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METHOD OF CASTING STEEL AND OTHER METALS

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In casting steel or other metals the molten metal is usually allowed to solidify undisturbed in the mold. In order to achieve certain specific objects, however, various treatments of the metal, during or after casting, have been suggested and employed, such as: centrifugal casting, compression of the partly solidified ingot, and subjecting the metal in the mold to agitation in various manners, e. g. by oscillating the mold up and down, sideways, about a vertical axis, or about a horizontal axis, or by a stirrer inserted into the fluid metal. Among benefits claimed to accrue from agitation may be mentioned: prevention of blow-holes, of pipe and other shrinkage cavities, of slag inclusions and certain surface defects; homogeneity of composition; fine-grained structure.

According to the present invention, after the metal has been cast into the mold, it is, at a given moment or during a given period to be defined below, agitated so as to produce a fine-grained solidification structure.

It is well known that, upon entering the mold, the molten metal immediately solidifies next to the mold walls, thus forming a thin layer or shell. For some time solidification then proceeds by continuous growth of the shell inwards. As a result of the increasing thickness of the shell, the increasing temperature of the mold and the separation of ingot and mold, mainly due to thermal dilatation of the latter, the growth of the shell is gradually retarded. During this process the temperature of the still fluid interior gradually falls, finally a point being reached, where independent crystal nuclei, so-called free crystals, are spontaneously formed here and there in the liquid, first in the cooler outer portions, not far from the growing shell, later further inwards towards the axis of the ingot or casting. Those nuclei, once formed, grow until they meet one another or the growing shell respectively. Thus the size of those crystals when completed, or, in other words, the grain size of the interior portion of the ingot, is determined by the number of nuclei formed during the period of solidification. Under ordinary conditions of casting comparatively few nuclei are formed and the structure of the interior accordingly becomes coarse-grained.

It is known that a fine-grained structure may be obtained by cold pouring, i. e. pouring the metal at or near to its freezing point. In that case the molten interior will cool down rapidly into a temperature range where numerous nuclei are formed, the first formed nuclei thus not having sufficient time to grow to substantial size. This method, however, can only be resorted to in special cases, for the following reasons. With the large capacity of modern melting furnaces, a great number of ingots are usually cast in succession from one ladle. Thus, when casting is commenced, the metal must be fairly hot, in order that the cooling off during casting shall not cause any considerable amount to freeze in the ladle. Generally, therefore, with present practice, only a small proportion of a heat can be made into fine-grained ingots.

According to the present invention which can be applied to hot-poured metal also, the metal, after it has been cast into the mold, is left undisturbed until the interior has cooled off to a temperature that approximately coincides with the spontaneous formation of independent crystal nuclei, and is then subjected to vigorous agitation, whereby numerous nuclei are formed and a fine-grained structure results. If the agitation is applied earlier than at the moment described and then left off, only a few nuclei may form which may then grow into large crystals; if it is started later, the nuclei formed spontaneously may already have grown into larger grains. It is essential that the agitation be not too mild, because the nuclei-producing effect would then be insufficient.

For smaller ingots a brief agitation is sufficient; for large ingots, where the temperature in different portions of the molten metal may differ considerably, it may be preferable or necessary to continue the treatment for some time or repeat it at suitable intervals in order that all portions may be treated at the temperature defined.

The moment suitable for agitation may be ascertained by experiment, a series of ingots being subjected to agitation at different times after pouring. The results are observed by examining the fracture or an etched section. The optimum time obviously depends on several variables such as: composition, temperature of pouring and cooling conditions, the latter in their turn varying with the size and shape of the ingot and the thermal characteristics of the mold.

The agitation may be performed in various ways, e. g. by oscillating the mold, by the use of a stirrer inserted from above into the metal or by "after-pouring" a fresh quantity of metal. After-pouring is a known method of reducing the size of the pipe, but as heretofore carried out without observing the time element, this method has only occasionally produced a fine-grained structure, the reason of which has then remained undiscovered.

Some of the experiments that led to the present invention showed that 9″ square ingots of 1.10 carbon steel poured at ordinary temperature became fine-grained throughout the interior portion when after-pouring took place 1½ or 1¾ minutes after the main pouring was finished. If an interval of 1¼ minutes elapsed before after-pouring, large grains formed in the upper part; if 2 minutes, in the lower part of the interior portion, which was otherwise fine-grained. This is due to the fact that the metal cools faster at the bottom of the ingot than at the top, the ingo having a downward taper.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

The method of producing an ingot which consists in pouring molten metal into a mold, allowing the metal adjacent to the walls of the mold to freeze and the metal in the interior molten portion to cool undisturbed, approximately to a temperature at which crystals begin to form spontaneously from independent nuclei, and, finally agitating the molten interior portion to thereby induce the formation of numerous crystal nuclei therein and thus to produce a fine grained structure in the interior portion of the finished product.

In witness whereof, I have hereunto signed my name.

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