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PROCESS FOR PRODUCING CAST IRON CASTINGS

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Our invention relates to the process of melting steel scrap, cast iron and pig iron in such quantities as to control the solidity penetrating power during the process of solidification so as to produce sound dense iron castings uniformly solid through all sections and having related physical properties, and to the casting produced by the process.

In the production of foundry castings it is a desideratum to obtain castings having physical properties and matrix structures best suited to the type of service in which the castings are to be used. The physical properties and matrix structures of castings are the important factors in the ability of the castings to meet the particular requirements of the use to which the castings are put.

There have been many approaches to the problem of obtaining desired physical properties and matrix structures in iron castings, some of which are successful to a limited degree. However, all of the known methods have a lack of uniformity and inherent limitations on the certainties of results.

In the ordinary method of making gray cast iron or semi-steel castings, certain mixtures of pig iron, scrap and/or steel are used to obtain in the finished casting a certain predetermined chemical composition, total carbon, silicon, manganese, sulphur and phosphorus. By adjusting this analysis, the resulting product has certain physical characteristics which identifies it as conforming to some recognized physical property specification.

A typical one is A. S. T. M. specifications A126–30:

Tensile strength minimum, 30,000 lbs. p. s. i.
Transverse load minimum, 3,300 lbs. on a 1.2 inch bar broken over 120 inch centers with a minimum deflection of .12 inch.
Chemical analysis, maximum .12 sulphur and maximum .75 phosphorus.

The result of this method of operation is to produce an iron which meets the physical property specification requirements on the standard A. F. A. arbitration bar or the A. S. T. M. test bar, yet the castings produced may still be rejected because of porosity or shrink defects when two or more sections conjoin; or the metal itself may lack closeness of grain and fail under pressure test or on machining may display structural weakness as is commonly revealed on machining the teeth of a gear blank, for example.

The remedy for these defects is sometimes sought in changing the chemical composition, or in the addition of special metals such as nickel, chrome, molybdenum, or copper, or a combination of these metals, but even so, trouble with leakers and open texture and mechanical weakness on change of section may still be evident.

In other words, the properties of the test bar do not tell whether the casting itself will be solid or acceptable, nor does an acceptable chemical specification assure a sound casting.

To eliminate such defects and to assure the production of castings that are sound and solid in all their sections, the applicants have discovered that chemical analysis of itself is of secondary consideration and is not a definite criterion of either the physical properties or of the solidity of any casting, but rather that the physical constitution of the iron, i. e., the arrangement of the structural components, one with another, is the determining factor. Our invention deals with physical constitutional control and enables us to manufacture an iron to some predetermined austenite content at the solidus, whose latent heat value of carbides on passing from the liquid to the solid condition is held within specific limits.

It is an object of our invention to provide an accurate method of producing castings having a relation of structural components to assure accurately controlled physical properties, solidity, and matrix structure.

Another object is the elimination of defects common to conjoining sections of iron castings.

Another object is the provision for accurately forecasting definite properties in relation to section of casting.

Another object is to control the solidity penetrating power of a given cast iron.

Another object is the provision for controlling the latent heat values of an iron on solidification.

Another object is to adjust the rate of recarbonization for castings of predetermined requirements.

Another object is a two-step process of making cast irons, comprising as a first step selecting a mixture of raw materials which when melted will yield a structural constitution having a direct relation with the carbide balance as measured by the quantity of free cementite present, and as a second step decomposing the free cementite so that the final structure consists of free carbon in a wholly pearlite matrix.

Another object is to provide for the relation of carbide balance in an iron of given physical constitution to a given section of casting.

Another object is to provide for the relation of carbide balance to section to effect better machinability in combination with the maximum physical properties in any given section.

Another object is to govern the structural constitution through the nature of the raw material making up the furnace charge.

Another object is to provide for and control the latent heat value of the molten iron.

Another object is the provision for inhibiting the formation of free ferrite which may otherwise form under the processes utilized in ordinary practice.

Another object of our invention is the provision of an iron casting in the "as cast" state having a solidity penetrating power such as gives solid castings of any dimension.

Other objects and a fuller understanding of our invention will become apparent from the following description and the claims herein.

How the process is applied in practice to assure the production of castings of uniform structure and properties, is illustrated by the following examples:

No. 1 assumes an iron made from a mixture comprising 70 per cent steel scrap, 20 per cent returned scrap, and 10 per cent pig iron, and

No. 2 assumes an iron made up approximately of 40 per cent steel scrap, 40 per cent returned scrap, and 20 per cent pig iron.

The chemical analysis of the resulting iron from each may or may not be exactly the same. This is not of prime importance. In each case, the mixture charged in the cupola is calculated to a given specific heat value at the solidus temperature of approximately 2150° F. which on cooling to room temperature, will result in a given amount of free cementite, which is the first step of our process.

Having obtained the correct amount of free cementite, the second step of our process consists of decomposing the excess cementite to assure that only a pearlitic matrix results, containing no free cementite or free ferrite, and yields uniformly solid homogeneous castings of maximum physical properties with free machining qualities.

As pointed out hereinbefore, we have found that the chemical analysis is not of itself a definite criterion of either the physical properties or of the solidity of a casting. This may be explained with reference to the following tests. Two mixtures of irons of approximately the same chemical analysis, pouring temperature, etc., were melted in the same cupola, with the same type of coke and under similar conditions of control.

The mixtures and the results are given below:

IRON NO. 1

Mixture:	Pounds
Pig iron	100
Silvery pig	80
Spiegel	5
Steel scrap	700
Returned scrap	115

Analysis

Total carbon	3.13
Silicon	1.53
Manganese	.63
Phosphorus	.14
Sulphur	.091

IRON NO. 2

Mixture:	Pounds
Pig iron	200
Silvery pig	---
Spiegel	---
Steel scrap	400
Returned scrap	400

Analysis

Total carbon	3.14
Silicon	1.54
Manganese	.61
Phosphorus	.15
Sulphur	.092

When these were poured into test bars of varying sizes molded from the same pattern, the following test results were obtained:

IRON NO. 1

Bar diameter	Tensile p. s. i.
1.013	49,700
.894	49,800
.765	51,200
.645	52,500
.525	54,800
.400	58,900

IRON NO. 2

Bar diameter	Tensile p. s. i.
1.035	40,700
.926	41,900
.804	40,100
.670	41,300
.532	47,500
.405	48,800

From these results it will be observed the chemical analysis is not the prime controlling factor of either the constitution or physical properties of the finished casting.

When Iron No. 1 was poured into a 4-inch or thicker casting, it was found to be uniformly solid and exhibited the same graphite structure from the edge to the center.

When Iron No. 2 was poured into castings 1-inch or even 2-inches thick, it was found to give uniformly solid castings but when it was poured into 4-inch thick castings, it was found that the graphite structure was larger in the center than in the outer zones and also that in the center of the casting, there was a patch of open texture material which had a low strength. When Iron No. 1 was poured into the same casting, that is, a 4-inch thick casting, substantially the same tensile strength was uniformly obtained throughout all sections, whereas in the case of Iron No. 2 when poured in the 4-inch thick casting, the tensile strength in the center of the section fell to less than half of that indicated by the 1.2 inch A. S. T. M. test bar.

This is what is meant by solidity penetrating power; Iron No. 1 was solid all the way through; Iron No. 2 was not.

Iron No. 1 may be seen to have the property of solidifying uniformly throughout all sections of reasonably proportioned castings, while Iron No. 2 is only capable of yielding uniformly solid castings to a thickness of approximately 2 inches.

Ordinary common gray iron such as is used in the average foundry, comprising a mixture of 40 per cent pig iron and 60 per cent scrap, would only give a solid casting to a depth approximating one inch.

For many years, this problem and its solution has baffled the foundry industry. Some claim a charcoal pig iron, or the use of specially slow melted high graphitic pig iron because of its improved fluidity results in a graphite nucleation which will correct the defect. Others endeavor to change the composition of the iron by adding alloys or by using mechanical chillers or casting in specially designed molds, etc.—all of which at the best, are but palliatives and have many definite limitations in their application to commercial manufacture of castings, including dependability of product, consistency of result and price.

Since shrinks are voids left between the dendrites after the eutectic liquid has drained out to make up for the liquid shrinkage in adjacent but cooler sections, the finer the dendritic pattern and the smaller the interstices between the crystals, the less likely the draining of the eutectic from one area to another. Instead of then having, as is so common with ordinary gray cast iron, a comparatively large porous section which in castings of heavy or varying sections means mechanical weakness and leakage if used under pressure, we have a large number of minute voids uniformly distributed but not interconnected, and which permit uniform solidification conditions throughout the whole mass.

This might be illustrated by pouring a casting of wedge form. The knife edge cools instantaneously while the heavy section cools much more slowly, and the result is a varying texture in the casting, from the knife edge to the center, and often a shrink spot in the center. The wedge-shaped casting has an acute angle, defining a knife edge, ranging from approximately 20 to 30 degrees.

If this wedge is poured with Iron No. 1, the depth of penetration of the cementitic carbide is much greater than in the case of gray cast iron, and the center of the mass is free from structural weakness.

If, however, the casting were poured with a high carbide value, the chances are it would not be machinable and may display hard white edges and free cementite. However, by decomposing this cementite to graphite and pearlite such that the final structure consists of free graphite or carbon in a substantially wholly pearlitic matrix, we reproduce an iron whose chilling value is the same as the gray iron above, yet at the same time produces a much more dense and refined structure, and which on pouring into the casting, is uniformly solid throughout.

In our invention the constitution of the metal is established according to the thickness and design of the casting. The establishment of the constitution of the metal may be explained by comparing two mixtures designated "A" and "B," each containing the same elements of charge and resulting in the same analysis but having a different recarbonization rate which affect the constitution of the melt.

A

75% steel
25% return scrap
Silicon and manganese
Briquettes to give a calculated chemical content of:

Total carbon	1.12
Silicon	1.50
Manganese	1.00
Phosphorus	.12

B

65% steel
35% return scrap
Silicon and manganese
Briquettes to give a calculated chemical content of:

Total carbon	1.53
Silicon	1.50
Manganese	1.00
Phosphorus	.12

On melting these two mixtures the chemical analysis of the resulting product was:

Total carbon	3.08
Silicon	1.46
Manganese	.89
Phosphorus	.120
Total carbon	3.08
Silicon	1.46
Manganese	.88
Phosphorus	.128

Thus the "A" mixture has a recarbonization value of 1.96% which is obtained by subtracting 1.12 total carbon in the mixture prior to melting from 3.08 total carbon for the mixture after melting, while the "B" mixture has a recarbonization value of 1.55% which is obtained by subtracting 1.53 total carbon for the mixture before melting from 3.08 total carbon for the mixture after melting. The constitution of the "A" iron measured in a wedge test of standard size was $2\frac{1}{32}$ while the constitution of the "B" iron measured by the same standard wedge test was $1\frac{1}{32}$. The wedge test comprises the pouring of a casting of a pre-determined length and of wedge form in cross-section with an acute angle of approximately 20 to 30 degrees. The wedges may be of several sizes, namely, one-half inch base with approximately 28.5° acute angle, three-fourths inch base with approximately 26.75° acute angle, one inch base with approximately 25° acute angle, and two inch base with approximately 23.5° acute angle. After the wedge casting is poured and cooled, it is broken in two so that the carbide balance may be observed. Upon observation one can discern that the acute angle portion has a white appearance while the remaining base portion has a gray appearance. In the white portion, the carbon is generally in combined form, and in the gray portion the free carbon is generally in graphite form. The white portion is unmachinable. The width across the face of the wedge at the line of demarcation between the white and the gray portion is a measure of the constitution of the iron. Thus, in the example of the "A" iron above, the wedge measured $2\frac{1}{32}$ inch across the face thereof at the line of demarcation. The wedge sizes are so proportioned that the distance across any one of the wedges at the line of demarcation is substantially the same for the metal having the same carbide balance. In other words, the constitution of the iron as measured by the wedge test is the same regardless of the particular size of standardized wedge used to make the test. The distance across the face of the wedge at the line of the demarcation between the white and the gray iron is sometimes referred to as the constitutional carbide wedge values, or more preferably as constitutional wedge values. The line of demarcation between the white and the gray iron as measured by the wedge test is also a measurement or indication of the sensitivity to chilling from the molten condition.

The two iron mixtures "A" and "B" when

graphitized to a 7/32 wedge show the following physical properties when poured into ¼-inch sections, the sections being poured with the graphitized "A" mixture being designated as "Iron No. A" and the section being poured with the graphitized "B" mixture being designated as "Iron No. B":

Iron No. A	*Iron No. B*
58,800 tensile (p. s. i.)	47,850 tensile (p. s. i.)

The graphitizing of the mixture may be done by any well known method and may comprise the mixing of graphitizing agents with the molten metal as it flows from the cupola or in the ladle and prior to the time the molten metal is poured into the molds. The graphitized metal when poured into a casting of wedge form shows a new or different line of demarcation between the white iron and the gray iron, in that the line of demarcation is shifted toward the knife edge of the wedge. Thus, when a mixture is said to be graphitized to a 7/32 wedge, it means that the distance across the face of the wedge at the line of demarcation is 7/32 of an inch and is, in simple terms, referred to as a 7/32 wedge. Technically, the distance across the face of the wedge at the new line of demarcation is referred to as processed carbide wedge value or processed wedge value as distinguished from constitutional wedge value. The distance at the new line of demarcation or the processed wedge value is a measurement or indication of the sensitivity to chilling from the molten condition and bears a direct ratio to the thickness of the casting to be made. It is to be noted that the ratio of the constitutional wedge (21/32) to the processed wedge (7/32) in the "A" iron is in the ratio of 3 to 1 while the ratio of the constitutional wedge (14/32) to the processed wedge (7/32) in the "B" iron is in the ratio of 2 to 1.

It has been found that when the ratio of constitutional wedge to the processed wedge is greater than 2.0 to 1, the physical properties of the resultant metal when poured in any section casting is always greater than when the ratio is less than 2.0 to 1; and that the physical properties of the metal are predicated on the relationship existing between the constitution of the melt recarbonization values of the mixture, and graphitization related to sections poured.

This is due to the factors in solidification wherein a higher quantity of primary austenite is formed before eutectic composition is reached resulting in a finer dendritic pattern. This factor controls the latent heat value in solidification, and irons made by the methods established herein result in iron solidifying at a substantially higher rate than that of ordinary cast iron, thus insuring a finer dendritic pattern and a deeper depth of solidity penetrating power.

Thus, by the process of controlling the quantity of primary austenite during the process of solidification and decomposing the resulting cementite formed at the main solidus point, we have, therefore, increased the speed of solidification and refined the crystal grain to such an extent that we are able to balance structure solidity and physical properties in such a manner as has hitherto been considered impossible.

As the specification of castings decrease in physical properties, the rate of recarbonization may also decrease and the ratio of constitutional wedge to the process wedge values may also decrease; however, for the purpose of solidity, density and correct crystal structure in conjoining sections, the ratios established later in this specification may be used.

Inasmuch as the determination of the constitution of the metal may be obtained by the wedge method, we have found that there is a direct relation between the constitution of the metal and the section to be made, and that there is a minimum value necessary in each casting to assure a uniformly solid section. The proper constitution of the metal having been obtained, the next step is to insure the proper decomposition to eliminate the free cementite which serves no other purpose than that of establishing a certain minimum latent heat value thus causing the molten iron to pass from the liquid to the solid condition in a minimum critical period of time. It must be pointed out that each step in this invention has a definite relation to the other and differs only according to the original constitution established as necessary for uniform solidity in a given thickness or design of casting. The following table is representative for two irons of different constitutional value:

Type of iron	Constitutional carbide values				Recarbonization value
	1-inch	2-inch	3-inch	4-inch (or larger)	
					Per cent
No. 1	13/32	18/32	29/32	24/32–54/32	2.50 to 1.50
No. 2	9/32	14/32	18/32	29/32–43/32	1.50 to 0.50

The above constitutional carbide values are now graphitized with any of the well-known graphitizers to a processed carbide value approximately as follows:

Type of iron	Processed carbide values				Resultant tensile
	1-inch	2-inch	3-inch	4-inch (or larger)	
					P. s. i.
No. 1	9/32	9/32	13/32	14/32–29/32	Approx. 48,000
No. 2	3/32	9/32	9/32	19/32–15/32	Approx. 40,000

The values given above are typical relations as will assure dense, solid, fine grained castings of definite physical properties which are fully machinable and having an all pearlitic structure.

It is to be observed that for a certain section to be made, a pre-determined process wedge value as measured by the remaining carbide at the tip of the wedge is required, and we find, for machinable castings, that the processed wedge value should not substantially exceed, as a maximum limit, a value greater than one-third the thickness of the casting to be made; and should not be substantially below, as a minimum limit, a value less than one-tenth of the thickness of the casting to be made for sections up to substantially one and one-half inch thick, and less than one-twelfth of the thickness of the casting to be made for sections ranging from substantially one and one-half inch thick to substantially four inches thick, and less than one-sixteenth of the thickness of the castings to be made for sections more than substantially four inches thick.

In explaining the above table of figures, let it be assumed in the operation of a foundry that the operator desires to pour a section or a casting one inch thick having a resultant tensile strength of approximately forty-eight thousand pounds p. s. i. The first step is to charge the cupola with a mixture having a recarbonization value ranging from

2.50% to 1.50% which gives a constitutional carbide value of substantially 12/32. In practice, this range of recarbonization values is preferably obtained by employing a 60% to 80% steel mix. After the constitutional carbide value of 12/32 is obtained, the next step is to graphitize the molten metal as it flows from the cupola or in the ladle to the processed carbide value of substantially 8/32. By maintaining the constitutional carbide value by recarbonization and the processed carbide value by graphitization as set forth in this example, the iron when molded into a one-inch section would have a resultant tensile strength of approximately forty-eight thousand pounds p. s. i.

When pouring uncommonly heavy sections in the foundry, the correct constitutional carbide values are sometimes obtained by raising the recarbonization value higher than given in the table above. As an illustration, it is necessary to have a recarbonization value of 2.50% to 3.00% when dealing with sections of 12 inches and up.

Although we have described our invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of the process, modification in the steps undertaken, variations in the materials used, and different values of wedges establishing carbide balance, may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

We claim as our invention:

1. A process for making cast iron castings, comprising selecting and melting a mixture of ferrous materials to give a constitutional carbide wedge value embraced within a range having a minimum value of more than one-sixth the average section of the casting to be made and a maximum value of less than two and one-half times the maximum processed carbide wedge values hereinafter specified, and graphitizing the molten metal to a processed carbide wedge value embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of said processed carbide range being greater than one to ten for castings up to substantially one and one-half inches thick, and being greater than one to twelve for castings ranging from substantially one and one-half inches to substantially four inches thick, and greater than one to sixteen for castings more than substantially four inches thick, said ratio at maximum values of the said processed carbide range to the thickness of the casting to be made being not greater than one to three.

2. The method of making cast iron castings, comprising the selection of a mixture of ferrous materials of a recarbonization value of substantially 2.50% to 1.50%, melting this mixture to give a constitutional carbide wedge value embraced in a range having a minimum value of at least substantially 12/32 for castings substantially one inch thick, 18/32 for castings substantially two inches thick, 20/32 for castings substantially three inches thick, and 24/32 to 54/32 for castings substantially four inches thick or thicker, and graphitizing the molten metal to a processed carbide wedge value embraced in a range having maximum values not greater than one-third the thickness of the casting to be made and minimum values of at least substantially 9/32 for castings substantially one inch thick, 8/32 for castings substantially two inches thick, 12/32 for castings substantially three inches thick, and 14/32 to 20/32 for castings substantially four inches thick or thicker, the maximum of the constitutional carbide wedge values being less than two and one-half the maximum processed carbide wedge values hereinabove defined.

3. The method of making cast iron castings, comprising the selection of a mixture of ferrous materials of a recarbonization value of substantially 1.50% to 0.50%, melting this mixture to give a constitutional carbide wedge value embraced in a range having a minimum value of at least substantially 8/32 for castings substantially one inch thick, 14/32 for castings substantially two inches thick, 18/32 for castings substantially three inches thick, and 20/32 to 43/32 for castings substantially four inches thick or thicker, and graphitizing the molten metal to a processed carbide wedge value embraced in a range having maximum values not greater than one-third the thickness of the casting to be made and minimum values of at least substantially 8/32 for castings substantially one inch thick, 8/32 for castings substantially two inches thick, 8/32 for castings substantially three inches thick, and 10/32 to 18/32 for castings substantially four inches thick or thicker, the maximum of the constitutional carbide range values being less than two and one-half times the maximum processed carbide wedge values hereinabove defined.

4. The method of making cast iron castings, comprising the melting of selected mixtures of ferrous materials to give a constitutional carbide wedge value embraced in a range having minimum values substantially 8/32 for castings of substantially one inch thick, 14/32 for castings substantially two inches thick, 18/32 for castings substantially three inches thick, and 20/32 to 43/32 for castings substantially four inches thick or thicker, and graphitizing the molten metal to a processed carbide wedge value embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of said processed carbide range being greater than one to ten for castings up to substantially one and one-half inch thick, and being greater than one to twelve for castings ranging from substantially one and one-half inches to substantially four inches thick, and greater than one to sixteen for castings more than substantially four inches thick, said ratio at maximum values of the said processed carbide range to the thickness of the casting to be made being not greater than one to three, the maximum of the constitutional carbide range values being less than two and one half times the maximum processed carbide wedge values hereinabove specified.

5. A process for making cast iron castings, comprising selecting and melting a mixture of ferrous material to give a constitutional carbide wedge value embraced within a range having a minimum value of more than one-sixth the average section of the casting to be made and a maximum value of less than two and one-half times the maximum processed carbide wedge values hereinafter specified, and graphitizing the molten metal to a processed carbide wedge value embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of said processed carbide range being greater than one to ten for castings up to substantially one and one-half inches thick, said ratio at maximum values of the said processed carbide range to the thickness of the castings to be made being not greater than one to three.

6. A process for making cast iron castings, comprising selecting and melting a mixture of ferrous materials to give a constitutional carbide wedge value embraced within a range having a minimum value of more than one-sixth the average section of the casting to be made and a maximum value of less than two and one-half times the maximum processed carbide wedge values hereinafter specified, and graphitizing the molten metal to a processed carbide wedge value embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of said processed carbide range being greater than one to twelve for castings ranging from substantially one and one-half inches to substantially four inches thick, said ratio at maximum values of the said processed carbide range to the thickness of the castings to be made being not greater than one to three.

7. A process for making cast iron castings, comprising selecting and melting a mixture of ferrous materials to give a constitutional carbide wedge value embraced within a range having a minimum value of more than one-sixth the average section of the casting to be made and a maximum value of less than two and one-half times the maximum processed carbide wedge values hereinafter specified, and graphitizing the molten metal to a processed carbide wedge value embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of said processed carbide range being greater than one to sixteen for castings more than substantially four inches thick, said ratio at maximum values of the said processed carbide range to the thickness of the casting to be made being not greater than one to three.

8. A process to give positive control of the physical properties in a ferrous casting, comprising selecting and melting a mixture of ferrous materials whereby the molten material, when cast in a standard wedge testpiece as described in the specification, and then broken in two, exhibits upon the broken faces both grey and white iron with a line of demarcation therebetween of such a length as to be embraced within a range having a minimum value of more than one sixth the average section of the castings to be made, and graphitizing the molten material whereby the graphitized molten material, when cast in a standard wedge test piece as described in the specification, and then broken in two, exhibits upon the broken faces a larger amount of grey iron and a smaller amount of white iron with a new and shorter line of demarcation than that exhibited on the first mentioned test piece, said new line of demarcation being of such length as to be embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of the range for the new line of demarcation being greater than one to ten for castings up to substantially one and one-half inches thick, said ratio at maximum values of the range for the new line of demarcation to the thickness of the castings to be made being not greater than one to three, the maximum value of the range for the first mentioned line of demarcation being less than two and one-half times the maximum length of the second line of demarcation.

9. A process to give positive control of the physical properties in a ferrous casting, comprising selecting and melting a mixture of ferrous materials whereby the molten material, when cast in a standard wedge test piece as described in the specification, and then broken in two, exhibits upon the broken faces both grey and white iron with a line of demarcation therebetween of such a length as to be embraced within a range having a minimum value of more than one sixth the average section of the castings to be made, and graphitizing the molten material whereby the graphitized molten material, when cast in a standard wedge test piece as described in the specification, and then broken in two, exhibits upon the broken faces a larger amount of grey iron and a smaller amount of white iron with a new and shorter line of demarcation than that exhibited on the first mentioned test piece, said new line of demarcation being of such a length as to be embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of the range for the new line of demarcation being greater than one to twelve for the castings ranging from substantially one and one-half inches to substantially four inches thick, said ratio at maximum values of the range for the new line of demarcation to the thickness of the castings to be made being not greater than one to three, the maximum value of the range for the first mentioned line of demarcation being less than two and one-half times the maximum length of the second line of demarcation.

10. A process to give positive control of the physical properties in a ferrous casting, comprising selecting and melting a mixture of ferrous materials whereby the molten material, when cast in a standard wedge test piece as described in the specification, and then broken in two, exhibits upon the broken faces both grey and white iron with a line of demarcation therebetween of such a length as to be embraced within a range having a minimum value of more than one sixth the average section of the castings to be made, and graphitizing the molten material whereby the graphitized molten material, when cast in a standard wedge test piece as described in the specification, and then broken in two, exhibits upon the broken faces a larger amount of grey iron and a smaller amount of white iron with a new and shorter line of demarcation than that exhibited on the first mentioned test piece, said new line of demarcation being of such a length as to be embraced within a range which bears a direct ratio to the thickness of the casting to be made, said ratio at minimum values of the range for the new line of demarcation being greater than one to sixteen for castings more than substantially four inches thick, said ratio at maximum values of the range for the new line of demarcation to the thickness of the castings to be made being not greater than one to three, the maximum value of the range for the first mentioned line of demarcation being less than two and one-half times the maximum length of the second line of demarcation.

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