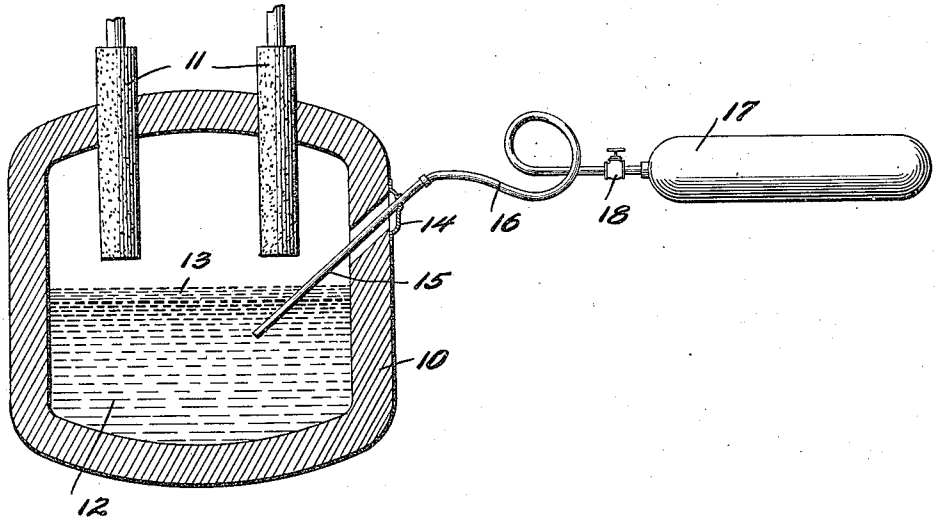
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METHOD OF MANUFACTURING LOW CARBON STEELS

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METHOD OF MANUFACTURING LOW-CARBON STEELS.

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To all whom it may concern:

Be it known that I, HENRY C. BIGGE, a citizen of the United States, and resident of Bethlehem, Lehigh County, State of Pennsylvania, have invented certain new and useful Improvements in Methods of Manufacturing Low-Carbon Steels, of which the following is a specification.

The present invention relates to methods of making low carbon steels containing alloying ingredients, both simple steels containing but small percentages of alloying materials, and alloy steels generally, containing alloying materials in sufficient quantities to modify substantially and positively some of their physical properties.

The percentage of carbon present in steels known as low carbon steels varies with the other ingredients of such steels. Thus a low carbon simple steel has a carbon content of from .01% to .10%. An alloy steel is said to be a low carbon steel when the carbon content varies from .01% to .18% and the carbon content in a high speed steel, which is an alloy steel having tungsten as its principal alloying ingredient, will vary from .10% to .80%. More specifically stated, by high speed steel is meant an alloy steel containing from 13% to 21% of tungsten.

As before stated the improved method may be employed in the manufacture of either simple steels or alloy steels but it is particularly useful in the manufacture of low carbon alloy steels having chromium, vanadium, tungsten, molybdenum, cobalt or uranium added as an alloying element.

The proper incorporation of the alloying elements into the body of the steel in such manner that a thorough intermixture of the alloying elements with the iron takes place has been attended with considerable difficulty. Generally speaking, such steels have been manufactured in electric furnaces and the present invention has particular reference to the manufacture of steels in electric furnaces. Commercially, electric steels are manufactured principally from scrap and it is generally the rule that the percentage of carbon in the scrap is higher than the percentage of carbon desired in the steel to be produced. It frequently occurs that the metal picks up additional carbon during the process of manufacture from the carbon electrodes of the electric furnace. Moreover, the alloying elements added in their commercial forms usually contain carbon such as, for example, ferro-chrome and ferro-vanadium which are frequently used in the manufacture of chrome and vanadium steels and contain carbon respectively to the extent of 2% and 5%. While it is possible to obtain commercial ferro-chrome and ferro-vanadium which have low carbon content these materials are not ordinarily used for the reason that their cost is prohibitive. It is therefore apparent that, in the ordinary manufacture of electric steels, the addition of the alloying elements tends to increase the carbon content of the resulting product. Another manner in which carbon finds its way into the steel is by means of the carbonaceous material, i. e., coal, coke, etc., which is added as a deoxidixing agent during the reducing stage.

It has been heretofore stated that the percentage of carbon in the steel might be reduced by adding to the charge, iron such as double refined iron, Swedish iron, or Bessemer iron containing only a small percentage of carbon, but the inclusion of such iron obviously reduces the percentage of alloying elements and necessitates the addition of such elements at a later time in order to compensate for the losses and to realize the the desired percentage in the finished product. It has also been customary to reduce the percentage of carbon by the addition of iron ore to the bath, however, the combined use of low carbon iron (containing little sulphur or phosporus) and low carbon alloying materials and iron ore has not proven a commercial method for the manufacture of low carbon simple steels and low carbon alloy steels, including high speed steels and tungsten steels generally.

The object of the present invention is to provide a commercial method whereby such steels may be easily and cheaply produced. I have discovered that the various low carbon electric steels described above may be produced commercially in an electric furnace from charges in which the percentage of carbon is relatively much higher than that desired in the finished product, by combining with steps of the process or processes heretofore employed, the novel step which consists in injecting oxygen under pressure into the bath of molten metal. The advantages flowing from this step are twofold, the first being that the carbon is burned out by the oxygen and its percentage rapidly

reduced, and the second being that extremely high temperatures are generated in the bath, far above those which may be obtained by the use of the electric heating arc alone, whereby a much more satisfactory combination of the alloying elements and the molten iron or steel is obtained.

This last mentioned result is particularly to be desired in the manufacture of tungsten steels, considerable difficulty having been experienced in the past in securing the thorough incorporation of the tungsten with the body of the metal, the tungsten having a tendency to segregate and to gather at the bottom of the bath. The high temperatures generated by the injection of oxygen, which are probably due to the actual burning of a portion of the iron and the carbon, are sufficient to effect a very thorough incorporation of the tungsten with the other elements in the bath.

The method may be carried out in apparatus of different kinds and in manufacturing low carbon steels of different compositions and in the following description one form of such apparatus is illustrated by way of example, as well as a complete description given of the method as employed in the production of low carbon simple steel and also as employed in producing an alloy steel, which may be either a high speed steel or a low carbon alloy steel. It will be understood that the method is particularly advantageous where tungsten is utilized as the alloying element but may be used with great efficiency where cobalt, molybdenum or other of the alloying elements are to be utilized.

In the drawing, the electric furnace 10 is shown in cross section, the electrodes being indicated at 11, the bath of molten metal at 12 and the layer of slag floating on the bath at 13. A swinging furnace door is indicated at 14 to normally close an aperture in the furnace and through this aperture may be inserted a metal tube 15 connected by a flexible hose or tube 16 with a tank or reservoir 17 adapted to contain oxygen under pressure. A valve 18 is provided for controlling the flow of oxygen. It will be understood that the tank or reservoir may be permanently mounted on the furnace if desired but preferably is formed separately therefrom and may be placed adjacent the furnace. The tube through which the oxygen passes into the furnace, and the end of which extends into the body of molten metal, is burned away rapidly while the oxygen is being introduced, and tubes of considerable length are therefore used.

In manufacturing a low carbon simple steel, for example, a low carbon manganese steel containing .04% carbon and 1% manganese the process is caried out as follows.

The charge may consist of steel scrap (high in carbon), iron ore and limestone. The charge is melted electrically and tested for carbon. If the percentage of carbon is over .10% further additions of iron ore are made from time to time until the percentage of carbon in the complete bath is approximately .05%. Further additions of iron ore will not reduce the percentage of carbon, and this is accomplished by interjecting oxygen under pressure into the bath in the manner described. The free end of the metal tube is forced through the slag and well into the molten metal. The valve of the container is then opened and the oxygen is permitted to escape from the container into the bath. The extreme end of the tube which is immersed in the bath, melts rapidly and for this reason comparatively long tubes should be used. In a charge approximating 6,500# of metal, I have found 220 cubic feet of oxygen will reduce the carbon content from approximately .05% to approximately .03%. After the percentage of carbon has been reduced by the interjection of oxygen as described above, the slag is removed, a layer of lime is spread over the molten metal and the heat is tapped into a ladle. The necessary additions are then made to give the required manganese content. Such additions will in the average case increase the carbon content from .03% to .04%.

In manufacturing low carbon alloy steels (including low carbon high speed steels and tungsten steels generally) for example, an alloy steel containing carbon in the amount of .35%, the process is carried out in the following manner. The initial charge consists mainly of alloy scrap (which usually contains carbon in excess of .70%) and limestone in the proportion of 97 to 3. After the charge is partially melted, oxygen is introduced into the bath under pressure until the scrap becomes completely molten. A test is then taken from the bath to ascertain the carbon content and if the percentage of carbon is found to be more than .30%, more oxygen is interjected from time to time until the carbon content of the bath is substantially .30%. I have found that the rate of reduction of carbon by the interjection of oxygen is the same as in the case of simple steels and in the case of the alloy steel under consideration, the oxygen should be continued until the percentage of carbon is approximately .30%.

Thereafter the bath is refined or deoxidized as follows: The slag is covered with a layer of pulverized silicon, coal and lime, together with fluor spar in the following percentages by weight of the total charge:

Coal	.08%
Silicon	.06%
Fluor spar	.08%
Lime	1.8 %

The charge is thereafter heated electrically until the slag becomes vitreous, gray in color and shows a tendency to slake when cold. The test after the conclusion of the reducing process will show the metal has increased its percentage of carbon from .30% to .35% due to the addition of the coal. It will be noted that the reduction in per cent of carbon by the use of oxygen is carried to .05 below the percentage desired in the finished product for the reason that approximately this amount is picked up during the refining process.

Due to the fact that the introduction of oxygen results in slight losses of alloying elements and the initial charge may not have contained alloying elements in sufficient proportions, it is necessary to add additional alloying elements in commercial forms and in predetermined quantities determined by the desired final analysis. Such alloying elements should be added after the deoxidation of the bath of metal and slag has been completed and the quantities added should be based on the analysis of the bath at that time. In general, I prefer however, to so gauge the constituents of the charge that it shall be necessary to add only small percentages of alloying elements after the interjection of oxygen, and in the case of high speed steel I so gauge the constituents of the charge as to make it unnecessary to add tungsten after the interjection of oxygen. If the analysis of the initial charge has been such as to indicate to the operator that additional alloying elements must be added in order to give the final analysis desired, then the reduction of carbon by the introduction of oxygen should be carried even further than indicated above and to an extent to compensate for the carbon contained in the commercial form of alloying elements.

While it is true that a certain percentage of the alloying elements are oxidized as a result of the interjection of oxygen according to my improved process, I have found that the cost of the alloying elements actually lost is negligible compared to the cost of production of the alloy steel. This is due to the fact that most of the alloying elements oxidized in the bath are absorbed by the slag and are precipitated back into the bath during the deoxidizing stage.

The two examples above given of ways in which the process may be carried out will enable one skilled in the art to have a complete understanding of the invention and will suggest the procedure to be followed in making any simple or alloy steel desired, which has a low carbon content. Variations from the order of procedure above outlined may be made and the process modified without departing from the spirit and scope of the invention.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. The process of manufacturing low-carbon steel which consists in melting a charge, in reducing the carbon content of the molten bath by the injection of the oxygen thereinto, and then in adding an element to the bath which involves an increase in the carbon content of the metal.

2. The process of manufacturing low-carbon alloy steel which consists in melting a charge, in introducing oxygen into the molten portion of the charge after the latter is partially or wholly melted so as to reduce the carbon content thereof to a point below that of the finished metal, and then in refining or deoxidizing the bath of metal, whereby a low-carbon steel may be produced and the increase in carbon content incident to refining be taken care of by carbon subtraction during the step of oxidation.

3. The process of manufacturing low-carbon steel which consists in introducing a charge of scrap, lime, ore, and alloying element or elements into an electric furnace, in electrically melting the charge, in introducing oxygen into the molten portion of the charge after it is wholly or partially melted to reduce the carbon content thereof and to increase the temperature of the bath, and then in adding material to the slag of the bath having a refining or deoxidizing effect on the latter.

4. The process of manufacturing low-carbon alloy steel which consists in introducing a charge of scrap, lime, ore, and tungsten into an electric furnace, in electrically melting the charge, in introducing oxygen into the charge after it is partially or wholly melted to reduce the carbon content thereof and to increase the temperature of the bath, and then in adding material to the slag of the bath having a deoxidizing effect on the latter.

In testimony whereof I hereunto affix my signature.

HENRY C. BIGGE.