

Oct. 1, 1946.

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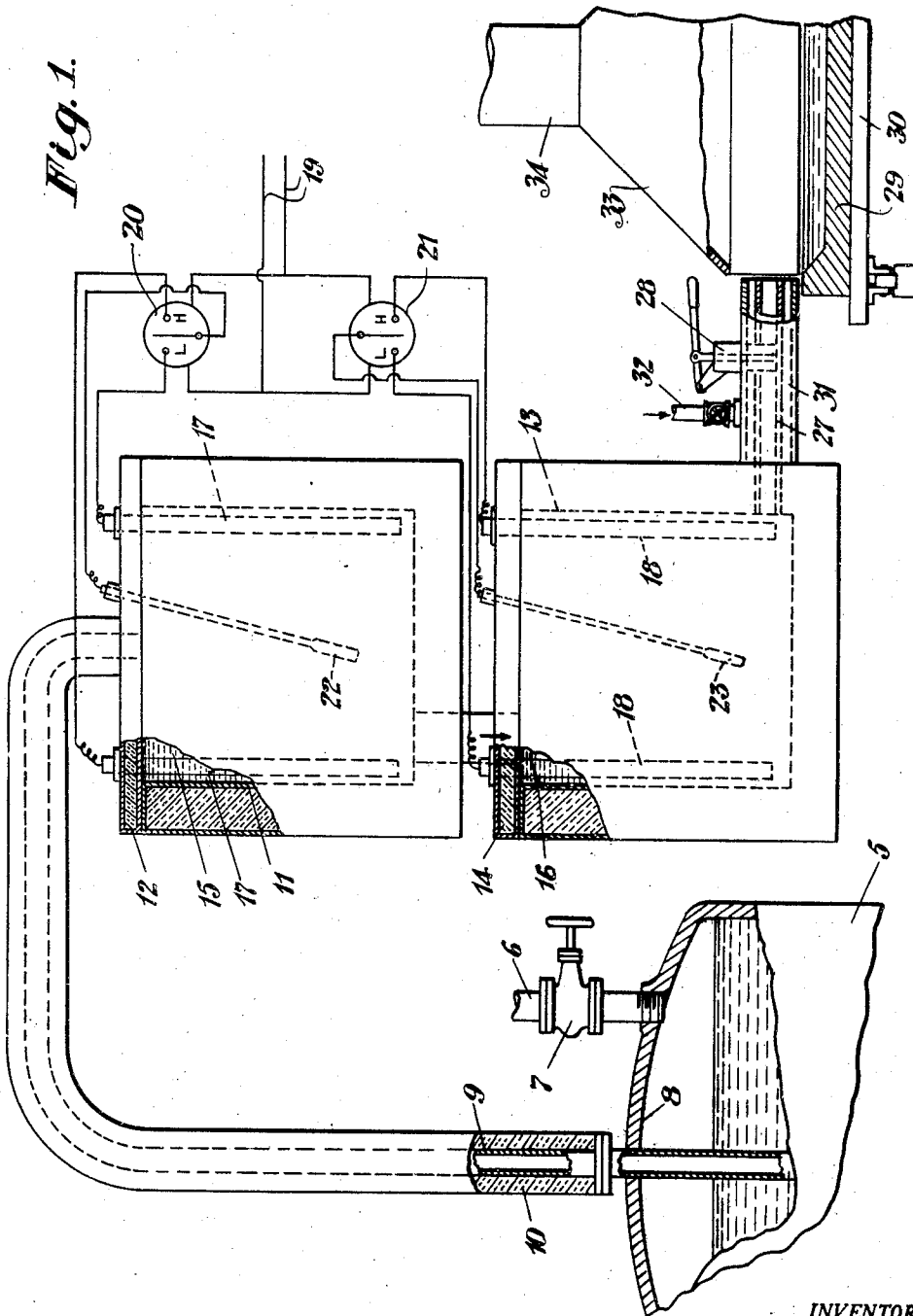
2,408,467

CONDITIONING MOLTEN METAL

Filed Nov. 10, 1944

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Fig. 1.



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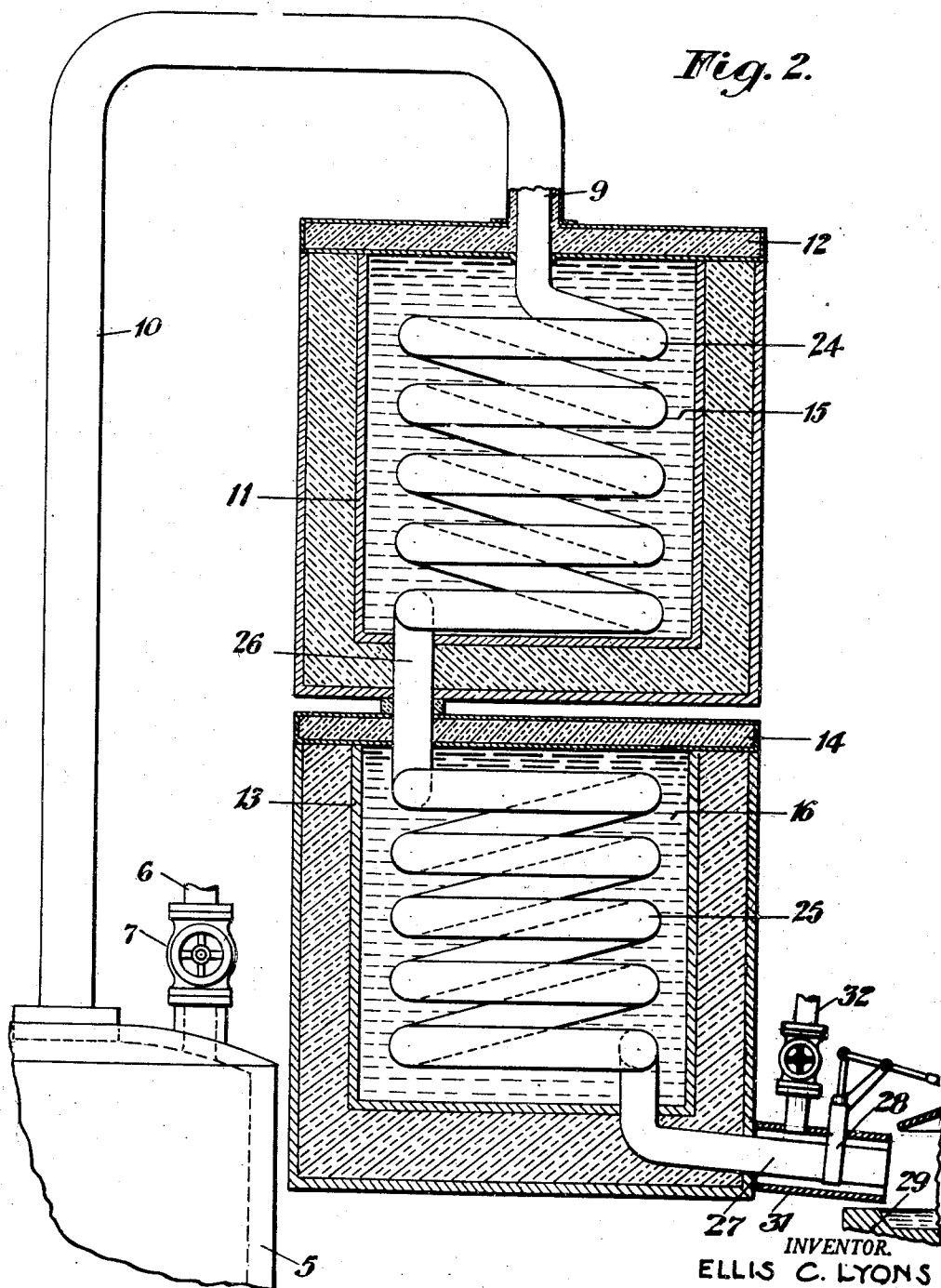
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Fig. 2.



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UNITED STATES PATENT OFFICE

2,408,467

CONDITIONING MOLTEN METAL

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Corporation, a corporation of the United States

Application November 10, 1944, Serial No. 562,863

7 Claims. (Cl. 22-200)

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This invention relates to the conditioning of easily oxidized metals, such as magnesium and magnesium base metals or alloys, for casting, and is more particularly concerned with the superheating and subsequent cooling to proper casting temperature of magnesium base alloys and like metals. The invention aims to provide certain improvements in conditioning such metals, particularly in superheating and subsequently cooling to proper casting temperature magnesium base alloys, as well as to provide improved apparatus therefor.

Magnesium base alloys are commonly employed for structural and other mechanical and commercial uses, as, for example, in the automotive and aircraft industries. Among the many alloys of this class may be mentioned, merely by way of example, the magnesium-aluminum-zinc-manganese alloys containing 0.1 to 12% aluminum, none up to 5% zinc, none up to 3% manganese and the balance essentially magnesium. Magnesium base alloys, particularly those containing aluminum, in the absence of special treatment, tend to solidify in a coarse grain structure. It is a matter of common knowledge that such alloys when of fine grain structure possess superior mechanical properties, enhanced amenability to solution treatment, shorter heat-treating requirements, and improved machinability. It is also a matter of common knowledge that this desirable fine grain structure can be obtained by superheating the molten alloy to temperatures far above the melting temperature of the alloy, as, for example, by superheating at a temperature between 850 and 950° C. According to the present customary practice, the alloy is heated to the superheating temperature, and cooled to the proper casting temperature, generally between 650 and 850° C. The superheating, as it is called, imparts to the subsequently solidified alloy a relatively fine grain structure with the attendant superior properties hereinbefore mentioned. The fine grain structure tends to persist, so that castings subsequently produced from superheated alloy possess a fine grain structure.

The present invention, in one of its aspects, provides an improved method of superheating and subsequently cooling to proper casting temperature a magnesium base metal or alloy. In accordance with this aspect of the invention, molten magnesium base metal is transferred, without contact with any oxidizing influence (such as air), from beneath the surface of a body of the molten metal to an elongated conduit having a super-

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heating section in direct communication with a cooling section. The molten metal is heated in the superheating section to the contemplated superheating temperature, substantially higher than the proper casting temperature, and in the cooling section the superheated metal is cooled to the proper casting temperature. Molten metal of the proper casting temperature is withdrawn from the cooling section, as required for casting or the like, and simultaneously an equivalent amount of molten metal is transferred to the superheating section of the conduit as hereinbefore described. Throughout the operation both sections of the conduit are filled with molten metal, so that at no time is the molten metal subjected to oxidizing or other contaminating influence during its transfer to and passage through the conduit. Preferably, the molten metal is transferred to the conduit by the pressure of an inert gas, and the same inert gaseous pressure discharges the molten metal of proper casting temperature from the cooling section of the conduit simultaneously with the transfer of an equivalent amount of molten metal to the superheating section of the conduit.

In its broader aspect, the invention provides an improved method of conditioning an easily oxidized metal for casting or the like by transferring molten metal from beneath the surface of a body of the molten metal to an elongated conduit. Thermal agencies operatively associated with the conduit bring the molten metal therein to a temperature within a predetermined range. Molten metal of a temperature within that range is withdrawn from the conduit as required for casting or the like simultaneously with the aforementioned transfer of an equivalent amount of molten metal to the conduit.

The improved apparatus of the invention is particularly adapted for carrying out the hereinbefore described improvements in conditioning easily oxidized metals, particularly magnesium base metals.

The novel features of the invention which I believe to be patentably characteristic thereof are set forth in the appended claims. The invention itself and the construction and operation of apparatus embodying the same will be best understood from the following description taken in conjunction with the accompanying drawings, in which,

Fig. 1 is an elevation, partly in section, of an apparatus embodying one aspect of the invention, and

Fig. 2 is an enlarged sectional elevation of

typical superheating and cooling units of the apparatus.

The molten metal to be cast is confined in a basin or crucible 5. Metal may be added to the basin from time to time, as required, by syphoning or in any other suitable manner. The surface of the molten metal in the basin may be covered by a protective flux if desired. Alternatively, as shown, an enclosed pot may be used. A pipe 6 having a valve 7 is threaded into the cover 8 for the pot, and serves to introduce an inert gas, such as sulphur dioxide, above the surface of the molten metal under a pressure sufficiently high to force the molten metal through a molten metal duct 9 to the superheating duct or conduit. The duct 9 extends into the body of molten metal in the pot 5 to a desired depth, and is covered, exteriorly of the pot, by thermal insulation 10.

The superheating unit comprises a thermally insulated tank or the like 11 having an insulated cover 12. The cooling unit comprises a similar insulated tank or the like 13 having an insulated cover 14. Preferably the superheating unit is positioned directly above the cooling unit, although the two units may be positioned side by side or in any other suitable relative positions. The tank 11 of the superheating unit is substantially filled with a fused salt bath 15, and the tank 13 is similarly filled with a fused salt bath 16. Pairs of electrodes 17 and 18 extend into the fused salt baths 15 and 16, respectively, and are electrically connected to a suitable source of electric energy 19 through thermostatic control devices 20 and 21, respectively, with which pyrometers 22 and 23, respectively, are operatively associated. As will be understood by those skilled in the art, the electrodes 17 and 18 and their associated thermostatic control devices automatically maintain the fused salt baths 15 and 16 at predetermined temperatures.

A molten metal conduit 24 is submerged in the fused salt bath 15, and a similar molten metal conduit 25 is submerged in the fused salt bath 16. The conduits 24 and 25 are preferably in the form of coils, and the lower end of the conduit 24 is connected to and communicates directly with the upper end of the conduit 25 by a conduit 26. The upper end of the conduit 24 is connected to and communicates directly with the conduit 9. The lower end of the conduit 25 is connected to a discharge or casting conduit 27 having a gate or other suitable valve 28. A mold 29, advantageously carried by a conveyor 30, is positioned under the discharge outlet of the casting conduit 27. The mold 29 may be of any desired type for casting ingots, slabs, billets or any other cast form. The conduit 27 is enclosed by a casing 31, suitably spaced therefrom, and sulphur dioxide or other suitable inert gas is introduced through a valved pipe 32 into the annular space between the conduit 27 and casing 31 and flows out of the open end of this space over the surface of the molten metal being cast in the mold 29. A hood 33 having a gas exhaust pipe 34 is mounted above the mold 29.

In the usual operation of the apparatus, the fused salt bath 15 is thermostatically maintained at a temperature which heats the molten metal in the conduit 24 to the contemplated temperature of superheat, usually from 850 to 950° C. Molten metal at the temperature of superheat flows through the connecting conduit 26 into the cooling conduit 25. The temperature of the fused salt bath 16 is thermostatically controlled to cool

the superheated molten metal to the proper casting temperature (e. g. 650 to 850° C.) before it is withdrawn from the cooling conduit 25. Obviously, the fused salt bath 16 absorbs heat from the superheated molten metal delivered to the cooling conduit 25, and the heat thus absorbed may be sufficient to maintain the fused salt bath at the necessary temperature for effecting the contemplated cooling of the superheated molten metal. By correlating the heat absorbed by the fused salt bath 16 to the heat radiated from the insulated tank 13, as for example by adjusting the thermal insulation about the tank, little, if any, additional heat need be supplied to the bath 16. Indeed, the thermal insulation of the tank 13 may be so effective that the fused salt bath may have to be artificially cooled in order to cool the superheated molten metal to the proper casting temperature. The temperature of "superheat" is uniformly and accurately controlled within narrow limits (e. g. within 5° C. or even less) and the temperature of casting is similarly uniformly and accurately controlled within the same narrow limits.

The conduits 9, 24, 26 and 25 constitute a continuous enclosed passage for the flow of molten metal from the basin 5 to the mold 29. The molten metal in its passage through these conduits is subjected to no oxidizing or other contaminating influence. During its passage through these conduits, the molten metal is "superheated" and then cooled to the proper casting temperature. Molten metal of the proper casting temperature is withdrawn, by manipulation of the valve 28, as required for filling the mold 29 and succeeding molds as moved into position beneath the discharge outlet of the casting conduit 27. The inert gaseous atmosphere above the molten metal being cast protects the casting against oxidation until it has set or solidified to the necessary extent. The gas pressure above the surface of the molten metal in the basin 5 moves the molten metal stream through the various conduits when the valve 28 is open. As molten metal of the proper casting temperature is withdrawn from the cooling conduit 25, an equivalent amount of molten metal at the temperature of "superheat" flows into that conduit, and simultaneously an equivalent amount of molten metal is delivered to the superheating conduit from the basin 5. The operations of superheating and cooling are appropriately adjusted so that casting is carried out in a substantially continuous manner. Additional metal may be introduced into the basin, from time to time as required, by syphoning or in any other suitable manner. Superheating, cooling and casting may thus proceed in a substantially continuous manner so long as the basin 5 contains molten metal.

In the heretofore customary practice of superheating magnesium base metals or alloys, a considerable volume of the molten metal is superheated in a pot or crucible, such for example as the basin 5. This volume of molten metal is then cooled to the proper casting temperature, and cast by pouring, ladling or the like. In accordance with the invention, the molten metal in the basin 5 is relatively quiescent, molten metal is withdrawn from the basin and delivered to the superheating unit without agitating or disturbing the molten metal in the basin, and is superheated only as required for the casting operation and hence in relatively small volume. Superheating proceeds continuously and simultaneously with casting. Thus, the invention elimi-

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nates heating large pots to the high temperatures of superheat, thereby extending their life, and effects a substantial saving in the time formerly involved in superheating and then cooling the molten metal, thereby speeding up general refinery and casting operations. Superheating relatively small volumes of the molten metal, in accordance with the invention, insures a more uniform product when cast, prevents flux and oxide inclusions in the ingots or other cast forms, and enables the production of clean castings of high purity, as the molten metal in the basin 5 is not disturbed or agitated during the operation.

The coiled forms of the conduits 24 and 25 provide elongated passages for the molten metal in the superheating and cooling units, respectively. The conduits have a considerable surface area in contact with their respective fused baths, thus facilitating prompt heat transfer. The volumetric capacity of the conduits 24 and 25 is such that an adequate volume of molten metal is continuously superheated and then cooled as the molten metal flows through the conduits in a more or less continuous manner as required for practically continuous casting.

While I prefer to submerge the superheating and cooling conduits in fused salt baths whose temperatures are automatically controlled within narrow limits, other heating and cooling agencies may be substituted for the fused salt baths without departing from the spirit of the invention. In large units, and in smaller units where necessary, appropriate means may be provided for agitating or circulating the fused salt baths in order to maintain the entire body of each bath at its contemplated operating temperature. Either the superheating unit or the cooling unit may be used alone, although the full advantages of the invention are realized by the conjoint use of the two units as hereinbefore described.

I claim:

1. The improvement in conditioning an easily oxidized metal for casting which comprises transferring molten metal without contact with air from beneath the surface of a body of the molten metal to an elongated conduit, heating the molten metal in the conduit to a temperature within a predetermined range above the temperature of the body of molten metal, and withdrawing molten metal at a temperature within said range from the conduit simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the conduit.

2. The improvement in conditioning an easily oxidized metal for casting which comprises transferring molten metal by the pressure of an inert gas from beneath the surface of a body of the molten metal to an elongated conduit, heating the molten metal in the conduit to a temperature within a predetermined range above the temperature of the body of molten metal, and discharging molten metal at a temperature within said range from the conduit by the aforesaid inert gaseous pressure simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the conduit.

3. The improvement in conditioning a magnesium base metal for casting which comprises transferring molten metal without contact with

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air from beneath the surface of a body of molten metal to an elongated conduit, heating the molten metal in the conduit to a temperature within a predetermined range above the temperature of the body of molten metal, and withdrawing molten metal at a temperature within said range from the conduit simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the conduit.

4. The improvement in conditioning a magnesium base metal for casting which comprises transferring molten metal by the pressure of an inert gas from beneath the surface of a body of the molten metal to an elongated conduit, heating the molten metal in the conduit to a temperature within a predetermined range above the temperature of the body of molten metal, and discharging molten metal at a temperature within said range from the conduit by the aforesaid inert gaseous pressure simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the conduit.

5. The improvement in conditioning a magnesium base metal for casting which comprises introducing the molten metal into an elongated conduit having a superheating section in direct communication with a cooling section, heating the molten metal in the superheating section to a temperature substantially above the proper casting temperature of the metal, cooling the molten metal in the cooling section to the proper casting temperature, and withdrawing molten metal of the proper casting temperature from the cooling section simultaneously with the introduction as aforesaid of an equivalent amount of molten metal into the superheating section.

6. The improvement in conditioning a magnesium base metal for casting which comprises transferring molten metal from beneath the surface of a body of the molten metal to an elongated conduit having a superheating section in direct communication with a cooling section, heating the molten metal in the superheating section to a temperature substantially above the proper casting temperature of the metal, cooling the molten metal in the cooling section to the proper casting temperature, and withdrawing molten metal of the proper casting temperature from the cooling section simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the superheating section of the conduit.

7. The improvement in conditioning a magnesium base metal for casting which comprises transferring molten metal by the pressure of an inert gas from beneath the surface of a body of the molten metal to an elongated conduit having a superheating section in direct communication with a cooling section, heating the molten metal in the superheating section to a temperature substantially above the proper casting temperature of the metal, cooling the molten metal in the cooling section to the proper casting temperature, and discharging molten metal of the proper casting temperature from the cooling section by the aforesaid inert gaseous pressure simultaneously with the transfer as aforesaid of an equivalent amount of molten metal to the superheating section of the conduit.

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