

Sept. 24, 1957

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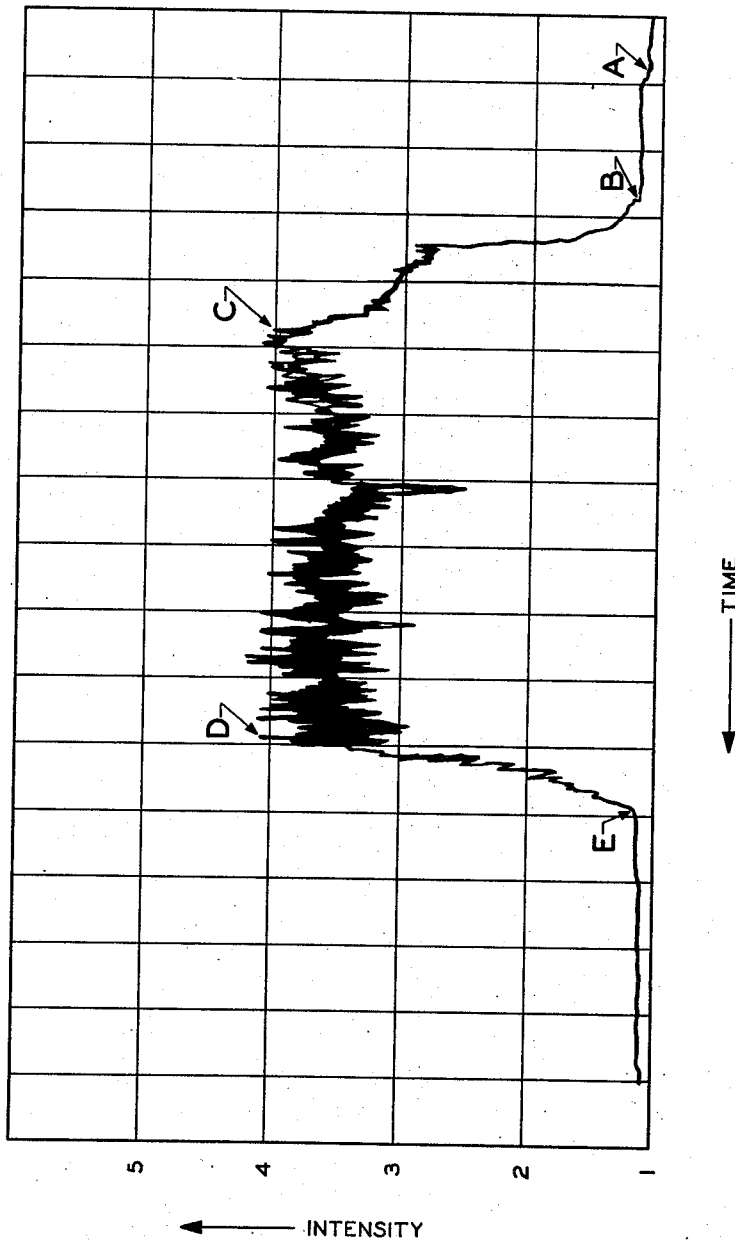
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METHOD OF CONTROLLING THE PARTIAL BLOWING OF BESSEMER STEEL

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Fig. 1.



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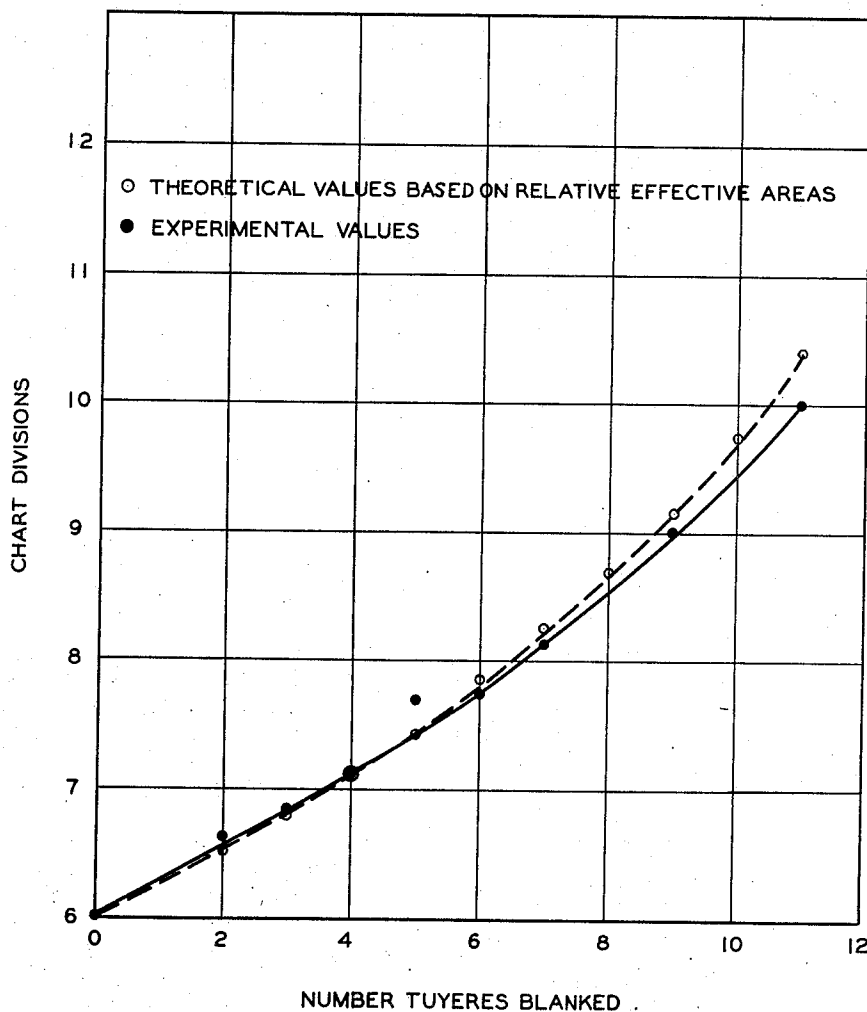
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Fig. 2.

EFFECT OF NUMBER TUYERES BLANKED
ON CARBON PLATEAU



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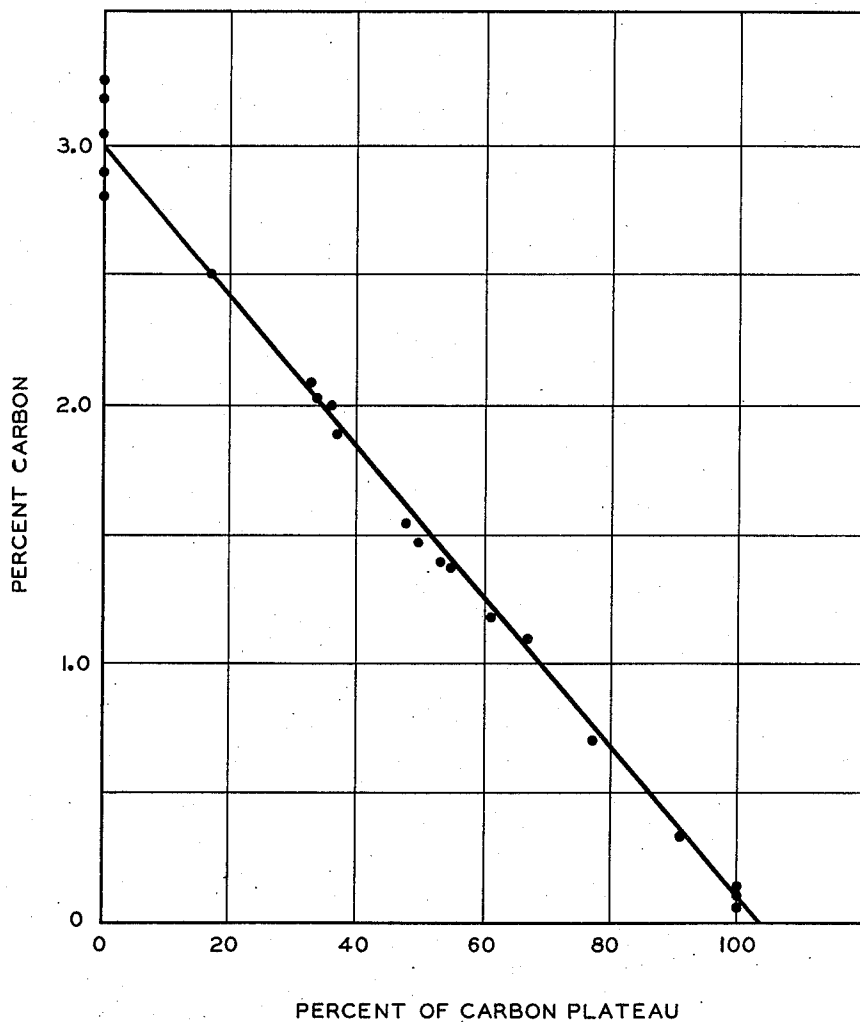
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Fig. 3.

CARBON VALUES DURING CARBON PLATEAU



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METHOD OF CONTROLLING THE PARTIAL
BLOWING OF BESSEMER STEEL

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5 Claims. (Cl. 75—60)

This invention is a method for controlling the partial blowing of Bessemer steel to obtain metal of any required carbon content.

In standard Bessemer converter practice, immediately after the vessel has received the charge of molten metal, the air blast is turned on, and the vessel is racked up to vertical position. The air of the blast is forced upward through the molten mass, and chemical action between the oxygen of the air and the contents of the vessel then begins. The oxidation takes place in successive stages, each of which may be observed visually. In the first stage, a stream of sparks and dense brown fumes, followed by a short dull red flame at the mouth of the vessel, indicates the progressive elimination of the silicon and manganese. In the second stage, the flame increases greatly, both in length and luminosity, and will maintain this magnitude for several minutes while most of the carbon is being removed. Just before the end of the carbon blow, in ordinary practice, the flame begins to drop and becomes less luminous. When the vessel is turned down and the blow is stopped at this point, or shortly thereafter, only very small amounts of carbon, e. g., 0.1 to 0.04 percent, will remain, and it then becomes necessary to add recarburizers and deoxidizers to restore the desired carbon content.

While the theoretical possibility of blowing a heat to approximately any carbon content by stopping the blow at an intermediate point has long been understood, the reactions involved are so rapid that it has been believed that products of uniform chemical composition could only be obtained by blowing to the drop of the flame, as above described, or until substantially all the carbon had been removed.

In such efforts at timed carbon control as have been made, the blower has attempted to control carbon content by regulating the length of the blow from the time the vessel is turned up. This practice will result in variations of as much as 0.5 percent plus or minus in desired carbon, whereas the instant invention permits Bessemer blows to be terminated at any desired carbon level between 3 percent and 0.1 percent within a range of plus or minus 0.15 percent carbon or less. This result of the invention is especially valuable in the so-called duplex process, in which the semi-finished metal is transferred to an open hearth furnace for the completion of the process.

One object of this invention, therefore, is to provide a method for controlling the partial blowing of a Bessemer converter to produce steel of any desired carbon content. Another object is to establish a reference point from which the rate of carbon elimination is linear and a predictable function of time.

Other objects, purposes and advantages will appear hereinafter, in the specification, drawings and claims.

In the annexed three (3) sheets of drawings:

Fig. 1 is a typical curve of radiant energy emission during the blow of a heat, and showing the carbon plateau;

Fig. 2 is a curve showing the effect of the number of

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tuyeres blanked on the duration of the carbon plateau; and

Fig. 3 illustrates the linear elimination of carbon at various percentages of the carbon plateau.

In a typical installation, a photo-electric tube is sighted through a proper frequency band pass filter onto the converter flame. The filter is preferably of the combination glass and liquid type described in my co-pending application Serial No. 143,749, filed February 11, 1950, for Determination of Temperature of Molten Metal, which filter is adapted to transmit only radiation in a wavelength range in which the characteristic radiation of iron is predominant, more specifically in the ultraviolet range between 0.32 and 0.36 micron, in which range I have found that the radiation intensity is uniformly correlated with the temperature of the bath. This tube converts the radiant energy into an electric current which is measured and permanently recorded as a curve on a chart by a high speed recorder. A typical curve is shown in Fig. 1, with the more significant points of change indicated by reference letters. Thus, the blow starts at point A but the oxidation of carbon does not begin until point B is reached. At point C the carbon blow is fully developed. This reference point C marks the start of the "carbon plateau" to be hereinafter discussed, and which extends to the point D. The point E marks the end of the blow.

The "carbon plateau" is the only period during the blow in which the rate of carbon elimination is a predictable function of time (or volume of air). As shown in Fig. 1, the duration of the carbon plateau, or the distance from C to D, is somewhat more than six divisions on the time scale, with each division representing approximately one minute of blowing time, but the carbon plateau period will lengthen proportionately as more and more tuyeres of the particular bottom are blanked out because of wear and breakage.

Since the blast pressure applied to a specific converter is usually a substantially fixed quantity, the real criterion of the length of the carbon plateau will then be the ratio of the effective area of the tuyeres in use to that of the total number of available tuyeres. However, as the exact number of tuyeres in use will always be known to the operator, this provides the most convenient indication of relative areas.

The following table (Table I) embodies the results of observations taken over 425 heats with regard to the influence on length of carbon plateau of the number of tuyeres blanked on a converter having 26 available tuyeres:

Table I.—Influence of number of blanked tuyeres

Number heats	Tuyeres blanked	Ave. chart div.
167	0	6.0
72	2	6.6
60	3	6.8
35	4	7.1
15	5	7.7
49	6	7.75
10	7	8.1
15	9	9.0
2	11	10.0

Fig. 2 represents the above data in curve form. The dotted curve is calculated from the number of tuyeres in use relative to the total number available in a new bottom and is based on an average carbon plateau duration of six time divisions for new bottoms. The solid curve is drawn from experimental values. For all practical purposes, the two curves coincide until more than six tuyeres are blocked off.

The significance of various particular points on the carbon plateau with respect to the carbon content of the

blown metal was definitely established by a series of tests, in each of which the vessel was turned down at some selected point on the carbon plateau and a spoon test, killed with aluminum, was taken by pouring a little metal out of the vessel. The results of such tests taken over a period of three months are shown in the following table (Table II), in which the beginning of the carbon plateau is taken as zero and the termination of the same is 100 percent.

Table II.—Percent carbon during carbon plateau

Percentage of carbon plateau	Percentage of carbon
0	3.05
16.7	2.51
32.2	2.09
33.8	2.03
36.0	2.01
37.8	1.89
48.0	1.65
50.0	1.48
50.0	1.48
53.2	1.42
54.8	1.38
61.0	1.18
66.2	1.09
78.0	.70
91.6	.34
100.0	.14
100.0	.13
100.0	.06

These results are plotted as a function of distance along the carbon plateau in Fig. 3. It is to be noted that the elimination of carbon proceeds linearly with time during the carbon plateau and with remarkable regularity from the beginning at about 3.0 percent carbon to the end at about 0.1 percent carbon. The most critical reference point is the beginning of the carbon plateau.

The following tabulation (Table III) summarizes a typical relationship under normal operating blast pressures (in the neighborhood of 20 pounds per square inch) between number of working tuyeres, length of time in carbon blow, and carbon content of blown metal. This table can be regarded as a working basis for time of turning down the vessel and shutting off the blast in the control method of the present invention.

Table III.—Relationship between number of working tuyeres and length of carbon blow for various finishing carbon contents

Number tuyeres working	Length of C plateau	Indicated point in C plateau at which blown metal contains				
		2.5% C	2.0% C	1.5% C	1.0% C	0.5% C
26	6.0 Div.	1.1 Div.	2.1 Div.	3.1 Div.	4.1 Div.	5.2 Div.
24	6.5	1.2	2.3	3.4	4.5	5.6
22	7.1	1.3	2.5	3.7	4.9	6.2
20	7.75	1.4	2.7	4.0	5.3	6.8
18	8.6	1.5	3.0	4.5	5.9	7.5
16	9.7	1.7	3.4	5.0	6.7	8.4

It is important to note that the instant of full development of the carbon blow (point C, Fig. 1) is independent of calibration, since it is a point on the time scale of the record. Within rather wide limits metal temperature does not affect the position of this point on the time scale, with the exception of those heats which have reached either too low or much too high a temperature during the preceding silicon blow. Since the filter and instruments used will provide very accurate indication of temperature,

however, such conditions are readily corrected by well known means during the progress of the blow.

Although this invention has been described hereinabove in considerable detail, it is not desired to have it limited to the exact and specific particulars stated, but there may also be used such modifications, substitutes or equivalents thereof as are included within the scope and spirit of the invention or pointed out in the appended claims.

What is claimed is:

1. In a method of controlling a Bessemer converter, the steps including applying blast to a bath of molten metal, measuring and recording the radiant energy emitted by the converter flame during the blow of the heat, taken the start of the carbon plateau on the record of such emission as a reference point, continuing to apply the blast and turning down the vessel and shutting off the blast at a predetermined period of time after the occurrence of said reference point to obtain the desired carbon level in the bath.

2. In a method of controlling a Bessemer converter, the steps including applying blast to the bath, measuring and recording the radiant energy emitted by the flame within a frequency band in which the characteristic radiation frequency of iron is predominant, taking the start of the carbon plateau on the record of such emission as a reference point, continuing to apply the blast for a period of time after the occurrence of the reference point determined by the desired carbon content of the finished metal and then turning down the vessel and shutting off the blast.

3. In a method of controlling a Bessemer converter, the steps including applying blast of known characteristics to the bath, measuring and recording the radiant energy emitted from a zone above said bath during the blow, taking the moment when full development of the carbon blow begins as a reference point for the start of the period of linear elimination of carbon, continuing to apply the blast for a period of time after the occurrence of the reference point determined by the amount of the blast and the desired carbon content of the finished metal and turning down the vessel and shutting off the blast when that period of time has elapsed.

4. In a method of controlling the partial blowing of Bessemer steel to any desired carbon content by means of a phototube, the steps including applying air blast to the bath, recording the radiant energy from the converter flame intercepted by the phototube, taking the beginning of the carbon plateau as a reference point, and turning down the vessel and stopping the blow when the elapsed time after the occurrence of the reference point indicates that the desired carbon content of the metal in the converter has been reached.

5. In a method of controlling the partial blowing of Bessemer steel to any desired carbon content by photoelectric means, the steps including applying air blast to the bath, recording the radiant energy from the converter flame incident upon the photoelectric means, taking the beginning of the carbon plateau as a reference point, and turning down the vessel and stopping the blow when the desired carbon content of the metal in the converter has been reached as determined by reference to said reference point.

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