Aug. 16, 1932. R. H. McCARROLL ET AL 1,871,544

CAST IRON ARTICLE AND METHOD OF MANUFACTURING THEREOF

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Fig. 1.

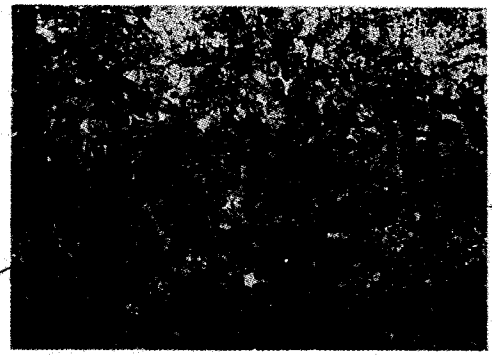


Fig. 2.

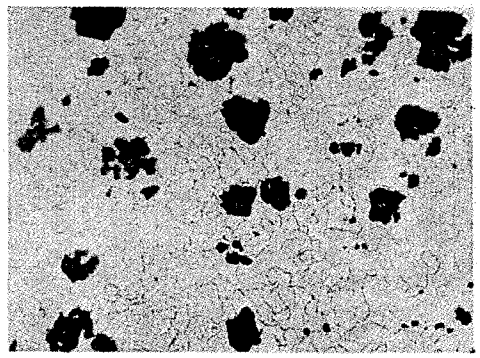
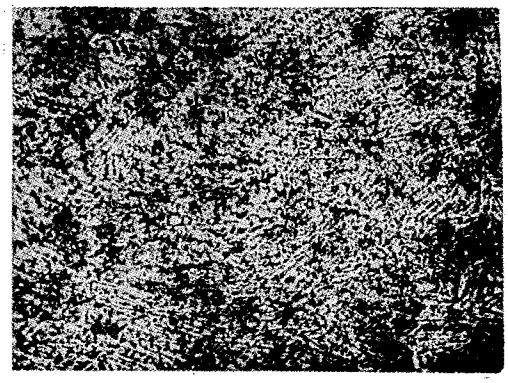


Fig. 3.



Inventors
Russell H. McCarroll
and Gosta Vennerholm

By *D. Joseph Farley*
Attorney

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Fig. 4.

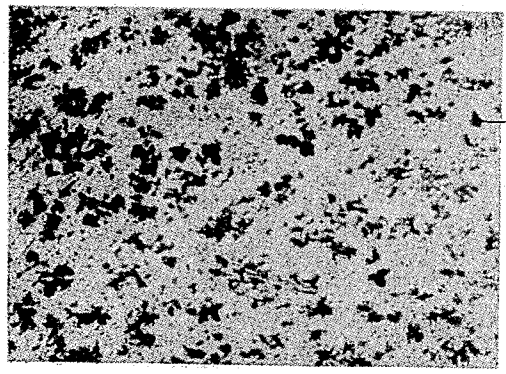


Fig. 5.

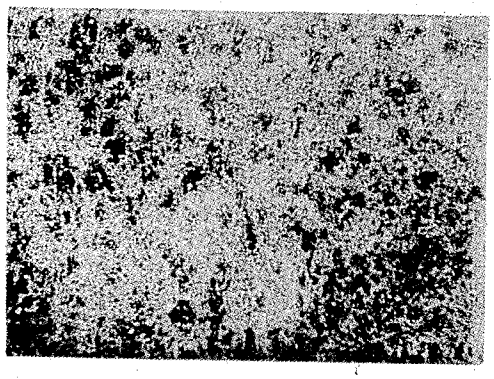
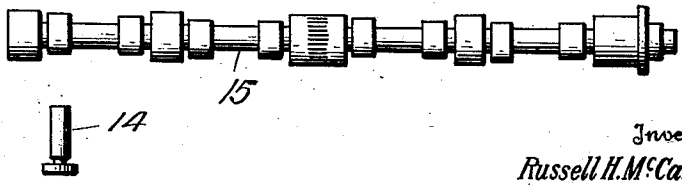


Fig 6.



Inventors
Russell H. McCarroll
and Gosta Vennerholm
By J. Joseph Farley
Attorney

Patented Aug. 16, 1932

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UNITED STATES PATENT OFFICE

RUSSELL H. McCARROLL AND GOSTA VENNERHOLM, OF DEARBORN, MICHIGAN, ASSIGNORS TO FORD MOTOR COMPANY, OF DEARBORN, MICHIGAN, A CORPORATION OF DELAWARE

CAST IRON ARTICLE AND METHOD OF MANUFACTURING THEREOF

Application filed December 26, 1930. Serial No. 504,836.

This invention relates to cast iron articles and to methods of manufacture thereof, and has for its principal object to provide a new and improved article made primarily of iron cast to a predetermined shape but which is so processed that the final product has its characteristics improved to such an extent over the ordinary cast iron article that the article so produced possesses in a large measure the desirable high physical properties of steel, while at the same time possessing the desirable attributes of cast iron with respect to low production costs.

Another object is to provide a new and improved method for the production of cast iron articles by the use of which the physical properties of such articles are vastly improved.

A further object is to provide an article of iron cast to a predetermined shape, capable of being annealed, heat treated and tempered in a manner analogous to the treatment of steel.

Another object is to provide a new and improved process for the treatment of cast iron which will produce not only annealing, hardening and tempering of the matrix, but will also result in a uniform distribution of the free carbon in small rounded globules or nodules, the presence of large graphitic flakes or fissures in the final product is avoided and an article of markedly uniform, homogeneous structure is secured.

The above and other objects will appear more fully from the following more detailed description which sets forth the principles underlying the present invention by reference to a satisfactory commercial reduction to practice thereof, the example described, however, having been selected for the purpose of the present application for illustrative purposes and not as setting forth the limits of said invention.

In view of the fact that the manufacturing cost of cast iron is so much lower than that of steel, and as cast iron is essentially a steel whose continuity is broken by free graphite, much time, study, and effort has been given by metallurgists to devise satisfactory, commercially practical, methods for treating cast iron in a manner analogous to the treatment of steel in order to secure a similar improvement in the properties of cast iron, but no one, at least as far as we are aware, has heretofore succeeded in obtaining the desired results. Such methods for treating cast iron in order to harden it as have heretofore been tried, either have not been practical from a commercial standpoint, or it has been found that uniformity of results were not obtainable.

The present invention will best be understood by reference to the accompanying drawings wherein:

Fig. 1 illustrates a typical cross-section of the ordinary sand cast grey iron;

Fig. 2, a similar section of malleableized iron;

Fig. 3, a similar section of an iron illustrating the result of the first step of the process of the present invention;

Fig. 4, the result of the second step of the present process;

Fig. 5, a cross-section of the final product of the present invention; and

Fig. 6, a somewhat diagrammatic view of articles manufactured in accordance with the present invention.

The cast iron used commercially may be said to be of the two following principal types, namely, grey cast iron and malleableized iron, the latter being a heat treated product of white iron. Grey cast iron is produced by a slow rate of cooling both through and below solidification. When the iron is in the liquid state, it consists of a solid solution of iron and iron carbide plus certain other elements such as silicon, manganese, phosphorus, sulphur, etc. During and after solidification, however, the iron carbide is very unstable, and is readily decomposed into iron and carbon. Two factors will promote this decomposition, viz, slow rate of cooling as above stated, and the presence of silicon.

On the other hand, white cast iron above referred to is iron in which the carbon is present in the combined state, that is, in the form of iron carbide and as a solid solution of iron and iron carbide. Iron of this type

is produced primary either by a fast rate of cooling resulting in chilled iron or by the presence of much manganese or sulphur. The chill cast iron is commercially used for articles in which hard wear resisting surfaces are desired. This type of iron is extremely hard and very brittle. Due to the extreme hardness and frangibility of the chill cast iron and the difficulty of machining it by the ordinary machine shop methods, its usefulness is very limited. Malleableized iron is white iron produced by low carbon and medium high manganese and that has been subjected to a special heat treatment, termed malleableizing. Malleableizing consists in heating the iron to a high temperature over a long period of time (for example, from 45 to 60 hours and then allowing it to cool slowly). The result is a perfect decomposition of the iron carbide into iron and carbon. The carbon, known as temper carbon, is found to have segregated into small rounded particles imbedded in a soft matrix of substantially pure iron. Malleableized iron is therefore very soft and rather ductile with relatively low strength. Its usefulness is therefore limited on this account, as well as on account of the slowness of its processing.

Figs. 1 and 2 of the drawings illustrate respectively the characteristic physical structure of ordinary grey cast iron and malleableized iron. By referring to Fig. 1 it will be noted that grey cast iron contains, interspersed through it, the relatively large particles of graphite indicate by the reference character 10 which particles are commonly referred to as graphitic flakes or fissures. The matrix of this iron is mainly pearlitic with free ferrite.

The presence of the graphitic flakes or fissures in grey cast iron obviously is one of the factors that contributes to the relative brittleness of cast iron. While heat treatment, such as is used in the hardening of steel, may be resorted to harden the matrix of grey cast iron, such heat treatment does not appreciably alter the size or distribution of graphite particles, and, as a hardening of the matrix results in a corresponding increase in its brittleness, no practical advantage, at least insofar as increased strength is concerned, has been apparent in hardened cast iron over ordinary grey iron. Therefore heat treatment of cast iron primarily to harden it has not heretofore been commercially practiced although heat treatment has been resorted to for replacing the well known aging process.

As hereinbefore pointed out, the rate of cooling controls the size of graphite and therefore the iron should be cooled as fast as possible, at least through the temperature range in which decomposition may take place. As iron having a carbon content of 4.2% is of eutectic composition, iron of such composition would have the minimum interval between liquid and solid, and therefore the smallest latent heat range and the fastest solidification. The amount of carbon in eutectic iron, however, is much more than desired in iron for ordinary usage, a carbon ratio of approximately 3%, giving much better results in practice for machine parts.

The addition of silicon however, results in a lowering of the solubility of the iron for carbon and also a lowering of the eutectic point. This lowering of the eutectic point enables us by adding silicon, to produce iron of the desired carbon content, and thereby to secure the fast solidification that characterizes the normal eutectic iron of 4.2% carbon ratio.

We have found as a result of a long period of investigation and study, that the physical properties of cast iron can be greatly improved and that an iron can be successfully produced upon a commercial basis that may be said to be between steel and cast iron, possessing the desirable qualities of the former with the respect to high strength, homogenity of cross-section, hardening, and tempering qualities, while at the same time possessing the desirable attribute of cast iron with respect to low production costs. We control the decomposition of the combined carbon and limit the size, shape and distribution of the particles of free carbon, by producing it in a form similar to temper carbon. We aim, primarily, by the process of the present invention to produce a matrix of approximately eutectoid composition, although we have found in practice that it is not essential to secure an eutectoid matrix.

The present invention has been successfully practiced upon a commercial scale for the production of cast iron having a carbon ratio not exceeding 3.7% to which we have found the addition of silicon of from 2.5% to 2.9% will produce the desired lowering of the eutectic to bring such eutectic approximately into alignment with the carbon abscissa of the iron-carbon diagram for iron of the desired carbon content. The molten iron is poured into metal molds, preferably of cast iron, to insure a rapid cooling of the molten metal. As soon as the metal has solidified sufficiently to retain its desired shape, the cast article is released from the mold. Due to the quick cooling and to the fact that the latent heat period has been reduced to a minimum, the product which results from the casting and quick cooling step is found to have a structure such as illustrated in Fig. 3. It will be noted by referring to this figure that there is an absence of the large graphitic flakes 10 such as present in the ordinary cast iron illustrated in Fig. 1.

After the casting and cooling of the article, it is subjected to a temperature above the critical range in order to decompose the com-

bined carbon. The nature of this heat treatment, i. e., the temperature and duration can, of course, be varied. After the heating period, the article is allowed to cool slowly. It is, however, essential that the temperature during heating be above the critical range. In practice it has been found that a temperature between 1600 and 1700° F., maintained for a period of from one to three hours, has given highly satisfactory results. The product that results from the heat treatment just described is illustrated in Fig. 4 of the drawings, from which it will be seen that the free carbon or graphitic particles have been collected or grouped into small, rounded particles 13 quite analogous to grouping of carbon particles of the malleableized iron illustrated in Fig. 2.

The above heat treatment is essentially an annealing process, the hardness is drawn from the metal and a soft casting having a Brinnell preferably under 228 is secured. The degree of annealing and the Brinnell hardness can be controlled by the temperature and duration of this heat treatment. After the castings are annealed as above described, they can readily be machined and rough ground to produce an article of the desired dimensions and configuration.

When the articles have been machined to the desired shape and size, they are then subjected to a further heat treatment at a high temperature above the critical range for producing a matrix in the form of a solid solution. Due to the fact that the free carbon has been segregated as shown in Fig. 4 into relatively small nuclei, a much larger proportion of the carbon of each nucleus is caused to penetrate into the matrix than would otherwise be possible if the carbon particles were of the larger size such as shown in Figs. 1 and 2. We have found in practice that satisfactory results are obtained by heating the iron to approximately 1550° to 1600° F. maintained for a period of approximately ten minutes. Variations of these figures may, of course, be resorted to in accordance with the chemical composition of the iron, and cross-section of the article.

After subjecting the articles to the last described heat treatment, they are cooled quickly, as for example, by quenching, preferably in an oil bath or water, or any other suitable quenching bath, maintained at approximately atmospheric temperature. In some cases it may be desirable to resort to air cooling. If desired, the article may also be temper-drawn after hardening, or subjected to any other treatment to eliminate strains. The resultant product is as illustrated in Fig. 5 from which it will be noted that the free carbon is uniformly distributed throughout the matrix in small rounded nodules. There is an entire absence of large graphitic flakes and fissures. Although the structure illustrated in Fig. 5 is essentially one in which the matrix is characteristically martensitic-troostitic, the matrix preferably is not above the martensitic range nor below the sorbitic range.

In Fig. 6 of the drawings we have illustrated various articles that have been produced by the processes herein described. The reference character 14 indicates a valve tappet or push rod such as employed for internal combustion engines. The reference character 15 indicates a cam shaft. The articles illustrated in Fig. 6 are shown merely by way of example and not as limiting the scope of the invention.

The invention is particularly well adapted for high speed production methods because of the quick cooling of the castings and the use of metal molds. In practice the molten metal is cast into the molds which are mounted on an intermittently rotatable table, and after a lapse of time sufficient to permit the metal to solidify, during which time the table revolves through a certain angle of rotation, the molds are opened automatically and the castings are preferably dropped onto a conveyor and passed through an annealing furnace. The above procedure has therefore resulted in a marked reduction in labor production costs over the ordinary sand casting procedure as well as in securing a product highly superior to the ordinary sand cast iron.

While we have for the purpose of this application referred to the manufacture of iron of not exceeding 3.7% carbon and 2.5% to 2.9% silicon, it will be understood that such ratios are given merely by way of example, and, as we have practiced the invention satisfactorily with irons having silicon contents not below 1.75% and carbon not below 2.0%, that the principles of the invention are not limited to use with iron of any specific carbon ratio, as long as the carbon and silicon contents fall within the limits above set forth and the iron is therefore what is termed in the art as high carbon, high silicon iron. Likewise, the specific temperatures and heat periods set forth are merely illustrative examples that have proven successful in practice. Obviously, many changes, variations and modifications may be resorted to according to the chemical composition of the iron, the requirements for any particular article, or the service to which it is to be put.

We claim:

1. An article of manufacture comprising cast iron containing not below 1.75 silicon, and having a matrix not above the martensitic range nor below the sorbitic range and having the free carbon content in the form of temper carbon.

2. An article of manufacture comprising cast iron containing not below 1.75 silicon, and having a matrix not above the marten-

sitic range nor below the sorbitic range and free from graphitic flakes or fissures.

3. An article of manufacture comprising cast iron containing not below 1.75% silicon and not below 2% carbon, having a matrix not above the martensitic range nor below the sorbitic range, and having the free carbon content in the form of temper carbon and free from graphitic flakes or fissures.

4. The process of manufacturing cast iron which consists in preparing a batch of molten metal having a carbon content greater than 2% and a silicon content greater than 1.75% while maintaining a higher carbon than silicon content, casting the metal in a metal mold to produce an article, allowing said article to cool, then subjecting it to a short cycle anneal of from 1600° to 1700° F. to produce a machinable product having a hardness below, but in the region of, 228 Brinnell, and finally subjecting to a reheating above the temperature of the critical followed by quenching to secure a matrix not above the martensitic nor below the sorbitic range.

In testimony whereof we affix our signatures hereto.

RUSSELL H. McCARROLL.
GOSTA VENNERHOLM.