A new Method for the Improvement of the Soundness of Steel Ingots by the Aid of Thermit.

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It is well known that all alloys in transition from the liquid to the solid state tend to lose their homogeneity. The constituents which in the liquid state were uniformly distributed begin to segregate on solidifying, with the result that ultimately the ingot when cold is no longer homogeneous and has not the desired composition in all parts. The attainment of homogeneity in the preparation of alloys is a matter that has consistently engaged the attention of metallurgists.

Steel, that is material made by a fusion process, must be regarded as an alloy of iron with several elements, more particularly carbon, manganese, and silicon; phosphorus, sulphur, and copper being also present as impurities. The purer the iron the higher its melting point, and the other constituents of the alloy, especially carbon, and also phosphorus and sulphur, have the effect of lowering the melting point. In the production of steel, therefore, the purest constituents, that is, those which have the highest melting point, are the first to solidify and settle at the bottom and sides of the ingot mould. At the centre and head of the ingot, on the other hand, where the metal remains longest fluid, are gathered the more readily fusible impure elements which have separated out during cooling. The principal elements which accumulate near the top in this way are sulphur and phosphorus, &c., which exercise so injurious an influence on the mechanical properties of the material.

The serviceableness of an ingot is not only reduced by the process of segregation, but by a whole series of other defects arising during cooling and freezing.

For instance, during the transition from the liquid to the solid condition the volume of the ingot undergoes a change due to shrinkage. As solidification progresses from the sides and bottom inwards and upwards, the neighbouring layers of liquid and semi-liquid material are attracted owing to the gradual diminution of the volume until finally, in the centre of the ingot and towards the end, a large hollow, known as the pipe, is formed, which is the distinctive and objectionable defect of almost all steel ingots.

This, however, by no means exhausts the list of defects arising during the cooling and solidifying of an ingot. The material undergoes further change, owing to the evolution of gases shortly before freezing in the case of metal to which no silicon addition is made either in the furnace or ladle, that is, material which has not been siliconised, and at the same time contains only a low percentage of carbon. The evolution of gas is very energetic, and is accompanied by vigorous sparking. The gases consist of hydrogen and carbon monoxide, and as long as the metal in the interior of the ingot is sufficiently
fluid they can escape freely and rapidly. But as cooling proceeds they become entangled and form blowholes of various dimensions within the ingot. These gas enclosures also adversely affect the homogeneity of the ingot, and frequently they exercise a most injurious effect on the quality of the material when they attain a considerable volume owing to their inability to work their way upwards through the already solidified metal.

By careful working, these defects in the ingot can be kept within comparatively reasonable bounds, and it is not the object of this paper to describe exactly the remedies usually resorted to. Mention may, however, here be made of a very valuable investigation by Dr. Canaris upon the influence of pouring upon the quality of mild steel blooms.* Dr. Canaris, who is the manager of the rolling-mills of Messrs. Schulz-Knaudt, Aktien Gesellschaft, at Angerort, near Duisburg, has exhaustively described the many precautions which are generally taken in order to obviate as far as possible the above enumerated defects arising during the freezing of a mild steel ingot.

The question of the prevention of piping in ingots is one that has always occupied the attention of metallurgists, and, among other remedies, the use of thermit was long ago recommended. The method of its application was to break open the crust which formed at the top of the metal in the mould, and to plunge a canister filled with thermit into the pipe, in order to remelt the surrounding parts. As soon as this remelting was effected, the hole was filled by pouring in fresh liquid steel from the ladle. The process as thus carried out was, therefore, a purely thermal one.

Unfortunately the method did not yield the desired results, in spite of the numerous trials made at a great many steelworks. In fact, it was only in exceptional cases that success was obtained, so that it was no wonder that this so-called anti-piping thermit process was soon discredited and forgotten.

Latterly, however, a new and very successful improvement of that old process has been made, which has proved very efficacious, especially in the treatment of non-siliconised steel, that is, steel to which no silicon addition has been made either in the furnace or in the ladle. At first sight it might be thought that the method had been altered only in one small detail, for the apparatus, consisting of a sheet metal canister filled with thermit, has been retained. It differs totally, however, in the mode of application and the result achieved.

Whereas formerly the thermit canister was used solely for the purpose of melting the upper portion of the ingot containing the pipe, the lower end having already solidified, the canister, according to the new method, is quickly plunged right to the bottom of the ingot before solidification has begun to set in, that is, before any of the defects referred to have had time to take effect. The reaction immediately causes an energetic ebullition of the liquid contents of the ingot mould, and the gases which have just begun to separate out are violently expelled, or, if the charge has not been siliconised, the bubbling of the metal due to the disengagement of the gas is incidentally checked. But the most noticeable feature is the sinking down of the liquid metal in the mould by more than a hand's-breadth as soon as

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* C. Canaria, "Doctor's Dissertation on the Influence of Pouring on the Quality of Mild Steel Blooms." Düsseldorf, Stahleten, G. m. b. H.