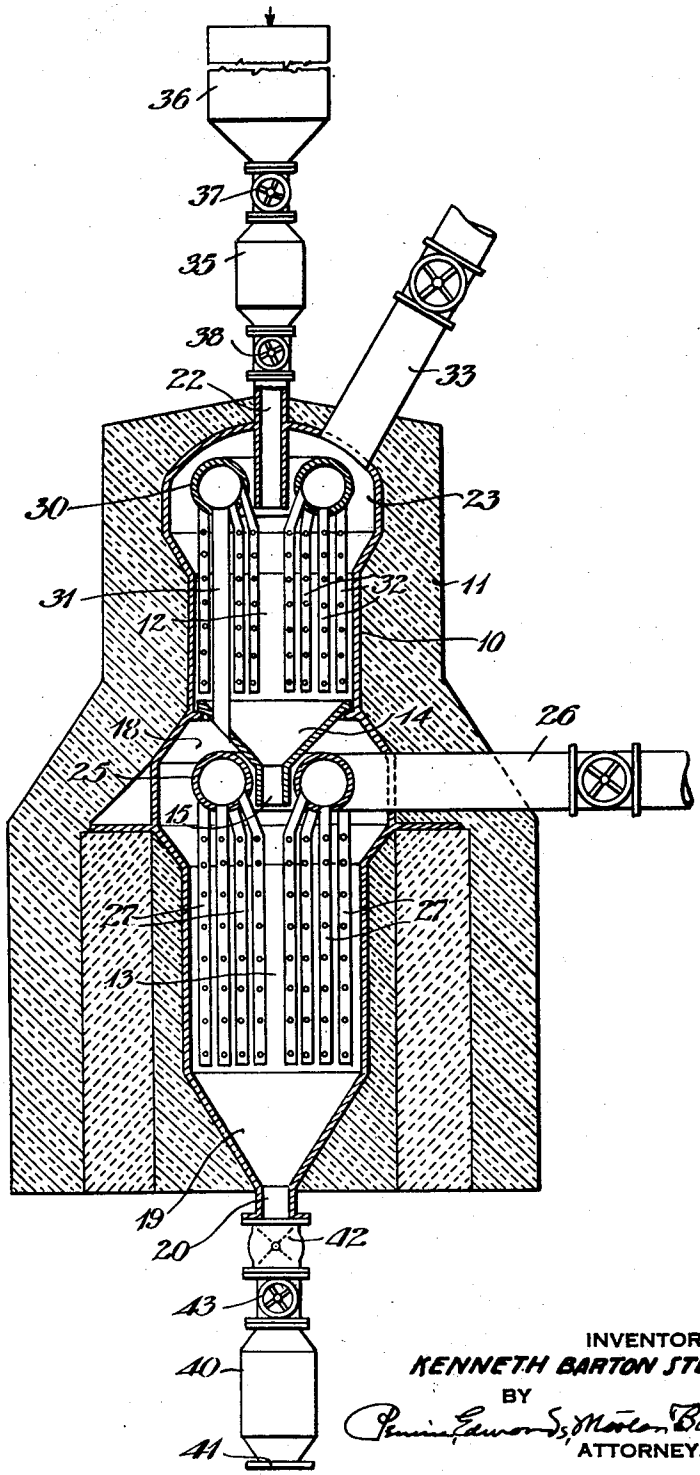
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APPARATUS FOR PRODUCING ACTIVATED CARBON

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APPARATUS FOR PRODUCING ACTIVATED CARBON

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1 Claim. (Cl. 202—99)

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This invention relates to apparatus for producing activated carbon and has for its object certain improvements in such apparatus for producing activated carbon of uniform high quality.

In the production of activated carbon, it is customary first to char or carbonize suitable raw carbonaceous material and then to activate it, usually with a hot mildly oxidizing gas, such as superheated steam. To this end, the activating gas is passed into a column of previously charred carbonaceous material. The gas tends to channel its way through the column of char, following the line of least resistance, with the result that the char is not uniformly activated.

Investigations confirm my discovery that an apparatus may be employed in which the carbonaceous material may be successively carbonized and activated, the structural elements of the apparatus being so arranged as to assure substantially uniform distribution of the carbonizing and activating gases among the solid particles of carbonaceous material. In this way each carbon particle receives substantially the same treatment.

In accordance with the invention, the apparatus comprises an upright retort with an inlet at the top for ingress of carbonaceous material and an outlet at the bottom for egress of activated carbon, the retort being divided into an upper carbonizing chamber and a lower activating chamber with a partition disposed between the two chambers with at least one opening therein for the passage downwardly of char from the upper chamber to the lower chamber and for the passage upwardly of gases from the lower chamber to the upper chamber. An outlet extends through the wall of the retort and connects the upper portion of the upper chamber for the passage of exhaust gases from the chamber.

In a preferred practice, a manifold is disposed in the upper portion of the lower chamber, an inlet extending through the wall of the retort and connecting the manifold for the passage of activating gas into the manifold. A plurality of spaced and perforated down-pipes depend from the manifold deeply into the lower chamber for the passage of activating gas from the manifold to the lower chamber. Another manifold is disposed in the upper portion of the upper chamber with one or more conduits connecting the upper portion of the lower chamber with the latter manifold. A plurality of spaced and perforated down-pipes depend from the latter manifold deeply into the upper chamber for the passage

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of carbonizing gases from the latter manifold into the upper chamber.

In another preferred practice of the invention, the partition between the two chambers is in the form of a hopper depending into the lower chamber to provide an open space in the upper portion above the normal level of carbon confined in the lower chamber to reduce the velocity of gases sweeping through the retort, thereby permitting the dropping of suspended fines. The upper portion of the lower chamber is preferably substantially greater in cross-sectional area than the main portion of the chamber to provide an enlarged space. This space may be regarded as a detention zone in which the velocity of the gas is reduced to drop the suspended fines while at the same time keeping the hot gas in the detention zone in direct contact and heat interchange relationship with the carbon to help provide the heat necessary to effect the desired activation.

The inlet at the top of the retort is preferably in the form of a conduit depending into the upper chamber to provide an open space above the normal level of carbonaceous material confined in the upper chamber to reduce the velocity of gases rising upwardly through the retort and thereby permitting the dropping of suspended fines. As with the lower chamber, the upper portion of the upper chamber is preferably substantially greater in cross-sectional area than the main portion of the chamber to provide additional space. This space also functions as a detection zone in which the velocity of the gases is reduced and suspended fines carried by the gases are dropped as they sweep through the carbonizing zone. While in the detention zone, the still hot gases are in direct contact and hence in heat interchange relationship with the carbon to help provide the heat necessary to effect the desired carbonization.

So that the carbonizing and activating steps may be conducted under pressure, the inlet at the top of the retort communicates with a charge chamber, a valve being disposed between the charge chamber and the inlet to open and close the passageway between the two. With an arrangement such as this, the valve may be opened to permit the passage of a charge of the raw carbonaceous material into the retort, after which the valve may be closed to prevent the escape of exhaust gases by way of the charge chamber. Exhaust gases are bled from the re-

tort through the automatic pressure controlled valve outlet connecting the upper chamber.

The outlet at the bottom of the retort communicates with a cooling chamber, a valve being disposed between the outlet and the cooling chamber to open and close the passageway between the two. A star discharge is preferably located at the outlet to transfer activated carbon from the retort to the cooling chamber. With the valve closed, pressure conditions may be maintained within the retort. From time to time the valve may be opened and the star discharge operated to transfer activated carbon from the retort to the cooling chamber, after which the valve is again closed to restore the desired pressure conditions within the retort.

These and other features of the invention will be better understood by referring to the accompanying drawing, taken in conjunction with the following description, which diagrammatically shows an apparatus illustrative of a practice of the invention.

The apparatus shown comprises a retort 10 having a heavy outer insulating jacket 11. The retort stands in an upright or vertical position and is generally cylindrical in plan, being divided into an upper or carbonizing chamber 12 and a lower or activating chamber 13. The two chambers are separated by a partition in the form of a hopper 14 with a depending outlet 15 to provide an open space in the upper portion of the lower chamber above the normal level of carbon confined in that chamber. The upper portion of the lower chamber is in the form of a bulged-out or enlarged section 18, making it substantially greater in cross-sectional area than the main portion of the chamber, to provide additional open space in the upper portion of the lower chamber. The lower portion of the lower chamber is in the form of an inverted frusto-conical section, or hopper, 19 with a depending outlet 20. The top of the retort is fitted with a depending inlet 22 to provide an open space in the upper portion of the upper chamber. The upper portion of the upper chamber is in the form of a bulged-out or enlarged section 23, making it substantially greater in cross-sectional area than the main portion of the chamber, to provide additional open space in the upper portion of the upper chamber.

A manifold 25, generally annular in shape, is disposed horizontally directly below the side wall of the hopper 14 and around depending outlet 15 in the open space in the upper portion of lower chamber 13. An inlet 26 extends through the wall of the retort and connects the manifold for the passage of activating gas into the manifold. A plurality of spaced and perforated down-pipes 27 depend from the manifold deeply into the lower chamber for the passage of activating gas from the manifold to the lower chamber. The number of downpipes and perforations is such as to assure a substantially even distribution of the activating gas in the body of char undergoing activation in the lower chamber.

A second manifold 30, also generally annular in shape, is disposed horizontally directly below the top wall of the retort and around depending inlet 22 in the open space in the upper portion of upper chamber 12. As shown, the manifold is supported on the side wall of hopper 14 by means of three vertical pipes 31 spaced at 120° angles. A plurality of spaced and perforated down-pipes 32 depend from the manifold deeply into the upper chamber for the passage of gases into the upper chamber from the manifold. The number of down-pipes and their perforations is such as to assure a substantially even dispersion of exhaust gases to the carbonaceous material undergoing charring in the upper chamber. A valved outlet 33 extends through the wall of the retort for the controlled passage of exhaust gases from the retort.

Inlet 22 at the top of the retort connects with a charge chamber 35 and a measuring bin 36, a valve 37 being interposed between the measuring bin and the charge chamber. A similar valve 38 is disposed between the charge chamber and the inlet of the retort.

Outlet 20 at the bottom of the retort connects with a charge chamber 40 fitted with an openable closure 41. In the specific construction shown, a star discharge 42 is associated with the outlet of the retort to facilitate removal of activated carbon therefrom. A valve 43 is interposed between the star discharge and the charge member.

The apparatus may be operated as follows:

Suitable carbonaceous material, such as finely divided anthracite coal, is fed into retort 10 until lower activating chamber 13 and upper carbonizing chamber 12 are filled. To this end, valve 43 is closed and valves 38 and 37 are opened, carbonaceous material being passed successively through measuring bin 36 and charge chamber 35 into the retort. When the lower and upper chambers are filled, valve 38 is closed.

Suitable activating gas is passed under positive pressure through valved inlet 26 into manifold 25 and then through perforated down-pipes 27 into the body of char confined in lower chamber 13. Due to the substantially even distribution of the relatively large number of perforated down-pipes, the activating gas is released substantially evenly throughout the body of char. The hot gas rises upwardly in the lower chamber in sweeping contact with the particles of char until it reaches the space in bulged-out section 18 above the top level of the body of char. This space may be considered a gas detention zone directly above the normal level of the carbon in the activating zone. The velocity of the gas is reduced as it enters the detention zone and drops suspended fines carried by the gas as it sweeps upwardly through the activating zone. While the hot gas is in the detention zone it remains in direct contact, and hence in heat-interchange relationship, with the carbon to help provide the heat necessary to effect the desired activation.

The hot gases then pass from the detention and activating zones, while still under substantial positive pressure, through pipes 31 into upper manifold 30 and then enter perforated down-pipes 32. Due to the substantially even distribution of the relatively large number of perforated down-pipes, the spent activating gases are distributed substantially evenly throughout the body of carbonaceous material. The gases rise completely through the body of material and enter bulged-out section 23 to the space above the normal level of the body of material confined in the upper chamber. The space may also be regarded as a detention zone, in which the velocity of the gases is reduced to permit the dropping of suspended fines carried by the gases. The still hot gases in the detention zone are kept in direct contact, and hence in heat interchange relationship, with the carbon to help provide the heat necessary to effect the desired carbonization. The spent or exhaust gases pass out of pressure

controlled valve outlet 33 while still under substantial positive pressure.

Activation of char in the lower chamber and charring of carbon in the upper chamber take place simultaneously. When the char in the lower chamber, particularly the lower portion of the lower chamber, is suitably activated, discharge valve 43 is opened and star discharge 42 is operated to withdraw activated carbon from the lower chamber to cooling chamber 40. As this occurs, the carbon above, in both the lower and upper chambers, settles or moves downwardly, thus leaving space in the upper portion of the upper chamber for additional carbonaceous material. After a desired amount of activated carbon is withdrawn, rotation of the star discharge is terminated and the discharge valve is closed; and after the activated carbon is cooled, closure 41 is opened to remove the carbon.

Additional carbonaceous material is placed in measuring bin 36 and passed into charge chamber 35. Valve 37 is closed and valve 38 is opened to drop the material through inlet 22 into the lower chamber.

The discharging and charging operations are conducted intermittently. The material in the upper and lower chambers in effect forms a continuous column which is progressively advanced by gravity through the retort. Due to the controlled manner in which the activating gas is introduced and the spent gases are withdrawn, the activating and carbonizing steps may be conducted under suitable pressure conditions. As the particles of carbonaceous material move downwardly through bulged-out section 23, and rub against down-pipes 32 and the side wall of the upper chamber and pass into restricted passageway 15 at the bottom of hopper 14, a gentle mixing action is obtained. This mixing action is continued as the charred carbon particles move through the restricted passageway and spread laterally across the retort, and as they move downwardly through bulged-out section 18 and rub against down-pipes 27 and the side wall of the lower chamber. The net effect is to combine gentle mixing with substantially even distribution of the heating gases, thus assuring substantially uniform treatment of the carbon particles.

Clogging of the manifolds and the down-pipes is prevented by keeping the gases substantially free of suspended fines. The gases tend to pick up fine solids in both the lower or activating chamber and the upper or carbonizing chamber and these solids would soon clog restricted openings if means were not provided to drop them out of the gas stream. These means comprise the bulged-out or expanded sections, the depending inlet and the hopper or funnel with its depending outlet between the two chambers. In these enlarged portions of the apparatus, the velocity of the gases is reduced to a point where the solids drop out. Another desirable feature of the apparatus is that the retort as a whole contains substantially no dead space in which material could collect and hence not be treated as is the remaining material. The structure shown is such as to insure substantially uniform charring and activation of the carbon.

Activating gases of various kinds may be employed. The most common are steam and carbon dioxide, or both. Activating gas may be obtained, for example, by burning combustible gas under pressure in air. The activating step is conducted under positive pressure, that is, superatmospheric pressure. This may vary over a rather wide

range but should be substantial, preferably in excess of 5 pounds per square inch gauge pressure. I have had excellent results with pressures in the neighborhood of 20 pounds per square inch gauge pressure. The pressure must, however, be consistent with safety, depending upon the strength of the apparatus.

Similarly, carbonizing gases of various kinds may be employed. It is economical to use the gases from the activating step for the carbonizing step, as described. It is also preferable to conduct the carbonizing step under a substantial positive pressure, say of the same order as in the activating step.

The flow of activating and carbonizing gases through the lower and upper chambers should be substantial and may, of course, vary over a rather wide range. I have, for example, passed activating gas in contact with the char at a temperature of about 1400° F. to about 1600° F. and at a rate of about 100 to 240 standard cubic feet of gas per hour per 1 to 2 pounds of activated carbon produced from the char; and carbonizing gas in contact with the carbon (Colorado subbituminous coal) at the rate of about 2500 to 6000 standard cubic feet of gas per 25 to 50 pounds of char per hour. Activation and carbonization of the carbon may be effected in a number of ways, such for example as described in my copending application Serial No. 501,044, filed September 3, 1943, now Patent No. 2,501,700.

It will be clear to those skilled in this art that the practice of the invention lends itself to various modifications. While the apparatus is particularly useful in the production of activated carbon, it may be used for other purposes; more especially, in the treatment of finely divided material with a gas, in which the gas is passed through the material and there is a tendency for suspended fines to be carried from the material by the gas.

This is the case, for example, in the exfoliation of vermiculite. When treated with heating gases under ordinary conditions, the problem of excessive product loss is twofold. In addition to fines, the large decrease in specific gravity on expansion makes treatment by direct contact with moving gases impractical because of an excessive loss of product in the exit gases. With apparatus of the present invention, however, these disadvantages may be largely overcome. Crushed vermiculite is placed therein and treated essentially as described above. Such fines as are produced are precipitated in the low velocity sections so that the exit gases are substantially free of fines.

Similar difficulties are encountered in the expansion or "popping" of perlite. They may be overcome when the perlite is treated like the vermiculite in accordance with the invention.

The section or sections of the apparatus specially provided to induce low velocity of the gases is particularly useful in any furnace and the like used for the treatment or drying of a relatively finely divided product in direct contact with moving gases. Such fines as are produced are precipitated from the stream of gases in the low velocity section, so that the gases may exit from the apparatus substantially free of fines.

I claim:

In apparatus for the production of activated carbon, the improvement comprising an upright retort with an inlet at the top for ingress of carbonaceous material and an outlet at the

bottom for egress of activated carbon, the retort being divided into an upper carbonizing chamber and a lower activating chamber, the upper portion of both the lower and upper chambers being substantially greater in cross-sectional area than the main portion of the respective chambers to provide spaces to reduce the velocity of gases rising upwardly through said respective chambers and thereby to permit the dropping of suspended fines, a manifold disposed in the enlarged upper portion of the lower chamber, an inlet extending through the wall of the retort and connecting with the manifold for the passage of activating gases into the manifold, a plurality of spaced perforated down-pipes depending from the manifold deeply into the lower chamber for the passage of activating gas from the manifold into said lower chamber, a manifold disposed in the enlarged upper portion of the upper chamber, a plurality of spaced and perforated down-pipes depending from said latter manifold deeply into the upper chamber for the passage of carbonizing gases from the latter manifold into said upper chamber, a partition disposed between the two chambers in the form of a hopper depending into the space formed by the enlarged portion at the upper end of the lower chamber, said hopper having an opening therein for the passage downwardly of charred carbon from the upper chamber to the lower chamber, at least

one conduit for conducting gases from the enlarged upper portion of the lower chamber surrounding said hopper to the manifold in the upper chamber, and an outlet extending through the wall of the retort and communicating with the enlarged upper portion of the upper chamber for the passage of exhaust gases from said upper chamber.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,502,592	Sauer	July 22, 1924
1,563,295	Sauer	Nov. 24, 1925
1,913,968	Winkler	June 13, 1933
1,955,025	Sabel et al.	Apr. 17, 1934
2,131,702	Berry	Sept. 27, 1938
2,162,763	Stuart	June 20, 1939
2,446,805	Bergstrom	Aug. 10, 1948
2,471,119	Peck et al.	May 24, 1949

FOREIGN PATENTS

Number	Country	Date
18,596 of 1934	Australia	July 24, 1934