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DISTILLATION OF CARBONACEOUS MATERIAL

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2 Sheets-Sheet 1

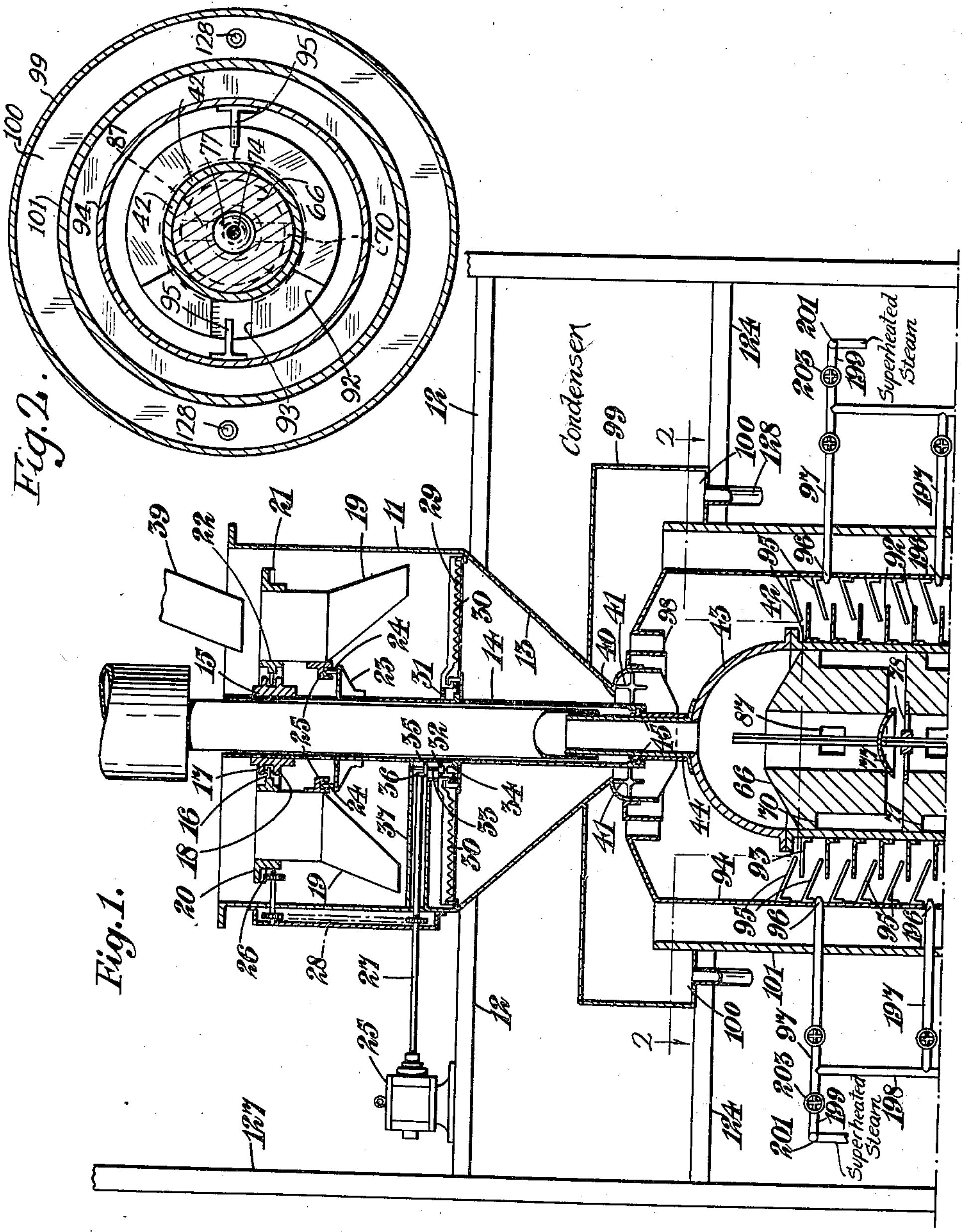

Fig. 1.

Fig. 2.

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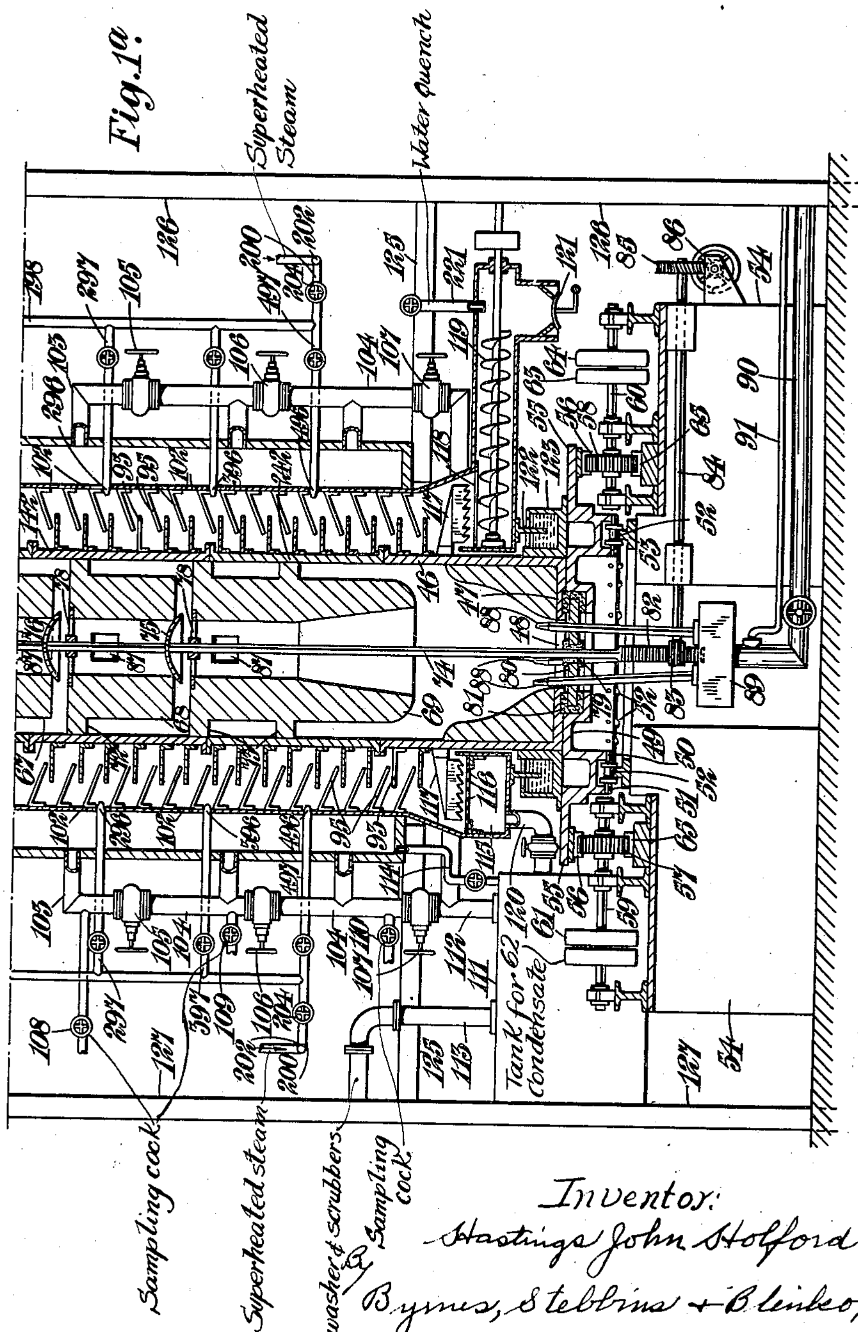

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DISTILLATION OF CARBONACEOUS MATERIAL

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2 Claims. (Cl. 202—104)

This invention relates to retorts for the distillation of carbonaceous material of the type comprising two concentric cylinders having an annular distillation space between them, the outer cylinder being fixed and the inner mounted for rotation about an upright axis, a plurality of perforated annular shelves carried by the inner cylinder in said distillation space, means for continuously supplying solid material to be distilled downwards in a thin stream over said shelves, and means for heating the interior of the inner cylinder.

Various constructions of retort of the type described have been proposed heretofore which were provided as usual with take-off means for conveying vaporized and gaseous distillation products from the distillation space, and with means for discharging residues from the retort at its lower end. In these proposed retorts, however, no provision was made for supplying superheated steam as a distilling medium to the annular distillation space or for obviating temperature fluctuations due to variations in the supply of the steam when using the retort for the distillation of carbonaceous materials of various kinds.

In a proposed construction of retort for the dry distillation of carbonaceous fuel of a type different from that to which the present invention relates, in that no steam was employed as a source of heat for the carbonaceous material, a body of refractory material of large heat capacity arranged in the inner cylinder was maintained in a hot condition by hot gases from a burner, but that refractory body did not fill the inner cylinder and was spaced away from its walls so that no heat passed by conduction to the shelves over which the carbonaceous material passed.

The present invention has for its object to enable carbonaceous material of widely different kinds, such as bituminous coal, peat, lignite, torbanite, shale, cannel coal and the like, to be distilled in apparatus of the type described in such manner that the heating conditions in various parts of the distillation space can be readily controlled according to the kind of material that is undergoing treatment, and be kept substantially constant, thereby ensuring efficient operation and a maximum through-put capacity upon a given ground space.

According to the invention, a retort for the distillation of carbonaceous material of the type described above is characterized in that steam-supply means for supplying superheated steam to the annular distillation space comprises a plurality of separately regulatable steam inlet nozzles arranged spaced apart one from another at various heights on the fixed cylinder, and a plurality of bodies of heat-resisting material of considerable heat-absorbing capacity are arranged in the inner cylinder in contact therewith at a plurality of situations spaced apart in the direction of its length. As compared with known apparatus of the type described, the improved construction enables carbonaceous material of widely different character, such as soft, highly bituminous coal or cannel coal, to be treated in the same apparatus owing to admitting the superheated steam at various heights at different places in the retort, and regulating the quantity of steam admitted at each height. As the carbonaceous material descends in thin layers or in a thin stream, and its total quantity in the apparatus at any time is relatively low, the total heat capacity of the carbonaceous material under treatment is small; any fluctuations in the rate of flow of the carbonaceous material through the apparatus are liable to give rise to considerable fluctuations in the temperature of treatment, and such variations would interfere with the uniformity and efficiency of the process, for which reason the body of refractory material of large heat capacity is provided for preventing considerable fluctuations in the temperature of the treatment by the superheated steam which might otherwise occur, owing to the employment of such steam as the heating medium, whereof the specific heat is low. The heat radiator of large heat capacity is maintained at an elevated temperature so as to act as a reservoir of heat, is situated close to the shelves, heats the latter directly by conduction, and thus stabilizes the heating conditions.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:—

Figures 1 and 1*a* show diagrammatically a complete distillation apparatus and comprise respectively views of the upper and lower halves of the apparatus seen partly in elevation and partly as a section taken through the central vertical axis thereof.

Figure 2 is a horizontal section taken on the line 2—2 in Figure 1, showing one of the shelves in plan.

Referring to the drawings, in Figure 1 the apparatus comprises a fixed upright cylindrical casing 94, within which rotates about an upright axis a heating unit or inner chamber 42 having a flue 14 at the top. The casing 94 and associated parts are supported by an iron framework comprising uprights 126—127 and cross members 12, 124, 125, while a set of concrete base members 54 take the weight of the rotating inner chamber 42. A hopper 11 is supported by the cross member 12 above the casing 94 around the flue 14, and has a sloping floor 13. The flue 14 carries at its upper end a collar 15 supporting rollers 16 mounted upon stub axles between flanges 17 and 18 at spaced intervals around its periphery. Supported within the upper portion of the hopper are four distributors 19 arranged at right angles (one pair only being visible in the drawings). The distributors 19 are held together by an annulus 20 of angle section provided with a rack 21 on the under side. A further annulus 22 secures together the inner sides of the distributors 19 and carries a track which runs on the rollers 16.

A circular flange 23 is supported by the flue 14 and provides another track upon which run rollers 24 carried in brackets 25 attached to the distributors 19 so as to support their weight. The distributors are thus rotatably mounted in the hopper. They are driven by a motor 25 mounted upon the cross member 12 through an intermediate shaft 27, a chain drive 28, and a pinion 26. The hopper 11 comprises a false bottom composed of a wire mesh screen 29, the mesh aperture of which may be adjusted by suitable means. Two pairs of rake arms 30 are mounted for rotation above the screen 29 and form part of an assembly of four such arms, the other pair being mounted at right angles to those shown. The rake arms 30 are each united to a ring 31 which carries an inwardly facing rack meshing with a pinion 32 carried by an axle 33 supported in a bracket 34 united to the flue 14. Mounted upon the axle 33 is a bevel pinion 35 which meshes with a similar pinion 36 driven from an extension of the shaft 27. The extension of shaft 27 is enclosed by a housing 37 which also serves as a bearing for shaft 33.

As the distributors 19 rotate they each come in turn below a chute 39 through which carbonaceous material is periodically delivered in a finely divided state from a skip-elevator. The speed of rotation of the distributors is adjusted to ensure that a distributor is passing beneath the chute 39 when carbonaceous material is issuing therefrom and the rotary movement of rakes 30 is correlated to that of the distributors to bring about maximum distribution of the carbonaceous material upon the surface of the screen 29.

The material passing through screen 29 falls down the inclined bottom 13 of the hopper and passes through an annular opening 40 beneath which are located a plurality of outlet valves 41 which may rotate under the weight of the material delivered to them to allow it to pass whilst maintaining a substantially gas-tight seal between the hopper and the casing 94 below. The upper end of the inner chamber 42 has a hemispherical roof 43, beneath the inlet valves 41, and the roof 43 terminates in a central vertical junction pipe 44 which enters the flue 14. The pipe 44 communicates with the interior of chamber 42 and serves to conduct waste gases or vapour from the interior of the heating chamber 42 to flue 14 and thence to the atmosphere. The chamber 42 is rotatably mounted. A gland 45 is provided between the flue and pipe 44.

Referring to Figure 1*a* it will be seen that chamber 42 is composed of three superposed open-ended circular sections 42, 142, 242 which are united together and also united to a bottom section 46, the lower end of which carries an inwardly extending diaphragm 47 provided with a central aperture 48. This rotatable structure is mounted upon a base plate 49 provided on its underside with depending flanges 50, 51 between which are mounted on spindles 152 a plurality of rollers 52. The rollers run upon an annular track 53 supported upon the four concrete blocks 54 hereinbefore referred to, which are spaced apart beneath the lower end of the apparatus, two only of the said blocks appearing in the figure. The base plate 49 is also provided with an outwardly facing flange 55 carrying a rack 56 on its underside which engages with driving pinions 57 and 58 on either side of the apparatus. The pinions 57 and 58 are mounted upon axles 59 and 60 which are supported for rotary movement in suitable bearings which in turn are mounted upon I-section angle irons. Fast and loose pulleys 61, 62 and 63, 64 are respectively mounted on shafts 59 and 60 for driving the pinions 57 and 58. In order to equalize the thrusts upon the chamber 42 two freely rotatable pinions similar to pinions 57 and 58 are arranged to engage with the rack 56 on a line at right angles to the shafts 59 and 60. Below, but out of contact with pinions 57 and 58 are disposed pairs of abutments 65 upon each side of the pinions. Should the chamber depart from its vertical alignment the abutments serve to jam the pinions and to restrict rotation of the inner chamber.

The inner chamber 42 carries firebrick elements 66, 67, 68 and 69 supported within it by flanges 70, 71, 72 and 73 integral therewith. The refractory elements are each formed with a central aperture through which passes a rod 74 carrying dampers 75, 76 and 77 for controlling the flow of the heating medium through the elements to the flue. Cross members 78 recessed in the refractory elements slidably engage rod 74 so that it may be moved in a vertical direction but is restricted from sideways movement. At the lower end of the inner chamber, rod 74 passes through a gland 79 carried by a circular plate 80 which works in a gland 81, for example packed with asbestos supported within a channel carried by the base-plate. The lower end of the rod 74 terminates in a rack 82 which engages with a pinion 83 carried at one end of a shaft 84 which is mounted for rotation in suitable brackets via a worm gearing 85 which may be actuated from a hand wheel 86. Upon rotation of the hand wheel the rod 74 may be raised or lowered, to bring the dampers 75, 76, and 77 into or out of engagement with the lower ends of the openings in the refractory elements. When the dampers are situated in their lowest position and seated on the refractory elements below them, they are closed and the gases cannot escape to atmosphere, whilst when they are in the upper position shown in the drawings, they are fully open and the heating medium will follow a tortuous path and will pass around the outside of the upper refractory elements and through their cross passages 87 before escaping to the flue; as a rule, however, when the retort is in full operation, the dampers will be raised only slightly from their seats to permit the heating medium to flow in part around the refractory elements and also through their central spaces.

The inner chamber is heated from a group of three nozzles 88 which pass through plate 80 and are united at their lower ends to a junction box 89 connected to a steam or gas line 90 and a compressed air line 91. When steam is used this is supplied to line 90 from a superheater and the superheated steam from nozzles 88 passes upwardly in contact with the refractory elements and raises them to a high temperature. The chamber 42 containing the highly heated refractory elements thus serves as a heat reservoir. When it is desired to supply combustible gas to the nozzles 89 line 90 is connected to a gas supply by means not shown and compressed air is introduced at the same time via conduit 91.

Upon the outside of chamber 42 are mounted a plurality of superposed circular shelves 92, each of which may be built up of three arcuate sections, as shown in Figure 2, and is provided with an opening 93, say over an arc of 10° around the shelf plan, as shown in Figure 2. The shelves are so positioned that the openings in adjacent shelves are displaced circumferentially; preferably the displacement is such that the openings form a helix. The inner chamber 42 is surrounded by a fixed casing 94 which forms between itself and chamber 42 a distillation chamber. A plurality of scraper or rabbling arms 95 are carried by casing 94 and project inwardly towards shelves 92 and terminate just out of contact therewith. The finely divided carbonaceous material issuing from outlet valves 41 drops upon the hemispherical roof 43 and is distributed therefrom upon the top shelf. Upon rotation of chamber 42 the material is agitated and turned over by the upper rabbling arms and eventually drops through the first opening 93 on to the second shelf whence it proceeds from shelf to shelf down the distillation chamber. During its passage downwardly the carbonaceous material is subjected to heat conducted through the shelves and radiated from the heat reservoir constituted by the firebrick elements contained within the inner chamber 42. Simultaneously superheated steam is introduced in contact with the carbonaceous material from nozzles 96, 196, 296, 396 and 496 arranged in four vertically disposed banks (two banks only appearing in the drawings) which are each connected via steam conduits 97, 197, 297, 397 and 497 with vertical steam pipes 198. The steam pipes 198 are in turn connected by pipes 199 and 200 to annular steam headers 201 and 202 serving to conduct superheated steam to each bank from a superheater. Each pipe 199 and 200 is provided with a cut-off valve 203, 204, respectively, which may be operated to enable steam to be delivered simultaneously to both ends of the vertical pipes 198 or at either end alone. In addition, steam conduits 97 to 497 each carry a cut-off valve so that the quantity of steam and points of steam introduction may be varied thus affording control over the temperature conditions obtaining at different zones in the distillation chamber. The products of distillation pass via an annular opening 98 at the top of the distillation chamber into a condenser 99 provided with a sump 100.

The casing 94 is surrounded by an outer casing 101 which opens at the top into the condenser 99. This is cooled by radiation into the atmosphere and also by water circulated through appropriate coils of pipe or around a jacket as may be found convenient. In addition, casing 94 is pierced with a number of apertures 102 through which volatile distillation products may escape from the distillation chamber into the outer casing 101 and thence to the condenser 99. Gas pipes 103 open out of the outer casing 101 and are united via branches 104, the flow of gas therethrough being controlled by valves 105, 106 and 107. Sampling cocks 108, 109, and 110 are provided adjacent the main control valves. The gas pipes lead into a tank 111 in which an extension of a pipe 112 dips under water or other fluid sealing medium. A conduit 113 opens into tank 111 above the liquid surface and is connected to a suction pump which distributes the gas coming from the distillation chamber to washers and scrubbers in the usual manner. The bottom of the chamber formed between the outer casing 101 and casing 94 is drained by a pipe 114 opening into tank 111, the flow of condensate therethrough being controlled by a suitable valve.

At the base of the distillation chamber is located an annular box 115 covered by a grating 116 over which sweep a plurality of rakes 117 carried by the inner chamber 43. The rakes serve to agitate the fully carbonized material dropping upon the grating from the last shelf and to advance it to an opening 118 in the grating below, in which is mounted a screw conveyor 119 suitably driven. Whilst the carbonized material is advanced towards the conveyor it is also drained of any condensed volatiles (tar, etc.) which pass through the grating into box 115 and thence by a valved pipe 120 below the liquid in tank 111. The material issuing from the screw conveyor is periodically released through a trap 121 and may be cooled by a water quench 221 located above the trap.

In order to secure a gas-tight seal at the lower end of the inner chamber 42 there is provided a downwardly-extending web 122 of T-shaped cross-section which dips below the surface of water or sand contained in an annular trough 123 and which rotates together with the inner chamber.

In the operation of the apparatus finely divided carbonaceous material is fed from chute 39 into the rotating distributors 19 and passes through the mesh screen 29 and thence via outlet valves 41 on to the dome 43 of the rotating inner chamber 42. The curved surface of the hemispherical dome 43 acts to distribute the falling material evenly upon the surface of the uppermost shelf. The spread material is continuously agitated and turned over under the action of the rabbling arms 95 which eventually sweep the material through the aperture 93 in the top shelf so that it falls by gravity upon the second shelf. This action is repeated throughout the series of shelves down the length of the distillation chamber and the progressing material is submitted during its passage downwards to the action of steam (superheated to for example 500° C.) which issues from nozzles 96. This admitted steam itself supplies part of the heat required. At the same time heat is radiated from the inner chamber and serves to maintain and stabilize the temperature conditions prevailing in the distillation chamber. The carbonaceous material undergoes distillation under the combined action of the heat and the steam and evolved gases and some distillation products pass off by way of openings 98 and 102, the condensible products being mainly condensed in the condenser 99 and collecting in the sump 100. The distillate is withdrawn periodically from the sump through a conduit 128 which is connected to a piston valve which may conveniently be thermostatically operated. The condensation occurring in the condenser 99 ensures a continuous flow of vapours to the condensing chamber, most of the condensible vapours passing out by way of opening 98. The non-condensible gases from the distillation operation are withdrawn under suction via the pipes **103**, **112** and **113**, and entrain with them to some extent tar-like materials which are deposited in tank **111**. By suitably regulating the temperature of the inner chamber and the degree of superheating of the steam supplied to the steam lines **97** it is possible to control the temperatures prevailing in the distillation chamber and to provide for graduated heating zones therein. In this way it becomes possible to adjust the temperature conditions according to the carbonaceous material which is to be employed.

The following Examples I to IV set forth temperatures observed from fourteen equally spaced pyrometers arranged in the casing **94** and extending from the top of the inner chamber to the outlet end thereof. The temperatures were varied for different carbonaceous material by adjusting the cut-off valves in the steam conduits.

Example I	Example II
Material used: Industrial coal ground to pass a screen having 50 mesh to the lineal inch.	Material used: Bituminous coal ground to pass a screen having 50 mesh to the lineal inch.
Approximate temperature in °C.	Approximate temperature in °C.
80	100
95	120
110	160
125	(Gas) 200
140	240
180	280
(Gas) 220	320
280	360
320	400
380	(Maximum production of gas and tar) 380
(Maximum production of gas and tar) 420	320
400	290
370	250
320	210

Example III	Example IV
Material used: Cannel coal ground to pass a screen having 50 mesh to the lineal inch.	Material used: Low volatile coal ground to pass a screen having 50 mesh to the lineal inch.
Approximate temperatures in °C.	Approximate temperatures in °C.
50	120
70	150
110	200
140	240
(Gas) 190	(Gas) 270
230	310
270	350
(Maximum production of gas and tar) 310	390
350	420
315	470
290	(Maximum production of gas and tar) 500
250	550
210	510
190	470

In Example I it was found that non-condensible gas started to be evolved at approximately 220° C. whilst the maximum production of gas and tar took place near the pyrometer which indicated a temperature of 400° C. Corresponding points for the beginning of gas evolution and the maximum production of gas and tar are shown in the Examples II, III and IV.

In order to take samples of the gases issuing into the gas chamber between casing **94** and the outer casing **101** the test cocks **108**, **109** and **110** may be used in conjunction with valves **105**, **106** and **107**. Thus by closing valves **105** and **106** and opening cock **110** a quantity of gas can be extracted through the test cock and analyzed. If cock **110** is then closed and valve **106** opened and a further quantity of gas withdrawn from cock **109**, a second analysis may be obtained. If this operation is repeated in respect of gas collected from test cock **108** a rough estimation of the constitution of the gases leaving the gas chamber at the three levels through pipes **103** may be obtained.

It will be understood that the speed of rotation of the inner chamber **43** may be regulated along with the rate of introduction of the carbonaceous material via the hopper **11**. It is thus possible to secure conditions which will enable an optimum yield of desired volatile products to be obtained having regard also to the possibility of varying the temperature of inner chamber **43** and the degree of superheating imparted to the steam. In an alternative construction the annular shelves **92** may be replaced by a continuous helix along which the material may be moved gradually from the top to the exit end of the distillation chamber. When a helical shelf formation is employed it is of course necessary to modify the mounting of the rabbling arms by providing for them to have freedom of vertical movement so that the inner chamber may rotate without jamming.

I claim:—

1. A retort for the distillation of carbonaceous material comprising a fixed casing, a heat radiator of large heat storage capacity within the casing and mounted for rotation about an upright axis, a plurality of shelves in tiers encircling and attached to the heat radiator, means for continuously supplying solid material to be distilled in a finely divided state to the top shelf and for distributing it evenly thereupon as a thin layer, each shelf having an opening to permit the passage of material from shelf to shelf, stationary inward projections carried by the casing for working the material on the shelves and downwards through said openings, means for heating said heat radiator, a plurality of steam inlets that open at situations spaced apart at different heights into the distillation space occupied by the shelves, separate regulating means for each steam inlet, take-off means for conveying vaporized and gaseous distillation products from the said distillation space, means for discharging residues from the retort at its lower end, which fixed casing is provided with a plurality of apertures in its walls to permit escape of volatiles to the outside thereof, an outer-casing affording a collecting space for the collection of said volatiles, a condensing casing surrounding said fixed and outer casings and connecting therewith, means to withdraw condensed products from the condensing casing, and a plurality of valve-controlled outlet pipes for volatiles connected at different heights to said collecting space.

2. A retort for the distillation of carbonaceous material, comprising two concentric cylinders having an annular distillation space between them, the outer cylinder being fixed and the inner mounted for rotation about an upright axis, a plurality of perforated annular shelves carried by the inner cylinder in said distillation space, means for continuously supplying solid material to be distilled downwards in a thin stream over said shelves, means for heating the interior of the inner cylinder, steam-supply means for supplying superheated steam to the distillation space comprising a plurality of separately regulatable steam-inlet nozzles arranged spaced apart one

from another at various heights on the fixed cylinder, a plurality of bodies of heat-resisting material of considerable heat-absorbing capacity arranged in the inner cylinder in contact therewith at a plurality of situations spaced apart in the direction of its length, take-off means for conveying vaporized and gaseous distillation products from the said distillation space, and means for discharging residues from the retort at its lower end.

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