(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 294 476 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
03.07.2019 Bulletin 2019/27

(21) Application number: **16774976.1**

(22) Date of filing: **12.05.2016**

(51) Int Cl.:
B22C 9/08 *(2006.01)*
B22C 9/02 *(2006.01)*
B22D 21/00 *(2006.01)*
B22D 25/02 *(2006.01)*
B22D 27/04 *(2006.01)*
B22C 9/12 *(2006.01)*
B22D 15/00 *(2006.01)*

(86) International application number:
PCT/HU2016/050019

(87) International publication number:
WO 2016/181177 (17.11.2016 Gazette 2016/46)

(54) **CASTING PROCESS AND SAND MOULD PROVIDED WITH AN INLET SYSTEM FOR PRODUCING AT LEAST PARTLY THIN WALLED ALUMINIUM CASTS WITH SAND MOULDING TECHNOLOGY BY MEANS OF GRAVITY CASTING**

GIESSVERFAHREN UND SANDFORM MIT EINLASSSYSTEM ZUR HERSTELLUNG VON MINDESTENS TEILWEISE DÜNNWANDIGEN ALUMINIUMFORMEN MIT SANDFORMTECHNOLOGIE MITTELS SCHWERKRAFTGIESSEN

PROCÉDÉ DE COULAGE ET MOULE EN SABLE POURVU D’UN SYSTÈME D’ADMISSION POUR PRODUIRE DES PIÈCES COULÉES EN ALUMINIUM À PAROIS AU MOINS PARTIELLEMENT MINCES AVEC LA TECHNOLOGIE DE MOULAGE AU SABLE AU MOYEN D’UN COULAGE PAR GRAVITÉ

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **14.05.2015 HU P1500230**

(43) Date of publication of application:
21.03.2018 Bulletin 2018/12

(73) Proprietor: **Alu-Öntö Kft.**
1215 Budapest (HU)

(72) Inventor: **HAJAS, Gergely**
1215 Budapest (HU)

(74) Representative: **Kacsuk, Zsófia**
Kacsukpatent Kft.
Üteg u. 11/a
1139 Budapest (HU)

(56) References cited:
JP-A- S5 731 463

- **DATABASE WPI Week 201479 Thomson Scientific, London, GB; AN 2014-V42473 XP002763862, -& CN 104 014 717 A (ZHU X) 3 September 2014 (2014-09-03)**

EP 3 294 476 B1

Description

[0001] The subject of the invention is a casting process to produce at least partly thin-walled aluminium castings by gravity casting and with sand moulding technology. Exemplary processes in this area are disclosed by JPS5731463 A and CN104014717 A. In the present invention, the wall thickness of the thin-walled part is 1-3 mm.

[0002] A further subject of the invention is a sand mould and an inlet system (gating system), which will allow manufacturing cast parts of this nature.

[0003] In order to produce aluminium casts, sand moulding techniques have been applied for a long time. The basic principle behind this technology is that a die cavity adjusted to the casting's geometry is made from suitable moulding sand. This cavity is then poured with molten aluminium according to the required temperature and other casting conditions. The moulding sand will then be removed from the solidified casting, which will be used for the specific purpose. The sand moulding technology offers the benefit of producing the sand mould in a relatively simple way; its drawback, however, is that a new sand mould is needed for each casting procedure, which requires producing a sand mould for every single casting, thus the mould cannot be reused. Consequently, the sand moulding technology has so far been applied for the manufacture of individual or small range castings. During the casting process the molten aluminium in the mould will spread under the effect of gravitation and will fill in the casting mould. This operation is called gravitation casting. Gravity casting is important as the crude or chemically bonded mould cannot bear high mechanical burden, which means that high pressure cannot be applied. The sand moulding gravity technology having been applied so far does not allow manufacturing thin-walled castings with dimensions larger than 50-100 times of the wall thickness.

[0004] The method to be applied in producing thin-walled castings of large surfaces (dimensions) is the high-pressure die casting process, in which the molten metal is fed by means of a pressure casting machine in a short period of time (0.01-0.05 s) and at an extremely high flow rate (20-80 m/s in the conduit) into the cavity of the cooled (cooled in a cooling system to 150-250 °C) where during the solidification process extremely high pressure (500-1500 bar) is applied. The casting machine and the casting mould are complex and costly, which makes them cost-effective only if large series of castings (several ten or hundred thousands, depending on the casting mass) are manufactured.

[0005] CN 1709612 Chinese patent description provides information on the process of manufacturing super-thin walled aluminium casts by means of high speed pressure. This process includes the following steps: a model casting mould is fitted into the die-casting machine then the parameters of die-casting are set. The casting pressure is 780 kg/cm^2, the temperature of the model casting mould is set to 250°C, the dissolvent temperature is 700°C, then the alumina alloy is injected into the die-casting machine. In order to achieve smaller than 1.0 mm wall thickness, 0.23 m/sec injection speed is applied. This is followed by removing the cast, which will be tested if it fulfils the international patent requirements. A casting produced in this way can primarily be applied in 3C products, such as for computer frames, digital cameras and mobile phones.

[0006] The conventional sand moulding technology and the pressure technology greatly differ from each other.

[0007] The conventional sand moulding technology is a complicated procedure, consisting of several steps, compared to high-pressure casting, in which almost the complete manufacturing process is performed by machines in order to achieve high manufacturing series.

[0008] The production of castings with low wall thickness, in the high-pressure casting process, is carried out with very short casting time and at an extremely high flow rate, which cannot be achieved through the gravitation casting process.

[0009] Other casting methods are also known, in which e.g. centrifugal force is applied to cope with the problems of filling up the mould, however, these processes cannot be applied in manufacturing large-sized, articulated castings. All the above suggests that gravity casting has physical limitations related to the casting value and to decreasing wall thickness of a casting to be produced and to increasing its dimensions.

[0010] All this suggests that the gravity sand mould casting process is applied in making casts with wall thickness of above 3.5 mm and with limited surface size related to the wall thickness (maximum 50-100 times larger).

Comparison as relates to foundries

[0011] The trends in casting technology, such as high-pressure - gravity - sand mould die casting - are becoming more and more specialised. There is no connection between each technology, they are getting increasingly separated, more and more complex technical solutions must be performed, and no technological fault is affordable, or at least at very high cost.

[0012] The foundries applying different casting processes tend to develop their own technologies in order to avoid risks which require modelling to make their product effective. Modelling has two different methods. One of them is virtual modelling, which is made by most foundries applying pressure die casting. A program related to the given technical parameters models the casting process and highlights the expected difficulties of casting. This method offers the advantage of quickness, but its drawback is that it will not provide evidence of the behaviour of the mould in real operating conditions.

[0013] The other modelling process is sand casting, which means that the actual casting is produced by a sand casting foundry. The casting produced with this method is like the original one as regards its geometry and structure.

[0014] In this case the piece allows measurements, helps design the technology, and draws the attention to the technological demand (e.g. running and feeding systems, etc.)

[0015] Its drawback, however, is that the process is slow and costly as compared to virtual modelling.

Comparison regarding the user

[0016] Currently the users' demands offer more and more requirements as well as the testing phases are separated.

[0017] It is a long time since modelling a product prior to mass production became accepted in car manufacturing; currently it has been the case in other industries as well. This method serves different purposes. Firstly, a prototype is made for different purposes (mechanical, assembly, operation under plant conditions, etc.); however, it can also be used for selling, presenting and marketing purposes.

[0018] Nevertheless, it is not all the same for what purposes the product is to be used (pressure, gravity or sand) and what kind of technical content the given cast has.

[0019] A given product or casting has basic properties that determine the technology to be applied; these are as follows: expected annual product number, dimensions, raw material, geometry, weight, and prescribed mechanical properties.

[0020] Once the customer has decided to employ test manufacture, he has the choice between two ways. One of them is to order the product with testing according to the final technology, which (concerning our case) is basically pressure die casting. The customer orders the pressure die and the casting technology, and waits for it to be prepared. Once the die has been produced, test casting is ordered, and providing it is based on a drawing or a model, the testing phase will be started.

[0021] This method is time consuming and costly, and includes a lot of uncertainties and risks on the customer's part until the test results meet the requirements.

[0022] Any development by a customer is not allowed to be mass produced without previous physical testing.

[0023] There are cases when the ordered product development cannot be modelled by cheap and fast alternative technology because the cast contains technical parameters that are casting technology specific.

[0024] In this case the customer will find other alternative solutions such as the piece being manufactured from pig or a plastic model being printed for demonstration purposes.

[0025] Until recently no sand die technology has existed which would enable producing prototype pieces of casts designed for pressure casting technology, which includes the following requirements related to the cast: 1-3 mm average wall thickness (this can be even 1 mm walls in certain parts), higher accuracy of the casting size, as well as maintenance of all these in case of large sized casts.

[0026] It has been recognised that the most important difficulty is that the above requirements must be fulfilled in a way when there is no die with the required heated, machine-powered closing force, thus the melt is to be fed into the die under atmospheric pressure.

[0027] In so far as a stable and technically identical sand cast can be produced by fulfilling the requirements but by neglecting the pressure technology, then an alternative technology has been provided for producing thin-walled casts by means of sand die casting technology. It must be stated that the term technically identical means that the material structure of the casting is different.

[0028] Specificity (related to what kind of cast designed for pressure casting requires replacement) is always determined by the requirements of the casting.

[0029] To produce a cast designed for pressure die-casting technology with sand moulding technology in which the average wall thickness is 4 mm or larger, the geometry is simple, or tolerated dimensions can be formed and upheld by machining creates no difficulty.

[0030] The cast produced in this way will ensure safe and quick testing and assembly according to the customer's demand, provides possibility for the introduction to the market, provides low level of producing costs (related to the cost level of pressure die-casting technology); what is even more important, it ensures quick and cost-effective modification and execution of possible design faults.

[0031] This process allows the developer-customer to provide such safe products for mass production, which will not carry technical and design risks and can be adjusted to market competition as related to both quickness and cost efficiency.

[0032] The objective of developing the process applied in the invention is to establish such a casting process, which is suitable for producing articulated, thin-walled aluminium casts by means of gravity sand mould casting supposing 1-3 mm wall thickness and 200-400 times larger sizes are provided.

[0033] It has been recognised that the method according to the present invention allows manufacturing larger sized castings as compared to the well-known process of gravity die casting. In this way the method according to the invention is suitable for manufacturing castings, which can be applied in practice. The products are mainly indoor and outdoor luminaires, engine parts - spare parts, cylinder-heads, machine components, spare parts for mechanical and precision engineering, fittings, etc. All these products can be produced with the method according to the invention in such quality that they will be suited for practical application under operational conditions. This will result in cost-effective development and more effective testing before the manufacture on large scale starts. Aluminium castings for different purposes are to be produced with this method economically, on small to medium scale, even in several hundred items.

[0034] The method according to the invention enables manufacturing larger sized castings at a much lower cost - in contrast to pressure casting - which will appear in the initial die cost and production time.

[0035] The subject of the invention is a method according to claim 1 and a sand mould provided with a gating system according to claim 10.

[0036] Certain preferred embodiments of the invention are defined in the dependent claims.

[0037] The further details of the invention are presented in connection with embodiments, with the help of drawings. In the drawings:

Figure 1a shows a schematic perspective view of the inner structure of a sand mould fitted with a gating system according to the invention.

Figure 1b shows a schematic cross sectional view of the sprues of the sand mould fitted with a gating system as regards Figure 1a.

Figure 1c shows a perspective image of a casting produced by means of a sand mould.

Figure 2 shows another schematic perspective view of the inner layout of the sand mould with a gating system.

[0038] Materials, tools and terms applied in the invention:

'Aluminium casting ': a casting which is made of Aluminium or Aluminium alloy.

'Aluminium alloy': generally 'silumin' alloys specifically (ENAC or other) alloy groups according to the patent such as AlSi12MgTi, AlSi7Mg, AlSi10Mg, AlSi9Cu (these are mainly used in the technology relative to the invention, but in certain cases other Al alloys can also be used).

'Articulated, rich in details': alloy with complex geometry in which in a given case stiffening ribbing is applied.

'Thin-walled': the average wall thickness of the alloy is 1-3 mm, its larger dimension is larger than 50 times or a 100 times of the wall thickness and change in the wall thickness will not exceed 50% of that.

'Pressure casting': A casting process in which liquid metal is poured by a casting machine during extremely short times (0.01-0.05 m/s) and at a very high flow rate (20-80 m/s in the channel) into the cooled (150-200 °C) mould cavity where extremely high pressure is applied while the metal is solidified.

'Gravity casting': A casting procedure in which liquid metal is poured into the mould cavity by gravity energy under atmospheric pressure. This casting technology operates by the principles of communicating vessels in which no further energy (e.g. centrifugal force effect) aids the molten metal fill in the mould cavity.

'Sand mould': refractory sand of 0.2-0.4 mm grain sizes (typically quartz sand but other kind of artificial sand can also occur) hardened with organic or non-organic bonding agent system in cold state (with chemical bond) or by heat (under the effect of being heated)

'Sand mould casting': pouring liquid metal into any kind of sand mould.

[0039] With the sand mould fitted with a gating system and by the method according the present invention, and to be introduced in the following, such -at least partly- thin-walled aluminium castings can be produced by sand moulding technology and gravity casting, in which the wall thickness of one or more parts is 1-3 mm and the largest dimension is multiplied by 100 times, or even 200-400 times compared to the wall thickness.

[0040] The largest dimension means the largest linear dimension of the given part of a casting, i.e. the longest side of the smallest prism which can involve the given part of the cast.

[0041] In Figure 1a and 1b the inner structure of the sand mould (12) fitted with a gating system (10) is shown. In figure 1a the outer edges of the sand mould are shown only as illustration around the inner formation in a perspective view.

[0042] The sand mould (12) includes an upper half (12a) and a bottom half (12b), which are joined in a parting plane (13) and these two parts form the mould cavity (16). In the present structure the mould cavity (16) is completely thin walled and provides casting (14) with 1-3 mm wall thickness, which is also separately shown in figure 1c. In figure 1c the casting (14) is not separated from the complete cast (14'), which means that the solidified parts of the melt in the gating system (10) are joined to the casting (14), which can be separated, e.g. by cutting them off the cast (14').

[0043] In the present case the gating system (10) comprises two sprues (18), one runner (20) by each sprue (18) and five gates (22) with inlets (22) opening from each runner (20) into the mould cavity (16).

[0044] The runners (20) allow the liquid metal to run in the parting plane (13) of the upper and bottom halves (12a and 12b) or in its vicinity from the sprues (18) to the gates (22). In the sand mould (12) according to the present invention, the fractioning and the segmented shaping of the runners (20) allow complete filling of the mould cavity (16) as well as reduces the formation of turbulence and foaming, and aids the formation of steady flow. These runners (20) can be trapezoidal in various sizes; e.g. upper width 10 mm, bottom width 21 mm, height 17 mm.

[0045] Gates (22) are channels connecting the runners (20) and the mould cavity (16) with the aim of allowing the liquid metal to run into the mould cavity (16), controlling flow rate and eliminating the formation of turbulence and foaming. They may have various shapes; e.g. gate width 42 mm, gate height corresponding to the wall thickness of the casting, e.g. 2 mm; widening width and height towards the runners: e.g. 10 mm and e.g. 16 mm respectively.

[0046] The sprue (18) preferably comprises a sprue part (24), which is formed in the sand mould (12), and an attachment (26) fitted to it from the outside. The upper part of the latter one is preferably formed as a pouring cup (28) to allow easier pouring of the melt into the sprue (18).

[0047] The gating system (10) is of narrowing cross section thus the flow cross section is getting narrower (including the possibility of a transitional increase) towards the inlets (22a). In this manner the flow rate of the melt will increase towards the inlets (22a) and will reach its highest rate at the inlets (22a). This arrangement is in contrast to the conventional sand mould technology, in which gating systems of expanding cross sections are applied since slow and laminar flow will result in higher cast quality in case of thick walled castings.

[0048] In the context of the present invention, a gating system (10) of narrowing cross section is any gating system, which ensures that the highest flow rate is at the inlets (22a) by narrowing the flow cross sections. For this reason at least the gates (22) are to be of narrowing cross section, i.e. the inner cross section of the gates (22) is narrowing towards the inlets (22a) and becomes the narrowest at the inlets (22a). The flow rate is at least twice or more advantageously 3-5 times higher than the average flow rate in the runners (20), or than the average flow rate in the sprue part (24) of the sprues (18), when no runners (20) are applied. This can be achieved by providing at least twice, but preferably 3-5 times smaller total cross section for the inlets (22a) of the gates (22) opening from the given runner (20), than that of the total cross section of the branches of the runner (20). In this case both runners (20) have two branches respectively, starting at the sprues (18).

[0049] Attachments (26) also contribute to the increase of flow rate. The gradient height between the upper port (i.e. the upper edge of the cup) of the sprue (18) and the parting plane (13) of the sand mould (12) is to be 0.3, preferably 0.6-1.3 times multiple of the largest dimension of the mould cavity (16).

[0050] Preferably vents (30) are also incorporated in the sand mould (12). Their task is to exhaust from the sand mould (12) the gases that are formed during casting as well as to exhaust air accumulated in front of the liquid metal. Preferably they have cylindrical shape. Their typical diameter is double the wall thickness of the cast (2-6 mm).

[0051] In case when the desired casting (14) contains thick-walled sections as well, a cooling metal, e.g. a cooling iron bar is embedded in the sand mould (12) at this region of the mould cavity (16) (not shown) This cooling iron bar will allow thick walled segments to solidify at an identical rate with the thin walled segments.

[0052] Known feeders can also be applied to feed the thick walled segments.

[0053] In Figure 2 the inner layout of the sand mould (12) and gating system (10) is illustrated, which includes four sprues (18) and four runners (20). Five gates (22) belong to each runner (20) along the longer sides of the mould cavity (16), while along the shorter sides four gates (22) are joined to each runner (20).

[0054] The sand mould (12) has preferably 2-5 gates (22) at each runner (20) and the number and layout of the gates (22) and runners (20) is chosen such that each part of the sand mould (12) producing a thin-walled casting portion having a dimension of 100-1000 cm^2 is provided with at least one gate (22). This arrangement will enable the melt to fill in the whole mould cavity (16) before getting solidified.

[0055] When wishing to produce castings (14) of smaller dimension the runners (20) can be dispensed with. In this case the gates (22) are directly connected to the bottom of the sprues (18). In order to produce castings (14) of larger dimension a number of segmented runners (20) or branching runners (20) may be applied, or it is also possible to connect several sprues (18) to one single runner (20).

[0056] The sand mould (12) provided with the gating system (10) accroding to the invention can be applied in the following way.

[0057] Generally used plastic patterns and mould cores can be applied to produce the sand mould (12) elements and cores. From moulding sand suitable for preheating the upper and bottom halves (12a, 12b) are produced, which will form the cavity corresponding to the casting (14). The sand mould (12) is preferably a chemically bonded dry mould which can tolerate heating.

[0058] Cross section, height and width of the elements of the gating system (10) used to fill up the mould cavity (16) are always determined by the features and casting position of the casting (14).

[0059] In order to avoid early solidification, the sand mould (12) is pre-heated at least in the thin walled regions of the casting up to 100°C, preferably up to 100-600°C, or even more preferably up to 300-500°C (or 0.5-0.8 times of the solidification temperature of the Aluminium alloy). Heating can be performed for example with gas flame. The embedded cooling iron bars, if there are any, are also heated until vapour precipitates and dries from their surface (the surface of the cooling iron bars must remain pure); then the surfaces of the mould cavity (16), the gates (22) and the runners (20) and sprue parts (24) are heated up again before the closing of the sand mould (12).

[0060] After the sand mould (12) has been closed and the attachments (26) of the gating system (10) have been mounted, the Aluminium melt is produced by heating Aluminium (or Al alloy). Before being fed into the gating system (10), the melt is overheated by 100°C, advantageously at least by 200°C, more preferably by 200-350°C, which will further contribute to avoiding too early solidification.

[0061] The liquid metal (melt) is introduced through the gating system (10), according to the invention, into the mould cavity (16) of the preheated upper and bottom halves (12a, 12b).

[0062] Preferably, the mould cavity (16) is filled with liquid metal by means of pouring ladles through the pouring cup (28) affixed to the attachment (26) of the sprue parts (24) of the upper mould half (12a), providing a uniform mould cavity filling.

[0063] Moulding sand and excess parts are removed from the solidified casting (14), after which the casting (14) can be applied according to its intended purpose.

[0064] The most difficult task with thin walled castings (14) and gravity casting is to force the molten metal to completely fill in the mould without solidification. To feed and cool at the same time so that the whole casting should become cooled and evenly solidified approximately at the same time.

[0065] In order to achieve this the following techniques are applied in: significant size difference of the trapezoidal form of the gates (22) (in practice this means a decrease in the flow cross section), segmenting of the runners (20), increasing pouring height (significant increase in the "liquid" column height relative to the dimensions of the piece), significantly increasing the mould temperature, significantly increasing over-heating temperature of the melt, and application of the above techniques possibly in combination, simultaneously.

[0066] To summarise all the above, prior to the casting process according to the invention, firstly the manufacturing tool is prepared based on a virtual model created by any generally used 3D design program or other suitable programs, which manufacturing tool enables the production of a negative of the part to be cast from sand. This is followed by segmenting the tool in accordance with the user's demand, and having regard to the shrinkage of the casting and moulding inclination. The next step is to determine the pouring position, which can be either vertical or horizontal, according to the geometry of the model, then the coring position of the possible cavities of the part will be given. When the part has been assembled from the upper and bottom halves (12a, 12b) and the possible cores, the required gates (22), sprues (18), vents (30), hidden feeders are designed, which will all be installed in the mould frame and be formed together with the upper and bottom halves (12a, 12b), this will allow producing identical parts by the casting process. The manufacturing tool is then treated with mould remover and filled in with washed and sized, chemically bonded sand. During the filling up the designed cooling iron is moulded in the sand as well as the upper part of the core is made rigid with iron strands. The upper and bottom halves (12a, 12b) are precisely joined by positioning devices, which are also included in the manufacturing tool. Overflow preventers prevent flow-off occurring from the mould buckling on the parting plane, followed by the upper and bottom halves (12a, 12b) being treated, heated and closed. In certain cases attachments (26) are adhered to the upper half (12a) and balanced. After casting the melt is allowed to cool and then the cores will be carefully removed from the casting, which is then cut off from the gates and finely purified. This process is followed by checking the main dimensions and delivered to the supplier for inspection. After the complete casting (14) has been tested, small quantity production will be launched.

[0067] Advantages of the application of the invention are as follows:

A direct economic benefit of the method according to the invention is that it allows manufacturing castings of almost identical properties related to the technical parameters, with low financial investment and during a fraction of time as compared to the production of large scale casts made by metal tool having high production cost.

[0068] In comparison with the castings produced with pressure technology, the quality of castings produced by the method according to the invention will be practically identical, however at lower cost and in a simpler way.

[0069] The method according to the invention is suitable for producing castings which are otherwise expensive to produce even on large scale, which castings can be applied for practical purposes.

[0070] The products of this kind are mainly indoor and outdoor luminaires, engine parts - spare parts, cylinder-heads, machine components, spare parts for mechanical and precision engineering, fittings, etc. All these products can be produced with the method according to th invention in such quality that they will be suited for practical application under operational conditions. This will result in cost-effective development and more effective testing before the manufacture on large scale is launched. Aluminium castings for different purposes are to be produced with this process applied in the invention on small to medium scale, even in several hundred pieces.

[0071] By this innovative process castings can be produced with lower machining tolerance and with less moulding incline, therefore dimensional accuracy is in compliance with the related standard, moreover this process allows achieving higher dimensional accuracy compared to that of gravity sand mould casting.

Claims

1. Casting process for producing at least partly thin-walled aluminium castings with sand mould technology by gravity casting, wherein wall thickness of a thin-walled part is 1-3 mm, **characterised by**:

   - providing a sand mould comprising a mould cavity,
   - producing a melt of aluminium content,
   - introducing the melt into the mould cavity at multiple points through a gating system of narrowing cross section.

2. The process according to claim 1 **characterised by** producing a casting the largest overall dimension of

which is more than 100 times, preferably at least 200-400 times of the wall thickness.

3. The process according to claims 1 or 2 **characterised by** providing a gating system of narrowing cross section for the mould cavity which contains at least two sprues each being in liquid communication with at least one gate respectively, each gate having an inlet opening into the mould cavity.

4. The process according to claim 3 **characterised by** providing liquid communication between at least two gates and at least one sprue with a runner, and the overall cross section of the inlets of the gates opening from one runner is at least two times smaller, more preferably 3-5 times smaller than the overall cross section of branches of the given runner.

5. The process according to claims 3 or 4 **characterised by** providing 2-4 gates per each runner, and selecting the number of gates and runners such that a thin-walled casting portion having a dimension of 100-1000 cm^2 is cast from one gate.

6. The process according to any one of claims 2 to 5 **characterised by** selecting the height of the sprue such that the drop between the upper inlet opening of the sprue and a parting plane of the sand mould is at least 0.1 times greater, preferably 0.6-1.3 times greater than the largest dimension of the casting to be produced.

7. The process according to any one of claims 1 to 6 **characterised by** preheating the sand mould before starting the casting at least in the segments of the thin-walled parts of the casting to at least 100°C but preferably to 200-600°C and even more preferably to 300-500°C.

8. The process according to claim 7 **characterised by** providing a cooling metal insert in the sand mould and heating the cooling metal insert prior to starting the casting until vapour is precipitated and the insert's surface becomes dry.

9. The process according to any one of claims 1 to 8 **characterised by** that prior to being poured into the gating system, the melt is overheated by at least 100°C, preferably by 200°C, more preferably by 200-350°C with respect to the melting point.

10. Sand mould provided with a gating system for producing at least partly thin-walled aluminium castings with sand moulding technology by gravity casting, wherein wall thickness of a thin-walled part is 1-3 mm and the largest dimension of the thin-walled part is at least 100 times, preferably at least 200-400 times greater than the wall thickness, **characterised by** that the sand mould contains a mould cavity for producing the at least partly thin-walled casting piece, and is provided with a gating system of an overall narrowing cross section, which contains at least two sprues each being in liquid communication with at least one gate respectively, each gate having an inlet opening into the mould cavity.

11. Sand mould provided with a gating system according to claim 10 **characterised by** having a runner providing liquid communication between at least one sprue and at least two gates.

12. Sand mould provided with a gating system according to claim 11 **characterised by** that the overall cross section of the inlets of the gates opening from one runner is at least two times smaller, preferably 3-5 times smaller than the overall cross section of branches of the given runner.

13. Sand mould provided with a gating system according to claims 11 or 12 **characterised by** comprising 2-4 gates per runner and the number and layout of the gates and runners is chosen such that each part of the sand mould producing a thin-walled casting portion having a dimension of 100-1000 cm^2 is provided with at least one gate.

14. Sand mould provided with a gating system according to any one of claims 10 to 13 **characterised by** that the sprue comprises a sprue part formed in the sand mould and an attachement joined to it from above.

15. Sand mould provided with a gating system according to any one of claims 10 to 14 **characterised by** that the drop between the upper inlet opening of the sprue and a parting plane of the sand mould is at least 0.1 times greater, preferably 0.6-1.3 times greater than the largest dimension of the mould cavity.

Patentansprüche

1. Gießverfahren zur Herstellung von mindestens teilweise dünnwandigen Aluminiumgussteilen mit Sandgussformtechnologie durch Schwerkraftgießen, worin die Wanddicke eines dünnwandigen Teils 1-3 mm beträgt, **gekennzeichnet durch**:

- Bereitstellen einer Sandgussform umfassend einen Gussformhohlraum,
- Herstellen einer Schmelze mit Aluminiumgehalt,
- Einführen der Schmelze in den Gussformhohlraum an multiplen Punkten durch ein Angusssystem mit einem verengenden Querschnitt.

2. Verfahren nach Anspruch 1, **gekennzeichnet**

durch das Herstellen eines Gussteils, dessen größte Gesamtabmessung mehr als 100-mal, vorzugsweise mindestens 200-400-mal so groß wie die Wanddicke ist.

3. Verfahren nach Anspruch 1 oder 2, **gekennzeichnet durch** das Bereitstellen eines Angusssystems mit einem verengenden Querschnitt für den Gussformhohlraum, das mindestens zwei Eingüsse beinhaltet, wobei jeder in Flüssigkeitsverbindung mit mindestens jeweils einem Anschnitt steht, wobei jeder Anschnitt eine Einlassöffnung in den Gussformhohlraum aufweist.

4. Verfahren nach Anspruch 3, **gekennzeichnet durch** das Bereitstellen einer Flüssigkeitsverbindung zwischen mindestens zwei Anschnitten und mindestens einem Einguss mit einem Angusskanal und wobei der Gesamtquerschnitt der Einlässe der Anschnitte, die sich von einem Angusskanal öffnen, mindestens zweimal kleiner, vorzugsweise 3-5-mal kleiner als der Gesamtquerschnitt der Abzweigungen des jeweiligen Angusskanals ist.

5. Verfahren nach Anspruch 3 oder 4, **gekennzeichnet durch** das Bereitstellen von 2-4 Anschnitten pro Angusskanal und das Auswählen der Anzahl von Anschnitten und Angusskanälen, sodass ein dünnwandiger Gussteilabschnitt mit einer Abmessung von 100-1000 cm^2 von einem Anschnitt gegossen wird.

6. Verfahren nach einem der Ansprüche 2 bis 5, **gekennzeichnet durch** das Auswählen der Höhe des Eingusses, sodass der Höhenunterschied zwischen der oberen Einlassöffnung der Eingusses und einer Teilungsebene der Sandgussform mindestens 0,1-mal größer, vorzugsweise 0,6-1,3-mal größer als die größte Abmessung des herzustellenden Gussteils ist.

7. Verfahren nach einem der Ansprüche 1 bis 6, **gekennzeichnet durch** das Vorwärmen der Sandgussform vor dem Beginn des Gusses mindestens in den Segmenten der dünnwandigen Teile des Gussteils auf mindestens 100 °C, jedoch vorzugsweise auf 200-600 °C und sogar bevorzugter auf 300-500 °C.

8. Verfahren nach Anspruch 7, **gekennzeichnet durch** das Bereitstellen einer kühlenden Metalleinlage in der Sandgussform und das Erwärmen der kühlenden Metalleinlage vor dem Beginn des Gusses, bis Dampf abgeschieden wird und die Oberfläche der Einlage trocken wird.

9. Verfahren nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** vor dem Gießen in das Angusssystem die Schmelze um mindestens 100°C, vorzugsweise um 200 °C, besonders bevorzugt um 200-350°C gegenüber dem Schmelzpunkt überhitzt wird.

10. Sandgussform, die mit einem Angusssystem zur Herstellung von mindestens teilweise dünnwandigen Aluminiumgussteilen mit Sandgussformtechnologie durch Schwerkraftgießen ausgestattet ist, worin die Wanddicke eines dünnwandigen Teils 1-3 mm beträgt und die größte Abmessung des dünnwandigen Teils mindestens 100-mal, vorzugsweise mindestens 200-400-mal größer als die Wanddicke ist, **dadurch gekennzeichnet dass** die Sandgussform einen Gussformhohlraum zur Herstellung des mindestens teilweise dünnwandigen Gussteils umfasst und mit einem Angusssystem mit einem insgesamt verengenden Querschnitt ausgestattet ist, das mindestens zwei Eingüsse beinhaltet, wobei jeder in Flüssigkeitsverbindung mit mindestens jeweils einem Anschnitt steht, wobei jeder Anschnitt eine Einlassöffnung in den Gussformhohlraum aufweist.

11. Mit einem Angusssystem ausgestattete Sandgussform nach Anspruch 10, **dadurch gekennzeichnet, dass** sie einen Angusskanal aufweist, der eine Flüssigkeitsverbindungen zwischen mindestens einem Einguss und mindestens zwei Anschnitten bereitstellt.

12. Mit einem Angusssystem ausgestattete Sandgussform nach Anspruch 11, **dadurch gekennzeichnet, dass** der Gesamtquerschnitt der Einlässe der Anschnitte, die sich von einem Angusskanal öffnen, mindestens zweimal kleiner, vorzugsweise 3-5-mal kleiner als der Gesamtquerschnitt der Abzweigungen des jeweiligen Angusskanals ist.

13. Mit einem Angusssystem ausgestattete Sandgussform nach Anspruch 11 oder 12, **dadurch gekennzeichnet, dass** es 2-4 Anschnitte pro Angusskanal umfasst und die Anzahl und das Layout der Anschnitte und Angusskanäle so ausgewählt ist, dass jedes Teil der Sandgussform, die einen dünnwandigen Gussteilabschnitt mit einer Abmessung von 100-1000 cm^2 herstellt, mit mindestens einem Anschnitt ausgestattet ist.

14. Mit einem Angusssystem ausgestattete Sandgussform nach einem der Ansprüche 10 bis 13, **dadurch gekennzeichnet, dass** der Einguss ein in der Sandgussform ausgebildetes Eingussteil und einen daran von oben verbundenen Ansatz umfasst.

15. Mit einem Angusssystem ausgestattete Sandgussform nach einem der Ansprüche 10 bis 14, **dadurch gekennzeichnet, dass** der Höhenunterschied zwischen der oberen Einlassöffnung der Eingusses und einer Teilungsebene der Sandgussform mindestens

0,1-mal größer, vorzugsweise 0,6-1,3-mal größer als die größte Abmessung des Gussformhohlraums ist.

Revendications

1. Procédé de coulage pour produire des pièces coulées en aluminium à parois au moins partiellement minces avec la technologie de moulage au sable au moyen d'un coulage par gravité, une épaisseur de paroi d'une partie à parois minces étant de 1 à 3 mm, **caractérisé par** :

   - la disposition d'un moule en sable comprenant une cavité de moule,
   - la production d'une masse fondue de contenu d'aluminium,
   - l'introduction de la masse fondue dans la cavité de moule à de multiples points par l'intermédiaire d'un système d'entrée à section transversale à rétrécissement.

2. Procédé selon la revendication 1, **caractérisé par** la production d'une pièce coulée dont la dimension globale la plus grande est plus de 100 fois, de préférence au moins 200 à 400 fois, l'épaisseur de paroi.

3. Procédé selon la revendication 1 ou 2, **caractérisé par** la disposition d'un système d'entrée à section transversale à rétrécissement pour la cavité de moule qui contient au moins deux jets de coulée qui sont chacun en communication fluidique avec respectivement au moins une attaque de coulée, chaque attaque de coulée ayant une entrée débouchant dans la cavité de moule.

4. Procédé selon la revendication 3, **caractérisé par** la disposition d'une communication fluidique entre au moins deux attaques de coulée et au moins un jet de coulée avec un canal de coulée, et la section transversale globale des entrées des attaques de coulée s'ouvrant à partir d'un canal de coulée étant au moins deux fois plus petite, de préférence 3 à 5 fois plus petite, que la section transversale globale de branches du canal de coulée donné.

5. Procédé selon la revendication 3 ou 4, **caractérisé par** la disposition de 2 à 4 attaques de coulée pour chaque canal de coulée, et la sélection du nombre d'attaques de coulée et de canaux de coulée de telle sorte qu'une partie de pièce coulée à parois minces ayant une dimension de 100 à 1000 cm^2 est coulée à partir d'une attaque de coulée.

6. Procédé selon l'une quelconque des revendications 2 à 5, **caractérisé par** la sélection de la hauteur du jet de coulée de telle sorte que la chute entre l'ouverture d'entrée supérieure du jet de coulée et un plan de séparation du moule en sable est au moins 0,1 fois plus grande, de préférence 0,6 à 1,3 fois plus grande, que la dimension la plus grande de la pièce coulée à produire.

7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé par** le préchauffage du moule en sable avant le début du coulage au moins dans les segments des parties à parois minces de la pièce coulée, à au moins 100°C, mais de préférence de 200 à 600°C, et de façon encore davantage préférée de 300 à 500°C.

8. Procédé selon la revendication 7, **caractérisé par** la disposition d'un insert métallique de refroidissement dans le moule en sable et le chauffage de l'insert métallique de refroidissement avant le début du coulage jusqu'à ce que de vapeur apparaisse et que la surface de l'insert devienne sèche.

9. Procédé selon l'une quelconque des revendications 1 à 8, **caractérisé par le fait qu'**avant d'être versée dans le système d'entrée, la masse fondue est surchauffée d'au moins 100°C, de préférence de 200°C, de façon davantage préférée de 200 à 350°C, par rapport au point de fusion.

10. Moule en sable comportant un système d'entrée pour produire des pièces coulées en aluminium à parois au moins partiellement minces avec la technologie de moulage au sable au moyen d'un coulage par gravité, une épaisseur de paroi d'une partie à parois minces étant de 1 à 3 mm, et la dimension la plus grande de la partie à parois minces étant au moins 100 fois, de préférence au moins 200 à 400 fois, plus grande que l'épaisseur de paroi, **caractérisé par le fait que** le moule en sable contient une cavité de moule pour produire la pièce coulée à parois au moins partiellement minces et comporte un système d'entrée d'une section transversale à rétrécissement global, qui contient au moins deux jets de coulée qui sont chacun en communication fluidique avec respectivement au moins une attaque de coulée, chaque attaque de coulée ayant une entrée débouchant dans la cavité de moule.

11. Moule en sable comportant un système d'entrée selon la revendication 10, **caractérisé par le fait qu'**il a un canal de coulée assurant une communication fluidique entre au moins un jet de coulée et au moins deux attaques de coulée.

12. Moule en sable comportant un système d'entrée selon la revendication 11, **caractérisé par le fait que** la section transversale globale des entrées des attaques de coulée s'ouvrant à partir d'un canal est au moins deux fois plus petite, de préférence 3 à 5 fois

plus petite, que la section transversale globale de branches du canal de coulée donné.

13. Moule en sable comportant un système d'entrée selon la revendication 11 ou 12, **caractérisé par le fait qu'**il comprend 2 à 4 attaques de coulée par canal de coulée, et le nombre et la disposition des attaques de coulée et des canaux de coulée sont choisis de telle sorte que chaque partie du moule en sable produisant une partie de pièce coulée à parois minces ayant une dimension de 100 à 1000 cm^2 comporte au moins une attaque de coulée.

14. Moule en sable comportant un système d'entrée selon l'une quelconque des revendications 10 à 13, **caractérisé par le fait que** le jet de coulée comprend une partie jet de coulée formée dans le moule en sable et une attache reliée à celui-ci à partir du dessus.

15. Moule en sable comportant un système d'entrée selon l'une quelconque des revendications 10 à 14, **caractérisé par le fait que** la chute entre l'ouverture d'entrée supérieure du jet de coulée et un plan de séparation du moule en sable est au moins 0,1 fois plus grande, de préférence 0,6 à 1,3 fois plus grande, que la dimension la plus grande de la cavité de moule.

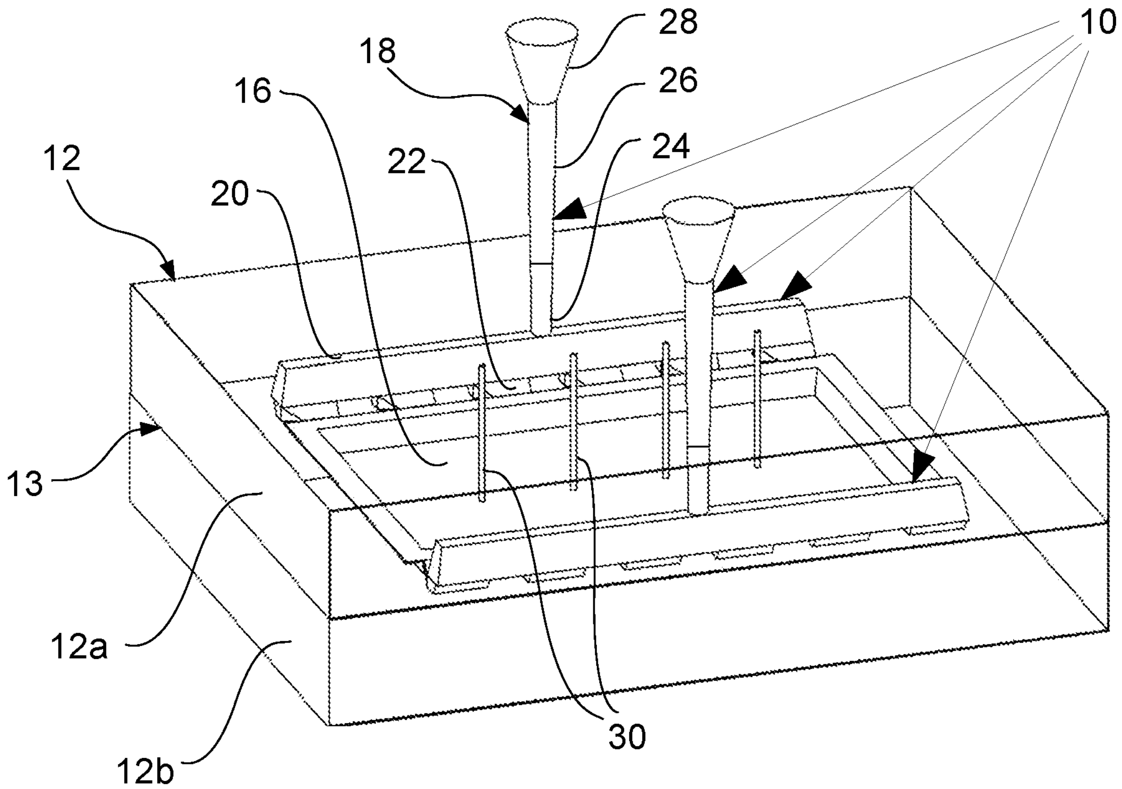
28
10
18
26
16
24
12
22
20
13
12a
12b
30

Fig. 1a

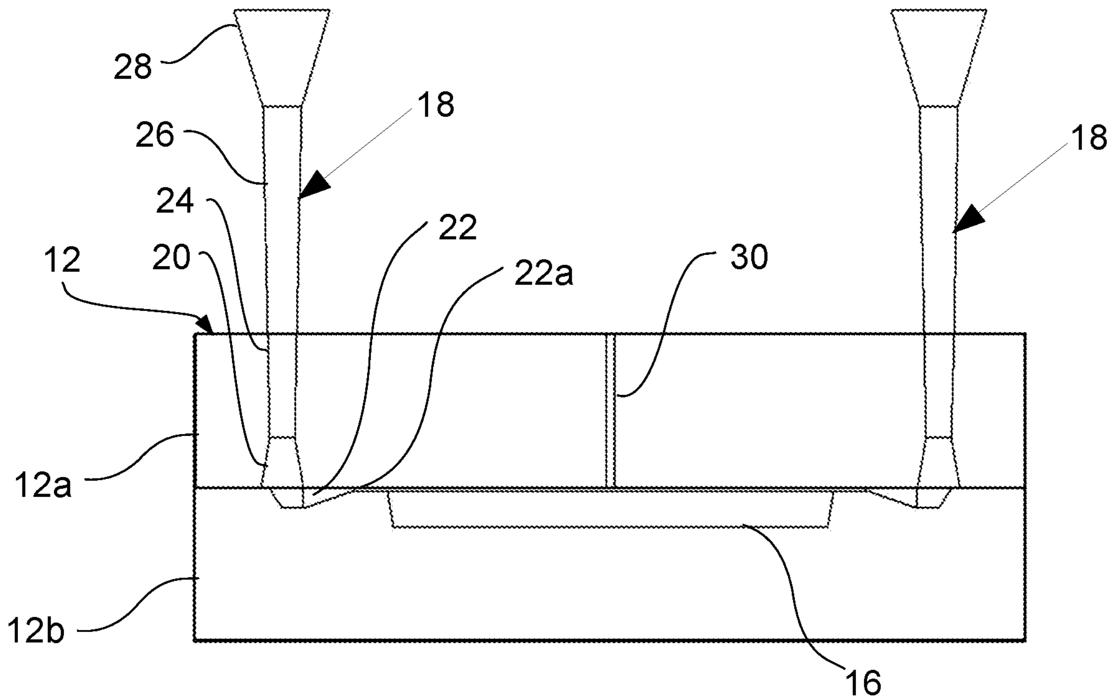
28
18
26
18
24
22
12
20
22a
30
12a
12b
16

Fig. 1b

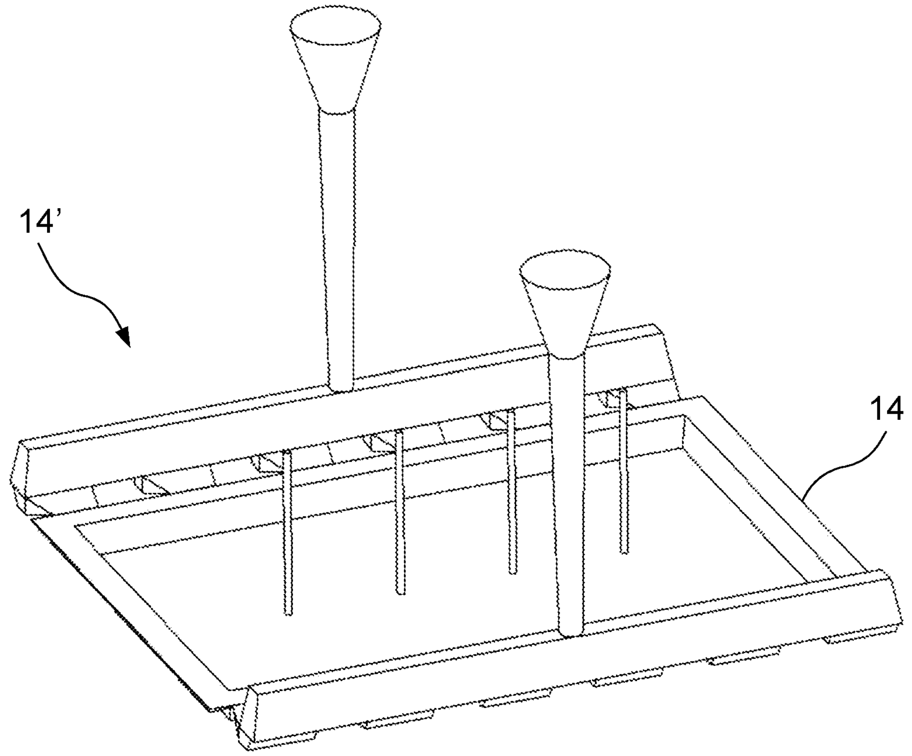

Fig. 1c

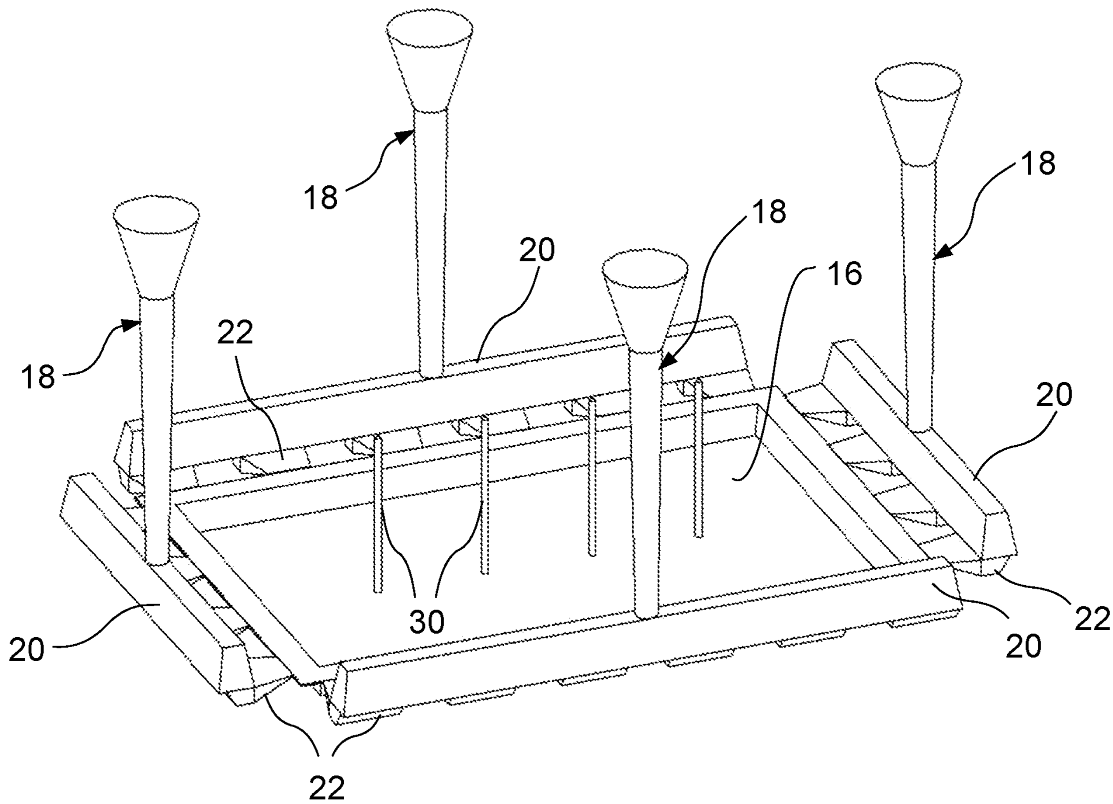

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP S5731463 A **[0001]**
- CN 104014717 A **[0001]**
- CN 1709612 **[0005]**