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PRODUCTION OF CASTINGS FREE FROM PIPES AND BLOW HOLES

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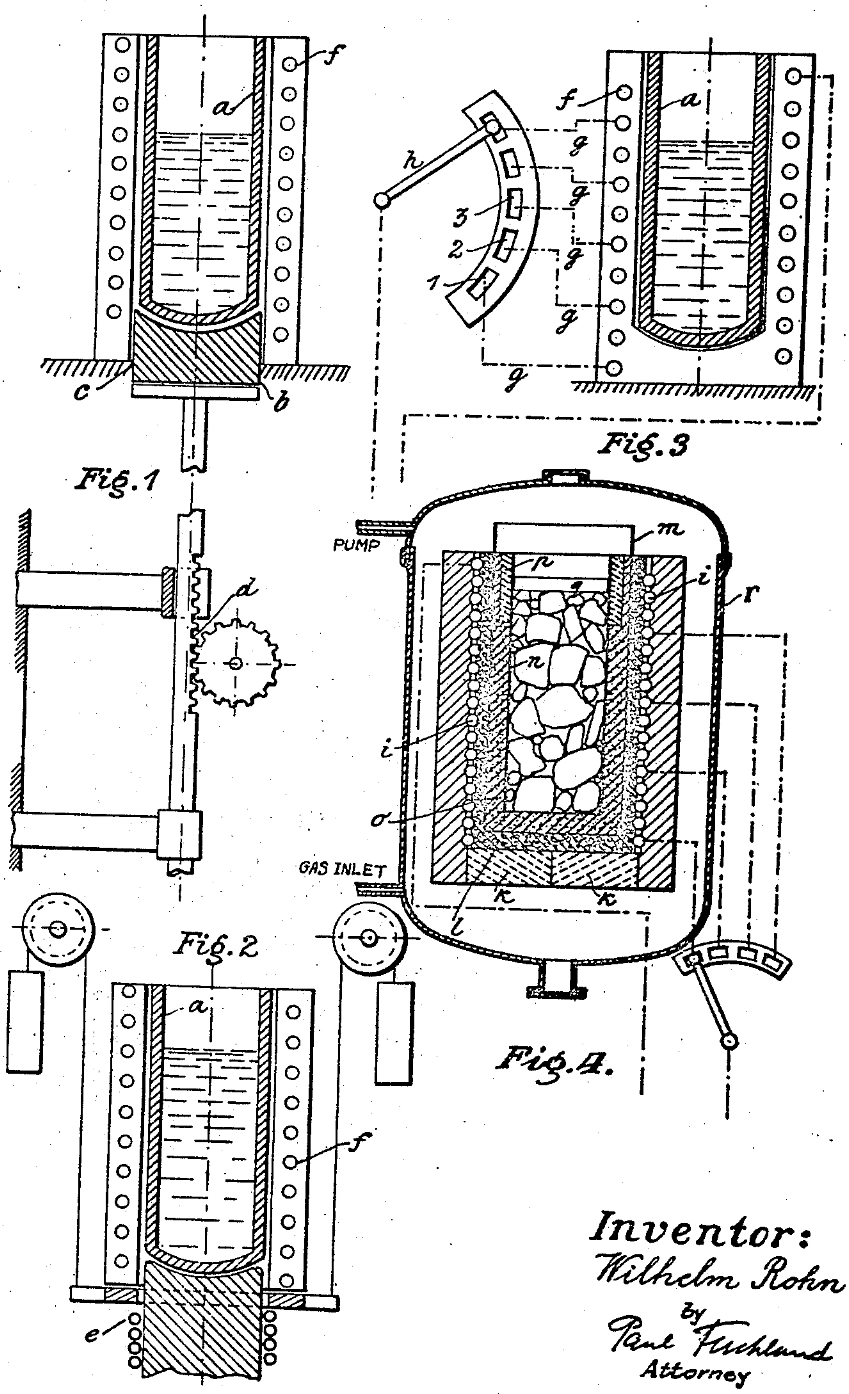

Fig. 1

Fig. 2

Fig. 3

Fig. 4.

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PRODUCTION OF CASTINGS FREE FROM PIPES AND BLOW-HOLES

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Blocks, sheets and articles of other shapes were hitherto produced in such a manner that the molten smelt from the furnace or the crucible was cast into a suitably selected mould and allowed to solidify therein. In this method there is always observed the disadvantage that the cast articles which are obtained, in spite of the casting methods which have been modified a considerable number of times, are never obtained free from pipes and blow-holes, so that a considerable waste occurs by reason of the lost head. There will now be described a method of producing such articles in a convenient manner and free from pipes and blow-holes.

The fundamental idea of the invention is not to pour the molten metal into a separate mould, but to allow it to solidify in the crucible itself, and to so select the cooling conditions that no pipes or blow-holes can be formed. On the same principle is also based for example, the production of the single crystals of salt and metal smelts but the use of such a method of operation for the production of blocks free from pipes and blow-holes was not known hitherto. The problem under consideration can be solved by causing the smelt to solidify from the bottom upwards. This can be effected by mounting the crucible on a vertically movable support. After the termination of the smelting process this support is lowered, and the crucible is thus brought with the bottom first gradually into colder zones, in such a manner that the bottom of the crucible first comes into the lower temperature, and the cooling of the crucible proceeds from the bottom upwards.

In order to enable the cooling to be better controlled it is preferable to provide in the lower part of the furnace, or under the bottom thereof stationary copper tubes, which pass round the support in circles and through which cooling water flows.

The same result can be obtained for example, in an electrically heated furnace by subdividing the heating coil, and after the completion of the fusion cutting this out in sections, beginning at the bottom at suitably selected periods of time. In an inductively heated electric smelting furnace the same result can be obtained by switching off the windings of the induction coil gradually, separately, or in groups, from the bottom, until finally the whole coil has been cut out. The action can also be supported or controlled by increasing the thickness of layer from the bottom upwards, of the refractory material between the smelt and the oven coil, which, for example, is water-cooled. In order to prevent a too early freezing of the upper layers of the smelt, there is preferably supplied to the upper coils, which still remain in operation, somewhat more energy than is actually required by them for participating in the complete operation of the furnace. Finally, such control may also be obtained by slowly raising the complete induction coil or the furnace casing.

A constructional example for an induction furnace, free from iron, is illustrated in Figs. 1 to 3. In these, *a* indicates the crucible which is mounted on the support *b*, which is passed through an opening *c* in the bottom of the furnace, and for example can be moved vertically by toothed wheel gear *d*, so that after the completion of the smelting the support *b*, together with the crucible *a* can gradually be lowered from the top downwardly. *f* indicates the windings of the primary coil. Underneath this may be provided a cooling device in the form of copper pipes *e*, through which water circulated. In the form of construction according to Fig. 2 the primary coil, after completion of the smelting, is raised at a suitably selected speed by a suitable device, for example by weights guided over rollers. According to Fig. 3 the coil *f* is provided with tapping points *g*, *g*, which enable sections of the coil to be cut out in stages. In the example of the circuit illustrated in the drawing the two lowermost windings are disconnected by moving the switch *h* from the segment 1 to the segment 2, on movement to segment 3 the next two windings and so forth. The production of the desired action may, if necessary, also be promoted by allowing a sufficiently thick plate of refractory and heating insulating material to float on the surface of the smelt or by placing simply on the surface of the smelt a layer of granular, refractory material. A sufficiently thick layer of slag of suitable composition may also act in this respect.

For this method of operation, the smelting vessel, particularly when a high-frequency furnace is used as the smelting furnace, may be of any suitable shape, so that it is possible to obtain moulded articles of any suitable character. The heating winding or primary coil is preferably arranged to suit the moulded article to be produced. In this manner it is possible to obtain with full certainty moulded castings free from blow-holes. A particularly suitable application is the direct production of slab blooms free from blow-holes, which directly have the most suitable shape for rolling plates.

It may be mentioned that a very advantageous method of operation is obtained when the above method is combined with the preparing method according to British specification No. 226,801. For this purpose it is advisable to adapt the method of operation according to British specification No. 226,801 in the manner illustrated in Fig. 4 in accordance with the requirements of the new method of operation. For example, in induction furnaces, free from iron, the lower opening of the somewhat cylindrical induction coil *i* is closed by a chamotte plate *k*, *k* formed of one or more parts. Onto this chamotte plate, is firstly charged up to a pre-determined depth of the layer a granular or sandy material *l* such as ground bauxite which at the temperatures occurring during the operation is not capable of sintering. There is then placed inside the coil on this layer a thin-walled sheet-metal cylinder *m*, and the intermediate space between the sheet-metal cylinder *m* and the induction coil *i* is filled with the same granular or sandy material which does not sinter at the temperatures which occur. Into the interior of the sheet-metal cylinder there is then placed for example, a sheet-metal casing *n*, of which the outer shape corresponds with the surface of the casting to be subsequently produced, according to British Patent 226,801 and in the interior of which is placed the material to be fused. The intermediate space between this sheet-metal template *n* and the sheet-metal cylinder *m* is filled with a granular or sandy material such as ground magnesite, or alumina, with the addition, if desired, of powdered glass or boric acid which at the temperatures occurring during the operation, is capable of sintering and retaining its shape. After the charging of the furnace has been completed in the manner indicated, the sheet-metal cylinder *m* is withdrawn, whereby the two layers of non-sintering granular or sandy material *l*, and the sintering material *o* are not intermixed, but simply put in contact with one another. This material *o*, by reason of the fact that it sinters at temperatures which are somewhat below the fusion point of the metal to be fused, or of the alloy to be fused, thus forms to some extent, a shape-retaining crucible. In the zone adjacent the upper opening of the induction coil *i* the temperature under the circumstances will not be sufficiently high in order to effect a sufficient sintering of the shape retaining material *o*. It may consequently be advisable when setting up the furnace to insert at this point a tubular section of refractory material as is indicated in the drawing of the furnace at *p*. In order to obtain a sufficient increase in temperature in these upper zones it may be advisable to cover the upper opening of the fusion chamber by a thick refractory plate *q* or to apply a layer of granular or sandy refractory material.

During the fusion process the material *l* will still be capable of crumbling, as this mass is not adapted to sinter at the temperatures which occur during operation. The mass *o* however, will sinter together into a shape-retaining crucible of like body at temperatures which are below the temperature at which the fusion commences. After the completion of the fusion the separate sections of the induction coil, commencing from the bottom, are disconnected in stages at suitable intervals of time and thus the smelt is caused to solidify from the bottom upwards, free from blow-holes and pipes. After the completion of the smelting and solidification the chamotte plate *k* is partly or wholly drawn to one side and the material *l*, which is still capable of crumbling, is allowed to run out downwardly. As soon as this has been done the casting which has been produced in the interior of the induction coil, with its surrounding sintered layer *o* is freely exposed, and can be readily removed, either upwardly or downwardly from the induction coil, whereupon the furnace can be re-charged. The layer *l*, which has not sintered and which has remained capable of crumbling, and is between the sintered part *o* and the coil or the heating element, also serves as a protection against furnace breakages. Should a crack occur in the sintered layer *o* for any reason, this could not be continued through the layer *l* as this layer remains crumbly and would thus prevent the passage of metal to the coil. Finally it is advisable also to combine the method of operation with that according to which the outer space between the coil or the heating element and the furnace casing is filled with a crumbly, sandy material. If in the case of an accident there should be such a collapse of the materials *l* and *o* that the molten smelt should come in contact with the induction coil or the heating element then the smelt could not pass into the space outside the induction coil or the heating element, and consequently could not come into contact with the furnace casing and thus damage this.

Finally it is possible to work a furnace operated in accordance with the construction above described readily in a gas-tight casing r (see Fig. 4) and to allow the fusion operation to take place in a protecting atmosphere or in a vacuum. As in accordance with the invention, the block, free from pipes and blow-holes, is produced at the place of fusion without casting, it is not necessary to provide separate devices for carrying out the casting in a protecting atmosphere or a vacuum, or to arrange the furnace together with the casing so as to be capable of being tilted for this purpose. This is of considerable importance in the case of induction furnaces free from iron as in such cases, as is well known, the casing must either consist of a non-conducting material (for example, earthenware) or of a poor-conducting metallic material which in addition must also be subdivided in a suitable manner so as to be electrically non-conducting. Both in the case of earthenware casings and subdivided metal casings the device for tilting causes considerable difficulties by reason of the mechanical strains to which the furnace is subjected, and it is therefore to be regarded as a technical improvement that the above described construction and methods of operation enable blocks and castings free from pipes and blow-holes to be produced in a constantly stationary furnace.

While I have shown and described my improved process and the means for producing castings free from blow-holes and pipes as pointed out above, I do not wish to limit myself to the exact steps and means described as I am aware that two or more of the steps described may be combined and many minor changes may be made in them without departing from the spirit of my invention, and I claim such equivalents as may suggest themselves to those skilled in the art.

I claim:

1. The method of producing castings free from pipes and blow-holes in smelting furnaces, which consist in melting the metal in the furnace, particularly in electrically heated furnaces such as resistance furnaces or induction and high-frequency furnaces and gradually solidifying the entirely molten metal from the bottom upwards in the smelting vessel.

2. The method of producing castings free from pipes and blow-holes in electrically heated smelting furnaces which consists in thoroughly melting the material in the furnace and then successively eliminating at an adjustable speed the action of the heating device from the bottom of the smelting vessel upwards.

3. The method of producing castings of a determined shape free from pipes and blowholes such as slab blooms for rolling plates which consists in smelting the metal or the alloy in a ceramic smelting vessel which has the same shape as the desired article to be produced, and gradually solidifying the entirely molten metal from the bottom upwards in the smelting vessel.

4. The method of producing castings free from pipes and blow holes in smelting furnaces, particularly in electrically heated furnaces such as resistance or induction and high-frequency furnaces which consists in excluding oxygen from the neighborhood of the smelting vessel during the smelting operation, smelting the metal and gradually solidifying the thoroughly liquefied metal from the bottom upwardly in the smelting vessel.

5. The method of producing ferrous metal castings free from pipes and blow holes in a ceramic lined smelting furnace particularly in electrically heated furnaces such as resistance furnaces or induction and high frequency furnaces which consists in melting the metal in the furnace and gradually solidifying the entirely molten metal from the bottom upwardly in the smelting vessel.

6. The method of producing castings free from pipes and blow-holes in electrically heated smelting furnaces such as resistance or induction and high-frequence furnaces which consists in first forming a sheet-metal casing of which the outer shape corresponds with the surface of the casting to be produced, surrounding the said casing with a layer of a granular material capable of sintering close below the melting temperature of the material to be smelted, surrounding the said layer with a layer of a granular material not sintering at the said temperature, then introducing the metal to be smelted into the interior of the metal casing, heating the metal by means of an electric current up to the molten state and gradually solidifying the molten metal, after completing the melt, from the bottom upwards in the smelting vessel.

7. The method of producing castings free from pipes and blow-holes in electrically heated smelting furnaces such as resistance or induction and high-frequency furnaces, which consists in first forming a sheet metal casing of which the outer shape corresponds with the surface of the casting to be produced, surrounding the said casing with a layer of a granular refractory material capable of sintering close below the melting temperature of the material to be smelted, surrounding the said layer with a further layer of a granular material not sintering at the temperature produced between the layer being capable of sintering and the heating devices, then introducing the metal to be smelted into the interior of the metal casing, heating the metal by means of an electric current up to the molten state, gradually solidi-

fying the molten metal, after completing the melt, from the bottom upwards in the smelting vessel, then allowing the not sintered material to flow out and removing the casting with the adhering sintered layer.

8. The method of producing castings free from pipes and blow-holes in electrically heated smelting furnaces such as resistance or induction and high-frequency furnaces which consists in first forming a sheet metal casing of which the outer shape corresponds with the surface of the casting to be produced, surrounding the lower, greater part of the said casing with a layer of a granular refractory material capable of sintering close below the melting temperature of the material to be smelted, and an upper, smaller part with a tube of refractory material, surrounding the said layer and the tubular element with a layer of granular material, not sintering at the said temperature, then introducing the metal to be smelted into the interior of the metal casing, heating the metal by means of an electric current up to molten state, and gradually solidifying the molten metal, after completing the melt, from the bottom upwards in the smelting vessel.

9. The method of producing castings free from pipes and blow-holes in electrically heated smelting furnaces such as resistance or induction and high-frequency furnaces which consists in first forming a sheet-metal casing of which the outer shape corresponds with the surface of the casting to be produced, surrounding the said casing with a layer of a granular refractory material capable of sintering close below the melting temperature of the material to be smelted, surrounding the said layer with a layer of a granular material, extending to the outer furnace walls, not sintering at the temperatures produced between the first layer and the furnace walls, then introducing the metal to be smelted into the interior of the metal casing, heating the metal by means of an electric current up to the molten state and gradually solidifying the molten metal, after completing the melt, from the bottom upwards in the smelting vessel.

In testimony whereof I affix my signature.

WILHELM ROHN.