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(71) Applicant: **TECHNOPROBE S.P.A.** [IT/IT]; Via Cavalieri di Vittorio Veneto, 2, 23870 Cernusco Lombardone (Lecco) (IT).

(72) Inventors: **CRIPPA, Roberto**; c/o TECHNOPROBE S.p.A., Via Cavalieri di Vittorio Veneto, 2, 23870 Cernusco Lombardone (Lecco) (IT). **VALLAURI, Raffaele**; c/o TECHNOPROBE S.p.A., Via Cavalieri di Vittorio Veneto, 2, 23870 Cernusco Lombardone (Lecco) (IT). **BERTARELLI, Emanuele**; c/o TECHNOPROBE S.p.A., Via Cavalieri di Vittorio Veneto, 2, 23870 Cernusco Lombardone (Lecco) (IT). **PEREGO, Daniele**; c/o TECHNOPROBE S.p.A., Via Cavalieri di Vittorio Veneto, 2, 23870 Cernusco Lombardone (Lecco) (IT).

(74) Agent: **FERRARI, Barbara**; BOTTI & FERRARI S.r.l., Via Cappellini, 11, 20124 Milano (IT).

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(54) Title: TESTING HEAD WITH VERTICAL PROBES HAVING AN IMPROVED SLIDING MOVEMENT WITHIN RESPECTIVE GUIDE HOLES AND CORRECT HOLDING OF THE PROBES WITHIN THE TESTING HEAD UNDER DIFFERENT OPERATIVE CONDITIONS

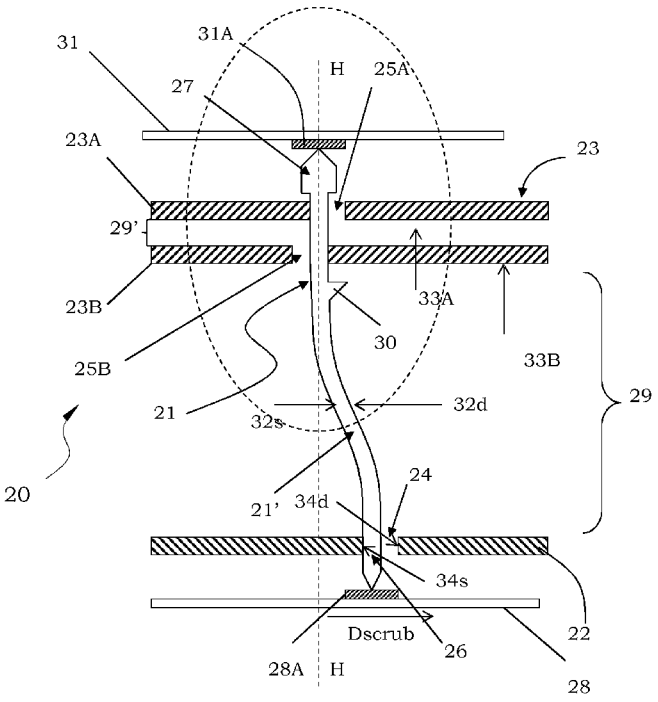

FIG. 2A

(57) Abstract: A testing head (20) with vertical probes for the functionality testing of a device under test (28), the testing head (20) comprising at least one couple of plate-like supports (22, 23) separated from each other by a suitable gap (29) and provided with respective guide holes (24; 25A, 25B) in order to slidably house a plurality of contact probes (21), each contact probe (21) comprising a rod-like body (21') extending along a preset longitudinal axis (HH) between a first and a second end (26, 27), the first end being a contact tip (26) adapted to abut onto a contact pad (28A) of the device under test (28) and the second end being a contact head (27) adapted to abut onto a contact pad (31A) of a space transformer (31). Suitably, at least one of the supports (23) comprises at least one couple of guides (23A, 23B) that are parallel to each other and separated by an additional gap (29') and provided with corresponding guide holes (25A, 25B). Additionally, each contact probe (21) comprises at least one protruding element or stopper (30) protruding from one of its lateral walls (32d, 32s), those lateral walls (32d, 32s) contacting one wall (35d, 35s, 36d, 36s) of at least one of the guide holes (25A, 25B) of the guides (23A, 23B).

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Title: "Testing head with vertical probes having an improved sliding movement within respective guide holes and correct holding of the probes within the testing head under different operative conditions"

DESCRIPTION

Field of application

The present invention relates to a testing head comprising a plurality of vertical probes having an improved sliding movement within respective guide holes and correct holding within the head itself.

More specifically, the invention refers to a testing head with vertical probes for the functionality testing of an electronic device, the testing head comprising at least one couple of plate-like supports separated from each other by a suitable gap and provided with respective guide holes in order to slidably house a plurality of contact probes, each contact probe comprising a rod-like body extending according a preset longitudinal axis between a first and a second end, the first end being a contact tip adapted to abut onto a contact pad of a device under test, and the second end being a contact head adapted to abut onto a contact pad of a space transformer.

The invention relates in particular, but not exclusively, to a testing head for testing electronic devices integrated on semiconductor wafers and the following description is made with reference to this field of application with the only purpose of simplifying its exposition.

Prior art

As it is well known, a testing head (probe head) is a device adapted to electrically connect a plurality of contact pads of a microstructure with corresponding channels of a testing machine that performs the functionality testing thereof, in particular the electrical one, or generically the test.

The test, which is performed on integrated circuits, is particularly useful to detect and isolate defective circuits already in the manufacturing step. Usually the testing heads are thus used to electrically test the circuits that

are integrated on a wafer before cutting and assembling them inside a chip containment package.

A testing head essentially comprises a plurality of movable contact elements or contact probes held by at least one couple of supports or guides, which are substantially plate-shaped and parallel to each other. Such plate-shaped supports are provided with suitable holes and arranged at a certain distance from each other in order to leave a free zone or gap for the movement and the possible deformation of the contact probes. The couple of plate-shaped supports includes in particular an upper plate-shaped support and a lower plate-shaped support, both provided with guide holes within which the contact probes axially slide, the probes being usually made of wires of special alloys having good electrical and mechanical properties.

The good connection between the contact probes and the contact pads of the device under test is ensured by pressing the testing head on the device itself, the contact probes, which are movable within the guide holes made in the upper and lower plate-shaped supports, undergoing a bending inside the gap between the two plate-shaped supports and a sliding within such guide holes during that pressing contact. Testing heads of this type, i.e. testing head with vertical probes, are usually called "vertical probe heads".

In essence, the testing heads with vertical probes have a gap within which a bending of the contact probes occurs, and such bending can be assisted by a suitable configuration of the probes themselves or of their supports, as schematically shown in Figure 1, where for sake of illustration simplicity only one contact probe of the plurality of probes usually included in a testing head has been shown.

In particular, Figure 1 schematically illustrates a testing head 1 comprising at least one lower plate-shaped support 2, usually indicated as "lower die", and one upper plate-shaped support 3, usually indicated as "upper die", having respective guide holes 4 and 5 within which at least one contact probe 6 slides.

The contact probe 6 terminates at one end with a contact tip 7 intended to abut onto a contact pad 8 of a device under test 10, so as to achieve the

mechanical and electrical contact between said device under test 10 and a test apparatus (not shown) of which such testing head forms a terminal element.

Here and hereinafter the term “contact tip” means an end zone or region of a contact probe designed to contact the device under test or the testing apparatus, said contact zone or region being not necessarily sharpened.

In some cases, the contact probes are fixedly fastened to the head itself in correspondence of the upper plate-shaped support: such testing heads are referred to as “blocked probe testing heads”.

More frequently, however, testing heads with unblocked probes, i.e. probes not fixedly fastened, are used, those probes being interfaced to a so-called board, possibly through a micro-contact board: such testing heads are referred to as non blocked probe testing heads. The micro-contact board is usually called "space transformer" as, besides contacting the probes, it also allows to spatially redistribute the contact pads made on it with respect to the contact pads on the device under test, in particular relaxing the distance constraints between the centers of the pads themselves.

In this case, as illustrated in Figure 1, the contact probe 6 has a further contact tip 15 towards a pad 11 of a plurality of contact pads of the space transformer 12. The good electrical contact between probes 6 and space transformer 12 is guaranteed in a similar manner to the contact with the device under test 10 by pressing the contact tips 15 of the contact probes 6 on the contact pads 11 of the space transformer 12.

The lower and upper plate-shaped supports 2 and 3 are suitably spaced by a gap 9 that allows the deformation of the contact probes 6. Finally, the guide holes 4 and 5 are sized so as to allow a sliding of the contact probe 6 therein.

The shape of the deformation undergone by the probes and the force required to produce such deformation are dependent on numerous factors, such as the physical characteristics of the alloy which makes the probes and the value of the offset between the guide holes in the upper plate-shaped support and the corresponding guide holes in the lower plate-shaped support.

The correct operation of a testing head is basically linked to two parameters: the vertical movement, or overtravel, of the contact probes and the horizontal movement, or scrub, of the contact tips of such contact probes. As is known, it is important to ensure the scrub of the contact tips so as to allow to scrub the surface of the contact pads, in this way removing the impurities that are for example in the form of a thin layer or oxide films, thus improving the contact carried out by the testing head.

All these features must be evaluated and calibrated in the manufacturing step of a testing head since the good electrical connection between the probes and the device under test must always be guaranteed. In the case of a testing head realized with the so-called "shifted plates" technology, the contact probes 6, which are also referred to as "buckling beam", are made straight, with a constant cross-section throughout their length, preferably rectangular, and usually they are sharpened at their ends in order to form the contact ends, in particular the contact tip 7 and the contact head 15 respectively, as shown in Figure 1. It is known to manufacture this type of testing heads by superimposing the plate-shaped supports in order to place the respective guide holes in a mutual correspondence, to fit the contact probes in those guide holes, to space the plate-shaped supports to form the so-called gap and then to offset or to shift such supports, causing a deformation of the probe body, in a substantially central position, as shown in Figure 1. These testing heads are also referred to as “shifted plate testing heads”.

It is also well known that such testing heads with probes of the "buckling beam" type have considerable problems of friction of the contact probes within the respective guide holes, which can make it difficult or even prevent the sliding of the probes therein.

In extreme cases, such a friction can thus cause the probes to get stuck in the relative guide holes, in particular in correspondence of the contact points between the sides of the probe and the walls of the guide holes of the plate-shaped supports, for example during the vertical displacement or overtravel of the probe for the pressing contact of the contact tip on a contact pad of a device under test. Then undesirably, during the testing operations, a non optimal contact between the probe and the contact pad is obtained, with consequent efficiency problems of the electrical test carried out by the testing head as a whole.

The decrease of such sliding friction of the probes is in some cases achieved thanks to the use of a plurality of plate-shaped guides, preferably two guides, which are parallel to each other in order to form at least one of the plate-shaped supports of the head.

In such case, however, mechanisms must usually be provided in order to prevent the probes from undesirably escaping from the testing heads, in particular during the absence of the device under test onto which the probes abut during the normal operation of the testing head.

A testing head with non blocked probes comprising a coating having a transversal dimension greater than that of the guide holes of the lower plate-shaped support, so as to avoid the fall by gravity of the contact probes, is described for example in US Patent No. 6,150,830 to Schmid et al. Other holding systems of the probes are described in the German patent application No. DE-A-3337915 in the name of Feinmetall GmbH and in US patent application published with No. US 2014/0118016 to Breinlinger et al., as well as in Italian patent application No. MI2008A000710 in the name of the Applicant itself.

Although advantageous under several aspects, the known solutions have some drawbacks; in particular, some of the testing heads made according to the known art are not yet able to prevent the probes from escaping from the guide holes, while other solutions introduce problems due to the probes getting stuck inside the guide holes, in particular during the movement in a direction orthogonal to the device under test of the respective contact tips. In yet other cases, the overall dimension of the probes is increased in a non acceptable way.

The technical problem of the present invention is thus to provide a testing head for microstructures having functional and structural characteristics such to allow the minimization of the friction forces existing between the lateral walls of the contact probes and the walls of the corresponding guide holes of the upper and lower supports, while ensuring a correct holding of the probes inside the testing head, so as to overcome the limits and drawbacks currently affecting the testing heads for microstructures made according to the known art.

Summary of the invention

The solution idea at the basis of the present invention is to realize a testing head with vertical probes having at least one upper or lower support comprising a plurality of parallel guides apt to improve the sliding of the contact probes within respective guide holes, as well as at least one element protruding from the body of such probes, which is also referred to as a stopper and is suitably positioned with respect to the supports so as to prevent the probes from escaping from the testing head also in the absence of a pressing contact with a device under test or with a space transformer.

On the basis of such solution idea the technical problem is solved by a testing head with vertical probes for the functionality testing of an electronic device, the testing head comprising at least one couple of plate-like supports separated one from the other by a suitable gap and provided with respective guide holes in order to slidably house a plurality of contact probes, each contact probe comprising a rod-like body extending along a preset longitudinal axis between a first and a second end, the first end being a contact tip adapted to abut onto a contact pad of a device under test and the second end being a contact head adapted to abut onto a contact pad of a space transformer, characterized in that at least one of such supports comprises at least one couple of guides that are parallel to each other and separated by an additional gap and provided with corresponding guide holes and in that each contact probe comprises at least one protruding element or stopper protruding from one of its lateral walls, that lateral wall contacting one wall of at least one of the guide holes of the guides.

More in particular, the invention comprises the following additional and optional characteristics, taken alone or in combination if needed.

According to another aspect of the invention, the contact head can have a diameter greater than a diameter of the guide holes of the guides, thus preventing the contact head from passing through the guide holes.

In particular, the stopper can be realized between the at least one support and further support, near the at least one support.

Alternatively, the stopper can be realized between the guides of the at least one support, in the additional gap.

According to another aspect of the invention, the contact probe can comprise a further stopper protruding from the same wall from which the at least one stopper protrudes.

Alternatively, the contact probe can comprise a further stopper protruding from an opposite wall with respect to the wall from which the at least one stopper protrudes.

The contact probe can also comprise at least further three stoppers, these four stoppers being protruding in couples from the walls of the contact probe and being arranged symmetrically to the longitudinal axis, a first and a third stopper being arranged between the at least one support and the further support, and a second and a fourth stopper being positioned between the guides of the at least one support.

According to another aspect of the invention, the contact probe can further comprise a notch realized in a wall of the contact probe opposite to the wall from which the at least one stopper protrudes.

In particular, the notch can realize a recess in the rod-like body of the contact probe having dimensions comparable to a lateral protrusion of the at least one stopper.

According to another aspect of the invention, the at least one stopper can have a lateral protrusion having dimensions comparable to a diameter of the contact probe and can be preferably between 5 and 40 μm.

According to yet another aspect of the invention, the at least one stopper can be arranged at a distance from the at least one support less than the sum of a length of the contact tip, protruding from the further support outside of the testing head, and a thickness of the further support.

Finally, according to another aspect of the invention, the at least one stopper may further comprise at least one undercut wall having a rounded shape.

In particular, such undercut wall can have a radius of curvature with between 0.001 μm and 0.1 μm.

The technical problem is also solved by a method for assembling a testing head as defined above, the method comprising at least the steps of:

- overlapping a lower support and a first and second guide of an upper support having the respective guide holes concentric to each other;

- inserting the contact probes into the respective aligned guide holes;

- first relative movement of the upper support, and in particular of the guides together, with respect to the lower support along a first direction, substantially perpendicular to the supports, passing the stopper through the corresponding guide holes of the upper support; and

- second relative movement of the upper support, and in particular of the guides together, with respect to the lower support along a second direction, substantially parallel to the supports.

According to another aspect of the invention, the method can further comprise a third step of relative movement of the first and second guide of the upper support with respect to each other along a third direction, parallel to the guides.

The characteristics and the advantages of the testing head according to the invention will be apparent from the following description of an embodiment thereof, given by way of an indicative and non-limiting example with reference to the accompanying drawings.

Brief Description of the Drawings

In such drawings:

- Figure 1 schematically shows a testing head realized according to the prior art;

- Figures 2A-2B schematically show an embodiment of the testing head according to the invention, in different operating conditions;

- Figure 3 schematically shows an enlarged view of a detail of the testing head of Figure 2A;

- Figures 4A-4C show successive steps of assembly of a testing head according to the present invention;

- Figures 5A-5B, 6A-6B, 7 and 8 schematically show alternative embodiments of the testing head according to the invention; and

- Figure 9 schematically shows an enlarged view of a detail of the testing head of Figure 2A, according to a preferred embodiment.

Detailed description

With reference to such Figures, and in particular to Figure 2A, a testing head realized according to the invention is described, the testing head being globally indicated as 20.

It should be noted that the Figures represent schematic views and are not drawn to scale, but instead they are drawn so as to emphasize the important features of the invention.

Additionally, in the Figures, the different pieces are shown schematically, as their shape can vary depending on the desired application.

In a similar manner to the testing head 1 realized according to the prior art and illustrated in Figure 1, the testing head 20 comprises a lower support 22, usually indicated as "lower die", and an upper support 23, usually indicated as "upper die "; as above, they are plate-shaped supports spaced apart by a suitable gap 29 and provided with respective guide holes within which a plurality of contact probes is slidingly housed.

For sake of illustration simplicity and clarity, in the Figures only one contact probe 21 is shown, that contact probe 21 comprising a rod-like body 21' having a predetermined longitudinal axis HH and axially sliding in the guide holes of the upper 23 and lower 22 supports, the rod-like body 21' ending with a first contact end or tip 26 and with a second contact end or head 27. More particularly, the contact tip 26 is apt to abut onto contact pads 28A of a device under test 28. In the example illustrated in Figure 2A, the testing head 20 is a non blocked probe testing head, i.e. the probes are not fixedly fastened, and the contact head 27 is apt to abut onto contact pads 31A of a space transformer 31.

In the case of testing heads for testing circuits that are integrated on wafers, it is known to use contact probes having a length between 2 mm and 9 mm. It is also known to use probes having a polygonal cross section, preferably rectangular or square; typical values of the section range from 10x10 microns to 50x140 microns.

Suitably, at least one of the lower or upper support comprises a plurality of plate-shaped guides parallel to each other, in order to facilitate the sliding of the contact probes 21 within the respective guide holes and to reduce the problems of probes getting stuck during their displacement due to the pressing contact of the respective contact tips 26 on the contact pads 28A of the device under test 28. In the example of Figure 2A, the upper support 23 comprises in particular at least one first and one second guide, 23A and 23B, which are parallel to each other are separated by an additional gap 29' and are provided with corresponding guide holes 25A and 25B for housing the contact probes 21. In similar manner, the lower support 22 comprises a plurality of guide holes 24 for housing the contact probes 21.

It is noted that the upper support 23 and the lower support 22 are mutually shifted so as to realize the desired deformation of the body 21' of the contact probe 21; furthermore, also the first guide 23A and the second guide 23B of the upper support 23 are mutually shifted in order to achieve the desired holding of the probes inside the testing head 20. As already mentioned in relation to the prior art, the holding of the contact probes 21 realized by the relative displacement (shift) of the guides 23A and 23B of the upper support 23 is not however able to prevent the contact probes 21 from sliding outside the testing head 20 in the absence of a device under test 28 or of a space transformer 31.

Moreover, the shift of the upper support 23 and the lower support 22 determines a direction of deformation of the contact probe 21 and thus the direction of movement of the relative contact tip 26 on the contact pad 28A of the device under test 28, indicated as scrub direction Dscrub in the Figure.

Such shift causes at least one first wall 32s of the contact probe 21 to contact a corresponding wall 34s of a lower guide hole 24 made in the lower support 22, a play being defined between a second wall 32d of the contact probe 21 and an opposite wall 34d of the lower guide hole 24, the amplitude of the play being determined by the size of the guide holes 24 of the lower support 22 with respect to a diameter of the contact probe 21, the word diameter meaning here and hereinafter the maximum transverse dimension, also in the case of probes with non-circular section.

It is noted that the first wall 32s of the contact probe 21 is in particular a wall that precedes the longitudinal axis HH of the probe itself with respect to the scrub direction Dscrub, while the second wall 32d of the contact probe 21 is a wall that follows this axis HH along the scrub direction Dscrub.

Additionally, the shift of the upper support 23 and the lower support 22, as well as the shift of the first guide 23A and the second guide 23B of the upper support 23, causes the first wall 32s of the contact probe 21 to contact a wall 35s of the guide hole 25A made in the first guide 23A of the upper support 23 and causes the second wall 32d of the contact probe 21 to contact a wall 36d of the guide hole 25B of the second guide 23B of the upper support 23, as shown in enlarged scale in Figure 3.

More particularly, the first wall 32s of the contact probe 21 is in contact with the wall 35s of the guide hole 25A, the wall 35s preceding the axis HH along the scrub direction Dscrub, while the second wall 32d of the contact probe 21 is in contact with the wall 36d of the guide hole 25B, the wall 36d following the axis HH along the scrub direction Dscrub.

Even in such a case, respective plays are defined between the second wall 32d of the contact probe 21 and an opposite wall 35d of the guide hole 25A of the first guide probe 23A of the upper support 23, as well as between the first wall 32s of the contact probe 21 and an opposite wall 36s of the guide hole 25B of the second guide 23B of the upper support 23, such plays having amplitudes depending on the sizing of the guide holes 25A and 25B made in the first and second guide 23A and 23B of the upper support 23 and on the diameter of the contact probe 21 housed therein.

More particularly, the wall 35d of the guide hole 25A of the first guide 23A is the one that follows the axis HH along the scrub direction Dscrub, while the wall 36s of the guide hole 25B of the second guide 23B is the one that precedes the axis HH along the scrub direction Dscrub.

Advantageously according to the present invention, the contact probe 21 further comprises at least one element protruding from the body 21', in correspondence of the first wall 32s or of the second wall 32d of the contact probe 21. This protruding element is apt in particular to realize

stop means (or abutment means) of the contact probe 21, so as to prevent the contact probe 21 from escaping from the testing head 20 even in the absence of a device under test 28 or of a space transformer 31, and it will be indicated in the following as stopper 30. Suitably, the stopper 30 is integral with the body 21' of the contact probe 21.

In particular, the stopper 30 is able to prevent an upward movement (in the local reference system of Figure 2A) of the corresponding contact probe 21.

In a preferred embodiment shown in Figure 2, the stopper 30 has the shape of a tooth, which is integral with the body 21' of the contact probe 21 and protrudes from the body 21' as a lateral lug (or protrusion) having a size comparable to the diameter of the contact probe 21 and in particular comprised between 5 and 40 μm, the term comparable meaning that the gap between such lateral dimension and the diameter of the contact probe 21 is less than 20%.

In the embodiment illustrated in Figure 2A, the stopper 30 is arranged so as to protrude from the second wall 32d of the contact probe 21 and is disposed between the second guide 23B of the upper support 23 and the lower support 22, in particular in close proximity to the second guide 23B. More particularly, during the normal operation of the testing head 20, the stopper 30 is not in contact with the upper support 23, so as not to interfere with the movement of the corresponding contact probe 21. The stopper 30 acts only on the occasion of any upward movement of the contact probe 21, for example in case of a removal of the space transformer 31 and of an undesired but temporary "gluing" between the contact heads 27 of the probes and the contact pads 31A of the space transformer 31.

Furthermore, the contact head 27 is realized so as to have a diameter larger than the diameter of the guide holes formed in the upper support 23, preventing a downward sliding (in local reference system of the Figure 2A) of the corresponding contact probe 21. Even in such a case, the term diameter, here and in the following means a maximum transverse dimension, even in case of non-circular holes.

In this way, the stopper 30 is arranged at the wall 36d of the guide hole 25B of the second guide 23B of the upper support 23, that wall 36d abutting onto the second wall 32d of the contact probe 21 from which the stopper 30 protrudes, ensuring, in combination with the contact head 27, the desired holding of the contact probe 21 inside the testing head 20 even in absence of a device under test 28 or of a space transformer 31. In particular, the contact head 27 is sized so as to have a dimension (i.e. its diameter) greater than the diameter of the guide holes 25A, 25B realized in the guides 23A, 23B of the upper support 23, thereby preventing a passage of the contact head 27 itself through those holes. Additionally, it is noted that the stopper 30 is able to prevent unwanted movements of the contact probes 21 during cleaning operations of the testing head 20, the cleaning operations being usually made, as it is well known, by powerful air jets, which are able in particular to move the contact probes. Finally, the presence of the stopper 30 ensures the retention of the contact probes 21 within the testing head 20, also when removing the space transformer 31 with breakage of possible oxides that retain the contact heads 27 at the contact pads 31A of the space transformer 31 itself.

In an alternative embodiment illustrated in Figure 2B, the stopper 30 is realized in such a way that it protrudes from the first wall 32s and is positioned between the first guide 23A and the second guide 23B of the upper support 23, in particular in the additional gap 29' and further close to the first guide 23A. More in particular, in case of an unwanted upward movement of the contact probe 21, for example due to the removal of the space transformer 31, the stopper 30 is apt to abut onto the undercut wall 33A of the first guide 23A of the upper support 23.

In other words, the stopper 30 is positioned below the first wall 35s of the guide hole 25A of the first guide 23A of the upper support 23, the wall 35s abutting onto the first wall 32s of the contact probe 21 from which the stopper 30 protrudes, ensuring, in combination with the contact head 27, the desired holding of the contact probe 21 inside the testing head 20 even in absence of a device under test 28 or of a space transformer 31.

It is noted that the arrangement of the stopper 30 between the first and the second guide 23A and 23B of the upper support 23, i.e. in the additional gap 29', is particularly advantageous since the additional gap 29' is an area with reduced stresses, in particular almost free from

bending, which bending instead affects the portion of the contact probe 21 disposed in the gap 29, that is, between the second guide 23B of the upper support 23 and the lower support 22. In this way, there is no risk of triggering unwanted breakages at the stopper 30, whose shape protruding from the wall of the contact probe 21 unavoidably leads to the presence of stress points. According to this embodiment, the stopper 30 is then made in a "stable" portion of the contact probe 21, in particular in a zone with controlled mechanical stress due to the reduced possibility of movement of the probe itself.

Essentially, the testing head 20 comprises at least one contact probe 21 provided with at least one stopper 30 arranged at the bottom of at least one guide 23A, 23B, respectively, of the upper support 23 at a wall, 32s, 32d, respectively, of the contact probe 21, the wall of the probe being in contact with a corresponding wall, 35s, 36d, respectively, of a guide hole, 25A, 25B, respectively, realized in that guide. More particularly, the stopper 30 is apt to abut onto an undercut wall, 33A, 33B, of the respective guide, 23A, 23B, of the upper support 23 under which it is positioned, in correspondence of a wall 32s, 32d, of the contact probe 21, the wall of the probe abutting onto a wall 35s, 36d, of the respective guide holes 25A, 25B, of the first and second guide 23A, 23B.

As mentioned above, when the stopper 30 is positioned between the second guide 23B of the upper support 23 and the lower support 22, it protrudes from the second wall 32d of the contact probe 21, and it is located at the wall 36d of the guide hole 25B, that wall following the axis HH along the scrub direction Dscrub, while when the stopper 30 is positioned between the first guide 23A and the second guide 23B of the upper support 23, it protrudes from the first wall 32s of the contact probe 21, and it is located at the wall 35s of the guide hole 25A, that wall preceding the axis HH along the scrub direction Dscrub.

It should be noted that the guide holes 25A, 25B realized in the guides 23A and 23B of the upper support 23 are suitably sized so as to allow the passage of the contact probe 21 also in correspondence of the stopper 30. In this way it is possible to assembly in an extremely simple way the testing head 20, as schematically shown in Figures 4A-4C.

In particular, in a first assembly step, the lower support 22 and the first and second guide 23A, 23B of the upper support 23 are overlapped so that the respective guide holes 24, 25A, 25B are concentric to each other; this overlap is followed by the insertion of the contact probes 21 in the respective guide holes. In particular, in the example illustrated in Figures 4A-4C, a testing head with vertical probes 20 and shifted plates is considered, in which the contact probes 21 do not initially have any pre-deformation, as shown in Figure 4A. It is obviously possible to use the following described method for assembling a testing head also in case of previously deformed probes.

The method also comprises a first step of relative movement of the lower support 22 and upper support 23, along a first direction S1, substantially perpendicular to the supports, and then to the device under test (not shown), that direction being indicated by an arrow in Figure 4B. In particular, the upper support 23, and in particular its guides 23A and23B together, is removed from the lower support 22 according to the direction S1.

As already pointed out, at least the guide holes 25A, 25B of the guides 23A, 23B of the upper support 23 are then suitably sized to allow the passage of the contact probes 21 provided with the stopper 30. More particularly, the guide holes 25A, 25B are realized with a diameter corresponding to the sum of the diameter of the contact probe 21 and of the lateral dimension of the stopper 30, in addition to a value that takes into account the process tolerances.

Finally, the method comprises a step of relative movement of the lower support 22 and the upper support 23 along a second direction S2, which is substantially parallel to the supports, and then to the device under test (not shown), that direction being indicated by an arrow in Figure 4C. In particular, the upper support 23, and in particular its guides 23A and 23B together, are shifted along the direction S2 with respect to to the lower support 22, causing a deformation of the body 21' of the contact probe 21. It is obviously possible to realize a different, in particular opposite and symmetrical, deformation of the body 21' of the contact probe 21 with a shift of the upper support 23 and lower support 22 in an opposite direction with respect to the direction S2 shown in the Figure. In this case also the positioning of the stopper 30 must be symmetrical,

however in such a way that it protrudes from a wall of the contact probe 21 in contact with a wall of a corresponding overlying guide hole.

Furthermore, the first and second guide 23A and 23B of the upper support 23 are shifted relatively to each other according a third direction S3, always parallel to the guides and indicated by a further arrow in Figure 4C. In this way, it is guaranteed a local holding of the contact probe 21 within the guide holes 25A, 25B of the guides 23A, 23B of the upper support 23.

As already indicated, this local holding of the contact probe 21 is, however, not sufficient to maintain in position the contact probe 21 in the absence of the device under test 28 or of the space transformer 31, onto whose pads the respective contact tip 26 and contact head 27 abut.

Suitably, at least one stopper 30 is provided protruding from the body 21' of the contact probe 21 which, in cooperation with a sizing of the contact head 27 having a diameter greater than the diameter of the guide holes 25A made in the first guide 23A of the upper support 23, prevents the contact probe from slipping out of the testing head 20 even in the absence of a device under test 28 or of a space transformer 31 having contact pads abutting respectively onto the contact tip 26 and onto the contact head 27 of that contact probe 21. Even in this case, during the normal operation of the testing head 20, the stopper 30 is not in contact with the upper support 23 and does not interfere with the movement of the contact probe 21.

According to an alternative embodiment illustrated in Figures 5A and 5B, the testing head 20 comprises at least one contact probe 21 with the stopper 30 protruding from the second wall 32d of the contact probe 21, the wall 32d abutting onto the wall 36d of the guide hole 25B of the second guide 23B of the upper support 23, overlying the stopper 30, and positioned between the second guide 23B of the upper support 23 and the lower support 22, as well as provided with a further stopper 30A protruding from the same second wall 32d and positioned between the first guide 23A and the second guide 23B of the upper support 23.

In this way, in fact, at least one of the stoppers 30 and 30A is prevented from moving through the guide holes since it is in correspondence of a

guide hole wall in contact with a wall of the contact probe 21, irrespective of the bending of the probe itself, commonly referred to as assembly angle of the probe.

In particular, the contact probe 21 can have a bending causing its contact tip 26 to move to the right with respect to its contact head 27, as in the example of Figure 5A, or to the left, as in the example of Figure 5B; in other words, this embodiment can be used for both the assembly angles of the contact probe 21, while the embodiments illustrated in Figures 2A and 2B can be used each for a specific assembly angle of the contact probe 21.

Furthermore, the stoppers 30 and 30A introduce a lateral protrusion in a same direction, thus ensuring to minimize the minimum diameter value which is necessary to provide for realizing the guide holes 25A, 25B of the guides 23A and 23B of the upper support 23, in order to ensure the correct passage of the contact probe 21 using the assembly method illustrated with reference to Figures 4A-4C.

More particularly, in the embodiment of Figure 5A, on the occasion of a possible upward movement of the contact probe 21, the stopper 30 acts abutting onto the undercut wall 33B of the second guide 23B of the upper support 23, while in the embodiment of Figure 5B the further stopper 30A acts abutting onto the undercut wall 33A of the first guide 23A of the upper support 23.

It is also possible to realize the further stopper 30A in such a way that it protrudes from a different wall with respect to the stopper 30, as shown schematically in Figures 6A and 6B.

In particular, as in the embodiment of Figure 6A, the testing head 20 comprises at least one contact probe 21 provided with the stopper 30 protruding from the second wall 32d of the contact probe 21 and provided with the further stopper 30A protruding from the first wall 32s of the contact probe 21. In particular, the stopper 30 is arranged between the second guide 23B of the upper support 23 and lower support 22, while the further stopper 30A is arranged between the first guide 23A and the second guide 23B of the upper support 23.

In such a configuration, both stoppers 30 and 30A are arranged at the wall of the contact probe 21, i.e. the wall 32d and 32s, respectively, those

walls being in contact with the wall 36d, 35s, respectively, of the guide hole above them, 25B, 25A respectively, and then provide an improved holding of the contact probe 21 within the testing head 20, even in absence of a device under test 28 or of a space transformer 31.

It is noted that the same embodiment is illustrated in Figure 6B, in presence of an opposite scrub direction Dscrub. Remembering that the first wall 32s of the contact probe 21 is the wall that precedes the axis HH with respect to the scrub direction Dscrub and that the second wall 32d is the wall that follows such axis HH along the scrub direction Dscrub, also in this case the testing head 20 comprises at least one contact probe 21 provided with the stopper 30 protruding from the second wall 32d of the contact probe 21 and provided with the further stopper 30A protruding from the first wall 32s of the contact probe 21. In particular, the stopper 30 is arranged between the second guide 23B of the upper support 23 and the lower support 22, while the further stopper 30A is arranged between the first guide 23A and the second guide 23B of the upper support 23.

Even in this case, both stoppers 30 and 30A are arranged in correspondence of the wall of the contact probe 21, i.e. the wall 32d, 32s, respectively, those walls being in contact with the wall 36d, 35s, respectively, of the guide hole above them, 25B, 25A, respectively, and thus ensure an improved holding of the contact probe 21 inside the testing head 20.

It is evident that also the embodiments of Figures 6A and 6B can be used each for a different assembly angle of the contact probe 21.

According to a further embodiment shown in Figure 7, the contact probe 21 can comprise at least four stoppers protruding from the walls of the contact probe 21 and arranged between the guides 23A and 23B of the upper support 23 as well as between the second guide 23B of the upper support 23 and the lower support 22. In particular, the contact probe 21 comprises a first stopper 30 protruding from the second wall 32d of the contact probe 21 and positioned between the second guide 23B of the upper support 23 and the lower support 22, a second stopper 30A protruding from the second wall 32d of the contact probe 21 and positioned between the first guide 23A and the second guide 23B of the upper support 23, as well as a third stopper 30B protruding from the first

wall 32s of the contact probe 21 and positioned between the second guide 23B of the upper support 23 and the lower support 22 and a fourth stopper 30C protruding from the first wall 32s of the contact probe 21 and positioned between the first guide 23A and the second guide 23B of the upper support 23.

In this way, the contact probe 21 includes four stoppers symmetrically arranged with respect to the axis HH, a first and a third stopper 30 and 30B being arranged between the upper support 23 and the lower support 22, and a second and a fourth stopper 30A and 30C being arranged between the guides 23A and 23B of the upper support 23.

In this way it is possible to ensure an improved holding due to the fact that a couple of stoppers is always apt to abut onto the undercut walls 33A and 33B of the first and second guide 23A and 23B of the upper support 23, regardless of the assembly angle of the contact probe 21, on the occasion of a possible upward movement of the probe itself (in the local reference system of the Figure).

According to a further embodiment, illustrated in Figure 8, the testing head 20 comprises at least one contact probe 21 provided with a stopper 30 protruding from a wall thereof, in particular from the second wall 32d, as well as a notch 40 realized in an opposite wall of the contact probe 21, in particular the first wall 32s, in correspondence of such stopper 30. In substance, the notch 40 produces a recess in the body 21' of the contact probe 21, the recess having dimensions comparable (in particular with a relative difference lower than 20%) to the lateral protrusion of the stopper 30, compensating for the increased dimension of the contact probe 21 introduced by the stopper 30 itself and thereby allowing to reduce the diameter of the guide holes 25A and 25B realized in the guides 23A and 23B of the upper support 23 in order to ensure the passage of the corresponding contact probe 21 in case of assembly by means of relative displacement of the supports 22 and 23, as explained with reference to Figures 4A-4C.

In particular, as already indicated, during the normal operation of the testing head 20, the stopper 30 is not in contact with the upper support 23, so as not to interfere with the movement of the corresponding contact

probe 21. Suitably, the stopper 30 acts so as to prevent an upward movement of the contact probe 21.

More in particular, advantageously according to the present invention, the stopper 30 is positioned so as to prevent the contact tip 26 of the contact probe 21 from exiting from the lower support 22, in particular from the corresponding guide hole 24. In fact, such movement out of the contact tip 26 makes the testing head 20 that includes the contact probe 21 unusable, until a new alignment of the guide hole 24 with the contact tip 26 is performed once the contact probe 21 has been repositioned.

The stopper 30 is then arranged at a distance D from the upper support 23, in particular from the undercut wall 33B of the second guide 23B, the distance D having a smaller value than the sum of the length Lp of the contact tip 26 protruding from the lower support 22 outside the testing head (and then outside of the gap 29) with a thickness Sp of the lower support 22 itself, in particular corresponding to the height of the respective guide hole 24, i.e. D <Sp + Lp.

It is emphasized that this suitable positioning of the stopper 30 is particularly advantageous in case of use of contact probes of the buckling beams type; in such case, in fact, the possible slipping of the contact tip 26 of a contact probe 21 from the guide hole 24 of the lower support 22 leads to an instantaneous straightening of the probe itself, which would prevent any attempt to repositioning it.

Moreover, the stopper 30 is positioned at a distance D greater than a minimum value equal to 5-10 μm, so as to ensure that such stopper 30 does not interfere with the normal operation of the testing head 20 that includes the contact probe 21. To avoid any interference problem, the distance D is preferably set so as to be greater than 100 μm, more preferably greater than 150 μm.

Finally, in a preferred embodiment of the invention, schematically illustrated in the enlarged view of Figure 9, the stopper 30 comprises at least one wall 30sq, in particular an undercut wall having a rounded shape, in particular with a radius of curvature rc having a value between 0,001 μm and 0.1 μm.

Suitably, thanks to this wall 30sq having rounded shape, the stopper 30 facilitates the passage of the contact probe 21 in the guide holes 25A and 25B made in the guides 23A and 23B of the upper support 23, when using the assembly method illustrated with reference to the Figures 4A-4C.

In particular, such preferred shape of the stopper 30 is particularly advantageous during the first step of the relative movement of the lower support 22 and the upper support 23, as shown in Figure 4B, when the upper support 23, and in particular its guides 23A and 23B together, is moved along the direction S1 (also indicated in Figure 9) from the lower support 22.

In particular, the rounded wall 30sq of the stopper 30 creates a surface that facilitates the sliding of guide holes along that wall, along the direction indicated by the arrow Fc in the Figure.

The testing heads realized according to the present invention have been shown to have very high operation performances. Advantageously, the frictional forces, existing between the walls of the contact probes and the walls of the guide holes of the supports that comprise them, are significantly reduced thanks to the use of at least two guides forming at least one of the supports, in particular the upper support, but the presence of at least one stopper ensures the proper functioning of the testing head, in particular the positioning and the holding in the operative measurement condition of the contact probes comprised in it.

The considerations made are also valid for different embodiments not explained here but still object of the present invention, such as, for example, a testing head having an upper support comprising a single guide and a lower support comprising at least two guides, as well as the case in which both the upper support and the lower support are realized by means of at least two guides or even a greater number of guides. In addition, the expedients adopted in relation to one embodiment can be used also for other embodiments and can be freely combined with one another even in a number greater than two.

It is emphasized that the reduction of the friction forces inside the testing head results in an improved functioning of the same, as well as in a prolonged life of the individual components, with a consequent economic

saving, the adopted configuration preventing an accidental exit of the contact probes from the respective guide holes.

Suitably, the contact head of each contact probe is sized so as to have a dimension higher than the diameter of the guide holes formed in the first guide of the upper support, thereby preventing a passage of the contact head itself through these holes. Additionally, the presence of the stopper is capable of preventing undesired movements of the contact probes on the occasion of cleaning operations of the testing head, which cleaning operations are (as it is well known) usually made by means of powerful air jets in particular able to move the contact probes, and to ensure the holding of the contact probes inside the testing head also on the occasion of the space transformer removal, the counterforce produced by the abutment of the stopper onto a corresponding undercut wall of the guides of the upper support ensuring the breaking of possible oxides which retain the contact heads to the pads of the space transformer itself.

It is noted that during the normal operation of the testing head, the stopper is not in contact with the upper support and thus does not interfere with the movement of the contact probes. Suitably, the stopper acts so as to prevent an upward movement of the contact probe.

In one embodiment, the stopper is positioned so as to prevent the contact tip of the contact probe from exiting from the lower support, in particular from the relative guide hole, which would make the testing head unusable, in particular in case of a buckling beams technology. More particularly, the stopper is positioned at a maximum distance from the upper support, the distance being equal to the sum of the length of the contact tip protruding from the lower support outside of the testing head and the height of the guide hole of the lower support.

Suitably, the combined use of at least two guides which realize at least one of the supports of the testing head, the proper sizing of the contact head with respect to the guide holes realized in such guides, and the use of the at least one stopper allow to guarantee a proper functioning of the testing head, in particular the absence of problems of probes getting stuck, as well as the holding of the probes inside the testing head, even in the absence of a device under test or of a space transformer, as well as during possible cleaning operations.

The proposed embodiments allow realizing different contact probes, which are usable in different operative conditions and in particular:

- a contact probe usable for only one assembly angle, as shown in Figures 2A and 2B; this embodiment is particularly simple and in any case ensures the proper retention of the probe in the testing head also in the absence of a device under test or of a space transformer; moreover, when the stopper is positioned between the guides included in at least one support, i.e. in an additional gap that is defined between them, it is possible to reduce the risk of triggering unwanted breakages in correspondence of the stopper since the stopper is realized in an area with reduced stresses, that area being in particular almost free from bending and in any case with controlled mechanical stress thanks to the reduced possibility of movement of the probe itself;

- a contact probe usable for two opposite assembly angles of the probes, as illustrated in Figures 5A and 5B, providing at least one pair of stopper; the movement through the guide holes of at least one stopper is prevented on the occasion of an upward movement of the contact probe, the stopper being in correspondence of a wall of the guide hole, that wall being in contact with a wall of the contact probe, regardless of the assembly angle of the probe; also this embodiment is particularly simple and in any case ensures the proper retention of the probe in the testing head, also in absence of a device under test or of a space transformer; furthermore, the positioning of the stoppers in such a way that they protrude from a same wall of the contact probe allows to reduce the overall dimensions of the probe itself;

- a contact probe usable for a single assembly angle with improved retention of the probe, as illustrated in Figures 6A and 6B, thanks to the use of stoppers protruding from both walls of the contact probe in a symmetrical configuration with respect to a longitudinal axis of the contact probe;

- a contact probe usable for both assembly angles with improved retention of the probe, as shown in Figure 7, thanks to the use of four stoppers protruding from both walls of the contact probe and arranged both between the guides of the upper support and between the upper support and the lower support in a completely symmetrical configuration;

according to that embodiment, a couple of stoppers is always apt to abut, on the occasion of an undesired upward movement of the contact probe, onto the undercut walls of the first and second guide of the upper support, regardless of the assembly angle of the contact probe; and

- a contact probe usable for only one assembly angle with reduction of the dimension of the probe in correspondence of the stopper, as shown in Figure 8, due to the use of a notch formed at the stopper and apt to compensate for the increase of dimension of the contact probe introduced by the stopper itself.

All the illustrated embodiments allow the use of the simple assembly method described with reference to Figures 4A-4C.

It should be also remarked the advantage linked to the fact that the contact probes are realized in a simple way and with reduced costs, with the respective stoppers being integral with the probe body and made directly from a mold by means of conventional photolithographic technologies, or by means of MEMS technology (Micro Electro-Mechanical System), or still with laser technology.

It must be finally pointed out that the stoppers affect a very small length of the body of the contact probes and they can be realized with particularly reduced dimensions (in particular their thickness).

Obviously, a person skilled in the art, in order to meet particular needs and specifications, can carry out numerous modifications and variations to the testing head described above, all included in the protection scope of the invention as defined by the following claims.

CLAIMS

1. A testing head (20) with vertical probes for the functionality testing of an electronic device, said testing head (20) comprising at least one couple of plate-like supports (22, 23) separated from each other by a suitable gap (29) and provided with respective guide holes (24; 25A, 25B) in order to slidably house a plurality of contact probes (21), each contact probe (21) comprising a rod-like body (21') extending along a preset longitudinal axis (HH) between a first and a second end (26, 27), said first end being a contact tip (26) adapted to abut onto a contact pad (28A) of a device under test (28) and said second end being a contact head (27) adapted to abut onto a contact pad (31A) of a space transformer (31), characterized in that at least one of said supports (23) comprises at least one couple of guides (23A, 23B) that are parallel to each other and separated by an additional gap (29') and provided with corresponding guide holes (25A, 25B) and in that each contact probe (21) comprises at least one protruding element or stopper (30) protruding from one of its lateral walls (32d, 32s), said lateral wall (32d, 32s) contacting one wall (35d, 35s, 36d, 36s) of at least one of said guide holes (25A, 25B) of said guides (23A, 23B).

2. The testing head (20) according to claim 1, wherein said contact head (27) has a diameter greater than a diameter of said guide holes (25A, 25B) of said guides (23A, 23B), thus preventing said contact head (27) from passing through said guide holes (25A, 25B).

3. The testing head (20) according to claim 1, wherein said stopper (30) is realized near said at least one support (23), between said at least one support (23) and said further support (22).

4. The testing head (20) according to claim 1, wherein said stopper (30) is realized between said guides (23A, 23B) of said at least one support (23), in said additional gap (29').

5. The testing head (20) according to any preceding claim, wherein said contact probe (21) comprises a further stopper (30A) protruding from the same wall (32d, 32s) from which protrudes said at least one stopper (30).

6. The testing head (20) according to any claim 1 to 4, wherein said contact probe (21) comprises a further stopper (30A) protruding from an opposing wall (32s, 32d) with respect to said wall (32d, 32s) from which protrudes said at least one stopper (30).

7. The testing head (20) according to any claim 1 to 4, wherein said contact probe (21) comprises at least further three stoppers (30A, 30B, 30C), said four stoppers being protruding in couples from said walls (32d, 32s) of said contact probe (21) and being arranged symmetrically to said longitudinal axis (HH), the first and third stoppers (30, 30B) being arranged between said at least one support (23) and said further support (22) and the second and fourth stoppers (30A, 30C) being arranged between said guides (23A, 23B) of said at least one support (23).

8. The testing head (20) according to any preceding claim, wherein said contact probe (21) further comprises a notch (40) realized in a wall (32s) of said contact probe (21) opposite to said wall (32d) from which protrudes said at least one stopper (30).

9. The testing head (20) according to claim 8, wherein said notch (40) realizes a recess in said rod-like body (21') of said contact probe (21) having dimensions comparable to a lateral protrusion of said at least one stopper (30).

10. The testing head (20) according to any preceding claim, wherein said at least one stopper (30) has a lateral protrusion having dimensions comparable to a diameter of said contact probe (21) and it is preferably between 5 and 40 μm.

11. The testing head (20) according to any preceding claim, wherein said at least one stopper (30) is arranged at a distance (D) from said at least one support (23) less than the sum of a length (Lp) of said contact tip (26) protruding from said further support (22) outside of said testing head (20) and a thickness (Sp) of said further support (22).

12. The testing head (20) according to any preceding claim, wherein said at least one stopper (30) comprises at least one undercut wall (30sq) having a rounded shape.

13. The testing head (20) according to claim 12, wherein said undercut wall (30sq) has a radius of curvature (rc) between 0.001 μm and 0.1 μm.

14. A method for assembling a testing head (20) according to any preceding claim, said method comprising at least the steps of:

- overlapping a lower support (22) and first and second guides (23A, 23B) of an upper support (23) having said respective guide holes (24, 25A, 25B) concentric to each other;

- inserting said contact probes (21) in said respective aligned guide holes (24, 25A, 25B);

- a first relative movement of said upper support (23), and particularly of said guides (23A, 23B) together, with respect to said lower support (22) along a first direction (S1), substantially perpendicular to said supports, passing said stopper (30) through said corresponding guide holes (25A, 25B) of said upper support (23); and

- a second relative movement of said upper support (23), and particularly of said guides (23A, 23B) together, with respect to said lower support (22) along a second direction (S2), substantially parallel to said supports.

15. The method according to claim 14, further comprising a third step of relative movement of said first and second guides (23A, 23B) of said upper support (23) with respect to each other along a third direction (S3), parallel to said guides.

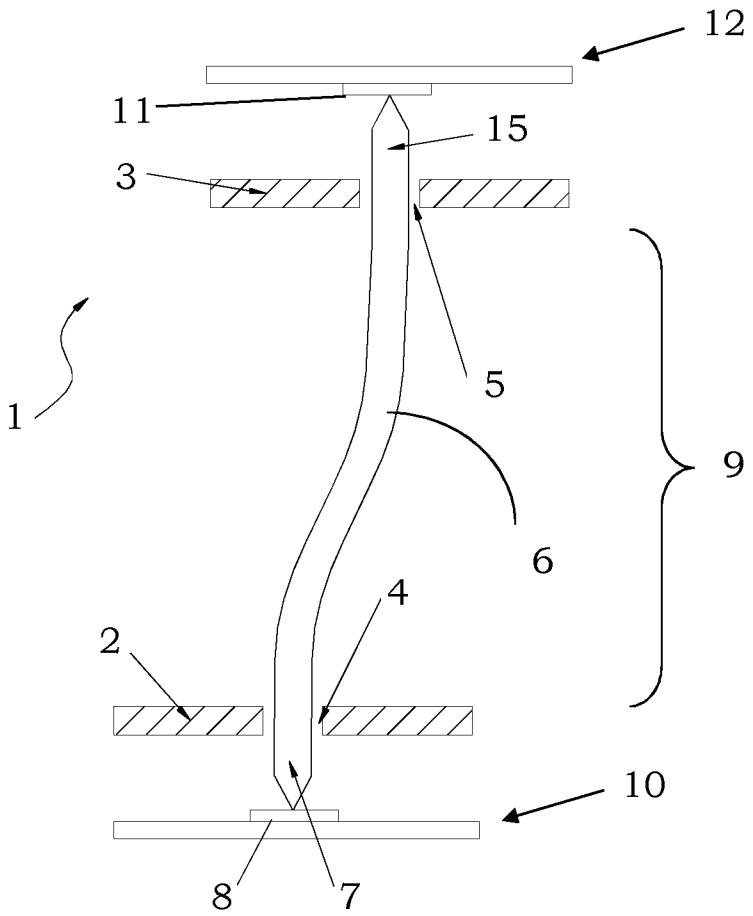
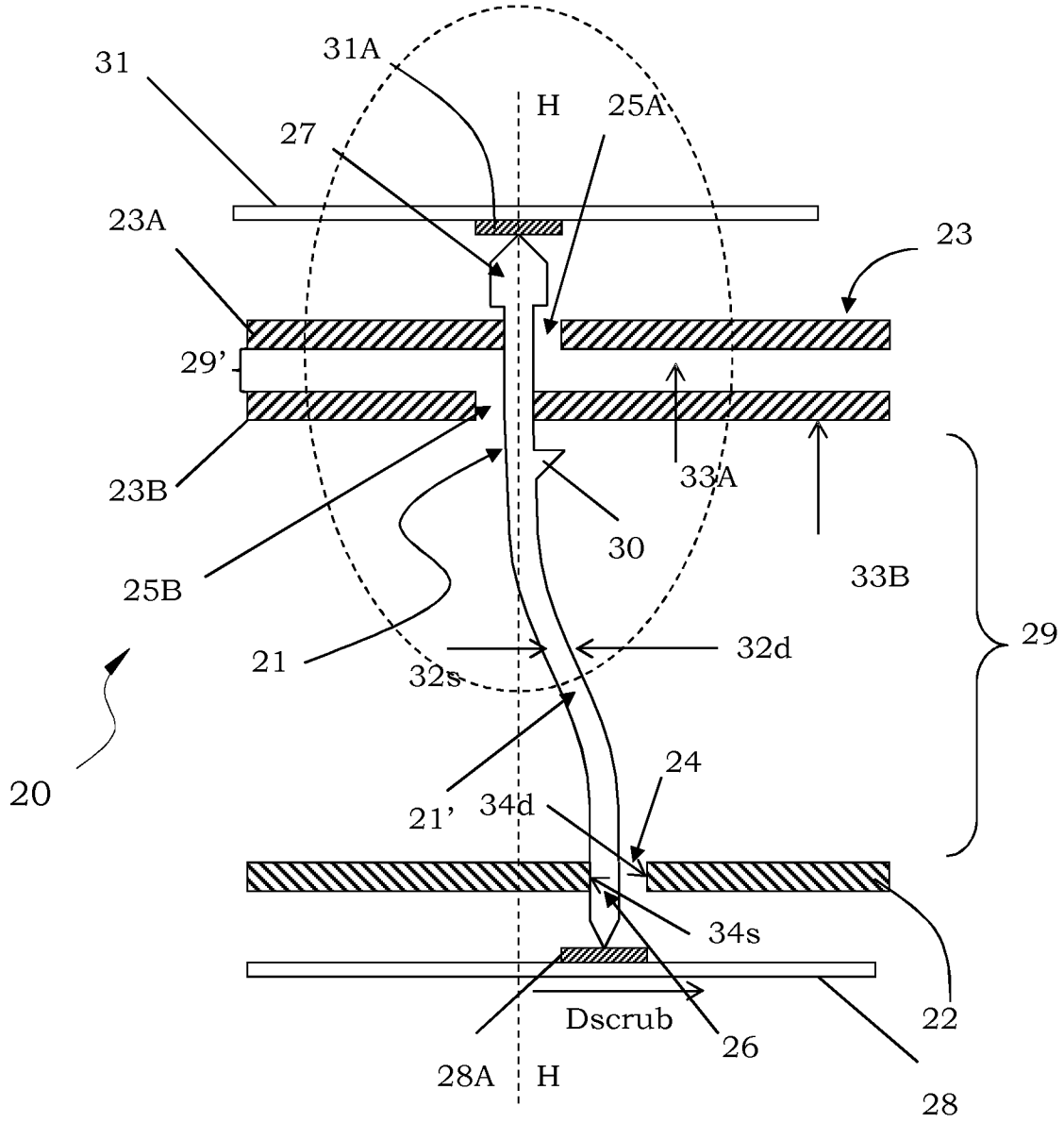


FIG. 1
PRIOR ART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28

FIG. 2A

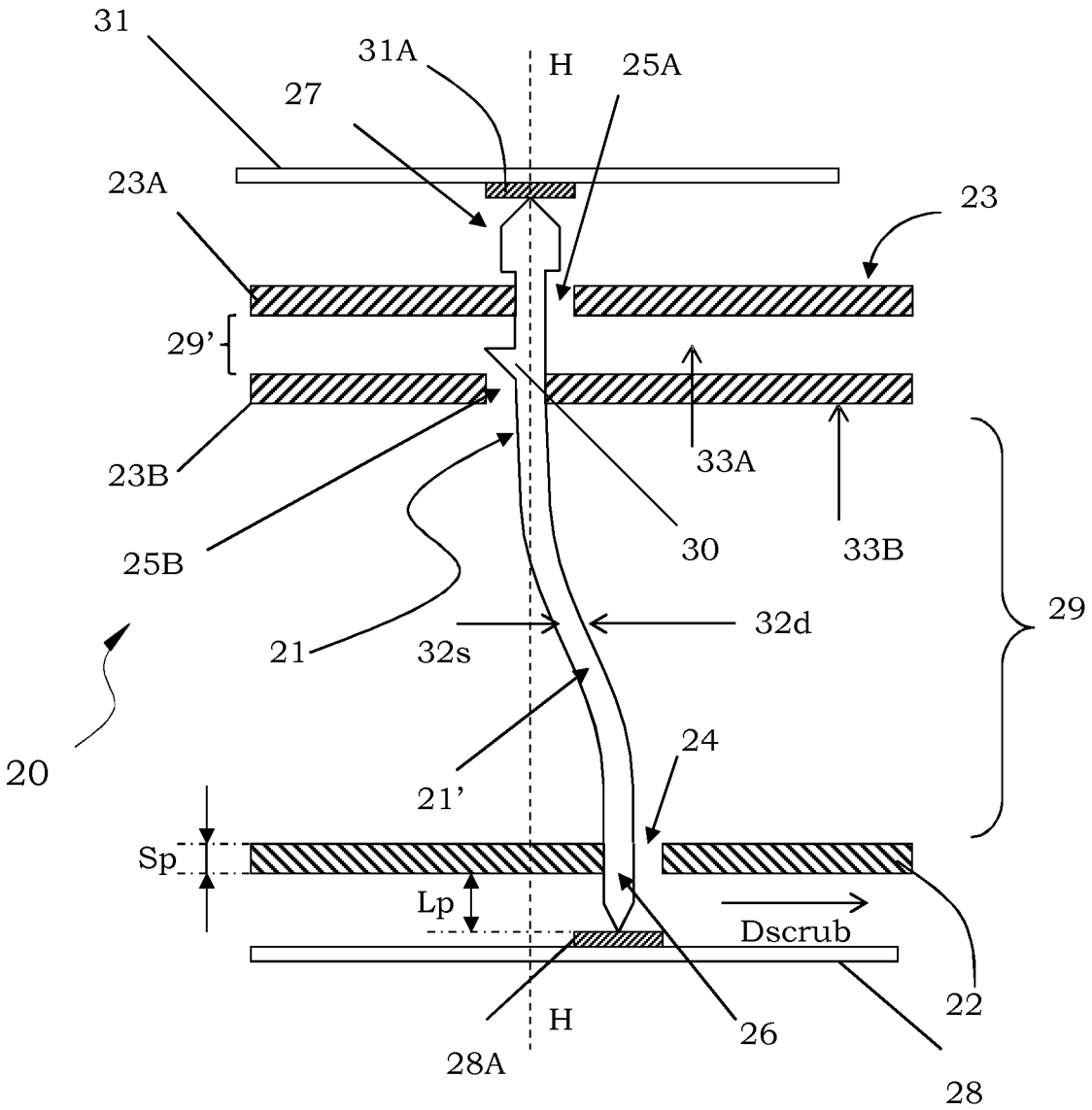
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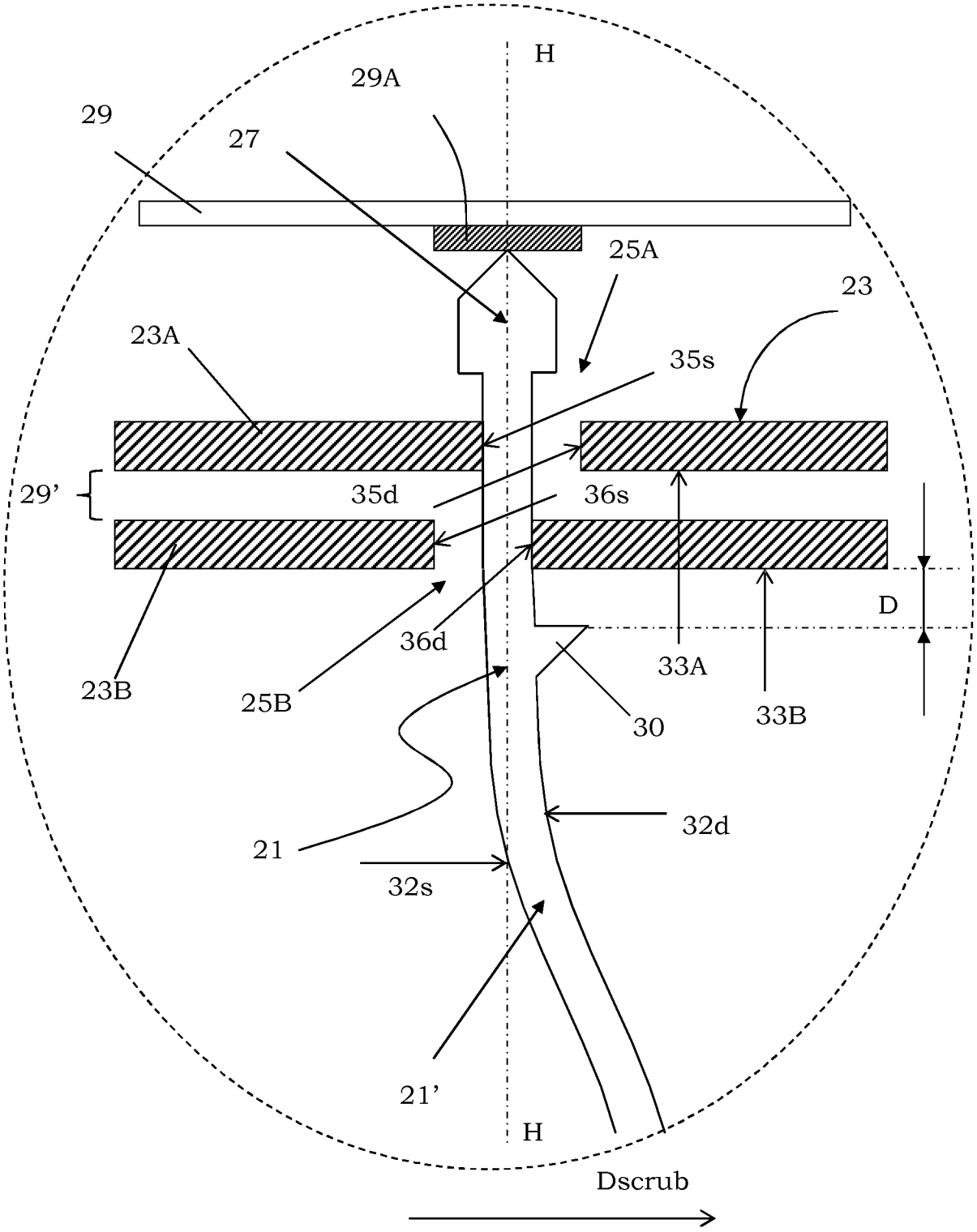
FIG. 2B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Dscrub

FIG. 3

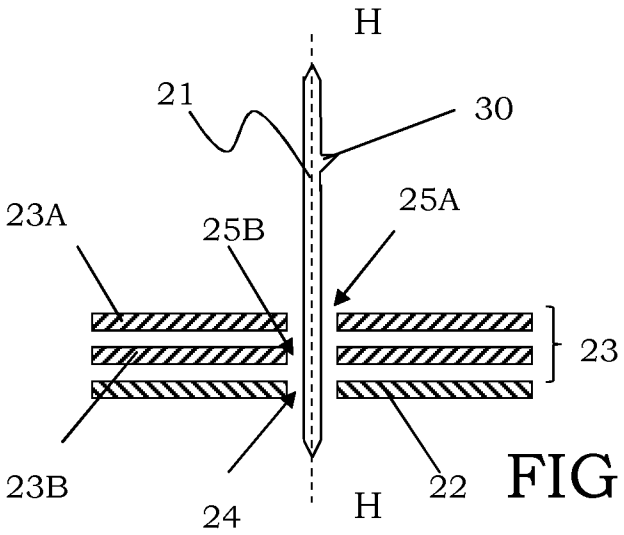


FIG. 4A

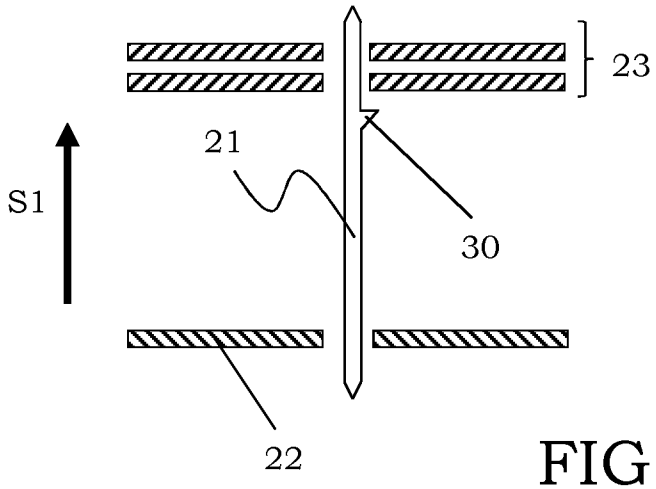


FIG. 4B

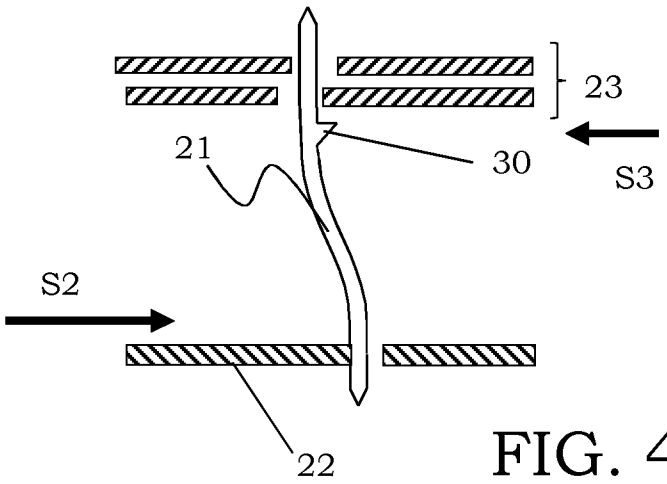
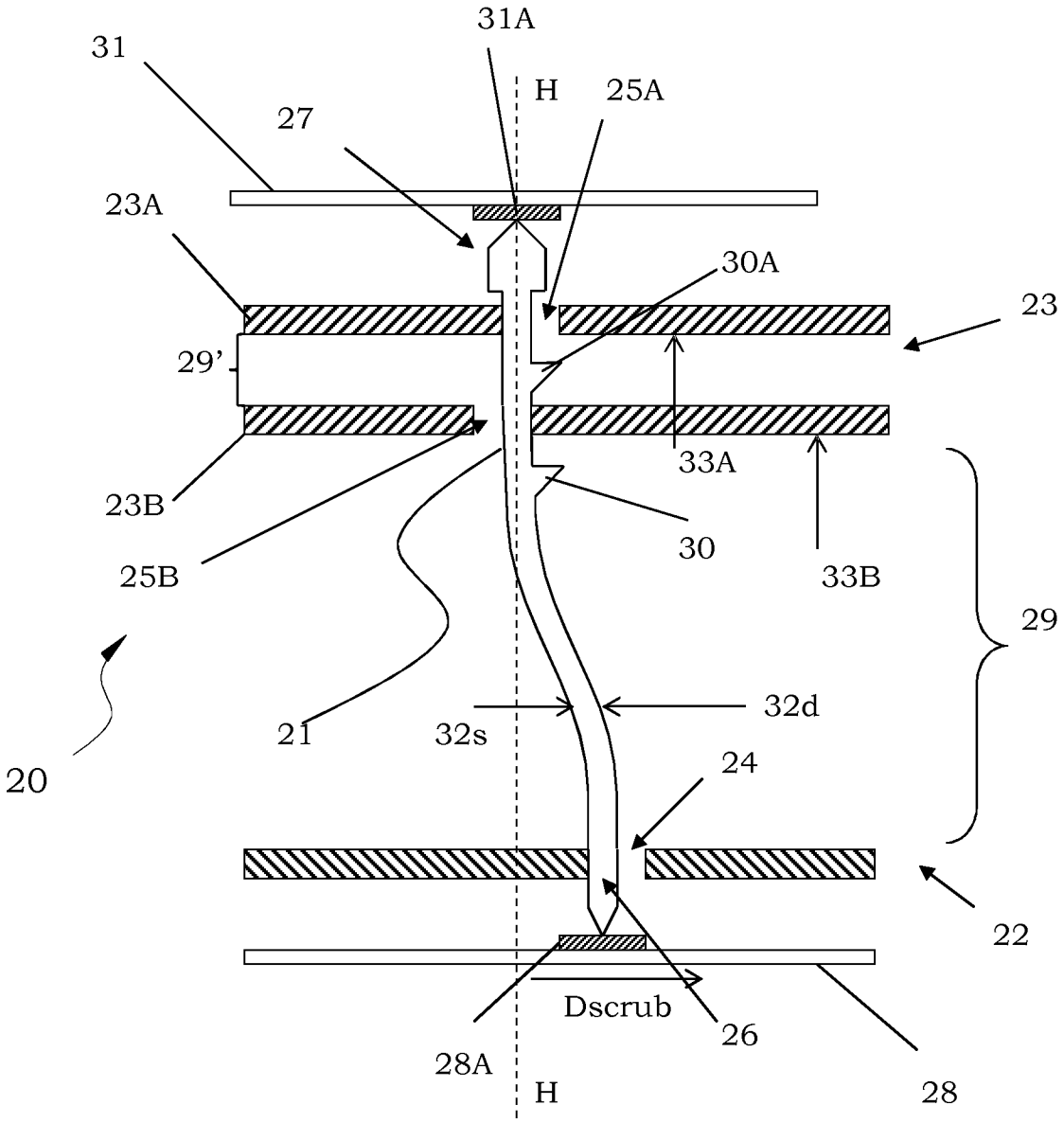


FIG. 4C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29'
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23B
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Dscrub
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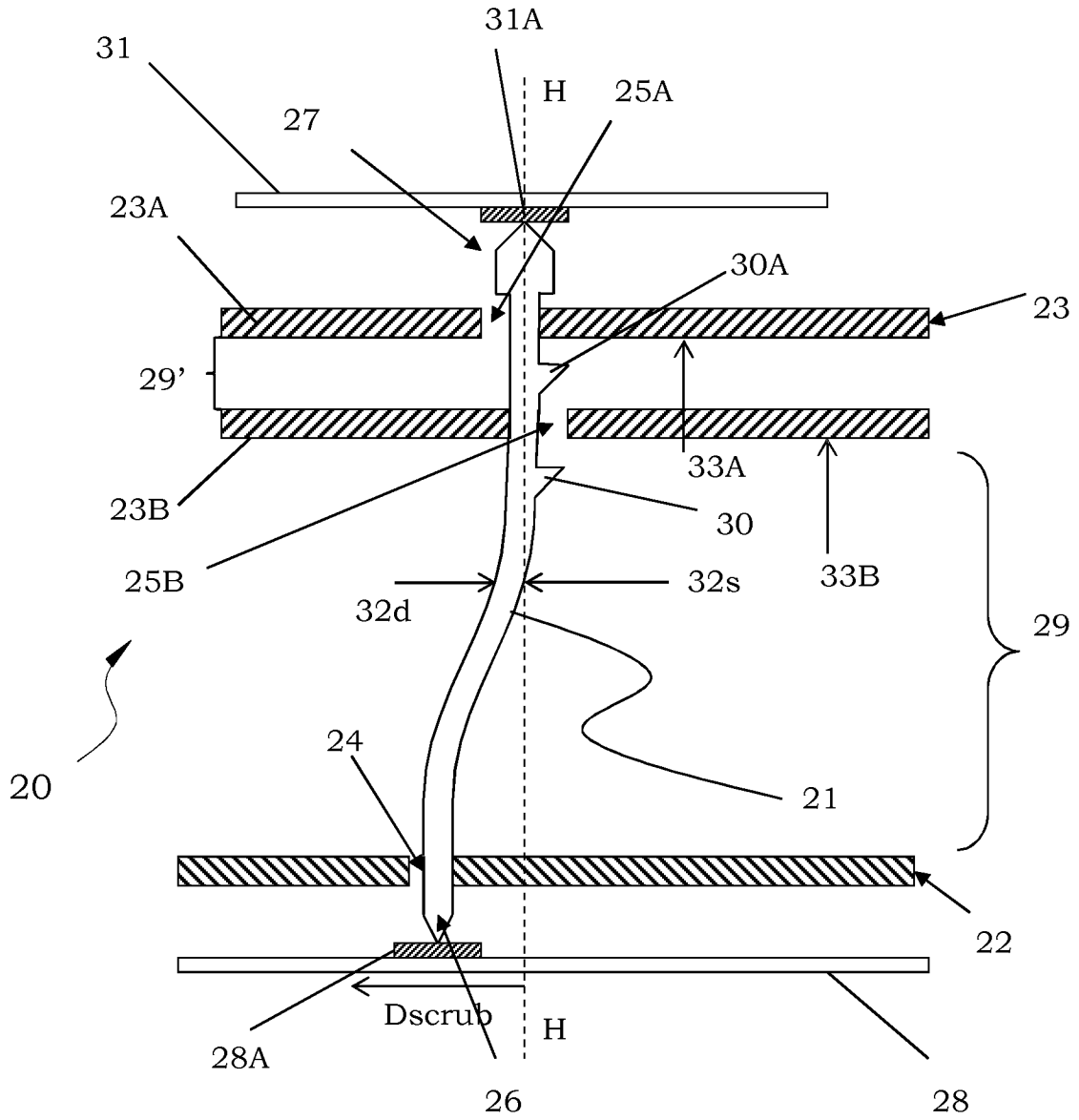
H
28

FIG. 5A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24
21
22
Dscrub
H
28A
26
28

FIG. 5B

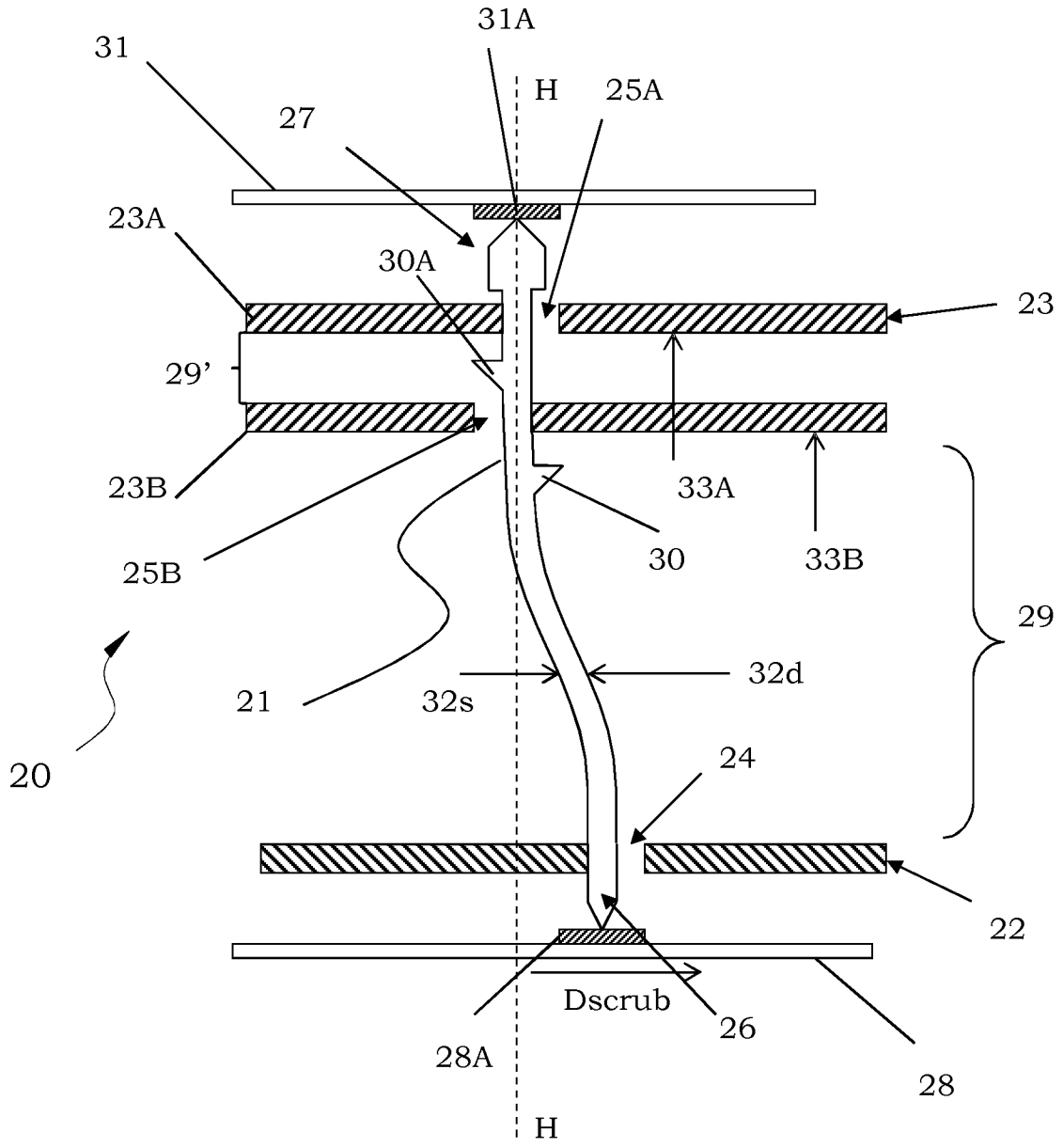
31A
31
H
25A
27
23A
30A
23
29'
23B
33A
25B
30
33B
29
21
32s
32d
20
24
22
Dscrub
26
28A
28
H

FIG. 6A

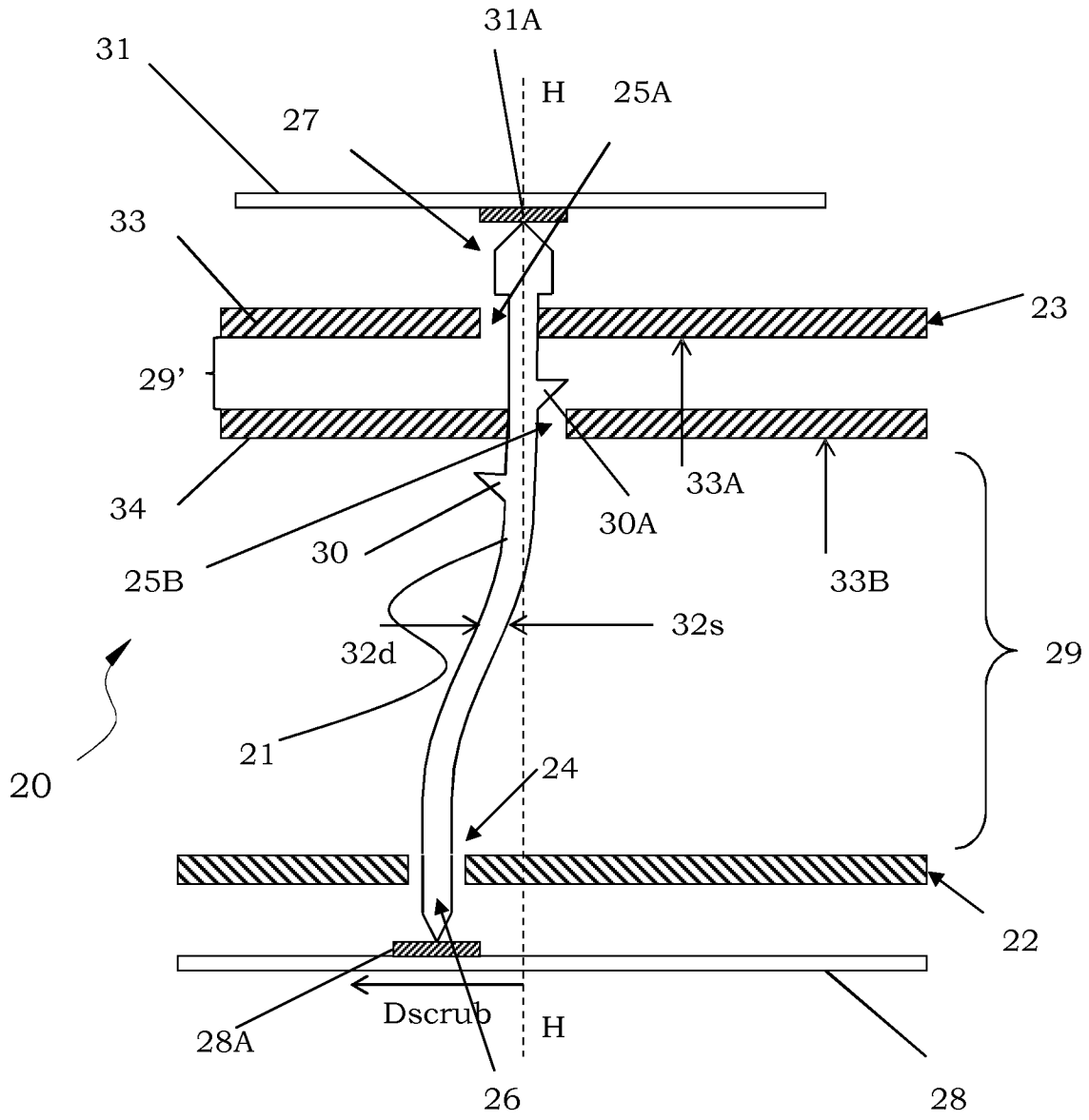
31A
31
H
25A
27
33
23
29'
34
33A
30A
30
25B
33B
32s
32d
29
20
21
24
22
Dscrub
H
28A
26
28

FIG. 6B

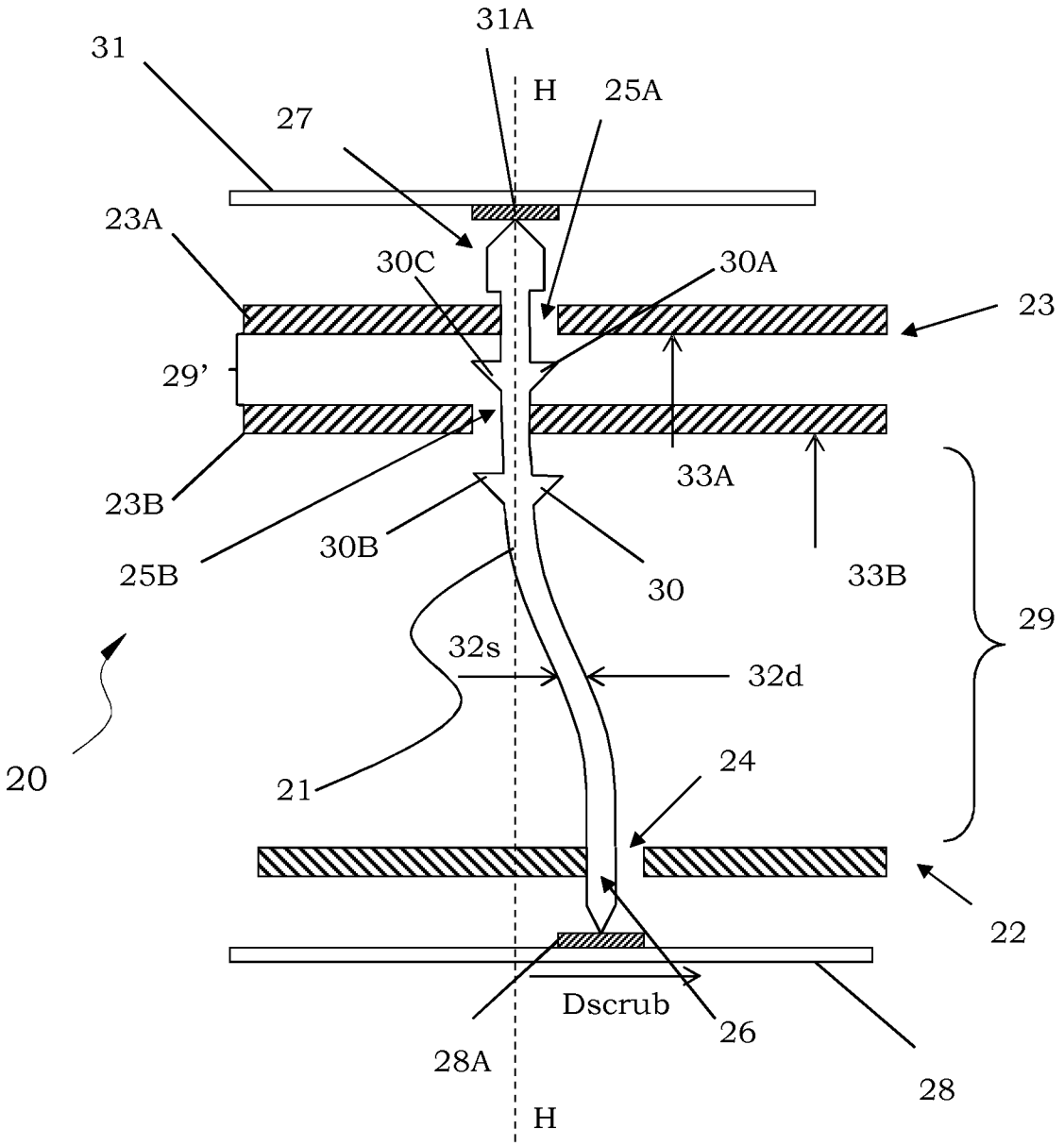
31A
31
H
25A
27
23A
30C
30A
23
29'
33A
23B
30B
25B
30
33B
29
32s
32d
20
21
24
22
Dscrub
26
28A
28
H

FIG. 7

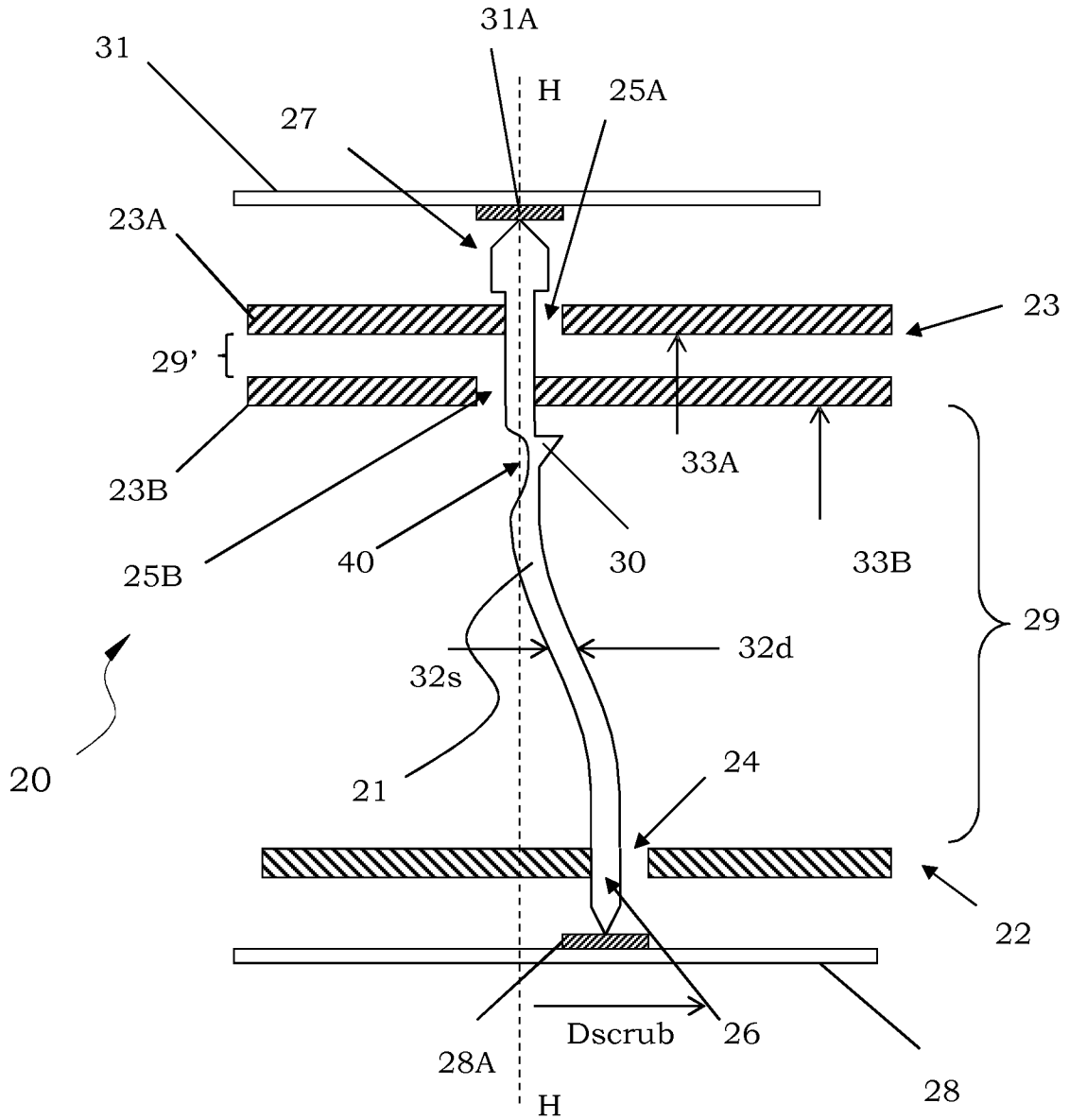
31A
31
H
25A
27
23A
23
29'
33A
23B
25B
40
30
33B
29
32d
32s
20
21
24
22
Dscrub
26
28A
28
H

FIG. 8

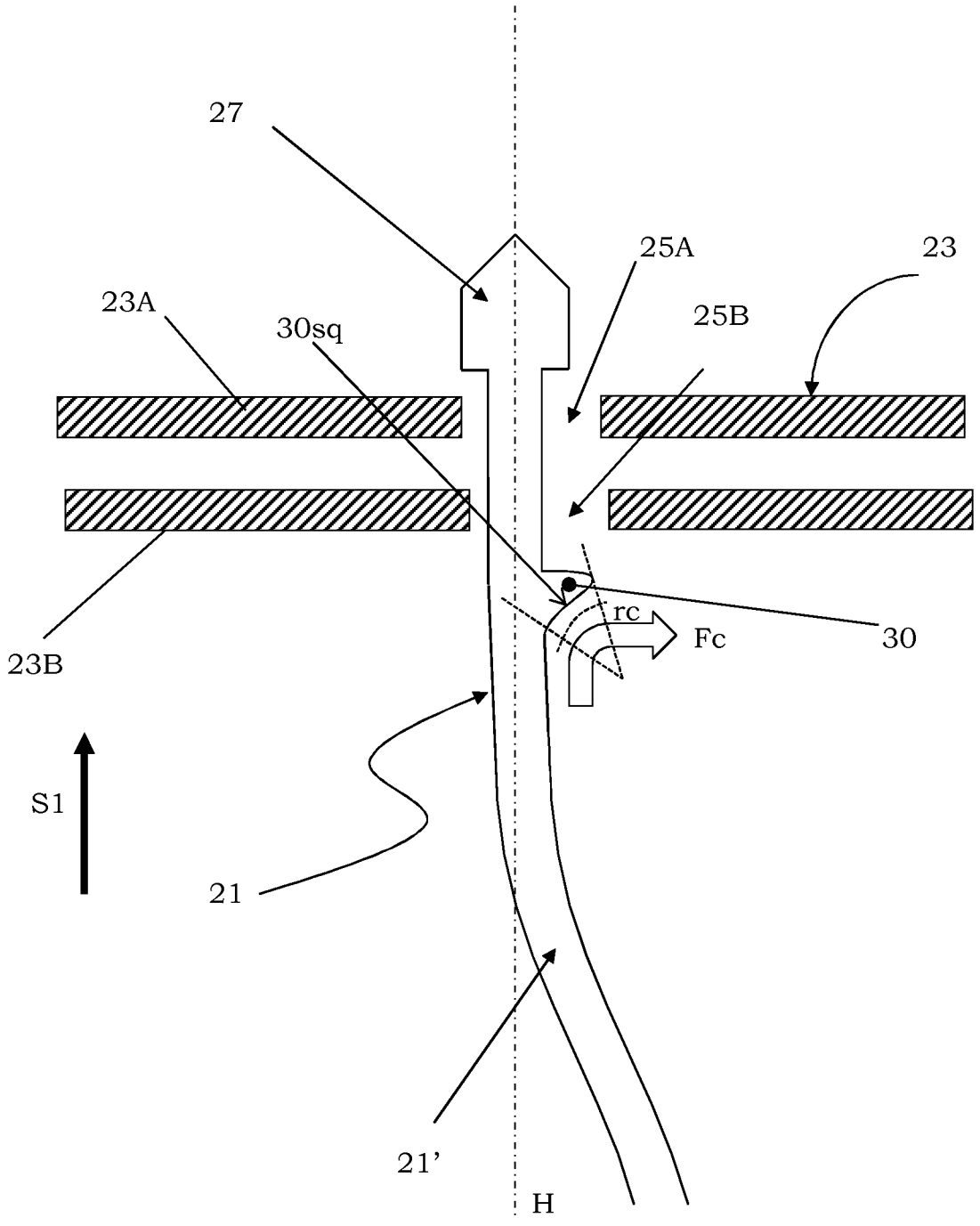

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/055228

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01R1/073 G01R1/067 H01R13/24
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01R H01R

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/102495 A1 (KISTER JANUARY [US]) 23 April 2009 (2009-04-23) paragraph [0017] - paragraph [0030]; figures 2-5	1-15
X	US 2015/015287 A1 (DEBAUCHE JOHN [US] ET AL) 15 January 2015 (2015-01-15) paragraph [0099] - paragraph [0128]; figures 1-18	1-15
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2016	05/07/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hijazi, Ali

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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PCT/EP2016/055228

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