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Continuously or semi-continuously supplying to a casting die or mould molten magnesium alloy treated to provided a grain refining effect.

Molten magnesium alloy is continuously or semi-continuously supplied to a casting die or mould (13) at the feed point (12) thereof through a closed conduit (5) through which molten alloy is passed without contact with the atmosphere. A first section (6) of the conduit (5) takes the form of a helix immersed in a fluidized bed (8) heating the alloy to a grain refining temperature. A subsequent second section (7) of the conduit (5) in the form of a helix is immersed in a second fluidized bed (9) in which the alloy is cooled to a controlled casting temperature. The conduit (5) supplies the alloy at the level (14) of the inlet (12) to the casting die or mould (13) by control of the pressure of the molten alloy in the conduit (5).

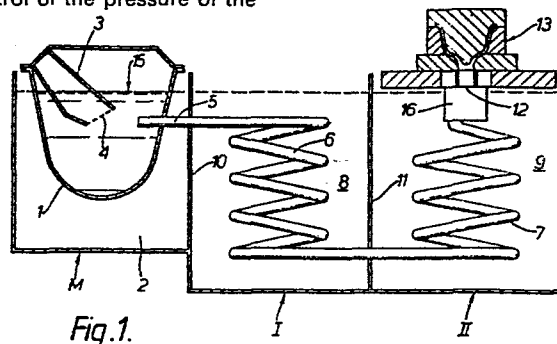


Fig.1.

CONTINUOUSLY OR SEMI-CONTINUOUSLY SUPPLYING TO A CASTING  
DIE OR MOULD MOLTEN MAGNESIUM ALLOY TREATED TO PROVIDED  
A GAIN REFINING EFFECT

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Magnesium alloys are known to be grain refined by the techniques of either superheating above the liquidus or by the addition of carbon in the form of carbon containing compounds or of other grain refining agents such as zirconium. This phenomenon is important because of the improvement in mechanical properties observed with a reduction in grain size. Both the technique of superheating and the technique involving an addition of grain refining agents are in commercial use, but the established methods have limitations giving rise to production problems. Part of the difficulty is that the mechanisms of the techniques, whilst being known to depend on a modification of the normal nucleation process, are not fully understood. Therefore, all commercial practice is based on empirical data.

Nevertheless, certain guidelines and criteria can be applied to the techniques to provide a reasonable level of reliability. These include the optimization of alloy composition and the establishment of temperatures and times at which grain refinement can take place.

The observance of these criteria can have serious limitations on certain types of production foundry processes, particularly those which rely on having a continuous supply of molten material.

With all the methods discussed above the metal has to be grain refined on a batch basis in open crucible type pots which are prevented from burning by the addition of a flux to the surface of the metal. The use of such flux, which may contain any or all of the compounds  $MgCl_2$ ,  $NaCl$ ,  $CaCl_2$ ,  $CaF_2$  and  $MgO$ , is undesirable in that great care must be taken in order to avoid any of these materials contaminating the metal used to produce castings. Failure to ensure inclusion-free metal may lead to the production of castings with impaired mechanical properties and poor corrosion resistance. The use of fluxes in the foundry also creates environmental problems because of their hygroscopic and corrosive nature.

In the case of superheating, whilst good reliability is experienced, high energy costs and considerable wear and tear on

crucibles has led to a greater commercial acceptance of the carbon grain refining technique, which can operate at much lower temperatures, for example at 750°C compared with 850°C for superheating.

5           However, the effectiveness of carbon grain refining would appear to be limited to relatively small melts treated on a batch basis, and the effect when using commercially available carbon containing compounds tends to be variable from batch to batch. Furthermore, the addition of these compounds may introduce unwanted  
10 elements into the melt which may have a deleterious effect on the alloy.

          In conventional low pressure die-casting systems the liquid metal has to be raised and lowered a distance of approximately 80 cm in a riser tube between the metal level in a holding pot and the  
15 level of the feed point of the die. This not only takes time in the injection cycle, but also leads to the creation of turbulence in the metal particularly when the metal falls back to the level in the holding pot. Such turbulence is undesirable in the production of high quality castings since air may aspirate into the metal leading  
20 to the formation of oxides in readily oxidisable alloys such as magnesium.

          One object of the invention is to overcome the problems and disadvantages discussed above and provide a method of continuously or semi-continuously supplying grain refined magnesium alloy to a  
25 casting die or mould, as well as an apparatus for carrying out the method.

          Further objects of the invention are to provide a method or an apparatus as indicated above which additionally will provide any or all of the following advantages:

- 30 1. Attainment of controlled temperatures which make it possible to obtain grain refinement without addition of compounds to the melt.
2. Prevention of oxidation and burning of magnesium alloy without the use of flux from the melting step through to the feed point of the die.
- 35 3. Efficient use of energy in providing the thermal requirements of the molten alloy.
4. Attainment of a continuous or semi-continuous supply of

liquid, grain refined metal to a die-casting apparatus at a level close to the feed point of the die.

Accordingly, the invention resides in a method and an apparatus as defined in claim 1 and claim 8, respectively.

5 According to claim 1 superheating and cooling of the alloy are carried out continuously or semi-continuously in successive sections of a closed conduit through which the molten alloy is passed without contact with the atmosphere, said conduit supplying the alloy at the level of the inlet to the casting die or mould by control of the pressure of the molten alloy in the conduit.

10 Although the method eliminates some disadvantages of the presently employed superheating processes, it is not restricted to non-use of grain refining compounds. Also other compounds improving the properties of the material such as the general corrosion behaviour may be added in the grain refining process.

15 The molten alloy may be supplied from a melting pot in which ingots are melted under protective atmosphere. However, it is also possible to supply the molten alloy to the conduit direct from a refining furnace omitting the ingot melting step.

20 Any suitable method of melting, superheating and cooling the alloy in the melting pot and the conduit, respectively, can be used. However, it is convenient to make use of the high thermal transfer properties of fluidized beds. In such a case the melting pot and said successive sections of the closed conduit are each immersed in closely adjacent separately controlled fluidized beds. Additional heat may be supplied to the melting pot and/or said first section of the conduit by heating elements associated with the pot and the conduit, respectively, or provided in the fluidized bed.

25 The conduit preferably follows a winding path, each of said successive sections of the conduit preferably forming a helix to provide a sufficiently large surface for transferring the necessary heat to or from the alloy in a minimum volume of the bed, thus facilitating rapid heat-up and cool-down periods.

30 Further features and advantages of the method and the apparatus will be apparent from the following detailed specification, reference being had to the drawing which diagrammatically indicates the principles on which the present invention is based.

Fig 1 is a highly diagrammatical vertical section through the apparatus according to the invention.

Fig 2 illustrates a detail of Fig 1 on a larger scale.

As seen in Fig 1 a melting pot 1 is immersed in a fluidized bed 2. This part of the apparatus constitutes a melting zone M. Metal may be added to the melting pot 1 in the form of ingots through an air lock 3 which minimizes the loss of oxidation preventing atmosphere in the melting pot 1. Such oxidation preventing atmosphere may consist of air with an addition of 0.1% SF<sub>6</sub>. In order to eliminate oxides added to the melt through for instance ingot skins a filter 4 is installed at the position where the lock 3 opens into the melting pot. Thus, all metal must pass the filter 4 before entering the melting pot 1. The filter may consist of a perforated steel screen which may either be cleaned and replaced periodically or may be in the form of a continuous sheet which is removed from the metal automatically exposing fresh screen to the incoming metal.

A conduit 5 is connected to the interior of the melting pot 1 at a level approximately 1/3 of the height of the metal below the surface 15 thereof where any contaminants remaining in the melt will be at a minimum. The conduit 5 passes into a superheating zone I in which a first section 6 of the conduit follows a helical path before continuing into a second helical section 7 positioned in a cooling zone II. Each of the helical sections 6 and 7 are submerged in a fluidized bed 8 and 9, respectively.

The fluidized beds 2, 8 and 9 are separated by partitions 10 and 11 and are separately controlled to provide a desired temperature of the molten alloy in the pot 1 and the sections 6 and 7. The fluidized beds may consist of alumina grit fluidized by compressed air which may be pre-heated. The upper levels of the fluidized beds 2, 8 and 9 have been indicated to be the same in Fig 1, but it is obviously possible to use different upper levels of the fluidized beds. The compressed air is supplied in a conventional manner at the lower end of the beds through tuyeres. However, to simplify the drawing such supply is not illustrated. Additional heat may be supplied to the melting pot 1 and/or the section 6 of the conduit 5 by heating elements (not shown) associated with the

pot 1 and the conduit 5, respectively, or provided in ~~fluidized~~ **01 61051** fluidized beds.

The temperature provided in zone M may be about 660°C. In the superheating zone I the metal may be heated to approximately 900°C, and in the cooling zone II the metal may be cooled down to a temperature of about 690°C, at which temperature the metal is presented at a level near to the feed point 12 of a casting die 13. The level 14 (Fig 2) of the metal near the feed point 12 is the same as the level 15 of the metal in the melting pot 1. The rate at which ingots are added through the lock 3 corresponds to the rate at which metal is required at the feed point 12. Obviously, the level of the metal in the melting pot 1 may be adjustable to control the metal level 15 and thereby the level 14 at which molten alloy is supplied at the feed point 12 of the casting die or mould 13. Thus, it will be possible to limit fluctuation of the metal level 14 to 1 cm or less. In a low pressure die casting system in which metal is fed into the die from the bottom, as illustrated in Fig 1, to achieve good running and feeding characteristics, any controllable lifting means such as mechanical, pneumatic, electrical or electromechanical systems may be used. In Fig 1 a pneumatic lifting means 16 is diagrammatically shown. The means 16, as illustrated in Fig 2, includes a pneumatically operated valve 17 and an inlet 18 for pressurized gas which may be air containing a small percentage of SF<sub>6</sub>. It should be evident that the introduction of pressurized gas through the opening 18 will make the metal in a riser tube 20 rise provided the valve 17 is closed. A gas inlet 19 serves to provide a protective gas such as air containing a small percentage of SF<sub>6</sub> to the mould or die 13 between each casting cycle, thereby protecting the surface of the metal in the riser tube from oxidation. To prevent molten metal from entering the passage 19 there is provided a skirt 21 providing a gas cushion between the skirt and the riser tube 20.

Alternatively, lifting may be achieved by the application of a vacuum to the die.

As metal is removed to the casting die 13 freshly molten metal is automatically drawn into the conduit 5 from the melting pot 1.

Secondary heat from the heating and cooling zones I and II,

respectively, may be used otherwise in the system. Thus, the fluidizing gas which is heated in the fluidized beds may be subsequently used for preheating incoming ingots and/or for heating the melting pot. Also recycling of the fluidizing air is obviously possible.

Although the present invention provides a convenient possibility of superheating the alloy while avoiding the disadvantages of previously used superheating processes there is nothing to prevent the continuous or semi-continuous supply of grain refining agents or other additions improving the properties of the material. Zirconium may be used as a grain refining agent for magnesium based alloys not containing aluminium, manganese or silicon. The zirconium in the form of a hardener or compound may be added to the system either at the melting pot or directly into the conduit by means of injection into the metal stream, the required amount being metered at a rate dependent on the metal flow. However, no flux will be required since the superheating is conducted in a conduit closed to the atmosphere and there is no holding pot from which the alloy must be lifted a substantial height to the feed point of the casting die. Close control of the superheating and casting temperatures is possible, and the metal can be supplied continuously or semi-continuously at the desired level without the use of valves or pumps.

For the purpose of mixing the components of the molten alloy, especially in the case where grain refining agents have been injected, a static mixing device may be provided in the conduit to agitate the molten alloy flow.

Finally, although heat exchanger systems in the form of fluidized beds are preferred, other heat exchanger systems like salt solutions may be used.

1. A method of continuously or semi-continuously supplying to a casting die or mould molten magnesium alloy that has been treated to provide a grain refining effect, said method comprising the steps of melting the alloy, superheating the molten alloy to a grain refining temperature and cooling the alloy to a controlled casting temperature, characterised in that the superheating and cooling steps are carried out continuously or semi-continuously in successive sections of a closed conduit through which the molten alloy is passed without contact with the atmosphere, said conduit supplying the alloy at the level of the inlet to the casting die or mould by control of the pressure of the molten alloy in the conduit.
2. A method according to claim 1, characterised in that ingots are melted under a protective atmosphere in a melting pot supplying molten alloy to the conduit.
3. A method according to claim 2, characterised in that the oxides introduced into the melt by for instance ingot skins are prevented from entering said conduit by means of a filter.
4. A method according to any of the preceding claims, characterised in that the melting and/or the heating of the alloy is effected by the fact that the melting pot and/or the superheating section of the conduit is or are immersed in a heat exchanger medium.
5. A method according to any of the preceding claims, characterised in that the cooling is effected by the fact that the cooling section of the conduit is immersed in a heat exchanger medium.
6. A method according to claim 4 or 5, characterised in that one or each heat exchanger medium is a fluidized bed of solid particles.
7. A method according to claim 6, characterised in that the

fluidizing gas which is heated in the fluidized beds is subsequently used for preheating incoming ingots and/or for heating the melting pot.

5 8. Apparatus for carrying out the method of claim 1, characterised by a closed conduit (5) for passing molten magnesium alloy without contact with the atmosphere from a supply of magnesium alloy to a casting die or mould (13), a first section (6) of said conduit (5) passing through a first zone (I) in which the alloy is superheated  
10 to a grain refining temperature, a second section (7) of said conduit (5) passing through a second zone (II) in which the alloy is cooled to a controlled casting temperature.

15 9. Apparatus according to claim 8, characterised in that said supply of molten alloy is a melting pot (1) sealed against the atmosphere and receiving ingots through an air lock (3).

20 10. Apparatus according to claim 9, characterised in that a filter (4) is provided in the melting pot (1) to prevent contaminations from entering the conduit (5).

25 11. Apparatus according to any of the claims 8 to 10, characterised in that the first and second zones (I, II) are closely adjacent separately controlled fluidized beds (8, 9).

12. Apparatus according to claim 9, characterised in that the melting pot (1) is immersed in a fluidized bed (2).

30 13. Apparatus according to claim 11 or 12, characterised in that additional heat is supplied to the melting pot (1) and/or said first section (6) of the conduit (5) by heating elements associated with the pot (1) and the conduit (5), respectively, or provided in the respective fluidized beds (2, 8).

35 14. Apparatus according to any of the claims 8-13, characterised in that the conduit (5) follows a winding path through each of said first and second zones (I, II) to provide a sufficiently large

surface for transferring the necessary heat to or from the alloy. **0161051**

15. Apparatus according to claim 14, characterised in that the conduit (5) follows a helical path through each of the first and second zones (I, II).

5 16. Apparatus according to any of the claims 8-15, characterised in that the level of the metal in the melting pot (1) is adjustable to control the metal level (15) therein and thereby the level (14) at which molten alloy is supplied at the feed point (12) of the casting die or mould (13).

10 17. Apparatus according to any of the claims 8 to 16, characterised in that a static mixing device is incorporated in the conduit (5).

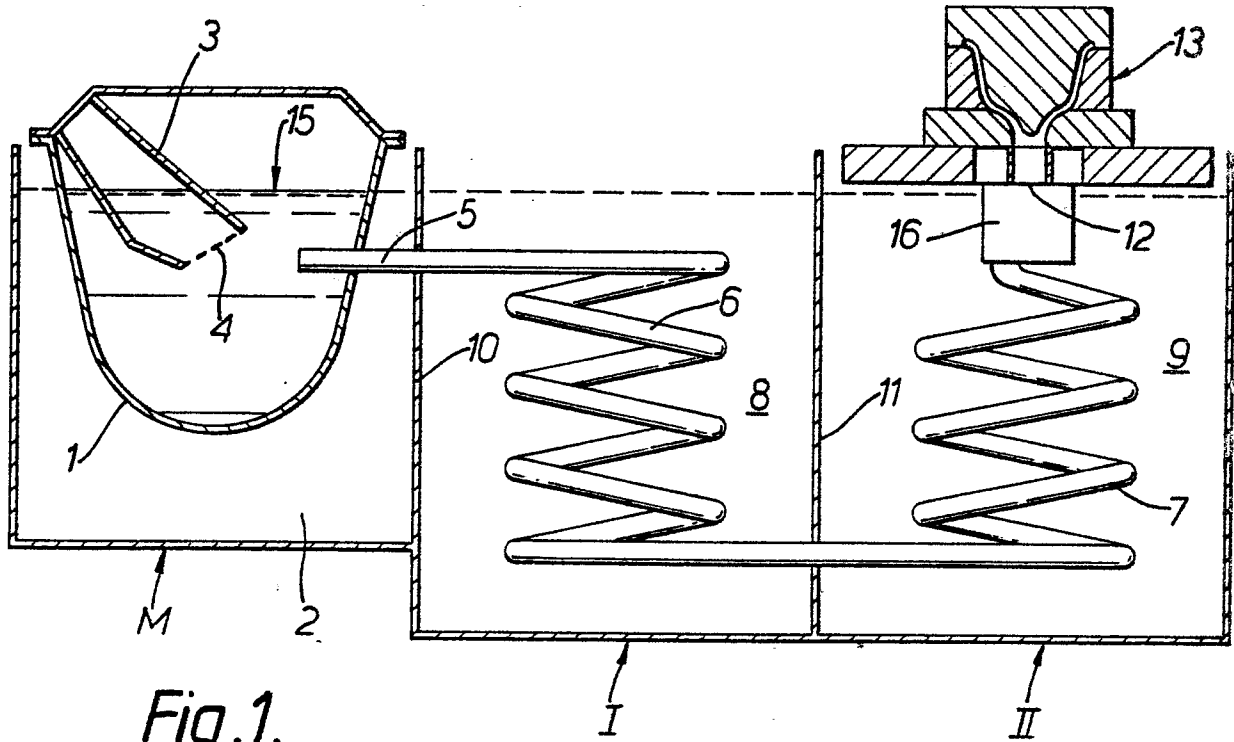


Fig. 1.

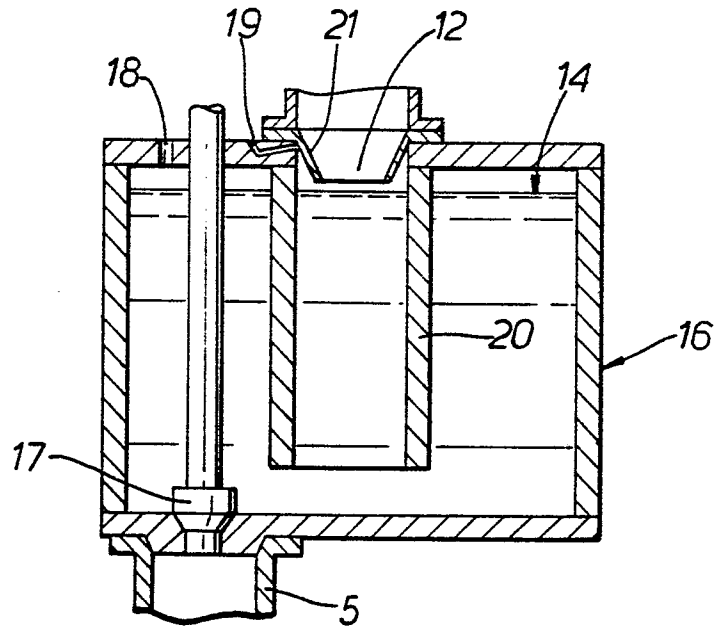


Fig. 2.



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. 4)
A	DE-A-2 805 751 (PROTHERM-OFENBAU) * Claims 1,6,9 *	1,8	B 22 D 21/00 B 22 D 21/04 B 22 D 18/04 F 27 B 14/04 C 22 B 26/22
A,P	DE-A-3 244 079 (BROWN, BOVERI & CIE.) * Claims 1,2; page 2, lines 12-16 *	3	
A	DE-A-2 914 347 (SCHWEIZERISCHE ALUMINIUM AG)		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			B 22 D 21/00 B 22 D 18/00 F 27 B 14/00 C 22 B 26/00
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 21-06-1985	Examiner GOLDSCHMIDT G
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