

July 30, 1957

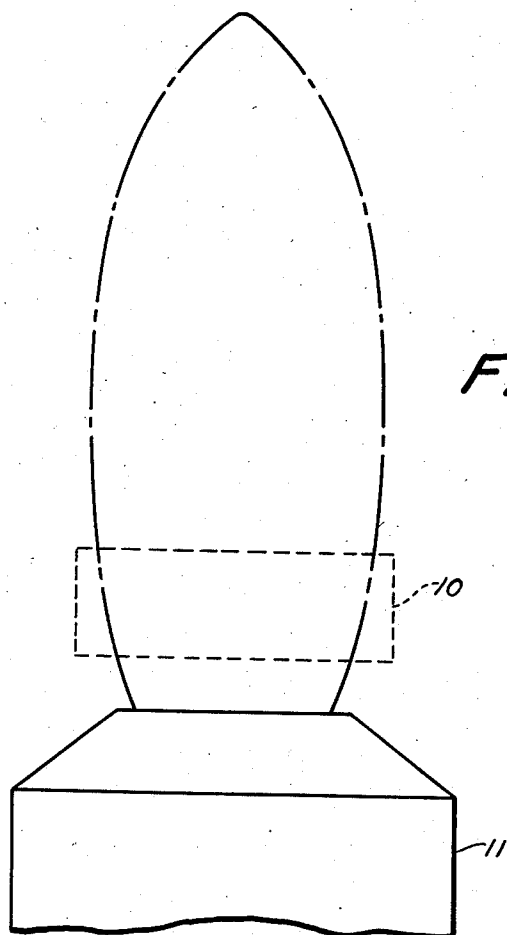
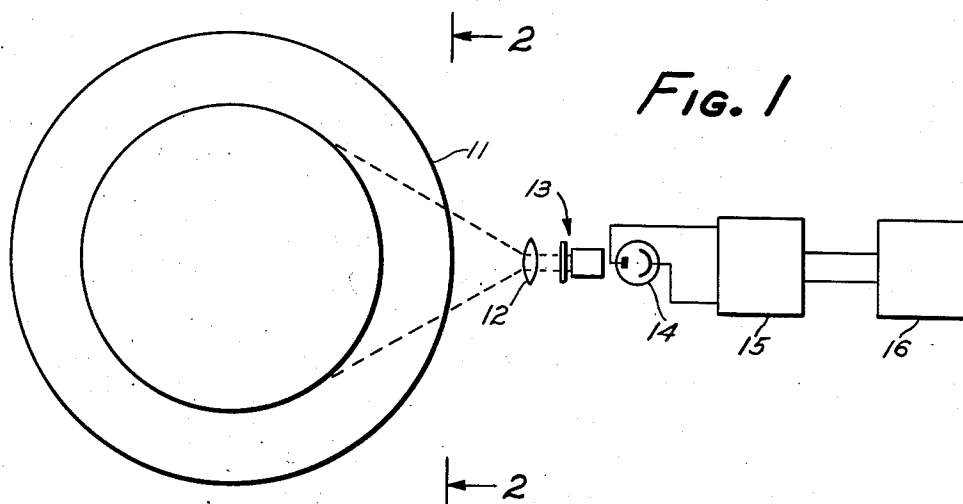
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PROCESS FOR OPERATING A BESSEMER CONVERTER

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4 Sheets-Sheet 1



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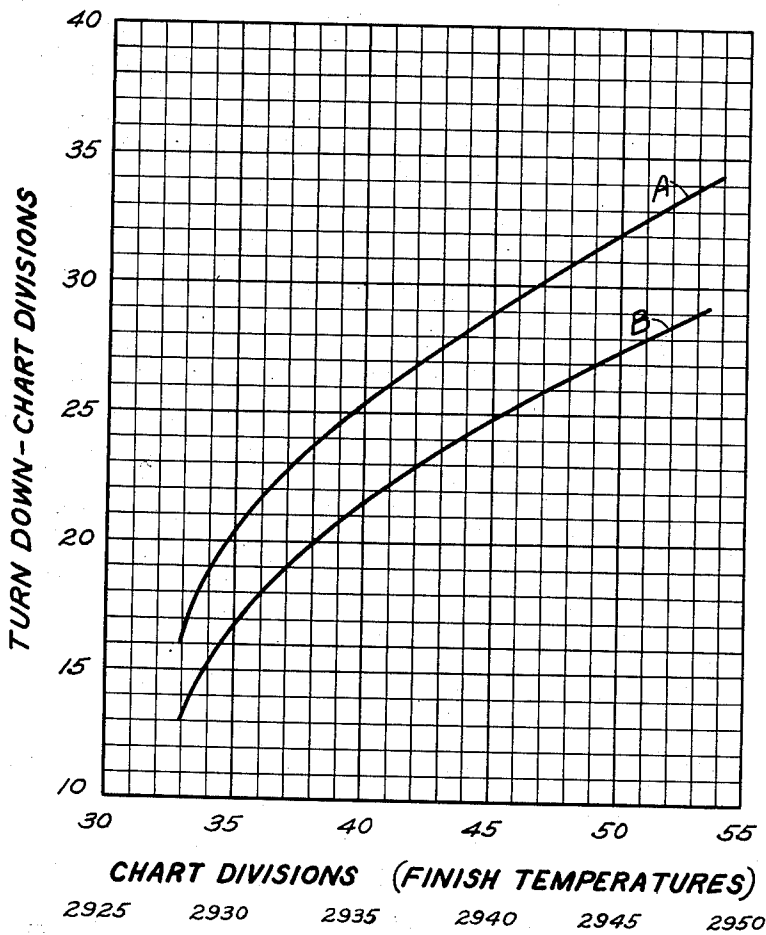
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FIG. 3



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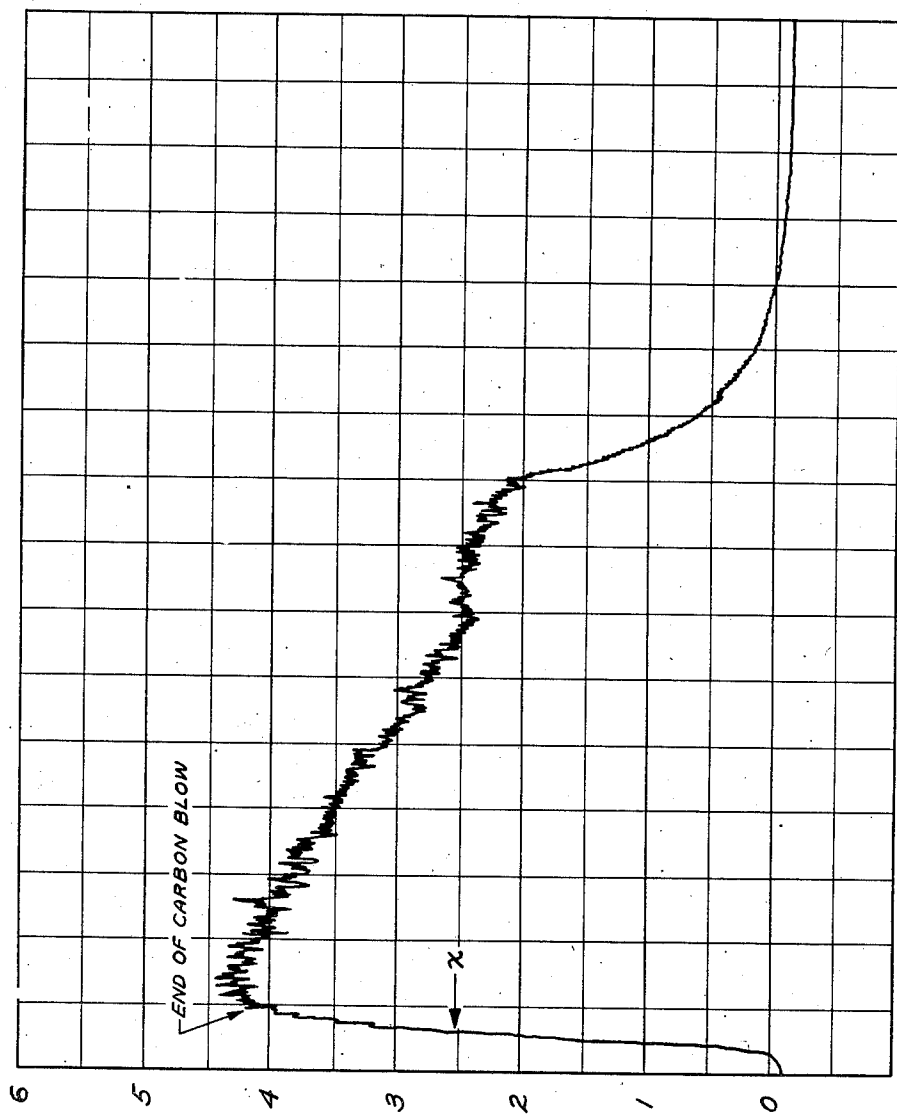


FIG. 4

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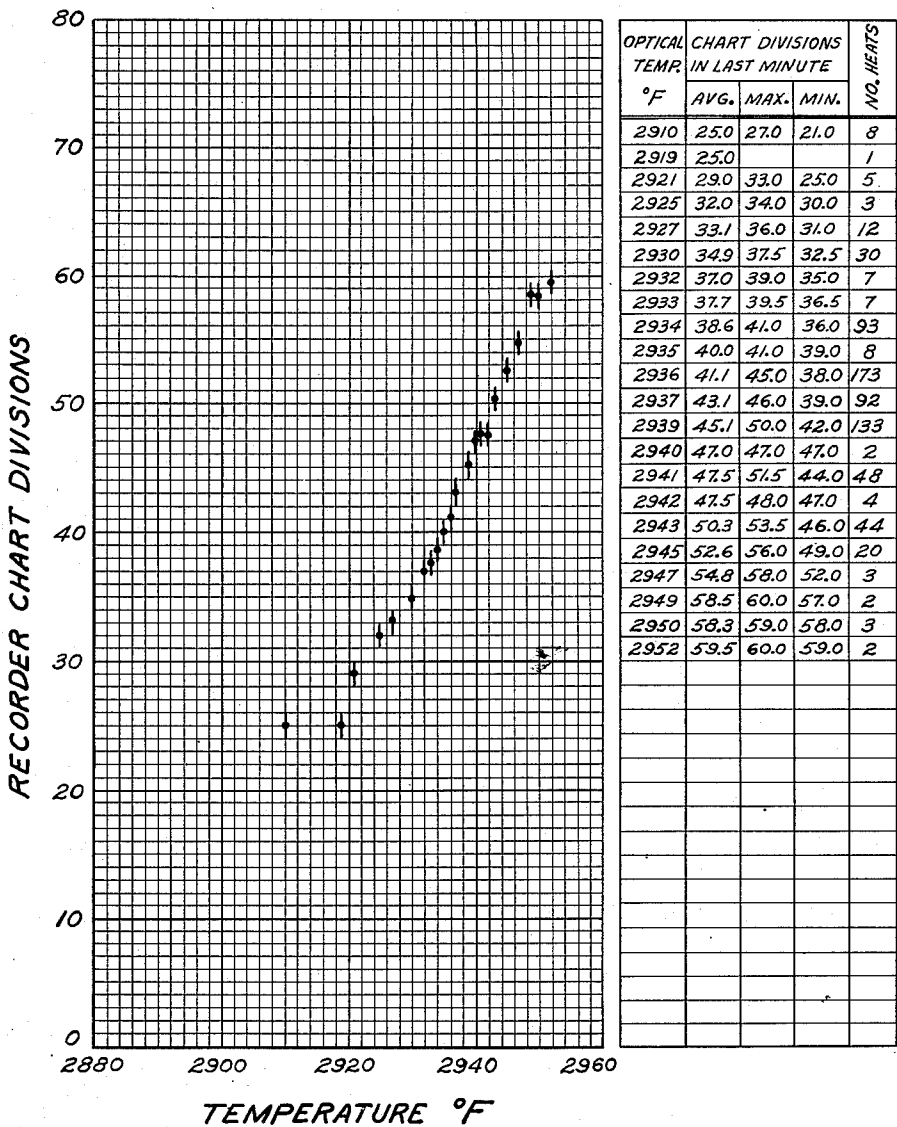
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FIG. 5



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PROCESS FOR OPERATING A BESSEMER CONVERTER

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4 Claims. (Cl. 75—60)

This invention relates to a process for operating a Bessemer converter which involves the determination of bath temperatures during the heat and control of the operation in accordance with such temperature determinations.

The matter of metal bath temperatures is of vital importance in Bessemer practice. A standard book on steel ("The Making, Shaping and Treating of Steel," by Camp and Francis, published by the United States Steel Corporation, 6th ed., 1951), says on page 396:

"The production of steel by the converter process requires careful temperature control in order to insure satisfactory practice. If the finished steel is too low in temperature, ladle skulling and pouring nozzle difficulties will be encountered which are undesirable from the viewpoint of steel quality. Steel with a high temperature not only contains excessive quantities of nitrogen and oxygen, but also is unsatisfactory in other respects."

In spite of the importance of temperature control in the operation of the Bessemer practice, up to the time of my invention, there has been no objective, quantitative, method of determining the metal temperatures during the blowing of the metal in the converter. It is possible by means of an optical pyrometer to determine the temperature of the metal while it is being poured from the converter, following the blow, but, obviously, such temperature determination is of no utility in controlling bath temperatures during the blow. This status of the art, prior to my invention, is indicated by the following from page 396 of "The Making, Shaping and Treating of Steel," cited above:

"The Bessemer blower is, therefore, confronted with the problem of producing steel at a satisfactory temperature which can be determined conveniently at the present time only with an optical pyrometer as the blown metal is poured into the ladle or during teeming. Many attempts have been made to develop a satisfactory device to measure temperature of the molten charge during the Bessemer blow, but a satisfactory technique has not been developed. The blower must continue to depend upon the characteristics of the flame."

Such prior practice has serious drawbacks. It requires highly skilled and experienced operators. Moreover, even with the most skilled observers, the judgment of the temperature of the metal is subjective. It is qualitative rather than quantitative. Consequently, there can be no exact control of the temperature of the bath to get the best possible results.

One of the more important periods of the heat so far as bath temperature is concerned is during the "carbon blow" to the time when the converter is "turned down" at the end of the heat. During this period it is important to know what the metal temperature is in order to take any necessary remedial action to obtain the most favorable metal temperatures possible at the end of the heat. It is also important to follow the temperature changes in the metal near the end of the carbon blow in

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order to know the most favorable time to "turn down" the converter.

By means of my process I am able to make a quantitative, instrumental determination of the temperature of the metal bath during the carbon blow, and, in the light of such temperature determinations, control the temperature of the metal during the blow, and turn down the converter at the optimum time.

My invention is based upon my discovery that the measurement of the radiation of the Bessemer flame during the carbon blow gives an indication of metal bath temperatures providing the radiation measured is confined to a certain narrow band of wave lengths and also providing that certain definite precautions are taken regarding the portion of the flame from which the measurements are taken. The "certain narrow band of wave lengths" is from 0.32 to 0.36 micron. This band contains as characteristic radiation, that is, radiation at specific wave lengths characteristic of a given element, only that due to iron. The intensity of the radiation in this band, much of which is characteristic of the element iron, is a function of the temperature in the molten metal. Since iron is the one constituent of the bath the amount of which remains relatively constant from start to finish of the blow, radiation from iron in the flame can be relied upon to give a stable indication of the metal temperature at any time during the blow. The "certain definite precautions" to be taken "regarding the portion of the flame" to be measured are as follows:

- The portion of the flame from which radiation is measured should be near the mouth of the converter.
- The portion of the flame should be the full width of the flame as viewed from the measuring instrument.
- The portion of the flame should be a relatively small fraction, say about one-sixth of the height of the flame and of constant length during the blow and from blow to blow.

Measurements of the flame radiation in this narrow band of wave lengths, conducted under the conditions just outlined, correspond very closely to the actual bath temperatures at the different stages of the carbon blow. My invention comprises the steps of conducting such measurements during the carbon blow and controlling the temperature of the bath during the carbon blow in accordance with such measurements, and turning down the converter in accordance with such measurements near the end of the carbon blow.

My invention will be more fully understood from the following description and claims, together with the drawings, in which

Fig. 1 is a schematic illustration of an arrangement of apparatus for measuring the temperature of a bath of molten metal in a Bessemer converter;

Fig. 2 is a schematic vertical sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a pair of curves showing the range of turn down points for a series of given finish temperatures;

Fig. 4 is a curve showing the progress of a particular heat; and

Fig. 5 is a chart showing the correlation of chart readings obtained from a number of heats by my method with temperatures of the same heats as determined by optical pyrometer during pouring of the molten metal.

Referring to the drawings, Figs. 1 and 2 illustrate an arrangement of apparatus whereby radiation from a zone 10 above a bath of molten metal in a Bessemer converter is measured. Radiation from such zone is directed via a lens system 12 through a filter 13 onto a photosensitive device 14 such as a phototube. The phototube is connected via an amplifying device 15 to an indicator 16. The amplifying device 15, which may be of

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a suitable vacuum-tube type, receives voltage variations from the phototube, amplifies them, and applies them to the indicator 16. This indicator may, for example, comprise a recording milliammeter, and may be calibrated directly in temperature.

As stated above, the radiation should be measured from a zone of the flame which is just above the mouth of the converter, which extends the full width of the flame, and is a relatively small fraction of the height of the flame of constant length during the blow. Such a zone is shown in broken lines at 10 in Fig. 2.

The filter 13 is one which will transmit radiation from zone 10 substantially only in the range having a wave length of between .32 and .36 micron.

The temperature of the molten metal in a Bessemer converter during the carbon blow, particularly towards the end of the blow, affects the quality of the finished steel and it also affects the economy and efficiency of subsequent rolling operations. It is very important to turn the vessel down so as to stop the blowing operation at the proper moment, since the extent to which the reaction is allowed to proceed is a major factor in determining the quality of the finished steel. A knowledge of the temperature of the metal toward the end of the blow is very necessary in determining the proper moment for turning down the vessel.

When a Bessemer vessel is first charged, the temperature of the liquid pig iron is usually about 2300 to 2400° F. The temperature rises during the silicon blow and during most of the carbon blow. The total temperature rise during the silicon and the carbon blows is about 500° F., of which about two-thirds to three-fourths occurs during the silicon blow, the remainder occurring during the carbon blow. Some grades of steel tend to cool off slightly during the last quarter of the carbon blow. The maximum temperature of the steel will normally be reached at a point lying somewhere between three-quarters of the way through the carbon blow and the end of the carbon blow. The final temperature of the finished blown molten metal, at the end of the carbon blow, may be termed the "finish" temperature. This temperature may be slightly less than the maximum temperature attained.

At the end of the blow, when the flame of the converter drops, the radiation in the selected frequency band diminishes sharply, and there is a consequent rapid drop in the response of the milliammeter 16, despite the fact that the temperature of the bath does not drop accordingly. The maximum indication of the recorder during the twenty or thirty seconds preceding the rapid drop of flame is, in operating the system described herein, regarded as the indication of the actual finish temperature.

It has been found that for each particular type of steel to be produced, there is an optimum value for the finish temperature.

It has also been found that the proper moment for turning down the converter is the moment when the indication of the milliammeter 16 has dropped to a predetermined percentage of its finish-temperature reading. This percentage depends upon the grade of steel desired and upon the value of the finish temperature itself.

Fig. 3 is based on a number of actual heats and shows the proper turn-down points for a number of finish temperatures. Curve "A" and curve "B" are the upper and lower limits of the range within which the turn down point for a given temperature will be located. These turn-down points are determined from actual operations based on finish temperatures determined in accordance with my method. The proper turn down point for any given finish temperature is susceptible of determination by experiment. It will be apparent, however, from Fig. 3 that for a heat having a given finish temperature, the turn-down point for that heat will be reached when the reading of the milliammeter has dropped to a division number within the range corresponding to that tempera-

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ture on the curves of Fig. 3. By following this procedure, "over-blowing" and "under blowing" are avoided.

The heat curve shown in Fig. 4 illustrates this point. As will be seen from this curve, the highest division number reached during the last 30 seconds of the blow was number 45, which corresponds to a finish temperature of 2940° F. By referring to the curves of Fig. 3, it will be seen that this temperature on the curves corresponds to division numbers in the range from twenty-five to twenty-nine. Applying this to the particular heat, the converter may be turned down when the reading has dropped to point X which is chart division number twenty-five, at the lower limit of the range. A turn down point anywhere within the range of twenty-nine to twenty-five will give satisfactory results.

Referring to Fig. 5, this chart clearly illustrates the dependability and reproducibility of temperature determinations arrived at by my method. For example a series of 173 heats blown in the same converter (not consecutively) showed a temperature of 2936° F. as determined by optical pyrometer during pouring of the molten metal. The finish temperatures of these same heats as indicated by my method during the last minute of blowing all fell within the narrow limits of 38 to 45 chart divisions. This shows that heats having the same finish temperatures as indicated by my method consistently give a reading on or near the same chart division, and that therefore my method can definitely be relied upon to give a true indication of the finish temperature of the metal.

As a further indication of the sensitivity of my method, of a large number of heats showing a chart division finish temperature below number thirty-five, about seventy percent showed skulls ranging from 100 pounds to 2000 pounds out of a heat weight of approximately 35,000 pounds. On the other hand, of a large number of heats showing chart division finish temperatures between numbers thirty-six and forty, only about twenty-six percent had skulls which ranged up to about 200 pounds.

Since with the present invention it is possible to measure the temperature of the molten metal continuously during the major portion of the carbon blow (excluding those portions at the very beginning and very end thereof when the flame provides insufficient excitation), it is possible to observe the progress of the temperature as the blow proceeds. In order to cause the finish temperature to be approximately an optimum value, it is sometimes desirable, from observations of the progress of the temperature, to take steps at a point, say, one-fifth or one-fourth of the way through the carbon blow, to prevent overheating, or to cause a more rapid temperature rise, if these steps appear necessary by means well known in the art.

With the apparatus and method of the present invention, the admission of steam to the Bessemer blast, in order to prevent overheating, produces a rise in the indication of the milliammeter so long as the steam is on. When the steaming operation is terminated, the indication will drop to a value below the value which would have existed in the absence of steaming. During steaming the indication of the milliammeter is not an accurate indication of temperature because radiation characteristic of (OH)- is added to that already being received by the phototube in the range of .32 to .36 micron.

One advantage of the use of the ultraviolet portion of the spectrum, as in the system described, is that if the flames from other distant converters, or patches of sky, come into the field of view of the phototube, no significant disturbance appears, during the carbon blow apparently because ultraviolet radiation from such distant sources is greatly attenuated by the time it reaches the phototube.

In actual operation my method has proved highly beneficial. The yield from heats blown in accordance

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with the method disclosed herein has been regularly larger than the yield from heats blown in accordance with conventional prior practice, while the billet reconditioning costs and rejections are consistently lower than with steel blown by methods heretofore used.

As an example of the results achieved by my method, there are shown below comparative figures for steel produced over a two month period. Column "X" gives figures for steel produced in that period by conventional methods, while column "Y" gives figures for steel produced during the same period, in the same plant, by my method. The improvement resulting from the use of my method is apparent.

	"X"	"Y"
Weight Rolled (lbs.)	217,970	567,120
Weight Reconditioned	10,980	12,990
Weight Rejected	3,820	1,100
Percent Reconditioned	5.04	2.30
Percent Rejected	1.75	.19

I claim:

1. A process of operating a Bessemer converter which comprises the steps of measuring the radiation of a portion of the flame during the carbon blow, such portion of the flame being that near the mouth of the converter for the full width of the flame and a fraction of the height of the flame of constant length, the radiation measured being substantially limited to that having wave lengths between 0.32 and 0.36 micron, controlling the temperature of the Bessemer metal in accordance with the radiation measurement during the carbon blow, and turning down the converter in accordance with the radiation measurement.

2. A process of operating a Bessemer converter which comprises the steps of measuring the radiation of a portion of the flame during the carbon blow, such portion of the flame being that near the mouth of the converter for the full width of the flame and a fraction of the height of the flame of constant length, the radiation measured being substantially limited to that having wave lengths between 0.32 and 0.36 micron, recording the radiation measurement so obtained on an instrument, said measurement being proportional to the temperature of the molten metal in the converter, blowing the metal

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until an indication of the finish temperature is reached, thereafter continuing the blow until the indication on said instrument has dropped by a predetermined amount and thereupon terminating the blow.

3. A process of operating a Bessemer converter which comprises the steps of measuring the radiation of a portion of the flame during the carbon blow, such portion of the flame being that near the mouth of the converter for the full width of the flame and a fraction of the height of the flame of constant length, the radiation measured being substantially limited to that having wave lengths between 0.32 and 0.36 micron, recording the radiation measurement so obtained on an instrument, such radiation measurement being proportional to the temperature of the molten metal in the converter, controlling the temperature of the molten metal in accordance with the temperature indication so obtained during the carbon blow, and turning down the converter in accordance with such temperature indication.

4. A process of operating a Bessemer converter which comprises the steps of measuring the radiation of a portion of the flame during the carbon blow, such portion of the flame being that near the mouth of the converter for the full width of the flame and a fraction of the height of the flame of constant length, the radiation measured being substantially limited to that having wave lengths between 0.32 and 0.36 micron, recording the radiation measurement so obtained on an instrument, such radiation measurement being proportional to the temperature of the molten metal in the converter, blowing the metal until an indication of the finish temperature is reached, thereafter continuing the blow until the indication on said instrument has dropped to a predetermined fraction of the finish temperature indication, and thereupon terminating the blow.

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