March 11, 1941. C. H. HUGHES 2,234,173

BROAD COKE OVEN

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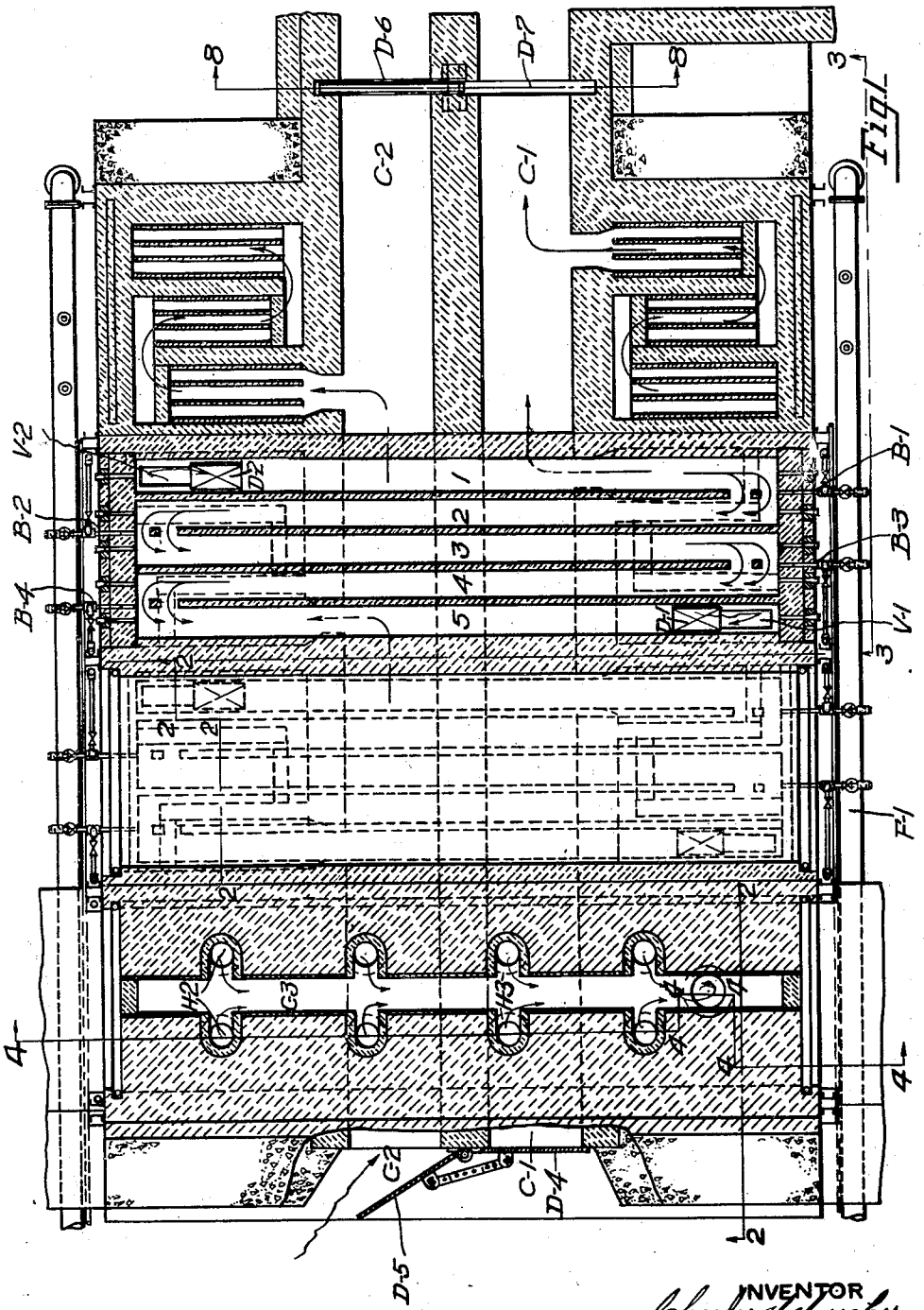


Fig. 1

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Fig. 3.

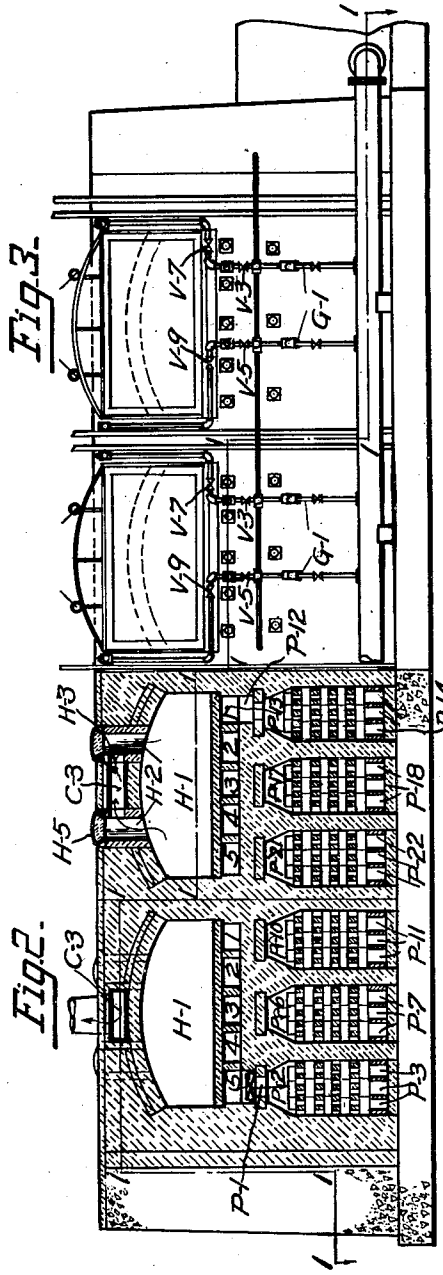


Fig. 2.

Fig. 5.

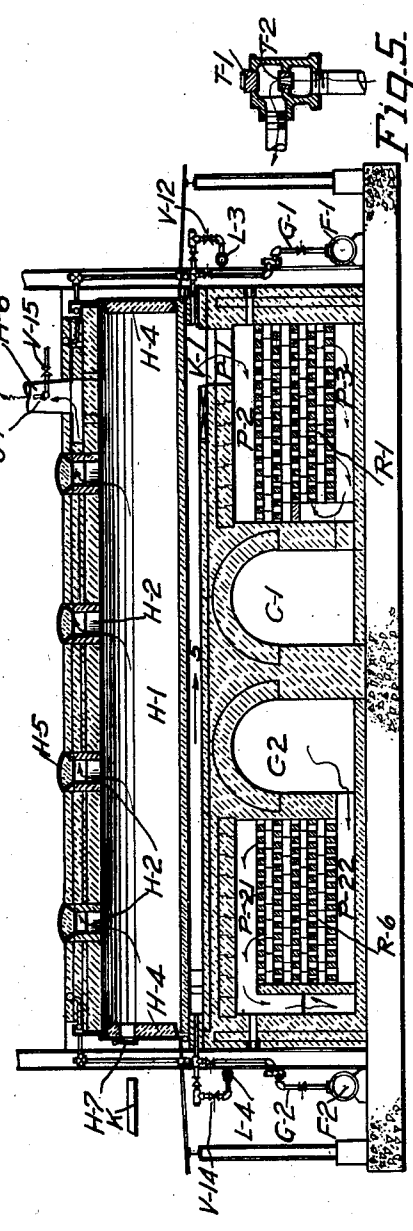


Fig. 4.

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Fig. 6.

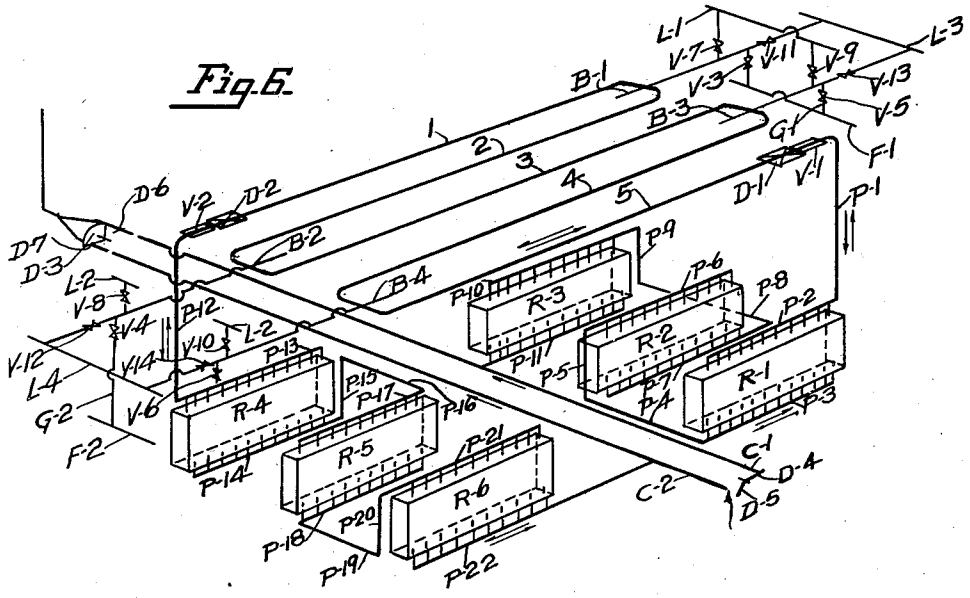


Fig. 7.

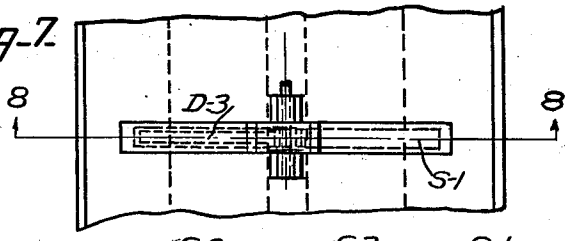
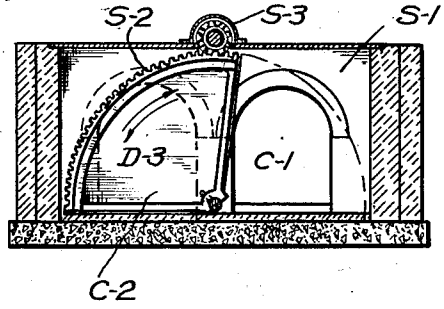


Fig. 8.



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Patented Mar. 11, 1941 2,234,173

UNITED STATES PATENT OFFICE

2,234,173

BROAD COKE OVEN

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Application January 24, 1940, Serial No. 315,317

12 Claims. (Cl. 202—102)

The present invention relates to by-product coke ovens and, more particularly, to by-product coke ovens of the broad, rectangular type.

It is well known by those skilled in the art that, in the earliest times coke was produced in mound-shaped Meilers, similar to the old method of burning charcoal in heaps. The beehive oven was a modification of these, except that it was built of brick instead of sod or clay, and the earliest record of coking coal in a regular oven is an English patent to St. John granted in 1620 for making coke in a beehive form of oven. Although a German chemist, Becher, received a patent in 1700 for recovering tar from coking coal, it appears that it was not until Clayton's discovery in 1737 that the formation of a combustible gas when coking coal was noticed. About the year 1767, a form of coke oven, producing coke and recovering some tar and ammonia, was constructed in Germany and was described as a dome-like fire clay retort. In 1781, an attempt appears to have been made to recover the by-products, and a patent to the Earl of Dundonald was issued, and in 1792 Murdoch experimented with making gas from coal in retorts. These efforts bore fruit, and twenty years later the streets of London were lighted by gas.

The earliest records of the rectangular, or retort, ovens show them in operation in Germany about 1830. They had open walls, pierced by horizontal and vertical flues, and the walls formed a rectangular space which contained the charge. In 1856, Knab is reported to have built a group of retort coke ovens to recover by-products and illuminating gas. These ovens had flues on the bottom only, but, of course, no regenerator or recuperator system was provided. Moreover, there was no attempt to furnish uniform heating to the oven sole, the fire or flame passing from a grate through a central flue and then returning through flues on both sides thereof. The following year, Appolt built his first ovens in the shape of vertical and, later, horizontal retorts, using his gas only for heating his oven through horizontal flues. This was about the earliest closed retort coke oven, utilizing the gas for its own heating. By 1861 the Coppee coke oven of Belgian invention was in use on the Continent, and in 1873–74 it was introduced into England. It had vertical flues and was of the non-recovery type.

About 1862, Carves of France introduced side flues in addition to the bottom flues of Knab. About 1880, Simon, an English inventor, improved the Carves oven very materially by adding recuperating flues. This oven had the oven flues placed horizontally, the gas and air being first burned in sole flues located underneath the oven chamber, then passing up through a riser to the ovens and down through three horizontal flues in series. In the years 1881 to 1883, Seibel patented an oven having horizontal flues and having neither grates nor regenerators. It is apparent that oven designs up to this time were so uneconomical of gas used in heating the ovens, or the coals were so lean in gas, that grates for burning coal were built into the ovens and the gas was first admitted over these grates, the amount of coal being such as to supply the required additional heat.

The first ovens of the Otto type had been erected in Germany in 1881, and in the same year Huessner appropriated the Knab-Carves model and built a hundred ovens in Germany, thus establishing the industry on a sound basis in that country, although the quality of coke from these ovens was inferior. In these ovens the flues were horizontal. A very substantial improvement was made by Hoffman, who added the Siemens regenerator to the Otto coke oven and thus provided the first really efficient coke oven, generally referred to in the art as the Otto-Hoffman coke oven. In 1888, Festner, a German inventor, changed the Otto-Hoffman design by using horizontal instead of vertical flues and abandoning the Siemens regenerators, replacing the same with a Ponsard gas furnace. Hoffman cooperated with Festner, and this design was called a Festner-Hoffman oven, having horizontal flues and recuperators. In 1887, the Semet-Solvay oven came into notice, the first of them having no recuperators or regenerators. It appears that some of the principal features of Semet's design were the introduction of the division wall, the building of the oven flue system as a sleeve out of D-shaped tile, and the starting of the combustion at the top, or No. 1, flue, and, in general, providing a structure which was strong, easily heated and had a reservoir of heat in the division walls.

From the foregoing historical survey of the development of the coke oven art, it appears that all designs of ovens for coking coal sprang from four roots classified as follows:

1. The beehive oven, which was developed from the mound of charcoal burners.

2. The Coppee oven, with vertical flues in the oven walls, these ovens being built narrow, long and high.

3. The Knab broad oven, with flues underneath.

4. The Knab oven modified by Carves, with the oven flues horizontally in the side walls as well as underneath.

The high, narrow coke ovens of the prior art described in the foregoing had various important disadvantages. For instance, a recent standard type was usually of the order of about 45 feet in length, about 16 feet high, and about 17 inches in width, and, because of their height and narrowness, they had to be constructed and built in very large individual units, so that the original cost of installation was extremely high. Generally speaking, it was not possible either to build or to operate relatively small units of the conventional type at a low cost.

Besides these economic disadvantages, the use of a high, narrow oven was limited to certain coals or coal mixtures. Coals which expanded upon coking could only be used if mixed with shrinking coals, as otherwise the wear on the walls was too great, and the increasing pressure might have led to destruction of the ovens. Using a large percentage of shrinking coals, as necessarily became general practice, the coal shrank away from the heating walls, causing the formation between coke and wall of irregular gaps and crevices which acted as channels for the gases distilled from the coal. Due to the irregularity of these channels, heat could not be applied so as to produce a uniformly carbonized coke in a short coking period, regardless of the method of heating or control employed.

It is well known in the art that channeling brought the rich gases into immediate contact with the highly heated refractory walls, producing two unfortunate results. First, the contact of the crude gases with some 1440 square feet of brick at the highest temperature in the oven caused the destruction of a part of the valuable by-products contained in the gases. Secondly, the gases acted as an insulator between the hot walls and the coking coal, preventing considerable heat from reaching the charge by conduction. Again, the gases, being much lower in temperature than the walls, took up considerable heat from them and thus prevented this amount of heat from reaching the core of the charge at all. Both of these effects resulted in greatly retarding the coking time and were diametrically opposed to the results desired, for it was, of course, the purpose of the operation to transfer heat from walls to coal charge as efficiently as possible and in the shortest time. Moreover, the heating of the gases had the undesirable effect of passing the gases to the by-product plant in a superheated state, necessitating larger condensing surfaces to cool them.

A further disadvantage of the high, narrow coke oven was that the width of the charge varied over the length of the oven, for practical reasons being smaller at the pusher end than at the coke discharge end. For the purpose of providing uniform coking throughout this constantly varying oven width, more gas had to be burned in the flues at the coke end of the oven, necessitating a difference in size of heating flues over the length of the oven. This required very accurate control of the fuel gas to the individual flues.

Under these conditions, it was difficult to control heating conditions in these ovens, the oven structure was intricate and expensive, resulting in high-cost coke, and the coke produced was primarily suitable only for metallurgical purposes and not for domestic use. The pressure in the plastic mass resulting from a deep, narrow charge materially affected the coke structure, so that a hard, dense, slow-burning coke having a close cell structure was necessarily produced. Coke for domestic use should have an open, free-burning cell structure, and, although the surplus coke produced in high, narrow ovens was sold for domestic uses, such coke was really only suitable for metallurgical purposes.

Subsequently, a broad rectangular sole-fired coke oven attempting to eliminate these disadvantages was developed, but other difficulties arose. Essentially, this broad oven construction provided a rectangular sole-fired coke oven having a multiplicity of long, independent, parallel heating flues arranged side by side, each of said flues being directly connected at each end to two shallow, horizontal hair-pin regenerators below and parallel to and individual to each separate heating flue for alternatly supplying heated air to the flues and receiving the heat of waste gases discharged therefrom. Each heating flue was provided with a burner or means for supplying rich fuel gas to both ends thereof.

In this manner, all of the flames burned in independent flues, entirely isolated from each other. These flames were all at one end of the oven and hence burned in the same direction, extending toward the other end of the oven. Burners were located at each end of the flues, and each heating flue and its associated regenerators could thus be alternately operated, independently of adjoining heating flues and regenerators.

Although this broad type oven could be built in relatively small units, the entire heating system and the so-called regenerators were fundamentally incorrect. The oven was designed for underfiring with rich coke oven gas only. The use of coke oven gas with preheated air gave a short and hot flame resulting in non-uniform heating of the long, straight, parallel and independent heating flues. An excessively high temperature occurred at each burner, producing danger points or hot spots. Moreover, the regenerators were so designed that the waste gas and incoming air always circulated in a horizontal direction, which failed to give satisfactory and efficient results.

In other words, by eliminating some of the disadvantages of prior ovens, the broad oven described introduced new difficulties which were in part much mose serious than the former. Thus, the ends of the heating flues in said broad oven were overheated, causing overcoking and quick overheating of the construction material of the oven, while black spots, too cold for proper coking, developed in the centers of the flues. Clearly, it was practically impossible to obtain proper coking of the center mass except, and then to only a small extent, by overcoking the masses at the ends of the flues. Then, the space provided above and below the regenerators was inadequate for the gases to spread or mushroom out before going through the checkerbrick. Moreover, the regenerators, which were individual for each flue, were insufficient in size and could not function satisfactorily. The velocity of the gases in the heating flues was too slow and in the regenerators too high for proper heat transfer. Of course, not only did this non-uniform distribution of heat greatly decrease the over-all efficiency of these ovens, but, especially, the hot spots, developed in the operation of the oven, caused early deterioration of the building mate-

rial and greatly increased the cost of operation and maintenance. Although these difficulties were well known in the art, and, from time to time, various suggestions and proposals were made to eliminate them, none of these suggestions and proposals, so far as I am aware, was completely satisfactory and successful on a practical and industrial scale.

I have discovered that the outstanding problem may be solved in a simple and completely satisfactory manner.

It is an object of the present invention to provide a by-product coke oven which eliminates the aforementioned difficulties in the construction and operation of conventional broad coke ovens.

It is another object of this invention to provide a broad, rectangular coke oven in which various coals, tars and oils can be used to produce a coke substance with burning characteristics different from those of coke produced heretofore in high, narrow ovens or beehive coke ovens.

It is a further object of the invention to provide a low-cost broad coke oven which is adapted to produce coke having an open, free-burning cell structure, thereby providing a coke oven which is suitable for supplying small communities, as well as large, with a fuel supply of gas and coke for domestic use.

It is also the intention of the present invention to contribute a broad coke oven of improved design in which means are incorporated for rapidly removing gases evolved during the coking operation, whereby prolonged contact of said gases with heated surfaces and consequent excessive cracking of hydrocarbons are avoided, thus producing an increased amount of light oils and tars.

My invention also provides a broad by-product coke oven having an auxiliary ejector system so disposed therein as to afford positive and controlled discharge through the gas offtake of gas and smoke evolved in the coking chamber during charging of the coal, thereby avoiding a smoke nuisance while charging coking coals into the coking chamber, whereby said coke oven can be located in residential districts.

Another object of my invention is to provide a by-product coke oven which can burn either rich fuel gas or, alternatively, an atomized liquid fuel, such as fuel oil or tar, such change in operation being easily, quickly and inexpensively accomplished, thereby allowing the operator to use up stocks of tar produced as a by-product, where these cannot otherwise be disposed of, to take full advantage of price differentials and other economic factors, and to make available for domestic or industrial service all of the rich coke oven gas evolved.

The present invention also has in prospect the provision of a broad coke oven having a series of interdependent and interconnected heating flues extending in continuous, serpentine character under the entire sole of the oven to afford a continuous stream of the heating fluid throughout the whole heating system, and having a plurality of burners in the series to furnish a more or less continuous flame throughout, whereby uniform heating conditions in all parts of the charge are obtained.

It is also an object of the invention to incorporate in a battery of broad coke ovens a novel combination of structural elements adapted to admit air required for combustion to a common flue serving as a manifold for all of the ovens in said battery.

The invention also contemplates the incorporation in a battery of broad coke ovens of a pair of flues common to all the ovens in the battery, serving as manifolds alternately for air to be preheated and for combustion products to be discharged, and reciprocal to each other in function, whereby the direction of flow of the hot gases through the heating flue system can be reversed, thereby insuring uniform heating over the entire floor of the oven.

It is also within the contemplation of the invention to incorporate in broad coke ovens, in novel combination with central air admission and waste gas discharge flues, in reciprocal operation, a plurality of gas burners so arranged in the heating flues that the flames, which burn constantly and at both ends of the oven at the same time, will change direction with the reversal of gases through the heating flues, lashing back and forth from one flue to another.

The invention further purposes to incorporate in by-product coke ovens, in combination with a pair of flues common to all the ovens in a battery and adapted for central admission of air and central discharge of combustion products, series-connected regenerators below and parallel to each oven and arranged to cause air which is being heated to ascend and to cause gas which is being cooled to descend, thereby obtaining uniformity of flow and an effective change of temperature of the different streams.

Still another object of my invention is to provide a battery of broad by-product coke ovens employing central air admission, wherein a novel combination of structural elements is disposed with respect to the series flue heating system of each oven in the battery for the purpose of independently controlling the amount of air admitted to said heating system of the individual oven.

This invention has the additional purpose of providing a broad, rectangular coke oven having a system of series-connected heating flues, said system containing a plurality of burners and being adapted serially to conduct through the successive flues all of the air required for combustion at the burners and all of the products of said combustion, thereby considerably increasing the volume of gases constantly circulating through all heating flues and causing a proportionate increase in gas velocity, whereby stagnant, insulating gas films are effectively scrubbed from brick surfaces and proper heat transfer is attained.

Moreover, the invention has in view the contribution of a coke oven having a system of heating flues so designed as to conduct the products of combustion to each successive flue in series, for the purpose of using said combustion products to prevent high heats or hot spots in the vicinity of the fuel burners and to lengthen the flame by means of the increased velocity resulting from the increased volume of gases circulating through all heating flues.

In addition, this invention provides a by-product coke oven of such design that swelling coals can be coked therein without damage to the oven structure.

My invention also provides a coke oven of the broad, rectangular, sole-fired type which can be built and operated in relatively small units on a practical and industrial scale at low cost and which is of high structural strength, thus impart-

ing long life to the oven and only requiring low maintenance charges.

Other and further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 illustrates a horizontal plan sectional view of a battery of four ovens embodying the principle of my invention, taken on line 1—1 of Figs. 2 and 3;

Fig. 2 is a vertical transverse sectional view through two of the ovens, taken on line 2—2 of Fig. 1;

Fig. 3 shows a front elevational view of two ovens, taken on line 3—3 of Fig. 1;

Fig. 4 depicts a vertical longitudinal sectional view of one of my ovens taken on line 4—4 of Fig. 1;

Fig. 5 is a vertical sectional view of the special L and orifice member through which the volume of fuel gas to each burner is regulated;

Fig. 6 depicts a perspective view of the heating system employed, showing the circulation through the heating flues, regenerators, fuel lines, and common air inlet and waste gas outlet flues;

Fig. 7 is a plan view of the preferred reversing damper arrangement between the oven battery and the stack; and

Fig. 8 shows this reversing damper in vertical sectional view.

Broadly stated, according to the principles of the present invention, a broad, rectangular coke oven is provided, having a heating system adapted to operate with either rich fuel gas, such as coke oven gas, or liquid fuels, such as fuel oils and tars. As in my copending application, Serial No. 301,172, filed October 25, 1939, the heating system consists of an uneven number of sole flues, preferably five, interconnected in series and arranged longitudinally of the oven to support and to heat the floor of said oven. These heating flues are connected by damper-controlled openings, located at opposite ends of the series, with two sets of vertical regenerators located below and parallel to the heating flues and ovens. The two sets of vertical regenerators are alternately used to supply preheated air to opposite ends of the series flue heating system and to receive the hot waste products of combustion. The regenerators, of which I prefer to employ three, connected in series in each set, have spacious, chamber-like passages both above and below the checkerbrick, giving the gases an opportunity to spread or mushroom out before passing through and thus increasing the time of contact and affording more effective heat transfer. Each set of regenerators communicates with one of two flues which are located transversely of the oven below the heating flues and preferably between the two sets of regenerators. My broad coke ovens are preferably arranged side by side in a battery, and the two transverse flues pass longitudinally of said battery to serve all of the ovens in common as manifolds alternately for air to be preheated and for combustion products to be discharged. Means associated with said common transverse flues are incorporated in the structure for the purpose of reversing the flow through the heating system in each oven, using a single reversing damper and a single pair of plate dampers for the entire battery. The draft for each oven is independently regulated by the dampers which control the openings connecting the heating flues with the regenerators.

The invention will now be more fully described to those skilled in the art, reference being had to the accompanying drawings illustrating a preferred embodiment of the present invention. Similar reference characters denote corresponding parts throughout the various figures.

Referring, now, more specifically to Figs. 1 to 4, it is readily observed that the oven battery of my invention comprises a plurality of domed, rectangular, broad coking chambers H—1, having charging holes or ports H—2 in their roofs, adapted to be sealed by covers H—5. An off-take duct H—3 is positioned near the top of each charging hole and communicates with a common gas duct C—3, which is located along the longitudinal axis of the oven roof. This common gas duct connects into an off-take pipe H—6 near the coke discharge end of the oven. An ejector J—1 connected with a steam or gas line is located in the off-take pipe, and a valve V—15 on said line is adapted to admit steam or gas under pressure to the ejector. The coking chambers are adapted to be sealed against the admission of air by oven doors H—4 at either end of each oven. There is a small door H—7 in the pusher side oven door.

Beneath each of these chambers and running parallel to the length of the oven, heating flues 1, 2, 3, 4 and 5 are arranged in horizontal position and are series-connected, being separated from each other by longitudinal partition walls alternately spaced from opposite ends of the ovens to form a turn between adjacent flues. The interconnected heating flues are provided at said turns with burning means, such as gas burners B—1, B—2, B—3 and B—4, which are supplied with fuel, as will be described infra.

Below the heating flues in each oven are located two series-connected sets of regenerators R—1, R—2, R—3 and R—4, R—5, R—6, built of standard checkerbrick or special checkerbrick in the usual manner. Regenerators R—1, R—2 and R—3 are connected in series with flue 5 and a transverse flue C—1 common to the entire battery by passages P—1 to P—11, inclusive (see also Fig. 6). Regenerators R—4, R—5 and R—6 are similarly connected with flue 1 and transverse flue C—2 by passages P—12 to P—22, inclusive. Flues C—1 and C—2 are preferably located on the same horizontal level as the regenerators and separate the two sets. They are adapted to serve all the ovens in the battery as manifolds for air to be preheated in the regenerators or for waste gas to be discharged to the stack. The alternate flow of air and waste gas and the circulation through the heating flues, regenerators and said common transverse flues are controlled by a reversing damper and plate dampers at the respective ends of the transverse flues and by dampers associated with the openings through which flues 1 and 5 communicate respectively with passages P—12 and P—1, leading to regenerators R—4 and R—1, respectively, as will be more fully explained hereinafter.

Passages P—2, P—6, P—10 and P—13, P—17, P—21, which lie above the checkerbrick in regenerators R—1, R—2, R—3 and R—4, R—5, R—6, respectively (see, especially, Fig. 2), are spacious and chamber-like and, when these regenerators are being used for waste combustion products, they are adapted to give these waste gases an opportunity to spread or mushroom out before passing downwardly through said regenerators. Similarly, passages P—3, P—7, P—11 and P—14, P—18, P—22, which lie below the

checkerbrick in said respective regenerators, are also spacious and chamber-like and are adapted to furnish an opportunity for air flowing to the regenerators to spread and mushroom out before its upward passage through said regenerators.

The terminal flues, 5 and 1, of the series flue heating system are connected through passages P—1 and P—12, respectively, with regenerators R—1 and R—4. The openings or ports V—1 and V—2 from said flues, respectively, into said passages are respectively controlled by dampers D—1 and D—2, adapted to slide over said ports and to effect partial or complete closure, thus providing regulation of the draft in each individual oven.

The transverse flues C—1 and C—2, referred to supra as being common to all the ovens in the battery, communicably connect with the atmosphere at one end of said flues and with the stack at the other end. At the atmosphere end, dampers adapted to cooperate with each other are provided, and I prefer to employ a pair of plate dampers D—4 and D—5, as shown in Fig. 1. These dampers are connected together by a link of such length that the opening of damper D—4 to admit air to flue C—1 effects the closing of damper D—5 to shut off flue C—2 from the atmosphere, and vice versa. At the stack end of the flues, a valve or valves adapted alternately to open the two flues to the stack are provided. In my preferred embodiment, I provide an open-walled casing containing a slot S—1 (see Figs. 7 and 8) large enough to cover the outlets of both flues. In this slot a reversing damper D—3 is provided, said damper being slightly larger than a quadrant of a circle and being rotatable about an axis located between the two flue outlets. In this manner, as will be evident from Fig. 8, damper D—3 is adapted alternately to close off flues C—1 or C—2, so that when damper D—3 is in a position such that flue C—1 is closed, flue C—2 will be open to the stack, and vice versa. Damper D—3 is equipped with a rack S—2 on its periphery, and a pinion S—3 is located in slot S—1 in such position that it can cooperate with said rack and thus actuate the damper. The reversing damper D—3 and the pair of plate dampers D—4 and D—5 are adapted to to operate together, so that, when flue C—1 is open to the atmosphere, it will be closed off from the stack, and during the same reversal period flue C—2 will be open to the stack but closed off from the atmosphere; similarly when flue C—2 is open to the atmosphere, flue C—1 will be open to the stack. The reversing mechanism for operating these dampers is not shown, as those skilled in the art are familiar with the construction and operation. In a preferred embodiment, it may be briefly described as comprising the usual gear drives set in motion electrically by means of standard reversing valve mechanisms. A time clock, which is set for fixed reversal periods, is adapted to make the necessary electrical contacts required for starting and stopping the motor used for shifting the gears.

Fuel gas manifolds F—1 and F—2 (see Fig. 4) run the length of the oven battery on opposite sides thereof and are adapted to supply burners B—1, B—2, B—3 and B—4 of each oven with rich fuel gas under a moderate and constant pressure. Riser pipes G—1 and G—2 from the supply manifolds to the burners are provided, and a special L and orifice are also furnished for the regulation of the fuel gas conducted therethrough. This L, depicted at Fig. 5, is equipped with a plug T—1 and a removable orifice member T—2 which is adapted to be replaced by other similar members having larger or smaller orifices as required. Valves V—3, V—4, V—5 and V—6 (see Figs. 3 and 6), located in the riser pipes from the supply manifolds to burners B—1, B—2, B—3, and B—4, respectively, are adapted to shut off the gas supply entirely.

Pipe lines L—1 and L—2, adapted for carrying fuel oil or tar, also run the length of the oven battery on opposite sides thereof. They are connected with burners B—1, B—2, B—3 and B—4 through valves V—7, V—8, V—9 and V—10, respectively, said valves being adapted to atomize the oil or tar. Air lines L—3 and L—4, running the length of the battery in association with the pipe lines, are also provided and connect into valves V—7, V—8, V—9 and V—10 through air-regulating valves V—11, V—12, V—13 and V—14, respectively, and are adapted to furnish air for said atomization.

In the operation of the oven as an entire unit, oven doors H—4 are closed and sealed air tight, as may be seen from Fig. 4. Coal is charged through the charging holes H—2 in the top of the oven (see also Fig. 2), and the cone-shaped piles are levelled off in the usual manner by a levelling rod K, introduced through a small door H—7 in the pusher side oven door. The charging hole covers H—5 are replaced and sealed air-tight. Fuel gas, fuel oil or tar is then burned with preheated air in the flues underneath the coking chamber to provide a substantially uniform coking temperature for the entire area of the oven sole upon which the coal charge is supported. As is well known to those skilled in the art, the coking temperature varies, depending upon whether low or high carbonization is desired. Thus, a suitable temperature for low coking, such as about 600 to about 700° C., to a suitable temperature for high coking, for example, about 1150 to about 1450° C., can be successfully used. Reversal periods of suitable duration are employed, as those skilled in the art will understand, and a reversal of about 15 minutes has been found to give satisfactory results when underfiring with rich fuel gas, fuel oil or tar and using preheated air to effect the combustion. When the coal is coked, oven doors H—4 are removed, and the coke is pushed in the customary manner.

The gases evolved during coking rise up to charging holes H—2 and pass through off-take ducts H—3 into the common gas duct C—3, where all the gases evolved in the ovens merge into a single stream. In this manner, the gases evolved are rapidly removed from the coking chamber, thus avoiding prolonged contact of said gases with heated surfaces and consequent excessive cracking of hydrocarbons, an increased amount of light oils and tars being produced. The gases are delivered by gas duct C—3 to an off-take pipe H—6 near the coke discharge end of the oven, and from there they pass to the by-product plant.

Ejector J—1, employed to suck the evolved gases into the off-take pipe, is used only during charging operations. Steam or gas under pressure is admitted through valve V—15. The flow of the steam or gas in an upward direction draws into the off-take pipe the gas and smoke evolved during the charging of the coal through the charging holes H—2. Without this induced draft, some of the evolved gases would escape into the atmosphere due to the removal of the charging hole covers H—5. The action of the

ejector in drawing these gases into the off-take pipe prevents a smoke nuisance during charging.

The operation of my improved broad coke oven will now be described particularly in conjunction with Fig. 6, which illustrates diagrammatically the flow of gases through the several flues, ducts, regenerators, dampers and valves, for the convenience of those skilled in the coke oven art.

It has been pointed out supra that my improved oven is adapted to burn both rich fuel gas and liquid fuels. The fuel gas is conducted at a moderate and constant pressure through supply manifolds F—1 and F—2 into risers G—1 and G—2. Its supply to the burners is regulated through a special L, conveniently located, as described before, in each of the risers. The size of the orifice used in the L controls the amount of fuel gas supplied to the burners. When fuel oil or tar are used instead of rich fuel gas for underfiring the ovens, gas valves V—3, V—4, V—5, and V—6 are closed. The oil or tar from pipe lines L—1 and L—2 flows into valves V—7, V—8, V—9 and V—10, and air is also supplied to these valves from air lines L—3 and L—4. The air serves to atomize the liquid fuel, which then passes to the burners. The volume of air for vaporizing said liquid fuel is regulated by means of valves V—11, V—12, V—13 and V—14.

Assuming that regenerators R—1, R—2 and R—3 are being preheated by outgoing products of combustion, damper D—4 is closed, shutting off flue C—1 from the atmosphere, and damper D—3 is in such position as to close the outlet from flue C—2 to the stack, leaving flue C—1 open thereto. Damper D—5, connected by a link to damper D—4, is open, so that air to be preheated can enter into flue C—2. It will be understood, of course, that, when an oven is in operation, ports V—1 and V—2 between the heating flues and the regenerators of that oven are open in some degree. Although the stack draft for each individual oven is regulated by the amount of closure of sliding dampers D—1 and D—2 over ports V—1 and V—2, respectively, they obviously can not be entirely closed during operation of the oven.

The air to be preheated enters flue C—2 through open damper D—5 and flows into the mushrooming chamber or passage P—22, which, as described above, is large enough to permit the air to spread out. The velocity of the air is thus reduced, and it then passes uniformly up through the hot checkerbrick in regenerator R—6 to passage P—21, whence, by passages P—20 and P—19, the now partially heated air is brought to the spacious passage P—18 below regenerator R—5. This checkerbrick is hotter than that in regenerator R—6, and the already heated air, upon passing through, is brought to a still higher temperature. Similarly, the air flows on through passages P—17, P—16, P—15 and P—14, successively, to regenerator R—4 and from there emerges into passage P—13 at a very high temperature. It will be observed that provision of relatively large gas spaces above and below the regenerators permits the gas (here, air) to spread out before entering the checkerbrick and thus slows down its passage through the regenerators, giving improved heat transfer. The hot air passes along passage P—13 above the regenerator R—4 and by passage P—12 and through port V—2 into heating flue 1. This preheated air for the combustion of the fuel gas at the burners is delivered in flue 1 in great excess over the air requirements for burner B—1 and, after the combustion at burner B—1, the air, still in considerable excess of the requirements of the next burner in the series, passes mixed with the products of combustion to burner B—2, and similarly to all burners successively.

The hot waste gases of combustion pass out of the series flue heating system from flue 5 through passage P—1 to passage P—2, which is sufficiently large for the gases to spread uniformly, and then downward, relatively slowly, through regenerator R—1. The waste gases are very hot at this point and give up a great deal of their heat to the checkerbrick in regenerator R—1, becoming considerably cooler as they pass down into passage P—3 below the regenerator. The gases are then brought through passages P—4 and P—5 to the roomy passage P—6 above regenerator R—2, and thence go down at reduced velocity through the checkerbrick in regenerator R—2, to give up much of their remaining heat thereto and to emerge considerably cooler in passage P—7 below. Similarly, the waste gases continue on through passages P—8, P—9 and P—10 and down through regenerator R—3, to emerge still cooler in passage P—11. These cooled combustion products flow through passage P—11 into flue C—1, whence they exit to the stack.

It is evident from the foregoing that, during the operation in the direction just detailed (i. e., air entering at damper D—5 and waste gases going to the stack through flue C—1), the draft set up is in the direction from heating flue 1, through flues 2, 3 and 4, to heating flue 5. Therefore, the flame at burner B—1, located at the turn between flues 1 and 2 (see also Fig. 1), is deflected by the draft into flue 2. Similarly, the flames of burners B—2, B—3 and B—4 are deflected into flues 3, 4 and 5, respectively. Thus, with the draft in this direction, there is no flame in flue 1, and the flames burn at the coke end (with respect to the oven) of flues 2 and 4 and at the pusher end of flues 3 and 5. The hottest end of flue 2—and this applies as well to flue 4—is under the coke end of the oven, and the flue gets progressively less heat from burner B—1 as one moves down toward the pusher end. Contrariwise, the hottest ends of flues 3 and 5 are those under the pusher end of the oven, while they get least heat from burners B—2 and B—4, respectively, at the ends under the coke end of the oven. It is obvious from this that flues 2 and 4 furnish most heat to the coke end of the oven on this run, somewhat less to the centre, and least to the pusher end, while flues 3 and 5 furnish most heat to the pusher end of the oven, somewhat less to the centre, and least to the coke end. Adding these two effects, the conclusion is arrived at that the sum of the heat furnished at any point along the length of the oven is about the same as at any other point, irrespective of the distance from the actual burners themselves.

Upon a reversal of the draft, accomplished by closing damper D—5, opening damper D—4 and rotating damper D—3 from its position in front of the outlet of flue C—2 to a position closing off flue C—1, as indicated supra, with the preheated air entering at the coke end (with respect to the oven above) of flue 5, the flames of burners B—4, B—3, B—2 and B—1 are deflected into flues 4, 3, 2 and 1, respectively. In this case, then, the flames burn at the pusher ends of flues 2 and 4 and at the coke ends of flues 1 and 3, so that

the effect of each individual flue upon the oven is just opposite to that detailed in the foregoing paragraph. The cumulative or additive effect of the whole series of flues beneath the oven, however, is exactly the same as in the other case. In other words, the heat furnished throughout a full cycle is practically uniform for the entire oven length, so that, with no black spots possible at the centres of the flues, there can be neither overcoking at the ends of the oven nor undercoking at its centre. Moreover, the reversal of the flames, being deflected alternately from one flue into another, eliminates the danger of hot spots.

When the regenerators R—1, R—2 and R—3 are raised to the temperature necessary for preheating the air, the directions of flow of the air and the waste gases are reversed in the manner described in the preceding paragraph, viz., by opening damper D—4, closing damper D—5 and rotating damper D—3 to close off flue C—1 from the stack and to open flue C—2 thereto. Air then enters flue C—1 through damper D—4 and, damper D—3 closing off the outlet of said flue C—1 to the stack, the air flows through passage P—11 and upward through regenerators R—3, R—2 and R—1 in series, by means of the interconnecting passages P—10 to P—2, described supra. Passage P—1 then carries the preheated air into heating flue 5. As detailed immediately above, the flames are then deflected by the draft into heating flues 4, 3, 2 and 1. The waste gases flow downward through regenerators R—4, R—5 and R—6 and through interconnecting passages P—12 to P—22 and so enter flue C—2 and out to the stack.

Stack draft or the draft induced by a fan is used for drawing air into the regenerators and for removing the gases of combustion. As explained supra, the stack draft for each individual oven is regulated by the position of slide dampers D—1 and D—2 over ports V—1 and V—2, respectively.

From the foregoing description, it will be appreciated by those skilled in the coke oven art that my broad, rectangular, by-product coke oven possesses extreme simplicity of operation. Furthermore, it will be observed that it is a low-cost oven designed for adaptability to changing circumstances, and that these qualities make it especially suitable for supplying small, as well as large, communities with a fuel supply of gas and coke for domestic use. The foregoing, with the other advantageous features described herein, give my novel and improved combination an adaptability and flexibility never before attained by the coke oven art.

It will also be appreciated that, with my novel broad coke ovens, it is possible to produce a coke which is far more suitable for domestic purposes than was the coke produced by the high, narrow ovens of the prior art. As explained supra, coke for domestic use should have an open, free-burning cell structure, and this type of coke can be made in my sole-fired broad oven. Leveling off the coal charge in my oven over the entire horizontal heating surface gives a thin layer of about 12 to about 20 inches in depth spread evenly over a surface about 35 to about 45 feet long and about 8 to about 12 feet wide. The free flow of hot, evolved gases through the thin coal charge and the low pressure to which the coal in the plastic state is subjected create entirely different carbonizing conditions from those prevailing in the high, narrow ovens. An open cell structure results, and, in addition to the fact that a different molecular arrangement of the coke structure is developed, the carbonizing reaction is accompanied by less than the amount of cracking of by-products which resulted from contact with the hot, vertical surfaces of the prior art. Thus, the broad, flat oven herein described can be operated to leave a suitable volume of volatile matter in the coke to insure the free-burning properties desirable in domestic coke. It will, of course, be understood that an appropriate mixture of coals can as readily produce a high grade metallurgical coke in my broad ovens, so that my ovens have the great adavntage of being adaptable to the production of either domestic or metallurgical coke.

Although the present invention has been disclosed in connection with a preferred embodiment thereof, variations and modifications may be resorted to by those skilled in the art, without departing from the principles of the invention. Thus, while a preferred arrangement of dampers and valves has been described and a preferred reversing mechanism for their operation has been indicated, those skilled in the coke oven art will readily perceive that other operative valvular means could be substituted for my arrangement and that other valve-actuating means could be used with satisfactory results. It will also be observed that, while I have preferred to employ a regenerative system under each oven which comprises two sets of vertical regenerators with each set comprising three regenerators connected in series, sets or one or two regenerators or of four or more series-connected regenerators could be satisfactorily used with relatively minor alterations and adjustments. Moreover, while I have described my invention particularly with reference to the coking of coal, it will be readily understood that it is as easily adaptable to the coking of any carbonaceous material, such as peat, tar, lignite, pitch, culm waste and other low grade coals, fuel oil, bunker oils and other petroleum products, and the like. I consider all of these variations and modifications to be within the true spirit and scope of the present invention, as disclosed in the foregoing description and defined by the appended claims.

I claim:

1. A by-product coke oven of the broad rectangular sole-fired type which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues arranged in parallel-spaced position underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, burning means located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burning means can be deflected by a draft along either of said adjacent heating flues depending upon the direction of the draft therein, means for supplying fluid fuel to said burning means, air inlet means for supplying air to said burning means, a waste gas stack for removing products of combustion of said burning means from said heating flues, a set of regenerators at each end of the oven respectively connected to the ends

of said heating passage, a pair of chimney-air flues positioned transversely to the coking chamber and in communication with said sets of regenerators, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

2. A by-product coke oven of the broad rectangular sole-fired type which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an odd number and arranged in parallel-spaced positions underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, a burner located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burners can be deflected by a draft along either of the flues adjacent said burner depending upon the direction of the draft therein, means for supplying fluid fuel to said burners, air inlet means for supplying air to said burners, a waste gas stack for removing products of combustion of said burners from said heating flues, a set of vertical regenerators at each end of the oven having a chamber-like space in the upper and lower portions thereof to cause spreading out of the gases passed therethrough, ducts connecting an upper chamber-like space in each set of regenerators to the terminal heating flues of said heating passage, a pair of horizontal chimney-air flues arranged transversely to said coking chamber and in communication with said sets of regenerators, ducts connecting a lower chamber-like space in each set of regenerators to said transverse chimney-air flues, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

3. A by-product coke oven of the broad rectangular sole-fired type which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an odd number and arranged in parallel-spaced position underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, a burner located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burners can be deflected by a draft along either of the flues adjacent said burner depending upon the direction of the draft therein, means for supplying rich fuel gas to said burners, means for supplying atomized liquid fuel to said burners, means for selectively actuating said fuel supply means, a pair of sets of vertical regenerators located beneath said heating flues having a chamber-like space in the upper and lower portions thereof to cause spreading out of the gases passed therethrough, a duct at each end of the oven respectively connecting an upper chamber-like space in each set of regenerators to the terminal heating flues of said heating passage, a pair of horizontal chimney-air flues arranged transversely of said coking chamber and in communication with said sets of regenerators, ducts respectively connecting a lower chamber-like space in each set of regenerators to said chimney-air transverse flues, air inlet ports at one end of said transverse chimney-air flues, a waste gas stack at the other end of said transverse chimney-air flues, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

4. The by-product coke oven construction as set forth in claim 3, wherein the valve means for interchangeably connecting one of the transverse flues with the air inlet ports and the other with the stack comprises a pair of plate dampers cooperating with said air inlet ports, and a quadrant-shaped reversing damper cooperating with said waste gas stack, said dampers being constructed and arranged to be operated in predetermined alternate sequence.

5. A by-product coke oven of the broad rectangular sole-fired type which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an odd number and arranged in parallel-spaced positions underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, a burner located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burners can be deflected by a draft along either of the flues adjacent said burn-

er depending upon the direction of the draft therein, means for supplying rich fuel gas to said burners, means for supplying liquid fuel and atomizing air under pressure to said burners, valve means for selectively controlling the admission of said gaseous and atomized liquid fuel, a pair of sets of serially connected vertical regenerators located beneath said heating flues having a chamber-like space in the upper and lower portions thereof to cause spreading out of the gases passed therethrough, a duct at each end of the oven respectively connecting the upper chamber-like space of a terminal regenerator of each of said sets of regenerators to the terminal heating flues of said heating passage, damper means intermediate to said ducts and said terminal heating flues, a pair of horizontal chimney-air flues arranged transversely to said coking chamber and in communication with said sets of regenerators, ducts respectively connecting the lower chamber-like space of the other terminal regenerator of each of said sets of regenerators to said transverse chimney-air flues, air inlet ports at one end of said transverse chimney-air flues, a waste gas stack at the other end of said transverse chimney-air flues, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

6. The by-product coke oven construction as set forth in claim 5 wherein each of the two sets of regenerators comprises three vertical regenerators serially connected with each other in such manner that the lower chamber-like space of the terminal regenerator connected to the heating flues is connected to the upper chamber-like space of the middle regenerator and that the lower chamber-like space of the middle regenerator is connected to the upper chamber-like space of the terminal regenerator connected to a transverse flue.

7. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues arranged in parallel-spaced position underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, a burner located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burners can be deflected by a draft along either of the flues adjacent said burner depending upon the direction of the draft therein, means for supplying fluid fuel to said burners, a set of regenerators at each end of said heating passage, a pair of chimney-air flues arranged transversely to said plurality of coke ovens and in common for all of the ovens of said battery communicating with said regenerators, air inlet ports at one end of said transverse chimney-air flues, a waste gas stack at the other end of said transverse chimney-air flues, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

8. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises a broad horizontal coking chamber having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues arranged in parallel-spaced position underneath the sole of the chamber and extending longitudinally substantially from end to end of the oven, longitudinal partition walls alternately spaced from the ends of the oven separating said flues from each other and connecting said flues in series to define a single serpentine heating passage under substantially the entire sole area of said coking chamber, a burner located at each turn between adjacent heating flues and positioned in substantial alignment with the partition walls whereby flames issuing from said burners can be deflected by a draft along either of the flues adjacent said burner depending upon the direction of the draft therein, means for supplying rich fuel gas to said burners, means for supplying liquid fuel and atomizing air under pressure to said burners, valve means for selectively controlling the admission of said gaseous and atomized liquid fuel, two series of vertical regenerators located beneath the heating flues and having inner portions of checkerbrick and chamber-like spaces both above and below the checkerbrick in each regenerator thereby giving gases passing through said regenerators an opportunity to mushroom out before passing through said checkerbrick and thus increasing the time of contact and affording a more effective heat transfer, a duct at each end of the oven connecting the upper chamber-like space of a terminal regenerator of each series of regenerators respectively to a terminal heating flue of said heating passage, damper means intermediate to said ducts and said terminal heating flues, a pair of horizontal chimney-air flues arranged transversely to said plurality of coke ovens and in common for all of the ovens of the battery located at the same level with and in between said sets of serially connected regenerators, ducts connecting the lower chamber-like spaces of the other terminal regenerators of each of said series of regenerators to said transverse chimney-air flues, air inlet ports at one end of said transverse chimney-air flues, a waste gas stack at the other end of said transverse chimney-air flues, single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flues disconnected from the chimney to the air while at the same time discon-

necting the other chimney-air flue from the air and automatic actuating means for said valve means for interchangeably connecting one of said transverse flues with said air ports and the other with said stack respectively to cause the flow of gases through the regenerators and said serpentine heating passage of each oven in alternating directions and to provide substantially uniform heating conditions over the entire area of the coking chamber.

9. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises in combination a long horizontal coking chamber broader than its height adapted to be sealed against the admission of air and having a sole thereunder, a plurality of longitudinal and horizontal heating flues located in parallel-spaced position underneath the sole of said chamber, each of said flues being connected with the adjacent flues on either side of it at alternate ends of said chamber respectively to form a serpentine heating passage, burners located at the turns between adjacent heating flues, a pair of sets of regenerators below said heating passage, each set having one end respectively connected to one end of said heating passage and adapted alternately to preheat air and to withdraw heat from the hot products of combustion, a pair of chimney-air flues arranged transversely to said plurality of coke ovens and in common for all of said coke ovens connected to the other ends of said sets of regenerators respectively, air inlet ports at one end of said transverse flues, a waste gas stack at the other end of said transverse flues, and gas stack at the other end of said transverse chimney-air flues, and single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

10. In a by-product coke oven of the broad rectangular sole-fired type, the combination which comprises a long horizontal coking chamber broader than its height adapted to be sealed against the admission of air and having a sole thereunder, a plurality of longitudinally extending horizontal heating flues located in parallel-spaced position underneath the sole of said chamber, each of said flues being connected with the adjacent flues on either side of it at alternate ends of said chamber respectively to form a serpentine heating passage, burners located at the turns between adjacent heating flues, a series of regenerators connected to each end of said heating passage respectively and adapted alternately to preheat air and to remove heat from the hot products of combustion, a pair of chimney-air flues arranged transversely of said coking chamber and connected to the other ends of said series of regenerators respectively, air inlet ports at one end of said transverse flues, a waste gas stack at the other end of said transverse chimney-air flues, and single chimney valve means for connecting one of said chimney-air flues to the chimney while at the same time disconnecting the other chimney-air flue from the chimney, and single air valve means cooperating with said chimney valve means for connecting the chimney-air flue disconnected from the chimney to the air while at the same time disconnecting the other chimney-air flue from the air, whereby a flow of gases is effected through said regenerators and said heating passage in alternating directions and whereby substantially uniform heating conditions are provided over substantially the entire sole area of the coking chamber.

11. In a by-product coke oven of the broad rectangular sole-fired type, the combination set forth in claim 10 which includes a plurality of take-off ducts in the roof of said coking chamber, and a common gas duct in communication with said take-off ducts whereby the gases evolved are rapidly removed from the coking chamber and prolonged contact of said gases with heated surfaces and consequent excessive cracking of hydrocarbons are eliminated, thereby providing an increased yield of by-products.

12. In a by-product coke oven of the broad rectangular sole-fired type, the combination set forth in claim 10 which includes a plurality of charging holes in the roof of said coking chamber, take-off ducts and a common horizontal gas duct connected to said charging holes for rapidly removing coking gases from said oven to eliminate prolonged contact of said gases with heated surfaces and consequent excessive cracking of hydrocarbons, an off-take pipe in communication with said horizontal gas duct, and ejector means for introducing a gaseous medium under pressure into the off-take pipe in an upward direction to provide an induced draft whereby gases and smoke evolved during the charging operation can be positively removed through the off-take pipe.

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