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(54) **CASTER TIP ARRANGEMENT FOR A CONTINUOUS CASTER**

(57) A caster tip arrangement (10) for a continuous caster (100) for casting an object (103) from a melt (101) with molten metal is proposed. The caster tip arrangement (10) comprises a first caster plate (12), a second caster plate (14) arranged opposite to the first caster plate (12), an inlet (18) for receiving a melt (101) with molten metal, an outlet (20) for discharging the melt (101) in a discharging direction (22), and at least one heating device (42). The first caster plate (12) and the second caster plate (14) are spaced apart from each other to form a guiding compartment (16) for guiding the melt (101) from the inlet (18) to the outlet (20), wherein at least a portion (30) of the guiding compartment (16) is divergently formed, such that the guiding compartment (16) extends from the inlet (18) to a first lateral boundary region (34) and a second lateral boundary region (36) of the caster tip arrangement (10) arranged opposite to the first lateral boundary region (34) in a longitudinal extension direction (29) of the caster tip arrangement (10) transverse to the discharging direction (22). Therein, the at least one heating device (42) is configured to locally heat the caster tip arrangement (10) in at least one of the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10).

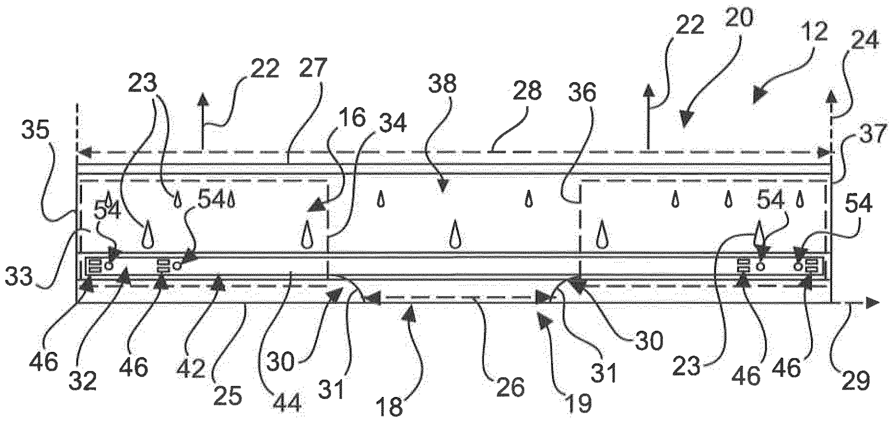

Fig.3B

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Description

Field of the Invention

[0001] Generally, the invention relates to casting an object from a melt comprising molten metal and/or to casting of molten metal into a solidified object, such as e.g. a sheet, a plate, a bar, an ingot, a strip or the like. Particularly, the invention relates to a caster tip arrangement for a continuous caster, a use of such caster tip arrangement in a continuous caster, a continuous caster with such caster tip arrangement, and a method for operating a continuous caster comprising such caster tip arrangement.

Background of the Invention

[0002] For casting an object, such as e.g. a sheet, a plate, a bar, an ingot, a strip or the like, from a melt comprising molten metal, various methods and devices have been developed.

[0003] An exemplary casting method is the so-called strip casting and/or continuous casting using a continuous caster and/or a continuous caster device, such as e.g. a block caster, a twin-roll caster and/or a twin-belt caster. Therein, a material comprising metal and/or an alloy is molten, e.g. by means of a melting furnace, and then supplied to a moving casting mold of the continuous caster, which may comprise e.g. a block chain arrangement with at least one moving block chain, a roll arrangement with at least one roll and/or a belt arrangement with at least one belt, for forming a metal strip. For the purpose of supplying the melt into a gap of the moving casting mold usually a nozzle system and/or a caster tip arrangement is used, wherein the caster tip arrangement comprises an outlet for discharging the melt and guiding the melt to the moving casting mold. The melt is then solidified and a continuous strip and/or metal band may be formed.

Summary of the Invention

[0004] It may be an objective of the present invention to provide an improved caster tip arrangement for a continuous caster for increasing a productivity of the continuous caster and/or for improving a quality of a casted object.

[0005] This objective is solved by the subject-matter of the independent claims, wherein further embodiments are incorporated in the dependent claims and the following description.

[0006] A first aspect of the invention relates to a caster tip arrangement for a continuous caster for casting an object from a melt with molten metal and/or for forming an object from a melt comprising molten metal. By way of example, the object may refer to a sheet, a plate, a bar, an ingot, a strip or any other kind of object. The caster tip arrangement comprises a first caster plate, a second caster plate arranged opposite to the first caster plate, an inlet for receiving a melt with molten metal, an outlet for discharging the melt in a discharging direction of the caster tip arrangement, and at least one heating device for heating at least a part of the caster tip arrangement. The first caster plate and the second caster plate are spaced apart from each other to form a guiding compartment for guiding the melt from the inlet to the outlet. Therein, at least a portion and/or a part of the guiding compartment is divergently formed from the inlet towards the outlet, such that the guiding compartment extends from the inlet to a first lateral boundary region and a second lateral boundary region of the caster tip arrangement. The second lateral boundary region is arranged opposite to the first lateral boundary region in a longitudinal extension direction of the caster tip arrangement transverse to the discharging direction. Further, the at least one heating device is configured to locally heat the caster tip arrangement in at least one of the first lateral boundary region and the second lateral boundary region of the caster tip arrangement. In other words, the at least one heating device may be configured to heat a partial region of the caster tip arrangement, which partial region is arranged and/or located in at least one of the first lateral boundary region and the second lateral boundary region. Also, the heating device may be configured to heat the caster tip arrangement in a first heating zone arranged in the first lateral boundary region and/or in a second heating zone arranged in the second lateral boundary region. Therein, the first heating zone may refer to a partial region of the first lateral boundary region or the first heating zone may refer to the entire first lateral boundary region. Likewise, the second heating zone may refer to a partial region of the second lateral boundary region or the second heating zone may refer to the entire second lateral boundary region. Accordingly, the term first lateral boundary region may refer to the first heating zone and/or the term second lateral boundary region may refer to the second heating zone.

[0007] Generally, the caster tip arrangement may refer to a melt distribution device, a nozzle arrangement and/or a feeding device of the continuous caster. Further, the continuous caster may refer to e.g. a strip caster for forming a strip of a material comprising metal. Particularly, the continuous caster may be configured for forming a strip, a plate, a sheet and/or a slab of material comprising e.g. aluminium, aluminium alloys, magnesium, magnesium alloys, steel, copper, lead, zinc and/or any other metal.

[0008] The first caster plate and the second caster plate may refer to plate-like structures and/or plate-like elements. Particularly, the first caster plate and/or the second caster plate may at least partly be manufactured from refractory material, such as e.g. ceramics material. Such ceramics material may for instance comprise alumina, silica, silicon nitride, refractory ceramic fibers, earth alkaline ceramic fibres, asbestos, sodium silicate and/or any other refractory material based on oxide, nitride, carbide or carbonitride.

[0009] The first caster plate and the second caster plate may be formed as a single part or as a plurality of parts. The first and second caster plates may be arranged substantially parallel to each other in a direction transverse to the discharging direction and/or transverse to the longitudinal extension direction, such that the guiding compartment is formed between the first and second caster plates. Optionally, the caster tip arrangement may comprise a first side panel and a second side panel. The first and second side panels may be arranged opposite to each other in the longitudinal extension direction of the caster tip arrangement. For instance, the first side panel may be arranged on a first outer edge of the caster tip arrangement and/or a first outer edge of the first and second caster plates. Likewise, the second side panel may be arranged on a second outer edge of the caster tip arrangement and/or a second outer edge of the first and second caster plates. Therein, the first and second side panels may connect the first caster plate and the second caster plate. Moreover, the first and second side panels may be configured and/or arranged to seal the guiding compartment on a first side of the caster tip arrangement and on a second side of the caster tip arrangement, respectively.

[0010] The inlet may refer to and/or comprise an inlet opening formed between the first caster plate and the second caster plate, wherein the inlet opening may be configured to receive the melt, e.g. from a headbox and/or a tundish of the continuous caster. Particularly, the inlet may be arranged on a front edge of the caster tip arrangement.

[0011] The outlet may refer to and/or comprise an outlet opening formed between the first caster plate and the second caster plate, wherein the outlet opening may be configured for discharging and/or supplying the melt in the discharging direction to other components of the continuous caster. Particularly, the outlet may be arranged on a rear edge of the caster tip arrangement arranged opposite to the front edge of the caster tip arrangement in the discharging direction. With respect to the inlet, the outlet may be arranged downstream of a streaming direction of the melt through the caster tip arrangement and/or through the guiding compartment, wherein the streaming direction may be substantially parallel to the discharging direction. Further, a length of the outlet may define a casting width over which the melt may be discharged. Therein, the length of the outlet and/or the casting width may be measured substantially parallel to the front edge and/or the rear edge of the caster tip arrangement. Accordingly, the length of the outlet and/or the casting width may be measured in a direction transverse and/or perpendicular to the discharging direction. Moreover, the length of the outlet may be larger than a length of the inlet measured substantially parallel to the front edge and/or the rear edge. Accordingly, also a cross-sectional area, a diameter, a perimeter and/or a circumference of the outlet may be larger than a cross-sectional area, a diameter, a perimeter and/or a circumference of the inlet.

[0012] Generally, the discharging direction may be substantially parallel to a transverse extension direction and/or a lateral extension direction of the caster tip arrangement, which transverse extension direction may be transverse and/or perpendicular to the front edge and/or the rear edge of the caster tip arrangement. By way of example, the discharging direction may be defined by a line connecting a center point of the inlet and a center point of the outlet. Moreover, the longitudinal extension direction of the caster tip arrangement may be substantially transverse and/or perpendicular to the transverse extension direction of the caster tip arrangement.

[0013] Further, the term "guiding compartment" may refer to a passageway and/or a passage for guiding the melt from the inlet to the outlet. The guiding compartment may be formed between the first caster plate and the second caster plate, and optionally between the first side panel and the second side panel. Therein, the guiding compartment may connect the inlet and the outlet of the caster tip arrangement. From the inlet towards the outlet, e.g. along the discharging direction and/or along the transverse extension direction of the caster tip arrangement, a diameter, a cross-sectional area and/or a circumference of the guiding compartment may increase at least in a portion of the guiding compartment, such that at least the portion of the guiding compartment is divergently formed and/or diverges in the longitudinal extension direction. In other words, at least a portion of the guiding compartment between the inlet and the outlet diverges along the longitudinal extension direction transverse to the discharging direction. By means of the at least partly divergently formed guiding compartment the melt may be spread from the inlet to the first lateral boundary region and the second lateral boundary region of the caster tip arrangement. Therein, the melt may be spread and/or distributed over and/or across at least a part of the casting width of the caster tip arrangement.

[0014] The first lateral boundary region may refer to a first outer region of the caster tip arrangement and/or of the guiding compartment. The first lateral boundary region may extend from a first outer edge and/or a first side of the caster tip arrangement along and/or substantially parallel to the longitudinal extension direction of the caster tip arrangement. Likewise, the second lateral boundary region may refer to a second outer region of the caster tip arrangement and/or of the guiding compartment. The second lateral boundary region may extend from a second outer edge and/or a second side of the caster tip arrangement along and/or substantially parallel to the longitudinal extension direction. Therein, the first outer edge and the second outer edge may be arranged opposite to each other in the longitudinal extension direction. As described above, the caster tip arrangement may optionally comprise a first side panel arranged on the first outer edge and a second side panel arranged on the second outer edge. Accordingly, the first lateral boundary region may be arranged adjacent to the first outer edge and/or adjacent to the first side panel. Further, the second lateral boundary region may be arranged adjacent to the second outer edge and/or adjacent to the second side panel.

[0015] Further, the term "locally heat" the caster tip arrangement may mean that the heating device is configured and/or arranged to heat a part of the caster tip arrangement in at least one of the first lateral boundary region and the second lateral boundary region. Also, the term "locally heat" may mean that the heating device is configured and/or arranged to heat the at least a part of the caster tip arrangement with locally variable heating intensity. Particularly, the heating device may be configured and/or arranged to heat only, solely and/or exclusively a partial region of the caster tip arrangement. The partial region heated by the heating device may be located in the first lateral boundary region and/or in the second lateral boundary region. By way of example, the heating device may be configured to heat a first heating zone arranged in the first lateral boundary region and/or to heat a second zone arranged in the second lateral boundary region. However, the heating device may also be configured to heat the entire first lateral boundary region and/or the entire second lateral boundary region. Preferably, the heating device may be configured and/or arranged to at least partly heat both the first lateral boundary region and the second lateral boundary region. Likewise, the heating device may be configured to heat both the first heating zone and the second heating zone. Further, the caster tip arrangement may comprise a center region arranged between the first lateral boundary region and the second lateral boundary region in the longitudinal extension direction, wherein the center region and/or melt in the center region may be heated less than the first lateral boundary region and/or less than the second lateral boundary region. However, the center region may alternatively not be heated by the heating device and/or the center region may be unheated.

[0016] Generally, the present invention may be considered being based on the following findings and insights. In a continuous caster, such as e.g. a strip caster, a melt may be supplied from a melting furnace e.g. via a trench and/or a launder to a moving casting mold, wherein the melt should be homogeneously distributed over the casting width in terms of a volume flow and/or in terms of a temperature distribution. For this purpose, usually the caster tip arrangement is used, which may also be referred to as "caster tip" and/or as "nozzle arrangement". For minimizing heat losses in the caster tip arrangement and/or in the first and second caster plates, the first and second caster plates may be manufactured from refractory ceramic fibers formed in a vacuum forming process. Generally, the first and second caster plates may be sensitive to mechanical strain and stress, which may result in a reduced lifetime. Since the melt inserted into the inlet of the caster tip arrangement is spread by means of the guiding compartment towards the first lateral boundary region and the second lateral boundary region, a temperature gradient of the melt may be present along the longitudinal extension direction due to different flow paths, different lengths of flow paths and/or different residence times of the melt within the guiding compartment. Particularly, a temperature gradient of the melt may be present at the outlet along the length of the outlet and/or over the casting width, which may be defined by the length of the outlet. Therein, the length of the outlet and/or the casting width may be measured along and/or substantially parallel to the longitudinal extension direction of the caster tip arrangement. Specifically, a temperature of the melt may be higher in a center region of the caster tip arrangement and/or a center region of the outlet with respect to the first lateral boundary region and/or a first outer region of the outlet adjacent to the first lateral boundary region. Likewise, the temperature of the melt may be higher in the center region of the caster tip arrangement and/or a center region of the outlet with respect to the second lateral boundary region and/or a second outer region of the outlet adjacent to the second lateral boundary region. Depending on the length of the caster tip arrangement, the length of the outlet and/or the casting width, the temperature differences may be in the range of about 1 °C (about 1 Kelvin) to about 60°C (about 60 Kelvin), particularly in the range of about 5°C (about 5 Kelvin) to about 30°C (about 30 Kelvin). Such inhomogeneity of the temperature may lead to varying solidification conditions of the melt, e.g. when the melt contacts a mold. In turn this may lead to quality relevant defects within the casted object, such as e.g. a casted strip. Moreover, the melt may be overheated in the center region of the caster tip arrangement and/or the center region of the outlet to ensure that the melt in the first and/or second outer regions of the outlet is not solidified before exiting the caster tip. Further, a casting velocity, which may refer to a velocity with which the melt is transferred through the caster tip arrangement, may be indirectly proportional to a maximum temperature of the melt in the caster tip arrangement. As a consequence, the casting velocity may be adapted to the maximum temperature of the melt in the caster tip arrangement. Hence, the casting velocity, a productivity and/or an efficiency of the caster may depend on the temperature gradient over the casting width.

[0017] By heating at least a part of the first lateral boundary region and/or at least a part of the second lateral boundary region by means of the heating device, the temperature gradient over the casting width may be minimized and/or eliminated. This may result in a homogeneous temperature distribution of the melt over the entire length of the outlet and/or over the entire casting width. Accordingly, the casting velocity may be adapted to a much smaller maximum temperature, and the casting velocity may be increased due to a reduction of a heat to be dissipated. In turn, this may lead to a reduction of energy consumption, an increased efficiency and/or an increased productivity of the caster. Apart from that, defects due to varying solidification conditions may be avoided, which may lead to an increased overall quality of the casted object.

[0018] It is to be noted that by means of the heating device also a specific temperature profile of the melt across the casting width may be adjusted and/or controlled, such that e.g. deviations in a roll cooling of a roll arrangement may be compensated by the temperature profile. This may further improve a quality of the casted object.

[0019] Apart from the above-mentioned advantages, actively controlling the temperature of the caster tip arrangement and/or of the melt in the guiding compartment, particularly controlling the temperature of melt near the first and/or second lateral boundary regions, may allow to use stable and/or less sensitive ceramics materials for the first and/or second caster plate, e.g. because the higher heat losses due to enhanced thermal conductivity of more stable and more dense materials might be compensated by the heating device and/or because strain and stress in the first and second caster plates may be reduced. In turn, this may increase overall equipment efficiency and/or reduce downtime and maintenance time for the caster. Also, a contamination of the casted object with material of the caster tip arrangement may be reduced and/or avoided, e.g. since spacers normally used to ensure separation of the first caster plate and the second caster plate may be avoided.

[0020] According to an embodiment, the first lateral boundary region extends from a first outer edge of the caster tip arrangement to maximal 35% of a total length of the caster tip arrangement in the longitudinal extension direction of the caster tip arrangement. Alternatively or additionally the second lateral boundary region extends from a second outer edge of the caster tip arrangement to maximal 35% of a total length of the caster tip arrangement in the longitudinal extension direction. Accordingly, each of the first lateral boundary region and the second lateral boundary region may comprise an area of maximal 35% of a total area of the caster tip arrangement. Also, each of the first lateral boundary region and the second lateral boundary region may comprise a volume of maximal 35% of a total volume of the caster tip arrangement and/or of a total volume of the guiding compartment. By actively heating only a part of or the entire first and/or second lateral boundary region, it may be ensured that the temperature gradient over the length of the outlet and/or over the casting width is minimized.

[0021] According to an embodiment, the heating device is configured to heat the melt in at least a part of at least one of the first lateral boundary region and the second lateral boundary region to a melt temperature of about 1 °C (about 1 Kelvin) to about 60°C (about 60 Kelvin) above a melting temperature of the molten metal comprised in the melt, particularly a melt temperature of 1°C (about 1 Kelvin) to about 30°C (about 30 Kelvin) above the melting temperature, and preferably a melt temperature of about 1°C(about 1 Kelvin) to about 15°C (about 15 Kelvin) above the melting temperature. This may allow to minimize and/or eliminate the temperature gradient and/or temperature differences of the melt across the casting width. Alternatively or additionally the at least one heating device is configured to heat the melt in at least a part of at least one of the first lateral boundary region and the second lateral boundary region to a temperature of about 1 °C (about 1 Kelvin) to about 60°C (about 60 Kelvin), particularly about 1°C (about 1 Kelvin) to about 30°C (about 30 Kelvin), and preferably about 1°C (about 1 Kelvin) to about 15°C (about 15 Kelvin), above a liquidus temperature of the melt, of the molten metal and/or of a molten alloy. By way of example, the melt may comprise aluminium, which may have a liquidus temperature of about 660°C (about 933.15 Kelvin). By heating at least a part of the first lateral boundary region and the second lateral boundary region as well as the melt crossing the first and/or second lateral boundary region, the melt may have a homogeneous temperature of about 661°C (about 934.15 Kelvin) to about 690°C (about 963.15 Kelvin), preferably about 670°C (about 943.15 Kelvin), at the outlet over the entire casting width. Accordingly, the heating device may be configured to heat the molten metal in at least a part of at least one of the first lateral boundary region and the second lateral boundary region to a melt temperature of about 661°C (about 934.15 Kelvin) to about 720 °C (about 993.15 Kelvin).

[0022] In accordance with the above-mentioned temperatures and/or temperature differences over the casting width, the heating device may be configured to provide an appropriate heating power. This heating power may depend on a strip speed v of the formed strip, a strip thickness d of the formed strip, and a temperature difference ΔT between a center and lateral edges of the strip. The heating device may be configured to compensate the temperature difference ΔT over a width W of the heating device by providing a heating power P. The heating power P normalized to the width W P/W is given as the product of the strip speed v, the strip thickness d, the temperature difference ΔT, a thermal capacity, and a density of the molten metal. Assuming typical values for these parameters, particularly a temperature difference of about 15°C, a strip speed of about 0.05 m/s, a strip thickness of about 0.005 m, a thermal capacity of about 1000 J/K/kg for aluminium, and a density of about 2700 kg/m^3 for aluminium, the heating device may be configured to provide a normalized heating power P/W of about 10125 Watt/meter. Accordingly, the heating device may be configured to provide about 10 kW heating power per meter width of the heating device.

[0023] According to an embodiment, the heating device comprises at least one heating element arranged between the first caster plate and the second caster plate. The heating device may also comprise a plurality of heating elements arranged between the first caster plate and the second caster plate. Particularly, at least one heating element may be arranged in the guiding compartment and/or may be in direct contact with the guiding compartment. This may allow to directly heat the melt within the guiding compartment and/or to increase a heat input into the melt. Also, a temperature of the melt may be controlled more precisely and/or energy may be saved. However, it should be noted that the at least one heating element may also be arranged on an outer surface of at least one of the first caster plate and the second caster plate. Generally, the heating element may be configured to actively heat at least a part of at least one of the first lateral boundary region and the second lateral boundary region. The at least one heating element may be e.g. an electrical heating element, a resistive heating element and/or any other kind of heating element.

[0024] According to an embodiment, the heating device comprises at least one heating element for resistively heating at least a part of at least one of the first lateral boundary region and the second lateral boundary region of the caster tip arrangement. Resistive heating may be advantageous in terms of an achievable maximum heating temperature and/or in terms of energy consumption.

[0025] According to an embodiment, the heating device comprises a refractory sheet and/or a ceramics sheet and at least one heating element arranged on a surface and/or a side of the refractory sheet. The refractory sheet may refer to a sheet, a plate, a bar and/or a slab of refractory material, such as e.g. refractory ceramics material. The refractory sheet may comprise the same material as the first and/or the second caster plates. The refractory sheet and the heating element may be at least partly arranged in the guiding compartment, in direct contact with the guiding compartment and/or between the first caster plate and the second caster plate. This may allow to directly contact the refractory sheet with the melt, which may further increase a heat input and/or a heat flow into the melt. By way of example the refractory sheet with the at least one heating element may refer to an insert part of the heating device, which may be at least partly inserted into the guiding compartment to locally and/or actively heat a part and/or a partial region of the caster tip arrangement.

[0026] According to an embodiment, the heating device comprises a refractory sheet comprising at least one of Silicon-Nitrite material, alumina material, silica material, and/or any other commonly used refractory materials. By way of example, Silicon-Nitrite may be particularly advantageous in terms of its refractory properties, thermal conductivity and wettability with aluminum melt for processing of molten aluminium or aluminium alloys.

[0027] According to an embodiment, the at least one heating element is arranged between the refractory sheet and one of the first caster plate and the second caster plate. Accordingly, the at least one heating element may be in direct contact with a side of one of the first caster plate and the second caster plate, which side faces the other one of the first and the second caster plate,

[0028] According to an embodiment, the at least one heating element comprises at least one conductive metal strip and/or at least one conductive metal element arranged on the surface and/or the side of the refractory sheet for resistively heating at least a part of at least one of the first lateral boundary region and the second lateral boundary region of the caster tip arrangement. The conductive metal element may e.g. be printed on the surface of the refractory sheet. The conductive metal element may be arranged and/or printed in an arbitrary pattern on the surface of the refractory sheet, such as e.g. a coil-like pattern. By printing the conductive metal element of the at least one heating device on the surface and/or the side of the refractory sheet, a mass of the heating device and/or a mass of the heating element may be reduced with respect to conventional heating elements and/or conventional heating devices. This in turn may allow a faster temperature change and/or a faster temperature control to be induced by the heating element with respect to conventional heating elements. Also, a precision of a temperature control by means of the printed conductive metal strip may be increased with respect to conventional heating elements.

[0029] According to an embodiment, the caster tip arrangement comprises a center region arranged between the first lateral boundary region and the second lateral boundary region in the longitudinal extension direction, wherein the at least one heating device is configured to heat the center region of the caster tip arrangement less than the first lateral boundary region and/or less than the second lateral boundary region of the caster tip arrangement. Accordingly, the at least one heating device may be configured to independently and/or separately control the temperature of the melt in the first lateral boundary region, the second lateral boundary region and/or the center region of the caster tip arrangement, such that temperature differences of the melt across the casting width at the outlet may be minimized and/or eliminated.

[0030] Generally, the heating device may be configured to heat a part of the melt having a longer residence time in the guiding compartment more than another part of the melt flowing directly from the inlet to the outlet, i.e. flowing along the shortest way through the guiding compartment. Therein, the residence time may refer to time the melt spends within the guiding compartment while flowing from the inlet to the outlet. By way of example, the heating device may comprise a plurality of independently controllable heating elements, wherein at least one heating element may be arranged in the first lateral boundary region, at least one heating element may be arranged in the second lateral boundary region and at least one heating element may be arranged in the center region between the first and second lateral boundary regions. The heating device may, thus, be configured to heat a part of the melt crossing the center region less than further parts of the melt crossing the first and/or second lateral boundary region.

[0031] According to an embodiment, the first caster plate comprises a recess and/or a notch on a side and/or on a surface of the first caster plate facing the second caster plate, wherein the recess extends from the first lateral boundary region to the second lateral boundary region along the longitudinal extension direction of the caster tip arrangement, such that the melt is spread by the recess from the inlet to the first lateral boundary region and the second lateral boundary region of the caster tip arrangement. The recess may e.g. be a notch, a channel-like structure and/or a channel formed on the side of the first caster plate. The melt and/or molten material entering the inlet may be guided by the guiding compartment to the recess, in which the melt may be directed and/or spread towards the first and second lateral boundary regions. Accordingly, the melt may be distributed via the recess over at least a part of the length of the caster tip arrangement and/or over at least a part of the casting width.

[0032] According to an embodiment, at least a part of the heating device is arranged in the recess. Particularly, at least one heating element of the heating device may be arranged in the recess in the first lateral boundary region of the caster tip arrangement. Alternatively or additionally, at least one heating element of the heating device may be arranged in the recess in the second lateral boundary region. Also, a refractory sheet of the heating device may at least partly be arranged in the recess. Particularly, the heating device may comprise a first heating element and a second heating element both arranged on a side of the refractory sheet. Therein, the refractory sheet may be arranged in the recess such that the first heating element may be arranged and/or located in the first lateral boundary region and such that the second heating element may be arranged and/or located in the second lateral boundary region. By arranging at least a part of the heating device in the recess, the melt exiting the recess may have a homogenous temperature distribution along the longitudinal extension direction of the caster tip arrangement.

[0033] According to an embodiment, the caster tip arrangement further comprises a temperature control device coupled to the heating device, wherein the temperature control device comprises at least one temperature sensor for determining a temperature of the melt in at least a part of the caster tip arrangement and/or in at least a part of the guiding compartment. By means of the temperature control device a heating temperature of the heating device and/or of the at least one heating element of the heating device may be actively controlled in response to a measured temperature. This may allow to further reduce and/or minimize a temperature gradient of the melt along the longitudinal extension direction of the caster tip arrangement. The heating device may comprise a plurality of heating elements and the temperature control device may comprise a plurality of temperature sensors, wherein each temperature sensor may be associated with at least one of the heating elements. Also, pairs of a heating element and a temperature sensor may be distributed and/or arranged in the first lateral boundary region, the second lateral boundary region and/or the center region. Therein, each of the heating elements may be independently controlled by the temperature control device in accordance with a temperature determined by the temperature sensor associated with the respective heating element. By way of example, the temperature control device may comprise at least one first temperature sensor arranged in the first lateral boundary region for determining the melt temperature in the first lateral boundary region. Further, the temperature control device may comprise at least one second temperature sensor arranged in the second lateral boundary region for determining the melt temperature in the second lateral boundary region. The temperature control device may also comprise at least one further temperature sensor arranged in the center region of the caster tip arrangement for determining the melt temperature in the center region of the caster tip arrangement.

[0034] Alternatively or additionally the temperature control device may comprise a plurality of temperature sensors arranged near and/or adjacent to the outlet. The temperature sensors may be distributed over the total length of the caster tip and/or over the casting width, such that the temperature may be determined by means of the temperature sensors across substantially the entire casting width.

[0035] It is to be noted, however, that the temperature sensors are optional only. The temperature of the melt across the casting width may be controlled by supplying different heating power to different heating elements of the heating device, wherein the heating device may be configured to control the melt temperature e.g. by means of calibration values for the heating power correlating the heating power with a heating temperature of a heating element.

[0036] A second aspect of the invention relates to a use of a caster tip arrangement, as described above and in the following, in a continuous caster for casting an object from a melt comprising molten metal, such as e.g. aluminium.

[0037] A third aspect of the invention relates to a continuous caster and/or a casting device, such as e.g. a strip-caster. The continuous caster comprises a roll arrangement with at least one roll for forming an object from a melt with molten metal, and a caster tip arrangement, as described above and in the following. Therein, the caster tip arrangement is configured to supply the melt via the outlet of the caster tip arrangement to the at least one roll of the roll arrangement, such that the object may be formed. Generally, the continuous caster may be a roll caster, a belt caster and/or a block caster, wherein in the two latter cases the at least one roll may be configured for driving a belt of the roll arrangement to form the object.

[0038] It should be noted that features, elements, functions and/or characteristics of the caster tip arrangement, as described above and in the following, may be features, elements, functions and/or characteristics of the continuous caster, as described above and in the following. Vice versa, features, elements, functions and/or characteristics of the continuous caster, as described above and in the following, may be features, elements, functions and/or characteristics of the caster tip arrangement, as described above and in the following.

[0039] According to an embodiment, the roll arrangement comprises at least two counter-rotating rolls, wherein the at least two counter-rotating rolls are spaced apart from each other by a gap. Therein, the caster tip arrangement is configured to supply the melt via the outlet of the caster tip arrangement to the gap between the at least two counter-rotating rolls. By way of example, the continuous caster may be a so-called twin roll caster, by means of which a strip of metal, e.g. an aluminium strip, may be produced directly from the melt in one process step that can combine casting and rolling between the two counter rotating rolls. The melt may be guided horizontally through the caster tip arrangement into the gap between the counter rotating rolls, which may e.g. be internally water-cooled to dissipate heat. Each of the rolls may consist of a core and a shrink fitted shell, which provides a moving mold surface to the melt. The rolls may e.g. be made from steel and/or copper and/or alloys and combinations thereof. The melt may be discharged at the outlet of the caster tip arrangement in a certain distance to a center line between center points of the rolls. This distance is commonly referred to as set-back. Solidification of the melt may start at the contact points between the melt and the two rolls. Through ongoing solidification strip shells on both roll surfaces may be formed, which meet at the so-called kissing point and unify under the roll pressure to one strip. At this point, solidification may be finalized and rolling deformation may take place uniformly within the roll gap.

[0040] A fourth aspect of the invention relates to a method for operating a continuous caster. The continuous caster comprises a roll arrangement with at least one roll for forming an object from a melt with molten metal and a caster tip arrangement, as described above and in the following. The method comprises the steps of:

- supplying a melt with molten metal to the inlet of the caster tip arrangement;
- guiding, with the guiding compartment of the caster tip arrangement, the melt from the inlet to and/or towards the first lateral boundary region and the second lateral boundary region of the caster tip arrangement;
- heating, with the heating device of the caster tip arrangement, at least a part of at least one of the first lateral boundary region and the second lateral boundary region of the caster tip arrangement;
- supplying the melt via the outlet of the caster tip arrangement to the at least one roll of the roll arrangement; and
- forming, with the at least one roll of the roll arrangement, an object from the melt.

[0041] It should be noted that features, elements, functions and/or characteristics of the caster tip arrangement and/or the continuous caster, as described above and in the following, may be features, elements, functions, characteristics and/or steps of the method, as described above and in the following. Vice versa, features, elements, functions, characteristics and/or steps of the method, as described above and in the following, may be features, elements, functions and/or characteristics of the caster tip arrangement and/or the continuous caster, as described above and in the following.

[0042] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

Brief Description of the Drawings

[0043] The subject-matter of the invention will be explained in more detail in the following with reference to exemplary embodiments which are illustrated in the attached figures.

Fig. 1A shows schematically a continuous casting line according to an exemplary embodiment of the invention.

Fig. 1B shows schematically a cross-sectional view of a part of the continuous caster of Fig. 1A.

Fig. 2 shows schematically a cross-sectional view of a part of a continuous caster according to an exemplary embodiment of the invention.

Fig. 3A shows schematically a cross-sectional view of a caster tip arrangement according to an exemplary embodiment of the invention.

Figs. 3B and 3C each show schematically a top-view of a part of the caster tip arrangement of Fig. 3A.

Fig. 3D shows schematically a side view of a heating device of the caster tip arrangement of Fig. 3A.

Fig. 4 shows schematically a first caster plate for a caster tip arrangement according to an exemplary embodiment of the invention.

Fig. 5 shows a flow chart illustrating steps of a method for operating a continuous caster according to an exemplary embodiment of the invention.

[0044] In principle, identical or similar parts are provided with the same reference symbols in the figures. The figures are not to scale.

Detailed Description of Embodiments

[0045] Fig. 1A shows schematically a continuous casting line 100, a continuous caster arrangement 100 and/or a continuous caster 100 according to an exemplary embodiment of the invention. Fig. 1B shows schematically a cross-sectional view of a part of the continuous casting line 100 of Fig. 1A. The continuous casting line 100 may be a so-called strip caster 100 for casting and/or forming a strip comprising metal, particularly a strip comprising aluminium.

[0046] The continuous casting line 100 and/or the continuous caster 100 comprises a furnace 102 for melting material comprising metal, particularly comprising aluminium. By means of the furnace 102 the material is heated above a melting temperature of the metal to generate a melt 101 comprising molten metal.

[0047] The continuous casting line 100 and/or the continuous caster 100 further comprises a holding furnace 104 for further heating the melt 101 and/or for keeping the melt 101 at a certain temperature above the melting temperature. The continuous caster 100 further comprises a melt treatment arrangement 106 for filtering and/or degassing and/or improving the quality of the melt 101.

[0048] The continuous casting line 100 and/or the continuous caster 100 further comprises a melt distribution device 108 with a tundish 110 and/or a headbox 110. The melt distribution device 108 further comprises a caster tip arrangement 10 fluidly coupled and/or connected to the tundish 110 or headbox 110. As will be described in more detail with reference to Figs. 4A to 4, the caster tip arrangement 10 comprises a first caster plate 12 and a second caster plate 14 arranged opposite to each other to form a guiding compartment 16 between the first caster plate 12 and the second caster plate 14. By means of the guiding compartment 16, the melt 101 is guided from an inlet 18 of the caster tip arrangement 10 to an outlet 20 of the caster tip arrangement 10. Therein, the inlet 18 may be fluidly coupled to an outlet of the tundish 110.

[0049] The continuous casting line 100 and/or the continuous caster 100 further comprises a roll arrangement 112 for forming an object 103 from the melt. The object 103 in the exemplary embodiment illustrated in Figs. 1A and 1B is a strip 103 comprising metal, particularly a strip 103 comprising aluminium. The roll arrangement 112 comprises two counter-rotating rolls 114a, 114b spaced apart from each other by a gap 116. Therein, the caster tip arrangement 10 is configured to supply the melt 101 via the outlet 20 of the caster tip arrangement 10 to the gap 116 between the two counter-rotating rolls 114a, 114b of the roll arrangement 112.

[0050] By means of the continuous casting line 100 and/or the continuous caster 100 the strip 103 comprising metal may be produced directly from the melt 101 in one process step that combines casting and rolling between the two counter rotating rolls 114a, 114b. The melt 101 may be guided horizontally through the caster tip arrangement 10 into the gap 116 between the counter rotating rolls 114a, 114b, which may e.g. be internally water-cooled to purge heat. Each of the rolls 114a, 114b may consist of a core 118a, 118b and a shrink fitted shell 120a, 120b, which provides a surface to the melt 101. The rolls 114a, 114b may e.g. be made from steel and/or copper. The melt 101 may be discharged at the outlet 20 of the caster tip arrangement 10 in a certain distance to a center line 121 between center points of the rolls 114a, 114b. This distance is commonly referred to as set-back. Solidification of the melt 101 may start at the contact points between the melt 101 and the two rolls 114a, 114b. Through ongoing solidification strip shells on both roll surfaces may be formed, which meet at the so-called kissing point and unify under the roll pressure to one strip 103, wherein the roll pressure is illustrated in Fig. 1B by the two antiparallel arrows. At this point, solidification may be finalized and rolling deformation may take place uniformly down to the center line 121. On the solid side of the casting line 100 and/or the roll arrangement 112, a release agent, e.g. an aqueous graphite suspension, may be applied by at least one spraying device 122 of the continuous caster 100. Such spraying process may provide a thermal barrier for heat flow between solidifying metal and the roll surface as well as it may avoid sticking of the strip 103 on the rolls 114a, 114b and lubrication in the deformation section between the kissing point and the center line 121.

[0051] The continuous caster 100 further comprises a coiler 124 for coiling the strip 103.

[0052] Fig. 2 shows schematically a cross-sectional view of a part of a continuous caster 100 according to an exemplary embodiment of the invention. Particularly, Fig. 2 shows a cross-sectional view of a melt distribution device 108 and a roll arrangement 112. If not stated otherwise, the melt distribution device 108 and the roll arrangement 112 of Fig. 2 comprise the same features, elements and/or characteristics as the melt distribution device 108 and the roll arrangement 112 shown in Figs. 1A and 1B.

[0053] In contrast to the roll arrangement 112 shown in Figs. 1A and 1B, the roll arrangement 112 shown in Fig. 2 comprises in total four rolls 114. More specifically, the roll arrangement 112 comprises two pairs 115a, 115b of co-rotating rolls 114.

[0054] The roll arrangement 112 further comprises two counter-rotating belts 117a, 117b, wherein each of the pairs 115a, 115b of co-rotating rolls 114 drives one of the belts 117a, 117b for forming the object 103. The object 103 may for instance be a strip 103 and/or a slab 103 comprising metal, e.g. aluminium.

[0055] Similarly, to the continuous caster 100 described with reference to Figs. 1A and 1B, the melt 101 may be provided via the tundish 110 to the inlet 18 of the caster tip arrangement 10 and guided by the guiding compartment 16 of the caster tip arrangement 10 to the outlet 20 of the caster tip arrangement 10. Via the outlet 20 of the caster tip arrangement 10, the melt 101 is supplied to a gap 116 formed between the two counter-rotating belts 117a, 117b, in which gap 116 the melt 101 may be solidified and the object 103 may be formed by rolling deformation, e.g. in a roller mill.

[0056] The roll arrangement 112 further comprises two belt quench devices 119a, 119b wherein each of the belt quench devices 119a, 119b may be configured for cooling one of the belts 117a, 117b.

[0057] Fig. 3A shows schematically a cross-sectional view of a caster tip arrangement 10 according to an exemplary embodiment of the invention. Figs. 3B and 3C each show schematically a top-view of a part of the caster tip arrangement 10 of Fig. 3A. Inter alia, Fig. 3B shows schematically a top view of a first caster plate 12 of the caster tip arrangement 10 of Fig. 3A, and Fig. 3C shows schematically a top view of a second caster plate 14 of the caster tip arrangement 10 of Fig. 3A. Further, Fig. 3D shows schematically a side-view of a heating device 42 of the caster tip arrangement 10 of Fig. 3A. If not stated otherwise, the caster tip arrangement 10 of Figs. 3A to 3D comprises the same features, elements and/or characteristics as the caster tip arrangement 10 described with reference to the previous Figures 1A to 2.

[0058] The caster tip arrangement 10 comprises a first caster plate 12 and a second caster plate 14 arranged opposite to each other. Therein, the first caster plate 12 may refer to a bottom plate 12, in which the melt 101 may be held by gravitational force. In contrast, the second caster plate 14 may refer to a top plate 14 of the caster tip arrangement 10. The first caster plate 12 and the second caster plate 14 are spaced apart from each other to form a guiding compartment 16, a passageway 16 and/or a passage 16 between the first caster plate 12 and the second caster plate 14 for guiding a melt 101 comprising molten metal, such as e.g. molten aluminium. Both the first and the second caster plates 12, 14 are manufactured from refractory material, such as e.g. refractory ceramics material.

[0059] The first and the second caster plates 12, 14 are spaced apart from each other by a plurality of spacers 23 and/or spacing elements 23, which may be arranged e.g. on the first caster plate 12 as illustrated in Fig. 3B. However, at least a part of the spacers 23 may alternatively or additionally be arranged on the second caster plate 14. The spacers 23 may be arbitrarily shaped. As exemplary shown in Fig. 3B, the spacers 23 may be streamlined shaped. However, it is to be noted that the spacing elements 23 are optional only.

[0060] The caster tip arrangement 10 further comprises an inlet 18 for receiving the melt 101, wherein the inlet 18 may e.g. be fluidly coupled and/or connected to a headbox 110 or tundish 110 (see Figs. 1 Band 2). The inlet 18 comprises an inlet opening 19 formed between the first caster plate 12 and the second caster plate 14 for receiving the melt 101 and for supplying the melt 101 to the guiding compartment 16. The inlet 18 and/or the inlet opening 19 is arranged and/or formed on a front edge 25 of the caster tip arrangement 10.

[0061] The caster tip arrangement 10 further comprises an outlet 20 for discharging the melt 101 in a discharging direction 22 of the caster tip arrangement 10 and/or for supplying the melt 101 e.g. to a roll arrangement 112 of a continuous caster 100, as shown in previous figures. The outlet 20 comprises an outlet opening 21 formed between the first caster plate 12 and the second caster plate 14. The outlet 20 and/or the outlet opening 21 is arranged and/or formed on a rear edge 27 of the caster tip arrangement 10, which rear edge 27 opposes and/or is arranged opposite to the front edge 25 in a transverse extension direction 24 of the caster tip arrangement 10. The transverse extension direction 24 may refer to a lateral extension direction 24 of the caster tip arrangement 10, and it may be parallel to the discharging direction 22 of the caster tip arrangement 10.

[0062] A length 26 of the inlet 18 is smaller than a length 28 of the outlet 20, wherein both the length 26 of the inlet 18 and the length 28 of the outlet 20 are measured along a longitudinal extension direction 29 of the caster tip arrangement 10. The longitudinal extension direction 29 may be substantially parallel to the front edge 25 and/or to the rear edge 27 of the caster tip arrangement 10. Further, the longitudinal extension direction 29 is transverse and/or perpendicular to the transverse extension direction 24 and/or the discharging direction 22. Therein, the length 28 of the outlet 20 defines a casting width of the caster tip arrangement 10, over which casting width the melt 101 is discharged via the outlet 20.

[0063] As the length 28 of the outlet 20 is larger than the length 26 of the inlet 18, at least a portion 30 of the guiding compartment 16 is divergently formed from the inlet 18 towards the outlet 20, such that the melt 101 is spread over at least a part of the length 28 of the outlet 18 and/or the casting width. To spread the melt 101, the divergently formed portion 30 of the guiding compartment 16 comprises two oppositely curved periphery surfaces 31 and a recess 32 arranged and/or formed on a side 33 of the first caster plate 12, which side 33 faces and/or is directed towards the second caster plate 14. However, it is to be noted that the divergently formed portion 30 may basically have any other shape suitable for spreading the melt 101.

[0064] The recess 32 may be a channel-like structure 32, a channel 32 and/or a notch 32 arranged on the side 33 of the first caster plate 14. The recess 32 extends substantially parallel to the longitudinal extension direction 29 of the caster tip arrangement 10. Moreover, the recess 32 extends from a first lateral boundary region 34 of the caster tip arrangement 10 to a second lateral boundary region 36 of the caster tip arrangement 10, such that the melt 101 is spread via the divergently formed portion 30 and/or via the recess 32 of the divergently formed portion 30 from the inlet 18 towards the first lateral boundary region 34 and towards the second lateral boundary region 36. Therein, the first lateral boundary region 34 is arranged opposite to the second lateral boundary region 36 in the longitudinal extension direction 29 of the caster tip arrangement 10. To efficiently spread the melt 101 in the guiding compartment 16, a protrusion 39 is formed on a side 41 of the second caster plate 14, wherein the protrusion 39 at least partly engages with the recess 32. The protrusion 39 may be arranged parallel to the longitudinal extension direction 29 and the side 41 faces and/or opposes the first caster plate 12.

[0065] The first lateral boundary region 34 extends from a first outer edge 35 and/or a first lateral edge 35 of the caster tip arrangement 10 in the longitudinal extension direction 29 to maximal 35% of a total length 28 of the caster tip arrangement 10. The first outer edge 35 may also refer to a first side panel 35 of the caster tip arrangement 10. The first outer edge 35 may connect the front edge 25 and the rear edge 27 of the caster tip arrangement 10. The total length 28 of the caster tip arrangement 10 may be substantially equal to the length 28 of the outlet 20. Similarly, the second lateral boundary region 36 extends from a second outer edge 37 and/or a second lateral edge 37 of the caster tip arrangement 10 in the longitudinal extension direction 29 to maximal 35% of a total length 28 of the caster tip arrangement 10. The second outer edge 37 may also refer to a second side panel 37 of the caster tip arrangement 10. The second outer edge 35 may connect the front edge 25 and the rear edge 27 of the caster tip arrangement 10. Between the first lateral boundary region 34 and the second lateral boundary region 36, a center region 38 of the caster tip arrangement 10 is arranged and/or located.

[0066] The caster tip arrangement 10 further comprises a heating device 42 arranged at least partly between the first caster plate 12 and the second caster plate 14. Accordingly, the heating device 42 is at least partly arranged in the guiding compartment 16. The heating device 42 comprises a refractory sheet 44 manufactured from refractory material, such as e.g. refractory ceramics material and/or Silicon-Nitrite, alumina, silica, and/or other commonly used refractory materials. The refractory sheet 44 is at least partly arranged in the recess 32 and extends along the longitudinal extension direction 29 of the caster tip arrangement 10. The refractory sheet 44 may be mechanically fixed to the side 33 of the first caster plate 12.

[0067] The heating device 42 further comprises one or more heating elements 46 arranged on and/or attached to a side 48 and/or a surface 48 of the refractory sheet 44. By way of example, the heating elements 46 may be configured for resistively heating at least a part of the first lateral boundary region 34 and the second lateral boundary region 36. However, the heating elements 46 may alternatively be any other kind of heating element 46, such as e.g. a heating coil, an electrical heating element or the like. Each of the heating elements 46 may comprise at least one conductive metal strip 50 and/or at least one conductive metal element 50. By way of example, the conductive metal strip 50 of each of the heating elements 46 may be printed on the side 48 of the refractory sheet 44. Further, the heating elements 46 are arranged between the refractory sheet 44 and the side 33 of the first caster plate 12 facing the second caster plate 14. By printing the conductive metal element 50 of the at least one heating device 42 on the surface 48 and/or the side 48 of the refractory sheet 44, a mass of the heating device 42 and/or a mass of the one or more heating elements 46 may be reduced with respect to conventional heating elements and/or conventional heating devices. This in turn may allow a faster temperature change and/or a faster temperature control to be induced by the heating element with respect to conventional heating elements. Also, a precision of a temperature control by means of the printed conductive metal strip 50 may be increased with respect to conventional heating elements.

[0068] It is to be noted that in the center region 38 no heating element 46 may be present and/or arranged. Accordingly, the center region 38 of the caster tip arrangement 10 may remain unheated, and the heating device 42 may be configured to only, solely, and/or exclusively heat the first lateral boundary region 34 and/or the second lateral boundary region 36. Particularly, the heating device 42 may be configured to heat both the first lateral boundary region 34 and the second lateral boundary region 36. Alternatively or additionally, the heating device may 42 may comprise a plurality heating elements 46 distributed substantially over the total length of the caster tip arrangement 10 along the longitudinal extension direction 29, wherein the heating device 42 may be configured to heat the heating elements 46 with variable heating intensity and/or with variable heating power. Particularly, the heating device 42 may be configured to heat heating elements 46 arranged in the center region 38 less than heating elements 46 arranged in the first and/or second lateral boundary region 34, 36, respectively.

[0069] Further, the caster tip arrangement 10 optionally comprises a temperature control device 52, which comprises one or more temperature sensors 54. Similarly to the heating elements 46, the temperature sensors 54 may be arranged on the side 48 of the refractory sheet 44 in order to determine and/or measure a temperature of the melt 101 in the first lateral boundary region 34 and/or in the second lateral boundary region 36. Alternatively or additionally, the temperature sensors 54 may be arranged near and/or adjacent to the outlet 20, such that a temperature of the melt 101 may be determined at the outlet 20. Therein, the temperature sensors 54 may be distributed over substantially the total length 28 of the outlet 20.

[0070] The temperature control device 52 is configured to control a heating temperature of each of the heating elements 46 in response to a temperature determined by means of at least a part of the temperature sensors 54. Therein, each of the heating elements 46 may be associated with at least one of the temperature sensors 54, which may be arranged e.g. directly adjacent to the respective heating element 46, and the temperature control device may be configured to independently and/or individually control the heating temperature of each of the heating elements 46. Alternatively, the temperature control device 52 may be configured to control the heating temperature of all heating elements 46. Alternatively, the temperature control device 52 may be configured to control the heating temperature of all heating elements 46 arranged in the first lateral boundary region 34, to independently control the heating temperature of all heating elements 46 arranged in the second lateral boundary region 36 and/or to independently control the heating temperature of all heating elements arranged in the center region 38.

[0071] It is to be noted, however, that the temperature sensors 54 are optional only. The temperature of the melt 101 across the casting width may be controlled by supplying different heating power to different heating elements 46 of the heating device 42, wherein the heating device 42 may be configured to control the melt temperature e.g. by means of calibration values for the heating power correlating the heating power with a heating temperature of the heating elements 46.

[0072] As explained in detail in the summary part, the melt 101 entering the inlet 18 is spread by the divergently formed portion 30 of the guiding compartment 16 and/or by the recess 32 towards the first lateral boundary region 34 and the second lateral boundary region 36, such that the melt 101 is spread over the length 28 of the outlet 20 and/or over the casting width. As a consequence, a part of the melt 101 being directed from the inlet 18 via one of the first and second lateral boundary regions 34, 36 has a longer flow path and/or residence time in the guiding compartment 16 than a part of the melt 101 travelling via the center region 38 along the discharging direction 22 from the inlet 18 to the outlet 20. Due to the differing flow paths and/or residence times, a temperature of the melt 101 in the first and second lateral boundary regions 34, 36 may be lower than a temperature of the melt 101 in the center region 38 of the guiding compartment 16 and/or of the caster tip arrangement 10. Accordingly, a temperature gradient may exist along the length 28 of the outlet 20 and/or across the casting width. This temperature gradient and/or temperature difference may be in the range of about 1°C (about 1 Kelvin) to about 60°C (about 60 Kelvin), particularly in the range of about 5°C (about 5 Kelvin) to about 30°C (about 30 Kelvin), depending on the length 28.

[0073] The heating device 42 is configured to minimize and/or eliminate this temperature difference and/or temperature gradient by locally heating the caster tip arrangement 10 in the first lateral boundary region 34, in the second lateral boundary region 36 and/or in the center region 38. By way of example, the heating device 42 may be configured to heat, with the heating elements 46, at least partly the molten metal in the first lateral boundary region 34, the second lateral boundary region 36, and/or the center region 38 to a melt temperature of about 1°C (about 1 Kelvin) to about 60°C (about 60 Kelvin), particularly about 1°C (about 1 Kelvin) to about 30°C (about 30 Kelvin), and preferably about 1°C (about 1 Kelvin) to about 15°C (about 15 Kelvin), above a melting temperature and/or above a liquidus temperature of the metal contained in the melt 101 in order to minimize the temperature gradient. This way, the melt 101 exiting the caster tip arrangement 10 at outlet 20 may have a homogeneous temperature. This allows to increase a productivity of a caster 100 and to reduce energy consumption because no overheating of the melt 101 may be required. Also, a quality of the casted object 103 may be improved, as explained in the summary part.

[0074] It is to be noted, that the heating device 42 and/or the temperature control device 52 may be configured to increase the heating temperature of each of the heating elements 46 according to a distance of the respective heating element 46 from the center region 38. In other words, a heating element 46 arranged closer to the first outer edge 35 may be heated to a higher heating temperature than another heating element 46 arranged closer to and/or arranged in the center region 38. Similarly, a heating element 46 arranged closer to the second outer edge 37 may be heated to a higher heating temperature than another heating element 46 arranged closer to and/or arranged in the center region 38. This way, the temperature gradient across the casting width may be further reduced.

[0075] Moreover, it is to be noted that the caster tip arrangement 10 may comprise a plurality of heating devices 42. By way of example, a first heating device 42 may be arranged in the first lateral boundary region 34 and a second heating device 42 may be arranged in the second lateral boundary region 36. Also, a further heating device 42 may be arranged in the center region 38.

[0076] Further, the one or more heating devices 42 of the caster tip arrangement 10 do not necessarily have to be arranged in the recess 32, but they can rather be arranged at an arbitrary location in the first lateral boundary region 34, in the second lateral boundary region 36 and/or the center region 38.

[0077] Moreover, the first caster plate 12 comprises a first curved outer region 60 and/or a first curved outer surface 60. Similarly, the second caster plate 14 comprises a second curved outer region 62 and/or a second curved outer surface 62. The first and second curved outer regions 60, 62 may have equal or differing radii of curvature. The first and second curved regions 60, 62 may be formed to allow the caster tip arrangement 10 to be arranged as close as possible to further components of the caster 100, such as e.g. the roll arrangement 112.

[0078] Fig. 4 shows schematically a first caster plate 12 for a caster tip arrangement 10 according to an exemplary embodiment of the invention. If not stated otherwise, the first caster plate 12 of Fig. 4 comprises the same functions, features, elements and/or characteristics as the first caster plates 12 described with reference to the previous figures.

[0079] In contrast to the first caster plate 12 shown in Fig. 3B, the divergently formed portion 30 of first caster plate 12 of Fig. 4 comprises two slanted surfaces 31 arranged transverse to the transverse extension direction 24 as well as transverse to the longitudinal extension direction 29. Accordingly, the slanted surfaces 31 may each extend diagonally from the inlet 18 to the outlet 20 such that the melt 101 is spread over the casting width. However, any other geometry of the divergently formed portion 30 is conceivable.

[0080] Further, on the side 32 facing the second caster plate 14 a first heating device 42a is arranged in the first lateral boundary region 34 and a second heating device 42 is arranged in the second lateral boundary region 36. Therein, each of the first and second heating devices 42a, 42b may be operated as described above with reference to Figs. 3A to 3D.

[0081] Fig. 5 shows a flow chart illustrating steps of a method for operating a continuous caster 100 according to an exemplary embodiment of the invention. If not stated otherwise, the continuous caster 100 comprises the same features, functions, elements, and/or characteristics as described with reference to previous figures.

[0082] Particularly, the continuous caster 100 comprises a roll arrangement 112 with at least one roll 114 for forming an object 103 from a melt 101 with molten metal and a caster tip arrangement 10, as described above with reference to previous figures.

[0083] In a first step S1 the melt 101 with molten metal is supplied to the inlet 18 of the caster tip arrangement 12. In a second step S2 the melt 101 is guided with the guiding compartment 16 of the caster tip arrangement 12 from the inlet 18 to and/or towards the first lateral boundary region 34 and the second lateral boundary region 36 of the caster tip arrangement 10. In a further step S3 at least a part of at least one of the first lateral boundary region 34 and the second lateral boundary region 36 of the caster tip arrangement 10 is locally heated with the heating device 42 of the caster tip arrangement 10. In a further step S4 the melt 101 is supplied via the outlet 20 of the caster tip arrangement 10 to the at least one roll 114 of the roll arrangement 112. In a further step S5 the object 103 is formed with the at least one roll 114 of the roll arrangement 112.

[0084] Further, the melt 101 may be overheated in the first lateral boundary region 34 and/or in the second lateral boundary region 36 in order to achieve a homogenous temperature of the melt 101 over the total length 28 of the outlet and in order to avoid a temperature decrease of the melt 101 at the edges of the outlet 20.

[0085] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art and practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0086] In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A caster tip arrangement (10) for a continuous caster (100) for casting an object (103) from a melt (101) with molten metal, the caster tip arrangement (10) comprising:

a first caster plate (12);
a second caster plate (14) arranged opposite to the first caster plate (12);
an inlet (18) for receiving a melt (101) with molten metal;
an outlet (20) for discharging the melt (101) in a discharging direction (22) of the caster tip arrangement (10); and
at least one heating device (42) for heating at least a part of the caster tip arrangement (10);
wherein the first caster plate (12) and the second caster plate (14) are spaced apart from each other to form a guiding compartment (16) for guiding the melt (101) from the inlet (18) to the outlet (20);
wherein at least a portion (30) of the guiding compartment (16) is divergently formed from the inlet (18) towards the outlet (20), such that the guiding compartment (16) extends from the inlet (18) to a first lateral boundary region (34) and a second lateral boundary region (36) of the caster tip arrangement (10);
wherein the second lateral boundary region (36) is arranged opposite to the first lateral boundary region (34) in a longitudinal extension direction (29) of the caster tip arrangement (10) transverse to the discharging direction (22); and
wherein the at least one heating device (42) is configured to locally heat the caster tip arrangement (10) in at least one of the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10).

2. The caster tip arrangement (10) according to claim 1, wherein the first lateral boundary region (34) extends from a first outer edge (35) of the caster tip arrangement (10) to maximal 35% of a total length (28) of the caster tip arrangement (10) in the longitudinal extension direction (29); and/or
wherein the second lateral boundary region (36) extends from a second outer edge (37) of the caster tip arrangement (10) to maximal 35% of a total length (28) of the caster tip arrangement (10) in the longitudinal extension direction (29).

3. The caster tip arrangement (10) according to any of claims 1 and 2,
wherein the heating device (42) is configured to heat the molten metal in at least a part of at least one of the first lateral boundary region (34) and the second lateral boundary region (36) to a melt temperature

of about 1°C to 60°C above a melting temperature of the molten metal comprised in the melt (101); and/or
wherein the at least one heating device (42) is configured to heat molten metal in at least a part of at least one of the first lateral boundary region (34) and the second lateral boundary region (36) to a temperature of about 1°C to 60°C above a liquidus temperature of the melt.

4. The caster tip arrangement (10) according to any of the preceding claims,
wherein the heating device (42) comprises at least one heating element (46) arranged between the first caster plate (12) and the second caster plate (14); and/or
wherein the heating device (42) comprises at least one heating element (46) for resistively heating at least a part of at least one of the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10).

5. The caster tip arrangement (10) according to any of the preceding claims,
wherein the heating device (42) comprises a refractory sheet (44) and at least one heating element (46) arranged on a surface (48) of the refractory sheet (44); and/or
wherein the heating device (42) comprises a refractory sheet (44) comprising at least one of Silicon-Nitrite material, alumina material, and silica material.

6. The caster tip arrangement (10) according to claim 5, wherein the at least one heating element (46) and the refractory sheet (44) are at least partly arranged in the guiding compartment (16); and/or
wherein the at least one heating element (46) is arranged between the refractory sheet (44) and one of the first caster plate (12) and the second caster plate (14).

7. The caster tip arrangement (10) according to any of claims 5 and 6,
wherein the at least one heating element (46) comprises at least one conductive metal element (50) arranged on the surface (48) of the refractory sheet (44) for resistively heating at least a part of at least one of the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10).

8. The caster tip arrangement (10) according to any of the preceding claims,
wherein the caster tip arrangement (10) comprises a center region (38) arranged between the first lateral boundary region (34) and the second lateral boundary region (36) in the longitudinal extension direction (29); and
wherein the at least one heating device is configured to heat the center region (38) of the caster tip arrangement (10) less than the first lateral boundary region (34) and/or less than the second lateral boundary region (3) of the caster tip arrangement (10).

9. The caster tip arrangement (10) according to any of the preceding claims,
wherein the first caster plate (12) comprises a recess (32) on a side (33) of the first caster plate (12) facing the second caster plate (14);
wherein the recess (32) extends from the first lateral boundary region (34) to the second lateral boundary region (36) along the longitudinal extension direction (29) of the caster tip arrangement (10), such that the melt (101) is spread by the recess (32) from the inlet (18) to the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10).

10. The caster tip arrangement (10) according to claim 9, wherein at least a part of the heating device (42) is arranged in the recess (32).

11. The caster tip arrangement (10) according to any of the preceding claims, further comprising:

a temperature control device (52) coupled to the heating device (42);
wherein the temperature control device (52) comprises at least one temperature sensor (54) for determining a temperature of the melt in at least a part of of the caster tip arrangement (10) and/or in at least a part of the guiding compartment (16).

12. Use of a caster tip arrangement (10) according to any of the preceding claims in a continuous caster (100) for casting an object (103) from a melt (101) comprising molten metal.

13. A continuous caster (101), comprising:

a roll arrangement (112) with at least one roll (114) for forming an object (103) from a melt (101) with molten metal; and
a caster tip arrangement (10) according to any of claims 1 to 11;
wherein the caster tip arrangement (10) is configured to supply the melt (101) via the outlet (20) of the caster tip arrangement (10) to the at least one roll (114) of the roll arrangement (112) for forming the object (103).

14. The continuous caster (100) according to claim 13, wherein the roll arrangement (112) comprises at least two counter-rotating rolls (114a, 114b);

wherein the at least two counter-rotating rolls (114a, 114b) are spaced apart from each other by a gap (116); and
wherein the caster tip arrangement (10) is configured to supply the melt (101) via the outlet (20) of the caster tip arrangement (10) to the gap (116) between the at least two counter-rotating rolls (114a, 114b) for forming the object (103).

15. A method for operating a continuous caster (100) comprising a roll arrangement (112) with at least one roll (114) for forming an object (103) from a melt (101) with molten metal and a caster tip arrangement (10) according to any of claims 1 to 11, the method comprising the steps of:

supplying a melt (101) with molten metal to the inlet (18) of the caster tip arrangement (10);
guiding, with the guiding compartment (16) of the caster tip arrangement (10), the melt (101) from the inlet (18) to the first lateral boundary region (34) and the second lateral boundary region (36) of the caster tip arrangement (10);
heating, with the heating device (42) of the caster tip arrangement (10), at least a part of at least one of the first lateral boundary region (34) and the second lateral boundary region (36);
supplying the melt (101) via the outlet (20) of the caster tip arrangement (10) to the at least one roll (114) of the roll arrangement (112); and
forming, with the at least one roll (114) of the roll arrangement (112), an object (103) from the melt (101).

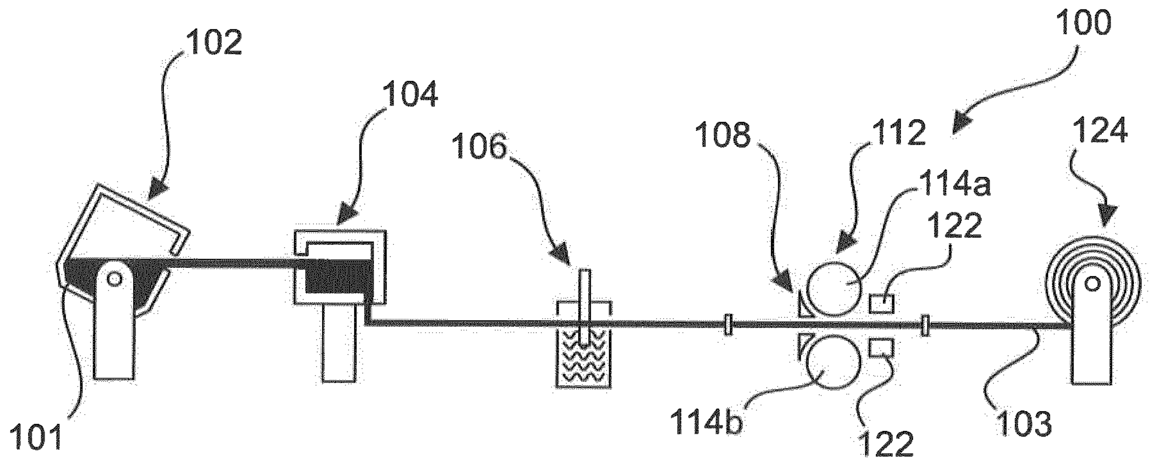

Fig. 1A

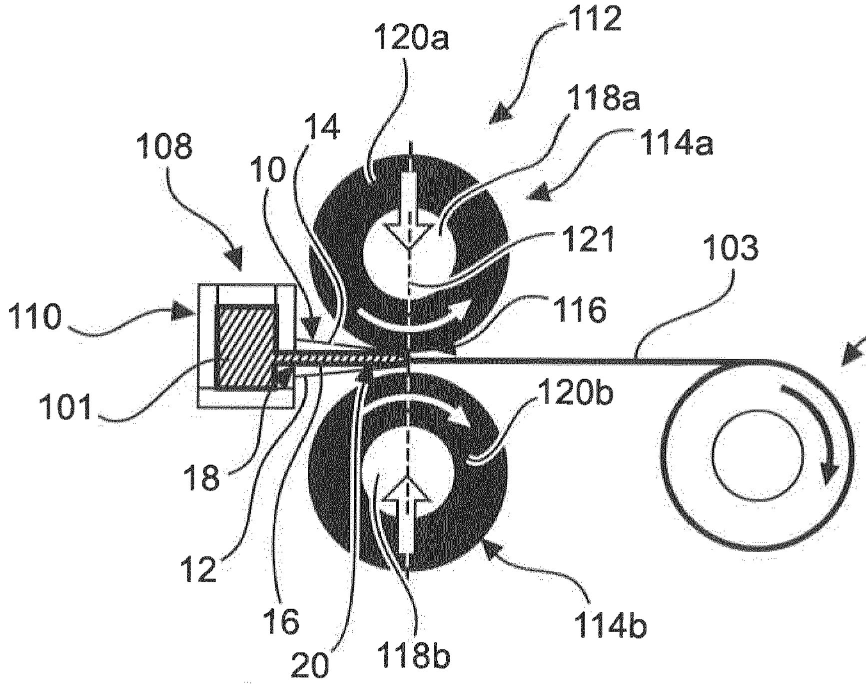

Fig. 1B

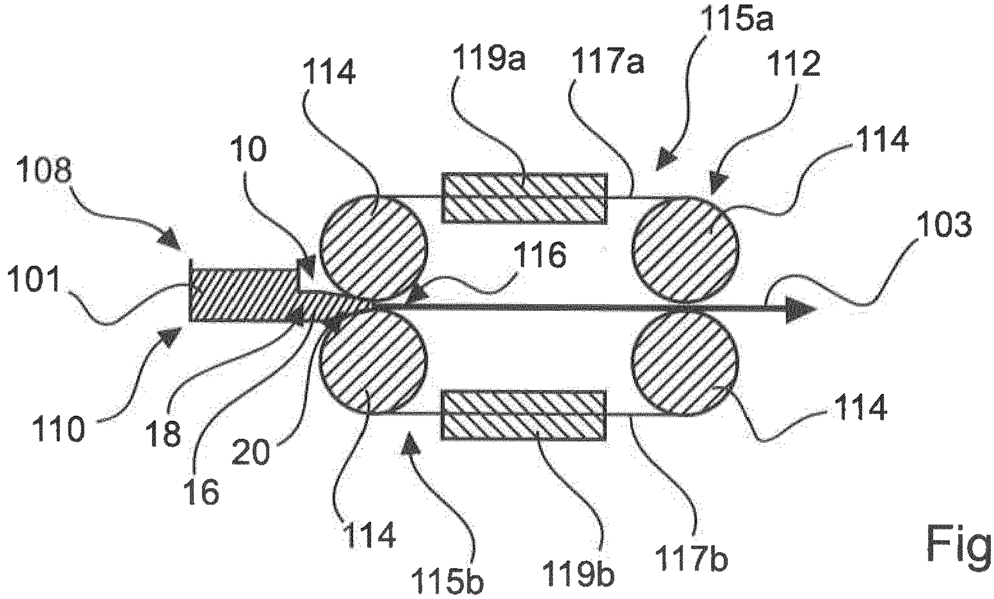

Fig.2

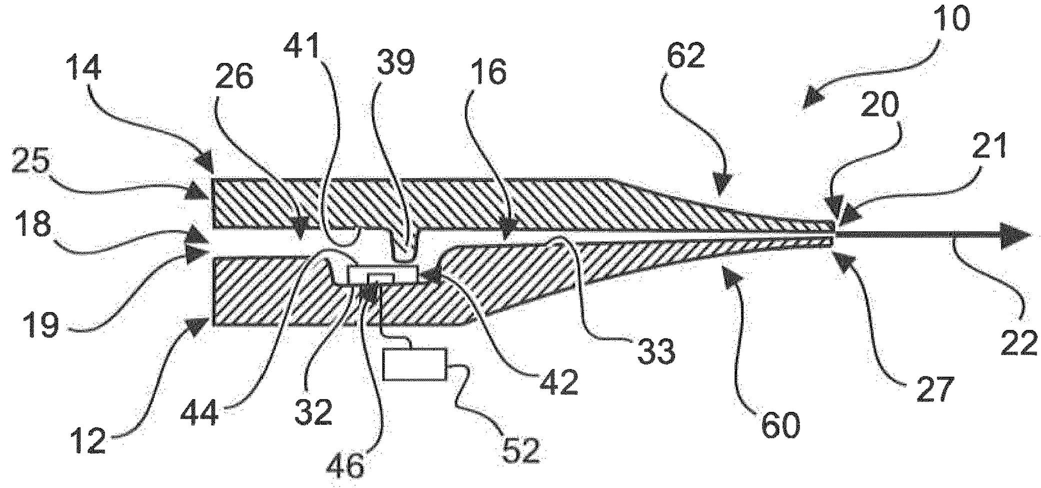

Fig.3A

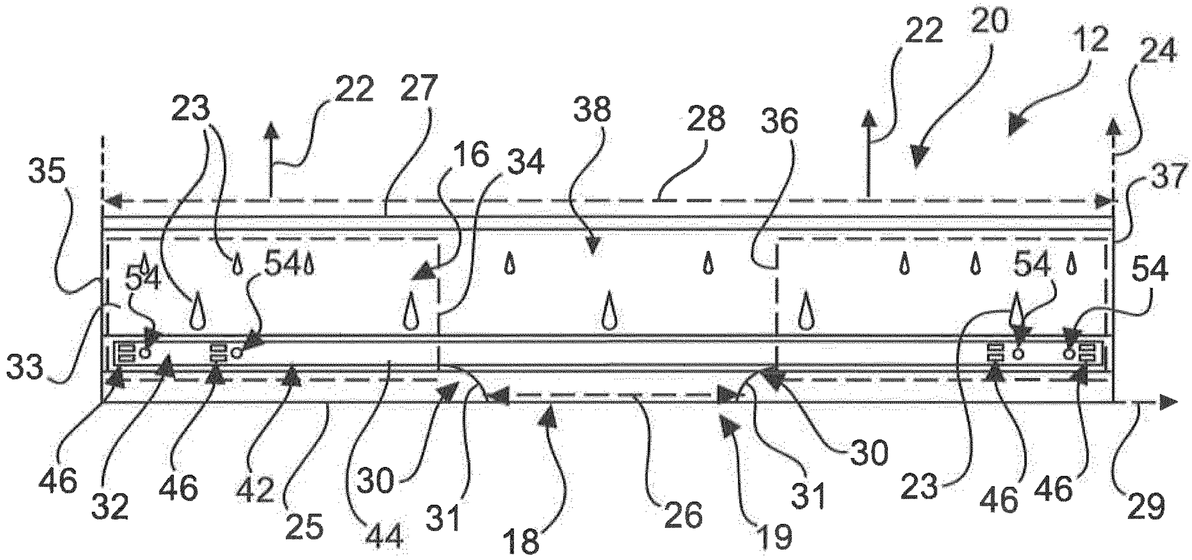

Fig.3B

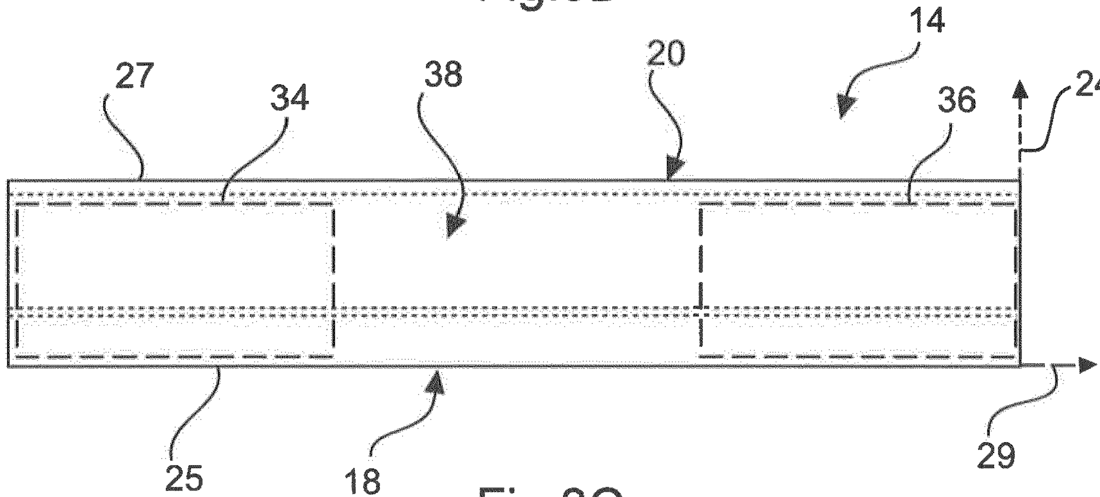

Fig.3C

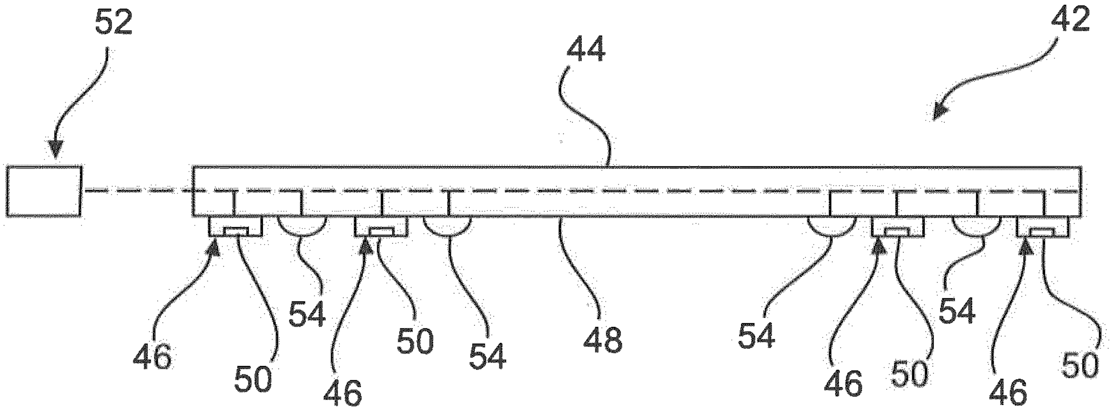

Fig.3D

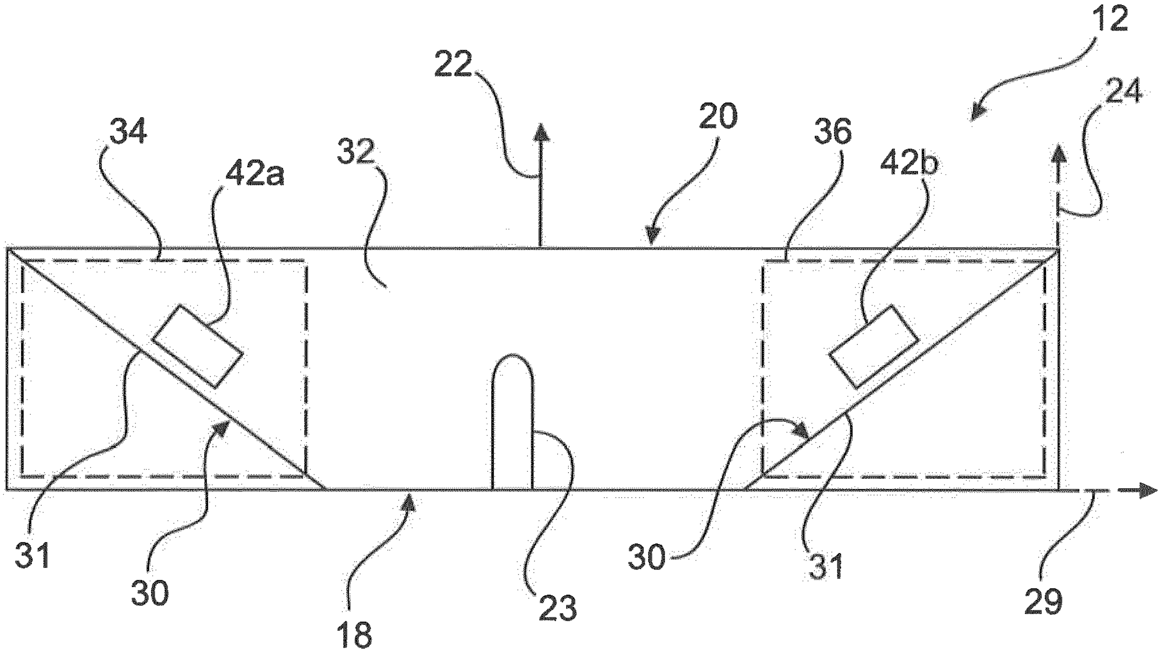

Fig.4

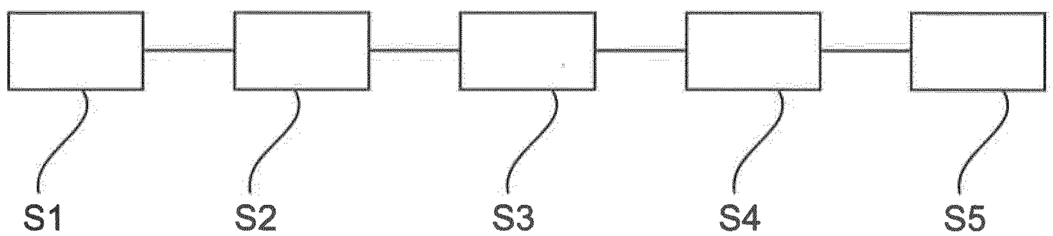

Fig.5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 6119

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2017/106435 A1 (VINCENT MARK [GB]) 20 April 2017 (2017-04-20) * claims; figures * -----	1-15	INV. B22D11/06
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TECHNICAL FIELDS SEARCHED (IPC)
B22D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 December 2017	Hodiamont, Susanna

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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14-12-2017

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