

Dec. 8, 1942.

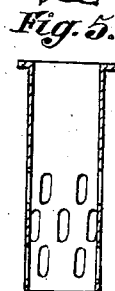
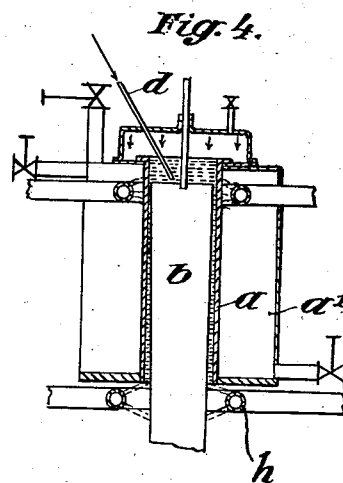
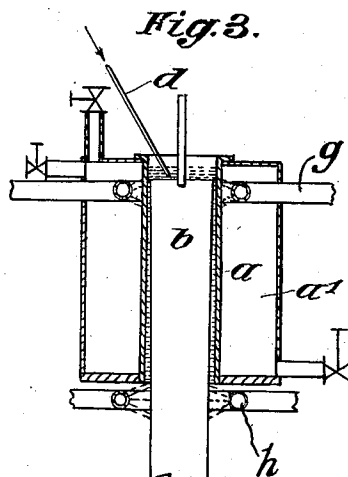
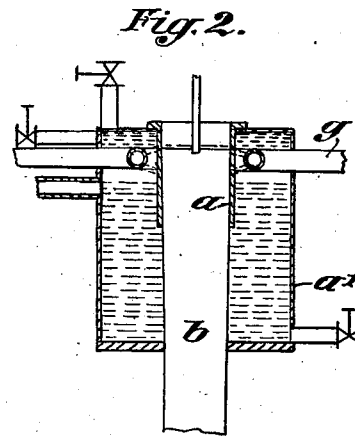
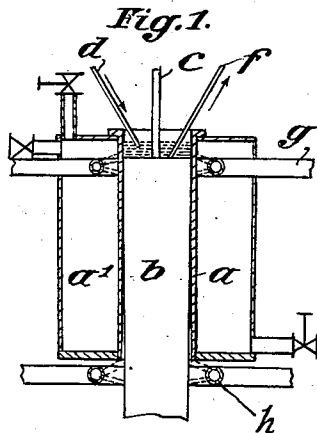
S. JUNGHANS

2,304,258

METHOD OF TREATING METALS AND METAL ALLOYS DURING CASTING

Filed June 3, 1938

2 Sheets-Sheet 1



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METHOD OF TREATING METALS AND METAL ALLOYS DURING CASTING

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2 Sheets-Sheet 2

*Fig. 6*

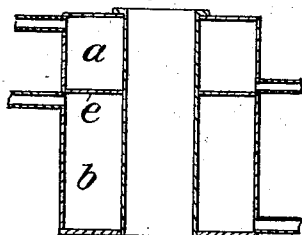


*Fig. 7*

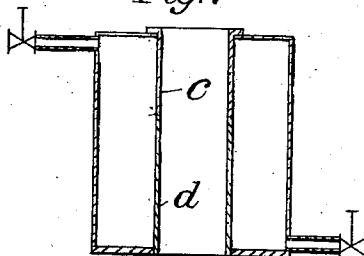


*Fig. 8*

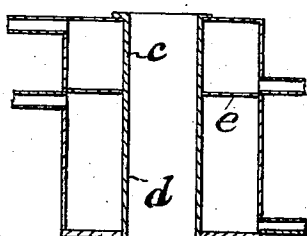


*Fig. 9*

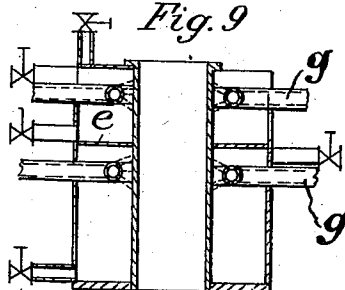


*Fig. 10*

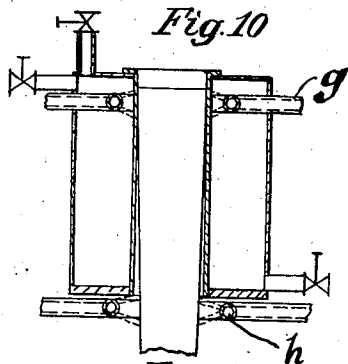


*Fig. 11*

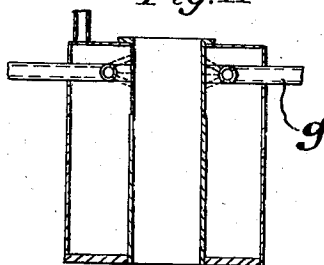


*Fig. 12*

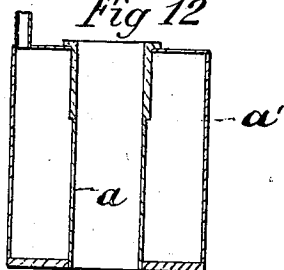


*Fig. 13*

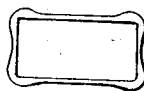
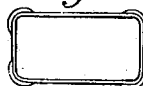


*Fig. 14*



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## UNITED STATES PATENT OFFICE

2,304,258

## METHOD OF TREATING METALS AND METAL ALLOYS DURING CASTING

Siegfried Junghans, Stuttgart, Germany, assign-  
or to Irving Rossi, New York, N. Y.Application June 3, 1938, Serial No. 211,651  
In Germany June 7, 1937

4 Claims. (Cl. 22—200.1)

When making castings the result aimed at is to obtain the most uniform, mostly very fine granular structure over the entire cross section of the casting. In addition, any liquation from the molten mass of any of the components must as far as possible be prevented. This result is aimed at by endeavouring to obtain the smallest possible liquid head of metal and to effect the quickest possible and most uniform cooling of the cast metal.

In hitherto known processes endeavours to obtain the quickest possible cooling of the metal entering the mould were made in the direction of making the walls of the mould of the most varied materials and of cooling the mould itself by means of the most varied cooling media, these being applied to the outside walls. However, all these methods have not so far enabled the molten mass after entering the mould to set quickly and uniformly over the entire cross section of the casting, or have done so only where complicated and expensive devices or processes have been employed.

According to the invention the desired effect is obtained in the most perfect manner by maintaining the inflowing molten mass and also the mould itself at a temperature which is only very little (approximately 50° C.) above the melting point of the metal in process of casting and by passing the cast metal through several cooling zones in the mould, which ensure a stage-by-stage uniform cooling.

One of the ways for treating light and heavy metals and metal alloys as well as metals or alloys having high and low melting points consists in so regulating the temperature of the inflowing metal (the casting temperature, especially in casting processes wherein comparatively small quantities of molten metal are conveyed to the casting mould per unit of time, that it is as low as possible, that is about 25 centigrade above the melting point of the metal in process of casting, and in any case its order of magnitude does not exceed about 50 centigrade above the said melting point. In the case of difficult cross-sections, such as, e. g., sections, or in the case of very large diameters, or again in the same of alloys the components of which easily tend to liquitate and/or again to separate, having such differing specific weights, it may happen that some alternative higher temperatures must be chosen. This provides the preliminary condition for the uniform casting as has been found by experiments.

According to a further feature, a cooling me-

dium is employed, in such fashion that the liquid casting material, i. e., the liquid casting head, and also the solidifying and solidified metal adjoining the same are immediately and continuously surrounded by a cooling medium upon or after entry into the mould. The procedure may accordingly be such that a layer of cooling medium is disposed continuously on the surface of the cast metal during the casting process, the temperature of which medium is adjusted in accordance with the above indicated requirements. It is possible to do this when the casting is carried out so that the flow of the molten mass does not break the surface of the liquid head in the mould, that is to say when the thin liquid skin (surface tension) which forms on the surface and may be further assisted by a more or less great formation of oxide skin, is not broken, for example where the nozzle conveying the molten metal mass has its discharge end below the surface of the liquid metal head, i. e., within the said liquid head. In addition to using a standard supply pipe for applying the cooling medium to the surface of the molten mass in the mould or for distributing it evenly over the said surface, a device, e. g. in the form of a douche, may be used.

According to the invention, the cooling is not limited to the provision of a layer of cooling medium on the liquid casting head, and independently of or also in a manner dependent on the cooling aforesaid then can also be cooled not only the already poured and still liquid portion, but also the already solidified metal. This cooling can take place in direct fashion by forcing the cooling medium from the top or the bottom into the space between the solidifying section and the wall of the mould. The cooling, however, can also take place indirectly by a unifold stage-by-stage cooling, in such a way that the chill mould used for the casting is exposed to temperatures decreasing in its longitudinal direction, the various cross sections of the chill mould being so cooled by these means that a quick solidification of the entire casting cross section does not occur until the temperature difference between metal inflow and mould wall has become so small as it can possibly be obtained in practice.

Substances may also be added to the cooling medium which act upon the solidifying metal during the setting. Reference is made mainly to chemical processes and conversions (e. g. alloying, deoxidation or the like) which may take place between the liquid metal head and the

liquids resting upon it. These effects may therefore be for the purpose of obtaining a refining of the metal or of a further alloying with chemical compounds in the solidifying metal.

Further features of the invention both as regards the method and the cooling arrangement will be apparent from the description, the claims and the drawings, in the last mentioned of which the arrangement of suitable cooling devices is illustrated diagrammatically by way of example.

Fig. 1 shows by way of example a casting device for the continuous casting of an endless metal bar.

Fig. 2 shows a special form of chill mould.

Fig. 3 shows the casting produced in the chill mould completely surrounded by a layer of cooling medium.

Fig. 4 shows an arrangement for conveying pressure to the cooling medium.

Fig. 5 illustrates a specially designed chill mould wall.

Fig. 6 shows a chill mould the cooling chamber of which is divided into two differently cooled sections.

Fig. 7 shows a chill mould without partition walls, but made of two different substances.

Fig. 8 shows a chill mould with partition wall and made of different substances.

Figs. 9 and 10 show a chill mould in the cooling chamber of which a further special passage for the cooling medium is incorporated.

Figs. 11 and 12 show chill moulds having walls of differing thickness by means of which different cooling effects are obtained, and

Figs. 13 and 14 show in diagrammatic cross section chill moulds possessing reinforcements or bands at certain points.

In Figures 1-5 *a* is the chill mould having a cooling jacket or chamber *a*<sup>1</sup>. *b* is the casting in process of formation, *c* is the supply pipe for the molten metal from a container into the chill mould. *d* are by way of example the cooling medium supply pipes. According to the example of application about to be described of the process according to the invention, the molten mass flows during the casting process into the chill mould at a temperature the order of magnitude of which lies not more than about 50° centigrade above the melting point of the metal to be cast. The cooling liquid admitted through the pipe *d* flows away from the liquid metal head through the line *f* (Fig. 1). The procedure may of course also be that after admitting the cooling medium through the line *d* it is caused to drain off from the liquid metal head downwardly between the solidifying metal and the wall of the chill mould (Fig. 3). Now, when care is taken to ensure that the quantity of cooling liquid admitted is always exactly the same as the quantity running off downwardly, the solidifying casting is then surrounded from top to bottom on all sides by the cooling liquid so that care is thus taken that there is not only a cooling from the sides and an additional cooling from below (see cooling device *h*, Fig. 1), but also that particularly the most recently arriving metal is always and uniformly cooled from above, so that a quick and uniform cooling over the entire cross section of the solidifying bar is ensured.

It is of course also possible instead of letting the cooling liquid flow in the downward direction from above, to hold it above the liquid metal head by means of suitable devices within the chill mould so that it forces its way from below upwardly,

e. g., in an embodiment according to Fig. 2. According to this illustration the chill mould proper *a* is only sufficiently long for solidifying and guiding the corresponding metal bar being cast, whereas the cooling chamber *a*<sup>1</sup> extends further downwardly. The cooling medium penetrates from the cooling chamber *a*<sup>1</sup>, i. e., from the lower end of the chill mould wall, between the solidifying casting and the mould wall upwardly and spreads itself over the liquid metal head. A further direct cooling of the casting is effected below the chill mould *a* in the cooling chamber *a*<sup>1</sup> and an indirect cooling is effected along the outer wall of the mould *a* in the upper portion of the cooling chamber *a*<sup>1</sup>.

Where the solidification of the metal or the manner in which the casting process is carried out do not allow of a uniform connection of the cooling liquid between the upper and lower end (liquid metal head and solidifying casting) the cooling medium must be introduced from above and from below, the lower part of the chill mould being for the purpose of uniform supply of cooling liquid extended downwardly as shown in Fig. 3, and a cooling device *h* arranged at the bottom of the mold to flow cooling medium upwardly into the space between the casting and the mold wall. In that case it will also be necessary to maintain a constant inward and outward flow of cooling medium or cooling liquid above the liquid metal head, which could be effected by providing inlet and outlet pipes *d* and *f* (Fig. 1).

Where the cooling (acting directly upon the casting) is to be effected under pressure, thus enabling the entire casting process to be also carried out under pressure, that is to say where the cooling medium is to be admitted to and drawn from the mould in such a way as to constantly remain under the desired pressure, which, as the cooling medium surrounds the entire casting, is consequently transmitted to the solidifying casting, a device according to Fig. 4 is provided wherein the upper chamber of the mould is rendered airtight by means of a bell. In that case it is of course necessary to keep the inflowing metal under the same pressure as the pressure of the cooling medium. If operations are carried out under pressure, the lower closure means of the mould must naturally also be such that the pressure can be maintained. For this purpose there are preferably employed stuffing boxes or the like.

Fig. 5 illustrates a chill mould possessing perforations through which the cooling medium flowing through the cooling jacket comes into direct contact with the casting and rinses it.

The cooling arrangements according to the examples of embodiment shown may in addition to the standard cooling chamber or cooling jacket *a*<sup>1</sup> possess a further special cooling chamber or a special cooling medium pipeline *g* or have such a pipeline passed through it. These special cooling chambers are preferably located at points where there is special need of cooling, e. g., opposite the liquid metal head. The cooling chambers *a*<sup>1</sup> and pipe line *g* may contain the same or differing cooling media under the same or differing pressures. Thus for instance the cooling chamber *a*<sup>1</sup> may receive circulating water in the usual manner, while the pipeline *g* conveys cooling water under pressure which is sprinkled against the walls of the chill mould.

The speed of solidification of the casting in process of formation may be regulated according to the temperature of the cooling liquid. The

cooling media, which if desired may be lukewarm, slightly or strongly warmed or even hot, may consist of water (clean, hard or soft water) colloidal solutions, salt solutions, acids, bases, liquids saturated with gases or other liquid or frothy combinations. According to the preceding statement the term cooling medium comprises any substance having a lower temperature than the molten mass to be cast; for example for the purposes of this application an oil heated to 500° C. or more is to be considered as a cooling medium if serving the purpose of cooling brass having a melting temperature of 1000° C., and in the same way water heated for example to 90° used for cooling an aluminium alloy having a melting point of 640° C.

Fig. 6 shows a chill mould the cooling chamber of which is divided by a partition wall in its upper third into cooling chambers *a* and *b*. This dividing of the cooling chamber enables the chambers *a* and *b* to receive different cooling media, e. g. in chamber *a* a cooling medium having a temperature of 600° C., in the chamber *b* water at a temperature of 20° C. It also enables cooling media having differing pressures to be used.

Fig. 7 shows a chill mould without partition walls but made of two different substances, e. g., of iron (*c*) of copper (*d*).

Fig. 8 shows a chill mould with a partition wall *e* and made of different substances (*c*, *d*).

Fig. 9 shows a chill mould in the cooling chamber of which a further special cooling medium supply line *f* is incorporated. This line serves the purpose of directing the cooling medium flowing in the direction of the wall of the mould, with or without special pressure, to a definite point of the wall. It has for instance been found very convenient for certain metals to convey the inflowing cooling medium, e. g., water, to the point where the freshly arriving liquid metal is received and to distribute the said water over the surface at that point.

Fig. 10 shows a mould having below it a cooling medium conduit *h* arranged in such a way that the cooling medium is so conveyed as to sprinkle the entire surface of the casting at the moment when owing to its shrinkage it separates from the wall of the mould.

This conduit *h* forces cooling medium into the space progressively formed between the solidified casting and the mold wall as the former shrinks away from the latter, and the said cooling medium in rising from its place of introduction into said space sprinkles the whole surface of the continuously formed casting. Another cooling medium conduit *g* is provided, as in Fig. 1, to provide auxiliary cooling to the upper or still liquid portion of the casting in contact with the mold wall. The apparatus shown in Fig. 10 is without the pipes *d* and *f* for maintaining a layer of cooling medium on the surface of the liquid metal head of the casting.

Figs. 11 and 12 show chill moulds having walls of differing thickness so that differing cooling effects are obtained.

Figs. 13 and 14 show a chill mould which at the points where a lesser cooling effect is to be obtained than in the entire mould, is provided with thickened parts or bends. These thickened parts or bends are especially suitable for chill moulds having sharp corners or in moulds for sections having strongly varying cross sections.

By means of chill mould designed and cooled in the manner described above it is now possible

completely to control the cooling and the solidification of the inflowing metal from the hereinbefore mentioned points of view, provided that the points of view mentioned in the following are also taken in consideration.

It is of course possible to influence the liquid metal already in the chill mould only if the cross section of the mould, the quantity of cooling medium and the quantity of the inflowing metals are in suitable ratios the one to the other, and are maintained at such ratios throughout the entire casting process. A further very essential condition is the one mentioned above that the casting temperature is kept only so high that the cooling arrangements of the mould and, where provided, also the device for distributing the molten mass as it arrives in the mould, are in fact capable of dissipating the inflowing heat including the latent heat of melting of the metal so quickly as to fulfill the condition of producing the lowest possible temperature difference.

A metal heated to slightly above its melting point now arrives in a chill mould according to Figs. 6-14 and is cooled there only to such an extent as to allow it to spread right out into contact with the walls of the mould. In the section *a* the mould is maintained at such a temperature or cooled to such an extent as to be only slightly cooler than the metal flowing towards its walls.

In this way a stronger cooling effect towards the centre of the mould is avoided. In this zone the only task of the mould is to ensure the formation of a quite thin skin in the form of the cross section of the mould.

The section *a* (Fig. 6) is dimensioned in such a way that the casting on its travel toward the section *b* does not enter the latter until the temperature difference between the centre of the casting cross section and the periphery has attained the lowest point obtainable in practice. In the section *b* the quickest possible cooling is effected, so as to obtain quick solidification through the entire cross section. Now, whether this cooling effect is obtained by the one or the other of the embodiments of moulds as shown in Figs. 6-14 is immaterial in principle, as long as just those means are chosen which are most satisfactory for the alloy in process of treatment.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:

1. A method of continuously casting metals in an open ended mold comprising in continuously pouring the metal in the upper part of the mold, drawing the casting from the lower opening of the mold, and conveying a cooling medium between the wall of the mold and the metal whereby the cooling medium contacts the metal at the top and sides, the metal being poured into the mold below the upper surface of the cooling medium over the top of the cast metal.

2. A method of continuously casting metals in an open ended mold comprising in continuously pouring the metal in the upper part of the mold, drawing the casting from the lower opening of the mold, and forcing a cooling medium between the wall of the mold and the cast metal against the metal whereby the cooling medium covers the top of the metal and the sides.

3. A method of continuously casting metals in an open ended mold comprising in continuously pouring the metal in the upper part of the mold, drawing the casting from the lower opening of the mold, conveying a cooling medium between

the wall of the mold and the cast metal whereby the cooling medium contacts and covers the sides and top of the cast metal, and conveying away the cooling medium in the upper part of the mold.

4. A method of continuously casting metals in an open ended mold comprising in continuously pouring the metal in the upper part of the mold, drawing the casting from the lower opening of

the mold, and conveying a cooling medium between the wall of the mold and the cast metal and the lower end of the mold and up along the sides of the cast metal and withdrawing the medium at the top of the mold where the casting metal enters the mold.

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