Nov. 9, 1954 J. D. NESBITT 2,693,952

FORGE FURNACE CONTROL

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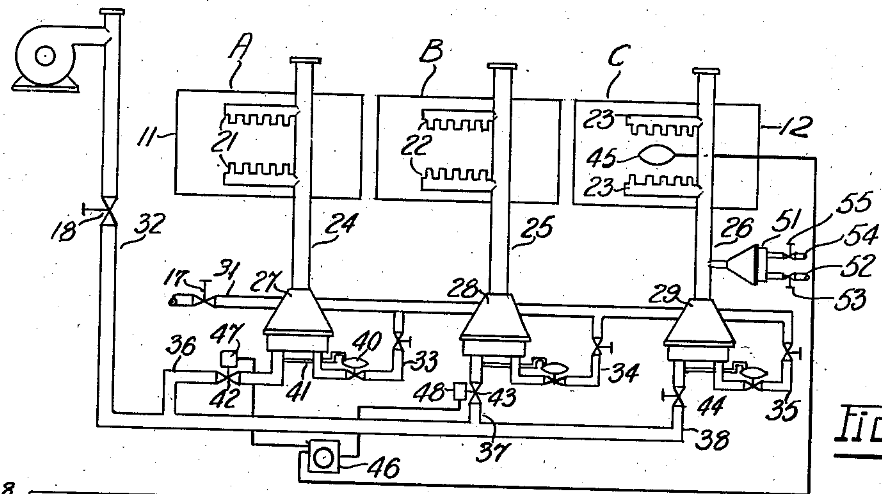

Fig.1.

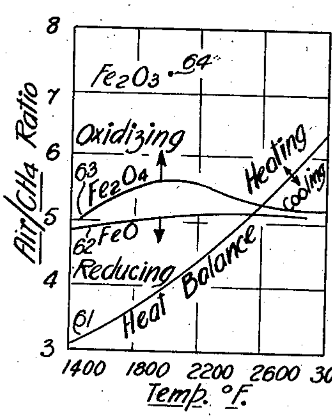

Fig.5.

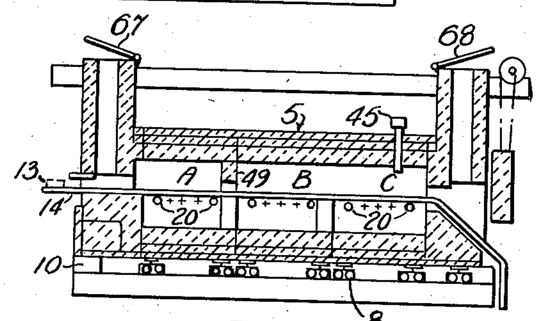

Fig.2.

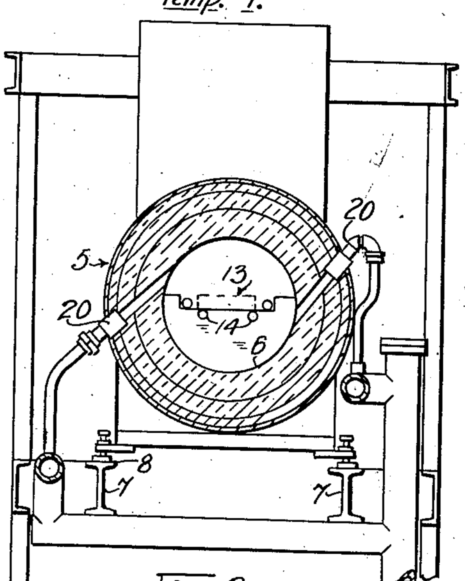

Fig.3.

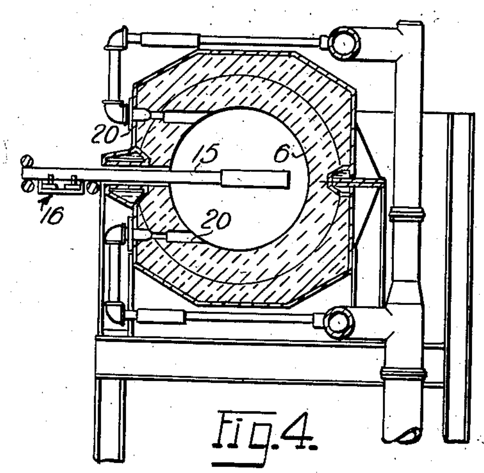

Fig.4.

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FORGE FURNACE CONTROL

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Application June 11, 1949, Serial No. 98,543

5 Claims. (Cl. 263—40)

The present invention relates to the heating of steel forging stock to forging temperature by advancing the work through a furnace chamber having a heating zone whose temperature is normally maintained substantially higher than the desired leaving temperature of the work so that the work must be advanced through the furnace at a predetermined minimum rate to avoid being overheated in said zone. In a heating system of this type, in case the demand for heated work is suddenly interrupted, the highly heated refractory which defines the furnace chamber contains enough heat to overheat the work if it is left in the furnace hence there is presented the problem of how to save the heated work from damage while retaining it in the furnace; and it is with the solution of this problem in a relatively simple and practical way that the present invention is primarily concerned.

For a consideration of what I consider to be novel and my invention, attention is directed to the following specification and the claims appended thereto.

In the accompanying drawing forming part of this specification—

Fig. 1 is a schematic representation of the method and apparatus involved in the present invention.

Fig. 2 is a longitudinal vertical sectional view of the type of furnace schematically shown in Fig. 1.

Fig. 3 is a transverse section vertical section of Fig. 2.

Fig. 4 is a view similar to Fig. 3 with some modifications.

Fig. 5 is a chart showing pertinent chemical and heat balance information.

The present invention is well adapted for use in connection with the furnace disclosed in my application filed May 19, 1949, Serial No. 94,216, and will therefore be described in that connection.

In its preferred form, the furnace chamber is cylindrical in transverse cross section and is defined by a structure **5** embodying an inner annular refractory lining **6**, the structure being supported on a pair of longitudinally extending girders **7** in a manner to permit free thermal expansion and contraction of said structure thereon, as indicated by rollers **8**, with reference to the anchored end **10** of said structure. The charge or work entering end of the furnace is at the left as viewed in Fig. 2. In Fig. 1, the furnace is diagrammatically indicated by the three aligned rectangular figures A, B and C, respectively, to indicate three successive heat zones in the furnace chamber. In Fig. 1, the charge end of the furnace is the left hand end **11** of zone A and the discharge end is at the right hand end **12** of zone C.

If the entire work piece **13** (see Figs. 2 and 3) must be heated to forging temperature, the pieces will ordinarily be pushed through the furnace on elevated skid rails **14**. On the other hand if the work pieces are elongated bodies **15** (see Fig. 4) of which only one end requires to be heated, said pieces will project into the furnace through a longitudinally extending slot in the sidewall thereof from any preferred supporting and conveying means **16** outside of the furnace chamber.

Heat is produced in the furnace chamber by longitudinally extending rows of burners **20** arranged to fire tangentially thereinto so that the flame of combustion may flow along the curved surface of the refractory lining **6** whereby to constitute said lining a source of radiant heat for heating the work pieces advancing through the furnace. Two such rows of burners will ordinarily suffice. Where the work pieces extend into the furnace through a slot as in Fig. 4, the burners are preferably arranged at

opposite sides of said slot so that one set of burners fires clockwise and the other counterclockwise into the furnace chamber; otherwise, as shown in Fig. 3, all of the burners fire in the same general direction.

The burners are manifolded into groups **21**, **22** and **23** corresponding to the heating zones A, B and C. The respective manifolds for said groups are indicated at **24**, **25** and **26**, respectively. To minimize explosion hazards, each manifold has its own air and fuel mixing device **27**, **28** and **29**, respectively. The main gas supply line is indicated at **31** and the main air supply line for air under pressure is indicated at **32**. Shut-off valves for these lines are indicated at **17** and **18**, respectively. Branch fuel gas lines **33**, **34** and **35** conduct the fuel to the several mixing devices and branch air lines **36**, **37** and **38** conduct the air thereto. Each branch air line is provided with a control valve **42**, **43** and **44**, respectively. The relative proportions of air and gas to each mixing device are automatically maintained by a gas governor **40** in each branch gas line, the governor being responsive to changes in pressure in the associated branch air line through a connecting pipe **41** in a manner to vary the gas flow in accordance as the air flow is varied. Ratio control means of this type are well known in the art.

The final heat zone C is not a soaking zone where the temperature of the work pieces is equalized but is a heating zone wherein the thermal head is maintained substantially higher, say 400 deg. F. higher, than the discharge temperature, say 2,300 deg. F., of the work pieces. When the demand for heated work is at a maximum, the heat input to the zones A and B is at a maximum. When the production demand for heated work is reduced, the rate of advance of the work pieces through the furnace must be correspondingly reduced. This presents the problem of how best to control the furnace to avoid overheating of the work and to prevent excessive scale formation on the work due to longer time in the furnace. This problem is solved not by reducing the thermal head of the final heat zone C but by controlling the heat input to the first heat zone A and then to the next heat zone B to such degree as may be necessary to insure that by the time the work piece has passed through the final high temperature heat zone C, it will not have been at scaling temperature substantially longer than when the work was being advanced through the furnace at maximum production rates with maximum heat input to zone A as well as the other zones B and C. The means for effecting such heat input control to the first zone A comprises a heat sensing element **45** mounted to be responsive to changes in temperature within the final heat zone C and more especially to the temperature of the work pieces in said zone. The said heat sensing element **45** operates a control instrument **46** which in turn operates a valve adjusting means **47** associated with the heat input control valve **42** for zone A to reduce the heat input to zone A as operating conditions may require. If still further reduction of heat input is required a valve adjusting means **48** associated with the control valve **43** for zone B is next operated on by the instrument **46** as will now be readily understood. It is preferred to separate zone A from the next succeeding zone B by means of a transversely extending heat shield **49** so that radiant heat in zone A is localized to that zone. The heat input to zone C to maintain the desired elevated temperature therein is determined by the setting of the control valve **44** for said zone. Hand setting of said valve **44** will ordinarily suffice but automatic control means may be employed.

The apparatus thus far described is substantially the same as that disclosed in my aforesaid application Serial No. 94,216.

To permit the already heated work to be retained in the furnace without damage by overheating and without excessive scale formation thereon in case the demand for heated work is suddenly interrupted, the present invention introduces into the furnace for contact with the highly heated refractory lining thereof a mixture of gases which when heated by said refractory will react endothermically and thereby rapidly lower the temperature of the surface of said refractory, the said mixture of gases (hereinafter sometimes called "atmosphere gas premix") being of such character that the reaction products will serve as a protective atmosphere for the heated work to reduce the formation of scale thereon to a minimum. The atmosphere gas premix is formed outside of the furnace chamber in a mixing device **51** to which air under appropriate pressure is delivered by a supply pipe **52** having a control valve **53** and to which fuel gas under appropriate pressure is delivered by a supply pipe **54** having a control valve **55**. The relative proportions of the air and fuel gas thus delivered to said mixing device **51** are controlled in any preferred way. Since the work in zone C is already at elevated temperature and therefore requires immediate protection against overheating it is into zone C that the mixture from the mixing device **51** is first introduced whereby to rapidly cool the refractory lining of that zone. The mixing device **51** therefore delivers to the manifold **26** for the burner group **23** associated with the zone C so that the mixture may enter said zone tangentially and therefore be rapidly heated to reaction temperature as it flows in contact with the highly heated curved boundary surface of said zone. To reduce draft through the furnace chamber to a minimum when the fuel supply to the furnace is shut off, the normally open flue dampers **67** and **68** are quickly closed by hand or otherwise, it being understood that it is desirable to maintain a plenum of protective atmosphere in the furnace chamber during that time to reduce the formation of scale on the heated work to a minimum.

Fig. 5 illustrates some chemical and thermal properties of varying ratios of the atmosphere gas premix. The ordinate is the ratio of air to methane, where methane is the well known methane equivalent of a hydrocarbon, and the abscissa is the reacting or equilibrium temperature. Curve **61** shows the thermal equilibrium mixtures of air and methane at various temperatures. Mixtures falling below the curve at a given temperature will react endothermically, and the proportionate distance of a point from the curve is an indication of the quantity of heat absorbed in the reaction. Curve **62** shows the temperatures at which the gases resulting from the reaction to equilibrium of a gas mixture of the air to gas ratio indicated will be in equilibrium with FeO, any richer premix resulting in an atmosphere reducing to FeO, and a leaner premix resulting in an atmosphere oxidizing to FeO. Curve **63** shows the same information with regard to Fe_3O_4 and the point **64** lies on a similar curve for Fe_2O_3. In the application of the present invention an atmosphere gas premix is chosen that is reducing to the several forms of scale, thus constituting a protective atmosphere, and at the same time having a high capacity to absorb heat in an endothermic reaction. The preferred ratio is 1:1 or ½:1 air to methane gas, thus allowing a maximum cooling effect without the bad effects of carbon deposition or sooting characteristic of richer air:gas mixtures. The mixture is admitted to the refractory wall in relatively small or thin streams for improved heat contact therewith for sufficient time to insure substantially complete reaction before passing to the center of the furnace, thereby protecting the work from further oxidation while cooling the furnace and the work to a desired temperature.

As an illustration of the beneficial effects obtained in the practice of the present invention the following may be cited:

Work was heated, in a furnace whose walls were maintained at 2,700 deg. F., to a core temperature of 2,200 deg. F. The scale formed in normal operation at 50% of the furnace design production rate was 0.010 inch on a 23 lb. piece of work, and after holding in an atmosphere in accordance with this invention for 25 minutes the scale was 0.008 inch. After reheating a corresponding piece to forging temperature, the scale was 0.017 inch. A similar work piece was heated to forging temperature, then cooled normally without an atmosphere to 2,100 deg. furnace temperature in 30 minutes and was found to have 0.56″ scale.

It is a feature of the present invention that the heating surface, i. e. the refractory walls, are cooled by direct application of a cooling gas, whereby heat by radiation to the work is substantially reduced. In the preferred form of the invention, as above described the cooling gas mixture of air and methane is mixed in a suitable mixing device **51** to form an atmosphere gas premix which, when it reacts against a furnace wall which is at a temperature higher than the theoretical flame temperature of the premix, curve **61**, removes heat from that wall, thereby cooling the wall to a temperature higher than the theoretical flame temperature, but sufficiently low to avoid damage to work which has been overlong retained in the furnace chauger. The atmosphere premix gas formed by the mixing device **51** is admitted to the furnace chamber and caused to whirl, thereby causing the gas to remove heat from the refractory walls and forming a blanket of protective atmosphere about the work. It is within the scope of the present invention to use other cooling gas than that illustrated. For example ammonia vapor would serve the same purpose, but is not preferred because of the hazard of the high hydrogen gas formed and because of the difficulty of supplying at will the desired quantity of the vapor. Vapors such as certain pine oil constituents might be used without air and the oxygen already present in the pine oil will prevent the deposition of soot, as is well known. Again the difficulty of maintaining a standby supply of such vapors discourages their use when, for example, natural gas and air are available.

It may be stated that it is preferred to admit the atmosphere forming gas to the furnace chamber through a series of laterally extending relatively small inlet ports tangent to the inner surface of said chamber whereby to produce in the chamber a plurality of laterally spaced streams of said gas and which collectively form a relatively thin layer of the gas next to said surface with the resultant more rapid cooling of said surface by endothermic reaction as will now be readily understood.

Since the preferred furnace utilizes a series of laterally extending burner ports which are tangent to the refractory wall and since the burners are turned off when the method of the present invention is employed and since it is structurally desirable to have a minimum of holes in the refractory walls, the said gas is admitted through the said burner ports.

What I claim as new is:

1. In the art of heating metal articles in a furnace chamber wherethrough said articles may be advanced for heating and wherein the furnace chamber normally constitutes the combustion chamber for heating fuel, the method of protecting said articles from oxidation when the articles must be temporarily retained in said chamber which comprises turning off the fuel to said chamber and admitting to said chamber through the fuel inlet ports a stream of a mixture of hydrocarbon fluid and air having such a ratio which at the temperature of the furnace walls will react endothermically to produce a reaction product serving as an atmosphere which will protect the articles from oxidation and will cool the furnace walls due to the heat absorbed by the reaction, said stream being in sufficient volume to maintain a plenum of protective atmosphere and at a rate to insure substantially complete reaction within the chamber to maintain therein a plenum of protective atmosphere.

2. In the method according to claim 1, the said chamber having an outlet for the said products of combustion and having a damper associated therewith, the step of closing said damper to reduce the quantity of gas required to maintain a plenum of protective atmosphere within the furnace chamber.

3. The method according to claim 1, wherein said mixture is sufficiently lean to avoid substantial sooting within the furnace chamber.

4. The method according to claim 1 wherein said mixture consists of methane gas and air in proportions equivalent to from about 1 to 1 to about ½ to 1 air to methane gas.

5. In the art of heating steel articles to temperatures above 1800° F. in a furnace chamber wherethrough said articles may be advanced for heating and wherein the furnace chamber normally constitutes the combustion chamber for heating fuel the method of protecting said articles from rapid oxidation at elevated temperatures above 1800° F. when said articles must be temporarily retained in said chamber, which comprises turning off the fuel for heating said chamber and admitting to said chamber a stream of an air-methane premix having an equivalent air to methane ratio of less than 5 to 1 and more than would cause substantial sooting within the furnace chamber, said mixture of methane gas and air having such a ratio which at the temperature of the furnace walls will react endothermically to produce a reaction product serving as an atmosphere which will protect the articles from oxidation and will cool the furnace walls due to the heat absorbed by the reaction, said stream being in sufficient volume to maintain a sub-

stantial plenum of protective atmosphere and at a rate to insure substantially complete reaction within the chamber.

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