

(57) **Abrégé(suite)/Abstract(continued):**

outlet (20a), which is arranged in the fibre infeed direction (V) downstream of the fibre conveying device (20f), and which is adapted for the simultaneous laying of a plurality of rovings (33; R1, R2 etc.) on a workpiece carrier (40) for constructing a three-dimensional preform (31), a fibre cutting device (21, 21i, 21j), which is arranged in the fibre infeed direction (V) downstream of the fibre conveying device (20f) and upstream of the outlet (20a) and is adapted for cutting the rovings (33; R1, R2 etc.), and a nozzle (22, 22i, 22j) for attaching a medium to the rovings (33; R1, R2 etc.), wherein the nozzle (22, 22i, 22j) is adapted for applying the medium to two sides of the rovings (33; R1, R2 etc.) and for introducing the medium into the rovings (33; R1, R2 etc.).

Abstract

A laying head for the manufacturing of fiber layers and structural component preforms of fibers is taught, comprising an inlet (20e) adapted for introducing a plurality of dry rovings (33; R1, R2...), a fiber conveying device (20f) for simultaneous and mutual independent conveying of roving (33; R1, R2...) in a fiber supply direction (V) introduced via the inlet (20e), an outlet (20a) arranged downstream in a fiber supply direction of the fiber conveying device (20f) and adapted for simultaneous laying of a plurality of rovings (33; R1, R2...) on a workpiece carrier (40) for forming a three-dimensional preform (31), a fiber-cutting device (21, 21i, 21j) arranged downstream in a fiber supply direction (V) of the fiber conveying device (20f) and upstream of the outlet (20a) and adapted for cutting the rovings (33; R1, R2...), and a nozzle (22, 22i, 22j) for applying a medium onto the rovings (33; R1, R2...), wherein the nozzle (22, 22i, 22j) is adapted for a two-sided application of the medium onto the rovings (33; R1, R2...) and for introducing the medium into the rovings (33; R1, R2...).

Laying Head and Apparatus and Method for Manufacturing a Three-Dimensional Preform for a Structural Component from a Fiber Composite Material

The present invention relates to a laying head and to an apparatus and a method for manufacturing a three-dimensional preform for a structural component from a fiber composite material.

A laying head, an apparatus and a method for manufacturing a three-dimensional preform for a structural component from a fiber composite material are known from WO 2011/128110 A1. It is referred to the description of the prior art and of the technological background on pages 1 to 3 of this printed document. It is taught in the printed document how a plurality of dry rovings can be supplied to a laying head and laid on a corresponding three-dimensional workpiece carrier for forming a three-dimensional preform, in order to manufacture a structural component preform for a structural component of fiber composite materials.

In this respect, the starting materials are, as in the present application, so-called rovings. A roving is a yarn consisting of a plurality of filaments made of the fiber material which could be called the actual fibers. Carbon fibers, glass fibers, aramid fibers etc. are preferably used as fiber composite materials. Such a roving can consist of several, such as e.g., 8 or 10 filaments up to some 10,000 or more filaments. A 50k roving consists, for example, of 50,000 filaments.

In the present application, the term fiber indicates a roving except when reference is explicitly made to individual filaments.

WO 2011/128110 A1 discloses the fixing of the beginnings and ends of the rovings at the edge of the workpiece carrier by means of adhesive.

Further devices and methods for attaching or introducing of adhesive onto or into rovings, respectively, are known from WO 2009/077581, EP 2 433 784 A1, WO 2009/158262 A1 and US 2011/0083605 A1

It is an object of the present invention to improve the possibilities of fixing the rovings and the possibilities of the application of media such as adhesive, binders, impregnating resins and the like.

This object is achieved by a laying head according to claim 1, an apparatus according to claim 14 and a method according to claim 15.

Further developments are given in the dependent claims.

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It is especially enabled to impregnate a medium into the rovings by means of a nozzle, that means to not only apply the medium such as an adhesive, a binder or a resin onto a roving from the outside, but to permeate/penetrate the roving with the medium.

10 This allows a fixing of the fiber set or rovings, respectively, to be laid in the fixing area of the workpiece carrier with a low cutting waist.

The process stability can be enhanced because all filaments at the ends of the corresponding rovings are embedded in adhesive/binder/resin, and by means of that, cannot be moved
15 unexpectedly somewhere else.

In the preferred embodiment, the sections of the rovings impregnated with adhesive can be centrally separated at the end of a laying path in a manner that an adhering portion for the end fixing of the rovings of the present laying path and the fixing portion for the start fixing of the
20 succeeding laying path can be obtained simultaneously.

Further features and advantages follow from the description of embodiments referring to the drawings. The drawings show:

25 Fig. 1 in a) a schematic view of a robot with laying head, roving bobbins and a workpiece carrier, and in b) a view of the front end of the robot with laying head during laying a fiber set onto the workpiece carrier;

Fig. 2 in a) a view of a workpiece carrier, and in b), c) and d) with laid fiber layers;
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Fig. 3 in a) a perspective view of a portion of a laying head according to a first embodiment, and in b) a side view of a portion of the laying head;

Fig 4 in a) a schematic perspective view of a nozzle according to an embodiment, in b) a perspective schematic view of a rear portion of the nozzle of Fig. 4a), and in c) a front
35 view of the portion of Fig. 4b);

Fig. 5 in a) a front view of the nozzle of Fig. 4a), in b) a top view of the nozzle of Fig. 5a), and in c) in the upper portion a side view of the nozzle of Fig. 5a) and in the lower portion an enlarged view of the portion framed with a dashed line in the upper portion; and

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Fig. 6 a schematic representation of the cutting of an impregnated roving, in a) before the cutting and in b) after the cutting.

Fig. 1a and 1b show schematically a robot 10 to which a laying head 20 is attached. A workpiece carrier 40 is held on a support 15 for the workpiece carrier. It is shown schematically that the laying head 20 is adapted to simultaneously lay a fiber set 30 of plural rovings onto the workpiece carrier 40. In Fig. 1a, 5 bobbins 51 of a fiber supply mechanism 50 are shown, onto which the fibers (rovings) 33 are wound and from where they are supplied to the laying head 20 via the fiber supply mechanism 50. In Fig. 1b), only 4 rovings are schematically shown. The fiber set 30 can comprise a plurality n of rovings, where $n = 2, 3, \dots$, wherein $n = 8$ or $n = 16$ or $n = 32$ are presently preferred.

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The arrangement serves to build up a three-dimensional preform for a structural component made of a fiber composite material with a multi-layer multi-axial fiber architecture (MAFA) similar to a multi-axial fabric (MAF).

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The fiber supply mechanism 50 comprises preferably a fiber guiding mechanism which is preferably implemented in the manner as shown in Fig. 12, 13 of WO 2011/128110 A1 and described with respect to these figures.

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According to the embodiments, the workpiece carrier 40 comprises a workpiece forming area 41 and an edge-fixing area 42, as shown in Fig. 2a). The workpiece forming area 41 corresponds to the desired three-dimensional shape of the preform. The edge-fixing area 42 serves for fixing the rovings 33 in the edge area of the workpiece carrier 40.

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In Fig. 2b), the workpiece carrier is shown with a first fiber layer 31a which has been laid on the workpiece carrier in a first orientation (axial direction). As indicated in Fig. 2b), the fiber layer 31a consists of rovings 33 which have been laid in this axial direction. In Fig. 2c), the same workpiece carrier 40 is shown, on which a second fiber layer 31b has been laid over the first fiber layer 31a. The fibers of the second fiber layer 31b have an orientation of -45 degrees

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relative to the orientation of the first fiber layer 31a. It is shown in Fig. 2d) how a third fiber layer 31c has been laid over the second fiber layer 31b, wherein it has been laid only on a part of the workpiece carrier 40. The third layer 31c has an orientation of +45 degrees relative to the first layer and thus of 90 degrees relative to the second layer 31b. The three layers 31a to 31c
5 form a multi-layer, multi-axial fiber architecture (MAFA) 31.

Again referring to Fig. 1a), it can be recognized that laying head 20 comprises an inlet 20e, via which the dry rovings 33 are supplied to the laying head. Laying head 20 further comprises an outlet 20a, from which the rovings 33 are output for laying the same onto the workpiece carrier
10 40, a pressing roller 20r being arranged at the output 20a, by means of which the output rovings 33 may eventually be pressed against the workpiece carrier 40. In Fig.1a), a fiber supply direction V for the direction of the conveying or transport, respectively, of the rovings 33 is indicated. A fiber conveying device 20f is provided downstream in the fiber supply direction V of the inlet 20e of the laying head 20. This fiber conveying device can be implemented, for
15 example, by a conveying unit as described in US 2009/0229760 A1. In principle, such a fiber supply according to the Eytelwein principle is known. Moreover, it is referred to the indicated US 2009/0229760 A1 and WO 2011/128110 A1 with respect to the fiber conveying device.

A fiber treatment unit 20b is schematically shown in Fig. 1a) downstream in the fiber supply
20 direction V of the fiber conveying device 20f. This fiber treatment unit 20b is described in more detail in the following referring to Fig. 3a) and b). In Fig. 3a), a perspective view of the portion 20b of the laying head for guiding and treatment of the rovings 33 and R_i , R_j , respectively, is shown in a supply direction V downstream of the fiber conveying device 20f until the pressing roller 20r. In Fig. 3b), the same portion 20b of the interior of the laying head 20 is
25 schematically shown in a side view. The rovings 33 supplied via the inlet 20e into the laying head 20 are divided into two groups of rovings R_i ($i = 1, 3, 5, \dots$) and R_j ($j = 2, 4, 6, \dots$) in the shown embodiment of the laying head. The group R_i includes the even-numbered rovings 33 and the group R_j includes the odd-numbered rovings 33. In the shown embodiment, $n = 16$ such that 8 rovings are present in group R_i ($i = 1, \dots, 15$) and 8 rovings are present in group R_j ($j = 2, \dots, 16$). The groups R_i and R_j are guided and treated on two separated paths P1 and P2.
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The division into the two groups and the separate paths P1 and P2 is not necessary. A single path without division/separation could be present, too. On the other hand, a plurality of more than two groups and paths could be implemented as well.

In the following, the treatment unit 20b for the path P1 is described. The description is valid in analogy for path P2. The reference numerals indicated with i for path P1 have a j instead of an i for the path P2.

5 The rovings 33, Ri are conveyed by the fiber conveying device in the fiber supply direction V and arrive downstream at a nozzle 22, 22i for applying and permeating a medium M into the rovings, which will be described in more detail hereinafter. The nozzle is adapted for applying a medium (adhesive, binder, resin, and the like) in such a manner that the medium is applied on both sides onto the rovings and permeated (impregnated) into the rovings. This applying and
10 permeating on both sides can be done continuously or clocked in sections.

In the following, a description is given of the case, where the medium is a so-called Hot-Melt Adhesive. Such a Hot-Melt-Adhesive is adhering/sticky above a predetermined temperature and is not adhering/sticky below the predetermined temperature (hereinafter indicated as adhering
15 temperature) but is still elastic over a significant temperature range.

In case of using such a Hot-Melt-Adhesive, it is preferred that a cooling device 23, 23i for cooling the rovings with the applied and permeated adhesive under the adhering temperature is provided downstream in the supply direction V of the nozzle 22.
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In the treatment unit 20b of the embodiment shown in Fig. 3, an intermediate conveying device 24, 24i is preferably provided downstream in the supply direction V of the nozzle 22, in case of the presence of the cooling device 23 downstream of the cooling device 23. The intermediate conveying device serves for a secure conveying of the roving downstream of the nozzle 22. A
25 fiber-cutting device 21, 21i is provided downstream in the supply direction of the nozzle 22 and, in case of presence of the cooling device 23 and/or of the intermediate conveying device 24, preferably downstream of these devices. The fiber-cutting device 21 is adapted for cutting the rovings. With respect to the specific embodiments of the fiber-cutting device, it is referred to Fig. 9 of WO 2011/128110 A1 and the corresponding description.

30 As has been explained before, a pressing roller 20r is arranged at the outlet 20a of the laying head 20. A heating device 25, 25i1, 25i2 is provided upstream in the supply direction V of the pressing roller 20r and downstream of the fiber cutting device 21, 21i. In the shown embodiment, the heating device 25i comprises two elements indicated with 25i1 and 25i2. The
35 first element 25i1 provided closer to the pressing roller 25r in the supply direction V is an end-

heating serving to heat the adhesive applied onto and permeated into the rovings 33Ri again above the adhering temperature (e.g. 100°C). The second element 25i2 is a heating for maintaining a predetermined temperature (e.g. 70°C) of the rovings (temperature holding heating).

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When the rovings 33Ri have been cut by the fiber cutting device 22, 22i, the end of the rovings 33Ri positioned upstream of the cutting plane may comprise adhesive. In order to prevent that this adhesive cools down too far below the adhering temperature, this portion of the rovings can be kept at a temperature below but close to the adhering temperature by means of the temperature holding heating 25i2.

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The laying head 20 and the robot 10 as well as the single components of the laying head 20 are controlled by a not-shown control device.

15 The workpiece carrier 40 is shown in Fig. 3 as a plane workpiece carrier. This serves merely for simplification of the representation.

In the following, the design of the nozzle 22, 22i, 22j is described in more detail referring to Fig. 4 and 5.

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A perspective view of the nozzle 22 in a schematic representation is shown in Fig. 4a). A roving 33 is supplied in the supply direction V into the nozzle 22 via a guiding path 22b formed on a protrusion 22P, where the guiding path 22b is shown in a plane configuration in the shown embodiment. The medium (e.g., adhesive) M is supplied via an opening provided at the upper side. In Fig. 4a), the body of the nozzle 22 downstream of the protrusion is shown as consisting of four parts 22-1 to 22-4, which are screwed to each other (not shown). This can also be well recognized in the side view of 5c). In Fig. 4b) and c), merely the rear portion is shown. For use in the description of the embodiment of the nozzle 22 and the adaption to passing through of the rovings 33, a coordinate system l-d-b is introduced, in which the axis l points in the longitudinal direction of the rovings 33 which corresponds to the supply direction V, the direction d points in the direction of the thickness of the rovings, and the direction b points in the direction of the width of the rovings. As can be well recognized in Fig. 4b), c) and 5a) to c), the nozzle 22 comprises a slit 22s which is adapted in its height and width to the dimensions of the rovings 33 to be passed through. The height s in the direction d of the slit corresponds to the height of the rovings 33 with a predetermined overmeasure. The slit 22s extends in a slit plane l-b with a

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height s in the thickness direction perpendicular to the slit plane l-b as a consequence. The determination of the overmeasure will be explained in the following. The width of the slit 22s, not provided with a reference numeral, corresponds to the width of the rovings with an overmeasure which is predetermined, too.

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The nozzle comprises a channel system 22a supplying two manifolds 22v with the medium M supplied via the inlet 22e. In case of the Hot-Melt-Adhesive, the same is supplied via the inlet 22e with a pressure of, for example, 50 bar.

10 One manifold 22v each is provided in the nozzle 22 above and below the passing-through slit 22s. An adhesive applier formed at a nozzle gap 22d leads from the manifold 22v arranged above the passing-through slit 22s to the passing-through slit. The nozzle gap 22d preferably comprises the width of the slit 22s. In the same manner, an adhesive applier formed as a nozzle gap 22d leads from the manifold 22v arranged below the passing-through slit 22s to the same.

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Provided corresponding supply of the medium M, the same is applied to the upper side and to the lower side of a passing-through roving 33 via the nozzle gap 22d as a consequence. By moving the roving in supply direction V, the same can be applied, depending on the controlled supply, section-wise or clocked or continuously.

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In order to not only apply the adhesive onto the roving but to impregnate the same into the roving, the passing-through slit 22s is adapted in its dimensions depending on the dimensions of the roving and the nature of the adhesive or of another medium as well as the supply pressure.

25 By means of this, an impregnation is enabled without redirection of the rovings perpendicular to the supply direction V. Furthermore, it is enabled to stop the adhesive application in a defined manner. An interruption of an adhesive supply by closing a valve leads to a pressure loss and thus to an abrupt end of the application.

30 For a usual Hot-Melt-Adhesive with an adhering temperature of approx. 150° C and a supply pressure of approx. 50 bar, an overmeasure of 0.05 to 0.1 mm can be selected for a 50k roving with 12 mm width and a thickness of approx. 0.3 mm to 0.35 mm in order to not only apply the Hot-Melt-Adhesive onto the roving, but to also introduce the same into the roving, that means, in order to impregnate the same. In such a case, the height of the slit 22s is consequently, e.g.,

0.4 mm. The open width w of the gap 22d is then in the range of 0.025 to 1 mm, that means is consequently, e.g., 0.05 mm.

Supporting measures such as a slight combing of the rovings directly before the medium supply
5 or the like are possible for promotion (see as well the fiber preparation described in WO 2011/128110 A1). In general, the overmeasure should be in the range of 0.025 to 0.2 mm in height direction d and/or in width direction b , for rovings with widths in the range from 5 to 100 mm and thicknesses in the range from 0.2 to 0.6 mm.

10 A single passing-through slit can be provided for all or plural rovings of one supply path P1, P2 in case of a roving and media combination, for which the impregnating is easy. It is, however, to be preferred to have a separate passing-through slit 22s per single roving.

In particular, adhesives are suitable as media, which are suitable for the start and end fixation of
15 the fiber layers 31a, b, c or their intermediate fixation, such as, for example, adhesives on EVA or polyolefine or epoxy basis. Binders and resins are also suitable media. In this respect, binders are used to apply the dry rovings with binder at the time of laying the same, in order to obtain a good-to-handle, dry (e.g. including no resin) preform and to avoid a slipping of the fibers during preform manufacturing. The application and permeating of resin can be used to achieve
20 that the resin does not have to be introduced into the preform in a process subsequent to the formation of the preform, but that the impregnation with resin occurs directly at the laying of the fibers (Online-Prepregging). If plural media should be applied, a separate nozzle 22 for each medium can be provided in each path P1, P2.

25 With respect to the binders and the resin, it has to be pointed out that the application in the laying head 20, in particular with the described nozzle 22, allows the handling of dry rovings from the bobbin until downstream the fiber conveying device in the laying head 20 and thus high velocities etc.

30 The described laying head and apparatus for manufacturing a three-dimensional preform for a structural member made of a fiber composite material with such a laying head, respectively, can be used consequently with a method of the type described in WO 2011/128110 A1 in a very advantageous manner and can further develop the same.

In particular, a further development of a method for manufacturing a preform for a structural member of a fiber composite material is enabled, in which the fixation of the end portions of the rovings on both sides of a cutting can be achieved in a very advantageous manner.

5 This will be explained using a case, in which dry rovings are laid on the workpiece carrier 40. A roving 33 is, as can be seen in Fig. 6a), coated over a predetermined length l with the medium M, which is a Hot-Melt-Adhesive in this case, and potentially impregnated. The length l shown in Fig. 6a) includes at least the predetermined lengths l_1 and l_2 shown in Fig. 6b), that means $l \geq l_1 + l_2$. The roving 33 is cut by the fiber cutting device 21 at a position determined in a
10 manner that, after the execution of the cutting along the cutting plane S, the end 33e can be fixed at the end of a laying path in the edge-fixing area with the adhesive M over the first predetermined length l_1 . On the other side of the cut S, the adhesive M is present with the second predetermined length l_2 at the downstream front end of the remaining portion of the roving 33, by means of which the roving 33 can be fixed at the workpiece carrier 40 at the
15 begin of the laying of the next laying path.

In general, this is not limited to an edge fixation but can also be applied in an analogous manner to the application of intermediate reinforcements or the like.

20 The nozzle gaps end in the described embodiment on one line relative to the supply direction. Alternatively, they could also be offset in the supply direction V. The nozzle gap is preferably formed in a linear manner. Alternatively, holes arranged in a linear manner or in a matrix are possible as outlet of the media applicator 22d. The downstream lip of the nozzle gap 22d can be formed protruding into the slit 22s, in order to effect a scraping (coating with a doctor blade).

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The design of the nozzle 22 with the four parts 22-1 to 22-4 enables to provide the nozzle gap 22d und the slit 22s at front faces of the four parts enabling a simpler manufacturing.

It is explicitly emphasized that the single elements and method steps which have been described
30 are also disclosed separately as separate subject-matters. For example, a design of the nozzle 22 is independent of the precise design of the laying head or of the arrangement within a laying head. The method described with respect to Fig. 6 can generally be implemented also without the laying head and/or the described nozzle. The same is true for the other described elements and method steps such as the heating device, the cooling device, the division of the paths etc. in
35 an analogous manner.

In the above-described embodiment, the medium such as, e.g., the adhesive is applied to and permeated into the rovings on both sides. The construction of the nozzle has been adapted correspondingly. Alternatively, it is possible to achieve an application and a permeation of the medium onto and into the rovings 33 with a single-sided media supply, as described hereinafter. The previous approaches to apply media such as adhesive, binder, resin essentially taught a type of contactless or pressureless application. The above-described nozzle results in that the medium is not only brought into contact with the rovings but is pressed into the roving. This can also be achieved with a single-sided media supply, that means, if, for example, only the upper nozzle 22d in Fig. 4, 5 is present, the medium is nevertheless pressed under pressure into the roving. This is achieved by having a kind of counterbearing on the other side of the roving, that means, the opposite side of the passing-through slit 22s, in a manner that a medium is pressed under pressure into the roving. To promote the impregnation, in particular in case of a single-sided media supply, it is to be preferred to reduce the grammage (mass per unit area) of the roving. This can be achieved, for example, by combing, spreading or other known measures for reducing the grammage. A single-sided or two-sided application, respectively, refers in the present application to the wider sides of the roving, that means, to the sides extending in the plane I-b in Fig. 4b).

It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges

Claims

1. Laying head for manufacturing of fiber layers and structural component preforms from
5 fibers, comprising
an inlet (20e) adapted for introducing a plurality of dry rovings (33; R1, R2...),
a fiber conveying device (20f) for simultaneous and mutually independent conveying of rovings
(33; R1, R2...) introduced via the inlet (20e) in a fiber supply direction (V),
an outlet (20a) arranged downstream in the fiber supply direction (V) of the fiber conveying
10 device (20f) and adapted for simultaneous laying of a plurality of rovings (33; R1, R2...) on a
workpiece carrier (40) for forming a three-dimensional preform (31),
a fiber-cutting device (21, 21i, 21j) provided downstream in the fiber supply direction (V) of
the fiber conveying device (20f) and upstream of the outlet (20a) and adapted for cutting the
rovings (33; R1, R2...), and
15 a nozzle (22, 22i, 22j) for applying a medium onto the rovings (33; R1, R2...),
wherein the roving (22, 22i, 22j) is adapted for applying the medium onto the rovings (33; R1,
R2...) and for introducing the medium into the rovings (33; R1, R2...) in that the nozzle
comprises a slit-shaped passing-through gap (22s) extending in a slit plane (l-b) and having, in a
thickness direction (d) perpendicular to the slit plane (l-b), a height (s) corresponding to the
20 height of a dry roving (33; R1, R2...) in thickness direction (d) plus a small overmeasure
selected such that an impregnation pressure for pressing the medium into the roving is
generated.
2. Laying head according to claim 1, wherein the nozzle (22, 22i, 22j) is arranged
25 downstream in supply direction (V) of the fiber conveying device (20f).
3. Laying head according to claim 1 or 2, wherein the nozzle (22, 22i, 22j) is arranged
upstream in supply direction (V) of the fiber cutting device (21, 21i, 21j).
- 30 4. Laying head according to one of claims 1 to 3, wherein
the rovings (33; R1, R2...) are guided into the nozzle (22) via a guiding path (22b).
5. Laying head according to one of claims 1 to 4, wherein
the nozzle (22, 22i, 22j) comprises a slit-shaped passing-through gap (22s) for each roving of
35 the plurality of rovings (33; R1, R2...).

6. Laying head according to one of claims 1 to 5, wherein a pressing roller (20r) is arranged at the outlet (20a).
- 5 7. Laying head according to claims 1 to 6, wherein a heating device (25, 25i1, 25i2, 25j1, 25j2) is arranged downstream in supply direction (V) of the fiber-cutting device (21, 21i, 21j).
8. Laying head according to one of claims 1 to 7, wherein
10 a cooling device (23, 23i, 23j) is arranged downstream in supply direction (V) of the nozzle (22, 22i, 22j) and upstream of the cutting device (21, 21i, 21j).
9. Laying head according to one of claims 1 to 8, wherein
15 an intermediate conveying device (24, 24i, 24j) is arranged downstream in supply direction (V) of the nozzle (22, 22i, 22j).
10. Laying head according to one of claims 1 to 9, wherein the nozzle (22, 22i, 22j) is adapted for a two-sided application and introduction of the medium onto/into the rovings.
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11. Laying head according to one of claims 7 to 10, wherein the heating device comprises an end heating (25i1, 25j1) for reheating the medium that has been applied onto the rovings (33; R1, R2...) and introduced into the rovings, which is arranged upstream in supply direction (V) of and adjacent to the pressing roller (20r).
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12. Laying head according to one of claims 1 to 11, wherein a plurality of supply paths (P1, P2) for the plurality of dry rovings (33), which are introduced through the inlet (20e), is provided in a manner such that the dry rovings are divided in groups (Ri, Rj), and that there are respectively provided for each of the groups, which are supplied to
30 the outlet (20a) via the separate supply paths (P1, P2), a corresponding nozzle (22i, 22j), cutting device (21i, 21j) and optionally a corresponding cooling device (23i, 23j), intermediate conveying device (24i, 24j) and a heating device (25i1, 25i2, 25j1, 25j2), respectively.
13. Laying head according to one of claims 1 to 12, wherein

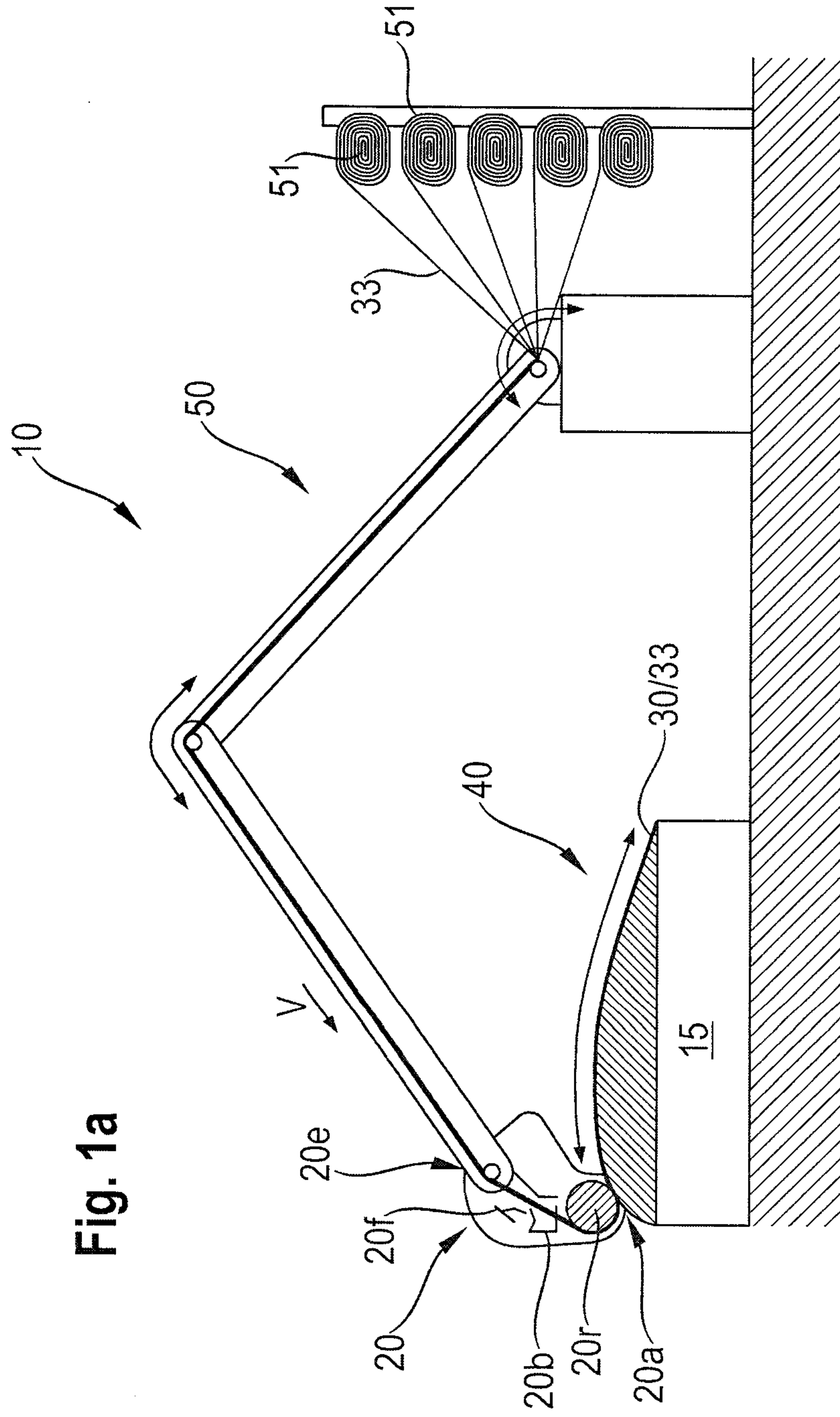
the nozzle (22, 22i, 22j) is adapted to a medium, that is selected from an adhesive for fixing the rovings, a binder for connecting the rovings, and a resin for impregnating the rovings.

14. Apparatus for forming a preform (31) for a structural member made of a fiber composite material, comprising
5 a workpiece carrier (40),
a laying head (20) according to one of claims 1 to 13 for laying a fiber set (30) of rovings (33) on the workpiece carrier (40), and
a transfer device for transferring the preform (31) from the workpiece carrier (40) to a
10 subsequent manufacturing step.

15. Method for forming a three-dimensional preform for a structural member made of a fiber composite material, comprising the following steps:

- a) providing a workpiece carrier (40) corresponding to the three-dimensional shape of the
15 preform (31);
- b) laying a fiber set (30) by simultaneous laying of a plurality of rovings (33) on the workpiece carrier (40);
- c) fixing the rovings (33) at the edge (42) of the workpiece carrier (40);
- d) repeating steps b) and c) according to a predetermined fiber set laying pattern for
20 forming the three-dimensional preform (31), wherein
 - d1) at each performing of step c), the rovings (33) are cut behind the sections of the rovings (33) already fixed or to be fixed at the edge of the workpiece carrier, and that the next performing of step b) is made thereafter;
- e) after finalizing the forming of the preform according to the predetermined fiber set
25 laying pattern in step d), transferring the three-dimensional preform (31) from the workpiece carrier (40) to the next manufacturing step, wherein
 - b1) the rovings of the fiber set are fixed at the beginning of the laying operation according to step b) at the edge of the workpiece carrier over a first predetermined length (l1),
 - d2) the sections of the rovings (33) already fixed or to be fixed at the edge of the
30 workpiece carrier according to step d1) are fixed over a second predetermined length (l2), and
 - d3) in step c) before the cutting, adhesive is applied onto the rovings (33) with a third predetermined length (l) corresponding at least to the sum of the first and second lengths (l1, l2) and the rovings (33) are cut according to step d1) in a manner that the adhesive remains with at least the second predetermined length (l2) on the one side of the cut on the section to be
35 fixed at the end of a laying path of the fiber set laying pattern and that adhesive remains in at

least the first predetermined length (11) for the fixing at the beginning of the next performing of step b) on the other side of the cut on the other end of the cut rovings (33).



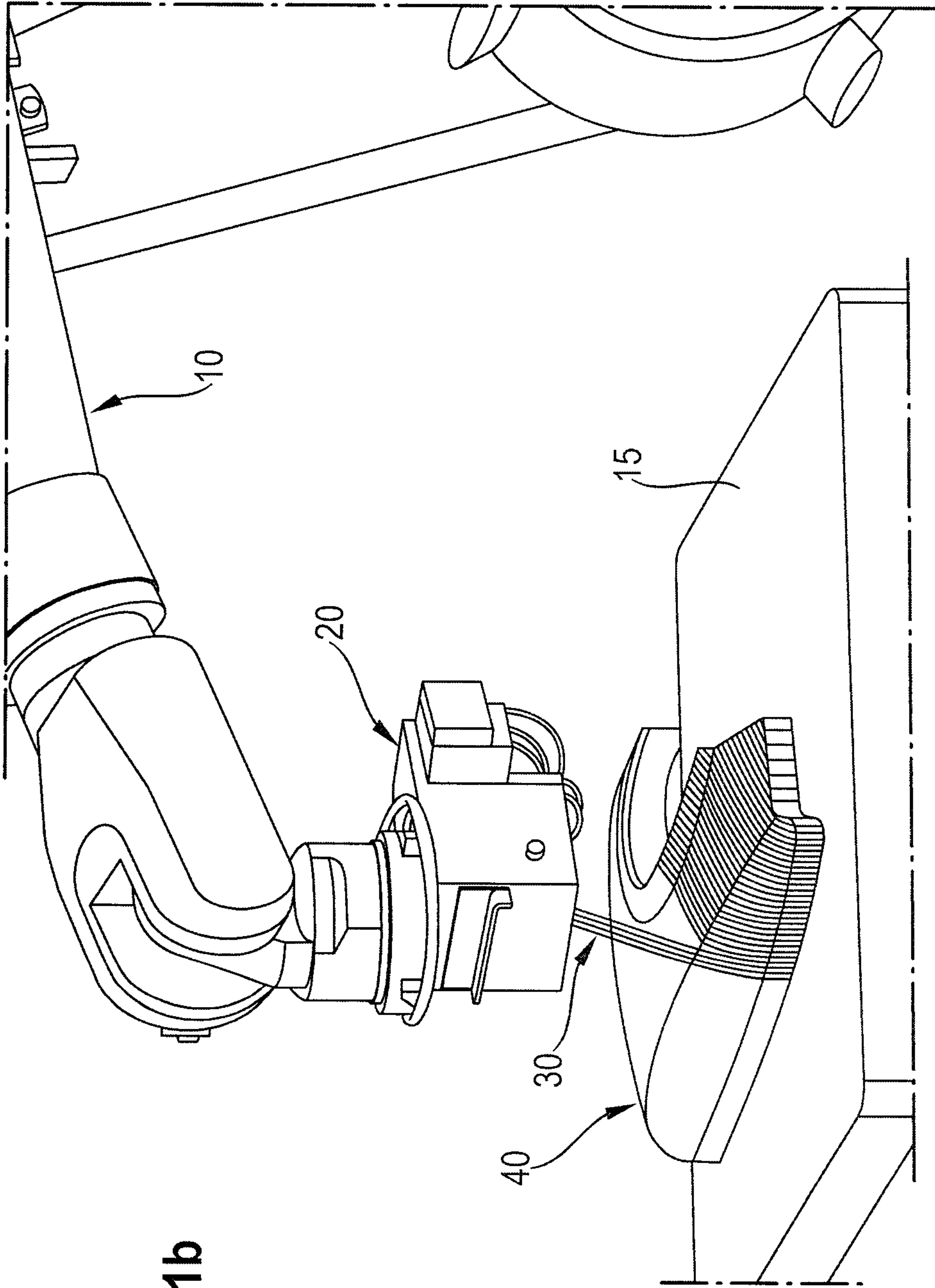


Fig. 1b

Fig. 2a

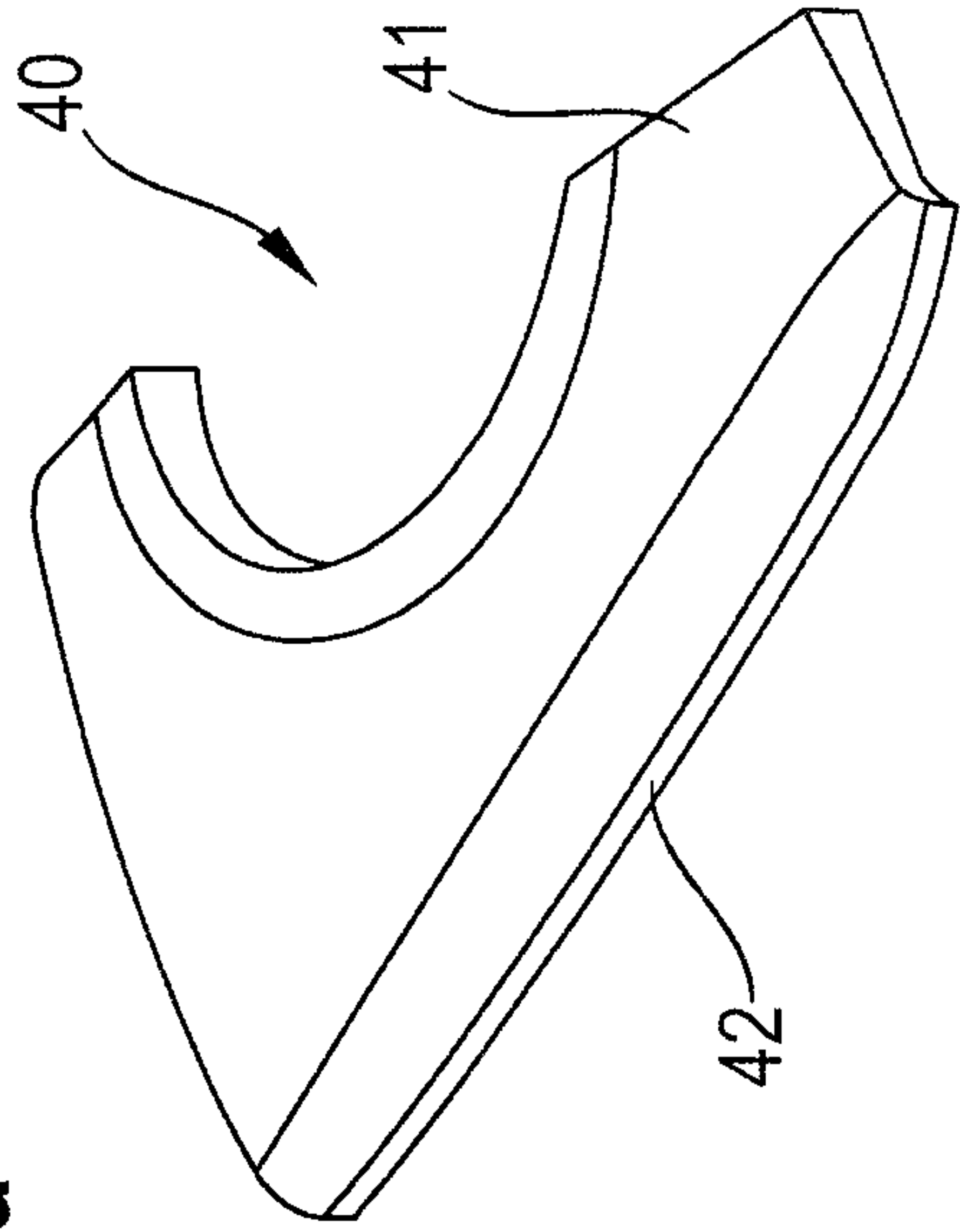


Fig. 2b

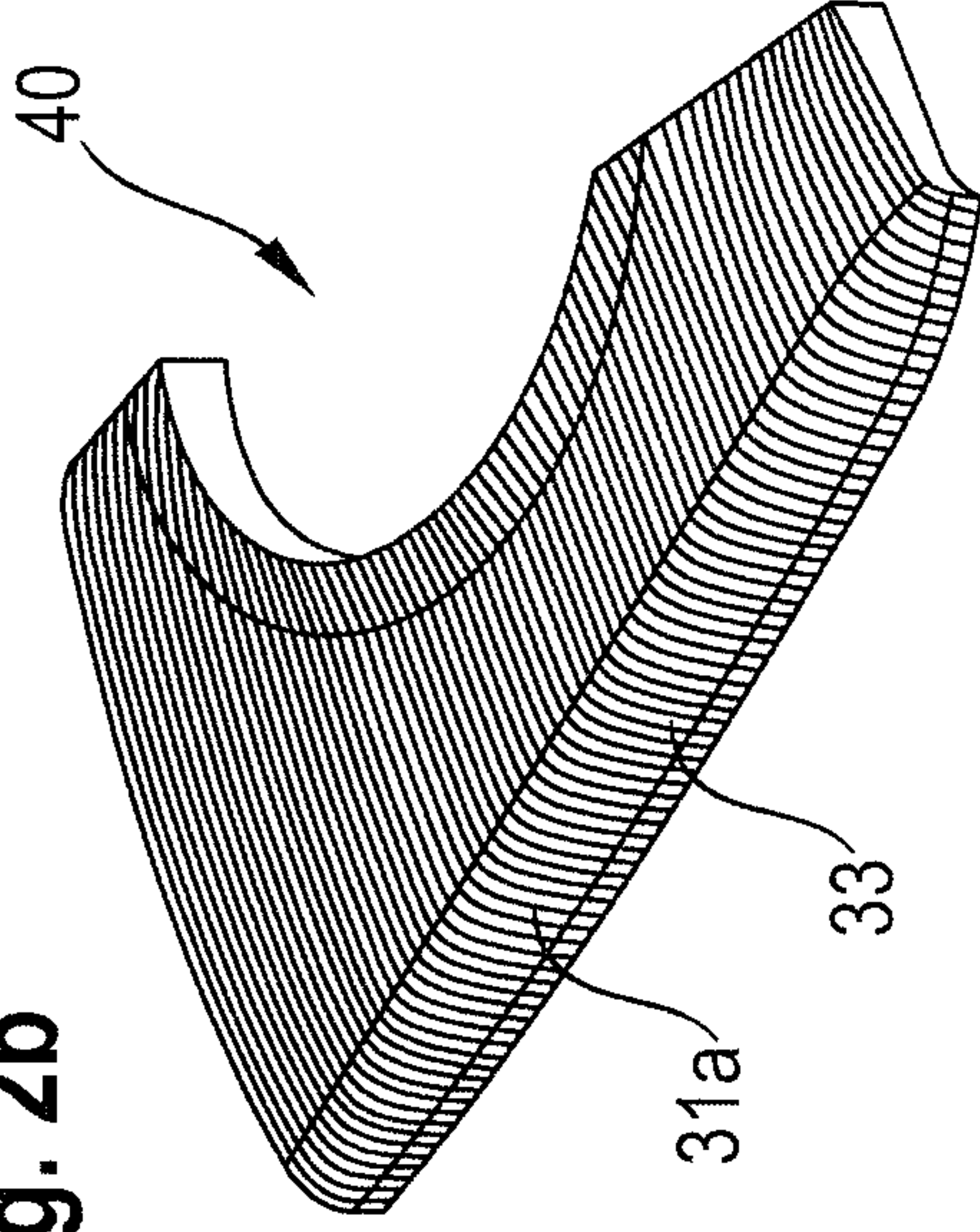


Fig. 2c

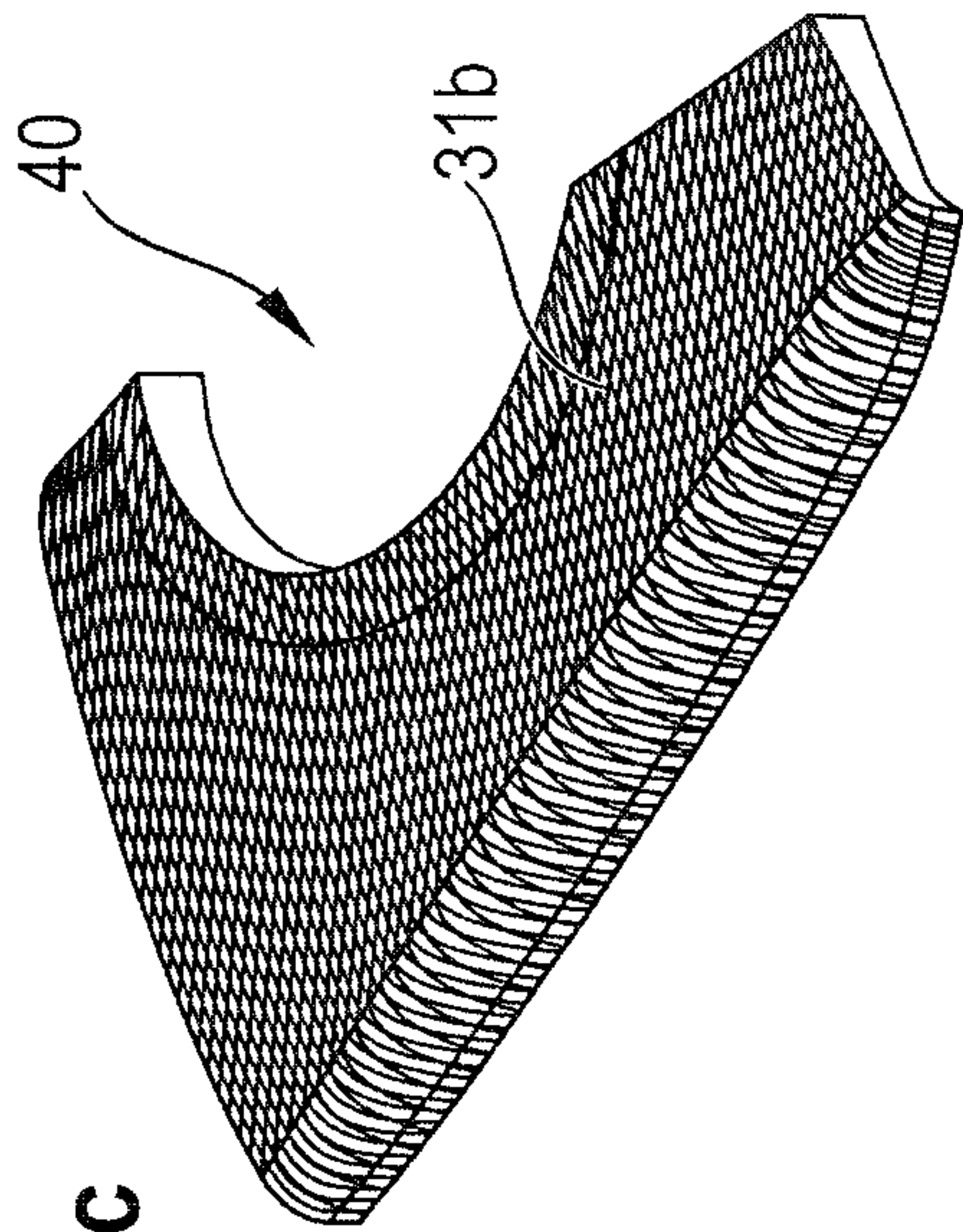
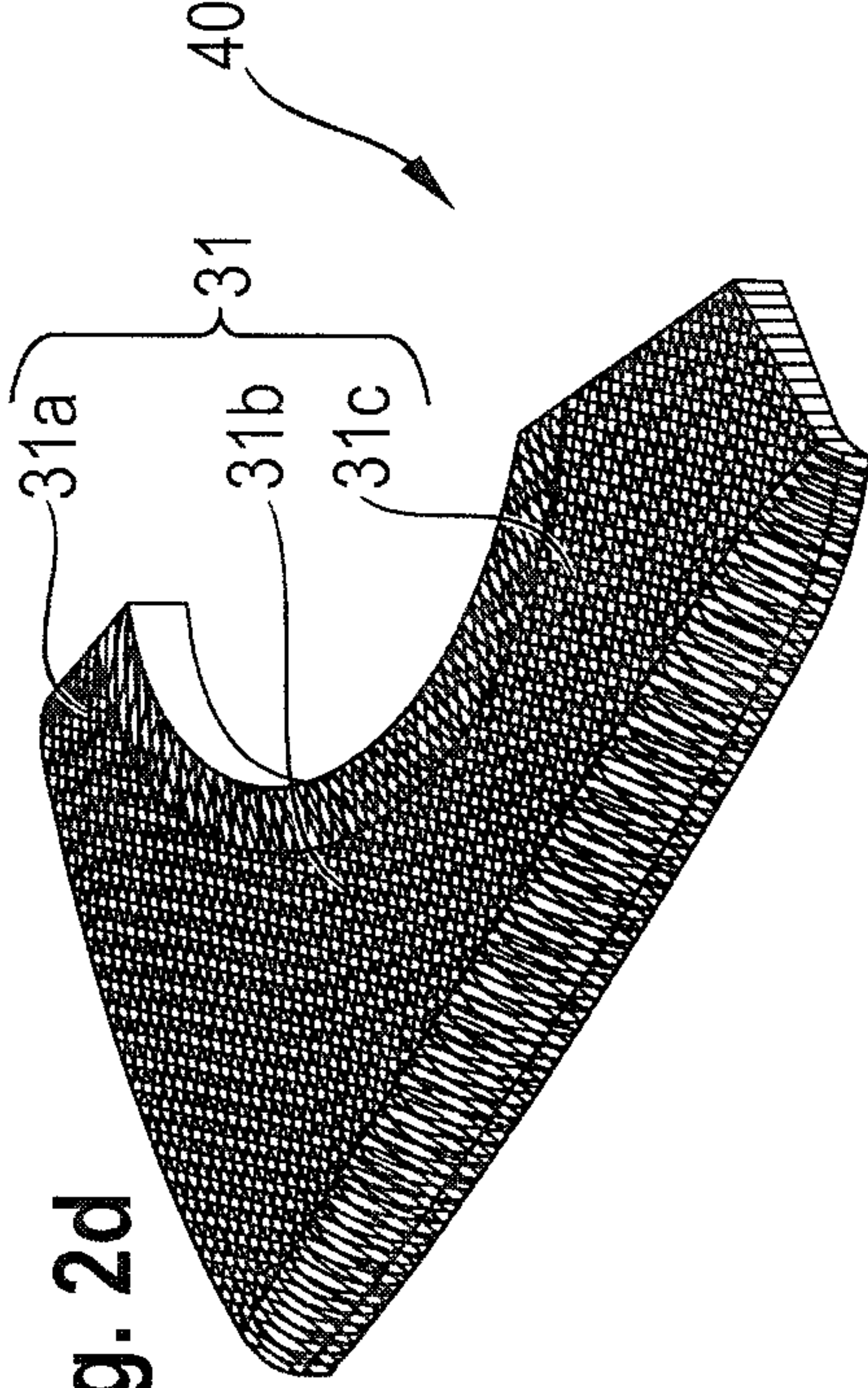


Fig. 2d



4 / 6

Fig. 3a

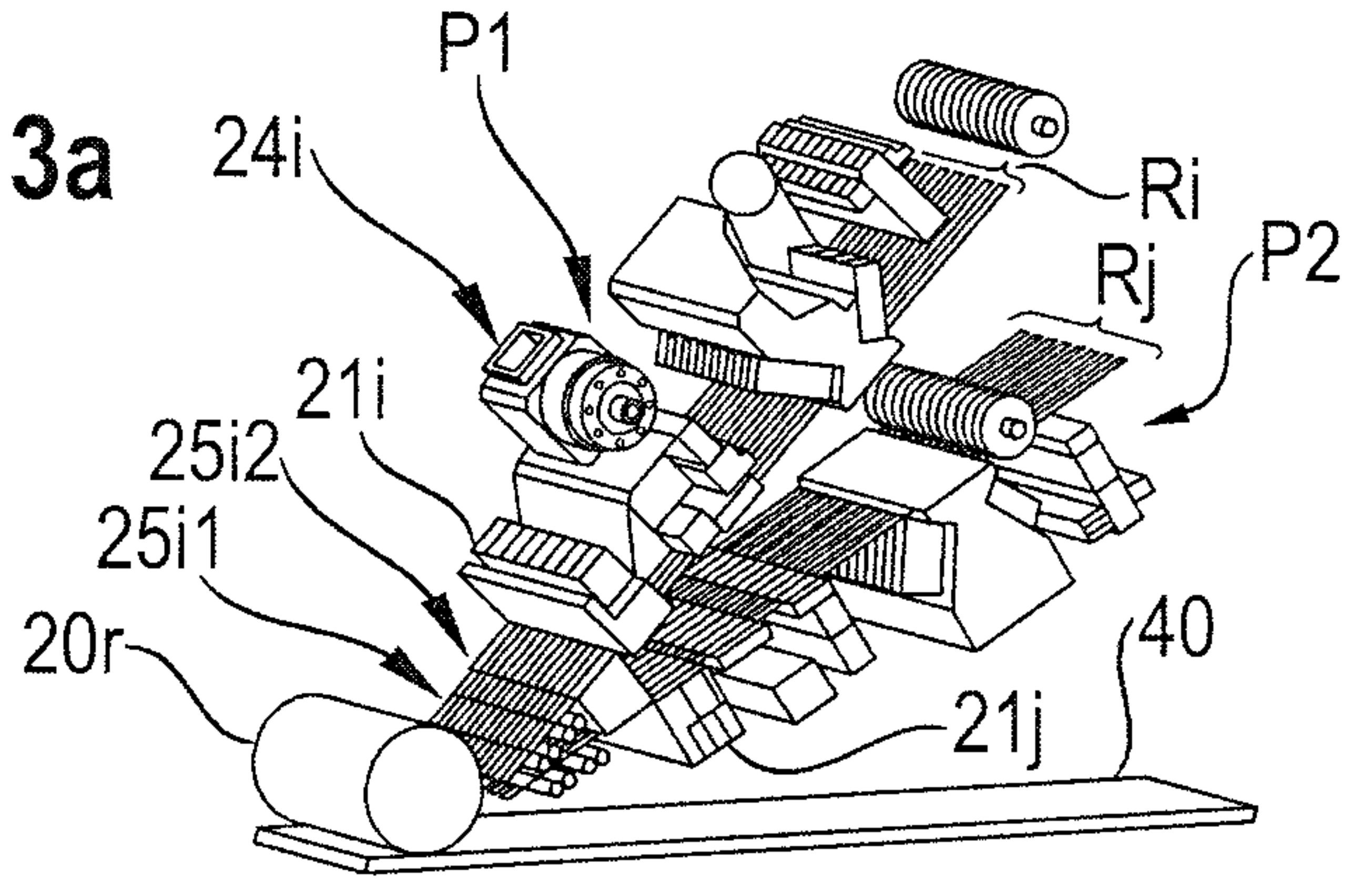


Fig. 3b

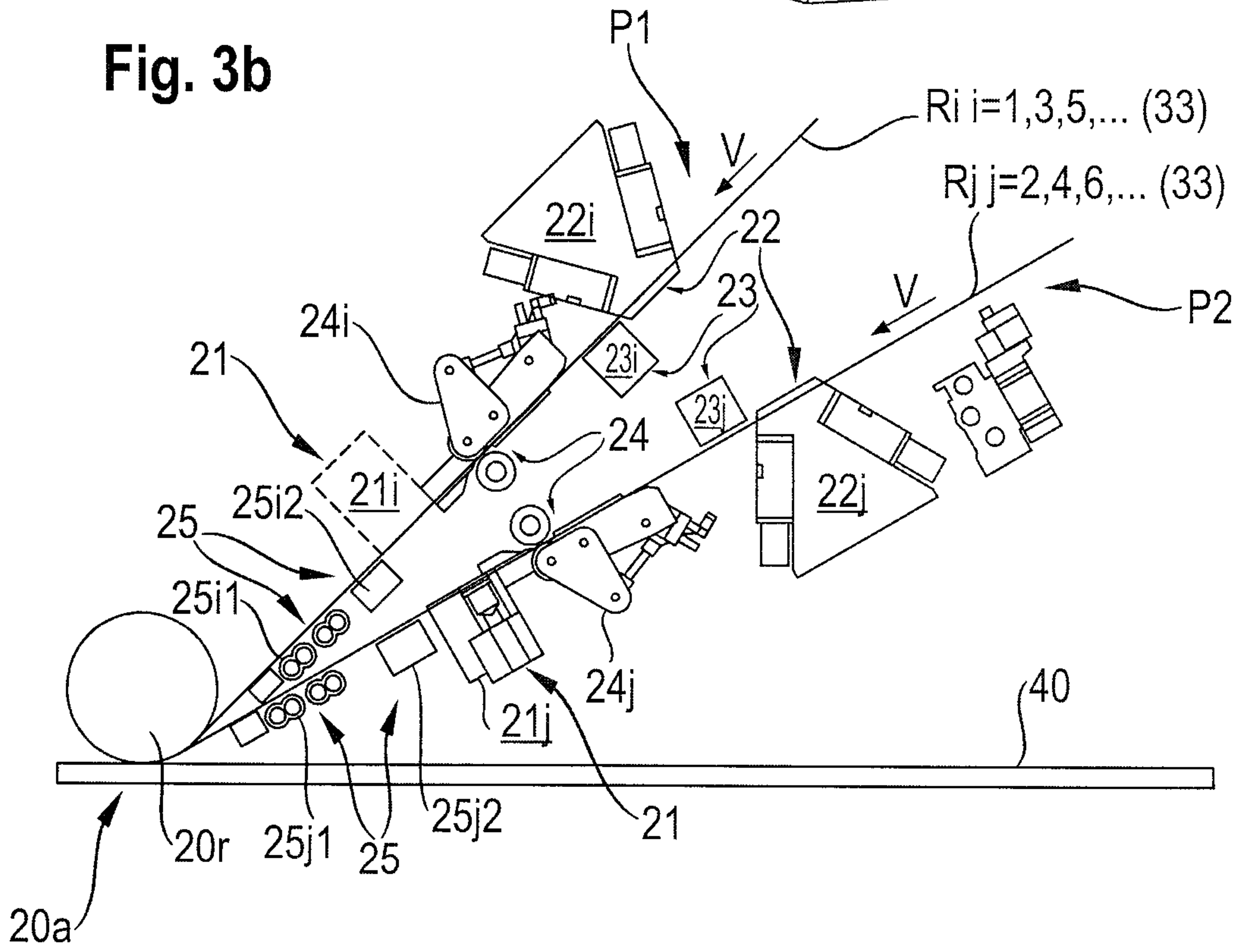


Fig. 6a

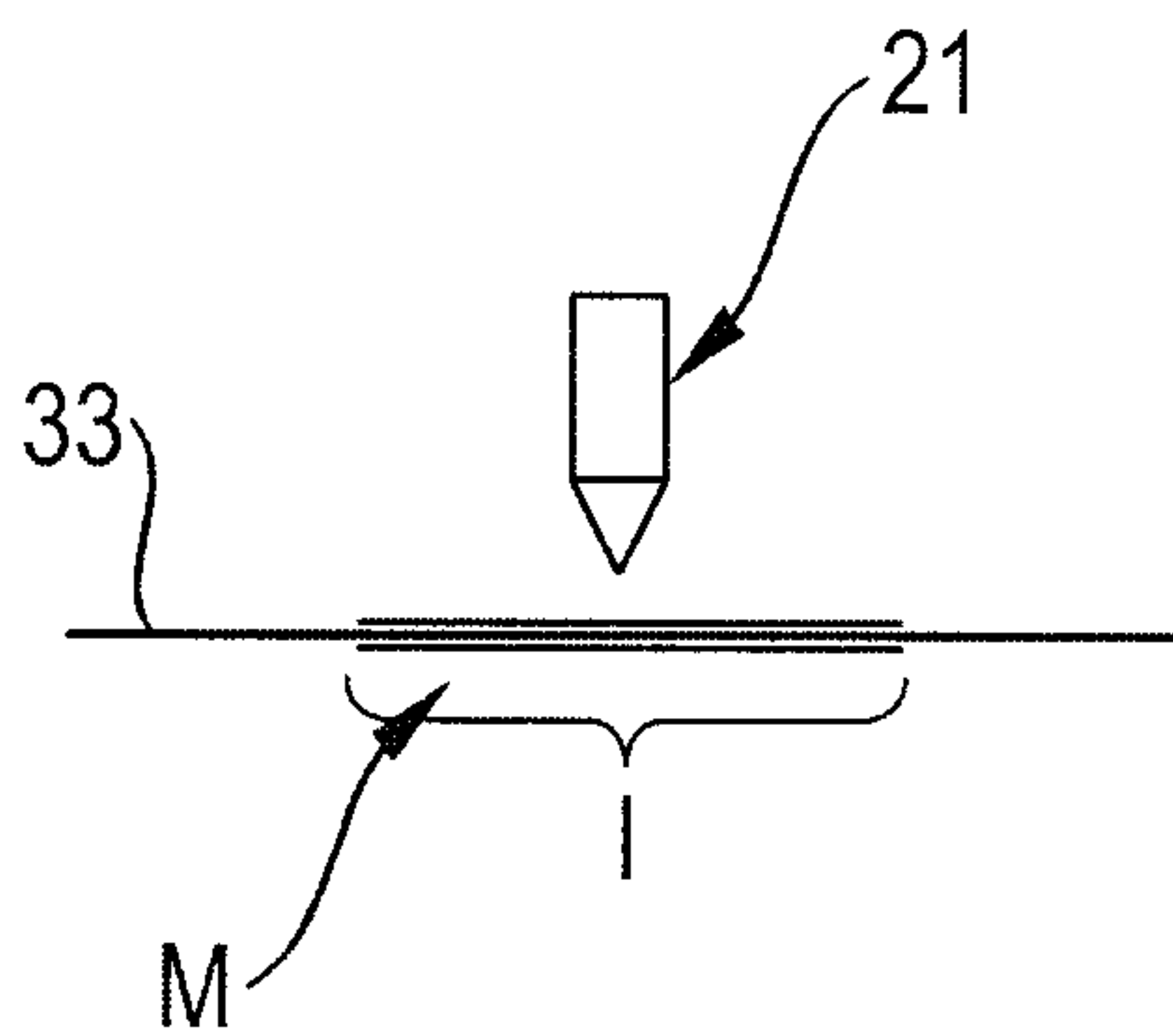


Fig. 6b

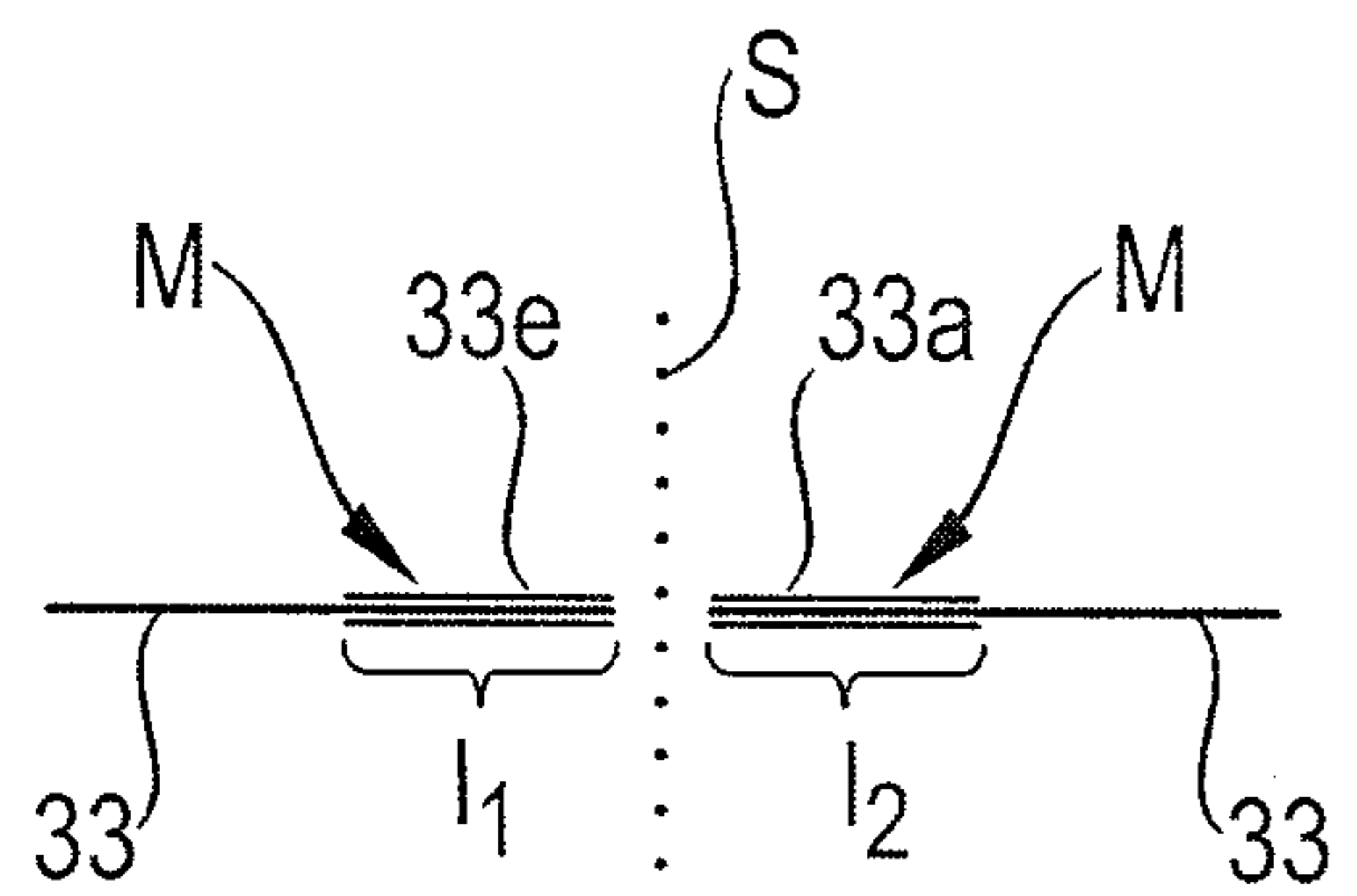


Fig. 4a

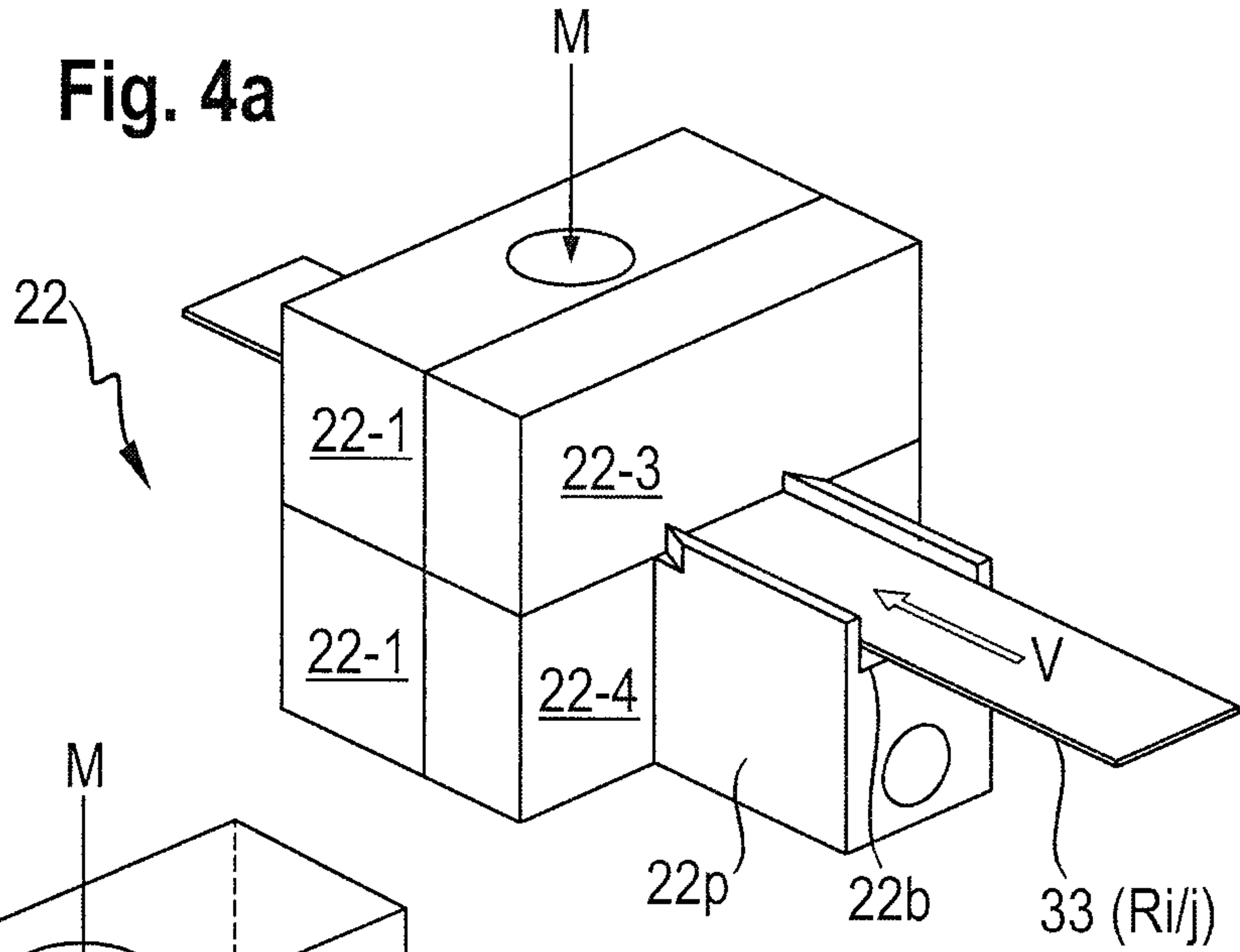


Fig. 4b

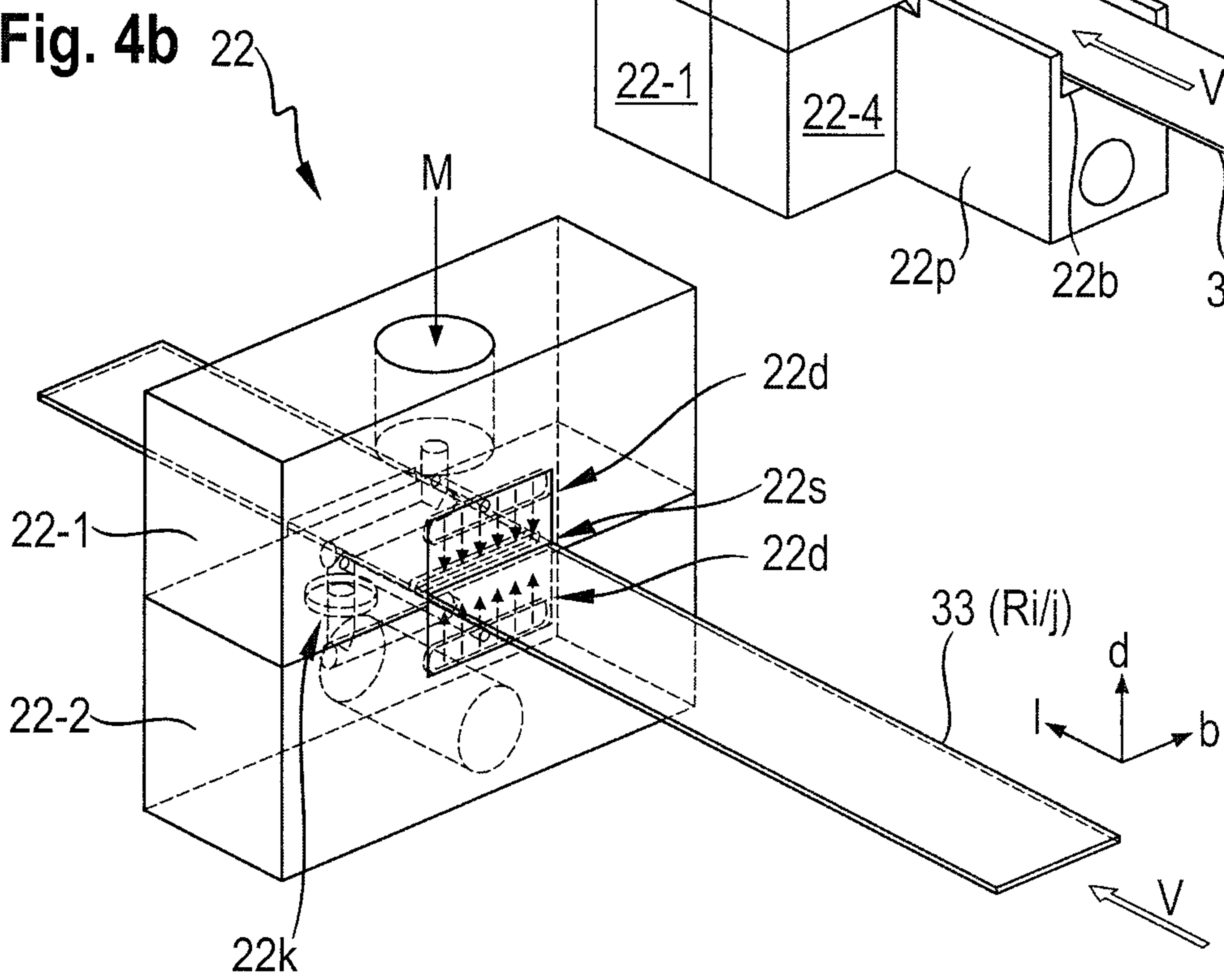
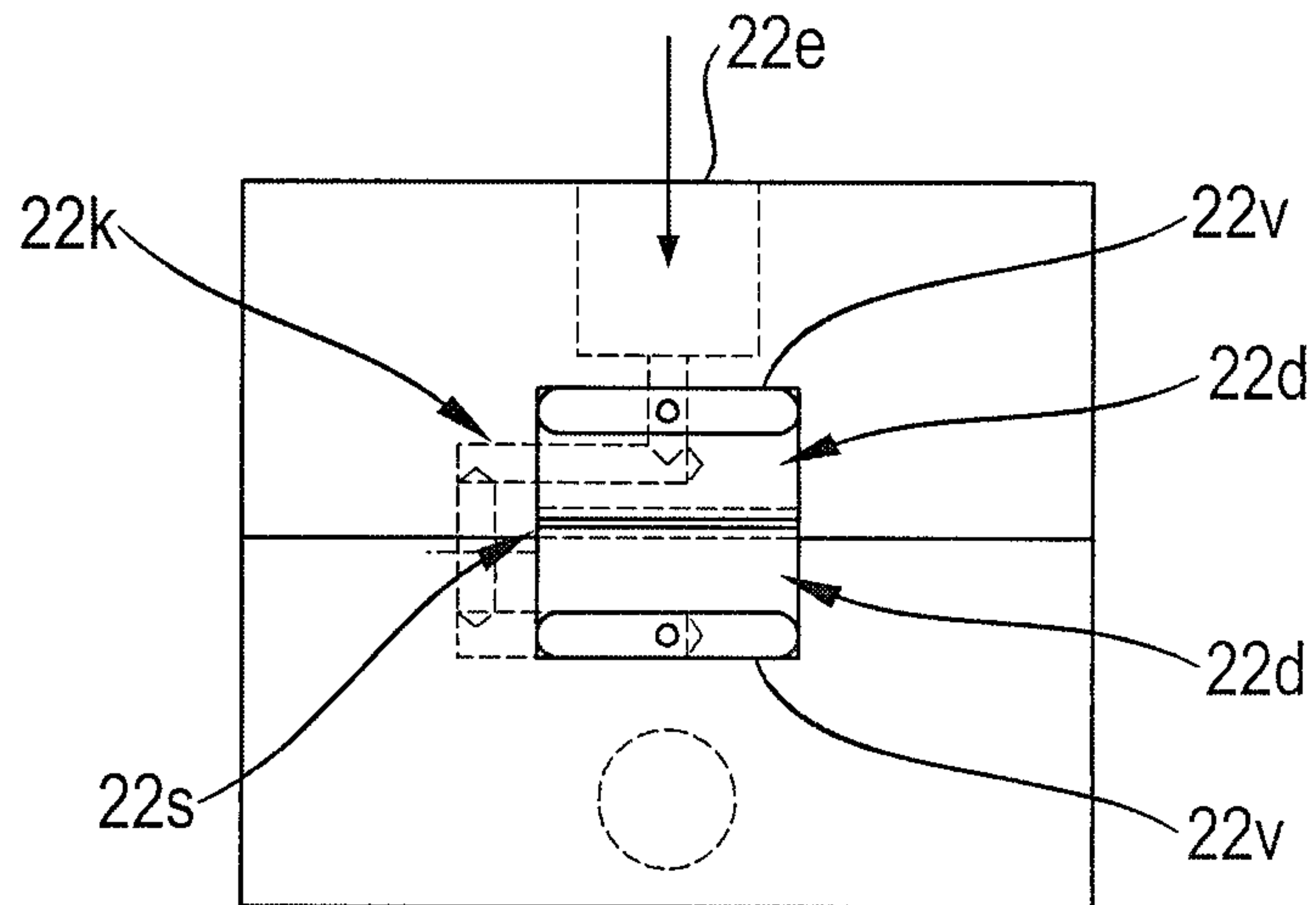


Fig. 4c



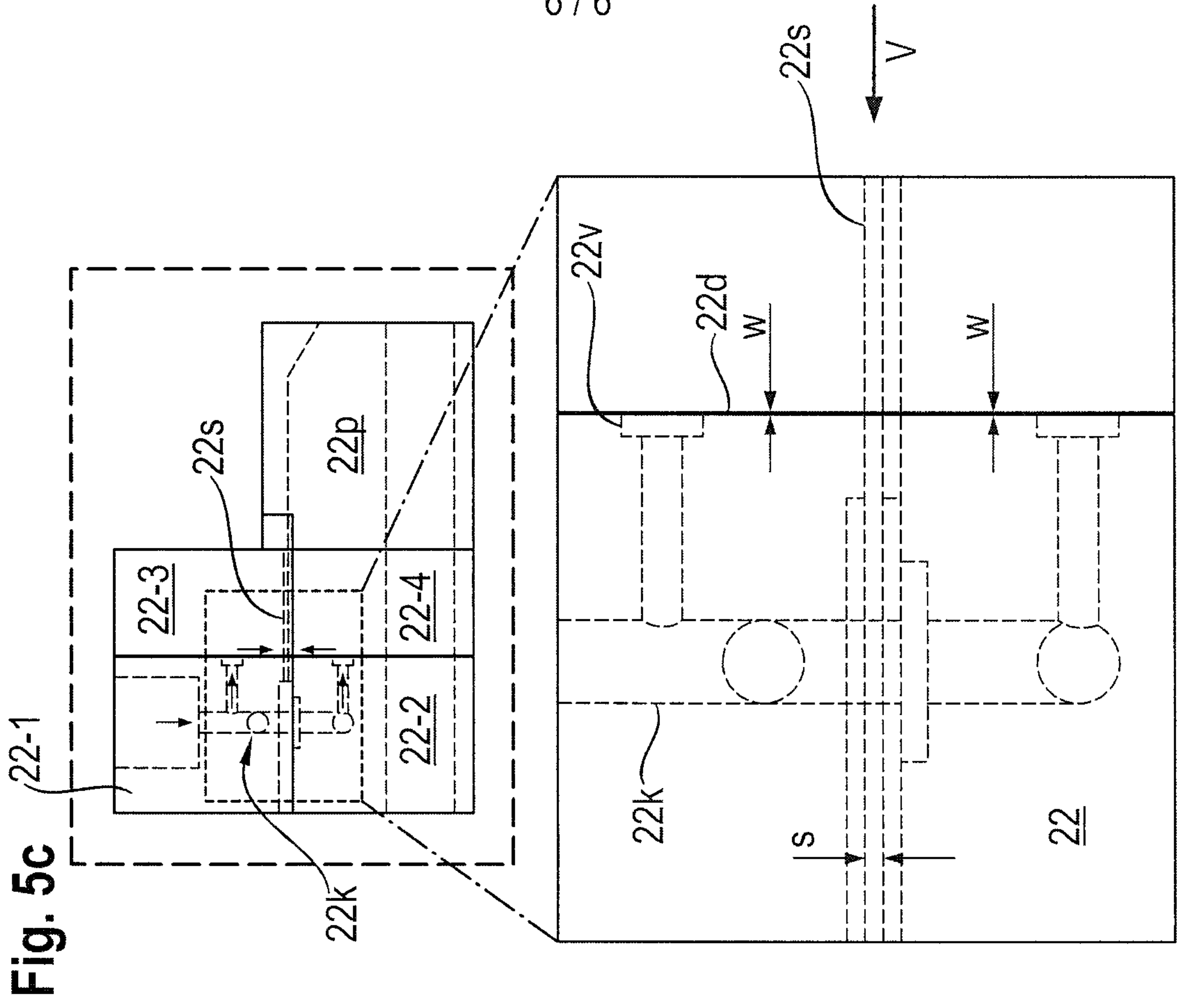


Fig. 5c

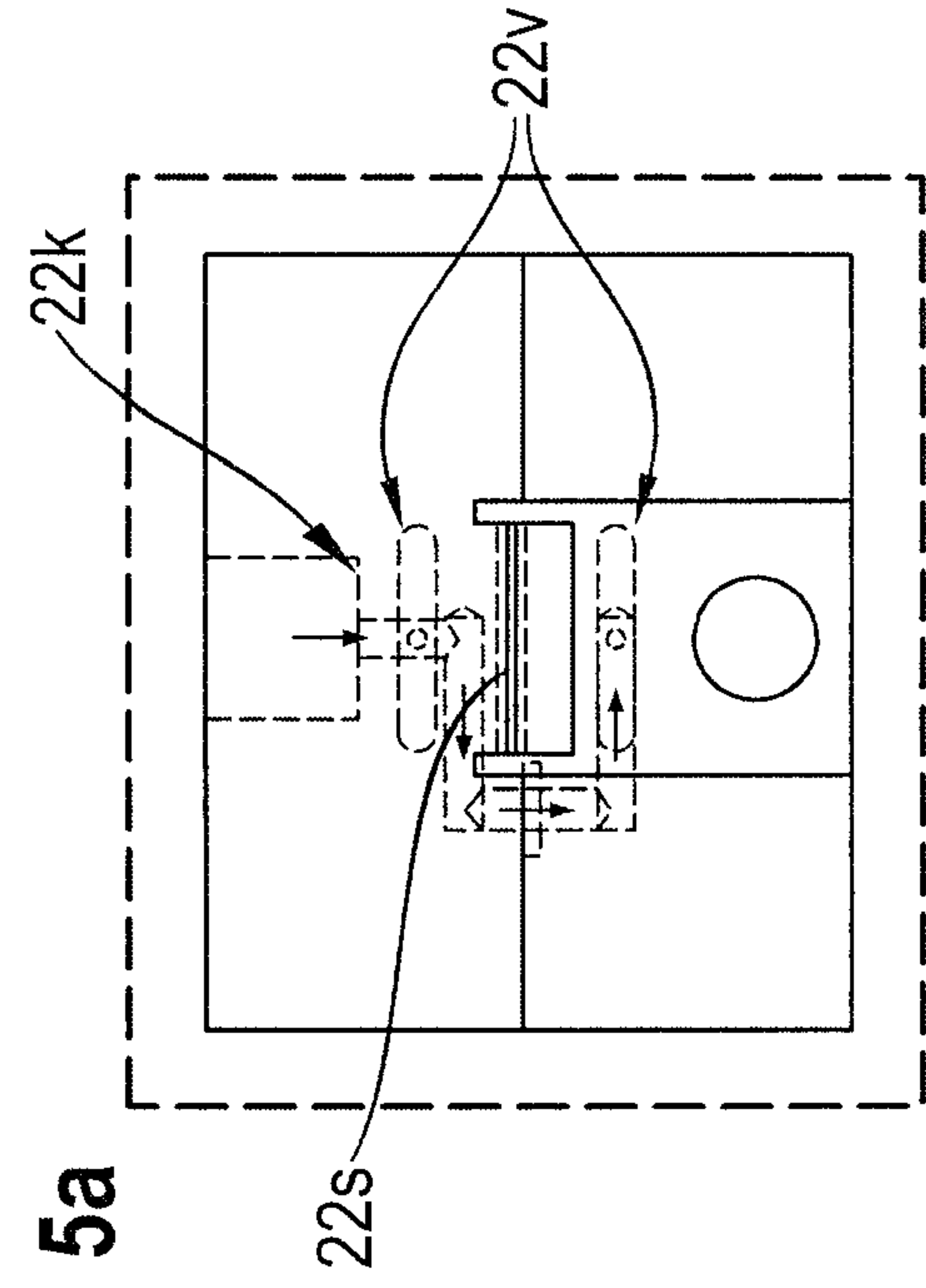


Fig. 5a

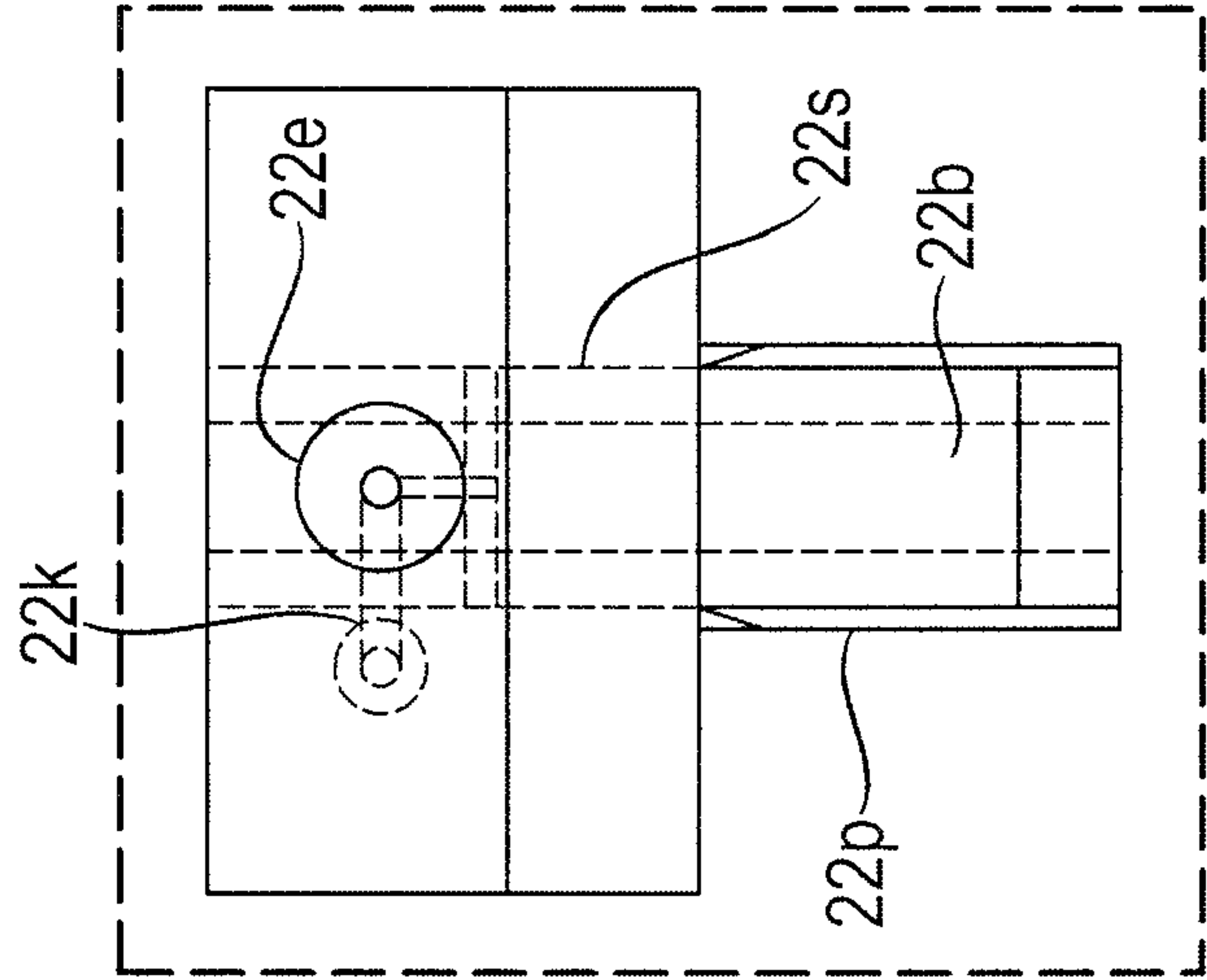


Fig. 5b

Fig. 3b

