July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 1

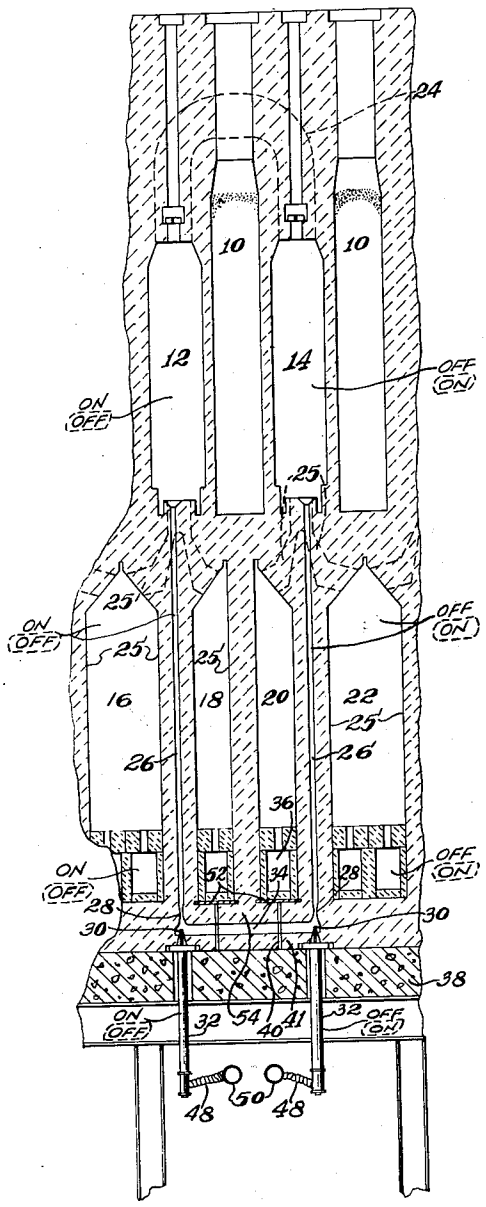


FIG. 1

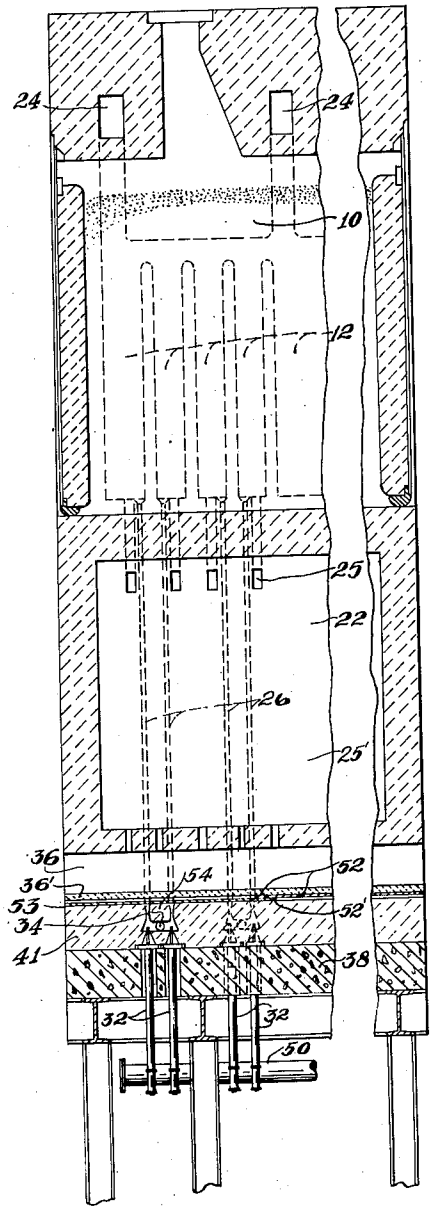


FIG. 2

INVENTOR.
JOSEPH VAN ACKEREN
BY
Thomas J. P. O'Brien
his ATTORNEY

July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 2

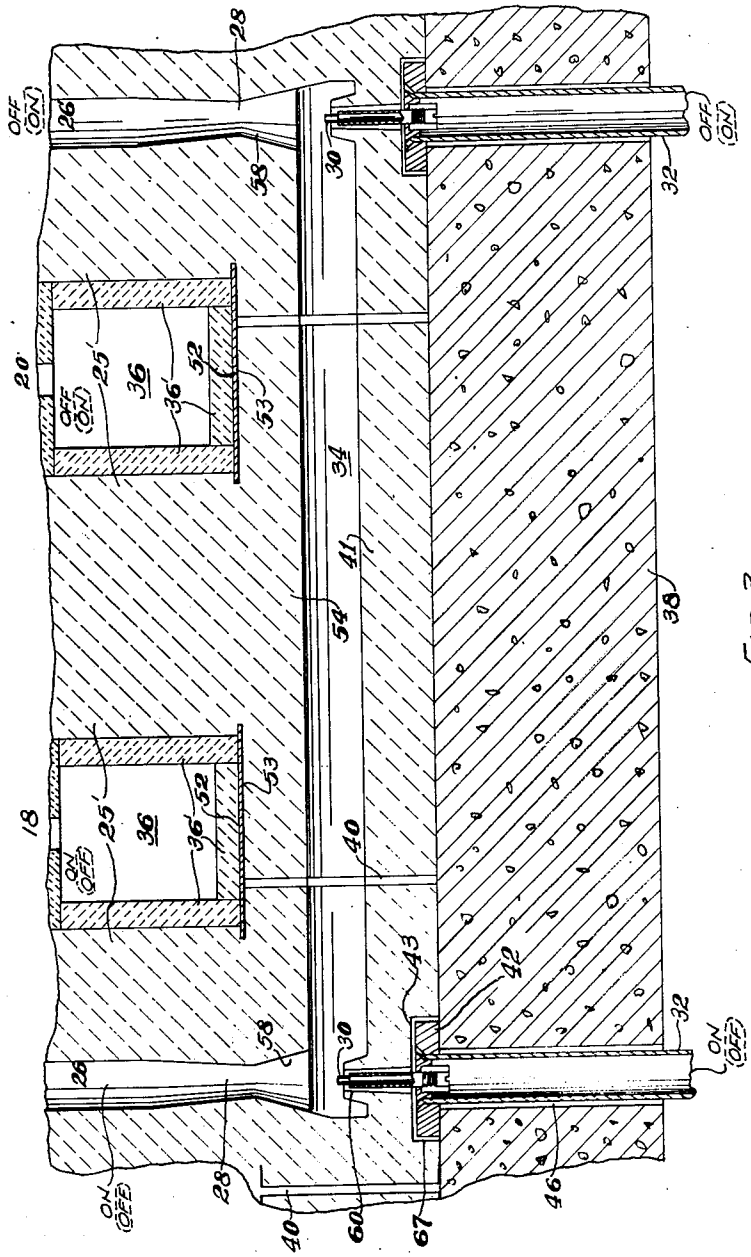


FIG. 3

INVENTOR.
JOSEPH VAN ACKEREN

BY
Thomas J. P. O'Brien
his ATTORNEY.

July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 3

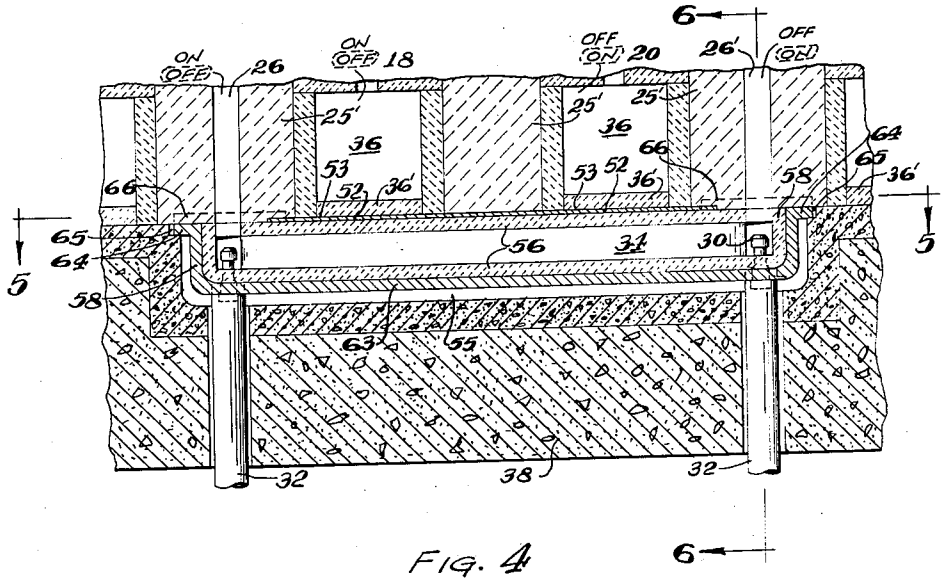


FIG. 4

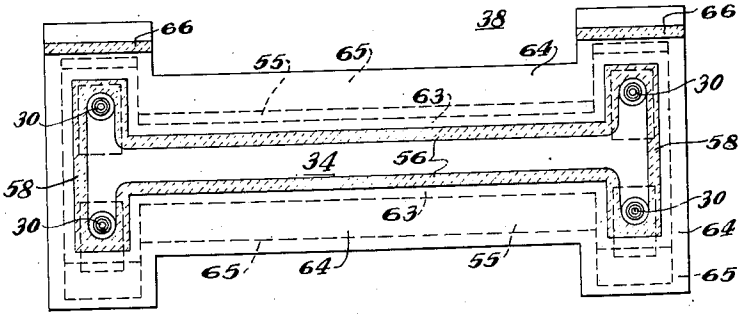


FIG. 5

INVENTOR.
JOSEPH VAN ACKEREN
BY
Thomas J. O'Brien
HIS ATTORNEY.

July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 4

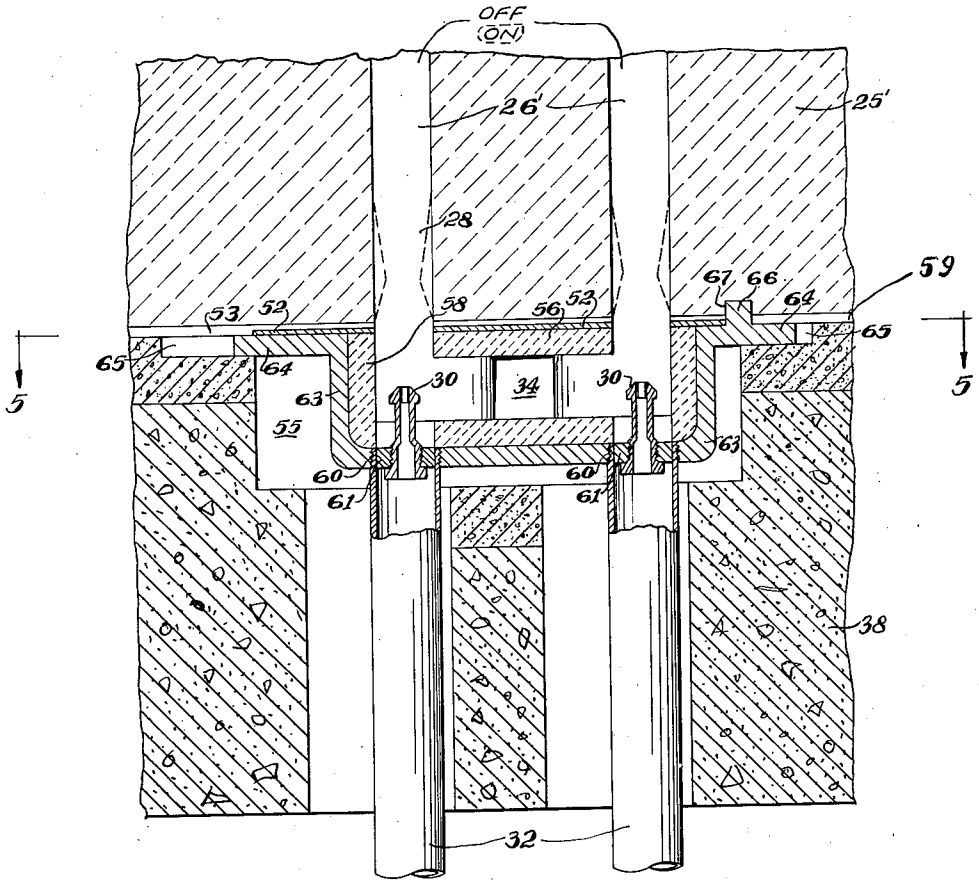


FIG. 6

INVENTOR.
JOSEPH VAN ACKEREN

BY
Thomas J. P. O'Brien
his ATTORNEY.

July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 5

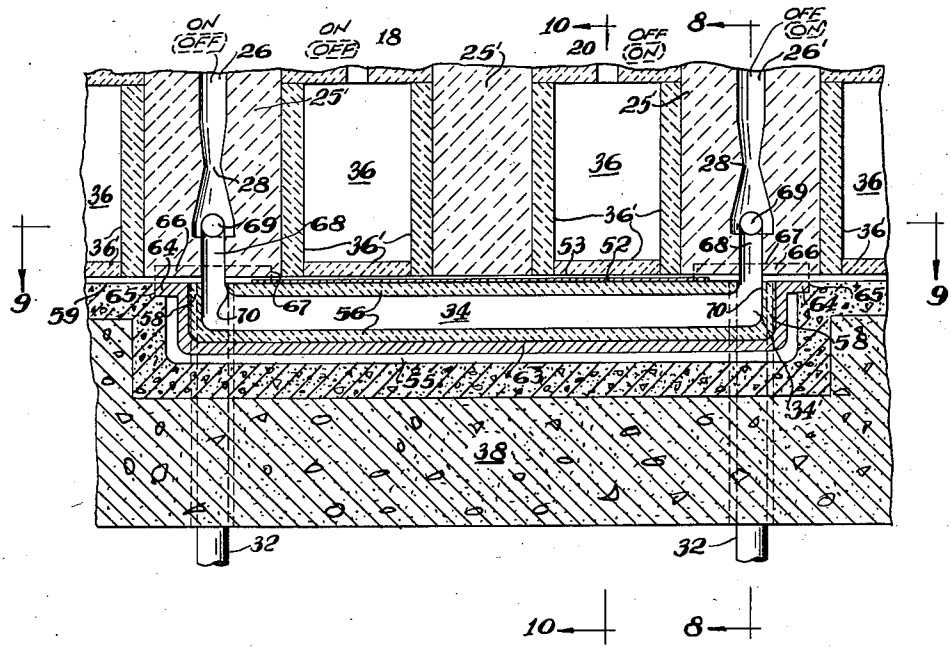


FIG. 7

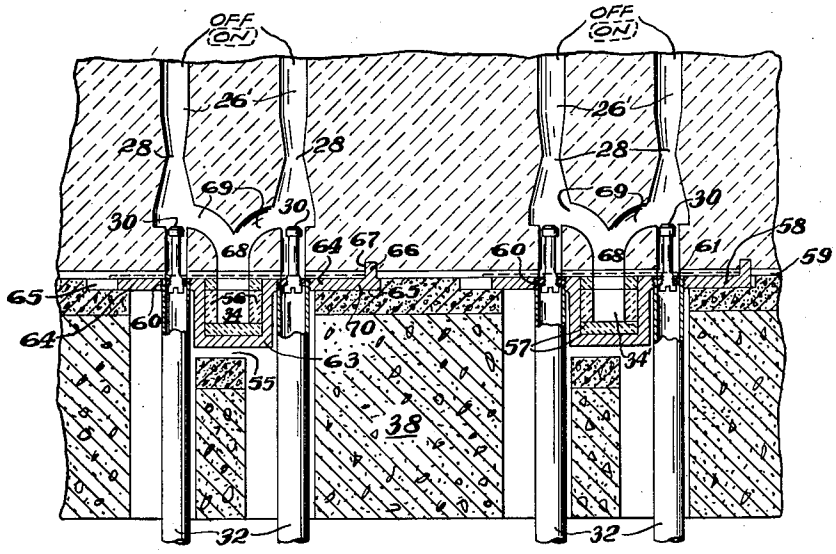


FIG. 8

INVENTOR.
JOSEPH VAN ACKEREN
BY
Thomas J. P. O'Brien
HIS ATTORNEY.

July 16, 1957 J. VAN ACKEREN 2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

Filed July 14, 1951 6 Sheets-Sheet 6

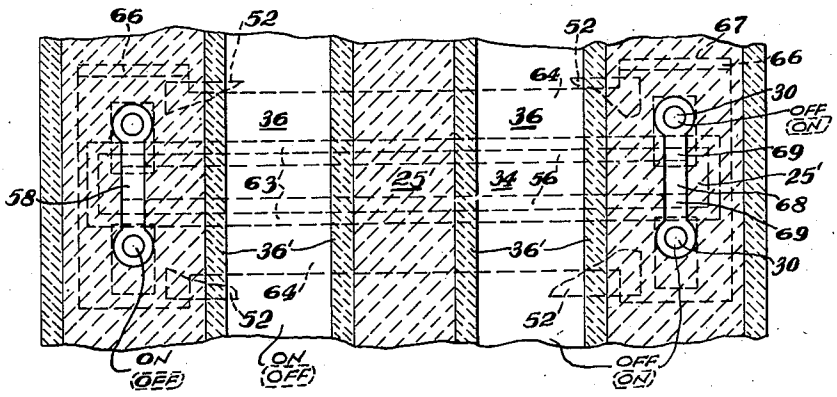


FIG. 9

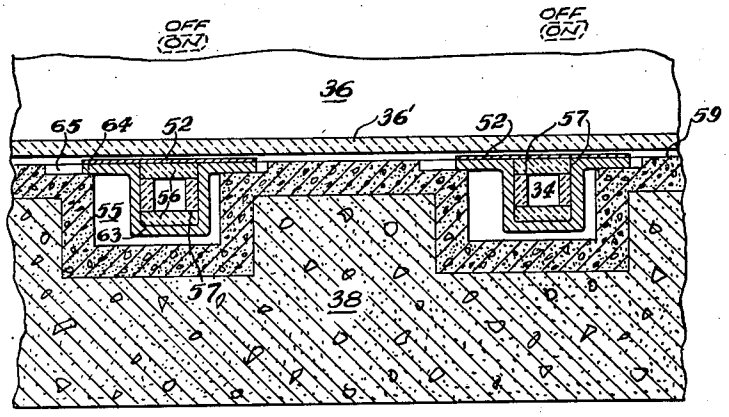


FIG. 10

INVENTOR.
JOSEPH VAN ACKEREN
BY
Thomas J. P. O'Brien
HIS ATTORNEY

United States Patent Office

2,799,632

Patented July 16, 1957

2,799,632

RECIRCULATION UNDERJET COKING RETORT OVEN

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

Application July 14, 1951, Serial No. 236,808

7 Claims. (Cl. 202—142)

This invention relates in general to improvements in coking retort oven batteries, and more particularly to improvements in the construction and operation of coking retort ovens of the type described and claimed in my Patents 2,306,678 of December 29, 1942 and 2,507,554 of May 16, 1950.

An object of the invention is to provide leakage-proof plates interposed in a horizontal plane in the masonry between the bottoms of the regenerator sole flues or channels, and the waste gas recirculation duct beneath the regenerator sole channels, which recirculation duct connects "on" and "off" rich gas risers to feed waste gas from the "off" combustion flues into admixture with rich gas prior to its discharge into "on" combustion flues, in ovens of the aforesaid type. These plates are provided here to further insure the absence of leakage from the regenerator sole flues into the recirculating duct.

A further object of the invention is to provide an underjet coke oven structure in which the recirculation duct, when located in the oven mat, and the rich gas nozzle of my aforesaid patent structure, are all interconnected or keyed with the silica brickwork, for simultaneous movement of them together, in unison with said silica brickwork, relative to the oven mat and the sole channels, as a single structural unitary whole, to maintain the recirculation duct as well as the nozzle, and the venturi throat, when employed, in alignment with each other and with the rest of the underjets, as the silica brickwork moves differentially relative to the concerete of the mat and to the clay of the brick of the sole channels.

Said coking retort ovens of my aforesaid patents are characterized by waste gas recirculation ducts beneath the sole channels of regenerators, which recirculation ducts connect "on" and "off" underjet ducts, or risers for feed of waste gas from the "off" to the "on" rich gas risers that feed vertical combustion flues of the heating walls alongside the coking chambers.

In operation, the "on" and "off" rich gas risers or underjet ducts are fed in alternation with rich gas, such as coke oven gas, in calibrated amounts which are introduced in the form of a jet by nozzles at the juncture of the recirculation duct with the "on" and "off" rich gas risers.

The jet action of the calibrated gas induces a flow of waste gas from the "off" riser through the recirculation duct into the "on" riser, in amounts proportionate to dilute the rich gas to produce elongation of its flame of combustion in the heating wall combustion flues, and thus effect relatively-uniform thermal conditions in the heating walls similar to that obtainable in underfiring with regeneratively preheated lean gas, such as producer gas and blast furnace gas.

In addition, the coke oven batteries of said patents are built of refractory shapes, and so the structure in the region of the bottom of the sole channels of the regenerators and the recirculation duct require joints for expansion.

As a consequence it is possible, in the course of the life of batteries of coke ovens so constituted, that small amounts of air or waste gas might be drawn into the recirculating ducts from the adjacent sole flues, disturbing the uniformity of heating achieved by the waste gas recirculating system, thus tending to vary the heat intensity in the various flues.

To alleviate this condition a metal conduit lined with fireclay inserted inside the recirculation ducts has been found suitable as disclosed in my aforesaid Patent 2,507,554. However, it is still possible with that construction for some leakage to occur in time around the metal liner and at its ends, if the expansion joint packing wears or fails, or the mortar joints develop fissures.

The present invention is directed to providing a more simple, more effective, and more economical solution of the problems that may arise in the subsequent operations of coke ovens of the waste gas recirculation type and the accomplishing of this in a manner that avoids the disadvantages above discussed.

Accordingly, the present invention provides for the purpose metal plates interposed in a horizontal plane in the brickwork between the bottoms of the sole channels, and the tops of the recirculation ducts that are beneath the sole channels, and that connect "on" and "off" rich gas risers or underjet ducts, to feed two sets of flues, operable in alternation for inflow combustion and simultaneous outflow of combustion products, as in the case of hair-pin, or other types of heating flue systems, and more particularly cross-over flue interconnected vertical combustion flue heating systems, as in my aforesaid patents.

Preferably these metal plates are of stainless steel, for example the conventional No. 24 gauge, type 302, and extend across the width of the regenerators into the regenerator division walls to seal off the sole channels and the joints for expansion of the surrounding structure relative to them from the recirculation ducts.

The plates preferably lie in the joint between the sole flue bottoms and the tops of the recirculation ducts. These plates act to intercept joints to insure the absence of leakage from the sole flues into the recirculation ducts, and into the rich gas riser ducts.

Such stainless steel plates will withstand the temperatures that exist in the recited specific location for said plates in such coke oven batteries, and will not deteriorate throughout the normal life of such batteries, being sufficiently heat and abrasion resistant under the expected normal service conditions, since like plates have been used in such batteries at higher levels to prevent leakage between "on" and "off" regenerators, and between "on" regenerators and "off" sole flues for "off" regenerators.

In one form, the invention is incorporated in a coke oven battery constructed in accordance with my aforesaid U. S. Patent No. 2,507,554. As there shown, the recirculation duct is incorporated in the brickwork immediately over the concrete oven mat between the same and the floors of the regenerator sole channels that are immediately above. While the metal liner and its lining of fireclay for the inside of the recirculation ducts may also be used as an auxiliary safeguard in connection with the recirculation duct, when employing the metal leakage-proof plates of the present invention between the top of the recirculation duct and the floor of the regenerator sole channels, preferably the inner metallic liner, and its fireclay lining is omitted when employing the joint intercepting metal plates in the location they are employed in accordance with the presently preferred embodiment, since the plates as used herein prevent flow of leakage around them, and make unnecessary the use of the expansion joint packing as in my prior construction.

In another form, the invention here is employed with the metal leakage-proof plates laid directly horizontally along the top surface of the concrete oven mat. In this form, the recirculation duct is located within the concrete mat of the oven as in my aforesaid Patent 2,306,678.

In this embodiment the regenerator sole-flue floor is laid directly on the concrete oven pad, with the metal joint-intercepting plate disposed in a horizontal plane in between, thus eliminating the silica brick fill under the sole flue as is required when the recirculation duct is built in the brickwork immediately over the concrete pad, as illustrated in the first described and preferred embodiment of this invention which incorporates those features of my aforesaid Patent 2,507,554.

This second embodiment of the invention also permits employing the same height of regenerative area with a decrease in the overall height of an oven battery, thus attaining the same heating effect in an oven battery but with a lower overall height.

In these two forms of the invention, the concrete mat and the clay brick of the sole flues expand at the same rate, whereas the silica of the regenerator division and pillar walls expands at a greater rate as compared with the clay and concrete, and so a concrete curb or equivalent is provided at each end of the sole flue to prevent the clay brick of the flue from being carried out with the silica as the brickwork is heated. In both cases the metal joint intercepting plate prevents leakage from the sole flue to the recirculation ducts by sealing off the open joints of the sole flues from the area of the recirculating ducts when the ducts are located either in the upper silica masonry or in the concrete mat, the plates being clamped by the silica brick walls while still permitting the differential expansion of the silica.

In the second embodiment of the invention, the waste gas recirculation duct is formed by arranging fireclay tile or brick liners within the concrete mat, which tile or liner brick form hollow sections with joints between them and joints between their outer surface and the surrounding structure.

At their ends the recirculation ducts are provided with gas riser extensions leading to, and in part constituting a part of, the rich gas risers or underjet ducts, and the venturi throat of my aforesaid patents may be formed within the upper silica brickwork above the plane of the top of the concrete mat. The removable calibrated nozzle is mounted in a metal gas line which line is connected to a gas riser extension of the recirculation duct that is located within the concrete mat, the nozzle being removably connected to a part of the metal gas line which is attached to the gas riser extension and which also passes through an enlarged passage in the portion of the concrete mat below the recirculation duct. The top of the nozzle terminates in the region of juncture of the rich gas riser or underjet duct with the recirculation duct through a gas riser extension portion thereof, for jetting the gas in a manner to induce the flow of recirculated waste gas.

The metal gas line and the removable nozzle as well as the recirculation duct all being connected together within the concrete mat through a gas riser extension portion of the recirculation duct, assures proper alignment of the gas line and its nozzles, and the recirculation duct for jetting in the rich coke oven gas, since they are formed in fixed relation to a rich gas riser extension portion of the recirculation duct element in the concrete mat, and thus assures alignment of the nozzle, its gas line, the rich gas riser extension of the duct, and the recirculation duct with each other below the rest of the portions of the so-called underjets that are formed as a channel in the silica brickwork of the regenerator division walls and extend from just above the concrete mat up to the bottoms of the combustion flues.

In this second embodiment, the recirculation duct and its gas riser extensions are formed to constitute a single

unitary whole movable as a unit within a free space in an upwardly open pocket in the top of the concrete mat and interconnected with the silica brickwork above the mat for movement in unison therewith.

In this embodiment, the recirculation duct and the gas riser extensions are in part formed as an upwardly open steel casting to permit lining it with fireclay or liner brick. When so lined the casting holds the entire recirculation duct and its gas riser extensions together as a unitary single entity and is located in the pocket in the concrete mat to permit the casting with its lining to be moved with the silica masonry as a structural entity relative to the concrete of the mat which encases it.

For effecting this unitary movement, the upper parts of the gas riser extension portions of the waste gas recirculation duct casting have a part or parts which project above the plane of the top of the concrete mat into integral relation with the bottom of the silica brickwork above the mat that contains the rest of the rich gas riser underjet.

With this form of the invention, the rich gas nozzles and their gas lines are interconnected as a single structural unitary whole with the recirculation duct, for simultaneous movement of them together in unison with the silica brickwork.

In this manner the rich gas nozzles and waste gas riser extensions and the rest of the recirculation duct structure are interconnected to the silica brickwork to simultaneously partake of the movement of the silica brickwork in its expansion and contraction. Thus, as the silica expands and contracts, the rich gas nozzles, their gas lines, and the recirculation duct units therefor, also simultaneously move in unison therewith relative to the concrete mat in which the recirculation duct and the rich gas nozzles are contained, and thus are kept in alignment with the rest of the underjets in the upper portion of the silica walls above the mat under all movement of the walls containing the rest of the underjets that lead up to the bottoms of the combustion flues. The removable rich gas nozzle and its pipe line are fixedly connected to an orifice member formed in a rich gas riser extension portion of the recirculation duct element, for their movement together as a single unitary whole with the silica brick wall above relative to the concrete mat and to the fireclay lining of the regenerator sole channels which expand less than the silica.

With this embodiment of the invention, the venturi throat is omitted in some instances, and in some instances is formed as an integral part of the portion of the rich gas riser underjet duct that is formed as a vertical channel in the brickwork of the silica regenerator division wall above.

Thus, the recirculation duct, the venturi throat, when used, and the removable gas jetting nozzle are kept in coaxial alignment, not only with each other but also with the rest of the rich gas riser ducts under all the movements of the silica brickwork relative to the concrete mat and the regenerator sole channels, as the rich gas nozzle is in my aforementioned Patent 2,507,554, since the recirculation duct is now integrated for movement in unison with all the other foregoing elements and with the silica regenerator division walls relative to the concrete mat and to the clay brick of the "on" and "off" regenerator sole flues, and the metal leakage-proof plate serves to prevent leakage from the sole flues into such a recirculation duct system when movably mounted directly below the sole flues in an upwardly open pocket in the concrete mat. This permits the sole flues to be disposed lower down on top of the mat while having the recirculating duct system contained movably in gas tight relation in an upwardly open pocket in the top of the mat directly under the sole channels.

In the form of the invention in which the recirculation duct, when located in the concrete mat, is fixedly interconnected with the silica brickwork of the regenerator

division walls, the leakage-proof plate is not overlapped lengthwise of the regenerators but extends under the area of the sole flues only immediately over the recirculation duct areas therebeneath.

It will be understood however, that the feature of interconnecting the rich gas risers, removable gas inlet nozzle, and recirculation duct, when located in the concrete mat, with the silica brickwork of the regenerator division walls for movement in unison is not limited in all its aspects to use entirely with the leakage-proof plates for intercepting joints, since much of the advantages of such keying or interlocking, or interconnection feature may be attained, although in a less advantageous way, without employing or requiring the leakage-proof feature to be used therewith in all instances.

In addition to the general objects recited above, the invention has for further objects such other improvements and advantages in construction and in operation as may be found to obtain in the structure hereinafter described or claimed.

In the accompanying drawing forming a part of this specification and showing for purposes of exemplification a preferred apparatus and method in which the invention may be embodied and practiced but without limiting the claimed invention in all its aspects to such illustrative instance or instances.

Figure 1 is a vertical sectional view of a part of an underjet coke oven battery, taken longitudinally of the battery, that is, transversely of the length of its coking chambers, and illustrating the preferred embodiment of the present invention.

Figure 2 is a vertical sectional view of the same taken at right angle to the section of Figure 1, that is, crosswise of the battery, longitudinally of the length of its coking chambers.

Figure 3 is an enlarged detail view in vertical cross-section lengthwise of the battery showing the relationship between the metal joint-intercepting plate and the sole channels of the regenerators and the top of the recirculation duct.

Figure 4 is a vertical sectional view illustrating a second embodiment of the present invention, the view illustrating a modified form of the construction illustrated in Figure 1, to incorporate the second embodiment of the invention, with the recirculation duct interconnected with the silica brick of the regenerator division walls, for movement in unison therewith relative to the concrete mat, and the rich gas nozzles connected with the duct to move together as a unit therewith in the region of the concrete mat; the views illustrating a structure in which the venturi throat is omitted, but may be employed, as indicated in dotted lines.

Figure 5 is a top plan view on line 5—5 of Figures 4 and 6.

Figure 6 is a vertical cross-sectional view of Figure 4, the view being taken at right angles to Figure 4, crosswise of the battery, that is longitudinally of the coking chambers and heating walls.

Figures 7 and 8 are views similar to Figures 4 and 6, illustrating another form of interconnecting the rich gas nozzles with the underjet duct for their movement as a single unitary whole with the regenerator division walls but with the discharge end of the nozzle located above the concrete mat for discharge into a venturi throat located in the region of the silica brickwork of the regenerator division walls.

Figure 9 is a top plan view on line 9—9 of Figure 7.

Figure 10 is a vertical cross-sectional view on line 10—10 of Figure 7.

The same characters of reference indicate the same parts throughout the several views.

The novel features of the invention are incorporated in cross-regenerative cross-overflue interconnected vertically flued by-product or chemical recovery coke oven of the type of J. Becker Patent No. 2,100,762, and for convenience the present invention will be confined to this application of the invention. The features of the invention are, however, readily susceptible for other uses, for example in connection with coke oven batteries of other forms, such as twin or hairpin flue types of underjet ovens, and other types of underjet ovens employing "on" and "off" combustion flues, regenerators, and underjets, hence it is manifest that the scope of the invention is not confined in all its aspects solely to the specific use and specific embodiments herein described.

The heating of the coke oven batteries is a continuous process which is carried out in two halves of a cycle. In one half of the cycle the heating flues are heated by combustion of air and fuel gas, the air being preheated in regenerators and gas likewise preheated in regenerators, when the underfiring is with lean gas, such as blast furnace gas or producer gas.

With rich gas firing, this gas is not preheated in the regenerators, but the lean gas regenerators in this instance, serve to supply preheated air. The heating flues, and the regenerators in the next half of the cycle operate to exhaust waste gas of combustion. When operable for inflow combustion, the heating flues, regenerators, and rich gas feed conduits are termed "on" combustion flues, regenerators, and rich gas conduits, and when operable for outflow of combustion, the term "off" is used.

The heating flues, regenerators, and rich gas conduits of said batteries are operatively disposed in two sets, for concurrent "on" and "off" flow. In one half of the cycle, one set of heating flues, and their air and gas supply mechanism serve for "on" flow, while the other set of heating flues and their regenerators serve for "off" flow concurrently of the waste gases of combustion from the first set. On reversal, for the next half of the heating cycle, the former "off" flow set becomes the "on" flow set for combustion, and the former "on" flow set becomes the "off" flow set for exhaust of the combustion gases.

For this, the combustion flues are connected at their upper parts for passage of the combustion products from the flues of one set to the flues of the other set in alternation, as shown in Figs. 1 and 2.

Referring to the drawings, the vertical combustion flues are connected by cross-over conduits **24** into two sets **12**, **14**, for concurrent "on" and "off" flow. Each flue **12**, **14**, is connected with a pair of cross-regenerators, the flue **12**, with an air regenerator **18** and a gas regenerator **16**, and the flues **14** are connected with an air regenerator **20** and a gas regenerator **22**. The regenerators **18**, **20**, serve the flues of a single heating wall individually, whereas the wide intermediate regenerators **16**, **22**, individually serve in common the flues of two adjacent heating walls.

Likewise, the flues **12** of one set are served individually by individual rich gas riser conduits or underjets **26**, whereas the flues **14** of the other set are served individually by individual rich gas risers or underjets **26'**.

The regenerators communicate by regenerator ducts and outlet ports **25** with the bottoms of the individual combustion flues, and the rich gas risers **26**, **26'** extend upwardly to the bottoms of the combustion flues through the silica brickwork of the regenerator division walls **25'** which also are pillar walls that support the upper masonry mass of silica brickwork, constituting the coking chambers **10** and vertically flued heating walls. At their lower ends the rich gas risers **26**, **26'** extend down into communication with the nozzles **30** of the underjet ducts, which nozzles are removably mounted in metal conduits **32** of the gas line, which are connected to headers **50**, by means of flexible tubing **48**, all of which are accessible to an attendant moving about in the basement space underneath the concrete mat **38**.

Referring to the embodiment illustrated in Figs. 1 to 3, for recirculation of waste gas into admixture with the rich gas when it flows into an "on" rich gas riser, the "on" and "off" rich gas risers are interconnected with each other by a recirculation duct **34** disposed underneath the sole

channels 36 of "on" and "off" regenerators that are located between those rich gas riser ducts 26, 26' which are interconnected by duct 34.

In this embodiment the duct 34 is located in silica brickwork above the concrete mat 38 and the rich gas risers are provided with a venturi throat 28 which forms a part of an aspirating mixer.

The nozzles 30 terminate below this throat 28 and at the juncture of the rich gas riser with the duct 34, so that discharge of gas from the nozzles 30 induces a flow of waste gas from an "off" combustion flue, down through its "off" rich gas riser, through the duct 34 into mixture with the gas being jetted from the nozzles 30, for dilution of that gas as it rises in the ducts 26, 26', before the rich gas discharges into the bottoms of the combustion flues 12, 14.

In this embodiment of the invention, the sole channels 36 are formed of clay brick, whereas the regenerator pillar-division walls 25' are composed of silica brickwork. It is necessary to provide silica brick between the bottoms of the clay brick sole channels 36 and the concrete of the oven mat 38, for equal expansion and alignment of the recirculation duct 34 with the portions of the rich gas risers in the silica division walls. Because of the greater differential in expansion of silica as compared with the concrete of the oven mat and the clay of the brick of the sole channel, the walls 25' are mounted on the mat 38 to permit their longitudinal movement, under expansion, relative to the mat. It is also necessary to provide expansion joints 40 for the transverse expansion (Fig. 3) movement of the silica brick fill 41 between the clay bottoms 36' of the sole channels 36 and the top of the concrete mat 38, to accommodate expansion lengthwise of the ducts 34, all as more particularly pointed out in my aforesaid Patent 2,507,554, which is hereby made a descriptive part hereof. Said joints 40 must extend down from the bottom 36' of the sole channels 36 to the top of the concrete mat 38.

The principal expansion of the oven structure and heating walls especially takes place when the oven battery is heated from a cold condition to a hot operating condition. Some different expansion and contraction also takes place when the operating temperature is materially changed for coking different types of coal in the chambers 10. The mortar joints between the bricks of walls 25', 41, are normally filled, but may, in time, develop fissures, allowing of some leakage under the pressure differential conditions. The weight of the upper masonry mass on the regenerator pillar-division walls 25' insures sufficient gas-tightness of the bottoms of those walls 25' with the top of the concrete mat 38, to prevent leakage through the expansion joint between them.

The expansion joints 40 normally close up, when the battery is heated up, and thus prevent leakage therethrough. However, in the course of time, it is possible that somewhere in the battery some of these numerous mortar joints, and expansion joints 40, may open up sufficiently for some air to leak from an "on" sole channel 36 above into the recirculation ducts 34, causing a small amount of air to mix with the rich gas issuing from an "on" jet 30, which might result in less uniformity in heating of the coking chambers.

In accordance with the present invention, to the end of further insuring against such leakage, metal joint-intercepting plates, plates 52 as I have above described, are laid on the brickwork 41, during the course of erection of the oven battery, in the horizontal plane of the area between the bottoms 36' of the sole channels 36 and the top 54 of the recirculation duct 34.

As shown in Figs. 1 to 3, the top 54 of the duct 34 is contiguous to the bottom 36' of the sole channels 36 and the plates 52 are laid on the top 54 so as to lie in the joints 53 between the bottoms 36' of the sole channels 36 for the regenerators and the top 54 of the recirculation duct 34.

Preferably the sole channels 36 are formed of special linings 36' laid within the regenerator bottoms and the plates 52 are interposed between the bottom clay liner 36' and the silica brickwork 41 therebeneath.

These plates 52 extend from side to side of the regenerator chamber area at the bottoms of the regenerators to at least the side surfaces of the adjacent pillar walls 25' and preferably extend at their sides into the joints of the brickwork in the pillar walls 25' to prevent leakage from the sole flues 36 into the recirculating ducts 34.

These plates 52 are, in the embodiment of Figs. 1–3, in sections lengthwise of the heating walls and coking chambers 10, and so are overlapped in end-to-end relation as at 52'.

Preferably they are of the now conventional stainless steel, and No. 24 gauge, type 302, although other gas impervious material also may be used which is of a composition capable of withstanding the temperatures and abrasion due to repeated expansion and contraction, of this region of these now conventional ovens, without deterioration during the normal expected life of this region of such batteries.

In the embodiment illustrated in Figs. 4 to 10, the recirculation ducts 34 are located in the concrete of the oven mat 38. In this embodiment, the mat 38 is formed with pockets 55 to receive the recirculation duct 34 in the form of precast fire-clay conduit members or liner brick, each duct 34 having gas riser extensions 58 at its opposite ends.

As shown in all Figures 4 to 10, the ducts 34 are connected with the rich gas risers 26, 26' of a plurality of combustion flues, so that each recirculation duct 34 serves in common two "off" and two "on" underjet ducts.

In the form of the embodiment illustrated in Figs. 4 to 10, the waste gas recirculation conduit 34 is formed by locating in upwardly open pockets 55 in the concrete mat, precast fireclay tubular sections or liner brick 56, of rectangular contour in cross-section on their inner tubular portion, and of rectangular contour in cross-section on their outer portions. The tubular duct 34 is formed of pre-cast fire-clay sections or liner brick 56 with joints 57, Figs. 8, 10. These sections or brick are wholly located in the concrete pocket 55, and terminate at their upper parts in the plane of the top 59 of the upper portion of the concrete mat 38.

The silica fill 41 as in Figs. 1–3, is omitted from beneath the "on" and "off" sole flues of the "on" and "off" regenerators. The fire-clay liner-brick 36' for the sole flue or channel 36 are then laid lower down immediately on the top 59 of the concrete of the mat 38 but with the metal plates 52 in between.

The venturi throat 28 is located above the gas riser extension 58 of the duct 34 in the portion of the underjet ducts in the silica walls above the plane of the top 59 of the concrete mat 38. The duct 34 is also provided at each end with an orifice member 60 for connection of the meal gas lines 32 for the vertical flues served by the underjet ducts 26, 26' that the recirculation duct 34 serves. The removable calibrated nozzles 30 are contained in these lines, with the nozzle projecting into the juncture of the recirculation duct 34 with the rich gas risers or underjets, the nozzle extending through the orifice member 60 for the line 32. The nozzle 30 is removably connected in an orifice member 61 in the line 32; members 58, 60, 61 also constitute a part of the gas underjets 26, 26'.

In my aforesaid Patent 2,507,554, provision is made for interlocking the gas line 32 and nozzles 30, with the silica brick of the structure 25' that is differentially expansible on top of the concrete mat 38, by means of metal blocks 42 in cement 43 in recesses 67 in the base of the silica walls 25', to move the nozzle 30 in correspondence with the movement of the silica brickwork 25', during its movement in expansion and contraction, relative to the concrete mat, and to the clay of the sole

channel liners 36', to thereby hold the nozzle 30 and venturi throat 28 in coaxial alignment with each other and with the axis of the upper portions of the rich gas riser ducts 26, 26', in the silica walls 25', as shown in Figs. 1–3 of my present invention.

To this end the present invention in Figs. 4 to 10 provides the recirculation duct and its gas riser extension, in part, in the form of a pre-cast upwardly open steel casting. For this, the recirculation duct 34 and its riser extensions 58 are in a multipart form of a lower pre-cast metal conduit trough 63, corresponding with a like but longer, wider, and deeper upwardly open pocket 55 formed in the top of the concrete mat 38, and an upper fireclay liner section comprising fire-clay liner-brick 56, which completes the formation of the recirculation ducts 34 and their riser extensions 58.

The pre-cast metal portion 63 has upper marginal terminal extensions 64 overlapping in slidable riding relation in a recess or ledge 65 in the upper part or top of the surrounding concrete of the mat 38.

The top of the metal casting and its fire-clay liner 56 terminate in the same plane as the plane 59 of the top of the mat 38 on which ride the silica brickwork 25' and the sole flue liner brick 36'.

The liner 56 is in the form of brick laid with joints 57, Figs. 8, 10, to form the four sides, top, bottom, and lateral walls of a recangular duct 34 terminating at each end in a riser section 58 leading upwardly into communication with the rich gas riser portions 26, 26' in the silica brick regenerator division walls 25', the specific structure of the brick 56 and joints 57, although not shown, being of conventional form.

The metal plate portion 63 of the recirculation ducts, likewise have, at each end of the duct 34 portion thereof, gas riser portions 58.

The upper fire-clay portion 56 and the lower metal casting portion 63 together constitute a single unitary whole or entity in which the casting of metal contains the fire-clay portion 56 together with the metal casting in a manner that the entire recirculation duct and its gas riser extensions are held together as a unitary single entity which is located in the pocket 55, in the top of the concrete mat 38, so as to permit the casting with its lining to be moved, as a single unitary whole relative to the concrete of the mat in which they are contained, by the movement of the silica brickwork 25' of the battery resting on top of the concrete mat 38, as it expands and contracts.

To this end, the gas riser extension portions 58 of casting 63, are provided with upper ribs 66 which extend upwardly from the top plane of the casting at the plane of the top of the concrete mat to a distance above the top of the concrete mat 38. These ribs or keys 66 form interlocks which project into the pocket, or groove, or joint, 67 in the bottom face of the lower portion of the silica walls 25', as in the case of the rich gas nozzles of my aforesaid Patent 2,507,554.

These ribs 66 serve to key and fix not only the nozzle 30 and gas line 32, but also the recirculation duct 34 and the riser extensions 58, to the upper silica brickwork 25' for movement in unison, as a single unitary whole, with each other and with the silica, relative to the less expansive clay of the sole channels and concrete of the oven mat. In this manner they are all held together in alignment with the gas risers 26, 26' and with each other, and with the nozzle 30 coaxially of the throat 28, when the latter is also used, with all movements of the silica brickwork 25' above.

In one form, Figs. 4 to 6, the venturi throat 28 is omitted from the upper extensions 58 and the rest of the rich gas underjets 26, 26', and the nozzle 30 terminates in the concrete mat at the level of the duct 34. The gas riser extension portions 58 are extended at each end of the duct 34 in the form of a T having at each end a gas riser outlet 58 forming a part of the underjets 26, 26'.

The nozzle 30 is removably mounted integrally with the duct 34 by means of a screw threaded engagement with an orifice member 61 secured to line 32 in screw threaded engagement with 60 formed in the metal of the duct 34 and all forming a part of the rich gas risers 26, 26'.

Alternatively, the rich gas underjets may be provided at their lower portions just above the top of the mat 38, with a venturi throat as indicated in dotted lines in Fig. 6.

In another form, Figs. 7–10, the venturi throat 28 is formed in the upper portions of the risers or underjets 26, 26' that are formed in the pillar walls 25', and more particularly are formed at a level below the tops of the sole channels 36.

In these instances, the nozzles 30 terminate below said throat 28 but above the top of the concrete mat 38.

In the form shown in Figs. 7–10, the riser extension portion 58 of the ducts 34 comprise a vertical duct 34' leading to a forked vertical duct 68 in the portion of the silica walls 25' between two riser ducts 26' (or 26), which duct 68 leads by forked extensions 69 to the two risers 26' (or 26). The metal wall portions 70 of the chamber portions for the gas riser extension portions 58 of the duct 34, are extended to the two risers 26' (or 26) and are there provided with the orifice members 60 which are in alignment with the rich gas risers 26, 26' and form a part thereof.

Within the orifice member 60 is removably mounted integrally with the duct member 34 as a whole, the nozzle 30 by means of screw-threaded engagement therewith.

The waste gas recirculation chamber portion 34' of the gas riser extension portion 58 of the duct 34 is confined to the width and depth of the main portion of the waste gas recirculation duct 34.

In the embodiments of Figs. 4–10, the stainless steel gas-leakage proof plate 52 lies underneath the bottoms 36' of the sole flue channels 36 and extends underneath the silica walls 25', lengthwise of the battery. These plates 52 extend crosswise of the battery from just in front of the ribs 66 to a point near the outside edge of the flange of the trough at the opposite side of the duct 34, overlapping the joint of the top bricks 56 of the recirculating duct 34 with the top of the metal troughs 64 which ride in the recess 65 thus intercepting the joints.

In this manner, as the rib 66 moves forward, toward the sides of the oven battery, in expansion, as the walls 25' expand and the recess 67 therein moves forward relative to the concrete mat 38, and the clay liners of the sole channels, the leakage proof joint intercepting plates 52 move forward in unison with the wall 25', rib 66, and with the recirculation duct 34 as a whole and the rich gas nozzles 30.

In operation, air and gas is introduced into the bottoms of the combustion flues of one set 12 wherein the flame extends to the tops of the flues, and extinguishes as the gas passes out into the upper ports and into the horizontal flues that discharge the waste gas to the crossover flues 24. The latter flues 24 pass the waste gases to the horizontal flue and upper ports in the next heating wall, whence the gas passes down through the flues of the other set 14.

The oven battery illustrated is of the combination type. Hence, when fired with rich gas, such as the coke oven gas that the chambers 10 generate, this gas is fed in by conduits 50, through flexible conduit 48 to metal-pipe 32 and nozzle 30 for delivery, through the throat 28 and upper portion of the underjets, to the bottoms of the flues 12. Simultaneously, air is admitted through the sole channels 36 of the pairs of regenerators 16, 18, to the latter, which discharge the air into the bottoms of the flues 12.

The waste gases exhaust through the flues 14 and their regenerators 20, 22, and their sole channels 36 to the waste heat tunnel and stack.

On reversal, the flow of gas and air is stopped to the conduits 50 and to the sole channels for the regenerators 16, 18, for the set of flues 12, and turned on into the con-

duits **50** and sole channels for the regenerators **20, 22**, for the set of flues **14**.

When underfiring with lean gas, such as producer gas or blast furnace gas, the conduits **50** are disconnected so that rich gas is not fed in through line **32** to the underjet ducts **30, 26, 26'**. Instead, the wide regenerators **16, 22**, are connected with a supply of lean gas, so that lean gas is fed on one half of the cycle by regenerators **16** and through the other regenerators **22** in the next cycle to the flues **12** and **14** in "off" and "on" operation simultaneously with the off and on operation of the regenerators **18, 20** for feed of air.

However, in the event the lean gas has such a low B. t. u. value that even after preheating in the regenerators, the heat effect is still insufficient to coke the coal charges in the oven chambers **10**, equivalently to rich gas or producer gas firing, as may be the case with blast furnace gas, as is pointed out in my aforesaid Patent 2,507,554, then the mains **50**, lines **32** and underjet ducts, **30, 26, 26'**, are also employed in "on" and "off" operation, in correspondence with the operation of the regenerators **16** and **22** for inflow of lean gas, to enrich the lean gas, such as blast furnace gas, in the bottoms of the flues **12, 14**, as it is fed in by the regenerators **16** and **22**, in alternation.

When the rich gas is fed in by the nozzles **30**, in rich gas underfiring, and in enriching during lean gas underfiring, the jet of rich gas, as it issues from the nozzle **30** into the rich gas riser portions in the region of their juncture with the recirculating ducts as by the gas riser extensions thereof, and below the throats **28** when they are also used, aspirates waste gas from the bottoms of the "off" operating combustion flues, down through their off rich gas risers, and through the recirculation ducts, into admixture with the rich gas being jetted in through the "on" nozzles **30**, whence the mixture flows up through the "on" rich gas risers or underjet ducts **26, 26'**, into the bottoms of the vertical combustion flues **12, 14**, then operable for "on" flow.

The jet nozzles **30**, for the individual flues are calibrated to introduce the proportionate amount of rich gas as required among the several flues, in rich gas underfiring, and likewise calibrated also for delivering minor enriching portions of such gas, when regeneratively underfiring with lean gas enriched with rich gas.

Thus, the velocity of flow of such calibrated amounts of rich gas also serves, with or without the throats **28**, to control the amount of waste gas that is recirculated to get a given predetermined heating effect in the combustion flues, all to the end of attaining uniformity in heating of the coke oven charges.

The leakage proof plates **52** insure the successful attainment of these ends, in all the described forms of the invention, since, should leaks develop in the region between the sole channels **36** and the recirculation ducts **34**, the plates **52** prevent the suction action of the jet at **30** from reaching the sole channels **36**, and thus prevent air, when flowing in through the sole channels to the regenerators, from by-passing the "on" regenerators and flowing instead into mixture with the gas from the nozzles **30** in the recirculation duct, whence it could act to vary the heat intensity in the various flues **12, 14**.

The plates **52** serve a like utility when the nozzles **30** are replaced by like nozzles calibrated and substituted for enriching lean gas since, in event of air leakage into the recirculation ducts, the uncontrolled dilution of the minor enriching portions of rich gas, might result in less uniformity of heating as a result of dilution rather than in uniform enriching of the lean gas from the regenerators.

These plates **52** cut through or intercept the path of flow of air or gas from the sole channel **36** to the recirculation ducts **34**, through the expansion joints **40** or any fissures that may arise in the mortar joints of Figs. 1–3, or in the fire-clay liner joints located in the concrete mat **38** in Figs. 4–10, while still permitting the differential movement of silica to take place relative to the clay and concrete.

While the leakage plates **52** are of especial utility in connection with the structure illustrated in Figs. 4 to 10, in insuring against leakage into the ducts **34** by reason of their multipart construction and their shiftable disposition in the concrete mat immediately under the regenerator sole channels, when located in the pocket **55** previously formed for this purpose in the concrete mat, the features of the interconnection with the silica, as in Figs. 4–10, are not limited in all aspects to utility in use with the plate **52**, since the feature of interlocking the recirculation duct, when located in the concrete mat, with the silica brickwork **25'** for movement in unison therewith and with the gas risers **26, 26'**, the venturi throat **28**, when it is employed, the nozzles **30**, and all as a unitary whole, is of utility also in other relations than in relation with such leakage proof plate **52**. Hence, the structure of Figs. 4 to 10 is not limited in all its aspects to use only with the gas-leakage proof features thereof.

The invention as hereinabove set forth is embodied in particular forms and manners, but may be variously embodied within the scope of the claims hereinafter made.

I claim:

1. A regenerative coke oven, comprising: a silica brickwork masonry mass constituted of horizontal coking chambers alternating in position side-by-side with flued heating walls, regenerators separated by oven supporting regenerator division walls located below the coking chambers and heating walls, clay brick sole channels below the regenerators, a concrete oven supporting mat above an accessible basement space beneath the mat, said regenerator division walls resting directly on the concrete of the top of the mat and being constituted of silica brickwork masonry where they rest on the concrete of the mat, and said clay brick sole channels being laid intermediate the silica masonry of the adjacent regenerator division walls and also resting directly on the concrete of the top of the mat, "on" and "off" rich gas risers extending upwardly through the concrete mat and through the silica masonry of the regenerator division walls into communication with the flues of the heating walls, waste gas recirculation ducts slidably disposed in pockets within the concrete mat and provided with gas riser extensions also located within the concrete mat for communicable connection as a part of the off and on gas risers in the regenerator division walls, said gas riser extensions being fixedly interconnected with the silica masonry of the bottoms of the regenerator division walls for movement in unison with each other relative to the concrete oven-mat and the clay sole channels, and said gas riser extensions and the rest of their recirculation ducts comprising a multipart construction innerlined with refractory and detachably secured together, as a single unitary whole, for movement relative to the concrete mat and the clay brick of the sole channels, with movement of the silica of the regenerator division walls, rich gas inlet nozzles removably fixed in the gas riser extensions and disposed therein to discharge rich gas in the form of a jet in the region of juncture of the recirculation ducts with the rich gas risers and coaxially of the latter, and metal joint intercepting plates interposed in a horizontal plane between the concrete of the top of the concrete mat and the clay and silica bottoms of the clay brick sole channels and silica brick regenerator division walls, to prevent leakage from the sole flues into the recirculation ducts.

2. A coking retort oven as claimed in claim 1, and in which the outlets of the rich gas inlet nozzles are disposed in the gas riser extensions of the recirculation ducts within the portions of the rich gas risers in the region of the concrete mat below the bottoms of the silica brickwork.

3. Apparatus as claimed in claim 1, and in which the recirculation duct and pocket construction comprises an upwardly open pocket for the recirculation duct and a lower upwardly open pan having an upper lining of liner brick to form the recirculating duct passage, said pan

having the riser extension portions to which the gas inlet nozzles are attached and having pan portions in overlapping relation with the concrete of the mat for sliding relation therewith.

4. A regenerative coke oven, comprising: a silica brickwork masonry mass constituted of horizontal coking chambers alternating in position side-by-side with flued heating walls, regenerators separated by oven supporting regenerator division walls located below the coking chambers and heating walls, clay brick sole channels below the regenerators, a concrete oven supporting mat above an accessible basement space beneath the mat, said regenerator division walls resting directly on the concrete of the top of the mat and being constituted of silica brickwork masonry where they rest on the concrete of the mat, and said clay brick sole channels being laid intermediate the silica masonry of the adjacent regenerator division walls and also resting directly on the concrete of the top of the mat, "on" and "off" rich gas risers extending upwardly through the concrete mat and through the silica masonry of the regenerator division walls into communication with the flues of the heating walls, waste gas recirculation ducts slidably disposed in pockets within the concrete mat and each provided at each end with waste gas duct branches terminating in gas riser extensions also located within the concrete mat for communicable connection as a part of the off and on gas risers in the regenerator division walls, rich gas inlet nozzles removably fixed in the gas riser extension and disposed therein to discharge rich gas in the form of a jet in the region of juncture of the recirculation ducts with the rich gas risers and coaxially of the latter, the gas riser extensions of the waste gas recirculation ducts being fixedly interconnected with the silica masonry of the bottoms of the regenerator division walls for movement of the nozzles, riser extension and the rest of the recirculation ducts in unison relative to the concrete oven-mat and the clay sole channels, said gas riser extensions and the rest of their recirculation ducts comprising a multipart construction inner-lined with refractory material and detachably secured together, as a single unitary whole, for movement relative to the concrete mat and the clay brick of the sole channels, with movement of the silica of the regenerator division walls, and said rich gas inlet nozzles being located within the structure so as to have their outlets in the region of the silica brickwork above the top of the concrete mat, and metal joint intercepting plates in a horizontal plane between the concrete of the top of the concrete mat and the clay and silica bottoms of the clay brick sole channels and silica brick regenerator division walls, to prevent leakage from the clay sole flues into the recirculation ducts.

5. A coking retort oven as claimed in claim 4, and in which a venturi throat is disposed within the gas risers at a level above the outlets of the rich gas inlet nozzles.

6. A regenerative coke oven, comprising: a silica brickwork masonry mass constituted of horizontal coking chambers alternating in position side-by-side with flued heating walls, regenerators separated by oven supporting regenerator-division walls located below the coking chambers and heating walls, clay brick sole channels below the regenerators, a concrete oven supporting mat above an accessible basement space beneath the mat, said regenerator-division walls resting directly on the concrete of the top of the mat and being constituted of silica brickwork masonry where they rest on the concrete of the mat, and said clay brick sole channels being laid intermediate the silica masonry of the adjacent regenerator division walls and also resting directly on the concrete of the top of the mat, "on" and "off" rich gas risers extending upwardly through the concrete mat and through the silica masonry heating walls, waste gas recirculation ducts slidably disposed in pockets within the concrete mat and provided each at each end with gas riser extensions on opposite sides of the ducts which extensions are also located within the top part of the concrete mat for communicable connection as a part of the off and on gas risers in the regenerator-division walls, rich gas inlet nozzles fixed in the gas riser extensions and disposed therein to discharge rich gas in the form of a jet into the rich gas risers and coaxially of the latter, forked extension ducts located in the silica brickwork of the regenerator division walls, each of which has a central branch which is aligned with one end of one of the recirculation ducts and has side branches leading to several gas risers at the level at which the aforesaid gas inlet nozzles discharge therein, and metal joint intercepting plates interposed in a horizontal plane between the concrete of the top of the concrete mat and the clay and silica bottoms of the clay brick sole channels and silica brick regenerator-division walls, to prevent leakage from the clay sole flues into the recirculation ducts.

7. A coking retort oven as claimed in claim 6, and in which a venturi throat is disposed within the gas risers at a level above the discharge ends of the branches of the forked extension duct.

References Cited in the file of this patent

UNITED STATES PATENTS

1,374,546	Becker	Apr. 12, 1921
1,509,196	Dressler	Sept. 23, 1924
2,098,013	Pavitt	Nov. 2, 1937
2,216,983	Otto	Oct. 8, 1940
2,306,678	Van Ackeren	Dec. 29, 1942
2,346,991	Otto	Apr. 18, 1944
2,470,112	Rueckel	May 17, 1949
2,507,554	Van Ackeren	May 16, 1950
2,516,929	Van Ackeren	Aug. 1, 1950