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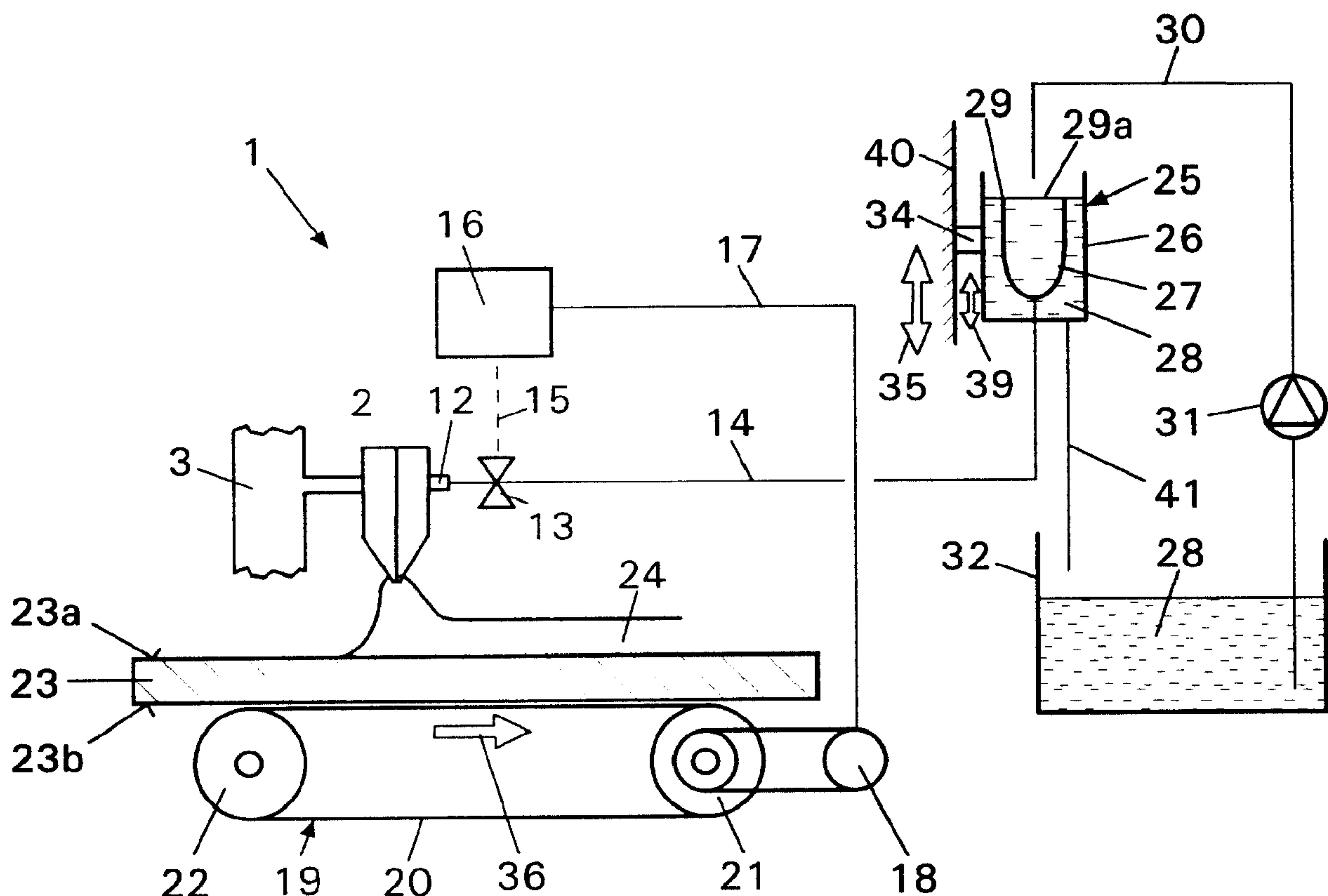
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(54) Titre : DISPOSITIF ET PROCEDURE POUR ENDUIRE UN SUBSTRAT A PLAT

(54) Title: DEVICE AND PROCEDURE FOR COATING A LEVEL SUBSTRATE



(57) Abrégé/Abstract:

Device for coating a level substrate with a coating module that has a capillary gap, in which the capillary gap is filled with a liquid coating medium and has an opening by which a surface of the coating substrate moves at a relatively short distance so that a layer is deposited onto the surface. The capillary gap opens downwardly and is supplied with coating medium from a supply chamber, with the substrate moving under the opening of the capillary gap while the coating surface faces up.



Abstract

Device for coating a level substrate with a coating module that has a capillary gap, in which the capillary gap is filled with a liquid coating medium and has an opening by which a surface of the coating substrate moves at a relatively short distance so that a layer is deposited onto the surface. The capillary gap opens downwardly and is supplied with coating medium from a supply chamber, with the substrate moving under the opening of the capillary gap while the coating surface faces up.

Device and Procedure for Coating a Level Substrate

The invention concerns a device for coating a level substrate using a coating module that has a capillary gap. This capillary gap is filled with a liquid coating medium and has an opening past which the surface of that substrate to be coated (coating substrate) will be moved at a relatively short distance so that the coat is deposited upon said surface.

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The invention also concerns a procedure for coating a substrate with a coating module, which the substrate with the surface to be coated (coating surface) moves by while a layer of the coating medium is deposited on this surface and more coating medium is supplied to the coating module.

10 A state of the art device of this type is familiar from US 5,650,196 and WO 94/25177. This device can provide rectangular or round plates with an even layer of varnish or another initially liquid medium, such as color filters or special protective layers. This device is used in particular in the field of thin film technology for the production of LCD screens, masks for semi-conductor manufacture and semi-conductor and ceramic substrates. This device is particularly distinguished
15 by producing a high uniformity of varnish layer thickness, especially on rectangular plates, while simultaneously using little varnish. The substrate moves over the capillary gap with the coating surface facing down during coating. The gap is arranged so that the coating medium is supplied independently by the capillary action of the gap at a particularly uniform speed. For example, this type of capillary action is achieved with a gap that is less than 0.5 mm wide. Due to
20 capillary action the coating medium rises independently against the force of gravity in the gap and is emitted at the opening of the capillary gap. In this procedure intermolecular binding forces, surface tension and the peculiarities of surface wetting are decisive. Usual coating speeds lie between 5 to 15 mm/s. Since the volume flow rate is determined to a large extent by intermolecular binding forces, coating speed cannot be increased significantly.

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The invention is based on the problem of creating a device of the said type that permits a

significantly increased coating speed but still guarantees uniform coating thickness and uses little material.

The problem is solved in the generic device by a capillary gap that is open at the bottom and filled with coating medium from a supply chamber. The substrate with the coating surface
5 passes underneath the opening of the gap. In the device, as envisioned by the invention, the volume flow rate through the capillary opening is not just determined by intermolecular binding forces but can be set deliberately. Therefore, significantly higher coating speeds, for example between 30 and 100 mm/s, can be achieved. Higher coating speeds permit relatively larger production and consequently a significant reduction in production costs.

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Particularly reliable filling of the coating area results from a further development of the invention in which an overflow container is provided, which is linked to the capillary gap through a fluid line and placed above the opening of the capillary gap. The overflow container is preferably mounted with adjustable elevation. The elevation of the overflow container is proportional to
15 the flow of the medium through the capillary gap and therefore to coating thickness.

Capillary gaps of different sizes can be produced if the coating module, according to a further development of the invention, has two parallel plates with a foil set between them. This permits the application of coating media of varying viscosity and the creation of variable layer thickness
20 with varying delivery speeds of the substrate beneath the capillary. A cutout in the foil is a simple way to determine the capillary gap. For example, the two plates can be screwed together but remain separable. An exchange of the foil to change the width of the capillary gap is particularly simple in such case.

25 It is essential here, too, that during coating the volume flow moves from the top downwards through the capillary gap and that the substrate moves by the capillary gap with the coating surface facing upward.

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Other advantageous features result from dependent patent claims and the following description and drawings.

An execution of the invention is explained in more detail below using the drawing. The following
5 are shown:

- Figure 1 a schematic view of the proper device,
- Figure 2 a view of the coating module,
- Figure 3 a section through the coating module along line III – III,
- 10 Figure 4 a section through the coating module along line IV – IV,
- Figure 5 a section through the coating module as in figure 3 but with filled capillary gap, and
- Figures 6 and 7 schematically the coating of the level substrate.

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The device 1 shown in figure 1 has a coating module 2 that is mounted on a frame 3. Below the coating module 2 a transport device 19 is positioned so that a coating substrate 23 passes the coating module 2, preferably horizontally, for the purpose of coating an upper, level surface 23a.
20 The substrate 23 is in particular a plate or a disc, for example a glass or ceramic disc. The coating module 2 is connected to an overflow container 25 with a fluid line 14 from which the coating medium 28 is supplied to the coating module 2 during coating.

According to figures 2 and 3 the coating module 2 exhibits two parallel plates 4 and 5 between
25 which a foil 6 of defined strength is set. For example, the two plates 4 and 5 consist of glass or metal and are sanded and polished to assure suitable surface quality. The foil 6 is provided with a cutout 8a as in figure 2, which forms a gap 8 that is generally rectangular and closed laterally and above. The gap 8 exhibits an opening 9 at the bottom that has a rectangular shape and is

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formed by the parallel and relatively sharp edges 7 of plates 4 and 5 as well as the lateral edges 6a of foil 6. The width A of the capillary gap 8 lies in a range of 5µm to several millimeters. For example, a capillary gap 8 with a width A of 150µm is suitable when applying a 2µm thick layer. The coating medium 28 is applied at a temperature of c. 20°C and exhibits a viscosity of c. 5 7mPas⁻¹.

The two plates 4 and 5 are firmly screwed together with a number of holding screws 33. The foil 6 is firmly fixed and liquid-proof between plates 4 and 5 because of the screws 33. After loosening the holding screws 33 the foil can be removed and replaced by another foil of different 10 strength. By exchanging the foil 6 the width A of the capillary gap 8 can be changed in a simple manner. The foil 6 is preferably a plastic or metal foil. Such foils can be produced within very low tolerances, for example, only a deviation of <1% in thickness. Therefore, the width A of the capillary gap 8 is exactly defined but can still be modified in a simple manner by exchanging the foil 6.

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On the inner side 5a of plate 5 a canal 10 is located, which essentially extends across the entire length of the capillary gap in figure 2 and is located in the upper part of the capillary gap 8. This canal 10 is linked to the liquid line 14 through a hole 11 in plate 5 and a connecting device 12. The flow through the line 14 can be regulated with valve 13. A controlling device 16 that is 20 connected to a valve 13 with a line 15 is provided for control. The valve 13 is preferably controlled pneumatically. However, control with a stepper motor is also perceivable.

The line 14 is connected to the overflow container 25, which is positioned above the opening 9 of the capillary gap 8. The overflow container 25 is attached to a carrier 40 with a suitable 25 adjustment device 34 so that its elevation can be set. The height of the overflow container 25 above the opening 9 lies in the area of 10 to 50 cm. The pressure of the coating medium 28 in the capillary gap is proportional to the elevation of the liquid level 29a above the opening 9 of the capillary gap 8. The pressure of the coating liquid 28a in the capillary gap can be exactly adjusted

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by adjusting the overflow container 25 in direction of the double arrow 39.

The overflow container 25 has an outer container 26 and an inner container 27. The inner container 27 is connected at its lower end to the liquid line 14 and has an overflow edge 29, over which the coating medium 28 can get from the inner container 27 to the outer container 26. A fluid pump 31 pumps the coating medium 28 from the storage container 32 through the liquid line 30 to the overflow container 25. Excess coating medium 28 is returned to the storage container 32 from the overflow container 25 through a return line 41. Therefore, the level of the liquid 29a is independent of the elevation of the overflow container 25 and also independent of the consumption of coating medium 28, which is maintained constant during coating. Likewise, the pressure of the coating medium 28 in the capillary gap 8 is guaranteed to be maintained constant during coating. A spiral conveyor or a pressure cylinder can also replace the overflow container 25. It is only essential that this device supply the medium at a constant pressure.

The transport device 19 has a continuous transport belt 20 that is laid around a drive roller 21 and a guide roller 22. The drive roller 21 is powered by a drive 18, for example an electric motor that is connected with a signalling line 17 to a control 16. Other transport devices are also conceivable, such as a transport sledge or a transport device on rollers. The substrate 23 can be held by its under side 23b using appropriate means that are not shown here, such as a vacuum plate. As in figure 1 the substrate 23 is transported from left to right by the transport device 19. Transport is preferably steady and can be adjusted by the control 16 without phases. The substrate 23 will preferably be transported in a horizontal direction. A slanted direction is also conceivable. Finally, an execution is conceivable in which the substrate 23 is not transported in a linear direction but rotated.

The individual steps of the process are explained in more detail in the following.

To fill the capillary gap 8 with coating medium 28, the latter 28 is pumped from the storage

container 32 to the overflow container 25 using the pump 31. From this container 25 the coating medium 28 flows into the capillary gap 8 when the valve 13 is open. The medium is held in the capillary gap 8 by capillary forces, with a meniscus 28b forming as in figure 5. In this case the pressure in the liquid 28a is particularly dependent on the elevation of the overflow container 25, viscosity of the coating medium 28 and temperature. The canal 10 aids an even distribution of the coating medium 28 over the entire length of the capillary gap 8.

The coating substrate 23 with the coating surface 23a facing up moves by the opening 9, while the valve 13 is closed. The valve 13 is opened while the substrate 23 is immobile and an even flow of the coating medium 28 through the capillary gap 8 is initiated. The gap S between the upper surface 23a and the edges 7 is now filled with substrate [sic] 23 and the substrate 23 is wetted. For wetting the substrate 23 is not transported for a time period of about 0.1 to 1 second. Subsequently the transport device 19 is activated and the substrate 23 in figure 7 is moved at a constant speed from left to right in the direction of the arrow 37. Since the coating liquid 28 is supplied in a constant manner at constant pressure, as mentioned before, an even coat 43 is formed on the substrate 23, as shown in figure 7.

The valve 13 is closed again after coating the substrate 23. Closing of the valve 13 preferably occurs before reaching the end of the substrate in such a way that when the end of the substrate is reached, the supply of the coating medium in the gap S is discontinued and the coating medium cannot flow over the edge at the end of the substrate. The right moment for closing is particularly dependent on the viscosity of the medium 28 and can be optimized in the process. The device 1 is then ready for another coating. The applied layer 43 is dried in familiar fashion. The coating thickness after drying amounts to 2.5 to 3 μ m, for example.

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Layer thickness is determined to a significant degree by the viscosity and solid content of the coating medium 28, the elevation of the overflow container 25 over the opening 9, the width A of the capillary gap 8 and transport speed of the substrate 23. The layer thickness of 2.5 to 3 μ m

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mentioned before is preserved, for example, with a coating medium 28 that has a solids content of 10% and a viscosity of c. 5.5 mPas^{-1} . The temperature of the coating medium 28 is 20°C here and the elevation of the overflow container 25 above the coating surface 23a is 28mm. The gap width A is $130\mu\text{m}$ and the transport speed 50 mm/s. Despite the relatively high transport speed 5 good uniformity of the layer 43 was achieved. Deviations in the thickness of the layer 43 were usually less than 1%.

What is the claimed is:

1. A method of coating a substrate, the method comprising:
 - supplying a liquid medium from a liquid medium supply device to a coating module including a slot;
 - passing a substrate to be coated underneath the slot of the coating module;
 - coating a surface of the substrate with the liquid medium via the slot of the coating module as the substrate passes underneath the slot; and
 - adjusting a pressure of the liquid medium in the slot of the coating module by changing an elevation of the liquid medium supply device relative to the coating module in order to adjust a thickness of the liquid medium coated onto the substrate.
2. The method of claim 1, further comprising adjusting a width of the slot by replacing a foil located between first and second opposing plates of the coating module which define the slot.
3. The method according to any one of claims 1 or 2, further comprising:
 - opening a valve between the coating module and the liquid medium supply device when the substrate is stationary in order to initiate flow of the liquid medium from the supply device to the slot of the coating module, and
 - after a predetermined period of time has passed since opening of the valve, initiating movement of the substrate in order to pass the substrate underneath the slot so that the substrate can be coated.
4. An apparatus for coating a substrate, the apparatus comprising:
 - a storage container or reservoir for holding a liquid coating medium;

a liquid medium supply device that receives liquid coating medium from the storage container or reservoir;

a coating module including an application slot that receives liquid coating medium from the liquid medium supply device, wherein said slot is open at a bottom thereof, such that when the substrate to be coated is moved beneath said slot, the surface of the substrate can be coated via said slot, and wherein the liquid medium supply device is located at an elevation above said coating module so that liquid medium is supplied from said liquid medium supply device to said coating module via a gravity feed;

wherein the elevation or height of said liquid medium supply device relative to said coating module is adjustable in order to vary a thickness of a layer of the liquid medium coating applied to the substrate via said slot; and

wherein said liquid medium supply device includes an inner container for holding liquid medium, and an outer container at least partially surrounding the inner container for holding liquid medium which overflows from the inner container, wherein liquid medium from the inner container is forwarded to the coating module via the gravity feed and liquid medium from the outer container is forwarded back to said storage container or reservoir.

5. The apparatus of claim 4, wherein said slot defines a width that is adjustable, said width of said slot being adjustable by varying a thickness of a foil placed between first and second opposing plates defining said slot.

6. The apparatus according to any one of claims 4 or 5, wherein said slot is located at an elevation above the surface of the substrate to which the liquid medium is to be applied.

7. The apparatus any one of claims 4 to 6, further including a valve connected to a liquid medium supply line provided between said coating module and said inner container of said liquid medium supply device.

8. The apparatus according to any one of claims 4 to 7, wherein said coating module includes a foil sheet provided between first and second opposing plates, wherein said foil sheet spaces said plates from one another in order to define a width of said slot.

9. The apparatus of claim 8, wherein said foil sheet includes a cut-out section defined therein, said cut-out section being provided at an area where said slot is defined between said plates.

10. An apparatus for coating a substrate, the apparatus comprising:
a storage container or reservoir for holding a liquid coating medium;
a liquid medium supply means for receiving a liquid coating medium from the storage container or reservoir;

coating module means including an application slot for receiving liquid coating medium from the liquid medium supply means and for applying the coating to a substrate passing beneath the slot, wherein the liquid medium supply means is located at an elevation above said coating module means so that liquid medium is supplied from said liquid medium supply means to said coating module means via a gravity feed;

wherein the elevation or height of said liquid medium supply means relative to said coating module means is adjustable in order to vary a thickness of a layer of the liquid medium coating applied to the substrate via said slot; and

wherein said liquid medium supply means includes an inner means for holding liquid medium, and an outer means at least partially surrounding the inner means for holding liquid medium which overflows from the inner means, wherein liquid medium from the inner means is forwarded to the coating module means via the gravity feed and liquid medium from the outer means is forwarded back to said storage container or reservoir.

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Fig. 1

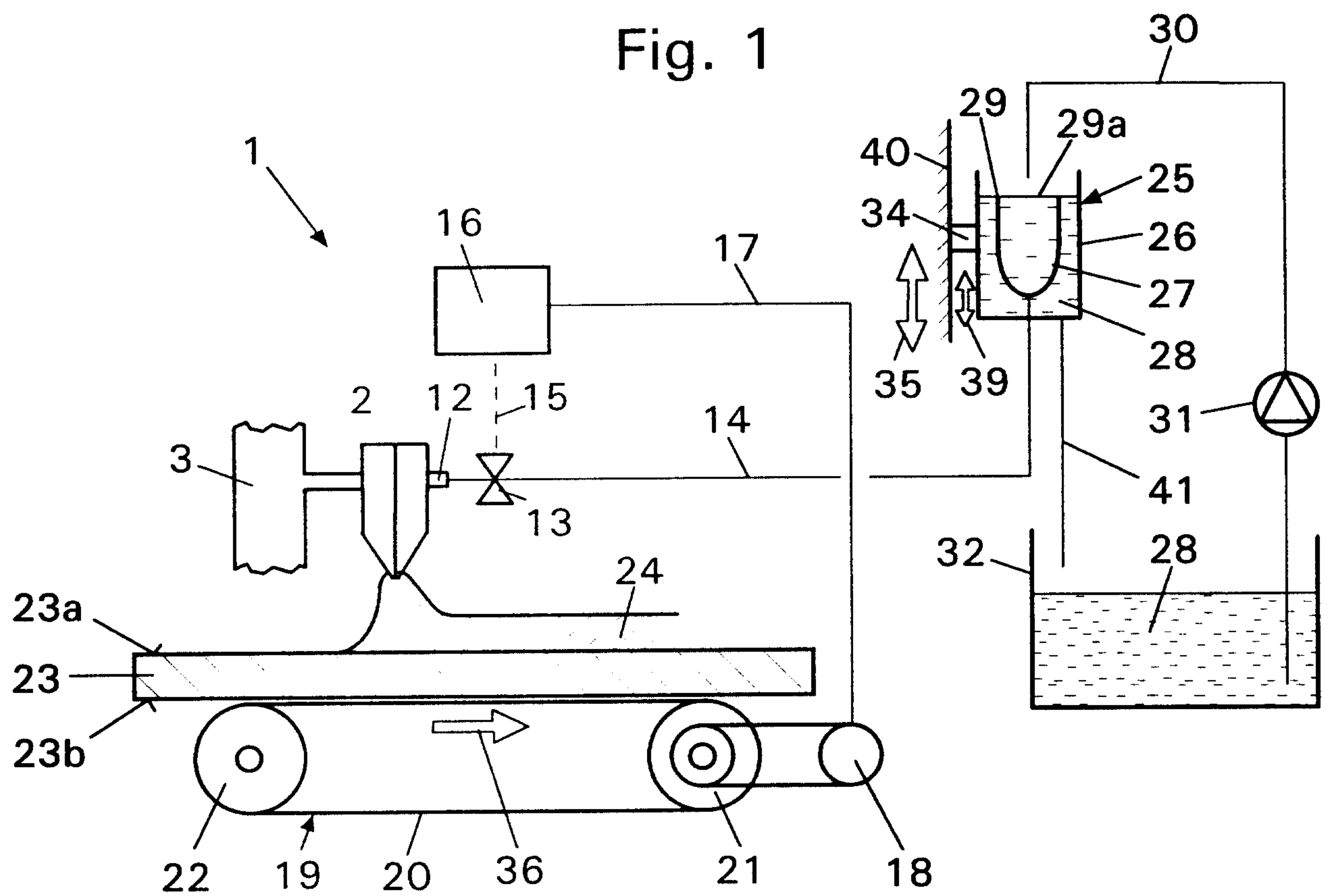


Fig. 2

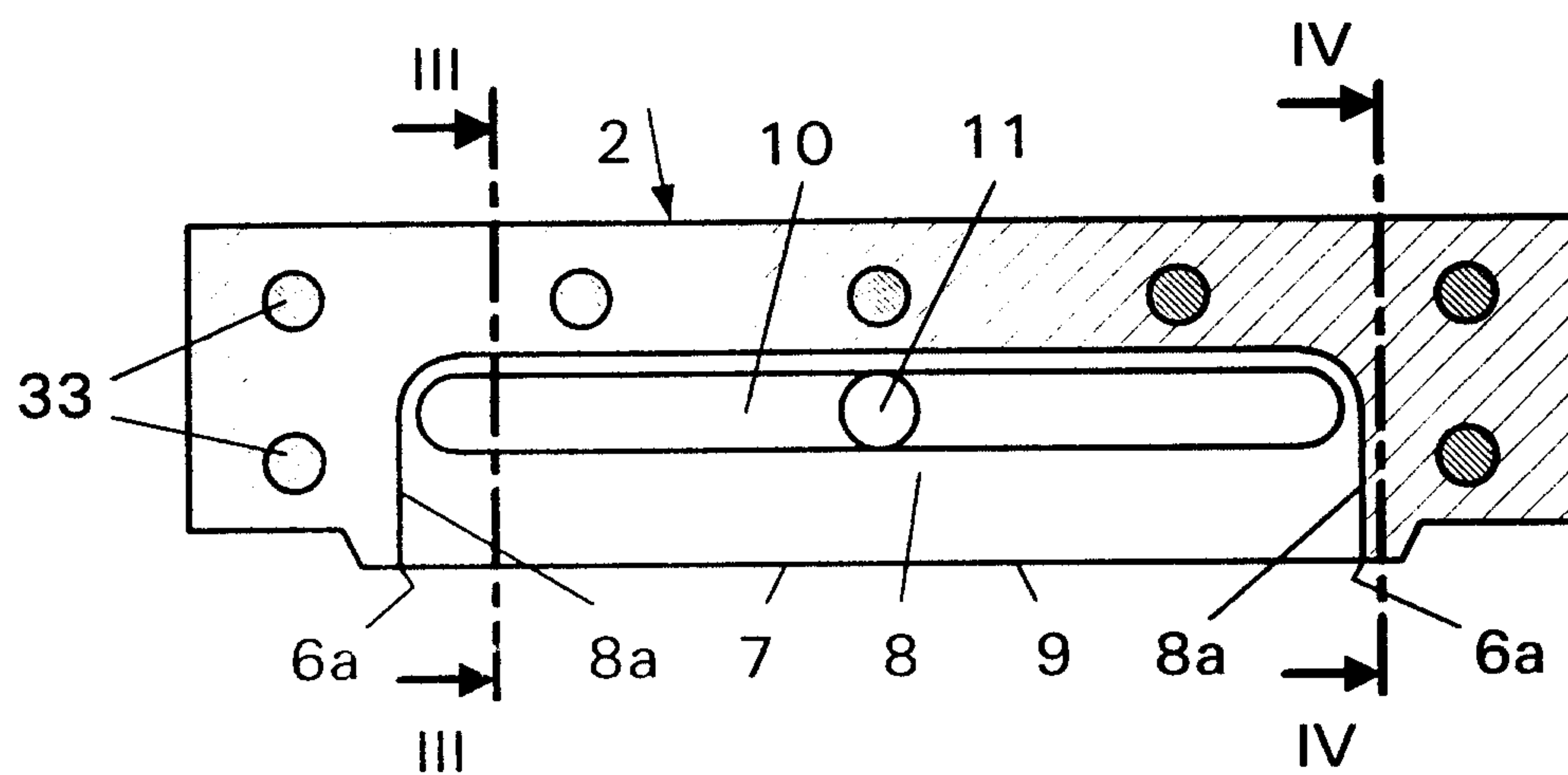


Fig. 3

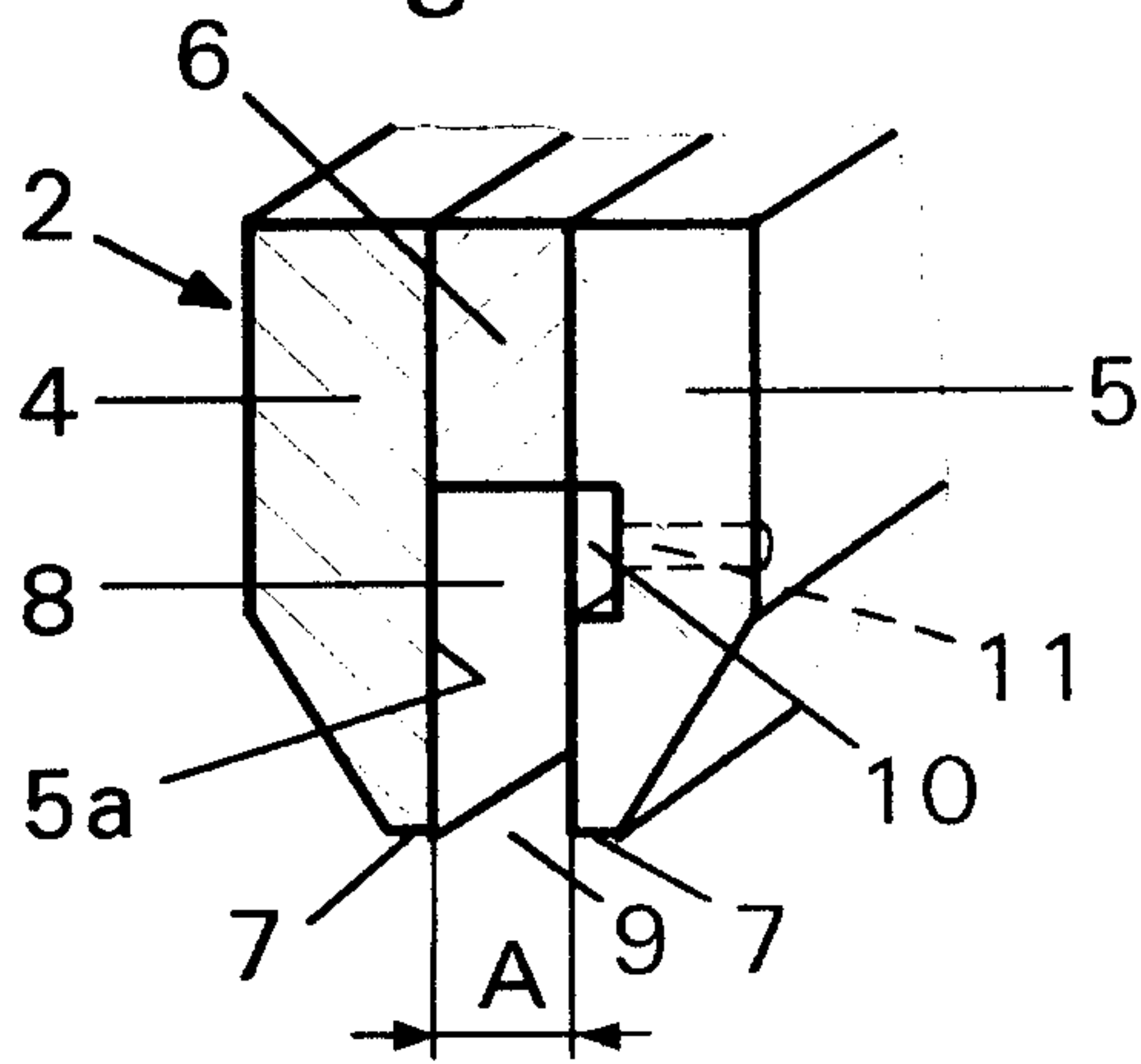


Fig. 4

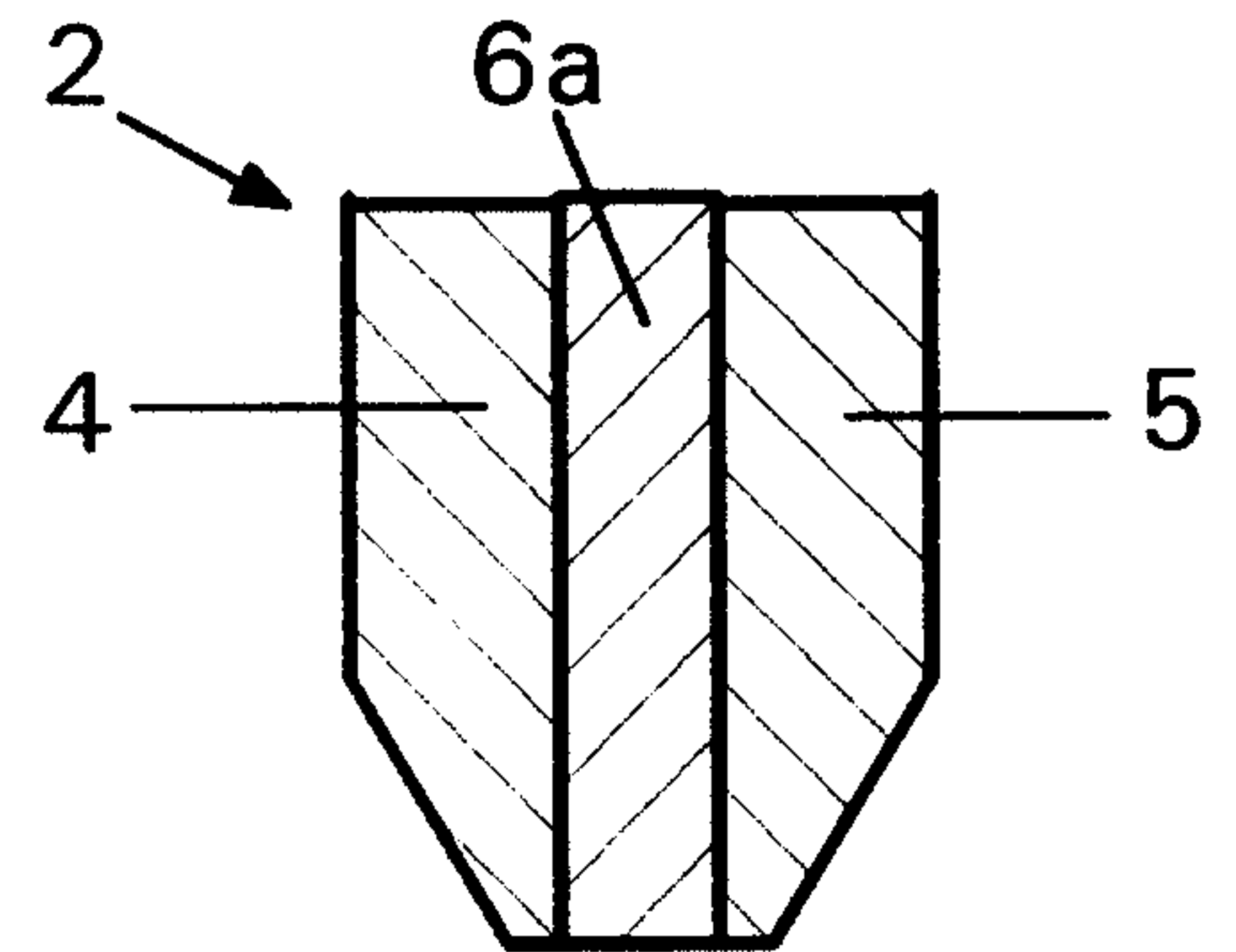


Fig. 5

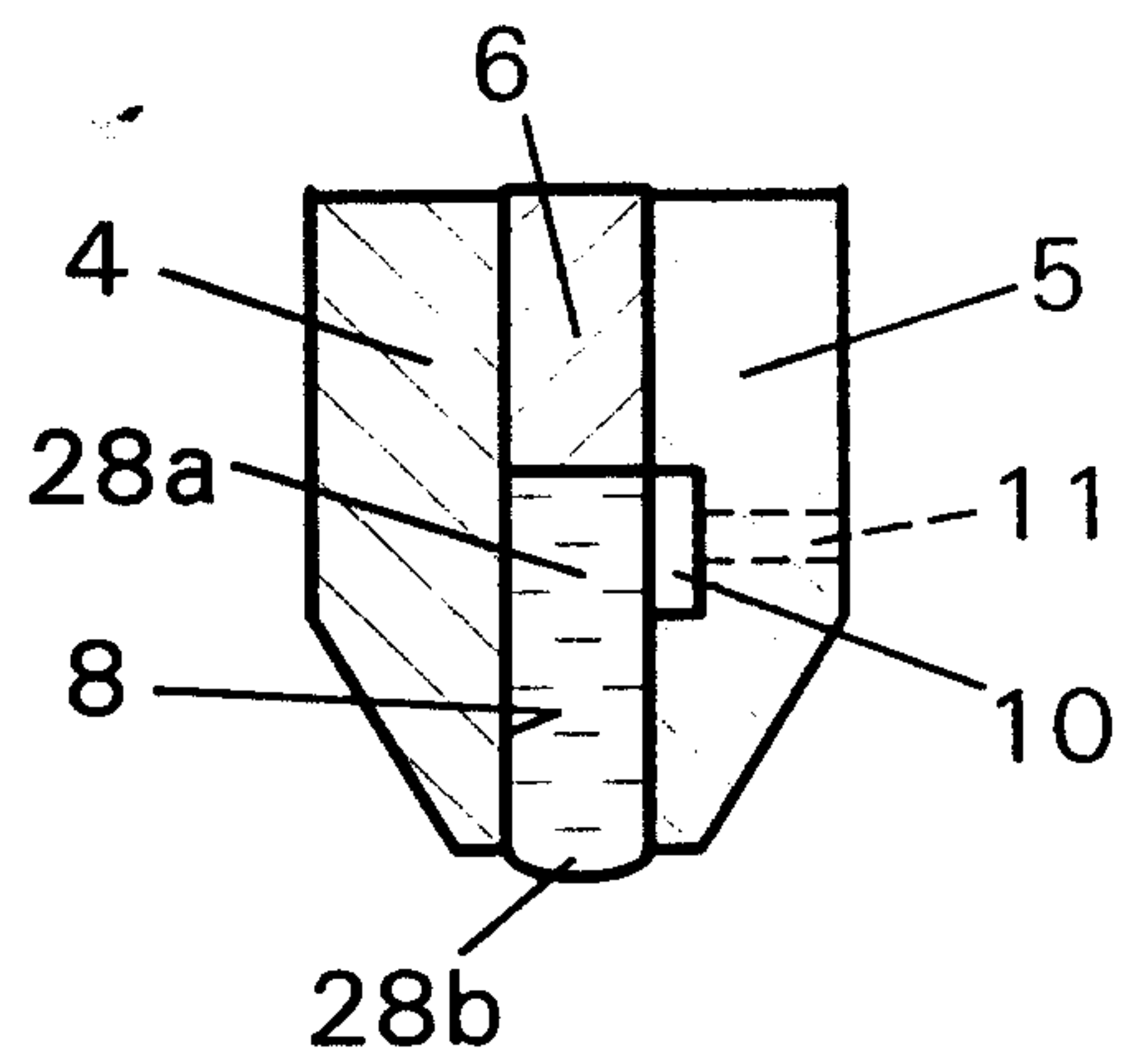


Fig. 6

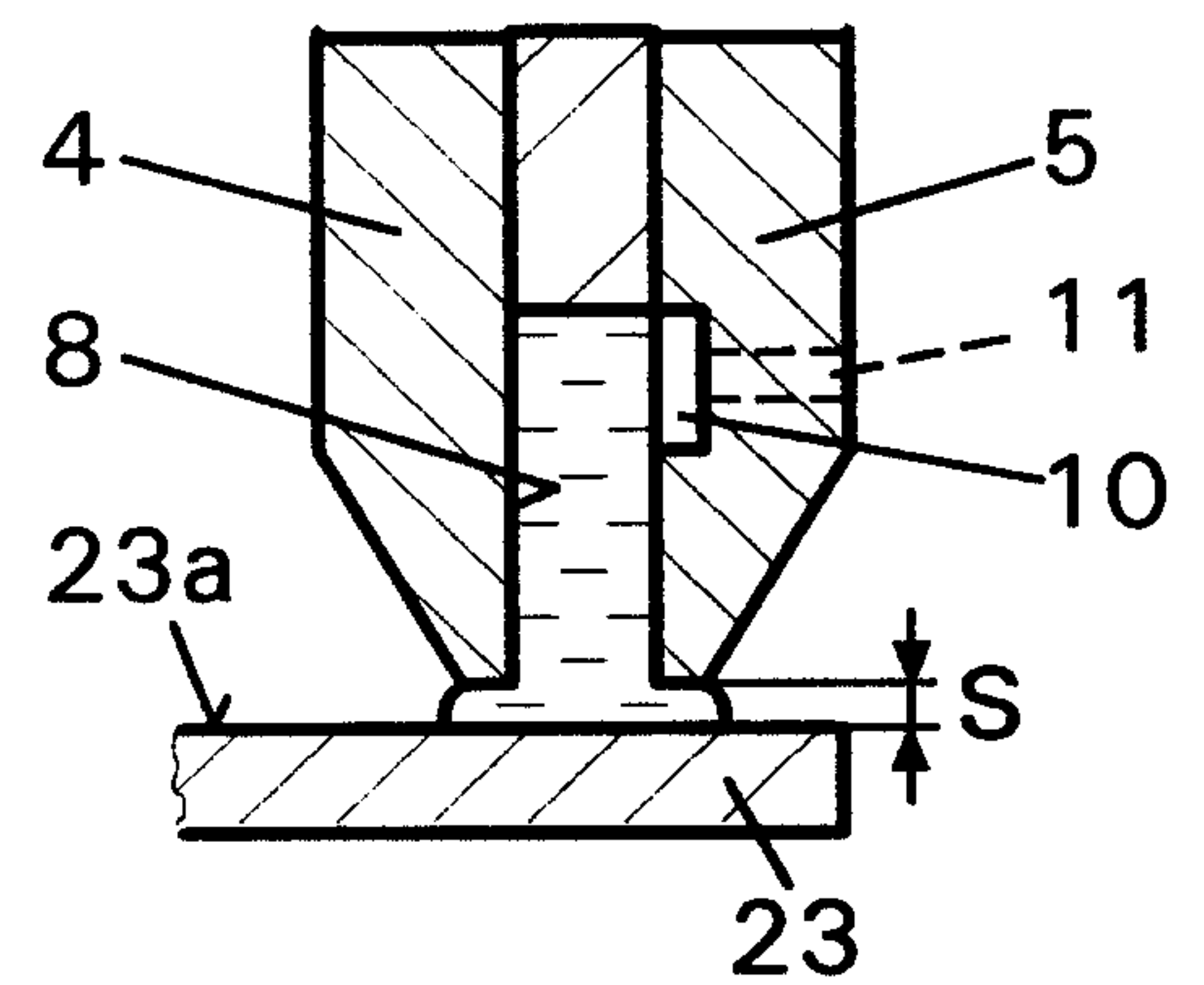


Fig. 7

