No. 711,904. Patented Oct. 21, 1902.

T. S. C. LOWE.

APPARATUS FOR THE MANUFACTURE OF COKE AND THE RECOVERY OF GASES THEREFROM.

(No Model.) (Application filed Aug. 12, 1901.) 3 Sheets—Sheet 1.

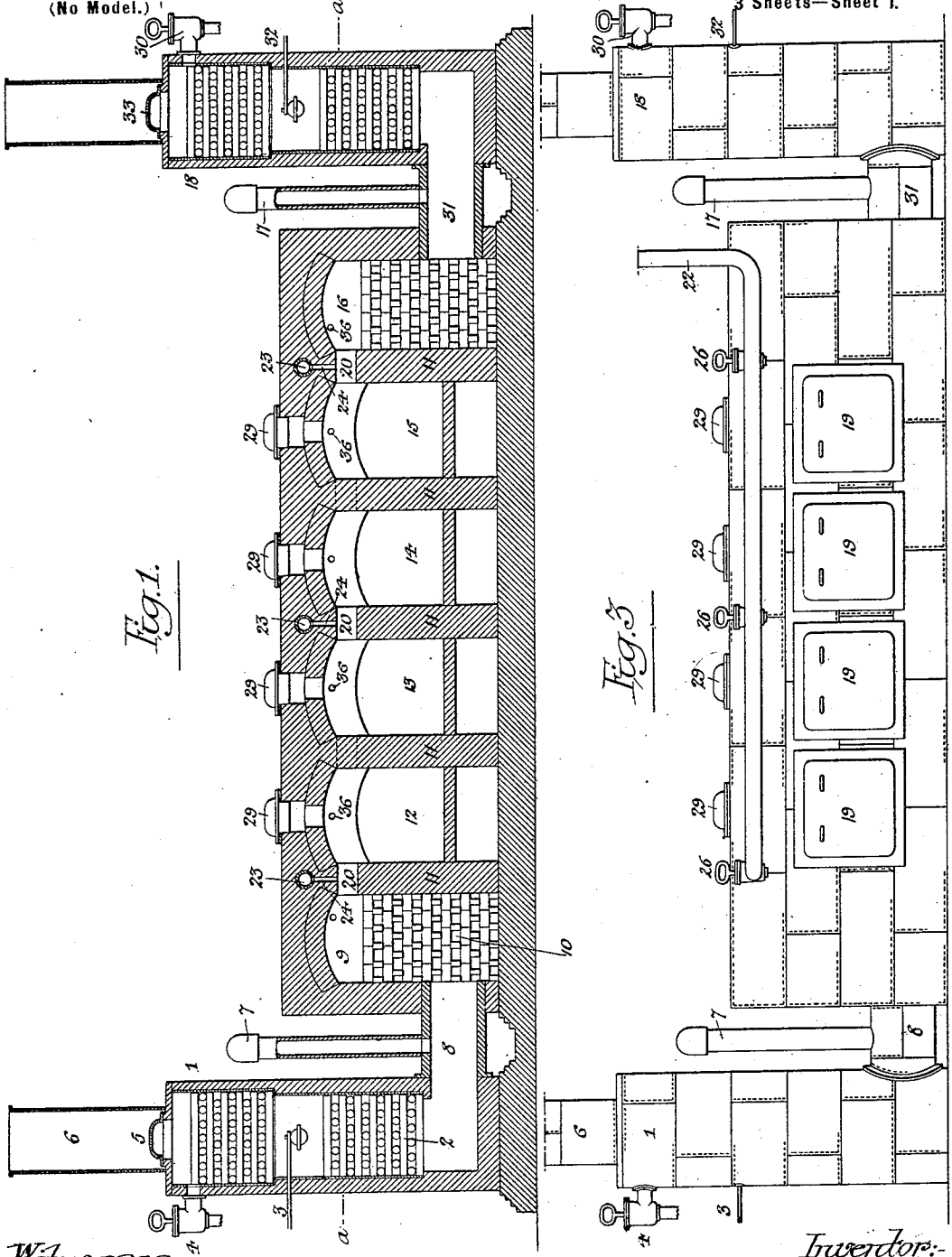

Fig. 1.

Fig. 3.

Witnesses:-
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Frank L. A. Graham.

Inventor:-
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(Application filed Aug. 12, 1901.)

(No Model.) 3 Sheets—Sheet 2.

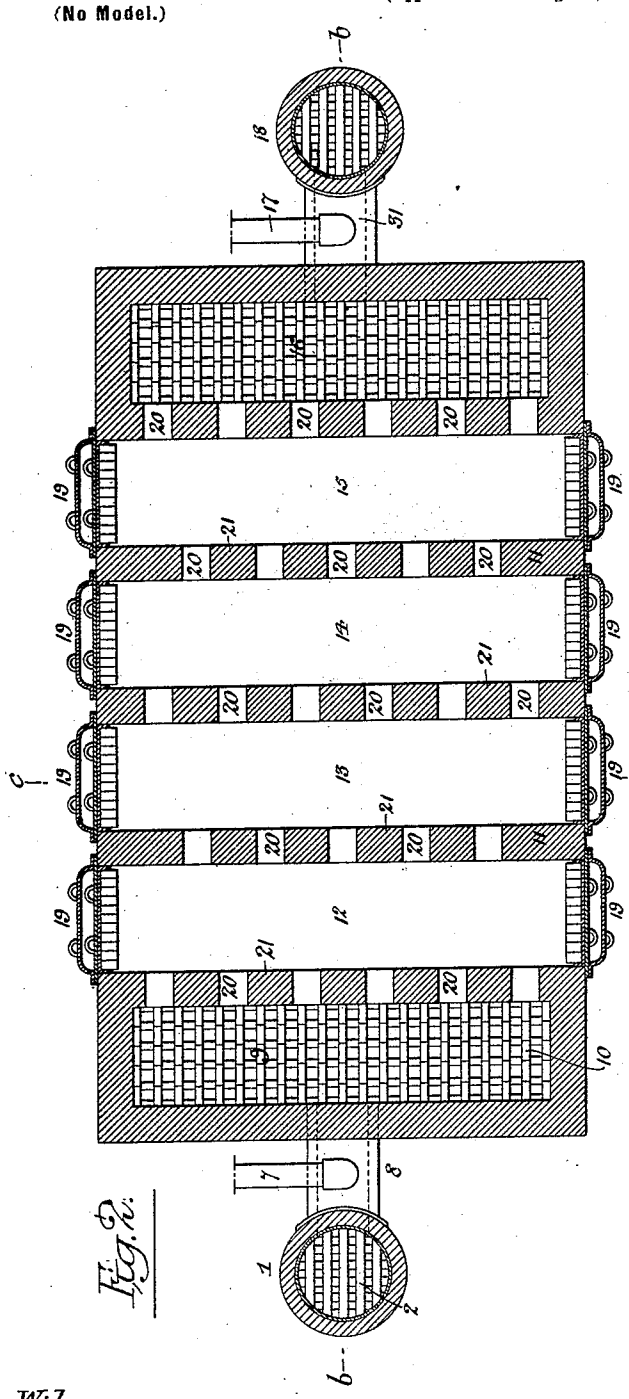

Fig. 4.

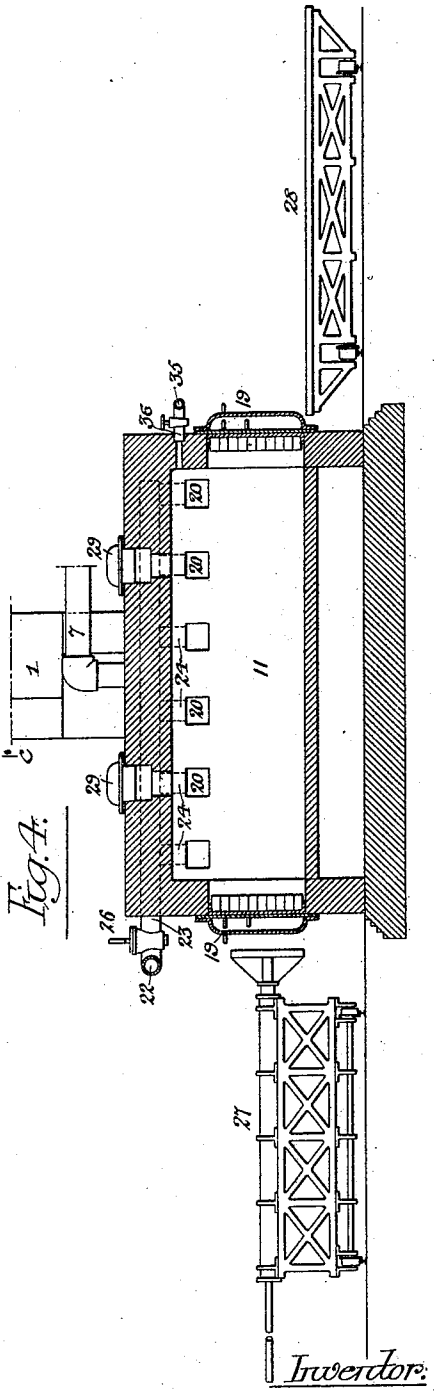

Fig. 5.

Witnesses:-
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(Application filed Aug. 12, 1901.)

(No Model.) 3 Sheets—Sheet 3.

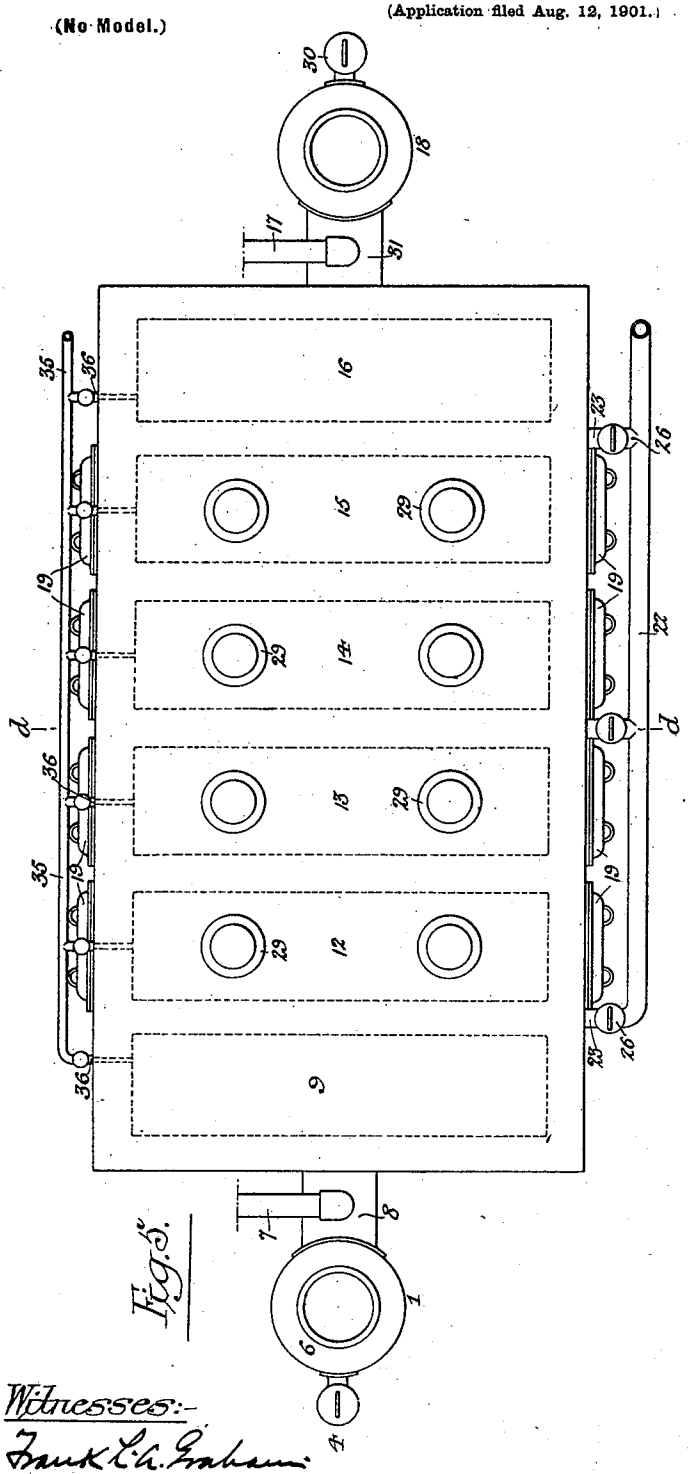

Fig. 5.

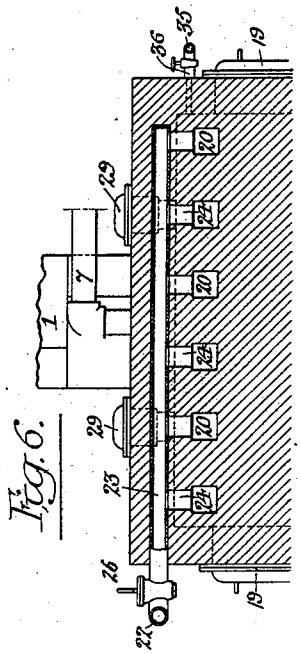

Fig. 6.

Witnesses:-
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UNITED STATES PATENT OFFICE.

THADDEUS S. C. LOWE, OF PASADENA, CALIFORNIA.

APPARATUS FOR THE MANUFACTURE OF COKE AND THE RECOVERY OF GASES THEREFROM.

SPECIFICATION forming part of Letters Patent No. 711,904, dated October 21, 1902.

Application filed August 12, 1901. Serial No. 71,751. (No model.)

To all whom it may concern:

Be it known that I, THADDEUS S. C. LOWE, of Pasadena, California, have invented new and useful Apparatus for the Manufacture of Coke and the Recovery of Gases Therefrom, of which the following is a specification.

In the accompanying drawings, Figure 1 represents a sectional elevation of the complete apparatus through line *b*. Fig. 2 shows a sectional ground plan of the same apparatus through line *a*. Fig. 3 shows an exterior elevation of the same apparatus. Fig. 4 shows a cross-section of one of the coke-ovens through line *c*. Fig. 5 is a plan view of the apparatus; and Fig. 6 is a transverse sectional view on the line *d*, Fig. 5.

In the manufacture of coke two general principles are employed. The one most generally in use is known as the "beehive" oven, so called from its shape. In the center of the arch of these ovens is a charging-hole, through which coal is introduced and leveled over the bottom of the oven to a depth of from one to three feet, the oven being preheated. On one side of the oven is an opening bricked up to within a few inches of the top, and through the opening thus left air is drawn into the oven for admixture with the gases evolved from the charge of coal. This mixture being ignited maintains the heat of the oven, thereby continuing the evolution of gas from the coal until the same is thoroughly coked. During the early stages of the coking period large volumes of combustible gas escape from the charging-hole of the oven and, igniting, burn in the open air, and the resulting heat from this secondary combustion is entirely wasted. After the gases have been extracted and the solid portions of the coal have been entirely converted into coke water is introduced directly onto the coke in sufficient quantities to cool it and to enable laborers to draw the same out through the opening in the side, which is made larger by removing the loose brick at that portion of the oven. This wasteful and slow method of producing coke is now more generally used than any other system simply because of the superior quality of coke made by reverberatory heat in internally-fired ovens. Many attempts have been made, but with slight success, to produce coke in a shorter time, where the coke in an incandescent state is discharged and cooled outside of the oven, principally for the purpose of retaining the heat, which is entirely lost in the aforementioned system. Other forms of ovens are employed to a limited extent, and the builders of the same have made efforts to overcome the difficulties of heating their ovens by utilizing a portion of the gases produced for that purpose; but as they are heated externally the same as the ordinary gas-house retort nearly all of the gas produced is required to keep up the necessary heat, and then the coke is inferior to that produced in the internally-heated ovens. Among the numerous difficulties in the way of an economical production of coke under these systems is the one of keeping up the heat inside of these large retorts, owing to the necessarily very thick fire-brick walls, which allow very little gas to be saved above that necessary to keep up the heat, and, again, the peculiar construction of these ovens makes them subject to frequent expensive repairs.

The difference between my process and the process above described is that instead of heating the ovens externally for producing coke I perform the heating internally and depend upon the reverberatory heat of the arches to do the coking, precisely as in the beehive type of oven, with the additional improvement over the beehive oven of so arranging the apparatus that the air for combustion of the gas arising from the coke is admitted at a very high degree of heat, and all of the gases not burned under the arches of the ovens during the heating process are completely consumed in heating the regenerators, superheaters, and especially-constructed steam-generators. The heating process being intermittent, the greater portion of the time consumed in the coking is utilized in taking off and saving the surplus gases arising from the coking coals. So far there have been no coke-ovens in use where the heating of the ovens has been intermittent and the gases evolved from the coal by the heat reflected from the internally-heated arches have been saved.

To give a clearer idea of my invention, I will now describe the drawings and later on the processes of its operation.

1 is a steam-generator and air-heater hav-

ing a non-conducting lining and loosely filled from top to bottom with metal bars 2, preferably of cast-iron, forming what I term a "regenerative" steam-generator.

3 is a water-pipe having a water-spraying nozzle for spraying water over the heated bars 2.

4 is an air-blast valve for admitting air at the top of the air-heater and steam-generator.

5 is a valved opening into the smoke-stack 6.

7 is a gas-take-off pipe.

8 is a flue connecting the steam-generator 1 with superheating-chamber 9.

10 represents loosely-laid fire-brick filling chamber 9 to the bottom of flue 20.

12 13 14 15 are coke-ovens separated by partition-walls 11.

16 is a second superheating-chamber loosely piled with fire-bricks, the same as in the chamber 9.

17 is a second gas-pipe for conveying gas from the coking apparatus.

18 is a second steam-generator and air-heater in every way like 1 as to construction, valve, stack, water-sprayer, &c.

19 represents movable doors or lids for opening the ovens for discharging the coke.

20 represents flues through which the gases and products of combustion pass while heating the arches of the coke-ovens and taking off gases from the same. Each of these flues is placed opposite to a pier or solid part of the partition-walls 21 in the present instance. This arrangement is for the purpose of breaking up the currents of heated gases for more intensely heating the arches and brickwork of the ovens, as well as to mix the vapors and volatile gases arising from the coke, whereby they are converted into a permanent gas even before they reach the superheaters 9 and 16.

22 is a blast-pipe connected with the flues 23 and provided with valves 26. These flues have slot-openings 24 for delivering atmospheric air into the flues 20. In this case there are two ovens between each blast-pipe.

27 is a discharging-ram for pushing the coke out of the coke-ovens onto a car 28.

35 is a pipe for hydrocarbon oils having valved branch pipes 36, leading to the coke-ovens and to the superheating-chambers.

When it is desired to put these coke-ovens and other apparatus connected therewith into operation, I first heat the ovens, superheaters, steam-generators, and connecting-flues in any manner desired. I then charge bituminous coal or other suitable coal into the coke-ovens 12, 13, 14, and 15 through openings or charging-holes 29. The pipes 7 and 17 are closed either by valves or water seals, and valve 5 in smoke-stack 6 is opened. The coal in all the coking-ovens is then ignited, and a blast of air is forced through valve 30, which in passing down through the metal bars is heated, and after passing through flue 31 passes up through the loosely-laid fire-brick in chamber 16, then out through flues 20 over the coal contained in coke-oven 15. The air mixed with the rising gas and the mixture is burned, and after passing over the coal in ovens 14 the gases of combustion become recarbonated, forming a mixture of carbonic-oxid and other gases. They then receive a fresh supply of air through middle pipe 23 and air-slot 24, and the mixture is again burned as it passes through the flues 20 in the partition or bridge wall separating the ovens, intensely heating the arch of oven 13 and being again recarbonated in oven 12, after which the gases are again mixed with air from another set of flues 23 and the mixture is burned in chamber 9. In this chamber the heat of the products of combustion is absorbed to a great extent in the open brickwork 10. Then the remaining heat of the products of combustion is imparted to the open iron bars in stack 1, said products of combustion finally escaping through valved opening 5 into the open air comparatively cold. In small works having a limited coal-surface area the successive admixture of air with the gases of combustion in heating the ovens would not be necessary, one air-blast from superheater 16 being used for admixture with the gases arising from the coking-coals for heating the walls and arches and a second blast of air for admixture with the gases as they enter superheating-chamber 9 for heating the open brickwork therein contained. These operations will heat the arches of all the coke-ovens to a high degree and cause a giving off of volatile gases from the bituminous coal contained in the coke-ovens. I now close the air-blast 30 and also the valved opening 5. Then I introduce water, preferably in the form of a spray, through pipe 32. The iron bars are still sufficiently hot to generate steam, which steam becomes gradually heated until the same has passed through flue 31 and then becomes further heated by passing up through the open or checker-work brick contained in chamber 16, so that when brought in contact with the volatile matters rising from the coal this highly-heated steam becomes decomposed in contact with the more solid portion of said volatile matters, until it finally becomes a mixture of hydrogen, carbon-monoxid or water gas, and hydrocarbon gas. If it is desired to enrich this gas to bring up the candle-power to the usual standard of gas furnished for lighting purposes, hydrocarbon oils are introduced at any point most desirable between the superheating-chambers 9 and 16. These extra hydrocarbons will immediately become volatilized in contact with the coking coals and the highly-heated brickwork and mingled with the gases from the water and coal will pass together into chamber 9, which has been previously highly heated, and after passing through this mass of open fire-brick to more thoroughly fix the gases they escape through pipe 7 into the usual washers, scrubbers, and purifiers on their way to places of storage or

consumption. This method of introducing steam, owing to its very high degree of heat, does not materially reduce the temperature of the ovens below that at which the steam has been superheated—say anywhere from 2,000° to 3,000° Fahrenheit—but, on the other hand, will tend to somewhat add to the heat during the decomposition of the highly-heated steam. The evaporation of the gases from the coal contained in all of the chambers will have a tendency to slowly reduce the temperature of the arches and surrounding brickwork below the point desirable for coke-making. At this point the heat is restored in the following manner: Stack-valve 33 is opened and air admitted through the center and right-hand blast-pipe 23 and also through valved pipe 4, first introducing water through pipe 3 into generator 1 to generate steam for driving out the gases to prevent explosions. The air becomes intensely heated in passing through the generator 1 and checker-work 10 in the superheater 9. Hence when it reaches the coking-chambers 12 13 and is mixed with the gases evolved from the coal therein the burning of these gases restores the heat taken away by the previous volatilization of the coal and any excess of hydrocarbons which may have been introduced. The gases are again mixed with a blast of air from the center blast-pipe 23 and after being burned in the ovens 14 and 15 and highly heating the arches thereof is lastly mixed with air and burned in flue 20 while leaving oven 15, and the heat of the products of combustion is again stored in and among the loosely-laid fire-brick in chamber 16, the last of the heat being taken out while said products are passing up through the metal bars in steam-generator 18, the products being finally discharged through stack-valve 33 comparatively cool. Thus the process of heating, followed by taking off the gases, is an alternating and intermittent one, and when all of the coal contained in the various coke-ovens has become converted into coke from top to bottom all of the volatile gases will have been utilized either in heating the apparatus or conveyed to points of storage or consumption.

I will describe one complete method of carrying out the process of manufacturing coke by my improved apparatus, although this may be slightly varied without departing from the main features of my invention. If, for instance, the several ovens and regenerators have been brought to a high heat and the coal to be coked is placed in the several ovens, air is admitted through the pipe 4 into the generator or heating-stack 1 and passes through the same and into the superheating-chamber 9 and then through the upper portions of the coke-ovens, uniting with the gases evolved from the coke in the first oven, and consequently forming a combustible mixture, which is burned in the several succeeding ovens, air being admitted to aid combustion and additional gas being supplied from each of the successive ovens. The products of combustion then pass through the superheating-chamber 16 and through the steam-generator and air-heater 18 and out from the stack. When the ovens are brought to the desired heat, the air-valve and the stack are closed, and the apparatus is then in condition to make gas. Water is admitted through the pipe 3 and coming in contact with the heated metal bars in the generator 1 is converted into steam, which is highly superheated as it passes through the chamber 9, and as it passes through the several ovens mingles with the gases evolved from the coke, and the collected gases pass into the chamber 16, where they become fixed and are carried off through the pipe 17. After this operation has been carried on for a certain length of time the temperature of the chambers becomes lowered. The water is then cut off and water is admitted through the pipe 32 for the purpose of driving the gases remaining in the apparatus to the opposite end, so as to avoid explosion. The air-pipe 30 is then opened and the stack-valve 5 is opened. Thus air is admitted to the generator 18, becomes highly heated in passing through the said generator and the chamber 16, and as it passes through the upper portion of the several ovens it mingles with the gases evolved from the coking coal and combustion takes place within the ovens, which brings the heat of the ovens up again. The products of combustion then pass into the chamber 9 in a highly-heated condition, so as to heat the checker-work therein, and then pass into the generator 1, highly heating the metal bars therein, and finally escape from the stack. After the apparatus is brought up to the desired heat the air-inlet is cut off and the stack-valve 5 closed, whereupon the apparatus is again in condition for making gas. Water is admitted through the pipe 32 and is converted into steam in the generator 18, which becomes superheated in the chamber 16 and passes through the upper portions of the ovens, mixing with the gases evolved from the coking coal in the ovens and passes into the chamber 9, where it becomes fixed by coming in contact with the highly-heated brickwork, and is then carried off through the pipe 7, and the above operation is repeated. It will be seen that the air passes first in one direction, then steam is passed in the same direction, then air is passed in the reverse direction, and the flow of steam in the same direction follows. It will be understood that in some instances if air is passed through the apparatus in one direction the steam may pass through the apparatus in the opposite direction, and this may be followed by a flow of air in the same direction. The superior heats obtained by this method will coke the coal in much less time than by any other known method, and by the extra intensity of the heat the coke becomes more firm and hard and will carry stock in a blast furnace or cupola equal to if not better than coke pro-

duced by the best coking systems now known, in addition to which all of the gases are saved and utilized without the use of any other fuels in producing the coke and gas.

If the coal has been placed in the ovens at different intervals, which in practice will be found the best method of operating a battery of ovens on this plan, I discharge the ovens in order, first taking those which have been the longest time exposed to the heat. For instance, if it is to be a twenty-four-hour coke one of the four ovens will be discharged every six hours; if a battery of twelve ovens, the coke would be discharged from one of the ovens every two hours. In this way there is at all times a continuous even flow of gases coming off from the coal, more than two-thirds of which can be saved for commercial purposes and the other third used to heat the brick and iron work.

The part of the hydrocarbons that is most efficient in aiding the decomposition of steam is that portion rising from the coal in a feathery lampblack form, and which in ordinary gas-works is now usually condensed into tar. Thus the permanent hydrocarbons or illuminants are not much, if at all, affected in this operation.

Care should be taken not to introduce over the coals more air or highly-heated steam than is necessary to burn the gases, and thus prevent either the atmosphere or the oxygen of the steam from attacking the solid coke in the ovens. Therefore the combustion and decomposition of the gases are only partial, except when the gases are last burned before entering the open brickwork chamber, when sufficient air should be introduced to perfectly burn the gases, and thus store up the largest amount of heat possible.

The end ovens being the nearest to the superheating-chambers will become the hottest, and the gas will be driven off in less time than in the middle ovens. I prefer when carbureting the gases and at suitable times for the protection of the coke to admit oil through pipe 35, preferably in a spray, over either the end oven or the one that has been longest exposed to the heat. In this way the steam for producing the water-gas will be decomposed before it reaches the open-work superheating or fixing chamber.

The object of the second stack of iron-work in the steam-generating stack above the water-sprayer is to so heat the atmospheric blast that it will not reduce the temperature in the iron bars in the lower portion of the steam-generating stack below the point that will thoroughly convert into steam all the water introduced and bring the same to a high degree of heat even before it finally reaches the fire-brick superheaters. In this method of construction I also extract more of the heat from the products of combustion while on their way out of the stack.

As above noted, all my coking-chambers herein described contain fire-brick partition-walls forming a number of smaller chambers, each partition having flues in the upper portion of the same, which flues are preferably so placed that the gases in passing from one coking-chamber to the other are made to discharge under an arch and against a wall or pier on the opposite side of each chamber, as shown in Fig. 2, in order to break up the current of hot gases and to more intimately bring the same into contact with the greatest possible amount of heated surfaces while passing in either direction to the superheaters through the various flues, over the coking coals, and under the arches covering each coke-oven.

In order to accomplish the coking of coal in a shorter time than is the case in other internally-heated ovens, it will often be found advantageous in addition to highly heating the air to also increase its volume to a point that would ordinarily consume a portion of the solid coal or coke in the chambers, more especially in those chambers nearest to the superheaters, and to avoid this danger of injury to the coke I introduce any suitable ashless volatile carbon or hydrocarbons—such as tar, asphaltum, or heavy crude hydrocarbon oils or oil residuals—onto the top of the coking coals. The coke resulting from these ashless carbons being on the top surface of the coking coals even should an excessive amount of heated air or highly-superheated steam come in contact with and consume a portion of the above-described ashless coke it would in no way injure the coke made from coals by leaving an excessive amount of ash, as would be the case if the coking coals were not thus protected. Among the ashless carbons to be introduced onto the coking coals or mixed with the coal before charging into the ovens are those carbons carried over from the coke-ovens and afterward washed and condensed out of the gas in the usual way of cleansing illuminating-gas. Much of this residuum floats with the water in the form of fine feathery coke or lampblack and is collected in suitable screens, while the liquid and heavy tar are separated from the fixed gases in suitable washers and scrubbers. All of these carbons may be mixed and returned to any one or more of the ovens onto the top of the coking coals, but I prefer to mix the fine lampblack sort of carbon with the coals before they are charged into the ovens and to introduce the more liquid tarry portions of the residuals onto the top of the coking coals, preferably into the oven next to the superheater, from which the hottest air-blast is taken and which usually make this oven the hottest. Simultaneously I spray water over the iron bars in the steam-generator, which is instantly converted into steam and while passing over the highly-heated brick-work in the superheaters becomes so heated that when it comes in contact with the feathery carbon or lampblack rising from these ashless carbons and that of the coal the

highly-heated steam becomes decomposed by taking up sufficient of the volatile carbon to form carbon monoxid and liberating the hydrogen of the steam. These gases then pass off through a second superheater, where the mixed gases are more thoroughly fixed and any remaining particles of carbon and steam are there decomposed in the usual way, as shown in my water-gas patent of September 11, 1875, No. 167,847.

The principal object of first bringing the steam to a high degree of heat before bringing the same into the ovens and over the coking coals is to prevent the passages and the arches of the coking-ovens from being too much reduced in temperature, and thereby check the process of coking, while taking off the surplus gases not needed in keeping up the heat in the process of coking. After a time this steam-superheater will become lowered in temperature to a point that will not keep up the heat in the top portion of the coking-ovens, which are also gradually reduced in temperature, due to the volatilization of a portion of the coal. I then restore the heat to the ovens and to the superheaters last used for superheating steam and the iron bars in the steam-generator connected with this superheater by reversing the current of gas and air for consuming the same in the ovens and the superheaters, when the operation proceeds as before.

Whenever the coking-ovens, superheaters, steam-generators, and brick-work have once become sufficiently heated to operate satisfactorily, it will require, according to size of works—say those of moderate capacity—about twenty minutes to take off the surplus gases, while fifteen minutes will generally suffice to restore the little heat that has been lost. Therefore it will be seen that this method of making coke is continuous, while the heating of the ovens and the collection of gases arising from the coking coal is alternating.

To prevent explosions, one of the most important features of this method of making coke consists in the process of first clearing the stacks and superheaters of combustible gases by driving the same out with steam, to be followed in the same direction with atmospheric air, the steam to be shut off when the air reaches such a point in the superheater or oven that it will safely ignite the gas when coming in contact with the same. In the meantime should any gases pass into the second superheater at the opposite side of the ovens unconsumed before air is admitted for their consumption the same will pass harmlessly out of the stack, for the reason that the last use made of that superheater was for conveying highly-heated steam to the ovens, and therefore contains nothing but steam until gases take its place.

When it is desired to manufacture coke from hydrocarbon oils or asphaltum instead of from coal, the same can be done in the apparatus herein described by admitting oils in limited quantities into any of the highly-heated ovens and bringing into contact with the vapors of the same the highly-heated steam from one of the steam-superheaters, which while passing through the flues and over the various succeeding ovens will deposit along the ovens those heavier portions of the hydrocarbons contained in the materials used, and the gases will be more thoroughly fixed by passing the same through a second superheater or fixing-chamber. The gases resulting from this process while passing through the usual washers and scrubbers will deposit any surplus hydrocarbons or lampblack not converted into gas. These heavier products can from time to time be returned to the ovens and, preferably, on the surface of the highly-heated coke resulting from the use of heavy hydrocarbon oils or asphaltums, and when sufficient of the heavier portions of the materials have been converted into coke the same can be discharged from the ovens in the same manner as is done when coke is made from coal. Coke made from these materials will contain little or no ash and is of superior value as fuel and can also be pulverized and used in the manufacture of electric and similar carbons.

An additional reason for having a second pile of open iron-work above the water-spraying device in the steam-generator, as above described, is to more thoroughly absorb the heat contained in the burned and waste gases while escaping through the stack and enable the air of combustion forced or drawn by natural draft through valved openings to become considerably heated on its way to the coke-ovens, as well as to prevent cooling the lower metal bars much, if any, below the steam-generating point. This form of coke-oven (one or more) can be operated successfully on natural draft by providing openings (not shown) at convenient points for admitting air to burn the gases arising from the coal in the ovens, and when desired by closing the draft-openings the other portion of the gas not needed for keeping up the heat may be recovered by the use of the ordinary well-known gas-exhauster, or the gas may be forced by its own pressure through the usual washers, scrubbers, and purifiers, as in the ordinary retort-gas system and also as in my water-gas generator patented in 1875, before alluded to. It will be seen that by my arrangement of coke-ovens and their connecting-flues as herein shown and described I am enabled to produce an enormous reservoir of incandescent coals under one roof composed of one or more arches of brickwork, and by partition-walls having openings in each near the arches any portion of the reservoir of coal or the resulting coke can be drawn from said oven without in any way affecting the balance of the coals or checking the coking process.

Where one large reservoir of coal is used under one arch, a bridge-wall or a series of bridge-walls can be built, so as to divide the

coal into sections, so that one may be discharged whenever desired without disturbing the balance of the coal. When the coking plant is operated as designed, the time required for discharging the finished coke and recharging the oven will be from three to five minutes, during which time the outside air will be drawn into the open oven through the open doors and the charging-holes in the top, which indrafts of air mix with the gases evolved from the coal in the adjoining ovens or compartments of the general coal-reservoir and cause the same to burn, so as to keep up the heat. The amount of air thus drawn into the coal-reservoir can be easily regulated by a damper in the open stack.

In some instances instead of opening both ends of the ovens and discharging the coke by means of a ram I open but one door and haul the coke out by means of an iron drag.

Over each opening or flue communicating with all the ovens and the brick superheaters I provide an air-inlet, preferably in the form of a slot 24, covering the entire width of the flue in order to bring the air into more direct contact with the gases and in regulated quantities whenever it is desired to burn the same. This method not only secures more perfect combustion, but also from the high heat thus obtained the flames will arise as they emerge from the flues and highly heat the arches and pass off without much, if any, of the free oxygen coming in contact with the coking coals in the ovens below. Also in consequence of each flue opening against solid wall 21 on the opposite side of the oven the zigzag motion of the flames serves more highly to heat the surfaces of the brickwork in each oven thus treated.

Were it not for the convenience of discharging the coke and the desirability of always having coal in the coking-hearths of the ovens in various stages of coking the partition-walls forming a series of ovens would not be needed, and in small works one oven may be used to advantage, especially when oil is used for carbureting the resulting gas, said single oven having on each side open brick-work superheaters and when found desirable steam-generators, all connected with flues arranged as above described. The best results, however, are obtained when the coal-reservoir is divided up by brick walls into a series of ovens parallel with each other and all having connecting-flues, as above set forth.

A series of ovens can be operated with fair results without the checker-work superheaters arranged on each side when said ovens are placed parallel with each other and connected with flues, as herein described, with means for admitting air and burning gases arising from the coals and when desired alternating the direction of the air and discharging coke in sections, as by the more complete apparatus above described.

In place of the checker-work brick superheaters on each side of the ovens one flue or a series of flues for absorbing the heat from the outgoing gases or other known means may be employed for saving and returning the waste heat to the coke-ovens; but I prefer the arrangement as described and shown in the drawings.

When I desire to create a more neutral flame than can be obtained in burning the gases arising from the coking coals to prevent free oxygen from coming in contact with the coke and consuming the same, I introduce in the form of spray or otherwise in regulated quantities either a small amount of tar or hydrocarbon oils, preferably over the oven in which the air first enters.

I do not herein claim the process of manufacturing coke and the recovery of gases evolved therefrom as herein set forth, said process forming the subject of a divisional application filed by me on the 25th day of February, 1902, Serial No. 95,498; nor do I claim the specific form of apparatus embodying one or more coke-ovens in combination with a steam-generator or steam-generators having upper and lower sets of metal bars, for this specific construction is covered by my application, Serial No. 124,761, filed September 25, 1902.

I claim as my invention—

1. The combination of two or more coke-ovens with passages connecting them in series above the coke-line, and means for passing air through the ovens and the passages, substantially as described.

2. The combination of one or more coke-ovens, with means for admitting air and steam alternately to the ovens above the coke-line, substantially as described.

3. The combination of a coke-oven, a superheater, an intermediate passage connecting the superheater with the coke-oven above the coke-line, and an air-supply to said intermediate passage, substantially as described.

4. The combination of one or more coke-ovens, a superheater at each side thereof and communicating therewith above the coke-line by a suitable passage so that the heated gases will pass from one superheating-chamber above the coke to the other superheating-chamber, substantially as described.

5. The combination of a coke-oven, a superheating-chamber on each side thereof and connected thereto above the coke-line, with means for admitting air to either superheater and exhausting the products of combustion from the other superheater, substantially as described.

6. The combination of one or more coke-ovens, a superheater at each side thereof communicating therewith above the coke-line, steam-generators, one communicating with one superheater and the other with the other superheater, means for admitting water to the steam-generators, means for exhausting the products of combustion from either superheater, and means for carrying off the gases, substantially as described.

7. The combination of one or more coke-ovens, a superheater at each side thereof and communicating therewith, air and steam inlet passages communicating with each superheater so that air or steam or a mixture thereof will be heated in passing through one superheater into the coke-ovens, substantially as described.

8. The combination of one or more coke-ovens, a superheater at each side thereof communicating therewith above the coke-line, steam-generators, one communicating with one superheater and the other with the other superheater, means for admitting air to the steam-generators, means for admitting water to the steam-generators, means for exhausting the products of combustion from either superheater, and means for carrying off the gases, substantially as described.

9. The combination of a plurality of coke-ovens in tandem series, intermediate passages forming communication between the several ovens above the coke-line, and air-inlet ports for supplying air to the ovens at different points along the series, substantially as described.

10. A plurality of coke-ovens, each having connecting-flues one with the other above the normal level of the coal to be coked, with means for admitting air at either end of said plurality of ovens, and ports for admitting air to any one or more of the intermediate ovens, substantially as described.

11. A plurality of coke-ovens, each having connecting-flues one with the other, said ovens being flanked at either end by superheating-chambers connecting with said ovens by flues, and means for admitting atmospheric air to any one or more of the intermediate ovens, substantially as described.

12. The combination of a plurality of coke-ovens in tandem series, intermediate passages forming communication between the several ovens above the coke-line, a superheater at each end of the series, and a steam-supply for the superheaters, substantially as described.

13. The combination of a plurality of coke-ovens in tandem series, intermediate passages forming communication between the several ovens above the coke-line, a superheater at each end of the series, and a regenerative steam-generator communicating with the superheaters, substantially as described.

14. The combination of a plurality of coke-ovens, passages connecting the ovens above the coke-line, a superheater and a steam-generator at each end of the ovens, passages forming communication between the superheaters and the ovens, and passages forming communication between the steam-generators and the superheaters, means for admitting air to either end of the apparatus, and means for admitting water to the steam-generators, exhaust-passages in each steam-generator, and means for carrying off the resultant gases, substantially as described.

15. The combination of a coking-oven, a superheater at each side thereof, air-blast pipes, passages forming communication between the oven and the superheaters, air-blast pipes communicating with said passages, and oil-pipes for admitting oil into the oven, substantially as described.

16. The combination of a coking-oven, a superheater at each side thereof, passages forming communication between the oven and the superheaters, a steam-supply communicating with the superheaters and oven, and an oil-pipe for admitting oil into the system, substantially as described.

17. One or more coking-ovens flanked at either end by superheaters, flues connecting the superheaters with the oven above the coking coal, valved openings for alternately admitting air for heating said oven and superheaters, and means for taking off the gases, substantially as described.

18. A series of elongated parallel coke-ovens, with flues connecting all of said ovens above the coke-line, substantially as described.

19. A series of coke-ovens with flues connecting said ovens above the coke-line, said flues being staggered, whereby to interrupt the direct flow of gases through the system, substantially as shown and described.

20. A series of elongated parallel coke-ovens, with flues connecting said ovens above the coke-line, in combination with two superheaters, 9 and 16, operated substantially as shown and described.

21. A series of elongated parallel coke-ovens, with flues connecting said ovens above the coke-line, in combination with two superheaters, 9 and 16, and steam-generators, 1 and 18, operated substantially as shown and described.

22. The combination in a coking plant, of a coke-oven, a steam-generator 1, connecting flues 8 with superheater 9, and a series of flues 20 connected with one or more coke-ovens, substantially as shown and described.

23. The combination in a coking plant, a steam-generator 1, flue 8, superheating-chamber 9, and one or more coking-ovens, superheater 16, flues 20 connecting said superheater and coking oven or ovens, flue 31 and steam-generator 18, substantially as shown and described.

24. The combination in a coking plant, of the coke-oven, having flues 20, an air-pipe 26, slotted ducts 23 connected therewith for conducting air for burning gases while passing through any of the flues 20, substantially as shown and described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THADDEUS S. C. LOWE.

Witnesses:
D. B. RICHARDS,
FRED. KRONENBERG, Jr.