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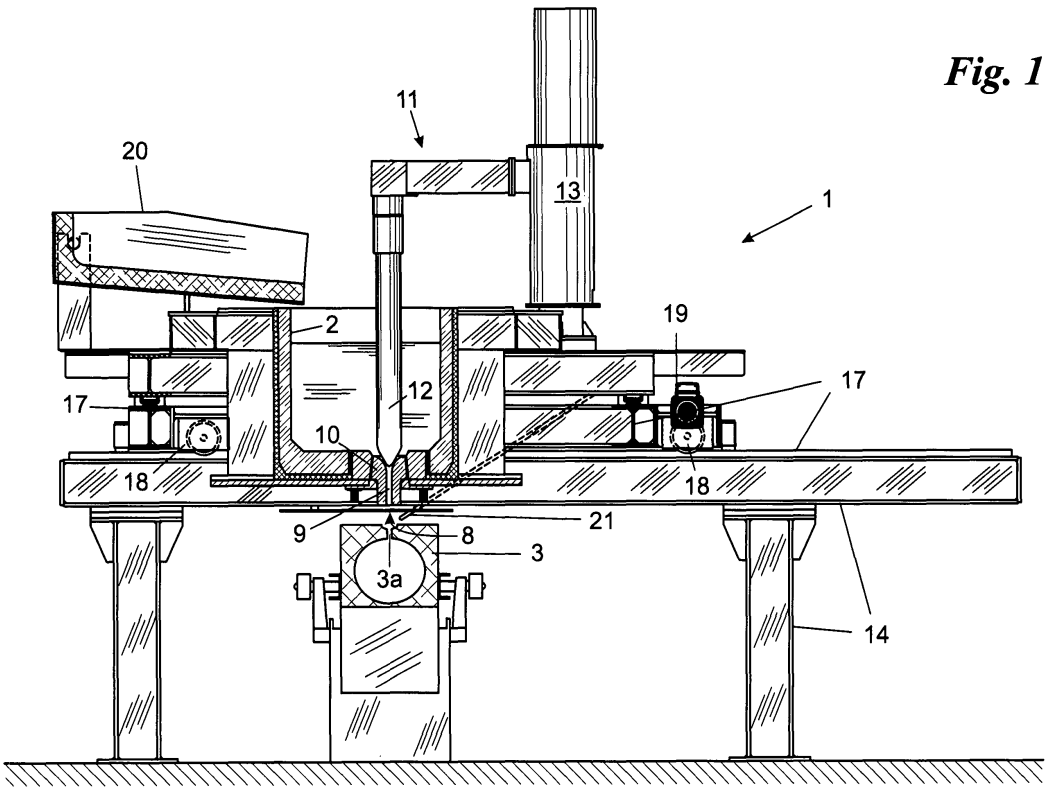
(54) Casting apparatus for metal materials

(57) There is provided a casting apparatus for metal materials, in particular nodular cast iron, comprising a crucible (2), suitable to be supplied with cast iron in liquid state and to contain the liquid cast iron, and including means (4) to heat the liquid cast iron contained in the crucible (2), suitable to keep the liquid cast iron at a specific temperature; the apparatus (1) also comprises a casting system (8), suitable to cast the liquid cast iron from the crucible (2) into a mold (3), and comprising a casting hole (9) located on the base of the crucible (2).

Fig. 1



EP 1 900 458 A1

Description

[0001] The present invention relates to an apparatus for casting metal materials, in particular nodular cast iron, of the type specified in the preamble of claim 1.

[0002] Systems for producing and casting metal materials are currently known, in particular systems for producing and casting nodular cast iron.

[0003] As it is known, cast iron is an iron-carbon alloy with a high carbon content. Due to the high amount of carbon, this clusters into graphite lamellae or spheroids inside the iron matrix.

[0004] In particular, nodular cast iron has elements in spheroidal graphite. It therefore has improved mechanical properties compared to lamellar cast iron, as spheroidal discontinuities have higher mechanical tolerances than lamellar discontinuities. Moreover, nodular cast iron still has the advantages of castability, workability and low costs of cast irons in general.

[0005] Due to the properties indicated, nodular cast iron is increasingly used to produce mechanical elements such as engines and the like.

[0006] Nodular cast iron is commonly produced in specific furnaces and subsequently cast, through ladles or the like, into specific molds.

[0007] Besides these advantages, nodular cast iron has noteworthy drawbacks during production and casting.

[0008] In fact, nodular cast iron is not particularly stable when in molten state. It deteriorates rapidly into lamellar cast iron and must therefore be cast rapidly into the specific molds.

[0009] The instability of nodular cast iron in molten state can be reduced by keeping it at a specific temperature, but even in this situation nodular cast iron remains unstable, although to a lesser extent.

[0010] To be able to produce high quality nodular cast iron elements it is therefore essential to calibrate the capacity of the furnace, the melting and spheroidization times of the cast iron and the casting times, with the quantity, speed and dimensions of the elements to be produced. In substance, a specific production and casting system is required for each type of element to be produced.

[0011] It is evident that this solution is not practical due to the extremely high costs, which would cancel out the advantages of nodular cast iron.

[0012] Nodular cast iron, and metal materials in general, also have noteworthy drawbacks during casting.

[0013] In fact, casting conventionally takes place by means of partial tipping of the crucible containing liquid cast iron. Therefore, slag inclusions, which lie on the surface of the cast iron bath, can occur inside the elements produced.

[0014] Therefore the technical problem of how to produce high quality cast iron elements, in particular nodular cast iron elements, at a moderate cost, remains unsolved.

[0015] In this situation the technical aim underlying the present invention is to devise an apparatus for casting metal materials, in particular nodular cast iron, capable of substantially overcoming the aforesaid drawbacks.

[0016] Within said technical aim, an important object of the invention is to produce a casting apparatus that makes it possible to produce high quality metal elements, particularly nodular cast iron elements, at moderate costs.

[0017] Another important object of the invention is to obtain a casting apparatus that allows optimum casting, without slag inclusions and the like.

[0018] Last but not least object of the invention, is to produce a casting apparatus which adapts to molds, and in particular to sequences of molds, of different types and dimensions.

[0019] Last but not least object of the invention is to produce a casting apparatus that adapts to production furnaces of different types and dimensions.

[0020] The technical aim and the objects specified are achieved by an apparatus for casting metal materials, in particular nodular cast iron, according to the appended Claim 1.

[0021] Further features and advantages of the invention are better explained below in the detailed description of a preferred embodiment of the invention, with reference to the attached drawings, wherein:

Figure 1 shows the apparatus according to the invention in a median section and in a side view;
Figure 2 shows a portion of the apparatus according to the invention in a median section and in a side view;
Figure 3 represents the apparatus according to the invention in a top view; and
Figure 4 shows a portion of the apparatus according to the invention in a top view.

[0022] With reference to the aforesaid Figures, the apparatus according to the invention is indicated as a whole with the numeral **1**.

[0023] It comprises a crucible **2** to collect the liquid metal, in particular liquid nodular cast iron. This crucible **2** is suitable to store the liquid nodular cast iron coming from a production furnace and to cast it into specific molds **3** or the like.

[0024] The liquid cast iron is fed to the crucible 2 opportunely by means of a charge channel **20** of the liquid metal. The charge channel 20 is also preferably removable and detachable from the apparatus 1.

[0025] The crucible 2 has a cylindrical shape and a capacity ranging from 0.5 t to 1.5 t of liquid cast iron, preferably approximately 1 t. It also has a diameter ranging from 600 mm to 700 mm and a height ranging from 550 mm to 670 mm.

[0026] The inner wall of the crucible 2 is realized by refractory material of known type.

[0027] The apparatus 1 also comprises means **4** to

heat the liquid cast iron contained inside the crucible 2.

[0028] The heating means 4 heat the liquid cast iron opportunely by means of the known electromagnetic induction process. This process is based on the physical principle of electromagnetism wherein a conducting coil through which an alternating electromagnetic current passes, creates an electromagnetic field in the areas surrounding the coil, in particular inside the virtual cylinder delimited by the coil. Consequently, through the Joule effect, the electromagnetic field heats the materials it passes through.

[0029] The heating means 4 therefore comprise a coil **5** through which an alternating current passes with frequencies ranging from 200 Hz to 300 Hz, preferably approximately 250 Hz, and with powers ranging from 100 kW to 200 kW, preferably around 150 kW.

[0030] The coil 5 is connected to a specific control unit **6** of the apparatus 1.

[0031] The control unit 6 is connected to the electricity network and supplies the coil 5 with alternating electrical current of adequate powers and frequencies.

[0032] It thus comprises an electrical transformer, cooling means and a computer suitable to manage the automated operations of the apparatus 1.

[0033] In particular, the control unit 6 is electrically connected to the coil 5 by means of specific liquid cooled electrical cables **7**. In particular, the electrical cables 7 comprise therewithin copper wires or the like, to conduct the alternating electrical current, and pipes, surrounding the copper wires, containing the cooling liquid and suitable to cool the copper wires.

[0034] The liquid cooled electrical cables 7 are connected to the coil 5 by means of releasable connections, in particular by means of quick-disconnect releasable connections.

[0035] The coil 5, supplied electrically by the electrical cables 7, is also liquid cooled. It is opportunely realized by a hollow copper pipe, inside which the cooling liquid flows.

[0036] Therefore, to cool the coil 5 a cooling circuit **5a** is provided. This circuit 5a is connected to the control unit 6 and comprises an inlet pipe that connects the control unit 6 to the coil 5, the cavity inside said coil 5, and an outlet pipe that connects the coil to the control unit 6. The inlet and outlet pipes are connected to the coil 5 by releasable connections, in particular by two threaded connections.

[0037] This technical solution achieves rapid coupling of the electrical cables 7 and of the cooling circuit 5A to the coil 5.

[0038] It must be noted that the crucible 2, comprising the heating means 4, substantially realizes a furnace, in particular a medium frequency induction furnace. Similar furnaces are known per se and utilized to produce specific metals. They have various advantages, including the absence of contact between the conductor material and the heated metal and the fact that they keep a uniform temperature inside the molten metal.

[0039] The crucible 2 also comprises a feed channel **15**, suitable to allow feed of inoculants or the like into the molten metal contained inside the crucible 2.

[0040] The crucible 2 also comprises a casting system **8** located on the base of the crucible 2 which preferably extends in the horizontal plane.

[0041] The casting system 8 comprises a casting hole **9**, produced on the base of the crucible 2, and a casting channel **10**, which surrounds the hole 9 and is made of refractory material, preferably graphite. The hole 9 opportunely has a circular section which in a first stretch tapers from the base of the crucible 2 downwards, while in a second stretch it remains constant.

[0042] Moreover, the casting hole 9 is located in an eccentric position on the base of the crucible 2, i.e. in an intermediate position between the center and the walls of the crucible 2, preferably in an intermediate position between the center of the base of the crucible and the perimeter portion of the crucible 2 diametrically opposite the charge channel 20. This solution achieves two important advantages: in the first place, as the hole is not positioned at the center of the base of the crucible 2 it does not excessively weaken said base; in the second place, the liquid cast iron supplied through the charge channel 20 does not flow directly into the crucible at the level of the casting hole 9, but at the level of the refractory forming the base of the crucible 2.

[0043] The casting system 8 also comprises a closing device **11** of the hole 9.

[0044] This closing device **11** opportunely comprises a rod **12**, which can be inserted in the hole 9 so as to completely block it. In particular, the rod 12 has a pointed end section which is inserted inside the first stretch of the casting hole 9.

[0045] The rod 12, realized by refractory material, extends in a direction substantially perpendicular to the base of the crucible 2 and therefore in a vertical direction, and passes through the inside of said crucible 2 containing the liquid metal.

[0046] The rod 12 is operated by a control mechanism **13**, which is part of the closing device 11, and comprising a brushless electric motor, suitable to lift and lower the rod 12. The control mechanism 13 is connected to the control unit 6 through which it, and consequently the closing device 11, can be operated.

[0047] Moreover, a video camera **21** suitable to detect correct relative positioning of the hole 9 and of the mold 3 and correct and complete filling of the mold 3, is opportunely positioned at the level of the casting channel 10, in the lower part thereof.

[0048] The crucible 2 is also opportunely positioned on a specific supporting structure **14**. The purpose of this structure 14 is to allow the molds 3 or the like to be inserted under the crucible 2, so that the liquid cast iron can flow into them.

[0049] In particular, the structure 14, in the case in which parts of engines for automobiles or the like are being cast and a train of molds is present, has a height

ranging from 1.5 to 2.5 m.

[0050] The supporting structure 14 comprises load cells **22** (Figure 3) located under the crucible 2. The load cells 22 are suitable to detect the mass of the crucible 2, and consequently the presence and quantity of liquid cast iron inside it. The load cells 22 are also connected to the control unit 6.

[0051] The supporting structure 14 also comprises means **16** (Figure 4) to move the crucible 2 in the plane parallel to the base of the crucible 2, i.e. substantially in the horizontal plane. The moving means 16 are also opportunely connected and controlled by the control unit 6.

[0052] This moving means 16 opportunely comprise two pairs of rails **17**, perpendicular to each other and defining two axes of movement **17a** and **17b**, a plurality of wheels **18** movable on the rails 17, and at least one electric motor **19**, suitable to allow rotation of the wheels 18 and relative movement of the structure 14 and crucible 2.

[0053] The moving means 16 are suitable to allow, along the first axis of movement 17a, travel ranging from 0.2 m to 0.3 m in both directions and, along the second axis of movement 17b, travel ranging from 0.2 m to 0.3 m in one direction, and from 1.0 m to 1.4 m in the other direction.

[0054] Operation of an apparatus 1 for casting metal materials, in particular nodular cast iron, described above in the structural sense, is as follows.

[0055] The cast iron, in particular nodular cast iron, is produced in the furnace and poured, through the charge channel 20, into the crucible 2.

[0056] The quantity of cast iron fed in is measured and regulated through the load cells 22 and the control unit 6.

[0057] The liquid cast iron is kept at a constant temperature in the crucible 2 by the heating means 4 described. These heating means 4 are consequently active and supplied by the supply means 6. Moreover, the casting system 8 is in the closed position; therefore, the rod 12, which is part of the closing device 11, is inserted in the casting hole 9, and prevents the liquid metal from passing through.

[0058] Various substances can be added to the liquid cast iron through the feed channel 15, for the purpose of improving the quality thereof. In particular, inoculants suitable to allow clustering of the graphite contained in the cast iron can be added.

[0059] Located under the crucible 2 is the mold 3, which is preferably part of a train of molds 3 moved automatically. As it is known, the molds have an inlet channel **3a** of the liquid metal.

[0060] The control unit 6 consequently controls, through the information received by the video camera 21, correct alignment of the casting hole 9 and of the inlet channel 3a of the mold.

[0061] When the control unit 6 detects incorrect reciprocal positioning of the hole 9 and the channel 3a, said unit 6 activates the means 16 to move the crucible 2. This moving means 16 can in fact vary the position of the crucible 2 and therefore the reciprocal position of the crucible and of the molds 3. Movements of a few centimeters or millimeters along the two axes of movement 17a and 17b, in the horizontal plane, are therefore sufficient to allow perfect reciprocal alignment between the casting hole 9 and the inlet channel 3a.

[0062] After correct alignment of the hole 9 and of the channel 3a has been detected, the control unit 6 controls movement of the closing device 11 to the open position: the rod 12 is lifted and moved away from the hole 9 which is consequently left open.

[0063] The liquid cast iron then flows through the casting channel 10 and, through the inlet channel 3a, into the mold 3.

[0064] The level of cast iron inside the mold 3 is monitored by the control unit 6 through the video camera 21.

[0065] Subsequent to filling of the mold 3, the closing device 11 is once again returned to the closed position: the rod 12 is lowered and inserted in the hole 9.

[0066] The mold 3, filled with liquid cast iron, is then replaced with another mold 3, and the mold filling process is repeated.

[0067] During filling of the molds 3, the quantity of liquid cast iron contained in the crucible 2 naturally decreases. This quantity is accurately monitored by the control unit 6 by means of the load cells 22 and, subsequent to a specific partial emptying, the need to fill the crucible 2 again is indicated. Filling takes place once again by means of the casting channel 20.

[0068] The apparatus 1 therefore makes it possible to perform the casting process in molds without interruptions. Nonetheless, maintenance operations and the like are at times necessary.

[0069] In fact, at times the crucible 2 must be emptied due to incorrect filling thereof, for instance when the liquid cast iron from the production furnace does not have the desired properties. Other times periodic operations to clean the crucible 2 are required.

[0070] These operations can be performed easily and rapidly due to the described properties of the apparatus 1.

[0071] In fact, to empty the crucible 2, it is sufficient to control the complete movement thereof along the direction of the axis of movement 17b which allows travel ranging from 1.0 m to 1.4 m. It is then sufficient to place a ladle or the like, under the crucible 2 and control opening of the closing device 11. The operation to clean the crucible 2 can instead by performed rapidly by disconnecting the crucible 2 from the electrical cables 7, and from the cooling circuit 5a and replacing it with a clean crucible 2.

[0072] The electrical cables 7 and the cooling circuit 5a can in fact be disconnected and reconnected rapidly; in fact, both have releasable connections separate from each other.

[0073] The invention comprises a new process for casting nodular cast iron.

[0074] This involves producing the cast iron in a production furnace and subsequently pouring it into a crucible 2 comprising the heating means 4 described.

[0075] The cast iron is subsequently cast into one or more molds 3, through the casting system 8 described.

[0076] The invention achieves important advantages.

[0077] In fact, the apparatus 1 makes it possible to produce high quality metal elements, made in particular of nodular cast iron, at moderate costs.

[0078] In fact, the liquid cast iron, in particular nodular cast iron, inside the crucible 2 is kept at optimum and even temperatures and is cast immediately and promptly.

[0079] A further advantage is represented by the fact that the apparatus 1 allows casting without inclusions of slag present in the bath of liquid cast iron. In fact, it is known that slag floats on the liquid cast iron and is therefore to be found on the upper surface of the bath. Consequently, the casting hole 9 located on the base allows exclusion of slag from the casting process.

[0080] Casting is moreover improved by the presence of the video camera 21 and of the control unit 6. In fact, these elements allow accurate casting in the inlet channel 3a of the mold 3.

[0081] Another advantage is represented by the specific dimensions of the crucible 2. In fact, it allows a metallostatic head adequate for the casting flow and, at the same time, a quantity of charge that allows the liquid cast iron contained in the crucible 2 to retain the spheroidizing effect.

[0082] Yet another advantage is represented by the fact that the apparatus 1 adapts to molds, and in particular to sequences of molds, of different types and dimensions and to production furnaces of any type and dimension.

[0083] Yet another advantage of the apparatus 1 is its high level of automation. In fact, it has load cells 22 for automatic control of the quantity of liquid cast iron in the crucible 2, and a video camera 21 to control correct filling of the molds 3.

[0084] Last but not least advantage of the apparatus 1 is realized by the fact that cleaning, maintenance and repair operations on the furnace can be performed rapidly.

Claims

1. Apparatus for casting metal materials, in particular nodular cast iron, comprising: a crucible (2) suitable to be supplied with said metal material in liquid state and to contain said liquid metal material, a casting system (8), suitable to cast said liquid metal material from said crucible (2) into a mold (3), **characterized in that** it comprises means (4) to heat said liquid metal material contained in said crucible (2), suitable to keep said liquid metal material at a specific temperature, and **in that** said casting system (8) comprises a casting hole (9) located on the base of said crucible (2).

2. Apparatus according to claim 1, wherein said heating means (4) are electromagnetic induction heating means with a frequency ranging from 200 Hz to 300 Hz and with powers ranging from 100 kW to 200 kW.

3. Apparatus according to claims 2, 3 and 4, wherein said heating means comprise a coil (5) through which an alternating electric current passes and liquid cooled, liquid cooled electrical cables (7) suitable to supply said alternating electric current to said coil (5), and a cooling circuit (5a) suitable to supply said cooling liquid to said coil (5), and wherein said cooling circuit (5a) and said liquid cooled electrical cables (7) have releasable connections (7b, 5a) separate from each other, and suitable to connect said cooling circuit (5a) and said liquid cooled electrical cables (7) to said coil (5).

4. Apparatus according to claims 1 and 2, wherein said crucible (2) has a cylindrical shape and a capacity ranging from 0.5 t to 1.5 t.

5. Apparatus according to claim 3, wherein said crucible (2) has a diameter ranging from 600 mm to 700 mm and a height ranging from 550 mm to 670 mm.

6. Apparatus according to one or more of the previous claims, wherein said casting hole (9) is located in an eccentric position, intermediate between the center and the edges of said crucible (2).

7. Apparatus according to one or more of the previous claims, wherein said casting system (8) comprises a closing device (11) including a rod (12) which can be inserted into said casting hole (9) and suitable to completely block said casting hole (9).

8. Apparatus according to claim 7, wherein said rod (12) extends substantially in a direction perpendicular to the base of said crucible (2) and passes through the inside of said crucible (2).

9. Apparatus according to claims 3 and 4, wherein said closing device (11) comprises a control mechanism (13) suitable to lift and lower said rod (12).

10. Apparatus according to one or more of the previous claims, suitable to fill a plurality of molds (3) through an inlet channel (3a) of said molds, and comprising at least one video camera (21), suitable to detect correct relative positioning of said casting hole (9) and said inlet channel (3a).

11. Apparatus according to one or more of the previous claims, comprising a charge channel (20), suitable to allow supply of said liquid metal material to said crucible (2).

12. Apparatus according to one or more of the previous claims, wherein said crucible (2) comprises a feed

channel (15) suitable to allow feed of inoculants into said nodular cast iron in liquid state.

13. Apparatus according to one or more of the previous claims, comprising a supporting structure (14) of said crucible (2) suitable to allow one or more molds (3) to be inserted under said crucible (2).

14. Apparatus according to one or more of the previous claims, comprising at least one load cell (22) located under said crucible (2), suitable to measure the mass of said liquid metal material contained in said crucible (2).

15. Apparatus according to one or more of the previous claims, comprising means (16) to move said crucible (2) in the horizontal plane.

16. Process for casting nodular cast iron, consisting of producing nodular cast iron in liquid state in a production furnace, pouring said nodular cast iron in liquid state into a crucible (2) comprising heating means (4), casting said nodular cast iron in liquid state into one or more molds (3), through a casting system (8) comprising a casting hole (9) located on the base of said crucible (2).

Fig. 1

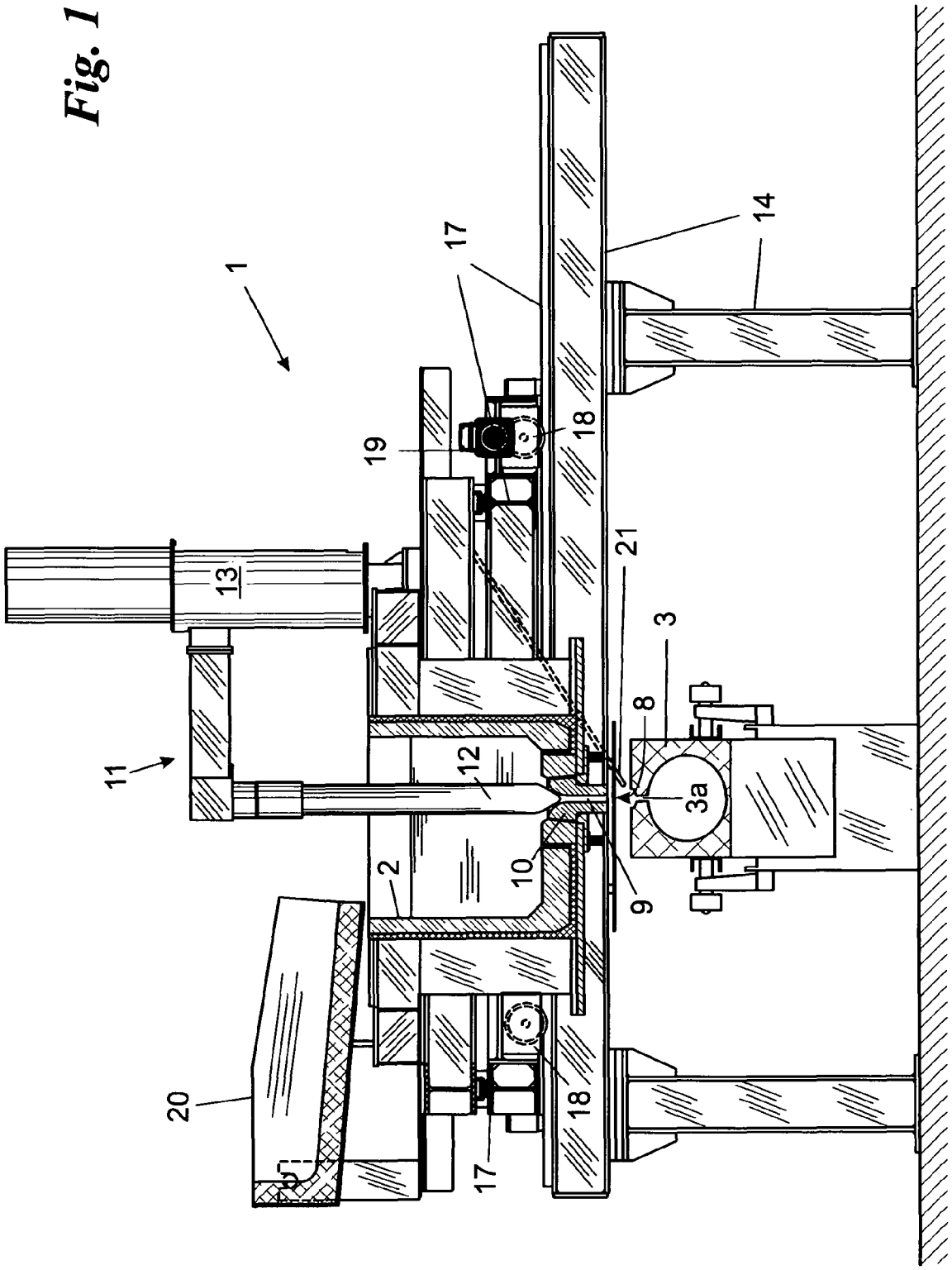
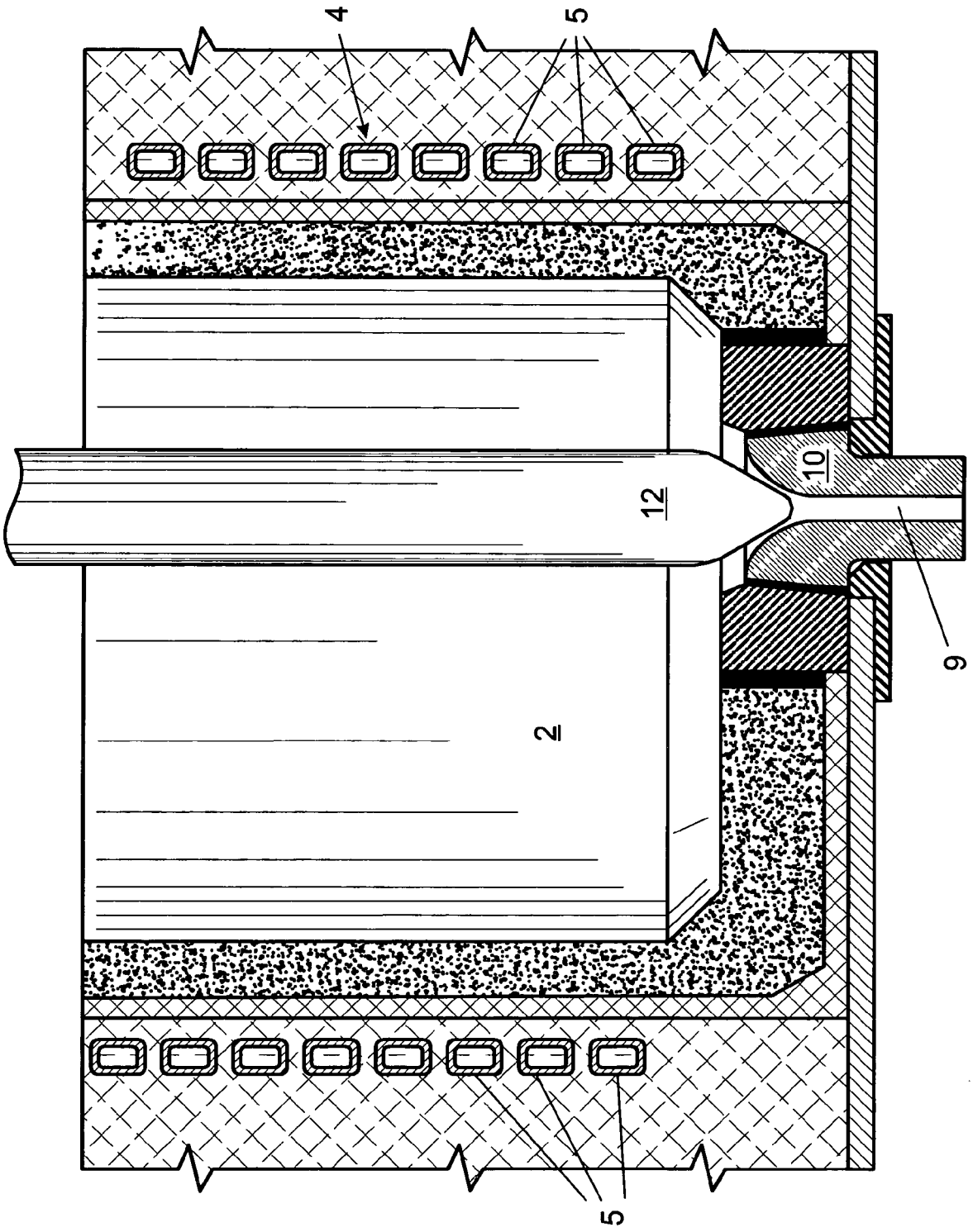


Fig. 2



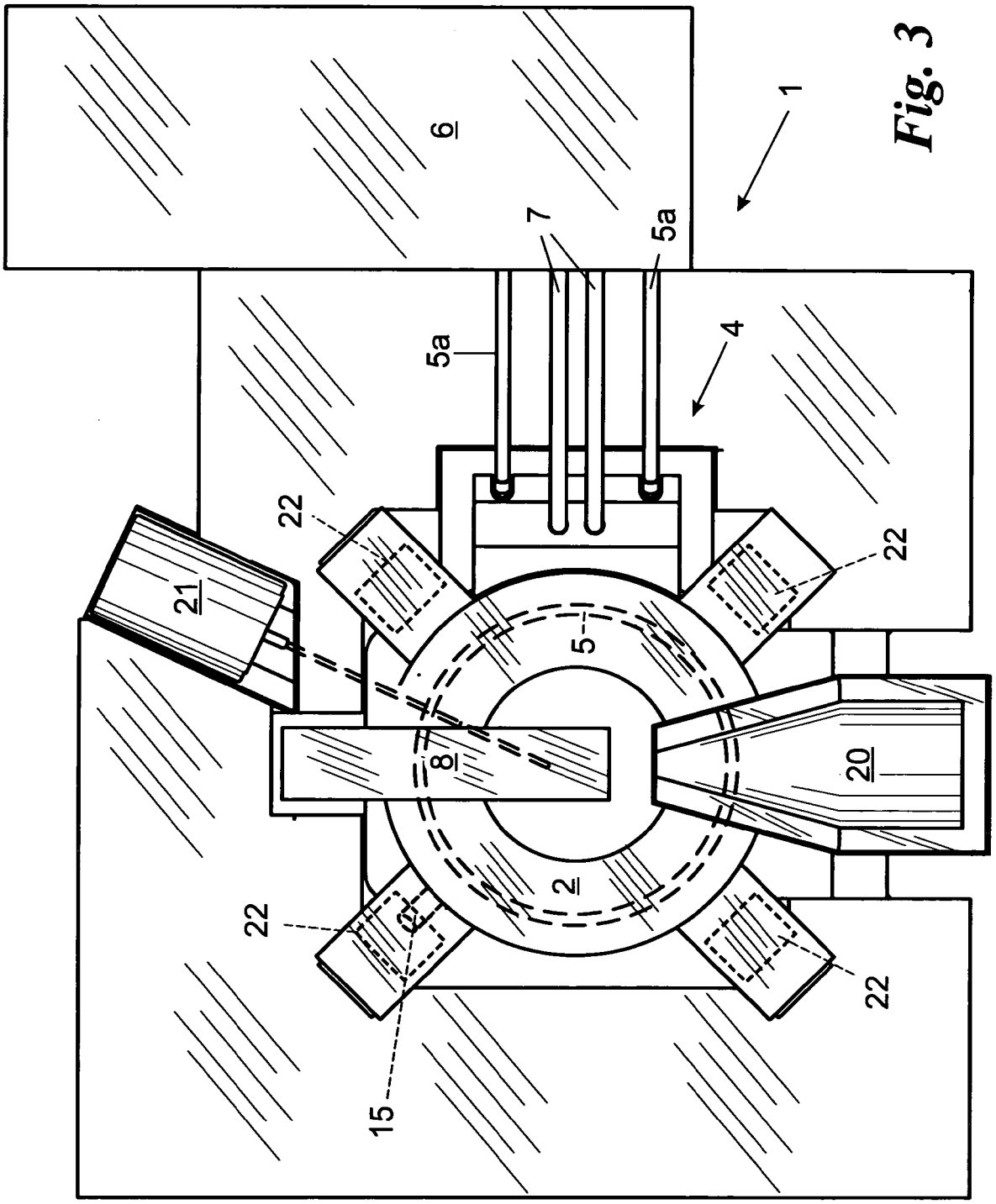


Fig. 3

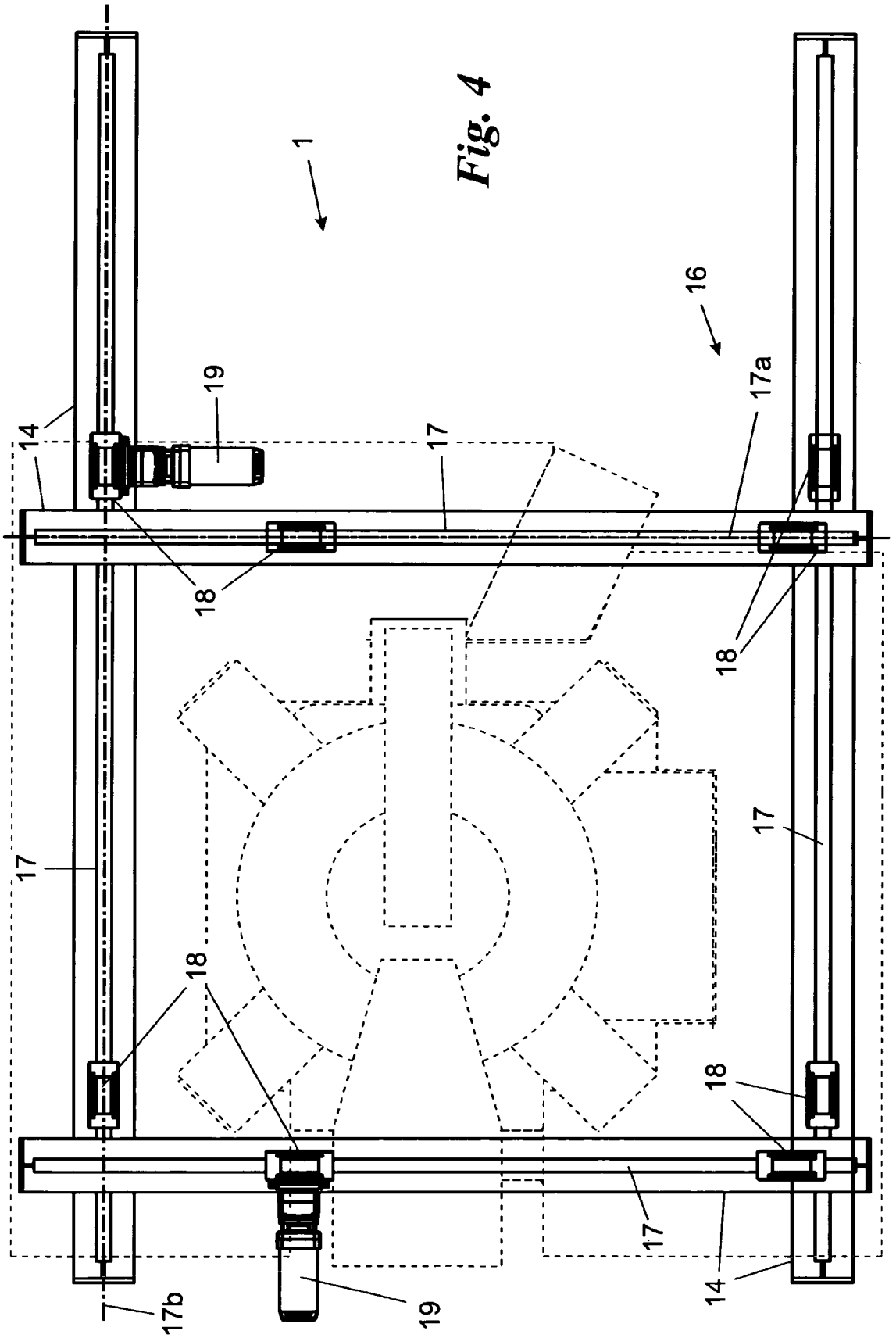


Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5638

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 March 2007	Hodiamont, Susanna

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

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2

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