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(54) **METHOD TO MANUFACTURE A CRYSTALLIZER WITH PLATES FOR THE CONTINUOUS
CASTING OF SLABS, AND CRYSTALLIZER THUS OBTAINED**

VERFAHREN ZUR HERSTELLUNG EINES KRISTALLISATORS MIT PLATTEN FÜR DAS
STRANGGIESSEN VON BRAMMEN UND IN DIESEM VERFAHREN HERGESTELLTER
KRISTALLISATOR

PROCÉDÉ DE FABRICATION D'UN CRISTALLISOIR À PLATEAUX POUR LA COULÉE EN
CONTINU DE PLAQUES, ET CRISTALLISOIR AINSI OBTENU

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a method to manufacture a crystallizer with plates for the continuous casting of slabs, used in the steel industry to cast thin, medium and thick slabs with a rectangular section with the long side much bigger than the short side.

[0002] The plates of the crystallizer are provided with a plurality of channels through which a cooling liquid is made to pass.

[0003] The present invention also concerns the crystallizer obtained with said method.

BACKGROUND OF THE INVENTION

[0004] Crystallizers with plates made of copper alloy for continuous casting are known, in particular for casting slabs, substantially comprising two wide walls facing each other to define, together with two narrow lateral walls, a pipe with a substantially rectangular section, through which the molten metal is continuously cast.

[0005] Each of the two wide walls comprises at least a plate, normally shaped on the internal face so as to define, in the central part and for a length which can occupy part or all the plate, a concave profile or recess. This recess in the upper part delimits a zone in which, during use, an unloader is able to be positioned with the function of taking the molten metal inside the crystallizer.

[0006] The concave profile is normally made by chip-removal operations which, however, entail a series of disadvantages.

[0007] In the first place, chip-removal operations are costly in terms of time and the equipment used, entailing obvious economic disadvantages. Moreover, it may sometimes be required to use different tools depending on the working step.

[0008] Furthermore, the final surface of the concave profile, obtained by chip-removal operations, may have surface imperfections, in particular in the connection curves, which could influence the correct formation of the skin of the cast product, and cause possible breakages thereof, if the contact between the molten metal and the plate is not optimal during casting.

[0009] Furthermore, high working costs can be caused by the initial piece to be worked, which obviously is defined by bigger sizes of the machining allowance with respect to the final product to be obtained. In other words, the discard of noble material removed during working is also a considerable cost.

[0010] All in all, these disadvantages determine a method for manufacturing the crystallizer that is rather laborious and costly, and a crystallizer that can have surface defects affecting the final quality of the metal product cast.

[0011] Methods for manufacturing plates for crystallizers of slabs are also known from documents EP-A-

0.564.860, DE-A-10.2006.033316 and EP-A-1.060.815. These provide to plastically deform a metal body, in general made of copper, to confer upon it the desired shape of the concave profile and define a recess of the crystallizer. The methods described in these documents provide that the shaping is performed by means of one or more molding, forging or pressing operations, using mobile punches or other analogous equipment.

[0012] With the methods described in the above documents, however, it is not possible to guarantee adequate precision or that a shape is obtained of the concave profile that respects the tolerances required for its subsequent use. In fact it is known that the zone near the concave profile, that is, the zone connecting the flat part and the curved part, is the most critical portion of the plate, that is, the portion most subject to phenomena of wear generated by the turbulence of the cast metal. In order to limit the phenomena of wear, the concave profile of the recess must adhere as strictly as possible to the specification geometric parameters.

[0013] It is also known that a plurality of longitudinal pipes must be made over the whole length of the wide walls in order to allow a cooling liquid to pass.

[0014] When they are made in the thickness of the wide walls, these longitudinal pipes are rather complicated to make, both because they have to have a very precise internal surface, and also because they require long and costly working with suitable tools.

[0015] One purpose of the present invention is to perfect a method to manufacture a crystallizer with plates for the continuous casting of slabs that allows to obtain, simply and quickly, plates for the crystallizer that meet the dimensional and tolerance constraints required by the specifications, also to increase the working life of the crystallizer itself.

[0016] Another purpose of the present invention is to perfect a method to manufacture a crystallizer for the continuous casting of slabs that provides a reduced number of steps and that allows to reduce the times and costs of manufacturing the crystallizer.

[0017] Another purpose of the present invention is to manufacture a crystallizer for continuous casting that is economical and that has standardized and repeatable characteristics, even in the presence of particular shapes.

[0018] Another purpose of the present invention is to reduce the costs of manufacturing the crystallizer, reducing as much as possible the volume of copper or alloys thereof used to make it.

[0019] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0020] The present invention is set forth and characterized in the independent claims, while the dependent

claims describe other characteristics of the invention or variants to the main inventive idea.

[0021] In accordance with the above purposes, a method according to the present invention, which overcomes the limits of the state of the art and eliminates the defects present therein, is used to manufacture a crystallizer for the continuous casting of slabs comprising at least two wide walls, facing each other, each provided with at least one plate and defining the wide sides of the cast slab.

[0022] The crystallizer also comprises two narrow walls, interposed at the ends of the wide walls, which define the overall width of the cast slab.

[0023] The method comprises at least a first step of making at least one of the wide walls having, in its surface development, at least one shaped portion.

[0024] According to one feature of the present invention, the method comprises at least the making of a molding apparatus provided with a mold and a counter-mold in which respective shaped surfaces are made. The shaped surfaces together define, when the mold and the counter-mold are in the operating molding position, a molding cavity, which defines in negative the entire surface development, in shape and size, of the at least one plate of the wide walls.

[0025] The method also comprises the molding of the plate using the mold and the counter-mold, to obtain the at least one plate directly in the finished form, without relative movements between mold and counter-mold.

[0026] In this way, the shaped portion and the whole surface development of the at least one plate are obtained by deforming the latter plastically and rapidly obtaining the desired shaping.

[0027] Thanks to the fact that the shaped surfaces of the mold and counter-mold faithfully reproduce the final shape of the plate to be obtained, it is possible to respect the design specifications and, in particular, the dimensional and geometrical tolerances, even very strict, at least of the shaped portion. As described above, the shaped portion, which during use will define the volume for the insertion of an unloader, is a critical zone of the whole crystallizer with regard to the phenomena of wear that can occur, and dimensional deviations of this part can considerably increase wear, reducing its working life.

[0028] Moreover, the use of molding techniques entails considerable savings in terms of time, equipment used and waste of material, given that molding, unlike known techniques such as for example chip-removal operations, is almost immediate and repetitive in the precision of the shaping desired.

[0029] According to the invention, moreover, savings are also obtained in terms of material used, since the molding operation does not produce any scrap.

[0030] Furthermore, the step of making the shaped portion is simplified, with the possibility of producing different profiles of shaped portions which, on the contrary, would be very complicated, long to make and costly, if chip-removal operations were used.

[0031] Furthermore, advantageously, molding does

not produce abrasions, scoring or other defects, and therefore the surface of the crystallizer that comes into contact with the molten metal does not need any further workings in order to be used.

[0032] This allows further economic saving in terms of less scrap, lower working costs and shorter manufacturing times.

[0033] According to some possible forms of embodiment, during molding two adjacent and overlapping plates are molded simultaneously in the molding apparatus, in order to form one of the wide walls, to define an internal surface and an external surface of the wide wall. Moreover, it can be provided that during the making of the molding apparatus, respective shaped surfaces are defined in the mold and the counter-mold, mating with the whole surface development of the internal surface and the external surface.

[0034] One possible form of embodiment provides that the method also comprises the coupling of the two plates to define together at least one of the wide walls.

[0035] The present invention also concerns a molding apparatus to make a crystallizer with plates for continuous casting, which comprises at least a mold and a counter-mold, each provided with respective shaped surfaces defining together, when the mold and the counter-mold are in the operating molding position, a molding cavity. The molding cavity defines in negative the whole surface development, in shape and size, of at least one plate of the wide walls.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] These and other characteristics of the present invention will become apparent from the following description of one form of embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1. is a cross section of a first form of embodiment of a crystallizer made according to the present invention;
- fig. 2 is a part of fig. 1;
- fig. 3 is an enlarged detail of part A in fig. 2;
- fig. 4a is a cross section of a second form of embodiment of the crystallizer in fig. 1;
- fig. 4b is a variant of fig. 4a;
- fig. 5 is a variant of fig. 4a;
- fig. 6a is an enlarged detail of fig. 5, in accordance with a first variant;
- fig. 6b is a variant of fig. 6a;
- fig. 6c is a variant of figs. 6a and 6b;
- figs. 7 and 8 are the schematic representations of a first production step of a part of the component in figs. 2, 4 and 5;
- fig. 9 is a schematic representation of a second production step of the component in figs. 4a, 4b and 5;
- fig. 10 is a variant of fig. 9.

[0037] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one form of embodiment can conveniently be incorporated into other forms of embodiment without further clarifications.

DETAILED DESCRIPTION OF SOME FORMS OF EMBODIMENT

[0038] With reference to fig. 1, a crystallizer with plates for the continuous casting of slabs according to the present invention is indicated in its entirety by the reference number 10.

[0039] The crystallizer 10 comprises two shaped wide walls 11, substantially identical to each other and disposed facing and distanced from each other by two narrow walls 12.

[0040] The wide walls 11, shaped in their central part, define along a longitudinal axis Z, a central cavity, or recess, 13, which extends from an entrance section to an exit section of the crystallizer 10. Inside the upper part of the central cavity 13 an unloader is able to be inserted, not shown in the drawings, with the function of taking the molten metal into the crystallizer 10.

[0041] The two narrow walls 12 are selectively adjustable, in a known manner, to define the distance between the wide walls 11 and hence the width of the slab exiting from the crystallizer 10.

[0042] In the form of embodiment in figs. 1 and 2, each wide wall 11 comprises a first plate 14 and a second plate 15, adjacent to each other, that is, overlapping and in contact with each other.

[0043] The first plate 14 comprises a first internal surface 16 in contact during use with the molten metal, and a first external surface 17 disposed in contact with the second plate 15. The second plate 15 comprises a second internal surface 18, cooperating with the first external surface 17 of the first plate 14, and a second external surface 19, in this case planar.

[0044] The first plate 14 and the second plate 15 are shaped in their central part, as is known, so as to define a concave portion 20, or shaped portion, able to allow the positioning of the unloader. The concave portion 20 extends longitudinally for the whole height of the crystallizer 10 and has a longitudinal inclination that diminishes until it is canceled or, in some cases, until it is almost canceled, in correspondence with the exit section.

[0045] Normally, the part of the unloader positioned between the two wide walls 11 is substantially oval in shape, and is positioned at the center of the central cavity 13 and coaxially to the longitudinal axis Z. The unloader is therefore partly surrounded by the concave portion 20 of the first plates 14.

[0046] The first plate 14 in this case is made of an alloy of copper and silver, or an alloy of copper, chromium and zirconium. The second plate 15 instead is made of steel.

[0047] According to a first form of embodiment shown

in figs. 1, 2 and 3, the first plate 14 and the second plate 15 are joined to each other mechanically by threaded connection means, in this case first screws 24 (fig. 3) inserted inside through clamping holes 25 and blind clamping holes 26, made respectively in the second plate 15 and the first plate 14. More specifically, into the blind clamping holes 26 threaded bushings 37 are screwed, into which in turn the first screws 24 are screwed.

[0048] This form of embodiment is particularly advantageous because, if the first plate 14 has to be replaced, for example for maintenance operations or due to heavy wear, the second plate 15 can be re-used.

[0049] According to a second form of embodiment, shown in figs. 4a, 4b, 5, 6a and 6b, the first plate 14 and the second plate 15 are reciprocally connected by means of a connection material 34 disposed between the first external surface 17 of the first plate 14 and the second internal surface 18 of the second plate 15, to define the intimate and permanent coupling of the first plate 14 and the second plate 15.

[0050] Some forms of embodiment provide that the connection material 34 consists of a brazing material.

[0051] The brazing material, merely by way of example, can be chosen from a group comprising alloys based on tin, lead, copper, silver, zinc or combinations thereof.

[0052] Although hereafter in the description we shall refer only to the solution which provides to use a brazing material, it cannot be excluded that, in other forms of embodiment, the connection between the first plate 14 and the second plate 15 is obtained by gluing operations, or using a gluing material.

[0053] Some forms of embodiment provide that the connection material 34 is a gluing material chosen from a group comprising at least epoxy resins, chionoacrylates or similar or comparable glues, suitable for the particular use.

[0054] According to some forms of embodiment (figs. 1-6c), at least one of either the first external surface 17 of the first plate 14 or the second internal surface 18 of the second plate 15 are provided with a plurality of longitudinal grooves 21, made open toward the outside and closed by the second plate 15 or respectively by the first plate 14 to define channels 22 for the passage of a cooling liquid. The channels 22 in turn are reciprocally connected to each other to define a cooling circuit inside which the cooling liquid or fluid is able to pass, in order to cool the first and second plates 14 and 15 and the molten metal.

[0055] Merely by way of example, the channels 22 are configured to resist pressure stresses exerted by the cooling liquid, normally in the range of about 20 bar.

[0056] The cooling liquid allows to obtain a uniform cooling of the whole cross section of the crystallizer 10. Merely by way of example, with reference to fig. 6c, it is provided that the first internal surface 16 of the first plate 14 is kept at a temperature of about 350°C, the surface of the channels 22 disposed nearest the first internal surface 16 is kept at a temperature of about 160°C, the interface zone between the first plate 14 and the second

plate 15 is kept at a temperature of about 60°C and the second external surface 19 of the second plate 15 is kept at a temperature of about 30°C.

[0057] It should be noted that the interface zone between first plate 14 and the second plate 15, that is, the zone where there is the connection material 34, is at a relatively low temperature, so as to advantageously preserve the sealing and connecting capacities of the connection material 34 from heat stresses.

[0058] In particular, in the forms of embodiment in figs. 1, 2, 3, 4b and 6c, the longitudinal grooves 21 are made in the first external surface 17 of the first plate 14 which are closed by the second plate 15 to define the channels 22.

[0059] According to a variant, shown in figs. 4a, 5, 6a and 6b, the longitudinal grooves 21 are made in the second internal surface 18 of the second plate 15. In this case, the longitudinal grooves 21 are closed by the first plate 14.

[0060] Merely by way of example, not restrictive of the present invention, in the case of channels 22 that are rectangular in shape, these have a width comprised between 5 mm and 12 mm and a depth comprised between 10 mm and 15 mm.

[0061] Other forms of embodiment, not shown in the drawings, provide to make longitudinal grooves 21 that are trapezoidal or dovetailed in shape, having the smaller base facing toward the surface where the grooves are made, and the bigger base facing toward the inside.

[0062] In a first form of embodiment, for example the one shown in figs. 1, 2 and 3, the first plate 14 has a constant thickness along its extension in width, while the second plate 15 has a variable thickness, reduced in correspondence to the central cavity 13.

[0063] In other forms of embodiment, for example those shown in figs. 4a, 4b and 5, both the first plate 14 and the second plate 15 have a uniform thickness along their extension in width. In this case, the second external surface 19 of the second plate 15 also has a curved profile to follow the concave portion 20.

[0064] Merely by way of example, not restrictive of the present invention, and with reference to the forms of embodiment in figs. 4a and 4b, the plate in which the longitudinal grooves 21 are made has a thickness comprised between 20 mm and 40 mm while the plate without longitudinal grooves has a thickness comprised between 10 mm and 20 mm.

[0065] More specifically, in the form of embodiment in figs. 4a and 4b, respectively the second plate 15 and the first plate 14 have maximum thickness to allow to obtain the longitudinal grooves 21.

[0066] The wide wall 11 can be associated by means of second screws 33 to a steel frame 27 (figs. 5, 6a, 6b and 6c) which defines a water box for the cooling circuit comprising said channels 22.

[0067] In some forms of embodiment (figs. 5, 6a, 6b and 6c), drainage channels 36 can be made in the second plate 15 and through the frame 27. The drainage chan-

nels 36 allow to discharge possible small losses of the cooling fluid circulating in the channels 22 which, due to the high pressure, could leak from the channels 22 through the surfaces 17 and 18 of the first and second plates 14, 15 in contact with each other.

[0068] Some forms of embodiment provide that on at least one of either the first plate 14 or the second plate 15 a plurality of notches 23 are made, configured to compensate the heat dilations to which they are subjected during casting.

[0069] In particular, in the form of embodiment in figs. 6a and 6b, the second plate 15 comprises a plurality of longitudinal notches 23 able to compensate the heat dilations to which the second plate 15 is subjected during casting, also because of the different material that the first and second plates 14 and 15 are made of.

[0070] The longitudinal notches 23 can be made on the second external surface 19 (fig. 6a) or, according to a variant, on the second internal surface 18 (fig. 6b).

[0071] In other forms of embodiment it is provided that the crystallizer 10 is provided not only with the longitudinal notches 23, but also with transverse notches 35 (fig. 6a), that is, notches that extend transversely with respect to the longitudinal axis Z, and having the same function as the longitudinal notches 23.

[0072] The interaction between the longitudinal 23 and transverse notches 35 allows to adapt to the heat dilations that the crystallizer 10 is subjected to during use, and to reduce the internal tensions thereof. In particular, the longitudinal notches 23 and the transverse notches 35 allow to adapt respectively to the transverse and longitudinal dilations to which the crystallizer 10 is subjected.

[0073] The longitudinal 23 and transverse 35 notches in this case have a rectangular section shape, although in other forms of embodiment they can have different shapes, with the shorter side having a width of about 4-5 mm.

[0074] According to a variant, the transverse notches 35 are made only in the zone which during use is disposed in proximity with the level of the molten metal in the crystallizer 10, or meniscus, where the heat stresses are greatest. The longitudinal 23 and transverse notches 35 are made for example by milling operations.

[0075] According to another variant, each wide wall 11 can consist of a single plate of copper alloy. In this case, the channels 22 are made longitudinally to the thickness of the plate.

[0076] In some forms of embodiment (fig. 3), seatings 40 are made on the second plate 15, in this case with a rectangular section, inside each of which a sealing packing 41 is disposed to ensure the watertight seal between the first plate 14 and second plate 15 of the wide wall 11.

[0077] The method to manufacture the crystallizer 10 as described heretofore comprises at least a first step in which at least the first plate 14, consisting for example of a rolled metal sheet with a good surface finish, is subjected to a molding operation using a mold 28 and a counter-mold 29 of a molding apparatus 30 (figs. 7 and 8).

According to possible implementations of the present invention, the molding apparatus 30 can be used for the simultaneous molding of the first plate 14 and the second plate 15 as will be described hereafter.

[0078] In particular, the mold 28 is provided with a shaped surface 42 which is shaped mating with the whole surface development of the first internal surface 16 of the first plate 14.

[0079] The counter-mold 29 is in turn provided with a shaped surface 43 which is shaped mating with the whole surface development of the first external surface 17 of the first plate 14, or if the first plate 14 and the second plate 15 are molded together, mating with the whole surface development of the peripheral second external surface 19.

[0080] The mold 28 and counter-mold 29, when put in their operating position, define with their respective shaped surfaces 42 and 43 a molding cavity 44.

[0081] The molding cavity 44 defines in negative the whole surface development, in shape and size, of the wide wall 11 in its definitive form.

[0082] In this way, the concave portion 20 is advantageously made in its finished form, that is, with a single operation and without needing to subject the first internal surface 16 and the first external surface 17 to further workings.

[0083] Furthermore, thanks to the fact that the shaped surfaces 42 and 43 faithfully reproduce the whole surface development of the first plate 14 and the second plate 15 in their final configuration, it is possible to guarantee that a first plate 14 and a second plate 15 are obtained which respect the required design specifications and, in particular, it is possible to respect the dimensional and geometrical tolerances required for the particular application.

[0084] The second plate 15 too (figs. 4a, 4b, 5, 6a, 6b, 6c) is shaped by molding in a dedicated mold and counter-mold like the first plate 14.

[0085] If both the first plate 14 and the second plate 15 are shaped by molding, independent molding operations are provided on the first plate 14 and the second plate 15, each on its own dedicated mold and counter-mold. Other forms of embodiment on the contrary provide to simultaneously carry out the molding operations on the first 14 and second plate 15, disposing them simultaneously, adjacent and overlapping each other, between the mold 28 and counter-mold 29.

[0086] In particular, in the form of embodiment that provides the mechanical union of the first and second plates 14 and 15, the second plate 15 is obtained by working on machine tools, since the subsequent re-use of the second plate 15, following the replacement of the first plate 14, allows to write off the production cost.

[0087] In the form of embodiment which uses connection material 34 to connect the first plate 14 with the second plate 15, on the contrary, the second plate 15 is also obtained by molding. In this way it is possible to shape the first external surface 17 of the first plate 14 mating

with the second internal surface 18 of the second plate 15 to allow them to be correctly overlapped and subsequently joined together.

[0088] Some forms of embodiment provide that the molding operations are performed cold.

[0089] In other forms of embodiment, the molding is performed hot.

[0090] The method also comprises making the longitudinal grooves 21 on the first plate 14 or on the second plate 15 or on both. Some forms of embodiment provide that the longitudinal grooves 21 are made by chip-removal operations, for example using a multi-tooth miller to reduce the operating times. In particular, the longitudinal grooves 21 are made by milling with a numerical control, so as to obtain high precision.

[0091] The longitudinal grooves 21 can be made before or after the molding operations.

[0092] Other forms of embodiment of the method also provide to make longitudinal notches 23 on the second plate 15.

[0093] The method then comprises a step of connecting the first plate 14 to the second plate 15 so as to define, when they are connected, the wide wall 11 and the cooling channels 22. As described above, the connection can be obtained using at least two alternatives.

[0094] The first alternative provides a mechanical union of the first and second plates 14 and 15, that is, inserting the first screws 24 inside the through clamping holes 25 and the corresponding blind clamping holes 26.

[0095] If the frame 27 is also present, this step also provides to join the frame 27 to the wide wall 11, using second screws 33.

[0096] The second alternative provides to join the first plate 14 and the second plate 15 using a connection material 34. In this case, the first external surface 17 and the second internal surface 18 are covered in a known manner, for example by spraying or spreading said connection material 34.

[0097] If the connection material 34 is a brazing material, it is necessary to proceed with the simultaneous heating of the first plate 14 and the second plate 15 in order to obtain their intimate and permanent coupling.

[0098] In this case, in fact, after the brazing material has been applied, the first plate 14 and the second plate 15 are aligned and overlapped, and are inserted between the same mold 28 and counter-mold 29 used for the molding operations. The latter are provided with a plurality of heating elements, such as for example resistances 31, shown schematically in figs. 9 and 10, which heat the first plate 14 and the second plate 15 to the temperature required by the brazing material, to define their intimate and permanent connection (fig. 9).

[0099] In other forms of embodiment, the mold 28 and counter-mold 29 used for brazing can be different from those used for the molding operations.

[0100] According to a variant, at least one of either the mold 28 or the counter-mold 29 (fig. 10), in this case both, are of the modular type and are divided into a plurality of

molding portions 32a, 32b. In particular, first molding portions 32a are provided, disposed centrally and suitable to define with their action the concave portion 20 of the first and second plates 14 and 15, and second molding portions 32b, which are associated laterally to the first molding portions 32a to define overall the mold 28 and counter-mold 29.

[0101] In particular, the first molding portions 32a of the mold 28 and counter-mold 29 have their respective shaped surfaces 42 and 43 which are shaped mating with the whole surface development of the concave portion 20 of the first and second plates 14 and 15.

[0102] In this way, the sizes of the mold 28 and counter-mold 29 can be modified in width, selectively adding and/or removing second molding portions 32b depending on the width of the first and second plates 14 and 15 to be made and/or joined (fig. 10). The first molding portions 32a remain substantially the same, even if crystallizers are made that have different widths of the first and second plates 14 and 15.

[0103] Subsequent steps provide possible workings such as, for example, making notches, holes, seatings for keys and/or tongues.

[0104] According to the invention, the molding operation to which at least the first plate 14 is subjected to obtain the first internal surface 16 determines various construction advantages including, mainly, a reduction in the manufacturing times, given that the molding operation is instantaneous compared with chip-removal operations.

[0105] Furthermore, a reduction is advantageously obtained in the manufacturing costs, due both to the equipment used and also to the limited quantity of material to be worked by chip-removal.

[0106] Advantageously, a first internal surface 16 is obtained having a surface quality that is in any case adequate because it is made for example from rolled sheet and suitable to generate a good surface quality of the slab exiting.

[0107] It is clear that modifications and/or additions of parts may be made to the method and crystallizer as described heretofore, without departing from the field and scope of the present invention.

[0108] For example, as shown in fig. 1, the narrow walls 12 of the crystallizer 10 can also be made in the same way as described with reference to the wide walls 11. In particular, in this case too, it is provided that the narrow walls 12 comprise an internal plate 38 and an external plate 39, reciprocally connected with each other in one of the ways described above for the first plate 14 and the second plate 15.

[0109] In this case too, it may be provided that on at least one of either the internal plate 38 or the external plate 39 longitudinal grooves are made in their reciprocal interface surface, to define channels 22 for the passage of cooling liquid.

[0110] Furthermore, in the same way as described above for the wide walls 11, the narrow walls can also

be provided with longitudinal and/or transverse notches to allow to compensate for dilations of the material.

5 Claims

1. Method to manufacture a crystallizer (10) with plates for continuous casting of slabs comprising at least two wide walls (11), facing each other and each provided with at least one plate (14, 15), said method comprising the making of at least one of said wide walls (11) having at least one concave portion (20) in its surface development, **characterized in that** it comprises:

- the making of a molding apparatus (30) provided with a mold (28) and a counter-mold (29), respective shaped surfaces (42, 43) being made in said mold (28) and said counter-mold (29) defining together, when said mold (28) and said counter-mold (29) are closed to each other in the operating molding position, a molding cavity (44), wherein said shaped surfaces (42, 43) faithfully reproduce the whole surface development of respectively an inner and an outer surfaces (16, 17; 18, 19) of at least said plate (14, 15), wherein said molding cavity (44) in turn defines in negative the whole surface development, in shape and size, of at least said plate (14, 15) of said wide walls (11);
- the compression molding of at least said plate (14, 15) closing to each other said mold (28) and said counter-mold (29), to obtain at least said plate (14, 15) directly in the finished form.

2. Method as in claim 1, **characterized in that** during said molding it provides to simultaneously mold, in said molding apparatus (30), two plates (14, 15), adjacent and overlapping with respect to each other, of at least one of said wide walls (11) in order to define an internal surface (16) and an external surface (19) of said wide wall (11), **and in that**, during the making of said molding apparatus (30), it provides to define in said mold (28) and said counter-mold (29) respective shaped surfaces (42, 43) which are shaped in a mating manner to the whole surface development of said internal surface (16) and said external surface (19).

3. Method as in claim 2, **characterized in that** it comprises the coupling of said two plates (14, 15) by means of threaded coupling means (24), or other suitable mechanical means.

4. Method as in claim 2, **characterized in that** it comprises the intimate and permanent coupling of said two plates (14, 15) by means of a connection material (34).

5. Method as in claim 4, **characterized in that** the coupling of said two plates (14, 15) provides brazing or gluing by means of a brazing and a gluing material.
6. Method as in claim 4 or 5, **characterized in that** the coupling of said two plates (14, 15) provides to interpose a brazing material between them, to simultaneously heat said plates (14, 15) to the temperature required by said brazing material and to put said plates (14, 15) in contact under pressure in order to define their intimate and permanent connection.
7. Method as in claim 6, **characterized in that** the heating and putting in contact under pressure of said two plates (14, 15) is carried out, in said molding apparatus (30), during the molding of said plates (14, 15).
8. Method as in any claim hereinbefore, **characterized in that** it comprises the making in said wide wall (11) of a plurality of channels (22) able to allow the passage of a cooling fluid.
9. Method as in any claim from 2 to 7 and in claim 8, **characterized in that** the making of said channels (22) provides to make a plurality of longitudinal grooves (21) on at least one of said two plates (14, 15), said longitudinal grooves (21) being made open toward the outside and suitable to be closed by the other of said two plates (15, 14) in order to define said channels (22) for the passage of a cooling fluid.
10. Method as in claim 9, **characterized in that** at least through the more external of the plates (14, 15) at least a drainage channel (36) is made, configured to discharge said cooling fluid that leaks from between said two plates (14, 15).
11. Method as in any claim from 2 to 10, **characterized in that** a plurality of notches (23, 35), configured to compensate thermal dilations, are made on at least one of said two plates (14, 15).
12. Method as in any claim hereinbefore, **characterized in that** said shaped portion (20) has a concave profile at least in correspondence to the central part of the face, which is internal during use, of said wide wall (11).
13. Method as in any claim hereinbefore, **characterized in that** the method provides that at least one of either the mold (28) and counter-mold (29) are of the modular type and are longitudinally divided into a plurality of molding portions (32a, 32b), and it provides that the sizes of said mold (28) and counter-mold (29) are adjustable selectively adding or removing molding portions (32b) laterally positioned with respect to the concave portion (20) of the side walls (11) depending on the width of said plates (14, 15).

14. Molding apparatus to make a crystallizer (10) with plates for the continuous casting of slabs, said crystallizer (10) with plates comprising at least two wide walls (11) facing each other and each provided with at least one plate (14, 15), at least one of said wide walls (11) being provided, in its surface development, with at least a shaped portion (20), **characterized in that** it comprises at least a mold (28) and a counter-mold (29), each provided with respective shaped surfaces (42, 43) defining together, when said mold (28) and said counter-mold (29) are closed to each other in the operating molding position, a molding cavity (44), wherein said shaped surfaces (42, 43) faithfully reproduce the whole surface development of respectively an inner and an outer surface (16, 17; 18, 19) of at least said plate (14, 15), wherein said molding cavity (44) in turn defines in negative the whole surface development, in shape and size, of at least said plate (14, 15) of said wide walls (11).

15. Apparatus as in claim 14, **characterized in that** at least one of either said mold (28) or said counter-mold (29) is the modular type, and are longitudinally divided into a plurality of molding portions (32a, 32b), wherein the first molding portions (32a) are disposed centrally and shaped mating with said shaped portion (20) of said wide walls (11), and the second molding portions (32b) are connected laterally to said first molding portions (32a) in order to define overall the adjustable width of said mold (28) and said counter-mold (29).

16. Apparatus as in claim 14 or 15, **characterized in that** at least one of either said mold (28) or said counter-mold (29) comprises a plurality of heating elements (31).

Patentansprüche

1. Verfahren zum Herstellen eines Kristallisators (10) mit Platten für das Stranggießen von Brammen, der mindestens zwei breite Wände (11) aufweist, die einander zugewandt sind und jeweils mit mindestens einer Platte (14, 15) versehen sind, wobei das Verfahren das Herstellen von mindestens einer der breiten Wände (11) mit mindestens einen konkaven Abschnitt (20) in ihrer Oberflächenentwicklung aufweist, **dadurch gekennzeichnet, dass** es aufweist:

- die Herstellung einer Formvorrichtung (30), die mit einer Form (28) und einer Gegenform (29) versehen ist, wobei jeweilige geformte Oberflächen (42, 43) in der Form (28) und der Gegenform (29) hergestellt werden, die, wenn sich die Form (28) und die Gegenform (29) zueinander geschlossen in der Betriebsformposition befinden,

- den, zusammen einen Formhohlraum (44) definieren, wobei die geformten Oberflächen (42, 43) treu die gesamte Oberflächenentwicklung von jeweils einer inneren und einer äußeren Oberfläche (16, 17; 18, 19) von mindestens der Platte (14, 15) reproduzieren, wobei der Formhohlraum (44) seinerseits die gesamte Oberflächenentwicklung, und zwar in Form und Größe, von mindestens der Platte (14, 15) der breiten Wände (11) negativ definiert;
- das Formpressen der mindestens einer Platte (14, 15), wobei die Form (28) und die Gegenform (29) zueinander geschlossen wird, um von mindestens der Platte (14, 15) direkt in der endbearbeiteten Form zu erhalten.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es während des Formens dafür sorgt, in der Formvorrichtung (30) zwei Platten (14, 15), die anliegend sind und überlappend in Bezug aufeinander, von mindestens einer der breiten Wände (11) gleichzeitig zu formen, um eine innere Oberfläche (16) und eine äußere Oberfläche (19) der breiten Wand (11) zu definieren, **und dadurch, dass** während der Herstellung der Formvorrichtung (30) es vorsieht, in der Form (28) und der Gegenform (29) jeweilige geformte Oberflächen (42, 43), die auf eine gegenstückartig zusammenpassende Weise zu der gesamten Oberflächenentwicklung der inneren Oberfläche (16) und der äußeren Oberfläche (19) geformt sind, zu definieren.
 3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** es die Kupplung der zwei Platten (14, 15) mittels Gewindekupplungsmitteln (24) oder anderen geeigneten mechanischen Mitteln aufweist.
 4. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** es die dichte und permanente Kupplung der zwei Platten (14, 15) mittels eines Verbindungsmaterials (34) aufweist.
 5. Verfahren nach Anspruch 4, **dadurch gekennzeichnet, dass** die Kupplung der zwei Platten (14, 15) (Hart-)Löten oder Kleben mittels eines (Hart-)Löt- und einen Klebematerials vorsieht.
 6. Verfahren nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** die Kupplung der zwei Platten (14, 15) vorsieht, ein (Hart-)Lötmaterial zwischen diesen dazwischenzusetzen, um die zwei Platten (14, 15) gleichzeitig auf die geforderte Temperatur des (Hart-)Lötmaterials zu erhitzen, und um die Platten (14, 15) unter Druck in Kontakt zu bringen, um deren dichte und dauerhafte Verbindung zu definieren.
 7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** das Erhitzen und unter Druck in Kontakt Bringen der beiden Platten (14, 15), in der Formvorrichtung (30), während des Formens der Platten (14, 15), durchgeführt wird.
 8. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es das Herstellen einer Vielzahl von Kanälen (22) in der breiten Wand (11), die den Durchlass eines Kühlfluids ermöglicht, aufweist.
 9. Verfahren nach einem der Ansprüche 2 bis 7 und nach Anspruch 8, **dadurch gekennzeichnet, dass** die Herstellung der Kanäle (22) vorsieht, eine Vielzahl von Längsnuten (21) auf mindestens einer der zwei Platten (14, 15) herzustellen, wobei die Längsnuten (21) nach außen offen und geeignet hergestellt werden, um von der anderen der zwei Platten (15, 14) geschlossen zu werden, um die Kanäle für den Durchlass eines Kühlfluids zu definieren.
 10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** wenigstens durch die äußere der Platten (14, 15) wenigstens ein Ablasskanal (36) hergestellt ist, der so aufgebaut ist, dass er das Kühlfluid ablässt, das von zwischen den zwei Platten leckt (14, 15).
 11. Verfahren nach einem der Ansprüche 2 bis 10, **dadurch gekennzeichnet, dass** eine Vielzahl von Kerben (23, 35), die zum Kompensieren thermischen Ausdehnungen aufgebaut sind, auf mindestens einer der zwei Platten (14, 15) hergestellt wird.
 12. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der geformte Abschnitt (20) ein konkaves Profil hat, zumindest in Korrespondenz zu dem zentralen Teil der Seite der breiten Wand (11), die während der Verwendung innen ist.
 13. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Verfahren vorsieht, dass mindestens eine von entweder der Form (28) oder der Gegenform (29) vom modularen Typ ist und in Längsrichtung in eine Vielzahl von Formabschnitten (32a, 32b) unterteilt ist, und es vorsieht, dass die Größen der Form (28) und Gegenform (29) einstellbar sind, und zwar durch selektives Hinzufügen oder Entfernen von Formabschnitten (32b), die seitlich in Bezug auf den konkaven Abschnitt (20) der Seitenwände (11) positioniert sind, und zwar in Abhängigkeit von der Breite der Platten (14, 15).
 14. Formvorrichtung zum Herstellen eines Kristallisators (10) mit Platten für das Stranggießen von Brammen, wobei der Kristallisator (10) mit Platten min-

destens zwei einander zugewandte, und jede mit mindestens einer Platte (14, 15) versehene, breite Wände (11) aufweist, wobei mindestens eine der breiten Wände (11) in ihrer Oberflächenentwicklung mit mindestens einem geformten Abschnitt (20) versehen ist, **dadurch gekennzeichnet, dass** sie mindestens eine Form (28) und eine Gegenform (29) aufweist, welche jeweils mit entsprechenden geformten Oberflächen (42, 43) versehen ist, die zusammen, wenn die Form (28) und die Gegenform (29) zueinander geschlossen in der Betriebsformposition sind, einen Formhohlraum (44) definieren, wobei die geformten Oberflächen (42, 43) treu die gesamte Oberflächenentwicklung von jeweils einer inneren und einer äußeren Oberfläche (16, 17; 18, 19) von mindestens der Platte (14, 15) reproduzieren, wobei der Formhohlraum (44) seinerseits die gesamte Oberflächenentwicklung, und zwar in Form und Größe, der mindestens einen Platte (14, 15) der breiten Wände (11) negativ definiert.

15. Vorrichtung nach Anspruch 14, **dadurch gekennzeichnet, dass** mindestens eine von entweder der Form (28) oder der Gegenform (29) der modulare Typ ist, und in Längsrichtung in eine Vielzahl von Formabschnitten (32a, 32b) unterteilt sind, wobei die ersten Formabschnitte (32a) zentral angeordnet und auf eine gegenstückartig zusammenpassende Weise zum geformten Abschnitt (20) der breiten Wände (11) geformt sind, und die zweiten Formabschnitte (32b), seitlich mit den ersten Formabschnitten (32a) verbunden sind, um insgesamt die einstellbare Breite der Form (28) und der Gegenform (29) zu definieren.
16. Vorrichtung nach Anspruch 14 oder 15, **dadurch gekennzeichnet, dass** mindestens eine von entweder der Form (28) oder der Gegenform (29) eine Vielzahl von Heizelementen (31) aufweist.

Revendications

1. Méthode de fabrication d'un cristallisateur (10) à plaques pour la coulée continue de brames comprenant au moins deux parois larges (11), se faisant face et munies chacune d'au moins une plaque (14, 15), ladite méthode comprenant la réalisation d'au moins une desdites parois larges (11) ayant au moins une partie concave (20) dans son développement de surface, **caractérisée en ce qu'elle comprend :**
- la réalisation d'un dispositif de moulage (30) muni d'un moule (28) et d'un contre-moule (29), des surfaces mises en forme respectives (42, 43) étant réalisées dans ledit moule (28) et ledit contre-moule (29) en définissant ensemble, lorsque ledit moule (28) et ledit contre-moule

(29) sont fermés l'un par rapport à l'autre dans la position de moulage opérationnelle, une cavité de moulage (44), dans laquelle lesdites surfaces mises en forme (42, 43) reproduisent fidèlement le développement de surface d'ensemble de surfaces respectivement interne et externe (16, 17; 18, 19) d'au moins ladite plaque (14, 15), dans laquelle ladite cavité de moulage (44) définit à son tour en négatif le développement de surface d'ensemble, en forme et en taille, d'au moins ladite plaque (14, 15) desdites parois larges (11) ;

- le moulage par compression d'au moins ladite plaque (14, 15) en fermant ledit moule (28) et ledit contre-moule (29) l'un par rapport à l'autre, pour obtenir au moins ladite plaque (14, 15) directement sous la forme finie.

2. Méthode selon la revendication 1, **caractérisée en ce que** pendant ledit moulage, il est prévu de mouler simultanément, dans ledit dispositif de moulage (30), deux plaques (14, 15), adjacentes et se chevauchant l'une par rapport à l'autre, d'au moins une desdites parois larges (11) pour définir une surface interne (16) et une surface externe (19) de ladite paroi large (11), **et en ce que**, lors de la fabrication dudit dispositif de moulage (30), il est prévu de définir dans ledit moule (28) et dans ledit contre-moule (29) des surfaces mises en forme respectives (42, 43) qui sont mises en forme de manière à correspondre à au développement de surface d'ensemble de ladite surface interne (16) et de ladite surface externe (19).
3. Méthode selon la revendication 2, **caractérisée en ce qu'elle** comprend le couplage desdites deux plaques (14, 15) par l'intermédiaire de moyens de couplage filetés (24), ou d'autres moyens mécaniques appropriés.
4. Méthode selon la revendication 2, **caractérisée en ce qu'elle** comprend le couplage intime et permanent desdites deux plaques (14, 15) par l'intermédiaire d'un matériau de connexion (34).
5. Méthode selon la revendication 4, **caractérisée en ce que** le couplage desdites deux plaques (14, 15) permet le brasage ou le collage au moyen d'un matériau de brasage et d'un matériau de collage.
6. Méthode selon la revendication 4 ou 5, **caractérisée en ce que** le couplage desdites deux plaques (14, 15) permet d'interposer un matériau de brasage entre elles, de chauffer simultanément lesdites plaques (14, 15) à la température requise par ledit matériau de brasage et de mettre lesdites plaques (14, 15) en contact sous pression pour définir leur connexion intime et permanente.

7. Méthode selon la revendication 6, **caractérisée en ce que** le chauffage et la mise en contact sous pression desdites deux plaques (14, 15) sont effectués, dans ledit dispositif de moulage (30), lors du moulage desdites plaques (14, 15). 5
8. Méthode selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'il** comprend la réalisation dans ladite paroi large (11) d'une pluralité de canaux (22) aptes à permettre le passage d'un fluide de refroidissement. 10
9. Méthode selon l'une quelconque des revendications 2 à 7 et selon la revendication 8, **caractérisée en ce que** la réalisation desdits canaux (22) permet de réaliser une pluralité de rainures longitudinales (21) sur au moins une desdites deux plaques (14, 15), lesdites rainures longitudinales (21) étant rendues ouvertes vers l'extérieur et aptes à être fermées par l'autre desdites deux plaques (15, 14) afin de définir lesdits canaux (22) pour le passage d'un fluide de refroidissement. 15 20
10. Méthode selon la revendication 9, **caractérisée en ce qu'au moins un canal de drainage** (36) est réalisé au moins à travers la plus externe des plaques (14, 15), configuré pour évacuer ledit fluide de refroidissement qui fuit d'entre lesdites deux plaques (14, 15). 25 30
11. Méthode selon l'une quelconque des revendications 2 à 10, **caractérisée en ce que** plusieurs encoches (23, 35), configurées pour compenser des dilatations thermiques, sont réalisées sur au moins une desdites deux plaques (14, 15). 35
12. Méthode selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ladite partie mise en forme (20) présente un profil concave au moins en correspondance avec la partie centrale de la face, qui est interne en utilisation, de ladite paroi large (11). 40
13. Méthode selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la méthode prévoit qu'au moins un parmi le moule (28) et le contre-moule (29) soit du type modulaire et soit divisé longitudinalement en une pluralité de parties de moulage (32a, 32b), et prévoit que les dimensions desdits moule (28) et contre-moule (29) sont ajustables sélectivement en ajoutant ou en retirant des parties de moulage (32b) positionnées latéralement par rapport à la partie concave (20) des parois latérales (11) en fonction de la largeur desdites plaques (14, 15). 45 50 55
14. Dispositif de moulage pour réaliser un cristallisateur (10) à plaques pour la coulée continue de brames, ledit cristallisateur (10) à plaques comportant au moins deux parois larges (11) se faisant face et chacune pourvue d'au moins une plaque (14, 15), au moins une desdites parois larges (11) étant pourvue, dans son développement de surface, d'au moins une partie mise en forme (20), **caractérisé en ce qu'il** comprend au moins un moule (28) et un contre-moule (29), chacun étant pourvu de surfaces mises en forme respectives (42, 43) définissant ensemble, lorsque ledit moule (28) et ledit contre-moule (29) sont fermés l'un par rapport à l'autre dans la position de moulage opérationnelle, une cavité de moulage (44), dans lequel lesdites surfaces mises en forme (42, 43) reproduisent fidèlement le développement de surface d'ensemble de surfaces respectivement interne et externe (16, 17 ; 18, 19) d'au moins ladite plaque (14, 15), dans lequel ladite cavité de moulage (44) définit à son tour le développement de surface d'ensemble, en forme et en taille, d'au moins ladite plaque (14, 15) desdites parois larges (11).
15. Dispositif selon la revendication 14, **caractérisé en ce qu'au moins l'un dudit moule** (28) ou dudit contre-moule (29) est du type modulaire, et est divisé longitudinalement en une pluralité de parties de moulage (32a, 32b), dans lequel les premières parties de moulage (32a) sont disposées au centre et mise en forme avec ladite partie mise en forme (20) desdites parois larges (11), et les secondes parties de moulage (32b) sont connectées latéralement auxdites premières parties de moulage (32a) afin de définir globalement la largeur ajustable dudit moule (28) et dudit contre-moule (29).
16. Dispositif selon la revendication 14 ou 15, **caractérisé en ce qu'au moins un dudit moule** (28) ou dudit contre-moule (29) comprend une pluralité d'éléments chauffants (31).

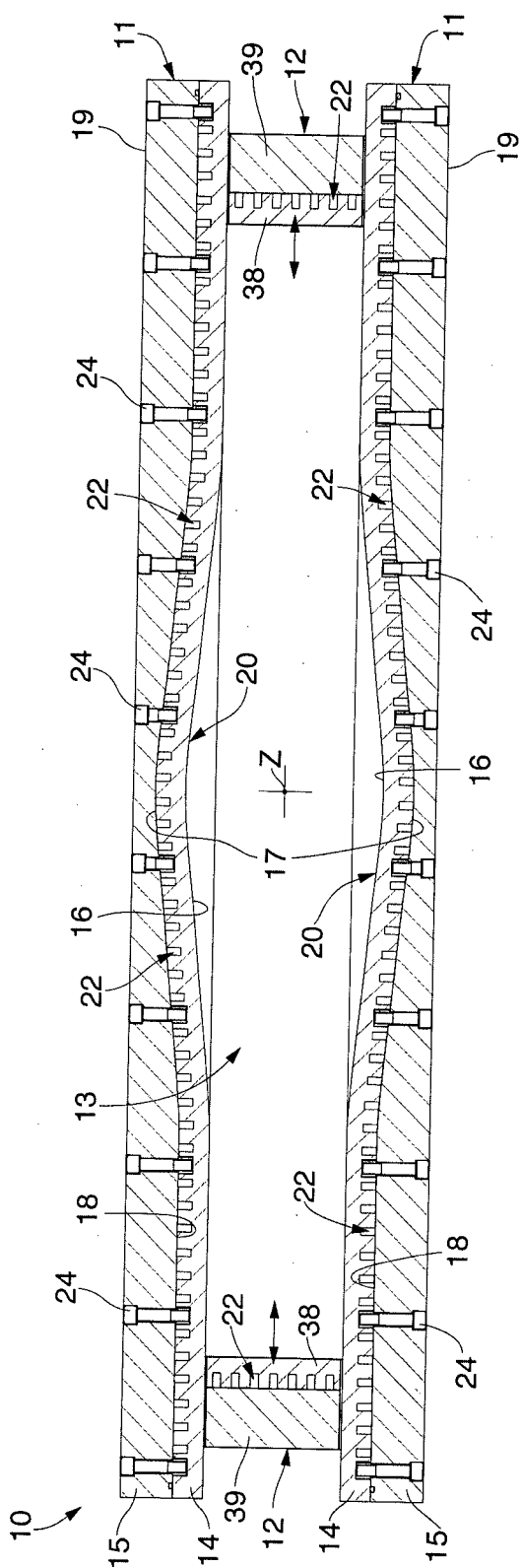


fig. 1

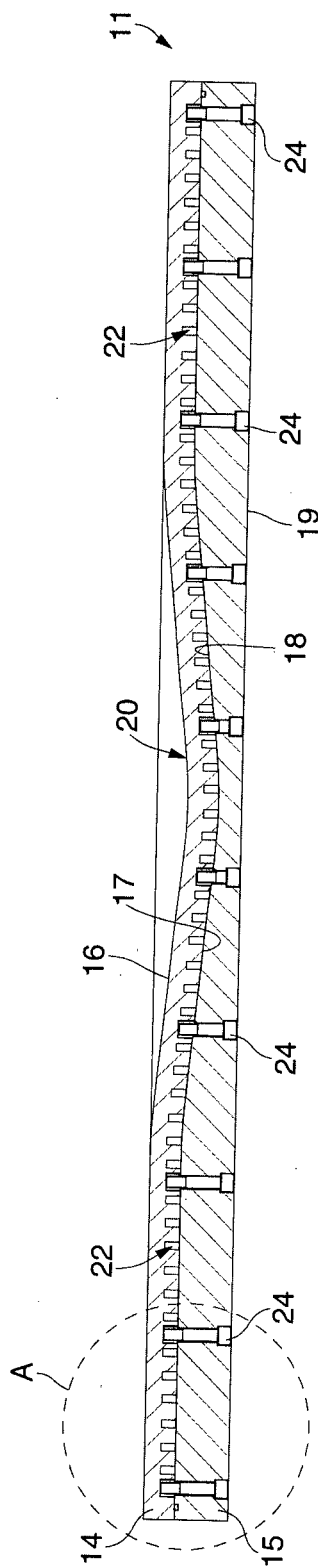


fig. 2

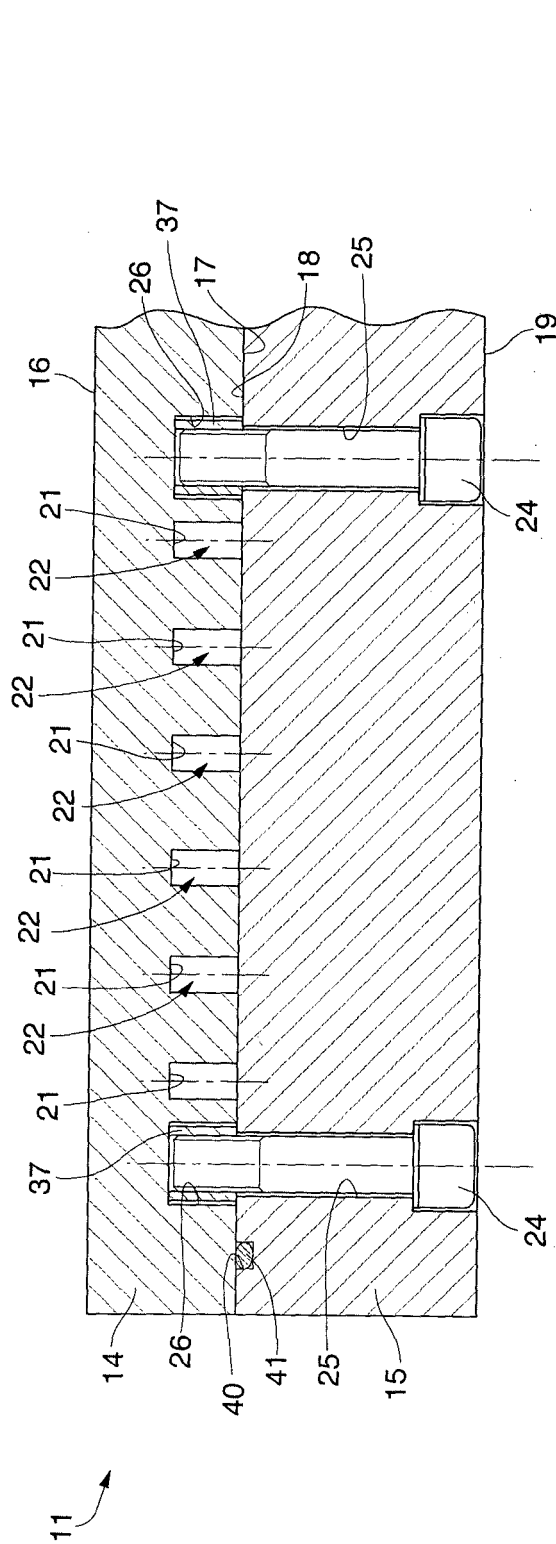


fig. 3

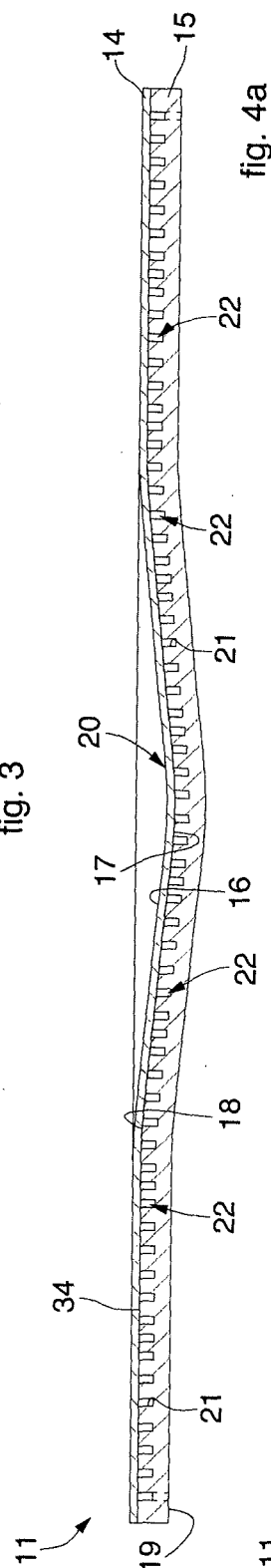


fig. 4a

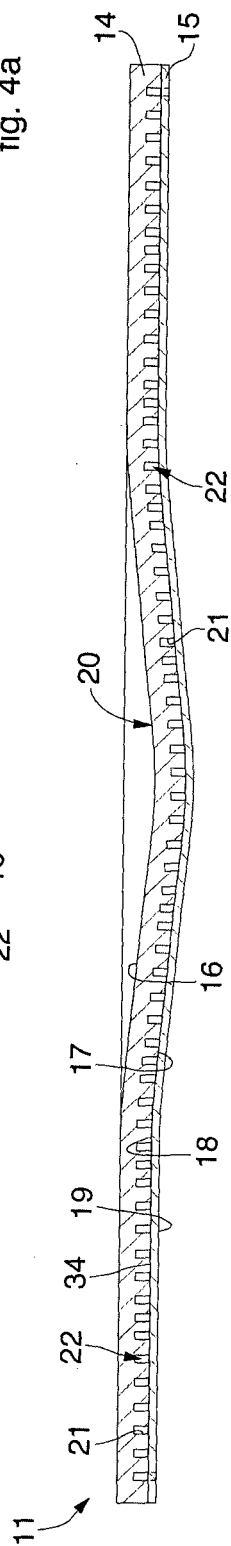


fig. 4b

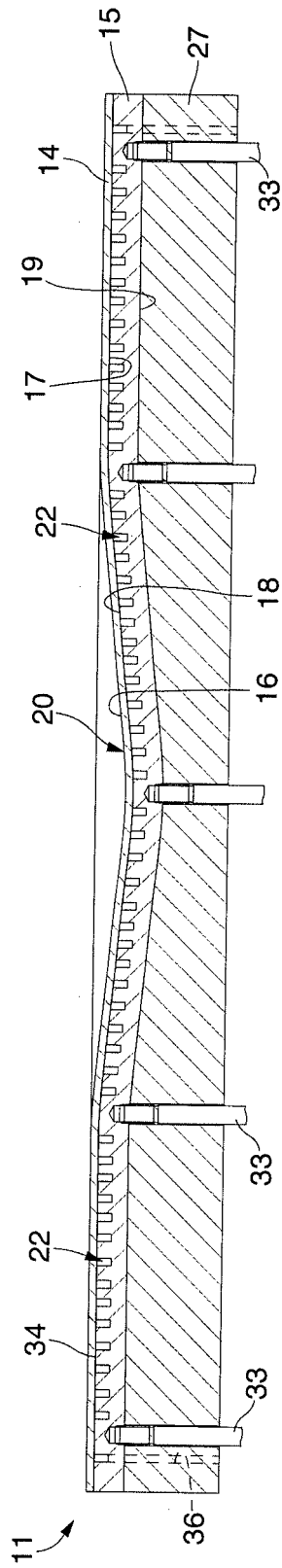


fig. 5

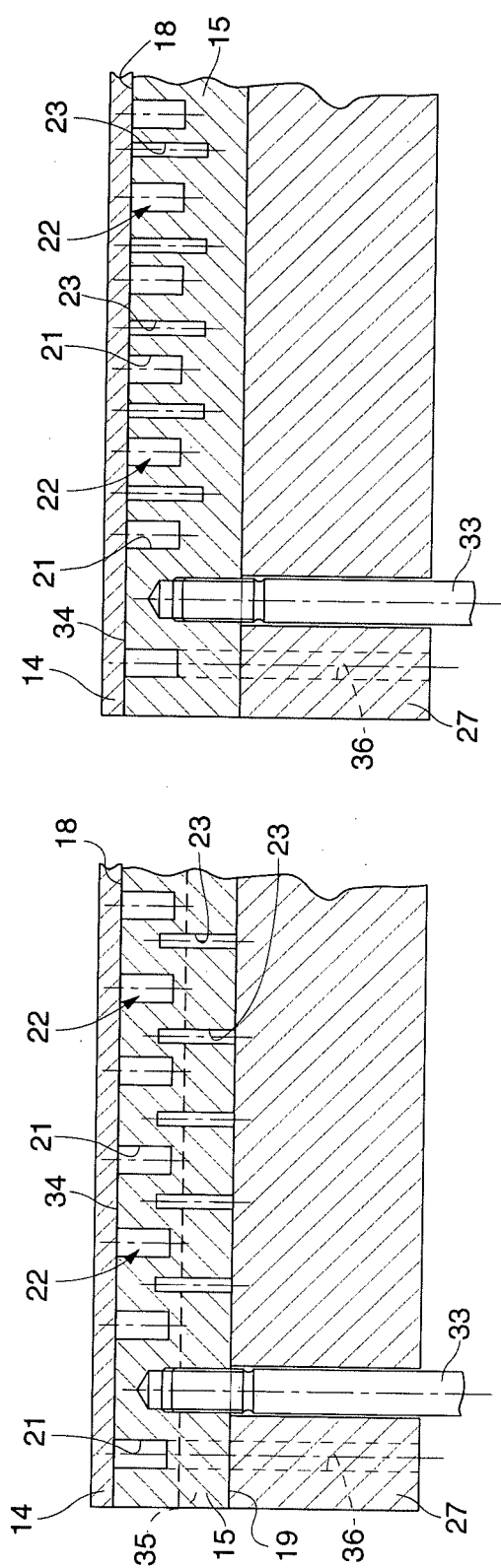


fig. 6a

fig. 6b

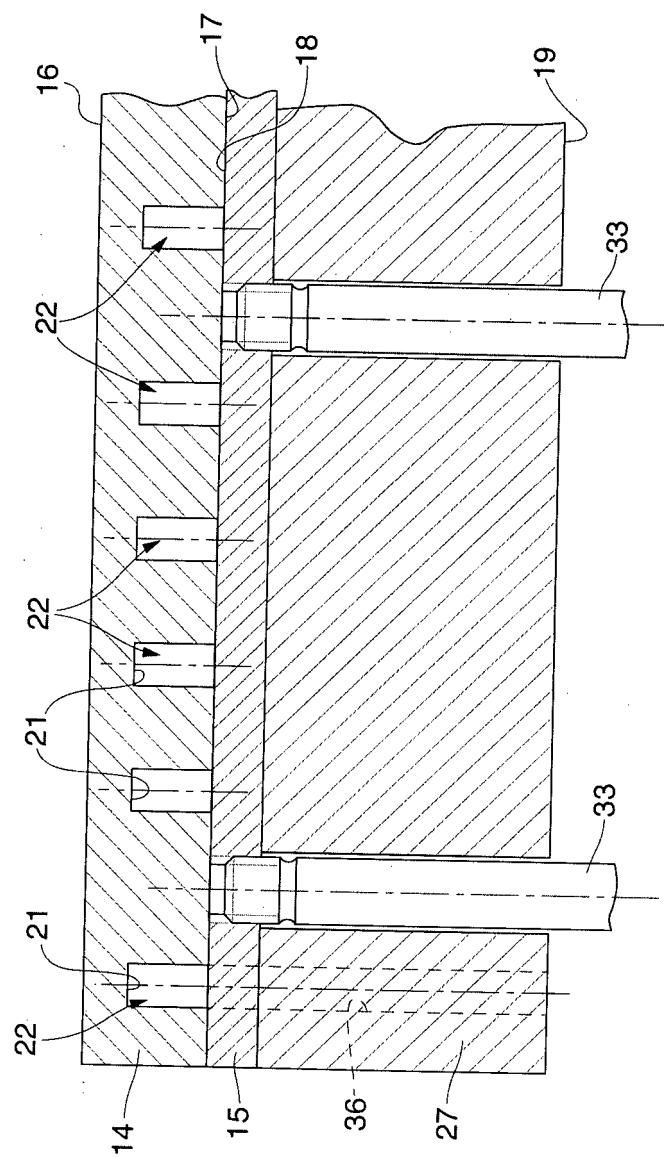
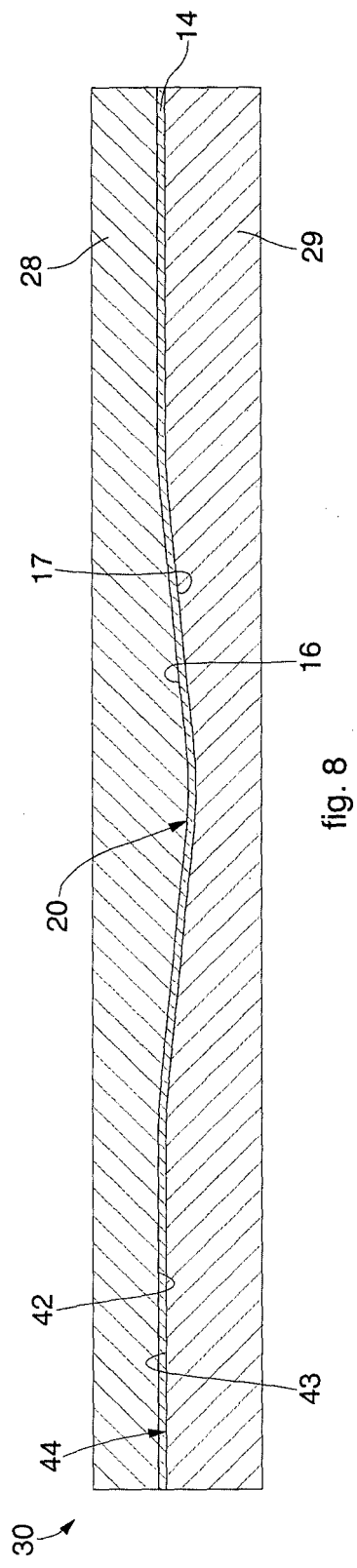
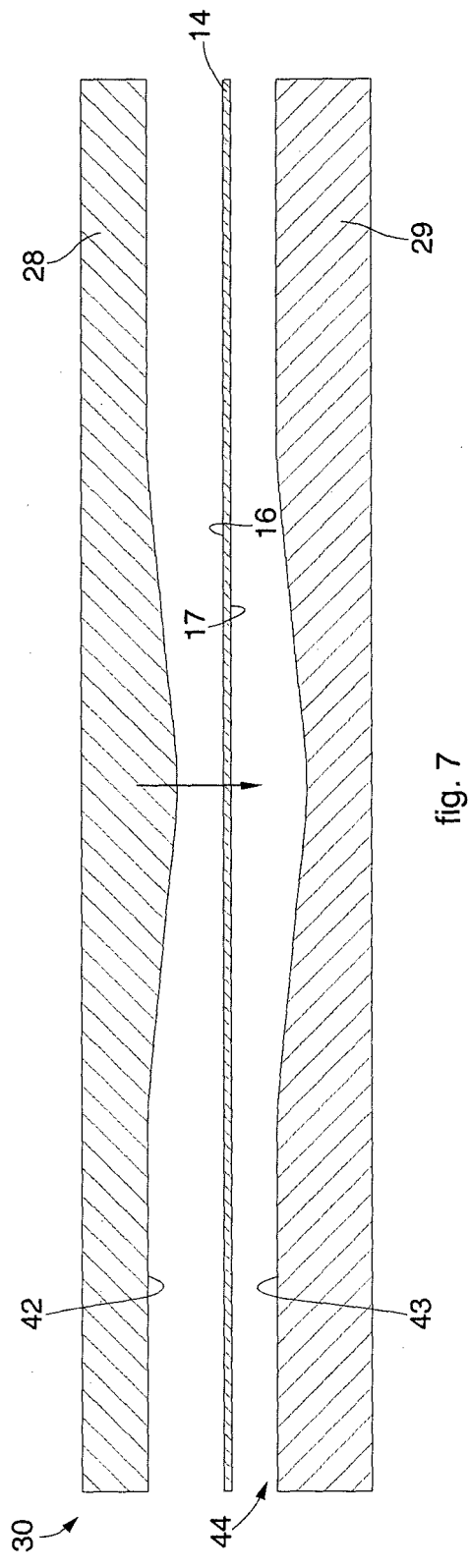
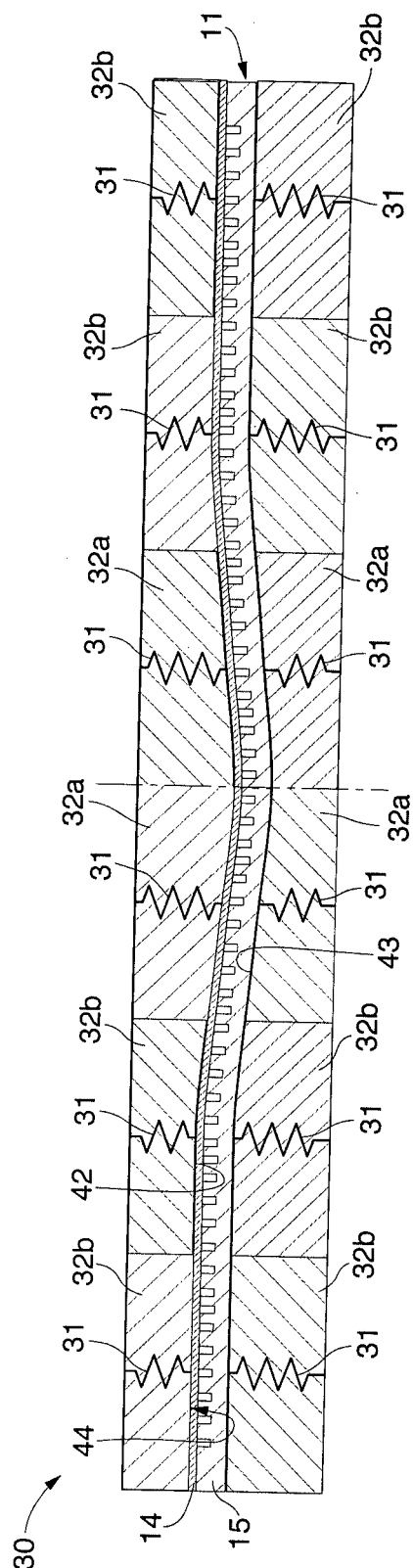
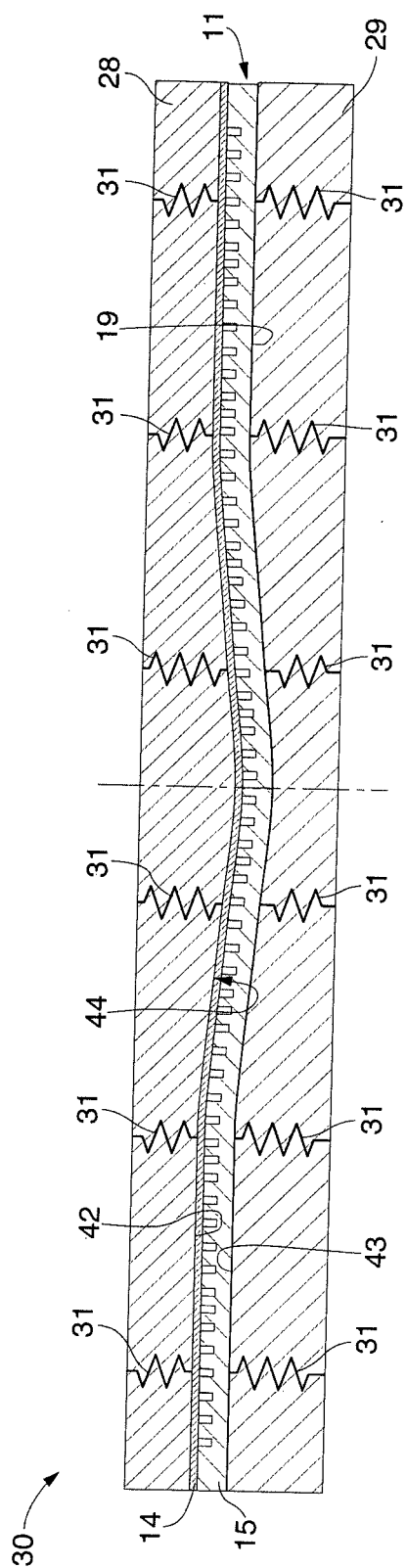


fig. 6c





REFERENCES CITED IN THE DESCRIPTION

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