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(71) Applicant: **Fasano, Fulvio**
33100 Udine (IT)

(72) Inventor: **Fasano, Fulvio**
33100 Udine (IT)

(74) Representative:
Modiano, Guido, Dr.-Ing. et al
Modiano & Associati SpA
Via Meravigli, 16
20123 Milano (IT)

(54) Continuous casting apparatus

(57) A continuous casting apparatus, particularly suitable for obtaining strips, thin slabs or other shapes, which comprises a tundish (1) for feeding molten metal which, by means of one or more free or submerged nozzles (2), pours into a basin (3) constituted by two bands (4,5) which are supported and advanced by motorized rollers (6,7), wherein the level of the meniscus (17) of the molten metal lies below the regions of lateral contact of the bands, said regions of lateral contact forming a closed profile which is adapted to prevent the escape of the molten metal that is present internally.

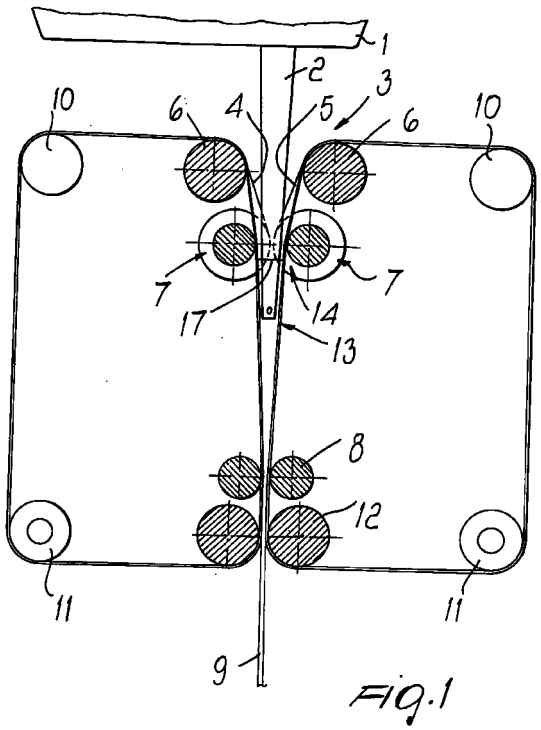

Fig.1

EP 1 084 777 A1

Description

[0001] The present invention relates to a continuous casting apparatus, particularly adapted for producing strips, slabs or other shapes.

[0002] The invention can be applied wherever one wishes to obtain a semi-finished part for subsequent hot and/or cold working.

[0003] The invention is also adapted for the online rolling of strips and bars according to the cast shape and to the product to be obtained.

[0004] The prior art includes various attempts mainly aimed at obtaining thin strips or slabs to be subjected to subsequent rolling.

[0005] Current conventional solutions provide for the manufacture of continuous-casting machines which use tracks, machines with paired rollers, single-roller machines, machines with a double vertical strip with fixed lateral containment elements, machines with a horizontal strip and an upper roller, and others.

[0006] Although these conventional solutions are efficient in theory, they show severe limitations in their practical execution; problems have in fact been found, and are as yet unsolved, which do not allow to build industrially valid plants.

[0007] All conventional embodiments in fact have solutions which are not sufficiently reliable and are sometimes complicated, such as: lateral containment of the molten metal, feeding of the molten metal, position of the meniscus with reference to the containment of the molten metal, control of the so-called kiss point, positive feeding of the molten metal, profile of the cast product and others, just to mention a few.

[0008] These negative or limitative aspects, combined with the operating difficulties, do not allow to achieve a satisfactory product quality.

[0009] The aim of the present invention is to solve the above-cited problems, eliminating the drawbacks of the prior art, by providing a continuous casting apparatus for obtaining strips, thin slabs or other shapes which is highly reliable in operation and industrially feasible at low costs.

[0010] Within the scope of this aim, an object of the present invention is to provide a continuous casting apparatus which allows to obtain strips, thin slabs or other shapes having high uniformity.

[0011] Another object is to provide a continuous casting apparatus which allows to achieve optimum lateral containment of the molten metal.

[0012] Another object of the present invention is to provide a continuous casting apparatus which allows to provide both thin slabs and bars having a chosen cross-section.

[0013] Another important object of the present invention is to provide a continuous casting apparatus which can achieve high casting speeds.

[0014] Another object is to provide a continuous casting apparatus which allows to achieve high productivity.

[0015] Another object is to provide a continuous casting apparatus which is highly flexible in operation without altering the quality of the final product.

[0016] Another important object is to provide a continuous casting apparatus in which the solidification skin being formed is free from thermomechanical stresses that can damage the final product.

[0017] Another important object is to provide a continuous casting apparatus in which the solidification heat of the molten metal can be transferred to the outside environment.

[0018] Another object of the present invention is to provide a continuous casting apparatus which is highly reliable and relatively easy to manufacture.

[0019] These and other objects which will become better apparent hereinafter are achieved by a continuous casting apparatus, particularly suitable for obtaining strips, thin slabs or other shapes, which comprises a tundish for feeding molten metal which, by means of one or more free or submerged nozzles, pours into a basin constituted by two metal bands which are supported and advanced by motorized rollers, characterized in that the level of the meniscus of the molten metal lies below the regions of lateral contact of the bands, said regions of lateral contact forming a closed profile which is adapted to prevent the escape of the molten metal that is present internally.

[0020] Further characteristics and advantages of the present invention will become better apparent from the following detailed description of preferred but not exclusive embodiments thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a schematic view of a possible continuous casting for strips and/or thin slabs according to the present invention;

Figure 2 is a schematic view of a possible continuous casting for other shapes according to the invention;

Figure 3 is a partial plan view of a possible continuous casting for strips according to the invention;

Figure 4 is a partial plan view of a possible continuous casting for thin slabs according to the invention;

Figure 5 is a partial plan view of a possible continuous casting for other shapes according to the invention;

Figure 6 is a schematic front view of a possible continuous casting for strips according to the invention;

Figure 7 is a schematic front view of a possible continuous casting for thin slabs according to the invention;

Figure 8 is a schematic front view of a portion of a possible continuous casting for other shapes according to the invention;

Figure 9a is a schematic longitudinal sectional view of a portion of a possible continuous casting for

strips and thin slabs according to the invention;

Figure 9b is a view of a detail of Figure 9a;

Figure 10 is a schematic longitudinal sectional view of a portion of a possible continuous casting for other shapes according to the invention;

Figures 11a, 11b, 11c, 11d and 11e are schematic views of some of the possible solutions regarding the lateral containment of the strips of a possible continuous casting for strips and other shapes according to the invention;

Figures 12a, 12b, 12c, 12d and 12e are schematic views of some of the possible solutions for lateral containment of the strips by means of sliding blocks to be used as an alternative to, or in combination with, the rollers of a possible continuous casting for strips and other shapes according to the invention;

Figures 13a, 13b are schematic views of one of the possible solutions for lateral containment by means of lateral strips, supported by chains or tracks, of a possible continuous casting for thin slabs according to the invention.

[0021] The continuous casting apparatus according to the present invention, generally shown by Figure 1, comprises a tundish, designated by the reference numeral 1, for feeding the molten metal which pours the molten metal into a basin 3 through one or more free or submerged nozzles, constituted for example by a tube 2.

[0022] The basin 3 is formed by two bands, designated by the reference numerals 4 and 5, which travel along a closed path and are arranged mirror-symmetrically with respect to the plane of arrangement of the tube 2.

[0023] The two bands are supported and advanced by a plurality of rollers; in the particular embodiment, the rollers are constituted by a first pair of rollers, designated by the reference numeral 6, and by a second pair of rollers, designated by the reference numeral 7.

[0024] The second pair of rollers is arranged in an underlying position, and the rollers, thanks to their particular profile, cause the bands 4 and 5 to form the basin for introducing the molten metal.

[0025] There is also provided a third pair of rollers, designated by the reference numeral 8, which is arranged below the second pair of rollers 7 toward the outlet of the approximately and determines the thickness of the strip or thin slab 9.

[0026] Other pairs of rollers, designated by the reference numerals 10, 11 and 12, are also present in order to provide the closed circuit along which the bands 4 and 5 travel.

[0027] The tube 2 is inserted between the two bands 4 and 5 and conveys the molten metal; its tip 13 is arranged at a plane of arrangement that lies below said second pair of rollers 7.

[0028] The second pair of rollers 7 is centrally provided with an appropriately shaped configuration so as to form, at the tube 2, a gap 14 which is for example substantially ellipsoidal in shape, as shown for example in Figures 3 and 4.

[0029] Moreover, Figure 8 is a detail view of the concave profile of the rollers 7, which shows how the outer surface of the rollers 7 is centrally shaped so as to form a concave portion 15 which is adapted to accommodate the central region of the band 4 and 5 which travels over the roller 7.

[0030] A very narrow space, which allows to achieve contact between the bands 4 and 5, is instead obtained at the sides of the mutually opposite surfaces of the second pair of rollers 7 and therefore at the lateral edges 16a and 16b.

[0031] One of the particularities of the present embodiment is that the level of the meniscus, designated by the reference numeral 17, lies below the regions of lateral contact of the bands 4 and 5.

[0032] This fact, together with the mentioned contact between the bands 4 and 5 at the lateral edges 16a and 16b of the second pair of rollers 7, allows to obtain, after said point, a lateral seal and therefore a closed profile which prevents the escape of the molten metal that is internally present.

[0033] The underlying third pair of rollers 8 is therefore appropriately spaced so as to allow to obtain the intended thickness of the strip 9 before merging in the point designated by the reference numeral 18 as complete solidification, shown in Figure 9b.

[0034] In order to ensure the integrity of the bands 4 and 5, in the region subjected to heat the bands are cooled for example with sprays of water as long as the cast product is enclosed between said strips.

[0035] The bands support the skin being formed, preventing it from being subjected to any thermomechanical stress that might damage the final product, and convey externally the solidification heat of the molten metal.

[0036] The thickness of the bands is contained between approximately 0.5 and 2 mm, in order to allow a thermal flow which is suitable for the requirements of the process and to contain the deformations of the bands in their path within the elastic limit of the material used (steel band).

[0037] The rollers instead advance and support the bands over their entire path, giving the bands the profile required by the process in each point of their path and assisting the bands in containing the metallostatic pressure.

[0038] Moreover, the rollers must apply the pressure required for the contact of the bands 4 and 5; such pressure can be provided by means of springs or other mechanical and/or hydraulic and/or pneumatic means.

[0039] The intended profile of the band at the basin for casting the molten metal can be achieved by subjecting said bands to traction or by virtue of auxiliary means such as contrast rollers or guiding rollers or sliders.

[0040] Figures 11a to 11e are views of possible lat-

eral embodiments of the bands 4 and 5, where in particular Figure 11a is a view of the configuration of the bands 4 and 5, already shown in Figure 1.

[0041] Figure 11b is instead a view of a second embodiment of the configuration of the bands 4 and 5, in which said bands are folded upward so as to form a contact point, designated by the reference letter A in all the figures, which is achieved by folding end portions 4a and 5a of the bands 4 and 5, respectively.

[0042] Figure 11c is a view of an embodiment of the bands 4 and 5 which is substantially similar to the embodiment shown in Figure 11a but in which the contact point A is determined by a curved blending portion of the internal profile of the bands 4 and 5.

[0043] In Figure 11d, the spacing between the bands 4 and 5 is instead achieved by interposing a spacer element 19, and in this case the contact point is given by the points of tangency, designated by the reference numerals A' and A'', of the spacer element 19 with respect to the bands 4 and 5.

[0044] Finally, Figure 11e is a view of a fifth embodiment of the bands 4 and 5, in which the contact point, designated by A, is achieved not by folding the bands 4 and 5 as shown in Figure 10b but by adding applied portions 20 and 21 inserted between the bands 4 and 5, so as to keep them substantially parallel.

[0045] As shown in Figures 12a to 12e, it is possible to provide sliders 22 which are suitable to achieve the lateral containment of the bands 4 and 5 below the second pair of rollers 7.

[0046] The bands 4 and 5 that slide over the first and second pairs of rollers 6 and 7 can be guided in their path so as to remain centered with respect to the surface of the rollers over which they slide and so as to be forced to assume the intended profile.

[0047] For this purpose it is possible to provide, as shown in Figure 8, guiding means 23, conveniently constituted for example, for each band, by two sliders which are arranged laterally to the path of the bands 4 and 5 between the pairs of rollers designated by the reference numerals 6 and 7, so as to constitute a sort of guide for giving the bands 4 and 5 the intended profile.

[0048] Figure 2 is a view of a second embodiment of the apparatus according to the present invention for producing other shapes in which, instead of providing another pair of flat rollers 8, there is a pair of rollers 24 which is identical in shape to the previous second pair of rollers 7.

[0049] The pair of rollers 24 allows to keep constant the profile between the bands 4 and 5 over their entire path in contact with the bar 9.

[0050] This, as shown in detail in Figure 10, allows to obtain, instead of thin strips or slabs, bars having a chosen appropriate cross-section which is determined by the profile of the pairs of rollers 7 and 24 over which the bands 4 and 5 slide.

[0051] Figure 10 is a schematic view which shows only the central portion of the apparatus according to the present invention, without showing the additional pairs of rollers 10, 11 and 12, which are of course present, since in this embodiment, too, the bands 4 and 5 follow a closed path around the pairs of rollers.

[0052] Figures 13a and 13b schematically illustrate one of the possible solutions for lateral containment, by means of lateral strips 25, which are supported by chains or tracks 26, of a possible continuous casting for thin slabs, designated by the reference numeral 9, according to the present invention.

[0053] It has thus been observed that the apparatus according to the present invention fully achieves the intended aim and objects, since a continuous casting apparatus for obtaining strips, thin slabs or other shapes has been obtained which is highly reliable in operation and industrially feasible at low cost, allowing to obtain strips, thin slabs or other highly uniform shapes, with optimum lateral containment of the molten metal.

[0054] The continuous casting apparatus further allows to provide thin slabs and bars having a chosen cross-section with a high casting speed and therefore with high productivity and operating flexibility, without altering the quality of the final product.

[0055] Finally, the solidification skin that forms is free from thermomechanical stresses which might damage the final product, since it is possible to transfer to the outside environment the solidification heat of the molten metal.

[0056] The apparatus thus conceived is susceptible of numerous other modifications and variations, all of which are within the scope of the same inventive concept.

[0057] Thus, for example, it is possible to provide a larger number of pairs of rollers than shown in the figures, and likewise the distance between the rollers of the second pair of rollers can be greater than the one shown.

[0058] It is further possible to modify the concave profile of their outer surface, in order to allow greater curvature of the bands 4 and 5 and thus achieve better lateral containment of the molten mass of metal.

[0059] All the details may also be replaced with other technically equivalent elements.

[0060] In practice, the materials employed, so long as they are compatible with the specific use, as well as the dimensions, may be any according to requirements and the to state of the art.

[0061] The disclosures in Italian Patent Application No. TV99A000100 from which this application claims priority are incorporated herein by reference.

[0062] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A continuous casting apparatus, particularly adapted for obtaining strips, thin slabs or other shapes, comprising a tundish for feeding molten metal which, by means of one or more free or submerged nozzles, pours into a basin constituted by two bands which are supported and advanced by motorized rollers, characterized in that the level of the meniscus of the molten metal lies below the regions of lateral contact of the bands, said regions of lateral contact forming a closed profile which is adapted to prevent the escape of the molten metal that is present internally.

2. The apparatus according to claim 1, characterized in that said pair of bands is supported and advanced by said motorized rollers which are adapted to form a closed circuit along which said strips travel.

3. The apparatus according to claim 1, characterized in that the shape of said basin into which the molten metal is cast through one or more free or submerged nozzles is given to said strips by the particular profile of said rollers for supporting and advancing said bands.

4. The apparatus according to claim 3, characterized in that a very narrow space is formed at the sides of the mutually opposite surfaces of a first pair of rollers that forms said casting basin, at the lateral edges, and is such as to allow to obtain contact between said metal bands.

5. The apparatus according to claim 3, characterized in that the level of the meniscus lies below the regions of lateral contact of said metal bands.

6. The apparatus according to claim 4, characterized in that a second pairs of rollers arranged downstream of said first pair that forms said casting basin determine, thanks to their profile, diameter and center distance, the final thickness of said strip or thin slab.

7. The apparatus according to claim 6, characterized in that the final thickness of said strip or of said thin slab is determined while the core is still liquid and therefore before the complete solidification of said thin strip or slab.

8. The apparatus according to claim 6, characterized in that said second pairs of rollers arranged downstream of said first pair of rollers that forms said casting basin are identical or similar in shape to said pair and are adapted to obtain in output bars having the intended cross-section or other shapes, said section being determined by the profile formed between said pairs of rollers over which said metal bands slide.

9. The apparatus according to claim 1, characterized in that in the region subjected to heat said bands are cooled while the cast product is enclosed between said bands, said bands supporting the skin being formed, protecting it from thermomechanical stresses which might damage the final product, and transferring externally the solidification heat of the molten metal.

10. The apparatus according to claim 1, characterized in that said rollers advance and support said bands over their entire path, giving said bands the profile required by the process in each point of their path, assisting said bands in containing the metallostatic pressure, said rollers applying the pressure required for the contact of said bands, said pressure being provided by means of contact means.

11. The apparatus according to claim 1, characterized in that the intended profile of the strip at the casting basin of the molten metal is achieved by subjecting said bands to traction.

12. The apparatus according to claim 1, characterized in that a chosen spacing between said bands is achieved by interposing a spacer element between said bands, a contact point being determined by points of tangency of said spacer element with respect to said bands.

13. The apparatus according to claim 1, characterized in that it comprises one or more sliders which are adapted to achieve lateral containment of said metal bands.

14. The apparatus according to claim 1, characterized in that said bands are folded inward, so as to determine a contact point obtained by the folding of end portions of said bands.

15. The apparatus according to claim 14, characterized in that said contact point is formed by a curved blending of an internal profile of said bands.

16. The apparatus according to claim 1, characterized in that a contact point between said bands is achieved by adding applied portions inserted between said bands so as to keep them substantially parallel.

17. The apparatus according to claim 13, characterized in that said one or more sliders are arranged laterally to the path of said bands.

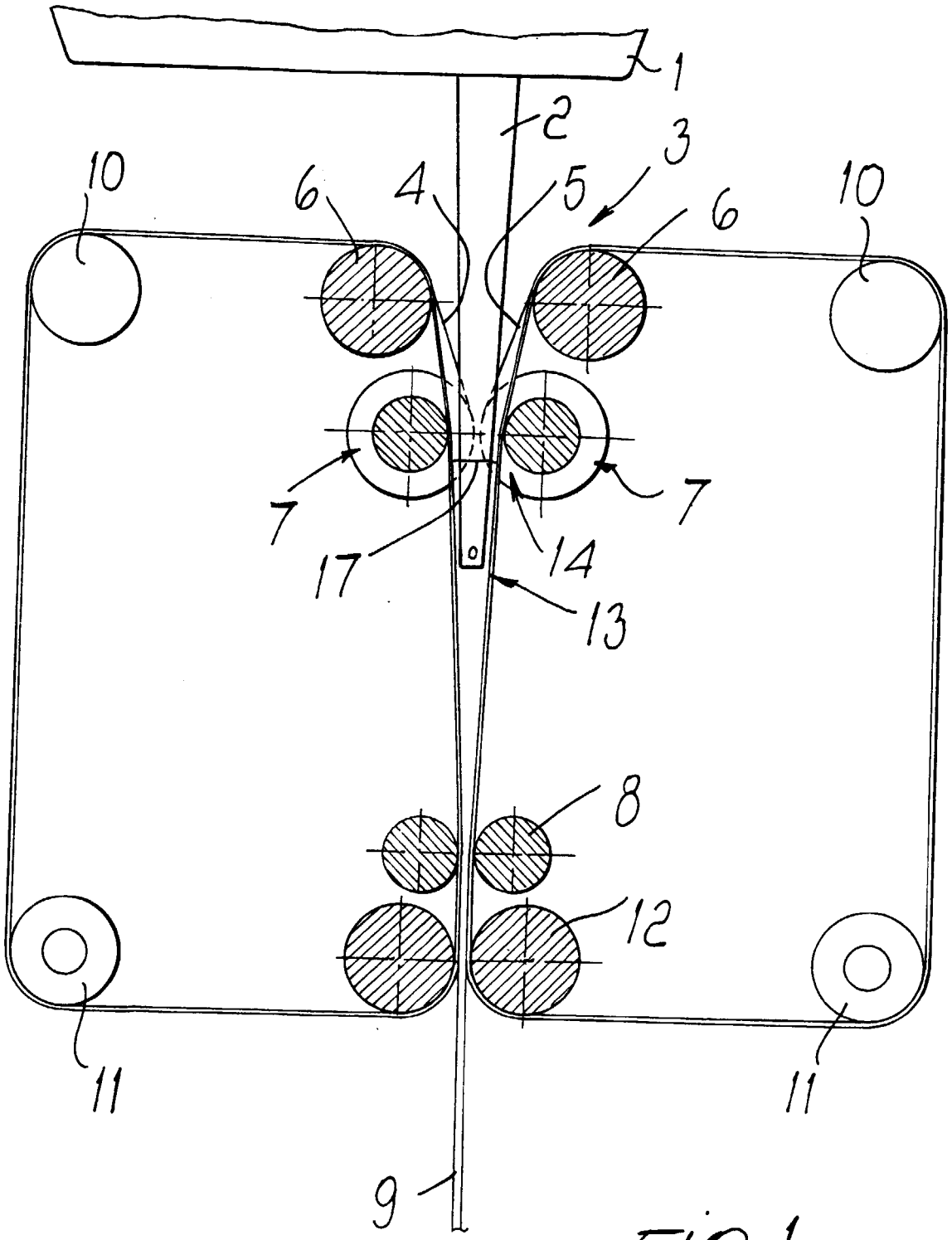

Fig.1

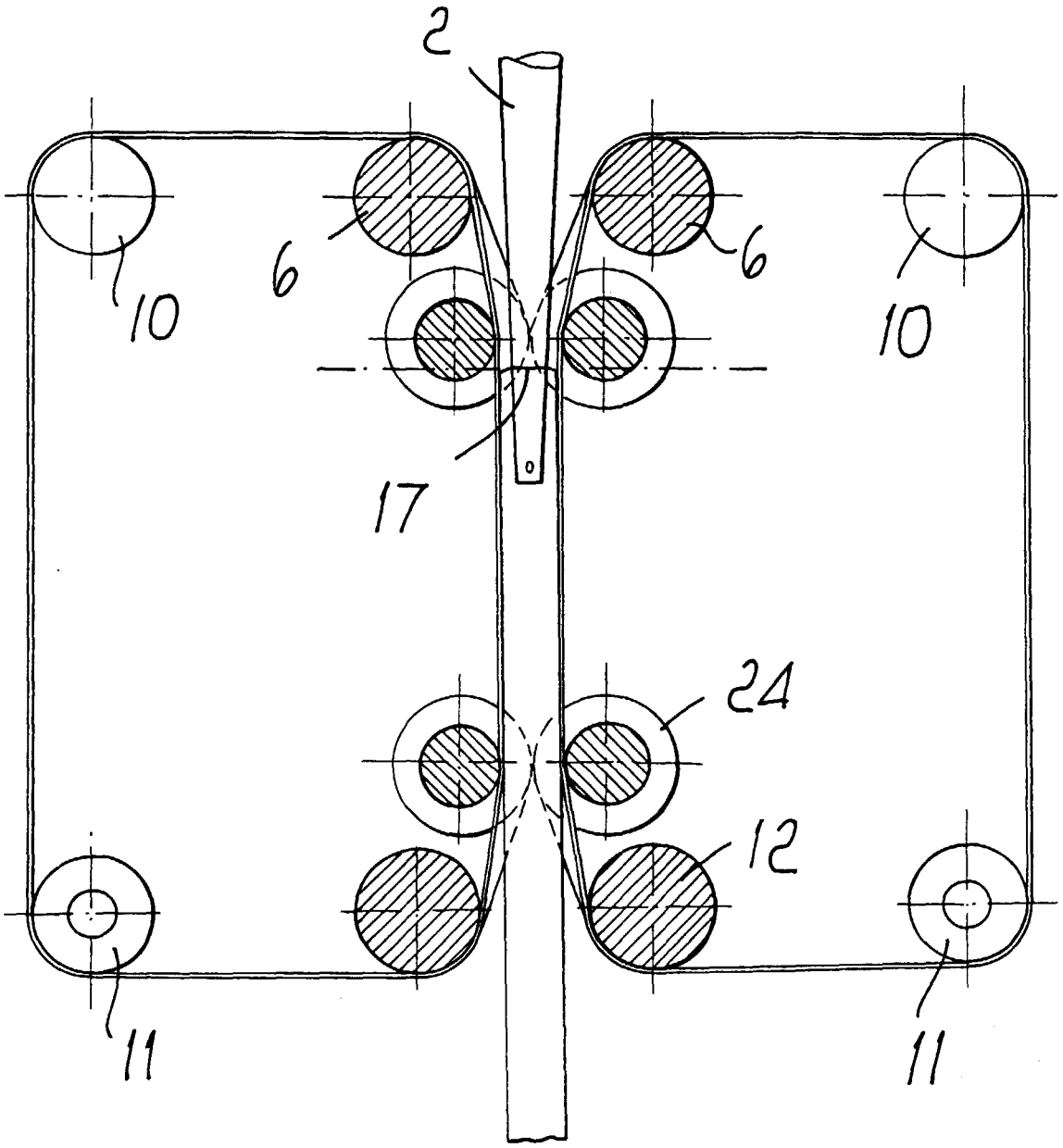

Fig. 2

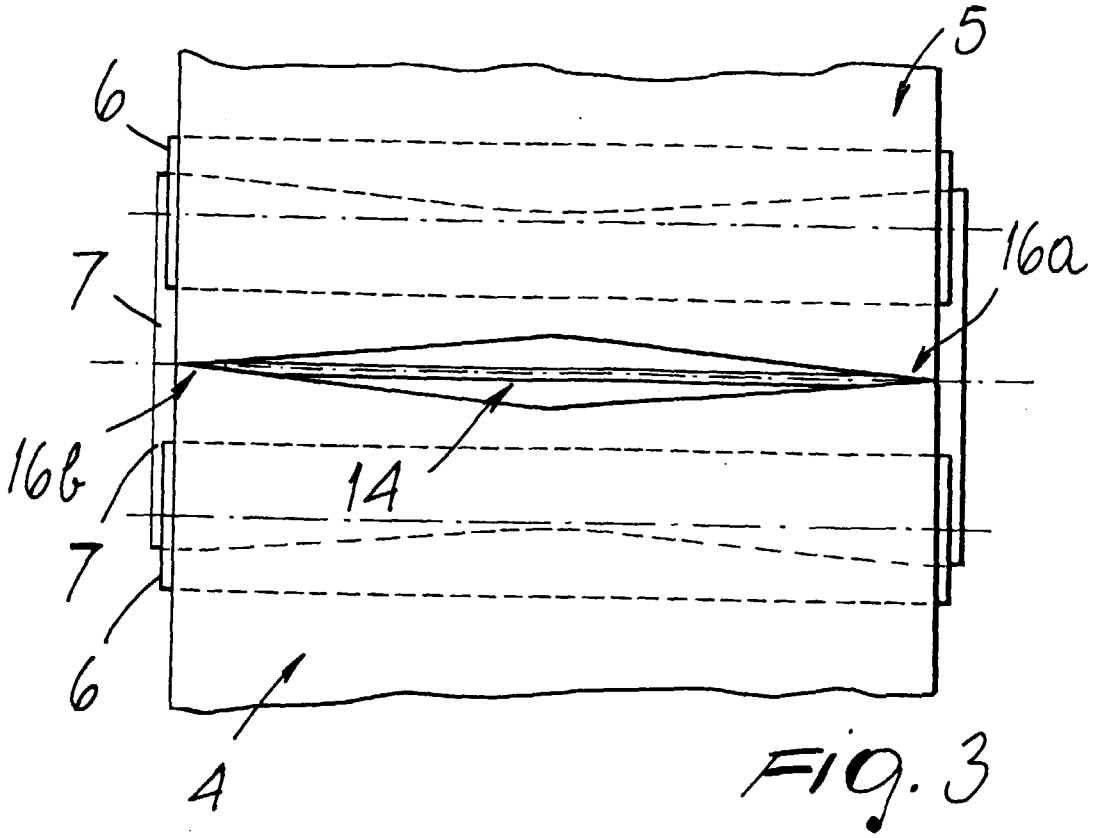

FIG. 3

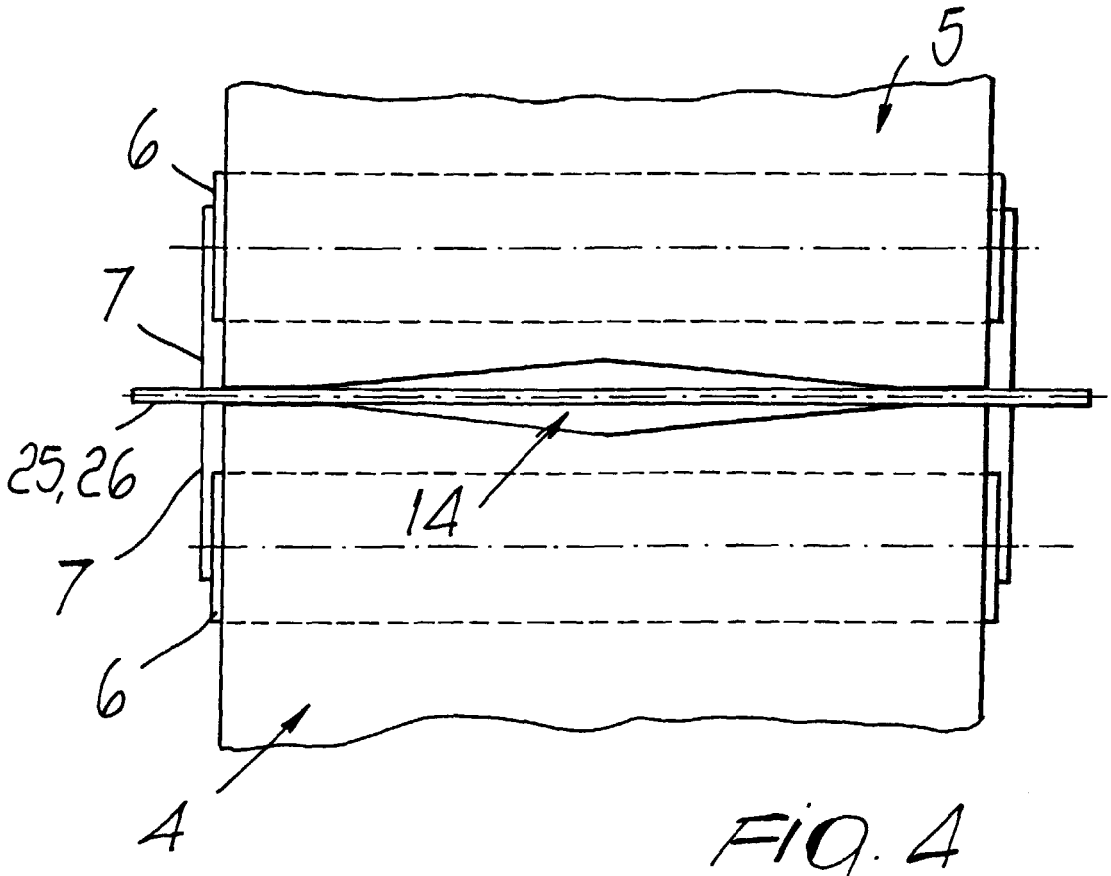

FIG. 4

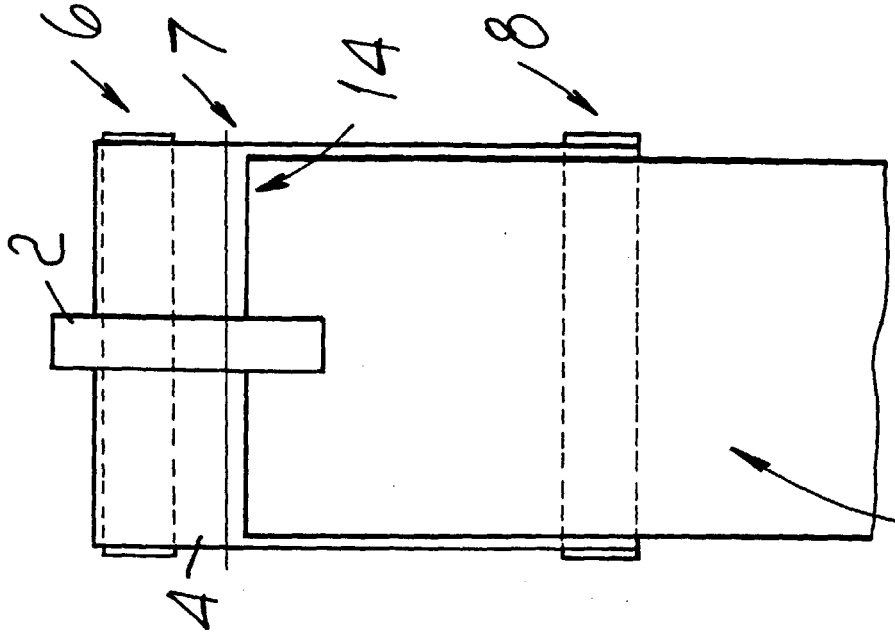

Fig. 6

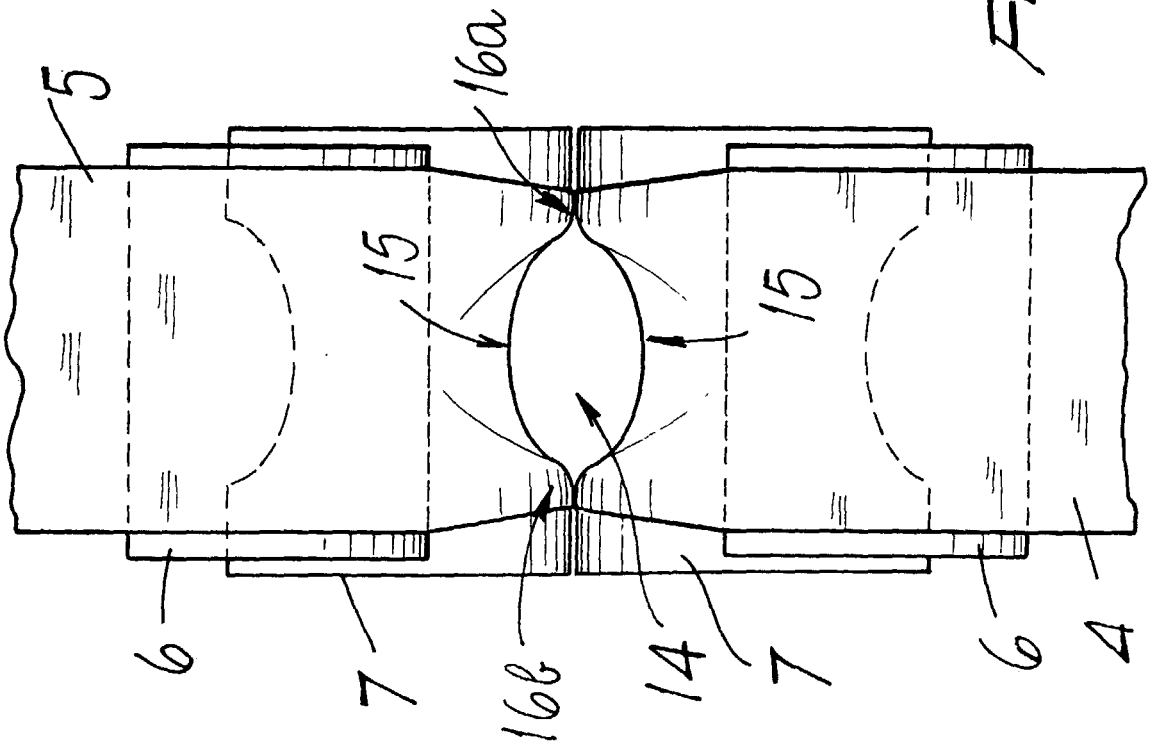

Fig. 5

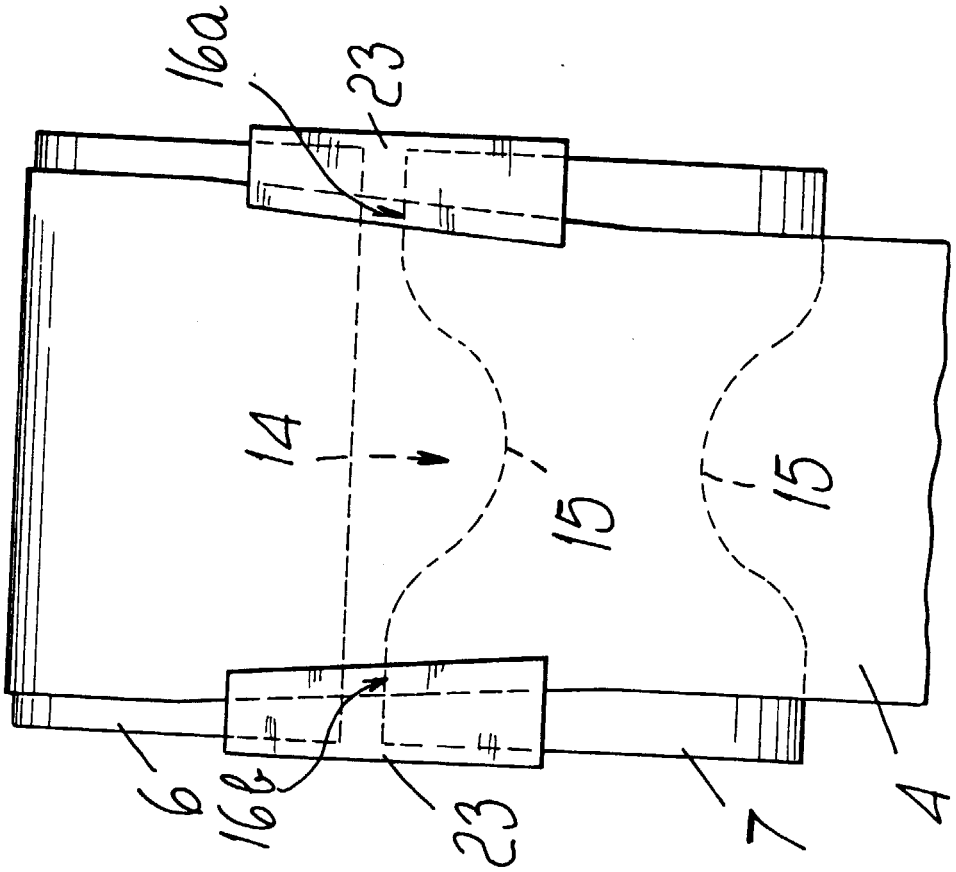

FIG. 8

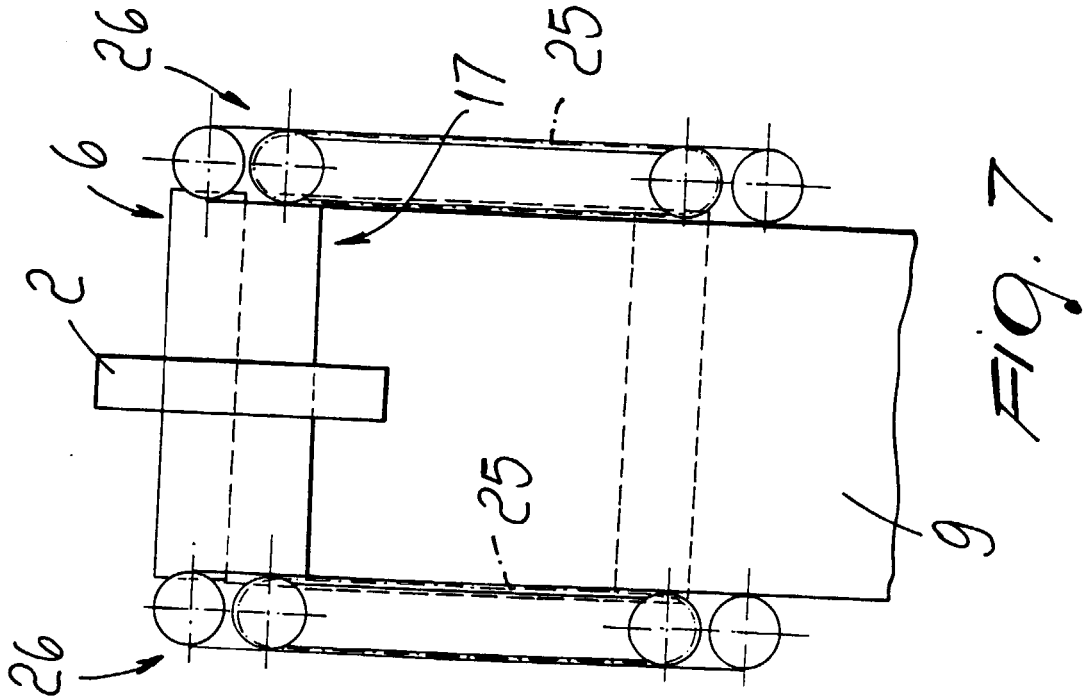

FIG. 7

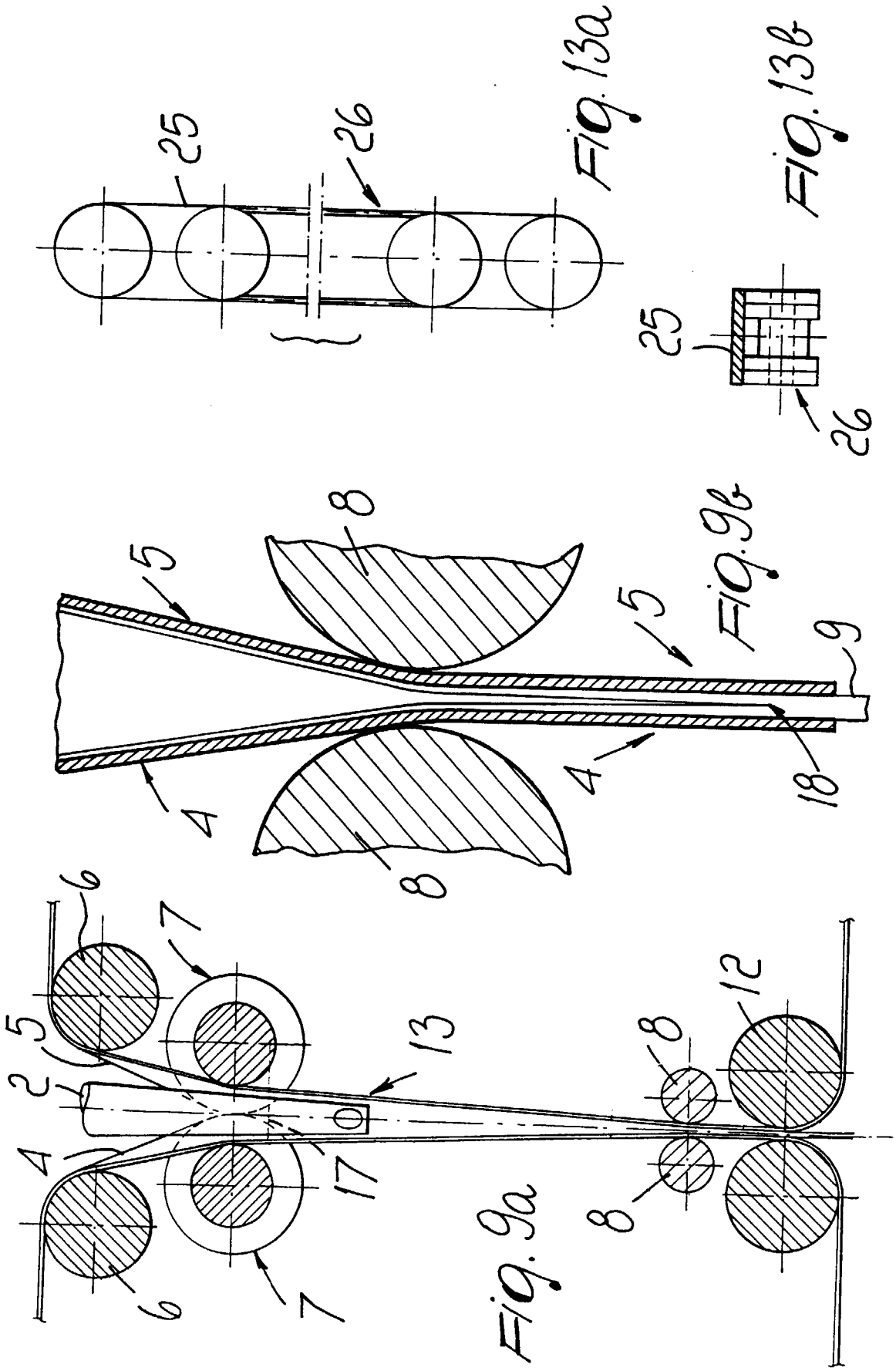
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Fig. 13a
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Fig. 13b
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Fig. 9b
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Fig. 9a

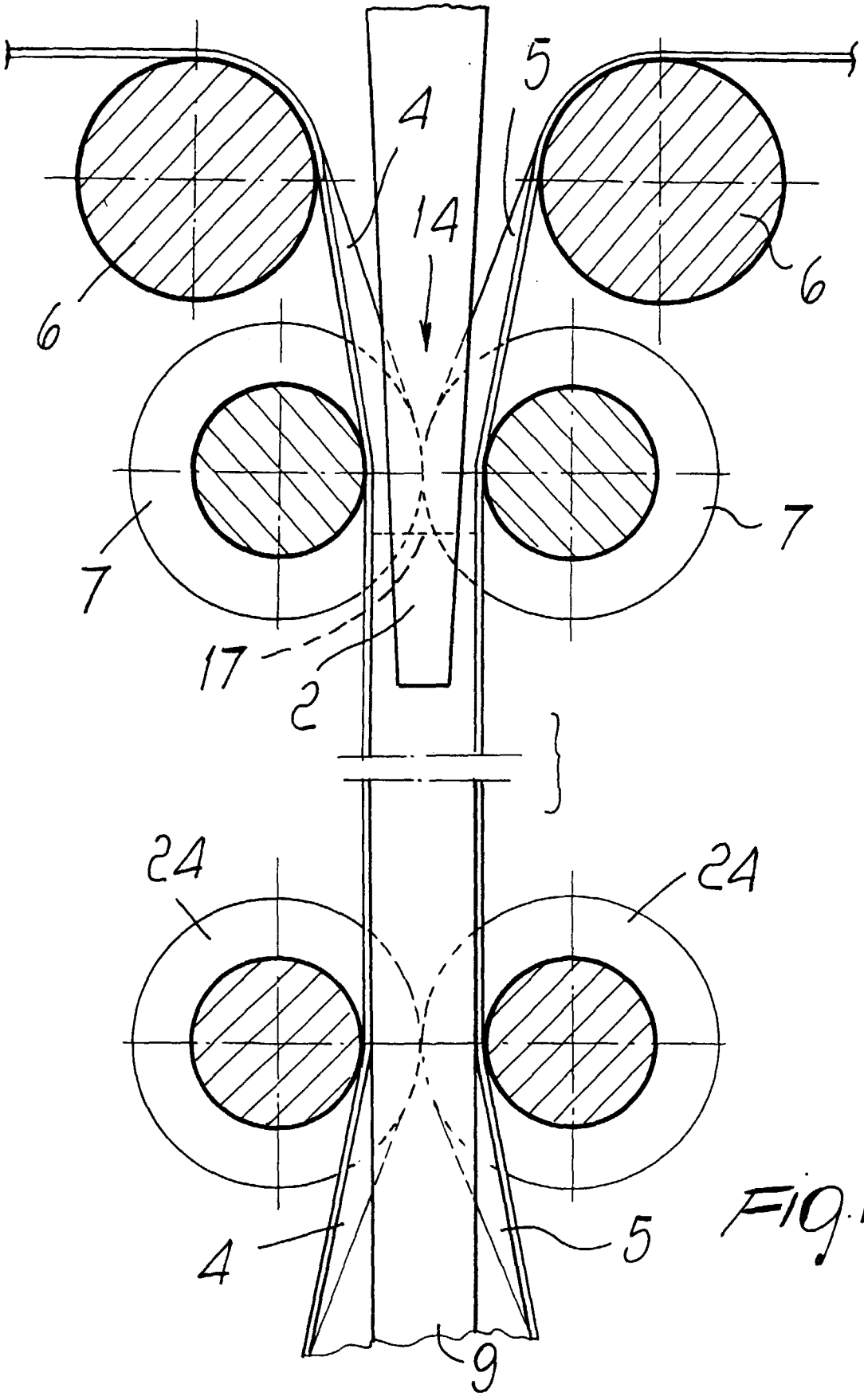


Fig.10

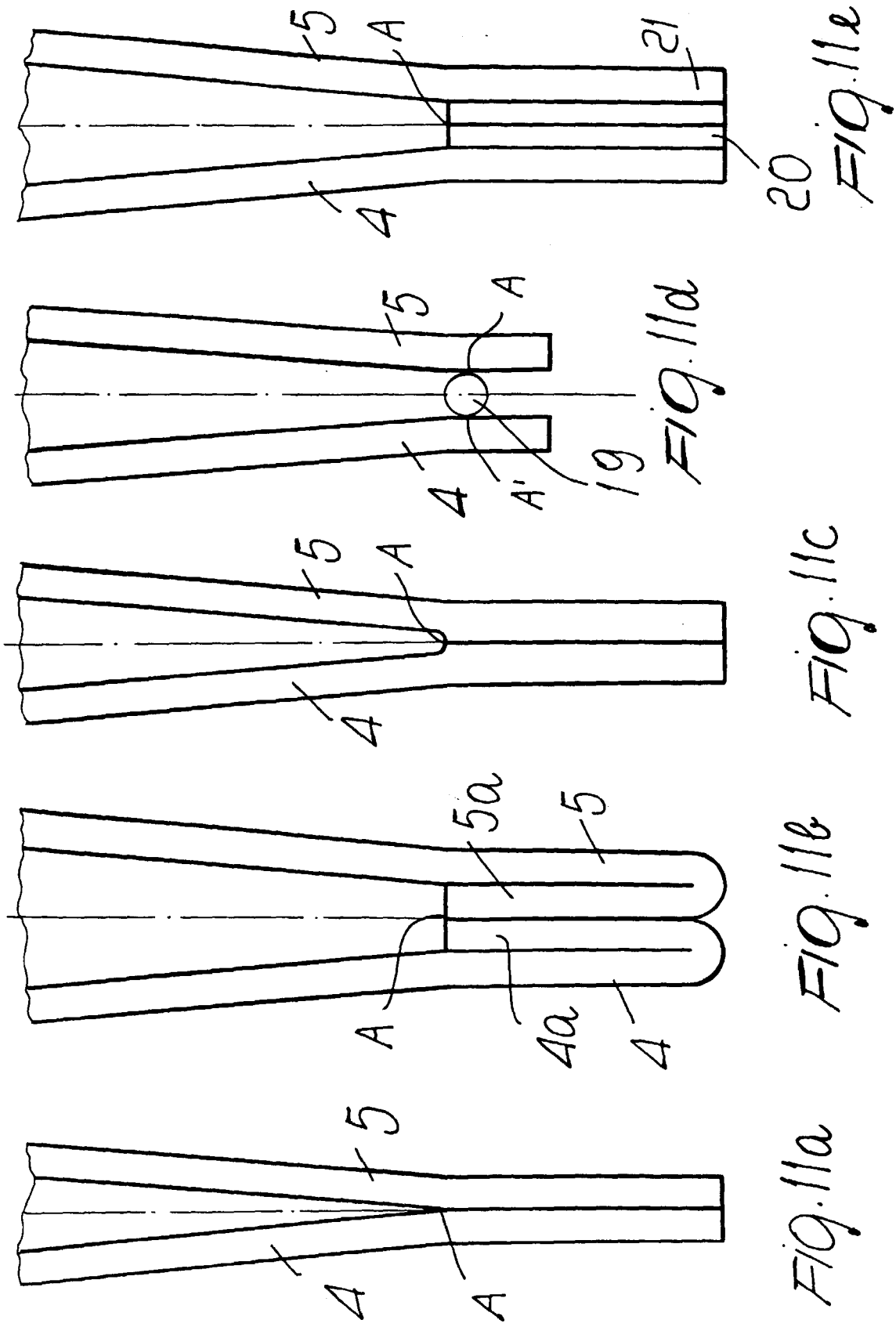


Fig. 11e

Fig. 11d

Fig. 11c

Fig. 11b

Fig. 11a

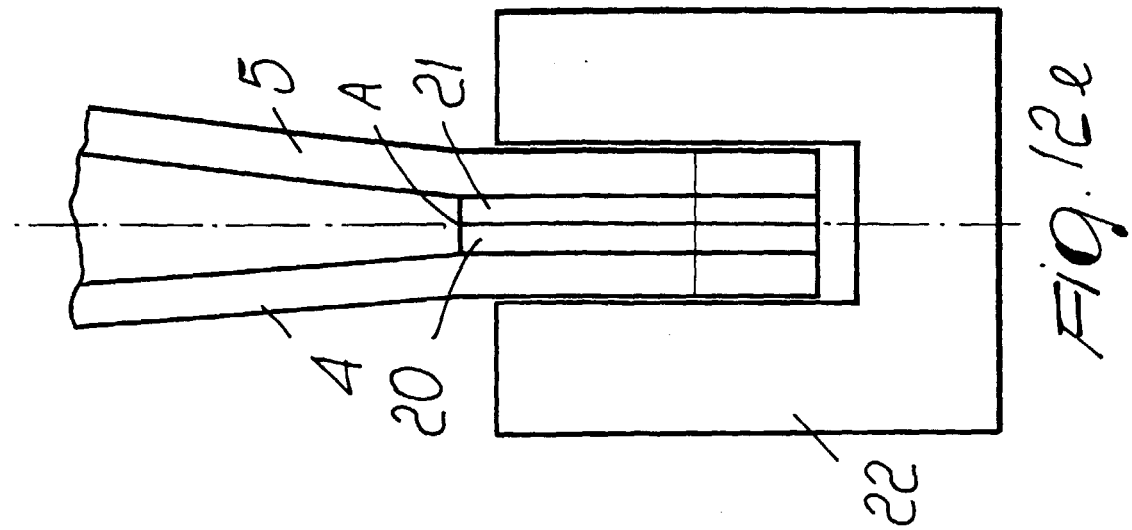


Fig. 12e

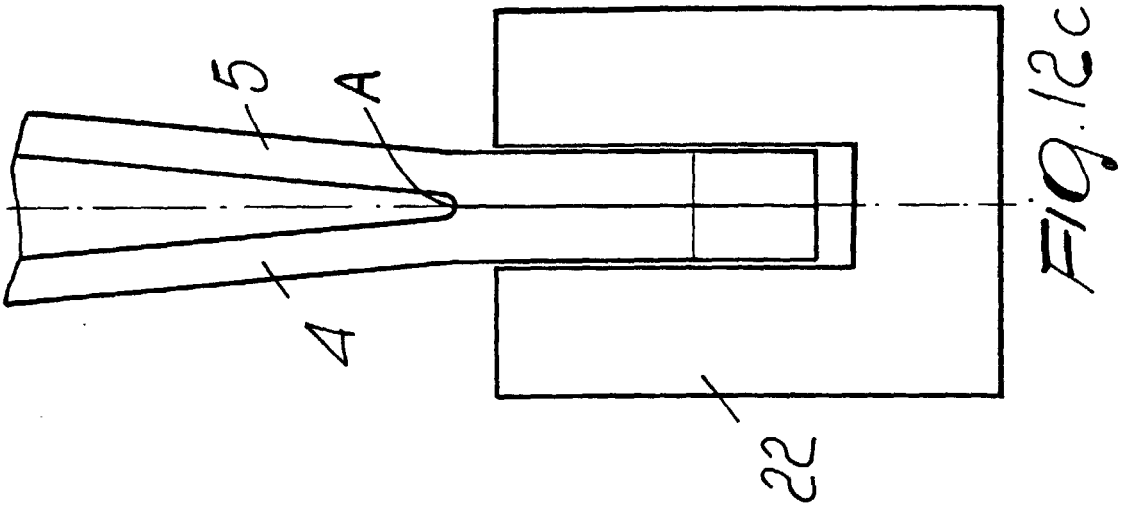


Fig. 12c

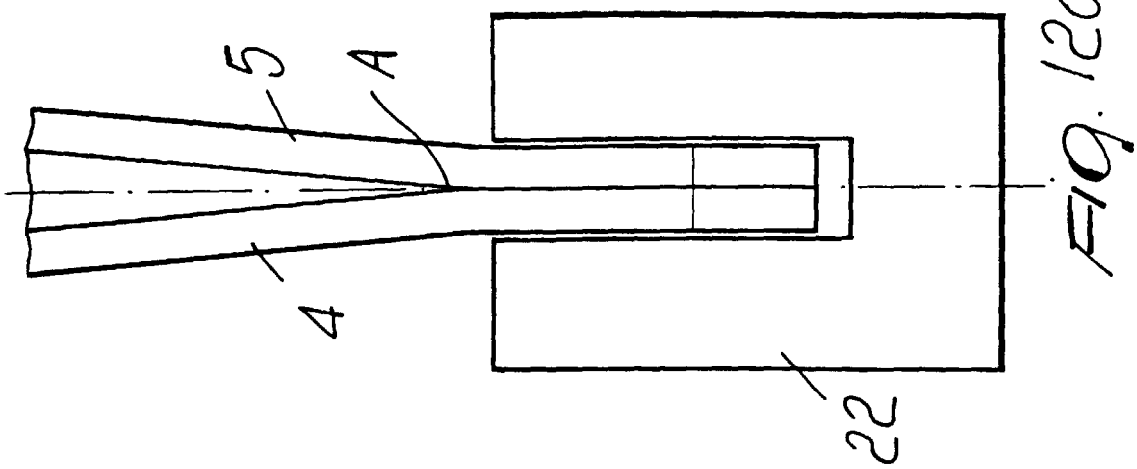


Fig. 12a

Fig.12d

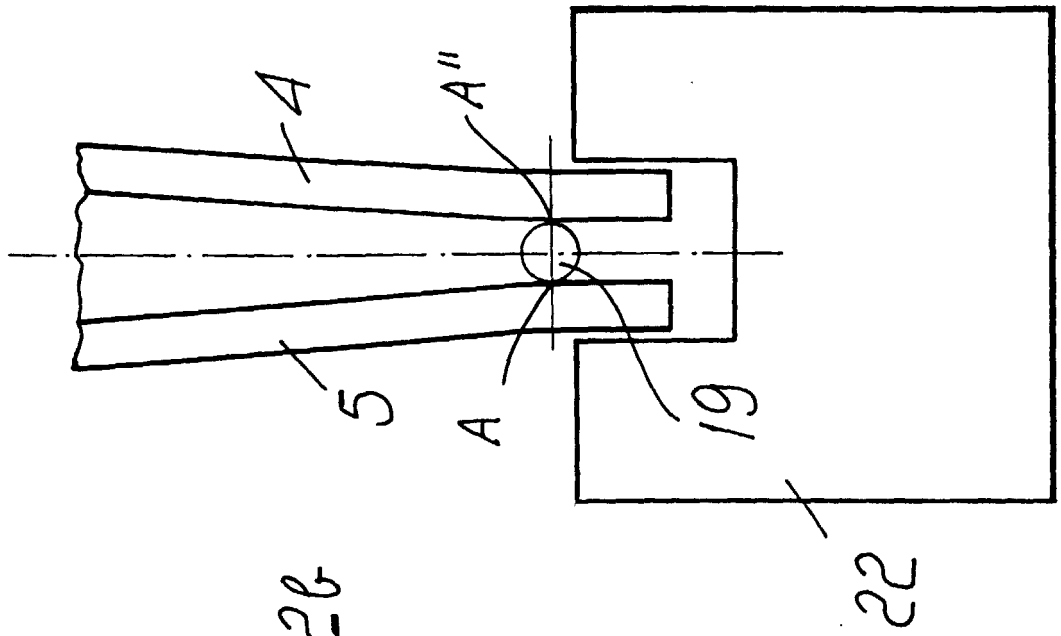
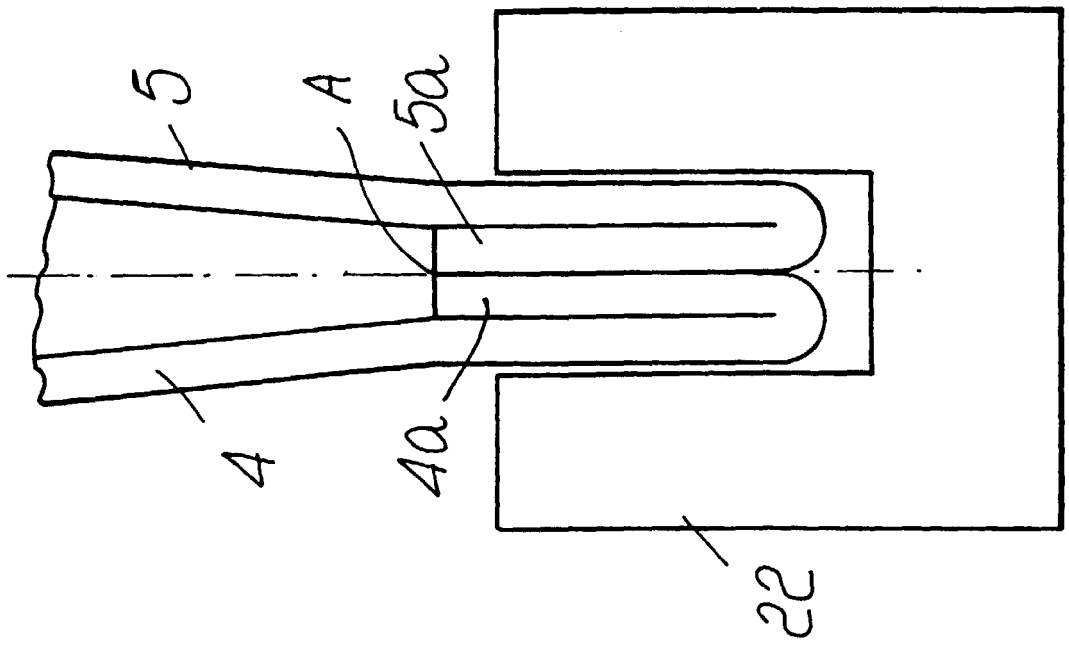


Fig.12b



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EUROPEAN SEARCH REPORT

Application Number
EP 00 11 8256

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	21 December 2000	Kesten, W

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82