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(54) **DEVICE AND METHOD FOR IMPROVED COOLING OF A METALLIC ALLOY IN A SAND MOLD**

(57) The device comprises a sand mold (1) with an inner cavity (2) fillable with a metallic alloy to be solidified inside the inner cavity, thermal energy extracting means (3) embedded at least partially in the sand mold (1) and comprising at least a conduct (32) and a coolant inside the conduct (32), movable in the conducts for extracting heat from the metallic alloy. A method is proposed comprising the steps of providing a sand mold comprising an inner cavity (2), providing thermal energy extracting means (3), the thermal energy extracting means (3) comprising at least a conduct (32),placing the thermal energy extracting means at least partially embedded in the sand mold (1), filling the inner cavity (2) with a metallic alloy to be solidified inside the inner cavity and circulating a coolant inside the conduct (32) for extracting heat from the metallic alloy.

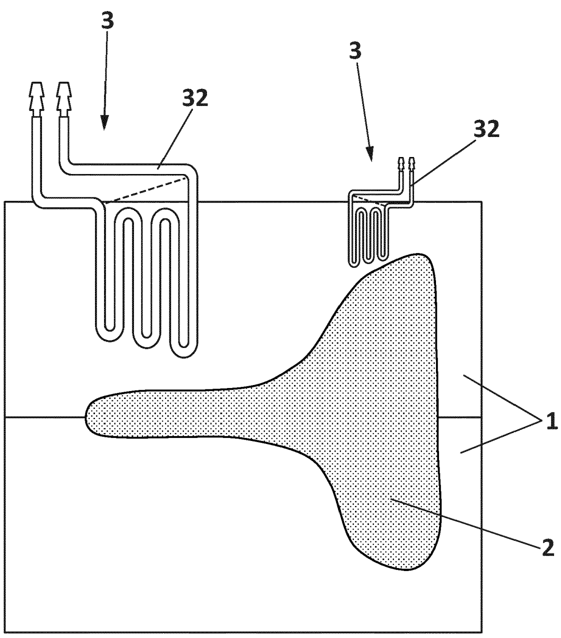

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The invention is encompassed in the field of metal casting in sand molds and especially to systems for reducing the time a metallic part must remain inside a sand mold before demolding while maintaining the mechanical properties of the part obtained.

BACKGROUND OF THE INVENTION

[0002] Among technologies for manufacturing heavy section parts larger than 40 kg, manufacturing with molten materials in sand molds has the advantage of achieving complex shapes. However, manufacturing of the molds and, above all, the long times the molten metal must remain in the mold until the alloy reaches a temperature which permits handling of the casting avoiding risk to operators, the part itself and the rest of the premises of the foundry, provokes that productivity of these sort of installations is extremely low.

[0003] Manufacturing heavy section parts from molten metallic alloys involve some hindrances and difficulties found in any complex process where it is necessary to control a large number of variables to achieve a product which has a quality meeting the requirements for such product. However, once the metal is introduced in the mold, no further action but waiting can be done. During the mentioned lapse, which may vary from between some hours to months depending on the thicknesses of the casting, the place where the mold is located and mainly the frames and sand are not available for other uses.

[0004] Nowadays, the usual method to modify the speed for extracting thermal energy from parts embedded in a sand mold is using metallic massive components, known as chills, weighing approximately in the range 15-50 kg for heavy section castings. Those chills are placed either in contact with the parts to be manufactured or embedded inside the sand mold. The chills placed in these fashions allow increasing cooling speed of portions of the part in contact with or close to the chills during the solidifying process. When the chill reaches temperatures close to those of the alloy it loses the capacity to extract heat. Therefore the chills are effective for some time (at the beginning of solidification) and their use is interesting in many applications because they help to reduce certain defects associated to solidification process, such as graphite degeneration in cast iron, segregation and shrinkage defects in metallic alloy casting in general, etc.

[0005] Another technique commonly used to reduce the time the part must remain inside the mold is to use sand type with a higher thermal conductivity. To achieve this, during production of these molds, some portions of the mold are prepared with a different type of sand, mainly chromite, which has higher thermal conductivity than conventional sand. Same as the chills, when this sand is supersaturated on heat the efficiency of heat release is notably slow down. As for chills, it mainly increases the cooling rate at the beginning of the solidification process. The use of chromite has the additional inconvenient of a much higher density than silica sand: and when it is used in combination with silica sand; they generated recycling or reusability problems

[0006] US2005056395A1 discloses a method of casting aluminum or aluminum alloy separating molds from a continuous molding train separately introducing the molds in water to speed up cooling. Once aluminum or aluminum alloy has solidified, the mold is dismantled and the sand after drying it can be reutilized.

[0007] US2005103407A1 discloses a method for producing light alloy casting in which a thermal treatment is given, avoiding the usual furnace where this thermal treatment is applied. Specifically, the applied thermal treatment consists of keeping for a specified period of time at a temperature around 200°C the casting part. Previous to the thermal treatment where the furnace is no longer required, the mold is submerged in water to apply to the casting a preceding cooling.

[0008] DE102014101609A1 discloses a method to cool a metallic part obtained by casting that is surrounded or enveloped in a rigid or flexible cover (sheath) and submerging the part inside the cover in a cooling fluid which is at a temperature lower than the temperature of the part.

[0009] JP2002307158A discloses a method to refrigerate a casting manufactured in green sand mold. The objective of the method is to embed the casting mold in an airtight structure. After casting a molten metal in a raw sand mold and cooling for a predetermined time (usually till solidification), the mold is airtightly surrounded and the inside of the airtight structure containing the mold is sucked and depressurized, whereby the mold is heated to a temperature higher than the moisture content. The boiling point is lowered, the water is boiled, and the part of sand not affected by the heat of the molten metal is disintegrated, separated and removed, leaving the cast in the state of being wrapped in the remaining sand which is heat affected. The objective of the secondary cooling is to achieve a sought after feature in the casting. The portion of sand in the mold not affected by the heating can be reused in future molds.

[0010] US2005056395A1, US2005103407A1 and DE102014101609A1 disclose cooling of the casting by submerging the mold in a tank containing a cooling fluid but many times it is not feasible to introduce the molds in water due to the weight, dimensions and risk of such hot temperature manipulation.

[0011] Despite the cited references refer to casting manufacturing methods including different cooling types, such methods are not directed to solve the problem of diminishing the waiting time for the heavy casting to achieve a temperature where the part can be manipulated and the sand, mold frames and the shop floor are available for further manufacturing. Quite to the contrary, the methods disclosed in US2005056395A1, US2005103407A1, DE102014101609A1 and JP2002307158A do require auxiliary facilities in addition to the mold itself: US2005056395A1, US2005103407A1 and DE102014101609A1 do need cooling fluid tanks where the molds are submerged, whereas JP2002307158A does necessitate a hermetic chamber where the mold is introduced.

[0012] Moreover, US2005056395A1, US2005103407A1, DE102014101609A1 and JP2002307158A also depend on a further additional facility to transport the molds to and from in the foundry, so that cooling by submersion (US2005056395A1, US2005103407A1, DE102014101609A1) or the stage in a hermetic chamber (JP2002307158A) can take place.

[0013] As it becomes apparent, the state of the art does not provide a solution for the problem of how to diminish the waiting time for the casting to achieve a temperature where the part can be manipulated and the sand, mold frames and the shop floor are available for other activities at the earliest convenience. Thus, the object of the invention is exactly to give a solution to the problem still to be solved: to decrease the time where the components of the mold and the space where the mold is located are blocked by the wait for the time when the temperature of the manufactured part allows for the following stages in the manufacturing process to be performed.

DESCRIPTION OF THE INVENTION

[0014] A first object of the invention relates to a device for improved cooling of a metallic alloy comprising
a sand mold with an inner cavity fillable with a metallic alloy to be solidified inside the inner cavity,
thermal energy extracting means embedded at least partially in the sand mold and comprising at least a conduct and a coolant inside the conduct, the coolant being movable in the conduct for extracting heat from the metallic alloy. The conduct can be a single continuous conduct or a plurality of conducts. The coolant can circulate in a closed loop circuit.

[0015] In one embodiment a part or surface of the thermal energy extracting means is in direct contact with the metallic alloy, when the metallic alloy fills the inner cavity (for example a part of the thermal energy extracting means has access, breaks in or delimits an area or portion of the inner cavity).

[0016] In another embodiment the thermal energy extracting means and the metallic alloy in the inner cavity are separated by a portion of sand mold. That means that there is not direct contact between the extracting means and the metallic alloy.

[0017] According to the invention the sand mold receives the molten metallic alloy and keeps the metallic alloy in the sand mold for a specified period during solidification and further cooling up to a temperature low enough to have the cast part ready for next stages in the production process. The cooling device can be considered as a thermal energy extracting system which can extract heat from:

1a) a metallic alloy area, to cool the metallic alloy area close to the thermal energy extracting means to obtain a direct cooling of the metallic alloy area and/or

1b) a mold portion, where the sand mold portion surrounding the thermal energy extracting means is cooled or refrigerated so as to obtain an indirect cooling of the metallic alloy and surrounding area;

[0018] In other words, the thermal energy extracting means can be configured to cool a metallic alloy area, a sand mold portion, or both.

[0019] Thus, the sand mold with the device for improved cooling of the invention increases thermal energy extracting capacity from the metallic alloy as compared to a sand mold without any cooling system or with usual metallic chills embedded in sand or in contact with the metallic alloy.

[0020] As mentioned previously the thermal energy extracting system can be arranged in two ways: in direct contact with the metallic alloy to be cooled or without direct contact. The first option, in direct contact with the metallic alloy to be cooled, renders a faster cooling than the second option.The system of the invention comprises both options, which can also be combined with each other.

[0021] The conduct of the thermal energy extracting system is configured to allow circulation of a coolant to evacuate heat from the element to be cooled. According to some embodiments of the invention, the conduct is configured as a cooling coil, being possible to have any configuration. In any case, the structure of the thermal energy extracting means are configured to maximize the heat exchange surface between the element to be cooled and the thermal extracting system. In other words, the structure of the thermal extracting means and the function of the coolant circulating through the conduct is to speed up the cooling of the element to be cooled.

[0022] According to an embodiment of the invention the thermal energy extracting means comprise a sleeve for housing at least partially the conduct. The sleeve is configured to allow heat transmission from the metallic alloy to the coolant in the conduct.

[0023] In one embodiment the sleeve is in direct contact with the metallic alloy when the metallic alloy fills the inner cavity such that the sleeve extracts heat directly from the metallic alloy and transfers this heat to the coolant.

[0024] In another embodiment the sleeve and the metallic alloy in the inner cavity are separated by a portion of the sand mold. That means that there is not direct contact between the sleeve and the metallic alloy, the sand extracting heat from the metallic alloy and the sleeve extracting heat form the sand surrounding the metallic alloy and transferring this heat to the coolant.

[0025] The function of the sleeve is, on the one side, to protect the conduct and, on the other side, to increase the heat exchange surface from which heat from an area of the metallic alloy or from a portion of sand can be released and transferred to the coolant. The sleeve also allows modifying the cooling effectiveness to adapt it to different needs when changing other operating parameters of the thermal energy extracting system such as the choice of coolant or flow rate when they are not enough to meet the required operating conditions. Accordingly, the sleeve allows modifying the size and pattern of the conduct without modifying the model used for conforming the sand mold, thereby providing a substantial reduction in cost.

[0026] In a preferred embodiment of the invention, the sleeve is metallic.

[0027] In an embodiment the sleeve is a solid piece in direct contact with the conduct. The sleeve can comprise housings for placing the conduct. The sleeve can also comprise channels for the circulation of the coolant directly inside the sleeve, without the use of a conduct as a separate element.

[0028] In an embodiment a surface or part of the thermal energy extracting means in contact with the metallic alloy can reproduce partially the shape of the inner cavity. That means that this surface or part of the thermal energy extracting conforms an area of the inner cavity and consequently is designed so as to reproduce partially the shape of the cast part to be obtained. When a sleeve is used, a part or surface of the sleeve reproduces the shape of the inner cavity.

[0029] The device of the invention can further comprise flow regulating means to regulate the coolant flow rate. This flow rate regulation allows controlling the cooling speed.

[0030] The device can also comprise temperature measuring means configured to measure a temperature of the metallic alloy, the coolant, the sand mold (in different positions of the sand mold) or the sleeve and any combinations thereof.

[0031] The device can also comprise control means configured to act on the flow regulating means depending on a temperature measured by the temperature measuring means.

[0032] The coolant can comprise a cooling agent selected from liquid and gas or any combinations thereof or any combination with solid particles (as for example liquid with suspension solid particles, etc.).

[0033] According to an embodiment of the invention the temperature of the coolant in the conduct is lower than the temperature of the metallic alloy in the inner cavity. Preferably the temperature of the coolant circulating in the conduct is lower than 400ªC. In these conditions the cooling rate of the metallic alloy increases in 15-70% (in relation to a metallic alloy in the same sand mold but without the device of the invention).

[0034] Thus the cooling pace can be controlled, for instance, with the type of coolant being used, with the flow rate and measuring temperature in relevant locations of the mold, metallic alloy or conduct. Controlling these parameters during the process, the refrigerating system enables governing the cooling rate of the alloy at a convenience. This allows to minimize the time required for the part to cool down to temperatures where the part can be manipulated significantly.

[0035] A second object of the invention is the use of the device described previously to improve the cooling of a metallic alloy, when a metallic alloy fills the inner cavity of the sand mold and a coolant circulates inside the conduct.

[0036] A third object of the invention is a method for improved cooling of a metallic alloy comprising the steps of:

providing a sand mold comprising an inner cavity,

providing thermal energy extracting means, the thermal energy extracting means comprising a conduct (a single continuous conduct or a plurality of conducts),

placing the thermal energy extracting means at least partially embedded in the sand mold,

filling the inner cavity with a metallic alloy to be solidified inside the inner cavity and

circulating a coolant inside the conduct for extracting heat from the metallic alloy.

In an embodiment the method further comprises

providing a sleeve,

placing the conduct at least partially inside the sleeve and

placing the sleeve embedded at least partially in the sand mold, the sleeve being configured to allow heat transmission from the metallic alloy to the coolant in the conduct.

[0037] The method can comprise placing the thermal energy extracting means in the mold such that a part or surface of the thermal energy extracting means is in direct contact with the metallic alloy, when the metallic alloy fills the inner cavity.

[0038] The method can comprise providing a thermal energy extracting which comprises a surface or part that reproduces partially the shape of the inner cavity and placing the thermal energy extracting means in the mold such that this part or surface of the thermal energy extracting means is in direct contact with the metallic alloy. This part or surface conforms an area of the inner cavity and consequently is designed so as to reproduce partially the shape of the cast part to be obtained. When a sleeve is used, a part or surface of the sleeve can reproduce at least partially the shape of the inner cavity and is placed in the sand mold to be in direct contact with the metallic alloy.

[0039] The method can comprise regulating the coolant flow rate inside the conduct.

[0040] The method can also comprise measuring the temperature of the metallic alloy when the metallic alloy fills the inner cavity, coolant in the conduct, sand mold and combinations thereof. The method can comprise actuating on the flow rate depending on the temperatures measured.

[0041] In an embodiment the method comprises circulating a coolant in the conduct at a temperature lower than 400°C.

[0042] In an embodiment the method comprises circulating a coolant in the conduct at a lower than the temperature of the metallic alloy in the inner cavity such that the cooling rate of the metallic alloy increases in 15-70%.

[0043] Thus, the device and method of the invention minimizes the time required for the part to cool down to temperatures where the part can be manipulated. Additionally, an increase in the cooling enables a refining of the structure which may improve the mechanical features of the material, metallic alloy, constituting the casting part.

[0044] A further object of the invention relates to a casting with improved mechanical properties due to the refinement of the structure obtained with the method described when using the device of the invention.

[0045] As described the invention comprises incorporating a thermal energy extracting system in a sand mold so that the cooling rate of a metallic alloy can be governed to increase the cooling speed of the casting as much as possible meanwhile the quality of the casting is maintained or even increased.

[0046] The thermal energy extracting system in the sand mold notably increases the solidifying rate of the casting in the affected area, which enhances minimizing/avoiding some structural complications associated to long permanence of the metallic alloy in liquid state in the interior of the sand mold, such as degenerated graphite, segregation phenomena and shrinkage appearance. Moreover, the structure of the metallic alloy can be refined, which improves mechanical features of the metallic alloy, although an increase in the residual tensions in the casting is to be avoided. Residual tensions are induced by large differences in cooling rates between near areas and can lead to cracks in the part. Thus, the dynamic cooling system proposed in the present invention is adaptable by means of type and flow of coolant to the maximum allowed cooling rate of the specific casted alloy.

[0047] On the other hand, in several alloys such as iron based alloy, it is also necessary to control throughout the process the cooling rate of the metallic alloy because phase transformations in eutectoid transition (solid-solid) define the final phases which appear at room temperature. Therefore, the cooling system of the present invention offers additional opportunities to fit the cooling rate to precisely control the cooling process to guarantee the casting meets the specified requirements at room temperature rather than cooling throughout the process at maximum rate (despite some alloys can bear that). To this end, the temperature in the sand mold and the amount of thermal energy extracted by the cooling device (obtained from the flow rate and temperatures of the metallic alloy, coolant in the conduct and sand mold in different locations and combinations thereof) is to be exactly measured in control means. Thus, upon controlling the temperature of the metallic alloy at every moment, an adequate flow rate of coolant to regulate cooling rate according to the needs of the alloy can be controlled. This way, a determined quality in the casting part can be obtained from different chemical compositions and different cooling rates by knowing the phenomena that at micro and macroscopic level define the phases present at room temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] To complete the description and in order to aid a better understanding of the characteristics of the invention, according to examples of preferred embodiments thereof, a set of drawings is enclosed forming an integral part of the description where, for purposes of illustration and in a non-limiting sense, the following is shown:

Figure 1 shows an arrangement of the device where the thermal energy extracting means comprise two conducts embedded directly in the sand mold and the conducts ar e not in direct contact with the alloy to be cooled.

Figure 2A shows an arrangement of the device with thermal energy extracting means comprising a sleeve and wherein the sleeve is in direct contact with the alloy to be cooled.

Figure 2B shows an arrangement of the device with thermal energy extracting means comprising a sleeve and wherein the sleeve is not in direct contact with the alloy to be cooled.

Figure 3 shows different views of a possible configuration of device for a generic part having a cube shape; to enhance clarity, these drawings exclude the mold.

Figure 4 shows a possible configuration of device of figure 3 and the connection to the coolant circulating systems.

Figure 5 shows cooling curves in a cube without, with a metallic chill and with a sleeve of the invention as it is shown in Figure 3, with the thermal energy extracting system located on the upper and one lateral face of the cube as shown in Figure 3.

Figure 6 shows an scheme of extraction of tensile and resilience tests ISO V (55x55x10 mm) from the cube casting with configuration of the thermal extracting device shown in Figure 3.

[0049] The device comprises:

1 Sand mold

2 the inner cavity of the sand mold

3 Thermal energy extracting system

31 Sleeve

32 Conduct

4 Flow regulating means

5 Pumps

6 Reservoir of tank for coolant

7 Control means

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0050] According to a first embodiment of the invention illustrated in figure 1, 2A and 2B, the sand mold 1 includes two thermal energy extracting means 3. Obviously the sand mold can incorporate only one thermal energy extracting means 3 or more than two.

[0051] According to an embodiment of the invention illustrated in figure 1, the sand mold 1 includes two thermal energy extracting means 3 with no direct contact with the metallic alloy inside the inner cavity 2 of the sand mold 1. The distance between the thermal energy extracting means 3 and the inner cavity 2 depends on the casting thickness, cooling rate and the risk of cracks appearance on this specific combination of casting part and metallic alloy. Figure 1 also shows that the conduct 32 conforms a heat exchange surface formed by a coil.

[0052] Figure 3 shows different views of the channel or conduct 32 of a thermal energy extracting means for a part having a cubic shape. For the sake of clarity, the sand mold 1 is not illustrated in the figures. The embodiment of figure 3 shows two coils of conducts 32, a first coil of conduct 32 close to the top face of the cube and a second coil of conduct 32 close to a side face of the cube.

[0053] In figures 2A and 2B the thermal energy extracting means 3 are enclosed on steel sleeves 31 and the conduct 32 where the coolant flows is in the form of coils housed partially inside the sleeves 31. In figure 2A two sleeves 31 are represented in direct contact with the metallic alloy in the inner cavity 2 without any sand mold portion in between, whilst in figure 2B the sleeves 31 are with no direct contact with the metallic alloy inside the inner cavity 2 of the sand mold 1 (i.e. with sand mold in between).

[0054] Figure 4 shows the connection of the coils of conduct 32 of figure 3 to flow regulating means 4 and reservoirs or tanks 6 containing the coolant (in a closed loop). Also pumps 5 for moving the coolant have been represented. The embodiment shown in figure 4 shows that each coil of conduct 32 is independent from the other; that is, there are two independent refrigerating circuits, each having its own reservoir or tank 6 and its flow regulating means 4 and pump 5. According to an installation as the one shown in figure 4, each reservoir or tank 6 has a capacity of 2000 liters, each flow regulating means 4 has a power of 0,57 kW and a flow rate of 22 liters/min. Depending on the temperature registered by measuring means which can be embedded directly in the metallic alloy, in the conduct or in the sand mold portion, the control means 7 can regulate the flow regulating means 4 to increase/decrease the flow of the coolant in a circuit to speed up/slow down cooling of the mold portion close to the thermal energy extracting means 3 connected to the specific flow regulating means 4. Thus, a local control on cooling rate of the casting or the mold portion can be achieved.

[0055] Figure 5 shows cooling curves from the central area of a cubic shaped cavity embedded in a sand mold with thermal energy exchange system in Figure 3. Figure 5 includes three curves: the cooling curve of a sand mold 1 without refrigeration (a), the cooling curve of a sand mold 1 with a thermal energy extracting means consisting on a metallic chill in contact with the alloy and without refrigeration (b) and the cooling curve of a sand mold 1 with a thermal extracting means consisting on a sleeve 31 according to the invention in contact with the metallic alloy and conduct 32 embedded in the sleeve 31 where a coolant (water) was flowing through, at a flow rate of 22 liters/min (c). Every curve starts from approximately the same temperature, at which the molten metallic alloy 2 is placed in the sand mold 1. The curves show that when a metallic chill or a sleeve 31 is in contact with the alloy the cooling rate increases notably compared with the curve obtained without any refrigeration. The decrease of the time at which the alloy is in liquid state reduces graphite degeneration in ductile iron, refines and homogenizes the size of the grains (any cast alloy) and reduces segregation phenomena (enrichment of the last to freeze liquid with these elements that segregate positively, i.e., these elements that are not adsorbed by the main cast alloy matrix, and deployment of the last to freeze liquid with these elements that segregate negatively, i.e., these elements that are preferably adsorbed by the main cast alloy matrix). After solidification both castings with metallic chill and with sleeve 31 cool down more or less at the same cooling rate up to the embodiment of the invention starts running. Once the refrigerating system is started (approximately when temperature is 1050°C in the center of the casting) it is noticeable that the casting with a thermal energy extracting means according to the embodiment of the invention cools down faster. The time to achieve a temperature at which the castings can be handled (450°C) is 20 h and 22 min (sand mold), 15 h and 44 min (sand mold with a metallic chill) and 9 h and 23 min (sand mold with the device of the invention). With the embodiment of the invention a reduction of about 54% and 40% in time compared with sand mold and sand mold with a metallic chill respectively is obtained.

[0056] The benefit of this increase of the cooling rate is shown in the mechanical properties obtained from the middle level of the cube regarding its height. Two samples are obtained at this level with an orientation parallel to the vertical sleeve (if any): at the geometrical center and at 20 mm from the surface where the sleeve is placed (if any) as it is shown schematically in Figure 6. The mechanical properties were determined at AZTERLAN facilities. Tensile test was carried out at room temperature according to UNE-EN ISO 6892-1:2017 standard with tensile test specimens 10 of 14 mm diameter according to UNE-EN 1563:2012 standard. Tensile tests were carried out using an Instron Universal testing machine to obtain yield strength (Y0.2, MPa), ultimate tensile strength (UTS, MPa) and elongation percentage, E (%). Charpy (V-notch) pendulum impact test was carried out at - 20°C according to UNE-EN ISO 148-1:2017 standard being the test specimens of 55x55x10 mm according to UNE-EN ISO 148-1:2017 standard. The obtained results show that elongation is increased about 20% and Charpy impact test values are more than doubled for similar UTS and Y0.2 values when both metallic chill and the embodiment of the invention are used.

Casting	Position of the sample	UTS (Mpa)	$Y_{0.2}$ (MPa)	E (%)	Charpy (J)		
					1	2	3
Without refrigeration	Centre	388	238	20.4	4	5	5
	20 mm	389	238	20.6	4	4	5
	from the surface						
Metallic chill	Centre	381	237	26.7	9	8	8
	20 mm from the surface	379	230	24.9	12	12	11
Sleeve & cooling system (embodiment of the invention)	Centre	381	233	24.2	8	10	11
	20 mm from the surface	384	233	26.1	16	15	14

[0057] In the context of the present invention, the term "approximately" and terms of its family (such as "approximate", etc.) should be understood as indicating values very near to those which accompany the aforementioned term. That is to say, a deviation within reasonable limits from an exact value should be accepted, because a skilled person in the art will understand that such a deviation from the values indicated is inevitable due to measurement inaccuracies, etc. The same applies to the terms "about" and "around" and "substantially".

[0058] On the other hand, the invention is obviously not limited to the specific embodiment(s) described herein, but also encompasses any variations that may be considered by any person skilled in the art (for example, as regards the choice of materials, dimensions, components, configuration, etc.), within the general scope of the invention as defined in the claims.

Claims

1. Device for improved cooling of a metallic alloy comprising

a sand mold (1) with an inner cavity (2) fillable with a metallic alloy to be solidified inside the inner cavity,
thermal energy extracting means (3) embedded at least partially in the sand mold (1) and comprising at least a conduct (32) and
a coolant inside the conduct (32), the coolant being movable in the conduct for extracting heat from the metallic alloy.

2. Device according to claim 1 wherein at least a surface or part of the thermal energy extracting means (3) is in direct contact with the metallic alloy, when the metallic alloy fills the inner cavity (2).

3. Device according to claim 2 wherein the surface or part of the thermal energy extracting means (3) in contact with the metallic alloy reproduces partially the shape of the inner cavity (2).

4. Device according to claim 1 wherein the thermal energy extracting means (3) and the metallic alloy in the inner cavity (2) are separated by a portion of sand mold.

5. Device according to any of previous claims wherein the thermal energy extracting means (3) comprise a sleeve (31) for housing at least partially the conduct (32), the sleeve (31) being configured to allow heat transmission from the metallic alloy to the coolant in the conduct (32).

6. Device according to any of previous claims comprising flow regulating means (40) to regulate the coolant flow rate inside the conduct (32).

7. Device according to any of previous claims comprising temperature measuring means (5) configured to measure a temperature of the metallic alloy (2) when the metallic alloy fills the inner cavity (2), the coolant in the conduct (32), the sand mold (1) and combinations thereof.

8. Device according to claims 6 and 7 comprising control means (6) configured to act on the flow regulating means (40) depending on a temperature measured by the temperature measuring means (5).

9. Device according to any of previous claims wherein the coolant comprises a cooling agent selected from liquid or gas or any combination thereof or any combination with solid particles and the temperature of the coolant circulating in the conduct (32) is lower than 400°C.

10. Device according to any of previous claims wherein the temperature of the coolant in the conduct (32) is lower than the temperature of the metallic alloy in the inner cavity (2) such that the cooling rate of the metallic alloy increases in 15-70%.

11. Method for improved cooling of a metallic alloy comprising the steps of:

providing a sand mold comprising an inner cavity (2),
providing thermal energy extracting means (3), the thermal energy extracting means (3) comprising at least a conduct (32),
placing the thermal energy extracting means at least partially embedded in the sand mold (1),

filling the inner cavity (2) with a metallic alloy to be solidified inside the inner cavity and
circulating a coolant inside the conduct (32) for extracting heat from the metallic alloy.

12. Method according to claim 11 comprising

providing a sleeve,
placing the conduct (32) at least partially inside the sleeve and
placing the sleeve embedded at least partially in the sand mold (1), the sleeve (31) being configured to allow heat transmission from the metallic alloy to the coolant in the conduct (32).

13. Method according to any of claims claim 11 or 12 comprising placing a part of the thermal energy extracting means (3) in direct contact with the metallic alloy, when the metallic alloy fills the inner cavity (2).

14. Use of device as in claims 1 to 10 to improve the cooling of a metallic alloy, when a metallic alloy fills the inner cavity (2) of a sand mold (1) and a coolant circulates inside the conduct (32).

15. A casting with improved mechanical properties due to the refinement of the structure obtained with the method of claims 11 to 13 when using a device as in any of claims 1 to 10.

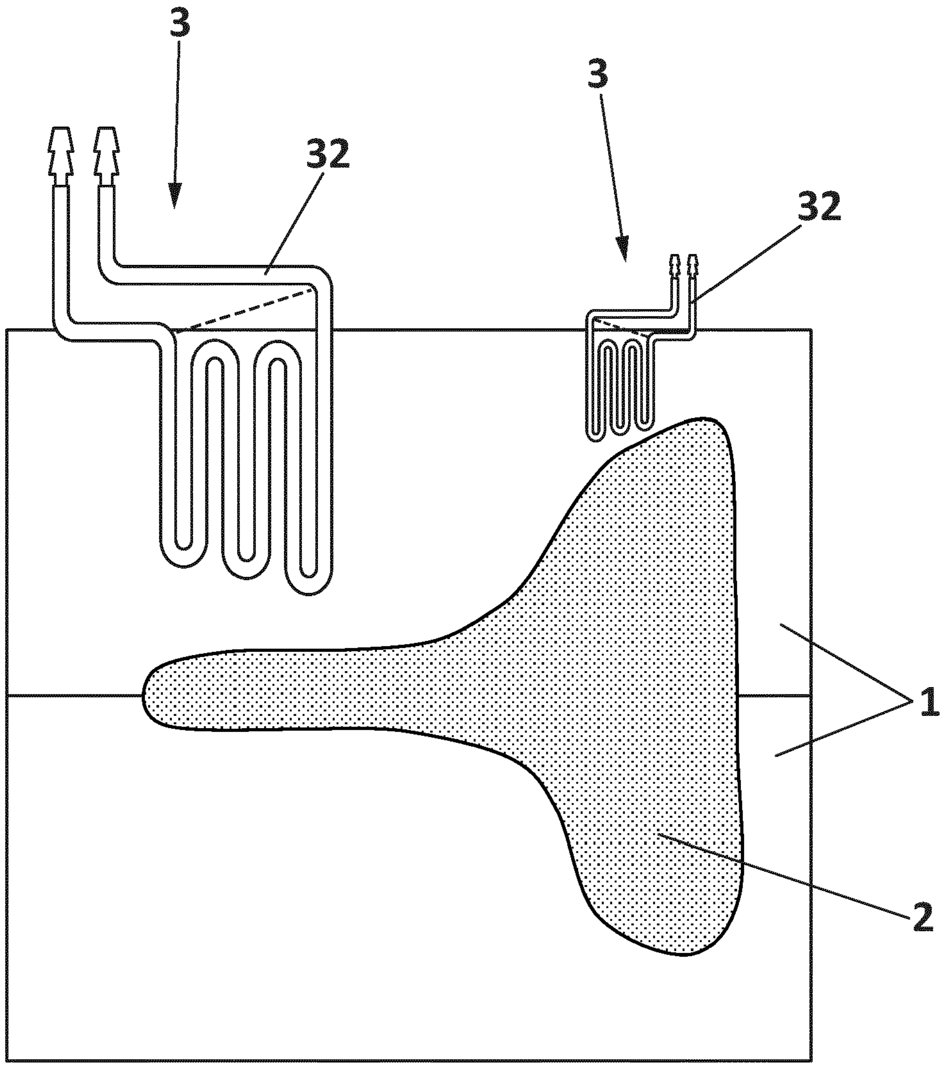

FIG. 1

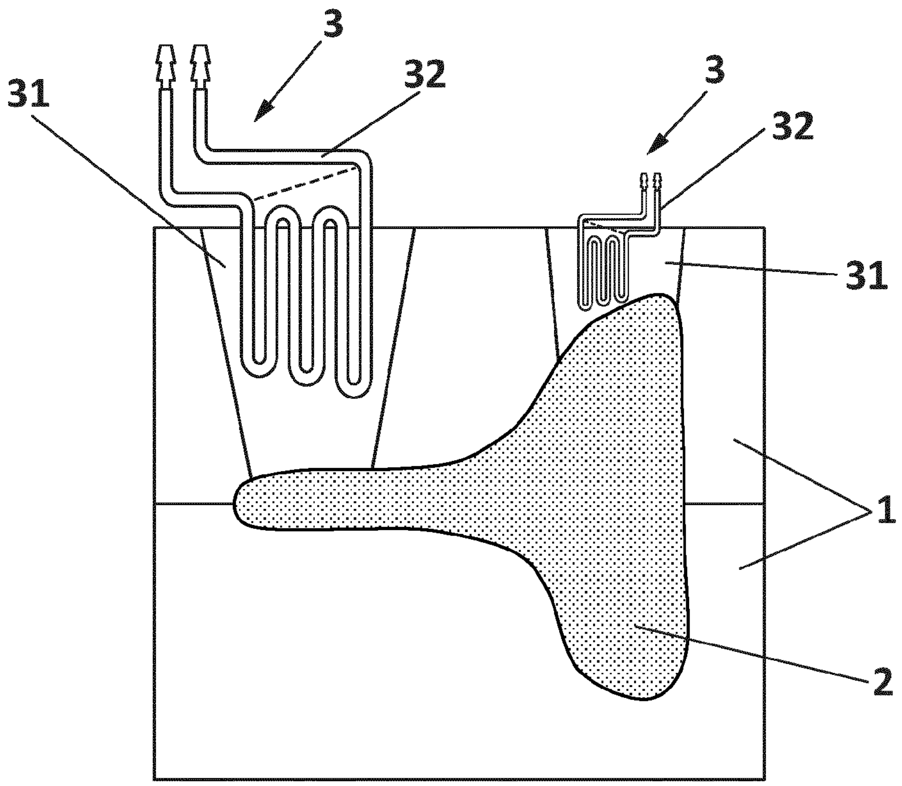

FIG. 2A

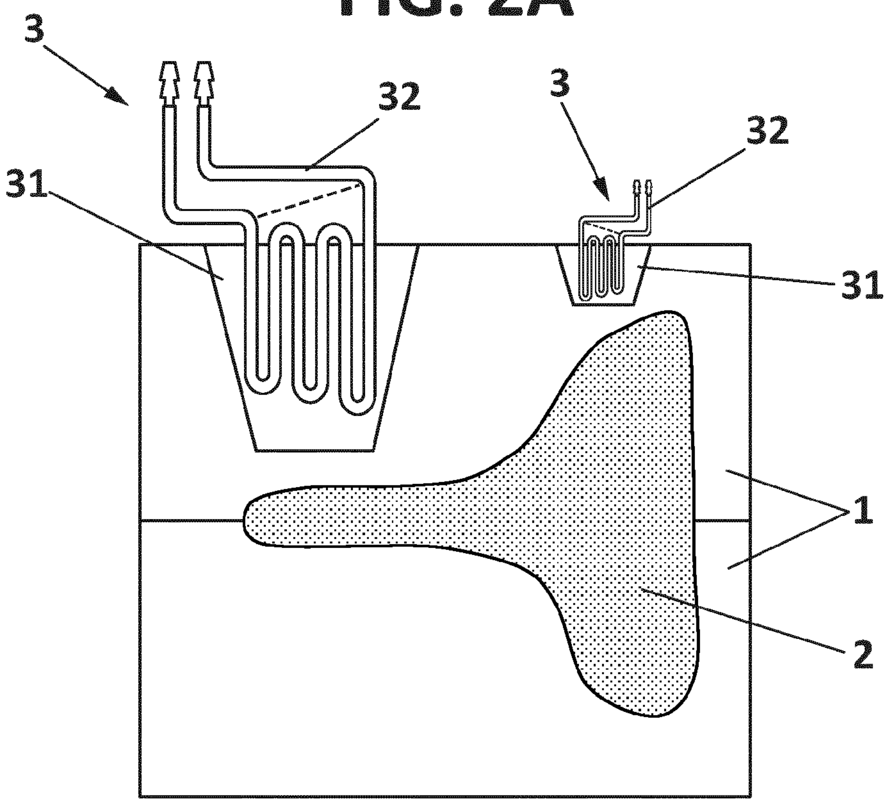

FIG. 2B

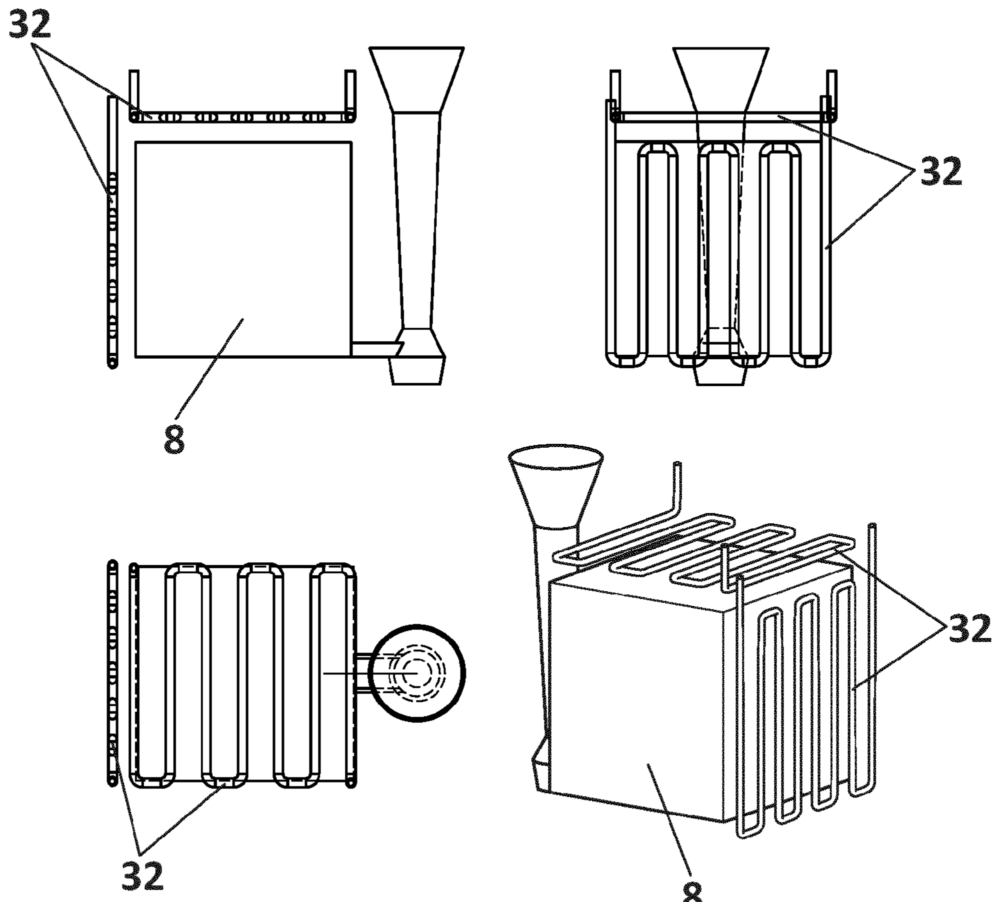

FIG. 3

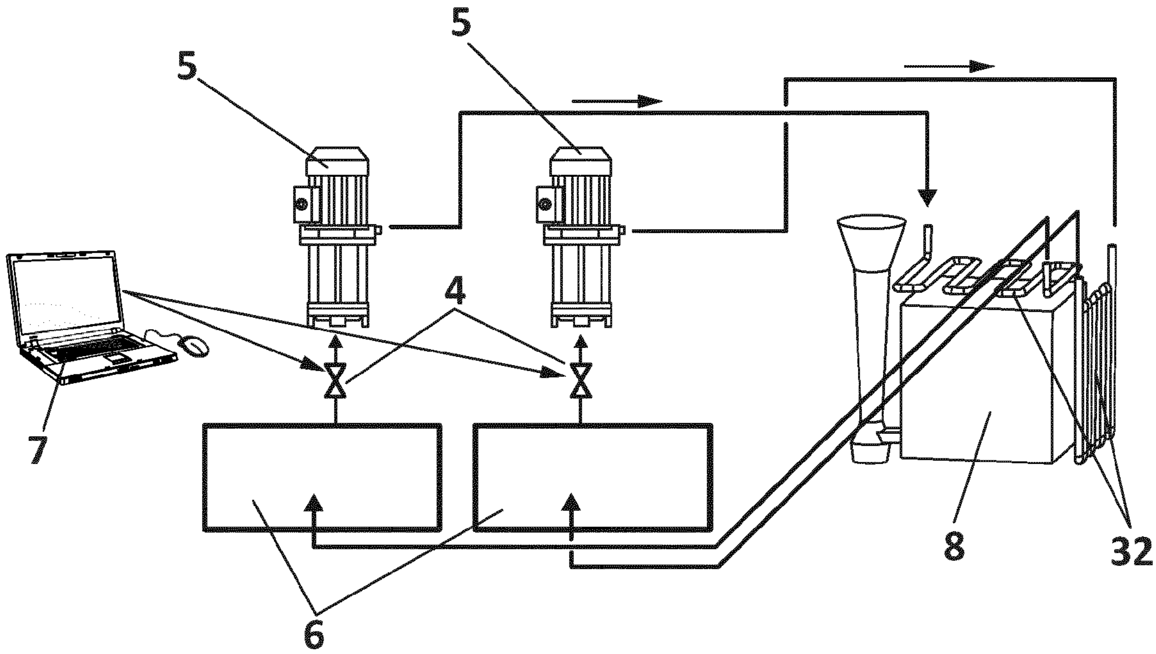

FIG. 4

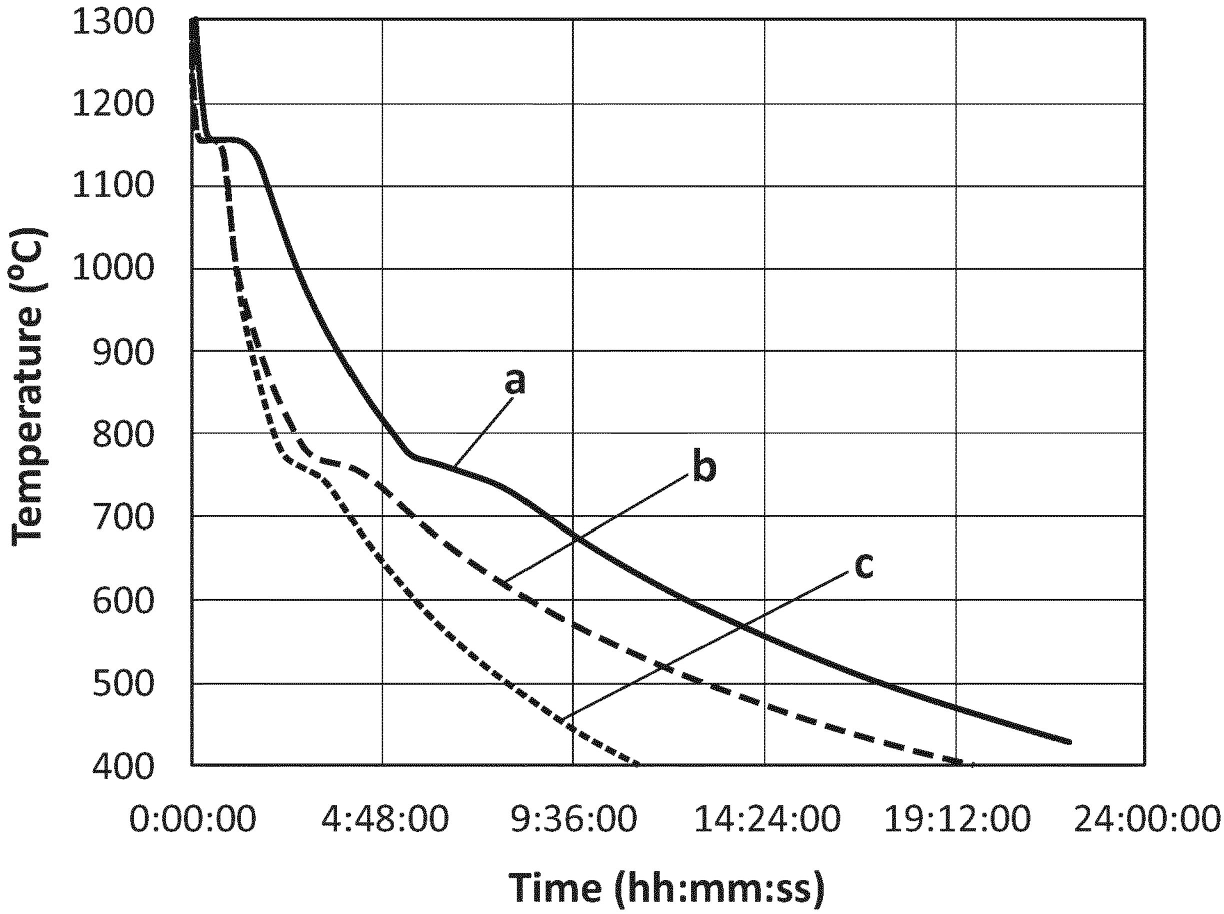
1300
1200
1100
1000
900
800
700
600
500
400
Temperature (ºC)
0:00:00
4:48:00
9:36:00
14:24:00
19:12:00
24:00:00
Time (hh:mm:ss)
a
b
c

FIG. 5

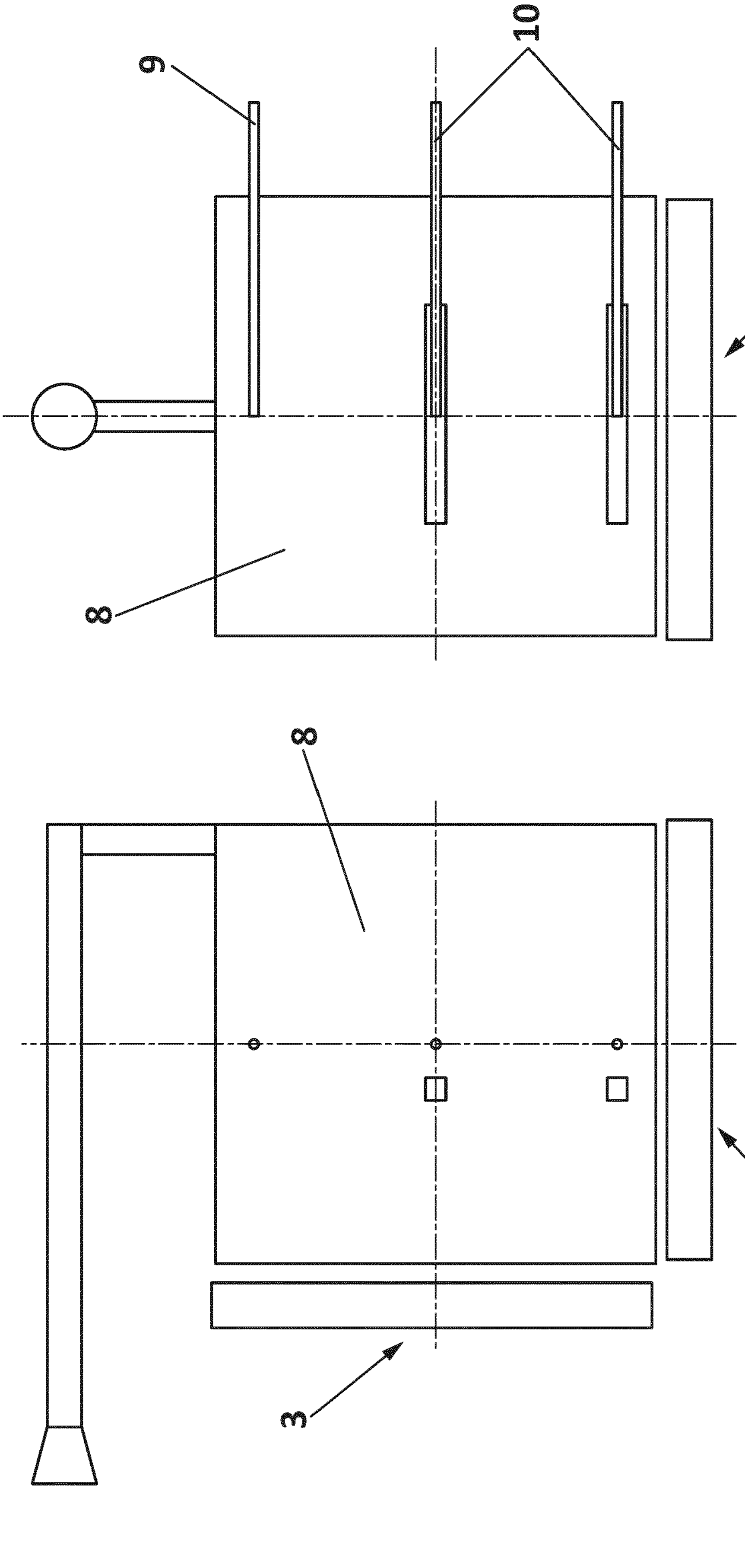

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 17 38 2911

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1

Place of search	Date of completion of the search	Examiner
Munich	16 April 2018	Scheid, Michael

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