Sept. 9, 1930. F. C. GREENE ET AL 1,775,280

METHOD AND APPARATUS FOR EXTRACTING VALUES FROM COAL AND THE LIKE

Filed April 9, 1919

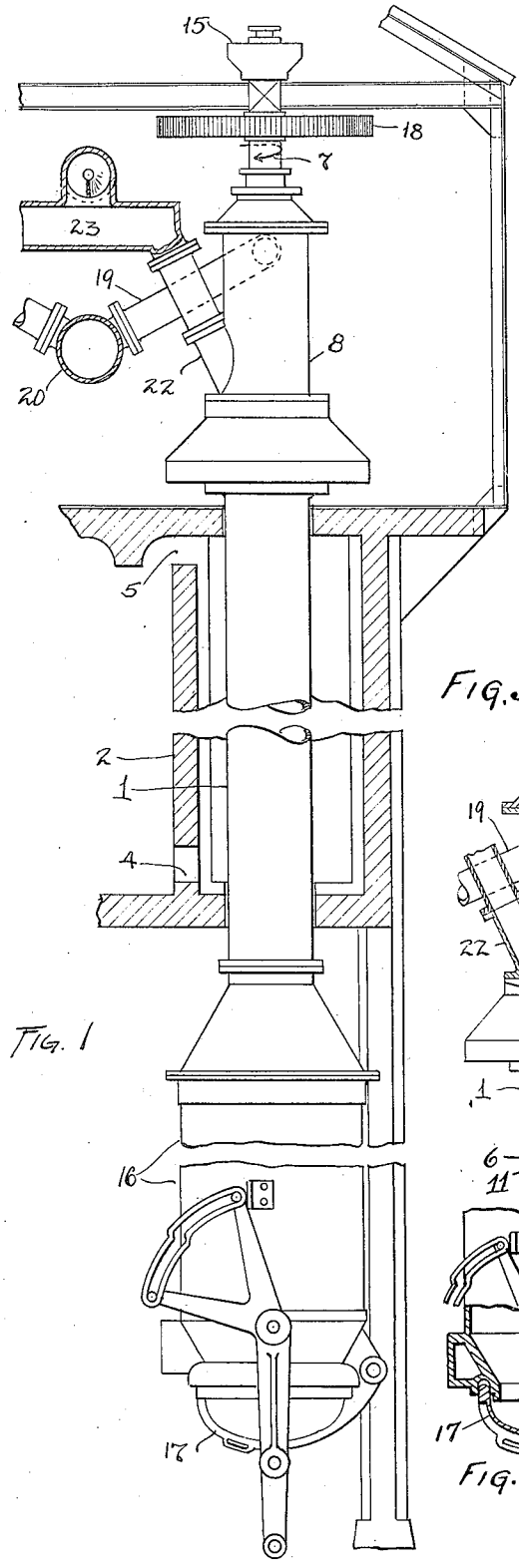

FIG. 1

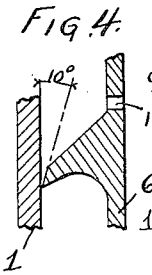

FIG. 4.

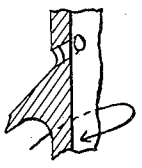

FIG. 5.

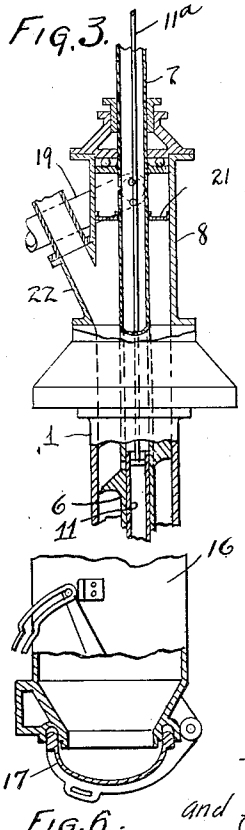

FIG. 3.

FIG. 6.

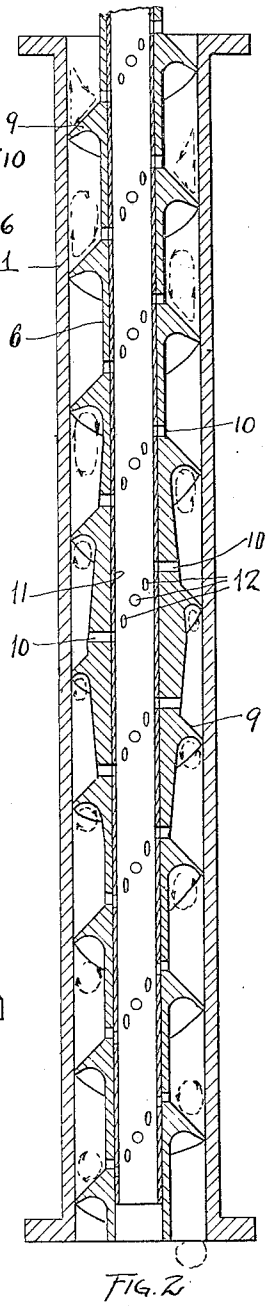

FIG. 2

INVENTORS
Frank C. Greene
and Irving F. Laucks
By Kay, Oberlin & Kay
ATTORNEYS.

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FRANK C. GREENE, OF DENVER, COLORADO, AND IRVING F. LAUCKS, OF SEATTLE, WASHINGTON, ASSIGNORS TO OLD BEN COAL CORPORATION, OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE

METHOD AND APPARATUS FOR EXTRACTING VALUES FROM COAL AND THE LIKE

Application filed April 9, 1919. Serial No. 288,684.

The agglomeration of coal, either coarse or fine, has been heretofore accomplished either by the action of heat, as in carbonization in a coke oven or retort, or by pressure as in briquetting, using a binder to cement together the component particles. Briquettes have also been made of such material and then carbonized. We have found that superior results are secured in handling materials of the class in question by simultaneously applying heat and pressure, preferably in a continuous carbonizing process, whereby a product is formed that exceeds ordinary coke in density, strength and toughness. At the same time provision may be made for the recovery to any desired degree of the volatile ingredients.

To the accomplishment of the foregoing and related ends, the invention, then, consists of the steps and means hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawing:—

Fig. 1 is a side elevation of a suitable retort and accessory apparatus adapted for the carrying out of our improved process; Fig. 2 is a central axial section of the retort proper; Fig. 3 is a similar section of a part of such apparatus; Fig. 4 is an enlarged detail; Fig. 5 is a sectional detail similar to Fig. 2, but showing a slightly modified construction, and Fig. 6 is a fragmentary view of the lower end of the retort partly in vertical section.

Taking bituminous coal for example, when this is subjected to a proper heat, it becomes soft and plastic, the degree of softness and plasticity varying somewhat with different coals. Small particles become attached to one another more or less, depending on the degree of heat and the kind of coal. Gas, moreover, begins to be formed by the decomposition and vaporization of substances in the coal which, on escaping, leaves pores and bubbles. At the same time the individual particles do not entirely coalesce, but are bound together rather loosely, and after the heat has increased somewhat beyond this stage, the coal loses its plasticity and becomes hard and brittle, or may be said to "set." Accordingly, if the particles are loosely attached when they reach this stage, they remain so in the coke product, and similarly if the pores are large, they remain unchanged in such product.

We have found, however, that by applying pressure at the proper time, so as to closely unite or squeeze together the particles while still plastic, the pores are closed up and a coke much more dense and strong results, superior in every way to a coke which has not undergone such treatment. If desired the temperature may now not only be raised sufficiently to destroy the plasticity and to set the mass, but the latter may be subjected to further carbonization to recover the further content of gas and oil which will be evolved upon application of such higher temperature. This further carbonization, under the conditions stated, does not apparently weaken the structure.

We preferably carry on the treatment just described in a continuous process, by introducing the material to be treated into the end of a vertical cylindrical retort through which a screw passes. In the zone in which pressure is to be applied, the cross-sectional area of the space between the screw and the confining walls of the retort is gradually reduced, so that gradually increasing pressure is applied as the material passes through this stage. The application of heat to the retort is so regulated, as is also the speed of rotation of the screw, that the coal or other material is made to reach the zone or stage in question at the time when its plasticity is just right to make a product of the desired structure. By proper modification of these two factors, a coke can be produced having almost any desired structure, strength, density, etc.

At the point of greatest constriction the heat is raised sufficiently to set the material, the pressure being continued until such "set" takes place. The coke may then either pass

into a cooling chamber, whence it may be discharged by suitable mechanism (or quenching may be substituted for such cooling), or such coke may be passed through a further section of the retort, preferably having a somewhat enlarged cross-sectional area, and there undergo further carbonization to increase the yield of gas and tar. In the first case the product will have a somewhat higher volatile content as well as density, while in the second, both such volatile content and density will be lower.

During the application of heat and pressure, the gases and vapors formed may either be removed from the material undergoing treatment, or the tar and resultant pitch therefrom formed by the heat may be allowed to remain partly or wholly in the mass undergoing treatment, thus acting as additional binding and plastic material. Where removed, these volatile constituents may be allowed to escape by their own pressure or drawn off by suction as desired, and then collected and condensed by any suitable means outside of the retort.

In the illustrative apparatus shown in the several figures of the drawing is shown a vertical retort 1 of general cylindrical form disposed within a suitable furnace chamber 2. The heating gases may enter the chamber 2 through the opening 4 at the bottom, and escape therefrom through the opening 5 at the top. Within such tubular retort is rotatably mounted a tubular shaft 6 (see Fig. 2), the upper end 7 of which projects beyond the upper end not only of the retort proper, but of the head 8 that surmounts the latter.

Said inner tubular shaft gradually increases in diameter from a point approximately one-third the distance from the upper end of the retort to a point approximately half way down such retort, and then gradually decreases again in diameter to a point removed about one-third the total length of the retort from the lower end of the latter, with the result that the annular space between the shaft and the inner walls of the retort is correspondingly constricted and then again enlarged to normal. Said tubular shaft is provided externally throughout its length with a spiral rib or flange 9, of a width to substantially span the annular space thus left between said shaft and retort. The upper face of this flange or screw is inclined downwardly and outwardly at an angle of approximately forty-five degrees, while its under face is concave, forming a continuous concavity around the helix of the screw, that produces a rolling and kneading action of the material, as will be presently described in detail. The outer edge of said flange or screw is leveled from the upper face to form a cutting edge which has a clearance angle between the face of the screw and the vertical retort of 10° more or less, as shown in the detail view of Fig. 4. The shaft is also provided with a series of holes or apertures 10 for the escape of vapors into its interior, these apertures being located just above the upper surface of the screw 9. These apertures may simply extend radially inwardly as shown in Fig. 2 or they may trend in the direction of rotation of the rotor 6 and incline upwardly, as shown in the modified construction in Fig. 5, in order to facilitate the withdrawal of such vapors. The size or number of these holes, through which the vapors may thus escape may be varied by the axial adjustment of a cylindrical shutter 11 that is fitted within the tubular shaft, as best shown in Fig. 2. This shutter can be raised or lowered as desired, through the medium of a shaft 11^a attached to its upper end and extending upwardly through the head 8 as shown in Fig. 3, with the result that all the apertures will be correspondingly closed or opened, or by a proper arrangement of the apertures 12 in the shutter certain of the apertures 11 in the tubular shaft may be shut off and a limited number left open, as will be readily understood.

The upper end of the tubular shaft is closed by a vacuum seal consisting of a suitable valve 15, while the lower end of each retort discharges into a chamber 16 which is likewise adapted to be sealed by means of a close fitting discharge gate 17. The detail of construction of such discharge gate need not be described since it forms no part of the present invention, being fully described and claimed in our co-pending application Serial No. 308,774, filed July 5, 1919. Driving means 18 for rotating the tubular shaft are connected with the upper end thereof, while its interior is connected through a duct 19 with a vapor main 20 that may be placed under suction by means not shown, and any desired degree of vacuum thus provided within the tube. Connected with the head 8, below the partition 21 therein that separates the vapor connection 19, is a duct 22 through which the coal or other like material is received from a conveyor trough 23 and supplied to the upper end of the retort.

Coals vary in their degree of plasticity, and the time and heat necessary to develop maximum plasticity. For this reason the proper relation of these factors must be determined for the particular coal at hand by trial, and no fixed rules can be laid down. In general, however, we have found that the time to reach maximum plasticity is under ten minutes, and the heat required is less than 1000 deg. F. As a result of the low temperature thus found sufficient, the retort may be made of metal. When the material is first received in the upper end thereof, it rests on the upper surface of the spiral screw 9, but as it becomes soft and plastic under the influence of heat, and furthermore reaches the con-

stricted portion of the passage through the retort, its movement tends to be retarded, and it shifts in location to the under side of the screw. As a result of the peculiar concave form of the latter, the material is here subjected to a rolling, or sort of kneading action, as indicated by the arrows applied to the dotted mass representing the material in Fig. 2. The result of this action is to make the structure of the coke, when set, much stronger and denser, the mass being correspondingly compressed, so that when the area of constriction is passed, even though the mass may expand somewhat, it will still be free to fall away from the under side of the screw and again rest on the upper surface of the same. It is finally discharged in more or less broken fragments from the lower end of the retort into the chamber 16 provided for its reception.

As previously indicated, provision is made for applying a suction to the interior of the tubular shaft if it is desired to accelerate the rate at which the vapors are evolved during the passage of the material through the retort. The rate of evolution of these vapors is also regulable by the position of the cylindrical shutter 11. As a result, more or less of the volatile matter may be left behind in the material to be there carbonized, and assists, by its action as a binder, in consolidating such material.

The process is not only applicable to bituminous coal, but also to mixtures of coal or other carbonaceous material, which in themselves have no cohesive or binding properties when hot, with other materials which have plasticity when hot, such as pitch, asphalt, etc. Lignite, for example, may be mixed with bituminous coal in suitable amount to provide the plastic material, or such lignite may be mixed with tar or pitch or other suitable binding material. The lignite thus used may be either raw or partly or wholly dried or carbonized. Likewise other carbonaceous material, such as coke breeze, or anthracite fines, may be agglomerated by this process. It is not attempted to form the product in pieces of regular shape, as in the case of briquetting processes, but merely of sufficient size so that they may be used as fuel or coke, where the fines or raw material could not be thus used. The process, it will be observed, is a carbonization process, with simultaneous application of pressure as well as heat, and withal continuous.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the steps or mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

We therefore particularly point out and distinctly claim as our invention:—

1. In a method of agglomerating carbonaceous material which may be rendered plastic and decomposed to form vapors and set by heating, the steps which comprise subjecting the material out of substantial contact with air to a progressively increasing temperature to a point where the material is rendered plastic and is decomposed to form vapors, and simultaneously applying progressively increasing pressure to the material up to the point of setting.

2. The method of agglomerating carbonaceous material which may be rendered plastic and decomposed to form vapors by heating, which comprises subjecting the same out of substantial contact with air to progressively increasing temperature and pressure to a point where the material becomes plastic and vapors are evolved by decomposition of the material and in a constricted space, but with a substantial portion of the surface of the mass unenclosed, whereby the evolved vapors may freely escape.

3. The method of agglomerating carbonaceous material which may be rendered plastic and decomposed to form vapors and then set by heating, which comprises subjecting the same out of substantial contact with air to a temperature where the material is rendered plastic and vapors are evolved by decomposition of the material, and simultaneously rolling and kneading the material while in such plastic state under gradually increasing pressure up to the point where the material sets.

4. The method of agglomerating carbonaceous material which may be rendered plastic and decomposed to form vapors and set by heating, which comprises subjecting the same out of substantial contact with air to a temperature where the material is rendered plastic and is decomposed to form vapors, simultaneously rolling and kneading the material while in such plastic state under gradually increasing applied pressure up to the point where the material sets, and withdrawing the vapors evolved during the foregoing.

5. The method of agglomerating carbonaceous material which may be rendered plastic and decomposed to form vapors and then set by heating, which comprises subjecting the same out of substantial contact with air simultaneously to temperature and pressure to a point where vapors are evolved by heat decomposition of the material and in a constricted space but with a substantial portion of the surface of the material unenclosed, whereby the evolved vapors may freely escape, and simultaneously rolling and kneading the material in such constricted space.

6. The method of agglomerating carbonaceous material which may be decomposed to form vapors by heating, which comprises

passing the material continuously through a spiral path, heating the material in the course of its passage through said path out of substantial contact with air to a temperature where vapors are evolved by decomposition of the material subjecting the material in the course of its passage along said path to pressure in a direction lateral thereof and causing a substantial portion of the surface of the ribbon to be exposed so as to allow the evolved vapors to escape freely.

7. The method of agglomerating bituminous coal that may be rendered plastic and decomposed to form vapors by heating, which comprises subjecting the same to heat to a temperature where the mass is rendered plastic and vapors are evolved by decomposition of the coal, simultaneously rolling and kneading the mass, and gradually restricting the movement of said mass while gradually applying progressively increasing pressure to the mass.

8. The method of agglomerating bituminous coal, which comprises subjecting the same to heat to a point where the mass is rendered plastic, and simultaneously rolling and kneading the mass under gradually increasing pressure up to the point where such mass sets.

9. The method of agglomerating bituminous coal, which comprises subjecting the same to heat to a point where the mass is rendered plastic, and simultaneously rolling and kneading the mass under gradually increasing pressure up to the point where such mass sets, and withdrawing the vapors evolved during the foregoing.

10. In apparatus of the character described, the combination of a retort adapted to be externally heated, and means within said retort defining a space therewith and adapted to pass material through said retort, said space intermediate its ends, gradually decreasing and then increasing in cross section transverse to the direction of travel of the material whereby varying pressure may be applied to such material.

11. In apparatus of the character described, the combination of a cylindrical retort, and a rotatable screw within said retort extending longitudinally thereof and adapted to pass material through said retort, the distance between the latter and the shaft of said screw decreasing and then increasing along said screw whereby varying pressure may be applied to such material.

12. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, said shaft having perforations whereby vapors evolved from such material may be withdrawn into its interior.

13. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, the upper face of said screw being inclined and its under face hollow concave.

14. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, the upper face of said screw being inclined and its under face hollow concave, and said shaft having perforations adjacent the upper face of said screw whereby vapors evolved from such material may be withdrawn into its interior.

15. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable vertical shaft within said retort, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, said shaft having perforations whereby vapors evolved from such material may be withdrawn into its interior, and means adapted to vary the extent of such perforations.

16. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, said shaft having perforations whereby vapors evolved from such material may be withdrawn into its interior, and a cylindrical shutter within said shaft movable to vary the extent of such perforations.

17. In apparatus of the character described, the combination of a retort adapted to be externally heated, and means within said retort and defining a space therewith and adapted to pass material through said retort, the space between the wall of said retort and said means being first constricted and then enlarged in the direction of travel of the material, whereby varying pressure may be applied to such material.

18. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longi-

tudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, the upper face of said screw being inclined and its under face hollow concave, the outer edge of said screw being formed into a cutting edge having a clearance angle between the face of the screw and the vertical wall of the retort of approximately 10°.

19. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, said shaft varying in diameter so as to vary the space between the same and said retort, and a spiral screw on said shaft adapted to pass material through such space, the upper face of such screw being inclined and its under face hollow concave, and said shaft having perforations from outside to inside of the hollow shaft, each perforation extending along a line, the inner end of which is inclined upwardy and peripherally of said shaft relative to a radial line which would intersect the axis of rotation of said shaft.

20. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort, and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, the upper face of said screw being inclined and its under face hollow concave, the outer edge of said screw being formed into a cutting edge and having a clearance angle between the face of the screw and the vertical wall of the retort of approximately 10°.

21. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, the upper face of said screw being inclined and its under face hollow concave in lateral cross section, and said shaft having perforations adjacent the upper face and spaced from the lower face of said screw whereby vapors evolved from such material may be withdrawn into its interior.

22. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, the upper face of such screw being inclined and its under face hollow concave in lateral cross-section, and said shaft having perforations from outside to inside of the hollow shaft, each perforation extending along a line, the inner end of which is inclined upwardly and peripherally of said shaft relative to a radial line which would intersect the axis of rotation of said shaft.

23. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, said shaft having perforations whereby vapors evolved from such material may be withdrawn into its interior, and means adapted to vary the extent of such perforations.

24. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, said shaft having perforations whereby vapors evolved from such material may be withdrawn into its interior, and a cylindrical shutter within said shaft movable to vary the extent of such perforations.

25. In apparatus of the character described, the combination of a vertically disposed cylindrical retort, a hollow rotatable shaft within said retort and extending longitudinally thereof, and a spiral screw on said shaft adapted to pass material through said retort, the upper face of said screw being inclined and its under face hollow concave, the outer edge of said screw being formed into a cutting edge and having a clearance angle between the face of the screw and the vertical wall of the retort.

Signed by us 1919.

FRANK C. GREENE.
IRVING F. LAUCKS.