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MALLEABLE CAST IRON

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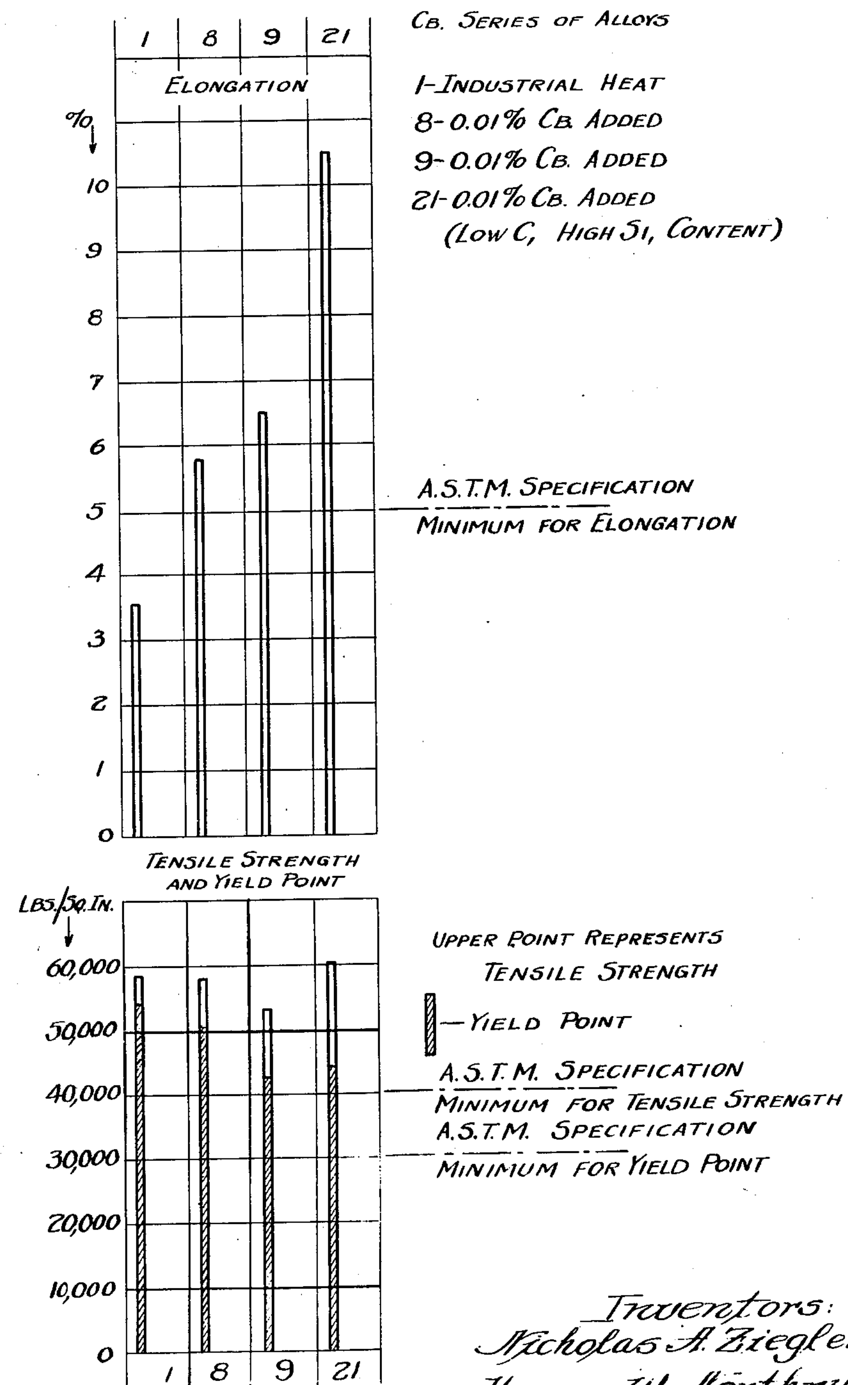

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MALLEABLE CAST IRON

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2 Claims. (Cl. 75—123)

This invention relates to the improvement in the group of alloys suitable for making malleable iron castings, which after being subjected to a suitable malleableizing heat treatment, will possess a tensile strength and yield point in accordance with the highest commercial standards and ductility, expressed in terms of percentage elongation, superior to that found in conventional material not treated in accordance with our invention.

A further object is the acceleration of the annealing rate by the addition of an element which will affect the rate of annealing and at the same time improve the physical properties of the final malleable iron casting.

Another object of the invention is the employment of a control of the annealing practice which will speed up the malleableizing operation so as to bring it into line with modern production advances.

While the iron alloys disclosed herein may be subjected to the customary annealing treatment in order to produce malleable cast iron, the optimum results may be expected only if the alloys of this invention are heat treated according to the established malleableizing practice and method outlined herein.

Malleable iron is first produced as a white iron with practically all its carbon in the combined form. It is rendered soft and ductile by annealing for prolonged periods at temperatures customarily in the neighborhood of 1560–1850 degrees Fahrenheit to cause the undissolved combined carbon or iron carbide to change to graphite; then follows cooling to a temperature in the vicinity of the critical range. The final product sought is a micro-structure consisting of rounded particles of temper carbon (graphite) embedded in a soft iron matrix.

The annealing process is by far the most time-consuming and therefore the most costly operation in the production of malleable iron castings, and consequently many attempts have been made to reduce the time required for the annealing cycle without sacrificing the traditional quality of fully annealed malleable iron, namely, good machinability, ductility, tensile strength and characteristic shock resistance.

The present invention contemplates the production of a high-quality malleable cast iron by the addition of small amounts of columbium to obstruct the formation of flake graphite in the white iron, and by employing an annealing cycle less time-consuming than the prior-art processes.

It is well known that silicon (as well as other "graphite formers" like copper or nickel) promotes the formation of graphite. This is equally ture regarding the formation of (1) flake graphite during the solidification period, resulting in a product known as "gray iron," and (2) "temper carbon" during the "annealing" or "malleableizing" of originally white iron, resulting in a product known as "malleable iron." It is equally well known that manganese (as well as other "carbide formers" like chromium, molybdenum, tungsten, etc.) acts in exactly opposite direction, i. e. retards the formation of graphite and promotes the formation of "combined carbon" or carbide. In the art of manufacturing malleable castings it thus becomes necessary to balance silicon and manganese so that upon solidification no free or flake graphite would be formed and all carbon would be present in combined form as carbides. At the same time these carbides should be sufficiently unstable so that upon reheating to the malleableizing temperatures they would break up or graphitize into temper carbon in reasonably short time periods. Thus it is always desirable to have in the malleable iron as much silicon as is permissible without developing flake graphite in the original (white) castings during the solidification period. It has been shown by various investigators that silicon greatly accelerates the malleableizing process (formation of temper carbon) by increasing the number of temper-graphite particles per unit volume, thereby reducing the distance the carbon has to diffuse before precipitating as graphite. It also has been shown that the malleableizing rate is accelerated not only by the ease of graphite nucleus formation and the mobility of the carbon atom, but is also influenced by the relative stability of the original combined carbon (carbides). In other words, it is desirable to add to the molten white iron a suitable element which would stabilize and promote formation of combined carbon (carbides) upon solidification, but, at the same time, during the malleableizing heat treatment, would not interfere with (and preferably would promote) breaking up of these carbides and formation of temper carbon. An outstanding example of an element which functions in this manner is tellurium.

We have discovered that by the introduction of up to 0.5% of columbium into the molten metal, the annealing process will be accelerated and the formation of temper carbon facilitated. As an indication of the favorable effect upon the physical properties of the product expressed in positive terms let us consider the results obtained with regard to per cent elongation.

It is well known that in malleable iron the desired ductility, expressed as elongation, is a more difficult property to develop than the tensile strength or the yield point. We have found that adding small but effective amounts of columbium to white iron considerably improves the ductility of the metal after the malleableizing annealing and also allows a simplified and shortened malleableizing treatment to be employed.

A series of experimental melts were prepared to which were added the specified amounts of columbium. Several test bars were taken from each heat and subjected to a certain malleableizing heat treating cycle, after which the test bars were subjected to the standard tensile tests. In each group of test bars thus treated, two test bars made of ordinary commercial cupola white iron, malleableized together with the former—the test data presented here are taken from only one representative cycle.

The program of this run was: heated to 1800° F. in 6 hours; held at 1800° F. for 12 hours; cooled to 1500° F. in 2 hours, held at 1500° F. for 4 hours, cooled to 1380° F. in 2 hours; held at 1380° F. for 4 hours; cooled to 1300° F. in one hour; held at 1300° F. for 4 hours; cooled to 1250° F. in one hour; held at 1250° F. for 4 hours; cooled to 600° F. with the furnace and air cooled to room temperature.

Table 1 gives the compositions of the test bars and the results of the standard tests of the bars thus prepared and treated, together with the same data for the industrial heat of ordinary commercial cupola malleable iron. The accompanying drawing is a graphic representation of the data presented in the table.

Table 1

Composition No.	Heat No.	Nominal chemical analysis						Physical properties			Remarks
		Si	Mn	S	P	T. C.	Added element Cb	Tensile strength	Yield point	Elongation	
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Lbs./sq. in.*	*Lbs./sq. in.*	*Per cent*	
1	5831	0.91	0.47	0.15	0.17	3.14	--------	57,000 60,800	50,300 56,400	3.0 4.0	Industrial heat.
8	2410	1.12	0.39	0.13	0.14	2.93	0.01	49,700 47,600	38,000 45,500	6.5 5.0	Columbium bearing malleable.
9	2409	1.50	0.42	0.12	0.12	2.70	0.01	53,600 52,800	42,400 43,400	6.5 6.5	
21	2452	1.96	0.47	0.08	0.11	1.92	0.01	60,000 59,400	43,800 45,400	11.0 10.0	Si is higher, C is lower.

iron were included and tested in parallel with the columbium treated irons.

The accompanying drawing shows a superposed chart arrangement in which the minimum specifications of the American Society for Testing Materials (A. S. T. M.) relative to elongation, yield point and tensile strength respectively from top to bottom of the chart are shown in comparison with the physical properties of the novel composition of our invention based upon the tests referred to.

The numerals 1, 3, 9 and 21 in the ordinate of the chart are representative of the various samples of compositions tested, the results of which tests clearly indicate the superiority of the composition of our invention. Explanation is made in the upper right hand corner of the drawing of the treatment or composition of each of the samples.

More specifically, we have discovered the following composition and percentage ranges to be satisfactory:

	Per cent
Silicon	.5 to 2.5
Manganese	.3 to 1.0
Sulphur	.2 maximum
Phosphorus	.4 maximum
Carbon	1.5 to 3.5
Columbium	Trace to .5
Iron	The remainder

Several different heat treating cycles were thus tried, but—in view of the fact that the columbium treated irons inevitably had physical properties superior to those of the ordinary cupola malleable

Referring to Table 1 and the drawing, composition #21, it will be noted that the ductility of composition designated No. 21 as expressed in elongation per cent is superior to the ductility of the other columbium-bearing alloys numbers 8 and 9, the difference being due to a lower carbon per cent. Tensile strength and yield point are also extremely favorable for this alloy.

While we have described our invention in terms of practical embodiments in order that a clear disclosure may be made to those skilled in the art, it will be understood that the scope of our invention is to be limited only as may be required by the state of the art and as defined by the following claims.

We claim:

1. A white cast iron of the character described comprising the following elements as essential constituents in approximately the proportions given: silicon 0.5–2.5%; manganese 0.3–1.0% sulphur 0.2% maximum; phosphorus 0.4% maximum; carbon 1.5–3.5%, and columbium added in proportions of from a trace up to 0.5%, the remainder being substantially iron.

2. A malleableized white cast iron of the character described comprising the following elements as essential constituents in approximately the proportions given: silicon 0.5–2.5%; manganese 0.3–1.0%; sulphur 0.2% maximum; phosphorus 0.4% maximum; carbon 1.5–3.5%, and columbium added in proportions of from a trace up to 0.5%, the remainder being substantially iron.

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