May 14, 1929. F. D. MARSHALL 1,713,189

METHOD OF PRODUCING MIXED COAL GAS AND WATER GAS

Filed April 10, 1926 3 Sheets-Sheet 1

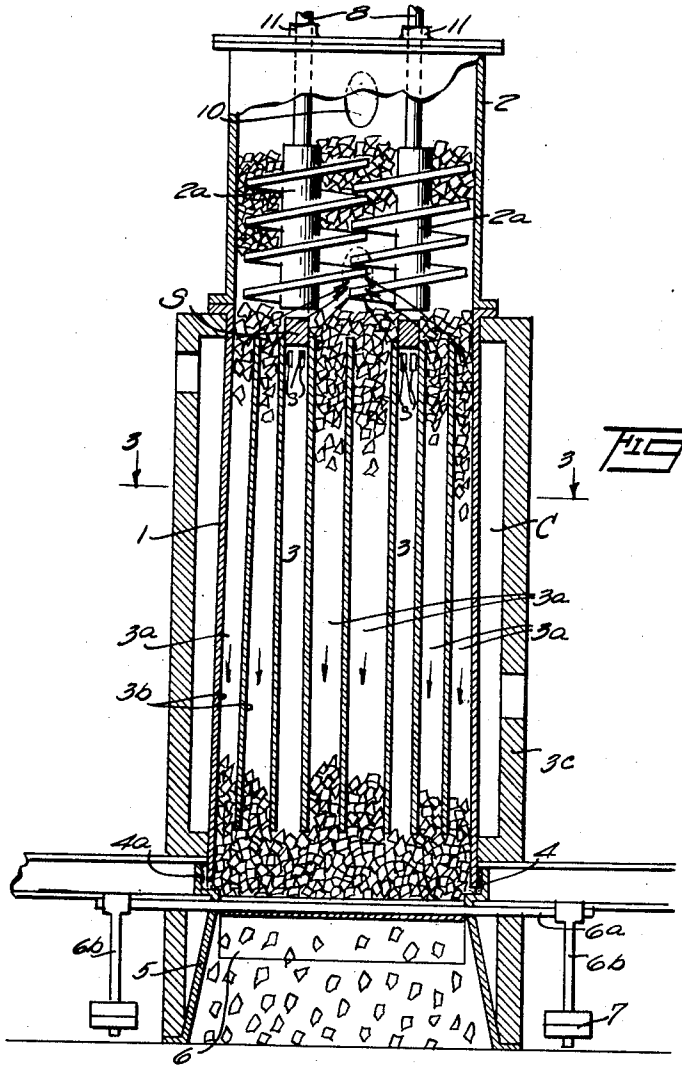


FIG. 1.

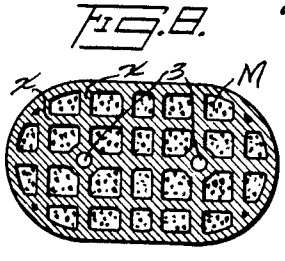


FIG. 3.

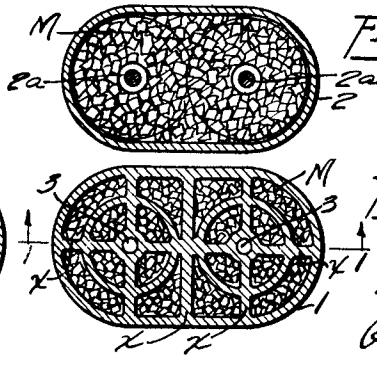


FIG. 2.

INVENTOR
FREDERICK DEACON MARSHALL
BY
Edmund S. Beach
ATTORNEY

May 14, 1929. F. D. MARSHALL 1,713,189

METHOD OF PRODUCING MIXED COAL GAS AND WATER GAS

Filed April 10, 1926 3 Sheets-Sheet 2

FIG. 4.

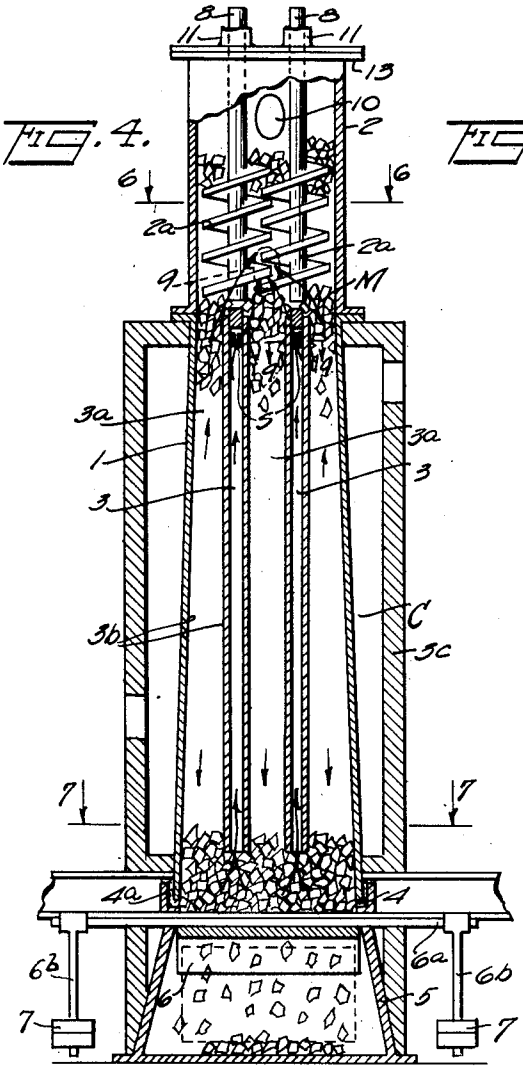


FIG. 5.

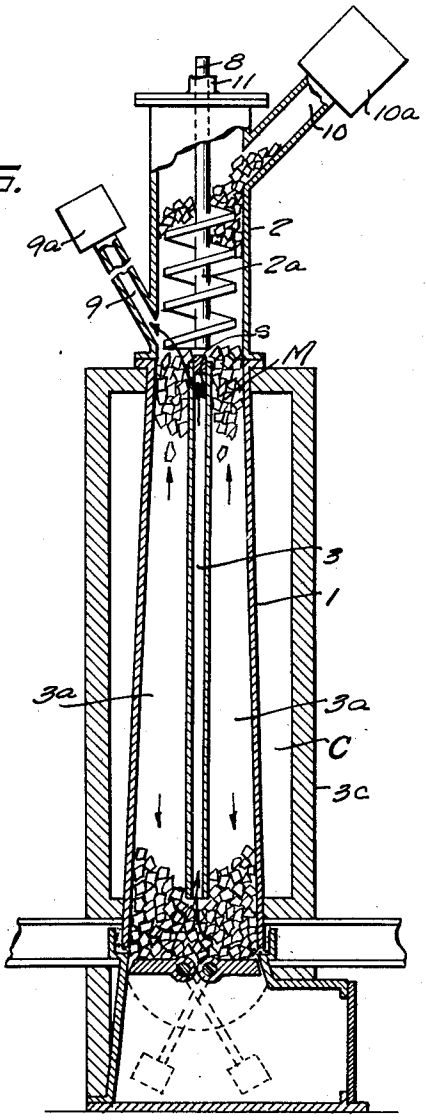


FIG. 6.

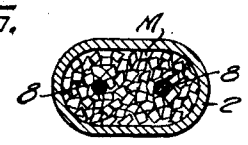


FIG. 7.

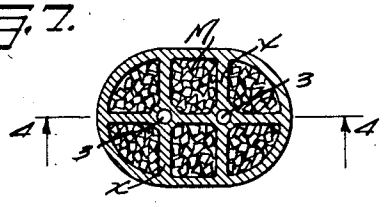
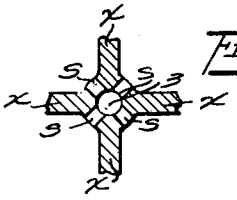


FIG. 9.



INVENTOR
FREDERICK DEACON MARSHALL
BY
Edward J. Read
ATTORNEY

May 14, 1929. F. D. MARSHALL 1,713,189

METHOD OF PRODUCING MIXED COAL GAS AND WATER GAS

Filed April 10, 1926 3 Sheets-Sheet 3

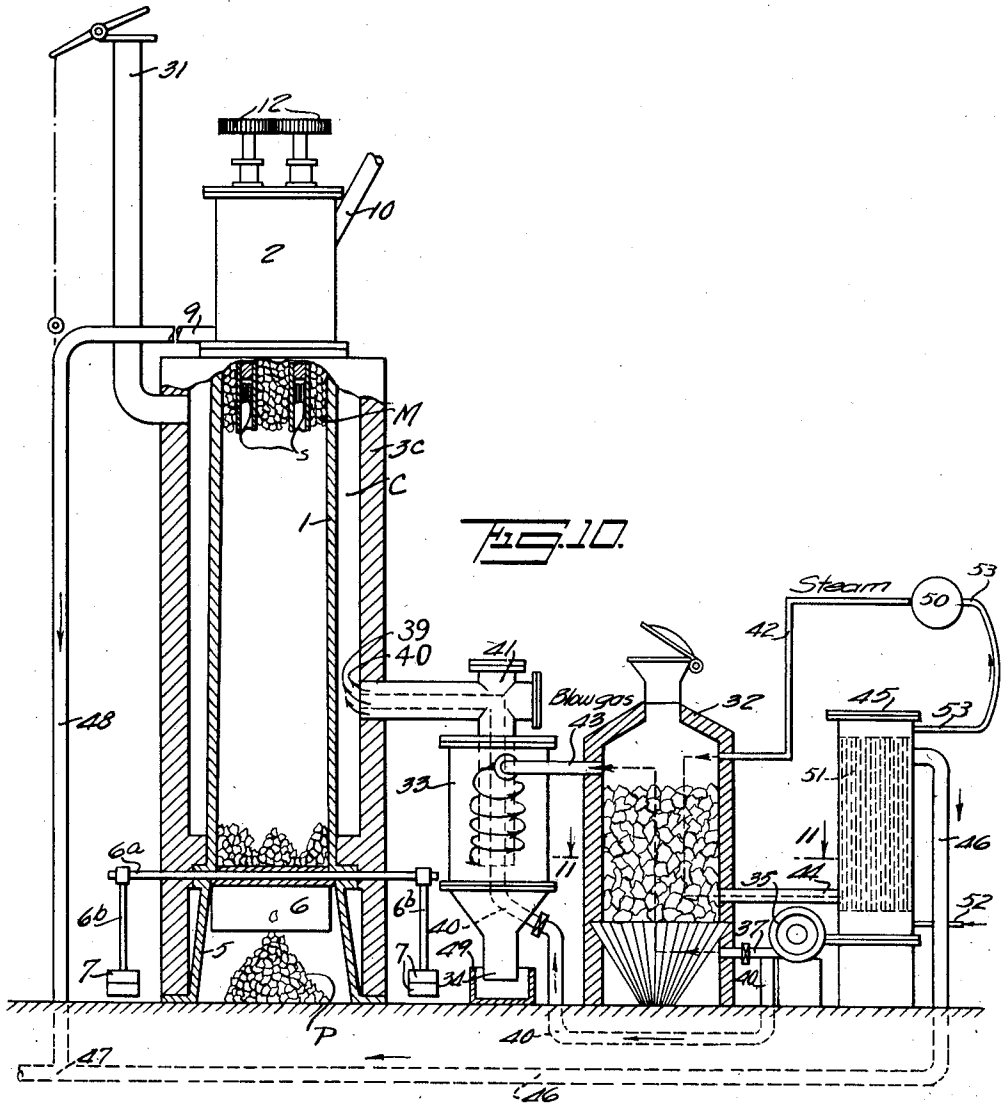


FIG. 10.

FIG. 11.

INVENTOR
FREDERICK OERCON MARSHALL
BY
Edmund S. Beach
ATTORNEY

Patented May 14, 1929. 1,713,189

UNITED STATES PATENT OFFICE.

FREDERICK DEACON MARSHALL, OF WEYBRIDGE, ENGLAND.

METHOD OF PRODUCING MIXED COAL GAS AND WATER GAS.

Application filed April 10, 1926. Serial No. 101,074.

This invention has reference to the art of treating carbonaceous substances for the production of useful by-products and, particularly, my invention relates to a new and useful method or process of producing mixed coal-gas and water-gas.

In the course of this description, various objects and effects of my invention will be made to appear and, to enable the same to be clearly understood, I have provided drawings showing a form of apparatus by which my process can be commercially practiced or carried out, and in said drawings:

Fig. 1 is a vertical, central section of the retort structure taken on line 1—1 of Fig. 3 showing a pair of top feed screws in elevation and illustrating by arrows the direction of fuel under carbonization and by other arrows the upward ascent of gas. The view also shows coke in the process of discharge from the under end of the retort.

Fig. 2 is a transverse section of the upper feeding casing structure illustrated in Fig. 1 and shows the feed casing with a charge of hydrocarbonaceous material, such as bituminous coal, within the casing.

Fig. 3 is a transverse section taken on the line 3—3 of Figure 1 through the retort casing proper and shows the relations of the cells for containing material to be carbonized, to the gas tubes or ducts.

Figs. 4 and 5 illustrate another form of the invention, Fig. 4 being a vertical central section of the retort structure taken on line 4—4 of Fig. 7 and Fig. 5 being a vertical central section at substantially right angles to Fig. 4.

Fig. 6 is a transverse section of the upper feed casing and with the fuel charge in place, at line 6—6 of Fig. 4; and

Fig. 7 is a transverse section of the retort taken on line 7—7 of Fig. 4.

Fig. 8, which is a horizontal sectional view, illustrates another form of cellular retort casing proper construction and wherein material to be carbonized is shown in place in vertical cells and wherein also gas ducts are shown.

Fig. 9 is a fragmentary horizontal sectional view showing the location of the gas outlets at the upper end portions of the gas tubes.

Fig. 10 is an elevation of a plant assemblage useful in operation of present method.

Fig. 11 is an elevational plan of what is shown in Fig. 10 partly in cross-section taken on the line 10—10 of Fig. 10.

I do not herein claim the apparatus set forth as that forms the subject matter of my application Ser. No. 101,073, filed April 10, 1926, which has matured into Patent No. 7,704,094, and of even date herewith. Said apparatus is also partially set forth in my application Ser. No. 101,072, filed April 10, 1926, which has matured into Patent No. 1,704,093.

In the accompanying drawings, 1 is the retort casing proper wherein the material to be gasified is contained. 2 is the head casing; 2^a are a pair of non-contacting feed screws which may either overlap or receive the peripheries of the helices just clearing each other; 3 are the gas ducts shown as connected by cross webs x to the inner sides of the retort casing. It will be noted that these ducts have gas escape openings at their upper end portions. Their tops are closed but they are open at their under ends. The charge receiving cells 3^a are open both at top and bottom. The cell walls are indicated by 3^b. All the duct or passageway walls are connected by webs x. The retort casing 1 is enclosed by a spaced apart combustion or heating chamber wall 3^c.

To prevent coal or other material passing down the gas ducts, the open top of each is fitted with a cover or stopper S above the gas duct escape slots s.

4 is the expansion joint shown in this case at the bottom end of the retort casing and formed by an annulus which encloses the lower end of the retort casing 1 with a space between the exterior of the casing wall and the interior wall of the annulus. This space is filled with a suitable packing 4^a; 5 is the coke receptacle which forms the frame work of balanced flap doors 6 shown attached to a rocker shaft 6^a, the ends of which are provided with counterweights 7 for closing and maintaining the doors in a closed position. 8 are the twin screw shafts; 9 is the gas outlet; 10 is the inlet for fuel to be gasified; 11 are gas-tight supporting glands from which the screws depend.

12 is the turning gear which has been specially designed for the present purpose and which is connectible with an electric motor. The speed of which may be stepped down to give the feed screws a rotational speed of from 6 to 10 revolutions per hour.

The cross section for a retort 1 shown in Fig. 8 is merely another form of the cellular construction above described.

The short screws in the upper non-heated casing act as collectors of the material and

propellers or plungers of the same to force the material which is fed to these screws or propellers downwards through the heated body of the retort casing proper, where the material undergoes carbonization or gasification.

The experience has been gained by the inventor to effect low temperature carbonization at a temperature ranging between 900°–1200° Fah. that the thickness of the material under the process of carbonization or gasification must not exceed four and one-half inches and that provision must be made for applying this heat to all four sides of the material.

As the density of the resultant coke from the material is entirely due not to temperature but to the expansion of the material while in a semi-carbonized or semi-plastic condition and as this expansion exerts a great force, provision must be made that the space through which the material is forced by the pressure, the screws to travel are of sufficient strength to withstand the great pressure.

The bore of the upper feeding casing and the lower carbonizing section is practically the same and when both are soon empty they would represent a true bore from end to end of both sections when fitted together.

The bore of the upper section is filled by the two screws which can be of the overlapping but non-contacting type, or the screws need not overlap but just clear each other.

The bore of the lower casing or retort proper is, however, cut up or sub-divided in horizontal and vertical alignment by a number of radially or transversely disposed members, but so that the spaces enclosed by these members do not exceed approximately four and one-half inches at their thickest line of diameter.

These radial and transverse members are an integral part of the retort casing itself, being cast as part of the same, and by reason of the conductivity of cast iron and by molecular affinity of the iron the heat applied to the exterior of the retort is conducted through all the transverse and radially disposed members and is so imparted to the material which fills the retort cells or chambers during its passage through the same.

The said cells or chambers need not necessarily be of the same cross-sectional area or shape as they may be so shaped as to produce slabs of coke, bearing always in mind the four and one-half inches condition or they may be disposed in honeycomb form for the purpose of producing a briquette like form of coke.

The said members or walls forming the cells or chambers may be located between the outer casing and inner hollow tubes. These tubes are used as gas ducts for aiding the rapid withdrawal of the evolved gases from the retort and have nothing to do with the heating of the same.

During the evolution of the gases the gas outlet is under the influence of sub-atmospheric pressure owing to the action of the gas exhauster 33, which is diagrammatically indicated.

The evolved gases find their way to their outlet through the centres of the charges of material as owing to the pressure exerted on the four sides by the expansion of the charges during carbonization, very little or no gas can find its way up between the outer sides of the charges and the inner surfaces of the containing cells or chambers.

The tube ducts being open at each end are naturally susceptible to the exhauster suction on the interior of the retort generally, and as the evolved gases seek to leave the centres of the charges by the path offering the least resistance, it is open for these gases to leave partly direct through the upper portion of the charges or partly through the lower ends of the gas-ducts, and the arrows in the drawing show the approximate paths the gases take.

Much value is attached to these ducts as the easier and with less resistance the gases can escape, the chances of their being "cracked" or split up is greatly lessened.

To increase the through-put capacity of the retort, the divisions in the retort may be disposed in an annular manner and provided all divisions are connected physically with the outer hearer periphery of the retort, the carbonization of the interior layers will be as equally well effected as in the outer layers.

The power exerted by the coacting screws in the upper casing on the mass of material forced through the lower casing is enormous and provision has to be made to eject the charge of carbonized coke from the casing automatically and continuously before the pressure on the material leads to destructive consequences.

According to my invention this is effected by the installation at the lower end of the casing of a coke box or receptacle within which a pair of flap doors are installed working on hinges which when in a horizontal condition close the bottom of the superimposed casing in a practically gas-tight manner as the edges of the flaps are bevelled to the same angle as the tapering sides of the coke box or receptacle against which they contact, so that the foot of the columns of coke in the casing rest on the flaps which are kept in position by a lever attached to each flap which levers are controlled by weights or springs.

The desired pressure to be exerted by the coacting screws on the charge of material to force the same through the lower casing having been ascertained the levers are weighted

accordingly so that when the pressure on the charge reaches a certain point the flaps are forced open and a portion of the charge in the form of coke is ejected into the gas-tight box or receptacle below the flaps. When the pressure is being relieved, the weight on the levers causes the flaps to return to a horizontal position.

At intervals the coke receptacle is opened and the coke removed during which period the revolution of the coacting screws may be stopped and the flaps held up to ensure against the entering of air into the retort casing.

The design of the flaps may be varied and instead of hinging them on their long sides they may be hinged on their short sides in either case being controlled by the outside levers fitted with either weights or springs.

The density of the coke can be varied by the amount of pressure it is subjected to during its formation in the retort and this controllable variation of pressure is another feature of my invention.

To take up the expansion of the retort in a vertically, longitudinal direction, it is proposed to intervene either between the upper non-heated casing or the lower non-heated section represented by the coke receptacle a loose joint of any desired construction.

The stoppers S at the upper ends of the gas tubes are fixed in place, thus preventing entrance of the material into the gas tubes or passageways; but the gas exit ports *s* are continuously open so that the generated gas may continuously escape therethrough, into the communicating space above and then to the exit 9, while the retorting operation is active.

The rocker shaft 6^a mounted in openings of the wall of the receiver 5 for coke or other residue of distillation, extends at both ends outwardly of the receiver. Each end has a dependent arm 6^b for reception of one or more removable weights 7, two of which are shown on each arm, Figs. 1, 4, 5 and 10. The weights may be increased or diminished in number according to the character of the material to be treated. Receiver 5 is practically air-tight but may be provided with an opening through which the residue of distillation may be removed from time to time, and the opening may be provided with a door, neither of which is shown.

The approximately flat-sided screw casing having arcuate walls, between each two flattened walls, is a feature of the invention. The arcuate walls are closely adjacent and partially enclose opposed portions of the food screw helices while the flattened sides, which are opposed to the overlap or overhang of the helices, affords greater space for material being fed than would be the case if the casings were of a cross-sectionally figure 8 contour.

The combustion chamber C is for heat applied during the retorting operation which may be a low temperature operation for which the apparatus is especially intended.

The intake 10 is provided, in practice, with a gas-tight charging device 10^a of any desired construction. The charging device is herein indicated diagrammatically.

In operation, succeeding initial charging, charge arresting and carbonization, the feed screws may be driven continuously and the charge arresting doors may be continuously opened for either partial momentary interruption of escape, or, for the continuous escape, of the coke into the coke box, with the box door closed to prevent inrush of air, all depending on the character of the material treated and the desire of the operator.

The described arrangement for disposition of the descending material in a plurality of relatively small, cross-sectional and relatively thin walled, lengthwise extending tubes and for simultaneous ascent of evolved gas through the corresponding gas tubes, insures a perfection of carbonization or distillation attended by maximum evolution by gas from the material.

Evolution and removal of the gas is continuous. The charging operation may be continuous or intermittent depending on the type of charging apparatus used. The discharge of the coke into the coke box is automatically intermittent.

In Fig. 5, the gas escape 9 is shown discharging into a diagrammatically illustrated exhauster 9^a. The exhauster connection is sufficient in practice to effect the ascent of gas into the escape 9, notwithstanding the pressure on the charge between the feed screws and flap doors. Some of the ascending gas escapes from fissures in the coke and some of it from material M thereabove.

During the operation of a water gas generator, as is well understood, the generator is filled with carbonaceous material such as coke and raised to incandescence by means of an air blast, technically called the blow period. When the proper degree of incandescence is reached, the blast or blow is shut off and steam is passed through the heated material, this operation being termed the run period. The interaction between the steam and the incandescent carbon generates the water gas which is a mixture composed principally of carbon monoxide and hydrogen. During the operation of manufacturing water gas, three sources of heat are developed apart from the heat which can be generated by burning the water gas itself. These three sources of heat have heretofore principally been regarded as waste heat and are as follows:—(1) the sensible heat of the air blow gas; (2) the heat generated by the combustion of the carbon-monoxide constituent of the blow gas, and (3) the sensible heat of the water gas, and

one of the objects of the present invention is to utilize the three aforesaid sources of heat in connection with the distillation of solid carbonaceous or other materials before they are allowed to pass to the chimney or stack.

Experiments have shown that the heat generated or obtained from the three aforesaid sources is sufficient to effect the distillation of carbonaceous materials.

According to one feature of the present invention, the hot blow gas is conveyed from the water gas generator with as little loss as possible of its so-called sensible heat and together with a supply of preheated air, is admitted to a combustion chamber composed of refractory material and which surrounds a retort within which a process of low or medium, distillation is to be carried on. A combustible mixture is thus produced wherein the sensible heat of the blow gas is added to the heat derived from the combustion of the blow gas itself.

Another feature of this invention is to employ the hot water gas for steam raising purposes or partial steam raising by passing the same through a heat interchanger, the heat generated in the heat interchanger being employed, for example, in raising the temperature of the water supplied to the interchanger which water may be employed in an adjacent boiler, for raising steam and at the same time cooling the hot water gas.

As the process of producing blow gas and water gas is intermittent, two water gas generators, may, if desired, be employed for alternate use.

During the blow period of gas generation and owing to the considerable pressure of the air employed for the blast or blow which air passes through the incandescent coke in the water gas generator a quantity of hot ashes, cinders and dust are carried away with the blow gas and normally are deposited in the neighborhood of the generator. Furthermore, the heat of the said ashes, representing about two per cent of the heat of the coke with which the generator is fed is lost.

According to another feature of the present invention, and in cases where blow gas is ignited in a combustion chamber for the purpose of treating carbonaceous or other materials, the blow gas, before entering the combustion chamber is passed through a so-called cyclone dust arrester. A suitable form of dust arrester consists of a cylindrical chamber with a conical lower part, the gases containing the cinders and dust being caused to enter the upper cylindrical part thereof at a tangent to the periphery of the cylinder, whereby a whirling or centrifugal motion is imparted to the entering gases. Consequently the dust and cinders are thrown against the sides of the chamber and, by gravity, fall to the bottom thereof where they may pass through a pipe or passage into a water sealed tank from which they are raked out from time to time.

According to a further feature of the present invention, and in cases where it is desired to ignite and utilize the blow gas in the aforesaid manner, use is made of the heat of the cinders and dust which pass into the dust extractor to preheat the air required for the purpose of igniting the blow gas. To this end an air inlet pipe is provided which extends axially through the cyclone dust extractor the said air pipe being surrounded by a concentrically mounted pipe or casing through which the blow gas, after the dust and ashes have been separated therefrom passes either to the retort, the boiler or elsewhere. Owing to this arrangement, and on account of the fact that the hot dust and ashes raise the temperature of the parts of the dust extractor to a considerable extent, the temperature of the air is also raised to a considerable extent, the heating operation being further assisted by the sensible heat of the blow gas which may flow along the exterior of the air pipe until both concentrically mounted pipes enter the combustion chamber of the retort or the like.

Referring to the plant structure (Figs. 10 and 11), 31 is a retort stack or snift valve structure, 32 a water gas generator, 33 a dust extractor and preheater, 34 the separated dust outlet of the dust extractor or separator; 35 is an air blower, 36 a motor connected with the blower, 37 the blower discharge pipe, 39 a blow gas duct, 40 a subsidiary air supply duct, the blow gas duct and subsidiary air duct discharging closely adjacent into the combustion chamber C; 41 is the vertical conduit leg of an L-shaped conduit the under end of which is open within the chamber of the dust extractor or separator and the upper horizontal leg of which is entrant into the combustion chamber. The subsidiary air pipe 40 extends from the blower discharge pipe 37 into the under portion of the dust separator 33, thence upwardly within and out of contact with the dependent conduit leg 41 and thence horizontally into the combustion chamber, the upper conduit leg forming the air supply duct 40 closely adjacent the closed blow gas duct 39. 42 is the steam run pipe for the water gas generator, 43 the blow gas discharge pipe from the water gas generator into the upper end of the dust extractor 33, pipe 43 entering the dust extractor, which is circular in cross-section, tangentially. 44 is the water gas escape pipe from the chamber into a heat interchanger 45; 46 is a conduit leading from the heat interchanger for conveyance of cooled water gas therefrom to the junction of the pipe 46 at 47 with the coal gas escape pipe 48 that is in connection with the gas escape pipe 9 of the retort apparatus. The dust extractor 33 has an under end, vertical dust and

cinder discharge into a water tank 49 or other suitable receptacle.

Referring to Figs. 10 and 11 of the drawings, 31 is a chimney stack which in connection with a water gas plant is termed "snift" valve. During the so-called air blow period this is opened by a lever attached to a chain; but during the steam run period, the valve is shut so as to retain the heat of the blow in the combustion chamber.

32 is the water gas generator of which any well-known type may be selected, the sequence of operations being practically the same whichever type of water gas generator be employed.

The fuel required by the water gas generator, viz: coke is preferably supplied from the carbonizing retort to generator 32 which in turn supplies the necessary heat to the retort to enable it to produce the necessary coke, the relation between the two apparatus items being thus reciprocal.

The coke in the water gas generator is blown to incandescence by the turbine positive air blower 35 which is actuated by motor 36. Air passes to the water gas generator 32 by pipe 37 upwards through the coke charge in the generator, being in its passage converted by contact with the red hot carbon into so-called blow gases which are largely a mixture of carbon monoxide (CO), and carbon dioxide (CO_2), and nitrogen (N_2).

These gases before passing into the combustion chamber C surrounding the retort enter the dust extractor 33 wherein, by the centrifugal action of the blast, the ashes, cinders and dust in the blow gases, representing some two per cent of the total heat of the fuel supplied to the generator, are absorbed; and the cleansed gases enter the port leading to the combustion chamber through duct 39.

The blow gases would be unignitable unless supplied with a sufficiency of air, preferably heated, as the hotter this air supply is the more effective and intense is the combustion of the combustible CO in the blow gases. Consequently, a certain quantity of the air representing the main blow to the water gas generator is tapped off by a subsidiary pipe 40 controlled by a valve, the pressure exerted by the turbine blower 35 being sufficient to force this air supply through the pipe 41 which passes through the lower end of the gas outlet pipe 40 and extends through the same. Both the main blow gas pipe 39 and the smaller air pipe 40 are entrant into the combustion chamber together, where ignition takes place; the air having picked up the heat from the ashes, cinders and dust which are scattered all over the interior of the dust extractor.

Returning to the water gas generator, the blow period as described above being finished, after say four minutes of air blow, the valves controlling the blow and likewise the cap of the chimney stack are closed. No valves are shown or described as the working of the valves are well known and to explain in detail well known operations would unnecessarily complicate both drawings and explanation.

The blow valves being closed, the valves operating the run are opened and steam is admitted by pipe 42 to the generator 32 and travels downwards for four minutes or so.

During the passage of the steam through the incandescent carbon, the same is converted into water gas,—a mixture composed mostly of hydrogen and carbon monoxide.

The water gas as it issues through pipe 44 is very hot; its sensible heat being somewhere near 1100° Fah. The temperature of a very large volume of the produced water gas, is such as to either raise some pounds of steam or to raise the temperature of cold water to over the boiling point so that this water could be used as feed water to an adjacent steam boiler.

It is necessary to cool the evolved, heated water gas to a normal atmospheric temperature before the same could be usefully employed.

Therefore, to accomplish both the cooling of the large quantity of heated water gas and to usefully employ the sensible heat of the same, the heated water gas is passed by pipe 44 into a so-called interchanger 45 which is fed by cold water which coming into contact with the sensible heat of the water gas, is raised to practically the same temperature, allowance being made for radiated and converted heat losses. But by a properly constructed heat interchanger, all the sensible heat can easily be removed from the heated water gas and a supply of low pressure steam or water heated to over 212° Fah. can be obtained.

On leaving the heat interchanger, the cooled water gas passes by pipe 46 to the pipe junction 47 where it meets and is mixed with rich coal gas from the retort through the pipe 48 that communicates with the gas outlet 9 of the retort.

In the distillation of coal, the products are a rich coal gas; ammonia vapors, tar oils containing spirits, oils, tar acids of the cresol-phenol types, paraffin wax, and pitch containing a very low percentage of free carbon and coke.

The quantity and quality of these products depends entirely on the temperature at which the fuel selected is carbonized in the special retort and one object of the process is to effect carbonization at a temperature which will yield a very rich gas of about 600–800 B. t. u. per cubic foot and which will produce oil-bearing vapors which, on being condensed, will be of the aliphatic series of paraffinoids and removed as far as possible from the aromatic or benzenoid series, and to effect this

result the temperature within the carbonizing and distillation retort itself must not exceed or considerably exceed some 1400° Fah. as beyond this temperature the benzenoid series begin to appear, and if the temperature be raised to a maximum the retorts could stand say 1700° Fah. the objectionable naphthalene series would likewise appear.

The dust laden blow gas enters the dust separator through its circular, casing side and discharging interiorly to some extent tangentially causes the dust laden gas to whirl violently as indicated by arrows, the dust and cinders dropping downwardly through the under outlet 34 into a water tank.

The coal becomes plastic in a stratum or in strata where it changes into coke in the retort. By keeping the in-fed coal and the coking plastic stratum or strata under constant pressure as described, the formation of thin and fragile walled coke cells is prevented and a dense compact coke product obtained. Such a densification is of very great importance to the coke product as it does not break up or give off coke dust as is the case with coarsely cellular coke. Moreover, the constant compression is favorable to evolution of the gas evolving from the coking portion of the coal and from the coal.

What I claim is:

The herein described method of making mixed coal-gas and water-gas, consisting in feeding coal under mechanical pressure through a plurality of passages into a vertical carbonizing retort; carbonizing the coal under mechanical pressure to produce coal-gas and coke; separately removing the coal-gas from the retort; passing the coke into a water-gas generator; air blasting the coke in the water-gas generator and thereby generating blow-gas; passing the blow-gas in heat interchange with air; mixing the blow-gas and heated air; burning the mixture and thereby externally heating the carbonizing retort; then alternately passing steam downwardly through the heated coke in the water-gas generator and thereby generating water-gas; separately removing the hot water gas from the water-gas generator; cooling the water-gas by heat interchange with water in a steam boiler and thereby generating steam for the water-gas generation; and then mixing the water-gas with the coal-gas, substantially as described.

Signed at New York city, in the county of New York and State of New York, this 12th day of March A. D. 1926.

FREDERICK DEACON MARSHALL.