March 3, 1964 J. VAN ACKEREN 3,123,540

HIGH CHAMBERED HORIZONTAL COKE OVENS

Filed April 13, 1961 3 Sheets-Sheet 1

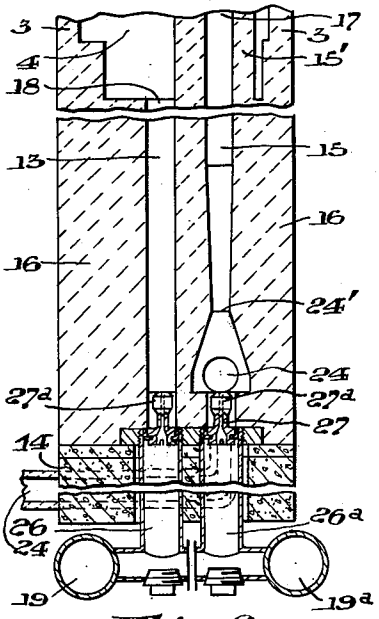


Fig. 6.

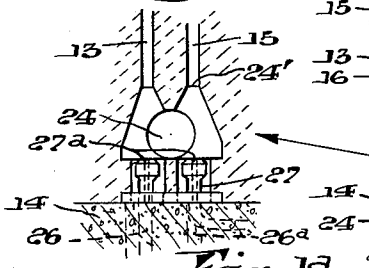


Fig. 1a.

Fig. 1.

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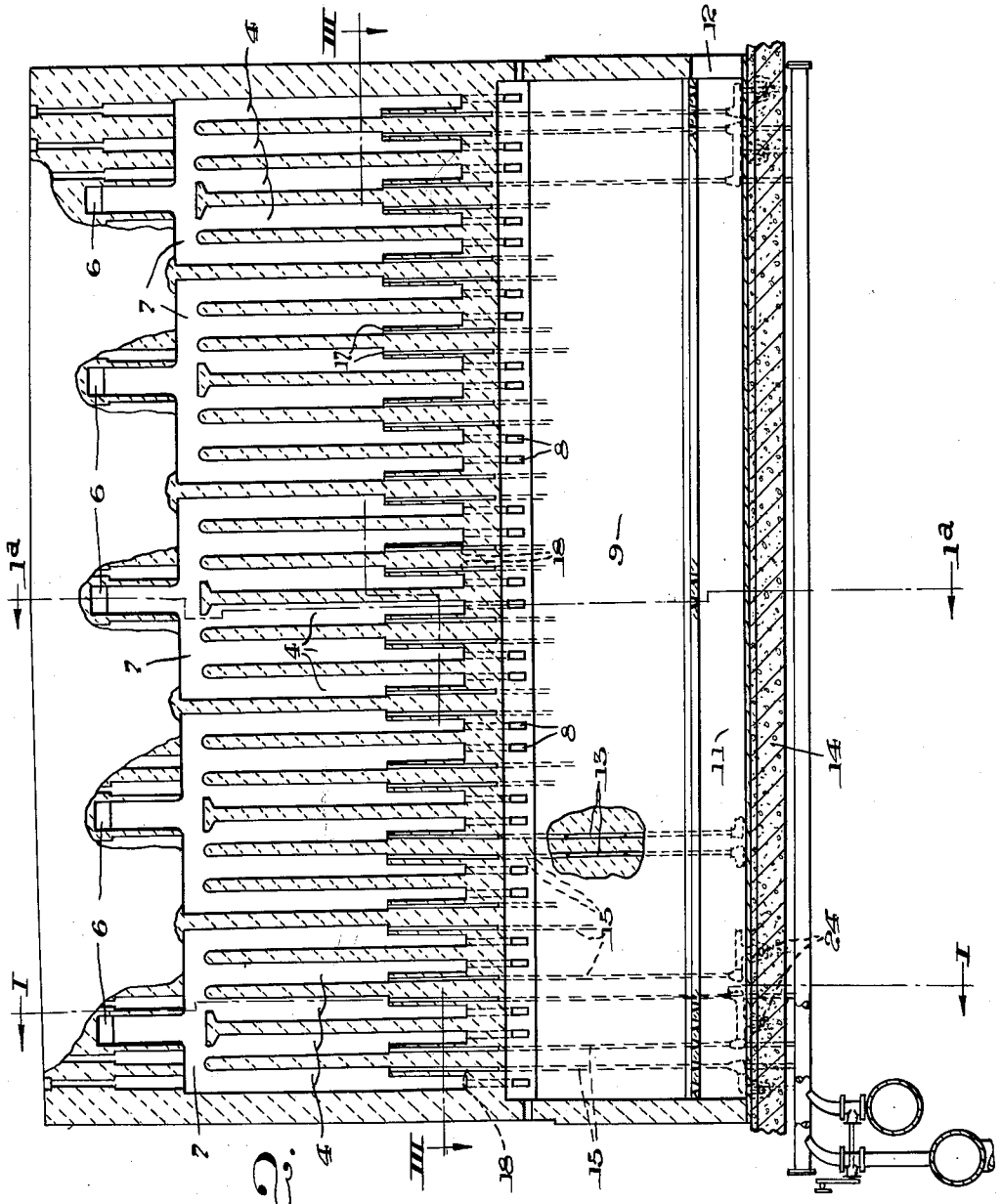


Fig. 2.

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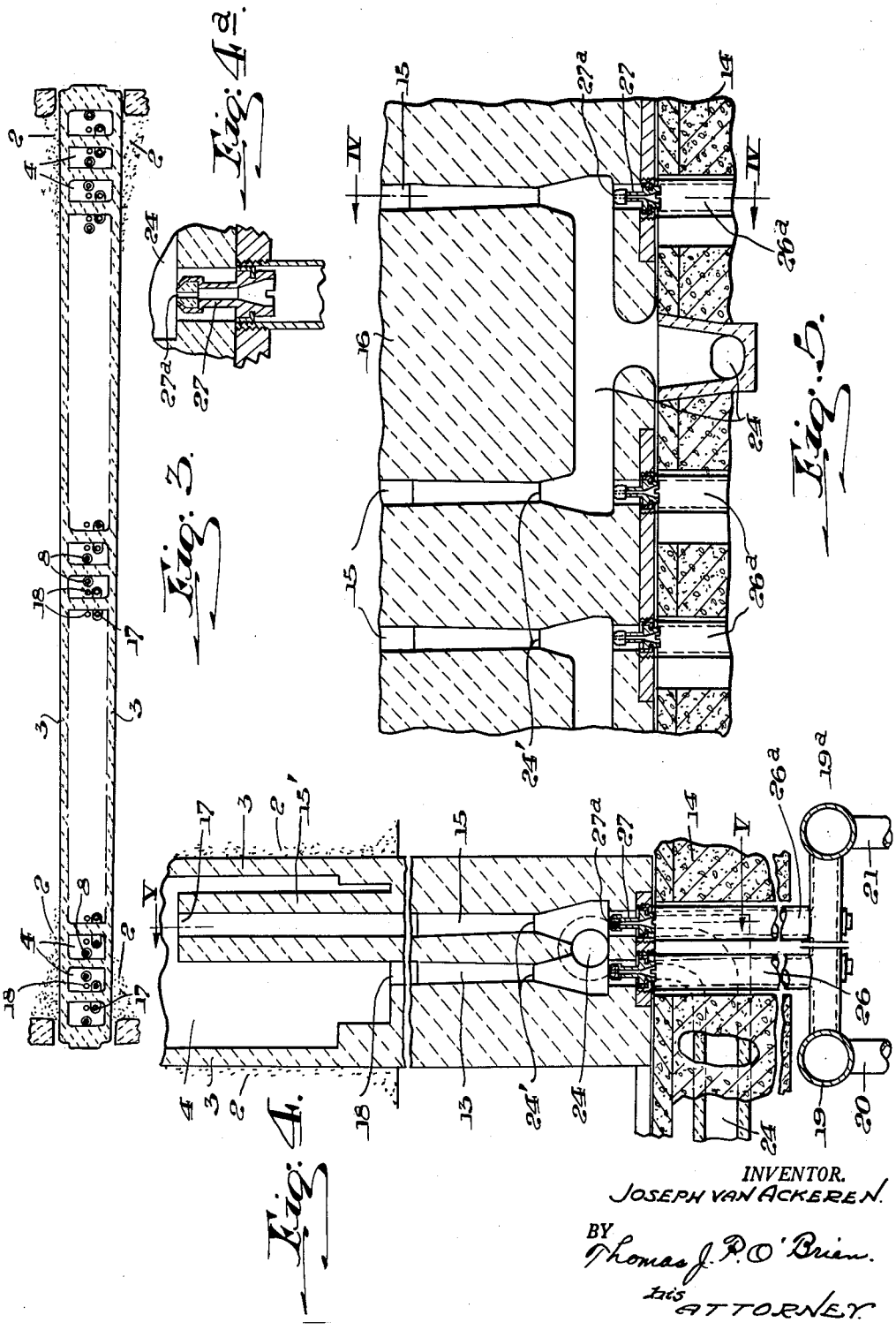


Fig. 4a.

Fig. 3.

Fig. 5.

Fig. 4.

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United States Patent Office 3,123,540 Patented Mar. 3, 1964

3,123,540

HIGH CHAMBERED HORIZONTAL COKE OVENS

Joseph van Ackeren, Pittsburgh, Pa., assignor to Koppers Company, Inc., a corporation of Delaware

Filed Apr. 13, 1961, Ser. No. 102,791
9 Claims. (Cl. 202—141)

This invention relates to by-product coke ovens and more particularly to improvements in the structural design and operation of horizontal coking retort ovens having regenerators and heating flues so arranged and equipped that the well known reversal of the heating of the flues in alternation can be employed. The invention relates more particularly to by-product coke ovens that employ underfiring with a high B.t.u. gas such as coke oven gas.

A primary object of the invention is the provision of improvements in coke-oven structures so as to provide coke ovens of substantially increased capacity that are capable of and equipped to produce coke of the uniform quality that is now produced only by coke ovens of lesser capacity.

Increasing the width of the coking chamber increases also the coking time and consequently this expedient will not increase the output of the oven per unit of time. Attempts, therefore, have been made to increase the capacity of the coke ovens by increasing the height of the coking chamber. This expedient has not proved entirely satisfactory because it has not heretofore been possible to greatly increase oven heights without encountering a marked reduction in coke quality because it has not been possible to heat the coal in the tall ovens uniformly.

Briefly stated, my invention consists in the provision of high capacity by-product coke ovens of a height exceeding that of conventional coke ovens by approximately fifty percent by which a coke of the uniform quality demanded by modern industrial technology can be manufactured; this is accomplished by providing, in combination, means for recirculating waste gas from the downflues to the inlet of the upflues, aspirating means for introducing the waste gas along with other fuel gas into the upper burning flues, a higher and a lower gas burner port in each of said flues of which at least the lower gas burner port is operatively connected to means for supplying thereto the recirculated waste gas, and separate gas headers including readily accessible control valves supplying separately the low burners and the high burners, said separate gas headers being selectively connected each to a source of rich gas and preferably the header for the high burner being connectable with sources of both rich and lean gas, so that either a rich gas or a mixture of rich and lean gas can be supplied to the high burner. This arrangement permits the use of a simple regenerator-air and waste-gas duct at the base of the flues.

The interrelation of the several elements of my novel combination of structural features incorporated in coke ovens of heights exceeding that of conventional ovens allows one to obtain the advantages of each of these combined elements without encountering the disadvantages that heretofore have been believed to be inherent and inseparable from the use of such elements. For example, the use of high and low burners together in a single flue has heretofore been believed to be substantially inoperable when a gas rich enough to give reasonably short coking times was employed because the higher burner would soon be plugged by carbon deposition therein as a result of the heating and cracking of the heating gas by the flame from the lower burner. Consequently it was thought that the best that could be accomplished was putting the high burner and low burner in adjacent flues. Even here trouble was encountered with carbon deposition of the higher burner because the riser to the nozzle

of the high burner would still be heated by the adjacent flue to temperatures that would cause cracking of the gas in the riser. Furthermore, this arrangement of burners in separate flues created a condition of relatively cool spots at the base of the high flue burner and prevented the attainment of uniform coking rates and coke quality, when in substantially higher ovens it is necessary that the high burner has to be located at elevations which create a substantially cooler area below that burner.

I have now solved this problem and can provide the advantages of heating the tall ovens by burners in a single flue through the interaction of the several elements enumerated above. Firstly, waste gas is aspirated into the gases flowing in the riser so that there is a dilution of rich gas in this riser before it is heated to cracking temperature. Secondly, by being in the same flue, we have the further advantage of mingling with partially burned gas from the lower burner so as to extend the flame length or flame propogation from the upper burner, thus providing an unexpected advantage of more uniform heating vertically up the oven wall. Thirdly, the combination with the foregoing elements of separate gas headers feeding underjet nozzles provides in itself a series of interrelated advantages. In the first place, by remotely operable valves, one can for example feed a mixture of blast furnace gas and rich gas into preferably the high-burner riser and this denser gas can be employed at any selected pressure (because it is fed through a separate system and because the nozzle itself can have a selected orifice as shown in Rueckel Patent No. 2,470,112) and consequent velocity to aspirate a calculated amount of waste gas into the flue. This permits a flexibility and accuracy of adjustment that can permit one for the first time with high ovens to control to a novel degree of accuracy the temperatures at any point in the flues. My combination of aspirating waste gas along with separate feeds of flexibly selectable rich or lean gas to the burners furthermore allows one to mix these gases in such final composition that formation of carbon in the flues is avoided. Again there is an interrelation here of elements of the combination that operate together to give a most advantageous result; the waste gas contains carbon dioxide and water vapor and, at the high temperatures existing in the ducts, carbon particles forming in the gas stream will automatically react with carbon dioxide and water forming water gas.

In the accompanying drawings forming a part of this specification, and showing for purposes of exemplification the best mode of practicing the same, the invention is embodied in a cross-over flue interconnected combustion flue system of the type described in Patent 1,374,546 of Joseph Becker. The invention, however, is not limited in its application to this system, but is equally applicable, as aforesaid, to the twin or hairpin flue system.

FIG. 1 is a diagrammatic vertical section, on the lines 1—1 and 1*a*—1*a* of FIG. 2 taken longitudinally of a battery of the well known Koppers-Becker underjet type of coke ovens of the abovementioned Becker patent, wherein there is embodied the features above set forth of separate riser channels of the present invention in conjunction with a waste gas recycling system for admixing a combustion medium, in advance of its delivery into both high and low burners in each of the flame flues, with waste gaseous combustion products from corresponding combustion products flues of the battery, together with separate headers and mains for the said riser channels to the high and low burners;

FIG. 1*a* is an enlarged view of a portion of FIG. 1, showing the junction of the underjet ducts with the aspirator portion of the recirculation ducts 24;

FIG. 2 is a vertical section taken transversely of the battery of FIG. 1 along the line II—II thereof;

FIG. 3 is a horizontal section taken on the line III—III of FIG. 2;

FIG. 4 is an enlarged view of a fraction of FIG. 1 showing in greater detail, on the line IV—IV of FIG. 5, the regulatory devices for delivering calibrated quantities of coke oven fuel gas into the riser channels in relation to the waste gas recirculating ducts in the underjet coke oven heating systems;

FIG. 4*a* is a still larger detail view of one underjet nozzle and its calibrated orifice tip as shown in the foregoing figures of the drawing;

FIG. 5 is a vertical cross-sectional view taken on the line V—V of FIG. 4, transversely of the battery, showing the high burner riser channel system in its relation to the low burner riser channel system;

FIG. 6 is a vertical cross-sectional view to illustrate the system as shown in FIG. 1, but modified to have the recirculation ducts connected only to the high burners and their riser channels, and not to the low burners.

The various features of the invention are shown in an oven which incorporates well known cross-over ducts arranged to flow combustion products issuing from the vertically disposed heating flues of an oven heating wall over the top of an adjacent coking chamber and into similar and similarly positioned heating flues of a heating wall adjacent the opposite side of such coking chamber.

As can be seen in FIGS. 1 to 5, the coke oven battery comprises a plurality of coking chambers 2 and heating walls 3 that are disposed in alternation lengthwise of the battery. The heating walls 3 are constituted of a row of vertical flame or combustion heating flues 4 that are disposed side-by-side crosswise of the battery, and are grouped for gas flow purposes in flow groups of several heating flues 4 having a common cross-over duct 6, whereby combustion products of each such flow group flow upward and over across the top of a coking chamber 2 into a corresponding flow group adjacent the opposite side of an intermediate coking chamber. Each flow group of flues 4 is provided with a common horizontal flue 7 and the flues of a flow group except the end groups are symmetrically disposed in respect of its cross-over duct 6. The two flow groups of flues at either end of the heating wall 3 are furnished with individual cross-overs which are unsymmetrically located to accommodate the differently proportionate amounts of combustion products produced by the large amounts of underfiring gas burned in flues at those locations, for the purposes of overcoming the greater radiation of the heating wall ends. In this connection, it is to be understood that the number of flues connected to these cross-over ducts and the number of cross-over ducts as well, can be varied in accordance with desired design.

The heating flues 4 of the heating walls each communicate individually by regenerator port and duct assemblies 8 with two cross-regenerators 9 therebeneath, each such regenerator being arranged to preheat combustion air at such times as the heating flues are being underfired with preheated rich fuel gas as, for example, obtains when the ovens of the battery are underfired with coke oven gas. One of the regenerators 9 of the pair of regenerators with which each heating flue 4 is communicably connected, is also adapted to preheat lean fuel gas delivered thereto from a lean-fuel-gas main flow box (not shown) to an inlet 12 (shown on FIG. 2) to the sole channels 11 in a well known manner, in those instances where the ovens are operated as "gas ovens" and are, therefore, underfired with extraneously derived lean gas, such as blast furnace or producer gas.

When the battery is heated by rich fuel gas of higher calorific value, this rich gas is delivered into the bottom of the heating flues 4 in accordance with the underjet principle by means of separate low burner and high burner rich gas riser channels 13 and 15, respectively, that extend from the lower surface of the supporting mat 14 of the battery upwards through regenerator walls 16 to the heating flues 4. As shown in FIGS. 1, 2, and 4 of the drawings, each riser channel 13 leads to a low gas burner port 18, and each riser channel 15 leads to a high burner port 17 through its associated riser extensions 15'. Each low burner riser channel 13 for all flues 4 in a heating wall communicates by means of underjet duct pipe connections 26 with a header pipe 19 below the mat 14, and each high burner riser channel 15 for each flue 4 likewise communicates, by means of underjet duct pipe connection 26*a*, to a separate header pipe 19*a*, whereby all the heating flues 4 in a single heating wall are simultaneously supplied with fuel gas from one side of the battery. The wall header pipes 19 and 19*a* communicate through individual pipe connections 20 and 21 with, respectively, separate principal supply mains 22 and 22*a* that extend lengthwise along the side of the battery and communicate through gas main 30 with a reservoir (not shown) of coke-oven gas from the battery. Valve and gas flow reversing mechanism 23 is provided to supply fuel gas to each heating wall in alternation with an associated heating wall thereadjacent.

The two sets of underjet riser channels 13 and 15 that are each associated with corresponding "on" and "off" heating flues of adjacent heating walls employing the same cross-over duct 6, are communicably connected adjacent their lower ends by means of a waste gas recirculation induction duct 24 located in mat 14. Such waste gas recirculation system is shown in detail in U.S. Patent No. 2,306,678 of Joseph van Ackeren. Waste combustion gases from the flues 4 are supplied through ducts 24 to risers 13 and 15 to respectively the low and high burner ports 18 and 17. The recirculation duct 24 can be arranged with respect to the mat in one of a number of ways, but is preferably arranged as shown in common assignee's copending application of Linwood G. Tucker, Jr., Serial No. 622,170, filed November 14, 1956, entitled "Recirculating Underjet Coking Retort Oven," in considerable detail, and, diagrammatically, in FIG. 5.

Fuel gas contained under pressure in the separate header pipes 19 and 19*a* of the distributive system, is allocated individually to low and high risers 13, 15, for each heating flue of an associated heating wall by means of the respectively aligned separate underjet duct branch pipe connections 26, 26*a*. Each branch pipe has a nozzle 27 containing a removable calibrated orifice tip as shown in FIG. 4*a*. These removable nozzles are described and claimed in the aforesaid Rueckel patent. The rate at which fuel gas is delivered to the individual underjet riser channels 13 and 15 is controlled by controlling the gas pressure in the separate supply mains 22 and 22*a* and by means of selecting a suitable size of 27*a*. These nozzles 27 are withdrawable downwardly through the pipes 26, 26*a* for removal and replacement of orifice tips 27*a*.

By means of the above-described system, fuel gas is individually injected into the riser channels 13 and 15, in the form of a jet which exerts a selective ejector effect on waste combustion gases contained in the recirculation induction ducts 24, causing waste gases of combustion to flow downwardly from an "off" flame flue 4 through its idle burners 17, 18, and their riser channels 15, 13 to the recirculation duct 24, and thence, individually upwardly with the jets of fuel gas for the separate high and low burners, to admix with the fuel gas as a diluent to enter the burners 17 and 18 separately for the "on" combustion flues 4.

Referring to FIGS. 1, 2, and 4, when riser channels 13 and 15 are delivering fuel gas to a flue 4 thereabove through the high and low gas burner ports 17 and 18, respectively, to cause such flue to operate as an upflow flue, the corresponding flue 4 of the adjacent heating wall, with which said flue is connected by cross-over duct 6 operates as a down-flow flue and is filled with

combustion products flowing downwardly to outflow regenerators. The recirculation duct 24 communicating with such downflow flue carries a portion of these combustion products from the downflow flue into the risers 13 and 15. These combustion products, which are relatively inert, mix with the rich fuel gas in the risers 13 and 15 and thus there is fed to the low gas burner port 18 and the high gas burner port 17 and the heating flue 4 thereabove, a diluted fuel gas of lower calorific value and of slower combustion characteristics than would otherwise obtain with undiluted rich fuel gas. This has the beneficial effect of making it possible to maintain a reduced temperature gradient between the tops and bottoms of the heating flues 4 to promote uniformity of heat distribution throughout the adjacent coal charge in the intervening coking chambers 2.

The recirculated waste fuel gas also contains carbon dioxide and water vapor. These components at the high temperatures prevailing in the risers and flues react with carbon molecules and prevent the deposition of carbon in the risers 15 and riser extensions 15' of the high gas burners 17, which would otherwise occur through the cracking of the undiluted rich fuel gases of higher calorific value, by the intense heat given off at the lower gas burner ports 18.

Fuel gas flowing through line 22*a* to the riser channels 15 for the high burner ports 17 is preferably fed at a higher pressure through the orifices 27 in the connections 26*a*, than the pressure at which the fuel gas is fed through line 22 to the orifices 27 to the riser channels 13 for the lower burner ports 18. This is done to provide a greater velocity of flow through the venturi 24' and to aspirate a greater portion of waste gas from the recirculation ducts 24 through the riser channels 15 than through riser channels 13. Thus, a more dilute and less easily cracked fuel gas is provided in risers 15, 15' and more carbon dioxide and water is supplied for faster and more complete reaction with carbon particles tending to form therein.

It has been found that in the absence of the above-described provision for recirculation of waste gas, preferably in greater volume in the high burner risers, in each twenty-five to thirty minutes period of on-flow operation of these lines in the regenerative cycle carbon builds up to an extent that drastically prevents uniform heating. An additional means for increasing the proportion of waste gas in the high burner risers is also provided by my combined apparatus. When a still greater difference in volume of waste gas is required for the high burner riser passages 15, 15', then blast furnace gas from line 28 is mixed with the coke oven gas in the main 22*a*. This blast furnace gas is denser than fuel gas such as coke oven gas and contains larger amounts of carbon dioxide. Such denser gas in mixture with the fuel gas acts, after the mixture of gas emerges from the calibrated orifices in the tip of the nozzle 27, to induce larger portions of waste gas to be aspirated from the recirculation ducts 24 into venturi 24' of the high burner lines 15, than the undiluted fuel gas does for the low burner lines 13.

Valves 29 in the mains 22, 22*a*, at a region remote from the oven battery, separately control the flow to all of the high 17 and low 18 burners of the battery from a single region.

In operation of my novel combination by underfiring with gas having a heating value of about 500 B.t.u. or more per cu. ft., the lower burners 18 are separately supplied with the coke-oven gas at a pressure such that a minor aspiration and admixture of waste gas occurs. The coke-oven gas is separately introduced at a higher pressure from line 22*a* and header 19*a* to the high burner riser channels 15, with orifices in the tips 27*a* calibrated to produce a jet velocity higher than the jet velocity of the gas from the tips in the nozzles 27 for the low burner riser channels 13. The jet velocity is so chosen that the heating value of the final gas mixture delivered at the high burners 17, these being from one to several feet above the base of the flues, is within the range of approximately 170 to 350 B.t.u. per cu. ft. of gas mixture.

To supply blast furnace gas to the high burner, the valve 31 in the blast furnace gas main 28 is opened and controlled amounts of blast furnace gas are mixed with the rich gas in the high burner rich gas main 22*a* before the rich gas branches off through the pipe connections 21 to emerge as a jet from the orifice tips in the nozzles 27 for the high burner riser channels 15.

The water and carbon dioxide content of recirculated waste gas are especially advantageous in suppressing the tendency for carbon deposition. The sensible heat content of the hot recirculated waste gas is also advantageous in maintaining a high flame temperature. External mixing of rich and lean gas from line 28 provides a control for the heat value and composition of the final mixture supplied to the high burners, after mixing with recirculated waste gas, over a much wider range than could be attained by providing only internal mixing of rich fuel gas with recirculated waste gas without external mixing with lean gas. External mixing with lean gas in this way provides a two-edged means of control of final composition by (1) its effect on the composition of the external mixture fed to the battery, and (2) by the effect on the ratio of recirculated waste gas caused by increasing the volume and specific gravity of the external gas mixture fed to the aspirating nozzle jets of the waste gas recirculating system. This increased volume and specific gravity of the motive gas fed to the aspirating jets provides the possibility of recirculating much more waste gas than could be aspirated by a nozzle jet recirculation system which has rather narrow limitations.

Accordingly, the valve 31 is adjusted, and the orifices in the nozzles 27 are selected, relative to the gas pressure in the rich gas main 22*a* to adjust the amounts of blast furnace gas and waste gas that are introduced into the rich gas to attain the desired heating value selected within the aforesaid 170 to 350 B.t.u. range, for the final gas mixture to be delivered to the high burners 17.

My improvement is not limited to coking retort ovens in which the high and low burners are both connected for waste gas recirculation. The apparatus system is also of utility when the structure is equipped for recirculation only to the high burners. In such case, the apparatus, as shown in FIG. 6, is the same as above-described in FIGS. 1 to 5, except that the riser channels 13 for the low burners 18 are not equipped with the venturi aspirators 24', nor otherwise connected up to the recirculation ducts 24. Only the rich gas risers 15 for the high burners communicate with the recirculation ducts through venturi aspirators 24'. The low burner rich gas riser channels 13 are, instead, formed of straight sides all the way down to the jet nozzles 27. The low burner when it is not supplied with a recirculation duct is customarily provided with an air intake (not shown) for decarbonizing the riser during the off period. Otherwise, the operation is the same as disclosed in connection with FIGS. 1 to 5, the difference being the waste gas is recirculated into the high burner rich gas riser channels 15 by the jet action of the rich gas to produce the required gas mixture of reduced heating value for delivery by the low burners 18, whereas no dilution of gas from the low burners 17 occurs.

The modification shown in FIG. 6 can be employed when, for example, a fuel gas or fuel gas mixture, such as a mixture of coke oven gas and blast furnace gas is available. This modification can be employed to advantage when the low burners are decarbonized with air during the off-cycle since the valuable effect of burning, during the off-cycle, carbon deposits with the remaining

air in the waste-heat gas, which is an advantageous feature of waste-gas recirculation, is not available to the low burners.

The invention as hereinabove set forth, is embodied in a particular form of construction, but may be variously embodied within the scope of the following claims.

I claim:

1. In a regenerative masonry underjet coking retort oven, the combination comprising: a row of coking chambers with two sets of vertical heating flues therefor operable in alternation as "on" and "off" burning combustion flues; a fuel gas low burner at the bottom of each flue and a fuel gas high burner at a level above the bottom of each flue; air regenerators below said row of coking chambers and heating flues and communicably connected with the bottoms of the heating flues, said regenerators being mounted above an accessible basement space; separate fuel gas riser channels in the regenerator masonry extending from the basement space individually upwardly to the separate high and low burners in each of the heating flues; waste gas recirculating ducts communicably connecting the high burner riser channels of the two sets of heating flues with each other in the region of the bottoms of the regenerators; fuel gas introduction means comprising individual fuel gas underjet ducts for each of the high and low riser channels with regulable orifice means for individually admitting fuel gas into the separate risers in the form of a jet, the regulable orifice means of the underjets for the high burner riser channels being so disposed with respect to recirculating ducts in communication therewith as to aspirate a flow of waste gaseous combustion products individually into the high burner riser channels when operable for onflow from heating flues of the set then operable as "off" burning flues, through their idle high burner rich gas risers and through the interconnecting waste gas recirculating ducts, at a velocity independent of the velocity of flow of the jets into the lower burner riser channels, to dilute the rich gas for the high burner riser channels to a composition which remains substantially undecomposed and free of carbon deposition while rising to the high burners.

2. Coke oven as claimed in claim 1, and in which the two sets of heating flues are constituted of crossover flue interconnected combustion flues on opposite sides of an intervening coking chamber.

3. Coke oven as claimed in claim 1, and in which the rich gas introduction means includes separate gas headers for the high and low burner rich gas riser channels and separate high and low burner gas mains, with an individual valve control remote from the battery, for the separate high and low burner gas mains.

4. Coke oven as claimed in claim 3, and which includes valve-controlled conduit means communicably connected with the high burner gas main for feed thereto of a denser fuel gas than the rich gas fed into said main, to augment the volume of waste gas recirculated by the rich gas into the high burner rich gas riser channels from the waste gas recirculating ducts.

5. In a horizontal coke oven battery a combination of heating elements therefor providing uniform heating for high-chambered ovens, the said combination comprising

(*a*) paired flues operable alternately in "on" and "off" combustion position,

(*b*) a high and a low burner in each of said flues,

(*c*) separate gas riser ducts connected to and feeding each burner,

(*d*) a waste gas recirculation duct connecting the high burner gas riser duct of the off-flue to at least one of the gas riser ducts to the on-flue,

(*e*) an aspirator duct between the recirculation duct and said high burner gas riser duct,

(*f*) separate high- and low-burner supply headers for the riser ducts feeding respectively the high and low burners,

(*g*) a first rich gas main communicably connected with the high-burner supply headers,

(*h*) a second rich gas main communicably connected with the low-burner supply headers and

(*i*) controllable conduit means connected to said first rich gas main for introducing thereto a fuel gas of greater density than the rich gas feed.

6. In a horizontal coke oven battery having side-by-side coking chambers and heating walls, said heating walls comprising

(*a*) a first and a second set of vertical flues operable in alternation as "on" and "off" combustion flues,

(*b*) a low burner port at the bottom of each of said flues,

(*c*) a high burner port at a level in each of said flues above the bottom thereof,

(*d*) a separate fuel gas riser channel extending downwardly from each of said low burner and high burner ports,

(*e*) waste gas recirculating ducts communicably connecting fuel gas riser channels in said first set of flues with fuel gas riser channels from said second set of flues,

(*f*) gas introduction means connected with each of said separate fuel gas riser channels for individually introducing fuel gas thereinto,

(*g*) means for increasing the velocity of the gas flow mounted in all gas introduction means connected with fuel gas riser channels having waste gas recirculating ducts communicating therewith,

(*h*) said velocity increasing means being so disposed with respect to said waste gas recirculating ducts as to aspirate a flow of waste combustion products from the "off" heating flues to the "on" heating flues through said waste gas recirculating ducts and the fuel gas riser channels connected thereto,

(*i*) said gas introduction means including

(1) a first rich gas main communicating with said high burner fuel gas riser channels,

(2) a second rich gas main communicating with said low burner fuel gas riser channels and

(3) controllable conduit means connected to said first rich gas main for introducing thereto a fuel gas of greater density than the rich gas feed.

7. A horizontal coke oven battery substantially as claimed in claim 6, wherein each of the fuel gas riser channels from the first set of flues is communicably connected with at least one gas riser channel from the second set of flues.

8. In a horizontal coke oven battery having side-by-side coking chambers and heating walls, said heating walls comprising

(*a*) a first and a second set of vertical flues operable in alternation as "on" and "off" combustion flues,

(*b*) a low burner port at the bottom of each of said flues,

(*c*) a high burner port at a level in each of said flues above the bottom thereof,

(*d*) a separate fuel gas riser channel extending downwardly from each of said low burner and high burner ports,

(*e*) a waste gas recirculating duct communicably connecting each of the fuel gas riser channels from said first set of flues with at least one fuel gas riser channel from said second set of flues,

(*f*) gas introduction means connected with each of said separate fuel gas riser channels for individually introducing fuel gas thereinto,

(*g*) nozzles mounted in all gas introduction means connected with fuel gas riser channels having waste gas recirculating ducts communicating therewith,

(*h*) said nozzles being so disposed with respect to said waste gas recirculating ducts as to aspirate a flow of waste combustion products from the "off" heating flues to the "on" heating flues through said waste

gas recirculating ducts and the fuel gas riser channels connected thereto,

(*i*) said gas introduction means including

(1) a first rich gas main communicating with said high burner fuel gas riser channels and

(2) a second rich gas main communicating with said low burner fuel gas riser channels.

9. In a horizontal coke oven battery having side-by-side coking chambers and heating walls, said heating walls comprising

(*a*) a first and a second set of vertical flues operable in alternation as "on" and "off" combustion flues,

(*b*) a low burner port at the bottom of each of said flues,

(*c*) a high burner port at a level in each of said flues above the bottom thereof,

(*d*) a separate fuel gas riser channel extending downwardly from each of said low burner and high burner ports,

(*e*) a waste gas recirculating duct communicably connecting each of the fuel gas riser channels from said first set of flues with at least one fuel gas riser channel from said second set of flues,

(*f*) gas introduction means connected with each of said separate fuel gas riser channels for individually introducing fuel gas thereinto,

(*g*) nozzles mounted in all gas introduction means connected with fuel gas riser channels having waste gas recirculating ducts communicating therewith,

(*h*) said nozzles being so disposed with respect to said waste gas recirculating ducts as to aspirate a flow of waste combustion products from the "off" heating flues to the "on" heating flues through said waste gas recirculating ducts and the fuel gas riser channels connected thereto,

(*i*) said gas introduction means including

(1) a first rich gas main communicating with said high burner fuel gas riser channels,

(2) a second rich gas main communicating with said low burner fuel gas riser channels and

(3) controllable conduit means connected to said first rich gas main for introducing thereto a fuel gas of greater density than the rich gas feed.

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