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## HARDENED CAST IRON.

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This invention relates to cast iron, and has for its object the production of a hardened cast iron of such relatively high uniformity of hardness as to adapt it to many new commercial uses.

As is well known, the process of hardening steel is so carried out that, on a reheating to the neighborhood of 700° C. (the point A<sup>1</sup> of the iron-carbon diagram), the structural constituents, pearlite and ferrite (or cementite) which are formed in the original gradual cooling of the steel are transformed back into a solid solution and then the decomposition of the solid solution is arrested, by a rapid cooling or quenching from above this critical point, at a stage where the chief constituent thereof is martensite, which is harder than ferrite and pearlite. Since the pearlite and ferrite present in the steel are finely divided and intermingled it results that when the steel is hardened a relatively high uniformity of hardness is obtained, and such uniformity increases with the original pearlite content in the total structure.

Eutectoid steel, therefore, having pearlite as its sole structural constituent, stands first or at the head as regards the possibility of uniformity in hardening.

Cast iron, as compared with steel, is made up of the following essential structural constituents, viz., cementite, pearlite, ferrite, graphite, and (according to its phosphorus, sulphur and manganese content) eutectic phosphide and manganese sulphide. Cementite contains about 6.6 per cent, pearlite about 0.9 per cent, and ferrite 0.05 per cent, of carbon. Moreover, in cast iron the different structural constituents are both coarser grained and much more unevenly distributed than in steel. Alongside of plate-like particles of graphite there will be wide bands of ferrite with occasional grains of pearlite, while at the outer surface of the piece the cementite will predominate; and, according to the presence of phosphorus, sulphur and manganese, the complexes, eutectic phosphide and manganese sulphide, will be irregularly imbedded in the structure. If such a cast iron is hardened, in the way in which steel is hardened, the pearlite and ferrite therein will be similarly transformed into martensite on reheating the point A<sup>1</sup>, but under no circumstances will it be possible to obtain a hardness even approximating uniformity, entire-

ly apart from the fact that the graphite, unevenly divided and separated more or less into nests, is entirely incapable of hardening and therefore opposes the hardening of the piece, and the more so since its more coarsely divided and more unevenly distributed particles destroy the continuity and coherence of the more ductile constituents. As a consequence, all previous attempts to harden cast iron, which have been numerous, have produced very unsatisfactory results.

The invention of the so-called pearlite casting process has now made it possible to produce a cast iron which possesses essentially the pearlite structure of eutectoid steel with the additional graphite showing only in small amounts finely divided and uniformly distributed.

Taking up anew my experiments in the hardening of cast iron, I have succeeded in obtaining with this new cast iron a hardness of such high uniformity that chisels and cutting tools for turning, planing and cutting lathes can be made therefrom and used with excellent results.

The method of producing my improved hardened cast iron will be apparent after the foregoing explanations. Thus, from a mixture having a small content of carbon, silicon, sulphur, manganese and phosphorous—for example, 2.9 per cent C., 0.8 per cent Si., 0.04 per cent S., 0.6 per cent Mn., and 0.1 per cent P.—bars are cast, according to the pearlite casting process as described in Letters Patent to Diefenthaler No. 1,502,983, July 29, 1924, to Diefenthaler & Sipp No. 1,544,562, July 7, 1925, and to Sipp No. 1,564,284, December 8, 1925, the iron structure of which is purely pearlitic, showing neither ferrite nor cementite, and which contains only a very slight strata of eutectic phosphite and manganese sulphite. Tools such as those above enumerated, or other articles as desired, are forged from these bars and are then hardened, by reheating and quenching, in the same way as steel,—thus, the article is first reheated to the neighborhood of 900° C. and rapidly cooled or quenched from such critical point, and is then again reheated to and rapidly cooled from the temperature required to produce the properties and characteristics desired. For example, a final reheating to and cooling from about 350° C. will increase the tough-

ness and tensile strength of the cast iron some fifty per cent, while a final reheating to and cooling from about 700° C. will produce a cast iron of above 300 Brinell hardness. The hardness of the cutting edges which may be obtained is scarcely distinguishable from that of hardened normal tool steel.

The invention opens up a vast new field for the use of cast iron, making possible its use for a great many articles for which cast iron had never before been even considered, and, in addition, possesses numerous advantages, as compared with the use of steel—for example, in cases where the complicated shape of the piece renders its production from wrought steel a matter of great difficulty. As against a steel mould casting, moreover, the pearlite cast and hardened cast iron has the advantage of a far greater density and the hardening thereof is a much more simple matter.

The new hardened cast iron can be obtained equally well from simple pearlite and from the so-called enriched pearlite cast iron, that is to say, a cast iron which is characterized by the pearlite structure and contains in addition a refining element such for example as nickel, titanium, and the like.

What I claim as new, and desire to secure by Letters Patent, is—

1. As a new article of manufacture, hardened gray cast iron having a low content of carbon, silicon, sulphur, manganese and phosphorous which has been hardened by reheating and cooling and is characterized by a fine division and even distribution of its constituent particles and by a high uniformity of hardness.

2. Hardened gray cast iron having a low content of carbon, silicon, sulphur, manganese and phosphorous and an additional en-

riching element such as nickel, which has been hardened by reheating and cooling and is characterized structurally by a fine and evenly distributed graining and high uniformity of hardness.

3. Hardened and tempered cast iron which has a low content of carbon and silicon and is characterized by fine evenly distributed grains produced by the reheating and cooling of a gray cast iron of substantially uniform pearlite structure with finely divided and evenly distributed graphite.

4. Hardened and tempered cast iron which has a low content of carbon and silicon and is characterized by fine evenly distributed grains produced by the reheating and cooling of a gray cast iron of substantially uniform pearlite structure with finely divided and evenly distributed graphite, and by a high density, toughness and uniformity of hardness.

5. As a new article of manufacture, an edged tool of tempered gray cast iron having a low content of carbon and silicon and characterized by a high density and toughness, a fine and even graining, and a high uniformity of hardness.

6. As a new article of manufacture, an edged tool of tempered gray cast iron having a low content of carbon and silicon which is characterized by a structure resulting from the reheating and cooling of a gray cast iron of lamellar pearlite with fine grainings of graphite and by a high uniformity of hardness.

7. As a new article of manufacture, a tool of tempered cast iron having a low content of carbon and silicon and characterized by a fine even grain and a high density and toughness.

8. A cutting tool of tempered gray cast iron.

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