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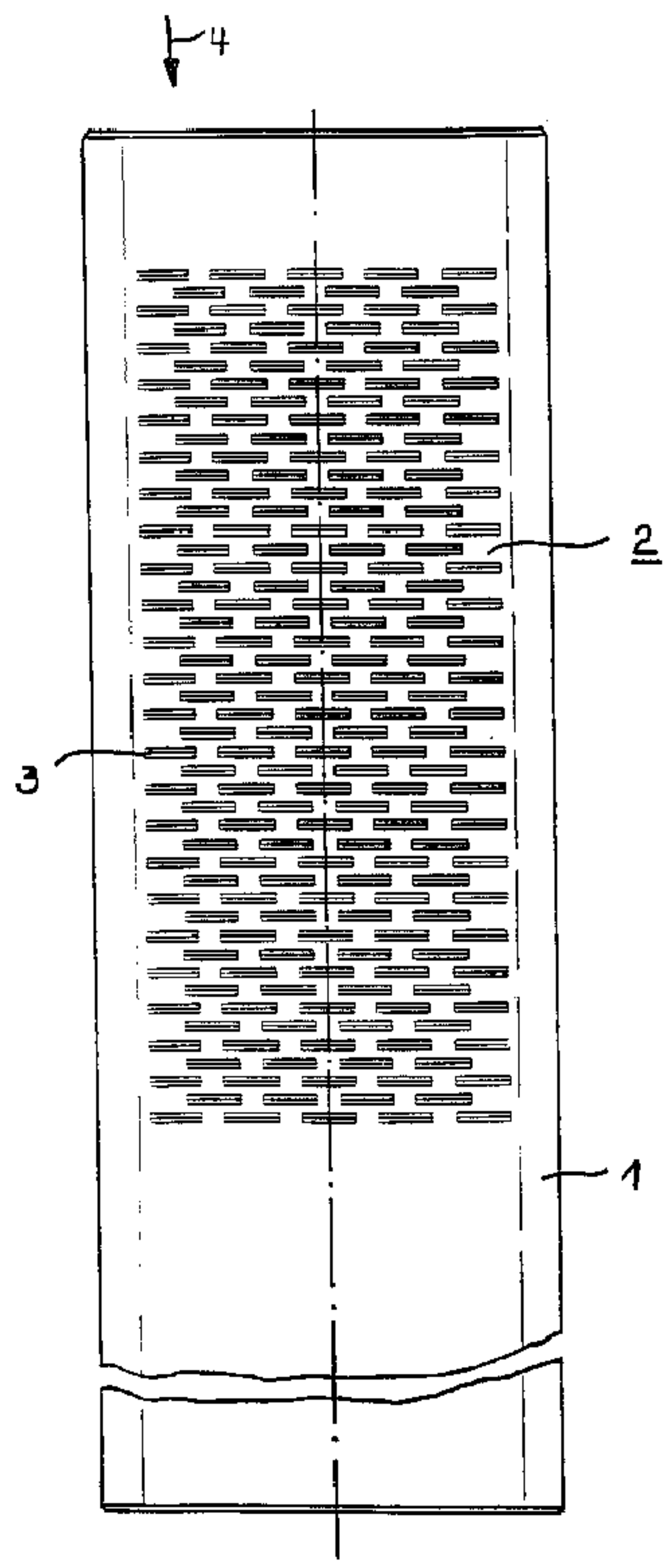
(54) Titre : MOULE A LINGOT POUR LA COULEE EN CONTINU DES METAUX
(54) Title: INGOT MOLD FOR THE CONTINUOUS CASTING OF METALS



(57) Abrégé/Abstract:
An ingot mold for the continuous casting of metals. The mold has a mold cavity that is open at opposing ends. The cross-sectional area at the casting pour-in-side is larger than the cross-sectional area of the end from which the billet emerges. To achieve higher casting performance and attain better billet quality via more uniform temperature distribution over the casting cross-section, the mold cavity has multiple conical depressions on an outer cooling surface. These depressions, which are arrayed over at least one area, constitute a region defining elevated heat transfer coefficients. The cooling surface in the bath level area of the ingot mold has a roughened structure over part of its surface, the roughened structure tapering in the casting direction.

Abstract

An ingot mold for the continuous casting of metals. The mold has a mold cavity that is open at opposing ends. The cross-sectional area at the casting pour-in-side is larger than the cross-sectional area of the end from which the billet emerges. To achieve higher casting performance and attain better billet quality via more uniform temperature distribution over the casting cross-section, the mold cavity has multiple conical depressions on an outer cooling surface. These depressions, which are arrayed over at least one area, constitute a region defining elevated heat transfer coefficients. The cooling surface in the bath level area of the ingot mold has a roughened structure over part of its surface, the roughened structure tapering in the casting direction.

INGOT MOLD FOR THE CONTINUOUS CASTING OF METALS

Background of the Invention

The present invention relates generally to an ingot mold for the continuous casting of metal, mainly steel, and particularly to a mold having a mold cavity that is open on two opposite ends, the cross-section of the mold cavity at the pour-in-side end being larger than at the end from which the billet emerges.

There is a need for an ingot mold of this type that offers both higher casting performance and better billet quality than has hitherto been the case. At the same time, heat dissipation from the partially molten billet should be optimized so as to increase the service life of the ingot mold.

Summary of the Invention

According to one aspect of the present invention there is provided an ingot mold having a central longitudinal axis in a casting direction for the continuous casting of metals, including steel, comprising a mold cavity having a first opening at a pour-in side and a second opening at an opposite side from which the billet emerges, the cross-sectional area of the mold cavity at the pour-in side being larger than at the end where the billet emerges, wherein the mold cavity has a multiple conical design; and an outer surface, said outer surface of said ingot mold having at least one region of axially interrupted depressions that defines a cooling surface of elevated heat transfer.

According to a second aspect of the present invention there is provided an ingot mold for the continuous casting of metals, comprising a mold cavity having a first opening at a pour-in side and a second opening at an opposite side from which the billet emerges, the cross-sectional area of the mold cavity at the pour-in side being larger than at the end where the billet emerges; and at least one, outer cooling surface having at least one region on which is located a pattern of depressions that extend from the outer surface inwardly towards the mold cavity, said depressions serving to enhance the rate of heat transfer from the ingot mold wherein a distance between the depressions lies in the range of 1 to 10 mm.

Thus, the present invention provides an ingot mold for the continuous casting of metals (primarily steel). The mold has a cavity that is open at opposed ends. The mold cavity at the inlet side is larger in cross-section than the opening at the other end of the cavity. The mold utilizes a multiple conical design to optimize heat transfer rate. A series of shaped depressions on at least a portion of a heat-transfer surface on the mold facilitates cooling of the mold.

Brief Description of the Drawings

For a more complete understanding of this invention, reference should now be made to the embodiments illustrated in greater detail in the accompanying drawings and described below. In the drawings:

Figure 1 a side schematic view of a first embodiment of a tubular ingot mold, constructed according to the principles of the invention;

Figure 2 is a side view of a second embodiment of a tubular ingot mold constructed according to the principles of the invention;

Figure 3 is a cross-sectional view of a mold cavity having triple conicity;

Figure 4 is a cross-sectional view of a mold cavity having a curved longitudinal axis;

Figures 5a, 5b, and 5c illustrate mold cavities having round, square, and polygonal cross-sections, respectively;

Figure 6 illustrates a mold cavity having a double-T type cross-section;

Figures 7a, 7b, and 7c illustrate in cross-section various suitable depression geometries; and

Figures 8a and 8b are plan and sectional views, respectively, of an ingot mold having a bulge at its pour-in side, where b is the extent to which the mold bulges and t is the wall thickness of the mold.

In Figures 1 and 2, the views shown are of the curved sides of the ingot mold.

Detailed Description of the Invention

Figure 1 shows a tubular ingot mold 1 for the continuous casting of steel. The particular embodiment shown has a square casting cross-section of 170 x 170 mm^2. The wall thickness of the curved ingot mold 1 (the casting radius is 8,000 mm) is 18 mm. The mold cavity of the approximately 800 mm long ingot mold 1 is subdivided into two conical areas. The first area, which extends 320 mm in the casting direction, has a conicity of 2.4 %/m; the adjacent 480 mm long portion has a conicity of 1 %/m.

With reference to Figure 1, a cooling-optimized area 2 is provided having depressions 3 in the cooling surface of the ingot mold 1. These depressions are triangular in cross-section, and extend over a partial length of approximately 310 mm that begins 60 mm downstream of the pour-in side 4.

To attain optimal solidification conditions for the steel billet during the casting operation, it has proven particularly advantageous to provide the structured cooling area 2 only on the curved exterior of the tubular ingot mold 1.

In the embodiment shown, the center-to-center distance of the depressions 3, which are triangular in cross-section, is 8 mm in the casting direction, the individual depressions 3 having a width of 4 mm. The maximum depth of the depressions 3 normal to the surface is 1.2 mm. (The foregoing dimensions of the cooling-optimized area 2 have been determined in casting-engineering tests.)

A second embodiment is shown in Figure 2. The tubular ingot mold 1 (which can be shaped for the continuous casting of square cross-sections as well) has a cooling-optimized area 2 which consists of a plurality of circular depressions 3. In this embodiment, the total trapezoidal-shaped area 2 over which these depressions run has a length of 250 mm, tapering in the casting direction by about 30%. (Again, the pour-in side is designated 4 and the end at which the billet emerges is designated 5.)

The shape of the depressions may vary. For example, the depressions may be triangular (Fig. 7a), trapezoidal (Fig. 7b), or round (Fig. 7c). Any one of these shapes may be used for the depressions exclusively, or the shapes may be combined. Preferably, the distance between such depressions lies within the range of 1 to 10 mm. In yet another embodiment, the ingot mold cooling surface is roughened so as to provide a pattern of sites of enhanced heat transfer. Such roughening is characterized by a mechanically applied structure with a peak-to-valley height of $R_t > 1.5$ μm. Regions of depressions may be combined with areas of patterned roughening in a single mold. In the embodiment shown in Fig. 6, a double-T type mold is provided with both regions of depressions (A1 and A2) and roughened zones (B, C, and D). Whatever the shape employed, these regions of enhanced heat transfer are generally located over the area of the mold where optimized heat dissipation is desired.

Other variations of the invention are contemplated and fall within the scope of the invention. For example, the invention is applicable both to ingot and plate molds. The middle axis of the ingot mold in the casting direction may be linear or curved (Fig. 4). The cross-sectional shape of the casting may be round (Fig. 5a), square (Fig. 5b), polygonal (Fig. 5c), or have a double-T shape as noted above (Fig. 6). The mold cavity may have a three-stage (Fig. 3) or parabolic conicity, and may have a bulge at the pour-in side that becomes smaller in the casting direction. For example, in the embodiment shown in Figs. 8a and 8b, the mold cavity has a bulge b that extends for no more than 50% of the length of the ingot mold.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An ingot mold having a central longitudinal axis in a casting direction for the continuous casting of metals, including steel, comprising:

a mold cavity having a first opening at a pour-in side and a second opening at an opposite side from which the billet emerges, the cross-sectional area of the mold cavity at the pour-in side being larger than at the end where the billet emerges, wherein the mold cavity has a multiple conical design; and

an outer surface, said outer surface of said ingot mold having at least one region of axially interrupted depressions that defines a cooling surface of elevated heat transfer.

2. The ingot mold according to claim 1, wherein the ingot mold has a central axis in the casting direction that is straight.

3. The ingot mold according to claim 1, wherein the ingot mold has a central axis in the casting direction that is curved.

4. The ingot mold according to claim 1, wherein the cross-sectional area of the mold cavity is round.

5. The ingot mold according to claim 1, wherein the cross-sectional area of the mold cavity is polygonal.

6. The ingot mold according to claim 1, wherein the cross-sectional area of the mold cavity has a double-T shape.

7. The ingot mold according to claim 1, wherein the mold cavity is conical in three stages.

8. The ingot mold according to claim 1, wherein the mold cavity has a parabolically shaped conicity.

9. The ingot mold according to claim 1, wherein at least a portion of the cooling surface is a roughened region so as to provide sites of elevated heat transfer.

10. The ingot mold according to claim 9, wherein the roughened region has a mechanically applied texture with a peak-to-valley height of $R_t > 1.5\ \mu m$.

11. The ingot mold according to claim 1, wherein the cooling surface of elevated heat transfer further comprises the depressions having a triangular cross-section, and the center-to-center distance between the depressions lies in the range of 1 to 10 mm.

12. The ingot mold according to claim 1, wherein the cooling surface of elevated heat transfer further comprises the depressions having a trapezoidal cross-section, and the center-to-center distance between the depressions lies in the range of 1 to 10 mm.

13. The ingot mold according to claim 1, wherein the cooling surface of elevated heat transfer further comprises

the depressions having a round cross-section, and the center-to-center distance between the depressions lies in the range of 1 to 10 mm.

14. The ingot mold according to claim 1, wherein the cooling surface of elevated heat transfer comprises sub-regions of differingly shaped depressions within the cooling surface.

15. The ingot mold according to claim 1, wherein the cooling surface of elevated heat transfer is provided in an area of greatest heat release.

16. The ingot mold according to claim 10, wherein the roughened region is provided in an area of greatest heat release.

17. The ingot mold according to claim 1, wherein the cooling surface has a structure which extends over an area symmetrical to a longitudinal axis of a casting surface and tapers in the casting direction.

18. The ingot mold according to claim 1, wherein the mold cavity has a bulge at the pour-in side which becomes smaller in the casting direction.

19. The ingot mold according to claim 18, wherein the length of the bulge amounts to a maximum of 50% of the ingot mold length.

20. The ingot mold according to claim 1, wherein the outer

surface of the ingot mold contains a zone having depressions and a zone having a roughened surface area.

21. An ingot mold for the continuous casting of metals, comprising:

a mold cavity having a first opening at a pour-in side and a second opening at an opposite side from which the billet emerges, the cross-sectional area of the mold cavity at the pour-in side being larger than at the end where the billet emerges; and

at least one, outer cooling surface having at least one region on which is located a pattern of depressions that extend from the outer surface inwardly towards the mold cavity, said depressions serving to enhance the rate of heat transfer from the ingot mold wherein a distance between the depressions lies in the range of 1 to 10 mm.

22. The ingot mold according to claim 1 or claim 21, wherein the depressions are evenly spaced from one another.

23. The ingot mold according to claim 1 or claim 21, wherein the depressions are round dimples.

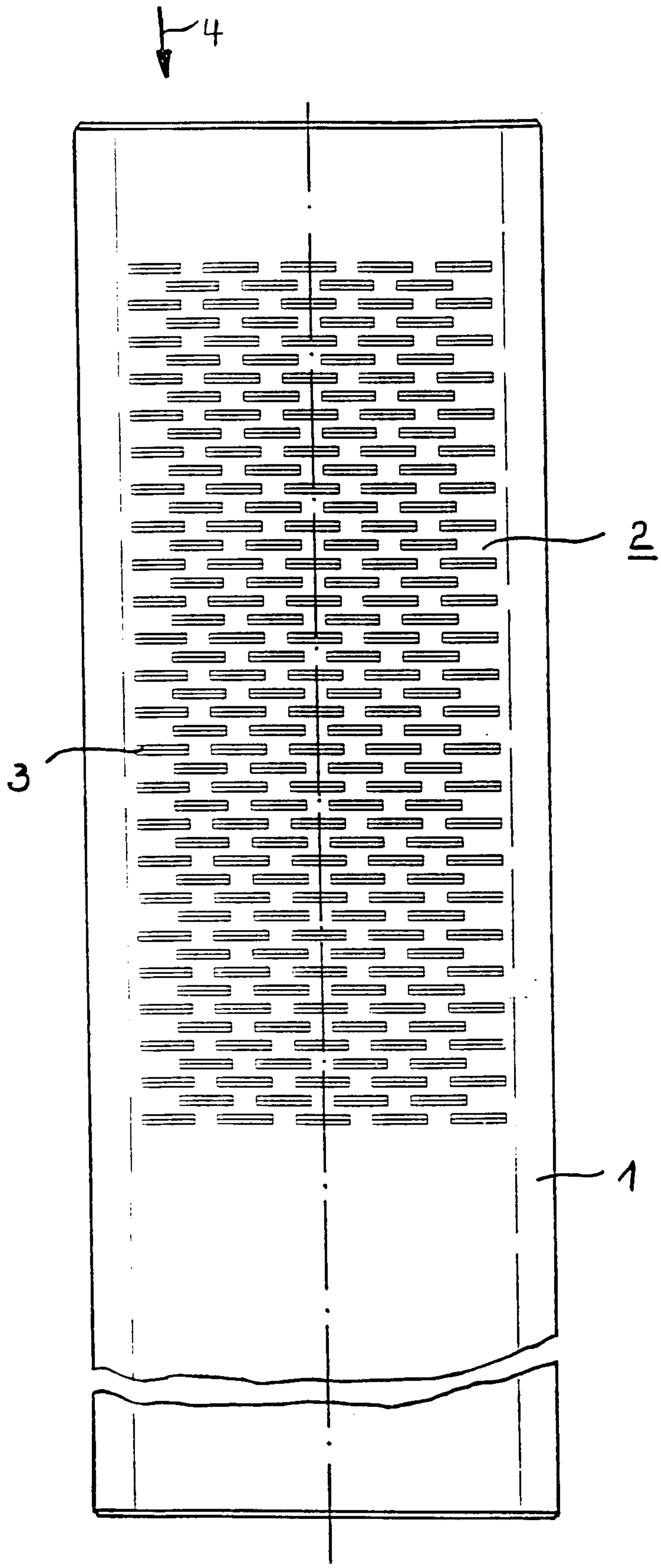


FIG.1

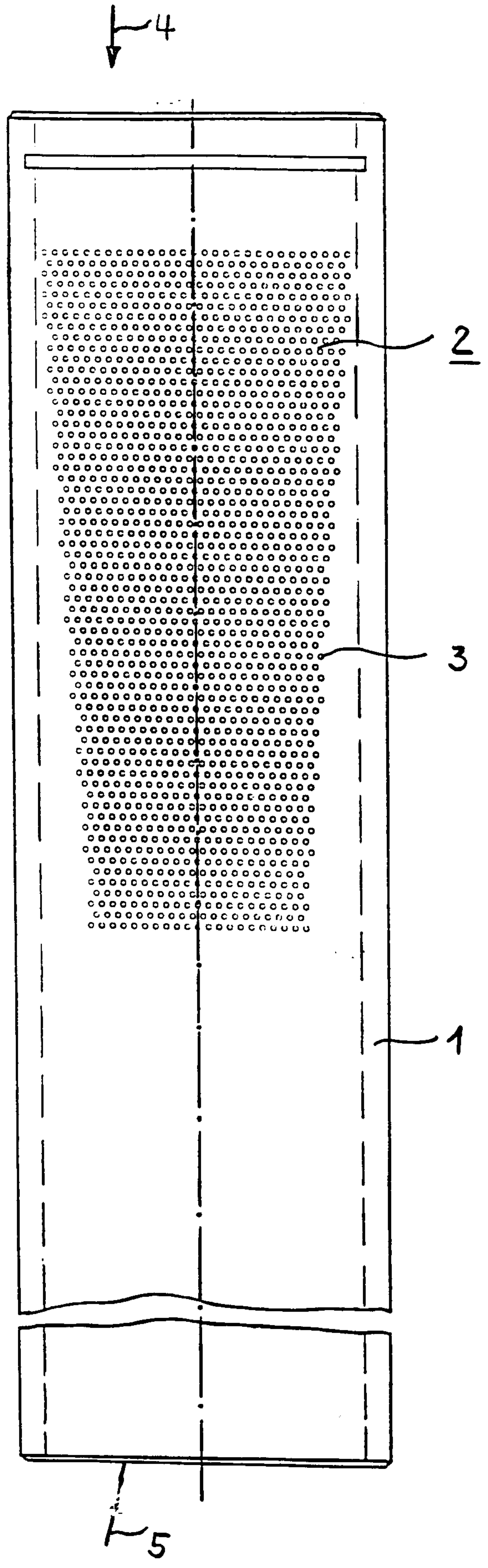


FIG. 2

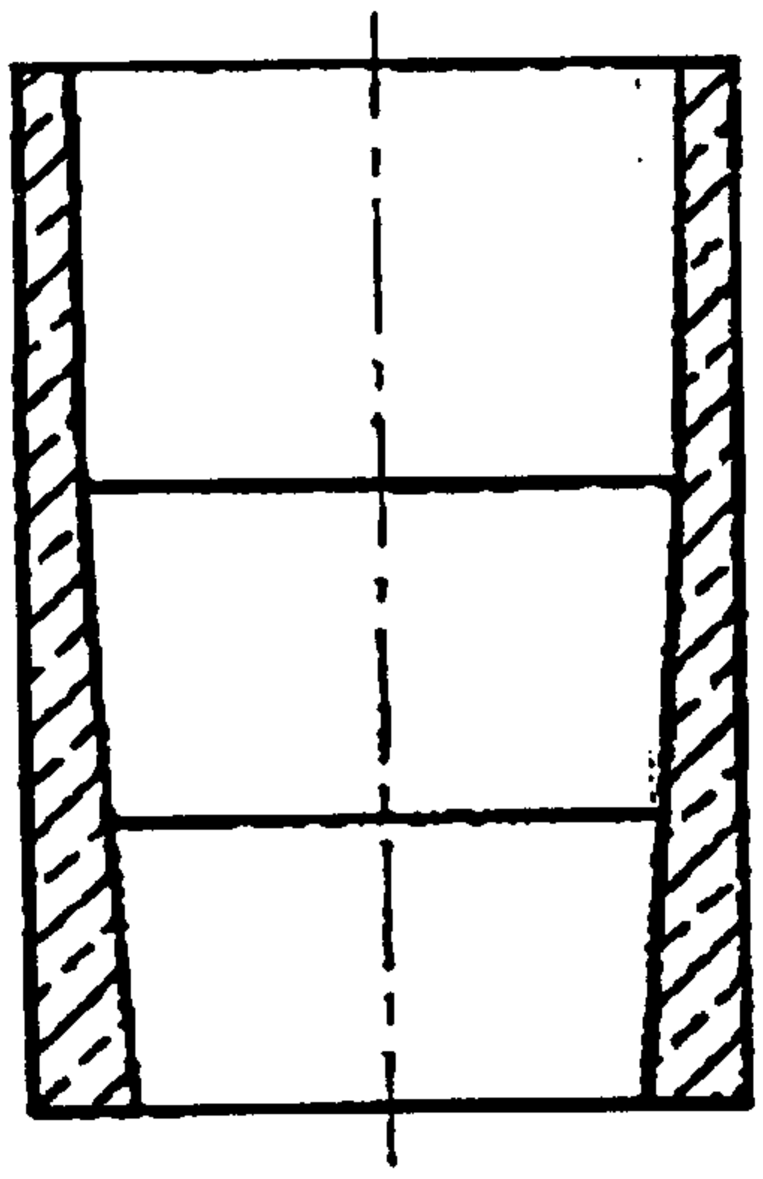


Fig. 3

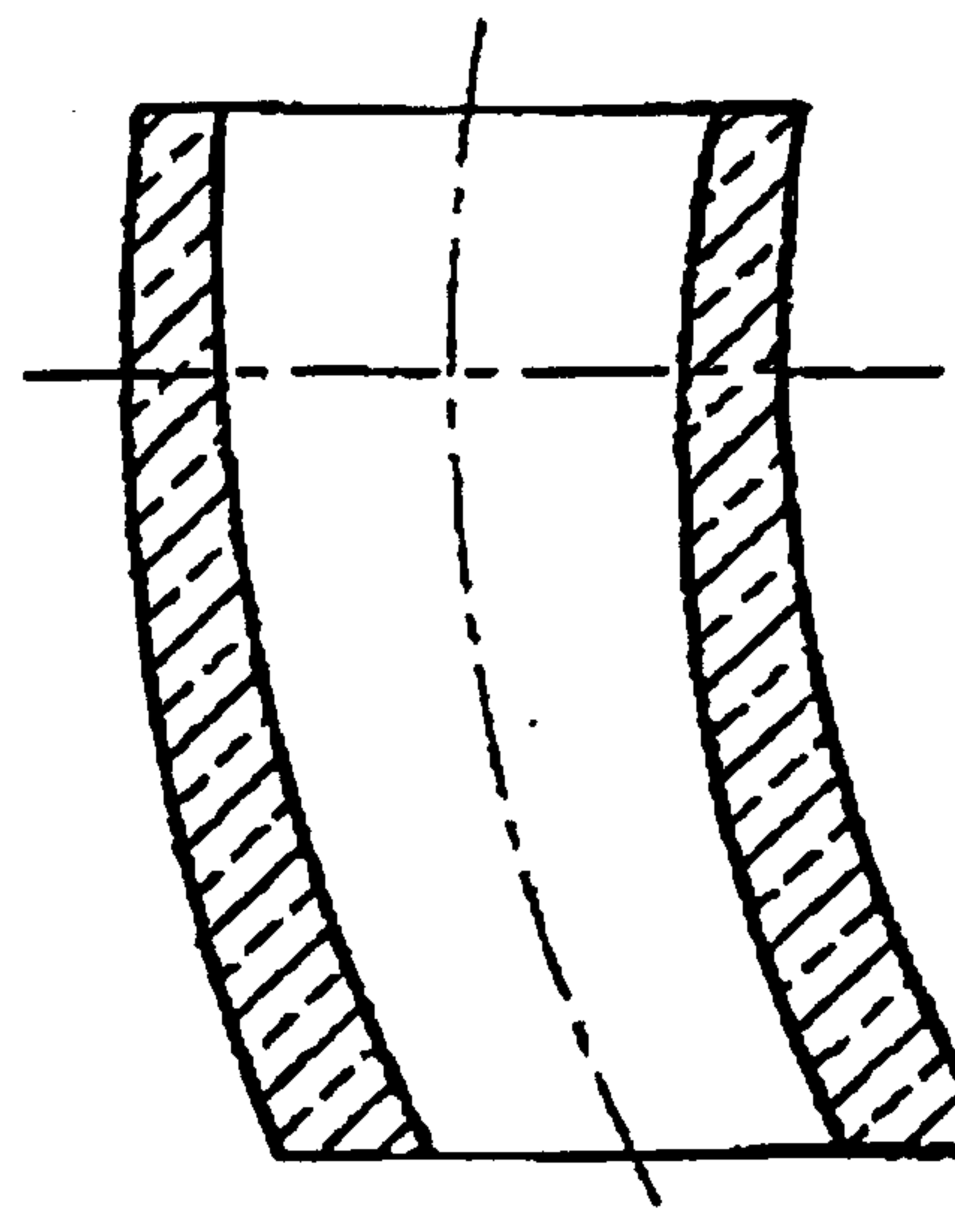


Fig. 4

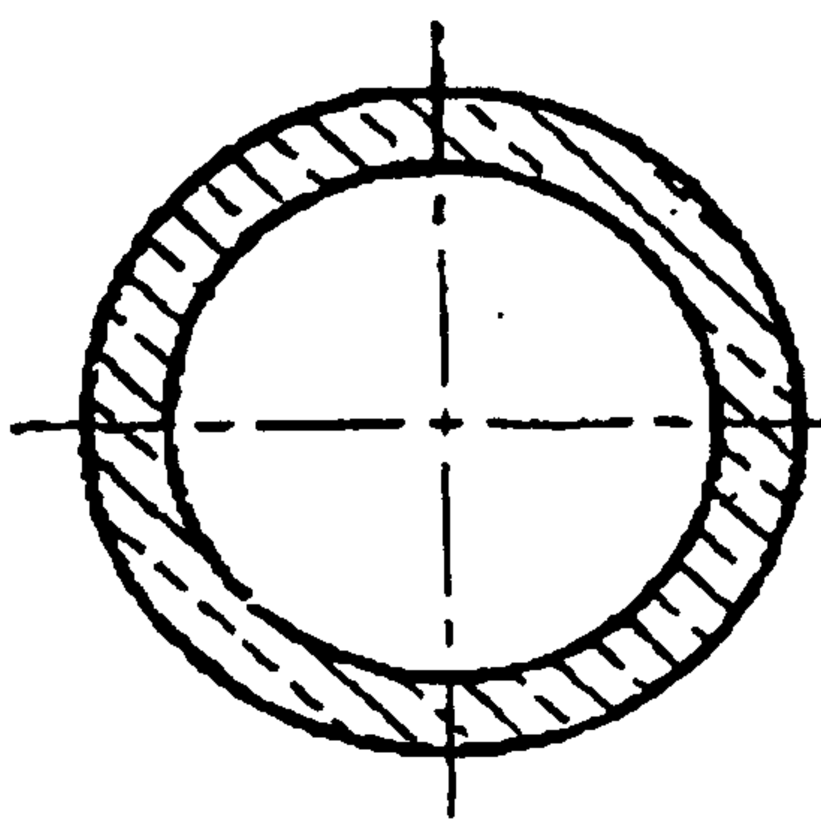


Fig 5a

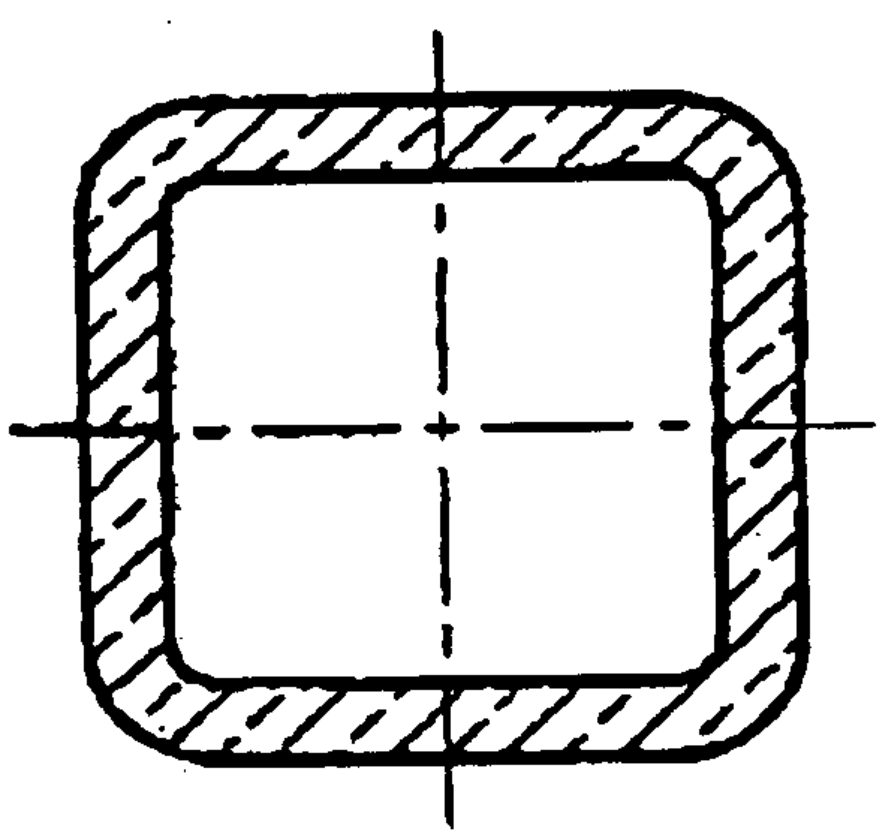


Fig 5b

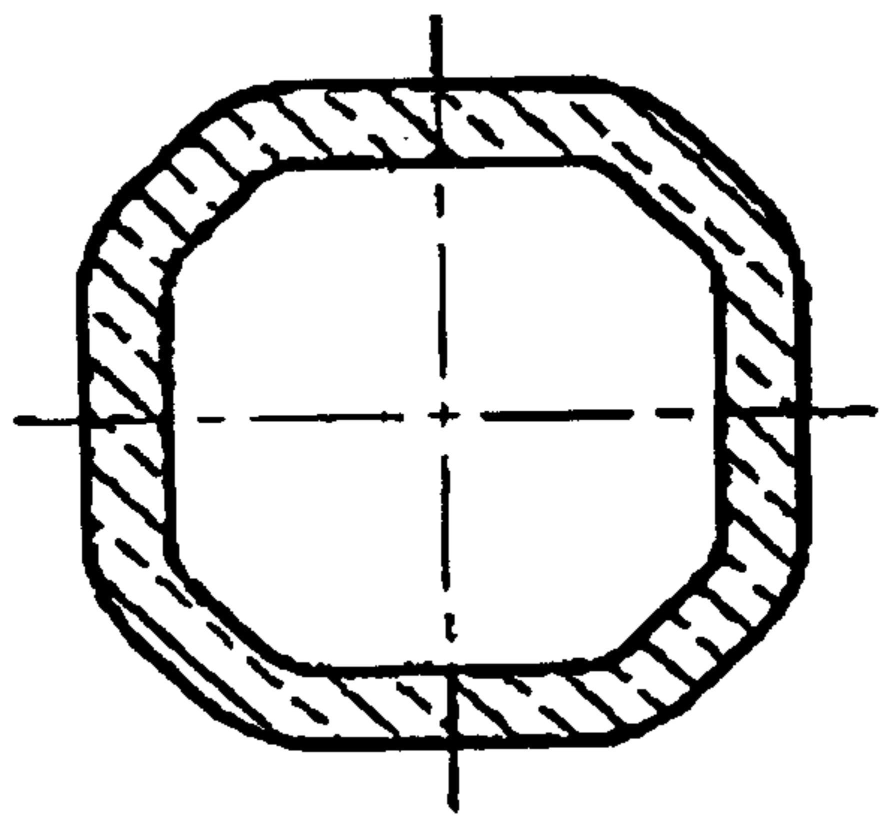


Fig 5c

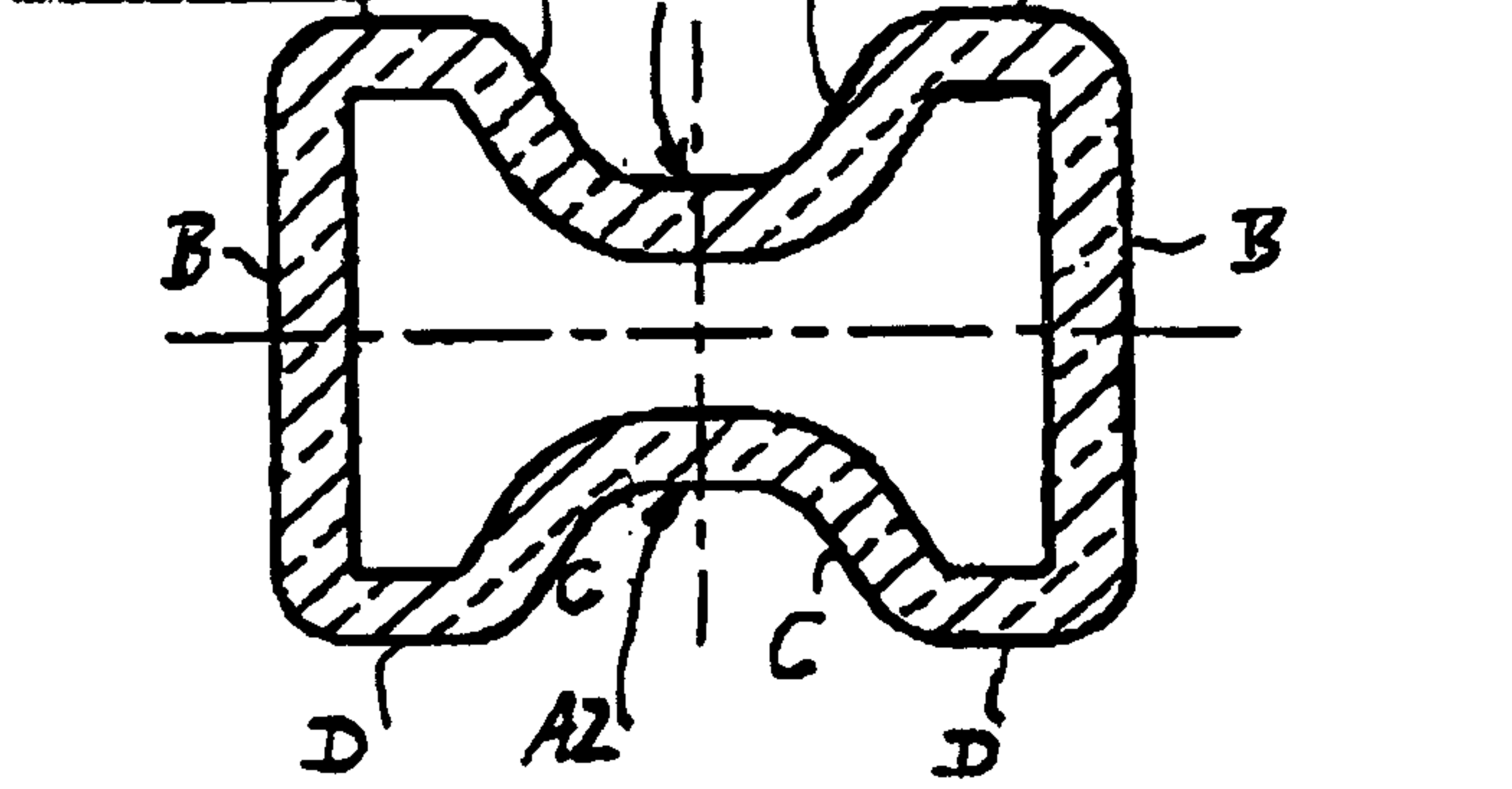


Fig. 6

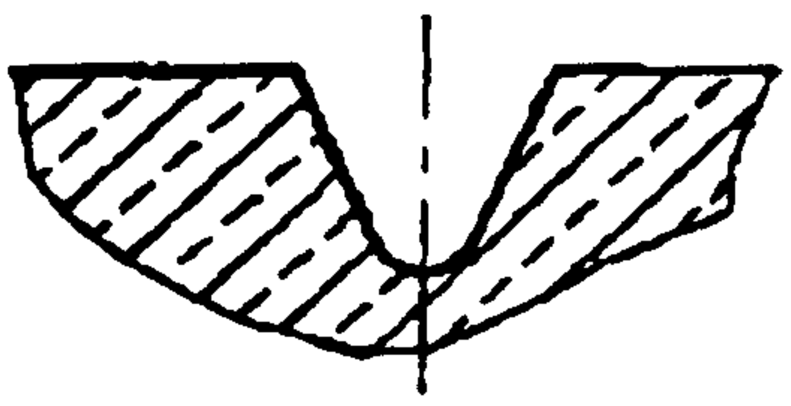


Fig. 7a

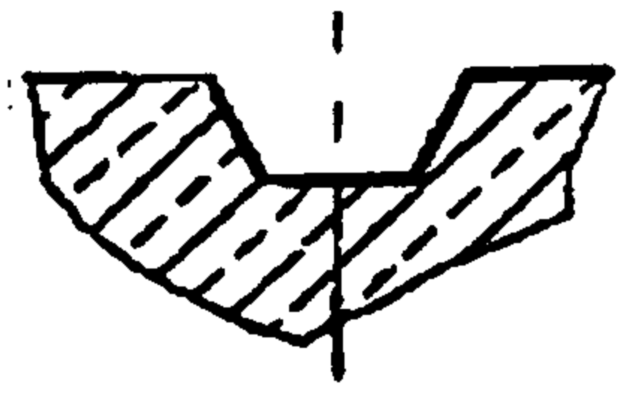


Fig 7b

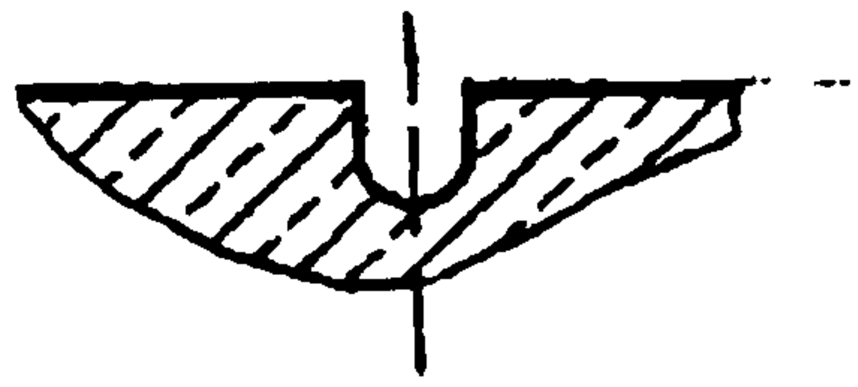


Fig. 7c

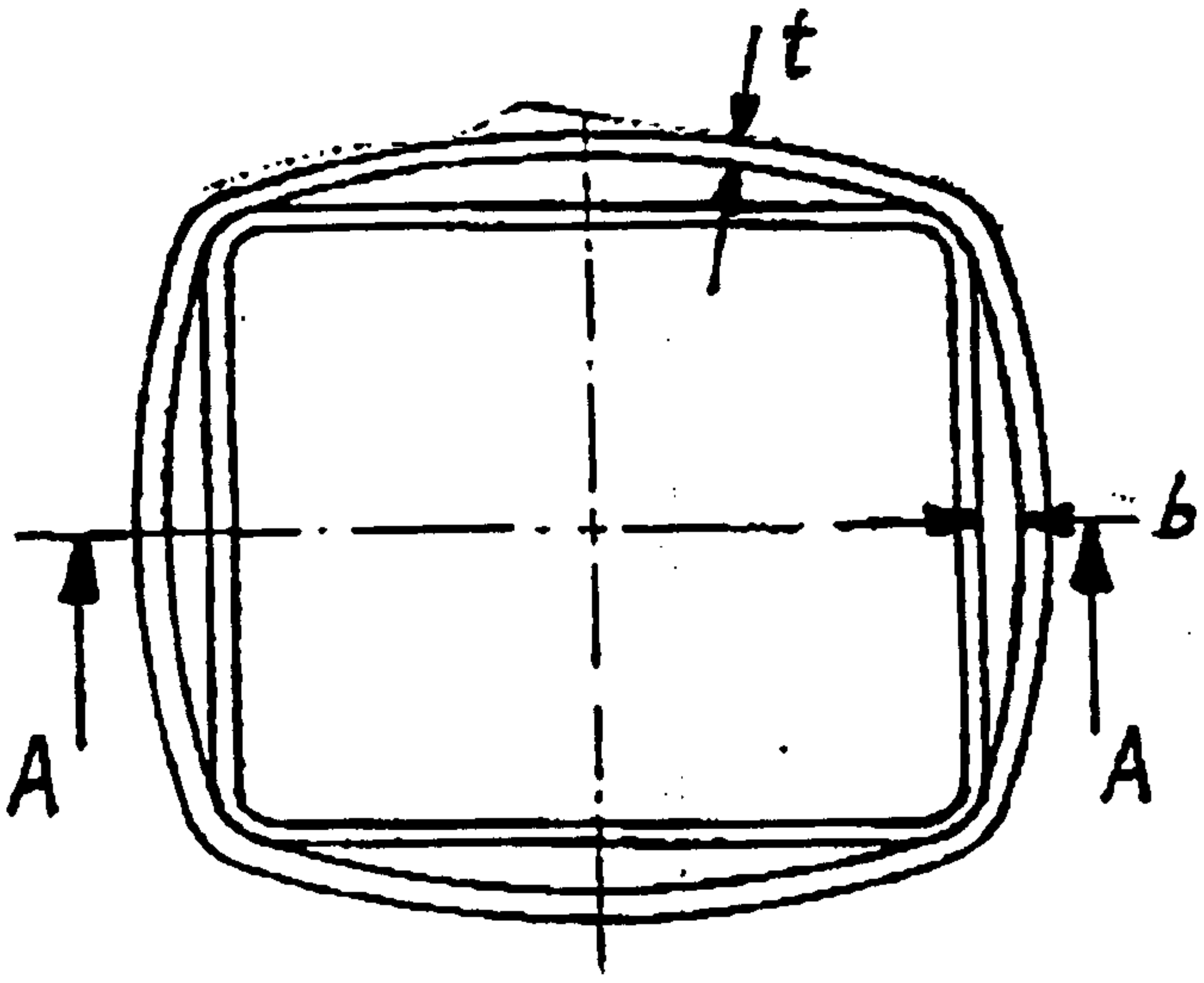


Fig. 8a

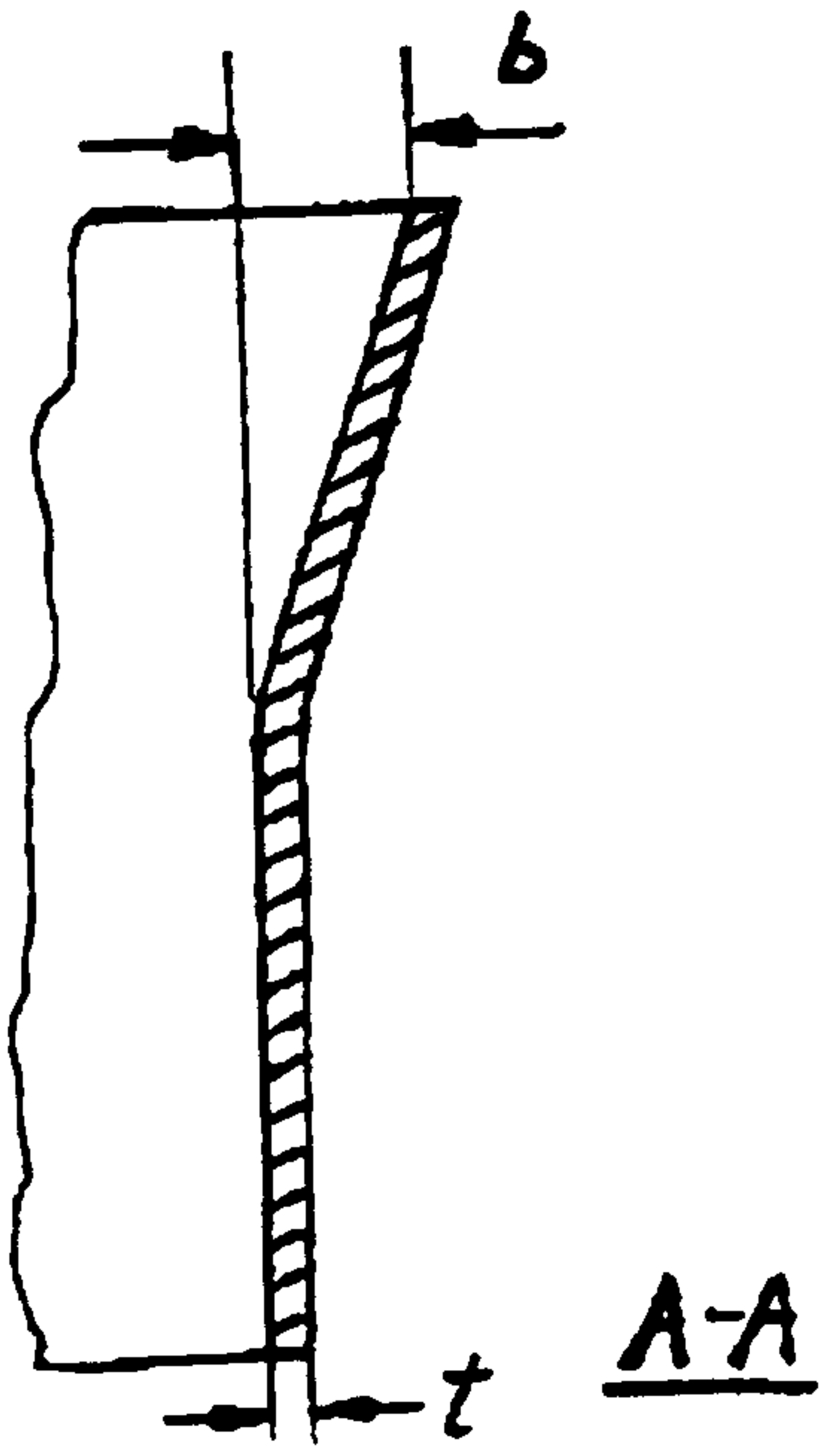
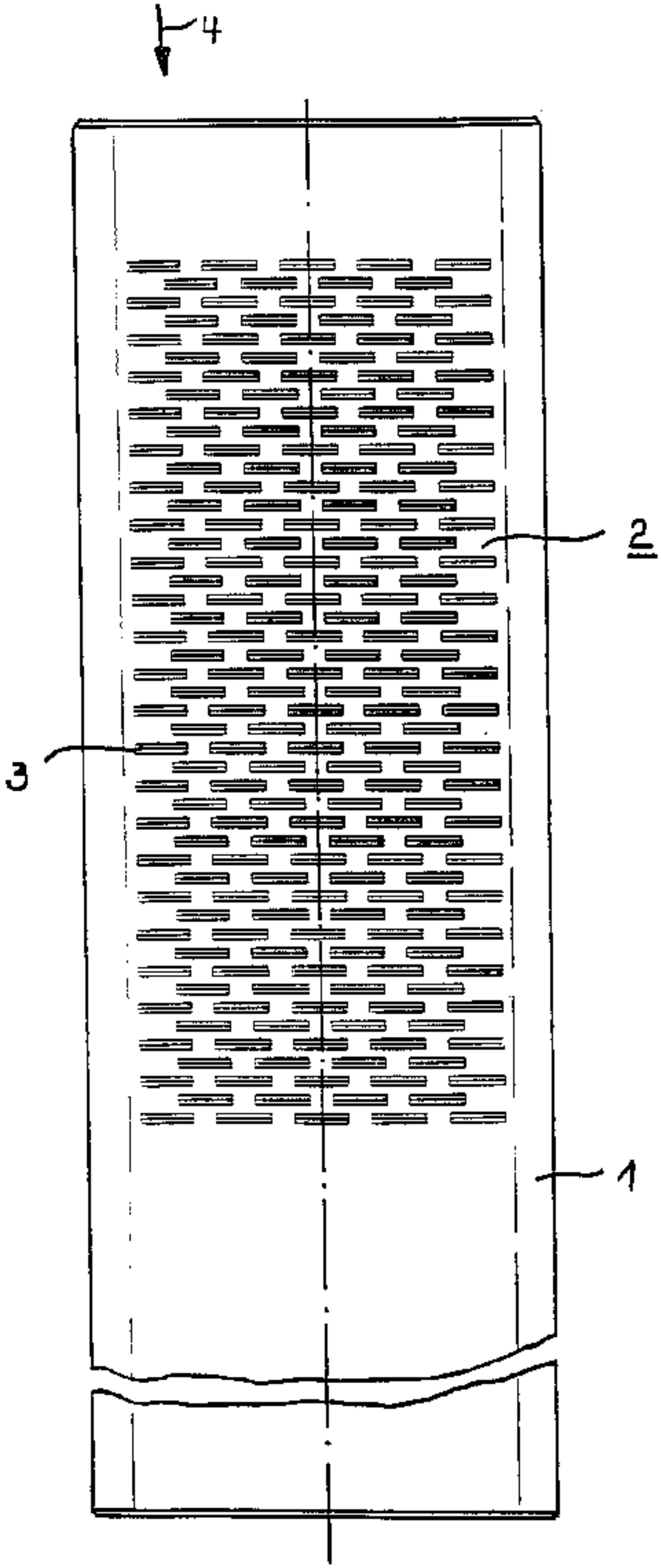


Fig. 8b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