from fig. 4a and 4b. It shows the dimensions of the wells 25 which are somewhat bigger than the dimensions of the respective grooves 23 or 23` respectively. As a consequence it is easy to fill these wells 25 and on the other hand by using the wells it is guaranteed, that the grooves 23 or 23` respectively are uniformly filled with the respective fluid media for sampling correction.

In fig. 4 the advantage of the present invention or inventive device respectively is shown very clearly, as the bent fluidic elements can be guided over the disk parallel to the surface of the disk, so that the sampling can be executed even if the local dimension proportions are limited. In other words in case of using a conventional pipette the space above a well-plate disk 21 has to be open or free respectively, while in case of the use of an inventive fluidic element a relative small gap above the surface is already sufficient.

In the following fig. 5 to 7 possible examples of the disposal of a sample should be explained in more details. In the fig. 5a and 5b the disposal of a sample is executed by simply dipping a bent fluidic element into a fleece or non-woven element 31. In fig. 5a the disposal of a sample into the fleece 31 from a tip element 13 is shown, while in fig. 5b the disposal of a sample into the fleece 31 is effected from a needle-shaped dip-end 9.

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The disposal of a sample may also be effected by contact of the tip-like-end of the bent fluidic elements onto a plain surface, as shown in the fig. 6a and 6b. Fig. 6a shows the principal of a fountain pen using an element 7 with an inner open capillary. The fluidic element 7 is preferably drawn for producing the stripe 33 containing the disposed liquid. In contrast fig. 6b shows the principal of a fountain pen using an element with an open outer capillary. The fluidic element 9 is preferably pushed to produce the stripe 35, containing the disposed liquid. But of course the fluidic element 7 may also be pushed while the fluidic element 9 may be drawn for the production of the respective stripes. Finally it should be mentioned, that the capillary at least in the area of the fountain pen like tip-end may also be formed in an open manner on both sides, which means, the capillary is open end-to-end analogue to a fountain pen, which is used e.g. for hand-writing.

Fig. 7 shows schematically and in perspective view a so-called multiplex-array with NxM mixing zones.

To produce a NxM-array a plurality of so-called fountain-pen needles are used as schematically shown in fig. 7. Needle elements 7 with open channels "inside" as well as bent needles 9 with open channels "outside" or needle tips with end-to-end open channels or capillaries may be used. By disposing the liquid from the needle tips 6 or 10 respectively the liquid stripes 33 and 35 can be drawn, the liquid lines are intersecting, so that mixed-zones 37 will occur. The shown configuration is as already mentioned above a so-called multiplex-array with NxM-mixing zones.

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With reference to fig. 8 and 9 it should be shown, how the transfer of a sample from one fluidic device to another fluidic device may be executed. For that reason in fig. 8a the transfer of a sample from a tip device 11 with a tip end 12 to a further tip device 11 with the tip end 12 is shown. The tip end 12 of the one device 11 is slipped over the opposed tip-end of the other device. It is important, that upon contact the two capillaries are overlapping. The one device is acting as a liquid source to the other empty device which acts as liquid acceptor. One condition is that the two devices which act comprise open capillaries, which are overlapping.

In fig. 8b shows in analogue manner the sample transfer from one needle 7 with the tip end 6 to a tip element 11 with the tip end 12. The transfer is executed by moving horizontally of the one device until a contact of the two capillary channels is reached for the transfer of the liquid. So that the transfer can occur the capillarity (capillary force) of the one tip element has to be bigger than the one within the capillary of the needle. This can be achieved by using smaller capillary dimensions in the tip element or by bigger capillary aspect ratios.

In fig. 9 a further possibility of the transfer of the liquid is shown. For that reason in one tip-like formed device 11 a channel 18 is formed to solve the problem of positioning. The needle-like device 7 is guided in a horizontal manner until the needle tip 6 engages into the positioning channel 18 and the transfer of the liquid may occur. In addition a narrowing portion 20 at the upper

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needle like device 7 can be arranged to allow an easier x/y-positioning. The positioning aids or positioning elements respectively can be integrated in a simple manner already e.g. within an etching mask. The individual bent  
5 elements may have additional structured portions such as e.g. groups or narrowing portions which enables the elements to engage in further elements or to compensate positioning inaccuracies between two elements. By using such positioning aids the safe transfer of fluids may be  
10 improved. The production of the mentioned auto-positioning or auto-adjusting structures is quasi free of charge and can e.g. be integrated already within the etching mask. For the production of the mentioned auto-positioning aids no further process steps are required. The elements include  
15 afterwards inherent those properties of the auto-adjustment and therefore no external auxiliary means are required anymore.

In fig. 1 to 9 only mainly individual fluidic elements are shown and in the following figures inventive structures  
20 should be explained in more details comprising a plurality of individual fluidic elements. For that reason fig. 10 shows a CD-like steel disk 41, in which e.g. by etching or punching a structure is created provided for the production of a respective fluidic structure by bending the various  
25 individual elements. This structure is suitable for the sampling of various samples at the same time or the disposal of a plurality of samples at the same time. The cassetting problem can be solved in the same manner.

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A structure, produced out of the steel CD 41 in fig. 10 is shown schematically and in perspective view in fig. 11. The out-of-plane bent structure is shown from above and from the side. Within the CD-disk 41 the stripe-like length  
5 sections 43 and 45 are produced by etching as well as the needle-like tips 47 in the centre of the disk. By bending along the polygon-like bending edge 42 the inner sections of the stripes 45 are bent downwards and at the same time the needle-tips in the centre of the CD-disk 41 are  
10 separated simultaneously to produce the fluidic needle elements 47 extending from the ends of the stripes 45, which elements are provided for sampling or disposal of samples.

In addition and as shown with reference to one specific  
15 stripe preferably in the centre-line of the strip-like sections 43 and 45 capillaries 46, preferably again by etching are produced as well as in addition so-called pots or wells 48 in the area of the outer stripes 43.

By means of a structure as shown in fig. 11 simultaneously  
20 a plurality of samples can be removed or sampled by dipping the needle tips 47 in respective sample grooves. The samples are collected from the tips of the needles 47, and transferred through the capillaries 46 into cavities or wells or pots 48 respectively. These enlarged reservoirs or  
25 pots, which are arranged on the disk-like sections 43 of the structure can be used for liquid sample detection or analysis such as e.g. by using infrared, NMR, etc.

In analogue manner in fig. 12 a further similar structure is shown in perspective view slightly from above, in which



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structure the strip-like sections 51 are arranged peripherally, which means at the outer outline of the structure 50. By using needle-like tips 53 again samples can be removed, which are transferred over capillaries 55  
5 into reservoirs or pots or cavities 57 or 59 respectively. The detection or analysis respectively of the sampled samples can be executed in the periphery sections, which means in the reservoirs 57 as well as in the upper horizontal area in the reservoirs or pots or wells 59.

10 In the example according fig. 11 a so-called drum-cassette "inside" and in fig. 12 a so-called drum-cassette "outside" is shown. It is possible to bend a disk-shaped structure in such a way that a drum is formed. The structures, shown in fig. 11 and 12 are so-called drum-cassettes which means the  
15 two shown structures can solve the problem of cassetting as at the same it is possible to sample or to dispose a plurality of samples. The cassetting is therefore a collection of several elements collected in one piece. Also other shapes (other than drums) can be possible for  
20 cassetting, for example a crown or also a CD like shown in fig. 13.

The cassette-like structures in addition have the advantage, that they can be stored or transported as e.g. stacks.

25 In fig. 13a to 13d a further embodiment of a possible inventive structure is shown comprising a plurality of fluidic elements, arranged on or at the structure. Fig. 13a shows in view from the top again an at least almost circular round metal disk or CD-like disk 61 at which

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peripherically extending the individual fluidic elements 63 are arranged. The individual fluidic elements can be produced by etching within the metal CD. As shown with reference to fig. 13b the individual fluidic elements 63 are elastic flat-spring like elements with restoring force. To get a better general overview in fig. 13b only one single fluidic element 63 is shown. The production of the flat spring like element is possible due to the mechanical elasticity of the metal material. As a result it is possible to produce specific activating principles such as the shown flat-spring or solid body articulations.

Fig. 13c shows a possible specific embodiment the flat spring 63 being combined with a bent needle-like tip 65. The combination of the bent needle-like tip enables an improved sampling of samples.

In fig. 13d schematically it is shown how a test strip contacting procedure can be achieved by use of a structure as shown in fig. 13a. Again in fig. 13d for a better overview only one pre-stressed fluidic element 63 having a needle-like tip 65 is shown. Further elements are only shown in outlines. The individual flat-spring-like elements 63 are slightly pre-bent in upward direction. By actuating e.g. with use of a circular actuating element 67 the individual flat spring like elements can be pushed downwards for contacting e.g. a test strip or a so-called well-plate disk, as shown e.g. in fig. 4. Now either the sample sampling or the sample dispensing can be carried out and after the transfer of the fluid has been executed the actuation can be cancelled and the flat spring like

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elements 63 will return to their pre-stressed position, so that the test-strip is deblocked.

So that the fluidic elements or the individual flat spring-like elements remain in their pre-stressed position for the  
5 production of the structure or the individual fluidic elements a material has to be used, which possesses certain elasticity or restoring force at deformation. Therefore in particular e.g. metal materials are suitable for the production of the proposed structures.

10 Furthermore it is also possible for actuating the fluidic elements or the flat spring-like elements to coat the metal substrate with a Piezo-substrat or a Bi-metal respectively, so that the actuation of the individual fluidic elements or flat spring-like elements can be executed by the movement  
15 of the Piezo-elements.

As already mentioned above the production of the flat-spring-like elements can be achieved by etching what shall be explained in more details with reference to the attached fig. 14a and 14b. First again a metal CD or metal disk 81  
20 is etched, so that the area or section 63 is partially separated from the metal disk.

As shown in fig. 14b by applying a force  $F$ , the element is bent at its front end in opposed direction to the force  $F$  with a certain transmission ratio.

25 In other words the pre-stress occurs as described with reference to the fig. 13a until 13d.

In addition the element, which is pre-bent with a certain transmission ratio, again, can be coated with a Piezo-

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substrate or Bi-metal, so that for sample-sampling or sample-disposal the activation is possible by means of the Piezo-element or bi-metal.

With reference to the fig. 15 and 16 the production of  
5 inventive fluidic elements should be explained in more details. Fig. 15a shows a planar structure 81 for fluidic amounts in the nl and  $\mu$ l-range produced conventially, which means on a substrate 81 the nl or  $\mu$ l-structure is produced by etching. At the respective ends of each element 83  
10 comprising a channel or capillary 84 of the structure a hole or cavity 85 is provided, if needed, which is big enough for applying a bending tool.

Fig. 15b shows the bent out-of-plane nl or  $\mu$ l-structure 87, in which the individual elements 83 are bent out, forming  
15 the bent element parts 88, which may have a bend or deflection in the range of approximately 90 degrees. Of course the angle can be different and can be in the range of only a few degrees up to an angle of almost 180 degrees.

The production of an individual structure element 83,  
20 comprising at least one fluidic channel 84 as described in particular with reference to the fig. 1 to 3 shall be described in more details with reference to fig. 16a until 16f. Fig. 16a shows in cross-sectional-view a metal-substrate corresponding to the substrate-plate 81 from fig.  
25 15. Substrate materials, which have to be suitable for the applications according the present invention must have the inherent feature of plastic deformation, which means as a consequence e.g. metals or elastic polymers, are suitable. The use of rather brittle, fragile or amorphous materials

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such as e.g. silicon, glass, etc., is only limited, as deflection in the third dimension is practically not possible.

In fig. 16b the metal substrate from fig. 16a is coated e.g. on both sides  
5 with a polymer layer 91, as usually used with etching procedures.

The polymer layer afterwards is partially exposed to light and partially removed by washing of the exposed parts, so that channel-like longitudinal extending free areas 93 will  
10 occur, as schematically shown in fig. 16c. By etching the metal the free areas 93 channel-like capillaries 95 will occur, as shown schematically in fig. 16d. Of course the etching has not to be executed on both sides and therefore only one surface of the metal sheet may be treated for the  
15 production of a capillary channel 95 which is open on one side only.

According a further embodiment it is even possible to produce a totally open passage 97 by etching of the metal, as schematically shown in fig. 16e.

20 Finally the polymer 91 shall be removed, so that the channel or capillary for an inventively proposed fluidic element is produced, as shown schematically in cross-section in fig. 16f.

It is now possible to leave open the channel, as shown e.g.  
25 at the fluidic elements in fig. 1b and 1c. But on the other side it is also possible to cover or to bond the open channels e.g. by use of a cover film as e.g. a metal film, so that a closed channel will be produced.

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At the same time at the production step of the channel-like capillaries by etching also transmission forces as described with reference to fig. 14, integrated guidances as positioning elements, etc. can be produced.

- 5 Furthermore from simple planar nl or  $\mu$ l-structures certain parts can be bent out of the two-dimensional plane into the third dimension (out-of-plane) by bending such as by arching, forming, etc., so that the inventive structures in the nl or  $\mu$ l-range will occur. The planar nl or  $\mu$ l-
- 10 structures can be produced with conventional, micro technological production methods, such as lithography or etching, as described with reference to fig. 15 and 16. To achieve the individual out of the plane bent elements 88 as shown in fig. 15b, various techniques may be applied. The
- 15 most common or obvious one is to simply press at least part of the element 83 out of the plane of the structure 81, e.g. by using a bending or punching tool. It is also possible to pull the element along a punching tool or an edge containing tool. A further possibility is to apply a
- 20 roller like tool. Again a further possibility is to apply heat on one surface of the structure or at least of an element to create a tension force, so that the bending procedure occurs without the use of a specific bending tool. Furthermore, if e.g. a symmetric edging is applied
- 25 during the production process of the channel or capillary like groove as described with reference to fig. 16a to 16f, also a certain tension force may be achieved, with the result of creating a bent out of the plane portion without the need of a specific bending tool.

[ ] [ ] [ ]

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The bent elements can fulfil various different functions, as e.g. contacting, needle-punching, reflecting, etc. Pre-conditions for bending an element out of the substrate plane is the at least partial etching through the whole  
5 substrate sheet, as in particular described with reference e.g. to fig. 13a, 13b, 14b, 15a and 15b. The "total-through-etching" makes it possible to produce the individual single bent elements.

The possibility of plastic deformation of the micro-  
10 structure makes it possible to include inherent into the micro-fluidic systems e.g. out-of-plane distance-producing elements, positioning holes, adjustment aids, positioning aids, stoppers, etc. as schematically shown in fig. 17a. This makes it possible to increase the improvement of e.g.  
15 the positioning of micro-fluidic elements in relation to an outside system. For the production of the mentioned adjustment or distance-producing elements no further process steps are required. If needed a further bending step has to be applied to bend those positioning elements  
20 or adjustment elements as the mentioned distance producing elements, as shown in fig. 17a out-of-plane. But usually those elements as the distance producing elements may be integrated e.g. within the etching mask. The fluidic elements therefore include inherent those positioning  
25 elements or distance producing elements and no further external auxiliary means are required. Those auxiliary means in addition may include the fluidic channels or capillaries. In any case the fluid is flowing "around-the-corner". Therefore, it is possible to create a plate  
30 optimization (which means to reduce the fluidic area).

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Furthermore, in fig. 17b a stack of a plurality of micro-fluidic devices of fig. 9, 17a is shown. In other words a plurality of micro-structures including distance-producing elements, stoppers, positioning holes, etc. can be stacked  
5 by an adequate positioning of those bent auxiliary parts. This makes it easier to create a cassetting of micro-structures (with or without fluidic).

As already mentioned above the present invention refers to nl and  $\mu$ l-structures for the transport and/or the transfer  
10 of very small amounts of liquids in the nl and  $\mu$ l-range. As an example for sampling blood a needle like tip having a length of e.g. 3mm can be used, the width of the needle-shaft may be approximately 400 $\mu$ m, the capillary may have a width of approximately 200 $\mu$ m and the depth of the  
15 capillary may be e.g. of about 80 $\mu$ m. The amount of blood to be sampled can be in the range between 2 $\mu$ l and 100 $\mu$ l. These values are of course examples given for the better understanding of the present invention and therefore the present invention is not at all restricted to the mentioned  
20 values. It should be shown how fine or small respectively the inventively described micro structures are and witch small liquid amounts are taken into consideration in the present invention.

25 The big advantage of the present invention is that sampling or sample-disposal "around-the-corner" is possible with using the bent nano-or micro-structures. By using the inventive devices or elements respectively or structures sampling or sample-disposal is possible in spatial or



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dimensional very limited conditions, as e.g. a fluidic device can be guided or moved parallel to a substrate or object respectively, from which a sample has to be sampled, which simplifies essentially the sampling of a sample.

- 5 The fluidic elements and structures which are shown with reference to the fig. 1 to 17 as well as the described production methods are of course only examples and the present invention is not at all limited to the figures, shown elements and describes procedures. The figures are
- 10 only used for the better understanding and in addition e.g. the used materials for the production of fluidic elements or structures respectively are of course not limited to metals or elastic polymers. It is also possible, that at least partially elastic ceramic-material can be used for
- 15 the production of the inventive elements or structures respectively. Furthermore it is not essential, if open or closed capillaries are used, if at the ends of the liquid devices needle-like-tips, edgeless ends, straight cut end-tips, rounded or waved or serrated ends are arranged.

20

**Claims:**

- 5 1. Device for sampling, transporting and/or disposal of fluid media in the nl- or  $\mu$ l-range characterized in, that within a substrate plane at least one longitudinal extending strip like portion is bent out of the plane of the substrate, which strip like portion is provided with an  
10 open or closed groove or capillary respectively and which is bent or accurate at least at one location out of the substrate plane.
2. Device according claim 1 characterized in that the groove or channel respectively is open and is arranged at  
15 the inner surface of the bent location.
3. Device according to one of the claims 1 or 2 characterized in that the groove or channel respectively is open and is arranged on the outside surface along the bent location.
- 20 4. Device according to one of the claims 1 to 3 characterized in that the groove or channel respectively is open and is arranged in the inside surface as well as on the outside surface of the bent location.
- 25 5. Device according to one of the claims 1 to 4 characterized in that at least one strip like portion comprises at least one end into which the open or closed capillary-like liquid groove or channel respectively is extended, which end is shaped according to its application

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or use as e.g. needle-like, straight-lined cut, tip-like, at least almost half circle shaped, rounded, etc.

6. Device according to one of the claims 1 to 5 characterized in that the substrate and/or the at least one portion or needle is consisting of a plastic formable material such as e.g. a metal or an elastic or plastic polymer.

7. Device according to one of the claims 1 to 6 characterized in that the bend-angle is in the range between 0 and 180°, preferably in the range between 60 and 120°, even more preferably approximately 90°.

8. Device according to one of the claims 1 to 7 characterized in that positioning elements are provided to enable adjustment or alignment for sample-sampling or sample-disposal respectively.

9. Device according to one of the claims 1 to 8 characterized in that a plurality of strip like portions is provided in or on the device, which comprise at least one groove or channel respectively and at least part of the portion is bent out of the plane of the substrate of the device.

10. Device according to one of the claims 1 to 9 characterized in that needle-like pipettes and/or tip like strip like portions are provided comprising at least an open or closed channel or groove respectively in the nl or  $\mu$ l-range and at least part of the portions are bent out of the substrate plane of the nl- or  $\mu$ -device with a bend-angle in the range between 0 and 180°, preferably in the

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range between 60 and 120°, even more preferably with an angle of approximately 90°.

11. Device according to one of the claims 1 to 10 characterized in that a plurality of bent portions or instruments are provided comprising peak-like, needle-like or tip-like ends such, that in a further device or structure touching or engaging at predetermined locations liquid samples can be sampled, can be disposed or can be transferred.

12. Device according to one of the claims 1 to 11 characterized in that the device or its substrate is at least almost circular, of square-like form, of hexagon-form and/or disk-like.

13. Device according to one of the claims 1 to 12 characterized in that the tip-like, needle-like or peak-like ends of the strip like portions are resilient pre-stressed arranged in or on the substrate of the device.

14. Structure containing at least one fluidic device according to one of the claims 1 to 13 for sampling, transporting and/or disposal of fluid media comprising at least one strip like portion with an open or closed groove or channel respectively, characterized in that at least one strip like portion of at least one device is bent at least at one location such, that the portion is bent out of the substrate plane of the respective device.

15. Arrangement for sampling fluid media using a fluidic device according to one of the claims 1 to 13 and/or a structure according to claim 14 comprising a panel or disk-like plate (21, 21') with two or more individual preferably

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straight-like or circular-like open grooves (23, 23') as media sources provided for the correction of samples.

16. Process for the production of a 3D fluidic device or structure respectively comprising the steps of producing at least one individual longitudinal extending element or strip like portion within a substrate by etching, punching or the like,  
of producing simultaneously or in a further step along at least one element or at least one strip like portion at least one channel or capillary like open or closed groove respectively by lithography or etching and  
of bending at least part of the element or portion out of the plane of the substrate, at least at one location by plastic, elastic or mechanical forming for the production of the so called out of plane device and/or structure.

17. Process according to claim 16 characterized in, that a plurality of longitudinal extending elements or strip like portions are produced, which are connected at one end to the substrate and are disconnected from the substrate at the opposite end and that within at least most of the elements or strip like portions, longitudinal extending grooves or channels are produced, which extend to the end of the element or portion, which is disconnected from the substrate and that at least most of the elements are bent out of the plane of the substrate, at at least one location of the element or the portion so that those elements or portions are bent or arcuated at at least the location out of the plane of the substrate to produce the so called out of plane device and/or structure.

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18. Process according to one of the claims 16 or 17,  
characterized in, that the bend out procedure of the  
elements or portions is executed by means of a roller like  
element or by pulling the elements or portions along an  
5 edge of a bending tool.

19. Process according to one of the claims 16 to 18  
characterized in, that the elements or portions are edged  
asymmetrically either by the production of the elements or  
strip like portions or at the production of the grooves or  
10 channels respectively, so that as a result due to tension  
forces, the elements or portions are bent out of the plane  
of the substrate.

20. Use of the device according to one of the claims 1 to  
13, or the structure according to claim 14 or an  
15 arrangement according to claim 15 for sampling of fluid  
samples or the disposal of fluid samples for diagnostic  
and/or analytic purpose in medical, pharmaceutical,  
chemical or biochemical processes.

21. Use of the process according to one of the claims 16 to  
20 19 for the production of so called 3D structures or so  
called out of plane structures.

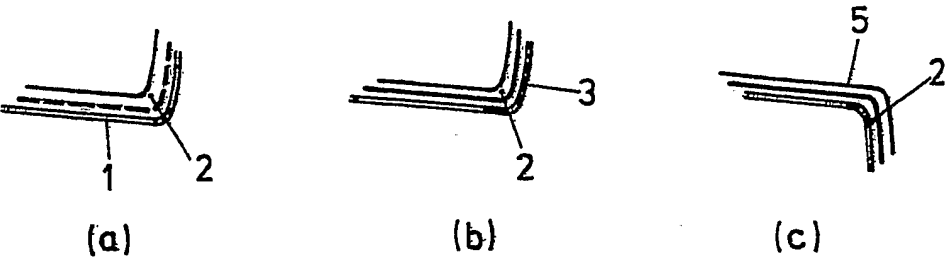


FIG.1

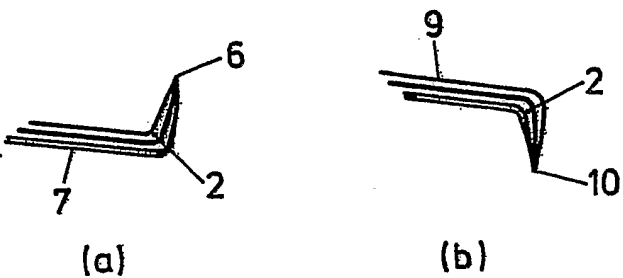


FIG.2

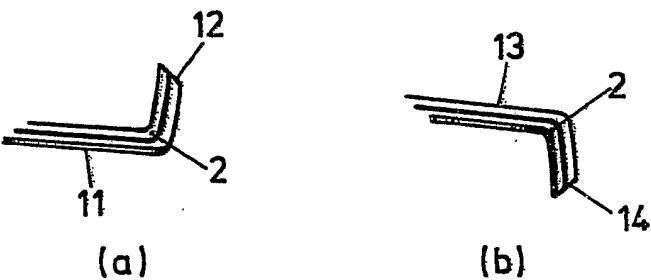


FIG.3

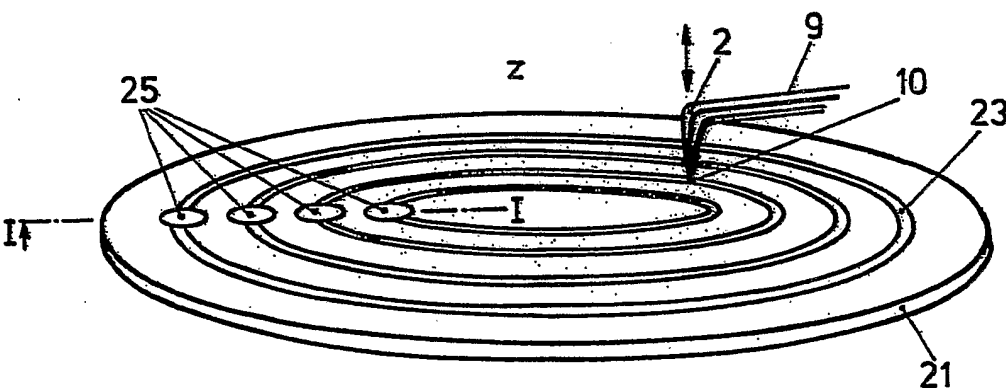


FIG.4a

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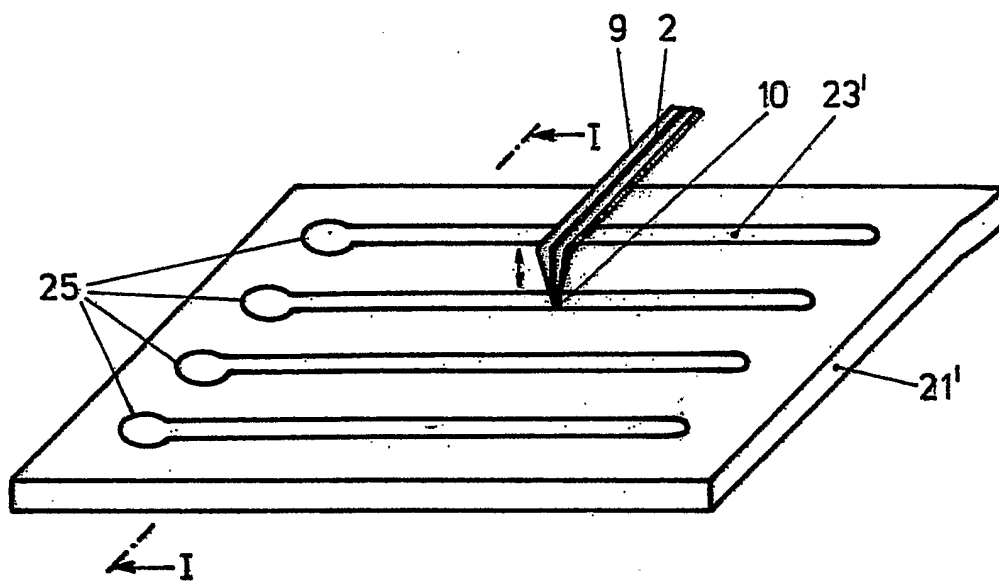


FIG. 4b

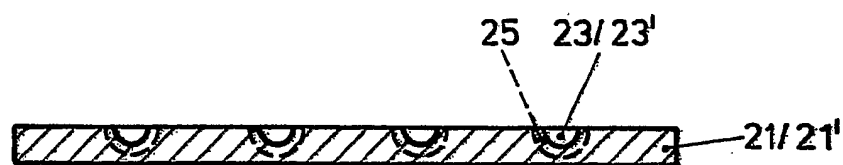
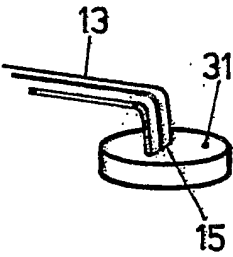


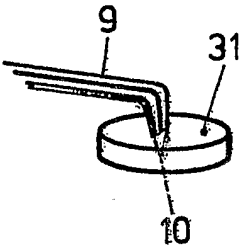
FIG. 4c



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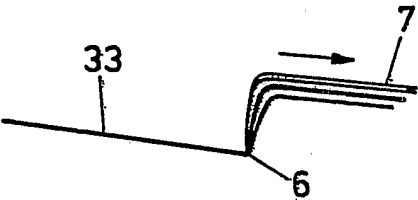


(a)

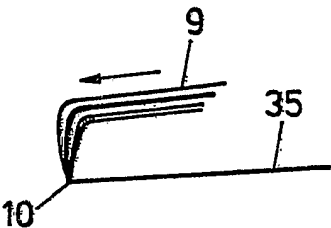


(b)

FIG. 5



(a)



(b)

FIG. 6

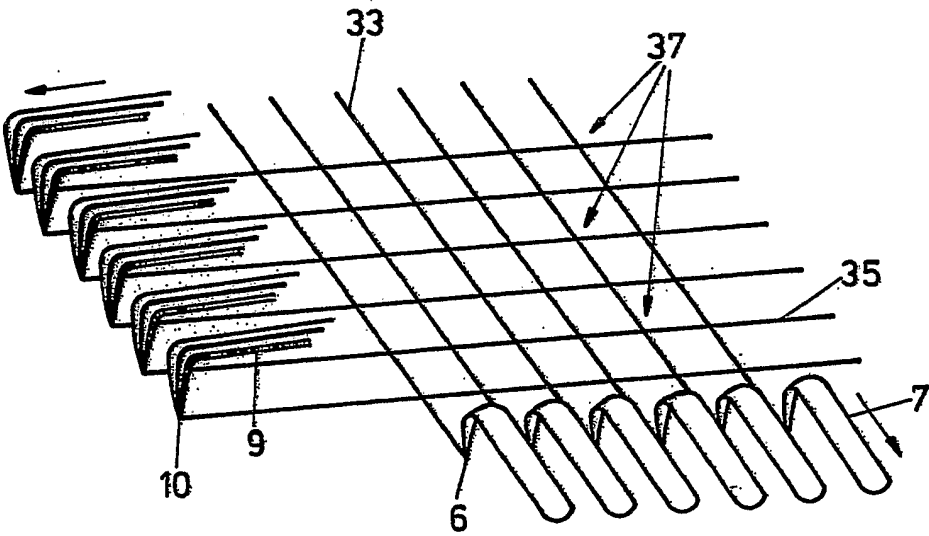


FIG. 7

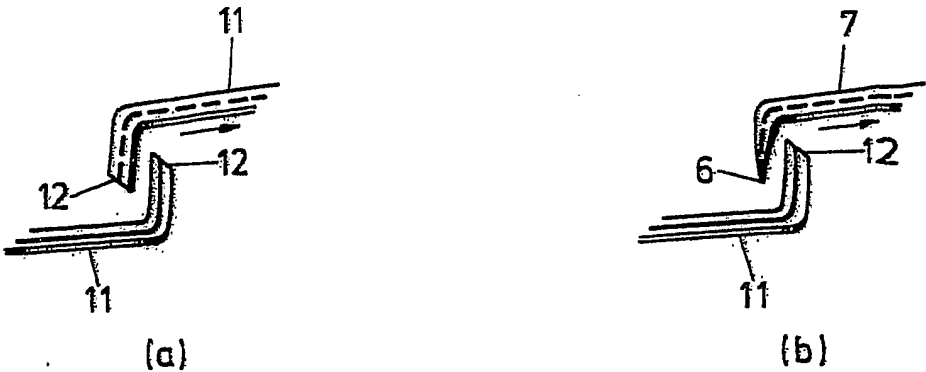
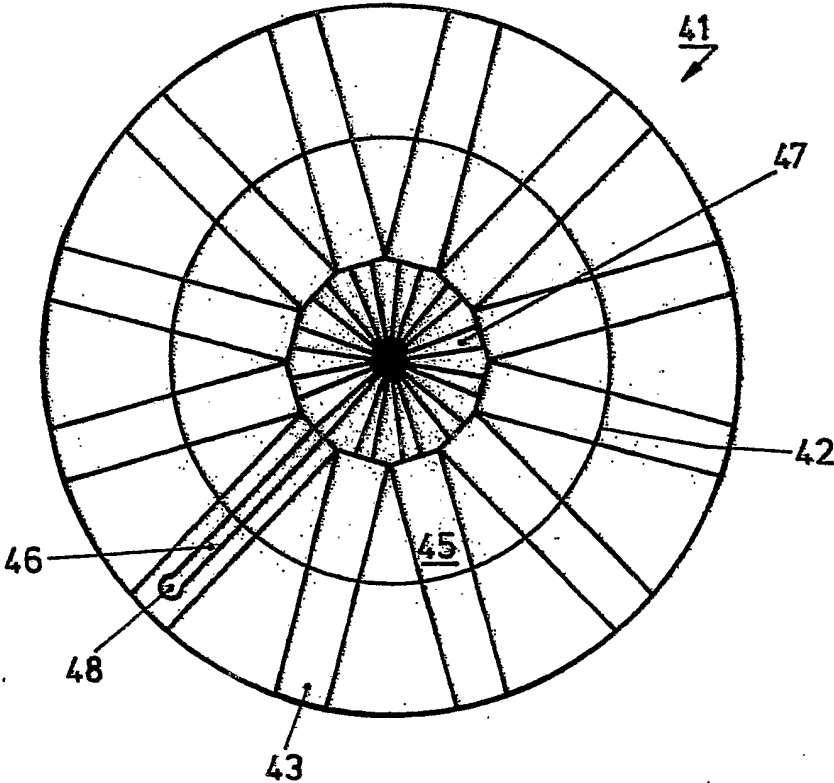
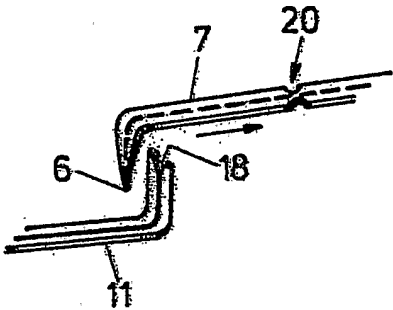


FIG. 8



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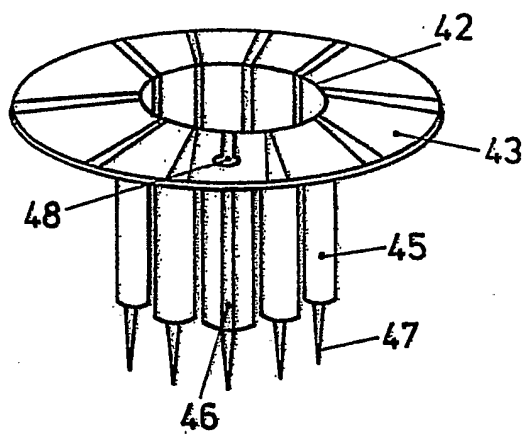


FIG. 11

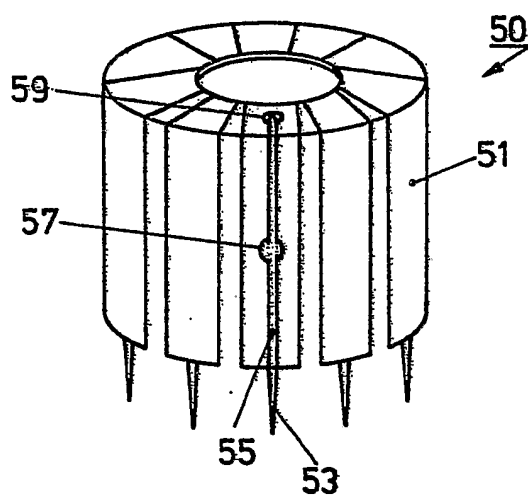


FIG. 12

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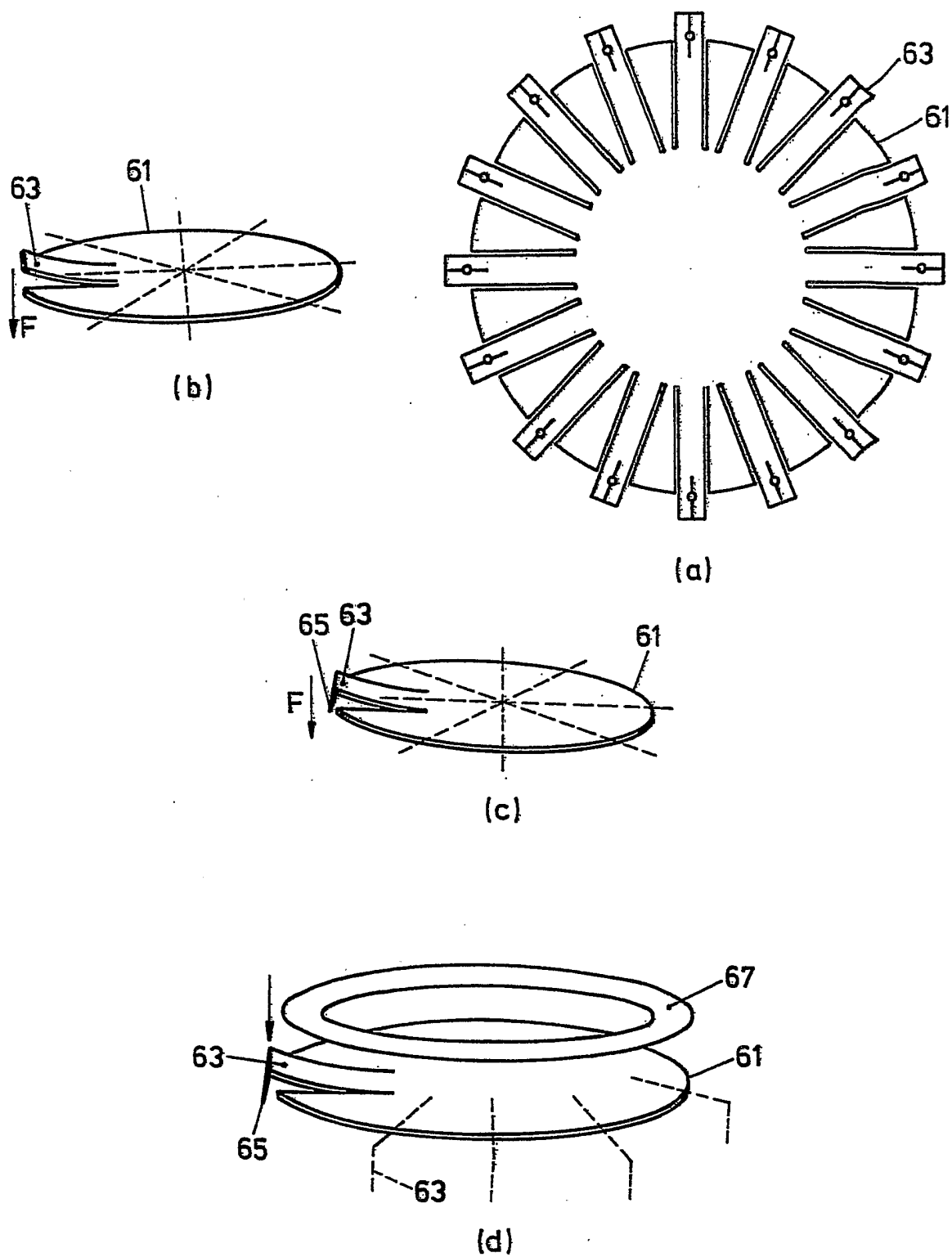


FIG.13

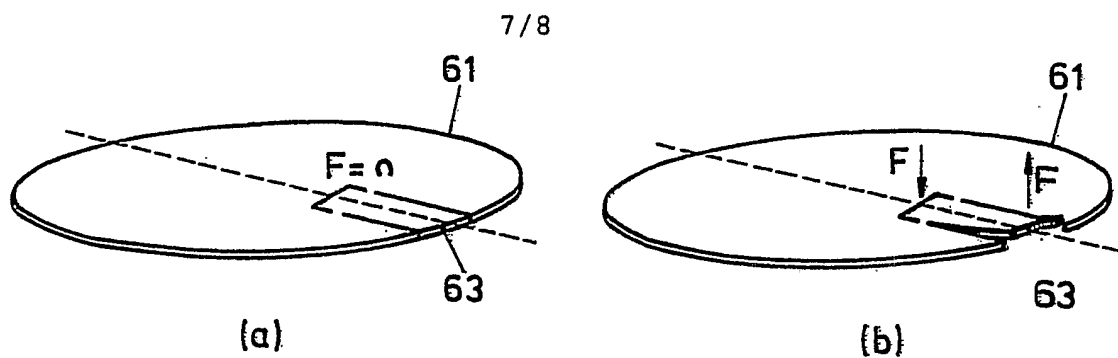


FIG. 14

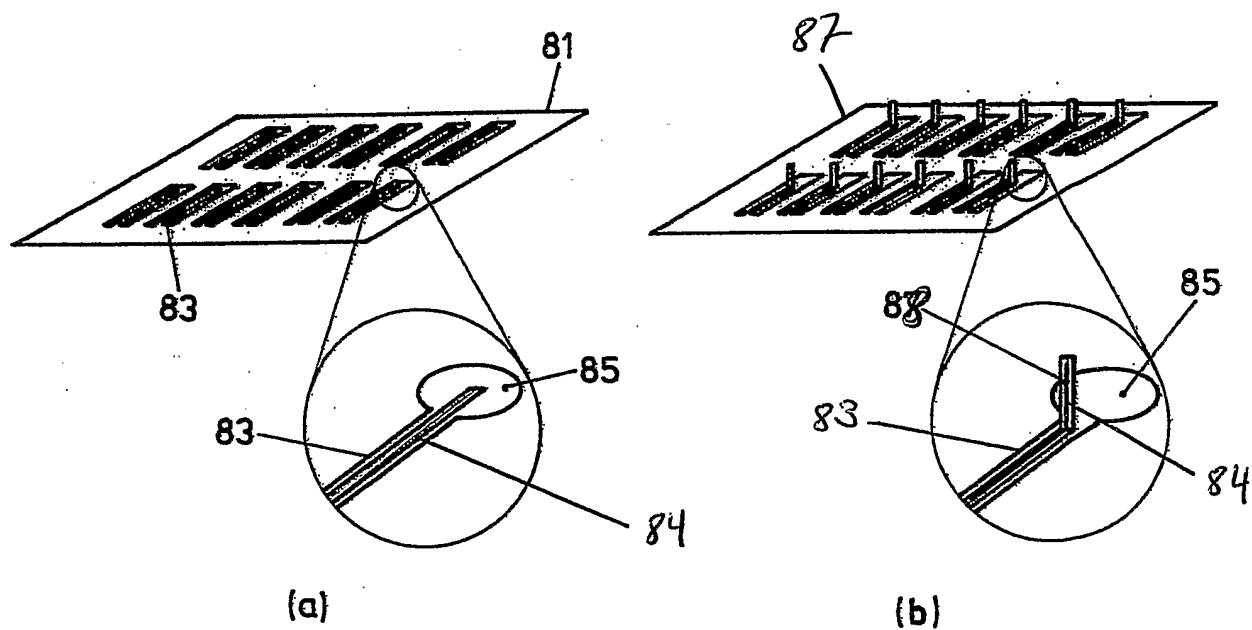


FIG. 15

FIG.16

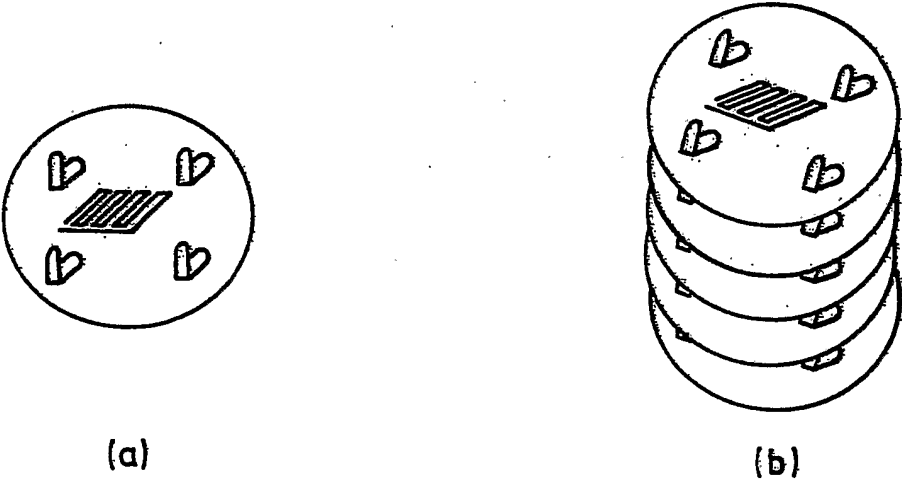
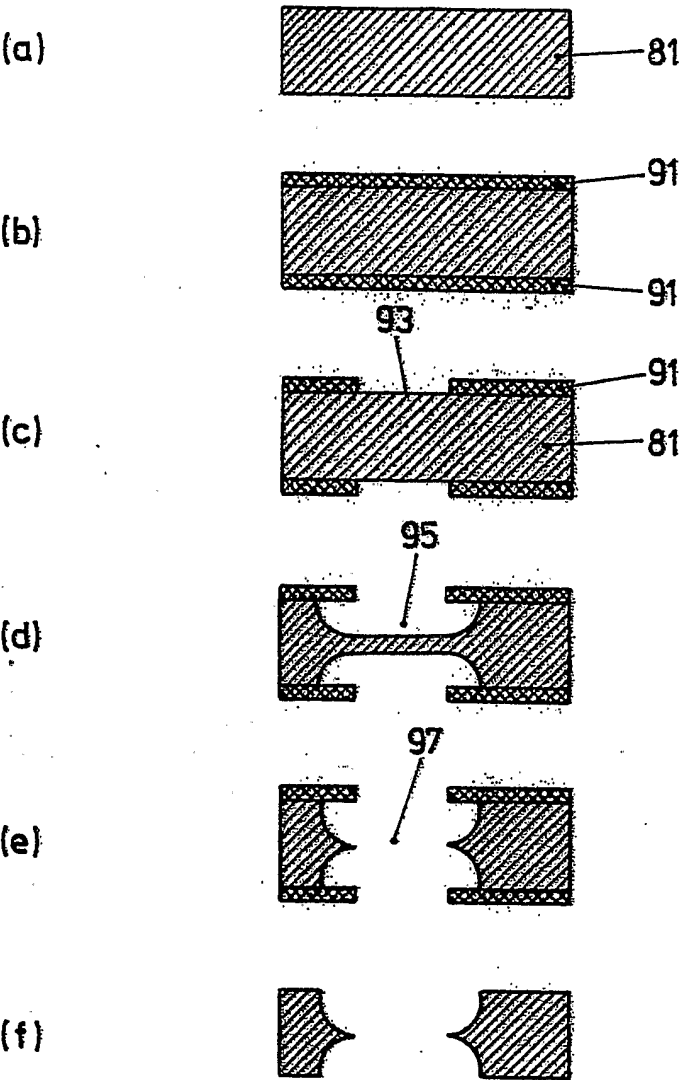


FIG.17