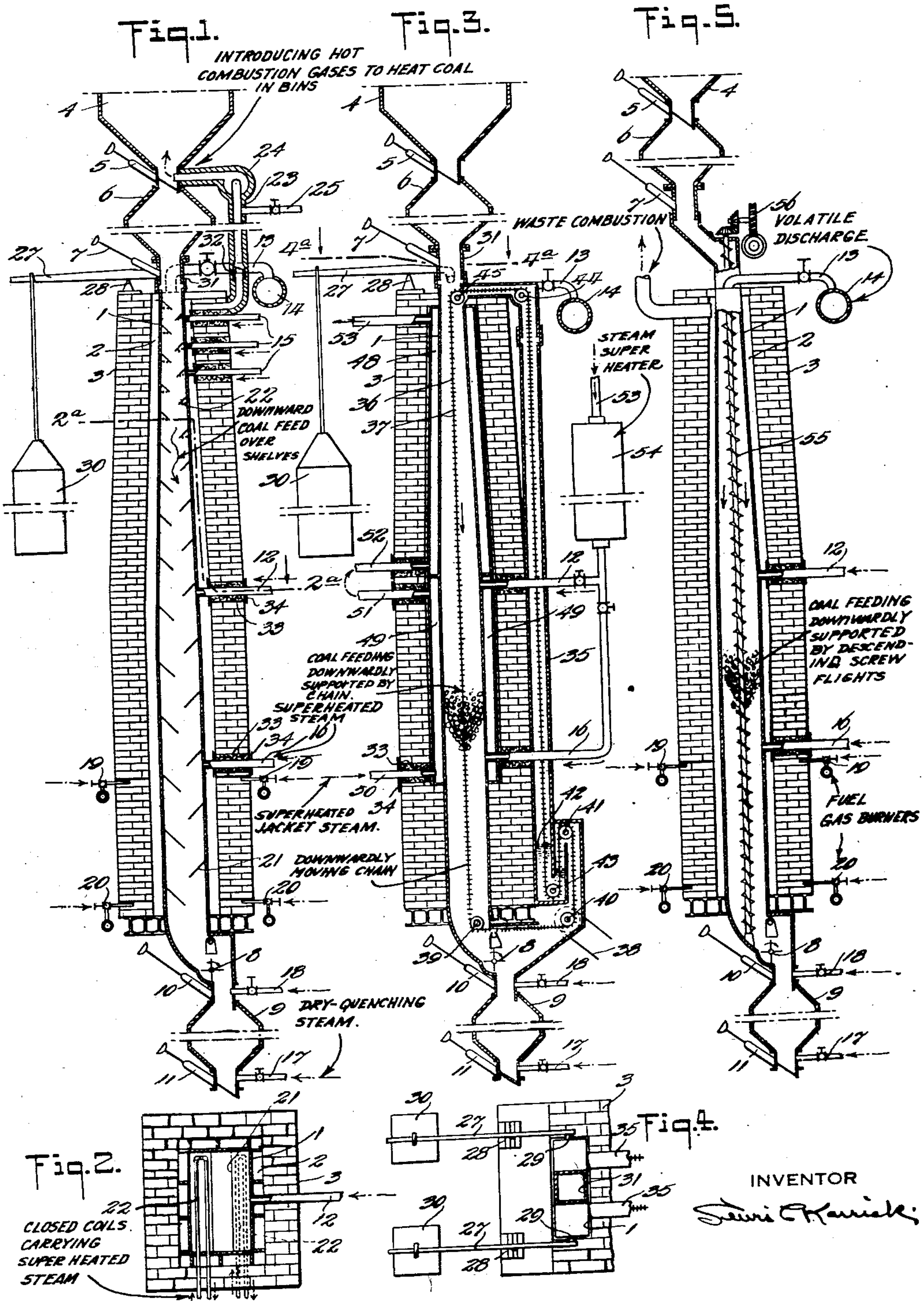
Dec. 12, 1933. L. C. KARRICK 1,938,596

RETORT

Filed June 14, 1928 2 Sheets-Sheet 1



INVENTOR

Lewis C. Karrick

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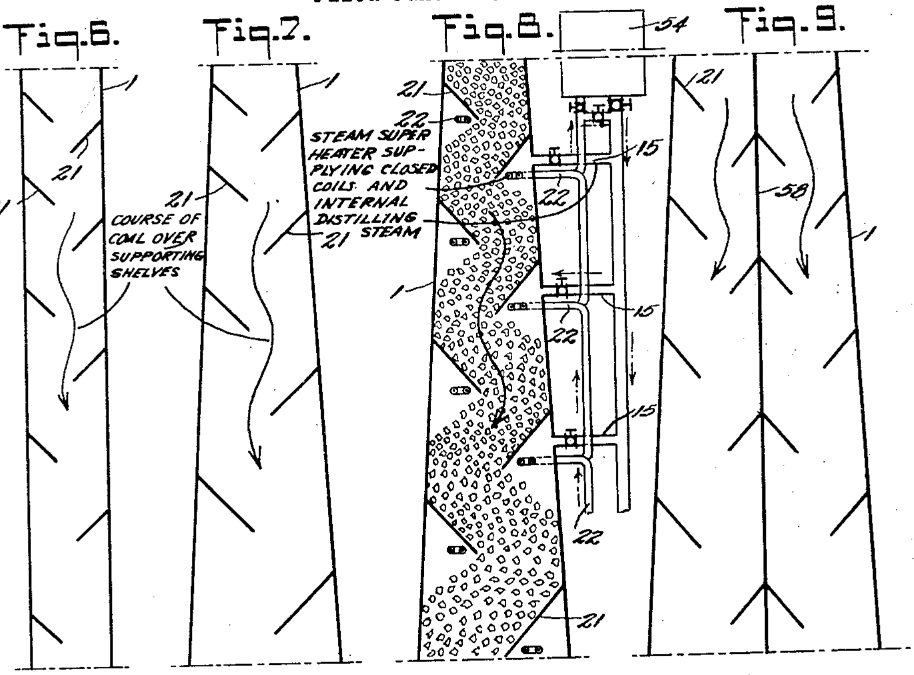

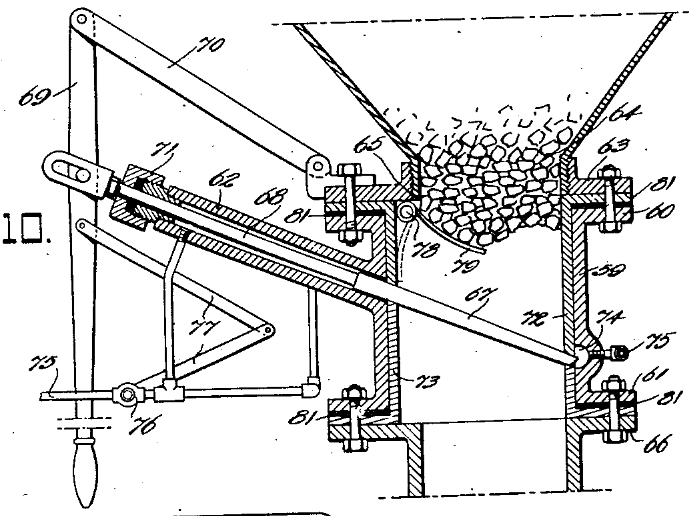

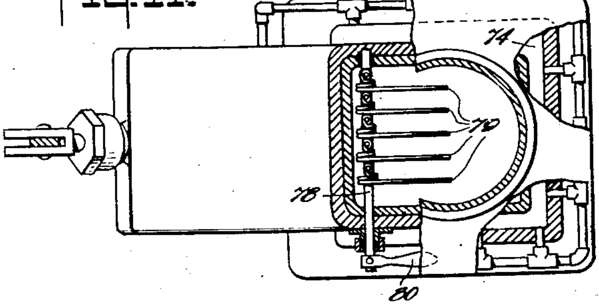

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UNITED STATES PATENT OFFICE

1,938,596

RETORT

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Application June 14, 1928. Serial No. 285,426

3 Claims. (Cl. 202—221)

This invention relates to apparatus for treating coal and other carbonaceous materials to obtain solid, liquid and gaseous products therefrom.

An object of the invention is a retort for distilling such materials under controlled conditions of low temperature carbonization to produce coke of improved physical and chemical properties, with accompanying high yield of valuable tar-oils and gases.

Further objects of the invention are to provide a retort for subjecting sized coals to variations in pressure during various stages of distillation so as to compress the resulting lumps of coke and prevent their excessive swelling or disintegration; for producing dense coke in lumps substantially the size of the lumps of coal treated; to increase the life and efficiency of metal retorts particularly by providing means for preventing warping or buckling in the region of greatest temperature; to increase the capacity of carbonizing chambers while controlling the effective weight of the contained material at all points therein; to provide an improved economical apparatus employing superheated steam as a principal heating medium for distilling carbonaceous materials; and to provide an improved quick-acting gas-tight valve for controlling the flow of solid material.

In using the retort carbonaceous material, preferably sized dust-free coal, is lowered by gravity through a heated retort or carbonizing chamber counter-flow to a rising current of superheated steam which carries the volatile distillates upwardly. In some cases, however, I pass the steam and gases in parallel flow with the coal as hereinafter described. In the preferred embodiment of the invention the superheated steam, preferably heated to above 1200° F., is introduced near the mid-point of the chamber and passes out at the top with the volatiles from the coal, and thence passes to condensers in which the tar-oils are separated from the gases and into fractions, and the water is removed. If it is desired to increase the yield of gas from the coal by removing additional quantities of the residual volatiles, and to convert part of the coke to water-gas, I introduce steam which is more highly heated into contact with the active coke toward the bottom of the chamber. The steam and the active coke from the process react rapidly above 1200° F. to form water-gas. This steam is quickly cooled to about 1200° F. by the endothermic reaction with the coke and, as it rises to the mid-point of the chamber, the steam now cooled to say 1200° F., together with the water-gas formed, serve to furnish the internal heat required for low-temperature distillation in the upper zone of the carbonizing chamber. In treating some coals it is desirable to subject the lumps while at low temperatures to a sudden blast of highly heated steam so as to quickly char or carbonize the surfaces, thereby "case hardening" the lumps and in such case I introduce the steam at points near the top of the chamber and remove part or all of the steam and volatiles at the mid-point of the chamber.

In the preferred form of the invention, I also heat the carbonizing chamber externally by passing hot gases or superheated steam through continuous vertical flues, or jackets, surrounding or comprising the walls of the chamber. These jackets are preferably installed in independent units surrounding the low temperature and the high temperature zones of the carbonizing chamber so that the chamber walls can be separately heated to the desired temperatures best suited to the reactions in the several parts of the chamber. I also provide radiators heated with superheated steam which are placed in the distilling zone to supply indirect internal heat when needed to control the temperature and quality of the vapors. Beneath the lower end of the carbonizing chamber I provide means for introducing saturated steam to dry-quench the coke product. This steam is employed in a quantity sufficient to cool the coke to near the temperature of the steam, after which it passes up through the carbonizing chamber abstracting further heat from the descending coke, thereby becoming superheated and assisting the distillation of the coal in the upper part of the chamber. Only such amount of dry-quenching steam is used as will economically cool the coke without reducing the inside operating temperatures of the carbonizing chamber.

From an economic standpoint it is desirable to pass the maximum possible tonnage through the carbonizing chamber. If a descending column of lump coal is heated very slowly, which is the case if the coal descends slowly in the carbonizing chamber, the weight supported by a lump of coal (the effective weight of the column exerted on any lump) is less than when the coal descends rapidly. This is because with the slower rate of distillation the coal becomes more uniformly plastic and compressible and tends to arch at many points, and because there is less agitation (a lower degree of mobility) of the column of coal when moving slowly. The only way to increase the capacity of a carbonizing chamber of given cross-section while allowing a proper rate-of-rise in temperature (time of heating) for lumps of a given size, is to increase the height of the carbonizing chamber and the corresponding rate of downward movement of the coal. In actual practice, however, it has heretofore been impossible to increase the capacity in this manner because of the added weight to which the coal is subjected by virtue of the increased height of the column, and the resulting tendency of the coal to agglomerate and clog the chamber.

This difficulty is overcome by the present invention which provides means for materially increasing the height and capacity of the carbonizing chamber without increasing, but in fact actually decreasing, as required, the effective weight or pressure to which the lumps of coal are subjected throughout the entire treatment. This is accomplished by providing a plurality of supporting members, spaced in predetermined relation inside the carbonizing chamber, to control the load supported by each lump of coal at any stage of its passage through the chamber. In one embodiment, hereinafter described, the distilling lumps are caused to roll one upon another as they descend. This latter treatment is beneficial in the case of some coals, causing the resulting lumps of coke to become rounded while experiencing very little abrasion. In all embodiments a certain amount of "loading" of the coal (pressure) is permitted at all times in order to control the density of the final coke product, but the "loading" is so gauged and of such amount that the result will be beneficial at each step. Regulated pressure is applied when the coal begins to expand or soften. The pressure is then reduced as the plasticity increases, but then reaches a maximum as the stage arrives where rigid coke is forming. Finally the pressure is reduced when excessive pressure might cause crushing of the rigid coke.

In the preferred form of the invention a plurality of variably spaced sloping supports are mounted within the carbonizing chamber to regulate the pressure on the lumps of coal at different stages of the heat treatment as the coal descends in contact with the superheated steam. In the simplest form, say for a coal that has practically no plastic or very weak stage in its distillation, I provide stationary sloping supports mounted in staggered relation on opposite walls of a carbonizing chamber which may be tapered or parallel. For this type of coal, the supports may be equally spaced and of such angle that the coal readily slides from one to another as it descends through the carbonizing chamber. The size, slope and space of the supports, as well as the clearance between the lower edge of the supports and the opposite wall, depend upon the size and shape of the coal to be treated, the mobility of the coal column, the nature of the treatment, and the size and shape of the carbonizing chamber, as hereinafter more fully described. In another form of the invention the supporting means for controlling the pressure on the lumps of coal may be in the form of a vertically moving element, such as a downwardly moving link chain having lateral extensions, or a continuous screw which provides a continuously descending helical support which may be varied as required. The feature of variable "loading" may also be accomplished simultaneously by the irregular spacing of sloping side-wall supports used in combination with central moving supports.

Another feature of the invention resides in a novel construction which increases the life and efficiency of all-metal retorts, particularly by preventing warping or buckling of the walls even in the region of greatest temperature. Heretofore it has been thought necessary to construct gas retorts and coke ovens of non-metallic materials in order to obtain satisfactory service under the high operating temperatures encountered. The commercial Scottish oil shale retort, which applies temperatures within the range used by my processes is constructed with brick walls in the lower (high-temperature) zone, and cast iron walls in the upper (low-temperature) zone. I provide an improved all-metal retort, preferably employing a chrome-iron alloy in cast or rolled plate form for the walls and flues in the high-temperature zone, and calorized steel plate or cast steel in the low-temperature zone. The seams throughout are welded or upset to insure a gas-tight structure when operated under pressure. Calorized steel will give good service in the lower zone if the process is operated principally for low temperature distillation treatment of coals and not at extremely high temperatures for the production of large quantities of water-gas.

In order to prevent the metal walls from warping due to stresses produced by sudden or uncontrollable fluctuation of the temperatures in the heat sources, the metal walls and reinforcing ribs are left free to expand and contract independently of the enclosing brick work. Also, in heating with gas, I prefer to use air and gas mixing blowers and burners that will insure a uniform and controlled quantity and quality of fuel, and which operation will be independent of atmospheric influences; such devices are perfected and are coming rapidly into wide commercial use. It is very important to minimize the pressure or weight stresses on the metal walls, particularly in the hottest zone, and this I accomplish preferably by suspending the retort from a point near its upper end where the temperatures of the retort walls are sufficiently low to obviate any danger of warping caused by the weight of the superimposed structure. I provide a simple and efficient arrangement of weights and counter-balances adjusted to take all the load off the portions of the metal walls which are subject to greatest temperature, and preferably maintain such portions of the walls under slight tension especially if the walls below are subject to dangerously high temperatures. The extreme tension to which the uppermost part of the metal walls is subjected will have no damaging effect because of their lower temperatures and greater metal strength. The arrangement for counter-balancing the weight of the retort provides constant metal tension at all times as the retort expands and contracts upwardly and downwardly with changes in temperature. In order to allow the vertical movement of the retort to be independent of the coal charging means, I provide a gas-tight slip-joint between the bottom of the coal charging means and the top closure of the carbonizing chamber.

These and other features of the invention will be described in connection with the accompanying drawings in which similar reference characters indicate corresponding parts in the several views, and in which:

Fig. 1 is a diagrammatic illustration of carbonizing apparatus embodying the invention;

Fig. 2 is a section taken on the line 2a—2a of Fig. 1;

Fig. 3 is a view similar to Fig. 1, showing a modified construction of the supporting means for controlling the pressure on the coal and a novel arrangement for heating the walls of the carbonizing chamber;

Fig. 4 is a section taken on the line 4a—4a of Fig. 3;

Fig. 5 is a view similar to Fig. 1, showing still another arrangement for controlling the pressure on the descending lumps of coal;

Figs. 6, 7, 8 and 9 are diagrammatic views showing various arrangements of sloping supports within the carbonizing chamber to regulate the pressure on the coal at different stages of treatment; Fig. 8 also shows a system of connections used for supplying direct and indirect internal heat to the chamber;

Fig. 10 is a sectional view of a quick-acting gas-tight valve for controlling the supply of solid material; and

Fig. 11 is a plan view partly in section thereof.

Arrows are shown on the drawings with full lines to indicate the movement of the solid carbonaceous material in the chamber, and with dot-and-dash lines to indicate the flow of steam, and with dotted lines to indicate the flow of air and fuel gas or products of combustion.

In Fig. 1 the metal reaction chamber 1 is surrounded by a system of flues 2 enclosed in heat insulating walls 3. Dust-free coal of substantially uniform size is charged into bunker 4 and is then fed through valve 5 into magazine 6 from which it flows continuously by gravity through valve 7 into the reaction chamber 1 which remains full of coal at all times. At the bottom of the reaction chamber is a discharge device comprising a wheel having pockets 8 which is rotated continuously in the direction of the arrow by means of any suitable power device, not shown, which withdraws coke from the reaction chamber and drops it into receiving bin 9 through valve 10 which normally remains open. At the bottom of bin 9 is a valve 11 which remains closed while bin 9 is being filled. After the bin 9 has been filled the valve 10 is closed and valve 11 opened momentarily to permit the contents to be removed, after which valve 11 is again closed and valve 10 opened and the operations repeated.

Superheated steam, or superheated steam and water-gas, for use in distilling the coal is preferably introduced into the reaction chamber by means of insulated pipe 12. This steam rises counter-flow to the descending column of coal while giving up its superheat to the coal, and is drawn off together with the volatiles from the coal by vapor pipe 13 and thence passes into main 14 leading to suitable fractionating condensers. Leading into the top of the reaction chamber are insulated pipes 15 by which superheated steam may be directed into contact with the incoming coal. I have found that some coals soften excessively when subjected to the dissolving and disintegrating effect of heavy condensates from the tar-oils which may precipitate or condense on the coal lumps which are at lower temperature toward the top of the chamber. Steam may be admitted through the pipes 15 to remove such heavy tar-oils and prevent them from condensing on the coal in the upper zone of the chamber. Superheated steam which may contain water-gas at very high temperature may also be admitted through pipes 15 in order to quickly carbonize the outer surface of the coal and thereby produce a shell or protective layer of coke on the lumps of coal. This latter procedure is used when the coal is of a fusing or weak type. In some cases the steam introduced through pipes 15 may be drawn off either partly or entirely at pipe 12 and is then carried to condensers by means of suitable conduits, not shown.

Near the bottom of the chamber 1 is another insulated pipe 16 by which superheated steam may be introduced into the reaction chamber when it is desired to form water-gas by the reaction of the superheated steam on the coke formed in the upper distillation zone. When superheated steam is introduced into the reaction chamber by pipe 16, the amount of superheated steam introduced through pipe 12 or pipes 15 may be reduced, or may be entirely shut off.

In order to dry-quench the coke formed by the process, and impart highly reactive properties thereto, saturated steam is introduced into the reaction chamber through pipe 17 located at the bottom of the receiving bin 9. This steam rises counter-flow to the coke and abstracts its heat, thereby becoming superheated and assisting the distillation of the coal in the upper part of the reaction chamber. When valve 10 is closed momentarily for the purpose of permitting the bin 9 to be emptied the saturated steam is introduced through supply pipe 18 while pipe 17 is shut off. The reaction chamber 1 is heated externally by burning gas in the flues 2 which surround the chamber. A plurality of gas burners 19 and 20 provides at different levels along the walls of the chambers means for regulating the amount of heat supplied to the various flues, and serves to control the temperature at different heights in the flues.

The reaction chamber 1 is provided with sloping supports 21 projecting from the side walls and mounted in staggered relation at varying distances from top to bottom. These supports are substantially flat, are placed at an angle steep enough to permit the lump coal to slide off the upper surface, and are spaced at suitable distances apart to prevent the lumps of coal at any point in the reaction chamber from being subjected to excessive weight such as would cause their agglomeration or disintegration. The sloping supports project part way across the reaction chamber leaving ample clearance between their outermost edges and the opposite wall, and between the adjacent supports, so that the coal will not arch and interrupt the continuous downward movement of the column. The tendency of most coals is either to fuse or disintegrate to some extent while being devolatilized. The provision of the sloping supports 21, however, largely prevents the coals from falling to pieces or compressing into agglomerated masses, so that the coke product remains in lumps substantially the size of the original lumps of coal and becomes sufficiently dense to withstand the wear and tear of handling. I have found that a coal of the fusing type may, when in lump form, be heated slowly so that all portions of the lump are at the same temperatures at the same time, and thereby the lump becomes uniformly plastic or fused throughout. If a lump of the same coal is heated more rapidly there will be a large difference in temperature between the outside and the inside during the distillation so that the outside will become plastic while the interior is still solid, and, as the treatment continues, the outside becomes a rigid coke while the interior is still plastic.

If the lump is subjected suddenly to very high temperatures the outside distills very rapidly or "scorches" and turns to coke so quickly that it tends to fall to pieces due to the quick changes of volume of the surface layers as they change to coke while the interior of the lump is substantially unaltered. These properties and phenomena are best exemplified by the behavior of large lumps of coal where the mass factor is important in relation to temperature differences at different depths, to the progress of the changes of state as distillation moves inwardly, and to changes of volume of the concentric layers of the distilling lump, etc. When a very small lump or dust-size particle of coal is subjected to the same heating conditions the above phenomena are substantially surface reactions and mass and thickness become inconsequential as factors limiting the rates or temperature at which heat may be applied.

Dust-size particles may be distilled or gasified by steam in a fraction of a second, but I have found that with such sizes the reactions are best accomplished by passing the material in suspension through externally heated tubes as described, for example, in my application Serial No. 144,947, filed October 29, 1926, and in my application Serial No. 241,287, filed December 20, 1927.

The intermediate sizes of coal such as are commonly known as "pea", "nut", "egg", etc., present problems of handling while distilling which are quite different from those met in handling the above extreme sizes and it is to such classes of coal that the present invention is particularly directed. The application of the invention is best illustrated by reference to the treatment of Utah coal from the Mesa Verde formation which is high oxygen bituminous coal containing my forty per cent volatiles. When lumps of Utah coal sized to 4 inches were confined under the pressure of contacting lumps and surrounded by steam at 1200° F. the surfaces of the lumps of coke flaked badly. However, when another similar charge of coal was distilled by heating with very gradual rise in temperature the lumps were substantially intact but were deformed somewhat by the pressure of adjacent lumps due to expansion of the mass. I have found that lumps of four-inch coal will not be excessively deformed by the weight of a moving column less than 20 feet high. Coal sized to 2½-inches and heated similarly did not flake off badly, but the lumps were more extensively deformed when subjected to a gradual rise of temperature. This coal will not be deformed materially when distilled under the weight of a moving column 15 feet high. Coal or 1½-inch size was less affected by contacting with steam at 1200° F., but when subjected to gradual rise of temperature the lumps could be completely distorted by continuous pressure. This coal was not materially deformed when distilled under a moving column 10 feet high. Coal of −1+¾− inch was very little affected by flaking when suddenly contacted with steam at 1200° F., but when subjected to a gradual rise of temperature and continuous pressure the lumps were pressed into a dense, homogeneous aggregate. This coal would deform and cohere considerably when distilled under a moving column 6 feet high. When the coal was of still smaller size the sudden hot blast of steam at 1200° F. did not cause disintegration of the particles if in a confined space such as a moving or stationary column. However, the small size of the coal particles permits about equal degrees of fusion to take place throughout the particles so that ½-inch coal coheres in a moving column 4 feet high and in a stationary column barely 2 feet high, whereas ⅛-inch coal coheres in a moving column of less than 1 foot in height and in a stationary column only 4 inches in height.

The sloping supports 21 are substantially flat, as shown, and slope downwardly toward the opposite wall of the reaction chamber 1, serving not only to support portions of the moving column but also to deflect the distilling lumps of coal repeatedly during their descent through the chamber. The clearance space between the lower edge of any support and the opposite wall should not be less than five times the maximum diameter of the largest lump of coal composing the charge since otherwise the charge might tend to form a rigid arch and stop moving. The vertical spacing of the supports 21 will vary in the different heating zones, depending upon the size and character of the coal treated, and should be the maximum that the distilling coal can support without disintegrating or agglomerating, thereby obtaining a maximum compression which results in producing extremely dense lumps of coke. When the walls of the chamber 1 are substantially vertical, as shown in Fig. 6, or slope outwardly very slightly, as shown in Fig. 1, the vertical spacing of the supports 21 should increase somewhat from top to bottom to cause continuous increase in the cross-section of the coal channel from top to bottom of the chamber, as shown.

Near the top of the reaction chamber 1 I provide coils 22 placed under the sloping supports and carrying superheated steam. These coils serve as a means of supplying internal radiated or conducted heat to the contents of the reaction chamber and thereby prevent condensation of heavy tar-oils from the rising current of fluids. The superheated steam is heated to the proper temperature to accomplish the desired transfer of heat and, for the sake of economy, is then preferably returned to a second superheater in which it is reheated and introduced through pipes 12, 15 or 16 to react with the coal by direct contact, the apparatus for circulating and reheating the steam in this manner being similar to that shown in Figs. 3 or 8. The coils 22 may be connected in series or parallel in order to govern the temperature gradient and amount of heat delivered to the upper portion of the distilling zone. The hot combustion gases passing upwardly through the flues 2 pass through insulated pipe 23 and are circulated by means of blower 24 into the bottom of bunker 4 and serve as a flexible means of preheating and drying the coal. By preheating the coal in the bunker 4 to about 400° F. by means of the stack gases very little condensation of heavy tar-oils will take place on the coal as it passes down through the distilling region of the chamber 1. If the coal is of the fusing type, the hot gas, supplemented by air supplied through branch pipe 25 serves to oxidize the outer surface of the lumps and reduces the tendency to cake or fuse.

The pipes 15 for introducing highly heated steam to the upper part of the reaction chamber may also be employed continuously in the modified distilling operation, mentioned above, by permitting part of the steam introduced therethrough to pass out through the top of the reaction chamber 1, and withdrawing the balance along with the mixed volatiles from the coal through the pipe 12 at the mid-point of the chamber. When the coal comes suddenly into contact with the highly heated steam admitted through the pipes 15 the surface of the lumps are "scorched" and rendered non-sticking. The surface layer or shell thus formed provides a supporting or protecting film to prevent excessive fusing and agglomerating which might otherwise result from a strictly "counterflow" treatment of such lump coal. When this modified distilling operation is employed further steam will be admitted as previously described, through the pipes 17 or 18 at the base of the chamber for dry-quenching and further gasification of the coke the same as when the superheated steam for distilation is introduced into the chamber through pipe 12.

The life and efficiency of the apparatus may be increased by constructing the lower portion of the metal reaction chamber 1 of alloys of chromium and iron, or of calorized steel, this portion being in the zone of highest temperature. The upper part of the chamber 1 may be of cast steel or calorized steel plate. The chamber is made gas-tight for operation under pressure, by welding or other suitable means. The space 2 is constructed with clearance to permit the walls of the chamber 1 to move freely in a lateral direction as they expand and contract. Means are provided for permitting the metal walls to move freely in a vertical direction, and to insure that such vertical movement will be substantially linear, thus preventing warping or buckling due to expansion in the region of greatest temperature under the weight of the superimposed structure. This is accomplished by providing a continuous upward tension on the walls of the chamber. In the form illustrated in Figs. 1, 3 and 4, beams 27 rest on fulcrums 28 supported by the brick walls 3. One end of each beam 27 engages a lug 29, these lugs being fastened adjacent the top on opposite sides of the walls 1. The opposite end of each beam 27 is counter-balanced by a weight 30. The weight 30 is adjusted to cause a slight tension in the metal in the hottest zone so as to prevent any tendency of the metal to warp or sag from downward pressure at any part of the metal walls. The lower end of the magazine 6 is connected to the top of the carbonizing chamber by means of a gas-tight slip-joint 31 which permits the walls of the chamber 1 to expand and contract vertically without permitting gas to leak out. A similar gas-tight slip-joint 32 is provided in the insulated pipe 23. The several supply pipes, such as 12, 15 and 16 which penetrate the brick wall 3 are provided with ample clearance around them to allow for expansion. The openings through the brick work are preferably provided with a yielding plug or bushing 33 of asbestos yarn or other similar material held in place by close-fitting metal discs or shields 34 surrounding the pipe.

Fig. 3 shows a modified arrangement for externally heating the walls of the reaction chamber, and a continuous device extending from top to bottom of the retort for supporting the weight of the column of coal during its downward movement. One or more continuous flexible members 36, which may be in the form of chains, are each provided with laterally extending projecting portions 37 spaced apart an amount depending upon the size and character of the lumps of coal being treated. Each continuous flexible member 36 passes through a vertical gas-tight housing 35 and is moved downwardly through chamber 1 by means of any suitable driving mechanism 38, passing around sprockets 39, 40 and 41, thence through liquid seal 42 and around sprocket 43, and over sprockets 44 and 45 to the top of the reaction chamber. The liquid in the seal 42 is preferably high-boiling tar-oils produced by the process, and serves to prevent the superheated steam from passing into housings 35. The lateral supports 37 of the flexible member 36 provide a continuous foothold for the coal, permitting the coal to arch against the lateral supports 37. In other words, the device provides a continuous "falling" or "receding" support against which the coal arches or is supported at many points. In this device, the effective load on any lump of coal at any position in the reaction chamber is approximately equal to the weight of a column of coal the height of which is slightly greater than the diameter of the retort, i. e., equal to the arching height of the coal undergoing treatment.

In Fig. 3 the walls of the reaction chamber are heated externally by means of heating jackets 48 and 49 supplied with superheated steam. The superheated steam enters jacket 49 through insulated pipe 50 and passes out through pipe 51. The source of this steam may be the re-heated exhaust steam from coils 22 when such coils are employed in the manner shown and described in connection with Figs. 1 and 8. The temperature of the steam supplied to the jacket 49 is equal to or greater than the superheated steam introduced into the reaction chamber 1 by means of pipe 12 in Fig. 1. The steam passing out through the pipe 51 may be passed through pipe 52 into the heating jacket 48 either directly or after first passing through a separate superheater, not shown, to raise the temperature if required. The superheated steam passes from the jacket 48 by way of pipe 53, and may then be heated by a separately fired superheater and then admitted to the interior of the reaction chamber 1 to contact with the coal therein. As illustrated, the pipe 53, which is broken away to simplify the showing, conducts the steam to a separate superheater 54 from which the superheated steam is passed through pipes 12 and 16 into the interior of the reaction chamber 1 to contact directly with the coal therein.

In Fig. 5 the arrangement of the hot gas flues 2 for externally heating the walls of the carbonizing chamber is similar to that shown in Fig. 1. In Fig. 5, however, a modified device for supporting the descending column of coal is shown, comprising a rotating screw 55 disposed between the walls of the chamber and driven by means of gears 56. The flights of the screw provide a foothold on which the lump coal arches against the side walls. This screw thereby provides a modified means of relieving the amount of downward pressure on the lumps during their entire passage through the carbonizing chamber. I have found that with this type of device some lump coals, particularly Utah coal, will form dense rounded lumps of coke when caused to move and roll continuously while passing down through the carbonizing chamber. The constructions shown in Figs. 3 and 5 for providing a continuous descending support for the coal may be used in carbonizing chambers provided with sloping side-supports, and may be used interchangeably in reaction chambers externally heated with hot products of combustion or with superheated steam, or in any reaction chambers without external heat. Also, the flights on the screw 55 may be variably spaced at different heights in the chamber.

In the construction employing sloping supports, as in Fig. 1, to allow the coal to receive the amount of pressure needed to increase its density while carbonizing, and yet prevent agglomeration of the lumps, I provide for irregular spacing of the sloping supports as illustrated diagrammatically in Figs. 6 and 7. The exact spacing and size of the sloping supports throughout the carbonizing chamber, as well as the question of using vertical or sloping walls must be determined by experiment with the individual coal to be treated in order to obtain the best results. Fig. 8 shows a column of coal passing down through a reaction chamber containing sloping side-supports so arranged, as in Figs. 1, 6 and 7, that the cross-section of the coal stream is constantly increasing. The maximum weight or pressure to which any lump of coal can be subjected is approximately equal to the height of the column of coal between corresponding points on adjacent supports on the same side of the carbonizing chamber. Fig. 8 also shows in larger scale the closed heating coils 22 placed under the sloping supports and the superheated steam inlets 15 with one form of interconnection between them. The exhaust steam from coils 22 may be heated in superheater 54, or may be by-passed around the superheater 54 by means of valves, and then introduced into pipes 15, as shown, as well as into pipes 12 and 16 in the lower walls of the chamber as shown in Figs. 1 and 3. Fig. 9 illustrates a means of arranging sloping supports extending from the side walls of a reaction chamber of larger lateral dimensions and extending also from both sides of a centrally disposed wall 58, and is useful as a means of adapting large carbonizing chambers to the treatment of coal of small sizes.

Figs. 10 and 11 illustrate a gas-tight coal valve suitable for charging and discharging the magazines and receiving bins of the carbonizer. The valve comprises an outer casting 59 with top and bottom flanges 60 and 61 and an extended compartment 62. Flange coupling 63 cooperates with flange 60 and has provided an opening 64 placed off center and of such diameter that it is flush with the interior wall of the valve on one side and overhangs the interior wall of the valve by a small distance on the other side as shown at 65. Bottom flange 66 cooperates with flange 61 and is similar to top flange 63. A sliding gate 67, provided with valve stem 68 is actuated by lever 69 and link 70 to move in and out of compartment 62. Stuffing box 71 provides means for operating the valve without leakage of gas. Within the valve casting 59 are provided flanged steel linings 72 and 73 which are cut at an angle to cooperate with the respective sides of the valve gate 67. The cooperating surface of the valve gate and the linings are ground to form gas-tight contacts.

The valve casting 59 is provided with a steam channel or recess 74 on its inner surface on three sides directly opposite the contiguous edges of the valve gate. A source of high pressure steam is connected to steam channel 74 by means of pipe and fittings 75. A valve 76 which controls the flow of high pressure steam is actuated by the lever 69 and linkages 77 to deliver steam to the interior of compartment 62 and into steam channel 74 as the valve gate is forced downwardly into place. It will be noted that the scavenging effect of the steam in removing dust from the valve seat is greatest as the gate approaches its seat due to the tapered construction of the gate 67.

In order to arrest the flow of coal prior to closing the valve gate, a means is provided comprising a shaft 78 and a plurality of independent flexible steel fingers 79 actuated by handle 80. Prior to closing the gate 67 the handle 80 on shaft 78 is set in a horizontal position, whereupon the spring fingers 79 clearly adjust themselves within the descending column of lumps and cause it to arch well above the line of the gate 67. In a few moments the lever 69 is forced inwardly a short distance, thus opening the steam valve 76 and releasing the the steam into the space 62 and 74. The further movement of lever 69 causes the gate to move into its seat. In order to provide a simple adjustment for seating the valve, I provide leaf shims 81 of any suitable material, such as metal, which may be removed as the cooperating surfaces of the valve gate 67 and linings 72 and 73 wear, to make a gas-tight fit. The gate 67 comprises a tapered plate with flat surfaces, as described above, and it is therefore easily resurfaced. Likewise, the cooperating surfaces of the linings 72 and 73 are flat plain surfaces and may be removed and ground smooth on a polishing table with little effort if adjustment becomes necessary. I have found that the gate operates with less binding if placed at an angle, either downward or upward, when cutting through a stream of lump material and I show it in this form since it may be desirable at times to quickly close the gate before the flow arresting means 79, 80 have had time to function. The valve is also suitable for use in conduits carrying highly heated steam in which case the linings 72 and 73, and the gate 67 will be of alloys such as chromium, iron, and nickel. The valve will be surrounded with insulating material to prevent loss of heat.

The coke produced as described above has desirable kindling and burning properties; it ignites as readily as raw coal, and burns smokelessly in all types of household and industrial appliances. The coke lumps are extremely dense and can be handled and shipped without breaking. The coke is also very active chemically and has adsorptive properties which I use to impart special kindling, light-giving and odor-giving properties thereto. I have immersed the hot dry-quenched coke in solutions of sodium nitrate or chlorate and found that the resulting dried coke was easily kindled with a match flame without additional kindling agents. This coke will also adsorb salts of metals and bases which impart color to the flame. The coke will also adsorb metallic copper from solutions of copper chloride, thereby copper-plating the cell walls; this fuel on burning gives a permanent azure flame, and the color-producing ingredient is not volatilized until the fuel is consumed. I have also found that oil of pine, cedar, etc., when adsorbed in the coke, give pleasant odors as the treated fuel is burned in open fire-places. These finished low-temperature coke products are obtained in the processes described above by introducing the desired ingredients into the receiving bin at the base of the carbonizing chamber where the adsorptions take place immediately as the coke is dry-quenched.

I claim:

1. The combination with a metal retort having substantially upright walls, of means for supplying heat to the chamber for heating material therein, means for supporting the retort at the base thereof, a lever engaging an upper portion

of said walls, and means acting on said lever to take up the expansion of said walls.

2. The combination with a metal retort having straight substantially upright walls, of means for supplying heat to the chamber for heating material therein, means for supporting the retort at the base thereof, a fulcrum, a beam supported by said fulcrum and having one end engaging an upper portion of said retort, and a counterpoise adjacent the other end of said beam acting in a linear direction to prevent said walls from warping due to expansion.

3. The combination with a gas-tight metal retort having elongated substantially upright walls, of a hopper communicating with the top of said retort for admitting lump coal thereto, means for supplying heat to said retort, means for withdrawing distillates which might form from the retort, a gas-tight slip joint between said hopper and the top of said retort, and means flexibly supporting the weight of the upper portion of said walls to permit expansion and contraction without warping.

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