

July 26, 1955

D. W. MURPHY

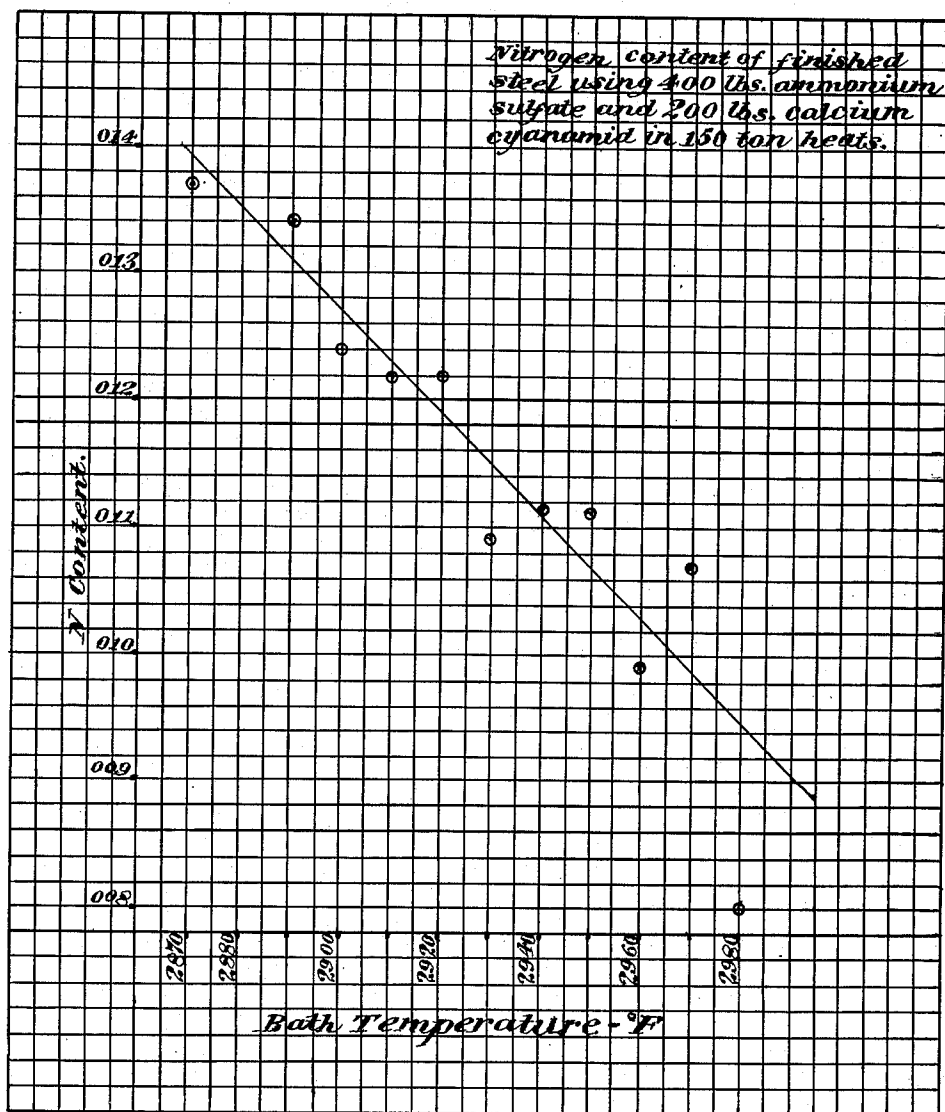
2,714,065

METHOD OF PRODUCING MACHINING STEEL

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3 Sheets-Sheet 1

Fig. 1.



INVENTOR

Donald W. Murphy.

BY *R. S. McLaugherty.*

ATTORNEY

July 26, 1955

D. W. MURPHY

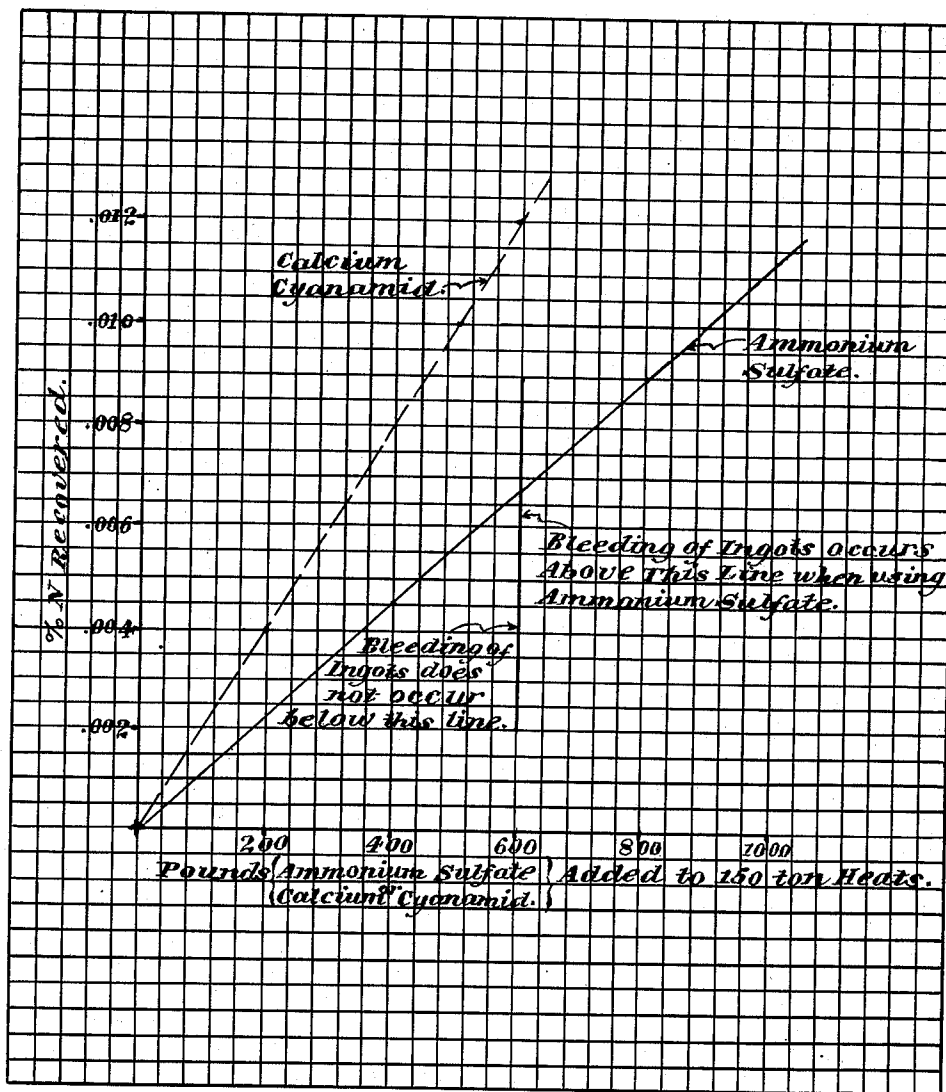
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Fig. 2.



INVENTOR

Donald W. Murphy.

BY *R. S. C. Dougherty.*
ATTORNEY

July 26, 1955

D. W. MURPHY

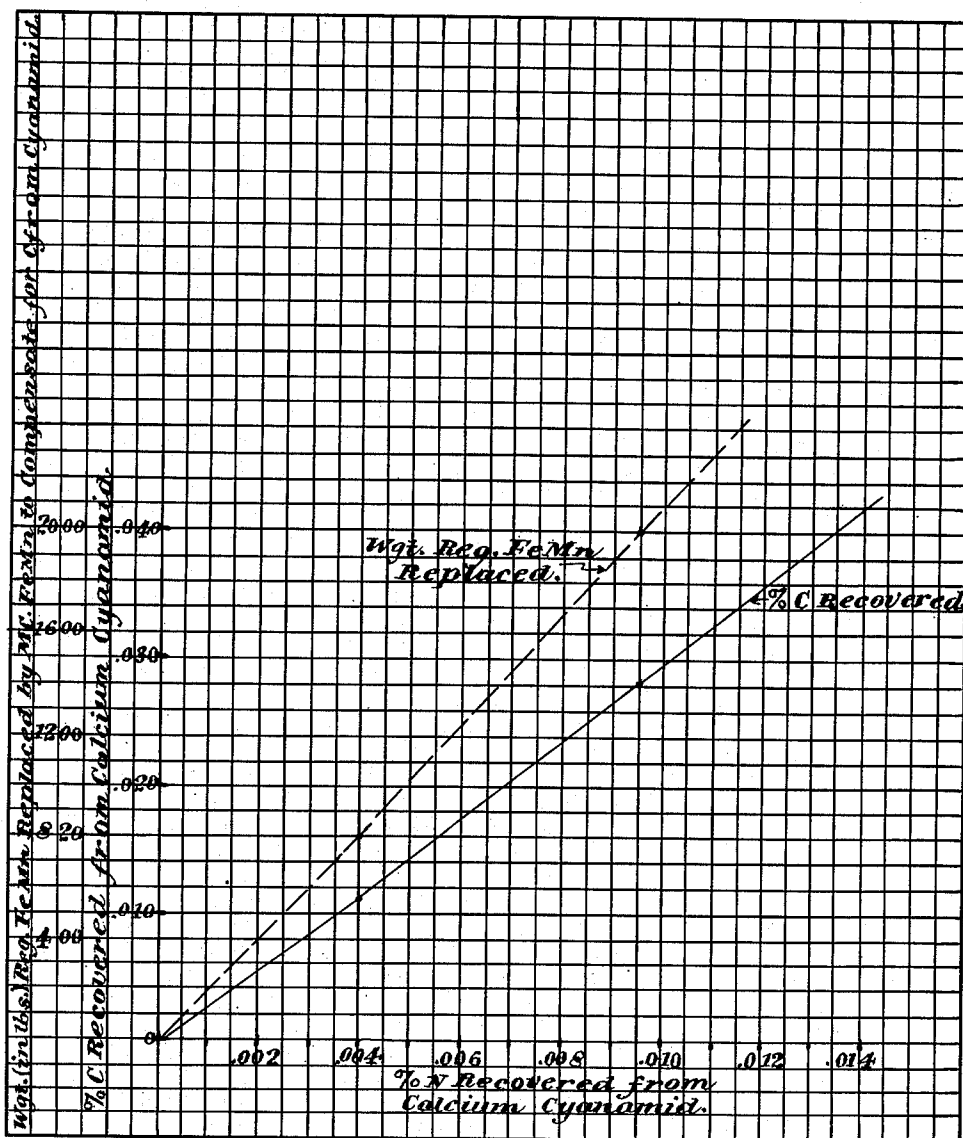
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Fig. 3.



INVENTOR

Donald W. Murphy.

BY *P. S. C. Dougherty.*
ATTORNEY

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METHOD OF PRODUCING MACHINING STEEL

Donald W. Murphy, Bethlehem, Pa., assignor to Bethlehem Steel Company, a corporation of Pennsylvania

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4 Claims. (Cl. 75—129)

This invention relates to improvements in processes of making machining steels.

It is an object of this invention to produce a steel having superior machining properties.

It is a further object of this invention to produce such a superior machining steel in the open hearth furnace.

It is a still further object of this invention to produce a superior machining steel at a cost lower than that of comparable steels heretofore produced.

It is a still further object of this invention to improve the ingot quality and rolling performance of machining steel made in the open hearth furnace.

The foregoing and other objects of my invention will be fully understood from the following description and claims together with the drawings, in which

Fig. 1 is a curve showing the relationship of tapping temperature to nitrogen recovery in the finished steel;

Fig. 2 is a curve showing the relationship between amounts of ammonium sulfate added to a heat of steel and bleeding in the ingots cast therefrom and also showing the nitrogen recovery from additions of calcium cyanamid; and

Fig. 3 is a curve showing the relationship between addition of calcium cyanamid and carbon recovered from such addition.

Steels containing up to .13% C; from .60% to 1.00% Mn; from .070% to .12% P; from .08% to .33% S; and from .010% to .018% N are well known to possess good to excellent machining properties depending upon the sulfur content. Heretofore such compositions have been made by the acid Bessemer process but I now have discovered a practice whereby such steels may be made by other steel-making processes, as for example by the basic open hearth process, with excellent results from the standpoint of machining.

In making these steels I have found it to be highly desirable from the standpoint of machining first to reduce the carbon content of the steel bath before tapping from the furnace to about .35% to .045%. This is preferably done by the use of gaseous oxygen at least during the later stages of making the heat, say from .20% carbon downward. The usual practice of adding ore to the slag results in a consumption of heat from bath and slag whereas by the use of gaseous oxygen heat may actually be gained by metal bath and slag which is highly desirable in the new practice. I have found that it is necessary, in order to secure good machining performance, and to maintain good nitrogen recovery, to have the metal bath at a temperature in the vicinity of 2900° F., as determined by a platinum-platinum rhodium thermocouple, somewhat before the final level of .035% to .045% carbon is attained and to maintain the bath in such a temperature range.

Figure 1 shows the variation of nitrogen content of the finished steel when made with one embodiment of my invention as related to bath temperature at tapping. This particular type of relationship was not expected by theory; in fact one might expect on that basis an im-

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proved efficiency of nitrogen recovery with increasing bath temperature. It is clear from the curve that, in addition to the effect of bath temperature on machining, it is also desirable, in order to maintain consistent nitrogen contents within the desired range in the finished steel, to keep bath temperatures in the range say from 2890° F. to 2930° F.

It is frequently the practice in making steels by, for example, the basic open hearth process, to block further oxidation reactions in the furnace by adding strong deoxidizing materials such as ferrosilicon, silico-manganese, aluminum, etc. just before tapping the heat. With my new practice such a step is unnecessary because at the low carbon level carbon elimination by oxidation is very slow. Furthermore, such a deoxidizing procedure by introducing refractory oxides into the metal bath is highly injurious to the machining qualities of the finished steel. Accordingly by my practice the heat is tapped at a very low carbon content with no addition to the bath in the furnace except ferromanganese if necessary.

In making free machining steels by my practice the most difficult element to introduce is nitrogen which must be raised to at least .010% from the normal content of the bath in the furnace which in the case of the open hearth process varies from about .002% to about .005%. It is well known in the art that nitrogen can be introduced into liquid steel by adding a substance such as ammonia or ammonium sulfate to the ladle during tapping. With such materials when proper amounts of nitrogen have been absorbed by the steel, there is also a considerable absorption of hydrogen by the steel, in fact more than it can retain on freezing. Consequently, when heats of the proper nitrogen content, having been raised to that level by the addition of ammonium sulfate or ammonia or other nitrogen-hydrogen containing material to the ladle or tapping stream, are teemed into ingot molds excessive "bleeding" of the ingot occurs during freezing of the steel. In Fig. 2 this relationship of "bleeding" to amount of ammonium sulfate added and amount of nitrogen recovered is shown in the case of 150 ton heats. It will be understood that different methods of addition may yield different nitrogen recoveries shifting thereby the point at which bleeding occurs. This "bleeding" is caused by hydrogen being rejected by the steel as it freezes, thus forcing metal upward and out of the original ingot. Such "bleeding" can not be stopped by capping materials such as ferrosilicon or aluminum which depend for their action on the fixation of oxygen dissolved in the steel.

It is also well known in the art to add to the ladle or tapping stream a material such as calcium cyanamid to thereby raise the nitrogen content of the steel. Figure 2 shows how nitrogen recovery varies for this material. For such purposes approximately 3 to 4 pounds of cyanamid per ton of steel are required to attain at least .010% nitrogen in the steel and the ingots poured from such steel do not bleed. This introduces the problem of compensating for the carbon picked up from the cyanamid. In meeting a specification of for example .10% C and .85% Mn this compensation takes the form of increased percentages of low or medium carbon ferromanganese compared to regular ferromanganese. In Figure 3 I have shown how the carbon content of the finished steel varies with the amount of nitrogen recovered from calcium cyanamid using the curve for calcium cyanamid additions in Figure 2. Also I have shown in this figure that to compensate for the amount of carbon absorbed from calcium cyanamid, increasing amounts of regular (6.5–7.0% C) ferromanganese must be replaced with the more expensive medium carbon grade (1.0–1.5% C) of ferromanganese accordingly as

it is desired to obtain increasing amounts of nitrogen from calcium cyanamid alone. Such substitution while feasible for most of these free machining grades is costly.

steels are available that the steels made by the new process are superior to the Bessemer steels in rate of production, possible cutting speed and tool life.

TABLE

Comparison of steels made by Bessemer process and by new process as in basic open hearth

Type of Steel	Process	Production Rate, Pieces/hour	Surface Speed, feet/min.	Tool Life Between Grinds, No. Pieces	Finish* Comparison
B1112—.16% to .23% S-----	Bessemer-----	148	185	1,695	50
B1112—.16% to .23% S-----	Open Hearth--	161	200	1,995	42
B1113—.24% to .33% S-----	Bessemer-----	188	245	2,080	25
B1113—.24% to .33% S-----	Open Hearth--	211	260	2,231	26
B1113—Low carbon, .07% C max.; .28% to .33% S-----	Bessemer-----	248	290	1,985	25
B1113—Low carbon, .07% C max.; .28% to .33% S-----	Open Hearth--	248	300	2,360	26

*Finish improves with decreasing numerical value.

To make a heat finishing .07% C maximum it is however impossible to use such quantities of cyanamid as 3 to 4 pounds/ton because the carbon pickup from cyanamid alone is sufficient to exceed the carbon specification.

In meeting this problem of excessive bleeding on the one hand and excessive carbon pickup on the other hand I have devised a practice of combining ammonium sulfate (or its equivalent ammonia) and cyanamid as addition materials for the purpose of attaining at least .010% nitrogen in the finished steel. Such combined additions are apparently more efficient in transferring nitrogen to the steel than either compound alone. In practice I so proportion the relative amounts of say ammonium sulfate and cyanamid as to eliminate bleeding and minimize carbon pickup. As an example for a 150 ton heat, a total of 600 pounds of nitrogen bearing materials is used, yielding on the average a steel containing .011 to .012% nitrogen. Of this total 400 pounds are ammonium sulfate and 200 pounds are cyanamid. With such a combination there is no bleeding of ingots as is found with straight sulfate additions and carbon pickup from cyanamid is restricted to approximately .01% instead of .025% to .030% usually obtained with straight cyanamid additions. By this means I have improved ingot quality and subsequent rolling performance by elimination of ingot bleeding, decreased ingot costs on such free machining grades by eliminating excessive use of low and medium carbon grades of ferromanganese and attained a more consistent and somewhat higher nitrogen content in the steel than was previously possible which is very desirable from the standpoint of machining performance.

In testing a large number of heats made by the regular Bessemer process and by my new process in actual production operations on automatic bar machines the figures quoted in the table are evidence of the superiority of steels made by the new method in this instance in the open hearth as compared to the classic Bessemer steels. It will be noted that in all categories where comparative

I claim:

1. In a process of making machining steel, the step of adding to molten steel in the ladle ammonium sulfate and calcium cyanamid in combined amount sufficient to result in a nitrogen content of at least .010% in the finished steel, the amount of ammonium sulfate added being approximately twice the amount of calcium cyanamid.

2. In a process of making machining steel in the open hearth, the step of incorporating nitrogen into the steel by adding to molten steel in the ladle ammonium sulfate and calcium cyanamid in combined amount sufficient to give the desired content of nitrogen in the finished steel while at the same time avoiding bleeding of the ingots cast from the steel and also avoiding excessive carbon pickup.

3. In a process of making machining steel having a carbon content of not over .13%, the step of incorporating nitrogen into the steel by adding to molten steel in the ladle ammonium sulfate and calcium cyanamid in combined amount sufficient to give the desired content of nitrogen in the finished steel without exceeding said carbon content, while at the same time avoiding bleeding of the ingots cast from said steel.

4. In a process of making machining steel in the open hearth furnace, the step of adding ammonium sulfate and calcium cyanamid to molten steel in the ladle in combined amount sufficient to result in a nitrogen content of at least .010% in the finished steel, the amount of ammonium sulfate added being approximately twice the amount of calcium cyanamid.

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