

May 12, 1959

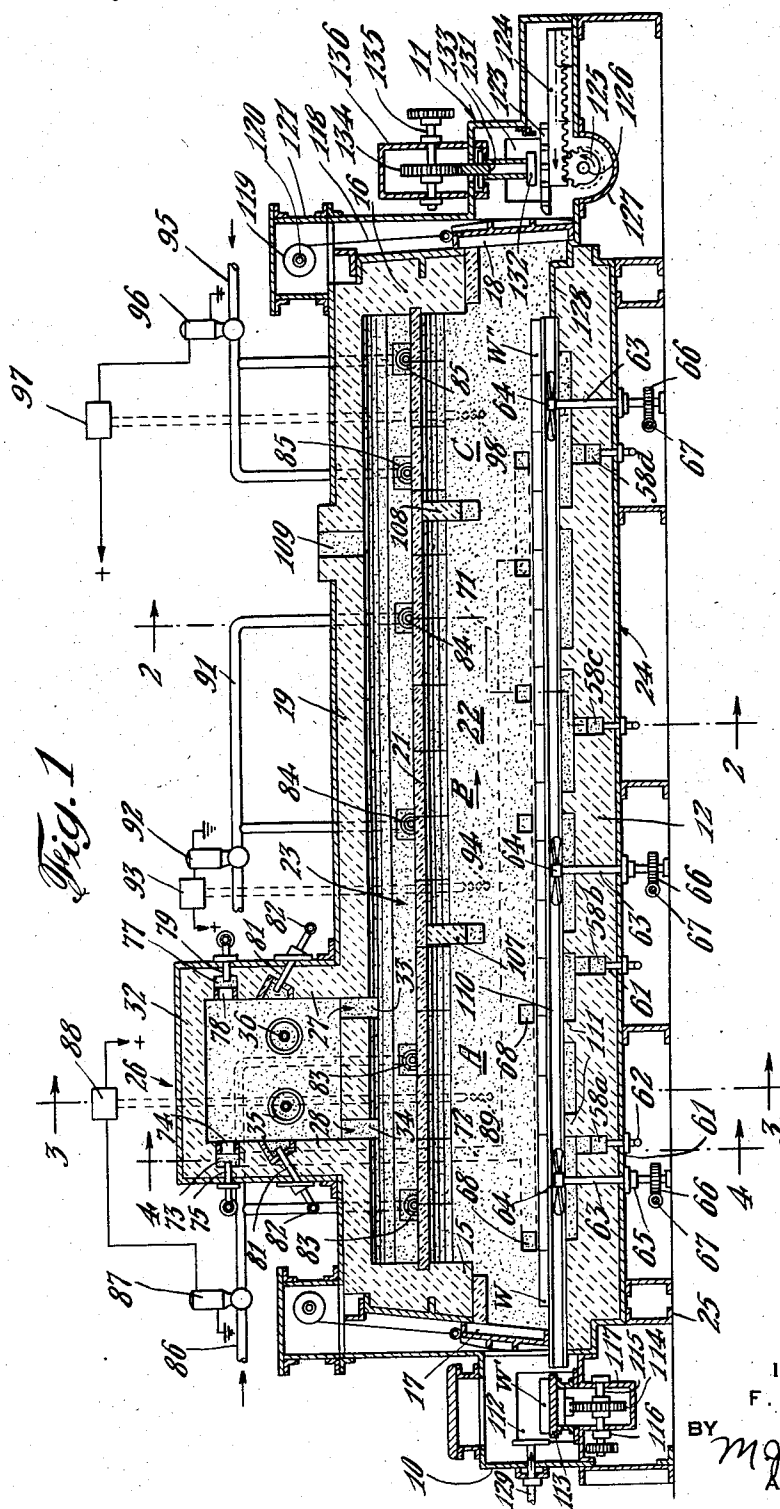
F. A. RUSCIANO

2,886,303

CARBURIZING FURNACES WITH RECUPERATIVE HEATING

Filed May 1, 1956

3 Sheets-Sheet 1



May 12, 1959

F. A. RUSCIANO

2,886,303

CARBURIZING FURNACES WITH RECUPERATIVE HEATING

Filed May 1, 1956

3 Sheets-Sheet 2

Fig. 2

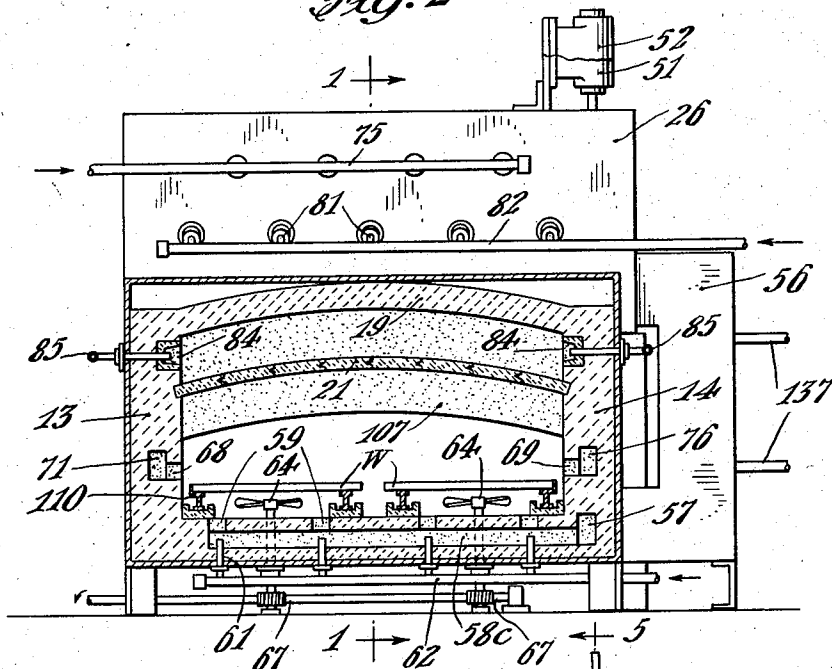
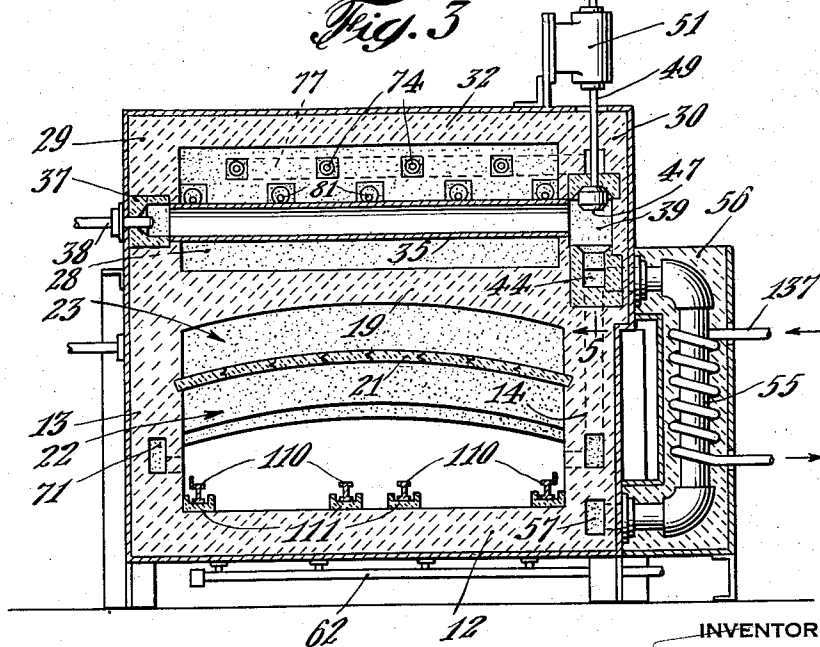


Fig. 3



INVENTOR

F. A. RUSCIANO

BY

M. J. Reynolds
ATTORNEY

May 12, 1959

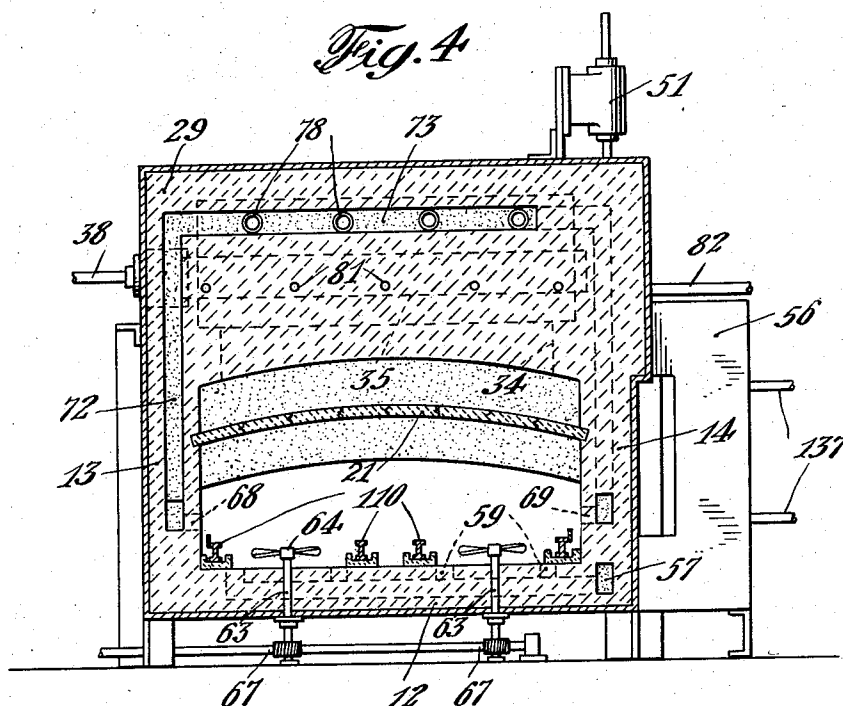
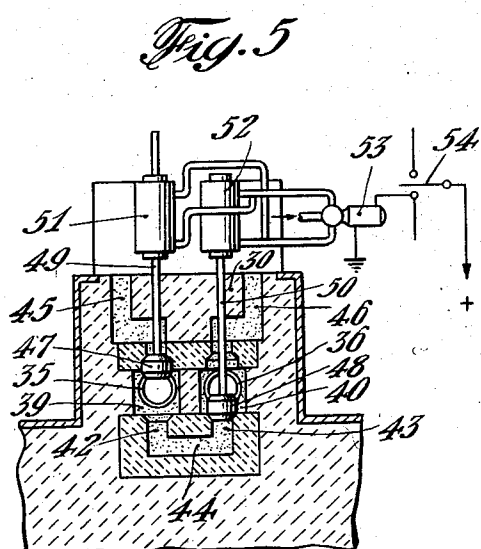
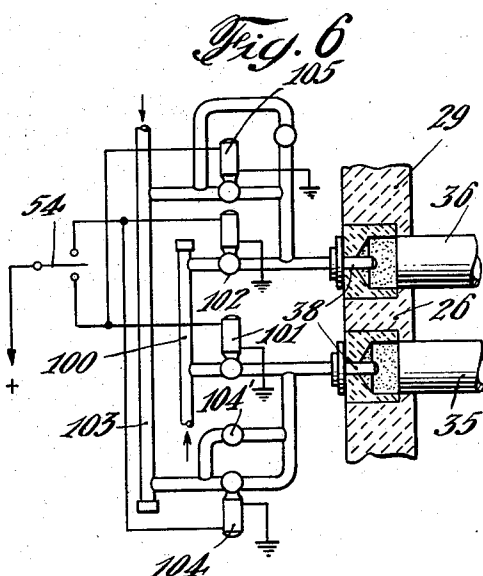
F. A. RUSCIANO

2,886,303

CARBURIZING FURNACES WITH RECUPERATIVE HEATING

Filed May 1, 1956

3 Sheets-Sheet 3



1

2,886,303

CARBURIZING FURNACES WITH RECUPERATIVE HEATING

Frank A. Rusciano, New York, N.Y., assignor to Metallurgical Processes Co., Newark, N.J., a corporation of New Jersey

Application May 1, 1956, Serial No. 582,010

1 Claim. (Cl. 266—5)

This invention relates to a furnace primarily for the carburization of steel, such furnace also being applicable to the heating of steel without decarburization thereof.

Normally, in the carburizing of steel, the carburizing gas is produced by reacting an endothermic mixture of fuel and air in a cracking chamber remote from the carburizing furnace, cooling the cracked gas to facilitate piping and valving of the gas to the furnace, and then introducing the cooled gas into the carburizing chamber of the furnace, either of the electric or indirectly heated type. This method is satisfactory for batch type furnaces which remain tightly closed during the carburizing cycle and which, therefore, require only a small flow or carburizing gases to maintain the furnace pressure against infiltration of the air. It is not suitable for use with large continuous carburizing furnaces in which the work is intermittently introduced at one end and similarly removed from the opposite end, due to the much larger volume of carburizing gas required to maintain such a furnace in satisfactory operation. The introduction of a cold gas into the carburizing chamber in any appreciable amount inherently results in a decrease in the carburization rate since this cold gas is relatively ineffective until it is brought up to the carburizing temperature of about 1700° to 1750° F. In addition the use of a cold gas has a retarding effect on the heating of the work.

The production of a carburizing gas atmosphere requires the use of an air-fuel mixture which is sufficiently rich in fuel to produce, on proper thermal reaction, products having both the CO_2/CO and $\text{H}_2\text{O}/\text{H}_2$ ratios to the left of the characteristic carburization curves. The air-fuel mixtures required to produce the desired hot carburizing gases will have only about 25% of the air which would be required for complete combustion of the fuel and, of course, is highly endothermic in nature. The proper cracking of such a mixture is best accomplished at high temperatures, of the order of 2250° F. to 2500° F., and this is particularly true where large quantities of carburizing gas are required since it greatly increases the cracking rate, enabling compact cracking equipment to be employed and reduces the deposition of soot.

The present invention contemplates the use of these hot cracked gases directly in the furnace work chamber, without previous cooling, at least to any substantial degree. This necessitates positioning of the cracking chambers in close proximity to or as an integral part of the furnace structure. Since only limited space is available in such location the use of small high temperature cracking units becomes essential. However, in the carburizing of steel it is usually desirable to limit the work temperature to about 1700° F. to 1750° F. for the purpose of maintaining certain grain structures and in the decarburization free annealing of steel even lower temperatures are required.

One of the objects of the present invention is, therefore, to produce a furnace and an atmosphere generator for use therewith, suitable for the carburization or decarburization free heating of steel in which the atmos-

2

phere is produced by high temperature thermal reaction and is supplied to the heating chamber substantially in its virginal heated form.

Another object is to provide a furnace of the above type in which thermally reacted furnace atmosphere gases are utilized to assist in the heating of the work.

Still another object is to provide furnace of the above nature in which provision is made for preventing local or surface overheating of the work by the hot atmosphere.

The products resulting from the cracking of the rich endothermic mixture have a very high potential heat content, in excess of that of the raw gas employed, and if vented from the furnace would burn at the vents, thereby producing a hazard. It would also result in an economic loss.

A further object is, therefore, to utilize the potential heat content of the atmosphere gases to supply, at least in part, the heating requirements of the furnace.

Still another object is to employ the potential heat content of the atmosphere gases to effect the thermal generation of additional atmosphere gases.

Another object is to provide a carburizing furnace of the continuous type which will be economical in operation and which will have a high carburizing rate.

Other objects and advantages will hereinafter appear.

In accordance with the present invention the carburizing or decarburization free atmosphere gases are produced in a reaction chamber closely associated with the work heating chamber so that they may be passed directly from the former to the latter in a highly heated and chemically active condition. Therefore, they not only carry appreciable amounts of heat into the furnace chamber but also, in the case of carburizing gases, are in a highly effective carburizing state. Provision is also made to vent these gases from the work chamber into thermal relation with the reaction chamber where additional air is supplied for the complete combustion thereof. The heat generated by this combustion serves to effect the endothermic cracking of the air-fuel mixture passing through the reaction chamber, and the heating of the resulting products to the desired high temperature for entrance into the work chamber. Structural arrangements are also provided for utilizing a part of the heat of this combustion for radiant heating of the work chamber.

The most desirable cracking temperature may be as much as 500° F. to 800° F. above the desired heating temperature of the work. Also in furnaces of the continuous type in which the work is entered at one end and removed at the opposite end it is necessary to maintain a substantial pressure of the atmosphere in the furnace to avoid influx of air and loss of atmosphere due to the frequent opening and closing of the furnace doors. This requires the use of large volumes of atmosphere. If any large quantity of this high temperature gas was to be admitted into the work chamber at any particular location overheating of the work adjacent such entrance position would be unavoidable. The present invention avoids this difficulty, while still utilizing these high temperature gases for heating of the furnace chamber by a number of expedients. First, the hot atmosphere gas is introduced into the work chamber at a large number of spaced points, substantially uniformly distributed throughout the floor of the furnace chamber, so that only a relatively small amount of gas is entered at any one point; secondly, this distribution is effected through conduits extending laterally though the floor or hearth whereby a substantial portion of the heat will be absorbed in heating this wall of the furnace; thirdly, the work is supported above the floor and the port area is made sufficiently large to permit slow entrance of the gases and lateral spreading thereof beneath the work so as to avoid localized impingement on

3

the work; fourthly, circulating fans are disposed beneath the work to enhance this spreading and rapidly force the gases past the work and into contact with the furnace walls whereby additional heat is given off, after which these gases, cooled substantially to the work chamber temperature, are drawn back beneath the work for mixture with the incoming hot gases; fifthly, a small amount of an uncracked hydrocarbon gas may, if desired, be admitted to the hot gas stream adjacent each entrance port, whereby to increase the carburizing potential of the atmosphere and to moderate its entrance temperature somewhat by admixture therewith and by endothermic absorption therefrom; and lastly, cooling means is provided in association with the conduit which conducts the atmosphere gases from the generator to the work chamber, for use whenever the temperature differential of the generator gases and the desired work temperature is sufficiently large to necessitate such additional cooling.

The construction and operation of the furnace will best be understood by reference to the accompanying drawings in which:

Fig. 1 is a longitudinal vertical section of a furnace embodying the invention;

Fig. 2 is a transverse sectional view of the furnace taken on line 2—2 of Fig. 1;

Fig. 3 is a transverse sectional view of the furnace taken on the line 3—3 of Fig. 1;

Fig. 4 is a vertical sectional view on the line 4—4 of Fig. 1;

Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 3; and

Fig. 6 is a diagrammatic view showing the fuel and air supply for the furnace atmosphere generators.

Referring first to Fig. 1 the furnace therein illustrated is of the continuous type in which work is entered at the left end, conveyed to the right through the furnace and extracted at the right hand end. In order to prevent entrance of air into the furnace heating chamber and loss of atmosphere from the furnace during loading and unloading of the work, each end is provided with a suitable vestibule. The work entering vestibule comprises a metal casing 10 and the work discharge vestibule comprises a somewhat similar casing 11, to be more fully described hereinafter. A suitable positive pressure is maintained within the work chamber to prevent air from entering from the vestibule.

The heating furnace comprises a refractory floor 12, side walls 13 and 14, (Fig. 2) end walls 15 and 16 having work receiving and work discharging openings respectively, normally closed by suitable doors 17 and 18 respectively, an arched refractory roof 19 and an intermediate horizontally extending arch 21 fabricated with thin interlocking plate sections composed of a refractory having good heat conductivity, such as silicon carbide, and serving to divide the interior of the furnace into a lower work heating chamber 22 and an upper combustion chamber 23. The exterior refractory walls of the furnace are contained within a suitable metal shell 24 supported on structural steel members, such as 25.

A second combustion chamber 26 extends transversely over the roof of the furnace adjacent to the charging end thereof and comprises the refractory side walls 27, 28, end walls 29, 30 forming continuations of the furnace side walls 13 and 14, respectively, and a roof 32. The chamber 26 is open to the combustion chamber 23 by means of two transverse slots 33, 34 extending through the roof 19 of the furnace, which also forms the floor of chamber 26.

Two parallel tubes 35 and 36, consisting of a heat resisting alloy or suitable refractory ceramic, extend through the chamber 26, being supported at their opposite ends in the vertical walls 29 and 30 of the chamber. Each of these tubes is provided with a suitable burner block 37, at its left end, as viewed in Fig. 3, through which a burner nozzle 38 extends. At the opposite ends, the tubes 35

4

and 36 are open to cavities 39, 40 respectively, (Fig. 5) in the wall 30, each of these cavities communicating through valved passageways 42, 43 respectively, with a common conduit 44. The cavities 39 and 40 are also provided with valved passageways 45 and 46, respectively, extending upwardly through the wall 30 to the exterior of the furnace. The passageways 42 and 45 are provided with seats engageable by the valve 47, in its lower or upper position, respectively, so as to close one and open the other passageway whereby the gaseous products to be developed in the tube 35 may pass either into the conduit 44 or be vented through the flue 45. The passageways 43 and 46 are similarly controlled by a valve 48. The valves 47 and 48 are carried by stems 49, 50, respectively, secured to the plungers of pneumatic cylinders 51 and 52, respectively, controlled by a suitable electrically operated reversing valve 53, energized through a switch 54 in such manner that one of the valves 47, 48 is raised when the other is lowered. The purpose of this arrangement is to permit the tubes 35, 36 to be used alternately to supply the desired atmosphere to the work chamber 22, and to permit the idle tube to be burned free of soot as will presently appear.

A tube 55 disposed externally of the furnace within suitable insulation 56 provides a passageway between the conduit 44 and a conduit 57 which extends longitudinally through the refractory side wall 14 adjacent to the base of the furnace. A number of conduits, such as 58a, 58b, 58c and 58d (Fig. 1) extend from conduit 57 transversely through the hearth or floor 112 and each of these conduits open into the work chamber 22, as by ports 59 (Fig. 2). As a consequence of this construction gases generated in one or the other of tubes 35 and 36 will be conducted into the work chamber 22 through the ports 59 at a large plurality of substantially uniformly disposed points.

The aggregate area of the ports 59 is such as to prevent rapid influx of the hot atmosphere into the work heating chamber, thereby avoiding impingement on a localized area of the work or work supporting trays and permitting lateral spreading of the gas beneath the work trays whereby a more uniform distribution of the heat is obtained.

Extending upwardly through the floor of the furnace, directly beneath each of the ports 59, is a pipe or nozzle 61 which may be provided, by cross manifolds 62, with a supplemental gas for addition to the furnace. The gas admitted through pipes 61 may be an uncracked hydrocarbon gas which serves to enrich the cracked hydrocarbon gas, thereby to enhance its carburizing potential. It serves the additional function of mixing with the hot incoming atmosphere and thereby moderating the temperature thereof, thus further reducing any tendency to locally overheat the work. This uncracked gas also reacts endothermically, to some extent, with the hot atmosphere and absorbs a portion of the heat therefrom.

Also extending upwardly through the floor of the furnace are the shafts 63 of gas circulating fans 64. The shafts 63, which may be water cooled, pass through suitable glands 65 and are rotated by gears 66, from cross shafts 67 driven in any suitable manner, as by individual motors. The fans 64 serve to draw gas downwardly along the side walls of the work chamber, which are at a lower temperature than the incoming gases, for admixture therewith below the work, this further moderating the temperature of the incoming gases. The fans also produce a more uniform distribution of the gaseous atmosphere in the work heating chamber.

The gaseous atmosphere provided for the work chamber is vented therefrom by side ports 68 and 69 disposed along the side walls 13 and 14, respectively. Ports 68 communicate with a passageway 71 in wall 13 extending longitudinally throughout the length of the furnace and having, adjacent the charging end of the furnace, a vertical flue section 72 extending upwardly through side

5

wall 13 and its continuation 29 (Fig. 4) and thence to a horizontal flue 73 in the wall 28 of combustion chamber 26. The flue 73 has a series of ports 74 entering into the chamber 26 and opposite each port the wall 28 is pierced by an airjet nozzle 75 disposed so as to discharge through the associated port 74.

The opposite vent ports 69 lead to a similar longitudinal flue 76 which leads to a horizontal flue 77 in wall 27 of the combustion chamber 26, provided with outlet ports 78 and air nozzles 79. The chamber 26 is also provided along each wall 27, 28 with a series of burners 81 supplied with a combustible air-fuel mixture by manifolds 82.

The ports 68, 69 are restricted with reference to the volume of gas supplied by tubes 35, 36 so as to maintain a furnace pressure of 0.03 to 0.09 inch of water so as to maintain a predetermined carburizing potential in the furnace and thus to avoid loss of atmosphere when the vestibule doors are opened.

The combustion chamber 23 in the upper portion of the furnace is also provided with a first group of burners 83, disposed over the charging end of the furnace, a second group of burners 84 disposed over the central or main carburizing section of the furnace and a third group of burners 85 adjacent to the discharge end of the furnace. Burners 83 are supplied with a combustible mixture by a manifold 86 containing an electric fuel valve 87 actuated by a control instrument 88 in response to a pyrometer 89 disposed in the charging or preheating end of the furnace. Burner group 84 is similarly supplied with a combustible mixture by manifold 91 having an electric valve 92 actuated in response to a control instrument 93 and an associated pyrometer 94 disposed in the central portion of the furnace and burner group 85 is likewise provided with a combustible mixture by manifold 95 and electric valve 96 under control of instrument 97 and a pyrometer 98 disposed adjacent the discharge end of the furnace.

Referring now to Fig. 6, the burners 38 of the gas generator tubes 35, 36 of combustion chamber 26 are each provided with a fuel-air mixture from a manifold 100 through normally closed electric valves 101, 102, respectively, and with air from a manifold 103, through valves 104, 105 respectively. The manual switch 54 in its lower position energizes valves 101 and 104 to admit the air-gas mixture to tube 35, a small amount of air only being admitted to tube 36 through the open by-pass 105' around valve 105. Switch 54, as heretofore described, also energizes electric reversing valve 53 at this time, to raise valve 47 (Fig. 5) and lower valve 48, thereby permitting the reaction products generated in tube 35 to pass into the work chamber of the furnace and venting the products resulting from reaction of the air in tube 36 with the carbon deposition therein, through flue 46 to the outside of the furnace. When switch 54 is moved to its upper contact tube 36 is supplied with the air-gas mixture and tube 35 is supplied with air alone, through electric valves 102, 104 and bypass 104' respectively, the vent valves 47 and 48, also reversing their position to place tube 36 in communication with the furnace chamber and tube 35 in communication with the vent 45. It will be understood that the air input to the idle tube is very small, of the order of 3 to 4% of the normal gas and air supply to the opposite tube. Normally the operation of tubes 35, 36 is alternated daily.

When it is desired to utilize the furnace for carburizing the gaseous mixture supplied through manifold 100 will be of sufficient richness, depending to some extent on the nature of the steel being heated, to produce, on cracking in the tube 35 or 36, reaction products which are carburizing in nature. Normally such products are producible with approximately 25% of the air required for complete combustion of the fuel. When decarburization free heating only is desired the aeration may be of the order of 30%. This rich mixture is endothermic

6

in nature and requires external heat produced in the combustion chamber 26 to effect the desired thermal reaction or cracking thereof. The cracked products, by virtue of the heat absorbed from the combustion chamber 26 contains sensible and potential heat in excess of that of the unreacted mixture employed and after passage into the work carburizing chamber 22, if these products were to be vented to the outer atmosphere, this would constitute an economic loss. Also these products may be, if desired, enriched with a small amount of raw fuel through the pipes or nozzle 61 whereby to increase the carburizing potential of the gaseous atmosphere, and these fuel additions add to the potential heat thereof. Furthermore, direct venting of the work chamber gases to the outer atmosphere would result in violent burning thereof at the vent ports. It is for these reasons, therefore, that the carburizing gases are channeled from the work chamber and introduced into the combustion chamber 26 through the ports 74 and 78, together with the remaining 70% to 75% of the air required for their complete combustion, and thus burned in heat transfer relation to the cracking tubes 35 and 36. This burning of the carburizing atmosphere is normally sufficient to maintain the cracking tubes in operation. The supplemental burners 81 are provided for the purpose of bringing the cracking chambers up to temperature, upon starting the furnace into operation and to supply additional heat energy when desired, either for high temperature cracking or to supplement the heat otherwise supplied to the furnace.

The chamber 26 vents through the passageways 33, 34 into the combustion chamber 23 so that the excess heat developed in the former chamber and not absorbed by the cracking operation is passed in contact with the arch 21 to thereby assist in heating of the work chamber.

The work chamber 22 is partially divided into three sections by the depending arch members 107, 108, namely; a preheat section A wherein the work is brought up to the carburizing temperature of about 1750° F., a carburizing section B in which the work is maintained at about 1750° F. during the carburizing cycle, and a discharge section C in which the work is allowed to cool to about 1500° F. before discharge into the air so as to meet the normal discharge and quenching conditions. The burner groups 83, 84 and 85 due to their individual control by the pyrometers 89, 94 and 98 disposed in the respective sections A, B and C serve to maintain the desired work temperature in the respective sections. Inasmuch as section A is required to bring the work up to the carburizing temperature from the cold condition, burners 83 are operated at a high head. Moreover the combustion chamber 26 vents directly into this portion of compartment 23 so as to add the heat of its combustion products to the heating-up zone of the furnace.

The burners 84 which are disposed over the main carburizing section of the furnace are only required to supply sufficient heat to overcome radiation losses and maintain the work at the desired carburizing temperature. Hence they may be operated to maintain a lower head over section B.

Section C is a cooling section and hence burners 85 are operated to produce a still lower head over this section, or, when required may be supplied with air alone to serve as a cooling medium. As a consequence the combustion chamber 23 is vented at 109 substantially between sections B and C, thus causing the high temperature gases generated above section A and those vented by the combustion chamber 26 to travel over section B and thus assist the burners 84 in maintaining the carburizing temperature in this middle section. This position of the vent also prevents these comparatively hot combustion products from entering the portion of compartment 23 which is disposed over cooling section C and interfering with the desired cooling action. Likewise the cooler gaseous medium introduced into compartment 23

over section C, by nozzles 85, is vented therefrom without entering over sections A or B.

In the operation of the furnace the trays W containing the work pieces to be carburized are advanced through the respective sections A, B and C on suitable rails 110 mounted upon piers 111 extending upwardly from the floor 12 so as to space the work above the circulating fan blades 64, as best seen in Fig. 2, and to permit proper circulation of the carburizing gases below the work. Assuming the furnace to be filled, the operation of removing a hot work tray and entering a cold one is as follows: The cold work tray W' (Fig. 1) is entered into the vestibule 10 through the door opening 112 by means of a conveyor 113 operated by a rack and pinion 114, through a shaft 115 passing through a gland 116 in the pinion well 117 and driven externally thereof in any suitable manner. This work piece is aligned with one of the pairs of rails 10 and door opening 112 is closed. Thereafter the discharge door 18 is opened by a cable 118 secured to a sheave 119 mounted on a shaft 120 passing through a gland, not shown, in the sheave housing 121 and driven externally thereof. The extracting mechanism, contained in vestibule 11 is then entered through the door opening. This mechanism comprises a grid 123 mounted on a rack 124 operated by a pinion 125 by a driven shaft 126 extending outwardly of the pinion well 127. Thus the grid 123 is advanced into the furnace above the door frame casting member 128. Thereupon furnace door 17 is opened and pusher member 129 operated to advance the work tray W' on to the rails 110, thus advancing the entire load and forcing the opposite end hot work tray W'' onto the grid 123. The grid 123 and pusher 129 are then each retracted and doors 17 and 18 closed. The door 131 in the discharge vestibule is then opened and the work tray W'' pushed laterally from the grid member through the door opening 131 onto a quench elevator (not shown) by a pusher mechanism comprising the pad 132 depending from a rack member 133 operated by a pinion 134 having a suitable drive shaft 135 extending outwardly through the pinon housing 136. This vestibule arrangement thus permits loading and unloading of the furnace without unduly disturbing the furnace atmosphere. The relative high pressure maintained in the furnace enables the carburizing atmosphere to be maintained with door 17 and 18 open into the vestibules 10 and 11.

It will be noted that the carburizing gases enter the work chamber at a relatively high temperature. This produces a very substantial increase in the carburizing rate as compared with the introduction of cold carburizing gases, which as stated results in a delay in the carburizing effectiveness of the gas until it is heated up in the work chamber, to the carburizing temperature. The present invention contemplates the entrance of a carburizing medium which is somewhat above the carburizing temperature of the work and thus eliminates this delay. In addition in place of subtracting heat from the work chamber, the carburizing gases add heat thereto so that the heating rate, for instance, in section A is not only increased but the surface of the metal may attain a carburizing temperature by contact with the hot entering gases early in the heating-up section of the furnace, thus increasing the effective length of the carburizing cycle.

In order to maintain certain grain structure in the metal it is not desirable to permit the work to attain tem-

perature much in excess of 1750° F., although in order to reduce sooting in the cracking tubes and to obtain suitable cracking reactions with some fuels it may be desirable to operate the cracking tubes at temperatures several hundred degrees in excess of the carburizing temperature. Therefore, when extreme temperature differentials exist, in order to prevent overheating of the surface of the work by such high temperature gases, despite the moderating conditions heretofore mentioned, a cooling coil 137 is provided about the conduit 55 extending from the cracking tubes 35, 36 into the work chamber. Any suitable cooling fluid, as air or water may be passed through the coil 137 to reduce the cracked gases to the desired usable temperature.

It is obvious that many structural variations may be made in the apparatus shown without departing from the essential attributes of the invention and therefore the present embodiment is to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claim rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claim are intended to be embraced therein.

What I claim is:

A continuous furnace for the carburizing of steel in an atmosphere produced by the thermal reaction of an endothermic mixture of a hydrocarbon fuel and air, in which work is passed through the furnace from end to end comprising refractory walls forming a work chamber having a heating-up zone and a carburizing zone, means for entering work into one end of said work chamber and means for extracting the work from the opposite end thereof, a gas generator forming an integral part of said furnace, said gas generator having a gaseous outlet port entering into a wall of said furnace, conduit means connecting said outlet port with said work chamber at a plurality of points distributed throughout the length thereof, a combustion chamber surrounding said gas generator, gas and air inlet means for said combustion chamber, a compartment extending over said work chamber substantially throughout the length thereof and separated therefrom by a wall having good heat conductivity, means for venting said combustion chamber into said compartment at one end thereof above the heating up zone, and means for venting said compartment at a point substantially over the terminal end of the carburizing zone, said gas generator further comprising a plurality of tubes extending through said combustion chamber, said conduit means being provided with valving means whereby any one of said tubes may be disconnected from said work chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

975,077	Rockwell	Nov. 8, 1910
1,304,258	Breaker	May 20, 1919
2,124,764	Comstock	July 26, 1938
2,161,162	Harsch	June 6, 1939
2,233,474	Dreffin	Mar. 4, 1941
2,275,106	Hayes	Mar. 3, 1942
2,589,811	Holcroft	Mar. 18, 1952
2,628,830	Kerr	Feb. 17, 1953
2,630,315	Munford	Mar. 3, 1953
2,759,863	Ness	Aug. 21, 1956
2,763,476	Ness et al.	Sept. 18, 1956