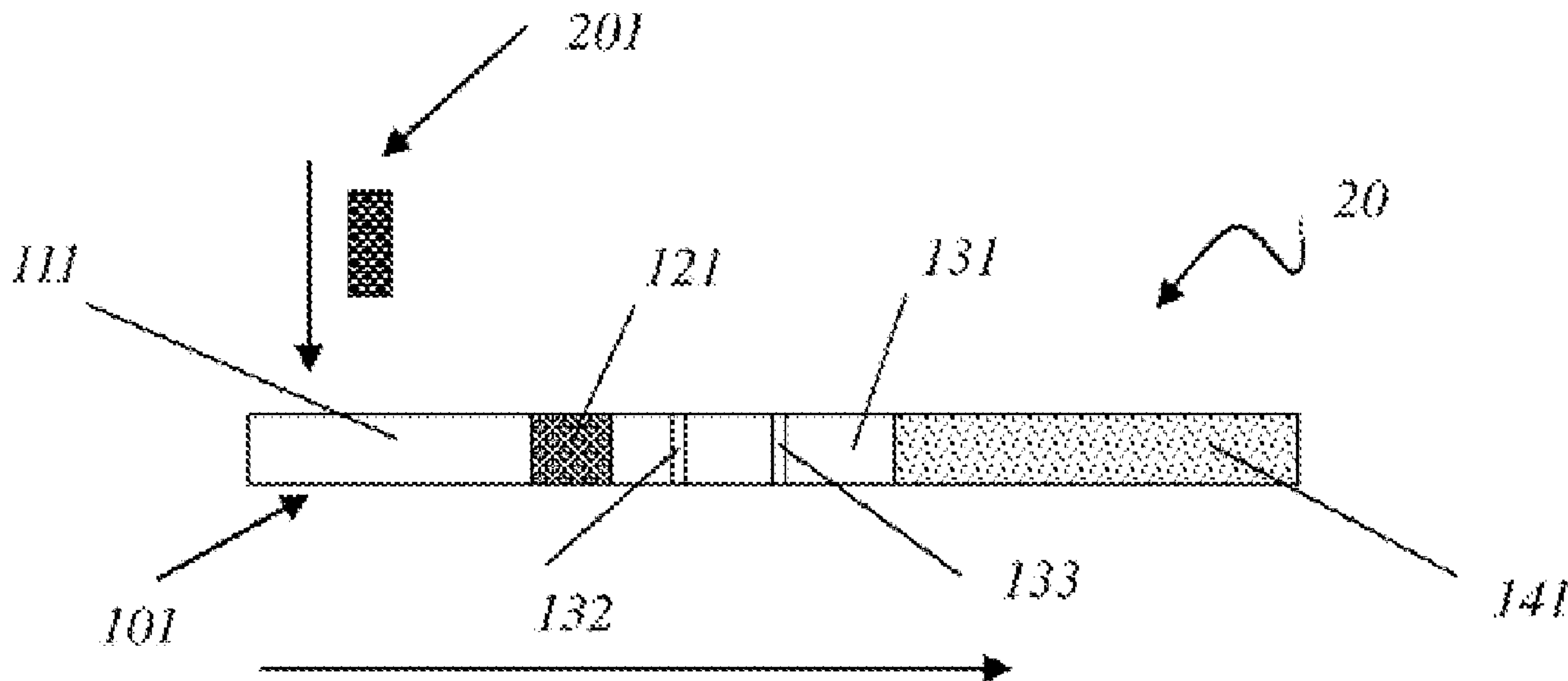




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 (54) Title: A TEST DEVICE FOR DETECTING AN ANALYTE IN A LIQUID SAMPLE



(57) **Abrégé/Abstract:**

A device for detecting fluid sample, a method and a kit are disclosed. The device includes a test piece (101) and the second reagent region (201). The test piece (101) comprises the first reagent region including a sample application region (111) and a label region, and a detection region (131). Specific molecules are immobilized in the detection region (131). The molecules include one of specific conjugates which is not specific to the analyte. The second reagent region (201) is placed at the upstream of the test piece (101), departs from the test piece (101) and is in fluid communication with the test piece (101). There is a specific molecule to the analyte in the second reagent region (201). After it is applied to the detection device, the sample will firstly react with the reagent in the second reagent region (201), then flow to the test piece (101) of the device to perform the reaction. The result can be obtained from the detection region (131) by naked eyes.

Abstract

[0074] The present invention relates to test devices, and in particular devices capable of detecting the presence or absence of an analyte in a sample, such as a liquid sample. Also provided are methods of using such devices for quantitative or qualitative measurement of one or more analytes in a liquid sample.

A TEST DEVICE FOR DETECTING AN ANALYTE IN A LIQUID SAMPLE

FIELD OF THE INVENTION

[0001] The present invention is directed to devices and methods for the detection of an analyte in a liquid sample.

BACKGROUND

[0002] Lateral flow devices have been described and utilized for detecting analyte(s) present in a test sample. An exemplary conventional lateral flow device is illustrated in Fig. 1C. The lateral flow test device 10 typically includes a reagent zone and a test zone 13. The reagent zone includes a sample receiving zone 11 and a label zone 12. The test zone 13 can contain a test result zone 132 and a control test result zone 133 located downstream of the test result zone 132. Typically, the sample receiving zone contains a porous sample receiving pad 111 and the label zone contains a conjugate pad 121, both of which constitute the reagent zone where all necessary assay reagents are contained therein. The test zone is typically in form of a test strip 131 with a test result zone 132 and a control test result zone 133 located downstream. A colorimetric readout appearing in the test result zone typically indicates the presence of the analyte being tested. The lateral flow device typically contains an absorbent pad 141, which is in fluid communication with the elements 11, 121, and 131 along the direction indicated by the arrow of Figure 1C. Conventional lateral device are made of nitrocellulose strip or nylon which are immobilized with binding agents that bind the analyte being tested. See, for example, the lateral flow test devices described in US 4857453;US 5073484;US 5119831;US 5185127;US 5275785;US 5416000;US 5504013;US 5602040;US 5622871;US 654162;US 5656503;US 5686315;US 5766961;US 5770460;US 5916815;US 5976895;US 6248598;US 6140136;US 6187269;US 6187598;US 6228660;US 6235241;US 6306642;US 6352862;US 6372515;US 6379620 and US 6403383.

[0003] Either competitive or non-competitive assays can be performed with the conventional lateral flow test devices for detecting the presence of an analyte in a liquid sample. However, such devices and methods are not particularly amenable to adjusting detection thresholds, which allow for a positive or negative signal to be produced at a predetermined analyte concentration. In addition, these devices and methods are not

particularly useful for measuring analytes at low concentrations with high degree of accuracy. When an analyte is present at very low concentration in a liquid sample, a buffer solution is required to extract the analyte from the sample, which can affect the result and create inconvenience and raise safety concerns to the person who is handling the assay. Therefore, there exists a need for testing devices that require minimum manual operation while ensuring accurate and reliable test results.

SUMMARY OF THE INVENTION

[0004] The present invention relates to test devices. A test device provided by the present invention includes a test element and a second reagent zone that can be separated from but also be in fluidic communication with the test element; wherein the test element includes a first reagent zone and a test zone. When using the test device, a liquid sample that is first applied to the second reagent zone flows to the first reagent zone and then to the test result zone. Using the test device not only increases the accuracy and/or sensitivity of the test, but avoids adding additional buffer solution into the liquid sample prior to applying the sample to the test device. An example of such buffer would be a buffer for extracting a small chemical from a liquid sample.

[0005] In one aspect of the present invention, a test device provided for detecting an analyte in a liquid sample comprises (1) a test element comprising a first reagent zone that is in fluid communication with a downstream test result zone, whereon a specific binding molecule is immobilized and; (2) a second reagent zone with a mobilizable dried binding moiety exhibiting for specific binding to the analyte, wherein the second reagent zone is in fluid communication with the test element and can be separate from the test element. When using the test device, the liquid sample is applied to the second reagent zone to form a liquid mixture and then allowed to flow to the detection zone of the test element, where a test result on the detection zone can be detected. Utilizing the devices and methods of the present invention can result in high detection sensitivity. In some embodiments, additional extraction solution or buffer solution is not added to the liquid sample prior to applying the liquid sample to the test device and/or after applying the liquid sample to the test device.

[0006] In some other embodiments, the devices and methods of the invention can be used to determine the presence or absence of an analyte in a sample using non-competitive binding. For example, the second zone can have a first mobilizeable binding moiety (Y1) that exhibits specific binding to a target analyte (A), wherein the first mobilizeable molecule can be conjugated with a first member (M1) of a specific binding pair (M1/M2) which is unrelated to the analyte; the first reagent zone can include a label zone with a detectable label (L) conjugated to a second mobilizable binding moiety (Y2) that exhibits specific binding to the target analyte; the detection zone can include a second member (M2) of the specific binding pair. The first member of the binding pair (M1) can bind to the second member of the binding pair (M2). When using the device, a liquid sample can be applied to the second reagent zone of the test device. If a target analyte is present in the liquid sample, the first mobilizeable binding moiety can bind the target analyte and form a complex (M1-Y1-A) that can be mobilized by the fluid sample from the second reagent zone into the label zone of the first reagent zone of the test element where a new complex is formed (M1-Y1-A-Y2-L). The new complex can reach to the detection zone where the detectable label can be captured by the second member of the binding pair (M2) to indicate that a target analyte is present in the liquid sample (a positive result). In preferred embodiments, the first reagent zone has a sample receiving zone that can be in fluidic communication with the label zone. The first reagent zone can receive the sample from the second reagent zone. If no target analyte present in the liquid sample, no detectable label is captured on the detection zone and a negative result is shown. Terms A, Y1, Y2, M1 and M2 are only used as to facilitate understanding of the present invention and do not limit the scope of the present invention. In other embodiments, when the analyte is an antibody, a first antigen having specific binding to the antibody is conjugated with a first member of a specific binding pair that is not relevant to the antibody. The antigen conjugated to the first member can be movably dried on the second reagent zone; a color label conjugated with a second antigen or binding moiety, exhibiting specific binding to the antibody, is movably dried on the label zone; and a second member of the specific binding pair is immobilized on the test result zone. In another embodiment, when the analyte is an antigen, a first antibody, conjugated with a first member of a specific binding pair that are not relevant to the antibody, specific

binding to the antigen, is moveable dried on the second reagent zone; a color label conjugated with a second antibody specific binding to the antigen is moveable dried on the label zone; a second member of the specific binding pair is immobilized on the test result zone. If the test sample contains the analyte being tested, the test zone will change color indicating a positive result. By contrast, there will be no color change if the analyte is absent and hence the result is negative.

[0007] Utilizing a competitive binding assay, in some embodiments, a specific binding molecule (Y1) for a target analyte is movably dried on the second reagent zone, wherein the molecule Y1 is conjugated with a first member M1 of a specific binding pair (M1/M2) that are not related to the target analyte; the label zone includes a detectable label (L) conjugated with an analyte mimic (A*) that can be moved by the liquid sample; and the second member M2 of the specific binding pair is immobilized on the test result zone. When using the test device, a liquid sample is applied to the test device as to contact to the second reagent zone first. If a target analyte is present in the liquid sample, then the analyte can be bound by the specific binding molecule as to form a complex (A-Y1-M1) that can be moved by the liquid flow to the label zone, which has element L-A*, and then the mixture, including the complex (A-Y1-M1), detectable label and the analyte mimic (L-A*), can be moved by the liquid sample to reach to the detection zone where a detectable label may not be captured. A negative result is detected on the test result zone. At the label zone, the complex (A-Y1-M1) can dissociate by competition with the labeled analyte mimic to form $A + Y1-M1 + L-A^*$ and then $A + L-A^*-Y1-M1$. The liquid sample containing the complexes flow to the test result zone, where the immobilized member (M2) on the test result zone captures the complexes by binding to M1 of the complex, allowing for determination of the test result. If no detectable label is captured at the test result zone, a positive result is detected, which indicates the presence of the analyte of interest in the sample. Conversely, a negative result indicates the absence of the analyte of interest in the sample.

[0008] In some preferred embodiments, the molecule dried on the second reagent zone is an antibody exhibiting specific binding to a target analyte, wherein the antibody is conjugated to a biotin molecule; the label zone of the test elements has a detectable label and an analyte mimic; and a streptavidin is immobilized on the test result zone. The

specific binding molecule pair (M1/M2) can be selected from one of these pairs: biotin/avidin, biotin/streptavidin, mouse IgG and anti-mouse IgG, rhodamine/anti-rhodamine, and antibody/antigen that not contain analyte antibody and analyte related.

[0009] In some other embodiments, a test device is provided for detecting an analyte in a liquid sample comprising (1) a test element including a first reagent zone that is in fluid communication with a detection zone, whereon a specific binding molecule is immobilized and; (2) a second reagent zone, in fluid communication with the test element and that is separate from the test element, where the second reagent zone has a moveably dried molecule exhibiting specific binding to an analyte; and wherein the second reagent zone can be contacted in a sample collection well that is a part of and in fluidic communication with a casing that also houses said test element. When detecting a target analyte in a liquid sample; the liquid sample is applied to the collection well as to contact to the second reagent zone first, then the liquid sample is moved to the test element contained within the casing. In a preferred embodiment, a specific binding molecule (Y1) having binding to the target analyte is movably dried on the second reagent zone, wherein the molecule Y1 is conjugated to a first member M1 of a specific binding pair (M1/M2), where M1 and M2 are not related to the target analyte and do not have specific binding to the target analyte; the label zone includes a detectable label (L) and a analyte mimic (A*) that can be moved by the liquid sample; and the second member M2 of the specific binding pair is immobilized on the test result zone.

[0010] Another aspect of the invention provides for a method for detecting an analyte in a liquid sample comprising providing a test device comprising a second reagent zone with a moveably dried molecule exhibiting specific binding to the analyte, where the second reagent zone is in fluid communication with a test element that comprises a first reagent zone, which is in fluid communication with a detection zone. The first reagent zone can comprise a label zone with a dried label. A specific binding molecule can be immobilized on the test result zone. The methods of the invention also provide for applying a liquid sample onto the second reagent zone, moving the liquid sample from the first reagent zone to the test result zone, and determining the test result based on the test result zone.

[0011] In another aspect of this present invention, a test kit is provided. The test kit includes a test device described above and a sample collector, the test device comprising a second reagent zone with a moveably dried molecule exhibiting specific binding to an analyte, where the reagent zone is in fluid communication with a test element that comprises a first reagent zone that is in fluid communication with a detection zone. The first reagent zone can comprise a label zone with a dried label and the rest result zone comprising a specific binding molecule that is immobilized. The second reagent zone can be separate from the test element.

INCORPORATION BY REFERENCE

[0012] All publications and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1A is a perspective view of a lateral flow device including a sample receiving pad 111, a label pad 121, test strip 131 and an absorbent pad 131 that are arranged on the back pad 151 in this order of the direction of the liquid flow.

[0014] Fig. 1B is a top view of a lateral flow device showing a test result zone 132 and a result control zone 131 on the test strip 131.

[0015] Fig. 1C is a perspective view of a lateral flow device showing a sample receiving zone 11, label zone 12, test result zone 13 and an absorbent zone 14 that are arranged in the direction of the liquid flow.

[0016] Fig. 2 is a perspective view of a test device.

[0017] Fig. 3A is an illustration of an embodiment of present invention before a liquid sample is applied to the second reagent zone.

[0018] Fig. 3B is an illustration of an embodiment of present invention showing a test result on the test result zone 13 after a liquid sample is applied to the second reagent zone if an analyte is present in the liquid sample.

[0019] Fig. 4A is an illustration of an embodiment of the present invention showing a test device before a liquid sample is applied to the second reagent zone.

- [0020] Fig. 4B is an illustration of an embodiment of present invention showing a test result on the test result zone 13 after a liquid sample is applied to the test device if an analyte is present in the liquid sample.
- [0021] Fig. 5A is an illustration of a test device.
- [0022] Fig. 5B is an illustration of the test device showing a test result on the test result zone after a liquid sample is applied to the second reagent zone of the test device, when an analyte is present in the liquid sample.
- [0023] Fig. 6 is a perspective view of a test device with a sample collection well 302 that is connected to a casing with a test element 10 therein, wherein a second reagent zone is configured to be within the sample collection well 601.
- [0024] Fig. 7A is a perspective view of the test device comprising a sample receiving well 302 with a second reagent zone on the porous member 2011.
- [0025] Fig. 7B is a perspective view of an unassembled sample receiving well and a porous member 2011.
- [0026] Fig. 7C is a perspective view of the sample receiving well that is attached to the porous member 2011 at a piece 3024.
- [0027] Fig. 7D is a perspective view of the sample receiving well that is attached to the porous member 2011 at a piece 3024.
- [0028] Figure 8 is a section view of the test device.
- [0029] Fig. 9 is a section view of the test device before applying a liquid sample to the sample receiving well.
- [0030] Fig. 10 is a section view of the test device after applying a liquid sample to the sample receiving well.

DETAILED DESCRIPTION

Definition

- [0031] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.
- [0032] "Assaying" denotes testing for or detecting the presence of a substance or material, such as, but not limited to, a chemical, an organic compound, an inorganic compound, a metabolic product, a drug or a drug metabolite, an organism or a metabolite of such an

organism, a nucleic acid, a protein, or a combination thereof. Optionally, assaying denotes measuring the amount of the substance or material. Assaying further denotes an immunological test, a chemical test, an enzymatic test, and the like.

[0033] "Sample" or "specimen" may be used interchangeably. "Sample" or "specimen" denotes any material to be assayed for the presence and/or concentration of an analyte in a sample or specimen, or to determine the presence and/or numbers of one or more components of a sample or specimen, or to make a qualitative assessment of a sample or specimen. A sample can be a fluid sample, such as a liquid sample. Examples of fluid samples that may be assayed include bodily fluids including but not limited to blood, serum, plasma, saliva, urine, ocular fluid, semen, and spinal fluid; water samples, such as samples of water from oceans, seas, lakes, rivers, and the like, or samples from home, municipal, or industrial water sources, runoff water or sewage samples; and food samples, such as milk or wine. Viscous liquid, semi-solid, or solid specimens may be used to create liquid solutions, eluates, suspensions, or extracts that can be samples. For example, throat or genital swabs may be suspended in a liquid solution to make a sample. Samples can include a combination of liquids, solids, gasses, or any combination thereof, as, for example a suspension of cells in a buffer or solution. Samples can comprise biological materials, such as cells, microbes, organelles, and biochemical complexes. Liquid samples can be made from solid, semisolid or highly viscous materials, such as soils, fecal matter, tissues, organs, biological fluids or other samples that are not fluid in nature. For example, these solid or semi-solid samples can be mixed with an appropriate solution, such as a buffer, such as a diluent or extraction buffer. The sample can be macerated, frozen and thawed, or otherwise extracted to form a fluid sample. Residual particulates can be removed or reduced using conventional methods, such as filtration or centrifugation.

[0034] "Upstream" and "downstream" refer to the liquid flows along the direction of the division. Upstream is located in the upper reaches of the liquid flow on the direction and downstream is located in the lower reaches of the liquid under the direction of flow. Upstream and downstream are a relative concept referring to the liquid from the upper reaches of the position to the lower reaches of the Flow downstream.

Test Elements

[0035] The test element can be lateral flow test strips, which are widely available for testing a broad range of analytes. However, any suitable test element can be used in the present invention.

[0036] A variety of test elements can be incorporated into the present invention. One type of test element is a test strip. Test strips are available in a variety of formats, such as immunoassay or chemical test format. The tests strips can be for detecting analytes of interest in a sample, such as a drug of abuse or a metabolite suggestive of health status. Test strips can also be configured for either noncompetitive or competitive assay format. In some formats, as illustrated in Fig. 1C, the test strips have a bibulous material having a first reagent zone that is upstream of a test result zone 13, which has a specific binding molecule. In a preferred embodiment, an absorbent zone 14 is downstream of the test result zone 13. All these zones are arranged in the direction of liquid flow. Certain amount of reagent for conducting the assay is treated on the sample receiving zone, such as a buffer solution to pre-treat the liquid sample. The label zone may have any detectable label, such as gold particles, latex particles or water-soluble dye, which can be conjugated to a specific binding molecule. The first reagent zone has a sample application zone 11, a label zone 12, and a test result zone. The sample is applied to the sample application zone and flows into the reagent zone by capillary action. In the reagent zone, the sample dissolves and mixes with reagents necessary for detection of the analyte (if present). The sample, now carrying the reagents, continues to flow to the test result zone. Additional reagents are immobilized in the test result zone, such as a specific binding molecule for the analyte. These reagents react with and bind to the analyte (if present) or one of the first reagents from the reagent zone. Labels for providing the detectable signal can be present in the reagent zone, or in a separate label zone.

[0037] Typically, in noncompetitive formats, a signal is produced if the sample contains the analyte, and no signal is produced if the analyte is not present. In competitive formats, a signal can be produced if no analyte is present and no signal if analyte is present.

[0038] When the test element is a test strip, it may be made of bibulous or non-bibulous material. A test strip can include more than one material, which are then in fluid communication. One material of a test strip may be overlaid on another material of the test strip, such as for example, filter paper overlaid on nitrocellulose. Alternatively or in

addition, a test strip may include a region comprising one or more materials followed by a region comprising one or more different materials. In this case, the regions are in fluid communication and may or may not partially overlap one another. The material or materials of the test strip can be bound to a support or solid surface such as a supporting sheet of plastic, to increase its handling strength.

[0039] In embodiments where the analyte is detected by a signal producing system, such as by one or more enzymes that specifically react with the analyte, one or more components of the signal producing system can be bound to the test result zone of the test strip material in the same manner as specific binding members are bound to the test strip material, as described above. Alternatively or in addition, components of the signal producing system, such as labeled reagents, that are included in the sample application zone, the reagent zone, or the test result zone of the test strip, or that are included throughout the test strip, may be impregnated into one or more materials of the test strip. This can be achieved either by surface application of solutions of such components or by immersion of the one or more test strip materials into solutions of such components. Following one or more applications or one or more immersions, the test strip material is dried. Alternatively or in addition, components of the signal producing system that are included in the sample application zone, the reagent zone, or the test result zone of the test strip, or that are included throughout the test strip, may be applied to the surface of one or more test strip materials of the test strip as was described for labeled reagents.

[0040] The zones can be arranged as follows: sample application zone, one or more reagent zones, one or more test result zones, one or more test result control zones, one or more adulteration zones, and one or more fluid absorbing zone. In some embodiments, the test results determination zone includes a control zone. All of these zones, or combinations thereof, can be provided in a single strip of a single material. Alternatively, the zones are made of different materials and are linked together in fluid communication. For example, the different zones can be in direct or indirect fluid communication. In this instance, the different zones can be joined end-to-end to be in fluid communication, overlapped to be in fluid communication, or be communicated by another member, such as a joining material, which is preferably bibulous such as filter paper, fiberglass or nitrocellulose. In using a joining material, a joining material may communicate fluid from end-to-end

joined zones or materials including such zones, end-to-end joined zones or materials including such zones that are not in fluid communication, or joined zones or materials that include such zones that are overlapped (such as but not limited to from top to bottom) but not in fluid communication.

The second reagent zone

[0041] As illustrated in Fig. 2, in an embodiment, the test device 20 can include a second reagent zone having a second reagent pad 201 that is in fluidic communication with and separated from a lateral flow test element 101 with a sample receiving pad 111, label pad 121, test strip 133 and an absorbent pad 141. These pads can be arranged in this order along the test strip in the direction of liquid sample flow. A test result zone 132 and a result control zone 33 can be located on the test strip 131.

[0042] In another embodiment, as illustrated in Fig. 3, the test device includes a second reagent zone and a test element with a sample receiving zone 11, label zone 12 and a test result zone 13. A first binding moiety (Y1) conjugated with a first member (M1) of a specific binding pair (M1/M2) that is not related to the analyte is moveably dried on the second reagent zone. The test element includes a sample receiving zone 11 downstream of the second reagent zone; a label zone 12 with a detectable label (L) and a second member (M2) of the specific binding pair; a test result zone 13 where a second binding moiety (Y2) is immobilized thereon; and wherein the first binding moiety and the second binding moiety can specifically bind the analyte in the liquid sample, as illustrated in Fig. 3A. When a liquid sample is applied to the second reagent zone of the test device, if the analyte (A) is present in the liquid sample, the analyte (A) can first be bound by the first binding moiety to form a first complex (A-Y1-M1) that can be moved by the liquid sample from the sample receiving zone to the label zone where a second complex will be formed (A-Y1-M1-M2-L) that will also be moved to the test result zone where the second complex will be captured by the immobilized second binding moiety Y2 and a positive result can be detected on the test result zone, as illustrated in Fig. 3B.

[0043] In another embodiment, as illustrated in Fig. 4, the test device includes a second reagent zone and a test element with a sample receiving zone 11, label zone 12 and a test result zone 13. A first binding moiety (Y1) conjugated with a first member (M1) of a specific binding pair (M1/M2) that is not related to the analyte is moveably dried on the

second reagent zone. The test element includes a sample receiving zone 11, at downstream of the second reagent zone; a label zone 12 with a detectable label (L) and a second binding moiety (Y2); a test result zone 13 where a second member (M2) is immobilized thereon; and wherein the first binding moiety and the second binding moiety can specifically bind the analyte in the liquid sample, as illustrated in Fig. 4A. When a liquid sample is applied to the second reagent zone of the test device, if the analyte (A) is present in the liquid sample, the analyte (A) will first be bound by the first binding moiety to form a first complex (A-Y1-M1) that will be moved by the liquid sample from the sample receiving zone to the label zone where a second complex will be formed (L-Y2-A-Y1-M1) that will also be moved to the test result zone where the second complex can be captured by the immobilized second member M2 and a positive result can be detected on the test result zone, as illustrated in Fig. 4B.

[0044] In another embodiment, illustrated in Fig. 5, a test device includes a second reagent zone with a first binding moiety (Y1) conjugated with a first member (M1) of a specific binding pair that are not related to the analyte in the liquid sample. The second reagent zone can be in fluidic communication with a test element that has a sample receiving zone 11, a label zone 12 with a detectable label (L) and an analyte mimic (A*), and a test result zone 13 where a second member (M2) is immobilized thereon. All these zones may be have this order of arrangement in the direction of the liquid flow, as illustrated in Fig. 5A. The amounts of the first molecule conjugated with the first member and the label conjugated with the analyte mimic can be adjusted. The adjustment can be based on a predetermined concentration C such that, e.g., in a drug abuse assay, when the concentration of an analyte is lower than a predetermined concentration C, the test result zone with a detectable label indicates a negative result (indicated by either presence or absence of a detectable label depending on the assay, e.g., if the assay utilizes competitive binding or not). When the concentration of an analyte is higher than a predetermined concentration C, the test result zone without a detectable label indicates a positive result (indicated by either presence or absence of a detectable label depending on the assay, e.g., if the assay utilizes competitive binding or not).

[0045] When a liquid sample is applied to the second reagent zone, if the concentration of analyte (A) is higher than the pre-determined value C, most of the first binding moiety

Y1 conjugated with the first member (M1) will bind to the analyte A to form a complex (A-Y1-M1). The complex with the remaining amount of the analyte (A) in the liquid sample, if any, will be moved with the liquid sample from the sample receiving zone to the label zone in which the label and the analyte mimic will competitively bind the first complex. Since most of the conjugate (Y1-M1) may be bound by the analyte, the label and the analyte mimic may not easily bind to the conjugate. When the liquid sample with the complex reaches the test result zone where the complex will be captured by the immobilized second member M2, a positive result will be detected via detecting the presence or absence of the label at the test result zone.

[0046] In contrast, if the concentration of the analyte is lower than the pre-determined value C, a part of the first binding moiety Y1 conjugated with the first member M1 will bind to the analyte A to form a complex (A-Y1-M1), and the remaining unbound first binding moiety Y1 conjugated with the first member M1 will flow with the complex to reach the label zone downstream of the second zone. At the label zone, the rest of the conjugate Y1-M1 will be bound by the analyte mimic that is conjugated with a detectable label to form a second complex L-A*-Y1-M1. Both of the complexes will be moved to the test result zone where the immobilized member M2 will capture the first member M1 of the complex with a label and the complex without any label. A negative result is determined by detecting the presence or absence of label on the test result, as illustrated in Fig. 5B.

[0047] With reference to figures 6, 7 and 8, another embodiment of the invention is shown having a casing 304 and a sample collection well 601. The test element 10 inside the casing 304 and the second reagent region 201 located in the sample collection well 601 are in fluid communication, meaning that the fluid from the sample collection well 601 can flow to the test element 10. This kind of fluid communication can be due to gravity, a fluid conducting structure between the sample collection well 601 and the test element 10 configured to make the liquid flow from the sample collector well to the test element. With reference to figure 8 in detail, the casing 304 has a result reading window 3041 which is opposite to the test result zone of test element 10 and a sample port 306, which comprises two sample leading ports 306-1 and 306-3. When the sample fluid is flowing from the sample leading port 306-1 and reaches the sample receiving zone of the test element 10, the analysis test can be finished.

[0048] In certain embodiments, the sample collection well 601 can include a first collection chamber 302 and a second collection chamber 303. The first collection chamber is composed of two opening ends: one opening end is for receiving a liquid sample or a sample, and another opening end has fluid passage holes 302-1, 302-1 or 302-3 as illustrated in Fig.7A-7D. An erect balk 3024 is located opposite to one of the fluid passage holes, such as 302-1. One end of the erect balk 3024 can be fixed on the outer wall of the first collection chamber 302; the opposite end of the balk can be extended through one of the fluid passage holes, such as 302-1. The second reagent region 201 comprises a porous strip 2011 with two ends 2013 and 2012. The strip can be fixed or contacted onto the surface of the balk as to make the end of the strip extend to the bottom of the second collection chamber 303 through the hole 302-1. Another side of the strip 2011 called the test portion 2013 can be extended through the fluid passing passage 320-1 and reach to the bottom of the second sample collection chamber 303. The strip 2011 with special substance like protein treatment can be made of fibrous material, such as fiberglass, filter paper or cellulose fiber and so on. With the reference of figure 9, the second reagent region 201 may exist in other formats in the sample collection well 601. For example, the strip 2011 can be directly placed on the bottom of the second sample collection chamber 302. In some other embodiments, the strip 2011 can be deposited on an isolated position formed by the first collection chamber 302 and the second collection chamber 303. The main purpose for this arrangement of the second reagent zone is so that it can be in fluid communication with the liquid sample in the collection well 601. The strip 2011 can be designed such that it is either fully or partially in contact with the liquid sample. In addition, the method of placing material on the second reagent region can be varied, e.g., the second reagent region can be directly treated, sprayed or dabbed. In these above embodiments, a molecule or binding moiety having specific binding to an analyte is moveably dried on the second reagent zone, similar to the porous strip 2011. The binding moiety can be conjugated with a first member of (M1) a specific binding pair (M1/M2) that is not related to the analyte. Additionally, the second reagent zone can further comprise other reagents or buffers for conducting the assay.

[0049] With the reference to figure 8, 9 and 10, the sample collection well 601 is connected with the reservoir 304 and come whole by a block ring 306-2 of the sample leading port

306. The second collection chamber 303 provides many liquid passage holes 303-1, 303-2 and 303-3, which are fixed with sealing rings 305-1, 305-2 and 305-3 at one end. In detail, the sample collection well 601 is situated in the sample leading port 306 on the top portion 3043 of the casing. The sample port 306 is integral to the top portion 3043 of the casing and has a guide slot cut therein parallel to the upper rim of the sample port 306. The second collection chamber 303 has a one guide pin extending from its exterior surface through the guide slot of the reservoir 304. Two or more guide slots and guide pins can be located on the reservoir 304 and the second collection chamber 303. The second collection chamber 303 and sample port 306 are adapted so that the second chamber can be rotated in the reservoir 304. A test device with a collection well can be found in other published applications, such as published application No. 2005/0180882A1.

[0050] This invention provides an example of drug abuse testing in a saliva sample. With the reference to figure 9, this figure shows the phase of sample collecting before assaying. The first collection chamber 302 is located in the second collection chamber 303. The liquid passage holes 303-1, 303-2 and 303-3 of the second collection chamber 303 are sealed with against bottom plate 306-4 of the sample leading region 306, instead being in fluidic communication with the sample leading ports 306-1, 306-3 of the sample leading region 306. Enhancing the sealing capability between the said two parts, other sealing rings 305-1, 305-2 and 305-3 can be fixed on a corresponding position of the passages for fluidic communication.

[0051] As illustrated in Figs. 6-10, when using the test device for detecting an analyte in a liquid sample, the steps are as follows: first, place the absorbent member 3012 of the sample collector 301 in the mouth of a test subject to absorb sufficient saliva from the mouth; insert the absorbent member 3012 into the first collection chamber 302 of the sample collection well 601 and compress the absorbent member to extract the sample from the absorbent member into the first chamber 302. The extracted sample will flow into the second collection chamber 303 through the sample passage holes 302-1, 302-2, and 302-3. In the second collection chamber 303, the reagent on the strip 2011 can contact the liquid sample for a period of time. In the cross-sectional view, it can be seen that when the sample collection well 601 is in the first position, the outlets of the first

collection chamber 302 and the inlets of the second collection chamber 303 are aligned, forming a passage for fluid communication in the lower chamber of the sample collection well. The strip 2011 can then be in fluid contact and react with the saliva sample. After a suitable reaction time, such as 10 s, 20 s, 30 s, 1 min, 2 min, 3 min, 4 min, 5 min, 6 min, 7 min, 8 min, 9 min, 10 min, 15 min, 20 min, 30 min, 45 min, or 60 min the sample collection well 601 can be rotated to a second position. In this second position, the liquid passing passage 303-1 is in communication with the sample leading port 306-1. Similarly, the liquid passing passage 303-3 is communicating with the sample leading port 306-3. Thus, fluid remaining in the lower chamber of the sample collection well 601 flows into the test compartment and contacts with the test element 10. When the sample fluid comes into contact with the test element 10, the fluid is absorbed by the test element 10 and the test element assay begins. Assay times may vary depending on the sample consistency or viscosity and the test element used. If the sample contains any drug molecule, a positive result may be determined by a lack of a line in the test result zone of the test element 10. If a drug molecule is not present in the sample, a negative test result can be observed through the window 3041 of the casing 304, which can be uncovered or covered by a transparent material. This invention illustrates another (and optional) step of using the device, capping the device. The saliva sample may also be directed to flow into a confirmation chamber 307 via the sample leading port 306-3, for further confirmation of the saliva sample tested. Cap 308 is placed on top of the sample collection well 601. The reservoir may still be sealed. The device may now be shipped to another location for confirmation testing. For confirmation testing, the orifice seal 3072 can be removed or broken and an aliquot of sample can be removed from the reservoir via the orifice 3073. The confirmation chamber can be formed from a bottom 3071 and sidewalls. The abovementioned saliva testing is an example to illustrate how the present invention can be used. Besides saliva testing, the present invention can also be used in many other applications including but not limited to whole blood testing, urine testing, and fecal testing.

[0052] In other embodiments, the second reagent zone may not be in the same device with the test element, and can be in another collection well that is separate from the casing. As disclosed in this present invention, the strip 2011 contains Y1 and M1, and the test

element contains M2. For example, the second reagent zone 201 can be located in a test tube that is used to receive a liquid sample. After the reagents on the second reagent zone 201 react with the sample, the mixture can be added onto the test element for conducting the assay. Sample collection devices are disclosed in the US Patents Nos. 6780160, 7048693, 5234001, 5830154, 5786427, 5573099, and US Patent Publication No. US 2001/0008614, and PCT Publication No. WO2005008216.

Test devices of the invention

[0053] A test device described herein can be used for detecting one or more analytes in a sample. While preferable embodiments of the invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. The devices and/or methods of the invention can be employed individually or combined with other devices, methods, and/or systems in manners known to those skilled in the arts for detection of one or more analytes in a sample.

[0054] The present invention relates to a test device, such as test for determining drugs of abuse in biological samples. As used in the specification and claims, the singular forms “a”, “an” and “the” include plural references unless the context clearly dictates otherwise. The test device of the present invention includes a test element and a second reagent zone that is separate from and in fluidic communication with the test element; wherein the test element includes a first reagent zone and a test result zone. When using the test device, a liquid sample can be applied to the second reagent zone, then flow to the first reagent zone, and then the test result zone.

The Analyte

[0055] In some embodiments, the analyte can be a drug of abuse. The term “drug of abuse” (DOA) refers to a drug that is taken for non-medicinal reasons (which can be for mind-altering effects). The abuse of such drugs can lead to physical and mental damage and (with some substances) dependence, addiction and/or death. Examples of DOAs include but are not limited to cocaine; amphetamines (e.g., black beauties, white bennies, dextroamphetamines, dexies, beans); methamphetamines (crank, meth, crystal, speed); barbiturates (Valium®, Roche Pharmaceuticals, Nutley, New Jersey); sedatives (i.e. sleep-aids); lysergic acid diethylamide (LSD); depressants (downers, goofballs, barbs, blue devils, yellow jackets, ludes); tricyclic antidepressants (TCA, e.g., imipramine,

amitriptyline and doxepin); phencyclidine (PCP); tetrahydrocannabinol (THC, pot, dope, hash, weed, etc.); and opiates (e.g., morphine, opium, codeine, heroin, oxycodone).

Legal drugs that are taken for medical reasons, but for which overdose can easily occur may also be tested for using these strips, for example, tricyclic antidepressants (imipramine and the like) and over the counter products containing acetaminophen.

Analyte mimic

[0056] As an alternative to a drug or drug metabolite, analyte mimic A* may be an analyte analogue that is capable of forming a complex with an antibody that also forms a complex with the analyte. For example, analyte mimic may be a fragment of an analyte, the fragment retaining an epitope of the analyte. The label can be linked with a linker that links the label and the analyte mimic. Typically, a linker has a binding site that is not present on the analyte, analyte mimic (A*) or label (L). For example, the binding site may be an epitope capable of being recognized by an antibody that does not recognize either the analyte, analyte mimic or the label. In some embodiments, the linker is capable of being recognized by antibodies that also do not recognize the binding sites of other linkers that may be present. Examples of such linkers include but are not limited to bovine serum albumin (BSA), keyhole limpet hemocyanin conjugate (KLH), and bovine benzoyllecgonine (BBG), bovine thyroglobulin (BTG), hen egg-white lysozyme (HEL), ovalbumin (OVA), sperm whale myoglobin (SWM), tetanus toxoid (TT), methylated bovine serum albumin (mBSA), Rabbit Serum Albumin (RSA).

EXAMPLES

BZO testing in saliva sample

Part one, test elements and devices assembly

[0057] With reference to figures 2, 6, and 7, the present invention illustrates the method of assembling the test devices.

NC membrane

[0058] Two lines, a test line and a control line, can be formed on a NC or nitrocellulose membrane so that the membrane can be used as a test pad. The test line is formed by coating the membrane with IgG and streptavidin- IgG solution. The control line is formed by coating the membrane with Goat Anti-Rabbit IgG solution. Both of the fixing

treatments are performed by an automatic spray machine. The concentrations of the reagents of both the test line and the control line is 0.3 mg/ml. The buffer is PBS buffer.

After coating, the NC membrane is dried in a 37°C oven.

Conjugate pad

[0059] The conjugate pad can be made of polyester membrane. BZO hapten antigen linked with BSA and gold colloid and Rabbit IgG antibody with gold colloid are placed on the polyester membrane. The optical density (OD) of the reagent solution is 75, 1x PBS with 1% BSA as a diluent. After reagent treatment, the treated polyester membrane is dried in a 37°C oven.

Sample receiving pad

[0060] Sample receiving pad can be made of glass fiber. The reagents on the sample receiving pad are: Borax (0.07M/L), Tween20 (1%), Cholic Acid (1%), Tris (0.1M). After reagent treatment, the treated glass fiber is dried in the 37°C oven.

Test element assembly

[0061] With reference to figure 2, parts of the test element can be assembled as shown. In detail, the sample receiving pad is upstream of the conjugate pad, the conjugate pad is located between the samples receiving pad and the test pad, and the absorption pad is located below the test pad. All the pads are supported by a non-bibulous piece.

The second reagent region

[0062] This second reagent region contains a strip 2011, which consists of a non-bibulous affix portion 2012 and a bibulous test portion 2013. The reagents, which are treated on the polyester membrane contain: anti-BZO antibody conjugated with Biotin, 1x PBS and 1% BSA, and the reagents then form a terminal solution with a concentration of 0.15 mg/ml. This piece of polyester membrane is then dried in a 37°C oven. Finally, the affix portion 2012 is connected together with the test portion 2013.

Device assembly

[0063]. With reference to figures 6, 7 and 9, the affixing portion 2012 of the strip 2011 is adhered to the erect balk 3022 of the first sample collection chamber 302. The test portion extends through the liquid hole 302-1 and reaches the bottom of the second

sample collection chamber 303. With reference to figure 9, the sample collection well 601 is fixed on the block ring 306-2 of the sample leading region 306, which is located in the sample port 306. The bottom of the sleeve is located on bottom plate 306-4 of the sample leading region 306. The test element is deposited between the upper portion of the casing 3043 and the lower portion of the casing 3045. The test line of the test element 10 is positioned relative to the result reading window; and the sample receiving region is positioned relative to the sample leading port 306-1. Assembly of the test device may be completed when the upper portion of the casing 3043 and the lower portion of the casing 3035 are attached to each other.

Part Two: strip and device assembly comparison

[0064] In contrast with the above mentioned strip, the conjugate pad of the comparison strip is treated with anti-BZO antibody. The optical density (OD) of the reagent solution is 75, 1x PBS with 1% BSA as the diluent. After treatment with reagent, the conjugate pad of the comparison strip can be dried in a 37°C oven.

[0065] The test membrane is treated with BZO hapten at the concentration of 0.3 mg/ml. The optical density (OD) of the reagent used is 75 OD, 1x PBS with 1% BSA as the diluent buffer. After the reagent treatment, the treated polyester membrane can be dried in a 37°C oven.

[0066] The saliva sample is mixed with BZO at a concentration of 5ng/ml, 7.5 ng/ml (cut-off), 10 ng/ml, 12.5 ng/ml, 15 ng/ml, or 30 ng/ml. All the detection results are read after 10 minutes. The cut-off value determines when a result should be read as positive. For example if the concentration of the analyte is higher than the cut-off concentration, the result should be positive; whereas if the concentration of the analyte is lower than the cut-off concentration, the result should be negative.

Assay operation for the test device

[0067] First, all the devices may be positioned as illustrated in figure 9. As shown in figure 9, the bottom of the second sample collection chamber 303 of the sample collection well 601 is sealed against the bottom plate 306-4.

[0068] Second, the sample is added to the sample collector and the sample specimen is allowed to react with the reagent contained in the second reagent zone of the sample collector for one minute.

[0069] The sample collection well 601 is rotated and the saliva sample flows from the sample collection well to the sample receiving zone of the test strip and complete the reaction.

[0070] The results are recorded after 10 minutes.

[0071] The results from using a conventional device are shown in Table 1.

TABLE 1

BZO Sample	Treatments			Result						Real result			Detection Ratio		
				Negative			Positive								
	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3
Negative sample	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
5ng/ml	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
7.5ng/ml	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
10ng/ml (Cut off)	10	10	10	<u>9</u>	<u>10</u>	<u>10</u>	<u>1</u>	<u>0</u>	<u>0</u>	N/A	N/A	N/A	N/A	N/A	N/A
12.5ng/ml	10	10	10	<u>9</u>	<u>9</u>	<u>10</u>	<u>1</u>	<u>1</u>	<u>0</u>	1	1	0	10%	10%	0
15ng/ml	10	10	10	<u>8</u>	<u>9</u>	<u>10</u>	<u>2</u>	<u>1</u>	<u>0</u>	2	1	0	20%	10%	0
30ng/ml	10	10	10	<u>8</u>	<u>9</u>	<u>9</u>	<u>2</u>	<u>1</u>	<u>1</u>	2	1	1	20%	10%	10%

[0072] Test results using the devices and methods of the invention are shown in Table 2.

TABLE 2

BZO sample	Treatments			Result						Real result			Detection Ratio		
				Negative			Positive								
	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3	Lot #1	Lot #2	Lot #3
Negative sample	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
50 ng/ml	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
7.5ng/ml	10	10	10	10	10	10	0	0	0	10	10	10	100%	100%	100%
10ng/ml (Cut off)	10	10	10	<u>5</u>	<u>5</u>	<u>6</u>	<u>5</u>	<u>5</u>	<u>4</u>	N/A	N/A	N/A	N/A	N/A	N/A
12.5ng/ml	10	10	10	<u>3</u>	<u>3</u>	<u>4</u>	<u>7</u>	<u>7</u>	<u>6</u>	7	7	6	70%	70%	60%
15ng/ml	10	10	10	<u>2</u>	<u>2</u>	<u>2</u>	<u>8</u>	<u>8</u>	<u>8</u>	8	8	8	80%	80%	80%
30ng/ml	10	10	10	<u>0</u>	<u>1</u>	<u>0</u>	<u>10</u>	<u>9</u>	<u>10</u>	10	9	10	100%	90%	100%

Result and Discussion

[0073] In some aspects, the present invention provides a device and a method for detecting a low concentration of analyte in a sample fluid with high sensitivity. The device and methods of the present invention retain the specificity for detecting an analyte in a sample fluid. To compare, for example, when the BZO concentration is as low as about 12.5 ng/ml, the known detection methods generally lead to 28 negative and only 2 positive results. The detection ratio is about 10%. However, the methods and devices disclosed in the present invention may give 20 positive results and 10 negative results. The detection ratio of the present invention is about 60%-70%. In another example, when the BZO concentrations are 12.5 and 15 ng/mL, the detection ratio of the known existing device is about 10%-20%. However, the detection ratio of the device of the present invention may be about 80%-100%, much greater than that of the current devices. In addition, 30 known negative samples have been tested using the device of the present invention, and it did not give any positive results, indicating that the device of the present invention does not adversely change the specificity for detecting an analyte in a liquid sample and, as well, the results for negative samples are not affected.

CLAIMS

What is claimed is:

1. A test device for detecting an analyte in a liquid sample, comprising: a test element comprising a first reagent zone located upstream of a test result zone where a specific binding molecule is immobilized thereon, wherein the first reagent zone is in fluid communication with a detection zone;
a second reagent zone located upstream of said first reagent zone and being in fluid communication with the first reagent zone where an analyte specific binding molecule is movable thereon.
2. The device of claim 1, wherein the second reagent zone is separated from the first reagent zone.
3. The device of claim 2, wherein the first reagent zone comprises a label area with a detectable label and an analyte mimic.
4. The device of claim 1, wherein the second zone further comprises a first member of a specific binding molecule pair that is unrelated to the analyte; and wherein the specific binding molecule on the test result zone specifically binds the second member of the specific binding molecule pair.
5. The device of claim 4, wherein the first member of the specific binding molecule pair is conjugated with the specific binding molecule for the analyte.
6. The device of claim 4, wherein the analyte specific binding molecule comprises an antibody.
7. The device of claim 1, wherein the analyte comprises a drug abuse chemical.
8. The device of claim 7, wherein the drug abuse chemical is THC or BZO.
9. The device of claim 2, wherein the second zone further comprises a first of a specific binding molecule pair that is unrelated to the analyte and wherein the reagent zone further comprises a label zone with a detectable label conjugated with the second of the specific binding molecule pair.
10. The device of claim 4 or 9, wherein the specific binding molecule pair is selected from one of these pairs: biotin/avidin, biotin/streptavidin, or mouse IgG and anti-mouse IgG.

11. The device of claim 4 or 9, wherein the detectable label comprises a color particle or a water-soluble dye.
12. The device of claim 1, wherein the device further comprises a house with the first reagent zone and the detection zone therein and a liquid sample container with the second reagent therein; and wherein the house and the liquid sample are in fluid communication.
13. The device of claim 1, wherein the liquid sample container is contacted with the house such that the liquid sample can flow from the container into the house.
14. The device of claim 1, wherein the first reagent zone and the detection zone are located on first porous membrane; and wherein the second reagent zone is located on a second porous membrane that is separated from the first porous membrane.
15. A method for detecting an analyte in a liquid sample comprising:
 - applying a liquid sample onto a second reagent zone of the test device of claim 1;
 - allowing the liquid sample to flow into a first reagent zone located upstream of a detection zone with an immobilized specific binding molecule thereon, wherein said first reagent zone comprises a detectable label; wherein a specific binding molecule for an analyte is movable dried on the second reagent zone that is separated from and in fluid communication with the first reagent zone;
 - detecting the test results on the detection zone.
16. The method of claim 15, wherein the first reagent zone comprises a label zone with a detectable label and an analyte mimic.
17. The method of claim 16, wherein the second reagent zone further comprises a first of a specific binding molecule pair that is not related to the analyte and the immobilized specific binding molecule comprises the second of the specific binding molecule pair.
18. The method of claim 16, wherein the second reagent zone is located on a second porous membrane and the first reagent zone and the detection zone are located on a first porous membrane.
19. The method of claim 18, wherein the second porous member is attached in a sample container that is connected with a house with the second porous membrane; and wherein the sample container is in fluid communication with the house.
20. The method of claim 19, the sample container is at upstream of the house.

21. The method of claim 17, wherein said specific binding molecule pair is selected from one of these pairs: biotin/avidin, biotin/streptavidin, or mouse IgG and anti-mouse IgG.
22. The method of claim 15, wherein the analyte comprises drug abuse chemicals.
23. The method of claim 15 further comprises incubating the liquid sample on the second reagent zone for a period of time after applying the liquid sample onto the second reagent zone.
24. The method of claim 23, wherein the time is from 1-30 minutes.

Drawings

Fig. 1A

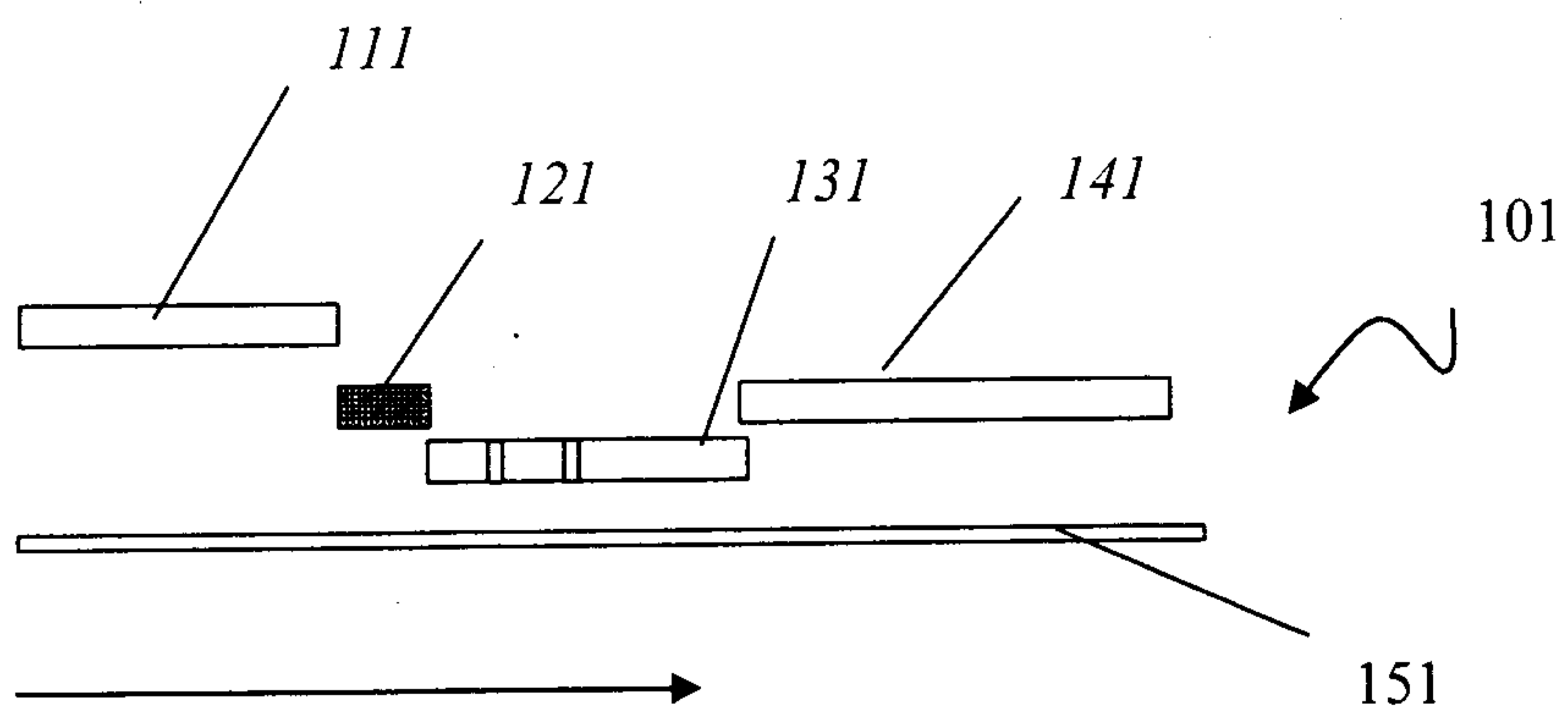


Fig. 1B

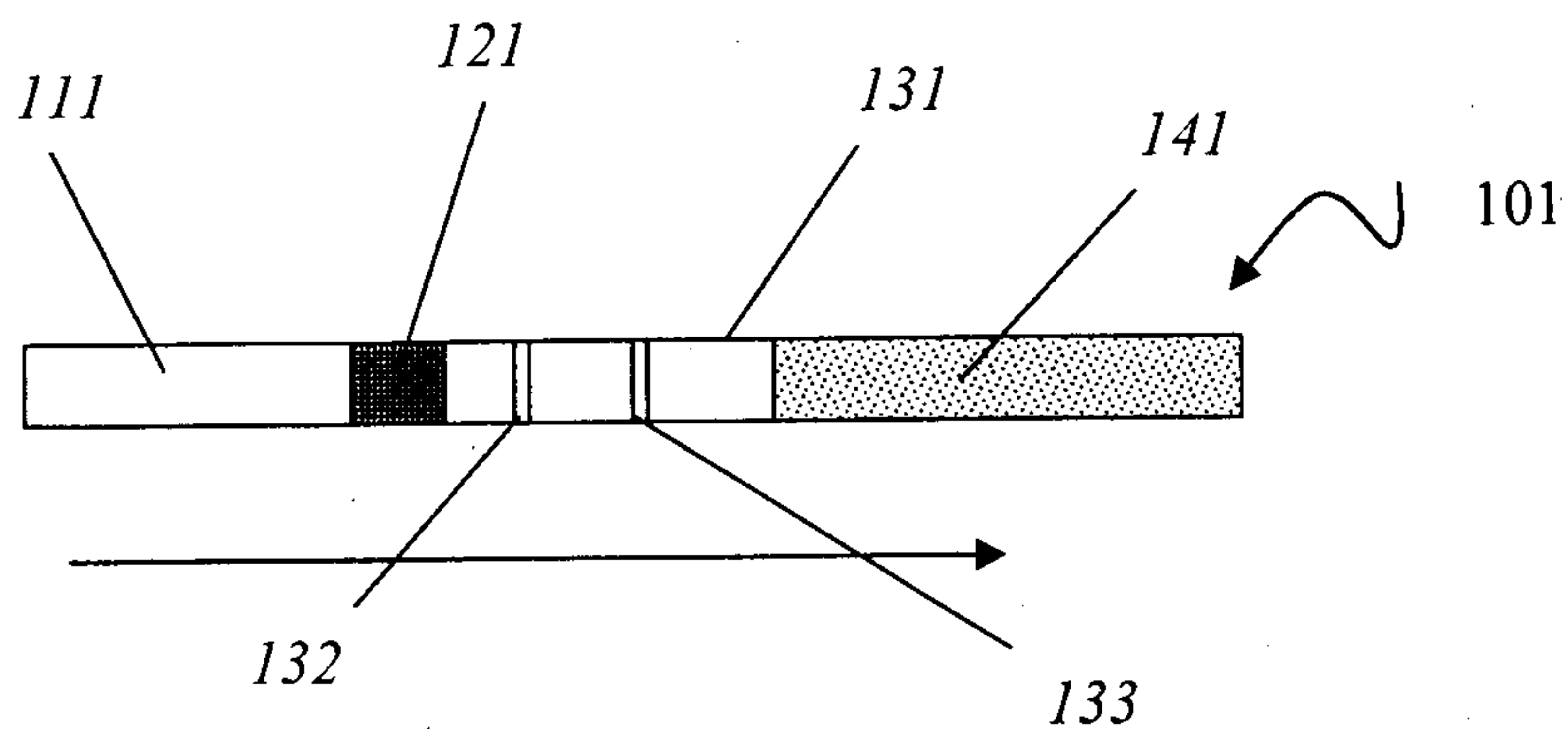


Fig. 1C

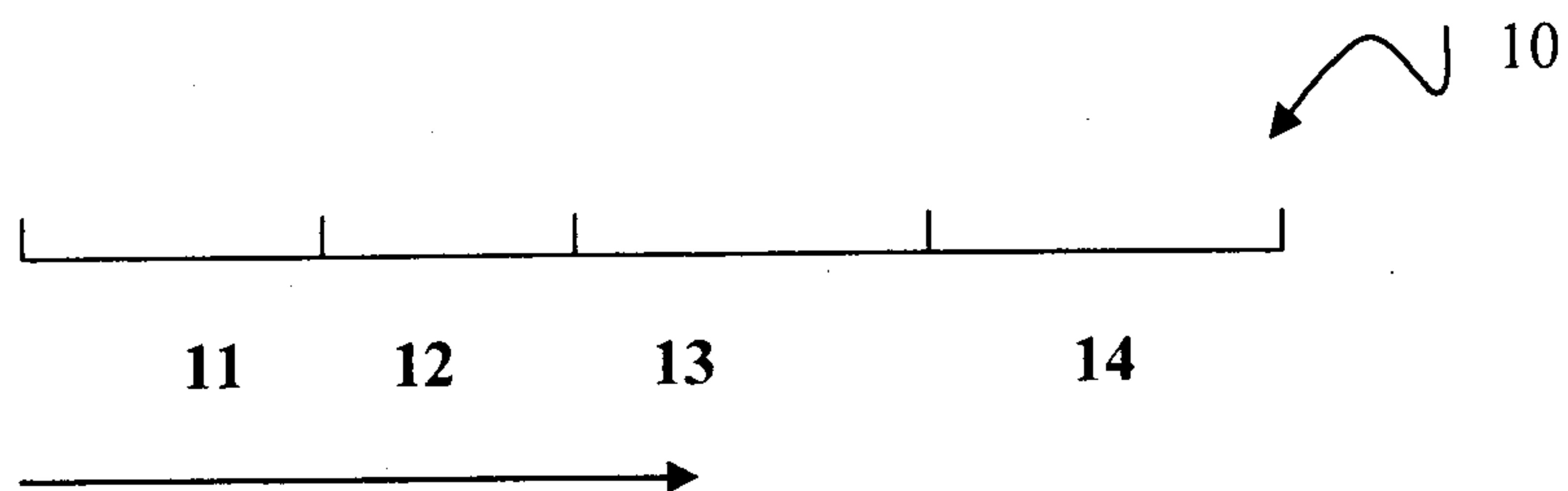


Fig. 2

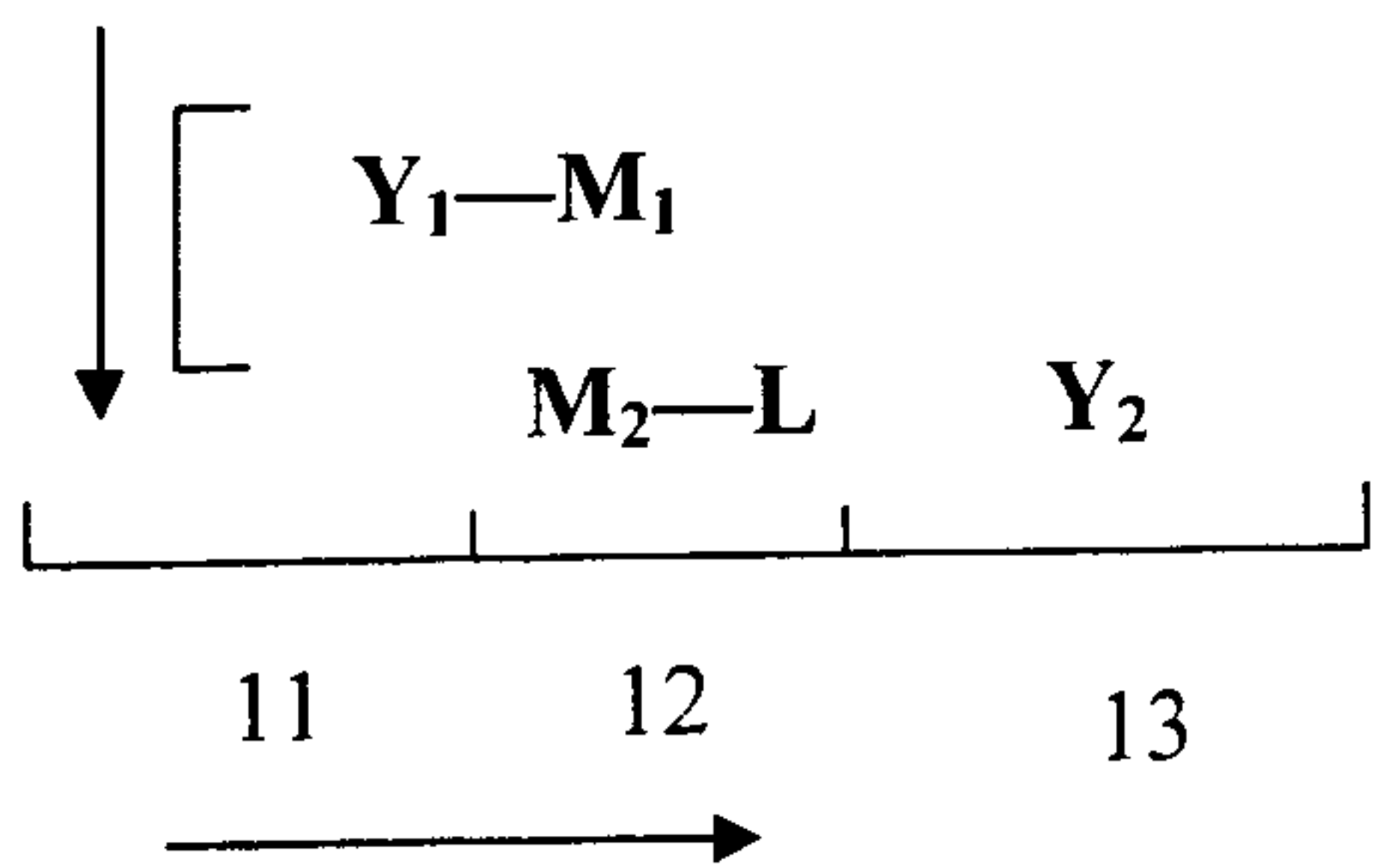
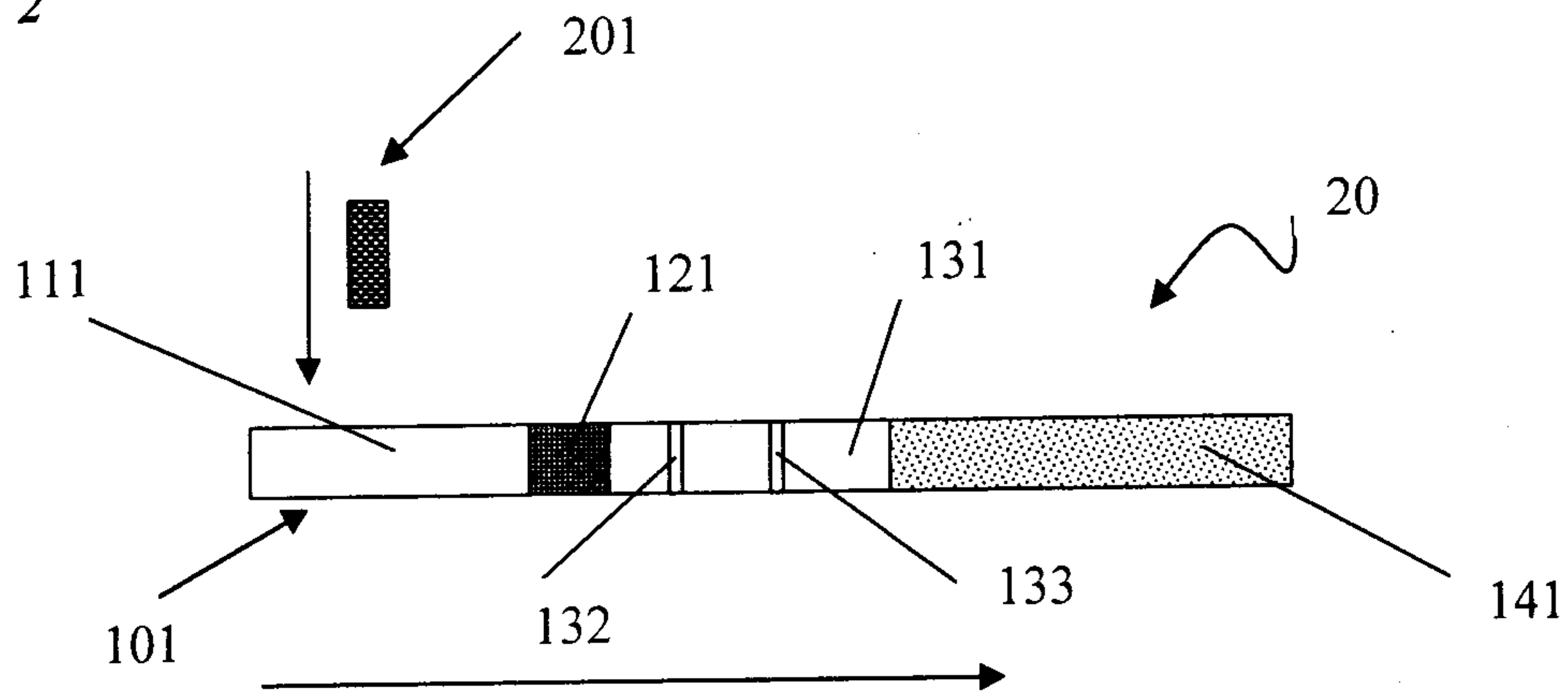


Fig. 3A

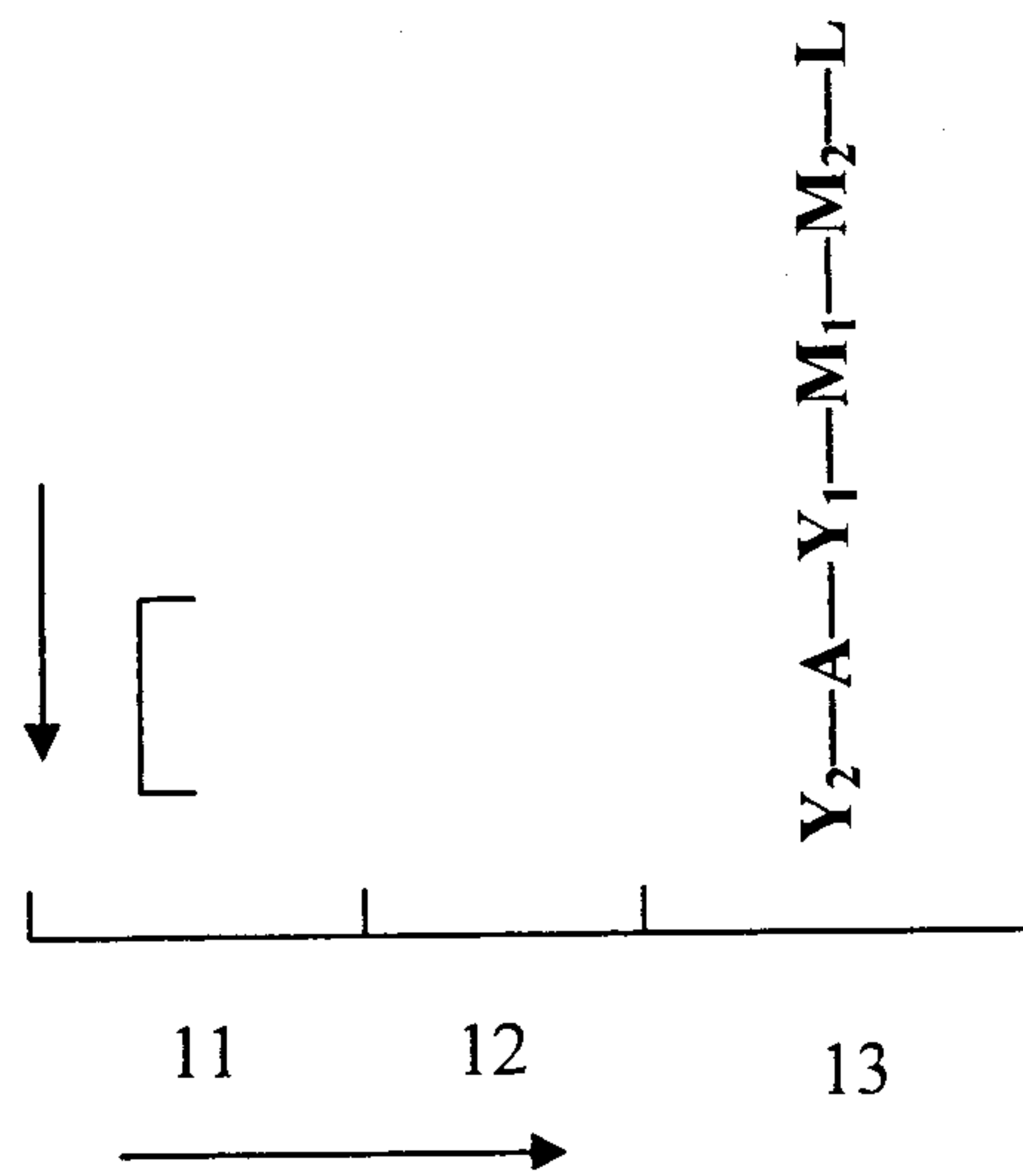


Fig. 3B

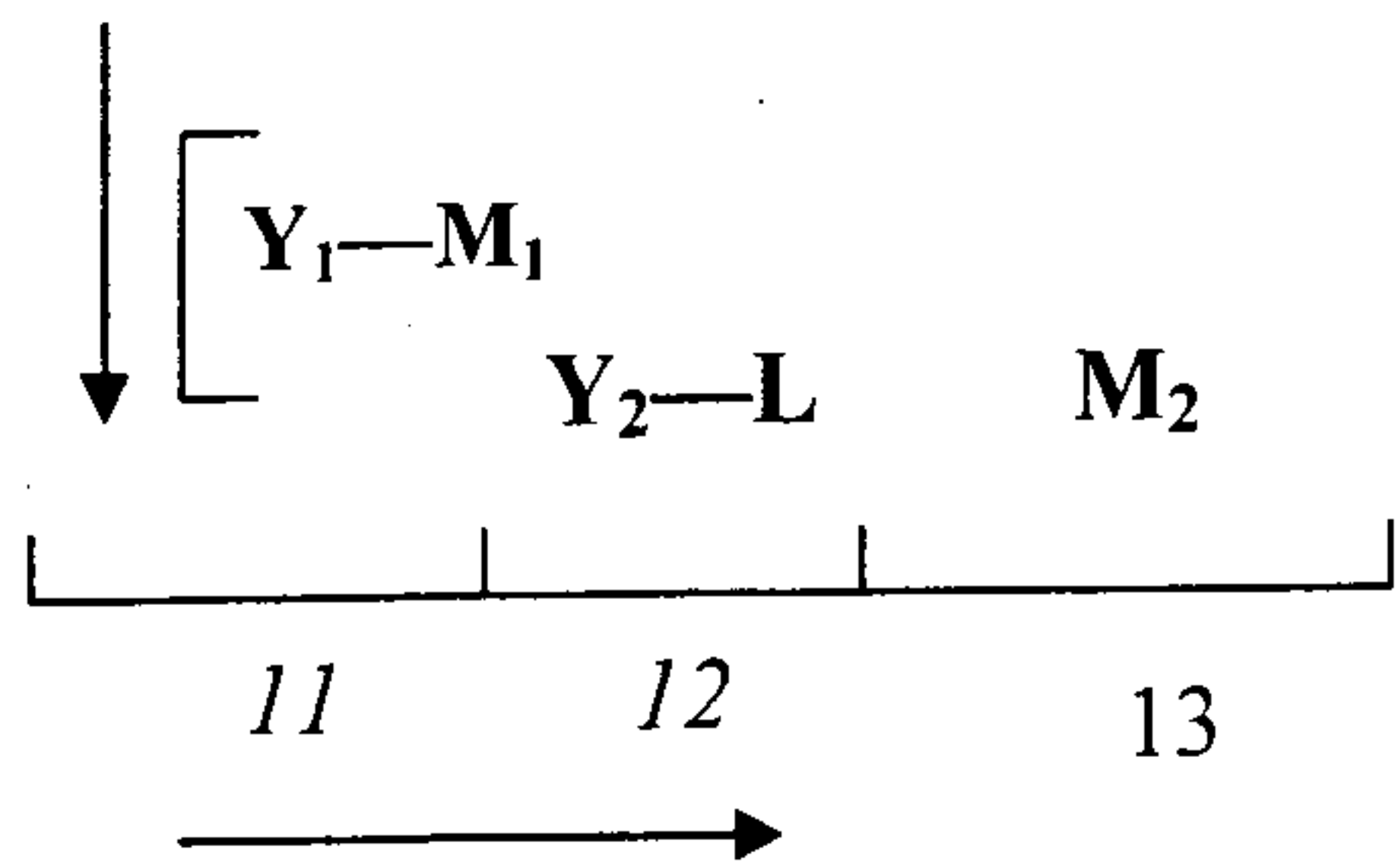


Fig. 4A

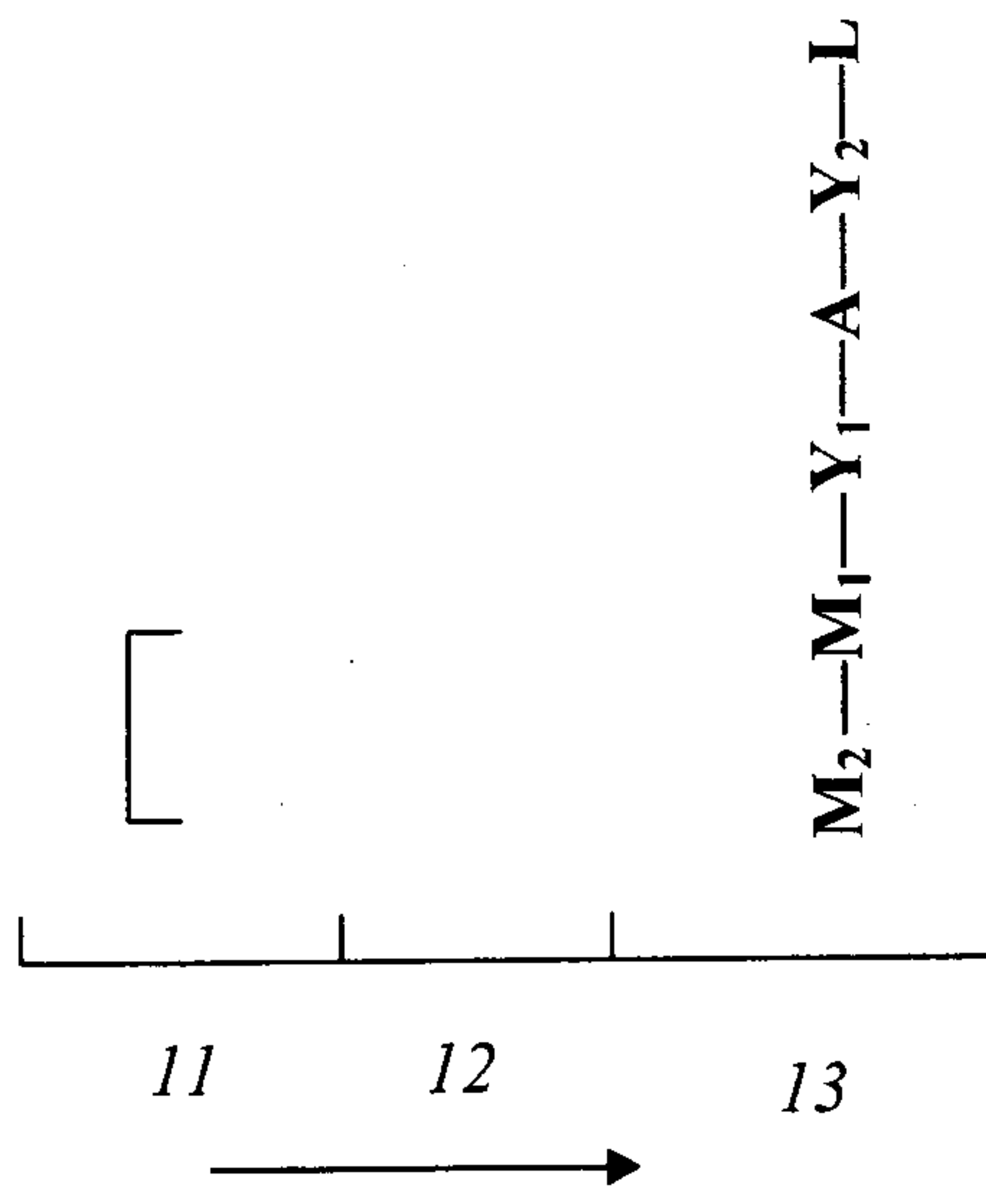


Fig. 4B

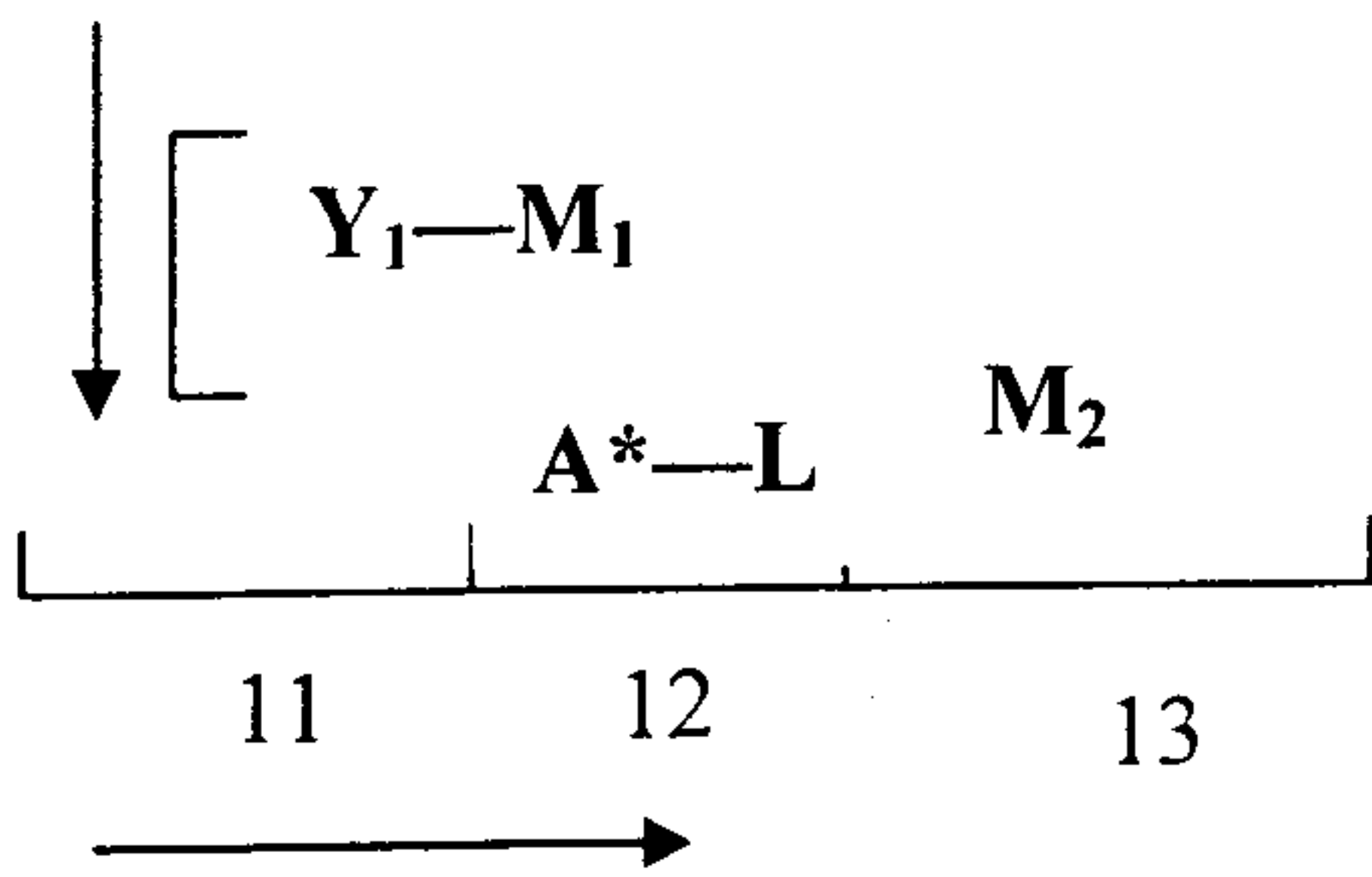


Fig. 5A

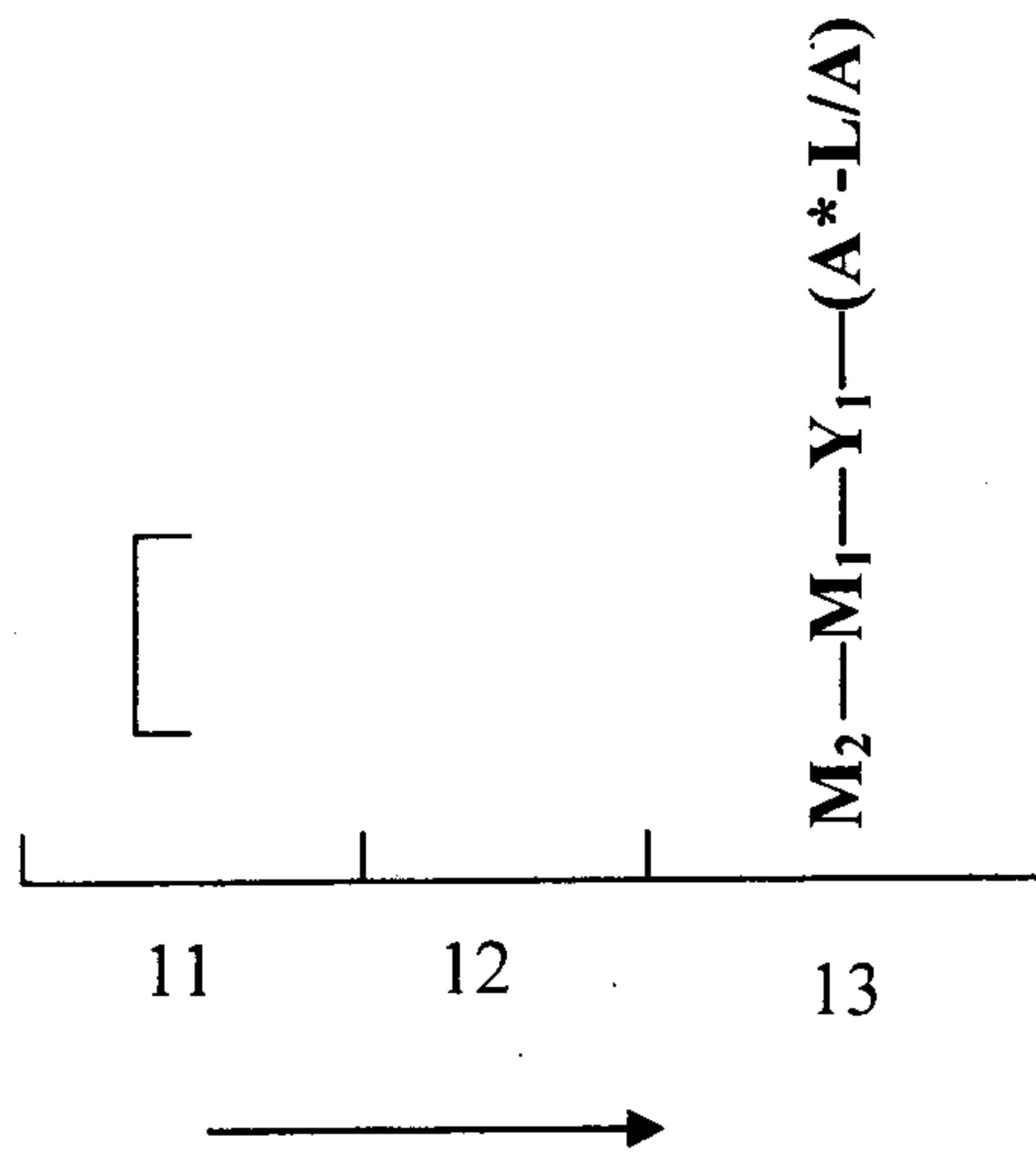


Fig. 5B

Fig. 6

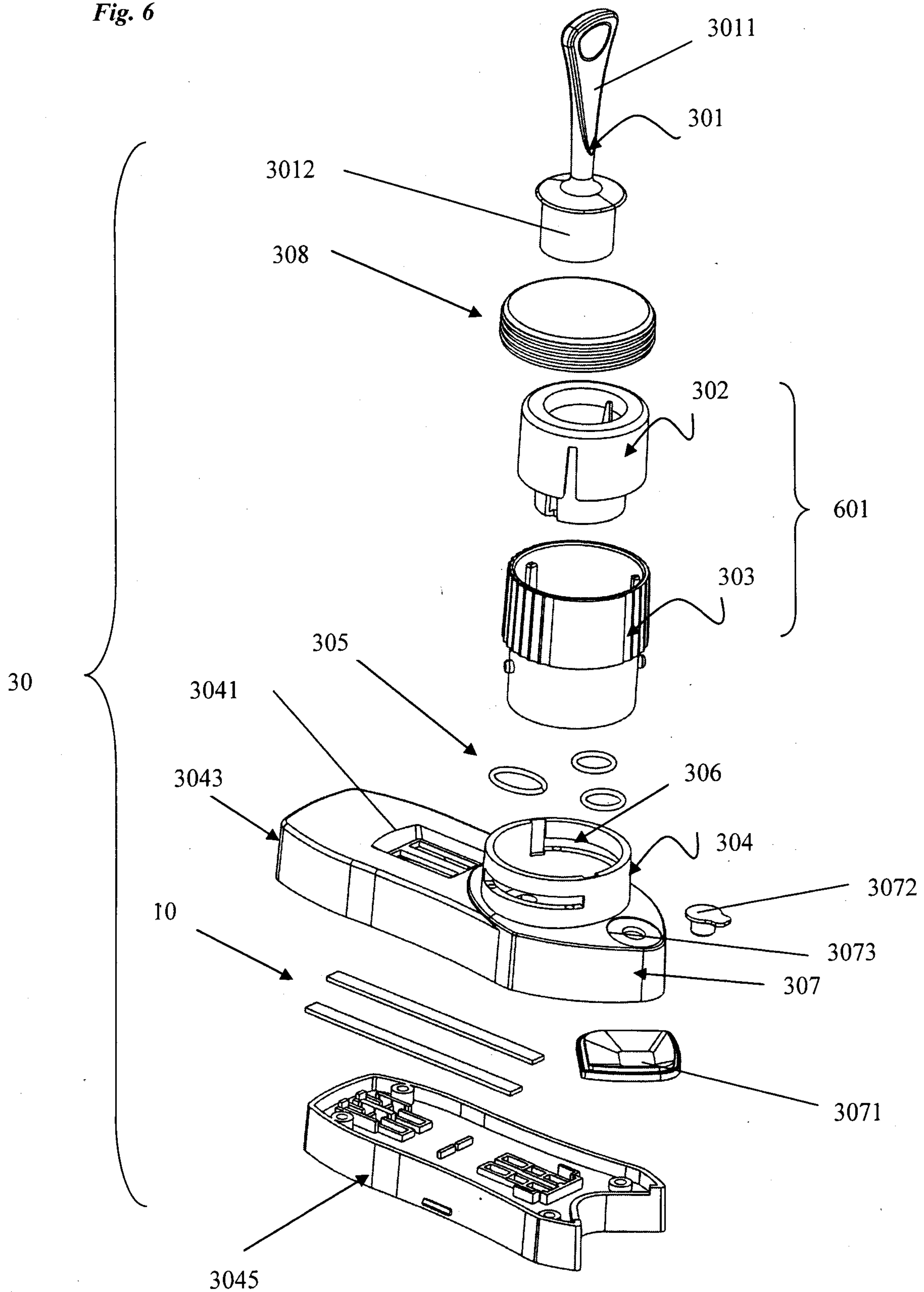
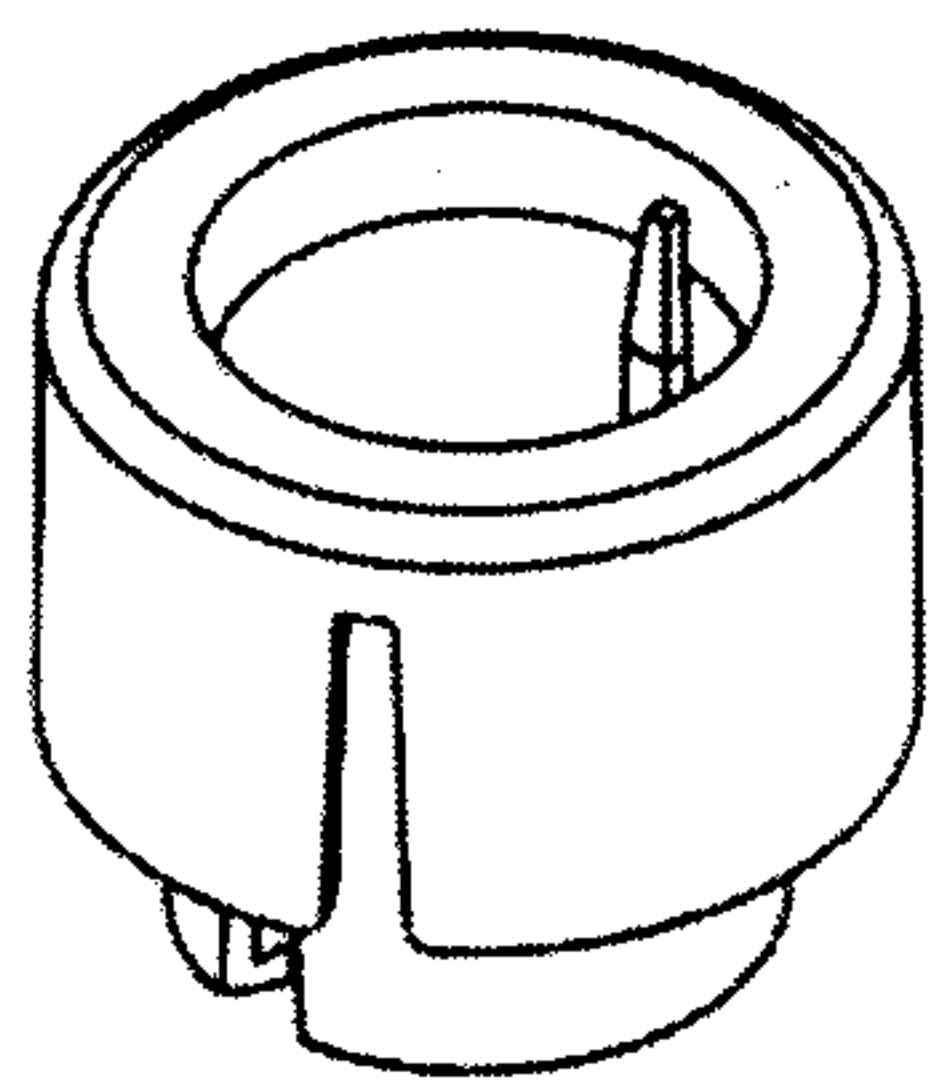


Fig. 7A



302-2

302

302-3

302

3024

2011

3025

Fig. 7B

302-1

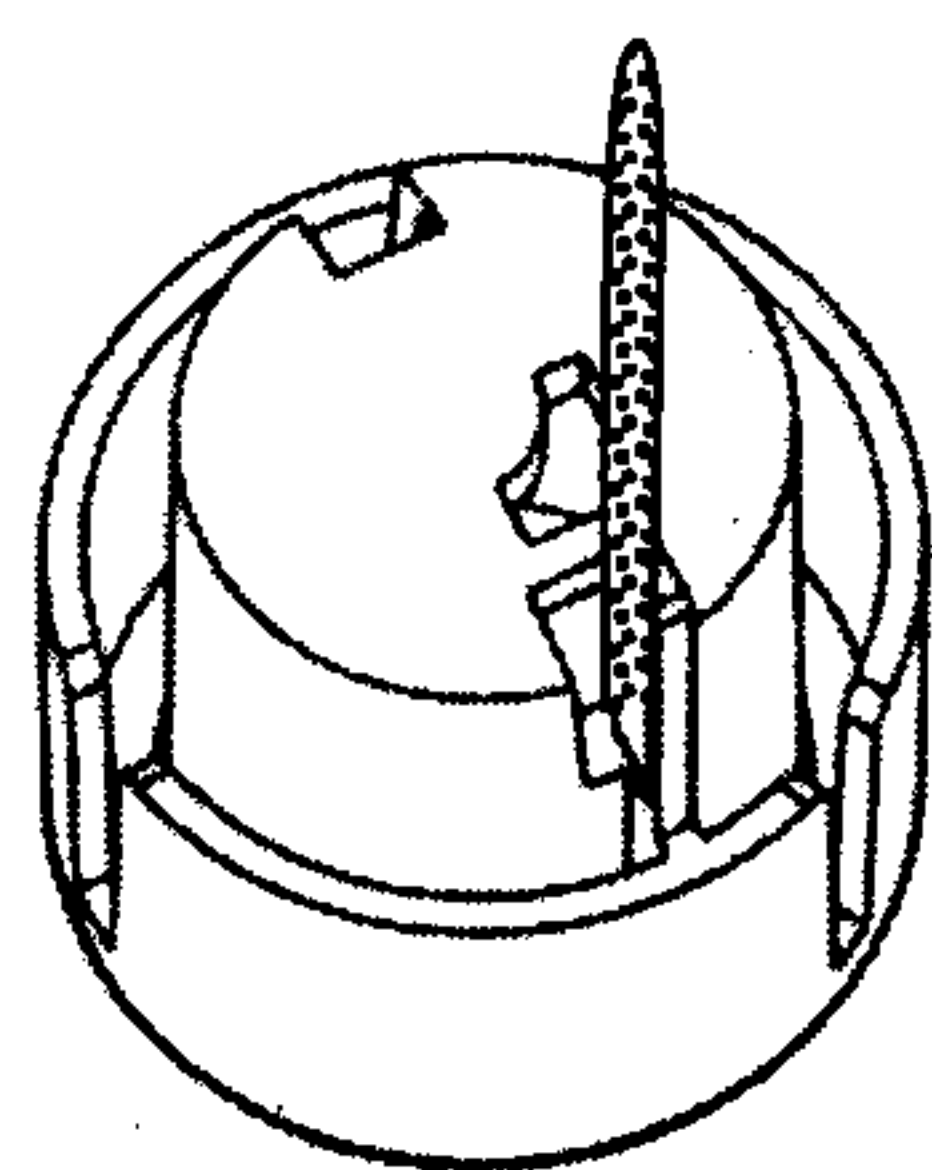


Fig. 7C

2012

2013

Fig. 7D

Fig. 8

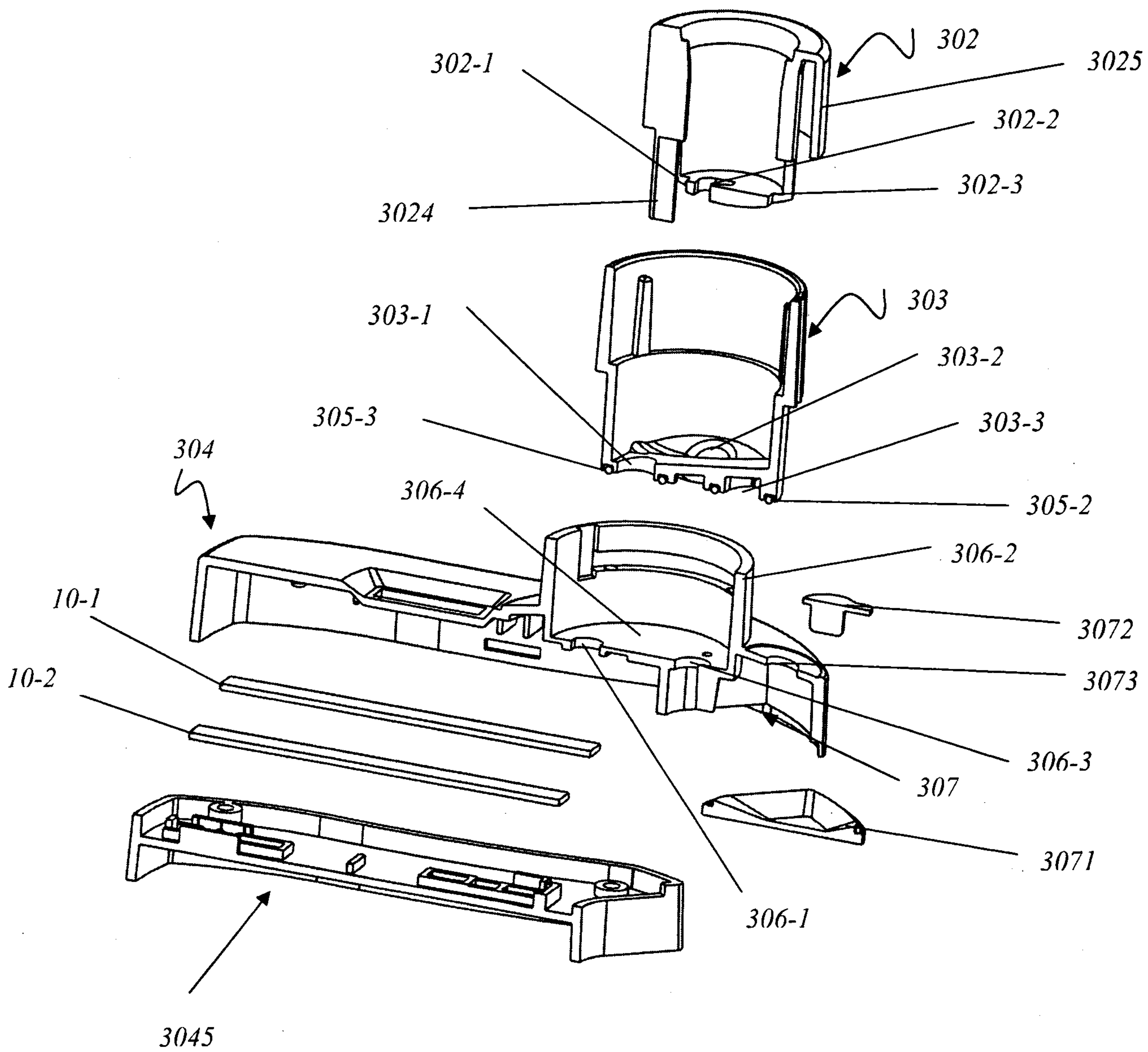


Fig. 9

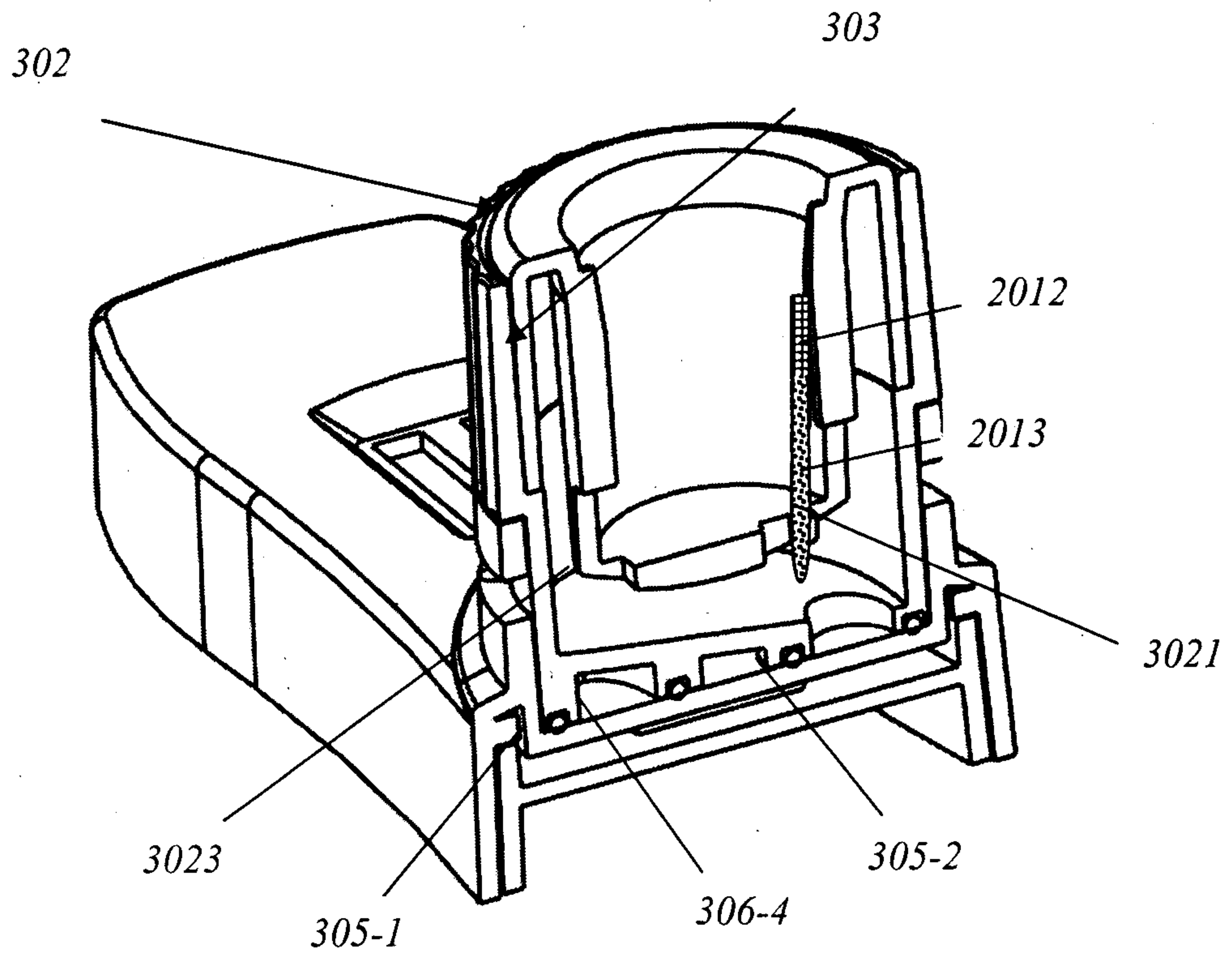


Fig. 10

