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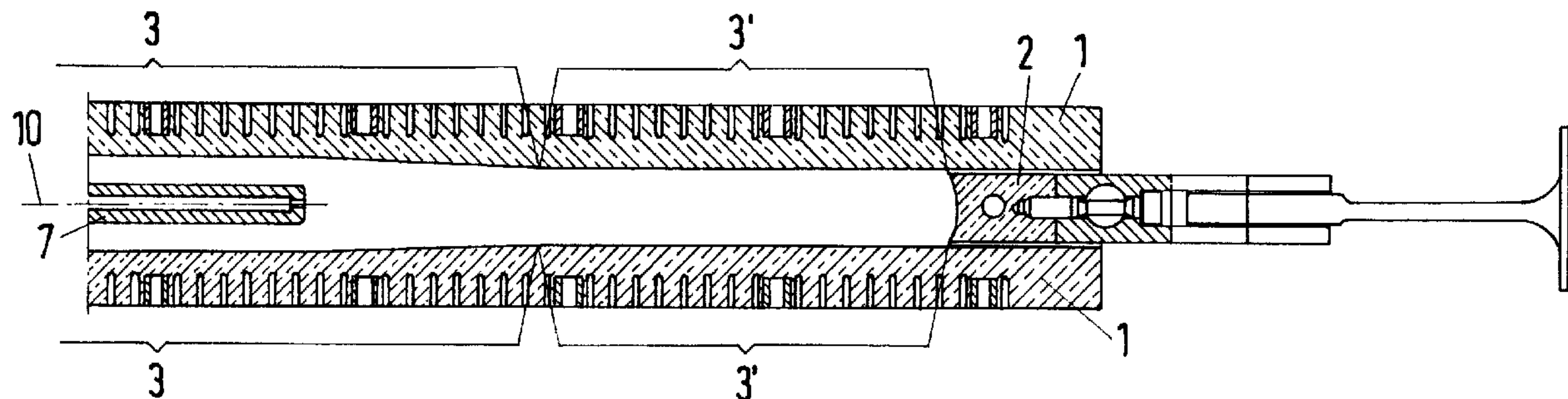
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(54) Titre : MOULE REFROIDI PAR LIQUIDE POUR LA COULEE CONTINUE DE BILLETES D'ACIER EN FORME DE
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(54) Title: LIQUID-COOLED MOULD FOR CONTINUOUS CASTING OF STEEL BILLETS IN SLAB FORM



(57) Abrégé/Abstract:

The invention concerns a liquid-cooled plate mold with adjustable width for the continuous casting of billets from steel in the form of slabs, particularly for a slab thickness of less than 100 mm. The shape-imparting broad side plates (1) and narrow side plates (2) of the ingot mold are constructed in the direction of their transverse extension so as to increase in cross section for the billet, while the narrow side plates (2) extend substantially parallel to one another along the height of the ingot mold. Further, the broad side plates (1) are constructed so as to be concave at least in a region (3) of smallest slab width in such a way that, in cross section, the apex height (13) of the ingot mold wall forming a curve has a determined height relative to a rectangle inserted in the drawing. The shape of the billet side plates at the billet outlet end (5) corresponds to the billet format to be produced.

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ABSTRACT

5 The invention concerns a liquid-cooled plate mold
with adjustable width for the continuous casting of billets
from steel in the form of slabs, particularly for a slab
thickness of less than 100 mm. The shape-imparting broad side
plates (1) and narrow side plates (2) of the ingot mold are
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narrow side plates (2) extend substantially parallel to one
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LIQUID-COOLED INGOT MOLD FOR THE CONTINUOUS CASTING OF STEEL
BILLETS IN THE FORM OF SLABS

The invention concerns a liquid-cooled plate mold with adjustable width for the continuous casting of billets
5 from steel in the form of slabs, particularly with a slab thickness of less than 100 mm.

For the production of steel billets in the form of slabs, it is conventional to employ ingot molds whose free cross-sectional surface at the mold outlet corresponds to the
10 desired billet format.

A corresponding ingot mold for a billet with oval cross section is known from U.S. Patent 2,767,448. This mold is a so-called block ingot mold, i.e. the cross section of the ingot mold cannot be changed and it is not suitable for
15 adjusting different billet formats. Further, an ingot mold is known from the prior art through DE 35 01 422 C2, whose narrow side walls can be adjusted to different billet dimensions and whose pour-in opening has an oval cross-sectional surface. The ingot mold tapers toward the outlet end in such a way that the
20 broad sides of the slab form parallel walls, while the narrow side walls diverge from the pour-in side to the pouring side, but retain their concave shape. Such an ingot mold is likewise known from EP 0 249 146 and U.S. Patent 4,716, 955.

Ingot molds are known from DE-A1 36 27 991 and WO
25 87/00099 which have plane surfaces on the narrow sides and convex broad sides along the entire height of the mold.

It must be noted that when using any of these ingot molds deformations occur in the billet shell when the billet passes through the mold, obviously because the billet shells
30 contact the mold wall in different ways, and these deformations can result in cracks in the billet shell.

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The object of the present invention is to improve the cooling conditions inside the continuous casting ingot mold and to prevent a blocking of the movement of the billet also in the width direction when the billet passes through the

ingot mold so as to eliminate the risk of longitudinal cracks and fissures as far as possible.

The invention provides a width-adjustable liquid-cooled plate ingot mold for the continuous casting from steel of billets in the form of slabs, said mold having an upper pour-in end (4) and a lower billet outlet end (5) and comprising: shape-imparting pairs of broad side plates (1) and narrow side plates (2), said narrow side plates (2) being substantially parallel to one another along the height of the ingot mold; each said broad side plate having a shape-imparting face that a central region (3) which when considered in a direction transverse to the length of the mold is concave towards the ingot such that, viewed in horizontal cross-section, the ingot mold wall forms, relative to a rectangle defined by lateral regions of the shape-imparting faces of said broad side plates (1) and said narrow side plates (2), a curve having an apex height (13) of at most 12 mm per 1000 mm slab width at the pour-in end (4) of the ingot mold; the shape of said shape-imparting faces of the broad side plates (1) at the billet outlet end (5) of the ingot mold corresponding to the billet format to be produced, wherein each broad side plate (1) is planar in said lateral region adjoining said narrow side plates (2), and has slot-like ducts (8) arranged in the side thereof opposite to the shape-imparting face.

A concomitant possibility of the invention consists in that the reduction in the apex height can be effected linearly as well as according to an e-function. The camber provided according to the invention can also diverge from the circular shape and can be a polygon or a combination of polygonal lines and base elements. On the whole, a camber which is optimal for the rolling process, e.g. 1 mm per side,

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is provided at the foot of the ingot mold, i.e. at the billet outlet end. Accordingly, the following rolling billet guide is constructed in accordance with the camber of the billet. One of the advantages of this is that all rollers having the
5 same diameter can be optionally converted with respect to their position and there is no need for deformation work with respect to changing the camber.

The drawings show by way of example only an embodiment of an ingot mold according to the invention:

10 Fig. 1 shows a top view of an ingot mold in cross section A-A according to Fig. 3 adjusted for a minimum slab width;

Fig. 2 is an enlarged partial view of Fig. 1 showing the position of the narrow sides adjusted for a
15 maximum slab width;

Fig. 3 shows a longitudinal section on line B-B of Fig. 1;

Fig. 4 is an enlarged view showing the adjusting region of the ingot mold to Figs.1 and 2;

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Fig. 5 shows another embodiment form in longitudinal section;

Figs. 6 to 8 show a modified construction in sections.

5 In the drawings, identical parts are provided with the same reference numbers. The ingot mold includes broad side plates 1 with narrow side plates 2 arranged between the latter so as to be displaceable. In the position shown in Fig. 1, the narrow side plates 2 define the smallest casting cross section
10 attainable with this ingot mold, i.e. the smallest slab width (b min.). In this region 3, a flat, curved recess which extends along this region 3, as seen in cross section, is worked into the broad side plates 1 on the sides forming the casting cross section. The apex of the curve or apex height 13
15 relative to a rectangle inserted in the drawing - chord of the curve - at the pour-in side 4 of the ingot mold is a maximum of 12 mm along a portion 6 of approximately one third the height of the ingot mold and then decreases toward the lower edge 5 of the ingot mold to a curve height of 1 mm (Fig. 5). The
20 selected camber at the pour-in side of the ingot mold corresponds to a maximum lengthening of the billet shell along the format width of 20% of the shrinkage.

Example:

	billet width	1,000 mm
25	shrinkage (0.8%)	8 mm
	additional elongation maximum	1.6 mm

Lateral regions 3', within which the narrow side plates 2 can be adjusted, adjoin the region 3 of the broad side plates 1 for the purpose of increasing the slab width (Fig. 2).
30 These regions 3' extend along the entire height of the ingot

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mold with a constant cross-sectional surface for the billet to be produced. The broad side plates 1 are formed in the region 3' in such a way that the surface enclosed by the broad sides forms an isosceles trapezoid as seen from the top proceeding
5 from the lateral sides of the rectangle inserted in the drawing, so that the larger base line of the trapezoid coincides with the lateral sides of the rectangle inserted in the drawing. The base line of the trapezoid is 0.4 mm longer than the opposite side. In view of this slope of the region
10 3', the contact pressure of the broad side plates pressing against the narrow side plates decreases at first when adjusting the width. The narrow side plates are then displaced and the broad side plates are then pressed against subsequently. The described construction of the broad side
15 plates 1 is applicable in straight and curved ingot molds and also in curved ingot molds with a plurality of different radii of curvature, as is shown in Fig. 3 and designated by R1 - R4.

Fig. 5 shows an ingot mold having a straight portion 6 with adjoining curved part on the pour-in side. The
20 submerged nozzle 7, which serves for the melt feed and is elongated in cross section, projects into the straight portion 6 of the ingot mold. The broad side plates 1 are cooled by means of water which is guided through ducts 8 in the rear side of the shape-imparting wall which is produced from copper. The
25 copper walls are fastened in a conventional manner, via bolts engaging in recesses 9, to a plate, not shown, which simultaneously covers the ducts.

The depth of the cooling ducts 8, at least in the upper half of the ingot mold, is so dimensioned that the
30 distance of the duct base 8' from the center 10 of the ingot mold to the narrow side walls 2 as seen from the top increases relative to the surface of the broad side plate 1 facing the melt.

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In Fig. 5, a region in which the apex height of the curve decreases linearly toward the ingot mold outlet 5 adjoins the region 6 of constant apex height 13 which comprises approximately one third of the height of the ingot mold and in every case covers the casting level region.

Fig. 3 shows another embodiment form. In this case, the ingot mold includes three regions with different apex heights 113 of the curve. The region 6, which is also designated by L1, corresponds to that described in Fig. 5. In the adjoining portion L2 which terminates approximately in the vertical center of the ingot mold at L1, the apex height 13 is reduced linearly to an amount 14 which corresponds to that at the ingot mold outlet 5. The lower portion 12 of the ingot mold accordingly has a constant apex height 13.

Whereas a certain camber is also present at the lower edge 5 of the ingot mold in the constructions described above, in the construction according to Figures 6 to 8 the shape of the broad side plates 1 at the lower edge - i.e. at the billet outlet end - of the ingot mold corresponds to the billet format to be produced. The transition from the cambered pour-in side 4 to the lower edge 5 clearly follows from the steps shown in Figures 6 to 8.

The process realized with the ingot mold according to the invention for producing a slightly cambered slab or thin slab results in the following advantages:

- uniform material flow of the rolling stock along the strip width in the roll gap and accordingly,

- highly consistent section of the finished strip,

- centric running of the slab or rolling stock in the ingot mold and from one pair of rollers or rolls to the other.

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The centric running of the slab in the ingot mold leads to the following advantages in technical respects relating to casting:

-uniform, specific conduction of heat into the narrow
5 and broad side copper plates and in both the horizontal and vertical directions,

-uniform gap formation between the billet shell and copper plate in the casting level region,

-uniform lubricating film formation of the casting
10 slag,

-the shrinking process of the billet, particularly in the width direction, is not hindered or blocked by means of parallel broad side copper plates, but rather is facilitated by the camber,

15 -increase in the temperature profile along the slab width in the region adjacent to the narrow side edges.

CLAIMS:

1. A width-adjustable liquid-cooled plate ingot mold for the continuous casting from steel of billets in the form of slabs, said mold having an upper pour-in end (4) and a
5 lower billet outlet end (5) and comprising:

shape-imparting pairs of broad side plates (1) and narrow side plates (2), said narrow side plates (2) being substantially parallel to one another along the height of the ingot mold;

10 each said broad side plate having a shape-imparting face that a central region (3) which when considered in a direction transverse to the length of the mold is concave towards the ingot such that, viewed in horizontal cross-section, the ingot mold wall forms, relative to a rectangle
15 defined by lateral regions of the shape-imparting faces of said broad side plates (1) and said narrow side plates (2), a curve having an apex height (13) of at most 12 mm per 1000 mm slab width at the pour-in end (4) of the ingot mold;

the shape of said shape-imparting faces of the
20 broad side plates (1) at the billet outlet end (5) of the ingot mold corresponding to the billet format to be produced, wherein each broad side plate (1) is planar in said lateral region adjoining said narrow side plates (2), and has slot-like ducts (8) arranged in the side thereof opposite to the
25 shape-imparting face.

2. An ingot mold according to claim 1, wherein said apex height (13) continuously decreases from the pour-in end (4) of the ingot mold to the billet outlet end (5) of the ingot mold.

3. An ingot mold according to claim 1, wherein said apex height (13) at the pour-in end (4) is between 5 and 12 mm.

4. An ingot mold according to claim 1, wherein the broad side plates (1) are constructed so as to be concave at the billet outlet end (5) of the ingot mold in such a way that the apex height (13) at this outlet end is still at least 0.5 to 2 mm.

5. An ingot mold according to any one of claims 1, 3 or 4, wherein the apex height (13) is constant over a region (6) of a third of the ingot mold height.

6. An ingot mold according to claim 5, wherein another portion (L2) terminating at approximately half the height of the ingot mold (at 11) adjoins the lower end of the region (6) of constant apex height (13) and the apex height (13) decreases linearly in said other portion (L2).

7. An ingot mold according to claim 6, wherein another portion (L2) terminating at approximately half the height of the ingot mold (at 11) adjoins the lower end of the region (6) of constant apex height (13) and in this portion (L2) the apex height (13) decreases linearly to an amount (14) which corresponds to the apex height at the ingot mold outlet (5) so that the lower half (12) of the ingot mold has a curved recess of constant apex height.

8. An ingot mold according to any one of claims 1 to 7, wherein the apex height of each broad side plate of the concave control region (3) of minimum slab width is not more than 20% of the shrinkage of approximately 1% of the billet width.

9. An ingot mold according to any one of claims 1 to 8, wherein said slot-like ducts (8) are spaced from the shape-imparting face of each of said broad side plates by an amount that increases with the spacing of said ducts from the center towards the lateral sides of said broad plates.

10. An ingot mold according to claim 9, wherein at least in the upper half of the ingot mold said ducts have bases that lie in a plane parallel to the central plane of the ingot mold.

10 11. An ingot mold according to any one of claims 1 to 10, wherein the broad side plates (1), which are planar in the adjusting region (3') of the narrow side plates (2), are inclined relative to a transverse central vertical plane of the mold, and in said lateral regions are at a constant distance from one another from the pour-in end (4) to the outlet end (5) of the ingot mold.

FETHERSTONHAUGH & CO.
PATENT AGENTS

OTTAWA, CANADA

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Fig.1

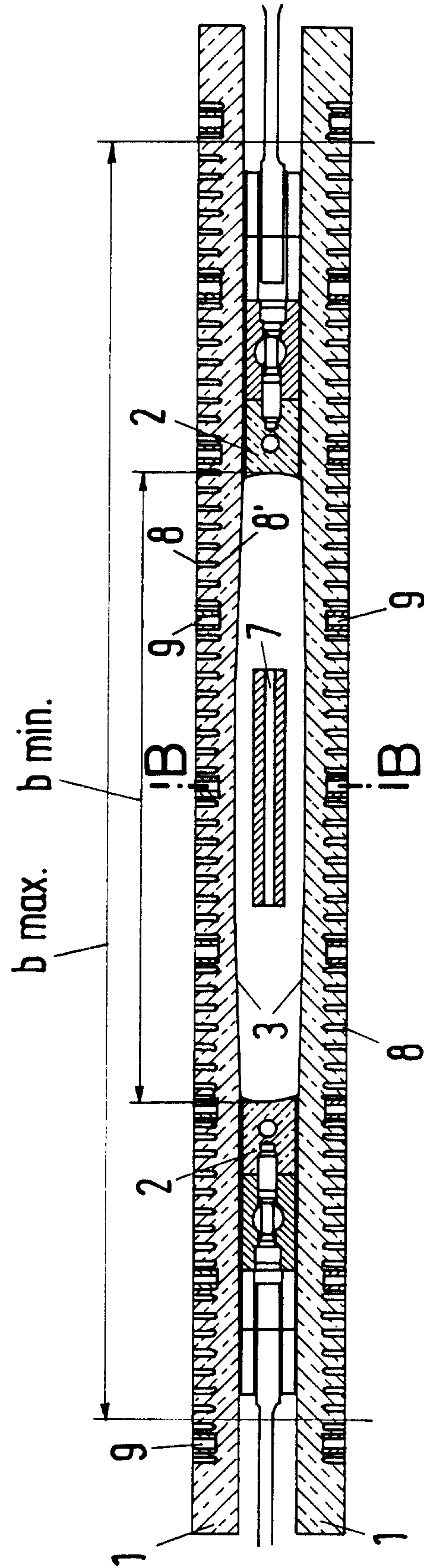


Fig. 2

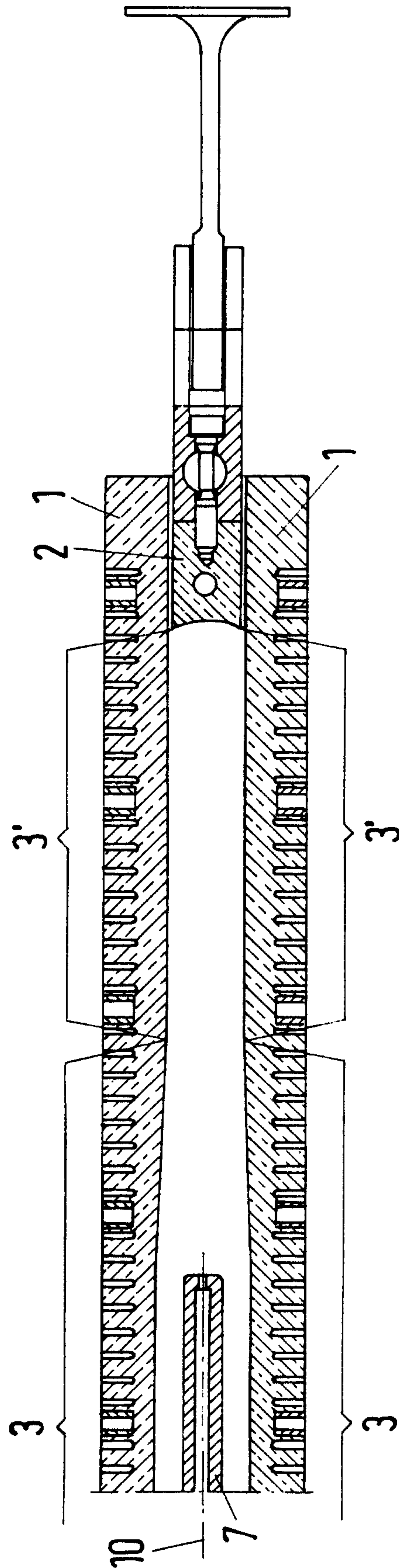


Fig.3

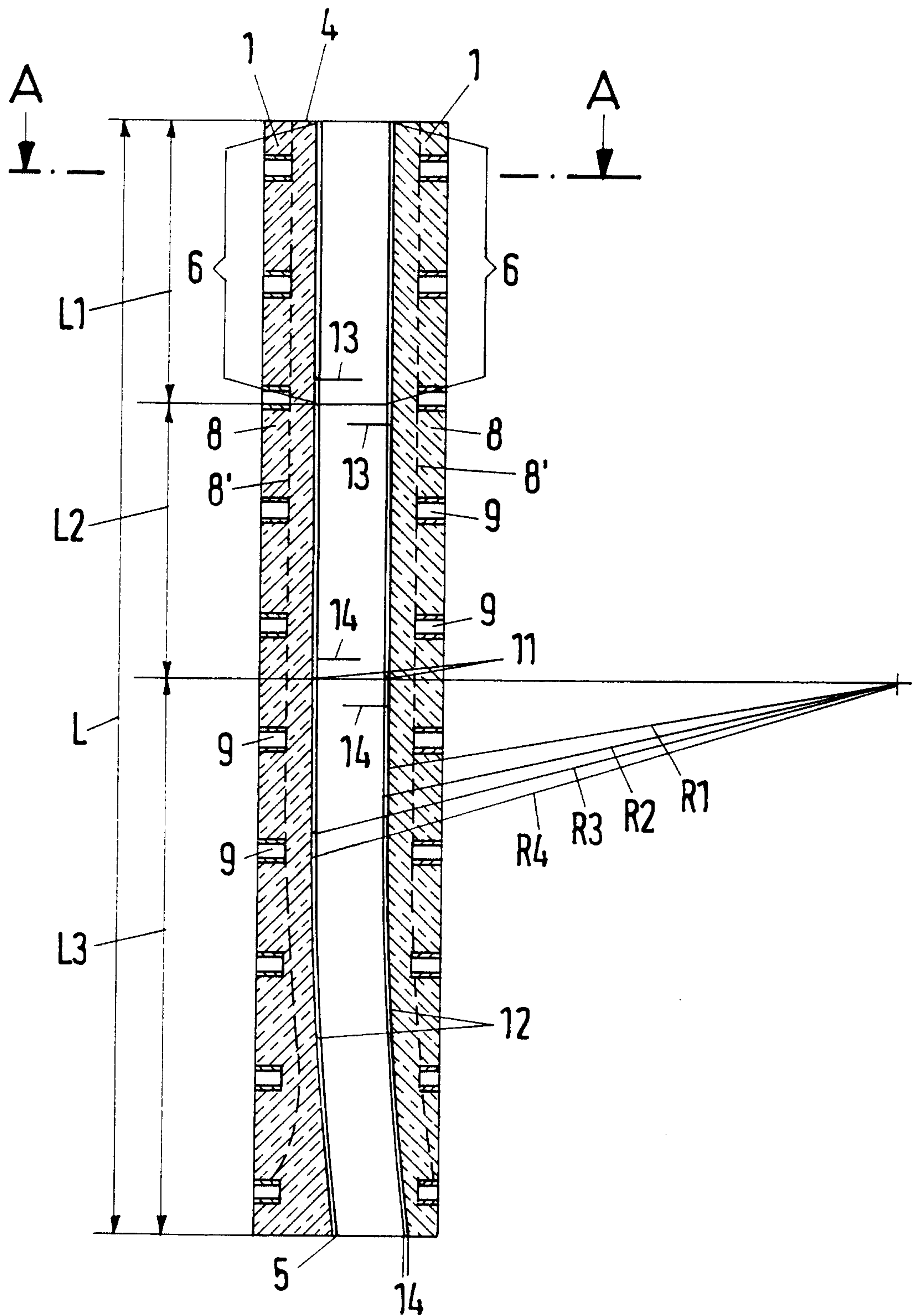
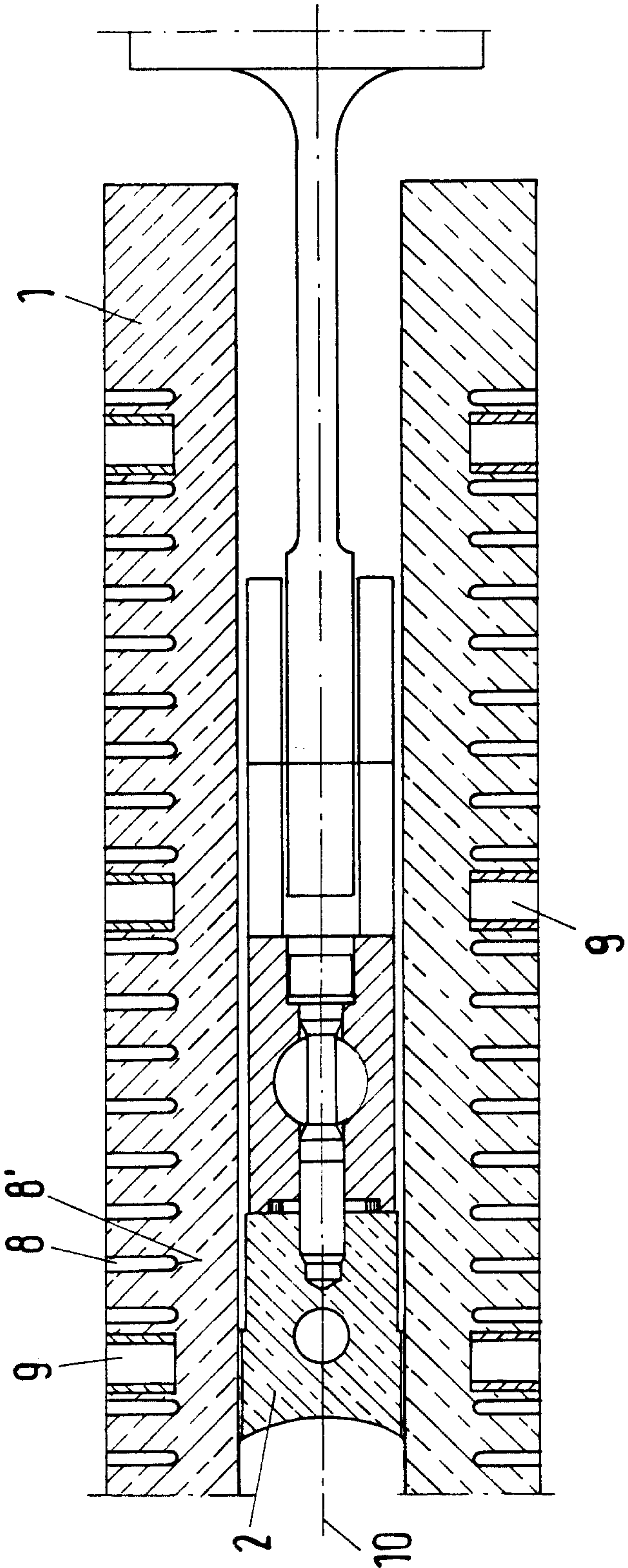
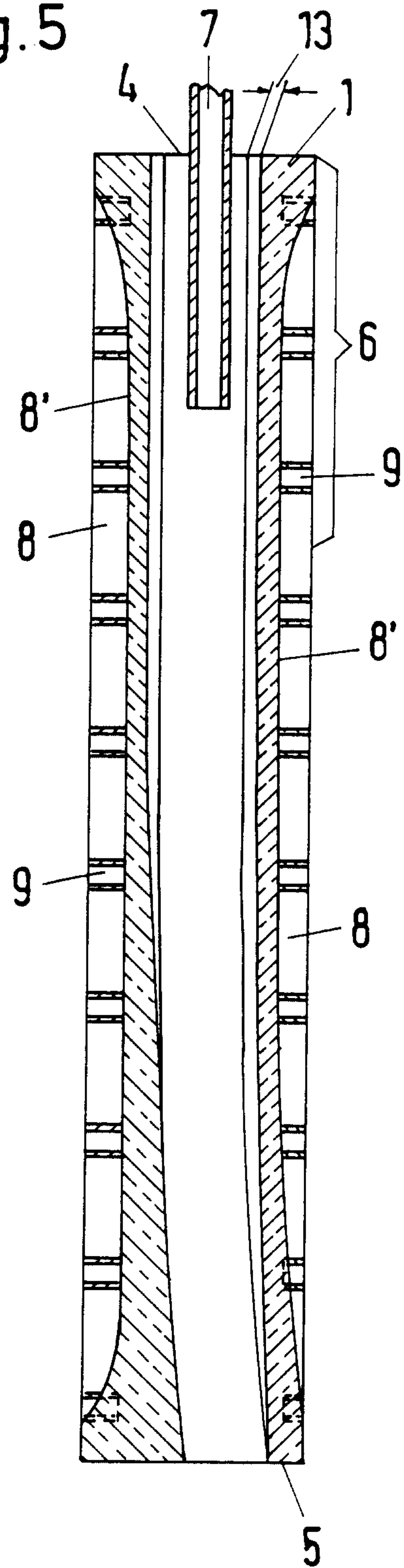


Fig. 4



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Fig.5



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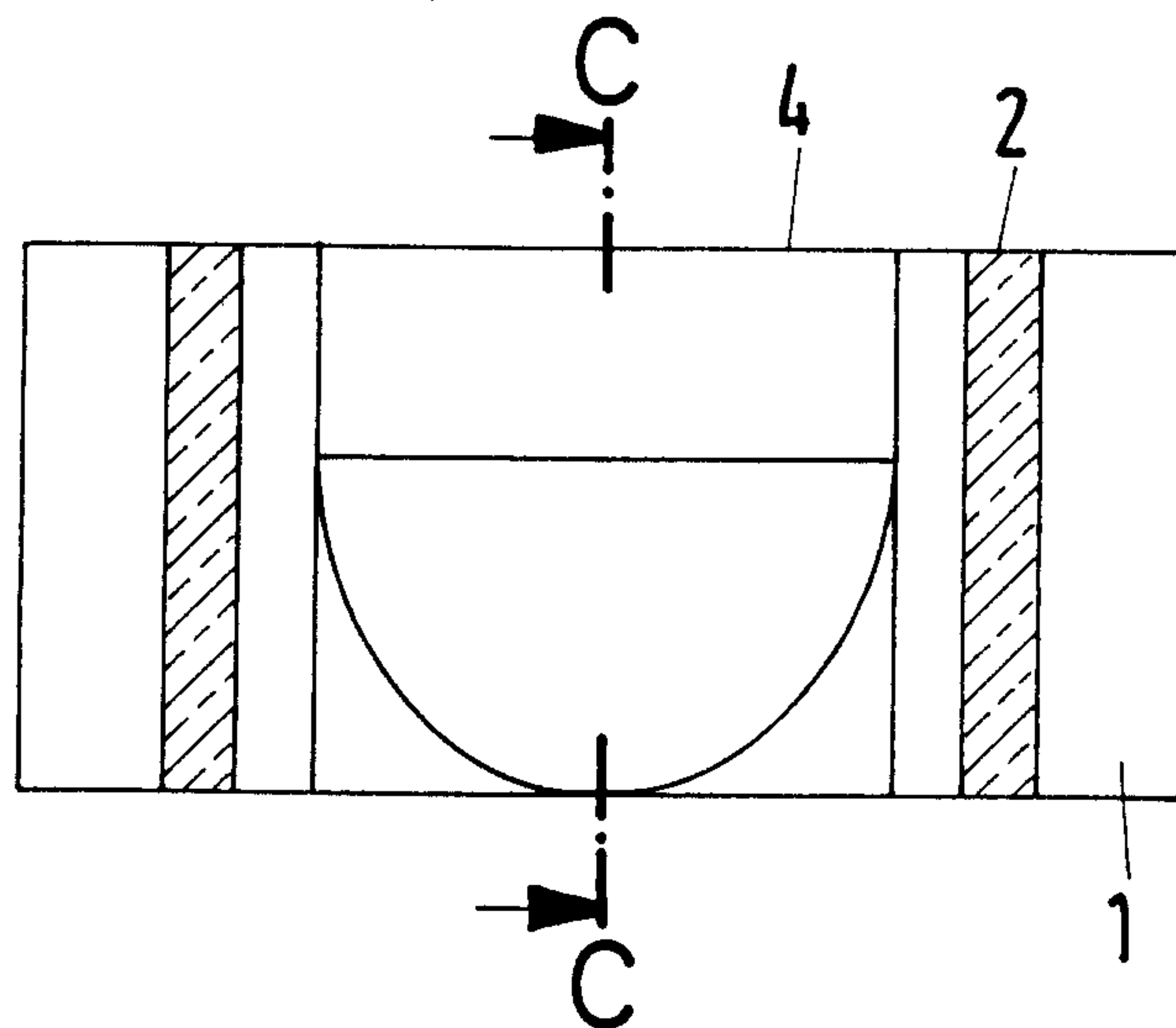
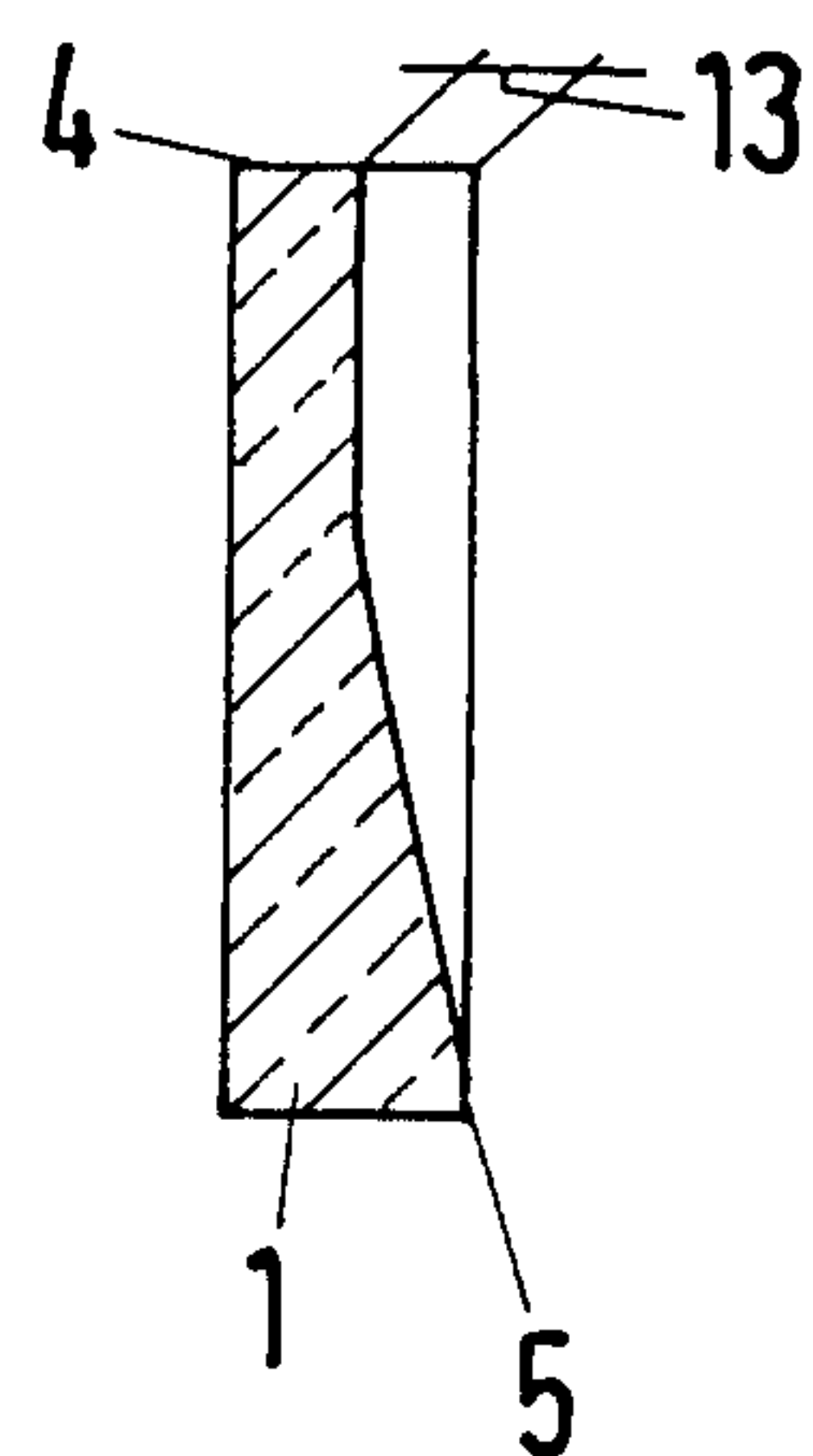
Fig.6
(D-D)Fig.7
(C-C)

Fig.8

