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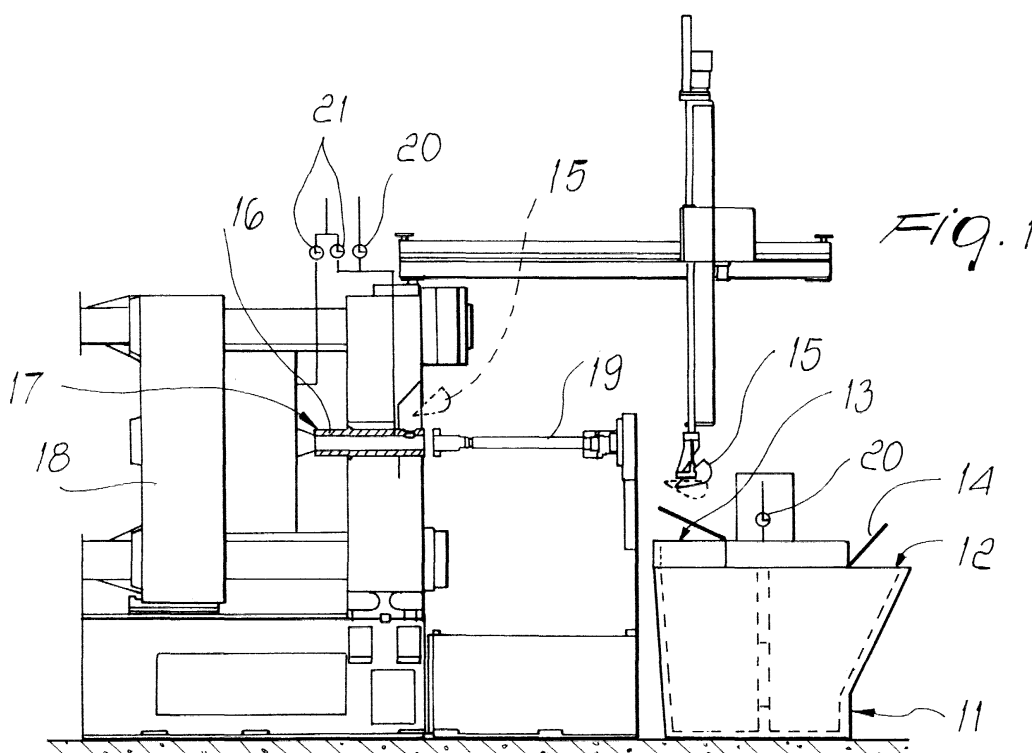
(54) **Vacuum die-casting method for producing castings of non-ferrous alloys**

(57) A vacuum die-casting method for producing castings of nonferrous alloys, comprising the steps of:

keeping a material of nonferrous alloy in a molten state in a holding furnace (11);
 transferring a preset amount of material from the furnace (11) to a die (18), at injectors;
 compressing the material in the die and allowing it

to cool.

The material, during the various steps, is continuously protected from contact with air, in regions not occupied by containment elements, by an atmosphere of gas which protects from contaminations and from the danger of oxidation, the gas having a higher relative density than air.



Description

[0001] The present invention relates to a vacuum die-casting method for producing castings of nonferrous alloys.

[0002] In recent years the use of light alloys to manufacture structural elements and/or components has been growing.

[0003] More and more assembly-line vehicles use chassis and body components made of light alloy.

[0004] The methods currently used to manufacture car chassis made of light material are forging, vacuum die-casting, and thixoforming.

[0005] Forged parts have a satisfactory grain structure and are suitable particularly for considerable lengths.

[0006] The die-casting process consists in keeping the molten material in a holding furnace, subsequently transferring a specific quantity thereof into an injector for compression inside a die, and finally cooling the resulting casting.

[0007] In vacuum die-casting, a vacuum is produced before the molten material is inserted in the die; the filigree-like structure type of the casting, with thicknesses of 4 to 8 mm, often requires wings and reinforcements in order to support the loads.

[0008] Thixoforming lies, in terms of technical method, between forging and die-casting.

[0009] With respect to forging and thixoforming, vacuum die-casting has slight advantages regarding component weight and greater freedom of configuration.

[0010] In terms of apparatus maintenance and amortization costs, the die-casting process is much more advantageous if it relates to the production of large batches meant for high-volume assembly lines.

[0011] However, the standard die-casting process is scarcely suited for the manufacture of car chassis or body components owing to its brittle fracture behavior and porosity.

[0012] Currently it is not possible to provide Al-Mg alloy castings, since the result are castings full of porosities.

[0013] In possible applications for the manufacture of car chassis, body components et cetera, the die-cast parts are castings which are welded and/or are required, in various forms, to have plastic deformation properties, whereas parts obtained with the standard die-casting process are characterized by high porosity, high value of gas inclusions, poor weldability and low expansion value.

[0014] Die-cast parts must have specific elongation properties, and since there are no nondestructive elongation tests for materials, if the testing of one casting determines that the parts do not comply with quality requirements it is necessary to discard the entire batch.

[0015] This explains the high degree of reliability that the process is required to have and cannot be ensured by the current method.

[0016] The aim of the present invention is to provide a vacuum die-casting method which solves, or substantially reduces, the problems of conventional pressure die-casting methods.

5 [0017] Within this aim, an object of the present invention is to obtain thin-walled and/or thick-walled castings which are free from gases and/or porosities, can be welded and/or have high expansion values, and L-shaped and pressure-tight castings.

10 [0018] Another object of the invention is to provide a die-casting method for obtaining castings which preserves the qualities of the light material used.

[0019] Another object of the present invention is to provide a die-casting method which is flexible in terms of the type of nonferrous alloy used.

15 [0020] Another object of the invention is to provide a die-casting method which is characterized by a high degree of reliability, in terms of quality requirements of the resulting castings.

20 [0021] This aim and these and other objects which will become better apparent hereinafter are achieved by a vacuum die-casting method for producing castings of nonferrous alloys, comprising the steps of:

- 25 -- keeping a material of nonferrous alloy in a molten state in a holding furnace;
- transferring a preset amount of said material from the furnace to a die, at injectors;
- 30 -- compressing the material in the die and allowing it to cool,

35 characterized in that said material, during the various steps, is continuously protected from contact with air, in regions not occupied by containment means, by an atmosphere of gas which protects from contaminations and from the danger of oxidation, said gas having a higher relative density than air.

[0022] Further characteristics and advantages of the present invention will become better apparent from the following detailed description of a preferred but not exclusive embodiment thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

45 Figure 1 is a view of an apparatus for performing a die-casting method according to the invention;
Figures 2 and 3 are schematic views of two steps of the operation of a component of the apparatus.

50 [0023] With particular reference to Figure 1, an apparatus particularly for performing a vacuum die-casting method according to the invention is generally designated by the reference numeral 10.

55 [0024] The method consists of a first step, in which the light material, usually a nonferrous aluminum alloy, is kept in a molten state in a holding furnace designated by the reference numeral 11.

[0025] The holding furnace 11 comprises a section 12

for filling with the material and a section 13 for withdrawal of the material in a liquid state.

[0026] During transfer from the filling section 12 to the withdrawal section 13, the material in the molten state is filtered.

[0027] During holding in the filling section 12, the material in the molten state is subjected to a degassing step by means of a rotor which is installed inside the furnace 11, with a cover 14 of the section 12 in the closed configuration.

[0028] The withdrawal section 13 is a region in which the material is in a quiescent state, free from gas bubbles and filtered and therefore has an optimum degree of purity for the subsequent operations.

[0029] While it is inside the furnace 11, the material is protected against contact with the air, in the regions not occupied by the containment walls, by an atmosphere of a protective gas having a higher relative density than air.

[0030] A preset amount of molten material is then poured from the withdrawal section 13, by means of a ladle 15, into a cylindrical chamber 16 of an injector which is generally designated by the reference numeral 17.

[0031] The ladle 15 enters the withdrawal section 13 only after being held proximate to the holding furnace 11 for a period required and sufficient to reach a given operating temperature, so as to avoid affecting the temperature of the molten material that is drawn.

[0032] The ladle 15 enters the filling section 12 at an angle which depends on the amount of molten material that it must draw; the inclination, particularly the height of the lowest edge of the ladle, determines the height of the free surface of the drawn material.

[0033] Also in this case, while the material is inside the ladle 15, it is protected against contact with air in the regions not occupied by the containment walls by an atmosphere of a protective gas having a higher relative density than air.

[0034] During the transfer of the molten material from the ladle 15 to the cylindrical chamber 16, the ladle 15 moves at a tipping rate which determines a constant filling rate of the cylindrical chamber 16 and a constant speed of the molten material, so as to minimize turbulence inside the cylindrical chamber 16.

[0035] In this manner it is possible to minimize the number of gas inclusions in the casting.

[0036] Once the filling step has ended, the injection of the molten material into dies, generally designated by the reference numeral 18, begins.

[0037] While the piston 19 of the injector 17 pushes the molten material contained in the cylindrical chamber 16, vacuum is produced inside said cylindrical chamber 16 and inside the dies 18.

[0038] In order to take into account shrinkage of the casting by a percentage which depends on the type of alloy used, there is also a step for topping up the liquid material.

[0039] As mentioned, during the various processing and transfer steps the material is protected against contact with air, in the regions not occupied by the containment means, by an atmosphere of a protective gas which has a greater relative density than air; advantageously, the protective gas is nitrogen, which has no environmental impact and is available at low cost as a residue of smelting.

[0040] The protective gas is thus contained in the holding furnace 11.

[0041] During withdrawal from the withdrawal section 13, the ladle 15, before making contact with the liquid material, enters the protective gas atmosphere.

[0042] The withdrawal method is such that the ladle 15 in any case contains an upper layer of protective gas even when it conveys the maximum possible quantity of liquid material.

[0043] As shown in Figures 2 and 3, the ladle in fact enters the section 13 at an angle and straightens after withdrawal, leaving an upper volume available for carrying the gas 22, while the lower volume is filled with material 23 in the liquid state.

[0044] Also the inside of the cylindrical chamber 16 is filled with protective gas, so that even during the filling of such chamber the liquid material never makes contact with the air, avoiding the danger of forming inclusions which are dangerous for the quality of the casting.

[0045] At the holding furnace 11 and at the injectors 17, the apparatus 10 is provided with valves 20 for introducing nitrogen and, at the dies 18 and injectors 17, with valves 21 for generating a vacuum.

[0046] In practice it has been observed that the present invention has achieved the intended aim and objects.

[0047] In particular, it is evident that the various steps of the method absolutely avoid contact with air, which would contaminate the material, oxidizing it, and the continuous degassing step allows the castings to be absolutely pure.

[0048] It is thus possible to obtain thin-walled and/or thick-walled castings, castings which are free from gas and/or porosities, are weldable and/or have high expansion values, and L-shaped and pressure-tight castings.

[0049] Since the casting has no porosities, it has a greater mechanical strength than an equal casting performed with known methods.

[0050] Accordingly, thermal treatments (which entail additional costs and longer times) are no longer required in order to attain strength values which cannot be achieved in known processes.

[0051] Moreover, for an equal required strength it is possible to reduce the thicknesses of the castings, with a consequent cost saving and an increase in manufacturing possibilities in the field of vehicle bodies.

[0052] Another particularly important fact is that it is possible to provide Al-Mg castings, which currently cannot be obtained due to the limitations linked to known technologies, which produce castings full of porosities.

[0053] The actual reliability of the process, which also takes into account the metallurgical properties of the materials used in order to optimize results, is further ensured.

[0054] The present invention is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept.

[0055] The technical details may be replaced with other technically equivalent elements.

[0056] The materials and the dimensions may be any according to requirements.

[0057] The disclosures in Italian Patent Application No. PD2000A000166 from which this application claims priority are incorporated herein by reference.

[0058] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

5. The method according to claim 4, further comprising the step of heating said ladle at the holding furnace before withdrawing the material.

5 6. The method according to claim 4, **characterized in that** the molten material is poured into the injectors by means of said ladle with an adjustable tipping rate.

10 7. The method according to claim 1, comprising the step of producing a vacuum inside the injectors and the die after the injector filling step.

15 8. The method according to claim 1, comprising the step of using nitrogen as a protective gas.

9. An apparatus for performing a method according to claim 1.

Claims

1. A vacuum die-casting method for producing castings of nonferrous alloys, comprising the steps of:

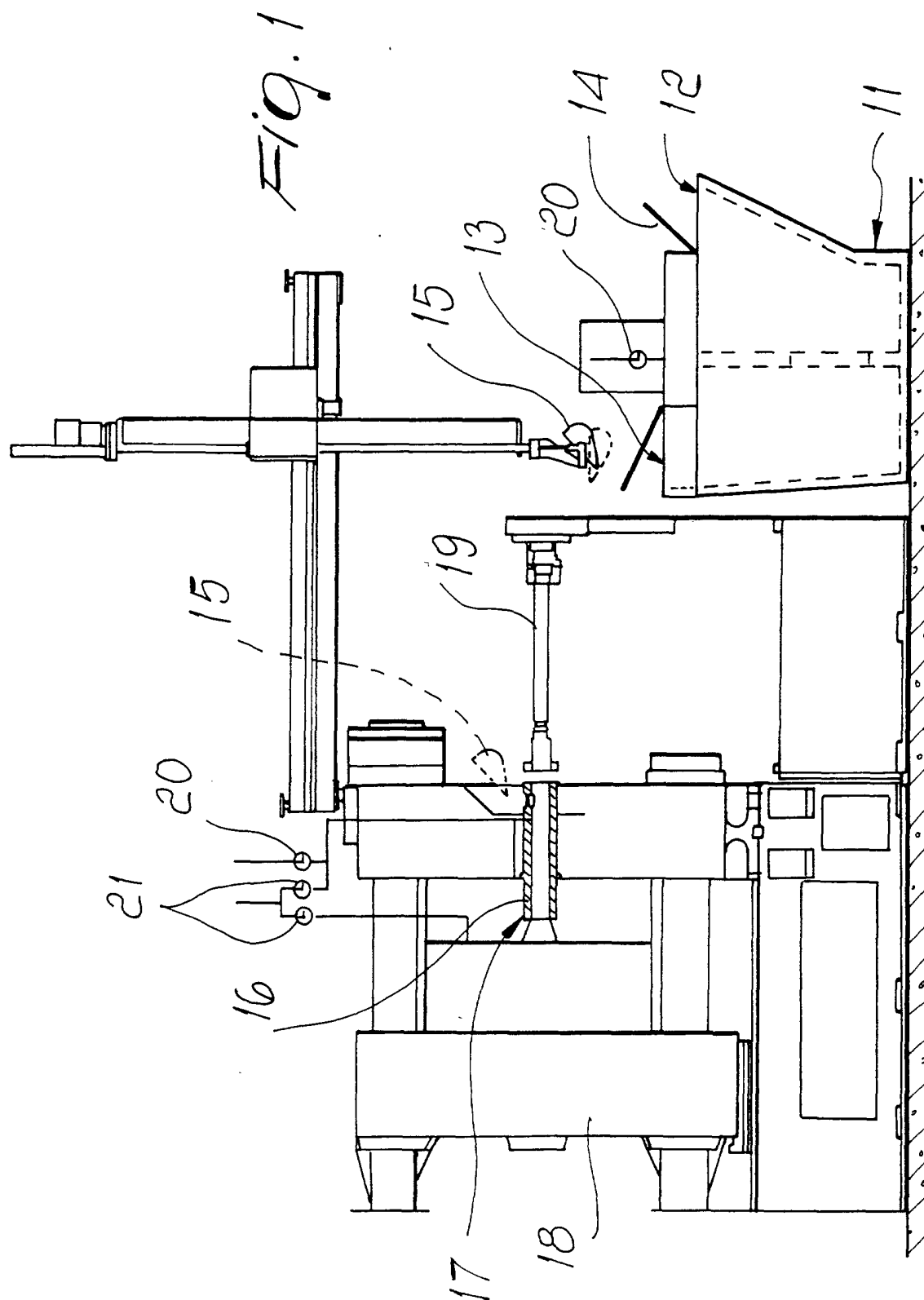
- keeping a material of nonferrous alloy in a molten state in a holding furnace;
- transferring a preset amount of said material from the furnace to a die, at injectors;
- compressing the material in the die and allowing it to cool,

characterized in that said material, during the various steps, is continuously protected from contact with air, in regions not occupied by containment means, by an atmosphere of gas which protects from contaminations and from the danger of oxidation, said gas having a higher relative density than air.

2. The method according to claim 1, further comprising the step of degassing continuously during holding, by means of a rotor, the material contained in a withdrawal section of the holding furnace.

3. The method according to claim 2, comprising the step of filtering the molten material during transfer from a section for filling with the material in the solid state to the withdrawal section, said sections being comprised within the holding furnace.

4. The method according to claim 1, comprising the step of transferring a preset amount of material into said die by means of a ladle, with adjustment of the amount of material withdrawn by tipping the ladle.



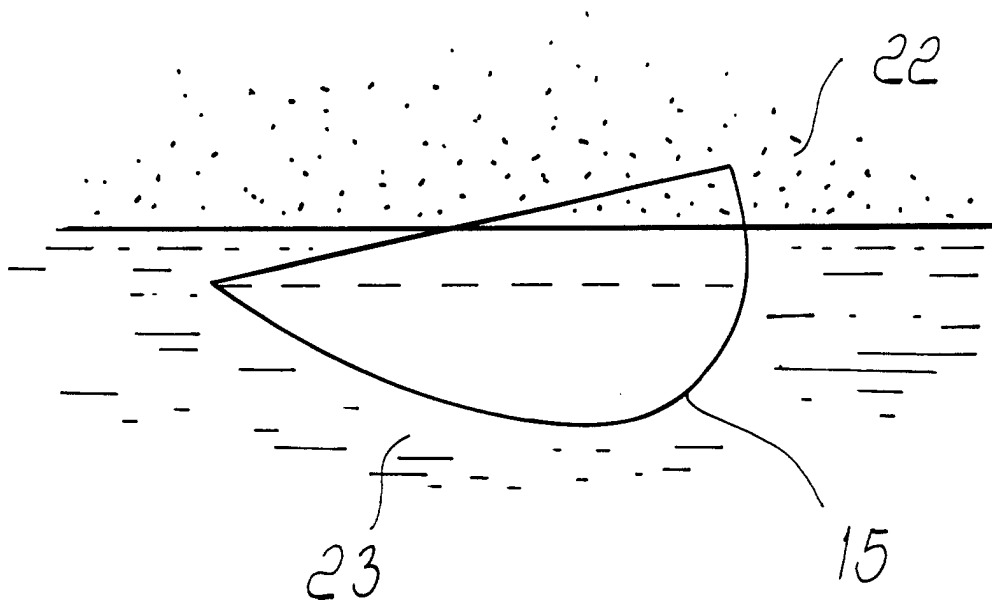


Fig. 2

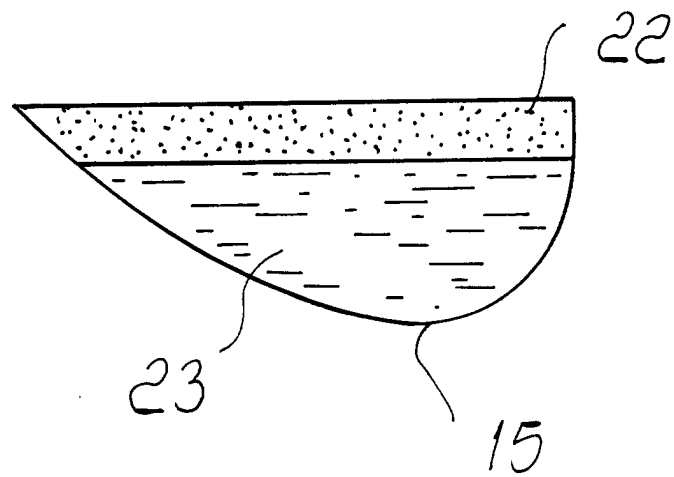


Fig. 3



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 01 11 2949

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Place of search THE HAGUE		Date of completion of the search 11 October 2001	Examiner Peis, S
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EPO FORM 1503 03/82 (P04001)

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