Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 1

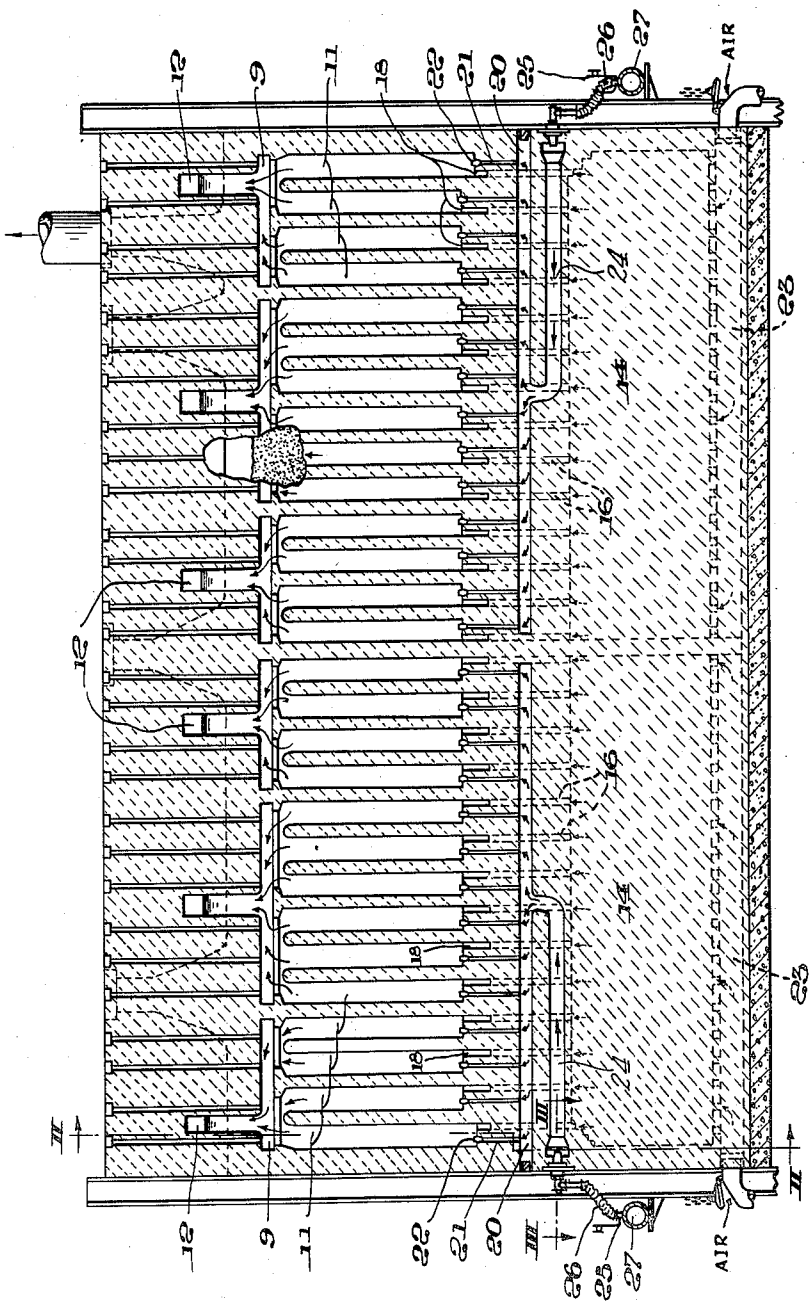


Fig. 1.

INVENTOR.
JOSEPH VAN ACKEREN
BY
Joseph B. Brick
his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 2

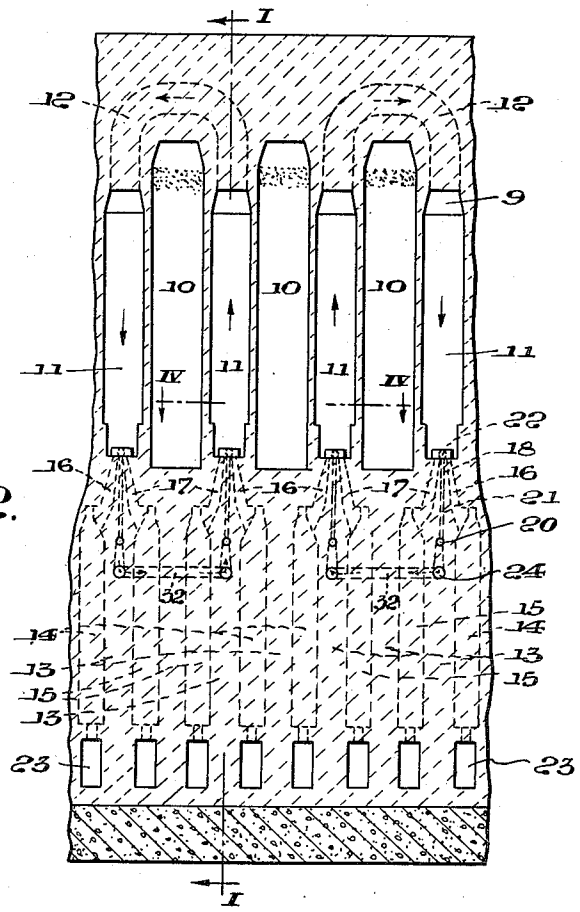


Fig. 3.

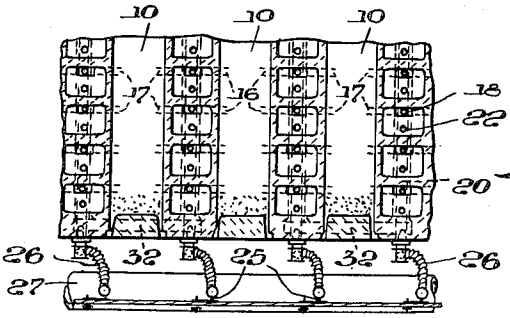


Fig. 4.

INVENTOR.
JOSEPH VAN ACKEREN.

BY Ralph B. Breck

his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 3

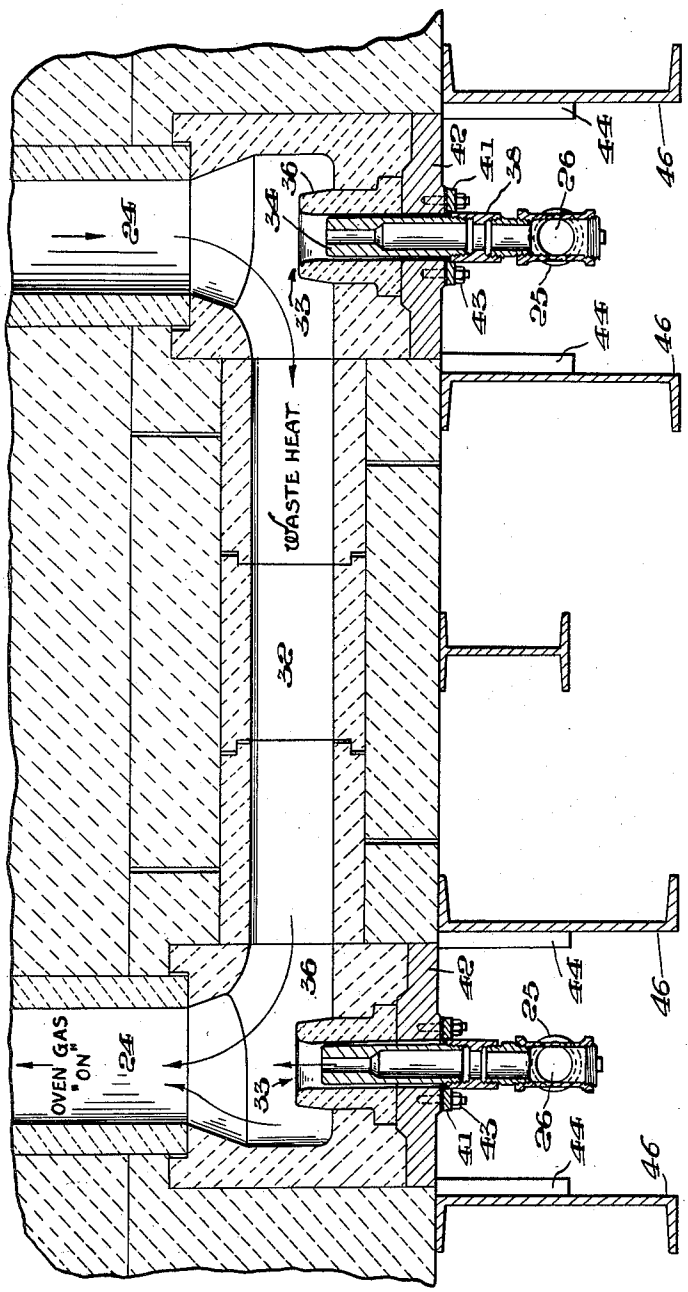


Fig. 3.

INVENTOR.
JOSEPH VAN ACKEREN.
BY Ralph B. Brick
his ATTORNEY.

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 4

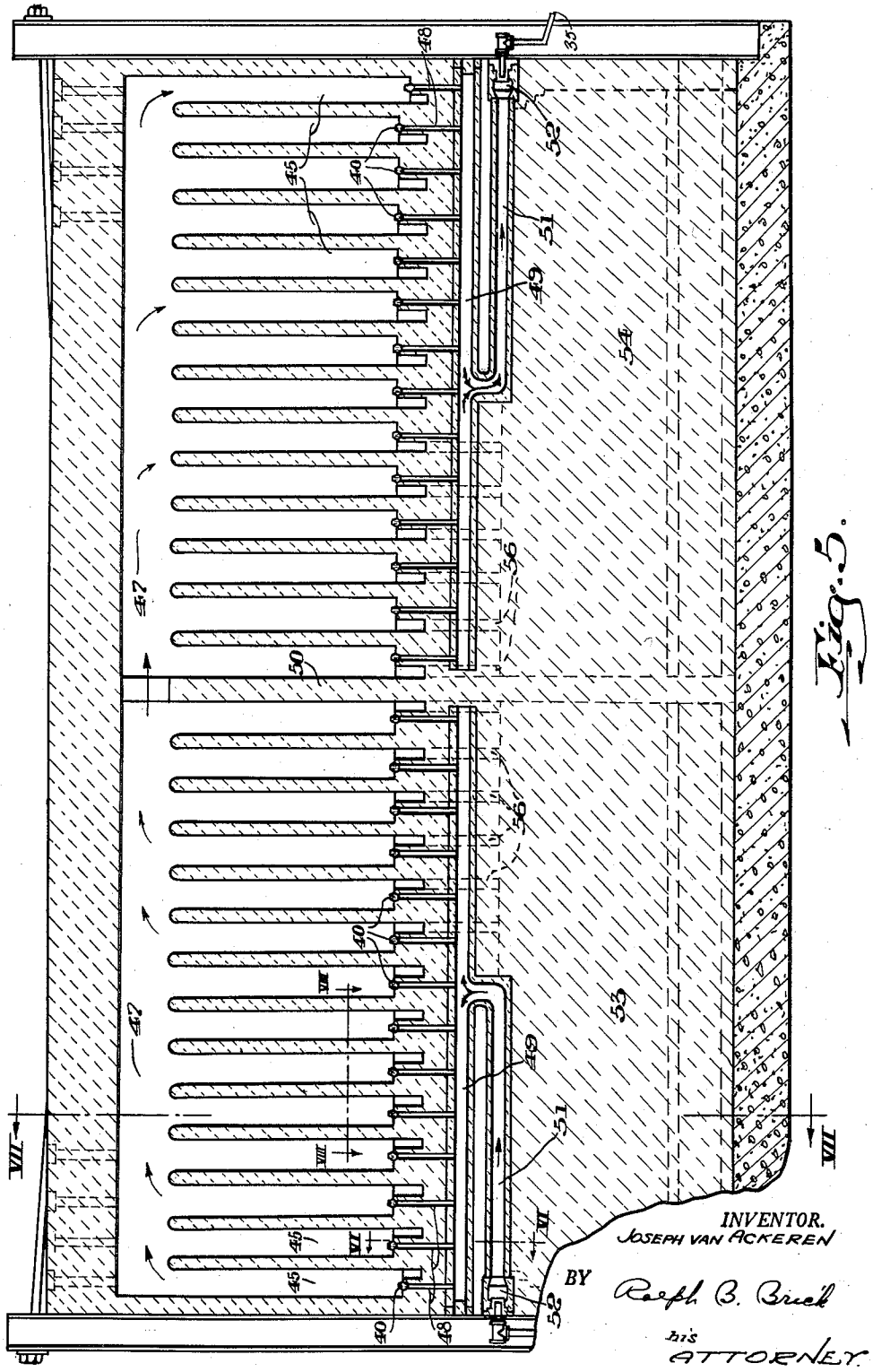


Fig. 5.

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

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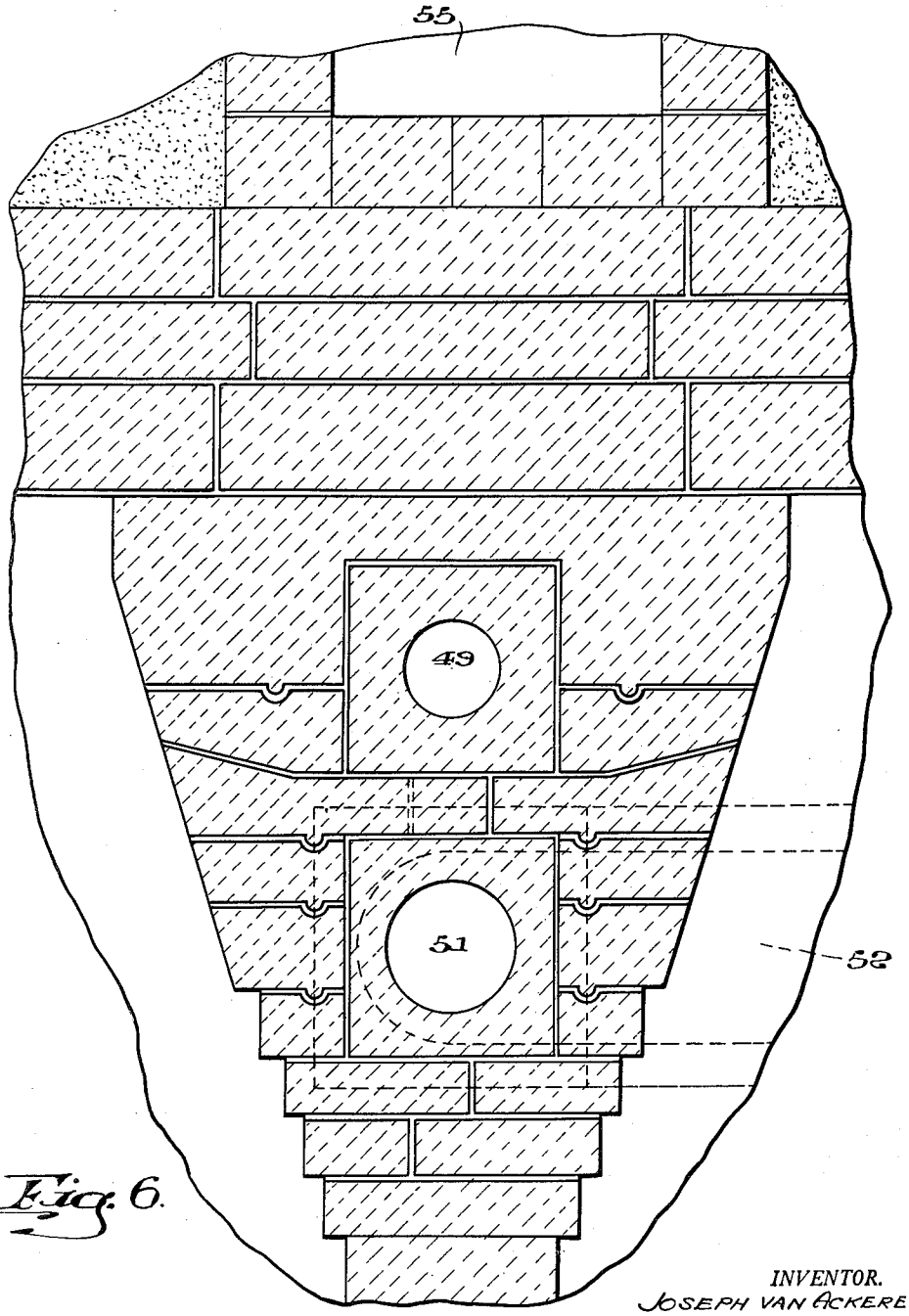


Fig. 6.

INVENTOR.
JOSEPH VAN ACKEREN

BY Ralph B. Brick
his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 6

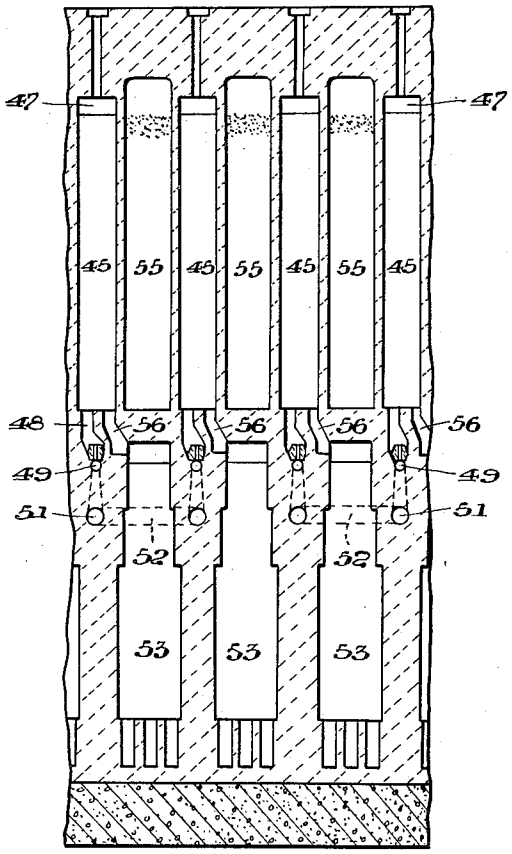


Fig. 7.

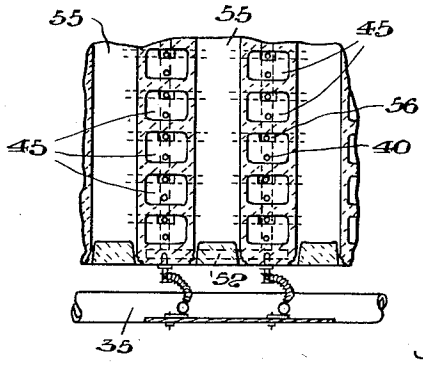


Fig. 8.

INVENTOR.
JOSEPH VAN ACKEREN

BY Ralph B. Brick

his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 7

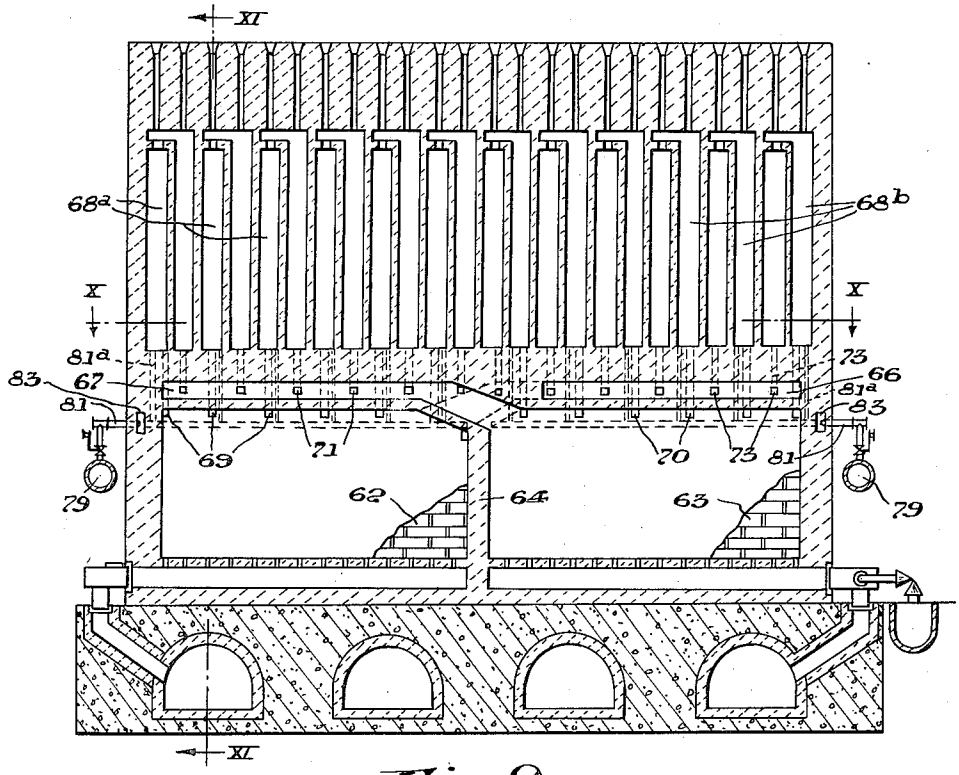


Fig. 9.

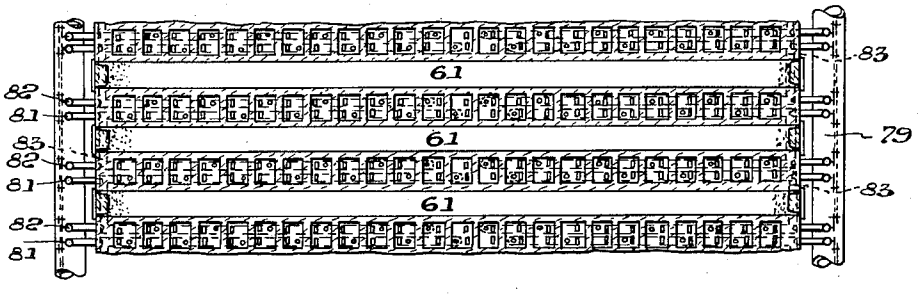


Fig. 10.

INVENTOR.
JOSEPH VAN ACKEREN

BY Ralph B. Brick

his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 8

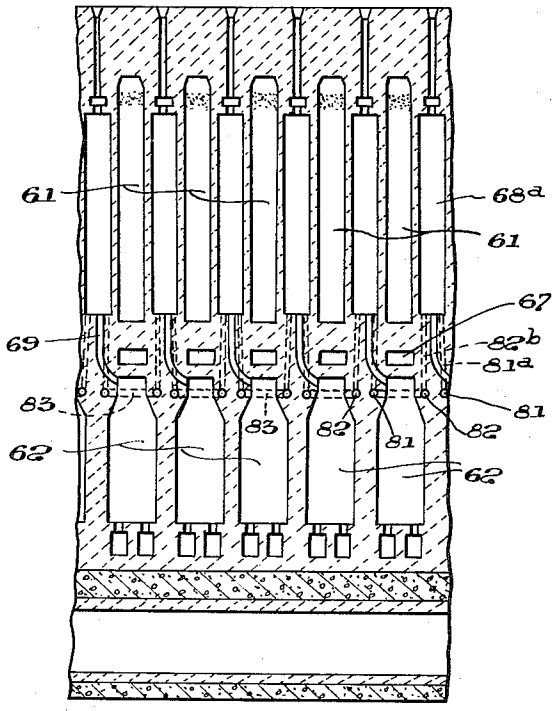


Fig. 11.

INVENTOR.
JOSEPH VAN ACKEREN
BY Ralph B. Brick
his ATTORNEY

Dec. 9, 1958 J. VAN ACKEREN 2,863,807

COKE OVEN STRUCTURE

Filed Oct. 3, 1955 9 Sheets-Sheet 9

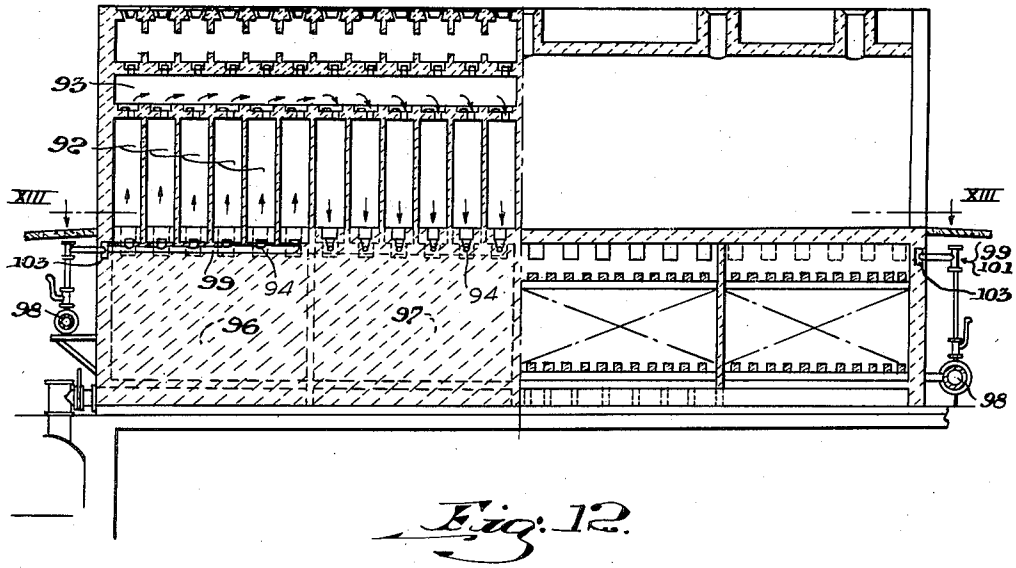


Fig. 12.

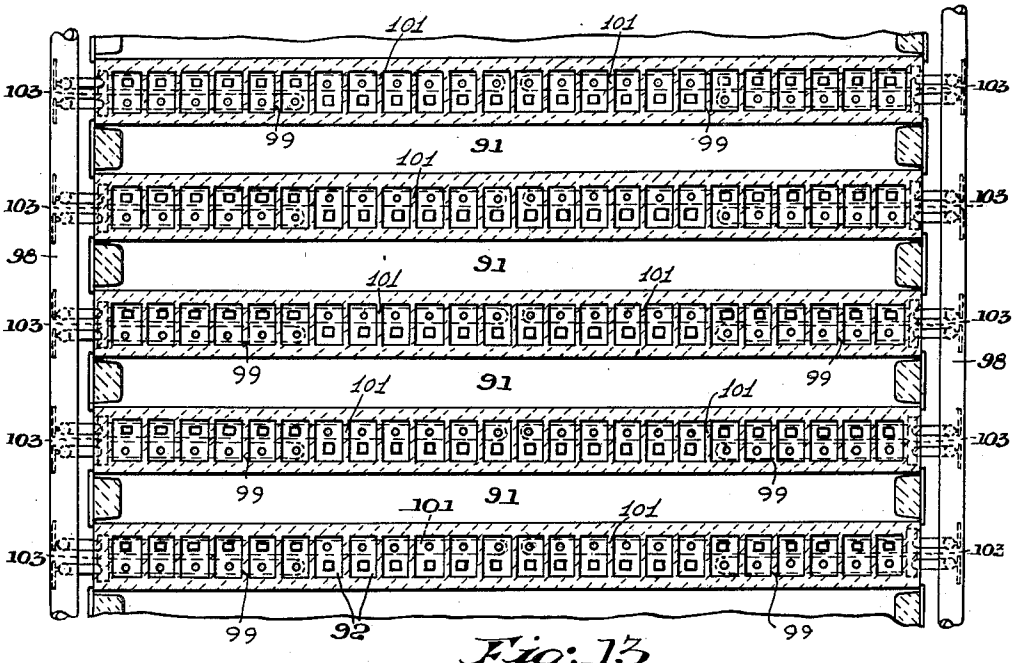


Fig. 13.

INVENTOR.
JOSEPH VAN ACKEREN.

BY Ralph B Brick
his ATTORNEY.

United States Patent Office

2,863,807

Patented Dec. 9, 1958

2,863,807

COKE OVEN STRUCTURE

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

Application October 3, 1955, Serial No. 538,168

9 Claims. (Cl. 202—142)

The present invention relates to improvements in the "gas gun" type of regenerative coke ovens and more particularly to those which provides uniform heating conditions, along the extended heating walls adjacent a coke oven chamber, during the heating of the walls with gases of relatively high calorific values such, for example, as are produced by the carbonization of coal in coke ovens.

The primary object of the present invention is the modification of the invention of applicant's Patent 2,306,678 to adapt the same to said gas gun type of coke oven and thus embody therein the waste gas recirculation principle of my said patent.

In applying heat to the heating flues of a coke oven battery, it is desirable that long flame combustion be obtained so that radiant heat is applied to a greater part of the flues in which combustion progresses, thus insuring a uniform temperature from the bottom to the top of both the flues and the coal charge heated in the chamber adjacent thereto. Such long flame combustion is readily obtainable along the extended heating walls during heating of the flues by means of leaner blast furnace or producer gases. However, when rich gases are used in these heating flues, it has been found desirable, in order to obtain long flame combustion, to effect a dilution of the rich gases with their products of combustion.

In the prior art, my patented structure aforesaid has been used in the underjet type oven which provides, within the masonry at the base of the regenerators of a coke oven battery, special duct means whereby the pressure of gases, in a distribution system for rich gases, can be utilized in the form of a jet having sufficient energy to induce a flow of hot combustion products of the heating flues and mix with the rich-fuel gases jetted. This produces a resultant mixture having a calorific value lowered from that of the rich gases and exhibiting slower burning characteristics when subsequently admitted into the lower portions of the heating flues. In effect, the combustive characteristics of rich-fuel gases introduced to the flues are automatically so altered that their heating effects become substantially similar to those obtainable in instances when underfiring is effected with well known lean gases. With such structure in an underjet type oven, the combustion of the rich-fuel gases in the heating flues is effectively retarded in a one-stage combustion system without interfering with the normal regenerative heating program for the battery or with the normal reversal of gaseous flow through the heating flues. Further, in such structure, means is provided to permit the underfiring gases of high calorific value to be continuously and automatically admixed with sufficient of their own combustion products derived directly from the heating flues. The resultant mixture which is of lower calorific value, upon entering the flame flues burns with a non-luminous flame and with a more gradual evolution of heat in a manner like that normally associated with the leaner fuel gases, to thus promote uniform temperature conditions along the heating flues and the walls they comprise.

The present invention provides a gas gun coke oven

structure which avails itself of the recirculation of waste-gases in a coke oven wherein rich-fuel gases are distributed to the lower portions of vertical heating flues from a "gas gun" or horizontal conduit that extends lengthwise of a heating wall, such gas gun being positioned beneath the lower portions of the heating flues and adjacent the upper portions of the regenerators connected to the flues. With the structure of the present invention, it is possible to obtain in an oven having the gas gun adjacent the lower portions of the heating flues, all of the desirable results that have been obtained by the recirculation of waste-gases in the underjet type oven in accordance with my aforesaid patent. In addition, coke oven structure is provided whereby, as in my said patent, rich-fuel gases can be diluted with their own combustion products, or waste-gases, inside of the battery-structure itself and at such locations therein that no significant increases in the magnitude of the fuel gas distributive system is required for their accommodation.

The present invention further provides a structure wherein the rich gas ports for the vertical flues can be located at substantially the same elevation as the air rich gas ports, this being the most desirable location for such ports since their location at a level below the air ports creates undesirable rapid mixing of gases and air due to the decrease of velocity of the gases, and their location above the air ports produces turbulent mixing when normal velocities are employed. This location of the gas and air ports at the same elevation is possible since the dilution of the rich-fuel gases with the waste-gases decreases the rate at which the less stable hydrocarbons in the coke oven gases react to form carbon, thus greatly reducing carbon deposits in the fuel gas nozzles and conduits to a point below a nuisance factor. In addition, the induction of waste-gases through "off" nozzles of gas guns in the lower portion of the vertical flues tends to remove in the downflow cycle any carbon deposits that might have lodged therefrom the reversely flowing rich gases on the previous upflow cycle in such flues.

Various other features of the present invention will become apparent from the disclosure set forth hereinafter.

More particularly, the present invention provides in a gas gun type regenerative horizontal coke oven having vertical flued heating walls on the sides of horizontal coking chambers, the flues of which are connected in two sets operable in alternation with each other for upflow combustion and downflow waste-gas products, and horizontal rich-fuel gas gun conduits for the heating flues extending horizontally along the length of the heating walls below the lower portion of the heating flues and adjacent the upper portion of the regenerator connected to such flues, the induction duct means disposed in the side face of the oven and communicably connecting the rich gas gun conduits for the flues of one set with the rich gas gun conduits for the flues of the other set, at a region adjacent the upper portion of the regenerators and at the ends of the heating walls, in advance of where the conduits port into their heating flues, and jet means disposed at each of the regions of juncture of the rich gas gun conduits at the side face of the oven with the aforementioned induction duct means therefore to effectively induce flow of waste-gases from the bottoms of the flues of each set when operable for downflow, through their then idle rich-gas gun conduits and induction duct means into the then rich gas gun conduits of the flues of the other set when concurrently operable for upflow combustion.

It is to be understood that various modifications can be made by one skilled in the art in the arrangement, form, and construction of the apparatus disclosed herein without departing from the scope or spirit of the present invention.

Referring to the drawings:

Figure 1 is a vertical cross-sectional view taken in a plane passing through the line I—I of Figure 2;

Figure 2 is a vertical sectional view taken longitudinally along the line II—II of Figure 1 of a portion of a battery of Becker-type horizontal coke ovens of Figure 1, provided with the present improvement for heating the walls of coking chambers;

Figure 3 is an enlarged fragmentary horizontal cross-sectional view taken in a plane passing through the line III—III of Figure 1 to more clearly disclose the induction duct means associated with the gas gun conduits of the ovens;

Figure 4 is an enlarged fragmentary horizontal cross-sectional view taken in a plane passing through the line IV—IV of Figure 2, disclosing in further detail the connection of the gas gun conduits with the vertical flues in the heating walls;

Figure 5 is a vertical section taken in a plane similar to the plane in which the section disclosed in Figure 1 is taken, disclosing a Koppers' type regenerative oven substantially like that disclosed in Patent No. 818,033, issued to H. Koppers on April 17, 1906, arranged to embody the present invention;

Figure 6 is an enlarged fragmentary vertical section taken in a plane passing through the line VI—VI of Figure 5, to show more clearly the inventive induction duct means;

Figure 7 is a vertical cross-sectional view of a portion of the oven taken in a plane passing through the line VII—VII of Figure 5;

Figure 8 is a horizontal fragmentary cross-sectional view taken in a plane passing through line VIII—VIII of Figure 5;

Figure 9 is a vertical section, taken in a plane similar to the plane in which the section disclosed in Figure 1 is taken, disclosing an oven construction of the Kreisstrom type like that disclosed in Patent No. 1,856,501, issued to F. Totzek on May 3, 1932, arranged to embody the induction duct means of the present invention;

Figure 10 is a horizontal cross-sectional view of a portion of the oven taken in a plane passing through the line X—X of Figure 9;

Figure 11 is an enlarged vertical sectional view of a portion of the oven taken in a plane passing through the line XI—XI of Figure 9 to disclose more clearly the induction duct means associated with this type oven;

Figure 12 is a vertical section, taken in a plane similar to the plane in which the section of Figure 1 is taken, of a coke oven structure like that disclosed in Patent No. 1,361,671, issued to C. Berthelot on December 7, 1920, and further including the inventive induction duct means; and

Figure 13 is a horizontal cross-sectional view of a portion of the oven taken in a plane passing through the line XIII—XIII of Figure 12.

Referring to the drawings and more particularly to Figures 1–4, there is disclosed a structure which embodies the features of the present invention shown as embodied in a well known Becker-type cross-over combination horizontal coke oven, wherein a set of heating flues of a heating wall are communicably connected with a corresponding set of heating flues in an adjacent heating wall by means of cross-over ducts that extend over the top of the intermediate coking chamber. Each of the coking chambers **10** is formed between spaced heating walls, each of which walls extends transversely of the battery and is comprised of a multiplicity of vertically disposed heating flues **11**, the flues of each heating wall being operatively divided into sets with the flues of each set having their upper portions connected by horizontally extending conduit like openings **9**, each of said conduit openings in turn being interconnected, by a cross-over duct or conduit **12** which passes over a coking chamber **10** (Figure 2), to a horizontal conduit **9** disposed in the opposite heating wall of the coking chamber. Thus, by means of a number of such cross-over ducts, the flue sets in each heating wall on one side of a coking chamber and the flue sets in the heating wall on the other side of such coking chamber are interconnected, and the so connected flue sets alternate periodically as flame-flues and combustion-product flues.

Each heating flue at its lower part communicates individually with a rich-fuel gas conduit **20** and with a pair of regenerators **14**, **15**, that are separated by and are adjacent opposite sides of a pillar wall **13** which helps support the flued heating wall thereabove. These regenerators **14** and **15** extend transversely of the width of the battery and are provided at their upper portions with ducts **16** and **17** respectively, whereby each heating flue of the heating wall above communicates individually with said regenerators and said ducts merge a short distance below the bottom of each flue into a common duct port **18** that operates as their heating flue inlet. The effective opening of said duct port, as is known in the art, is regulated by a port-core (not shown in detail) that is replaceably mounted atop that portion of the capital of pillar wall **13** which serves to form the dividing wall between the inclined aforementioned ducts **16** and **17**. Rich-fuel gases, at such times as the illustrated battery is heated by their combustion and to which the embodiment of the present invention is particularly related, are introduced into the gas gun conduits **20**, each of which extends inwardly from the side face of the battery at the end of a heating wall lengthwise thereof under the heating flues **11**, being formed as a hollow passage in the silica masonry between the bottoms of the flues **11** and the upper portions of regenerators **14**, **15**. In the embodiment of the invention disclosed in Figures 1–4, each of the gas gun conduits **20** extends substantially half the length of a pillar wall **13** wherein it is formed, the fuel gases being aportioned to all of the heating flues of the heating wall above by means of upwardly extending branch riser conduits **21** and calibrated nozzles **22**, each of said riser conduits and nozzles being individual to a heating flue. During rich gas firing, air for combustion is supplied to the vertical flues from regenerators **14**, **15** located beneath the flues **11**, and the combustion products therefrom are delivered to the battery stack through another pair of adjacent regenerators **14**, **15** that communicate with the same common cross-over duct **12**. As is known in the art, the instant oven can also be preheated with lean gases and in such a situation, the upflow regenerators **14** are adapted to receive, instead of air, lean gases from an outside reservoir therefor through the sole channels **23**, for preheating said gases prior to their delivery to the associated flame flues. The adjacent upflowing regenerators **15** serve to preheat the air required for the combustion of the lean gases. At such times as the heating flues are operating as downflow flues, all of the regenerators **14** and **15** connected thereto serve to carry combustion products to the battery stack (not shown). It is to be noted that, during a regenerative heating cycle in the battery illustrated in Figures 1–4, all of the heating flues in the same heating wall function simultaneously either as upflow flame flues or downflow combustion product flues.

In operation of the oven on rich-fuel gases, the combustion products formed by the combustion of rich gases and air in the flame-flues, flow upwardly therein and all the combustion products from all of the heating flues comprising the heating wall flue set commingle at their tops in the common horizontal flues **9**, passing into the cross-over ducts **12** and over the top of the coking chamber **10** into a corresponding set of heating flues in an adjacent heating wall on their way to the battery stack.

In one embodiment of the present invention, the rich gases are introduced into each of the gas gun conduits **20**, for distribution by branch riser conduits **21** to the vertically disposed heating flues **11**, by means of dis-

tributor ducts 24, each of which is positioned in silica masonry immediately below one of the gas gun conduits 20 and above the regenerators 14 and 15, one end of each of these distributor ducts leading to an outside wall of the oven at a side face of the battery where it is connected through a valve 25 to a conduit 26, which in turn is connected to the rich gas header main 27, extending along the length of the oven battery. The other end of each duct 24 is connected to the main part of the gas gun conduit 20 thereabove, intermediate the ends of the latter and substantially at the middle portion thereof, thus insuring that rich gases introduced in 20 are maintained at sufficient pressure near the opposite ends thereof for effective firing of the flues fed by the branch riser conduit 21 of such gas gun 20. In this connection, it will be noted that nozzles 22 are positioned in the lower portion of the vertically disposed heating flues 11 at substantially the same level as the inlet port ends 18 of the ducts 16, 17 of the regenerators 14 and 15. Accordingly, it is possible, with such positioning, for the regenerator entering through the air inlet ducts 16, 17, and the rich gases entering through nozzles 22 from the gas guns 20 to obtain a uniform and effective mixing, thus avoiding the rapid mixing of gases and air created when the rich gas port is below the regenerator air port and avoiding the turbulent mixing of gases and air when the rich gas port 22 is above the regenerator air port 18. It is also to be noted that the cross-sectional area of each of the distributor ducts 24 is substantially larger than that of each of gas gun conduits 20, ducts 24 being sufficiently large to accommodate the rich gases to be fed to ducts 20.

In this embodiment of the present invention, and referring to Figures 2–4 of the drawings, it can be seen that the adjacent outer ends of adjacent pairs of distributor ducts 24 are communicably connected by induction ducts 32. The ducts 32, as disclosed in Figures 2–4, are disposed in the silica masonry at the side face of the battery at the ends of the heating walls, each induction duct 32 connecting the corresponding ends of a pair of distributor conduits 24 as aforementioned, the distributor conduits of each connected pair being alternately operable with respect to each other when the battery is operated for rich gas firing.

For connecting the induction the duct-connected ends of each pair of the distributor conduits 24 with the fuel gas supply main 27 outside the oven at the outer end of the heating walls, pairs of spaced apart jet members 33 are provided (Figure 3). Each of these jet members is comprised of a nozzle portion 34 communicating with induction duct 32 and directed into the end of the distributor conduit 24, the nozzle being surrounded by a silica tubular member or shield 36, the end of which can project to substantially the centerline of the induction duct 32. This shield which protects the steel nozzle from intense waste-gas heat, can project to the centerline to obtain optimum aspirating conditions as will be seen hereinafter. In this connection, it is to be noted that each of the ends of the distributor ducts 24 have, at the region where they are connected to the induction duct 32, a reduced throat portion, which can be shaped in one of a number of ways, including a Venturi-like design, to provide effective waste-gas induction and recirculation.

Each of the nozzle portions 34 has its end opposite to the end at the induction duct 32, connected by a coupling member 38 to a conduit 26 leading through a valve 25 to the rich gas header main 27. Welded to the coupling 38, along its outer periphery, is a flange 41, this flange being tapped and held by means of bolts 43 to side face plate 42 embedded in the face of the outer wall of the battery. The face plate 42, in turn, is held in position by extensions 44 integral with the buckstays 46 for the oven battery.

Through the jet means, rich-fuel gases are injected into the distributor ducts 24 in the form of a jet, thus exerting an aspirating effect on waste-gases in the downflow flues 11 in the heating walls, bringing the waste-gases through nozzles 22, riser branches 21, gas gun conduits 20, and distributor branch 27 into the induction ducts 32 to flow inwardly with the jetted rich-fuel gases, in admixture therewith as a diluent, into the "on" distributor conduit 24 with which the jet means feeding rich gas is associated. More particularly, when the jet means for one heating wall is delivering rich-fuel gases to the flame flues in the heating wall on one side of the oven, the corresponding heating flues of the adjacent wall connected thereto by the cross-over ducts 12 are filled with combustion products flowing downwardly to the outflow regenerator. The jet of rich-fuel gases into its distributor duct 24 for its associated "on" flue set induces a portion of the combustion products therefrom to flow from a corresponding "off" flue set to pass through the nozzles 22 in the flues of such "off" set downwardly into the gas gun duct 20, along the distributor duct 24, and through the induction duct 32 to mix with these in flowing rich-fuel gases. Inasmuch as the combustion products are relatively inert, their mixing with the rich-fuel gases has the effect of introducing into the lower portions of the heating flues, when operable for "on" inflow, fuel gases of lower calorific value and slower combustion characteristics then would obtain if only undiluted rich gases were introduced by themselves into such flues. The introduction of such a diluted mixture into the flues during "on" combustion has the beneficial effects of maintaining a long, rather than short, burning flame within the flues, thus providing a reduced temperature gradient between the tops and the bottoms of the flues to promote a uniformity of heat distribution throughout the height of an adjacent coal charge disposed in an adjacent coking chamber. It will be apparent from the disclosure, as set forth here-and-above, that a reversal of flow of gases operates in a similar but reverse manner, to permit uniform heating along both sides of the coking chamber.

From the above, it can be seen that the apparatus of the invention furnishes means whereby in "gas gun" type coke ovens rich-fuel gases can be continuously and automatically diluted with inert gases inside of the battery structure and before they enter the heating flues, thus making it possible to retard the combustion rate of rich-fuel gases and to obtain the benefits of firing with lean gases of optionally regulable low calorific value without increasing the load of recirculated combustion products flowed through the regenerators, or disturbing the normal flow through the heating flues of the columns of fuel gases and air introduced at their lower parts. In addition, the apparatus of the invention provides a means wherein carbon collecting on the nozzles of the rich gas-gun riser ducts is maintained at a minimum, the inventive apparatus further insuring by means of distributor ducts that there is a substantially uniform distribution of the rich gases to main ducts with a minimum of pressure drop. In this connection, it is to be noted that the uniform heating obtained from the tops to the bottoms of the flues of the heating walls is not only provided in those vertical flues in the central portion of the heating walls but in those vertical flues at the end portions of the heating walls as well.

Referring to Figures 5–8 of the drawings, another embodiment of the present invention is disclosed wherein the induction duct means are shown in association with a well known Koppers' type oven similar to that disclosed in the long since expired Patent No. 818,033, issued to H. Koppers on April 17, 1906. In this type oven, coking chambers 55 are heated through heating walls disposed on opposite sides of each chamber, and alternating upflow and downflow flue sets are positioned as pairs in the same heating wall in end-to-end relationship, to present what is known in the art as a single divided flue

group, the flues 45 of both sets being connected to each other at their upper portions by a horizontal flue 47 (Figure 5) which extends the entire length of the upper portion of the heating wall, the sets of flues being separated by a dividing wall 50 which extends transversely of the mid portions of the heating walls of the oven.

In the oven, the gas gun riser conduits 48 with their nozzles 40, the main gas-gun conduits 49, distributor conduits 51, and the induction ducts 52, along with the gas header main arrangement 35 (Figure 8), are arranged substantially like the rich gas duct system disclosed in Figures 1-4, with the regenerators 53 and 54 positioned below this rich gas duct system, these regenerators 53 and 54 communicating with the heating flues 45 immediately thereabove by means of the ducts or conduits 56.

Referring to Figure 6 of the drawings, it will be noted that the distributor conduit 51 is of a substantially larger cross-sectional area than the main gas-gun conduit 49 to accommodate the volume of gases necessary to serve all of the vertical flues connected to the main conduit. This difference of relative cross-sectional areas between the main and distributor conduits is also employed in the main and distributor conduit arrangement disclosed in the coke oven of Figures 1-4 as aforementioned.

In operation of the oven disclosed in Figures 5-8, rich gases are caused to flow upwardly in one of the two sets of vertical flues positioned in end-to-end relationship in a heating wall on one side of a coking chamber, the gases passing along conduit 47 and flowing downwardly as combustion products in the other of the two sets of vertical flues positioned in such heating wall on the other side of dividing wall 50. The upflowing gases comprise a mixture of rich gases from the main gas-gun conduit 49 which is associated with the set of upflow vertical flues, air from a regenerator 53 which communicates with the upflow vertical flue set through regenerator ducts 56, and waste gases from an induction duct 52 which communicates with the distributor conduit 51 for the main conduit 49. The waste gases which are induced into the induction duct 52 are provided by simultaneously operating on downflow of combustion products, the other set of flues with which duct 52 communicates, this set of flues being positioned in the adjacent heating wall on the opposite side of the coking chamber and on the same side of its dividing wall 50 as is the set of vertical flues operating on upflow in the other heating wall with respect to its dividing wall 50. In other words, when the end-to-end sets of flues in one heating wall for one of the coking chambers are cooperatively operating on upflow-downflow respectively during one cycle of heating operations, the correspondingly positioned sets of end-to-end flues in the other heating wall for the same coking chamber are cooperatively operating in the reverse order, or on downflow-upflow respectively during the same such cycle of heating operations. The induction of the waste gases is brought about in the same manner as that described for the oven disclosed in Figures 1-4, rich gas jet means (not shown in detail) for one heating wall cooperating with the induction duct 52 to induce waste gases from the downflow flue set in the adjacent wall to flow through duct 52 and to combine with the rich gases from said jet means before entering the upflow vertical flue set in the heating wall served by said one heating wall. It will be obvious that a reversal of flow in the ovens does not alter the effects of the operation of the oven with this induction duct means, such reversal of flow operating in substantially the same way as above described, only in a reverse manner, to provide uniform heating from the tops to the bottoms of the vertical flue sets along the entire length of the heating walls.

Referring to Figures 9–11 of the drawings, another modified embodiment of the present invention is disclosed wherein induction duct means are shown in association with a well known Kreisstrom type oven similar to that disclosed in expired Patent No.1,856,501, issued to F. Totzek on May 3, 1932. By using the induction duct means of the present invention with the Kreisstrom type oven in the manner disclosed hereinafter, it is possible to obtain positive and uniform dilution of the rich-fuel gases going to all the vertical flues of a set by mixing all of such gases with all of the induced waste gases in one conduit means prior to the introduction of the gases into the vertical flues of the set. More particularly, in this oven, there is provided a series of alternate coking chambers 61 (Figure 10) and heating walls therefor, arranged laterally of each other in a row. Pairs of regenerators 62 and 63 are positioned below the bottoms of the coking chambers and heating walls, the regenerators of each pair being on opposite sides of a wall 64 which extends longitudinally of the oven. Each of the regenerators of pairs 62, 63 are provided with extension-ways 66, 67 respectively, each of these extension-ways extending from its regenerator in a scissorwise manner over the other regenerator of the same pair.

As can be seen in Figure 9, each of the heating walls is comprised of vertical heating flues, being arranged in a well known "hair-pin type" manner so as to form two sets of vertical flues 68*a* and 68*b*, each vertical flue limb of a pair of one set being communicably connected at its top with the top of a vertical flue limb of a pair of the other set to thus provide two sets of vertical flues operable for concurrent upflow combustion and downflow of waste gases in alternation with each other long the heating walls of the coking chamber. The vertical flues of the set of limbs 68*a* in the left hand half of the heating wall are connected at their lower portions with the regenerator 62 directly through passages or ducts 69 and, the vertical flues of the set of limbs 63*a* in the right hand half of the heating wall are connected at their lower portions with the regenerator 62 through extension-way 66 and ducts 73. In like manner, each of the flues of the set of limbs 68*b* communicates with regenerator 63. Thus, in the left hand half of the wall, flues of limb set 68*b* communicates with regenerator 63 through the passages or ducts 71 and the extensionway 67, while the flues of limb set 68*b* in the right hand half of the wall communicate directly with regenerator 63 through passageways or ducts 70.

In order to heat the oven with rich gases, air for combustion passes through the regenerators 62 and 63 in alternation and the rich gases are supplied through gas main headers 79, arranged on opposite side faces of the oven battery, to the heating flues 68*a* through the rich gas gun conduits 81 and branch riser conduits 81*a* in one working stage, and, in the other working stage, to the heating flues 68*b* through the rich gas gun conduits 82 and branch riser conduits 82*b*. In this connection, it is to be noted that induction duct means 83 are provided in the silica masonry along the side faces of the battery at the end extremities of the heating walls below the lower portions of the heating flues and adjacent the upper portions of the regenerators 62 and 63. Each of these induction ducts 83 connects the rich gas gun conduits 81 for the flues 68*a* in one heating wall on one side of a coking chamber 61 with the rich gas gun conduits 82 for the flues 68*b* in a heating wall on the other side of the same coking chamber 61, the induction ducts 83 connecting the pairs of rich gas gun conduits being of a structure and operating in a manner substantially like the induction duct means disclosed in Figures 5–8. Accordingly, in the operation of the oven disclosed in Figures 9–11, when rich gases are passed in upflow to the vertical flues 63*a* from the rich gas gun conduits 81 through branch riser conduits 81*a* and air is passed from the generator 62 through regenerator ducts 69, 73, waste gases from the heating flues 68*b* disposed in an adjacent heating wall are induced into the induction ducts 83 by jet means like those disclosed in Figures 1–4 associated with the gas gun 81 and the induction ducts 83. In this connection, it is to be noted that during one cycle of operation, flues 68*a* on

either side of coking chamber **61** are all operating in one direction of flow while flues **68***b* on either side of the coking chambers are all operating in the opposite direction of flow, a portion of the waste gases of the downflow flues being mixed with the rich gases on upflow in a manner and for the purposes aforedescribed. It is to be noted further that although only single rich gas gun conduits are shown in Figures 9–11 of the drawings, the invention contemplates the use of the lower distributor ducts such as those disclosed in Figures 1–4 and 5–8 with the rich gas gun conduits disclosed. It is also to be noted that each of the induction ducts **83** can be arranged to connect the rich gas gun conduits **81** for the flues **68***a* in one heating wall with the rich gas gun conduits **82** for the flues **68***b* in the same heating wall, rather than in a different heating wall, in a manner substantially like that disclosed for Figures 12 and 13 described hereinafter.

It will be apparent that a reversal of flow in the ovens does not alter the effect of the operation of the oven with this induction means in either of the above described arrangements, such reversal of flow operating in substantially the same way as above disclosed, only in a reverse manner, to produce heat in all of the connected vertical flue sets along the entire length of each of the heating walls.

Referring to Figures 12 and 13 of the drawings, still another embodiment of the present invention is disclosed wherein the induction duct means are shown in association with a well known Berthelot type oven similar to that disclosed in the long since expired Patent No. 1,361,671, issued to C. Berthelot on December 7, 1920, and commonly referred to as an oven wherein the sets of flues of each heating wall are operatively disposed as a double divided group thereof. In this type oven, one set of the flues extends along a portion only of substantially a first half of the length of a heating wall and the second set of flues operable in alternation therewith extends along the remainder of the first half of the length of the heating wall, a third and fourth set of flues being similarly arranged in the second half of the length of the heating wall.

More particularly, the oven disclosed in Figures 12 and 13 comprises a series of alternate coking chambers **91** and heating walls therefor, arranged laterally of each other in a row. Each of the heating walls is comprised of four sets of vertical flues **92**, the four sets being divided into two pairs with the cooperating flue sets of each pair communicating with each other at their upper portions by means of horizontal flues **93**. In this manner, a double divided group of flues is present in each heating wall with two sets of flues **92** connected to one of the horizontal flues **93** comprising a first and second set of flues in the heating wall and the other two sets of vertical flues connected to the other of the horizontal flues **93** comprising a third and fourth set of vertical flues. Positioned below each of the upper horizontal flue connected sets of vertical flues are the regenerators **96** and **97**, these regenerators being connected to the lower portions of the upper connected sets of vertical flues by ducts **94** so that the connected sets of flues operate in alternation with each other for on upflow and off downflow.

In a manner similar to that described for Figures 1–4, main rich gas headers **98** extend longitudinally outside the side faces of the battery at the ends of the heating walls on either side thereof, these main rich gas headers being connected in a know manner to rich gas gun conduits **99** and **101** which project inwardly adjacent the upper portion of the regenerators and below the bottoms of vertical flue sets. Rich gas gun conduits **99** project inwardly a sufficient distance toward the center of the oven to port into the first and fourth sets of flues respectively and rich gas gun conduits **101** project inwardly from the ends of the walls alongside and beyond the rich gas gun conduits **99** to port into the second and third sets of flues respectively. Induction duct means **103** including rich

gas jet means (not shown in detail, but substantially like that disclosed above) are provided in the side faces of the battery at the ends of the heating walls below the lower portions of the vertical flues and adjacent the upper portions of the regenerators, these induction duct means connect the conduits **99** for the sets of flues of one heating wall for a coking chamber with the conduits **101** for the other sets of flues of the same heating wall.

In the operation of the oven disclosed in Figures 12–13, gases are caused to flow upwardly in one of two connected flue sets positioned in each half of the heating walls on either side of coking chambers **91**, the gases passing along the horizontal flues **93** connecting the vertical flue sets and flowing downwardly as combustion products in the other set of the two sets of connected vertical flues. The upflowing gases comprise a mixture of rich gases from the rich gas gun conduits associated with the sets of upflow vertical flues (which, if the upflow were in the first and fourth flue sets of the heating walls would be conduits **99**, and if the upflow were in the second and third flue sets of the heating walls would be conduits **101**), air from one of the regenerators **96** or **97** (depending upon which set of flues is being fired), and waste gases from induction ducts **103** which connect the rich gas gun conduits **99** on one side of each coking chamber with rich gas gun conduits **101** on the same side of the same coking chamber.

It is to be noted that the induction ducts **103** can also be connected in a manner similar to that disclosed in Figures 9–11, the induction ducts connecting the rich gas-gun conduits **99** for one side of a coking chamber with the rich gas-gun conduits **101** on the other side of the same coking chamber, in such instances. In this latter arrangement, the waste gases which are induced into the induction duct **103** are provided by simultaneously operating on upflow, in a like manner, the other connected set of flues with which duct **103** communicates, this connected set of flues being positioned similarly in the adjacent heating wall on the opposite side of the coking chamber, the first set of such set of flues being operated on upflow simultaneously with the upflow operation of the first set of flues initially mentioned.

The induction of the waste gases in both of the above described arrangements is brought about in a manner similar to that described for the oven disclosed in Figures 1–4, rich gas jet means (not shown in detail) cooperating with the induction duct **103** to induce waste gases from a downflow flue set to flow through duct **103** and to combine with the rich gases before entering an upflow vertical flue set. It will be obvious that a reversal of flow in the ovens does not alter the effects of the operation of the oven with this induction means in either of the above described arrangements, such reversal of flow operating in substantially the same way as above disclosed, only in a reversed manner, to produce heat in all of the connected vertical flue sets along the entire length of each of the heating walls.

Through the described gas-flow regulating means for each of the various types of ovens above described, it is possible to circulate combustion products between operatively interconnected heating flue sets in such a manner that certain of the well known undesirable combustion characteristics exhibited by gases of high-heating value can be substantially eliminated to the general advantage of these type ovens and of the thermal conditions maintainable in their heating walls. The present invention provides means whereby these objectives are simply and cheaply realizable by means of the idle rich gas riser conduits and their nozzles, as in my aforesaid patent, as illustrated in Rueckel Patent 2,470,112, but by further adapting the feature of utilizing the gas-gun conduits also for conveying the waste gas due to the novel feature of interconnecting the gas guns with the recirculation induction ducts at the side face of the battery, and thus without the circulation of excessive amounts of combustion products through the regenerators or the

heating flues, and without maintaining abnormally high pressure in the fuel-gas distributive system or disturbing the normal streamline flow of gases through the heating flues.

It is to be understood that when any of the ovens above described are fired with lean gases, the circulation of combustion products in the rich gas distributive system and heating flues is automatically cut-off so that the leaner blast furnace gases or producer gases usually used as the firing medium in such instances are thus advantageously subjected to no further reduction in their calorific values before they are introduced into the heating flues.

It is also to be understood that the quantity of combustion products circulated between heating flues can be so controlled as to be optionally variable in accordance with the characteristics of the employed firing gases, by varying the nozzle orifice diameter and pressure, and by varying the position of the nozzle with respect to the centerline of the induction duct.

The invention as here-in-above set forth is disclosed as employed in a number of particular forms and can be variously employed in other forms within the scope of the claims hereinafter claimed.

The invention claimed is:

1. In a regeneratively heated coke oven battery formed of silica masonry comprising horizontal coking chambers each having heating walls on opposite sides thereof with vertical flues disposed in a row alongside the coking chambers and operatively disposed for upflow combustion and downflow of combustion products in alternation; regenerators at a level below the bottoms of the coking chambers and heating walls and communicating with the vertical flues in said heating walls; and horizontal rich-fuel gas gun conduits extending from the side face of the battery lengthwise of the heating walls under the heating flues, in the masonry between the bottom of the flues and the uppermost portions of the regenerators, said gas gun conduits communicating through masonry riser conduits and ports distributed longitudinally of said gas gun conduits, and being operably disposed in pairs for inflow in each conduit of a pair in alternation with the other conduit of a pair; and jet means for each gas gun conduit of a pair disposed along the side face of the battery, at the outer end of the heating walls, operatively connect each gas gun conduit of a pair with a fuel gas supply main, along the outside of said side face of the battery, in alternation with the connection of the jet means of the other conduit of the same pair, for effecting inflow of rich gas from said fuel gas main to the rich gas gun conduits of the same pair in alternation with each other, for upflow combustion in the flues served by the respective conduits of a pair in alternation with each other; the improvement comprising, induction ducts disposed lengthwise alongside the aforesaid side face of the battery, in the masonry at the region between the bottoms of the ends of the heating walls and coking chambers and the uppermost parts of the regenerators, said induction ducts communicably connecting each rich gas gun conduit of a said pair with the other at their jet connected ends, for flow of combustion products from the flues served by the respective rich gas gun conduits, when said flues are operable for downflow of combustion products, through their aforesaid masonry riser conduits and ports and rich gas gun conduits, by way of said induction ducts, to combine with the rich fuel gas from the jet means then operable for inflow of rich gas and through the other rich gas gun conduit of the same pair and its masonry riser conduits and ports and their vertical flues, then operable for upflow combustion, under the jet action of the rich gas from said fuel gas main at the side face of the battery as the rich gas leaves the jet means to enter the other rich gas gun conduit then operable for inflow.

2. Apparatus as claimed in claim 1, and in which said rich-fuel gas gun conduit 5 includes a main conduit communicating through said riser conduits and masonry ports with its vertical flues, and a distributor conduit below and communicably connected to said main conduit intermediate the ends thereof, and said induction duct and jet means connect with the distributor conduits.

3. The apparatus of claim 1, and in which the vertical flues of the heating walls are cross-over flue interconnected into two sets with one set in the heating wall on one side of a coking chamber and the other set in the heating wall on the other side of said coking chamber, for the aforesaid alternating upflow combustion and downflow of combustion products.

4. The apparatus of claim 1, and in which the vertical flues of the heating walls comprise flues in two sets in the same heating wall for concurrent upflow combustion and downflow of combustion products, in end-to-end relationship, with horizontal duct means communicably connecting the tops of the flues of one set with the tops of the flues of the other set, for alternating flow to and from each set in each heating wall.

5. The apparatus of claim 4, wherein the two sets of flues of each heating wall are operatively disposed therein as a single divided group thereof, with one set of flues extending at least one-half the length of the heating wall and the other set of flues extending the remainder of the length of said wall.

6. The apparatus of claim 4, wherein the two sets of flues of each heating wall are operatively disposed therein as a double divided group thereof, with flues of one set extending for a portion only of one-half the length of the heating wall, flues of the other set which are operable in alternation therewith extending the remainder of that half the length of said heating wall, and flues of said one set and said other set being similarly arranged in the other half of the length of said wall.

7. The apparatus of claim 6, wherein said induction ducts connect the different rich gas gun conduits which port into different flue sets in the same heating wall.

8. The apparatus of claim 4, and in which said induction ducts connect rich gas gun conduits which port into different flue sets in the heating walls on opposite sides of an intervening coking chamber.

9. Apparatus as claimed in claim 4, and in which the flues of each heating wall are communicably connected, at their upper parts, in pairs for operation in alternation with each other, for upflow combustion in one flue of each pair and concurrent downflow of the waste-gas combustion products in the other flue of each pair, and the regenerators, which communicate with flues of a pair, are disposed on opposite sides of a division wall extending longitudinally of the battery, and have an extension jutting from each regenerator over the other regenerator on the opposite side of said division wall, and the flues of each pair have one limb communicating directly with a regenerator below the pair and have the other limb communicating indirectly, through an extension with the other regenerator on the opposite side of said division wall.

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