June 29, 1926. 1,590,739

G. S. EVANS

PURIFICATION OF IRON

Filed April 10, 1925

Fig. 2.

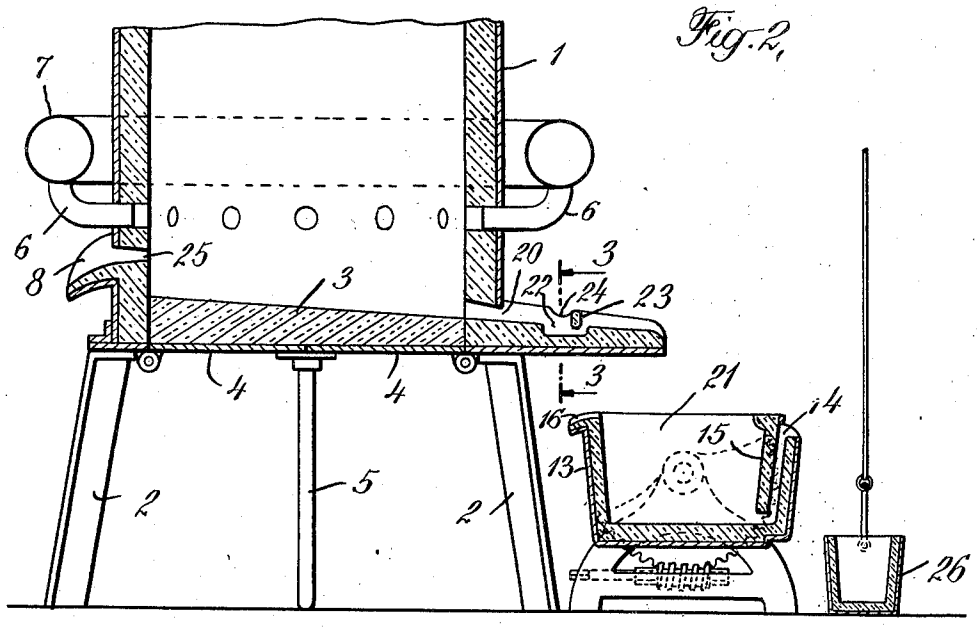


Fig. 1

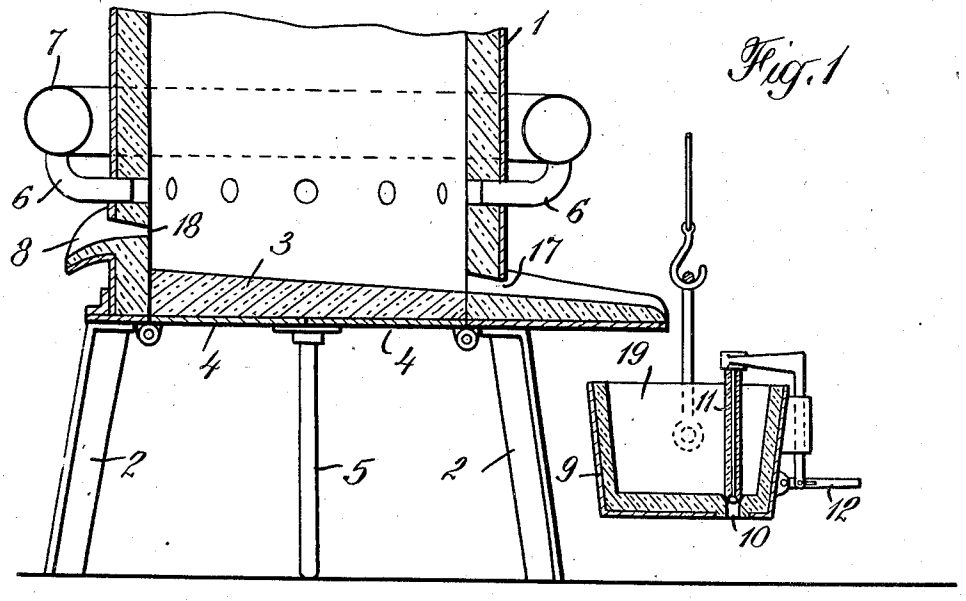
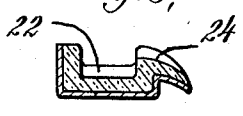


Fig. 3.



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UNITED STATES PATENT OFFICE.

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PURIFICATION OF IRON.

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This invention relates to improvements in the refining of cast iron. The invention relates more particularly to the refining of molten iron for the production of chilled iron castings such as car wheels, but the invention is of value and application in connection with the refining of cast iron generally where high grade castings are required. In my prior application filed April 23, 1924, Serial No. 708,410, I have described an improved method of refining molten cast iron with alkaline reagents, such as soda ash or mixtures of soda ash with materials such as calcium carbonate, and, in one aspect, the present invention relates to further improvements upon the method described in this prior application.

Various proposals have been made for refining molten cast iron as it comes from the cupola or other melting furnace and before it is cast, but the methods hitherto proposed have involved the refining of individual batches or ladles of molten iron as a whole, the entire batch or ladle then being cast, successive batches or ladles being treated with fresh refining material. In the processes of such prior proposals, the removal from each batch or ladle of the slag formed is usually important, and it is common in the case of such processes to provide for the addition of other materials such as limestone or sand together with the refining material to thicken up the resultant slag, so that it can more readily be removed after completion of the refining operation or so that it can more easily be kept back while castings are poured. There are several disadvantages incident to such processes. For example, it has usually been necessary in the practice of such processes to employ an excessive amount of refining material to remove a given quantity of sulfur or otherwise to refine the metal, and the excess of refining material has frequently had an adverse effect upon other elements which are contained in the iron and which it is undesirable to remove, such as silicon and manganese. Variations incident to such batch refining operations have also tended to produce erratic casting results due to variations in the composition of the treated product. Such operations also have involved delays in holding up the batch or ladle of iron being treated for the refining operation to be completed, interfering with foundry routine and also unnecessarily cooling the molten metal, sometimes below the desirable casting temperature, particularly for pouring light castings. The complete removal of the slag formed in such processes is also difficult, and in the case of highly alkaline slags is dangerous due to spattering of the slag which is very corrosive to the skin of workers. Incomplete removal of the slag, moreover, results in the possibility of pouring some slag with the molten iron which destroys the molds resulting in bad castings. Where materials are used to thicken up the slag which is formed, they have an objectionable cooling effect and frequently reduce the efficiency of the refining material. In the production of cast iron of high quality, and particularly in the case of specification work where rigid standards must be met, chemical composition of the iron and physical structure of the castings are important both from the standpoint of absolute analysis and physical properties and from the standpoint of uniformity. The sulfur content and the degree of deoxidation, for example, vary considerably in ordinary cupola or melting furnace practice, and the batch by batch or ladle by ladle refining processes of previous proposals are not adapted to correct these conditions with the production of a uniformly high grade product.

This invention provides an improved method of refining molten cast iron as it comes from the cupola or other melting furnace without application of extraneous heat which overcomes or reduces the disadvantages incident to methods heretofore available and which has particularly the important advantage of enabling the production of a more uniform cast iron throughout prolonged periods of operation providing a uniform metal for pouring. This invention provides an improved method of desulfurizing molten cast iron, and the refining method of the present invention is also useful in deoxidizing the molten iron as well as in removing impurities such as oxides and occluded or entrained slag particles and gases which tend to produce defective castings. The method of this inventon, moreover, is readily employed in conjunction with ordinary foundry operations without extensive modification of equipment and without interfering with the normal routine of foundry operations. Other features and

advantages of the invention will appear as the description proceeds.

According to the present invention, the molten iron is subjected to the action of an alkaline refining agent during its passage from the cupola or melting furnace to the mold. A pool of molten cast iron is maintained in a suitable mixing reservoir or bull ladle and molten iron is supplied to this pool from the cupola or melting furnace and refined iron is withdrawn from this pool for pouring as required in the foundry operation, and the refining operation is carried out upon this pool of molten cast iron. This pool of molten iron, upon which the refining operation is carried out, is relatively large with reference to the amounts of iron added to and withdrawn therefrom, and the additions and withdrawals of molten iron from the pool are correlated to maintain the pool during the entire period of operation or heat. The refining operation is carried out by an alkaline slag bath which is maintained in contact with the molten iron in the pool. The refining slag is maintained active by the addition, as required, of fresh quantities of alkaline refining material. The impurities removed from the iron accumulate in the slag and excess slag may be removed during the operation. The addition of fresh alkaline refining material to the slag may be periodic, as may be the withdrawal of molten iron from the pool and the removal of excess slag. The withdrawal of molten iron from the pool for pouring, for example, may be in batches amounting to somewhat less than 20 or 30% of the then contents of the pool. The additions of fresh material to the slag and the removals of excess slag, for example, may be in the neighborhood of 10% of the slag body or somewhat more. Molten iron from the cupola or melting furnace may be supplied to the pool either in a more or less continuous manner or in periodic batches. Molten iron for pouring is withdrawn from the pool below the slag level to separate the iron and slag and to avoid contamination of the withdrawn metal with slag.

The alkaline refining material employed, according to the present invention, is fused soda ash (commercial sodium carbonate) or an equivalent soda ash reagent. The soda ash refining material may be employed in admixture with limestone, dolomite or the like. Other alkaline chemicals or earths, such as potash, calcium oxide, barium or magnesium carbonates and various mixtures and proportions of these reagents are also useful in carrying out the invention. The refining material, if a mixture, is advantageously prepared by thoroughly mixing the dry ingredients in the powdered form, after which the mixture is fused together and cast into briquettes, or sintered into lump form, or briquetted under pressure, to prevent the loss of material as dust and to prevent any injurious effects upon the health and comfort of workers during the carrying out of the process. Single refining reagents may similarly, with advantage, be fused and cast or pressed into briquettes or sintered into lump form. The refining material is employed in such proportions as are required to effect the maximum reduction of sulfur and entrained slag particles per unit of reagent with a minimum injurious effect upon the other elements usually found in the cast iron and upon the lining of the ladle or reservoir in which the process is carried out.

In carrying out the present invention, accordingly, a molten pool of cast iron is maintained, to which molten iron is supplied and from which refined iron is withdrawn as required, and an alkaline refining slag is maintained on the pool of molten iron, fresh alkaline refining material being added to the slag and excess slag being removed from time to time as necessary. Close control over the content of sulfur, silicon, manganese, carbon and other elements contained in the cast iron, which is essential to the proper regulation of the physical properties of the finished castings, is provided by the improved refining operation, and uniformity is promoted by carrying out the refining operation upon a pool which is maintained throughout the period of operation. Variations in constitution of the molten iron supplied to the pool are, to a large extent, overcome in the pool by admixture of the unrefined molten iron with the relatively large amount of molten iron in the pool as it is supplied to the pool. The pool thus acts to equalize variations in the constitution of molten iron supplied to the pool. The maintenance of the slag body on the pool of molten iron with progressive replacement by increments also promotes a more uniform refining operation by assisting in maintaining a more uniform slag composition. The maintenance of the pool of molten iron also assists in maintaining correct temperature conditions, the uniform temperature conditions obtained in carrying out the invention being of special value in insuring correct pouring temperature. The maintenance of the pool of molten iron also provides a supply of molten iron for pouring which is not cut off or interrupted by the refining operation but which is always available for pouring in the regular routine of foundry operation. The equalizing effect of the pool of molten iron as employed in the refining operation of this invention, moreover, makes it possible to correct changes in the composition of the molten iron supplied from the cupola or melting furnace by appropriate changes in the composition of the cupola charge, or by ladle additions, without losing

in production the metal already melted or melted in the interim. The correct balance between the different elements in the treated or processed metal to give the desired physical properties in the finished castings may thus be controlled and maintained. The slag body maintained on the pool of molten iron also assists in distributing fresh refining material as it is added in contact with the molten iron and makes for more effective use of the refining material. The maintenance of the pool of molten iron and the slag body in contact with each other also provides for prolonged contact between the molten iron and the refining slag, further promoting the effectiveness of the refining material.

The invention will be further described in connection with the accompanying drawings, which illustrate in a diagrammatic and conventional manner apparatus adapted for carrying the process of the invention into practical effect. It will be understood that the apparatus illustrated in the drawings is chosen for the purposes of illustration as representing types of apparatus in which the invention may be carried out but that the invention is not limited to operations carried out in the specific types of apparatus shown.

In the drawings—

Fig. 1 is a vertical sectional view through the lower portion of a cupola shown together with a mixing reservoir or bull ladle.

Fig. 2 is a view similar to Fig. 1 showing the lower portion of a modified type of cupola shown together with a different type of mixing reservoir or bull ladle and with a pouring ladle, and

Fig. 3 is a section on line 3—3 of Fig. 2 showing a detail of the cupola spout.

The cupolas illustrated in both figures of the drawings are in general of the usual construction and operation, and comprise a refractor lined shell 1 supported on legs 2, the furnace bottom 3, also refractory lined, being supported on doors 4 held closed by support 5. A number of tuyères 6 are arranged opening into the furnace at some distance above the bottom and are connected to a common blast pipe 7. A slag spout 8, is also provided opening into the furnace a short distance below the tuyères. Two general methods of carrying out the process of the invention will be described in connection with the apparatus illustrated, that is either with continuous tapping of the molten iron from the cupola or with removal of the molten iron from the cupola periodically with separation of the cupola slag in the cupola proper. For convenience, the first of these two methods will be described as carried out in apparatus as illustrated in Fig. 2 and the second as carried out in the apparatus as illustrated in Fig. 1. Different types of mixing or refining ladles are also shown in the two figures, but it will be apparent that the use of a particular type of refining ladle is not essential to either way of carrying out the process. It is, however, advantageous to employ certain types of ladles as will be pointed out in the following description. The bull ladle illustrated in Fig. 1 is of the bottom pouring type, and comprises a refractory lined shell 9 provided with a pouring nozzle 10 arranged in the bottom, a stopper of refractory material 11 operated by means of lever 12 and seating on the pouring nozzle being arranged to control the discharge of molten metal from the ladle. The bull ladle illustrated in Fig. 2 is of the teapot type and is provided with a pouring spout adapted to separate molten metal from the refining slag in the ladle, the spout being arranged to pour metal from the lower part of the pool in the ladle. This ladle comprises a refractory lined shell 13 mounted on trunnions and provided with tilting means. A pouring spout 14 divided from the interior of the ladle by a refractory slag bridge 15 is arranged opening into the bottom of the ladle, and a draining spout 16 for the discharge of slag is arranged in the opposite side of the ladle.

Referring to Fig. 1, in one way of carrying out the invention, the tapping hole 17 is stopped up with plastic clay in the ordinary way and the molten iron together with the slag resulting from the coke ash and other impurities in the iron gradually rise in the cupola, the slag being lighter remaining on the top surface so that when it reaches the level of the cupola slag hole 18 it drains off. The tapping hole 17 is then opened and the metal is allowed to flow into the bull ladle 19. The molten iron is thus withdrawn from the cupola in periodic batches. As soon as the molten iron begins to flow into the bull ladle, the refining agent is dumped into the cupola spout and washed down into the mixing ladle, or it may be dumped directly into the refining ladle. Initially, a sufficient quantity of refining material is added to form a covering bath over the surface of the metal, for example of a depth of about 1 inch, and this initial quantity is usually from 2 to 5 times more per ton than is used throughout the remainder of the heat thereafter. This large amount of refining material supplied at the start assists in promoting the desired reaction at the beginning of the operation and assists in maintaining a uniform composition of refined metal throughout the heat. The initial amount of refining material supplied may, for example, be about 10 to 15 lbs. based on the soda ash reagent content of the refining material, per ton capacity of the bull ladle. With a cupola or melting furnace melting about 15 tons per hour, the refining ladle may have a capacity in the neighborhood of

10 tons or somewhat more. The addition of refining material to the iron flowing through the cupola spout has the advantage of drying off any surface moisture and preventing the possibilty of an explosion in the refining ladle. After all of the molten iron has flowed from the cupola and the slag begins to show the tapping hole 17 is again stopped and the cupola is allowed to fill up until the impurities are again drained off through the slag spout 18, when the operation is repeated. After the initial operation, however, about 1/3 or a less quantity of the amount of refining agent initially employed is added per ton of metal, for example, subsequent additions of the refining agent may approximate 3 lbs. per ton of metal or somewhat more. The fresh refining material mixes with the slag containing partially spent material remaining on the pool of iron in the ladle and the fresh batches of hot molten iron mix with the refined iron which is held in the ladle. Refined iron is withdrawn from the ladle through the pouring nozzle 10 as required for pouring castings. After the slag bath on the surface of the pool of molten iron in the refining ladle increases from 2 to 4 fold, a portion of the slag is drawn off, but leaving a sufficient amount of slag to provide a sufficient bath to properly carry out the operation on subsequent additions of metal. In short heats, using small quantities of refining materials, the slag may be allowed to accumulate throughout the entire heat and the entire slag mass may be removed at the conclusion of the heat.

Another, and more advantageous way to carry out the invention, is with continuous tapping of the molten metal from the cupola into the refining reservoir or ladle. With continuous tapping, hotter metal is available because the cupola is kept clear of slag so that the coke bed below the tuyère level is kept alive by the blast and is available for heating the drop of molten iron as it flows over the coke in its passage to the hearth. A fuel saving may also be effected by lowering the tuyère level. The continuous addition of molten iron as melted to the pool in the mixing reservoir also results in a more uniform temperature and composition of the iron as poured and avoids rapid changes that sometimes develop between cupola taps in the case of intermittent tapping. Referring to Fig. 2, in this way of carrying out the invention, the molten metal is withdrawn more or less continuously from the cupola through the tapping hole 20 as it is melted, and the slag and impurities resulting from the melting process in the cupola are removed by skimming them off as the metal flows from the cupola into the mixing ladle 21. For this purpose, a slag spout is provided, the metal flowing through the trap 22 under the slag bridge 23 and slag being removed through spout 24. In carrying out the process in this way, the tapping hole 20 is initially stopped up and the molten iron is allowed to accumulate in the cupola until it approaches the slag hole 25, after which the tapping hole is opened and the metal is allowed to flow continuously thereafter throughout the length of the heat, passing through the slag trap under the bridge. The refining material is either dumped into the spout beyond the bridge and allowed to flow into the refining ladle with the molten iron or the refining material may be dumped into the ladle directly. As previously described, a greater quantity of refining material per ton of metal is employed on the start than is used thereafter. After all of the initially collected molten iron has run from the cupola, slag begins to come off with the stream of iron and is skimmed off while the molten iron continues to pass through the slag trap and into the refining ladle at a more or less uniform rate per hour. The refining material may be added either to the molten iron flowing through the spout and allowed to be washed down into the ladle or dumped into the ladle every 5 to 20 minutes throughout the remainder of the heat or as may be found to give the most uniform results. Initially, sufficient molten metal is run into the bull ladle before the addition of refining material to seal up the opening to the ladle spout in order to prevent the refining material from passing into the spout, and afterwards sufficient molten metal is held in the ladle to keep the full ladle spout sealed. Slag is withdrawn from the bull ladle illustrated by tipping the ladle backwards and pouring the excess slag off through the spout 16. The refined iron is drawn off through the ladle spout into the pouring ladle 26 as required for pouring and without particular regard to the refining operation, the slag bath being held back by the refractory bridge 15. The hot molten iron fresh from the cupola, together with additional quantities of fresh refining material in small increments are thus continuously mixing with the cooler and refined pool of iron in the ladle and with the slag bath containing partially spent reagent on the pool of iron in the ladle. The maintenance of a more or less uniform composition of metal as well as the maintenance of a more or less uniform temperature throughout the entire heat is thus promoted.

In the refining ladle, in either method of operation, the refining slag is kept in contact with the pool of molten metal. The reaction causes agitation, and the movement of the highly fluid alkaline slag bath and of the molten metal rapidly brings practically the entire pool of molten iron into contact with the active reagents in the refining slag bath. The alkaline slag employed accord-

ing to the present invention, has a very low specific gravity, even lower than ordinary cupola slag, so that the slag does not penetrate the bath of molten iron to any substantial extent. The slag is also very fluid. The low specific gravity and the high fluidity of the refining slag assists in preventing any possibility of the slag or refining material being absorbed or entrained in the iron and carried into the molds. While the reaction goes on only at the surface of the pool, the movement of the mass is so rapid that repeated tests of samples taken at the same time from the surface and the bottom of a 10 ton refining ladle show no appreciable difference in chemical composition. The slag bath covering the surface of the pool of molten metal in the refining reservoir is also highly refractive and assists in preventing losses of heat from the pool of molten metal by radiation.

One of the important advantages of the present invention is the uniformity as to constitution, temperature and supply of molten cast iron which it makes available. One of the principal difficulties previously encountered in the refining of cast iron has been the non-uniformity of the metal as supplied from the cupola or melting furnace or from batch refining operations, and this invention is well adapted to overcome difficulties of this nature. Another important advantage of the present invention is that it makes it possible to use a larger percentage of scrap iron in the cupola or melting furnace charge with a saving in mixture cost and at the same time obtaining a more uniform metal with lower foundry losses. This invention also makes possible the use of lower grade scrap, e. g. scrap of excessively high sulfur content, which is now lost to the industry.

The entire chilled iron wheel industry, is based upon what is known as the chilling quality of molten cast iron of certain compositions when cast against a chiller. This property varies with the composition and physical condition of the iron and it is necessary to hold the metal within very close limits to insure satisfactory results. In producing chilled iron wheels in ordinary foundry practice this characteristic of chilling quality is followed, or controlled, by chill test ingots which are cast about every 20 to 30 wheels poured. Mixture changes in the cupola or melting furnace charge, or additions of corrective alloys to the ladle, are then made as required to hold the chill within the proper range throughout the heat. It has been found in the commercial application of this invention over a period of a year that the chill test ingots, or control tests, run more uniform, that is they stay within a narrower range of chill where the continuous refining and mixing process of this invention is employed than is the case where molten iron from similar charge mixtures are cast without refinement. As an illustration, the following log of a typical heat covering approximately 300 standard railway chilled iron wheels is given. Each test was taken every 30 wheels. The first table shows the actual chill test of the control ingots from a heat cast under the ordinary practice, and the second table shows the same from a heat wherein the refining process of the present invention was used.

Log of unrefined heat.

Test ingot No.	1	2	3	4	5	6	7	8	9	10
Chill in inches	1.50	1.55	1.60	1.55	1.50	1.40	1.35	1.40	1.35	1.35

Log of refined heat.

Test ingot No.	1	2	3	4	5	6	7	8	9	10
Chill in inches	1.60	1.50	1.45	1.50	1.55	1.55	1.50	1.45	1.45	1.50

It will be noted that the extreme variation in the tests of the untreated heat is 0.25 inches in depth of chill as compared to an extreme variation of .15 inch for the refined heat. The chill on test ingots is a comparative indication of the chill on the finished wheel. The wearing quality, or life, as well as the strength, of the finished wheel also varies with the chill and it is therefore important to keep this factor reasonably constant. Specifications covering wheels for use on the American Railway Association Lines cover rather close chill limits in the tread of the wheels and where the test ingots vary much from the regular standards it is often necessary to reject wheels either for too low or for too high chill. This forms a considerable burden upon the chilled wheel industry, particularly when foundries are operating under stress of output and when it is impossible to secure the usual high grade of coke necessary for the manufacture of specification castings.

In the usual foundry practice, several wheels are poured between the time of actual taking of the control test and its examination, the lapsed time being required for the test ingot to properly cool, and it often happens that wheels are lost, due to change in composition of the metal before it can be corrected by ladle additions of ferro alloys after seeing the test ingot, thus resulting in an expense both for wheels lost and for the high priced alloys added. The use of the present process in one instance showed a reduction in losses on account of defects chargeable to such metal conditions of 39% for 9 months practical operation as compared to the operations before the present process was employed.

In addition to the removal of sulfur,

metalloids, occluded slag particles, and gases which tend to produce segregation and otherwise produce defective castings, the processed metal will generally show more uniform composition, as illustrated in the following table, which is a log of a regular chilled iron wheel heat, showing analyses of samples taken of the molten iron before and after the refining treatment.

	% Silicon.		% Manganese.		% Combined carbon.		% Sulfur.	
	Before refining.	After refining.	Before refining.	After refining.	Before refining.	After refining.	Before refining.	After refining.
Sample No. 1	.70	.70	.72	.66	.86	.80	.187	.137
2	.77	.71	.82	.70	.76	.78	.178	.134
3	.75	.70	.80	.70	.75	.83	.180	.130
4	.72	.70	.64	.66	.77	.77	.202	.138
5	.71	.70	.63	.69	.82	.78	.200	.135
6	.75	.67	.73	.66	.80	.80	.199	.139
7	.80	.70	.80	.66	.84	.82	.200	.141
8	.75	.72	.89	.68	.81	.81	.195	.142
Average samples	.74	.70	.75	.68	.80	.80	.193	.137
1-8 points variation	.10	.05	.26	.04	.11	.06	.024	.012

Uniformity of composition is the prime essential to uniform castings and particularly so as to uniform chilled cast wheels where the elements silicon, manganese, and carbon are required to be held in very close limits in order properly to control the chill, shrinkage and strength of the finished wheel; and it is borne out by a practical use of the process, covering the production of over 1,000,000 wheels, that greater uniformity and generally better castings are obtained from the refined metal. The refined metal shows a more uniform physical structure with less tendency to segregation of impurities due both to the removal of the loosely held impurities and probably to thorough deoxidation of the metal.

The refining process also appears to break up the larger graphite flakes and results in a generally denser structure in the castings. For example, 36 test bars each of untreated and treated iron were broken on a testing machine and the fracture of each bar was closely inspected for any minute defects showing up on microscopic examination, and it was found that 48% of bars from the untreated iron showed some minor defects as against only 16.7% of bars from the treated iron. The comparative strength and hardness of the above mentioned bars, a representative average of 36 in each case, is shown in the following table.

	Transverse strength lbs. per sq. in.	Deflection inches.	Ultimate tensile strength # pr. sq. in.	Shore hardness.
Ordinary cast iron	4353	.189	31843	28
Refined cast iron	4410	.214	32437	26

It will be noted that the refined iron is materially softer resulting in 10 to 20% greater machineability, which, together with greater density, constitutes a very desirable advantage, particularly where density is of importance. The increased bending power and the greater elongation before rupture of the refined cast iron are of particular importance in the wheel industry where these properties largely determine the strength of the finished wheel and its ability to withstand the strains of railway service.

The final effects of the treatment upon the wearing quality of chilled iron, which of course is the fact governing the life of chilled iron wheels in service, can only be determined through observation of a large number of wheels over a period of years, since the life of the average chilled iron wheel varies from 3 to 5 years. However, it is believed that the lower sulfur, and particularly the removal of occluded slag particles which with the sulfur tend to segregate in the casting, will have a tendency to prevent what is commonly termed "shell-outs" in the wheel industry or breaking down of the chill in spots in the tread of the wheel as sometimes occurs in service. It is also impracticable to determine whether the chill from a thoroughly refined iron has a greater density, however, it has been found that thoroughly deoxidized iron has a less tendency to malleableize or soften upon annealing, and it is believed that this will result in an ultimately harder or tougher chill. High sulfur is usually accompanied with high combined carbon, and the combination of these two cause brittleness in the cast iron, and this is another undesirable condition which the process of the present invention tends to reduce, insuring in the wheel industry against failures under the stress of railway service shocks.

The following instance will illustrate another advantage of the present invention as actually obtained in wheel foundry practice. In the refining of cast iron having a sulfur content of .20%, the sulfur content was reduced to .137% with the use of approximately 5 lbs. of refining material per ton of metal applied in accordance with the present invention. To obtain a similar reduction in sulfur content of the same metal and using the same refining material, under similar temperature conditions, in the ordinary batch method of treatment, 8¾ lbs. of refining material per ton of metal were required. The process of the invention is also of special advantage for treating cast irons having a sulfur content of .12% or less where it is desired to reduce the sulfur to .05% or less, and in the treatment of such low sulfur irons the process of the invention has been found peculiarly effective.

In carrying out the process of the inven-

tion, the quantity of sulfur, occluded slag particles, gases, etc. which are refined out of the molten metal will depend upon the composition of the metal as it comes from the cupola or melting furnace, its temperature, and the quantity of refining material added per ton of metal, and is under control of the operator at all times. The process of the invention has been worked out in the foundry of one of the larger chilled iron wheel manufacturers, and it has therefore been described particularly as related to this industry. However, the process of the invention is applicable to other branches of the cast iron industry, and is useful wherever high grade castings are desired.

I claim:

1. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, supplying molten iron to the said pool and withdrawing refined iron therefrom, the additions and withdrawals of molten iron being correlated to maintain the said pool, maintainiing an alkaline refining slag on the said pool of molten iron and supplying fresh allkaline refining material to said slag as the operation proceeds.

2. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, supplying molten iron to the said pool and periodically withdrawing refined iron therefrom, the additions and withdrawals of molten iron being correlated to maintain the said pool, maintaining an alkaline refining slag on the said pool of molten iron and periodically supplying fresh alkaline refining material thereto as the operation proceeds.

3. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, continuously supplying molten iron to the said pool, withdrawing refined iron therefrom, the withdrawals of molten iron being correlated with the supply to maintain the said pool, maintaining an alkaline refining slag on the said pool of molten iron and supplying fresh alkaline refining material thereto as the operation proceeds.

4. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, continuously supplying molten iron to the said pool, periodically withdrawing refined iron therefrom, the periodic withdrawals of molten iron being correlated with the supply to maintain the said pool, maintaining an alkaline refining slag on the said pool of molten iron and periodically supplying fresh alkaline refining material thereto as the operation proceeds.

5. An improved process for desulphurizing and refining iron which comprises discharging molten iron from a melting furnace into a non-heated receptacle, maintaining an alkaline refining slag on the molten iron in the said receptacle, supplying fresh alkaline refining material to the said slag as the operation progresses, and periodically withdrawing part of the refined molten iron from the said receptacle, a pool of molten iron being maintained in contact with the refining slag in the said receptacle during the operation.

6. An improved process for desulphurizing and refining iron which comprises discharging molten iron from a melting furnace into a non-heated receptacle, maintaining an alkaline refining slag on the molten iron in the said receptacle, supplying fresh alkaline refining material to the stream of molten iron flowing from the melting furnace to the receptacle as the operation progresses, and periodically withdrawing a part of the refined molten iron from the receptacle, a pool of molten iron being maintained in contact with the refining slag in the said receptacle during the operation.

7. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, supplying molten iron to the said pool and withdrawing refined iron therefrom, the additions and withdrawals of molten iron being correlated to maintain the said pool, maintaining a refining slag containing a soda ash reagent on the said pool of molten iron, and supplying fresh soda ash reagent to the said slag as the operation proceeds.

8. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, continuously supplying molten iron to the said pool, withdrawing refined iron therefrom, the withdrawals of molten iron from the pool being correlated with the supply to maintain the pool, maintainiing a refining slag containing a soda ash reagent on the said pool of molten iron, and supplying fresh soda ash reagent to the slag as the operation proceeds.

9. An improved process for desulphurizing and refining iron which comprises maintaining a molten pool of the iron exteriorly of the melting furnace, continuously supplying molten iron to the said pool and periodically withdrawing refined iron therefrom, the withdrawals of molten iron from the pool being correlated with the supply to maintain the said pool, maintaining a refining slag containing a soda ash reagent on the said pool of molten iron, and peri-

odically supplying fresh soda ash reagent to the said slag during the operation.

10. An improved process for desulphurizing and refining iron which comprises discharging molten iron from a melting furnace into a non-heated receptacle, maintaining a refining slag containing a soda ash reagent on the molten iron in the receptacle, supplying fresh soda ash reagent to the said slag during the operation, and periodically withdrawing a part of the refined molten iron from the receptacle, a pool of molten iron being maintained in contact with the refining slag in the receptacle during the refining operation.

11. An improved process for desulphurizing and refining iron which comprises discharging molten iron from a melting furnace into a non-heated receptacle, maintaining a refining slag containing a soda ash reagent on the molten iron in the receptacle, supplying fresh soda ash reagent to the stream of molten iron flowing from the melting furnace to the receptacle as the operation progresses, and periodically withdrawing a part of the refined molten iron from the receptacle, a pool of molten iron being maintained therein in contact with the refining slag during the operation.

In testimony whereof I affix my signature.

GEORGE S. EVANS.