Oct. 14, 1941. C. H. HUGHES 2,259,380

BROAD COKE OVEN

Filed March 8, 1940 3 Sheets-Sheet 1

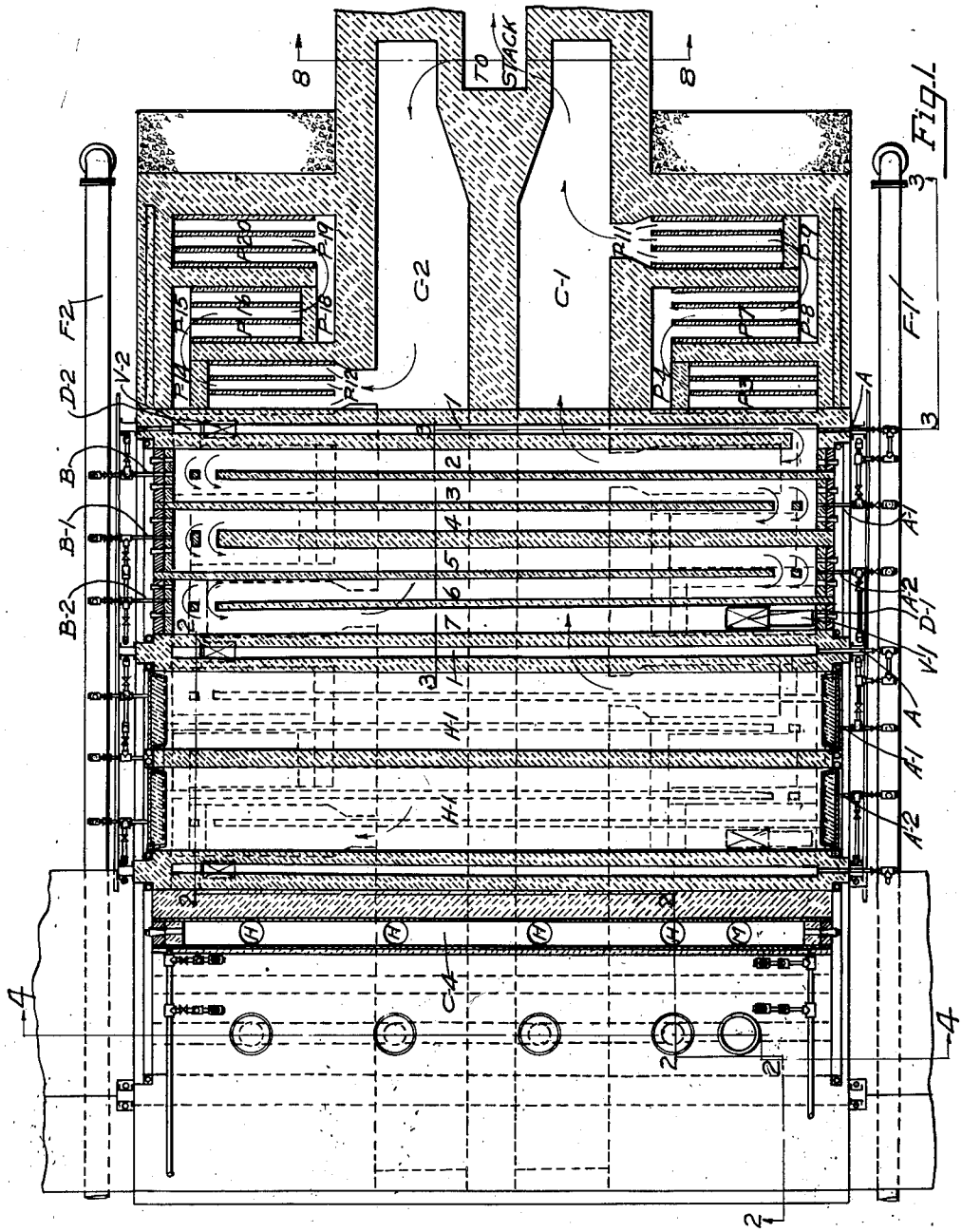

Fig. 1

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BROAD COKE OVEN

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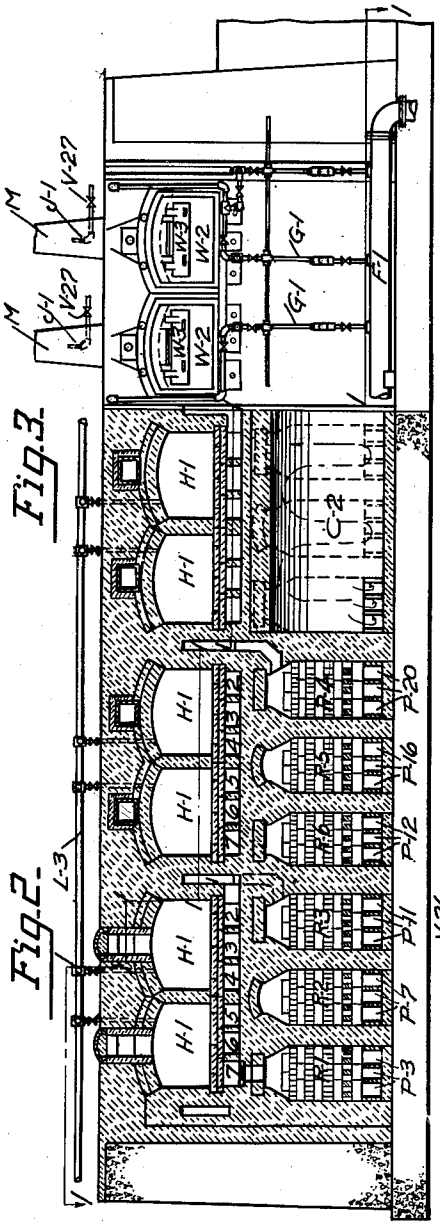

Fig. 3.

Fig. 2.

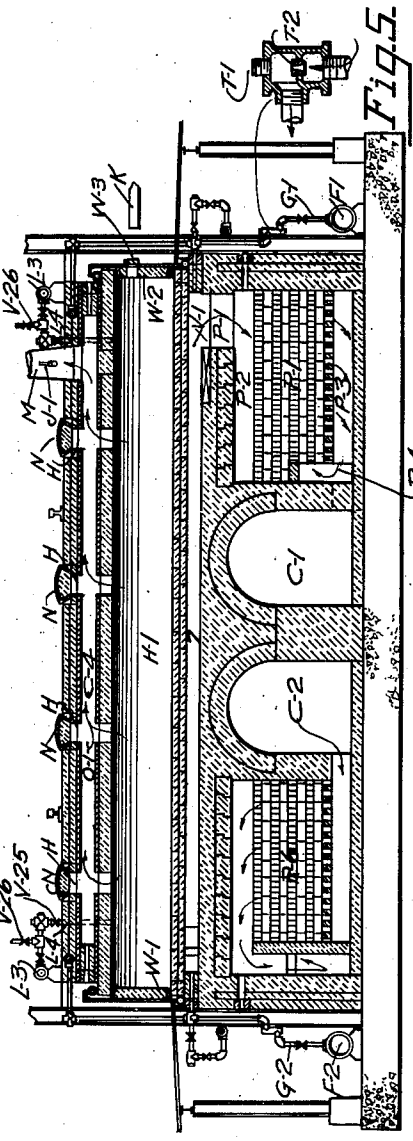

Fig. 5.

Fig. 4.

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Fig. 6.

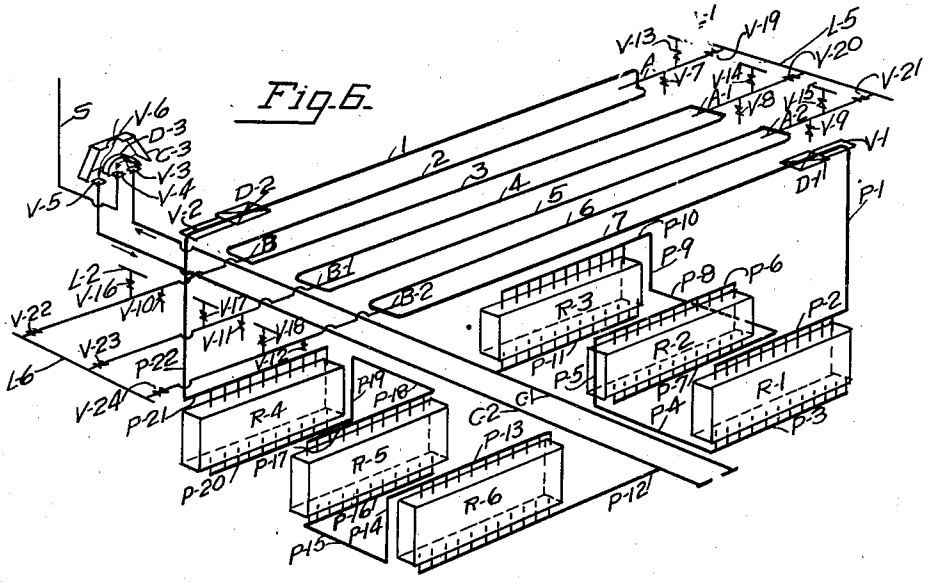


Fig. 7.

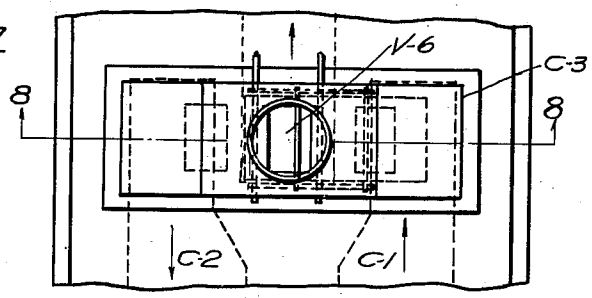
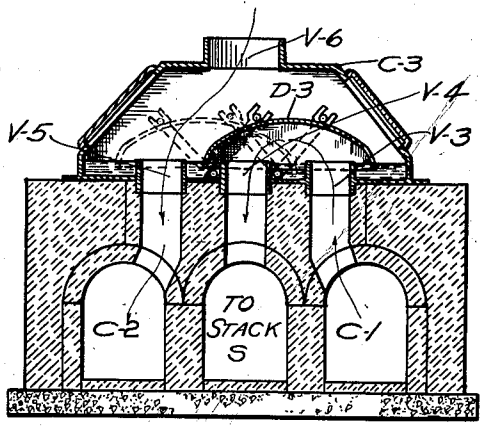


Fig. 8.



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2,259,380

UNITED STATES PATENT OFFICE

2,259,380

BROAD COKE OVEN

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Application March 8, 1940, Serial No. 322,875

19 Claims. (Cl. 202—145)

The present invention relates to by-product coke ovens and, more particularly, to by-product coke ovens of the broad, rectangular type for coking pitch, tarry matters and coal. The invention particularly contemplates by-product coke ovens for the coking of pitch of a quality suitable for carbon electrodes, carbon brushes and other articles where a high percentage of pure carbon is required.

As those skilled in the art know, 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 this 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. In order to provide for 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. Subsequently, a broad rectangular sole-fired coke oven attempting to eliminate these disadvantages and to coke coal at a lower cost 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 alternately 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 and isolated flues in the same direction and extended from one end toward the other end of the oven. Thus, each heating flue and its associated regenerators could be alternately operated, independently of adjoining heating flues and regenerators.

Although this type of broad 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 more 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 regenerator 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 material and greatly increased the cost of operation and maintenance. The above difficulties

were accentuated when it was desired to coke pitch of a quality suitable for carbon electrodes, carbon brushes and other articles where a high percentage of pure carbon was required. Between the years 1906 to 1923 attempts were made by coke oven builders and operators to coke pitch in by-product coke ovens. Various special oven designs were tried, without success. The principal cause of failure was due to the location of the heating flues. All such flues, either horizontal or vertical, were adjacent to the coking chamber. The pitch seeped through the brick joints and filled the heating flues where it would solidify and stop the circulation. Since the year 1923, the bulk of pitch has been coked in beehive ovens in which there are no heating flues. The coking process is to charge several tons of flake pitch into the beehive oven, ignite the pitch and after the coking process is completed remove the coked residue. In this operation about 50% of the original charge of pitch is burned to provide heat for coking. The evolved gas is conducted into a hot flue situated above a row of beehives where it is burned with a loss of all by-products. The hot waste gas from the hot flue is conducted to a waste heat boiler for making low pressure steam.

Another difficulty associated with the coking of pitch was foaming of the liquid pitch at certain temperatures during the coking process. Also, the charge of pitch into broad coke ovens has, of necessity, covered too large an area of the heating surface per charge, producing instant boiling of great intensity before the charge could be increased to the proper depth. Likewise, the flow of pitch into the oven over a large area had a chilling effect on the brickwork causing some spalling contraction of the brickwork with subsequent leakage of pitch into the heating flues. 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 of medium-width in which pitch, tarry matters and coal can be coked in a substantially automatically controlled manner.

It is another object of the present invention to provide a by-product coke oven, including a series-flue heating system interconnected in series and arranged so that each oven is heated by three sole flues while the seventh flue located in the division walls completes the circulation to the opposite ends of the two sides of regenerators.

It is a further object of the invention to provide a novel and improved by-product coke oven particularly adapted for coking pitch and similar tarry matters in which means are provided for quickly removing the evolved gases and to prevent a long contact of the gases with heated surfaces which might cause break down or cracking of the hydrocarbons in the gas.

My invention also provides a broad by-product coke oven for coking pitch, having means for charging the pitch either in liquid form through supply pipes or in flake or lump form through charging holes.

Another object of my invention is to provide a by-product coke oven for coking tarry materials having steam connections through the fluid pitch supply pipes for the introduction of steam whereby foaming of the pitch can be effectively prevented.

The present invention also has in prospect the provision of a broad coke oven having a heating flue system so designed as to conduct the products of combustion to each succeeding flue in series for the purpose of preventing high heats or hot spots in the vicinity of the fuel burners and to lengthen the flame thereby to assure the proper heat transfer by means of the increased velocity which removes stagnant gas films from the brick surfaces.

It is also an object of the invention to incorporate in a battery of broad coke ovens means for reversing the direction of flow of the hot gases through the heating flue system whereby uniform heating over the entire floor of the oven may be insured.

The invention also contemplates the arrangement of regenerators below and parallel to the ovens of a battery of broad coke ovens, to insure the flow of waste hot gas and air vertically through the regenerators in the correct relative direction.

It is also within the contemplation of the invention to incorporate into broad coke ovens slide dampers at the opposite ends of the waste flue heating system in such positions that the slides can be used to regulate the stack pull to each special heating system whenever necessary.

The invention further proposes to incorporate in by-product coke ovens fuel burners in such positions that the constantly burning flames will change direction upon the reversal of gases through the heating system.

Still another object of my invention is to provide means for using fuel oil or tar to heat a battery of ovens in place of rich coke oven gas so that all gas evolved may be available for domestic or industrial use.

The invention has the additional purpose of providing a broad, rectangular coke oven having means for introducing the charge of pitch into the ovens in contrast to the intermittent introduction of pitch in conventional pitch coking processes.

Moreover, the invention has in view a broad coke oven of novel character having the heating flues and the gas off-take flues so arranged that they may be opened for the purpose of removing carbon deposits.

In addition, the invention also provides a by-product coke oven including a standard three-way reversing valve, operated with conventional reversing valve equipment, to control the flow of waste gas to the stack and the flow of incoming combustion air.

The invention also contemplates a novel process for coking pitch in broad coke ovens which eliminates the disadvantages of conventional coking processes and is capable of producing a high yield of coke of a quality suitable for carbon electrodes, carbon brushes and other articles where a high percentage of pure carbon is required.

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 view, having parts in section, of eight medium-width pitch ovens embodying the invention, taken on lines 1—1 of Fig. 2 and

Fig. 2 depicts a transverse vertical sectional view taken on line 2—2 of Fig. 1;

Fig. 3 shows a vertical sectional view of a section of the chimney flue and the front elevation of two ovens, taken on lines 3—3 of Fig. 1;

Fig. 4 illustrates a vertical, longitudinal sectional view of one of the ovens and of the regenerators taken on line 4—4 of Fig. 1;

Fig. 5 depicts a vertical section through the special L and the removable diaphragm assembly through which the volume of fuel gas to each burner is regulated;

Fig. 6 depicts a perspective view of a heating system employed in the coke ovens of the invention, 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 on a larger scale of the reversing damper incorporated into the coke oven battery of the invention; and

Fig. 8 is a vertical sectional view of the three-way reversing damper taken on line 8—8 of Fig. 7.

Broadly stated, according to the principles of the present invention, a battery of rectangular, medium-width broad coke ovens is provided in which a plurality of pairs of coke ovens are heated with an even number of sole flues, preferably six, of which three flues heat each oven and all six flues are interconnected with the seventh circulation flue in series. The shape of this seventh or circulation flue is not important but it must have the same cross sectional area as each of the heating flues. For structural reasons, however, it is preferred to make the seventh flue narrow and high as a flue of such shape fits in a wall between header brick without having to cut the brick. The heating system common to two coke ovens and the circulation flue are connected by openings located at opposite ends with two sets of vertical regenerators located below and parallel to the heating flues of the ovens. These two sets of 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 have spacious chamber-like passages, both above and below the checkerbrick, giving the gases and air an opportunity to spread or mushroom out before passing through the regenerators. This spreading out of the gases greatly increases the time of contact, and provides the proper contact time for efficient heat transfer. The regenerators also incorporate the correct principle of heat exchange according to which a gas which is being heated must ascend through the checkerbricks, while the gas which is being cooled must descend, if uniformity of flow and high heat transfer efficiency is to be attained. Burners are arranged at the turning points of adjoining sole flues which may be operated by either rich fuel gas or fuel oil or tar for underfiring the ovens. I also provide transverse or chimney flues in common for the complete battery of coke ovens, these transverse flues being arranged side by side transversely of the ovens and are used alternately for waste gas and air. This arrangement keeps all the flues within the oven structure in a simple, efficient and compact form. The waste gas flues in common for all ovens are provided at one end of their ends with a three-way reversing valve for periodically reversing the flow of air and waste gas in accordance with conventional regenerator practice.

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 will be readily observed that the oven battery of my invention comprises a plurality of domed, rectangular coking chambers H—1 of medium-width and arranged in pairs. Each of these coking chambers has charging holes or ports H in their roofs, adapted to be sealed by covers N. An off-take duct O—1 is positioned near the top of each charging hole and communicates with the common gas duct C—4, which is located along the longitudinal axis of the oven roof. This common gas duct connects into an off-take pipe M near the coke charge end of the oven. An ejector J—1 connected with the steam or gas line is located in the off-take pipe, and a valve B—27 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 W—1 and W—2 at either end of each oven. There is a small door W—3 in the pusher side oven door W—3 through which a levelling ram K may be introduced, when necessary.

Beneath each pair of these chambers and running parallel to the length of the oven, heating flues 1, 2, 3, 4, 5 and 6 are arranged in horizontal position, three such heating flues being provided in the sole of each oven. These sole flues 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. In addition, a seventh circulation flue 7 is provided between each pair of ovens in the division walls thereof. The purpose of this seventh flue is to complete the circulation to the opposite ends of the two sets of regenerators. The interconnected heating flues 1 to 7 are provided at the turns with burning means, such as gas burners A, A—1, A—2, B B—1 and B—2 which are supplied with fluid fuel, as it will be described more fully hereinafter. Below the heating flues in each pair of ovens 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 7 and the 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 three-way reversing damper D—3. This reversing damper is mounted in a reversing damper casing C—3. Transverse flue C—1 ends in an opening V—3, transverse flue C—2 ends in an opening V—5, and a similar opening V—4 connects to stack S. In the illustrated position of the three-way reversing damper, the air to be preheated enters trans-

verse or chimney flue C—2 through open slots V—6 and V—5, the reversing damper D—3 being shifted to connected openings V—3 and V—4.

Passages P—2, P—6, P—10 and P—21, P—17, P—13, 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, 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 to said regenerators. Similarly, passages P—3, P—7, P—11 and P—20, P—16, and P—12, 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 7 and 1, of the series-flue heating system are connected through passages P—1 and P—22, 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.

Fuel gas manifolds F—1 and F—2 (see Fig. 4) run along the length of the oven battery on opposite sides thereof and are adapted to supply burners A, A—1, A—2 and B, B—1, B—2 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 orifices are also furnished for the regulation of the fuel gas conducted therethrough. This L depicted in Fig. 5 is equipped with a plug T—1 and with 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—7, V—8, V—9 and V—10, V—11, V—12 (see Fig. 6), located in the riser pipes from the supply manifolds to burners A, A—1, A—2 and B, B—1, B—2, 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 A, A—1, A—2 and B, B—1, B—2 through valves V—13, V—14, V—15, and V—16, V—17, V—18, respectively, said valves being adapted to atomize the oil or tar. Air lines L—5 and L—6, running the length of the battery in association with the pipe lines, are also provided and connect into valves V—13, V—14, V—15 and V—16, V—17, V—18 through air regulating valves V—19, V—20, V—21, and V—22, V—23, V—24, respectively, and are adapted to furnish air for said atomization.

The supply pipe L—3, running transversely across the complete battery of ovens, is provided for supplying the liquid pitch to be coked through pipe L—4, the flow of pitch being controlled by means of a valve V—25. Steam to prevent foaming of the pitch in the oven may be admitted through valve V—26 and pipe —4 into the coking chamber. (Figs. 1, 2 and 4.)

In the operation of the oven as an entire unit, oven doors W—1 and W—2 are closed and sealed air-tight, as may be seen from Fig. 4. Liquid pitch from supply pipe L—3 is charged to pipe L—4 and valve V—25 into coking chamber H—1. If steam is needed to prevent foaming of the pitch in the coking chamber, it is admitted through a valve V—26 and pipe L—4 into said chamber. When flake or lump pitch or coal are used, they are charged through charging holes H in the top of the ovens. The flake or lump pitch, when heated, will become plastic and will flow to a uniform depth during coking. On the other hand, if coal is charged, the cone-shaped piles are leveled off in the usual manner by a leveling ram K introduced through a small door W—3 in the pusher side oven door W—2. The charging covers N are replaced and sealed air-tight. Fuel gas, fuel oil or tar is then burned with preheated air in the heating flues underneath the coking chambers to provide a 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 readily understand, and a reversal period 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 coking process is finished, oven doors W—1 and W—2 are removed, and the coke is pushed in the customary manner. The gases evolved during coking rise up through charging holes H and pass through off-take ducts O—1 into the common gas duct C—4, where all the gases evolved in the ovens merge into a single stream. A gas off-take M is provided at the end of each oven and from there to the by-product plant. In this manner, the gases evolved are rapidly removed from the coking chamber, thus avoiding prolonged contact of said gases with heated surfaces and consequently excessive cracking of hydrocarbons is effectively prevented and an increased amount of light oil and tar is produced when coking coal.

An ejector J—1, located in gas off-take pipe M, is employed to suck the evolved gases to the off-take pipe. This ejector is used only during charging operation. Steam or gas under pressure is admitted through valve V—27. The flow of the steam or gas in an upward direction draws into the off-take pipe the gas and smoke during the charging of the coal through the charging holes H. Without this induced draft some of the evolved gases could escape into the atmosphere due to the removal of the charging coal covers N. 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 in the foregoing, 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. When fuel oil or tar are used instead of rich

fuel gas for underfiring the ovens, gas valves V—7 to V—12, inclusive, are closed. The oil or tar from pipe lines L—1 and L—2 flows into valves V—13 to V—18, inclusive, and air is also supplied to these valves from air lines L—5 and L—6. 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—19 to V—24, inclusive.

Assuming that regenerators R—1, R—2 and R—3 are being preheated, damper slots V—1, V—2, V—3 and V—4 are open, permitting a flow of waste gas to chimney flue C—1 and stack S. The air to be preheated enters chimney flue C—2, through open slots V—5 and V—6 in the reversing damper casing C—3, the reversing damper D—3 being shifted to the position in which openings V—3 and V—4 are connected.

The air flows from chimney flue C—2 into passage P—12 or regenerator R—6 which is large enough to permit the air to mushroom out, and then uniformly up through the hot checkerbrick to passage P—13. From here, by passages P—14 and P—15, the now partially heated air is brought to a spacious passage P—16 below regenerator R—5. It then flows in a similar manner through the regenerators R—5 and R—4 through flue P—22 to heating flue 1. The preheated air for combustion of the fuel gas or vaporized fuel oil at the burners is delivered in flue 1 in great excess over the air required for burner A. After the combustion at burner A, the air in considerable excess of the requirements of the next burner in the series passes mixed with the products of combustion to burner B and similarly to all burners successively. The hot waste gases of combustion pass out of the series flue heating system from flue 7 through passage P—1 to passage P—2 above regenerator R—1. Passage P—2 is sufficiently large for the gases to spread uniformly and then downward relatively slowly through regenerator R—1 to passage P—3 below regenerator R—1, and then successively through passages P—4 to P—11 and regenerators R—2 and R—3 and into chimney flue C—1. It will be noted that flue 7 is located in the wall between the adjoining pairs of coking chambers whereby the side walls of such chambers are likewise heated and prevents chilling of the tarry materials to be coked. In addition, the object of the provision of the seventh flue, is to complete the circulation of heating gases to the opposite ends of the two sets of regenerators.

Upon a reversal of the draft accomplished as described above with a preheated air entering at the pusher end of flue 7, the flames of burner B—2, B—1 and B are deflected into flues 6, 4 and 2 respectively, and flames of burner A—2, A—1 and A are deflected into flues 5, 3 and 1, respectively. In this case, the flames burn at the pusher ends of flues 5, 3 and 1 and at the coke end of flues 6, 4 and 2 so that the effect of each individual flue upon the oven is just opposite to that described in the foregoing. The cumulative or additive effect of the whole series of flues beneath the oven, however, is the same on both reversals. The heat throughout the full cycle is uniform for the entire oven.

The reversal of the flames being deflected alternately from one flue into another, mixed with the products of combustion, eliminates the danger of hot spots when regenerators R—1, R—2 and R—3 are raised to the temperature for preheating the air. The direction of flow of the air and waste gases is reversed by shifting damper D—3 to cover valve openings V—4 and V—5 and to leave valve opening V—3 open for the admission of air to chimney flue C—1. Air then enters chimney flue C—1 through passage P—11 to regenerator R—3 through successive passages P—11 to P—1, inclusive, regenerators R—3, R—2 and R—1 to heating flue 7. Stack draft or an induced draft fan is used for drawing air into the regenerators and for removing the gases of combustion. The stack draft for each heating system of seven flues is regulated by the position of slide damper D—1 over opening V—1 and damper D—2 over opening V—2. In the operation of the two ovens heated by one common heating system, it is not necessary to charge the pitch or coal into each oven simultaneously, as each oven having separate charging means and individual oven doors can be operated on different schedules.

After the pitch or coal is coked, oven doors W—1 and W—T are removed and the coke is pushed in the customary manner.

It will be noted that the broad coke ovens embodying the invention provide various important advantages. Due to the fact that the heating flues are placed under the floor of the oven, any pitch seeping into these flues will be quickly burned in the presence of the burning fuel gas. Any unburned carbon or carbon ash can be raked or blown out by removing the panel wall at the ends of the heating flues. The walls separating each heating flue extend to the face of the outside wall, and each end panel can be removed without disturbing the adjoining brickwork whereby inspection and maintenance of the heating flues is greatly facilitated.

It is also to be observed that in the closed type coking chamber embodying the invention none of the pitch charged into the closed oven chamber is burned as in the conventional beehive pitch oven. The gas evolved is recovered for underfiring the oven and, if the gas yield is insufficient for heating the oven, oil can be used. Thus, great efficiency and economy of operation are obtained.

Moreover, the present invention provides a novel and improved process for coking pitch. As a result of the flat oven floor, a pitch coke of uniform thickness is produced. All pitch is charged into the oven quickly. The mass starts coking uniformly over the entire oven floor area insuring a uniformly dense coke. Either liquid, flake or lump pitch can be charged into the oven and foaming of the pitch is prevented by admitting steam into the coking chamber.

Furthermore, the present invention makes it possible to coke two ovens with the use of a heating system common to both ovens. If the volume of gas evolved from the pitch is not sufficient for underfiring, then coal can be coked in one oven to provide sufficient gas while the other oven can be used for coking pitch. In contrast to the conventional coking ovens, in the coke ovens embodying the invention the fuel gas burns constantly and the flame only changes direction on reversals, means being provided for regulating the volume of gas separately to each burner.

Although the present invention has been described 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 present invention. I consider all of these variations and modifications as within the true spirit and scope of the present invention as disclosed in the fore-

going 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 pair of broad, elongated, horizontal, combined coking chambers of brick construction having a common wall therebetween and having a common sole of brick construction thereunder for holding carbonaceous material including pitch, tarry matter and coal thereon; each of said pairs of combined coking chambers being adapted to contain carbonaceous material during coking and being adapted to be sealed against the admission of air and against communication with the other coking chamber; a heating flue system arranged underneath substantially the entire common sole of said pair of combined coking chambers and extending substantially from end to end of the said pair of combined coking chambers; burning means associated with said heating system to provide heat throughout the same; said burning means provided with constantly burning flames during the operation of said combined coking chambers to furnish substantially uniform heating conditions over substantially the entire sole area of said combined coking chambers; means for providing fuel to said burning means; means for providing air to burn said fuel in said burning means; a waste gas stack for removing products of combustion from said burning means associated with said heating system; and a plurality of vertical checkerbrick regenerators associated with said pair of combined coking chambers and communicably connected thereto and to said air means and waste gas stack whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for said pair of coking chambers and whereby uniform heating conditions over substantially the entire sole area of said pair of combined coking chambers can be attained.

2. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad, elongated, horizontal, combined coking chambers of brick construction having a common wall therebetween and having a common sole of brick construction thereunder for holding carbonaceous material including pitch, tarry matter and coal thereon; each of said pairs of combined coking chambers being adapted to contain carbonaceous material during coking and being adapted to be sealed against the admission of air and against communication with the other coking chamber; a heating flue system arranged underneath substantially the entire common sole of said pair of combined coking chambers and extending substantially from end to end of the said pair of combined coking chambers; burning means associated with said heating system to provide heat throughout the same; said burning means provided with constantly burning flames during the operation of said combined coking chambers to furnish substantially uniform heating conditions over substantially the entire sole area of said combined coking chambers; means for providing fuel to said burning means; means for providing air to burn said fuel in said burning means; a plurality of take-off ducts in the roof of each of said coking chambers whereby gaseous products evolved in each of said coking chambers are rapidly removed therefrom and prolonged contact of said gases with heated surfaces with resulting excessive cracking of hydrocarbons is substantially eliminated; a waste gas stack for removing products of combustion from said burning means associated with said heating system; and a plurality of vertical checkerbrick regenerators associated with said pair of combined coking chambers and communicably connected thereto and to said air means and waste gas stack whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for said pair of coking chambers and whereby uniform heating conditions over substantially the entire sole area of said pair of combined coking chambers can be attained.

3. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad, elongated, horizontal, combined coking chambers of brick construction having a common wall therebetween and having a common sole of brick construction thereunder for holding carbonaceous material including pitch, tarry matter and coal thereon; each of said pairs of combined coking chambers being adapted to contain carbonaceous material during coking and being adapted to be sealed against the admission of air and against communication with the other coking chamber; a heating flue system arranged underneath substantially the entire common sole of said pair of combined coking chambers and extending substantially from end to end of the said pair of combined coking chambers; burning means associated with said heating system to provide heat throughout the same; said burning means provided with constantly burning flames during the operation of said combined coking chambers to furnish substantially uniform heating conditions over substantially the entire sole area of said combined coking chambers; means for providing fuel to said burning means; means for providing air to burn said fuel in said burning means; a plurality of take-off ducts in the roof of each of said coking chambers whereby gaseous products evolved in each of said coking chambers are rapidly removed therefrom and prolonged contact of said gases with heated surfaces with resulting excessive cracking of hydrocarbons is substantially eliminated; a common horizontal duct built in the roof of each of said coking chambers and connected to said plurality of take-off ducts for removing gaseous products from each of said coking chambers and protecting said products from the heat within said coking chambers; a waste gas stack for removing products of combustion from said burning means associated with said heating system; and a plurality of vertical checkerbrick regenerators associated with said pair of combined coking chambers and communicably connected thereto and to said air means and waste gas stack whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for said pair of coking chambers and whereby uniform heating conditions over substantially the entire sole area of said pair of combined coking chambers can be attained.

4. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad, elongated, horizontal, combined coking chambers of brick construction having a common wall therebetween and having a common sole of brick construction thereunder for holding carbonaceous material including pitch, tarry matter and coal thereon; each of said pairs of combined coking chambers being adapted to contain carbonaceous material during coking and being adapted to be sealed against the admission of

air and against communication with the other coking chamber; a heating flue system arranged underneath substantially the entire common sole of said pair of combined coking chambers and extending substantially from end to end of the said pair of combined coking chambers; burning means associated with said heating system to provide heat throughout the same; said burning means provided with constantly burning flames during the operation of said combined coking chambers to furnish substantially uniform heating conditions over substantially the entire sole area of said combined coking chambers; means for providing fuel to said burning means; means for providing air to burn said fuel in said burning means; a plurality of take-off ducts in the roof of each of said coking chambers whereby gaseous products evolved in each of said coking chambers are rapidly removed therefrom and prolonged contact of said gases with heated surfaces with resulting excessive cracking of hydrocarbons is substantially eliminated; a common horizontal duct built in the roof of each of said coking chambers and connected to said plurality of take-off ducts for removing gaseous products from each of said coking chambers and protecting said products from the heat within said coking chambers; an off-take pipe connected to said common horizontal gas duct for removing said gaseous products, and an ejector means for introducing a gaseous medium under pressure into the off-take pipe in an upward direction during the charging of said coking chambers to remove gases and smoke evolved; a waste gas stack for removing products of combustion from said burning means associated with said heating system; and a plurality of vertical checkerbrick regenerators associated with said pair of combined coking chambers and communicably connected thereto and to said air means and waste gas stack whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for said pair of coking chambers and whereby uniform heating conditions over substantially the entire sole area of said pair of combined coking chambers can be attained.

5. A coke oven battery comprising a plurality of by-product coke ovens arranged side by side, each of said coke ovens having the structure set forth in claim 1.

6. A coke oven battery comprising a plurality of by-product coke ovens arranged side by side, each of said coke ovens having the structure set forth in claim 3.

7. A coke oven battery comprising a plurality of by-product coke ovens arranged side by side, each of said coke ovens having the structure set forth in claim 3.

8. A coke oven battery comprising a plurality of by-product coke ovens arranged side by side, each of said coke ovens having the structure set forth in claim 4.

9. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad horizontal coking chambers 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 said chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separating said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues, thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, 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 flues depending upon the direction of the draft therein, means for supplying fluid fuel to said burning means, air inlets for supplying air to said burning means, a waste gas stack for removing products of combustion of said burning means from said heating flues, and regenerators located beneath said heating flues and communicably connected to said flues and to said air inlets and waste gas stack, respectively, whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for a pair of coking chambers and whereby substantially uniform heating conditions over the entire sole area of a pair of coking chambers can be attained.

10. A by-product coke oven of the broad rectangular sole fired type which comprises a pair of broad horizontal coking chambers having a sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an even number and arranged in parallel spaced position underneath the sole of said chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separting said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues, thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, a circulation flue connected to one end of said heating passage, 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 pair of horizontal and transverse flues below said heating flues communicating with said air inlet means and said waste gas stack, and two sets of vertical regenerators located beneath said heating flues and communicably connected with said heating passage and said circulation flue and with the pair of transverse flues whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for a pair of coking chambers and whereby substantially uniform heating conditions over the entire sole area of a pair of coking chambers can be attained.

11. The by-product coke oven construction as set forth in claim 7 wherein each of the two sets of vertical regenerators comprises three vertical regenerators serially connected to each other from the lower part of the regenerator connected with the heating flues to the upper part of the middle regenerator and from the lower part of the middle regenerator to the upper part of the regenerator connected with a transverse flue.

12. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad horizontal coking chambers having a

sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an even number and arranged in parallel-spaced position underneath the sole of said chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separating said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues, thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, a circulation flue connected to one terminal flue of said heating passage, 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, two sets of series 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 connecting the upper chamber-like spaces of said regenerators to the other terminal heating flue of said heating passage and to the end of said circulation flue respectively, a pair of horizontal and transverse flues communicating with said sets of regenerators, ducts connecting the lower chamber-like spaces of said regenerators to said transverse flues, an air inlet port and a waste gas stack at one end of said transverse flues, and means for alternately and selectively connecting said transverse flues with said port and with said stack respectively to cause the flow of gases through said regenerators and said heating passage and circulation flue in alternating direction whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for a pair of coking chambers and whereby substantially uniform heating conditions over the entire sole area of a pair of coking chambers can be attained.

13. A by-product coke oven of the broad rectangular sole-fired type which comprises a pair of broad horizontal coking chambers having a common sole thereunder and adapted to be sealed against the admission of air, a plurality of horizontal heating flues having an even number and arranged in parallel-spaced positions underneath the sole of said chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separating said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues, thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, a circulation flue connected to one of the terminal heating flues of said heating passage, 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 sets of serially connected 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 connecting the upper chamber-like spaces of said regenerators to the other of the terminal heating flues of said heating passage and to the end of said circulation flue respectively, damper means intermediate to said ducts and said terminal flues, a pair of horizontal and transverse flues in communication with said sets of regenerators, ducts connecting the lower chamber-like spaces of said regenerators to said transverse flues, an air inlet port and a waste gas stack at one end of said transverse flues, and valve means for alternately and selectively connecting said transverse flues with said port and with said stack respectively to cause the flow of gases through said regenerators and said heating passage and said circulation flue in alternating direction whereby a broad by-product coke oven is provided having a single heating system and a single regenerative system for a pair of coking chambers and whereby substantially uniform heating conditions over the entire sole area of a pair of coking chambers can be attained.

14. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises a pair of broad horizontal coking chambers having a common sole thereunder and adapted to be sealed against the admissoin of air, a plurality of horizontal heating flues arranged in parallel-spaced position underneath the sole of said pair of chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separating said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues, thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, a circulation flue connected to one of the terminal heating flues of said heating passage, 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, two sets of serially connected 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 connecting the upper chamber-like spaces of said regenerators to the other of the terminal heating flues of said heating passage and to the end of said circulation flue respectively, a pair of horizontal and transverse flues in common for all of the ovens of said battery located at the same level with said sets of regenerators, ducts connecting the lower chamber-like spaces of all of said regenerators to said transverse flues, an air inlet port and a waste gas stack at one end of said transverse flues, and three-way valve means for alternately and selectively connecting said transverse flues with said port and with said stack respectively to cause the flow of gases through said regenerators and said heating passages and associated circulation flues in alternating direction whereby a broad by-product coke

oven is provided having a single heating system and a single regenerative system for a pair of coking chambers and whereby substantially uniform heating conditions over the entire sole area of a pair of coking chambers can be attained.

15. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises a pair of broad horizontal coking chambers having a common 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 said pair of chambers and extending longitudinally substantially from end to end of the said pair of coking chambers, longitudinal partition walls separating said flues from each other and alternately spaced from the ends of the oven to form a turn between any two adjacent flues thereby defining a single serpentine heating passage under substantially the entire sole area of and in common for said pair of coking chambers, a narrow and high circulation flue connected to one end of said heating passage and located in the common wall between two adjoining pairs of coking chambers, 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 spaces of the terminal regenerators of the series to one of the terminal heating flues of said heating passage and to the end of said circulation flue respectively, damper means intermediate to said ducts and said terminal heating flues, a pair of horizontal and transverse flues 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 said regenerators to said transverse flues, an air inlet port and a waste gas stack at one end of said transverse flues, valve means located intermediate said transverse flues and said air inlet port and waste gas stack respectively, and automatic actuating means for said valve means constructed and arranged to alternately and selectively connect said transverse flues with said port and with said stack respectively to cause the flow of gases through the regenerators and said serpentine heating passage and circulation flue of each pair of coking chambers in alternating directions and to provide substantially uniform heating conditions over the entire area of said pair of coking chambers.

16. In a by-product coke oven of the broad rectangular sole-fired type, the combination which comprises a pair of long horizontal coking chambers broader than their height adapted to be sealed against the admission of air and having a common sole thereunder, a plurality of longitudinally extending horizontal heating flues located in parallel-spaced position underneath the sole of said pair of chambers, each of said flues being connected with the adjacent flues on either side of it at alternate ends of said chambers respectively to form a serpentine heating passage in common for said pair of chambers, a circulation flue connected to one end of said heating passage, burners located at the turns between adjacent heating flues, two series of regenerators below said heating passage connected respectively to one end of said passage and to said circulation flue and adapted to alternately preheat air and to remove heat from the hot products of combustion, a pair of transverse flues located at the same level with and connected to the other ends of said series of regenerators, respectively, an air inlet port and a waste gas stack at one end of said transverse flues, and valve means for selectively and alternately connecting said port and said stack to said transverse flues.

17. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises in combination a pair of long horizontal coking chambers broader than their height adapted to be sealed against the admission of air and having a common sole thereunder, a plurality of longitudinal and horizontal heating flues located in parallel-spaced position underneath the sole of said pair of chambers, each of said flues being connected with the adjacent flues on either side of it at alternate ends of said chambers respectively to form a serpentine heating passage in common for said pair of chambers, a circulation flue connected to one end of said heating passage, burners located at the turns between adjacent flues, a pair of sets of series-connected regenerators below said heating pasage having one of their ends respectively connected to one of the ends of said heating passage and of said circulation flue and adapted to alternately preheat air and to withdraw heat from the hot products of combustion, a pair of transverse flues in common for all of said coke ovens of the battery located at the same level with and connected to the other ends of said series of regenerators, an air inlet port and a waste gas stack at one end of said transverse flues, valve means for selectively and alternately connecting said port and said stack to said transverse flues, a plurality of take-off ducts in the roof of said coking chambers, and a common gas duct in communication with said take-off ducts for each of said coking chambers whereby the gases evolved are rapidly removed from said coking chambers and prolonged contact of said gases with heated surfaces and consequent excessive cracking of hydrocarbons are eliminated.

18. A coke oven battery comprising a plurality of broad by-product coke ovens arranged side by side each of which comprises in combination a pair of long horizontal coking chambers broader than their height adapted to be sealed against the admission of air and having a common sole thereunder, a plurality of longitudinal and horizontal heating flues located in parallel-spaced position underneath the common sole of said pair of chambers, each of said flues being connected with the adjacent flues on either side thereof at alternate ends of said chamber respectively to form a serpentine heating passage in common for said pair of chambers, a circulation flue connected to one end of said heating passage, burners located at the turns between ad-

jacent flues, a pair of sets of series-connected regenerators below said heating passage having one of their ends respectively connected to one of the ends of said heating passage and of said circulation flue and adapted to alternately preheat air and to withdraw heat from the hot products of combustion, a pair of transverse flues in common for all of said coke ovens located at the same level with and connected to the other ends of said series of regenerators, an air inlet port and a waste gas stack at one end of said transverse flues, valve means for selectively and alternately connecting said port and said stack to said transverse flues, charging holes in the roof of each of said coking chambers, take-off ducts and a common horizontal gas duct connected to said charging holes to rapidly remove coking gases from said oven, 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 the upward direction during the charging operation to remove the gases and smoke evolved.

19. In a by-product coke oven of the broad rectangular sole-fired type for coking pitch, the combination which comprises a pair of long horizontal coking chambers broader than their height adapted to be sealed against the admission of air and having a common sole thereunder, a plurality of longitudinally extending horizontal heating flues located in parallel-spaced position underneath the sole of said pair of chambers, each of said flues being connected with the adjacent flues on either side thereof at alternate ends of said chambers respectively to form a serpentine heating passage in common for said pair of chambers, a circulation flue connected to one end of said heating passage, burners located at the turns between adjacent heating flues, two series of regenerators below said heating passage connected respectively to one end of said passage and to said circulation flue and adapted to alternately preheat air and to remove heat from the hot products of combustion, a pair of transverse flues located at the same level with and connected to the other ends of said series of regenerators, respectively, an air inlet port and a waste gas stack at one end of said transverse flues, valve means for selectively and alternately connecting said port and said stack to said transverse flues, charging holes for introducing solid pitch into said chambers, conduit means for introducing liquid pitch into said chambers, and means for introducing steam into said chambers to prevent foaming of said pitch.

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