Jan. 13, 1953 F. O. HESS 2,625,387

METHOD OF HEATING

Filed March 17, 1949

FIG. 1

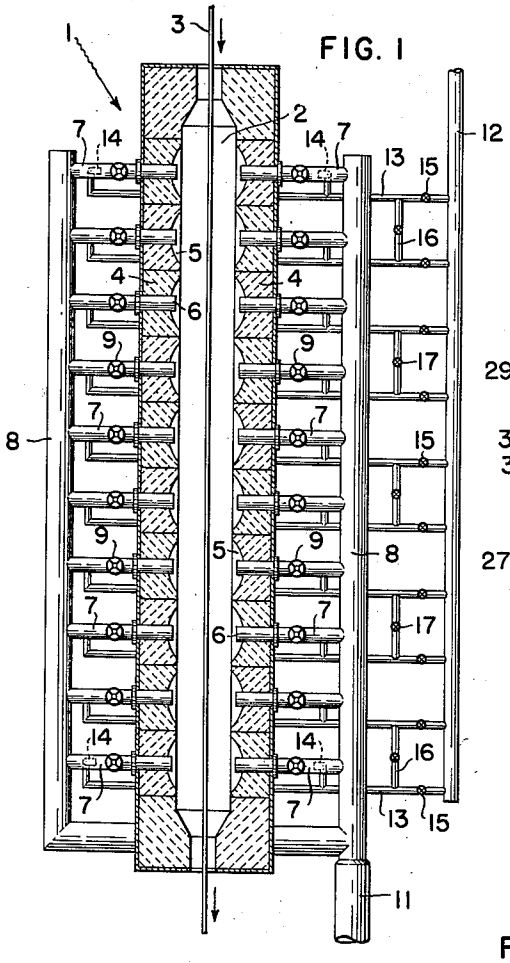


FIG. 3

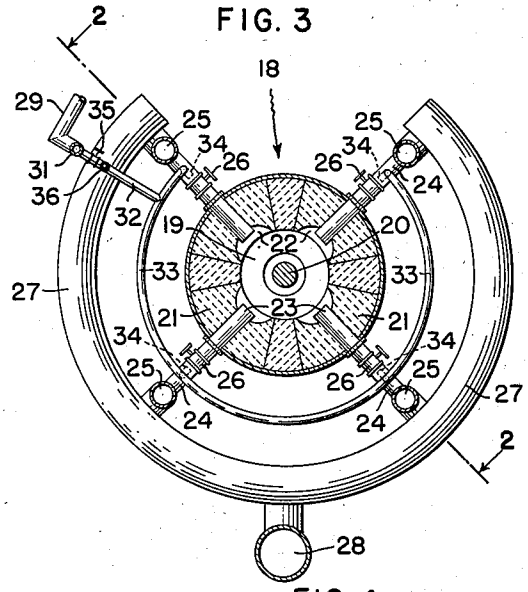


FIG. 4

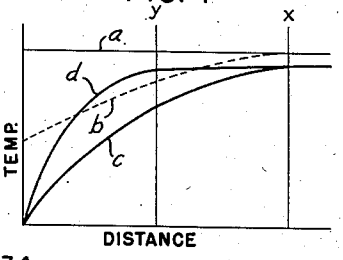
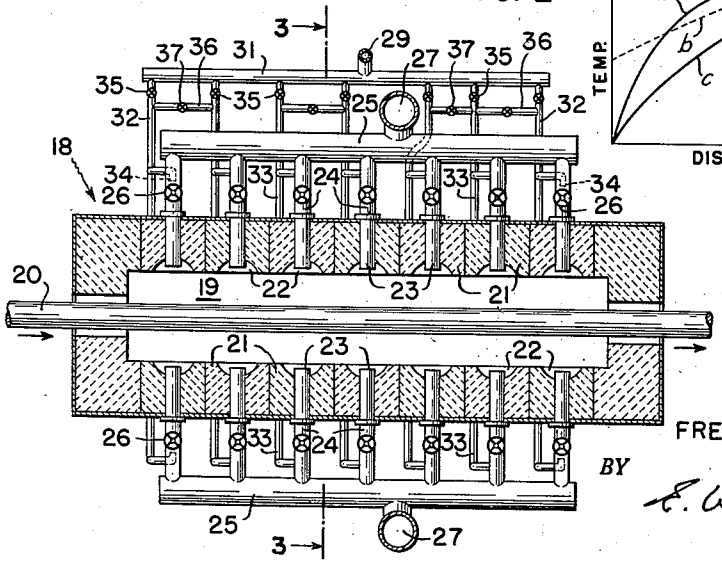


FIG. 2



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Patented Jan. 13, 1953

2,625,387

UNITED STATES PATENT OFFICE

2,625,387

METHOD OF HEATING

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Application March 17, 1949, Serial No. 81,886

6 Claims. (Cl. 263—52)

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The present invention relates to the rapid heating of metal objects such as sheets, billets and the like, and more particularly to a method of bringing metal up to temperature as rapidly as possible with due consideration to the physical characteristics of the materials of which the heating apparatus is made.

In modern heat treating practice, such as the continuous annealing or normalizing of strip and the continuous heating of billets or slabs, it is desirable to bring the metal up to temperature as rapidly as possible. The speed of heating, however, has substantially reached its limit when considering the capacities of the burners and the materials of which the furnaces are made when they are operated in accordance with conventional practices. Therefore, in order to increase production of a plant with present equipment and operating techniques, it is necessary either to duplicate the furnace installation or to increase its size. Either of these alternatives is expensive, and in many cases equally as important, requires the use of additional space.

In ordinary furnace practice it is common to have a furnace chamber divided into zones so that the work can be brought up to temperature in what amounts to a series of steps. By dividing the furnace chamber into zones it is possible to prevent, to a certain extent, one zone from being robbed of heat by another zone in which the temperature of the work, or the load, is at a different value. Ordinarily that portion of the furnace chamber receiving the work is the coldest and is frequently referred to as a preheating zone. This is true because the cold work cools down the furnace and prevents a high temperature from being reached, even when the burners are being fired at capacity. In distinguishing from this method of operation, the invention herein is directed to maintaining all portions of the furnace chamber or heating path at the same maximum operating temperature by varying the firing of each portion in accordance with the work temperature at that portion. As more heat is absorbed by the work where the temperature gradient is the largest, the furnace temperature can be maintained constant throughout by varying the heat input in accordance with the temperature of the work as it travels through the furnace chamber. With this type of operation the work is brought up to temperature in an absolute minimum of time. Accordingly for a given size furnace the production is increased since the work can be moved through the furnace faster.

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In practicing the present invention each portion of the furnace is maintained at the maximum operating temperature regardless of the temperature of the work at that portion of the furnace. Stated another way, heat is supplied to a furnace chamber at varying temperatures at different portions of the chamber, with the greatest amount of heat being supplied at the point where the work is the coldest. In actual practice heat is supplied from a plurality of burners located along the path of movement of the work. The fuel and combustion supporting gas to the burners is regulated in such a manner that the heating value thereof varies in accordance with the temperature of the work at any given point along its path of travel.

The ordinary fuels used in firing a furnace are not able to maintain the maximum temperature a furnace can stand when the work is cold, because the cold charge will reduce the temperature to a point where combustion is incomplete and inefficient. To overcome this fault the percentage of oxygen supplied to those burners near the entrance of the furnace where the cold work is introduced is increased. Ordinarily the temperature produced by the increased percentage of oxygen would be sufficient to ruin the furnace lining. But the cooling effect of the work will reduce the dangerous temperatures produced by the increased oxygen to a point equal to the maximum desired operating temperature. The amount of oxygen used at each point of a furnace chamber will be determined empirically for a given size and composition of material. Thereafter a run can be duplicated.

It is an object of the invention to provide a method of heating continuously elongated work in which the work is heated as rapidly as possible by keeping all portions of the furnace chamber or heating path at the maximum operating temperature. By this means the maximum temperature obtainable is applied to the work from the instant it enters the furnace. Consequently the work will be brought up to temperature in a minimum of time.

It is a further object of the invention to provide a method of heating continuously metal in a furnace chamber by firing the chamber at different rates in different portions thereof.

It is a further object of the invention to heat a furnace charge to a desired temperature in a minimum of time by the use of an ordinary fuel and a combustion supporting gas with the latter being supplied in quantities depending upon the temperature of the charge.

It is a further and more specific object of the invention to fire the burners of a furnace with a particular type of fuel such as a combustible mixture of gas and air, and to supplement this fuel with oxygen. The oxygen is supplied to the different burners in varying amounts depending upon their location in the furnace, and depending upon the temperature of the work adjacent to each individual burner.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

In the drawings:

Figure 1 is a view in section of one form of furnace incorporating the present invention;

Figure 2 is a sectional view of another form of furnace incorporating the invention, taken on line 2—2 of Figure 3;

Figure 3 is a section taken on line 3—3 of Figure 2; and

Figure 4 is a diagram illustrating the principles of the invention.

There is shown in Figure 1 a furnace 1 that has a furnace chamber forming a heating path through which a strip 3 is passed to be heated to some desired temperature, such as that necessary for annealing. The furnace is constructed in accordance with ordinary furnace practice of refractory members capable of withstanding the temperature to which the furnace is subjected, which refractory members are backed up by suitably braced sheet metal work.

Incorporated in the refractory of the furnace and forming part of the walls thereof are a number of burner blocks 4 each of which is provided with a burner cup 5. The burners are of a type fully disclosed in my Patent No. 2,215,079 and reference may be had thereto for a more detailed description of the burners and their operation. It is sufficient for purposes of the present disclosure to say that a combustible mixture of gas and air is supplied to, and burned in, each cup 5 by a distributor member 6. Burning of the mixture heats the cups to incandescence so that they radiate heat to the work passing in front of them. Heat is also radiated to the remainder of the furnace walls to heat them to incandescence at a slightly lower temperature than the cups themselves. Thus there is produced a radiant heating path through which the strip moves. The high temperature products of combustion resulting from the burning of the combustible mixture also help to heat the strip. The distributors 6 are supplied by individual pipes 7 extending from a manifold 8. Each pipe 7 has in it a valve 9 so that the individual burners may be shut off, if necessary, in order to obtain the proper heat pattern on the work. The individual manifolds 8 are connected with a main supply pipe 11 that has a combustible mixture of gas and air forced through it under a suitable pressure from a mixing machine. It is noted that while only one burner is shown at each level in the sectional view, any number of burners may be used on each level of the furnace depending upon the width of the furnace chamber. Each of the burners on a given level will be supplied from the same manifold so that each of the burners in a given position vertically of the furnace will receive the same amount of mixture to be burned therein.

Oxygen in addition to that occurring in the atmosphere can be supplied to each burner in regulated amounts. The oxygen flows under suitable pressure through a pipe 12 that has branches 13 extending from it. Each branch 13 serves all of the burners on a given vertical level in the furnace. Oxygen is passed from the pipes 13 into pipes 7 and the burners by means of a suitable mixing type connection indicated at 14. Each of the pipes 13 is provided with a valve 15 so that the amount of supplemental oxygen which is supplied to the burners on a given level of the furnace may be regulated individually. At times it may be desirable to adjust the supply of oxygen simultaneously for burners at different levels. To this end various of the pipes 13 are connected by a pipe 16 that has a valve 17 in it. By suitably manipulating valves 15 and 17 oxygen can be supplied to the burners on one level or a plurality of levels in the quantities that are necessary.

In operating the furnace for annealing purposes, for example, a continuous sheet of metal in strip form is moved from the top of the furnace through the furnace chamber and out at the bottom. During this passage through the furnace the strip is brought up to the desired temperature. As the strip leaves the furnace it may be passed into a cooling chamber whereby controlled cooling can be obtained so that the desired metallurgical characteristics of the metal are brought out as a result of the treatment. Ordinarily the combustible mixture of gas and air will be supplied through pipe 11 to the various manifolds and to each burner at substantially equal volumes. The heat produced by the burners in the form of radiant heat from the incandescent cups 5, and the radiant furnace walls, as well as the hot products of combustion which are circulated through the furnace chamber, is used to heat the strip. The higher the temperature that can be obtained the more rapidly the metal can be brought up to temperature and with the ceramics available today the highest safe operating temperature of these burners over a period of time has been found in practice to be in the neighborhood of 2700° F. Therefore sufficient fuel is supplied through the distributors to maintain the burner cups at this temperature. Such a temperature can be obtained with a mixture of ordinary manufactured gas or natural gas and air if there are stable conditions in the furnace chamber. When a cold object is moved in front of the cups, however, their temperature is reduced by radiation to the object, and by an amount proportional to the difference in temperature between the object and the burner cup. In a furnace a cold charge will reduce the gas temperature to a point where combustion is incomplete and inefficient. The heat necessary to bring the cup up to its optimum temperature, assuming that the object or work temperature did not increase, as would be the case at a given point along the path of a moving strip, can only be obtained by the use of a higher temperature fuel. For this reason supplementary oxygen is introduced to the burners at various levels in amounts proportional to the temperature of the strip at those levels. Thus the furnace chamber or heating path is maintained at the optimum temperature from one end to the other.

The strip is introduced into the furnace chamber at ambient temperature, which can be considered 70° F. for purposes of this description,

and it is gradually heated as it passes through the furnace until it reaches an annealing temperature of approximately 1500° F. just prior to the time it leaves the furnace chamber. In order to obtain this temperature in the strip in the least possible time the furnace chamber is kept at the highest safe temperature. With furnaces made of presently available refractories the burner cups can be maintained at about 2700° F. with the temperature in the furnace chamber about 2400° F. to 2550° F. Higher temperatures can be obtained, but if so the life of the refractory furnace lining is shortened to a point where it is uneconomical. Since the strip is always below the temperature of the cups the latter will be cooled down below their optimum temperature of 2700° F. with a resultant cooling of the entire furnace chamber.

The cups and wall forming the first portion of the heating path of the strip will be cooled down more than will the latter portion of the heating path. By the time the strip has reached the end of the furnace it will be up to the required temperature of 1500° F., or for some purposes to 2200° F., and will have practically no cooling effect on the furnace walls. It will be apparent that if the temperature of the furnace near the entrance can be raised to its optimum and maintained at that point the strip can be heated at a more rapid rate. This is due to the increased temperature differential between the radiant walls and the strip. Figure 4 illustrates graphically the conditions that are obtained without and with supplemental oxygen. In that figure the line *a* indicates the optimum temperature of the heating path, or furnace chamber. This temperature will change and have a gradient approximately as indicated by the dash line *b* when a strip to be heated is moving through it. The temperature is lowest at the entrance and is at the optimum value at the exit of the chamber. Strip traveling through the furnace will have its temperature raised substantially in accordance with curve *c*, until it reaches its desired value at point *x*. It will be noted that the temperature differential between curves *b* and *c* is constantly diminishing from entrance to exit where the strip is up to temperature. If the furnace temperature is maintained at its optimum value throughout the rate of heating of the work traveling at the same speed will be substantially increased, as indicated by curve *d*, so that it is up to temperature by the time it reaches point *y*. This means that the same amount of work can be heated by a shorter furnace. Conversely, work can be moved through a furnace of a given length at a higher speed and still be heated to the desired temperature. In either case an increase in production per square foot of furnace wall area is obtained.

The optimum temperature cannot readily be obtained by the use of more burners since they are still using fuel of the same B.t.u. value. Additional burners, if they can be added, will produce more heat of the same temperature, but not the higher temperature which is necessary to increase the temperature differential between the furnace walls and the work. In order to compensate for the loss of heat from the cups and walls by radiation to the cold strip or work passing in front of them suppplemental oxygen is supplied to the burners along with the combustible mixture. Enough oxygen is admitted through the pipe **13** for the burners at any one vertical position in the furnace chamber to bring the temperature of the cups of these burners up to the optimum temperature of 2700° F. It will be apparent that decreasing amounts of oxygen are needed in the cups at progressively lower levels in the furnace chamber. It may be that no oxygen at all is needed by the last few rows of burners. The amount of oxygen that is needed in any group or groups of burners will vary with the thickness of the strip and with its heat absorbing capacities. After the oxygen supply to each level of burners has been adjusted for a given strip and set of conditions it will not have to be changed.

As long as the strip is moving through the furnace chamber from a substantially constant entrance temperature the temperature of the cups of each burner can be held at the optimum value. If, however, the strip should stop moving the supply of oxygen, as well as the supply of the combustible mixture would have to be reduced in order to prevent overheating of the refractory burners as well as burning of the work. The supply of fuel, both oxygen and combustible mixture, to the burners can be controlled automatically by any conventional temperature control system, such as one in which a radiation pyrometer is used to adjust valves in the fuel and oxygen supply lines.

In the embodiment described above there is disclosed a furnace which is designed to heat strip material. In Figures 2 and 3 there is disclosed a furnace in which rods, billets and the like may be heated in accordance with the same method used in connection with heating strip. Disclosed in Figures 2 and 3 there is a furnace **18** having a chamber **19** forming a heating path through which an elongated rod **20** is passing. This furnace is generally cylindrical in shape and has restricted openings at its ends through which the work passes. The inside of the furnace is provided with a plurality of rows of burners **21** having cups **22** that are supplied with a fuel through distributors **23**. These burners are similar to the burners described in connection with Figure 1 and operate in a similar manner to heat the interior of the furnace chamber to incandescence. Each of the burners is supplied with a combustible mixture through pipes **24** that are connected to manifolds **25**. A valve **26** is located in each pipe **24**. As shown in Figure 3 of the drawing there are four rows of burners and a manifold **25** for each row. These manifolds are in turn supplied by a substantially circular pipe **27** that is connected with a main **28**. The main itself is supplied with a combustible mixture of gas and air from a suitable mixing machine and may be used to feed the mixture to a series of furnaces, if more than one is necessary in order to heat properly the work.

Supplemental oxygen is used to increase the temperature of the furnace by increasing that of the burners in each individual row lengthwise of the furnace. As shown herein, oxygen is supplied through a pipe **29** to a manifold **31** extending the length of the furnace. This manifold has a plurality of pipes **32** connected with it that in turn supply substantially circular pipes **33**. Each of the latter pipes feeds oxygen through mixing nozzles **34** to one row of burners circumferentially of the furnace. There is provided a pipe **33** for each row of burners as is best shown in the drawings. The supply of oxygen to each row of burners can be adjusted individually by means of valves **35**. When it is desirable or necessary to regulate simultaneously more than

one row of burners with the same amount of oxygen, valves **37** in connecting pipes **36** extending between pipes **32** can be used. Thus by manipulating valves **35** and **37** the proper amount of oxygen can be fed to the burners of each row individually or to a plurality of rows.

The operation of this type of furnace is similar to that described above in that a combustible mixture is supplied through the pipe **28** and the various manifolds to the burners where it is ignited to burn and heat the cups of the burners to incandescence and in turn heat the furnace wall. The rod is therefore heated by radiant heat as well as by the high temperature products of combustion produced as a result of burning the fuel. Supplemental oxygen in the amount necessary to maintain the cup temperature of each row of burners at its optimum value of approximately 2700° F. can be supplied by adjusting the valves **35**. Since the work is heated progressively as it moves from left to right through the furnace the amount of oxygen that is necessary in order to maintain each portion of the furnace at the proper temperature will be reduced in the various circumferential rows of burners extending from left to right. Therefore the valve **35** supplying the left hand row of burners will be opened wider than the valve **35** supplying the next adjacent row of burners. The adjustment of these valves is such that the temperature of each row of cups is maintained at its optimum operating value irrespective of the temperature of the work. The cold work entering the left end of the furnace chamber will tend to withdraw more heat on that end of the furnace than will the hot work on the right end of the furnace.

Any suitable or necessary type of control can be used in order to regulate the temperature of the furnace in response to either the furnace temperature or the temperature of the work. For example, the type of control system that is disclosed in Hess et al. application Serial Number 761,602, filed July 17, 1947, could very well be used with the present furnace, particularly if more than one of these furnaces is used in series to form the heating path for the work.

From the above description it will be seen that there is provided means for maintaining the temperature of a furnace the same from one end to the other while it is being used to heat work continuously, whether the work is in the form of strip or rods. This temperature is maintained by the use of varying amounts of supplemental oxygen depending upon the heat transfer to the work at any particular point. The result is to produce a high temperature gradient between the work and the furnace wall at the entrance of the furnace, which temperature gradient decreases as the work moves through its heating path toward the exit. The larger temperature gradient which is maintained at the entrance end of the furnace insures that the work will be heated as rapidly as is possible. By maintaining the temperature of the furnace at the maximum value at which it can operate without being damaged, the work can be brought to its desired temperature in a minimum of time. This means that the furnace of a given size can heat more work per unit of time than it is possible to heat if the supplemental oxygen is not used or that a greater amount of work can be heated per unit time by a smaller furnace.

The principle of heating described above is applicable to all types of work in which a heating cycle is to be followed. The method is equally as efficient when being used for batch processes such as open hearth operation or glass furnaces as it is for the heating of a continuously moving body. By following the method disclosed herein the output of existing furnaces can be substantially increased without alterations. The fast heating obtained by following the present disclosure cannot be obtained by the installation of additional burners in a furnace, if it is possible to do so, or by burning larger volumes of gas in existing burners. To obtain the desired rate of heating it is necessary to use supplemental oxygen in varying amounts along with the regularly used combustible mixture.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me it will be apparent to those skilled in the art that changes and modifications may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention, as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of heating continuously which comprises moving the work to be heated continuously in a given heating path through a furnace chamber, supplying heat to the work at the normal capacity of the furnace or higher from a plurality of burners located in the furnace adjacent to the work along its path of travel, which includes supplying from a first supply a combustible fuel mixture of gas and air at the same rate to each of the burners, the work cooling the burners varying amounts at varying points along its path of travel, and supplying additional oxygen from a second supply to various of the burners in varying amounts sufficient to overcome the heat loss at each burner whereby the burners will all be at substantially the same temperature.

2. The method of heating continuously metal work of elongated extent which comprises moving the work continuously through a furnace chamber, supplying heat at the normal maximum energy level of the furnace to the work from a plurality of rows of burners located adjacent to the work along its path of travel, which includes supplying a combustible fuel mixture of gas and air from a first source at substantially the same rate to each of the burners, the work cooling the furnace varying amounts along its path of travel with the greatest amount of cooling taking place near the entrance of the furnace chamber, supplying additional oxygen from a second source to various of the burners in an amount sufficient normally to overcome the furnace and burners to overcome the heat loss from the furnace adjacent to said burners to the work, and regulating the supply of oxygen so that the entire furnace will be at substantially the same temperature from one end to the other.

3. The method of heating continuously work which comprises passing the work continuously through a furnace chamber, supplying heat to the work at the normal energy level of the furnace from a plurality of burners located in the furnace at various points along the path of travel of the work which includes supplying a combustible fuel mixture of gas and air from a source thereof to each of said burners, the mixture being supplied at substantially the same rate to each burner, supplying additional oxygen from a dif-

ferent source to various of said burners at varying rates, said oxygen serving to create a large temperature difference between the work and the burners which decreases as the work moves through the furnace chamber, and regulating the supply of oxygen so that the temperature of all of the burners is substantially equal at the maximum for which the burners are designed.

4. The method of heating continuously at a high rate elongated metal work which comprises passing the work continuously through a place of heating, heating the work progressively from ambient to the desired temperature as it moves through the place of heating by a plurality of burners located at spaced points along the path of travel of the work, which includes supplying from a first source the maximum amount of a combustible mixture of gas and air from which it was designed to each of the burners, supplying a variable amount of oxygen from a second source to some of the burners, and regulating the amount of oxygen supplied to those burners to maintain the temperature of all of the burners at substantially the same temperature regardless of the position of the individual burner along the path of travel of the work.

5. The method of heating continuously an elongated piece of work passing through a furnace chamber, the chamber normally tending to be cooled a varying amount below its optimum temperature by the work with the greatest amount of cooling taking place near the entrance of the chamber, which comprises moving the work continuously through the furnace chamber, supplying heat at various points in the furnace chamber in an amount substantially equal to the maximum amount for which the furnace is designed to maintain the chamber temperature even from one end to the other under stable conditions, supplying additional heat at a higher temperature than that for which the furnace is designed to the entrance end of the chamber to compensate for the reduction in temperature of that portion of the chamber due to passage of the work, and regulating the amount of said additional heat to maintain the temperature of the chamber substantially constant from end to end when work is passing therethrough.

6. The method of heating work continuously which comprises the steps of passing the work through a heating path surrounded by a plurality of walls, the work having a tendency to cool down the walls varying amounts depending upon the temperature of the work at a given point in the heating path, heating the walls to incandescence by the combustion of the normal maximum amount of a fuel mixture at various points along the heating path, and regulating a secondary supply of combustion supporting gas in the combustible mixture supplied to said various points so that without the work the walls would be overheated to maintain a normal and substantially constant degree of incandescence of the walls from one end of the heating path to the other regardless of the temperature of the work.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,956,401	Russ	Apr. 24, 1934
2,067,436	Coberly	Jan. 12, 1937
2,205,182	Whitten	June 18, 1940
2,296,387	Inskeep et al.	Sept. 22, 1942
2,412,758	Smith	Dec. 12, 1946
2,446,511	Kerry et al.	Aug. 3, 1948
2,518,996	Peckham	Aug. 15, 1950

FOREIGN PATENTS

Number	Country	Date
464,425	Great Britain	Apr. 19, 1937
570,002	Great Britain	June 18, 1945