This invention relates to the distillation of carbonaceous material, such as shales, cannel coal, torbanite, other oil-bearing coals, peat or cellulose material, and wood suitable for manufacturing charcoal, or other raw material such as nut shells adapted for the manufacture of charcoal.

A primary object of the present invention is to enable carbonaceous material, or cellulose material, or other raw materials suitable for carbonisation to be subjected to destructive distillation in the same vertical retort in an improved manner, with or without the recovery of by-products, such as liquid fuel, spirit, power and heating gases, tar, coke and other commercial by-products. Another object is to provide an improved vertical retort for use in subjecting any of said materials to such a distillation process.

According to a feature of the invention, there is provided a method of distilling carbonaceous or cellulose materials, or other raw materials adapted to be subjected to destructive distillation by carbonisation, by subjecting the raw material to the destructive heating action of and contact with a fluid heating medium as the material descends through a vertical retort shaft surrounded by a vertically continuous jacket space, characterised by externally heating the lower part of the retort shaft containing the zone of destructive distillation and also the upper part of the retort shaft above that zone, by a fluid heating medium flowing up the jacket space from the lower part to the upper part thereof, and thereby pre-heating the raw material fed into the retort prior to its reaching the zone of destructive distillation.

Preferably the raw material is fed in successive batches into the destructive distillation zone with an appreciable time interval between two successive batches, and the carbonaceous residue is preferably removed in batches from the lower end of the retort shaft with an appreciable time interval between two successive batches.

According to another feature of the invention provision is made for heating the retort shaft externally with gas, such as producer-gas, that is admitted to the jacket space, and is obtained as a by-product from the retort.

 Provision is also preferably made for supplying super-heated steam or both separately or as a mixture into the externally heated retort shaft.

The invention also provides for use in carrying into practice the improved method of distilling raw materials set forth above, a vertical retort comprising a retort shaft in combination with an external casing or jacket that is spaced away from the retort shaft and provides a vertically continuous jacket space surrounding the retort shaft, means arranged to pass a fluid heating medium up the jacket space and out of the top thereof, means arranged to admit a fluid heating medium to a charge of raw material in a lower destructive distillation zone and in an upper pre-heating zone in the externally heated retort shaft, and feed means comprising an inlet valve arranged to feed the raw material in a succession of batches into the retort shaft with a time interval between the feed of each two successive batches.

The inlet valve and outlet valve at the bottom of the retort preferably both open downwardly and may be provided each with manually-operated actuating means. Alternatively, mechanical means may be provided for operating said valves in synchronism.

Conveniently the lower end of the retort shaft constituting the distillation zone comprises two sections each of a frusto-conical formation of different length joined together at their widest parts with the shorter section directed downwards below the longer section.

Preferably, the bottom portion of the jacket surrounding the distillation zone is of larger diameter than the upper portion and constitutes a gas-heating chamber, into which tuyères open for the supply of heating gas to the entire jacket.

According to another feature of the invention, non-mechanical indicating means is preferably mounted on the retort for indicating a high level and a low level of the charge in the retort shaft as described hereinafter.

Preferably the outlet at the bottom of the retort shaft surrounded by the jacket opens downwards into a quenching device arranged to quench carboniferous solid residue discharged from the retort shaft.

This quenching device preferably comprises a water jacket with baffle members arranged within it, and quenching pipes associated with the baffle members as described hereinafter.

Conveniently, a conveyor of the endless member type, such as a drag link conveyor, is arranged below the retort shaft, preferably at the bottom of the quenching device for receiving the solid carbonized residue from the retort shaft and conveying it away. Means may be provided for conveying the quenched material and water to an oil separator.

This endless conveyor is preferably of the water-trough type.

Preferably means are provided for conducting the water from the oil separator through a cooling tower back again to the quenching device.

The invention also provides a method of op-
erating a distillation plant having a bank or more than one bank of vertical retorts each as set forth above, which method comprises the steps of removing the spent carboniferous material in falling streams from all the retorts in a bank continuously quenching the streams of spent material, supplying the quenched material and water continuously to oil-separation apparatus, and continuously removing the separated oil and the spent material from which the oil has been removed.

The invention further provides a distillation plant having one or more than one bank of vertical retorts each as set forth above, wherein a conveyer of the endless member type, which may be a quenching conveyer, is arranged to convey spent carboniferous material falling on to it from the outlets of all the retorts in a bank, and deliver it to oil-separation apparatus and to an elevated bunker for supplying raw material to all the retorts in a bank will be described herein-after.

The following is a description of a plant suitable for the recovery of oil from shale, reference being made to the accompanying drawings in which:

Figure 1, divided into separate subfigures 1A and 1B, shows the general lay-out of the apparatus;

Figure 2 is a diagrammatic view showing the various steps in the process; and

Figure 3 is an enlarged vertical section and elevation of two of the retorts.

Referring to Figure 1 the shale from a store or hopper wagon is delivered through a conveyor 12 into a conveyer 13. The conveyer delivers the shale to a bucket elevator 14 from which it passes through a chute 15 to a roll crusher 16, from the crusher it passes to another bucket conveyer 17 and thence to a screening device 18. The shale which is to be distilled is passed from the screen to another bucket conveyer 19, while the dust from the screen is passed to a Redler conveyer 20. The shale to be distilled is delivered by the last-mentioned bucket conveyer 19 to a conveyor indicated generally at 20 which is of the extendible kind so that it may deliver into any one of a number of bucket elevators 21 arranged above a bank of retorts 22, the construction of which is described later. The spent shale after being quenched in a quenching device 23 at the bottom of each retort, falls onto a conveyer 24 of the water trough type which conveyor extends away from the battery of retorts and over the upper part of a settling tank 25 which removes the sludge and oil while the spent shale is delivered onto a conveyer 26 leading to a dump. The settling tank contains an oil separator 27 of the type described in British Patent No. 287,750 (complete specification accepted August 27, 1925), while the quenching water is delivered by a pump 28 to a cooling tower not shown from whence it passes back again to the quenching device 23.

The distillate gases from the retorts pass oil out from the tops thereof through a conduit 29 leading to condensers 30, 31 and a scrubber 32 shown in Figure 2 and the gaseous fractions are stored in a gas holder 33, whence, after being supplemented by gas from an auxiliary gas producer 34 which pass back again to the retort, a part of the gases being delivered into the interior of the retort through a conduit 35 and a part being delivered into jacket space through the conduit 36. In addition to the gas being passed into the interior of the retort there is a supply through a conduit 38 of superheated steam derived from a super-heater 37, Figure 2, which receives steam from a boiler 40. In addition the super-heater supplies steam to the auxiliary gas producer 34 through the conduit 39.

The condensate oil from the condensers 30 and 31 passes through the conduits 41 and 42 to a dehydrator 43 and thence through conduit 44 to an oil refining plant, indicated generally at 45. The hot gases which leave the jackets of the retorts pass through conduits 46 to a waste heat recovery boiler 47 which leads hot water through conduit 48 to the main boiler 40.

Referring now to Figure 3, it will be seen that the retort comprises a vertical mild steel tubular shaft 50 which is surrounded by brick work 51 having a lining of fire bricks 52. The lining is spaced away from the retort shaft as to provide a jacket space 53 which is widest at 54 near the bottom of the retort shaft, the bottom portion of the retort shaft is provided with a conical portion 55 widening as it extends downwardly and which is connected with a conical portion 56 which narrows as it extends downwardly. This later conical portion is supported by a part 57 of the fire brick lining.

The upper portions 58 of the retort shafts are cylindrical in form and are secured together by bolts passing through flanges 58, being readily portable whereby erection of the plant is facilitated.

The retort shaft may be formed from best quality boiler plate of 25-32 tons tensile strength made into tubular sections and having secured thereto angle sections whereby the parts of the retort shaft may be securely connected. The other end of each retort shaft projects above the brick work at 59 and is provided with outlet conduits 60 which feed the aforesaid conduits 29 leading to the condensers. The upper extremities of the retort shafts terminate in funnel shaped members 61 which are fed through chutes 62 from the aforesaid hoppers 21. As will be seen each hopper 21 and chute 62 are mounted on a framework 63 disposed between two retorts. A valve member 64 is associated with the bottom of the funnel-shaped member 61 and another valve member 65 is associated with the chute 62. A third conical valve member 66 is associated with the outlet at the bottom of the conical section 56 of the retort. The valve members 64 and 66 are interlinked by mechanism not shown which is driven through suitable gearing from a prime mover so that periodically a charge of shale is introduced into each retort and spent shale is released from the bottom of the retort. The conical valve member 66 is slidably mounted on the conduit 67 through which superheated steam or gas or both may be introduced into the retort. In the event of both steam and gas being employed separate concentric supply pipes may be employed so that the gas and steam meet at the nozzle 68 within the retort. The combustible gases are introduced into the larger space 54 of the jacket around the retort through nozzles or tuyeres 69 which are fed through the aforesaid conduits 35. The distillation of the shale for the most part, takes place in the lower portion of the retort provided by the conical portions 55 and 56, while the shale in passing downwardly through the upper portions of the retort is preheated by the hot gases in the jacket space 53. The hot gases leave the upper part of this jacket space through outlets 70 which lead to the aforesaid waste heat conduits 46. A gas seal is pro-
vided between the tubular retort and the jacket wall by means of a skirt portion 11 attached to the retort and extending downwardly into a circumferential channel 12 supported by a brickwork and lining.

When the conical valve 66 is closed and distillation is taking place there may be a tendency for crude oil to collect at the junction between the valve and the lower portion of the retort part 56. This oil may be led away through ports 73 in the retort part 56 which ports lead to a channel 74 on the outside of the retort from which a delivery conduit extends. When the conical valve 66 is open the spent shale drops into the quenching device 23 which comprises an encircling wall to which is attached a number of baffle plates 76 inclined inwardly and downwardly. Spray pipes 76 are provided near the lower edges of the baffle plates so that the spent shale falls through a shower of liquid and eventually drops on to the water channel conveyor 24. This conveyor comprises a cast iron water-tight trough in which moves the upper run of an endless chain provided with drag bars, which trough is provided at a water discharge point with a screen or grating 77 to prevent any material passing into the settling tanks 25 hereinafter referred to. Air supply pipes 77 (not shown in Figure 3 but shown in Figure 2) are provided for supplying air for combustion of the gases both within the retort and within the jacket space. The air may be supplied by induction or by a fan. Similarly, a force feed may be provided for the gas as by a booster indicated at 78 in Figure 2.

Numbered indicating devices 79 for indicating the level of the shale within the retort may be provided at various levels, but in Figure 3 only one is shown towards the top of the jacket space and comprises a tubular casing 80 which extends through the jacket into an aperture in the retort shaft and contains a photo-sensitive device such as a photo-electric cell that it is connected to a control system comprising an electric circuit containing a thermionic vacuum valve controlling a relay arranged to operate a visual or acoustic indicating device. The arrangement is such that when the level of the shale in the retort shaft falls below a low level indicator and rises above a high level indicator the respective indicators are actuated so that the outlet and the inlet valves can be operated accordingly.

The pre-heating zone or chamber constituted by the upper part of the jacket space is preferably made of solid highly refractory material surrounded by best quality brickwork, the whole being suitably stiffened and supported by brickwork and tie-rods. The upper cylindrical portion of the brickwork surrounding the retort shaft preferably has mild steel angle bands 81 arranged encircling it at various levels. The brickwork setting carrying the lined jacket is preferably carried on brick columns 82.

Eight thermo-couple pyrometers (not shown) may be fitted to the retort, four in the gas-admission chamber at different levels, and one at other appropriate points to give:

(a) Temperature of the superheated steam,
(b) Temperature of the gas entering both the preheating zone and the firing chamber at the base of the retort shaft,
(c) Temperature of the gas and hydrocarbon vapours passing out of the retort shaft,
(d) Temperature of the gases leaving the preheating zone of the jacket.

All these pyrometers may be coupled to an instrument panel at a pyrometer station. These pyrometers in conjunction with the high and low level indicating or alarm devices provide for full control of the working of the retort by the operator, and regulation of the conditions of working is consequently very simple.

It will be appreciated that owing to the action of superheated steam, the interior of the retort shaft becomes quickly covered with a hard and impenetrable scale, which obviates the necessity for a brick lining of the retort shaft, and consequently eliminates the heavy cost of maintenance and renewal of such a lining which is a feature of many known retorts used for carbonisation processes. The steel retort shaft may be replaced by a tubular refractory shaft.

The described vertical retort may be used with or without by-products recovery plant as referred to above.

Preferably, however, a plant for distilling the carbonaceous or cellulosic material, particularly shale, by the method set forth above, comprises a plurality of the vertical retorts e.g. 20 thereof, arranged in two rows forming two banks in one block. In such a block the spent shale conveyor 24 and below the quenching device at the bottom of one end retort may extend under all the other retorts in the bank to a quenching and settling tank 25 or pit. This tank or pit may be sunk in the ground and may be constructed of reinforced concrete, and may comprise a vertical partition wall 83 dividing it into two compartments whereof a larger compartment constitutes a sludge settling tank situated below the said screen or grid of the conveyor trough, and a smaller compartment which is in open communication through the partition wall above the larger compartment. The larger compartment may be provided with means for filtering the water, so that clean water can be pumped back to said cooling tower and the quenching device. Oil in both of these compartments will float as a layer on the water in both the compartments. Adjoining the pit and conveniently forming an end part of the same structure, is a third compartment 84 constituting a pump room accommodating an oil pump and a water recirculating pump, above which the trough conveyor extends to above the end of a delivery conveyor for spent shale leading to a dump.

The smaller compartment is preferably provided with a dehydrator 27 for use in the gravitational separation of oil from the water. This dehydrator preferably comprises a vertical column provided with a series of baffles and the liquid to be separated is passed into the column through a rotatable distributor which directs the entering liquid against a distributing surface. The rotatable distributor is preferably in the form of a cap over the end of the inlet pipe, which cap is made with inclined slots and for enabling the flow of the entering liquid to rotate it. The discharge of the oil is preferably effected automatically through an oil discharge valve at or near the top of the column by means of lever control gear adjusted for varying gravities. The separated oil is allowed to flow down the upper portion of the column through a valve under the control of a float adapted to sink in oil and float in water, while the separated water and impurities are withdrawn from the bottom of the column. The valve-controlling float may be mounted in a flat chamber external to the column, but communicating with it at the top and
bottom, and controlling the oil outlet valve through adjustable lever connections. The oil pump in the pump room is controlled by a float switch depending on the level of the oil in the pump room. The pit is of sufficient size to act as a cooling tank for reducing the temperature of the water due to atmospheric conditions. The water lost will be by evaporation, and this can be replaced from a supply pipe controlled by a float-controlled valve.

The banks of retorts may be used in combination with by-product recovery apparatus, which is common to them both, and comprises one or more water-cooled condensers 34, for hydrogenation volatiles and distillate liquor connection by a liquor receiver, e.g., a tar receiver 35, with the volatile outlet pipe 29 of each retort, and in addition, a gas-exhaustor 36, a gas-scrubber 32, a water-circulating pump 37 connected to the condenser or condensers. In such a plant steam supply means may comprise the gas-fired steam boiler 46, and the gas-fired steam superheater 31 connected therewith that are of sufficient capacity and are arranged to supply superheated steam to each retort in each bank simultaneously.

The by-product recovery apparatus is connected by piping 29 to the volatile outlets of all the retorts of the banks. The aforesaid gas-holder 33 may be connected by way of the gas-scrubber 32 and exhaustor 36 to the condensers 34, 31 for supplying gas to the steam boiler 46 and superheater 31, and also for collecting gas in bulk quantity for industrial purposes. An ammonia recovery plant having a hydro-extractor associated with it may be connected to the gas-scrubber. A fractionation unit 88 may also be connected to the tar accumulation tanks for fractionating the tar into various oils etc., at suitable boiling points. The auxiliary gas-producer 34 may be connected to the gas pipe between the gas-holder and the steam boiler. A gas-engine (not shown) connected with this auxiliary producer may be arranged to drive a dynamo.

The invention is not restricted to the precise constructional details enumerated. For example, in some cases the described vertical retorts may be arranged in banks of three or four retorts in each bank, and when four such banks are provided it is possible to arrange a battery of from 8 up to 32 retorts, with a by-product recovery plant common to them all. If more than 32 retorts are required, then one or more additional banks may be arranged in parallel with the other banks, but these additional banks would require additional boiler, superheater and condensing plant.

We claim:
1. A distillation apparatus for oil-shale and materials having like expansion properties under heat, comprising a vertical retort shaft an upper part of which is of substantially constant cross-sectional area while the bottom of the retort shaft consists of two superimposed sections of frustoconical shape joined together at their widest parts, a jacket wall surrounding the retort shaft so as to provide a heating jacket space extending round the retort shaft over the greater part of the height thereof from a position above the bottom of the upper section, the lower portion of the upper section and the whole of the lower section lying beneath the jacket space and being unheated, which jacket space is of greater width around the upper portion of the upper of the two superimposed sections, means for introducing fluid heating medium both into the bottom of the retort shaft and into the jacket space opposite the upper of the two superimposed sections, means for introducing the materials to be distilled into the top of the retort shaft and means for releasing the spent material from the lower of the two superimposed sections, which provides an outlet from the retort shaft.
2. A distillation apparatus for oil-bearing minerals, such as oil-shale, comprising a vertical retort shaft, which retort shaft is formed by a cylindrical upper part and two superimposed sections of frusto-conical shape joined to each other at their widest parts and secured to the lower end of said cylindrical upper part, a jacket wall surrounding the retort shaft and spaced away therefrom so as to provide a heating jacket space extending upwardly around the retort shaft from a position above the bottom of the upper section, the lower portion of the upper section and the whole of the lower section lying beneath the jacket space and being unheated, for the greater part of the height of said cylindrical upper part, said jacket space being of greater width around the upper of said two superimposed sections, a nozzle in the bottom of the retort shaft for introducing fluid heating medium into the retort shaft, gas burners in the jacket wall opposite the upper of said two superimposed sections and valve means for introducing the mineral into the top of the retort shaft and for releasing the spent mineral from the lower of said two superimposed sections, which lower section provides an outlet from the retort shaft.
3. An apparatus as claimed in claim 2 for the distillation of oil-bearing minerals, such as oil-shale, in which there are provided a quenching device below the retort shaft arranged to receive the discharges spent mineral and a water and oil separator arranged to receive quenched mineral and water from the quenching device.

HASTINGS JOHN HOLIFORD, ALEXANDER JOHN CHALLIS.

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