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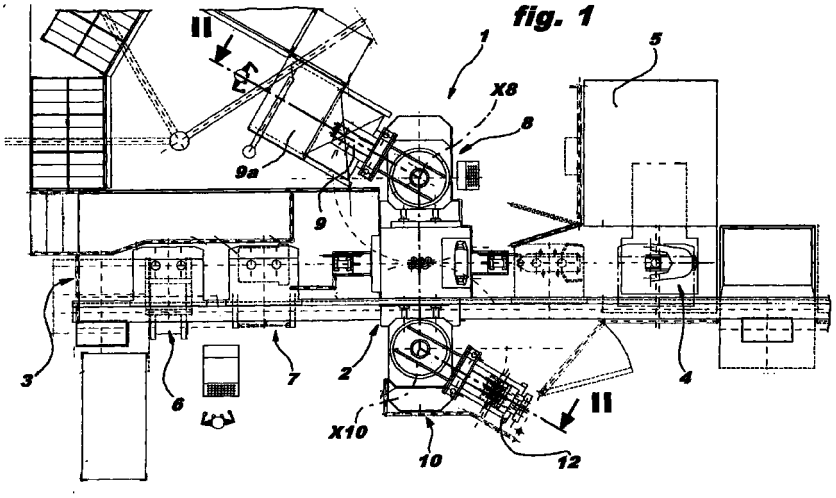
(54) A process and system for manufacturing cast articles provided with inserts

(57) During the production of castings incorporating inserts such as, for example, internal-combustion-engine blocks incorporating cylinder liners (C) as inserts, there is provision for the inserts (C) to be subjected to a pre-heating step (12) prior to insertion in the casting cavity.

fig. 1



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Description

[0001] The present invention addresses in general the problem of the manufacture of castings with inserts.

[0002] A classic example of application of this technique is the manufacture of mechanical components such as internal-combustion-engine blocks and heads. In this field, the part as a whole (that is, the block or the head) is generally produced, for example, by casting of light alloy, whereas the elements which are subjected to greater stress (the cylinder jackets or "liners", the cylinder heads, the valve seats, etc.) are made of a different material (cast iron, steel, ceramic materials, etc.).

[0003] The relevant technical and patent literature is immense and covers various areas such as, for example, the nature and the geometry of the inserts, the relative production technology (particularly with regard to the selection of the materials), and the need to ensure firm and durable anchorage of the insert to the surrounding structure.

[0004] A wide range of solutions to this latter problem has been found, ranging, for example, from the production of a shaped coupling formed with the use of particular geometry of the insert to the establishment of a type of structural bond, even at metallurgical level, between the material of the insert and the surrounding material, as well as solutions which resort to the production of tight mechanical couplings.

[0005] For example, during the production of blocks for internal-combustion engines, a known solution provides for fine machining of the block so as to transform the cavities of the cylinders formed by casting into seats in which the cylinder liners can be fitted only after cooling to extremely low temperature (achieved by immersion in liquid nitrogen) with consequent contraction of the liners in a diametral direction. The subsequent return of the block/liner assembly to ambient temperature and, in particular, to working temperatures causes the liners to expand again so as to achieve a condition of firm restraint inside the block.

[0006] This method is quite complex to implement, particularly with regard to the criticality of the respective parameters.

[0007] The object of the present invention is to provide a solution which can combine the required excellent final result with an ability to implement a quick and efficient industrial process.

[0008] According to the present invention, this object is achieved by means of a method having the characteristics recited in the following claims. A further subject of the invention is a system for implementing the method.

[0009] The invention will now be described, purely by way of non-limiting example, with reference to the appended drawings, in which:

Figure 1 is a general plan view of a system according to the invention, and

Figure 2 is a sectioned/elevational view taken on the broken line II-II of Figure 1.

[0010] In the drawings, a system for the manufacture of cast elements (so-called "castings") in which one or more inserts are included is generally indicated 1.

[0011] By way of indication, (naturally, this should not be interpreted as limiting of the scope of the invention), the system 1 may be used, for example, for the manufacture of internal-combustion-engine blocks made of light alloy in which the inserts are constituted by the cylinder liners which are made of a metallic material, for example, cast iron, having greater resistance to mechanical and thermal stress. In particular, the embodiment illustrated relates to the production of internal-combustion-engine blocks comprising six cylinders in a V-arrangement.

[0012] The general layout of the system shown in Figure 1 may be considered generally known. Only the elements of specific importance and interest for the purposes of the implementation of the present invention will therefore be described in detail in the following description. For the construction of the parts and elements not shown in detail, reference may therefore be made to any known casting system.

[0013] Basically, the heart of the system 1 is constituted by a casting station 2 towards which a line for the loading and advance of the casting cores converges from one side and a casting robot 4 converges from the other side, the casting robot 4 taking the hot casting material (for example fused light alloy) from a furnace 5 and then advances towards the casting station 2 where the material is poured into the casting dies (moulds).

[0014] In the embodiment described herein, there is provision for the presence of two sets of cores (corresponding to the engine cavity and to the respective spaces) shown in the region of respective axes, indicated 6 and 7.

[0015] A robot, generally indicated 8, usually has a flag-like or lantern-like structure (in this connection, see in particular the view of Figure 2) and acts as an output robot. In practice, the gripping structure 9 of the robot 8 can be brought (see in particular Figure 2) to the vicinity of the casting station 2 in order to pick up the castings formed therein, to lift them, and to transfer them, by rotating about its own principal vertical axis X8, to an output station 9a.

[0016] In the embodiment described herein (which - it is pointed out once more - is an example and should not therefore be interpreted as limiting of the scope of the invention), the solution according to the invention provides for the presence of a further robot 10 in a position approximately symmetrical to that of the robot 8 with respect to the axis defined by the core loading axis and by the axis of the station 2 (the so-called bench-mould axis). As can be seen in the elevational view of Figure 2, the robot 10 has a structure substantially similar to that of the robot 8 described above.

[0017] This robot thus also has a generally flag-like or lantern-like structure with a vertical pillar which can rotate about a respective vertical axis X10 and an arm carrying at its end a structure 11 which can pick up the inserts, that is, in the specific case, the liners, in order then to position them inside the casting moulds.

[0018] In particular, the lifting structure 11 is intended to pick up the liners from a pre-heating unit 12, the characteristics of which can be seen in greater detail in the view of Figure 2.

[0019] In this connection, it should be borne in mind that the embodiment illustrated herein relates to the production of V-shaped engine blocks for which an inclined arrangement of the liners is required.

[0020] In the embodiment illustrated, the elements which provide for the pre-heating and for the handling of the liners therefore have a corresponding inclination. Clearly, however, in the case of engines of different types, for example, non-V-shaped engines, this inclination of the pre- heating and lifting elements would in fact be unnecessary. More generally, however, these elements (the pre-heating and gripping elements) may have any orientations and relative positions, in dependence on specific production requirements.

[0021] In the embodiment described herein, the gripping structure 11 comprises a number of gripping units 13 equal to the number of liners to be positioned inside each casting (six in the embodiment shown).

[0022] Each gripping unit 13 is constituted in general by an element movable on an inclined guide 14 fixed to a framework 15 carried by the arm of the robot 10.

[0023] The movement of the elements 13 on the guides 14 is brought about under the control of drive elements such as, for example, fluid actuators, not shown explicitly in the drawings.

[0024] Moreover, each gripping element 13 has, at its lower end, a head 16 which can enter a liner to be picked up in order to perform therein, for example, a radial expansion or opening-out movement brought about by drive means of known type not specifically shown in the drawings and possibly subservient to the general movement of the unit 13 on the guide 14. Each unit 13 can thus exert a gripping action on a liner and, by returning upwards along the respective guide 14, can support the liner on the gripping structure 11 of the robot 10.

[0025] As can be seen in Figure 2, the pre-heating unit 12 has a configuration generally complementary to that of the gripping structure 11.

[0026] The unit 12 is usually constituted by a block 17 of thermally conductive material such as metal disposed on a solid bench 18 and having corresponding cavities 19 forming seats in which the liners C to be (pre)-heated are disposed. In view of the times normally required for performing the casting process, which are controlled basically by the need to cool the casting just formed before discharging it from the station 2, the insertion of the liners C in the unit 12 may be performed manually by a person employed for this purpose. Naturally, an automatic loading operation may also be performed, for example, by a unit similar to the gripping unit 11.

[0027] The cavities 19 usually have a generally cylindrical shape which enables heating elements (typically electrical resistors) to be placed both outside and inside each cavity 19.

[0028] In the specific embodiment illustrated, the reference numerals 20 indicate resistors - of known type - disposed in the block 17 of the unit 12 so as to extend in the vicinity of the outer surface of each cavity 19, and hence in the vicinity of the wall of the liner C inserted in the cavity. The reference numeral 21 indicates further heating elements, usually also constituted by electrical resistors, which extend inside the cavity 19 so that they can be disposed inside the cavities of the liners C subjected to pre-heating.

[0029] The operating sequence of the system shown in Figure 1 corresponds substantially to the normal operating sequence provided for in a plant of this type, with the difference that the robot 10 inserts the liners C in the die or mould provided for the casting after picking them up from the pre-heating unit 12. This is done in a manner such that, when the casting robot 4 pours casting material into the mould, the liners C are at a high temperature, considerably higher than ambient temperature.

[0030] Whilst it is not desired to be bound to any specific theory in this connection, tests carried out by the Applicant show that, as a result of the pre-heating to which they have been subjected, the liners are incorporated in the casting, establishing a particularly firm, stable and durable bond, amply adequate for withstanding over time the stresses normally imposed on an insert such as a cylinder liner inserted in an internal-combustion engine.

[0031] In particular, tests carried out by the Applicant show that excellent results can be achieved with casting materials (for example, aluminium alloys, various light alloys, etc.) cast at temperatures of the order of 730-800°C, when - at the time of casting - the inserts in question (made, for example, of cast iron) are at a temperature of the order of about 300-350°C.

[0032] The solution according to the invention enables the temperature of the inserts to be regulated particularly precisely on account of the fact that a limited reduction in the temperature of the inserts is generally observed from the moment at which they are extracted from the pre-heating unit 12 to the moment at which the casting is performed, after they have been positioned in the mould.

[0033] As can be seen in Figure 2, the pre-heating unit 12 usually has a geometry correlated with the geometry of the gripping structure 11 which in turn is linked with the geometry of the arrangement of the liners in the casting mould.

[0034] In the embodiment illustrated, the gripping unit

11 has a generally V-shaped configuration with two rows of three gripping elements 13 defining an imaginary dihedron - with a given dihedral angle and a downwardly-facing edge - precisely reproducing the aforementioned V-shaped configuration.

[0035] The pre-heating unit 12 has a complementary shape since the cavities 19, of which there are also six, are arranged in two rows also defining an imaginary dihedron oriented in an inverted position relative to the structure 11 (that is, with the same dihedral angle but with the edge facing upwards).

[0036] In operation, the robot 10 brings the gripping structure 11 to the vicinity of the pre-heating unit 12.

[0037] The elements 13 of one of the two rows are then moved downwards along the respective guides 14 into one of the rows of cavities 19 (for example, the gripping elements 13 situated on the left in Figure 2 move down into the cavities 19 situated on the right in the same drawing), so as to extract from the unit 12 three liners C which are picked up by the structure 11. Immediately afterwards, the same operation is repeated with the other row of gripping elements 13 (for example, those on the right) which move down into a corresponding row of cavities 19 (the left-hand row of Figure 2) in order to pick up the other three liners housed in these cavities and return them upwards on the structure 11.

[0038] At this point, the robot 10 rotates about its vertical axis X10 so as to bring the structure 11 above the casting station 2 where the two rows of liners are placed inside the casting mould by an operation substantially complementary to that described above. Naturally, cores and/or complementary elements are provided in the mould for receiving the liners C, keeping them positioned precisely in the desired final positions of incorporation in the casting (in this case, the block).

[0039] Since this operation is performed automatically and in accordance with a precisely programmed sequence, it is possible to determine precisely the preheating temperature at which the liners C should be picked up by the unit 12 in order to be at the desired temperature at the time of casting.

[0040] For example, tests carried out by the Applicant show that the period of time which elapses between the picking-up of the liners C from the unit 12 and the moment of casting is typically of the order of about 25 seconds. The corresponding reduction in the temperature of the liners C is typically of the order of about 50°; in this connection, it may be noted that the foundry environment is itself a fairly hot environment so that, particularly after positioning in the vicinity of and in the mould, the cooling of the liners C is in fact negligible. The desired result can consequently easily be achieved by setting the pre- heating temperature at a level higher than the final desired temperature level to an extent exactly equal to the amount of cooling considered above.

[0041] Naturally, the principle of the invention remaining the same, the details of construction and forms of embodiment may be varied widely without thereby departing from the scope of the present invention as defined by the following claims.

Claims

1. A method of producing castings each incorporating at least one insert (C), comprising the steps of:

   - providing a casting cavity (2),

   - locating (10) the at least one insert (C) in the casting cavity, and

   - casting (4) hot casting material (5) into the cavity, the subsequent cooling of the casting material bringing about solidification of the material and consequent incorporation of the at least one insert (C) in the casting thus formed,

   characterized in that it comprises the step of pre-heating (12) the at least one insert (C) with a view to its insertion in the casting cavity.

2. A method according to Claim 1, characterized in that it comprises the steps of:

   - pre-heating (12) the at least one insert (C) in a position remote from the casting cavity, and

   - transferring the at least one pre-heated (12) insert from the remote position to the casting cavity.

3. A method according to Claim 2, characterized in that it comprises the steps of:

   - transferring the at least one pre-heated insert from the remote position to the casting cavity within a period of time of predetermined duration between the moment at which the at least one insert is picked up from the remote position and the moment at which the hot casting material is cast in the cavity with the at least one insert located in the cavity,

   - determining the extent of the reduction in the temperature of the at least one insert during the said period of time, and

   - performing the pre-heating to a temperature which exceeds the desired temperature of the at least one insert at the moment at which the hot casting material is cast into the cavity by an amount corresponding to the extent of the temperature reduction.

4. A system for producing castings each incorporating at least one insert (C), comprising:

- a casting station (2) with associated means (3, 4, 6, 7) for forming a casting cavity,

- loading means (10) for placing the at least one insert in the casting cavity,

- casting means (4, 5) for casting hot casting material into the cavity, the subsequent cooling of the casting material bringing about solidification of the material and consequent incorporation of the at least one insert (C) in the casting thus formed,
characterized in that it comprises pre-heating means (12) for pre-heating the at least one insert (C) with a view to its insertion in the casting cavity by the loading means (10).

5. A system according to Claim 4, characterized in that the loading means (10) comprise a robot (10) having a gripping structure (11) movable selectively between the pre-heating means (12) and the casting cavity (2).

6. A system according to Claim 5, characterized in that the robot (10) has a generally lantern-like structure with a pillar which can rotate about a vertical axis (X10) and an arm projecting from the pillar and carrying the gripping structure (11) in a distal position.

7. A structure according to any one of Claims 4 to 6, characterized in that the loading means (10) comprise a gripping structure (11) with at least one element (13) movable (14) towards an extended position for gripping the at least one insert (C).

8. A system according to Claim 7, characterized in that the at least one element (13) has a gripping head (16) which can cooperate with the at least one insert.

9. A system according to Claim 8, characterized in that the gripping head (16) operates by a general opening-out movement.

10. A system according to any one of Claims 4 to 9, usable for the production of castings constituted by internal-combustion-engine blocks incorporating, as inserts, cylinder liners (C) disposed in two rows in a V-shaped arrangement, characterized in that the loading means (10) comprise a gripping structure (11) having gripping elements (13), also disposed in two rows in a V-shaped arrangement such that the gripping elements (13) of one row and of the other row can cooperate, respectively, with the cylinder liners (C) of one row and of the other row.

11. A system according to any one of Claims 4 to 10, characterized in that the pre-heating means (12) comprise:

- a block (17) of thermally conductive material having at least one cavity (19) for housing the at least one insert (C), and

- heating means (20, 21) for selectively heating the block (17) at least adjacent the at least one cavity (19).

12. A system according to Claim 11, characterized in that the heating means (20, 21) comprise electrical heating means.

13. A system according to Claim 11 or Claim 12, characterized in that the heating means comprise:

- first heating means (20) located in the block (17) generally outside the at least one cavity (19), and

- second heating means (21) extending inside the at least one cavity (19).

14. A system according to Claim 13, characterized in that the at least one cavity (19) is cylindrical, and in that the first heating means (20) extend in the block (17) of thermally conductive material in a position peripherally outside the cavity (19), and in that the second heating means (21) extend generally axially inside the cavity (19).

15. A system according to Claim 9 and Claim 10, characterized in that the pre-heating means also comprise cavities (19), arranged in two further rows, for housing respective rows of cylinder liners (C).

16. A system according to Claim 15, characterized in that:

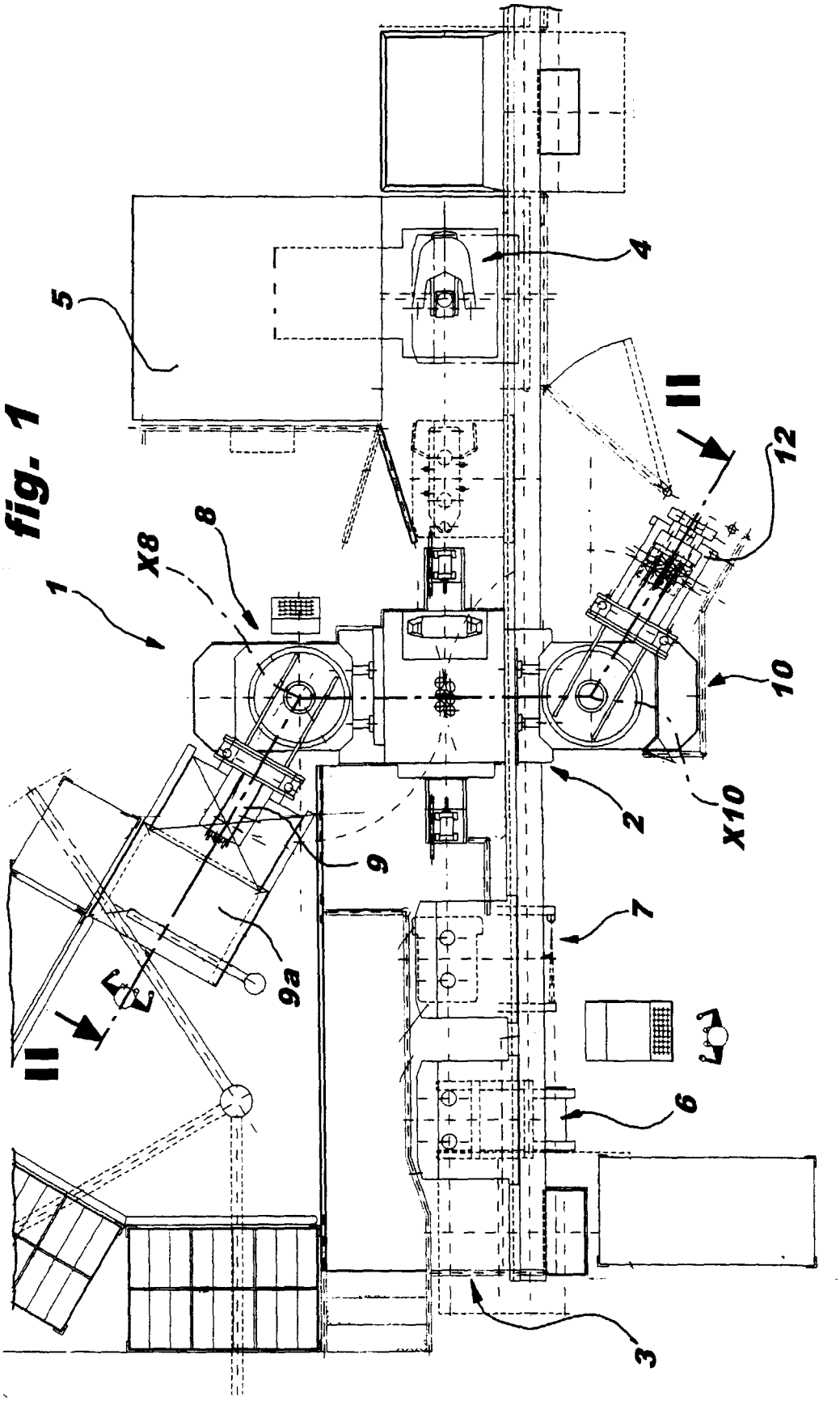
- the two rows of gripping elements (13) are arranged in a generally dihedron-like configuration with a given dihedral angle and with a downwardly-facing edge, and

- the further respective rows of cavities (19) provided in the pre-heating means (12) are also arranged in a generally dihedron-like configuration with an angle corresponding to the given dihedral angle and with an upwardly-facing edge.

17. A system according to any one of Claims 4 to 16, characterized in that the casting means (4) cast the hot casting material at a temperature of the order of about 730-800°C, and in that the pre-heating means (12) heat the at least one insert (C) to a tem-

perature such that the at least one insert is at a temperature of the order of about 300-350°C at the time of casting.

fig. 1



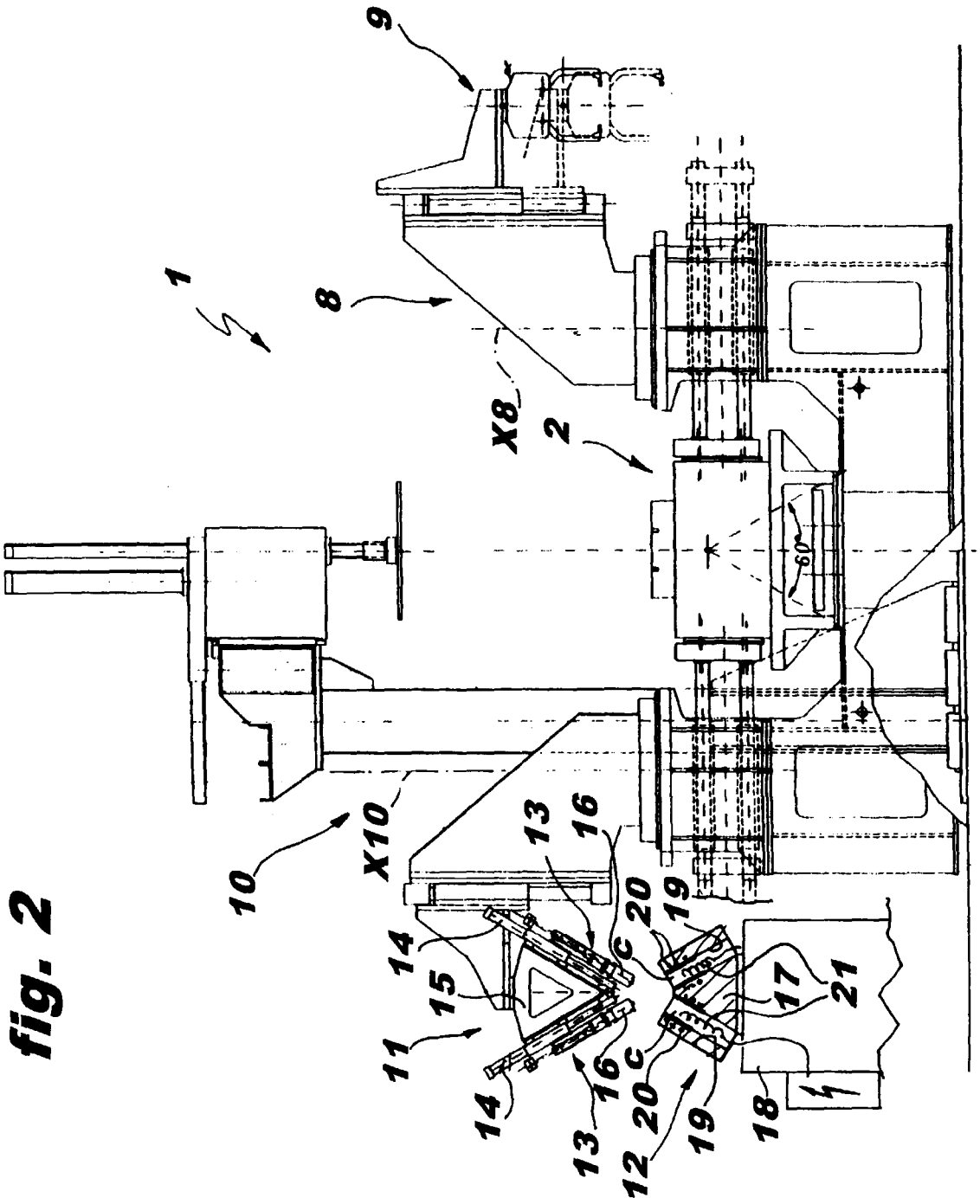


fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 98 83 0495

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 523 (M-1049), 16 November 1990 & JP 02 220754 A (SUZUKI MOTOR CO LTD), 3 September 1990 * abstract *	1,2,4	B22D19/00 B22D47/00
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 045 (M-667), 10 February 1988 & JP 62 197266 A (HONDA MOTOR CO LTD), 31 August 1987 * abstract *	1,2	
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 381 (M-1162), 26 September 1991 & JP 03 155450 A (TOKAI CARBON CO LTD), 3 July 1991 * abstract *	1,2	
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 083 (M-1216), 28 February 1992 & JP 03 268855 A (TOYOTA MOTOR CORP), 29 November 1991 * abstract *	1,2	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B22D
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 365 (M-1442), 9 July 1993 & JP 05 057420 A (IKEGAI CORP), 9 March 1993 * abstract *	1,2	
X	US 4 738 298 A (TARUNO YASUNORI ET AL) 19 April 1988 * claim 6 *	1,2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 December 1998	WOUDENBERG, S

CATEGORY OF CITED DOCUMENTS

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