

Nov. 28, 1950

G. W. WALLACE
CARBONIZATION APPARATUS

2,531,998

Filed Sept. 20, 1945

3 Sheets-Sheet 1

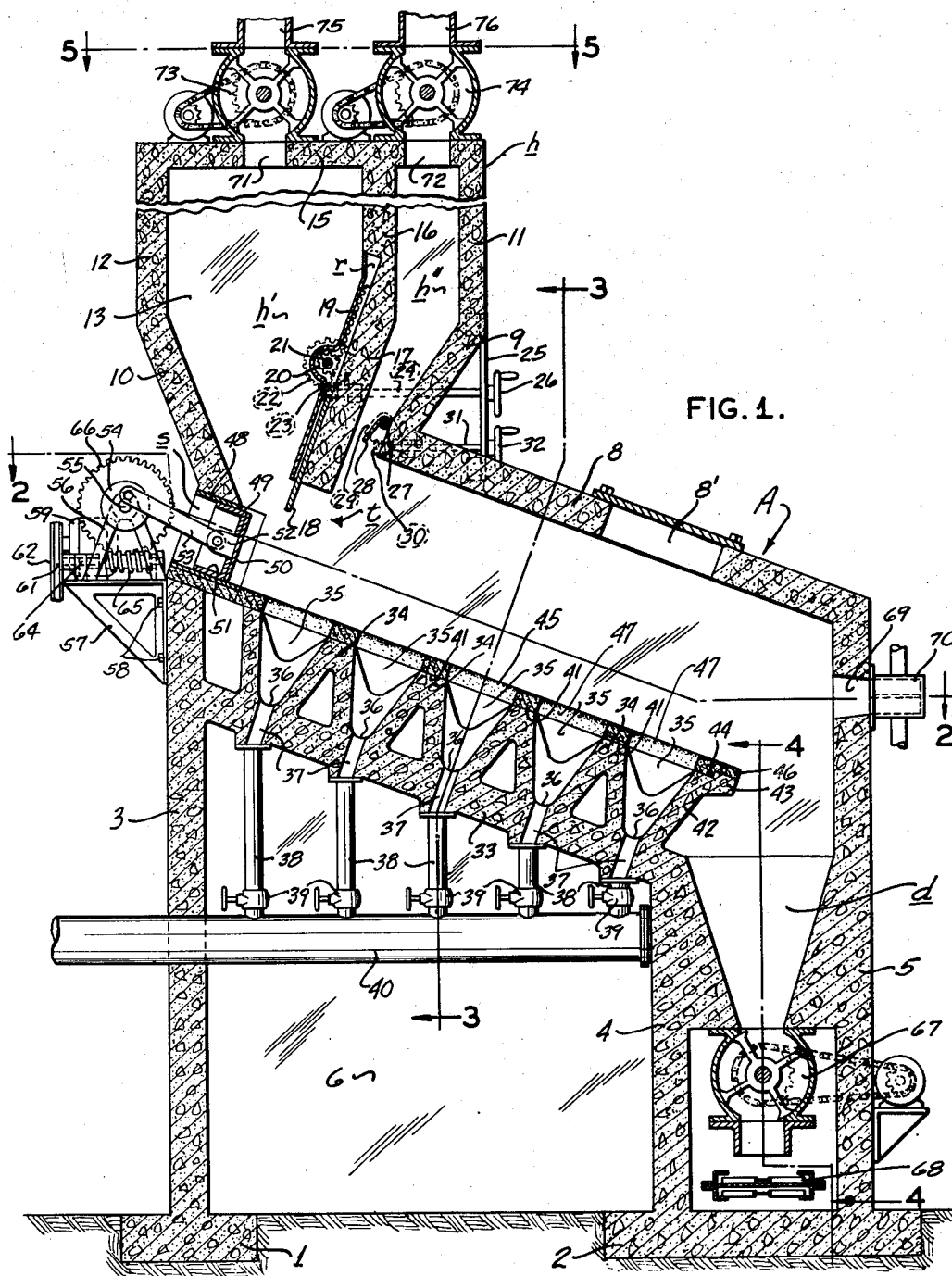


FIG. 1.

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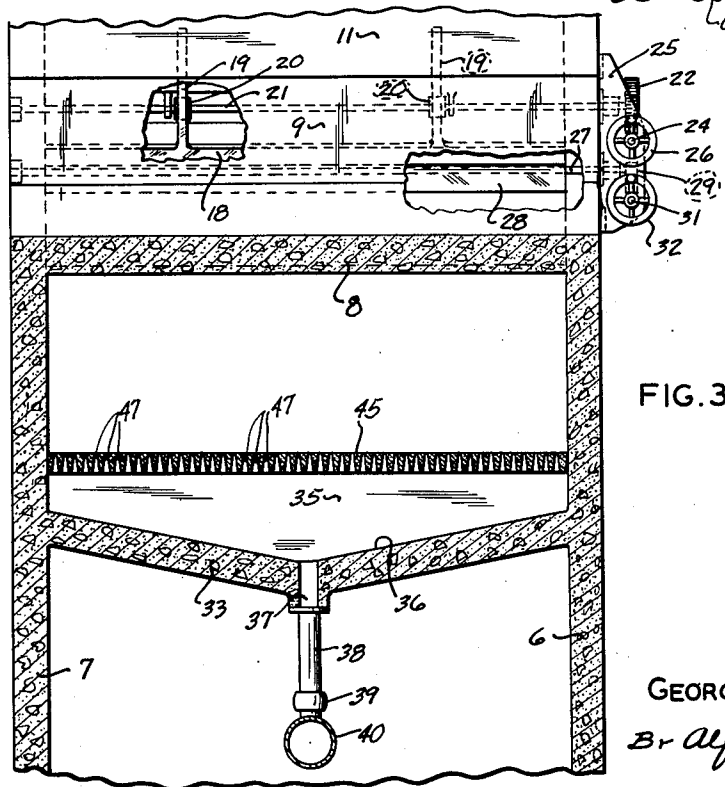
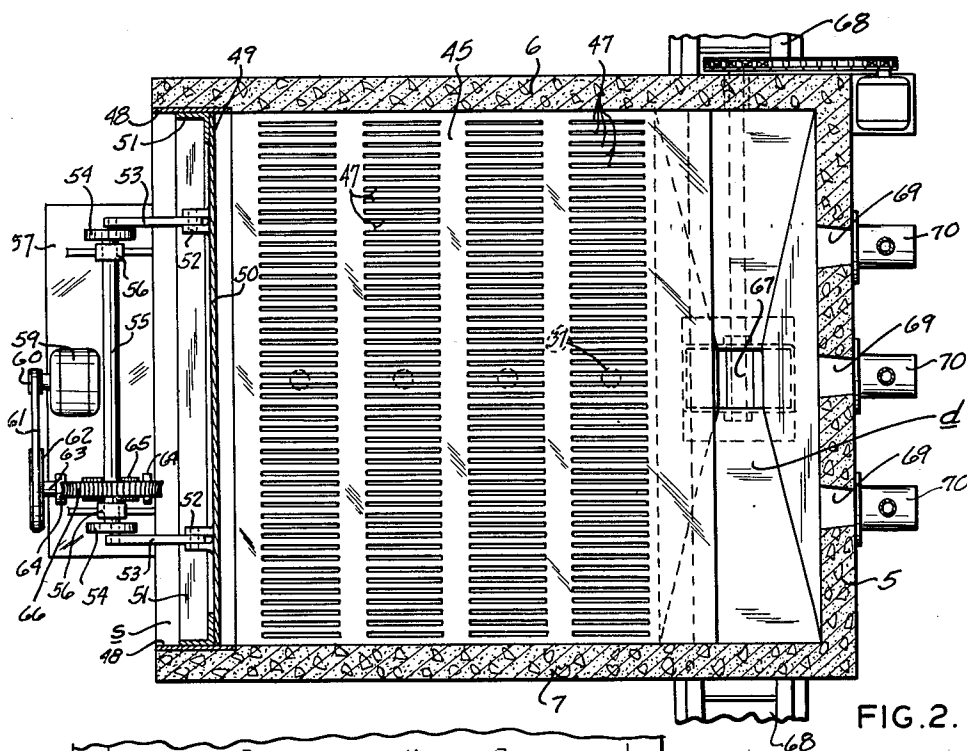
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3 Sheets--Sheet 2



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3 Sheets-Sheet 3

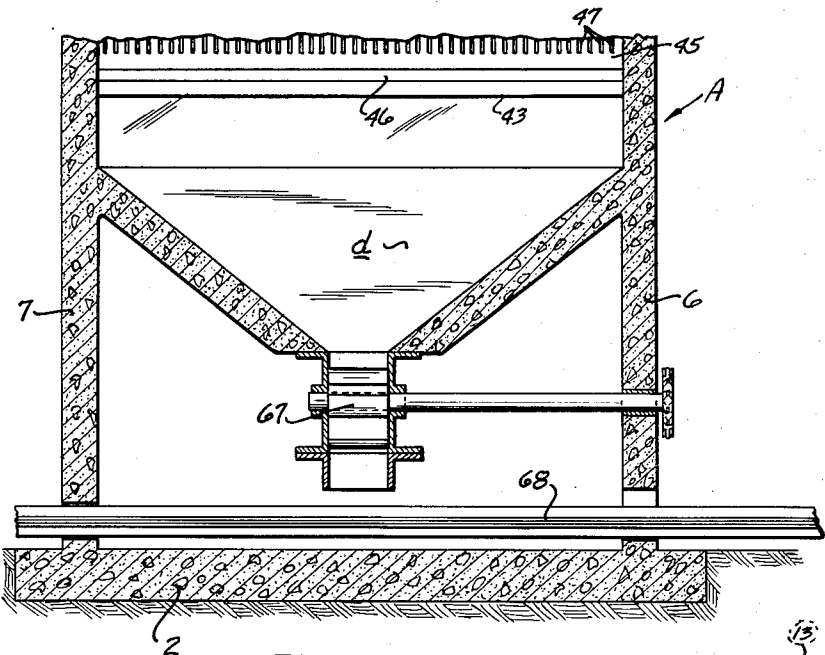


FIG. 4.

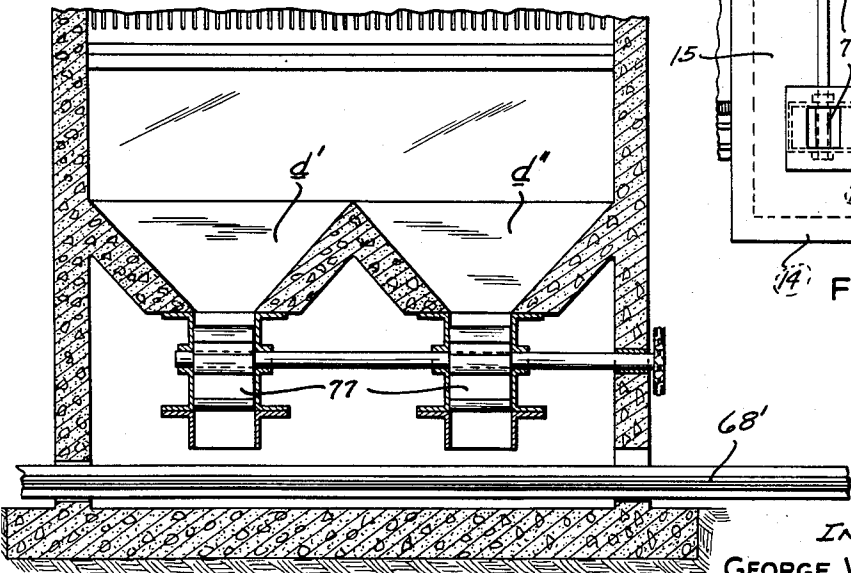


FIG. 6.

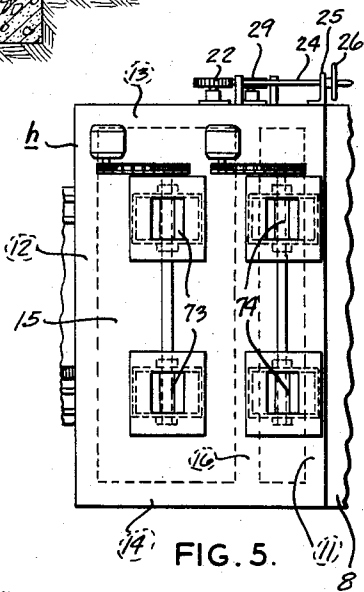


FIG. 5.

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2,531,998

CARBONIZATION APPARATUS

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Application September 20, 1945, Serial No. 617,603

5 Claims. (Cl. 202—99)

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This invention relates to certain new and useful improvements in methods and apparatus for carrying out controlled oxidation and destructive distillation of carbonaceous matter such as coal, peat, oil shale, and the like.

It is the principal object of the present invention to provide simple and economical methods and apparatus for carrying out controlled oxidation and destructive distillation of coal, cannel coal, oil shale, peat and similar carbonaceous materials to obtain high yields of oils and other by-products.

Another object of the present invention is to provide a unitary grate which will support carbonaceous materials during controlled oxidation and destructive distillation procedures, and will withstand the high temperatures to which it is normally subjected when hot combustion gases are passed therethrough.

In the drawings,

Figure 1 is a vertical sectional view of a preferred form of apparatus embodying the present invention;

Figure 2 is a horizontal sectional view taken along line 2—2 of Figure 1;

Figure 3 is a transverse sectional view taken along line 3—3 of Figure 1;

Figure 4 is a fragmentary sectional view taken along line 4—4 of Figure 1, showing in greater detail the discharge end of the apparatus;

Figure 5 is a top plan view of the apparatus; and

Figure 6 is a fragmentary sectional view of a modified or alternative form of discharge mechanism forming a part of the present invention.

Referring now in more detail, and by reference characters to the drawings which illustrate a preferred embodiment of the present invention, A designates a continuous carbonization and destructive distillation oven or furnace, preferably of monolithic construction and comprising rear and front footings 1, 2, formed preferably of suitable concrete set into the surface of the ground or upon any other suitable supporting base. Rising vertically from the rear footing, 1, is a rear wall, 3, and similarly rising from the front footing, 2, are spaced parallel forward walls 4, 5, all being integrally connected at their vertical ends with side walls, 6, 7. Joined integrally at its forward margin to the upper end of the front wall 5, and at its side margins to the upper ends of the side walls 6, 7, is a downwardly and forwardly inclined top wall 8, which terminates at its rear horizontal edge in forwardly and upwardly spaced relationship to the upper edge of the rear wall 3 in the

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provision of an intake throat *t*. Preferably, though not necessarily, the top wall 8 is provided with one or more conventionally sized manholes 8' to permit access to the interior of the furnace A for repairs, cleaning, and the like. Formed as an integral and upwardly extending continuation of the furnace structure, and positioned above the intake throat *t*, is an intake hopper *h* comprising outwardly and upwardly diverging front and rear throat-walls 9, 10, and front and rear vertical walls, 11, 12, integrally connected on their lateral or vertical margins by side walls 13, 14. The front and rear vertical walls 11, 12, and the side walls 13, 14, of the hopper *h* are integrally connected along their upper margins by a closure-forming top wall 15, and the rear throat-wall 10 terminates at its lower horizontal margin in upwardly spaced relation to the opposing upper margin of the rear wall 3 in the provision of an elongated rectangular opening or slot *s*.

Joined integrally along its upper and side margins to the top wall 15 and the side walls 13, 14, respectively, and extending transversely across the interior of the hopper *h*, is an intermediate dividing wall 16 having a lower portion 17 extending obliquely downwardly and rearwardly, terminating approximately at the line of the intake throat *t* and dividing the hopper *h* into two separate compartments *h'*, *h''*. Upon the rearwardly presented face of its inclined bottom portion 17, the wall 16 is cut away to provide a shallow recess *r* extending across its entire width from one side wall 13 to the other side wall, 14, and slidably mounted within the recess is a shiftable gate, 18, projecting at its lower end downwardly at an oblique angle across the intake throat *t*, and at its upper end being provided with a rack bar, 19, for meshing engagement with an actuating pinion 20, which is, in turn, pinned to a horizontal shaft, 21, journaled at its opposite ends in the side walls, 13, 14, and at one end projecting through the side wall, 13. Pinned upon the outwardly projecting end of the shaft, 21, is a worm gear, 22, meshing with a driving worm, 23, pinned upon the free end of a control shaft, 24, which is conventionally journaled upon, and extends horizontally forwardly along, the outwardly presented face of the side wall, 13, and at its forward end projects through a bracket plate, 25, being, on such forwardly projecting end, provided with an operating handwheel, 26.

Also journaled at its end in, and extending horizontally between, the side walls, 13, 14, adjacent the lower end of the front throat-wall, 9, is a shaft, 27, which is provided, along that por-

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tion of its length which extends within the hopper compartment h'' , with a rigidly attached flap-gate, 28. At one end the shaft, 27, projects outwardly through the side wall, 13, and upon such outwardly projecting end is provided with a worm gear segment, 29, meshing with a driving worm, 30, which is, in turn, pinned upon the rearward free end of a control shaft, 31, journaled upon, and extending horizontally along, the outwardly presented face of the side wall, 13, in downwardly spaced parallel relation to the shaft, 24, and similarly projecting at its forward end through the bracket plate, 25, being on such forward end provided with an operating hand-wheel, 32.

Integrally joined at its lower forward margin to the upper margin of the intermediate front wall, 4, and along its lateral margins to the side walls, 6, 7, is a rearwardly and upwardly inclined grate base, 33, which is substantially parallel to the top wall, 8, and is integrally joined along its rearward margin to the rear wall, 3, in downwardly spaced relation to the upper margin thereof. Along its upper face, the grate base, 33, is integrally provided with a plurality of transverse ribs, 34, extending fully across the interior of the furnace A, being integrally joined at their lateral margins to the side walls, 6, 7, and having a vertical cross sectional shape resembling an inverted V, whereby to provide a plurality of spaced parallel intermediate troughs, 35. The troughs, 35, are thus complementarily V-shaped in vertical cross section and are, furthermore, provided with a rounded bottom wall section, 36, which inclines downwardly and inwardly from the opposite side walls, 6, 7, to a more or less central "low point" and is there provided with a downwardly directed drainage aperture or passage, 37, extending through the grate base, 33, and opening into a downwardly directed vertical outlet pipe, 38. The several outlet pipes, 38, are each provided with hand operated valves, 39, and are thence connected to a common exhaust header, 40, which extends horizontally rearwardly through the rear wall, 3, and is, at its remote end, connected to a suitable exhaust mechanism (not shown).

The upper ends or apices of the transverse ribs 34 are provided with upwardly presented flat surfaces 41, all lying in a plane passing through the upper marginal edge of the rear wall 3 and parallel to the grate base 33. The grate base 33 is also provided adjacent its lower or forward end with an outwardly inclined single transverse rib 42, which constitutes the front wall of the forwardmost trough 35 and is provided at its upper margin with a flange 43 having a recess 44, the bottom flat wall of which is co-planar with the rib surfaces 41. Mounted flatwise upon the rib surfaces 41, is a grate 45, being transversely relieved along the under face adjacent its forward edge in the provision of a flange 46 for grate-retentive interfitting engagement with the flange 43 of the grate base 33. At its upper end, the grate 45 extends across the inclined upper horizontal margin of the rear wall 3 and terminates in more or less flush alignment with the outwardly presented or rear face thereof. In the areas directly above each of the troughs 35, the grate 45 is provided with a transversely extending series of spaced parallel slots 47, which are substantially equal in length to the longitudinal dimension of the troughs 35 at the top or widest point thereof. The slots 47 furthermore

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are relatively narrow at the top and widen somewhat as they extend downwardly, so that the slots 47 are wider on the under face of the grate 45 than they are on the top face thereof, all as best seen in Figure 3.

In the rectangular opening or slot s defined by the lower horizontal margin of the front wall 10, the adjacent portions of the inner faces of the side walls 6, 7, and the upper rear face portion of the grate 45, is a rectangular box-like steel frame 48 having smooth machined inner faces, and reciprocally mounted therein, is a complementarily shaped box-like feed plunger 49 having a forwardly presented pusher plate 50 and a rearwardly extending marginal skirt 51, which is of sufficient width to remain, at least partially, within the frame 48 even when the feed plunger 49 is at its forwardmost position of reciprocation. Fixed upon the rearward face of the pusher plate 50, is a plurality of rearwardly extending bosses 52 and swingably pivoted thereto are rearwardly extending actuating links 53 operably connected at their outer ends to eccentric driving wheels 54, which are, in turn, pinned upon the opposite ends of a horizontal drive shaft 55 rotatively extending through journals 56 rigidly mounted upon the upper face of a supporting bracket 57 secured, as by means of lag bolts 58, upon the outer face of the rear wall 3. Also rigidly mounted upon the upper face of the bracket 57, is an electric motor 59 having a driving pulley 60 connected by means of a conventional V-belt 61 to a drive wheel 62 fixed upon the rearwardly projecting end of a jack-shaft 63 rotatively mounted in and extending horizontally through suitable journals 64. Pinned or otherwise suitably fixed to the jack-shaft 63 intermediate the journals 64, is a driving worm 65 meshing with a worm gear 66, which is, in turn, pinned or otherwise fixed upon the shaft 55, all as best seen in Figures 1 and 2.

The intermediate front wall 4 is enlarged for approximately the upper half of its height and the corresponding and adjacent portions of the front wall 5 and side walls 6, 7, are similarly enlarged to provide a downwardly converging discharge hopper d , which opens at its lower end to a conventional motor-driven star feeder 67, which, in turn, discharges downwardly to a horizontally disposed conventional type flight conveyor 68 extending laterally outwardly through the side walls 6, 7.

Adjacent its upper end, the front wall 5 is provided with a plurality of tuyères 69 provided preferably with conventional gaseous fuel burners 70. Although, in the preferred form shown, the fuel burners are designed for gaseous fuel, it will, of course, be understood that fuel burners adapted for burning oil or pulverized coal may be employed.

The top wall 15 is provided with a plurality of apertures 71, 72, respectively opening into the hopper compartments h' , h'' , and mounted upon the upper face of the top wall 15 in superposed relation to the apertures 71, 72, are conventional motor-driven star feeders 73, 74, which are, in turn, connected at their upper ends through intake ducts 75, 76, to conventional raw material storage bins (not shown). In the embodiment illustrated, each of the hopper compartments h' , h'' , is respectively provided with two gang-connected star feeders 73, 74, as best seen in Figure 5, but it will, of course, be understood that any number of such star feeders can be employed, de-

pending upon the overall width and size of the oven or furnace A.

If desired, I may provide a modified form of discharge hopper consisting of two transversely spaced funnel-like compartments or chutes *d'*, *d''*, which respectively open at their lower ends to a pair of gang-connected star feeders 77, which, in turn, discharge onto a flight conveyor 88', all as best seen in Figure 6.

The grate 45 is constructed of refractory material, may be cast as shown in the drawings using a high temperature cement, or may be made up of special fire brick suitably reinforced. The cement and aggregate used must be capable of supporting the weight of the material and withstanding continuous operating temperatures in excess of 1000° F., and the grate, furthermore, may be pre-cast in sections or may be cast in place.

The upper surface of the grate 45, whether pre-cast or cast in situ, is preferably finished by embedding into the upper or exposed face thereof a small amount of abrasion-resisting material, such as Carborundum. It has also been found that the use of trap rock or ground fire brick as the aggregate also insures a longer life to the grate.

The grate 45 is sloped from the feed end at an angle, which must be selected in reference to the carbonaceous material for which the furnace is being designed. This angle must be such as to cause the carbonaceous material to move down the grate with a minimum amount of sliding friction and, at the same time, not cause such material to move by gravity. This slope for most carbonaceous materials has been found to be between 15° and 25°. It is important that this slope be adjusted to the material and its particle size, so that the bed of material will move over the grate at the desired thickness and the bed will, furthermore, be substantially uniform over the greater part of the grate area. If the slope is too little, the material will bunch up or be thicker at the feed end, which is detrimental to the control of the carbonization through the regulation of the hot gases passing downwardly through the material.

The hot combustion gases, along with the volatile products resulting from the carbonization, are drawn through the troughs 35 and outwardly through the header 40. The amount of such hot combustion gases passing downwardly through the material being carbonized may be carefully controlled and regulated by the several valves 39, thereby permitting the creation of a number of zones in the carbonizing area and in the material passing over the grate. It will be observed that almost any desired control may be obtained using this arrangement ranging from drying to final carbonization. Because the several troughs 35 may be held under a partial vacuum, it is possible to achieve close control of the gases passing through the material being carbonized. As has been above stated, the header 40 conducts the gases and vapors to conventional gas exhausters, scrubbers, and condensers. If desired, however, the outlets from each gas and vapor collecting chamber can be arranged so that any liquids leaving the same would be trapped out separately.

Where the size of the material is large enough to prevent plugging of the grate openings, the material to be carbonized may be fed into the furnace A through the hopper compartment *h'* alone.

The thickness of the bed of material being

carbonized may be regulated by upward or downward adjustment of the plate 18. I have found that substantially all of the coking reactions can be caused to take place in a bed of coal eighteen inches thick. In the case of some materials, a much thicker bed may be required for most efficient operation. I have also found that the temperature of the gases used to effect the carbonization may be controlled to some extent by diluting the same with cold inert gases or the gases produced in the carbonization.

The end product resulting from the carbonization of some substances has been found to be excellent activated carbon and the activity of such end product may be improved by admitting some steam along with the gases used for combustion. The steam may be admitted to the carbonization chamber by passing it up through the end product collected in the discharge hopper *d*, thereby obtaining a considerable degree of superheat and, at the same time, cooling the residue to some extent.

When it is necessary to screen out fine sizes of material, the coarser or larger pieces are charged in through the hopper *h'* to form the bottom layer of the bed and the fine sizes are charged in through the hopper *h''* to form a top layer on the bed of material passing over the grate 45. In either case, the reciprocating plunger 49, during its forward stroke, moves the pervious bed of carbonaceous material forward and downward over the grate 45 and upon its return stroke permits additional new material to fall down and become incorporated into the moving pervious bed. Finally, as the material has been completely reacted, it moves off over the lower end of the grate 45 and drops into the discharge hopper *d*.

The hot gaseous products of combustion used to effect the carbonization are produced by burning some or all of the gases produced in the carbonizing operation or may be obtained by burning some or all of the carbon remaining in the carbonized residue, depending on the character of the material being carbonized. When coal, cannel coal, or lignite constitute the raw material, usually sufficient gas is obtained to furnish the necessary heat. With some materials, such as oil shale, containing a relatively small amount of organic matter, it may be necessary to burn a portion of the material or the carbon in the residue in order to secure the required amount of heat.

It should be understood that changes and modifications in the form, construction, arrangement, and combination of the several parts of the furnace or oven may be made and substituted for those herein shown and described without departing from the nature and principle of my invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An apparatus for the carbonization of carbonaceous material comprising a closed carbonizing chamber, the bottom of which consists of a stationary inclined foraminous grate arranged at an angle to the horizontal sufficient to cause the material to move down the grate with a minimum amount of sliding friction but less than the angle of repose of the material so as not to cause such material to move by gravity, a feed spout adjacent the upper end of the grate for depositing a regulated quantity of the carbonaceous material onto said grate, a plurality of stationary troughs below the grate, each trough having a separate valve to control the amount of gases passed down-

wardly through the material as it passes over the grate at the zone above each trough, pusher means adjacent the upper end of the grate for causing said material to travel over said grate, and means for admitting hot gaseous products of combustion into said chamber and causing said gases to pass downwardly through said material and grate.

2. Apparatus for the carbonization of carbonaceous material comprising a closed carbonizing chamber having a bottom wall including a forwardly and downwardly inclined grate arranged at an angle to the horizontal sufficient to cause the material to move down the grate with a minimum amount of sliding friction but less than the angle of repose of the material so as not to cause such material to move by gravity, feed means adjacent the upper end of the grate for deposit of material onto the grate, means adjacent the upper end of the grate for pushing the material down the grate, said grate being provided with a plurality of foraminous areas, each of said areas extending transversely across the grate for substantially the entire width thereof, said foraminous areas furthermore being spaced from each other lengthwise of the chamber, and a stationary false bottom disposed in spaced parallel relationship beneath said grate having a plurality of transverse walls extending upwardly toward said grate sub-dividing the space between the grate and said false bottom into a plurality of separate suction chambers so arranged that one of said suction chambers is associated with each foraminous area of the grate, and means for admitting combustion gases into the chamber over the grate.

3. Apparatus for the carbonization of carbonaceous material comprising a closed carbonizing chamber having a bottom wall including a forwardly and downwardly inclined grate arranged at an angle to the horizontal sufficient to cause the material to move down the grate with a minimum amount of sliding friction but less than the angle of repose of the material so as not to cause such material to move by gravity, feed means adjacent the upper end of the grate for deposit of material onto the grate, means adjacent the upper end of the grate for pushing the material down the grate, said grate being provided with a plurality of foraminous areas, each of said areas extending transversely across the grate for substantially the entire width thereof, said foraminous areas furthermore being spaced from each other lengthwise of the chamber, a stationary false bottom disposed in spaced parallel relationship beneath said grate having a plurality of transverse walls extending upwardly toward said grate sub-dividing the space between the grate and said false bottom into a plurality of separate suction chambers so arranged that one of said suction chambers is associated with each foraminous area of the grate, and means associated with each of said chambers for controlling the draft therethrough, and means for admitting combustion gases into the chamber over the grate.

4. Apparatus for the carbonization of carbonaceous material comprising a closed carbonizing chamber having a bottom wall including a forwardly and downwardly inclined grate arranged at an angle to the horizontal sufficient to cause the material to move down the grate with a minimum amount of sliding friction but less than the angle of repose of the material so as not to cause such material to move by gravity, feed means adjacent the upper end of the grate for deposit of material onto the grate, means adjacent the

upper end of the grate for pushing the material down the grate, said grate being provided with a plurality of foraminous areas, each of said areas extending transversely across the grate for substantially the entire width thereof, said foraminous areas furthermore being spaced from each other lengthwise of the chamber, a stationary false bottom disposed in spaced parallel relationship beneath said grate having a plurality of transverse walls extending upwardly toward said grate sub-dividing the space between the grate and said false bottom into a plurality of separate suction chambers so arranged that one of said suction chambers is associated with each foraminous area of the grate, and gas injection nozzle means mounted at the lower end of said chamber for projecting hot combustion gases upwardly over said grate.

5. Apparatus for the carbonization of carbonaceous material comprising a closed carbonizing chamber having a bottom wall including a forwardly and downwardly inclined grate arranged at an angle to the horizontal sufficient to cause the material to move down the grate with a minimum amount of sliding friction but less than the angle of repose of the material so as not to cause such material to move by gravity, feed means adjacent the upper end of the grate for deposit of material onto the grate, means adjacent the upper end of the grate for pushing the material down the grate, said grate being provided with a plurality of foraminous areas, each of said areas extending transversely across the grate for substantially the entire width thereof, said foraminous areas furthermore being spaced from each other lengthwise of the chamber, a stationary false bottom disposed in spaced parallel relationship beneath said grate having a plurality of transverse walls extending upwardly toward said grate sub-dividing the space between the grate and said false bottom into a plurality of separate suction chambers so arranged that one of said suction chambers is associated with each foraminous area of the grate, said chambers having front, back and bottom walls all mutually converging inwardly and downwardly toward the center thereof and being at such central portion provided with a discharge aperture and means associated with each such discharge aperture for controlling the draft therethrough.

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