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(71) Applicant: **DANIELI & C. OFFICINE MECCANICHE S.p.A.**
Via Nazionale, 19
I-33042 Buttrio (UD) (IT)

(72) Inventor: **Benedetti, Giampietro**
Via degli Aceri 32
I-33030 Campoformido (UD) (IT)

Inventor: **Gensini, Gianni**
Ouartieri Industriali
I-33010 S. Stefano di Buia (UD) (IT)
Inventor: **Pavlicevic, Milorad**
Via Pracchiuso 31/7
I-33100 Udine (IT)
Inventor: **Poloni, Alfredo**
Via General Paolini 29
I-34070 Redipuglia (GO) (IT)

(74) Representative: **Petraz, Gilberto Luigi**
GLP S.r.l.
Piazzale Cavedalis 6/2
I-33100 Udine (IT)

(54) Downstream mould portion with thin sidewalls for continuous casting

(57) Downstream mould portion with thin sidewalls for continuous casting of slabs, billets or blooms (22), which is applied to a mould (11) comprising at least a crystalliser (12) cooperating with a discharge nozzle (13) suitable to discharge the molten metal to be cast, the crystalliser (12) being associated with a closed-circuit primary cooling system with cooling fluid under pressure, the cooling system comprising a first cooling chamber (23) with an inner circulation of cooling fluid, the downstream mould portion (10) consisting of a plurality of independent elements (10a) defining a cross-section substantially the same as that of the slab, billet or bloom (22) passing through, each element (10a) of the downstream mould portion comprising at least one outer sidewall (16) and one inner sidewall (17) which define a second closed chamber (18) for the circulation of a cooling fluid under pressure, the outer sidewall (16) cooperating with means (20) to feed and means (19) to discharge the cooling fluid, the inner sidewall (17) in contact with the slab, billet or bloom (22) having a continuous resilient thickness of the order of 4 to 10 mm., the pressure of the cooling fluid being governed functionally by the thrusts and deformations of the inner sidewall (17) due to overheating.

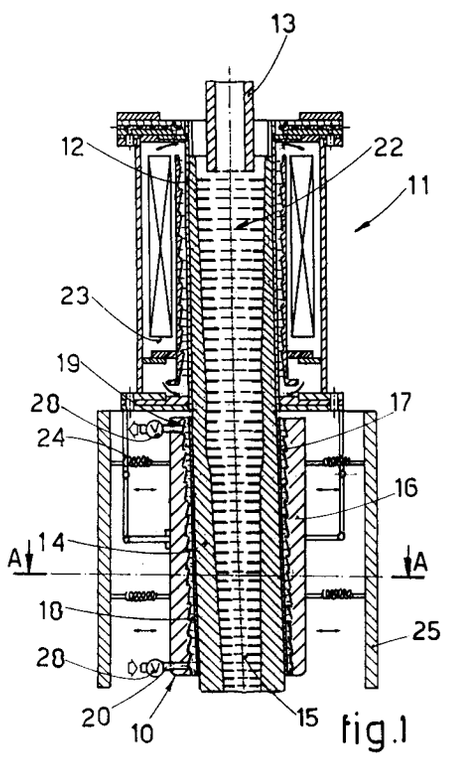

fig.1

EP 0 686 444 A1

This invention concerns a downstream mould portion with thin sidewalls for continuous casting, as set forth in the main claim.

The downstream mould portion according to the invention is employed in the continuous casting of thin and medium slabs, billets, blooms, etc. having a round, square, polygonal or any other analogous cross-section in general.

In the description that follows we shall speak preferably of slabs but will mean thereby that the downstream mould portion of this invention is applied to all types of products produced by continuous casting, as indicated above.

The problems concerning the cooling of cast slabs are well known in the continuous casting process. In fact, this cooling should achieve a compromise as regards the solidifying of the cast slab as quickly as possible without creating tensions in the skin being formed.

These tensions often lead to the occurrence of cracks and deformations in the solidified skin, and these cracks and deformations impair the level of quality of the finished product.

The state of the art includes the provision of a downstream mould portion at the outlet of, and in prolongation of, the oscillatory crystallizer which defines the specific form of the cast slab, this downstream mould portion including an intensive cooling system.

In this downstream mould portion the slab passing through undergoes a quick removal of heat owing to the action of high-efficiency cooling means.

In some cases the cooling fluid is delivered directly into contact with the solidified skin of the slab.

This type of intensive cooling, owing to the inclusion of a liquid core in the slab, leads to the creation of a heterogeneous crystalline structure which may be the source of a plurality of shortcomings such as fragility of the slab, the formation of cracks owing to internal tensions, a scanty coherence in the central zone and yet other drawbacks.

All these shortcomings have an unfavourable effect on the employment and subsequent processings of the product thus obtained.

The state of the art includes various types of downstream mould portions employed for the formation of slabs having a square or rectangular cross-section or of slabs having a round cross-section.

The former slabs are generally shaped with four or more elements or plates arranged as the sides of a square and separated at the angles where they converge.

The latter slabs are shaped with shell elements arranged according to a circumference, as can be seen in EP-A-0268143 for instance.

US-A-2,698,467 discloses a downstream mould portion with helicoidal grooves on its periphery; this document, however, does not teach how to adjust the dimensions of the downstream mould portion to the actual dimensions of the slab passing through nor how to ensure the desired pressure against the slab.

EP-A-0367024 in the name of the present applicants teaches the provision of a downstream mould portion consisting of a plurality of independent, movable and self-aligning elements, whereby the sides of each element together with those of the neighbouring element define clefts having a development not parallel to the axis and surface of the solidifying slab.

This disclosure, while being satisfactory, does not overcome the problems fully, is complex to construct, use and maintain and does not ensure a fully efficient level of cooling.

Patent CH-B-357.835 discloses downstream mould portion devices with a cooling chamber with a circulation of cooling fluid, the sidewall in contact with the product leaving the mould being characterised by a surface extending within the cooling chamber; this extending surface stiffens the sidewall itself of the downstream mould portion.

The present applicants have designed, tested and embodied this invention to overcome the problems which have been the subject of complaints in the state of the art and to achieve further advantages.

This invention is set forth and characterised in the main claim, while the dependent claims describe variants of the idea of the main embodiment.

The purpose of the invention is to embody a downstream mould portion applied to a continuous casting mould, in which it is possible to carry out a high-efficiency accelerated and intensive cooling.

According to the invention the downstream mould portion consists of several elements the intersection of the surfaces of which defines a closed cross-section substantially analogous to the cross-section of the slab, billet or bloom passing through.

Each of the elements forming the downstream mould portion has a box-shaped structure defined by an outer sidewall and an inner sidewall.

These inner and outer sidewalls define between them a second chamber for circulation of a cooling fluid under pressure.

According to the invention the inner sidewall of the downstream mould portion, namely the sidewall facing towards the slab passing through, has a conformation such as to make its behaviour resilient and, according to the invention, a very modest thickness of the order of 4 to 10 mm. but advantageously about 5 to 6 mm.

According to the invention the natural tendency to the outward deformation of the inner sidewall owing to the very high temperatures involved and the modest thickness is counterbalanced by the inward pressure of the cooling fluid circulating within the second fluid circulation chamber.

This pressure of the cooling fluid therefore depends on the thrusts and outward deformations of the inner sidewall due to the overheating.

The pressure of the cooling fluid against the inner sidewall causes a resilient inward thrust, counterbalances the tensions due to deformation by overheating and keeps the inner sidewall, in fact, adhering to the solidifying skin of the slab.

This leads to a more constant and uniform nature of the heat exchange between the cooling fluid under pressure and the slab.

According to a variant each element forming the downstream mould portion consists in turn of a plurality of substantially vertical panels associated with one another.

According to a further variant the corners of the slab are not cooled by the cooling fluid circulating in the chamber of the downstream mould portion, the purpose being to minimise the lengthwise cracks in the surface of the slab.

According to yet another variant the corners of the slab may be partly cooled, for instance by the delivery of jets of water.

According to the invention at least the side of the outer sidewall facing the second chamber holding the circulating cooling fluid under pressure is shaped and conformed in a manner so as to break up the fluid streams of the outermost layer of the cooling fluid, thus forcing and making swirling the motion of the cooling fluid and improving the heat exchange.

According to a variant a plurality of hollows or other agitation elements are provided in the side of the inner sidewall of the downstream mould portion facing towards the second chamber holding the circulating cooling fluid and break up the outermost surface layer of the fluid, thus causing a further accentuation of the heat exchange.

According to a further variant a plurality of enlargements and narrowings is provided on the side of the outer sidewall of the downstream mould portion facing towards the second chamber for the circulation of a cooling fluid and imparts to the fluid a turbulent and swirling motion.

The elements forming the downstream mould portion according to the invention are advantageously associated with resilient pressure means ,which are known in themselves and are suitable to maintain continuously the contact with the slab passing through.

The attached figures are given as a non-restrictive example and show some preferred embodiments of the invention as follows:

- Fig 1 shows a lengthwise section of a continuous casting mould equipped with a downstream mould portion according to the invention;
- Fig.2 shows in an enlarged scale a partial lengthwise section of the sidewall of the downstream mould portion according to the invention;
- Fig.3 shows a cross-section along the line A-A of Fig.1;
- Fig.4 shows a variant of Fig.3;
- Fig.5 shows a variant of Fig.2;
- Fig.6 shows a partial cross-section of the downstream mould portion according to the invention;
- Fig.7 shows a view along the line B-B of Fig.2.

A downstream mould portion 10 according to the invention is applied to a mould 11 comprising an oscillatory crystallizer 12, within which is located a discharge nozzle 13, the outlet of which is generally positioned below the meniscus of molten metal.

The crystallizer 12 cooperates with a closed-circuit primary cooling system that comprises a first chamber 23 for circulation of the cooling fluid, this first chamber 23 being adjacent to the crystallizer sidewall facing the molten metal.

A first thickness 14 of solidified skin is formed in the slab 22 within the crystallizer 12, whereas the core 15 of the cast slab remains substantially liquid.

The downstream mould portion 10 according to the invention is positioned at the outlet of, and in prolongation of, the crystallizer 12.

In the example shown in Figs.3 and 4 the downstream mould portion 10 consists of four elements 10a arranged about the periphery of the slab 22 and defining a passage having a cross-section of dimensions substantially mating with the cross-section of the slab 22 itself.

In particular, in the example of Fig.3 the cast product has a substantially square cross-section, whereas in the example of Fig.4 the cross-section of the product is substantially rectangular.

Each element 10a possesses a box-shaped structure comprising a first outer sidewall 16 and a second inner sidewall 17, these sidewalls 16-17 defining between them one or more second chambers 18 for the circulation of a cooling fluid under pressure.

The outer sidewall 16 is associated with at least one conduit 20 to feed a cooling fluid under pressure and at least one conduit 19 to discharge cooling fluid under pressure, the conduits 19-20 being associated with means 28 that adjust and close the flow of fluid.

The inner sidewall 17 faces the slab 22 passing through and has a very modest thickness of about 4 to 10 mm., but advantageously about 5 to 6 mm.

According to the invention the natural tendency of the inner sidewall 17 to become deformed outwards owing to the very great heat exchange with the slab 22 passing through, this tendency being accentuated by the modest thickness of the inner sidewall 17 itself, is compensated by acting on the pressure of the cooling fluid circulating within the second chamber 18.

This pressure acts against the inner sidewall 17 and causes a resilient thrust towards the slab 22, thus counterbalancing the thrusts due to deformation and, in fact, maintaining the inner sidewall 17 in a condition of adherence to the solidified skin 14 of the slab 22.

This makes it possible also to keep constant and uniform the heat exchange between the cooling fluid and the slab 22, this heat exchange reaching very high values in view of the very modest thickness of the inner sidewall 17.

According to the invention the side of the outer sidewall 16 facing the second chamber 18 for circulation of the cooling fluid is shaped and conformed to break up the fluid stream and thus to make swirling the movement of the cooling fluid and to increase the coefficient of the heat exchange between the cooling fluid and the inner sidewall 17 of the downstream mould portion 10.

In the embodiment shown in Figs.2 and 5 the conformation provides alternate narrowed areas 26 and enlarged areas 27 for the purpose of causing in the circulating fluid a desired turbulence.

These enlarged areas 27 and narrowed areas 26 may have a polygonal development (Fig.5) or a development producing a Venturi effect (Fig.2), which makes the motion of the fluid swirling and accentuates the heat exchange.

According to a variant the side of the inner sidewall 17 facing the second chamber 18 for the circulation of fluid includes a plurality of agitation elements shaped in this case as cavities 21, into which the cooling fluid enters, thus breaking up the outermost layer of the fluid and causing a further accentuation of the heat exchange.

According to the invention the cavities 21 may have a horizontal or substantially horizontal development 21a or an inclined development 21b (Fig.7).

Each element 10a of the downstream mould portion 10 includes springs 24, which are associated with a stationary supporting structure 25 and are suitable to maintain contact between the inner sidewall 17 and the slab 22 passing through and to exert a desired pressure against the slab 22.

According to the variant of Fig.4 each element 10a forming the downstream mould portion 10 is embodied with a plurality of vertical adjacent panels 110, each of which includes its own inner 17 and outer 16 sidewalls and a second chamber 18 for circulation of the cooling-fluid.

These vertical panels 110, according to a variant, can cooperate independently with the position-adjustment springs 24 for the purpose of providing an independent adaptation of one to the other.

Claims

1. Downstream mould portion (10) with thin sidewalls for continuous casting of slabs, billets or blooms (22), which is applied to a mould (11) comprising at least a crystalliser (12) cooperating with a discharge nozzle (13) suitable to discharge the molten metal to be cast, the crystalliser (12) being associated with a closed-circuit primary cooling system with cooling fluid under pressure, the cooling system comprising a first cooling chamber (23) with an inner circulation of cooling fluid, the downstream mould portion consisting of a plurality of independent elements (10a) defining a cross-section substantially the same as that of the slab, billet or bloom (22) passing through, each element (10a) of the downstream mould portion comprising at least one outer sidewall (16) and one inner sidewall (17) which define a second closed chamber (18) for the circulation of a cooling fluid under pressure, the outer sidewall (16) cooperating with means (20) to feed and means (19) to discharge the cooling fluid, the downstream mould portion being characterized in that the inner sidewall (17) in contact with the slab, billet or bloom (22) has a continuous resilient thickness of the order of 4 to 10 mm., and in that the pressure of the cooling fluid is governed functionally by the thrusts and deformations of the inner sidewall (17) due to overheating.

2. Downstream mould portion as in Claim 1, in which the inner sidewall (17) has a thickness of about 5 to 6 mm.

3. Downstream mould portion as in Claim 1 or 2, in which the side of the inner sidewall (17) facing towards the second chamber (18) for circulation of fluid includes means (21) suitable to break up the outermost layer of the stream of cooling fluid and to make the movement of the cooling fluid disturbed and swirling.

4. Downstream mould portion as in Claim 3, in which the means suitable to break up the outermost layer of the stream of cooling fluid consist of horizontal (21a) or inclined (21b)

hollows (21) provided in the surface of the inner sidewall (17) facing towards the second chamber (18) for circulation of the fluid.

5. Downstream mould portion as in any claim hereinbefore, in which the face of the outer sidewall (16)facing towards the second chamber (18) for circulation of the fluid contains alternate consecutive enlarged areas (26) and narrowed areas (27) which agitate the motion of the cooling fluid.

6. Downstream mould portion as in any claim hereinbefore, in which the consecutive enlarged areas (26) and narrowed areas (27) have a polygonal conformation (Fig.5).

7. Downstream mould portion as in Claim 5, in which the consecutive enlarged areas (26) and narrowed areas (27) have a conformation suitable to create a Venturi effect on the circulating fluid (Fig.2).

8. Downstream mould portion as in any claim hereinbefore, in which the elements (10a) have a width smaller than the relative side of the slab, billet or bloom (22).

9. Downstream mould portion as in any claim hereinbefore, in which the corners of the slab, billet or bloom (22) are not cooled.

10. Downstream mould portion as in any of Claims 1 to 8 inclusive, in which the corners of the slab, billet or bloom (22) are at least partly cooled by jets of water.

11. Downstream mould portion as in any claim hereinbefore, in which each element (10a) constituting the downstream mould portion (10) is embodied with a plurality of panels (110) positioned side by side and substantially parallel to the axis of the movement of the slab, billet or bloom (22).

12. Downstream mould portion as in any claim hereinbefore, in which each element (10a) constituting the downstream mould portion (10) is associated with positioning means applying a resilient pressure towards the slab, billet or bloom (22).

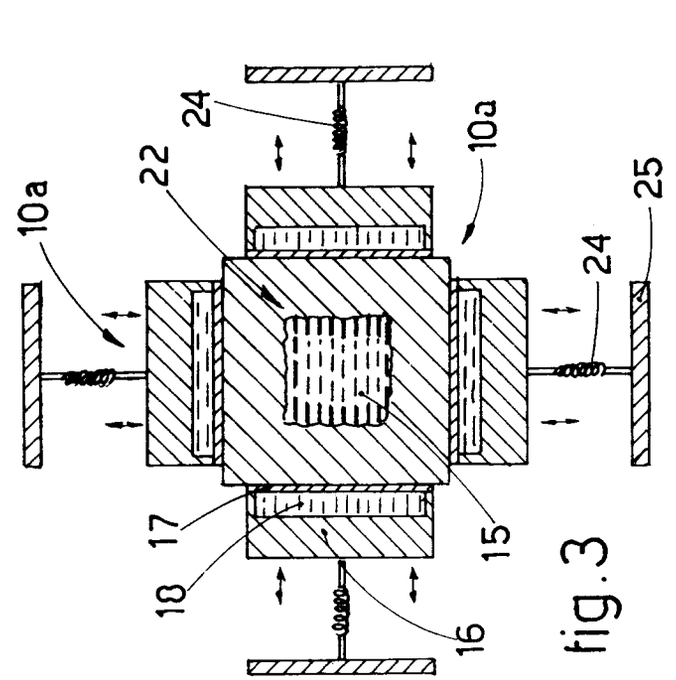

fig.3

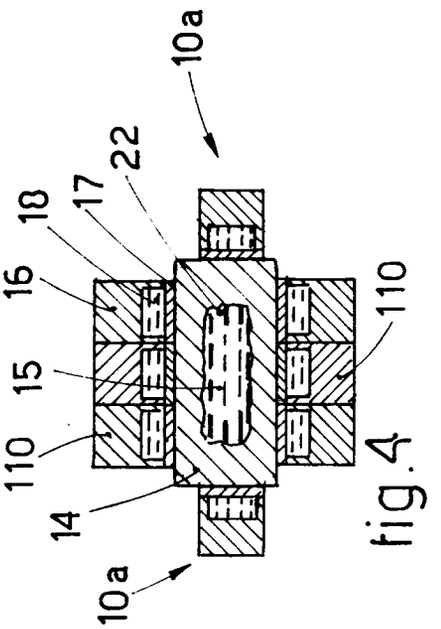

fig.4

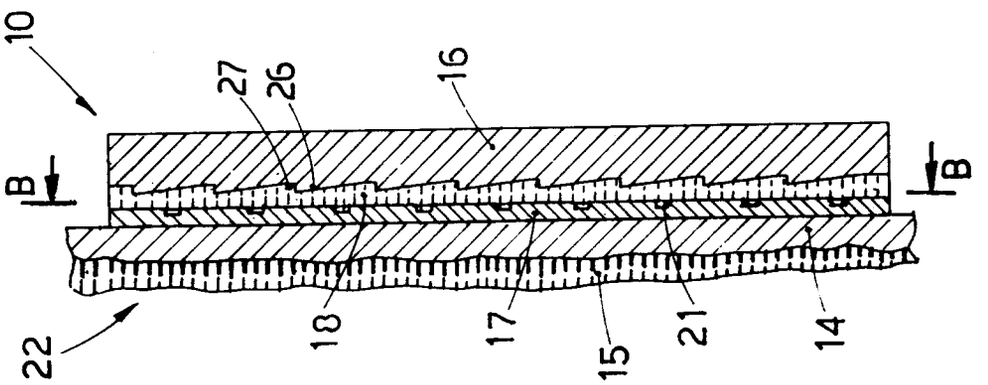

fig.2

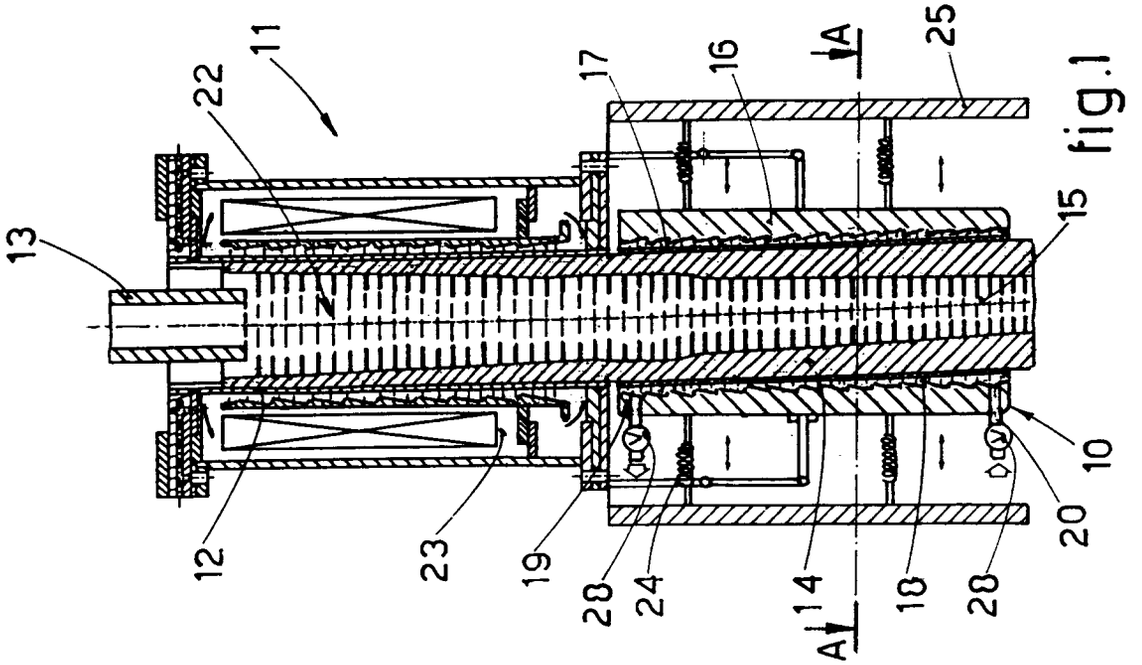

fig.1

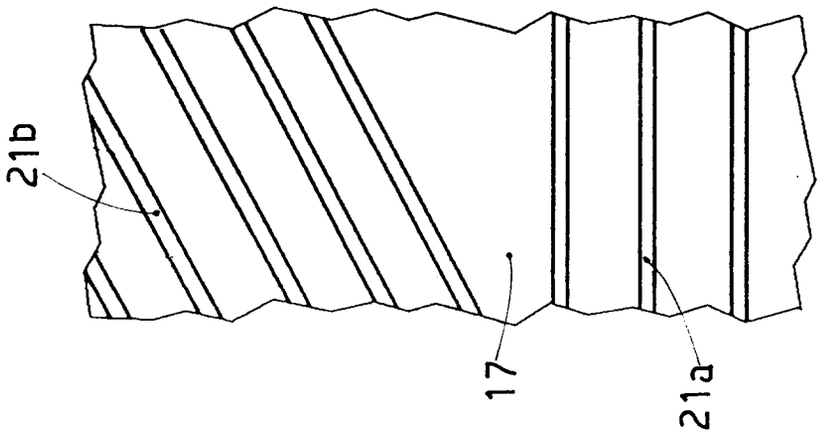

fig.7

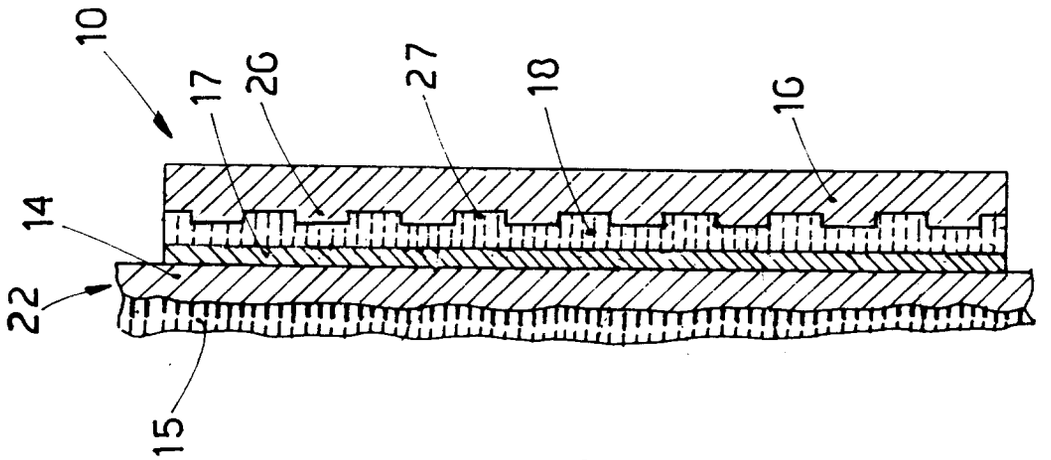

fig.5

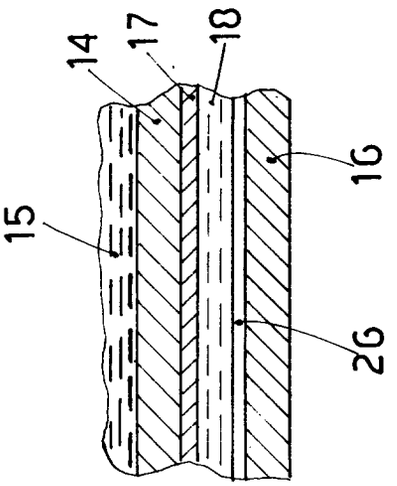

fig.6

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EUROPEAN SEARCH REPORT

Application Number
EP 95 10 7943

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.6)
Y	CH-A-357 835 (SCHLOEMANN AG) 15 December 1961 * claim; figures 2-4 *	1,3,8,9, 11,12	B22D11/124 B22D11/128 B22D11/04
Y	PATENT ABSTRACTS OF JAPAN vol. 008 no. 270 (M-344) ,11 December 1984 & JP-A-59 141347 (KUROKI KOGYOSHO:KK) 14 August 1984, * abstract *	1,3,8,9, 11,12	
A	PATENT ABSTRACTS OF JAPAN vol. 008 no. 270 (M-344) ,11 December 1984 & JP-A-59 141348 (KUROKI KOGYOSHO:KK) 14 August 1984, * abstract *	3	
A	FR-A-1 465 163 (CONCAST AG) 6 January 1967 * claims; figures *	1,9,11	
A,D	EP-A-0 268 143 (CONCAST STANDARD AG ODOC CAESAR ACCESSION NUMBER: US3688833) 25 May 1988 * claims; figures *	12	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B22D
A	US-A-3 688 833 (BYKOV ET AL) 5 September 1972 * claims; figures *	11	
A,D	US-A-2 698 467 (TARQUINEE ET AL.) 4 January 1955		
A,D	EP-A-0 367 024 (DANIELI & C. OFFICINE MECCANICHE S.P.A.) 9 May 1990		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 October 1995	Wittblad, U

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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